1989

Bald eagle nesting ecology and habitat use: Lake McDonald Glacier National Park Montana

Richard E. Yates
The University of Montana

BALD EAGLE NESTING ECOLOGY AND HABITAT USE: LAKE McDONALD, GLACIER NATIONAL PARK, MONTANA

by

Richard E. Yates

B.S., University of Montana, 1981

Presented in partial fulfillment of the requirements

for the degree of

Master of Science

UNIVERSITY OF MONTANA

1989

Approved by:

B. Riley McClelland

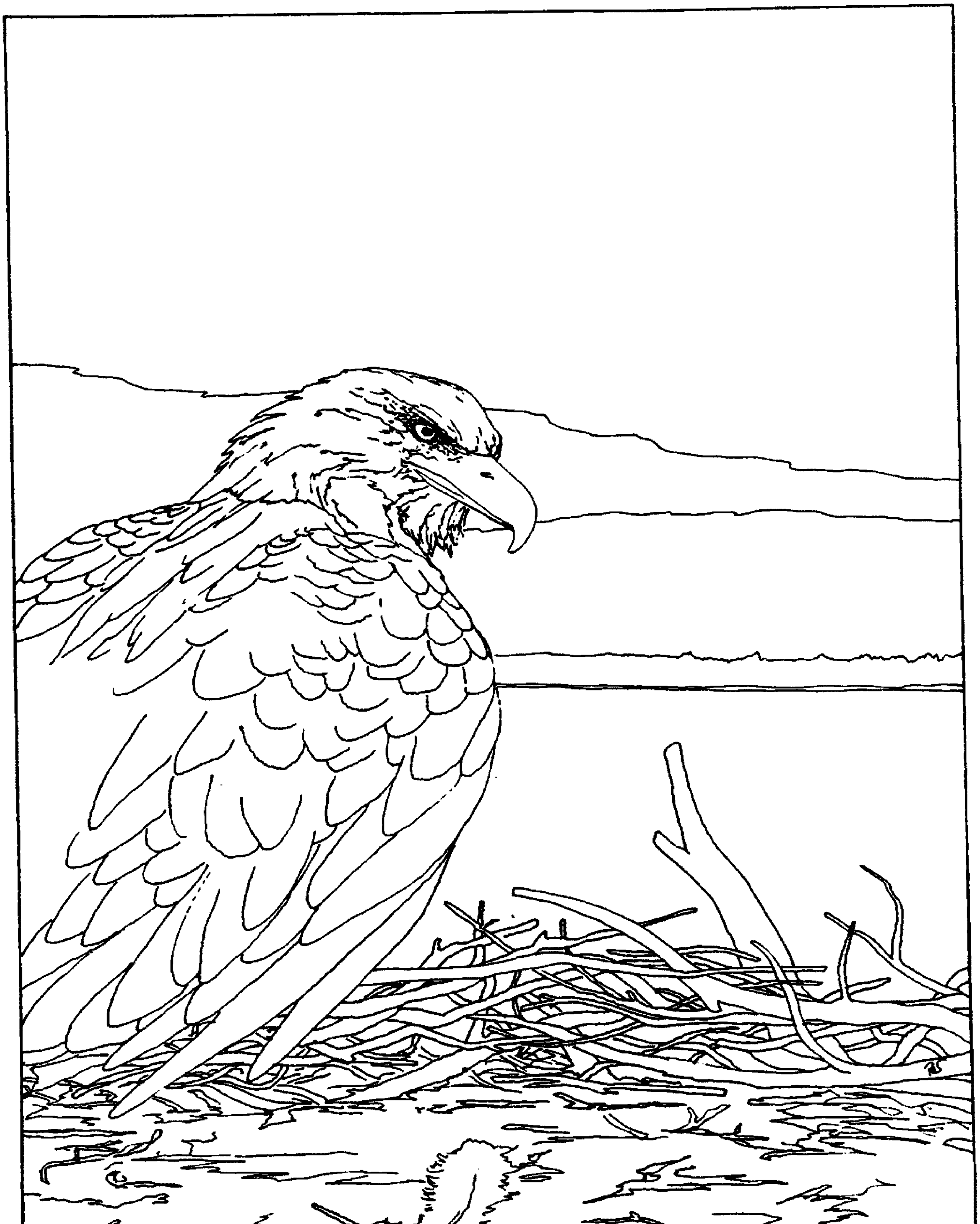
Chairman, Board of Examiners

[signature]

Dean, Graduate School

March 3, 1989

Date



Frontispiece.--Empty Nest, by Paul Scherner.

