MIGRATION, HOME RANGE, AND IMPORTANT USE AREAS

OF FLORIDA SUB-ADULT BALD EAGLES

by

ELIZABETH KYNOR MOJICA

(Under the Direction of J. Michael Meyers and Steven B. Castleberry)

ABSTRACT

Long distance movements of Bald Eagles (*Haliaeetus leucocephalus*) have prevented a thorough documentation of their migration when monitored with traditional methods of banding and radio telemetry. I used satellite telemetry to determine diurnal and nocturnal important use areas (IUAs), migration routes, stopover sites, and home ranges of 69 migratory and non-migratory Florida sub-adult Bald Eagles. I located 151 daytime IUAs in 20 states and provinces, and 50 nocturnal roosts in 8 states and provinces. There was no difference in coarse home range size of migratory eagles between sexes in winter or summer (2-way ANOVA sex x season). Coarse home ranges were larger in winter ($\bar{x}$ = 25,218 km^2, 95% CI: 13,015 – 37,421) than summer ($\bar{x}$ = 6,166 km^2, 95% CI: 2,696 – 9,637; $F_{1,64}$ = 4.03, P = 0.01). Eagles made equal use of Coastal Plain (n = 24) and Appalachian Mountain (n = 26) migratory routes during the first migration north. I recommend conserving nocturnal roosts and undeveloped shoreline forest within IUAs for sustained recruitment of Florida Bald Eagles.

INDEX WORDS: Bald Eagle, *Haliaeetus leucocephalus,* migration, stopover, roost, nearest neighbor, kernel density estimation, home range, habitat, Florida, sub-adult, satellite telemetry

MIGRATION, HOME RANGE, AND IMPORTANT USE AREAS OF FLORIDA SUB-ADULT BALD EAGLES

by

ELIZABETH KYNOR MOJICA

B.S., Trinity University, 1999

A Thesis Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

ATHENS, GEORGIA

2006

MIGRATION, HOME RANGE, AND IMPORTANT USE AREAS OF FLORIDA SUB-ADULT BALD EAGLES

by

ELIZABETH KYNOR MOJICA

Major Professor:	J. Michael Meyers Steven B. Castleberry
Committee:	Gary W. Barrett Robert J. Warren

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
December 2006

DEDICATION

To my Grandmothers Elberta and Edith, whose love of birds and research inspired me.

ACKNOWLEDGEMENTS

I thank my advisor Joe Meyers for his patience and tireless detailed revisions. He took me on as a student before I had funding for this project and I am grateful he was willing to provide me with this research opportunity. Thanks to my committee members Bob Warren, Gary Barrett, and Steven Castleberry for their comments and suggestions.

Many heartfelt thanks go to my husband Gil, who was very patient with my fluctuating stress levels and the nights and weekends I spent at the office. I am deeply grateful for the initial funding for my first year of graduate school provided by my late grandparents Jim and Edith Sprouse.

I give special thanks to Katherin Haley who secured the funding for this project and guided the contract through the bureaucratic maze. Brian Millsap encouraged me to work on eagles and initiated this new phase of his initial study. Both gave valuable comments on the agency final report preceding my thesis.

Funding for this project was provided by the Florida Non-Game Wildlife Trust Fund, The U.S. Fish and Wildlife Service, The University of Georgia, Warnell School of Forestry and Natural Resources, USGS Patuxent Wildlife Research Center, and the Georgia Ornithological Society.

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER 1
INTRODUCTION

The Bald Eagle (*Haliaeetus leucocephalus*) is the national bird of the United States of America and a symbol of freedom and national pride for American citizens. Recent Bald Eagle recovery is the successful result of state and federal endangered species programs. Eagles are federally threatened and receive substantial habitat protection. The management focus for the species is protecting and monitoring nesting territories. Little emphasis, however, is currently placed on conserving roosts or foraging areas used by non-breeding eagles. Protecting quality habitat used by non-breeding eagles, both adults and sub-adults, may be a more appropriate long-term management strategy and could substantially increase Bald Eagle recruitment (Simons et al. 1988, McClelland et al. 1994).

Florida provides habitat for 1,133 breeding pairs, the largest number of nesting Bald Eagles in the lower 48 states (United States Fish and Wildlife Service 2000, Nesbitt et al. 2003). Although the Florida eagle population appears stable, the threat of habitat loss remains a concern (Wood et al. 1989). As the human population increases in Florida and throughout the United States, eagles are encountering an increasing human presence that may degrade or destroy Bald Eagle habitat (Millsap et al. 2004). Bald Eagles and other migratory species are at greater risk than resident species because they use multiple habitats and locations throughout the calendar year (Berthold 2001). Bald Eagles travel several thousand kilometers between seasonally used habitats.

The objectives of this study were to determine the migratory patterns, timing, and seasonal home ranges of Florida sub-adult Bald Eagles (ages 0-5 years old). In addition, I identified specific locations that may be important to Florida eagles in future conservation plans.

Life History

The breeding range for the Bald Eagle extends from Mexico and Florida north and west to Alaska and to eastern Canada (Gerrard and Bortolotti 1988). During winter, eagles migrate south to temperate regions of North America (Buehler 2000). Bald Eagles build nests in forests near shorelines and construct large stick nests in older conifers or cliffs. Breeding territories are used annually by the same pair (Gerrard and Bortolotti 1988). Eagles initiate nest building from September to January and fledge nestlings from January to March (Broley 1947, Millsap et al. 2004). Eagles are non-breeding sub-adults until they molt to their definitive adult plumage and begin breeding at 4-5 years old (McCollough 1989, Buehler 2000). Bald Eagles live an average of 15 years (Harmata et al. 1999).

Bald Eagles feed primarily on freshwater fish. Waterfowl and shorebirds are taken during winter. Eagles also feed opportunistically and will consume road kill and other carcasses (Gerrard and Bortolotti 1988, Millsap et al. 2004).

Migration is defined as a seasonal shift of birds between breeding and non-breeding ranges to increase foraging opportunity or to seek warmer temperatures (Newton 1979). Bald Eagles are medium-distance migrants (Heintzelman 1975). Florida's nesting eagles were originally believed to be sedentary, permanent residents of the state because adults were often seen year-round (Broley 1947). Bird banding,

hawk migration counts, and radio-telemetry, indicated that Florida eagles were partial migrants. Most breeding adults remain in Florida year-round, and sub-adults and non-breeding adults migrate north during summer months (Wood and Collopy 1994). Until recently, all non-breeding Florida eagles were thought to migrate outside of the state in summer. Non-migratory sub-adults were not documented, however, until eagles were located in Florida year-round using satellite telemetry (Millsap et al. 2004).

Bald Eagles initiate migration near the spring and fall equinoxes when weather systems change air temperatures and barometric pressure (Heintzelman 1975). Sub-adult eagles leave Florida for northern climates when maximum air temperatures reach 30˚C (86˚F). In addition to temperature, peak fish abundance in Florida may be a factor related to eagle migration. Fish are readily available during Florida's mild winter months, but may be unavailable in summer when fish move to deeper cold water out of reach of foraging eagles (Wood and Collopy 1994). Eagles depart Florida in spring from early April to the middle of May (Broley 1947, Wood and Collopy 1994). Sub-adults begin arriving in the Chesapeake Bay region in mid-April (Buehler et al. 1991). In fall, eagles return to Florida from mid-September to mid-November (Broley 1947, Buehler et al. 1991, Wood and Collopy 1994).

Eagles migrate in flyways or landscape corridors concentrated around coastlines, mountain ranges, and river systems. Flyways represent patches of habitat used as migration stopover sites for seasonal movements >1,000 km in length. Stopover habitat can be used to manage eagle populations by creating networks of resting and foraging areas (Berthold 2001).

Florida Bald Eagles may use three flyways: Atlantic coast, Appalachian Mountains, and Mississippi River valley. Eagles' use of the coastal flyway is well-documented through hawk migration stations and sightings of banded birds. Florida eagles frequent coastal areas of the Carolinas, Chesapeake Bay, Maine, and Canada's maritime provinces (Broley 1947, Wood and Collopy 1994, Millsap et al. 2004). Use of other flyways by Florida eagles is poorly understood. Sightings of banded and marked Florida eagles in the Great Lakes area and at various points in the Appalachian Mountains indicate use of these flyways (Wood and Collopy 1994). VHF-radio-telemetry and banding studies provide incomplete information on eagle migration because of limited sightings during large distance movements. Satellite telemetry data could increase our knowledge of eagle migration.

Bald Eagles migrate long distances to reach summering or wintering sites. Eagles soar on air thermals or natural updrafts 60 to180 m above ground (Newton 1979, McClelland et al. 1994). Depending on weather patterns, eagles fly 100 to 450 km/day during migration (Harmata 1982, Grubb et al. 1994, Wood and Collopy 1994). Eagles stop to roost overnight and sometimes stay longer to rest or forage. Stopover sites may be used for longer periods of time. Stopover sites are defined as areas visited >24 hours during migration (Laing et al. 2005), where the eagle ceases directional movement or concentrates movements locally (Ueta and Higuchi 2002). Eagles use up to 5 stopovers during migration, staying at each location for up to 4 weeks (Laing et al. 2005).

Bald Eagles can exhibit nomadic wandering, an uncommon raptor behavior (McClelland et al. 1994, Laing et al. 2005). Nomads drift from place to place exploiting

varying levels of food abundance (Newton 1979). Sub-adult eagles can continue to move from one site to the next for the entire summer (McClelland et al. 1994, Laing et al. 2005). Nomadic movement patterns appear more common in younger eagles, which spend more time roaming than adults (Hodges et al. 1987, Wood and Collopy 1994). Nomadism during sub-adult years may help eagles find preferred foraging sites during adulthood. The extent to which Florida sub-adult eagles use nomadic foraging is unknown. Tracking Florida eagles with satellite telemetry may provide a more complete record of movements and document nomadic behavior.

Florida is the winter home of approximately 2,250 breeding adults and 2,000 sub-adults fledged from Florida nests (Nesbitt et al. 2003). Florida is also home to a few northern birds during winter (Postupalsky 1976). Wintering sub-adults in this study mainly concentrated in western and central Florida and the panhandle of the Gulf Coast (Millsap et al. 2004).

During summer months, Florida eagles can be found in more than 17 states and 6 Canadian provinces (Broley 1947). Eagles migrate up to 2,200 km from Florida (Broley 1947, Newton 1979). Florida sub-adults frequent the Canadian maritime provinces as well as the Chesapeake Bay and coastal Carolinas (Buehler et al. 1991, Wood and Collopy 1994, Millsap et al. 2004). Identifying and conserving these areas is important because eagles show site fidelity to foraging areas (Gerrard et al. 1978, Harmata 1982, McClelland et al. 1994, Wood and Collopy 1994).

The ability to track wide-ranging movements of Bald Eagles confounds accurate estimation of home range size. Home range estimates using conventional VHF telemetry range from 102 to 593 km^2 (Grubb et al. 1989, McClelland et al. 1994).

Radio-tagged eagles can fly outside the range of a VHF receiver 51% of the time; therefore, many of their movements were previously unknown (Grubb et al. 1994) and home range size estimates were imprecise. In contrast to VHF telemetry, satellite telemetry home ranges (95% minimum convex polygons) for 2 sub-adult eagles ranged from 11,106 to 53,946 km^2 (Grubb et al. 1994). The discrepancy between telemetry techniques highlights gaps in information collected during 30 years of research on this species. Bald Eagle home range size estimates need to be reevaluated using satellite telemetry data.

Status and Conservation

Pre-European Bald Eagle population estimates range from 250,000 to 500,000 individuals (Gerrard and Bortolotti 1988). Population abundance declined in the late 19^{th} through the mid-20^{th} centuries for several reasons. Productivity rates declined from over-harvesting of eggs and feathers for private and scientific collections. Eagles also were incidentally killed from scavenging poisoned carcasses intended for mammalian livestock predators (Gerrard and Bortolotti 1988). In the 1940s to 1970s, Bald Eagles accumulated large amounts of the pesticide dichloro-diphenyl-trichloroethane (DDT). While the level was not toxic, it impaired reproduction. Eagle populations slowly recovered after the United States banned DDT in 1972 (Buehler 2000).

Eagle nesting and roosting habitat is managed primarily through regional management guidelines (United States Fish and Wildlife Service 1987). Five United States recovery regions were established in the 1980s with separate recovery goals. The southeastern states region reached productivity and nesting goals in 1991 (United States Fish and Wildlife Service 1999). Florida nesting territory numbers increased

from 88 in 1973 to 1,133 in 2003. An estimated 4,250 adults and sub-adults occur in Florida (Nesbitt et al. 2003).

In 1999, the United States Fish and Wildlife Service (USFWS) proposed removing the Bald Eagle from the list of endangered and threatened wildlife because the species met all the USFWS recovery goals (United States Fish and Wildlife Service 1999). The final ruling to remove this species was delayed by the development of National Bald Eagle Management Guidelines. These guidelines give habitat management recommendations and clarification of the term “take” (United States Fish and Wildlife Service 2006). After delisting, the Bald Eagle will continue to be protected by the Bald and Golden Eagle Protection Act and Migratory Bird Treaty Act (United States Fish and Wildlife Service 1999).

Study Overview

In 1996, the Florida Fish and Wildlife Conservation Commission initiated a research project to investigate survival and fecundity differences between rural and suburban Bald Eagle nests. Eagle nestlings (n = 69) were banded and fitted with 5-yr satellite transmitters during the 1997-2001 breeding seasons. Location data were analyzed roughly and some migratory movements were mapped (Millsap et al. 2004). After completion of the initial study, we realized satellite locations could be used to describe the post-dispersal movements of sub-adult eagles. We set 4 main objectives including both natural history descriptions and habitat identification to assist in management of the species. First, we identified routes used and distance traveled during migration. Second, we calculated home range size. Third, we used nearest-neighbor clustering to identify areas important to migratory eagles. Finally, based on

these results, we made recommendations for protecting habitat for private landowners and state and federal land managers.

Literature Cited

Berthold, P. 2001. Bird migration: a general survey. Oxford University Press, Oxford, England.

Broley, C. L. 1947. Migration and nesting of Florida Bald Eagles. Wilson Bulletin 59:3-20.

Buehler, D. A., T. J. Mersmann, J. D. Fraser, and J. K. D. Seegar. 1991. Differences in distribution of breeding, non-breeding, and migrant Bald Eagles on the northern Chesapeake Bay. Condor 93:399-408.

Buehler, D. A. 2000. Bald Eagle (*Haliaeetus leucocephalus*). *In* The Birds of North America, No. 506A (A. Poole and F. Gill, editors). The Birds of North America, Inc, Philadelphia, Pennsylvania.

Gerrard, J. M., D. W. A. Whitfield, P. Gerrard, P. N. Gerrard, and W. J. Maher. 1978. Migratory movements and plumage of subadult Saskatchewan Bald Eagles. Canadian Field Naturalist 92:375-382.

Gerrard, J. M. and G. R. Bortolotti. 1988. The Bald Eagle: haunts and habits of a wilderness monarch. Smithsonian Institution Press, Washington, D.C.

Grubb, T. G., S. J. Nagiller, W. L. Eakle, and G. A. Goodwin. 1989. Winter roosting patterns of Bald Eagles (*Haliaeetus leucocephalus*) in north-central Arizona. Southwestern Naturalist 34:453-459.

Grubb, T. G., W. W. Bowerman, and P. H. Howey. 1994. Tracking local and seasonal movements of wintering Bald Eagles *Haliaeetus leucocephalus* from Arizona and Michigan with satellite telemetry. Pages 347-358 *in* Proceedings of the IV World Conference on Birds of Prey and Owls (B.-U. Meyburg and R. D. Chancellor, Eds). The Pica Press, Berlin, Germany.

Harmata, A. R. 1982. Statewide endangered species research: behavior and ecology of wintering and migrant Bald Eagles in the Rocky Mountains. Project Number MONT. SE-001-R /JOB 01/FIN. Montana Department of Fish Wildlife and Parks, Helena, Montana.

Heintzelman, D. S. 1975. Autumn hawk flights: the migrations in Eastern North America. Rutgers University Press, Rutgers, New Jersey.

Hodges, J. I., E. L. Beocker, and A. J. Hansen. 1987. Movements of radio-tagged Bald Eagles, *Haliaeetus leucocephalus*, in and from southeastern Alaska. Canadian Field Naturalist 101:136-140.

Laing, D. K., D. M. Bird, and T. E. Chubbs. 2005. First complete migration cycles for juvenile Bald Eagles (*Haliaeetus leucocephalus*) from Labrador. Journal of Raptor Research 39:11-18.

McClelland, B. R., L. S. Young, P. T. McClelland, J. G. Crenshaw, H. L. Allen, and D. S. Shea. 1994. Migration ecology of Bald Eagles from autumn concentrations in Glacier National Park, Montana. Wildlife Monographs 125:1-61.

McCullough, M. A. 1989. Molting sequence and aging of Bald Eagles. Wilson Bulletin 101:1-10.

Millsap, B., T. Breen, E. McConnell, T. Steffer, L. Phillips, N. Douglass, and S. Taylor. 2004. Comparative fecundity and survival of Bald Eagles fledged from suburban and rural natal areas in Florida. Journal of Wildlife Management 68:1018-1031.

Nesbitt, S. A., J. A. Bozzo, N. J. Douglass, K. Lamonte, P. S. Kubilis, T. W. Regan, S. T. Schwikert, and J. H. White. 2003. Bald Eagle population monitoring, annual report. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, South Dakota.

Postupalsky, S. 1976. Banded northern Bald Eagles in Florida and other southern states. Auk 93:835-836.

Schempf, P. E. 1997. Bald Eagle longevity record from southeastern Alaska. Journal of Field Ornithology 68:150–151.

Ueta, M. and H. Higuchi. 2002. Difference in migration pattern between adult and immature birds using satellites. Auk 119:832-835.

U.S. Fish and Wildlife Service. 1987. Management guidelines for the Bald Eagle in the southeast region. United States Fish and Wildlife Service, Atlanta, Georgia.

U.S. Fish and Wildlife Service. 1999. Proposed rule to remove the Bald Eagle in the lower 48 states from the list of endangered and threatened wildlife. Federal Register 64:36454-36464.

U.S. Fish and Wildlife Service. 2000. Bald Eagle pairs in the lower 48 States. United States Fish and Wildlife Service Region 3,

http://midwest.USFWS.gov/eagle/population/2000mapofprs.html (accessed November 2004).

Wood, P. B., T. C. Edwards, and M. W. Collopy. 1989. Characteristics of Bald Eagle nesting habitat in Florida. Journal of Wildlife Management 53:441-449.

Wood, P. B., and M. W. Collopy. 1994. Population ecology of sub-adult southern Bald Eagles in Florida: post-fledging ecology, migration patterns, habitat use, and survival. Nongame wildlife program project NG87-026, final report, Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Chapter 2

MIGRATION OF FLORIDA SUB-ADULT BALD EAGLES[1]

[1] Mojica, E.K., J.M. Meyers, B.A. Millsap, K.L. Haley. *To be submitted to The Wilson Journal of Ornithology*

Abstract: Long distance movements of Bald Eagles (*Haliaeetus leucocephalus)* has hindered a thorough documentation of their migration when monitored with traditional methods of banding and radio-telemetry. We used satellite telemetry locations with 1 km accuracy to determine migration routes and stopover sites of 48 migratory Florida sub-adult Bald Eagles. We measured number of days traveled during migration, path of migration, and distance traveled from winter to summer areas. Eagles used both Coastal Plain (*n* = 24) and Appalachian Mountain (*n* = 26) routes on their first migration north. Mountain migrants traveled farther ($\bar{x}$ = 2,112 km; 95% CI: 1,815 – 2,410) than coastal migrants ($\bar{x}$ = 1,397 km; 95% CI: 1,087 – 1,706). About half (47%) of migratory eagles (*n* = 25) used stopovers during migration and stayed 6 to 31 days ($\bar{x}$ = 14.8 days; 95% CI: 12.8 – 16.8). We recommend that stopover site locations be added to GIS databases for improving conservation policies of Bald Eagles. Bald Eagle habitat used by non-breeding sub-adults may need conservation and management to sustain recent increases in the Florida eagle population.

KEY WORDS: Bald Eagle, *Haliaeetus leucocephalus,* migration, stopover, migration route, Florida, satellite telemetry

Introduction

The migration of Bald Eagles (*Haliaeetus leucocephalus*) has been studied with limited success using band recoveries and VHF radio-transmitters (Harmata et al. 1985, Hunt et al. 1992, McClelland et al. 1994, Wood and Collopy 1994, Harmata 2002). Bald Eagles are medium-distance migrants that use two regional migration strategies: complete and partial migrations (Heintzelman 1975, Newton 1979). In Florida, eagles are partial migrants where sub-adults migrate north in summer months, but many adults remain year-round residents (Broley 1947, Wood and Collopy 1994). Band recoveries indicate that Florida eagles migrate as far north as Prince Edward Island, Canada in summer and return to Florida in winter (Broley 1947, Wood and Collopy 1994, Millsap et al. 2004). In the past, technological problems with tracking migration and the cost of equipment and person-hours to follow eagles prevented a complete data record of long-distance eagle movements. Tracking wildlife using satellite telemetry allows biologists to collect regular unbiased locations of migrating species. Our objectives were to document the pathways, determine timing, and locate stopover sites of Florida sub-adult Bald Eagle migration in eastern North America using satellite telemetry.

Methods

We used satellite locations collected on average every 7 days for 12 hours during 1997-2004 from migratory Florida sub-adult Bald Eagles (n = 54). Eagles were fitted with 5-yr, 95-g platform terminal transmitters (PTTs) as nestlings during 1997-2001 (Millsap et al. 2004). Location accuracy was tested using known locations of nestling eagles prior to fledging and locations were determined to be accurate within 1 km by Millsap et al. 2004.

We estimated number of days traveled during spring and fall migration using dates of departure and arrival. We calculated departure date by averaging satellite transmission dates for each eagle during the week of departure when they made continuous directional movements north or south. We did not use data if the interval between transmissions was >2.5 weeks to avoid inaccurate departure date estimates from missing values. The arrival date was determined as the first day the eagle stopped migration, and began a period of localized movements (<100 km radius) for >31 days. We averaged migration departure dates for each season. We averaged the first migrating date post-dispersal separately because movements of newly fledged eagles may vary from older sub-adults (Gerrard et al. 1978). We compared difference between the number of days traveled during migration for each eagle's first north and south migrations (paired *t*-test, $n = 40$).

We determined first-year migration routes using satellite data accurate >1 km to define routes taken by migrating eagles. During the migration period, we plotted satellite locations in ArcView 3.2 (Environmental Systems Research Institute, Redlands, CA 1999) with an Albers Equal Area Conic projection and then connected locations on a map of eastern North America. We categorized migration routes with proximity to the Appalachian Mountains, i.e., any northward movement within the mountain boundary (Sure!Maps Raster 1995) was classified as mountain and travel east of the mountains as coastal. To examine route fidelity, we compared route changes for an individual in one year by age class (1 yr, 2 yr, 3-5 yr) using a Pearson chi-square test. We calculated distance traveled by adding the linear distances between winter and summer

areas for each eagle. We compared migration distance between routes, sexes, and calendar year using 3-way ANOVA (SAS Institute, Inc. 1999).

We defined a stopover site as an area where an eagle made localized movements 6 to 31 days during the migration period. If the eagle remained in an area >6 days, we had at least 2 locations confirming use of the area. We recorded the closest body of water using United States and Canadian hydrology data layers in ArcView (Natural Resources Canada 2001, United States Geological Survey 2003). We measured the distance between stopovers for an eagle and the time spent at each stop. If an eagle used multiple stopovers, we averaged the distance traveled between stopovers. We used a one-way ANOVA to compare distances traveled by eagles on their first north and south migrations.

Results

Recently fledged eagles began their first migration April through August ($\bar{x}$ = May 30, median = May 24, *n* = 52). Older sub-adults began migrating north from Florida earlier in the spring from late March to late July ($\bar{x}$ = May 2, median = April 30, *n* = 71). The return trip south began in late July through late December for all age classes ($\bar{x}$ = September 19, median = September 23, *n* = 104, Fig. 2.1, Appendix A). Number of days traveled on the first migration was longer for southward movements than for northward movements (paired *t*-test, $\bar{x}$ difference = 11 days, df = 38, *t* = 2.2, *P* = 0.032).

During their first year, eagles flew north in spring along the Coastal Plain (*n* = 24) and Appalachian Mountains (*n* = 26, Fig. 2.2). Two eagles used the lower Mississippi

River Valley to migrate into Mississippi and Missouri. Eagles changed routes less between north and south movements as they aged (χ^2 = 13.22, df = 2, *P* = 0.001). One-year old eagles changed routes 57% of the time, 2-year olds 30%, and 3-5 year olds changed only 17% of the time.

We found no difference for distance traveled by sex ($F_{1, 31}$= 0.86, *P* = 0.36), year ($F_{3, 31}$= 0.25, *P* = 0.86), or the interaction terms; however, route distances did differ. Coastal migrants traveled less ($\bar{x}$ = 1,397 km) than mountain migrants ($\bar{x}$ = 2,112 km; $F_{1, 31}$= 9.11, *P* = 0.005). One eagle spent the summer 4,146 km north of Florida in coastal Labrador, Canada (51°N), but the northern most latitude visited was 55°N in NW Labrador. Another eagle traveled only 340 km north of Florida to spend the summer on Lake Marion, South Carolina (33°N).

We documented 25 of 53 migratory eagles using stopovers (Appendix B). Eagles visited stopovers 1 to 3 times during migration, staying 6 to 31 days ($\bar{x}$ = 14.8 days, median = 14 days; 95% CI: 12.8 – 16.8; n = 54; Fig. 2.3). Most stopover site durations were $\leq$31 days, but one female (PTT 22988) spent the summer in New York and during the first migration south, remained at a West Virginia stopover for 54 days, and continued south to Florida (removed from analysis because it did not meet stopover criteria). Mean distance traveled between stops on first migration north ($\bar{x}$ = 1,405 km; 95% CI: 901 – 1,908; *n* = 9) was not different from first migration south ($\bar{x}$ = 779 km; 95% CI: 402 – 1,156; n = 16; one-way ANOVA $F_{1, 23}$= 4.23, *P* = 0.051).

Discussion

Bald Eagles migrate each fall and spring to exploit seasonally available food. Eagles feed primarily on exothermic fish that are sensitized to seasonal temperature fluctuations (Gerrard and Bortolotti 1988). Eagles in Florida are thought to migrate to cooler latitudes in summer to escape high temperatures and increase prey availability (Wood and Collopy 1994). Our average fall and spring migration dates correspond to previous reports from banding stations and telemetry studies (Broley 1947, Buehler et al. 1991, Weidensaul 2000). Wide variation in both departure and return dates suggests migration behavior cannot be attributed solely to prey abundance or air temperature.

We found previously undescribed Bald Eagle migratory routes along the Appalachian Mountains and Mississippi Valley. Earlier studies indicated that eagles predominantly used coastal routes (Broley 1947, Wood and Collopy 1994), however, we found equal use of coastal and mountain migratory routes. Eagles of both sexes and all sub-adult age classes used both migratory routes. We suggest route choice may depend on prevailing winds at the time of migration or genetic pre-programming (Broley 1947, Hunt et al. 1992). In the 1940s, biologists hypothesized that Florida eagles found summering in Midwestern states used the Mississippi Valley during migration (Broley 1947). Two eagles (4%) in this study used the Mississippi Valley flyway, but only the lower portion of that flyway. One female (PTT 24979) spent 2 consecutive summers in southern Illinois on the Mississippi River and wintered on the Florida panhandle. Another female (PTT 13498) spent 4 summers in northeastern Alabama and southern Tennessee, and spent the winters in west-central Florida (Appendix C). In addition, 1

male (PTT 24981) migrated north through the Appalachian Mountains before moving west to spend the summer on Lake Erie. The Atlantic Coast, Appalachian Mountain, and Mississippi River migratory routes we describe may be specific to Florida Bald Eagles. Other eagle populations in the southeastern U.S. likely use variations of these routes (Gill 1990). The increase in migration route fidelity as eagles age suggests a learning curve for young eagles. As an eagle gains more experience, it may learn to prefer certain stopover sites on a particular migration route.

We recorded migration distances >1,000 km farther than those reported in previous studies for adults and sub-adults (range: 1,450 to 3,032 km) from summer and nesting ranges to wintering ranges (Grubb et al. 1994, McClelland et al. 1994, Wood and Collopy 1994). We attribute discovery of this greater distance to satellite tracking in remote areas of Canada. Two eagles, however, stopped their northerly migration in Georgia and South Carolina, while the remaining eagles traveled several thousand additional kilometers. Some of the difference in distance traveled can be explained by migration routes, because coastal migrants traveled less distance overall than mountain migrants. Mountain migrants may be able to travel farther by soaring or gliding on more abundant updrafts than are found in the Coastal Plain (Heintzelman 1975, Hunt et al. 1992).

Stopover sites are important areas along the migration route where most eagles spent 1 to 4 weeks before continuing on to their destination. Our estimated mean time spent at stopovers was consistent with previous studies of hatch-year sub-adults ($\bar{x}$ = 14.5, range 1-25 days; Restani 2000, Laing et al. 2005). Approximately half the eagles were not detected using stopovers, but this could be related to our sampling

interval (1 transmission/week). Eagles may have used stopovers ≤6 days and therefore went undetected by the satellite transmissions. The comparison of distances traveled between stopover sites was not different, but this could be attributed to low sample sizes. On average, southbound eagles stopped after less distance traveled than northbound eagles. This southbound tendency to stop may explain the long time spent in fall migration.

In summary, our results provide substantial information on Bald Eagle migratory timing, routes, and stopovers than previously described from banding and VHF telemetry studies. Detailed knowledge of eagle migration is important for managing this wide-ranging species. Eagles may benefit from a national or international management plan rather than the current U.S. regional eagle plans. Conserving migratory stopover habitat we identified may ensure the continued recruitment of the Florida eagle population and their movements throughout eastern North America.

Acknowledgements

This research was funded by the Florida Non-game Wildlife Trust Fund, U.S. Fish and Wildlife Service (Section 6), USGS Patuxent Wildlife Research Center, The University of Georgia, Warnell School of Forestry and Natural Resources, Georgia Ornithological Society, and the Sprouse family.

Literature Cited

Broley, C. L. 1947. Migration and nesting of Florida Bald Eagles. Wilson Bulletin 59:3-20.

Buehler, D. A., T. J. Mersmann, J. D. Fraser, and J. K. D. Seegar. 1991. Differences in distribution of breeding, non-breeding, and migrant Bald Eagles on the northern Chesapeake Bay. Condor 93:399-408.

Gerrard, J. M., D. W. A. Whitfield, P. Gerrard, P. N. Gerrard, and W. J. Maher. 1978. Migratory movements and plumage of subadult Saskatchewan Bald Eagles. Canadian Field Naturalist 92:375-382.

Gerrard, J. M., and G. R. Bortolotti. 1988. The Bald Eagle: haunts and habits of a wilderness monarch. Smithsonian Institution Press, Washington, D.C.

Gill, F. B. 1990. Ornithology. W.H. Freeman and Co., New York, New York.

Grubb, T. G., W. W. Bowerman, and P. H. Howey. 1994. Tracking local and seasonal movements of wintering Bald Eagles *Haliaeetus leucocephalus* from Arizona and Michigan with satellite telemetry. Pages 347-358 *in* Proceedings of the IV World Conference on Birds of Prey and Owls (B.-U. Meyburg and R. D. Chancellor, Eds.). The Pica Press, Berlin, Germany.

Harmata, A. R., J. E. Toepfer, and J. M. Gerrard. 1985. Fall migration of Bald Eagles produced in northern Saskatchewan. Blue Jay 43:232-237.

Harmata, A. R. 2002. Vernal migration of Bald Eagles from a southern Colorado wintering area. Journal of Raptor Research 36:256-264.

Heintzelman, D. S. 1975. Autumn hawk flights: the migrations in Eastern North America. Rutgers University Press, Rutgers, New Jersey.

Hunt, W. G., R. E. Jackman, J. M. Jenkins, C. G. Thelander, and R. N. Lehman. 1992. Northward post-fledging migration of California Bald Eagles. Journal of Raptor Research 26:19-23.

Laing, D. K., D. M. Bird, and T. E. Chubbs. 2005. First complete migration cycles for juvenile Bald Eagles (*Haliaeetus leucocephalus*) from Labrador. Journal of Raptor Research 39:11-18.

McClelland, B. R., L. S. Young, P. T. McClelland, J. G. Crenshaw, H. L. Allen, and D. S. Shea. 1994. Migration ecology of Bald Eagles from autumn concentrations in Glacier National Park, Montana. Wildlife Monographs 125:1-61.

Millsap, B., T. Breen, E. McConnell, T. Steffer, L. Phillips, N. Douglass, and S. Taylor. 2004. Comparative fecundity and survival of Bald Eagles fledged from suburban and rural natal areas in Florida. Journal of Wildlife Management 68:1018-1031.

Natural Resources Canada. 2001. National topographic database: hydrography features. Centre for Topographic Information, Natural Resources Canada, Sherbrooke, Quebec, Canada.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, South Dakota.

Restani, M. 2000. Age-specific stopover behavior of migrant Bald Eagles. Wilson Bulletin 112:28-34.

SAS Institute, Inc. 1999. SAS/STAT User's Guide, version 8. SAS Institute, Inc. Cary, North Carolina.

Sure!Maps Raster. 1995. Eastern U.S.: NH, VT, NY, MA, PA, RI, CT, NJ, DE, MD, DC, VA, WV, NC, SC, GA, FL, ME. Horizons Technologies, Inc., San Diego, California.

United States Geological Survey. 2003. U.S. national atlas water feature areas: aqueducts, canals, dams, intercoastal waterways, rivers, and streams. Reston, Virginia.

Weidensaul, S. 2000. The raptor almanac: a comprehensive guide to eagles, hawks, falcons, and vultures. The Lyons Press, New York, New York.

Wood, P. B., and M. W. Collopy. 1994. Population ecology of sub-adult southern Bald Eagles in Florida: post-fledging ecology, migration patterns, habitat use, and survival. Nongame wildlife program project NG87-026, final report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

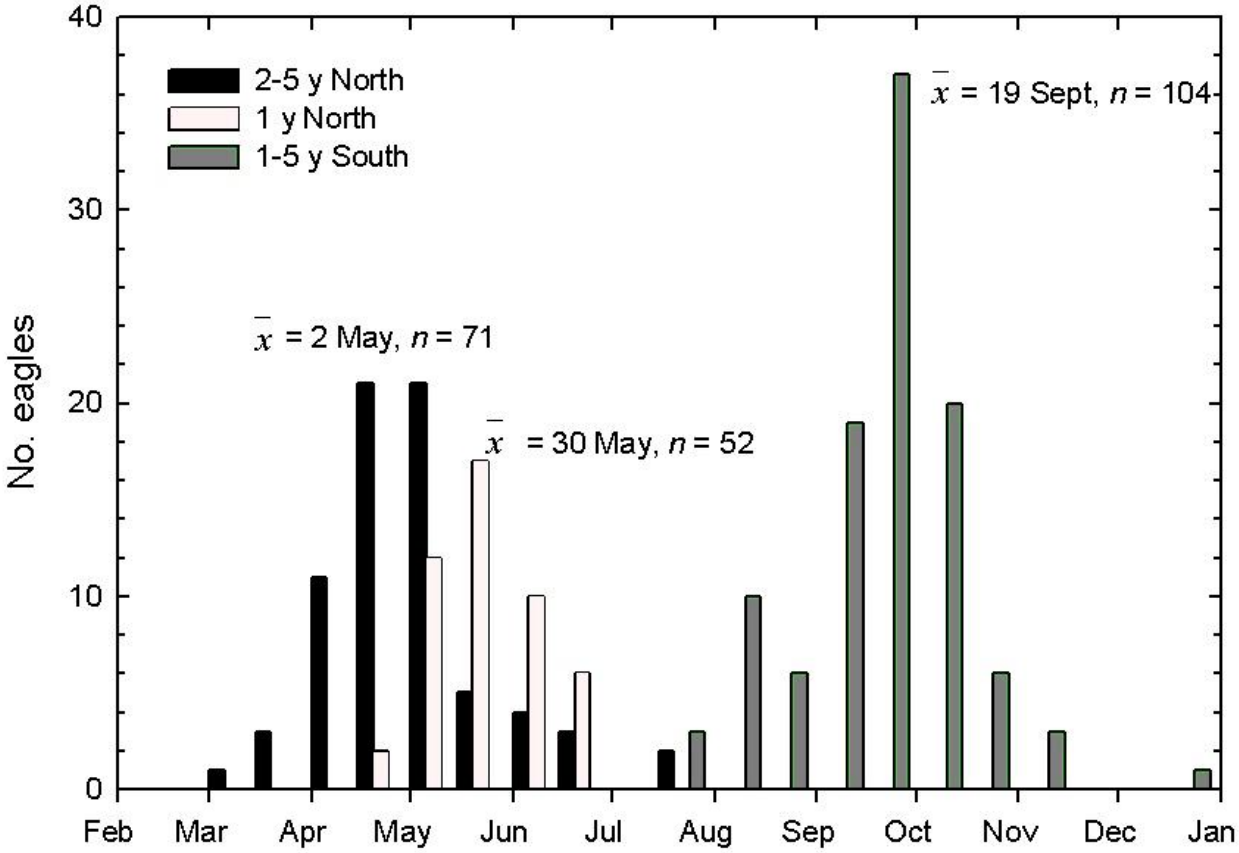


Figure 2.1. Florida sub-adult Bald Eagle migration initiation north and south, 1997-2004. First-year eagles migrated later in the spring than older sub-adults.

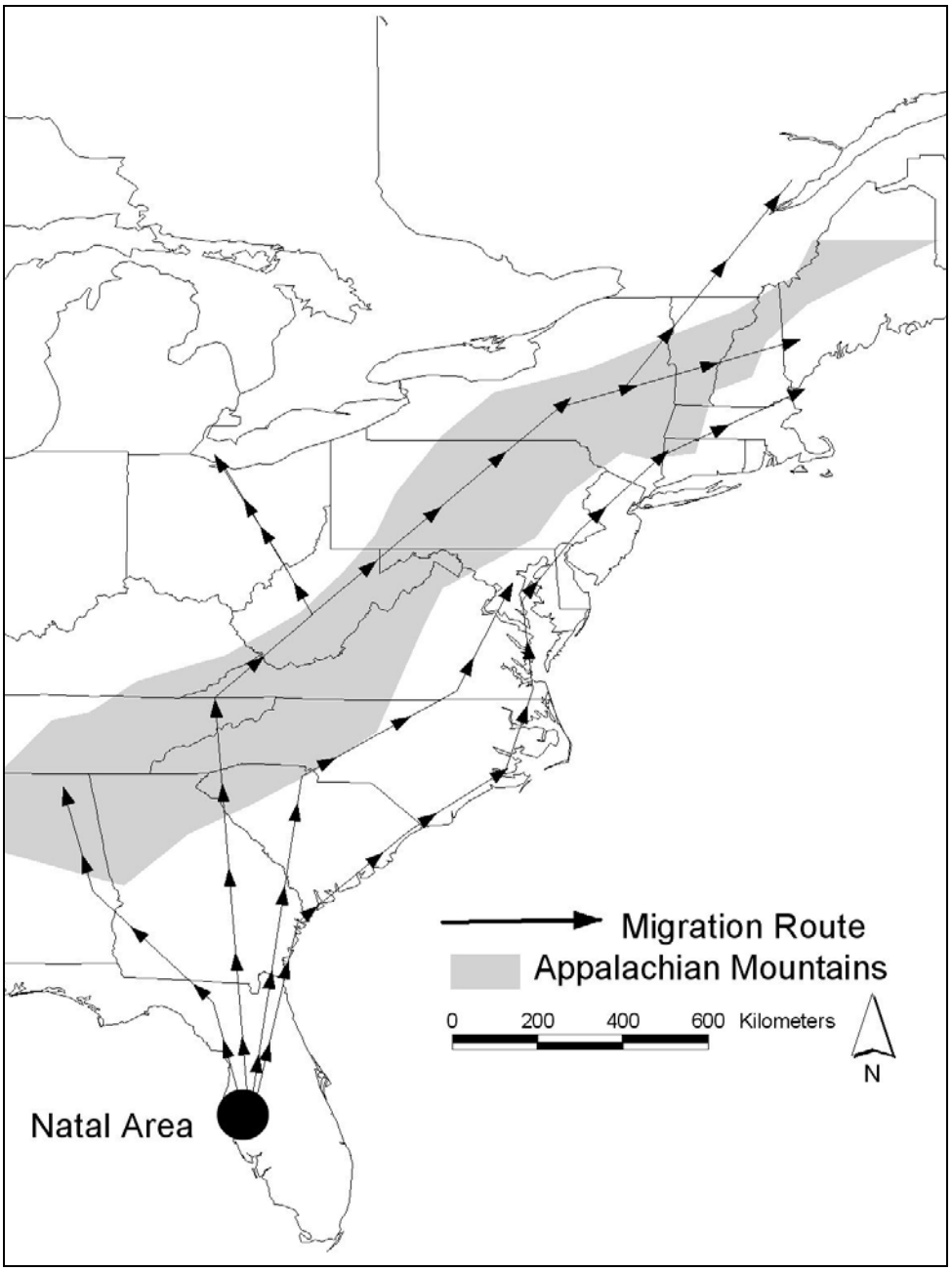


Figure 2.2. Migration routes followed by Florida sub-adult Bald Eagles (*n* = 54) in eastern North America, 1997-2004. Return routes south are similar.

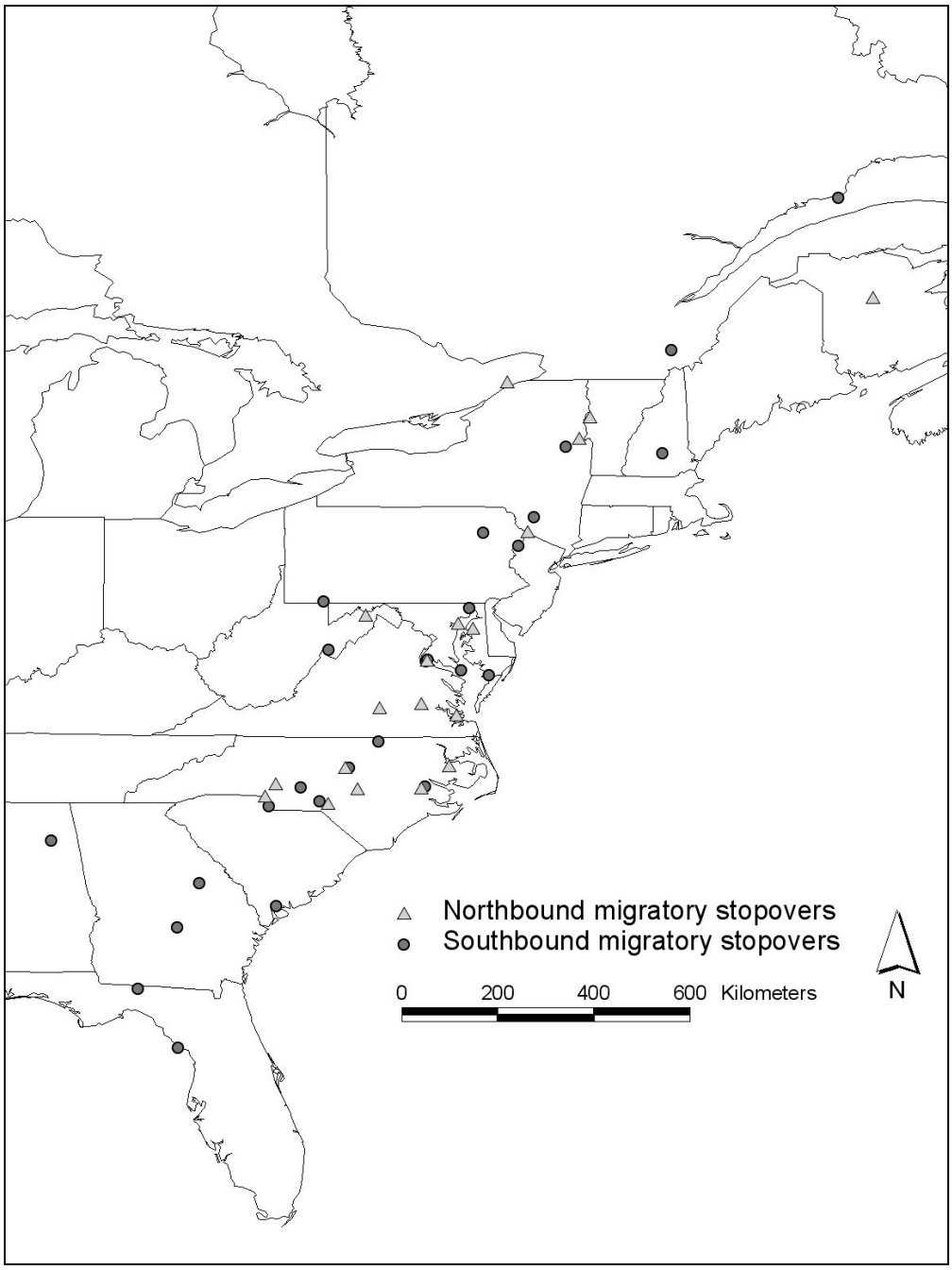


Figure 2.3. Stopover sites used by Florida sub-adult Bald Eagles (*n* = 25) ages 1-4 during northbound and southbound migration in eastern North America, 1997-2004. Eagles remained at sites 6-31 days.