ABSTRACT

Yates, Richard E., M.S., Winter 1989 Wildlife Biology

Bald eagle nesting ecology and habitat use: Lake McDonald, Glacier National Park, Montana (102 pp.)

Director: B. Riley McClelland

Bald eagle (Haliaeetus leucocephalus) nesting activity was studied at Lake McDonald in Glacier National Park, Montana from 10 January 1986 through 13 August 1987. In April 1986, after 18 days of incubation the nest failed as an indirect result of food stress. Female mate replacement occurred in April 1987, but no egg was produced.

The adult male eagle was equipped with a radio transmitter in March 1986 and telemetry locations were used to determine defended territory (12.6 sq km), nesting home range (235 sq km), and regional range (over 3000 sq km) and to document nearly 3000 perch-sites. Seasonal maps show the male eagle's relative frequency of use of specific perch sites. Foraging perches at Lake McDonald were concentrated at inlets, points, and shallow bays. Long-range movements to southeastern British Columbia (144 km from Lake McDonald) were documented in summers 1986 and 1987. The Primary Use Zone, the area where the eagles did most of their foraging and loafing, was mapped based on 3266 hours of observation. Roost sites were in proximity to the nest site during nesting and to foraging sites during non-nesting.

Threats to the resident pair include human disturbance, food stress, habitat loss, collision with vehicles or trains, shooting, and trapping. All 5 stream inlets on the territory are influenced by human activity and facilities. Human disturbance compounds the negative effects of the marginal prey base at Lake McDonald. Recent removal of old-growth vegetation along the lakeshore and at Lake McDonald Lodge has accelerated habitat deterioration. Site-specific management recommendations stress reducing human disturbances at foraging sites and maintaining old-growth and screening vegetation at nest, forage, and roost sites. Reduction of human disturbance and an increase in foraging opportunities at the head of Lake McDonald during the critical nesting season (1 Mar - 15 May) and during autumn kokanee salmon (Oncorhynchus nerka) spawning runs (1 Nov - 31 Dec) may improve bald eagle productivity at this breeding area.

CONTENTS

CONTENTS (CONTINUED)

CONTENTS (CONTINUED)

ACKNOWLEDGMENTS

Many people contributed to the success of this study. I am indebted to my graduate committee chairman, Dr. B. Riley McClelland, for his continual guidance, support, patience, and encouragement throughout all phases of the project. I could not have accomplished any part of the study or of my educational goals without his help. I thank the other members of my committee, Drs. Richard Hutto and Hans Zuuring, for their comments and suggestions on the study design, their editorial expertise, and for their contribution to my academic accomplishments. Dr. Dave Patterson provided statistical advice and insight into data analysis design. However, I am solely responsible for any errors.

Funding was provided by Glacier National Park and the University of Montana School of Forestry. I thank the staff at the Glacier National Park Science Center for office space and supplies, with special appreciation extended to Kathy Dimont. Logistical support was provided by the following individuals at Glacier National Park: Willy Colony, Steve Fugett, Tom Habecker, John James, Frank Levandowski, Elwood Lynn, Leo Marnell, Don Martinus, Nola Morey, Mike Ober, Dan O'Brien, and Gary Vodenhal.

Rob Bennetts, Steve Cain, Jay Crenshaw, Carl Key, and Riley McClelland assisted with the study design, and their suggestions and comments were greatly appreciated. Those assisting in the field were: Rob Bennetts; Millie Carson; Elaine Caton; Carl Key; Doug Killerud; Rosemary Ljung; Pat, Riley, and Terrance McClelland; and Mary McFadzen. I thank these individuals for putting in many long hours of observation during often less than ideal conditions. The dedication, integrity, patience, and professional expertise of Elaine and Mary were invaluable to me throughout the study. Without their input, suggestions, hard work, encouragement, and friendship this project could not have been a success. I thank pilots Mike Strand, Jerry Syth, and Bill Werner for their abilities to safely fly among mountains.

The task of data entry was expedited with the help of Peggy Holwick, Mary McFadzen, and Vita Wright; their assistance is greatly appreciated. I thank Ursula Mattson for lending me her computer during a critical writing stage. Preparation of the perch-site maps could not have been accomplished without the help of Adele Karolik, Carl Key, and Mary McFadzen. I am grateful to them for their patience, hard work, and professional abilities.