Chapter 3

HOME RANGE SIZES OF MIGRATORY AND NON-MIGRATORY FLORIDA SUB-ADULT BALD EAGLES[1]

[1] Mojica, E.K., J.M. Meyers, B.A. Millsap, K.L. Haley. *To be submitted to Journal of Raptor Research*

Abstract: We estimated seasonal home ranges of 44 sub-adult Florida Bald Eagles (*Haliaeetus leucocephalus*) by using satellite transmitter locations. We calculated a coarse estimation of home range (CHR) size using 95% kernel density estimates for migratory sub-adult eagles. We compared CHR size during the eagles' first year by sex x season (winter and summer) using a 2-way ANOVA. We found no difference in CHR size between sexes ($F_{1,64}$ = 0.57, P = 0.45) or the interaction term ($F_{1,64}$ = 2.15, P = 0.15). CHRs of migratory eagles were larger in winter ($\bar{x}$ = 25,218 km^2; 95% CI: 13,015 – 37,421) than summer ($\bar{x}$ = 6,166 km^2; 95% CI: 2,696 – 9,637; $F_{1,64}$ = 4.03, P = 0.01). Mean non-migratory sub-adult home ranges during the first year were 16,339 km^2 in winter (n = 4) and 15,120 km^2 in summer (n = 3). Our CHR estimates for migratory sub-adults were 26 times greater using satellite telemetry than previously reported in VHF-telemetry studies. We suggest that the greater home range difference between telemetry methods is a result of difficulties manually tracking wide-ranging movements of large raptors.

Keywords: home range, Bald Eagle, *Haliaeetus leucocephalus,* kernel density, satellite telemetry

Introduction

The federally threatened Bald Eagle (*Haliaeetus leucocephalus*) was recently proposed by the United States Fish and Wildlife Service for removal from the endangered species list (United States Fish and Wildlife Service 1999). Bald Eagles inhabit riparian areas in North America, from northern Mexico to Alaska and Canada. This species is primarily a fish predator that migrates to areas of seasonally abundant food (Gerrard and Bortolotti 1988). Breeding territories for adult eagles are estimated between 1 to 4 km^2 in size (Mahaffy and Frenzel 1987, Gerrard et al. 1992) and are probably dependent on the food supply. Sub-adult eagle home ranges are not restricted in size or location because they lack nests. Previous estimates of sub-adult home range size vary widely depending on methods. VHF-telemetry studies documented home ranges from 102 to 593 km^2 (Grubb et al. 1989, McClelland et al. 1994). In contrast, an initial study using satellite telemetry indicated home ranges can be much larger, e.g., 11,000 to 53,000 km^2 (Grubb et al. 1994).

Bald Eagles are partial migrants in Florida, where sub-adults migrate north in spring to the Chesapeake Bay and coastal Maine (Millsap et al. 2004) while many adults remain in Florida during the summer. Knowledge of sub-adult migratory movements and seasonal home range size is limited. Several researchers have tracked sub-adult eagle migration (Hunt et al. 1992, McClelland et al. 1994, Laing et al. 2005), but none has quantified seasonal home range sizes adequately because of limitations following wide-ranging movements with

VHF-telemetry. Determining a more accurate sub-adult eagle home range size could assist us in managing for a growing population of Bald Eagles.

Herein, we estimated home ranges for 69 sub-adults tagged as nestlings with 5-yr satellite transmitters. Our objectives were to determine home range sizes and compare sizes by season and sex.

Methods

Migratory home ranges

We collected satellite location data for all analyses from sub-adult Florida Bald Eagles (*n* = 69) tagged as nestlings by Millsap et al. (2004). We analyzed migratory and non-migratory eagle movements separately. Of 61 migratory eagles, only 40 had sufficient locations to calculate home range size. We used the term coarse home range (CHR) to describe areas used by migratory eagles in winter or summer because our sampling technique (1 transmission period/week) may not provide enough locations to generate complete home ranges. We used standard home range analysis techniques to determine CHR area (km^2), but it should be used cautiously because it is a conservative estimate and may underestimate home range size. Accuracy of satellite locations was determined by comparing locations of eagle nestling locations pre-fledging with known nest sites. Locations for use in our analyses were determined to be accurate to 1 km (see Millsap et al. 2004). We believe this is an acceptable error rate for large CHRs in this study.

For migratory eagles, summer and winter seasons began at cessation of directional migratory movement for >31 days or 4 weekly locations. We defined

nomadic eagles as those using multiple chronologically concentrated sites >100 km apart. We calculated CHRs for nomads (n = 6) separately for each site and summed areas by season for each eagle. We based the 100 km distance on minimum daily migration movements of sub-adult eagles (McClelland et al. 1994, Wood and Collopy 1994), and assumed eagles traveling >100-km made a permanent change in location. CHR size did not differ between nomadic and migratory eagles (one-way ANOVA $F_{1,30}$ = 0.23, P = 0.63), and we pooled them for CHR analysis.

We calculated fixed kernel density (KD) CHR for summer and winter seasons when $\geq$10 locations were available (using the most accurate location per day). We used Animal Movement Extension (Hooge and Eichenlaub 2000) in ArcView 3.2 (Environmental Systems Research Institute, Redlands, CA) to batch process KD areas. To maintain sample independence for ANOVA, we used only the first year of data for each eagle in our comparisons of seasonal CHR areas. We tested differences of home range size by sex and winter or summer season using a 2-way ANOVA of 95% KD contours (SAS Institute Inc. 2003). We described movements of nomadic eagles by estimating the minimum number of days spent at each location. We used α = 0.05 for all statistical tests.

To estimate annual site fidelity, we overlapped seasonal 95% KD contours between first and second years for each eagle (n = 13). We counted the number of eagles that overlapped any part of their home ranges from year 1 to year 2 and calculated the percentage of overlap between years.

Non-migratory home ranges

We considered an eagle non-migratory if it remained in Florida during the summer months (n = 8). We analyzed location data for non-migratory eagles to determine seasonal differences (winter and summer) in home range size. For non-migratory eagles, we defined seasons by the average eagle departure from Florida (May 14, n = 123, beginning of summer) and arrival dates (October 14, n = 103, beginning of winter) of migratory eagles. We calculated fixed KD using least-squares cross-validation (Worton 1989) only for eagles with home ranges that achieved an asymptotic value (Harris et al. 1990) using a minimum convex polygon (MCP) bootstrapping script in the Animal Movement Extension. Unlike migratory eagles, we considered non-migratory eagles to have traditionally defined home ranges because they reached an asymptotic value in the bootstrapping procedure and therefore could be compared to home range sizes reported in other studies. We summarized data for winter and summer home range sizes, but low sample size limited further analysis by sex or season.

Results

Migratory home ranges

We found no difference in CHR size between sexes ($F_{1,64}$ = 0.57, P = 0.45) or the sex x season interaction ($F_{1,64}$ = 2.15, P = 0.15). CHR size was different for winter and summer seasons ($F_{1,64}$ = 4.03, P = 0.01). Winter CHRs ($\bar{x}$ = 25,218 km^2; 95% CI: 13,015 – 37,421) were greater than 4 times larger than summer CHRs ($\bar{x}$ = 6,166 km^2; 95% CI: 2,696 – 9,637; Table 3.1 and Fig. 3.1).

Most eagles visited several winter areas within Florida >100 km apart and returned to each area several times. Nomadic eagles (*n* = 12) visited 2 to 3 discrete locations chronologically during summer months (see e.g., Fig. 3.2). Eagles spent an average of 55 days at each site (95% CI: 47- 64 days) before moving.

Migratory eagles revisited at least part of their first CHR in their second year, during summer (77% of eagles) and winter months (92% of eagles; see e.g., Fig. 3.3). CHR areas overlapped between years 1 and 2 an average of 39% in summer and 45% in winter.

Non-migratory home ranges

A low sample size did not permit analysis of non-migratory eagle home ranges by sex and season. Winter 95% KDs ranged from 1,461 to 26,619 km^2 and summer 95% KDs ranged from 4,634 to 32,443 km^2 for ages 1-3 years (Table 3.2).

Discussion

Migratory home ranges

During summer months, we found that eagles (32%) exhibited nomadic behavior, visiting multiple foraging sites >100 km apart. Other biologists also reported this phenomenon in Bald Eagles (Gerrard et al. 1978, McClelland et al. 1994, Laing et al. 2005). Sub-adults may roam more than older birds, presumably to gain foraging and migration experience (Wood and Collopy 1994). Migrant sub-adult eagles may stay in an area only while food resources are

abundant because their non-breeding status allows flexibility to explore new foraging sites (Buehler et al. 1991). Some previously reported sub-adult home ranges (Grubb et al. 1989, McClelland et al. 1994) may be underestimates because of difficulties in tracking nomadic eagle movements accurately.

Bald Eagles are sexually dimorphic, with adult females weighing >20% more than males (Dunning 1993). We expected female eagles to have larger home ranges than males, similar to other raptors (Newton 1979). We found no difference in CHR size between migratory male and female sub-adult eagles likely because confidence intervals were large. We suggest that the eagles' non-breeding status may account for similar CHRs between sexes. Our findings were similar to an earlier VHF study on unmated adult bald eagles (n = 11) that also found home range size did not differ between sexes (Harmata 1982).

Our findings were consistent with prior studies which demonstrated that Bald Eagles have a high degree of fidelity to both summering and wintering sites (Harmata 1982, McClelland et al. 1994, Wood and Collopy 1994). In addition, we found that home ranges overlapped <50% of the area from year 1 to 2. This may indicate that eagles revisit sites from previous years but they also explore many new sites. This behavior may be important for determining an eagle's future breeding territory or for finding foraging areas.

Our estimates of CHR were considerably larger than those reported in VHF studies of sub-adult eagles in which CHRs ranged from 102 to 593 km^2 (Grubb et al. 1989, McClelland et al. 1994). Our CHRs were comparable, however, to a satellite telemetry study of two Canadian sub-adult eagles where

MCP estimates ranged from 11,106 to 26,431 km^2 in winter and from 47,280 to 53,946 km^2 in summer (Grubb et al. 1994). Our winter CHRs were similar to the Canadian eagles, but our estimates of summer CHRs were markedly less. Contrary to the Canadian sub-adult study, we found that Florida sub-adults had larger winter CHRs compared to summer CHRs. Winter CHRs may be greater in Florida during winter months because of a concentration of conspecifics, which would increase competition for prey. Additionally, resident adult eagles in Florida may compete with migratory sub-adults for more productive foraging sites because they used these areas year-round. Given that migratory winter CHRs were similar in size to non-migratory home ranges, it is possible that both sub-adult groups competed for foraging areas with territorial adults during the winter breeding season. This may require eagles to use larger areas to obtain adequate food resources.

Non-migratory home ranges

Prior to this study, biologists reported that all sub-adult eagles migrated north and breeding adults remained in Florida during summer months (Wood and Collopy 1994). A summer roost in Everglades National Park, Florida, included sub-adults (Curnutt 1992), but their migratory behavior was unknown without additional tracking. We found conclusive evidence, however, that sub-adults can be non-migratory in Florida.

Non-migratory eagle home ranges often included both Florida coasts. Sub-adults visited several foraging areas repeatedly during a season and throughout their first 3 years. Home ranges of non-migratory eagles were larger

than those reported previously using VHF telemetry (Grubb et al. 1989, McClelland et al. 1994). Non-migratory home range sizes, however, were comparable to winter MCPs in a sub-adult eagle satellite study in Arizona with size estimates ranging from 11,000 to 26,000 km^2 (Grubb et al. 1994).

The seasonal presence of migratory eagles can affect the distribution of resident non-breeding eagles (Buehler et al. 1991). We were unable to determine if Florida sub-adult non-migratory eagles were affected by the departure and arrival of the migrant eagle population because of small sample size.

Wide-ranging movements create problems with VHF-radio home range estimation for Bald Eagles on their summering and wintering grounds. Radio-tagged eagles exceed the range of VHF transmitters/receivers 51% of the time; therefore, many of their movements were previously unknown (Grubb et al. 1994). This limited range of detection likely caused imprecise measurements and reports of small home ranges. We reported CHR estimates using data unbiased by the researcher's ability to locate the animal and suggest they are a more realistic estimate of the actual area used seasonally by sub-adult eagles. We encourage that migratory and non-migratory Bald Eagle home ranges be incorporated in future management of the species. Accurate home range sizes give biologists and resource managers a better understanding of the amount of habitat needed to maintain eagle population abundance.

Acknowledgements

Funding for this research was provided by the Florida Non-game Wildlife Trust Fund, U.S. Fish and Wildlife Service (Section 6), USGS Patuxent Wildlife Research Center, The University of Georgia, Warnell School of Forestry and Natural Resources, Georgia Ornithological Society, and the Sprouse family.

Literature Cited

Buehler, D.A., T.J. Mersmann, J.D. Fraser, and J.K.D. Seegar. 1991. Differences in distribution of breeding, non-breeding, and migrant Bald Eagles on the northern Chesapeake Bay. *Condor* 93:399-408.

Curnutt, J.L. 1992. Dynamics of a year-round communal roost of Bald Eagles. *Wilson Bull.* 104:536-540.

Dunning, J.B. 1993. CRC handbook of avian body masses. CRC Press, Boca Raton, FL U.S.A.

Gerrard, J.M., D.W.A. Whitfield, P. Gerrard, P.N. Gerrard, and W.J. Maher. 1978. Migratory movements and plumage of subadult Saskatchewan Bald Eagles. *Can. Field-Nat.* 92:375-382.

Gerrard, J.M. and G.R. Bortolotti. 1988. The Bald Eagle: haunts and habits of a wilderness monarch. Smithsonian Institution Press, Washington, DC U.S.A.

Gerrard, J.M., A.R. Harmata, and P.N. Gerrard. 1992. Home range and activity of a pair of Bald Eagles breeding in northern Saskatchewan. *J. Raptor Res.* 26:229-234.

Grubb, T.G., S.J. Nagiller, W.L. Eakle, and G.A. Goodwin. 1989. Winter roosting patterns of Bald Eagles (*Haliaeetus leucocephalus*) in north-central Arizona. *Southwest. Nat.* 34:453-459.

Grubb, T.G., W.W. Bowerman, and P.H. Howey. 1994. Tracking local and seasonal movements of wintering Bald Eagles *Haliaeetus leucocephalus* from Arizona and Michigan with satellite telemetry. Pages 347-358 *in* B.-U. Meyburg and R. D. Chancellor [Eds.], Proceedings of the IV World Conference on Birds of Prey and Owls. The Pica Press, Berlin, Germany.

Harmata, A.R. 1982. Statewide endangered species research: behavior and ecology of wintering and migrant Bald Eagles in the Rocky Mountains. Project Number MONT. SE-001-R /JOB 01/FIN. Montana Department of Fish Wildlife and Parks, Helena, MT U.S.A.

Harris, S., W.J. Cresswell, P.G. Forde, W.J. Trewhella, T. Woollard, and S. Wray. 1990. Home-range analysis using radio-tracking data--a review of problems and techniques particularly as applied to the study of mammals. *Mammal. Rev.* 20:97-123.

Hooge, P.N. and B. Eichenlaub. 2000. Animal movement extension to ArcView, version 2.04. USGS Alaska Science Center - Biological Science Office. Anchorage, AK U.S.A.

Hunt, W.G., R.E. Jackman, J.M. Jenkins, C.G. Thelander, and R.N. Lehman. 1992. Northward post-fledging migration of California Bald Eagles. *J. Raptor Res.* 26:19-23.

Laing, D.K., D.M. Bird, and T.E. Chubbs. 2005. First complete migration cycles for juvenile Bald Eagles (*Haliaeetus leucocephalus*) from Labrador. *J. Raptor Res.* 39:11-18.

Mahaffy, M.S. and L.D. Frenzel. 1987. Elicited territorial responses of northern Bald Eagles near active nests. *J. Wildl. Manag.* 51:551–554.

McClelland, B.R., L.S. Young, P.T. McClelland, J.G. Crenshaw, H.L. Allen, and D.S. Shea. 1994. Migration ecology of Bald Eagles from autumn concentrations in Glacier National Park, Montana. *Wildl. Monogr.* 125:1-61.

Millsap, B., T. Breen, E. McConnell, T. Steffer, L. Phillips, N. Douglass, and S. Taylor. 2004. Comparative fecundity and survival of Bald Eagles fledged from suburban and rural natal areas in Florida. *J. Wildl. Manag.* 68:1018-1031.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, SD U.S.A.

SAS Institute Inc. 2003. JMP start statistics, version 5.1. Thomson Learning, Belmont, CA U.S.A.

United States Fish and Wildlife Service. 1999. Proposed rule to remove the Bald Eagle in the lower 48 states from the list of endangered and threatened wildlife. Federal Register 64:36454-36464.

Wood, P.B. and M.W. Collopy. 1994. Population ecology of sub-adult southern Bald Eagles in Florida: post-fledging ecology, migration patterns, habitat use, and survival. Nongame wildlife program project NG87-026, final report. Florida Game and Fresh Water Fish Commission, Tallahassee, FL, U.S.A.

Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. *Ecology* 70:164-168.

Table 3.1 Mean coarse home ranges of migratory Florida sub-adult Bald Eagles tracked with satellite transmitters, 1997-2004.

Age	95% kernel	n
Summer		
Females		
1	4,299	20
2	4,097	13
3	1,819	7
4	1,476	2
Males		
1	8,833	14
2	6,309	7
3	3,513	1
4	96	3
5	2,005	1
Winter		
Females		
1	30,239	22
2	14,680	14
3	20,812	9
4	22,953	1
Males		
1	16,013	12
2	7,106	7
3	6,956	2
4	1,659	3

Table 3.2 Mean seasonal home ranges of non-migratory Florida sub-adult Bald Eagles tracked with satellite transmitters, 1997-2004.

Age (year)	95% kernel (km^2)	n
Summer		
1	16,339	4
2	22,679	2
3	10,597	2
Winter		
1	15,120	3
2	11,781	2
3	5,683	2

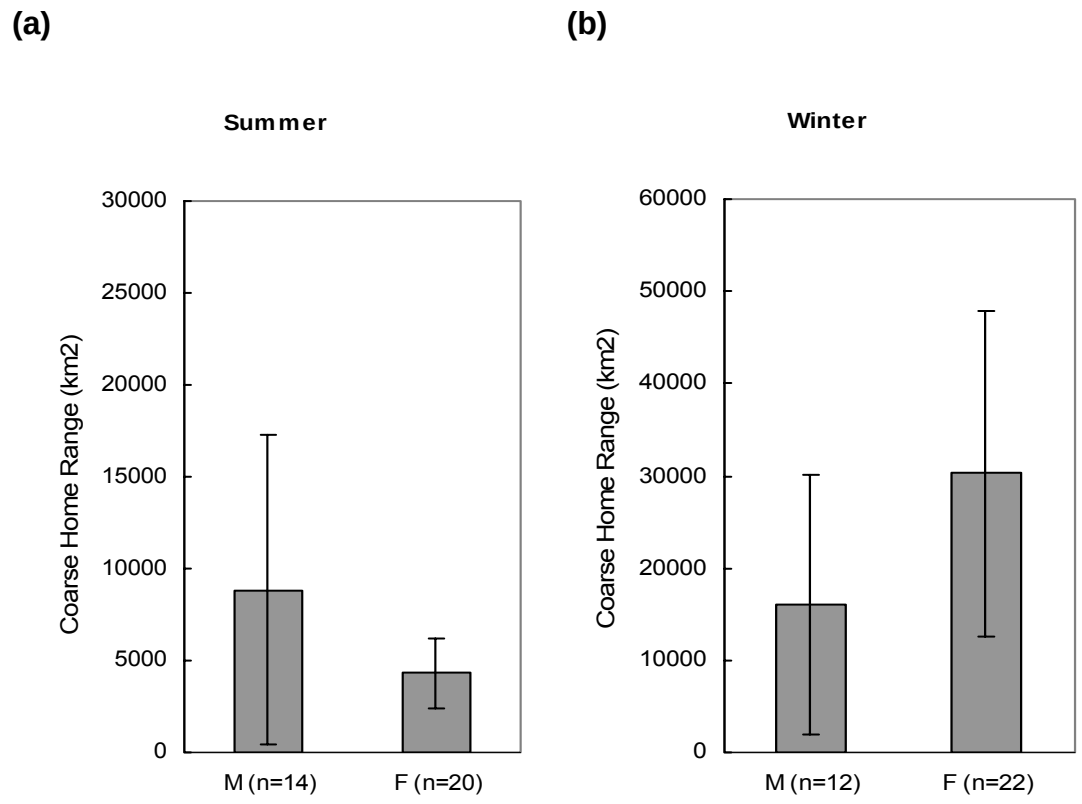


Figure 3.1. Mean first year seasonal coarse home ranges (CHRs, 95% CI) for male and female migratory Florida sub-adult Bald Eagles, 1997-2004. Summer months were spent north of Florida (a), while winter months were spent mainly in Florida (b).

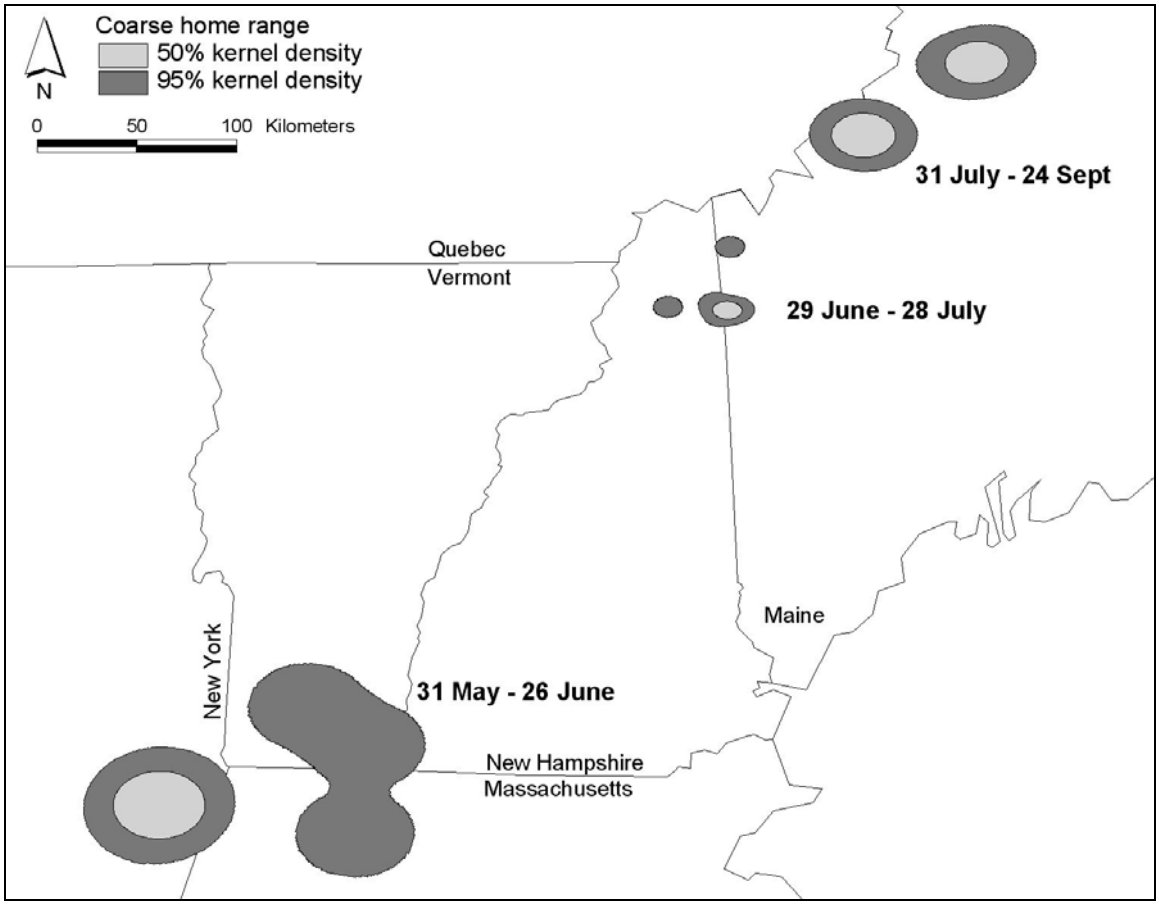


Figure 3.2. Nomadic coarse home ranges of female Bald Eagle 22985 during the first summer north of Florida, 2001. The combined 95% kernel density for 3 areas visited during the summer was 9,487 km^2.

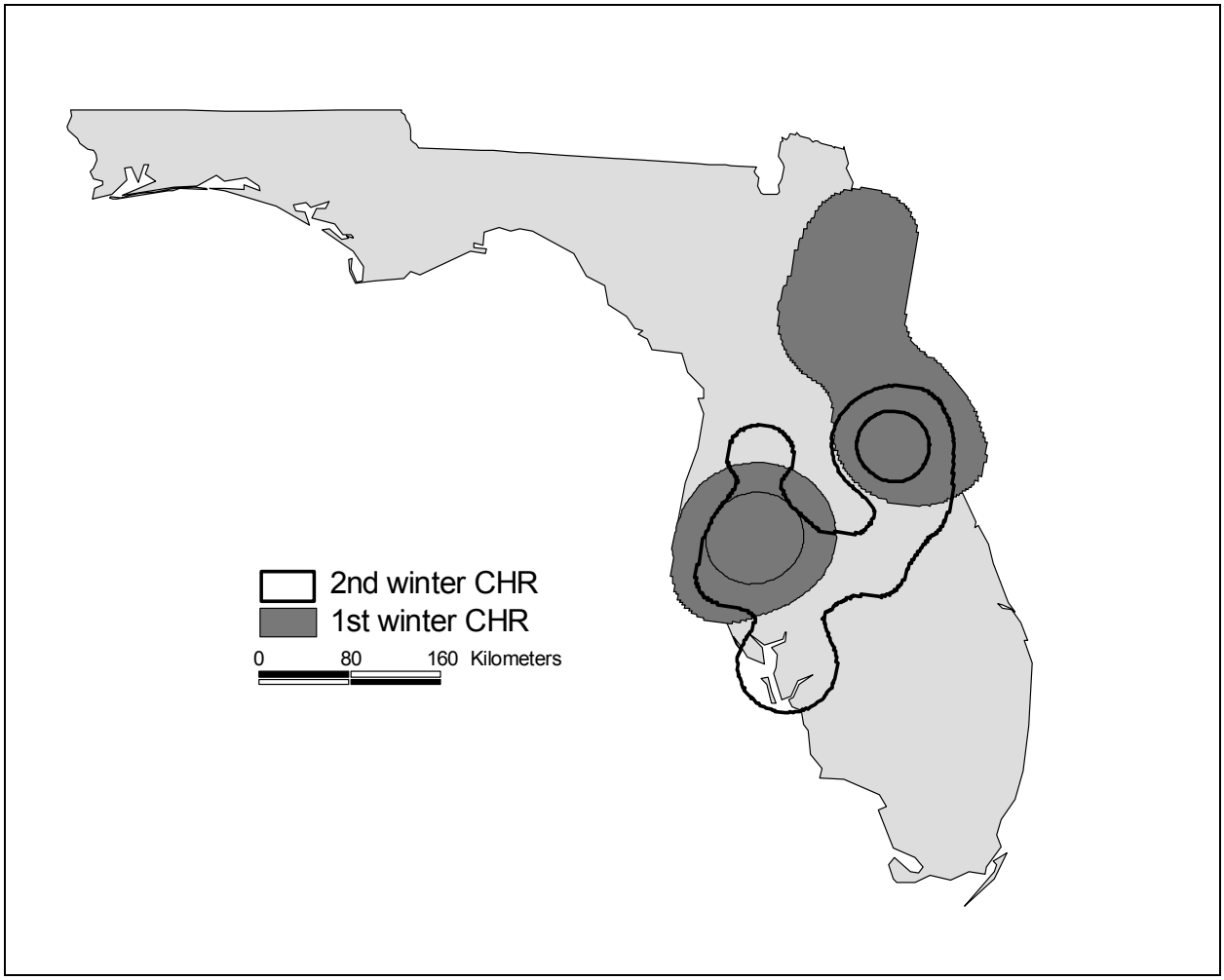


Figure 3.3. Area overlap of first two winter coarse home ranges (CHR) for migratory female Bald Eagle 22985, Florida, 2001-2002. Polygons represent 95% and 50% kernel densities.

Chapter 4

SEASONAL IMPORTANT USE AREAS OF FLORIDA SUB-ADULT BALD EAGLES[1]

[1] Mojica, E.K., J.M. Meyers, B.A. Millsap, K.L. Haley. *To be submitted to Journal of Wildlife Management*

Abstract: Long distance migration movements of bald eagles (*Haliaeetus leucocephalus*) prevent a thorough study of their migration movements with traditional methods of banding and VHF radio-telemetry. We used satellite telemetry to determine important use areas (IUAs) for 48 migratory Florida sub-adult bald eagles. We used a nearest neighbor analysis to identify daytime foraging and nocturnal roosting IUAs. We found 151 daytime IUAs ($\bar{x}$ = 610 km^2 95% kernel density, 95% CI: 515 – 706) in 20 states and provinces, and 50 nocturnal roosts in 8 states and provinces. Most roosts (68%) were visited by multiple eagles. We recommend locations of IUAs be added to GIS databases for future management and conservation land purchases. Bald eagle nesting habitat receives federal protection, but habitat used by non-breeding sub-adult eagles is mostly unprotected. We recommend conserving and protecting sub-adult nocturnal roosts and managing undeveloped shoreline forest for eagles within the IUAs identified in this study.

KEY WORDS: Bald eagle, *Haliaeetus leucocephalus*, important use area, nearest neighbor, roost, satellite telemetry.

Introduction

The bald eagle (*Haliaeetus leucocephalus*) population in the lower 48 states is under review for removal from the endangered species list. If removed, the species will be protected by two federal laws: the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act (United States Fish and Wildlife Service 1999). Habitat protection under the Endangered Species Act includes nesting and roosting habitat (United States Fish and Wildlife Service 1987). Foraging habitat will also receive protection according to the proposed National Bald Eagle Management Guidelines (United States Fish and Wildlife Service 2006a).

For the past 30 years, successful management of bald eagle nesting habitat allowed the U.S. population in the lower 48 states to rebound to approximately 6,900 breeding pairs and an unknown number of sub-adults (United States Fish and Wildlife Service 2006*b*). Nests are fairly easy to identify and locate for management purposes; however, foraging and roosting habitat is more difficult to locate and classify. Current habitat management emphasizes protecting nesting territories. Non-breeding eagles, such as sub-adults (<5 years old) or adults in the non-breeding season, receive little habitat protection. Conservation of foraging and roosting areas may be critical for eagles' access to food resources and shelter from inclement weather (Stalmaster and Gessaman 1984). Previous studies have identified foraging and roosting areas important to non-breeding eagles (Anthony et al. 1982, Luukkonen et al. 1989, Buehler et al. 1991*a,* Gerrard et al. 1992, McClelland et al. 1994), but the importance of these areas is biased by observations and access to eagle habitat. Information on non-breeding eagle movements is relatively incomplete. Our objective was to identify

non-breeding foraging and roosting habitat for Florida sub-adult bald eagles (≤ age 5) throughout eastern North America using satellite telemetry.

Methods

We used location data collected by Millsap et al. (2004) for 69 bald eagles fitted with 5-yr satellite transmitters as nestlings in Florida. These data were used to identify daytime foraging areas and nocturnal roosts used consistently by these eagles. We identified important use areas (IUAs) with nearest-neighbor cluster analysis in CrimeStats III (Levine 2004) by combining location data for all migratory individuals. The clustering technique describes groups or patterns within the data set and highlights geographic areas used by several eagles (≥1 yr) or by one eagle in multiple years (Everitt et al. 2001).

Initially, we selected satellite location data using criteria determined by Millsap et al. (2004) to be accurate within 1 km. Separate data sets for day and night locations were generated to determine daytime foraging and nocturnal roosting IUAs for migratory eagles, which spend summers north of Florida. We randomly selected locations collected for each eagle in the first 7 months after transmitter deployment from stratified sets (by months) to avoid weighting birds during more frequent bi-weekly transmission period. We used 4 weekly locations per month (transmitted every 7 days for 12 hrs). The most accurate location for each day was selected for daytime (between sunrise and 1 hr before sunset) and nighttime (locations 1 hr after sunset to sunrise, Luukkonen et al. 1989). We calculated sunrise and sunset times within each degree latitude and compiled daytime and nighttime locations for eagles (1997-2004).

We determined daytime IUAs as areas with ≥2 satellite locations in a ≤25 km threshold distance in CrimeStats III. We estimated this threshold distance from average daily movements of Florida sub-adult eagles located on the Chesapeake Bay. We combined daytime locations within each IUA ellipse and calculated a kernel density area (km^2). We classified nighttime locations as roosting areas with ≥2 locations in ≤1 km threshold distance (the satellite accuracy error rate). IUAs identified in Florida were classified as winter and those outside Florida as summer. We ranked IUAs by bird-years, which we calculated as the sum of the seasons each individual eagle used a site. We ranked IUAs overall for each state by bird-years. We assumed conservation of IUAs with the highest number of bird-years would have the greatest benefit to the bald eagle population because it would conserve an area used repeatedly or by multiple eagles. Bodies of water (Natural Resources Canada 2001, United States Geological Survey 2003) ≤5 km and conservation lands (Conservation Biology Institute 2006) ≤1 km were described for each IUA. Roosts reported in other studies were located mostly ≤0.75 km of water bodies (Steenhof et al. 1980, Chester et al. 1990, Buehler et al. 1991*b*). We chose a 5-km distance to water to allow for satellite location error.

Results

We found 151 IUAs in eastern North America using daytime locations (Fig. 4.1). Kernel density within the IUAs ranged from 0 km^2 to 3,637 km^2 (mean = 610 km^2, 95% CI: 515 – 706, Appendix D). The highest ranked IUAs in winter were located in the eagles' natal area in southwestern Florida (Table 4.1). In summer, the highest ranked IUAs were located in the Chesapeake Bay (Fig. 4.2) and in northern North Carolina.

We identified conservation lands that overlapped each IUA (*n* = 267, Appendix E). We found 35 IUAs (23%) were located on private lands.

We identified 50 nocturnal roosts in Florida, Maryland, North Carolina, New York, Pennsylvania, Virginia, Vermont, and Nova Scotia (Appendix F). The winter roost on the South Prong Alafia River in Hillsborough County, Florida had the highest bird-year rank (bird-year = 19). The highest ranking summer roost was on the Potomac River (bird-year = 15) in Charles County, Maryland, 4 km south of the Indian Head Naval Station. Most roosts (68%) were used by more than one eagle.

Discussion

Most IUAs overlapped protected conservation lands, but 23% were on private lands and may warrant future conservation. Large IUAs highlight a need for cooperative agreements with private landowners to manage eagles using broadly distributed natural resources outside of established public lands (Drewien et al. 1999).

Bald eagles use both communal and solitary nocturnal roosts near large water bodies (Buehler et al. 1991*b*). We found all of our roosts located ≤5 km from water. Other researchers found roosts ≤10 km from water bodies (Steenhof et al. 1980, Chester et al. 1990, Buehler et al. 1991*b*). Habitat protection of nocturnal communal eagle roosts is an important management guideline (United States Fish and Wildlife Service 1987); therefore, the 50 roosts reported herein should be of interest to local agencies for management and protection.

A limited number of Florida eagle foraging and roosting sites are described in previous studies (Broley 1947, Buehler et al. 1991*b*, Wood and Collopy 1994). Our study, however, is the first to report the significance of these sites using a large sample

size and unbiased sampling technique (satellite telemetry). Bird-year ranking allowed evaluation of IUAs by number of eagles using the site or by repeated use by one eagle. Another eagle study in the Chesapeake Bay noted locations used by migrant Florida eagles (Buehler et al. 1991*a*). We found these and additional IUAs throughout eastern North America. We estimated that only 15% of IUAs identified in this study have been reported previously for migratory bald eagles, including areas of the Chesapeake Bay, B. Everett Jordan Lake, Gulf of St. Lawrence, St. John's River, and coastal South Carolina (Stocek 1985, Luukkonen et al. 1989, Buehler et al. 1991*a*, Bryan et al. 1996, Laing et al. 2005).

Management Implications

Successful reintroduction and restoration efforts lead to the proposed removal of the bald eagle from the endangered species list (United States Fish and Wildlife Service 1999). Continual bald eagle population growth may cause increased competition between humans and eagles for shoreline habitat (Buehler et al. 1991*b*). Disturbance from human activities was identified as a concern, for which current regulations provide a protective buffer surrounding nests (United States Fish and Wildlife Service 1987). Little habitat protection, however, is accorded to non-breeding eagles. Protecting non-breeding habitat may increase sub-adult eagle survival and ensure successful recruitment into the breeding population (Simons et al. 1988). Eagle survival may increase with repeated use of familiar habitat in IUAs (Drewien et al. 1999).

We identified IUAs, important for foraging and roosting sub-adult eagles that need to be considered in management practices of this species. IUAs we discovered in the eastern United States and Canada will be added to state and federal GIS databases

for management and potential conservation land purchases or easements. We provide a list of public lands with IUAs located (Appendix E) and recommend managers consider potential effects that recreation or land management practices may have on the eagle population.

The *Management Guidelines for the Bald Eagle in the Southeast Region* emphasize conservation of communal roosts and protection from human disturbances (United States Fish and Wildlife Service 1987). Luukkonen et al. (1989) recommended conserving nocturnal roosts as a high priority for eagle management because they believed that daytime foraging and perch habitat was not limiting. Conservation of nocturnal roost sites is a viable management option because roosts are usually small (<1 km^2) and easily located and delineated. Actual roost locations provided herein should be verified on the ground. Daytime IUAs are more difficult to define in terms of specific tracts of land to protect, but in general, maintaining undeveloped shoreline forest would protect a majority of nocturnal roosting and daytime perching habitat for eagles (Buehler et al. 1991*b*).

We recommend conservation and protection of communal nocturnal roost IUAs (Appendix F) and general conservation of shoreline habitat in IUAs (Appendix D, Buehler et al. 1991*b*). We encourage continued regional and national conservation of bald eagle habitat and coordination among wildlife agencies, non-governmental organizations, and private landowners. We believe formation of a bald eagle working group will help continue the successful conservation of our national symbol.

Acknowledgements

We thank the Florida Non-game Wildlife Trust Fund, U.S. Fish and Wildlife Service (Section 6 program), USGS Patuxent Wildlife Research Center, The University of Georgia, Warnell School of Forestry and Natural Resources, Georgia Ornithological Society, and the Sprouse family for project funding and support.

Literature Cited

Anthony, R. G., R. L. Knight, G. T. Allen, B. R. McClelland, and J. I. Hodges. 1982. Habitat use by nesting and roosting bald eagles in the Pacific Northwest. Transactions of the North American Wildlife and Natural Resources Conference 47:332-342.

Broley, C. L. 1947. Migration and nesting of Florida bald eagles. Wilson Bulletin 59:3-20.

Bryan, A. L., T. M. Murphy, K. L. Bildstein, I. L. Brisbin, and J. J. Mayer. 1996. Use of reservoirs and other artificial impoundments by bald eagles in South Carolina. Pages 285-297 *in* D. Bird, D. Varland and J. Negro, editors. Raptors in human landscapes: adaptations to built and cultivated environments. Academic Press, San Diego, California, USA.

Buehler, D. A., T. J. Mersmann, J. D. Fraser, and J. K. D. Seegar. 1991*a*. Differences in distribution of breeding, non-breeding, and migrant bald eagles on the northern Chesapeake Bay. Condor 93:399-408.

Buehler, D. A., T. J. Mersmann, J. D. Fraser, and J. K. D. Seegar. 1991*b*. Nonbreeding bald eagle communal and solitary roosting behavior and roost habitat on the northern Chesapeake Bay. Journal of Wildlife Management 55:273-281.

Chester, D. N., D. F. Stauffer, T. J. Smith, D. R. Luukkonen, and J. D. Fraser. 1990. Habitat use by non-breeding bald eagles in North Carolina. Journal of Wildlife Management 54:223-234.

Conservation Biology Institute. 2006. Protected areas database, version 4. Corvallis, Oregon, USA.

Drewien, R. C., W. M. Brown, J. D. Varley, and D. C. Lockman. 1999. Seasonal movements of Sandhill Cranes radiomarked in Yellowstone National Park and Jackson Hole, Wyoming. Journal of Wildlife Management 63:126-136.

Everitt, B., S. Landau, and M. Leese. 2001. Cluster analysis. Oxford University Press, London, England.

Gerrard, J. M., P. N. Gerrard, P. N. Gerrard, G. R. Bortolotti, and E. H. Dzus. 1992. A 24-year study of bald eagles on Besnard Lake, Saskatchewan. Journal of Raptor Research 26:159-166.

Laing, D. K., D. M. Bird, and T. E. Chubbs. 2005. First complete migration cycles for juvenile bald eagles (*Haliaeetus leucocephalus*) from Labrador. Journal of Raptor Research 39:11-18.

Levine, N. 2004. CrimeStat: a spatial statistics program for the analysis of crime incident locations, version 3.0. Ned Levine & Associates, Houston, TX, and the National Institute of Justice, Washington, D.C., USA.

Luukkonen, D. R., T. J. Smith, D. N. Chester, J. D. Fraser, and D. F. Stauffer. 1989. Ecology, habitat, and management of bald eagles at B. Everett Jordan Lake and Falls Lake, North Carolina, final report. United States Army Corps of Engineers, Wilmington, North Carolina, USA.

McClelland, B. R., L. S. Young, P. T. McClelland, J. G. Crenshaw, H. L. Allen, and D. S. Shea. 1994. Migration ecology of bald eagles from autumn concentrations in Glacier National Park, Montana. Wildlife Monographs 125:1-61.

Millsap, B., T. Breen, E. McConnell, T. Steffer, L. Phillips, N. Douglass, and S. Taylor. 2004. Comparative fecundity and survival of bald eagles fledged from suburban and rural natal areas in Florida. Journal of Wildlife Management 68:1018-1031.

Natural Resources Canada. 2001. National topographic database: hydrography features. Centre for Topographic Information, Natural Resources Canada. Sherbrooke, Quebec, Canada.

Simons, T., S. K. Sherrod, M. W. Collopy, and M. A. Jenkins. 1988. Restoring the bald eagle. American Scientist 76:253-268.

Stalmaster, M. V., and J. A. Gessaman. 1984. Ecological energetics and foraging behavior of overwintering bald eagles. Ecological Monographs 54:407-428.

Steenhof, K., S. S. Berlinger, and L. H. Fredrickson. 1980. Habitat use by wintering bald eagles in South Dakota. Journal of Wildlife Management 44:798-805.

Stocek, R. F. 1985. The bald eagle in New Brunswick. Pages 44-47 *in* J. M. Gerrard and T. M. Ingram, editors. Proceedings of The bald eagle days. White Horse Plains Publishers, Winnipeg, Canada.

United States Geological Survey. 2003. U.S. national atlas water feature areas: aqueducts, canals, dams, intercoastal waterways, rivers, and streams. Reston, Virginia, USA.

United States Fish and Wildlife Service. 1987. Management guidelines for the bald eagle in the southeast region. United States Fish and Wildlife Service, Atlanta, Georgia, USA.

United States Fish and Wildlife Service. 1999. Proposed rule to remove the bald eagle in the lower 48 states from the list of endangered and threatened wildlife. Federal Register 64:36454-36464.