Glacier National Park naturalists Ellen Horowitz and Becky Williams obtained important eagle sightings while on duty at Lake McDonald. Their interest and involvement provided me with approbation as well as data.

I extend special thanks to my friends Beth, Carola, Chuck, Doc, Krebs, Lanny, Lindy, Mary, Pat, Peg, Rob, and Smitty for sharing their encouragement, perspective, sanctuary, laughter, and supper.

Finally, I am grateful to my mother for her devotion, praise, and prodding. For some reason, she knew I could do it.

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

LIST OF APPENDICES

INTRODUCTION

Bald eagle (Haliaeetus leucocephalus) productivity for 5 breeding areas in Glacier National Park (GNP) averaged 0.64 young per occupied nest from 1982 through 1988. The low productivity of GNP's bald eagles is in contrast to the recent increased productivity in the rest of Montana's breeding bald eagle population (Flath and Hazelwood 1986). Montana had 69 occupied bald eagle territories in 1988; 53 were successful (77%), and 1.48 young fledged per occupied nest (D. Flath, Mont. Dept. Fish, Wildl. and Parks, pers. commun.). I chose the Lake McDonald (LM) breeding area in GNP as a study site because of its low productivity (0.4 young per occupancy from 1982 through 1987), high level of human activity, and good accessibility compared to other park areas.

Availability of nesting sites in old-growth forest stands and an abundance of food at the onset of nesting are the two most important factors in the initiation and success of bald eagle nesting (Allen and Knight 1984). Food and nest sites also are the most important resources influencing the breeding density of bald eagles (Newton 1979). Destruction of nesting habitat has limited bald eagle reproduction (Grier 1982) and potential for recovery from endangered status.

Little information is available on bald eagle food habits and prey base characteristics and precisely how they relate to nesting success (Grubb and Allen 1984). Harsh weather elevates energy demands for bald eagles (Stalmaster and Newman 1978) and may lead to nest failure if the prey base is marginal. Attempts to quantify the effects of human disturbance on productivity (Mathisen 1968, Jueneman 1973, McEwan and Hirth 1979, Lehman et al. 1980) have met with limited success (Oakleaf and Silovsky 1984). Some bald eagles avoid areas where there is human activity, thus eagles may be excluded from foraging sites (Stalmaster and Newman 1978, Fraser et al. 1985, Craig et al. 1988).

The Endangered Species Act (1973) mandates protection of critical feeding and nesting habitat for the recovery of bald eagle populations. Research is essential to the development of site-specific management plans which aid bald eagle recovery efforts (Stalmaster 1987). The primary objective of the bald eagle recovery process is to provide secure habitat and increase population levels in specific geographic areas (Pacific Bald Eagle Recovery Plan 1986). The basic ecology of bald eagles in Montana was identified in the Montana Bald Eagle Management Plan (MBEMP) (1986) as the first research priority in the recovery of this species. Identification of breeding adult home ranges and characterization of nest sites and surrounding habitat are essential components of this research. Preparation of site-specific management plans for bald eagle breeding areas is identified in the MBEMP (1986) as a priority to ensure the continued recovery of bald eagles in Montana. Habitat use, prey base, and human disturbance impacts need to be identified before agencies complete bald eagle nest-site management plans (Grubb and Allen 1984, Oakleaf and Silovsky 1984).

Home range programs such as "McPaal" (Stuwe and Blowhowiak 1986) and the Use-Zone concept (MBEWG 1986) outline general areas of bald eagle use but lack detailed perch-site locations and the weighted importance of specific foraging areas. Temporal shifts in bald eagle use of foraging and roosting areas must be considered when bald eagle habitat is identified. GNP is attempting to provide for the enjoyment of park visitors while preserving and enhancing essential habitat for bald eagles. Detailed information on temporal and spacial use patterns of eagles at LM can aid managers in accomplishing these goals. However, there are limitations to the conclusions that can be drawn from the study of a single pair of bald eagles over a 20 month period. Extrapolation of information from the LM study to other bald eagle territories would be unwarranted.