United States Fish and Wildlife Service. 2006a. Draft: National management guidelines for bald eagles. <http://www.fws.gov/migratorybirds/baldeagle.htm> Accessed 6 August 2006.

U.S. Fish & Wildlife Service. 2006*b*. Bald Eagle *Haliaeetus leucocephalus*. U.S. Fish & Wildlife Service, Division of Migratory Bird Management. <http://www.fws.gov/migratorybirds/baldeagle.htm> Accessed 1 March 2006.

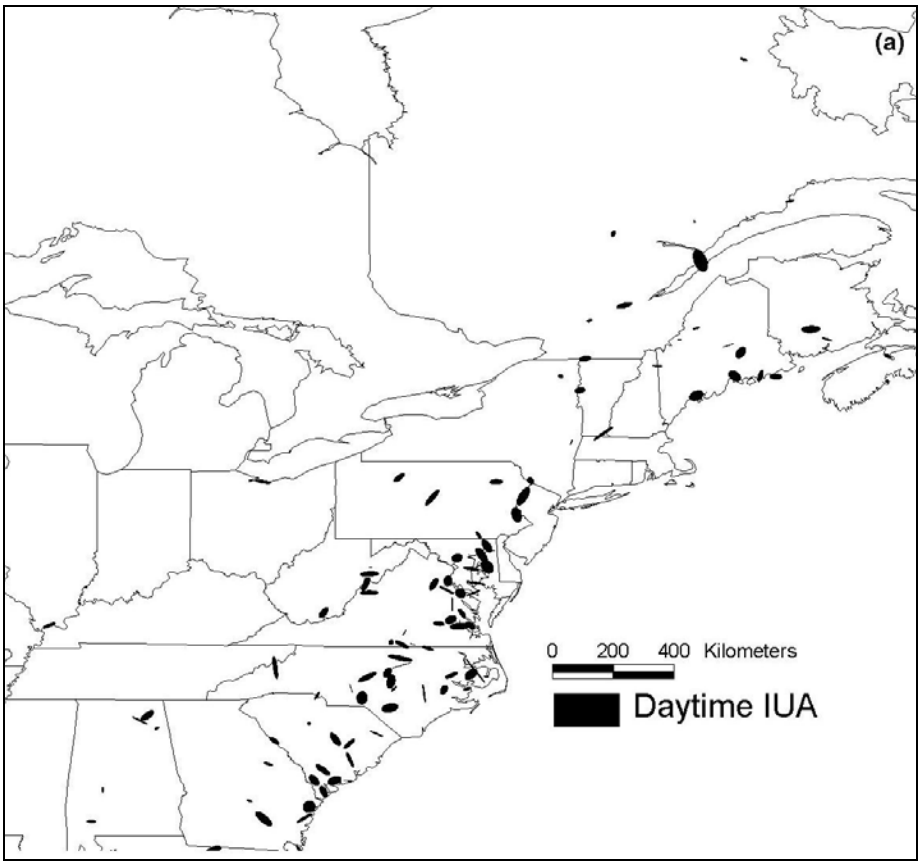
Wood, P. B., and M. W. Collopy. 1994. Population ecology of sub-adult southern bald eagles in Florida: post-fledging ecology, migration patterns, habitat use, and survival. Nongame wildlife program project NG87-026, final report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA.

Table 4.1. Highest ranked daytime important use areas (IUAs) of Florida sub-adult bald eagles on summer and winter grounds, 1997-2004. IUAs were identified using nearest neighbor clustering (Crimestat III) and ranked by bird-year.

IUAs by waterbody	County	State	95% kernel (km^2)[a]	Bird-years[b]
Winter				
S. Prong Alafia River	Hillsborough	FL	182	19
Peace River	Polk	FL	464	19
Braden River	Manatee	FL	666	19
Saddle Creek	Polk	FL	415	18
Summer				
Potomac River	Charles	MD	364	15
Susquehanna River	Cecil	MD	677	14
Seaforth Lake	Chatham	NC	307	13
Potomac River	Westmoreland	VA	279	12

[a] Kernel density estimates were performed on locations within each IUA.

[b] The sum of the number of seasons individual eagles used the site.



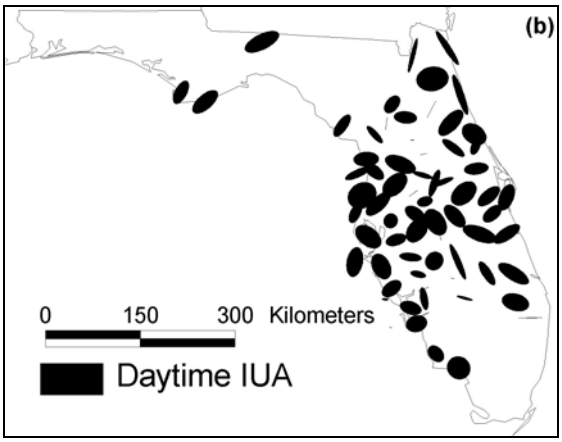


Figure 4.1. Daytime important use areas (IUAs) for migratory Florida sub-adult bald eagles. Eagles spent summer months north of Florida (a) and winter months within Florida (b). IUAs were visited by >1 eagle or 1 eagle in multiple years.

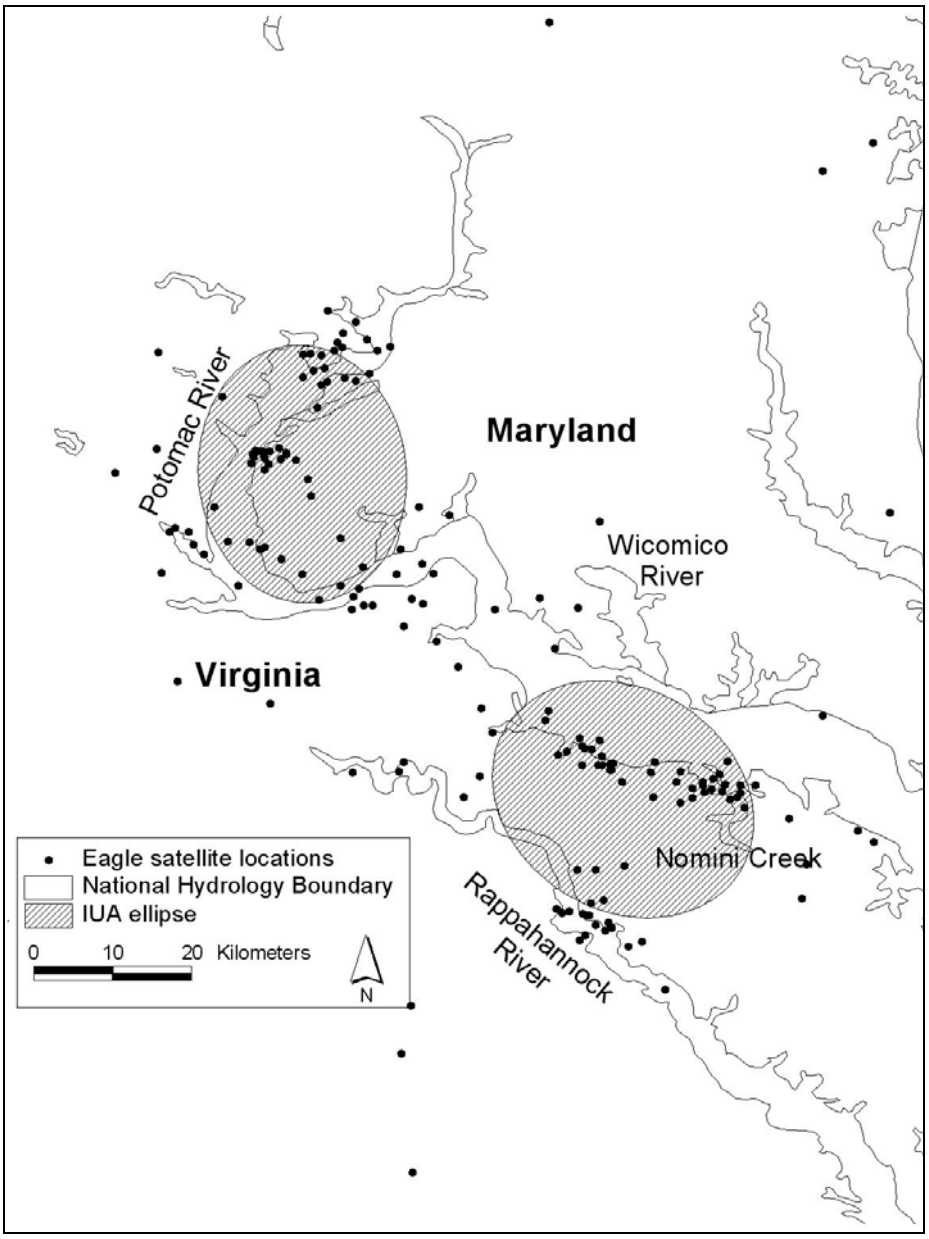


Figure 4.2. Two of the highest ranked bald eagle daytime summer important use areas (IUAs) on the Potomac River, Virginia and Maryland, 1997-2004. Ranking based on number of repeated visits and by number of individual birds using the site. The upper Potomac River IUA ranked highest (15 bird-years) and the lower Potomac River IUA ranked fourth (12 bird-years).

CHAPTER 5
CONCLUSIONS

Use of satellite telemetry in wildlife research is a relatively new technological development and continues to receive some skepticism. The main criticisms of the technology are limited accuracy and high cost of transmitters and satellite time. The benefits, however, are incomparable to any other tracking technique. Satellite telemetry allows biologists to collect data during migration that would otherwise be difficult or impossible. Bald Eagle migration was studied with VHF-telemetry during the 1980's to 1990's, but many research questions remain unanswered. The results of the current study indicate satellite telemetry can be used to expand existing information on raptor migration and home range behavior.

With satellite telemetry, I was able to document previously unrecorded accounts of migration routes, migration distances, stopover sites, home ranges, and site fidelity. I discovered that eagles made equal use of both Appalachian Mountain and coastal migration routes. Eagles migrate anywhere from 340 to 4,146 km from Florida. Eagles on the coastal route traveled farther than mountain migrants. We were able to document stopovers that may be critical habitat for migratory eagles.

I found home range sizes for both migratory and non-migratory eagles were larger than any home ranges estimated previously using VHF telemetry. Although the study was not initially designed to determine home range, I believe my estimates can be used as a foundation for further research. Ideally, transmitters would give a location at

least once a day for home range estimation. Unfortunately, shortening the transmitter duty cycle would also shorten the battery life (≤5 yr).

The identification of important use areas (IUA) was a significant outcome of this research project. This study confirmed that Bald Eagles use sizeable amounts of habitats both during migration and on summer and winter territories. I provided locations for habitat used both day and night and ranked them for future conservation. With the development of the new national eagle guidelines, this information is timely and applicable.

APPENDIX A. Migration routes, migration distance, and number of days traveled for Florida sub-adult Bald Eagles with satellite transmitters (Platform Terminal Transmitter – PTT), 1997-2004.

PTT	Sex	Age	Route North[a]	No. Days	Depart North	Arrive North	Distance (km^2)	Route South[a]	No. Days	Depart South	Arrive South
01438	F	1	C	22	6/25	7/17	726	C	8	9/21	9/29
01438C	F	1	C	5	5/13	5/18	1120	U	[b]		
01439	F	1	M	39	5/31	7/9	2794	C	10	10/9	10/19
01439	F	2	C	11	3/31	4/11	673	C	24	10/1	10/25
01439	F	3	C	[b]			1415	U	[b]		
01439	F	4	C	18	5/2	5/20	1268	C	18	9/26	10/14
02216B	F	1	C	[b]	7/10		619	C	3	7/20	7/23
02216C	F	1	C	15	5/9	5/24	1332	C	3	9/19	9/22
02216C	F	2	C	17	4/4	4/21	821	C	17	9/26	10/13
02217	M	1	M	48	5/30	7/17	2874	C	62	8/20	10/21
03542	F	1	C	5	7/23	7/28	596	C	6	7/30	8/5
03543	F	1	M	36	6/10	7/16	1192	M	48	10/15	12/2
03543	F	2	C	17	5/11	5/28	975	M	11	10/20	10/31
03543	F	3	C	47	4/30	6/16	1112	M	12	9/24	10/6
03543	F	4	C	4	4/20	4/24	907	U	[b]		
03558	M	1	C	9	5/24	6/2	1034	U	[c]		
03567	F	1	U	2	6/22	6/24	431	U	[c]		
03567B	M	1	M	24	5/21	6/14	2351	C	33	9/26	10/29
12558	M	1	M	11	5/10	5/21	1945	M	19	8/8	8/27
12558B	F	1	M	11	5/19	5/30	2380	M	26	9/7	10/3
13167	F	1	O	23	6/10	7/3	1081	U	[b]		
13167	F	2	C	27	4/30	5/27	1039	U	[b]		
13487	M	1	M	50	5/7	6/26	4146	C	94	8/3	11/5
13487	M	2	M	25	5/13	6/7	3321	C	62	9/1	11/2
13487	M	3	M	33	6/18	7/21	3119	U	48	8/24	10/11
13487	M	4	C	26	6/11	7/7	3122	C	[b]	9/1	
13490	M	1	C	17	7/5	7/22	1215	U	[b]		
13494	F	1	M	26	5/17	6/12	2628	C	106	8/9	11/23
13494	F	2	C	44	6/30	8/13	1170	C	19	10/28	11/16
13494	F	3	C	20	6/8	6/28	1231	C	20	9/28	10/18
13494	F	4	C	[b]			1275	U	[b]		
13498	F	1	U	[b]				M	46	12/30	2/14
13498	F	2	M	11	6/5	6/16	771	M	54	10/6	11/29
13498	F	3	U	[b]				M	36	9/22	10/28
13498	F	4	M	15	4/19	5/4	731	M	29	9/19	10/18
13520	F	1	C	15	5/11	5/26	1288	C	11	10/6	10/17
13520	F	2	C	30	4/4	5/4	3061	C	11	10/13	10/24
13520	F	3	C	32	4/25	5/27	1265	C	10	9/30	10/10
13520	F	4	C	54	4/12	6/5	1428	U	[d]		
22985	F	1	M	11	5/20	5/31	1846	C	58	9/28	11/25
22985	F	2	M	24	4/30	5/24	1397	C	17	11/3	11/20
22985	F	3	C	24	4/25	5/19	1365	C	10	9/11	9/21

Appendix A. Continued.

PTT	Sex	Age	Route North[a]	Num Days	Depart North	Arrive North	Distance (km^2)	Route South[a]	Num Days	Depart South	Arrive South
22985	F	4	C	[b]	4/19		533	U	[d]		
22987	M	1	C	29	5/9	6/7	1543	U	[c]		
22988	M	1	M	25	6/2	6/27	2278	M	106	8/13	11/27
22988	M	2	C	74	4/3	6/16	1895	M	49	9/25	11/13
22988	M	3	C	119	3/20	7/17	2229	M	33	10/4	11/6
22989	F	1	C	7	5/5	5/12	1281	U	[c]		
22990	F	1	U	[b]				M	49	9/25	11/13
22990	F	2	C	10	5/4	5/14	1291	M	42	9/19	10/31
22992	F	1	C	17	5/20	6/6	1325	U	[b]		
22992	F	2	U	[b]				C	39	10/5	11/13
22992	F	3	C	11	5/3	5/14	1083	C	18	10/3	10/21
22992	F	4	C	11	4/17	4/28	1051	C	11	9/10	9/21
22993	M	1	C	8	5/20	5/28	1497	C	18	10/6	10/24
22993	M	2	C	18	4/20	5/8	1482	C	11	9/26	10/7
22995	F	1	M	27	5/5	6/1	2085	U	[c]		
22996	F	1	C	32	4/22	5/24	3125	C	92	9/30	12/31
22996	F	2	C	25	5/3	5/28	2641	C	48	9/28	11/15
22996	F	3	C	55	4/8	6/2	2456	C	27	9/28	10/25
22997	F	1	M	48	6/18	8/5	3059	M	18	9/3	9/21
22997	F	2	C	17	4/21	5/8	2264	C	25	10/8	11/2
22997	F	3	C	31	5/4	6/4	2914	C	24	9/10	10/4
22997	F	4	C	55	4/7	6/1	1715	C	11	8/19	8/30
24977	F	1	M	18	5/10	5/28	2486	C	104	8/21	12/3
24977	F	2	C	26	5/4	5/30	1369	C	25	10/29	11/23
24978	F	1	C	16	5/15	5/31	1281	C	17	8/13	8/30
24978	F	2	C	16	5/2	5/18	966	C	12	8/3	8/15
24978	F	3	U	[b]				C	20	9/1	9/21
24978	F	4	C	33	4/1	5/4	1012	U	[b]		
24979	F	1	M	44	7/1	8/14	1739	O	11	11/14	11/25
24979	F	2	M	23	3/22	4/14	943	O	19	10/8	10/27
24980	M	1	C	5	6/14	6/19	1168	C	12	9/26	10/8
24980	M	2	C	12	5/16	5/28	1203	C	3	10/11	10/14
24980	M	3	C	3	4/23	4/26	1180	C	11	9/9	9/20
24980	M	4	C	12	4/21	5/3	1215	U	[b]		
24981	M	1	M	5	5/18	5/23	1438	M	15	9/15	9/30
24981	M	2	M	89	5/11	8/8	3379	M	17	9/3	9/20
24981	M	3	M	7	5/12	5/19	1150	C	68	8/11	10/18
24981	M	4	M	38	4/30	6/7	1737	M	10	9/13	9/23
24982	F	1	C	16	6/3	6/19	1612	C	20	9/28	10/18
24982	F	2	C	11	4/13	4/24	1284	U	[c]		
24983	M	1	C	111	4/17	8/6	3736	M	20	9/21	10/11
24983	M	2	C	20	5/22	6/11	1269	U	[c]		
24984	M	1	C	17	5/15	6/1	2155	C	20	9/23	10/13
24984	M	2	C	19	5/17	6/5	1182	M	12	10/21	11/2
24984	M	3	C	24	5/1	5/25	1437	C	51	9/16	11/6
24984	M	4	C	[b]		7/15	1315	C	19	10/6	10/25
24984	M	5	C	19	6/6	6/25	727	M	24	9/28	10/22
24985	M	1	C	9	6/13	6/22	1464	C	12	9/25	10/7

Appendix A. Continued.

PTT	Sex	Age	Route North[a]	Num Days	Depart North	Arrive North	Distance (km^2)	Route South[a]	Num Days	Depart South	Arrive South
24985	M	3	C	3	7/23	7/26	950	U	[b]		
24985	M	4	C	31	7/18	8/18	1080	C	16	9/10	9/26
24986	F	1	M	47	6/11	7/28	1135	C	10	9/9	9/19
24986	F	2	C	20	4/27	5/17	1060	C	12	10/5	10/17
24986	F	3	C	4	5/10	5/14	986	U	[b]		
24986	F	4	U	[b]				C	12	9/13	9/25
28106C	F	1	M	8	8/15	8/23	920	M	8	8/25	9/2
28107B	M	1	M	17	6/11	6/28	1744	C	47	9/16	11/2
28107B	M	2	C	11	5/12	5/23	687	C	25	9/21	10/16
28107B	M	3	C	11	4/12	4/23	1508	C	[b]		
28108	M	1	M	[b]	5/31		970	U	[d]		
28108B	M	1	C	10	5/5	5/15	1325	C	10	9/24	10/4
28108B	M	2	C	18	5/19	6/6	1347	C	11	10/7	10/18
28108B	M	3	C	3	5/10	5/13	976	C	11	9/28	10/9
28108B	M	4	C	19	4/24	5/12	1022	C	10	9/27	10/7
28108B	M	5	C	18	4/15	5/3	621	U	[c]		
28109	F	1	M	25	6/4	6/29	2851	U	[d]		
28110	F	1	M	13	5/21	6/3	1469	C	53	10/19	12/11
28110	F	2	M	14	5/24	6/7	1290	C	[b]		
28110B	F	1	M	15	6/27	7/12	1238	M	18	10/14	11/1
28110B	F	2	M	17	4/9	4/26	1207	U	[d]		
28112B	M	1	M	26	5/29	6/24	2905	C	64	8/7	10/10
28112B	M	2	C	26	4/25	5/21	1992	C	26	9/21	10/17
28112B	M	3	C	41	5/10	6/20	2268	C	14	9/18	10/2
28112B	M	4	C	41	5/3	6/13	2234	C	26	9/15	10/11
28113	F	1	C	36	5/11	6/16	1417	C	60	9/21	11/20
28113	F	2	C	66	5/5	7/10	2902	M	73	8/19	10/31
28113	F	3	C	[b]		6/20		C	52	8/12	10/3
28113	F	4	C	24	5/14	6/7	2254	C	74	7/24	10/6
28114	F	1	M	24	5/1	5/25	2315	C	24	9/9	10/3
28114	F	2	C	101	4/21	7/31	4308	C	51	9/23	11/13
28114	F	3	C	[b]		5/6	2597	C	25	9/5	9/30
28115	M	1	C	6	5/25	5/31	752	C	11	11/2	11/13
28115	M	2	C	3	5/6	5/9	636	C	10	10/3	10/13
28115	M	3	C	3	4/26	4/29	688	U	[d]		
28116	F	1	M	54	6/18	8/11	2738	U	[b]		
28117	F	1	C	5	5/23	5/28	1075	C	31	10/8	11/8
28117	F	2	C	7	5/5	5/12	1308	C	18	9/13	10/1
28118B	F	1	M	13	6/30	7/13	1389	C	31	10/8	11/8
28118B	F	2	C	25	4/23	5/18	1057	C	10	9/27	10/7
28118B	F	3	C	18	4/6	4/24	1167	C	64	8/8	10/11
28118B	F	4	C	60	3/10	5/9	1288	C	[b]	9/11	
28119	M	1	C	6	6/2	6/8	832	C	7	10/7	10/14
28119	M	2	C	10	6/16	6/26	694	C	10	9/2	9/12

[a] C = coastal, M = mountain, O = other, U = unknown
[b] Number of days traveled not calculated because of a large interval in satellite transmissions.
[c] Dead.
[d] Transmitter failed; fate of eagle unknown.

APPENDIX B. Stopover locations of migratory Florida sub-adult Bald Eagles (*n* = 25) tracked with satellite transmitters, 1997-2004. Eagles remained at stopover sites 6-31 days.

Stopover	Latitude	Longitude	Owner (if known)	Water type	State
Lower Suwanee River NWR	29.210	-83.040	USFWS[a]	River	FL
Lake Miccosukee	30.600	-83.990		Lake	FL
Ocmulgee River	32.060	-83.060		River	GA
Coosaw River	32.570	-80.700		River	SC
J. Strom Thurmond Lake	33.110	-82.520	US ACE[a]	Reservoir	GA
Weiss Lake	34.180	-85.720		Lake	AL
Sandhills Game Land, McKinney Lake National Fish Hatchery	35.000	-79.660	NC Wildlife Resources Commission	Lake	NC
Lake Wylie	35.150	-80.980		Lake	NC
Cape Fear River	35.340	-78.790		River	NC
Neuse River	35.350	-77.280		River	NC
Lake Tillery, Badin Lake	35.370	-80.120		Lake	NC
Lake Norman	35.440	-80.720		Lake	NC
B. Everett Jordan Lake	35.840	-78.960	US ACE	Reservoir	NC
John H. Kerr Reservoir	36.460	-78.280	US ACE	Reservoir	NC
Langley AFB, Chesapeake Bay	37.080	-76.440	US DOD[a]	Bay	VA
Appomattox River	37.250	-78.270		River	VA
James River, Presquile NWR	37.350	-77.280	USFWS	River	VA
Chesapeake Bay	38.030	-75.670		Bay	MD
Chesapeake Bay	38.140	-76.330		Bay	MD
Potomac River, Caledon SP	38.350	-77.160	VA Dept of Conservation and Recreation	River	VA
Potomac River	38.510	-77.260		River	MD
N Fork South Branch Potomac River	38.630	-79.470		River	WV
Potomac River	38.640	-77.110		River	MD
Chester River	39.130	-76.060		River	MD
Back River, North Point SP	39.240	-76.400	MD DNR[a]	River	MD
Chesapeake and Ohio Canal National Historic Park	39.440	-78.590	NPS[a]	Canal	WV
Susquehanna River	39.610	-76.140		River	MD
Youghiogneny River Lake	39.760	-79.580		Lake	PA
Delaware River NRA	41.080	-74.980	NPS	River	PA
Susquehanna River	41.400	-75.810		River	PA
Upper Delaware Management Area NRA	41.420	-74.770	NPS	River	PA
Neversink Reservoir	41.760	-74.610		Reservoir	NY
Merrimack River	43.280	-71.560		River	NH

Appendix B. Continued.

Stopover	Latitude	Longitude	Owner	Water type	State
Lake George, Adirondack Park State Forest Preserve	43.620	-73.540		Lake	NY
Lake Champlain	44.130	-73.300		Lake	VT
Lake Saint Lawrence	44.960	-75.250		Lake	NY
St. Francis River	45.720	-71.350		River	CAN
Tuadook River	46.950	-66.590		River	CAN
St. Lawrence River	49.320	-67.400		River	CAN
Strait of Belle Isle	50.330	-59.620		Bay	CAN

[a] Owner abbreviations in alphabetical order: Maryland Department of Natural Resources, National Park Service, United States Army Core of Engineers, United States Department of Defense, and United States Fish and Wildlife Service.

APPENDIX C. Tracking history of satellite-tagged Florida sub-adult Bald Eagles, 1997-2004.

PTT[a]	Sex	Age[b]	Season[c]	Location
01438	F	1	S	Lake Miccosukee, Leon Co., FL
				Dead: Poisoned, May's Pond Plantation, Jefferson Co., FL
01438B	M	1	S	n/a, died in nest
				Dead: disease (Chlymadia), in nest, FL
01438C	F	1	S	Neuse River, Pitt Co., NC
			W	Tamiami Canal, Collier Co., FL
				Unknown: PTT harness severed by eagle, found in Collier Co., FL
01439	F	1	S	Conowingo Reservoir, Lancaster Co., PA
		1	W	Ashepoo River, Colleton Co., SC
		2	S	Rappahannock River, Richmond Co., VA
		2	W	Tamiami Canal, Collier Co., FL
		3	S	Rappahannock River, Richmond Co., VA
		3	W	Turner River Canal, Collier Co., FL
		4	S	Conowingo Reservoir, Lancaster Co., PA
		4	W	Tamiami Canal, Collier Co., FL
				Unknown: transmitter battery failure
02216	F	1	S	n/a, died near nest
				Dead: storm trauma, Manatee Co., GL
02216B	F	1	S	Pine Island Sound, Lee Co., FL
				Dead: electrocuted, Charlotte, Co., FL
02216C	F	1	S	Potomac River, King Co., VA
		1	W	St. John's River, Volusia Co., FL
		2	S	Potomac River, Fairfax Co., VA
		2	W	Myakka River, Sarasota Co., FL
				Unknown: transmitter battery failure
02217	M	1	S	Kennebec River, Sagadahoc Co., ME
		1	W	Hancock Lake, Polk Co., FL
				Dead: unknown cause, Hillsborough Co., FL
03542	F	1	S	Tomoka River, Volusia Co., FL
				Unknown: transmitter battery failure
03543	F	1	S	Knapp Creek, Summers Co., WV
		1	W	Blue Cypress Lake, Indian River Co., FL
		2	S	B. Everett Jordan Lake, Chatham Co., NC
		2	W	St. John's River, Brevard Co., FL
		3	S	John H. Kerr Reservoir, Halifax Co., VA
		3	W	St. John's River, Brevard Co., FL
		4	S	John H. Kerr Reservoir, Halifax Co., VA
		4	W	St. John's River, Brevard Co., FL
				Dead: vehicle collision, Brevard Co., FL
03557	M	1	S	Lake Dora, Lake Co., FL
		1	W	Braden River, Manatee Co., FL
		2	S	Braden River, Manatee Co., FL
				Dead: vehicle collision, Manatee Co., FL
03557b	F	1	S	Tomoka River, Volusia Co., FL
		1	W	Charlotte Harbor, Charlotte Co., FL
		2	S	Charlotte Harbor, Charlotte Co., FL

Appendix C. Continued

PTT	Sex	Age	Season	Location
03557b	F	2	W	Charlotte Harbor, Charlotte Co., FL
		3	S	Charlotte Harbor, Charlotte Co., FL
		3	W	Charlotte Harbor, Charlotte Co., FL
		4	S	Charlotte Harbor, Charlotte Co., FL
		4	W	Charlotte Harbor, Charlotte Co., FL
				Unknown: transmitter battery failure
03558	M	1	S	Pamlico River, Beaufort Co., NC
				Dead: shot at fish hatchery, Beaufort Co., NC
03567	F	1	S	St. John's River, Duval Co., FL
				Dead: electrocuted, Duval Co., FL
03567B	M	1	S	Penobscot River, Penobscot Co., ME
		1	W	Newnan's Lake, Alachua Co., FL
				Unknown: transmitter battery failure
12558	M	1	S	Great South Bay, Nassau Co., NY
				Dead: unknown cause, Nelson Co., VA
12558B	F	1	S	Penobscot River, Penobscot Co., ME
		1	W	J. Strom Thurmond Lake, Lincoln Co., GA
				Unknown: PTT harness severed by eagle, found in Highlands Co., FL
13167	F	1	S	Big Brush Creek, Hale Co., AL
		1	W	Blue Cypress Lake, Indian River Co., FL
		2	S	Neuse River, Craven Co., NC
		2	W	Charlotte Harbor, Charlotte Co., FL
				Unknown: transmitter battery failure
13487	M	1	S	Gulf of St. Lawrence, Newfoundland, Canada
		1	W	Lake Okeechobee, Highlands Co., FL
		2	S	Menihek Lake, Newfoundland, Canada
		2	W	Lake Okeechobee, Highlands Co., FL
		3	S	Lac St. Jean, Quebec, Canada
		3	W	Alafia River, Hillsborough Co., FL
		4	S	Lac St. Jean, Quebec, Canada
		4	W	S. Prong Alafia River, Hillsborough Co., FL
13490	M	1	S	Shearon Harris Reservoir, Wake Co., NC
		1	W	Combahee River, Colleton Co., SC
		2	S	Myakka River, Sarasota Co., FL
		2	W	Caloosahatchee River, Lee Co., FL
		3	S	Myakka River, Sarasota Co., FL
		3	W	Myakka River, Sarasota Co., FL
		4	S	Myakka River, Sarasota Co., FL
				Unknown: transmitter battery failure
13494	F	1	S	Lac St. Jean, Quebec, Canada
		1	W	Lake Hatchineha, Polk Co., FL
		2	S	Shenandoah River, Fauquier Co., VA
		2	W	Withlacoochee River, Pasco Co., FL
		3	S	Potomac River, Loudoun Co., VA
		3	W	Withlacoochee River, Pasco Co., FL
		4	S	no locations received
		4	W	Withlacoochee River, Pasco Co., FL
		5	S	Potomac River, Loudoun Co., VA

Appendix C. Continued

PTT	Sex	Age	Season	Location
13494	F	5	W	Withlacoochee River, Pasco Co., FL
				Unknown: transmitter battery failure
13498	F	1	S	Guntersville Lake, Jackson Co., AL
		1	W	Big Fish Lake, Pasco Co., FL
		2	S	Guntersville Lake, Marshall Co., AL
		2	W	Big Fish Lake, Pasco Co., FL
		3	S	Guntersville Lake, Marshall Co., AL
		3	W	Lake Hancock, Polk Co., FL
		4	S	Center Hill Lake, Decal Co., TN
		4	W	Lake Hancock, Polk Co., FL
				Injured: vehicle collision, unreleasable, Polk Co., FL
13510	M	1	S	Charlotte Harbor, Charlotte Co., FL
				Dead: unknown cause
13520	F	1	S	Potomac River, Westmoreland Co., VA
		1	W	Alafia River, Hillsborough Co., FL
		2	S	Potomac River, Westmoreland Co., VA
		2	W	Alafia River, Hillsborough Co., FL
		3	S	Potomac River, Westmoreland Co., VA
		3	W	Alafia River, Hillsborough Co., FL
		4	S	Potomac River, Westmoreland Co., VA
				Unknown: transmitter battery failure
22985	F	1	S	Androscoggin River, Coos Co., NH
		1	W	Lake Moultrie, Berkley Co., SC
		2	S	Susquehanna River, Cecil Co., MD
		2	W	Econlockhatchee River, Seminole Co., FL
		3	S	Susquehanna River, Cecil Co., MD
		3	W	Lake Okeechobee, Palm Beach Co., FL
		4	S	no locations received
		4	W	no locations received
		5	S	no locations received
		5	W	no locations received
				Dead: electrocuted, Glades Co., FL
22986	M	1	S	n/a, died near nest
				Dead: unknown cause, Sarasota Co., FL
22987	M	1	S	Sassafras River, Cecil Co., MD
				Dead: unknown cause, Cecil Co., MD
22988	F	1	S	Richelleu River, Quebec, Canada
		1	W	Tomoka River, Volusia Co., FL
		2	S	Lake Champlain, Quebec, Canada
		2	W	Lake Okeechobee, Palm Beach Co., FL
		3	S	Lake Champlain, Franklin Co., VT
		3	W	Lake Okeechobee, Palm Beach Co., FL
				Dead: unknown cause, Nassau Co., FL
22989	F	1	S	James River, Hopewell City Co., VA
				Dead: unknown cause, Hopewell City Co., VA
22990	F	1	S	Lake Erie, Erie Co., OH
		1	W	Manatee River, Manatee Co., FL
		2	S	Huron River, Erie Co., OH
		2	W	Manatee River, Manatee Co., FL

Appendix C. Continued

PTT	Sex	Age	Season	Location
22990	F			Dead: unknown cause, Hillsborough Co., FL
22991	F	1	S	Econlockhatchee River, Seminole Co., FL
		1	W	Econlockhatchee River, Seminole Co., FL
		2	S	Econlockhatchee River, Seminole Co., FL
		2	W	Kissimmee River, Osceola Co., FL
		3	S	Manatee River, Manatee Co., FL
		3	W	Myakka River, Sarasota Co., FL
				Unknown: transmitter battery failure
22992	F	1	S	Susquehanna River, Harford Co., MD
		1	W	Suwannee River, Levy Co., FL
		2	S	Rappahannock River, Richmond Co., VA
		2	W	Suwannee River, Levy Co., FL
		3	S	Rappahannock River, Richmond Co., VA
		3	W	Wolf Sink, Levy Co., FL
				Dead: unknown cause, Levy Co., FL
22993	M	1	S	Potomac River, Charles Co., MD
		1	W	Charlotte Harbor, Charlotte Co., FL
		2	S	Potomac River, Charles Co., MD
		2	W	Charlotte Harbor, Charlotte Co., FL
				Dead: unknown cause, Lee Co., FL
22994	F	1	S	n/a, died near nest
				Dead: unknown cause, Lee Co., FL
22995	F	1	S	Potomac River, Charles Co., MD
				Dead: unknown collision, Harford Co., MD
22996	F	1	S	Avon River, Nova Scotia, Canada
		1	W	Lake Tohopekaliga, Osceola Co., FL
		2	S	Avon River, Nova Scotia, Canada
		2	W	Lake Tohopekaliga, Osceola Co., FL
		3	S	Avon River, Nova Scotia, Canada
		3	W	Lake Tohopekaliga, Osceola Co., FL
		4	S	no locations received
		4	W	no locations received
				Dead: electrocuted, Orange Co., FL
22997	F	1	S	Penobscot River, Hancock Co., ME
		1	W	Anclote River, Pasco Co., FL
		2	S	Delaware River, Pike Co., PA
		2	W	Alafia River, Hillsborough Co., FL
		3	S	Delaware River, Pike Co., PA
		3	W	Alafia River, Hillsborough Co., FL
		4	S	Delaware River, Sullivan Co., NY
				Dead: unknown cause, Charles City, MD
24977	F	1	S	Atlantic Ocean, Washington Co., ME
		1	W	Myakka River, Sarasota Co., FL
		2	S	Susquehanna River, Lucerne Co., PA
		2	W	Myakka River, Sarasota Co., FL
				Unknown: transmitter battery failure
24978	F	1	S	Albermarle Sound, Washington Co., NC
		1	W	Alafia River, Hillsborough Co., FL
		2	S	Albermarle Sound, Washington Co., NC

Appendix C. Continued

PTT	Sex	Age	Season	Location
24978	F	2	W	Alafia River, Hillsborough Co., FL
		3	S	Albermarle Sound, Washington Co., NC
		3	W	Alafia River, Hillsborough Co., FL
		4	S	Pamlico River, Beaufort Co., NC
		4	W	Alafia River, Hillsborough Co., FL
		5	S	Albermarle Sound, Washington Co., NC
		5	W	no locations received
				Dead: electrocuted, Hillsborough Co., FL
24979	F	1	S	Ohio River, Massac Co., IL
		1	W	Apalachicola River, Gulf Co., FL
		2	S	Ohio River, Massac Co., IL
		2	W	Dannelly Reservoir, Dallas Co., AL
				Dead: unknown cause, Monroe Co., AL
24980	M	1	S	Pamlico River, Pitt Co., NC
		1	W	The Everglades, Collier Co., FL
		2	S	Pamlico River, Pitt Co., NC
		2	W	Charlotte Harbor, Lee Co., FL
		3	S	Neuse River, Craven Co., NC
		3	W	Charlotte Harbor, Charlotte Co., FL
		4	S	Pamlico River, Pitt Co., NC
		4	W	Charlotte Harbor, Lee Co., FL
		5	S	Roanoke River, Martin Co., NC
		5	W	no locations received
				Dead: unknown cause, Charlotte Co., FL
24981	M	1	S	Sandusky River, Sandusky Co., OH
		1	W	Withlacoochee River, Sumter Co., FL
		2	S	Lake St. Lawrence, St. Lawrence Co., NY
		2	W	Withlacoochee River, Sumter Co., FL
		3	S	Sandusky Bay, Sandusky Co., OH
		3	W	Withlacoochee River, Sumter Co., FL
		4	S	S. Branch Potomac River, Pendleton Co., WV
		4	W	Withlacoochee River, Sumter Co., FL
				Dead: unknown cause, Sumter Co., FL
24982	F	1	S	Conowingo Reservoir, Lancaster Co., PA
		1	W	Charlotte Harbor, Charlotte Co., FL
		2	S	James River, James City Co., VA
				Dead: unknown cause, Newport News City Co., VA
24983	M	1	S	Foster Joseph Sayers Lake, Centre Co., PA
		1	W	St. John's River, Seminole Co., FL
		2	S	Foster Joseph Sayers Lake, Centre Co., PA
				Dead: unknown cause, Clinton Co., PA
24984	M	1	S	James River, Prince George Co., VA
		1	W	S. Prong Alafia River, Hillsborough Co., FL
		2	S	Pamunkey River, New Kent Co., VA
		2	W	Hancock Lake, Polk Co., FL
		3	S	B. Everett Jordan Lake, Chatham Co., NC
		3	W	Hancock Lake, Polk Co., FL
		4	S	B. Everett Jordan Lake, Chatham Co., NC
		4	W	Hancock Lake, Polk Co., FL

Appendix C. Continued

PTT	Sex	Age	Season	Location
24984	M	5	S	James River, Charles City Co., VA
		5	W	Hancock Lake, Polk Co., FL
				Unknown: transmitter battery failure
24985	M	1	S	Roanoke River, Martin Co., NC
		1	W	Charlotte Harbor, Lee Co., FL
		2	S	Neuse River, Craven Co., NC
		2	W	Charlotte Harbor, Lee Co., FL
		3	S	Neuse River, Craven Co., NC
		3	W	Charlotte Harbor, Lee Co., FL
		4	S	Neuse River, Craven Co., NC
		4	W	Charlotte Harbor, Lee Co., FL
				Dead: unknown cause, Lee Co., FL
24986	F	1	S	Lake Murray, Newberry Co., SC
		1	W	Econlockhatchee River, Orange Co., FL
		2	S	John H. Kerr Reservoir, Mecklenburg Co., VA
		2	W	Lake Conway, Orange Co., FL
		3	S	John H. Kerr Reservoir, Mecklenburg Co., VA
		3	W	Hancock Lake, Polk Co., FL
		4	S	Lake Gaston, Warren Co., NC
		4	W	Hancock Lake, Polk Co., FL
				Dead: unknown cause, Polk Co., FL
28106	M	1	S	n/a, transmitter failed with eagle in nest
				Unknown: transmitter battery failure
28106B	M	1	S	n/a, died near nest
				Dead: starvation, Hillsborough Co., FL
28106C	F	1	S	Little Tennessee River, Graham Co., NC
		1	W	Lake Okeechobee, Okeechobee Co., FL
		2	S	Charlotte Harbor, Charlotte Co., FL
				Dead: unknown cause, Charlotte Co., FL
28107	M	1	S	n/a, transmitter failed with eagle in nest
				Dead: unknown cause, unknown county, FL
28107B	M	1	S	Lake Moultrie, Berkley Co., SC
		1	W	St. John's River, Orange Co., FL
		2	S	Sassafras River, Cecil Co., MD
		2	W	Lake Kissimmee, Osceola Co., FL
		3	S	Bohemia River, Cecil Co., MD
		3	W	Lake Kissimmee, Osceola Co., FL
				Dead: unknown cause, Osceola Co., FL
28108	M	1	S	Weiss Lake, Cherokee Co., AL
				Unknown: transmitter battery failure
28108B	M	1	S	Potomac River, Westmoreland Co., VA
		1	W	Manatee River, Manatee Co., FL
		2	S	Potomac River, Westmoreland Co., VA
		2	W	Lemon Bay, Sarasota Co., FL
		3	S	Falls Lake Reservoir, Wake Co., NC
		3	W	Lemon Bay, Sarasota Co., FL
		4	S	John H. Kerr Reservoir, Vance Co., NC
		4	W	Myakka River, Sarasota Co., FL
		5	S	B. Everett Jordan Lake, Chatham Co., NC

Appendix C. Continued

PTT	Sex	Age	Season	Location
28108B	M			Dead: unknown causes, Chatham Co., NC
28109	F	1	S	St. Croix River, Washington Co., ME
				Unknown: transmitter battery failure
28109B	M	1	S	Lake Harris, Lake Co., FL
		1	W	Manatee River, Manatee Co., FL
		2	S	Lake Harris, Lake Co., FL
		2	W	Manatee River, Manatee Co., FL
		3	S	no locations received
		3	W	Alafia River, Hillsborough Co., FL
		4	S	Lake Harris, Lake Co., FL
		4	W	Manatee River, Manatee Co., FL
				Unknown: transmitter battery failure
28110	F	1	S	Potomac River, Westmoreland Co., VA
		1	W	Econlockhatchee River, Orange Co., FL
		2	S	Potomac River, Westmoreland Co., VA
		2	W	Peace River, Sarasota Co., FL
		3	S	Lake Harris, Lake Co., FL
28110B	F	1	S	S. Branch Potomac River, Highland Co., VA
		1	W	Crews Lake, Pasco Co., FL
		2	S	S. Branch Potomac River, Highland Co., VA
				Unknown: PTT harness severed by eagle, found in Pendleton Co., WV
28111	M	1	S	n/a, few locations received before failure
				Unknown: transmitter battery failure
28112	F	1	S	n/a, transmitter failed with eagle in nest
				Unknown: transmitter battery failure
28112B	M	1	S	St. Lawrence River, Quebec, Canada
		1	W	Lake Tohopekaliga, Osceola Co., FL
		2	S	Lake Champlain, Addison Co., VT
		2	W	Lake Tohopekaliga, Osceola Co., FL
		3	S	St. Lawrence River, Quebec, Canada
		3	W	Lake Tohopekaliga, Osceola Co., FL
		4	S	St. Lawrence River, Quebec, Canada
		4	W	Econlockhatchee River, Orange Co., FL
				Unknown: transmitter battery failure
28113	F	1	S	John H. Kerr Reservoir, Mecklenburg Co., VA
		1	W	Lake Tohopekaliga, Osceola Co., FL
		2	S	Mirimichi River, New Brunswick, Canada
		2	W	Econlockhatchee River, Orange Co., FL
		3	S	St. John River, New Brunswick, Canada
		3	W	St. John's River, Seminole Co., FL
		4	S	St. John River, New Brunswick, Canada
		4	W	Spruce Creek, Volusia Co., FL
				Unknown: transmitter battery failure
28114	F	1	S	St. Lawrence River, Quebec, Canada
		1	W	Lake Okeechobee, Martin Co., FL
		2	S	St. Lawrence River, Quebec, Canada
		2	W	St. Lucie River, Martin Co., FL
		3	S	St. Lawrence River, Quebec, Canada

Appendix C. Continued

PTT	Sex	Age	Season	Location
28114	F	3	W	St. Lucie River, Martin Co., FL
		4	S	St. Lucie River, Martin Co., FL
				Dead: unknown cause, Martin Co., FL
28115	M	1	S	Lake Strom Thurmond, Lincoln Co., GA
		1	W	Manatee River, Manatee Co., FL
		2	S	Lake Strom Thurmond, Lincoln Co., GA
		2	W	Manatee River, Manatee Co., FL
		3	S	Lake Strom Thurmond, Lincoln Co., GA
				Unknown: transmitter battery failure
28116	F	1	S	Lake Michigan, Emmet Co., MI
		1	W	Cypress Lake, Osceola Co., FL
		2	S	Lake Huron, Ontario, Canada
		2	W	Cypress Lake, Osceola Co., FL
28117	F	1	S	James River, Prince George Co., VA
		1	W	Anclote River, Pasco Co., FL
		2	S	John H. Kerr Reservoir, Mecklenburg Co., VA
		2	W	Lake Thonotosassa, Hillsborough Co., FL
		3	S	John H. Kerr Reservoir, Mecklenburg Co., VA
		3	W	Tampa Bay, Hillsborough Co., FL
				Unknown: transmitter battery failure
28118	U	1	S	n/a, died in nest
				Dead: avian pox, Lee Co., FL
28118B	F	1	S	Roanoke Rapids Lake, Northampton Co., NC
		1	W	Charlotte Harbor, Charlotte Co., FL
		2	S	Roanoke Rapids Lake, Northampton Co., NC
		2	W	Charlotte Harbor, Charlotte Co., FL
		3	S	Roanoke Rapids Lake, Northampton Co., NC
		3	W	Lemon Bay, Sarasota Co., FL
		4	S	Lake Gaston, Mecklenburg Co., VA
		4	W	Peace River, Charlotte Co., FL
		5	S	Lake Gaston, Mecklenburg Co., VA
		5	W	Myakka River, Sarasota Co., FL
				Unknown: transmitter battery failure
28119	M	1	S	Little PeeDee River, Marion Co., SC
		1	W	Myakka River, Sarasota Co., FL
		2	S	Lake Marion, Clarendon Co., SC
		2	W	Braden River, Manatee Co., FL
		3	S	Lake Marion, Clarendon Co., SC
		3	W	Braden River, Manatee Co., FL
				Dead: unknown cause, Manatee Co., FL

[a] PTT = platform terminal transmitter, satellite transmitter number used to identify each eagle.
[b] Age = year: 1 = hatch year (0-1 year old), etc.
[c] S= summer, W = winter.

APPENDIX D. Important use areas (IUAs) for migratory Florida Bald Eagles identified using nearest-neighbor clustering of >1 eagles or >1 seasons for an individual eagle within a 25 km radius. Locations were collected from sunrise to one hour before sunset, 1997-2004. A 95% kernel density area (km^2) was calculated on all points within each IUA cluster.

Waterbody	State	County or Province	Latitude	Longitude	No. individuals	95% kernel (km^2)
St. John River	CAN	New Brunswick	45.881	-66.533	2	1081
Avon River	CAN	Nova Scotia	45.204	-63.393	1	207
Bay of Fundy	CAN	Nova Scotia	45.090	-64.266	1	78
Lake Caniapiscan	CAN	Quebec	53.801	-68.511	1	48
St. Pierre Lake	CAN	Quebec	46.130	-73.050	1	52
St. Lawrence River	CAN	Quebec	47.892	-69.787	1	2138
St. Lawrence River	CAN	Quebec	46.582	-72.021	1	668
St. Lawrence River	CAN	Quebec	49.639	-67.147	2	188
Lake Guntersville	AL	Marshall	34.388	-86.282	1	812
Lake Guntersville	AL	Marshall	34.535	-86.059	1	1168
Lochloosa Lake	FL	Alachua	29.483	-82.104	4	155
Newnan's Lake	FL	Alachua	29.668	-82.294	4	585
Banana Creek	FL	Brevard	28.602	-80.635	2	0
Banana River	FL	Brevard	28.349	-80.668	2	1219
St John's River	FL	Brevard	28.363	-80.920	7	200
Lemon Bay	FL	Charlotte	26.898	-82.393	4	31
Peace River	FL	Charlotte	26.907	-81.840	4	490
Charlotte Harbor	FL	Charlotte	26.775	-82.030	7	273
Crystal Bay	FL	Citrus	28.719	-82.552	4	841
Crystal Bay	FL	Citrus	28.889	-82.663	4	1008
Homosassa Bay	FL	Citrus	28.686	-82.786	4	685
St John's River	FL	Clay	30.030	-81.720	4	1565
Tamiami Canal	FL	Collier	25.924	-81.347	2	318
Golden Gate Canal	FL	Collier	26.124	-81.671	7	203
Prairie Creek	FL	De Soto	27.043	-81.848	2	0
Peace River	FL	Desoto	27.254	-81.922	3	171
Apalachicola River	FL	Franklin	29.704	-84.952	2	1454
Fisheating Creek	FL	Glades	26.915	-81.263	3	216
Intercoastal Waterway	FL	Gulf	29.841	-85.295	1	804
Peace River	FL	Hardee	27.442	-81.694	5	745
Kissimmee River	FL	Highland	27.268	-80.945	2	627
Fisheating Creek	FL	Highlands	27.197	-81.435	2	0
Lake Istokpoga	FL	Highlands	27.433	-81.360	3	1416
Hillsborough River	FL	Hillsborough	28.014	-82.314	7	394

Appendix D. Continued.

Waterbody	State	County or Province	Latitude	Longitude	No. individuals	95% kernel (km^2)
South Prong Alafia River	FL	Hillsborough	27.744	-82.239	10	182
Blue Cypress Lake	FL	Indian River	27.828	-80.665	3	1024
Lake Apopka	FL	Lake	28.546	-81.694	3	166
St. John's River	FL	Lake	29.050	-81.422	4	834
Lake Apopka	FL	Lake	28.564	-81.583	1	92
Lake Harris	FL	Lake	28.663	-81.859	2	312
Caloosahatchee River	FL	Lee	26.552	-81.946	3	607
Gulf of Mexico	FL	Lee	26.497	-82.313	2	0
Lake Miccosukee	FL	Leon	30.557	-84.145	2	499
Gulf of Mexico	FL	Levy	29.143	-83.074	1	0
Suwannee River	FL	Levy	29.366	-83.004	1	176
Withlacoochee River	FL	Levy	29.240	-82.541	2	436
Gulf of Mexico	FL	Manatee	27.428	-82.824	4	1088
Braden River	FL	Manatee	27.365	-82.448	9	666
Ocklawaha River	FL	Marion	28.962	-81.850	2	0
Ocklawaha River	FL	Marion	29.161	-82.006	2	0
Lake Okeechobee	FL	Martin	26.856	-80.540	4	914
Nassau River	FL	Nassau	30.471	-81.509	4	1725
St. Mary's River	FL	Nassau	30.365	-82.000	3	1208
St. Lucie River	FL	Okeechobee	27.263	-80.568	5	1181
Econlockhatchee River	FL	Orange	28.402	-81.275	9	605
Lake Kissimmee	FL	Osceola	27.826	-81.049	6	1280
Tohopekaliga Lake	FL	Osceola	28.080	-81.404	7	559
St. John's River	FL	Osceola	28.114	-80.870	2	478
Everglades Swamp	FL	Palm Beach	26.635	-80.326	2	0
Anclote River	FL	Pasco	28.252	-82.493	9	582
Gulf of Mexico	FL	Pasco	28.374	-82.720	3	1495
Anclote River	FL	Pasco	28.126	-82.815	2	272
Tampa Bay	FL	Pinellas	27.789	-82.631	5	1142
Buffum Lake	FL	Polk	27.771	-81.607	2	0
Saddle Creek	FL	Polk	28.106	-81.963	9	415
Peace River	FL	Polk	27.881	-81.939	11	464
Withlacoochee River	FL	Polk	28.288	-81.829	3	396
Peace River	FL	Polk	27.994	-81.677	6	876
Withlacoochee River	FL	Putnam	28.525	-82.255	5	1288
Ocklawaha River	FL	Putnam	29.598	-81.736	2	0
Myakka River	FL	Sarasota	27.051	-82.301	11	483
St John's River	FL	Seminole	28.755	-81.097	6	301
Tolomato River	FL	St. John's	29.805	-81.325	4	2009
Withlacoochee River	FL	Sumter	28.816	-82.177	3	662
Withlacoochee River	FL	Sumter	28.403	-81.995	2	0

Appendix D. Continued.

Waterbody	State	County or Province	Latitude	Longitude	No. individuals	95% kernel (km^2)
Tomoka River	FL	Volusia	29.070	-81.108	8	178
Tomoka River	FL	Volusia	29.244	-81.127	8	361
Lake George	FL	Volusia	29.407	-81.458	3	1686
Weiss Lake	GA	Cherokee	34.166	-85.779	1	95
Alabaha River	GA	Coffee	31.500	-82.635	3	1340
Turnpike Creek	GA	Dodge	32.031	-83.054	3	126
Ogeechee River	GA	Liberty	31.856	-81.299	4	836
Lake Strom Thurmond	GA	Lincoln	33.800	-82.326	2	243
Sapelo River	GA	McIntosh	31.522	-81.442	4	1248
Ohio River	KY	McCracken	37.184	-88.958	1	9
Connecticut River	MA	Franklin	42.816	-72.647	3	1668
Patapsco River	MD	Anne Arundel	39.160	-76.545	2	0
Patuxent River	MD	Anne Arundel	38.845	-76.531	3	665
Patuxent River	MD	Calvert	38.431	-76.390	2	918
Susquehanna River	MD	Cecil	39.517	-76.075	9	677
Potomac River	MD	Charles	38.497	-77.211	12	364
Chesapeake Bay	MD	Kent	39.249	-76.226	3	616
Patuxent River	MD	Montgomery	39.165	-76.946	1	163
Wye East River	MD	Talbot	38.904	-76.061	2	871
Androscoggin River	ME	Cumberland	43.926	-69.906	3	982
Frenchman Bay	ME	Hancock	44.507	-68.019	3	411
Penobscot River	ME	Penobscot	45.193	-68.598	3	89
Seboeis Lake	ME	Piscataquis	45.404	-68.960	2	0
Pamlico River	NC	Beaufort	35.519	-76.872	2	0
Seaforth Lake	NC	Chatham	35.795	-78.993	9	307
Albemarle Sound	NC	Chowan	35.847	-76.406	3	3637
Core Creek	NC	Craven	35.289	-77.332	2	230
Neuse River	NC	Granville	36.220	-78.623	2	1882
Horse Creek	NC	Manatee	27.499	-82.032	3	491
Roanoke Rapids Lake	NC	Northampton	36.507	-77.804	2	180
Tranters Creek	NC	Pitt	35.716	-77.118	3	269
Deep River	NC	Randolph	35.665	-79.589	3	1364
Pee Dee River	NC	Richmond	35.056	-79.743	3	1303
Cape Fear River	NC	Robeson	34.761	-78.923	4	1580
LakeTillery	NC	Stanly	35.335	-80.066	2	0
Falls Lake Reservoir	NC	Wake	36.011	-78.571	2	953
Shearon Harris Reservoir	NC	Wake	35.531	-78.894	3	495
East Dismal Swamp	NC	Washington	35.747	-76.536	2	491
Neuse River	NC	Wayne	35.184	-77.918	4	1291
Cane River	NC	Yancy	35.942	-82.298	2	2413
Huron River	OH	Erie	41.403	-82.656	1	147
Delaware River	PA	Bucks	40.428	-75.197	2	1424
Susquehanna River	PA	Lancaster	39.837	-76.313	3	115
Delaware River	PA	Pike	41.434	-74.782	1	40

Appendix D. Continued.

Waterbody	State	County or Province	Latitude	Longitude	No. individuals	95% kernel (km^2)
Delaware River	PA	Pike	40.973	-74.999	4	2409
Susquehanna River	PA	Wyoming	41.399	-75.791	2	151
Lake Moultrie	SC	Berkeley	33.246	-80.102	2	618
Pocotaligo River	SC	Clarendon	33.702	-80.124	3	438
Combahee River	SC	Colleton	32.624	-80.561	6	651
Combahee River	SC	Colleton	32.942	-80.898	3	1218
Broad Run	SC	Fairfield	34.298	-81.303	2	53
Savannah River	SC	Hampton	32.636	-81.154	8	444
Broad River	SC	Jasper	32.302	-80.878	2	73
Little Pee Dee River	SC	Marion	34.000	-79.318	2	41
Wateree River	SC	Sumter	33.840	-80.531	3	923
Lake Wylie	SC	York	35.118	-81.071	2	290
Cowpasture River	VA	Bath	38.141	-79.536	3	551
Appomattox River	VA	Chesterfield	37.237	-77.479	4	571
Rappahannock River	VA	Culpepper	38.395	-77.634	3	471
Roanoke River	VA	Halifax	36.622	-78.573	3	539
Dan River	VA	Halifax	36.683	-78.887	2	228
James River	VA	James City	37.175	-76.556	4	154
Rappahannock River	VA	King George	38.218	-77.251	3	713
Mattaponi River	VA	King William	37.812	-77.091	3	785
Potomac River	VA	Loudoun	39.062	-77.373	2	255
Roanoke River	VA	Mecklenburg	36.626	-78.258	2	0
Pamunkey River	VA	New Kent	37.530	-76.799	2	424
James River	VA	Prince George	37.354	-77.132	7	305
James River	VA	Surry	37.158	-76.875	6	907
Potomac River	VA	Westmoreland	38.130	-76.467	4	576
Potomac River	VA	Westmoreland	38.128	-76.848	7	279
Lake Champlain	VT	Addison	44.089	-73.328	2	116
Lake Champlain	VT	Franklin	45.015	-73.180	3	171
South Fork Potomac River	WV	Pendleton	38.395	-79.637	2	911
North Fork South Branch Potomac River	WV	Randolph	38.696	-79.528	2	306
Knapp Creek	WV	Summers	37.557	-80.871	1	165

APPENDIX E. Conservation land used by migratory Florida sub-adult Bald Eagles, 1997-2004. Areas overlapped boundaries of important use areas identified by nearest neighbor clustering analysis of >1 eagles or >1 seasons for and individual eagle within a 25 km radius. Locations were collected from sunrise to one hour before sunset.

Protected Area	State	Owner	Managing Agency	Type
Monsanto State Park	AL	State	Alabama Department of Conservation & Natural Resources	State Park
Lake Guntersville State Park	AL	State	Alabama Department of Conservation & Natural Resources	State Park
Timucuan Ecological and Historic Preserve	FL	Federal	National Park Service	National Research Reserve
Marjory Stoneman Douglas Wilderness Area	FL	Federal	National Park Service	Wilderness Area
Cape Canaveral Air Station	FL	Federal	U.S. Department of Defense	Military Reservation
Mayport Naval Station	FL	Federal	U.S. Department of Defense	Military Reservation
Chassahowitzka NWR	FL	Federal	U.S. Fish and Wildlife Service	National Wildlife Refuge
Lower Suwannee NWR	FL	Federal	U.S. Fish and Wildlife Service	National Wildlife Refuge
St. Johns NWR	FL	Federal	U.S. Fish and Wildlife Service	National Wildlife Refuge
Alexander Springs Wilderness Area	FL	Federal	U.S. Fish and Wildlife Service	Wilderness Area
Chassahowitzka Wilderness Area	FL	Federal	U.S. Fish and Wildlife Service	Wilderness Area
Ocala NF	FL	Federal	U.S. Forest Service	National Forest
Micco Scrub Sanctuary	FL	Local	Brevard County Parks & Recreation Department	Natural Area
Charlotte Flatwoods	FL	Local	Charlotte County Parks & Recreation Department	Other
Port Orange City Forest	FL	Local	City of Port Orange	Other
Betz Tiger Point Park	FL	Local	Duval County/City of Jacksonville	City Park
Cypress Lakes Preserve	FL	Local	Hernando County Planning Department	Nature Preserve
Brooker Creek	FL	Local	Hillsborough County	Nature Preserve
Balm-Boyette Scrub	FL	Local	Hillsborough County	Nature Preserve
Fish Hawk	FL	Local	Hillsborough County	Other
Balm Scrub	FL	Local	Hillsborough County	Other
Alafia River Corridor	FL	Local	Hillsborough County Parks, Recreation & Conservation	Conservation Area
Lettuce Lake Regional Park	FL	Local	Hillsborough County Parks, Recreation & Conservation	County Park

Appendix E. Continued.

Protected Area	State	Owner	Managing Agency	Type
Triple Creek	FL	Local	Hillsborough County Parks, Recreation & Conservation	Natural Area
Cone Ranch	FL	Local	Hillsborough County Parks, Recreation & Conservation	Other
Yellow Fever Creek Preserve	FL	Local	Lee County Parks & Recreation	Natural Area
Prairie Pines Preserve	FL	Local	Lee County Parks & Recreation	Natural Area
San Carlos Bay - Bunche Beach Preserve	FL	Local	Lee County Parks & Recreation	Natural Area
Matanzas Pass Preserve	FL	Local	Lee County Parks & Recreation	Nature Preserve
Pine Island Preserve	FL	Local	Manatee County Conservation Lands Management Division	Natural Area
Duette Park	FL	Local	Manatee County Planning Department	County Park
Oakland Nature Preserve	FL	Local	Oakland Nature Preserve, Inc.	Natural Area
Brooker Creek Preserve	FL	Local	Pinellas County Department of Environmental Management	Nature Preserve
Cross Bar Ranch Wellfield	FL	Local	Pinellas County Utilities Department	Other
All-Bar Ranch	FL	Local	Pinellas County Utilities Department	Other
Lake Hancock Circle B Bar Reserve	FL	Local	Polk County Environmental Services Department	Natural Area
Saddle Creek County Park	FL	Local	Polk County Parks & Recreation Division	County Park
Pinelands Reserve	FL	Local	Sarasota County Natural Resources Department	Nature Preserve
Jelks Preserve	FL	Local	Sarasota County Natural Resources Department	Nature Preserve
T. Mabry Carlton, Jr. Memorial Reserve	FL	Local	Sarasota County Natural Resources Department	Nature Preserve
Abolay-Lykes Property	FL	Local	Sarasota County Natural Resources Department	Other
Indianola Mounds	FL	Local	Sarasota County Natural Resources Department	Other
Sarasota Ranch Lands	FL	Local	Sarasota County Natural Resources Department	Other
Blind Pass Park	FL	Local	Sarasota County Parks & Recreation Department	County Park
Lake Proctor Wilderness Area	FL	Local	Seminole County Planning & Development Department	Wilderness Area
C-23/C-24 Storage Reservoirs	FL	Local	South Florida Water Management District	Other
Pasco I	FL	Local	Southwest Florida Water Management District	Conservation Area
Deer Prairie Creek	FL	Local	Southwest Florida Water Management District	Conservation Area
St. Lucie Pinelands	FL	Local	St. Lucie County Public Works Department	Other

Appendix E. Continued.

Protected Area	State	Owner	Managing Agency	Type
Florida Coastal Islands Sanctuaries	FL	Private	Audubon of Florida	Private Conservation
Jahna Industries CE	FL	Private	Florida Department of Environmental Protection	Conservation Easement
GSLA Land Protection Agreement	FL	Private	Florida Department of Environmental Protection	Conservation Easement
Hines CE	FL	Private	Florida Department of Environmental Protection	Conservation Easement
Miami Corporation	FL	Private	Florida Fish and Wildlife Conservation Commission	Private
Lake Panasoffkee CE	FL	Private	Southwest Florida Water Management District	Conservation Easement
Myakkahatchee Creek	FL	Private	Southwest Florida Water Management District	Conservation Easement
Pasco I CE	FL	Private	Southwest Florida Water Management District	Conservation Easement
Timber Company CE	FL	Private	St. Johns River Water Management District	Conservation Easement
NATC Oak Hammock CE	FL	Private	Suwannee River Water Management District	Conservation Easement
NATC Suwannee Swamp CE	FL	Private	Suwannee River Water Management District	Conservation Easement
David and Sarah Meeks CE	FL	Private	Suwannee River Water Management District	Conservation Easement
Jack and Loy Ann Mann CE	FL	Private	Suwannee River Water Management District	Conservation Easement
Disney Wilderness Preserve	FL	Private	The Nature Conservancy	Private Conservation
Apalachicola NERR	FL	State	Florida Department of Environmental Protection	National Research Reserve
Clear Springs	FL	State	Florida Department of Environmental Protection	Other State
South Prong Alafia River	FL	State	Florida Department of Environmental Protection	Other State
Pinellas County Aquatic Preserve	FL	State	Florida Department of Environmental Protection	State Aquatic Reserve
Charlotte Harbor Aquatic Preserve	FL	State	Florida Department of Environmental Protection	State Aquatic Reserve
Big Bend Aquatic Preserve	FL	State	Florida Department of Environmental Protection	State Aquatic Reserve
Lemon Bay Aquatic Preserve	FL	State	Florida Department of Environmental Protection	State Aquatic Reserve
Estero Bay Aquatic Preserve	FL	State	Florida Department of Environmental Protection	State Aquatic Reserve
Charlotte Harbor State Buffer Preserve	FL	State	Florida Department of Environmental Protection	State Nature Reserve
Crystal River State Buffer Preserve	FL	State	Florida Department of Environmental Protection	State Nature Reserve

Appendix E. Continued.

Protected Area	State	Owner	Managing Agency	Type
Estero Bay State Buffer Preserve	FL	State	Florida Department of Environmental Protection	State Nature Reserve
Pumpkin Hill Creek State Buffer Preserve	FL	State	Florida Department of Environmental Protection	State Nature Reserve
St. Joseph Bay State Buffer Preserve	FL	State	Florida Department of Environmental Protection	State Nature Reserve
Hontoon Island State Park	FL	State	Florida Department of Environmental Protection	State Park
Crystal River Archaeological State Park	FL	State	Florida Department of Environmental Protection	State Park
Fakahatchee Strand Preserve State Park	FL	State	Florida Department of Environmental Protection	State Park
Faver-Dykes State Park	FL	State	Florida Department of Environmental Protection	State Park
Blue Spring State Park	FL	State	Florida Department of Environmental Protection	State Park
Hillsborough River State Park	FL	State	Florida Department of Environmental Protection	State Park
Lake Louisa State Park	FL	State	Florida Department of Environmental Protection	State Park
Myakka River State Park	FL	State	Florida Department of Environmental Protection	State Park
Paynes Prairie Preserve State Park	FL	State	Florida Department of Environmental Protection	State Park
William Beardall Tosohatchee State Reserve	FL	State	Florida Department of Environmental Protection	State Park
Withlacoochee Trail State Park	FL	State	Florida Department of Environmental Protection	State Park
Lake Kissimmee State Park	FL	State	Florida Department of Environmental Protection	State Park
General James A. Van Fleet Trail State Park	FL	State	Florida Department of Environmental Protection	State Park
Alafia River State Park	FL	State	Florida Department of Environmental Protection	State Recreation Area
Goethe SF	FL	State	Florida Division of Forestry	State Forest
Withlacoochee SF	FL	State	Florida Division of Forestry	State Forest
Tiger Bay SF	FL	State	Florida Division of Forestry	State Forest
Tate's Hell SF	FL	State	Florida Division of Forestry	State Forest
Picayune Strand SF	FL	State	Florida Division of Forestry	State Forest
Myakka SF	FL	State	Florida Division of Forestry	State Forest
Matanzas SF	FL	State	Florida Division of Forestry	State Forest
Lake George SF	FL	State	Florida Division of Forestry	State Forest
Little Big Econ SF	FL	State	Florida Division of Forestry	State Forest
Apalachicola River WEA	FL	State	Florida Fish and Wildlife Conservation Commission	Conservation Area
Paradise Island	FL	State	Florida Fish and Wildlife Conservation Commission	Other State

Appendix E. Continued.

Protected Area	State	Owner	Managing Agency	Type
Relay WMA	FL	State	Florida Fish and Wildlife Conservation Commission	Wildlife Management Area
J. W. Corbett WMA	FL	State	Florida Fish and Wildlife Conservation Commission	Wildlife Management Area
Half Moon WMA	FL	State	Florida Fish and Wildlife Conservation Commission	Wildlife Management Area
Fred C. Babcock-Cecil M. Webb WMA	FL	State	Florida Fish and Wildlife Conservation Commission	Wildlife Management Area
Fisheating Creek WMA	FL	State	Florida Fish and Wildlife Conservation Commission	Wildlife Management Area
Three Lakes WMA	FL	State	Florida Fish and Wildlife Conservation Commission	Wildlife Management Area
Bull Creek WMA	FL	State	Florida Fish and Wildlife Conservation Commission	Wildlife Management Area
Babcock-Webb WMA	FL	State	Florida Fish and Wildlife Conservation Commission	Wildlife Management Area
Marjorie Harris Carr Cross Florida Greenway SRCA	FL	State	Florida Natural Areas Inventory	Conservation Area
Stormwater Treatment Areas	FL	State	South Florida Water Management District	Other State
Kissimmee River	FL	State	South Florida Water Management District	Other State
Kissimmee Chain of Lakes	FL	State	South Florida Water Management District	Other State
Allapattah Flats	FL	State	South Florida Water Management District	Other State
Upper Lakes Basin Watershed	FL	State	South Florida Water Management District	Other State
Myakka River	FL	State	Southwest Florida Water Management District	Other State
Lower Hillsborough Flood Detention Area	FL	State	Southwest Florida Water Management District	Other State
Lower Hillsborough Flood Detention Area	FL	State	Southwest Florida Water Management District	Other State
Lake Thonotosassa	FL	State	Southwest Florida Water Management District	Other State
Annutteliga Hammock	FL	State	Southwest Florida Water Management District	Other State
Upper Hillsborough	FL	State	Southwest Florida Water Management District	Other State
Starkey	FL	State	Southwest Florida Water Management District	Other State
Green Swamp	FL	State	Southwest Florida Water Management District	Other State
River Lakes CA	FL	State	St. Johns River Water Management District	Conservation Area
Twelve Mile Swamp CA	FL	State	St. Johns River Water Management District	Conservation Area

Appendix E. Continued.

Protected Area	State	Owner	Managing Agency	Type
Blue Cypress CA	FL	State	St. Johns River Water Management District	Conservation Area
Three Forks Marsh CA	FL	State	St. Johns River Water Management District	Conservation Area
Lochloosa Wildlife CA	FL	State	St. Johns River Water Management District	Conservation Area
Lake George CA	FL	State	St. Johns River Water Management District	Conservation Area
Pellicer Creek Corridor CA	FL	State	St. Johns River Water Management District	Conservation Area
Hal Scott Regional Preserve and Park	FL	State	St. Johns River Water Management District	Natural Area
Fourth Volusia	FL	State	St. Johns River Water Management District	Other State
Altamaha River Scenic Easements	GA	Federal	Georgia Department of Natural Resources	Other Federal
Unknown	GA	Federal	U.S. Army Corps of Engineers	Other Federal
Fort Stewart	GA	Federal	U.S. Department of Defense	Military Reservation
Fort McAllister State Park	GA	State	Georgia Department of Natural Resources	State Park
King Tract WMA	GA	State	Georgia Department of Natural Resources	Wildlife Management Area
Richmond Hill WMA	GA	State	Georgia Department of Natural Resources	Wildlife Management Area
Altamaha WMA	GA	State	Georgia Department of Natural Resources	Wildlife Management Area
H.O. Cook SF	MA	State	Massachusetts Dept of Environmental Management	State Forest
Chesapeake & Ohio Canal NHP	MD	Federal	National Park Service	National Historic Site
Grove Neck Wildlife Sanctuary	MD	Federal	U.S. Army Corps of Engineers	Other Federal
Stemmers MHA	MD	Federal	U.S. Army Corps of Engineers	Other Federal
Aberdeen Proving Ground	MD	Federal	U.S. Department of Defense	Military Reservation
NSWC Indian Head	MD	Federal	U.S. Department of Defense	Military Reservation
Tridelphia Watershed	MD	Local	Local County Parks Department	County Park
Turners Creek Park	MD	Local	Local County Parks Department	County Park
T. Howard Duckett Waters	MD	Local	Local County Parks Department	County Park
Patuxent River Watershed	MD	Local	Local County Parks Department	County Park
Mariner Point Park	MD	Local	Local County Parks Department	County Park
Hawlings River Regional Park	MD	Local	Local County Parks Department	County Park
Francis Silver Park	MD	Local	Local County Parks Department	County Park
Halls Cross Elementary School Park	MD	Local	Local County Parks Department	County Park
North Deen Park	MD	Local	Local County Parks Department	County Park
Smithsonian Environmental Center	MD	Private	Smithsonian Institution	Private Conservation

Appendix E. Continued.

Protected Area	State	Owner	Managing Agency	Type
Sassafras NRMA	MD	State	Maryland Department of Natural Resources	Other State
Doncaster SF	MD	State	Maryland Department of Natural Resources	State Forest
Mattawoman NEA	MD	State	Maryland Department of Natural Resources	State Natural Area
Elk Neck State Park	MD	State	Maryland Department of Natural Resources	State Park
Gunpowder Falls State Park	MD	State	Maryland Department of Natural Resources	State Park
Susquehanna State Park	MD	State	Maryland Department of Natural Resources	State Park
Dierrsen WMA	MD	State	Maryland Department of Natural Resources	Wildlife Management Area
McKee Beshers	MD	State	Maryland Department of Natural Resources	Wildlife Management Area
Brunswick Naval Air Station	ME	Federal	U.S. Department of Defense	Military Reservation
Mill Stream Landing	ME	Private	Freeport Conservation Trust	Conservation Area
Mast Landing Sanctuary	ME	Private	Maine Audubon Society	Nature Preserve
Penobscot Indian Nation Reservation	ME	Tribal	Penobscot Indian Nation	Native American Land
Jordan Lake Educational SF	NC	Federal	North Carolina Division of Forest Resources	State Forest
Jordan Lake SRA	NC	Federal	North Carolina Division of Parks & Recreation	State Recreation Area
Falls Lake SRA	NC	Federal	North Carolina Division of Parks & Recreation	State Recreation Area
Jordan Game Land	NC	Federal	North Carolina Wildlife Resource Commission	Other State
Butner-Falls of Neuse Game Land	NC	Federal	North Carolina Wildlife Resource Commission	Other State
Falls Lake	NC	Federal	U.S. Army Corps of Engineers	Other Federal
Jordan Lake	NC	Federal	U.S. Army Corps of Engineers	Other Federal
Kerr Reservoir	NC	Federal	U.S. Army Corps of Engineers	Other Federal
Pocosin Lakes NWR	NC	Federal	U.S. Fish and Wildlife Service	National Wildlife Refuge
Uwharrie NF	NC	Federal	U.S. Forest Service	National Forest
Pisgah NF	NC	Federal	U.S. Forest Service	National Forest
Voice of America, Site A	NC	Federal	U.S. Information Services	Other Federal
Shearon Harris County Park	NC	Local	Wake County	County Park
Big Tom Wilson Preserve	NC	Private	American Farmland Trust	Conservation Easement
Scuppernong River Preserve	NC	Private	The Nature Conservancy	Private Conservation
Unknown	NC	Private	U.S. Fish and Wildlife Service	Conservation Easement
Lake Phelps State Lake	NC	State	North Carolina Division of Parks & Recreation	Other State
Mount Mitchell State Park	NC	State	North Carolina Division of Parks & Recreation	State Park

Appendix E. Continued.

Protected Area	State	Owner	Managing Agency	Type
Pettigrew State Park	NC	State	North Carolina Division of Parks & Recreation	State Park
Lantern Acres Game Land/Creswell Wetlands	NC	State	North Carolina Wildlife Resource Commission	Other State
Sandhills Game Land	NC	State	North Carolina Wildlife Resource Commission	Other State
Delaware Water Gap NRA	NJ	Federal	National Park Service	National Recreation Area
Paulinskill Trail	NJ	State	New Jersey Department of Environmental Protection	Other State
Mongaup Valley WMA	NY	State	Unknown	Wildlife Management Area
Cherry Island State WMA	NY	State	Unknown	Wildlife Management Area
Putnam Marsh	OH	Private	The Nature Conservancy	Nature Preserve
Unknown	OH	Private	Unknown	Private
Dupont Marsh NA	OH	State	Erie County Park District	Natural Area
Old Woman Creek SNP	OH	State	Ohio Department of Natural Resources	State Nature Reserve
Sheldon Marsh SNP	OH	State	Ohio Department of Natural Resources	State Nature Reserve
Delaware River NRA	PA	Federal	National Park Service	National Recreation Area
Upper Delaware Management Area	PA	Federal	National Park Service	National Recreation Area
Del River Open Space	PA	Local	County or Local Parks Department	Other
Mt. Jack	PA	Local	County or Local Parks Department	Other
Peace Valley	PA	Local	County or Local Parks Department	Other
Delaware SF	PA	State	Pennsylvania Bureau of Forestry	State Forest
Susquehannock State Park	PA	State	Pennsylvania Bureau of State Parks	State Park
State Game Land 56	PA	State	Pennsylvania Game Commission	Wildlife Management Area
Shaw AFB	SC	Federal	U.S. Department of Defense	Military Reservation
ACE Basin NWR	SC	Federal	U.S. Fish and Wildlife Service	National Wildlife Refuge
Musselboro Island	SC	Private	Ducks Unlimited	Private Conservation
Parkers Ferry	SC	Private	Ducks Unlimited	Private Conservation
Bolders Island	SC	Private	Ducks Unlimited	Private Conservation
Chehaw Combahee Plantation	SC	Private	Ducks Unlimited	Private Conservation
Church Tract	SC	Private	Ducks Unlimited	Private Conservation
Willtown Bluff Plantation	SC	Private	Ducks Unlimited	Private Conservation
Pon Pon Plantation	SC	Private	Ducks Unlimited	Private Conservation
Ashepoo Plantation	SC	Private	Ducks Unlimited	Private Conservation
Paul and Dalton Plantation	SC	Private	Lowcountry Open Land Trust	Private Conservation
Oak Grove	SC	Private	Lowcountry Open Land Trust	Private Conservation
Nemours Plantation	SC	Private	Nemours Wildlife Foundation	Private Conservation
Hope Plantation	SC	Private	The Nature Conservancy	Conservation Easement

Appendix E. Continued.

Protected Area	State	Owner	Managing Agency	Type
Santee Cooper Hydroelectric Project	SC	State	Public Service Authority	Other State
St. Helena Sound HP	SC	State	South Carolina Department of Natural Resources	Natural Area
Bear Island WMA	SC	State	South Carolina Department of Natural Resources	Wildlife Management Area
Donnelley WMA	SC	State	South Carolina Department of Natural Resources	Wildlife Management Area
North Cherokee NF & WMA	TN	Federal	U.S. Forest Service	National Forest
Colonial NHP	VA	Federal	National Park Service	National Historic Site
George Washington Birthplace NM	VA	Federal	National Park Service	National Monument
Petersburg NB	VA	Federal	National Park Service	National Park
Petersburg NB	VA	Federal	National Park Service	National Park
Yorktown Naval Weapons Station	VA	Federal	U.S. Department of Defense	Military Reservation
Fort Lee	VA	Federal	U.S. Department of Defense	Military Reservation
Buggs Island Lake	VA	Federal	U.S. Department of Defense	Water
John H. Kerr Reservoir	VA	Federal	U.S. Department of Defense	Water
Hogan Creek WMA - Kerr Reservoir	VA	Federal	U.S. Department of Defense	Wildlife Management Area
Dan River WMA	VA	Federal	U.S. Department of Defense	Wildlife Management Area
Cargills Creek WMA - Kerr Reservoir	VA	Federal	U.S. Department of Defense	Wildlife Management Area
Harrison Lake NWR	VA	Federal	U.S. Fish and Wildlife Service	National Wildlife Refuge
Presquile NWR	VA	Federal	U.S. Fish and Wildlife Service	National Wildlife Refuge
Mason Neck NWR	VA	Federal	U.S. Fish and Wildlife Service	National Wildlife Refuge
James River NWR	VA	Federal	U.S. Fish and Wildlife Service	National Wildlife Refuge
Rappahannock River NWR	VA	Federal	U.S. Fish and Wildlife Service	National Wildlife Refuge
Scott Hollow Barren SBA	VA	Federal	U.S. Forest Service	National Forest
George Washington NF	VA	Federal	U.S. Forest Service	National Forest
Laurel Fork SBA	VA	Federal	U.S. Forest Service	National Forest
John H. Kerr Reservoir Easements	VA	Private	U.S. Department of Defense	Conservation Easement
John H. Kerr Reservoir Easements	VA	Private	U.S. Department of Defense	Conservation Easement
John H. Kerr Reservoir Easements	VA	Private	U.S. Department of Defense	Conservation Easement
John H. Kerr Reservoir Easements	VA	Private	U.S. Department of Defense	Conservation Easement
John H. Kerr Reservoir Easements	VA	Private	U.S. Department of Defense	Conservation Easement
John H. Kerr Reservoir Easements	VA	Private	U.S. Department of Defense	Conservation Easement
John H. Kerr Reservoir Easements	VA	Private	U.S. Department of Defense	Conservation Easement

Appendix E. Continued.

Protected Area	State	Owner	Managing Agency	Type
John H. Kerr Reservoir Easements	VA	Private	U.S. Department of Defense	Conservation Easement
Mason Neck State Park	VA	State	Virginia Department of Conservation and Recreation	State Park
Occoneechee State Park	VA	State	Virginia Department of Conservation and Recreation	State Park
Staunton River State Park	VA	State	Virginia Department of Conservation and Recreation	State Park
Westmoreland State Park	VA	State	Virginia Department of Conservation and Recreation	State Park
York River State Park	VA	State	Virginia Department of Conservation and Recreation	State Park
Hog Island WMA	VA	State	Virginia Department of Game and Inland Fisheries	Wildlife Management Area
Lands End WMA	VA	State	Virginia Department of Game and Inland Fisheries	Wildlife Management Area
Missisquoi NWR	VT	Federal	U.S. Fish and Wildlife Service	National Wildlife Refuge
Rock River Access Area	VT	State	Vermont Department of Fish and Wildlife	Other State
Dead Creek Wildlife Management Area	VT	State	Vermont Department of Fish and Wildlife	Wildlife Management Area
Rock River Wildlife Management Area	VT	State	Vermont Department of Fish and Wildlife	Wildlife Management Area
Highgate State Park	VT	State	Vermont Department of Forest Parks and Recreation	State Park
Monongahela NF	WV	Federal	U.S. Forest Service	National Forest
Spruce Knob- Seneca Rocks NRA	WV	Federal	U.S. Forest Service	National Recreation Area
Laurel Fork South Wilderness	WV	Federal	U.S. Forest Service	Wilderness Area
Bluestone Lake WMA	WV	Federal	West Virginia Division of Natural Resources (federally owned)	Wildlife Management Area

APPENDIX F. Nocturnal roost locations in the eastern United States and Canada for migratory Florida sub-adult Bald Eagles, 1997-2004. Roosts were identified as 1 km areas containing > 1 eagle or >1 season for an individual eagle. Data were collected between one hour after sunset to sunrise.

Waterbody	County	State	Latitude	Longitude	Public Land	Agency	No. individuals
Lochloosa Lake	Alachua	FL	29.528	-82.151	Lochloosa Wildlife Conservation Area	St. Johns River Water Management District	2
Lochloosa Lake	Alachua	FL	29.517	-82.037	n/a		2
Charlotte Harbor	Charlotte	FL	26.855	-82.182	Charlotte Harbor State Buffer Preserve	Florida Department of Environmental Protection	2
Charlotte Harbor	Charlotte	FL	26.810	-81.979	Babcock-Webb WMA	Florida Fish and Wildlife Conservation Commission	3
Everglades	Collier	FL	26.131	-81.638	Picayune Strand State Forest	Florida Division of Forestry	3
S. Prong Alafia River	Hillsborough	FL	27.764	-82.195	Balm-Boyette Scrub	Hillsborough County	4
Manatee River	Manatee	FL	27.562	-82.495	n/a		1
Sarasota Bay	Manatee	FL	27.437	-82.648	n/a		1
Manatee River	Manatee	FL	27.480	-82.464	n/a		5
Lake Okeechobee	Martin	FL	27.151	-80.638	n/a		2
St Lucie Canal	Martin	FL	27.187	-80.368	n/a		2
Lake Okeechobee	Okeechobee	FL	27.327	-80.689	n/a		3
Econlockhatchee River	Orange	FL	28.483	-81.169	n/a		2
Lake Helen Blazes	Osceola	FL	27.985	-80.890	Bull Creek WMA	Florida Fish and Wildlife Conservation Commission	2
Lake Kissimmee	Osceola	FL	27.866	-81.260	Kissimmee Chain of Lakes	South Florida Water Management District	2
Tohopekaliga Lake	Osceola	FL	28.172	-81.426	n/a		2
Tohopekaliga Lake	Osceola	FL	28.200	-81.352	n/a		1
Tohopekaliga Lake	Osceola	FL	28.221	-81.423	n/a		2
Lake Okeechobee	Palm Beach	FL	26.761	-80.541	n/a		1
Itchepackesassa Creek	Polk	FL	28.062	-81.900	Tenoroc Fish Management Area	Florida Fish and Wildlife Conservation Commission	1
Hancock Lake	Polk	FL	27.993	-81.870	Lake Hancock Circle B Bar Ranch	Polk County	5
Myakka River	Sarasota	FL	26.992	-82.310	n/a		3
Lower Myakka Lake	Sarasota	FL	27.232	-82.410	n/a		4
Lower Myakka Lake	Sarasota	FL	27.188	-82.374	Pinelands Reserve	Sarasota County	3
St Johns River	Seminole	FL	28.786	-81.112	n/a		4
Johns Lake	Sumter	FL	28.704	-82.014	n/a		1
Tsala Apopka Lake	Sumter	FL	28.670	-82.215	n/a		1
Tomoka River	Volusia	FL	29.102	-81.123	Port Orange City Forest	City of Port Orange	3
Sassafras River	Cecil	MD	39.383	-75.978	n/a		3
Susquehanna River	Cecil	MD	39.663	-76.163	n/a		3
Potomac River	Charles	MD	38.508	-77.257	n/a		3
B. Everett Jordan Lake	Chatham	NC	35.688	-79.080	B. Everett Jordan Lake	US Army Core of Engineers	2

Appendix F. Continued.

Waterbody	County	State	Latitude	Longitude	Public Land	Agency	No. individuals
B. Everett Jordan Lake	Chatham	NC	35.840	-78.972	B. Everett Jordan Lake	US Army Core of Engineers	3
Core Creek	Craven	NC	35.209	-77.350	n/a		2
Roanoke Rapids Lake	Northampton	NC	36.492	-77.714	n/a		2
Grindle Creek	Pitt	NC	35.666	-77.224	n/a		1
Tranters Creek	Pitt	NC	35.705	-77.198	n/a		1
Lake Champlain	Clinton	NY	44.946	-73.350	Kings Bay WMA	New York State Department of Environmental Conservation	1
Delaware River	Orange	NY	41.397	-74.726	n/a		1
Delaware River	Orange	NY	41.431	-74.743	Mongaup Valley WMA	New York State Department of Environmental Conservation	1
Muddy River Reservoir	Lancaster	PA	39.833	-76.300	n/a		2
James River	Chesterfield	VA	37.358	-77.284	Presquile NWR	US Fish and Wildlife Service	1
Potomac River	Fairfax	VA	38.615	-77.195	Mason Neck NWR	US Fish and Wildlife Service	3
Rappahannock River	King George	VA	38.168	-77.087	Rappahannock NWR	US Fish and Wildlife Service	2
James River	Prince George	VA	37.301	-77.116	James River NWR	US Fish and Wildlife Service	2
James River	Prince George	VA	37.303	-77.008	n/a		2
Rappahannock River	Richmond	VA	37.998	-76.891	n/a		2
Potomac River	Westmoreland	VA	38.141	-76.759	n/a		1
Lake Champlain	Franklin	VT	45.010	-73.094	Highgate State Park	Vermont Department of Forest Parks and Recreation	1
Avon River	Nova Scotia	CAN	45.082	-64.283	n/a		1