The objectives of the LM study were to:

1. Characterize nest-site habitat
2. Determine seasonal food habits
3. Determine nesting territory and home range
4. Determine perch-site frequency and habitat use
5. Provide information and recommendations to GNP for the preparation of a site-specific management plan
6. Identify research questions concerning bald eagle productivity

STUDY AREA

GNP encompasses 410,000 ha, extending on both sides of the Continental Divide in northwestern Montana. The park is the southern portion of Waterton-Glacier International Peace Park and part of the World Biosphere Reserve System. LM is situated on the west side of the Continental Divide (Fig. 1) and is the largest glacial lake (16 km X 3 km) in the park. The Lake covers 2,761 ha and has a maximum depth of 146 m (U.S. Fish and Wildl. Ser. 1980). Recreational facilities and homes are associated with the inlets of each of the 6 perennial streams flowing into LM (Fig. 2). There are large campgrounds at Fish Creek and Sprague Creek, private homes at Kelly, Jackson, and Upper McDonald Creeks (UMC), and

Figure 1. Lower McDonald Valley study area.

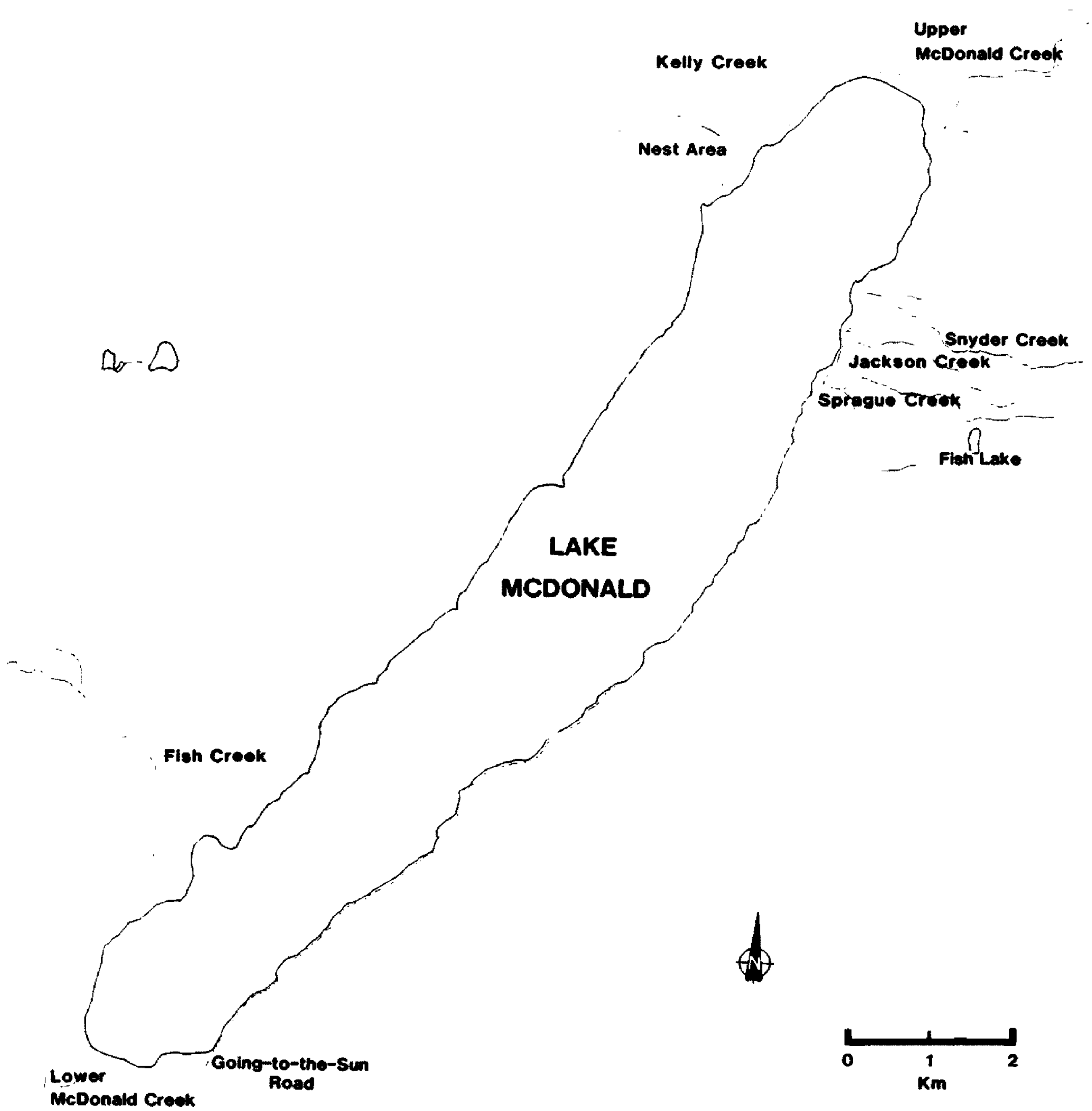
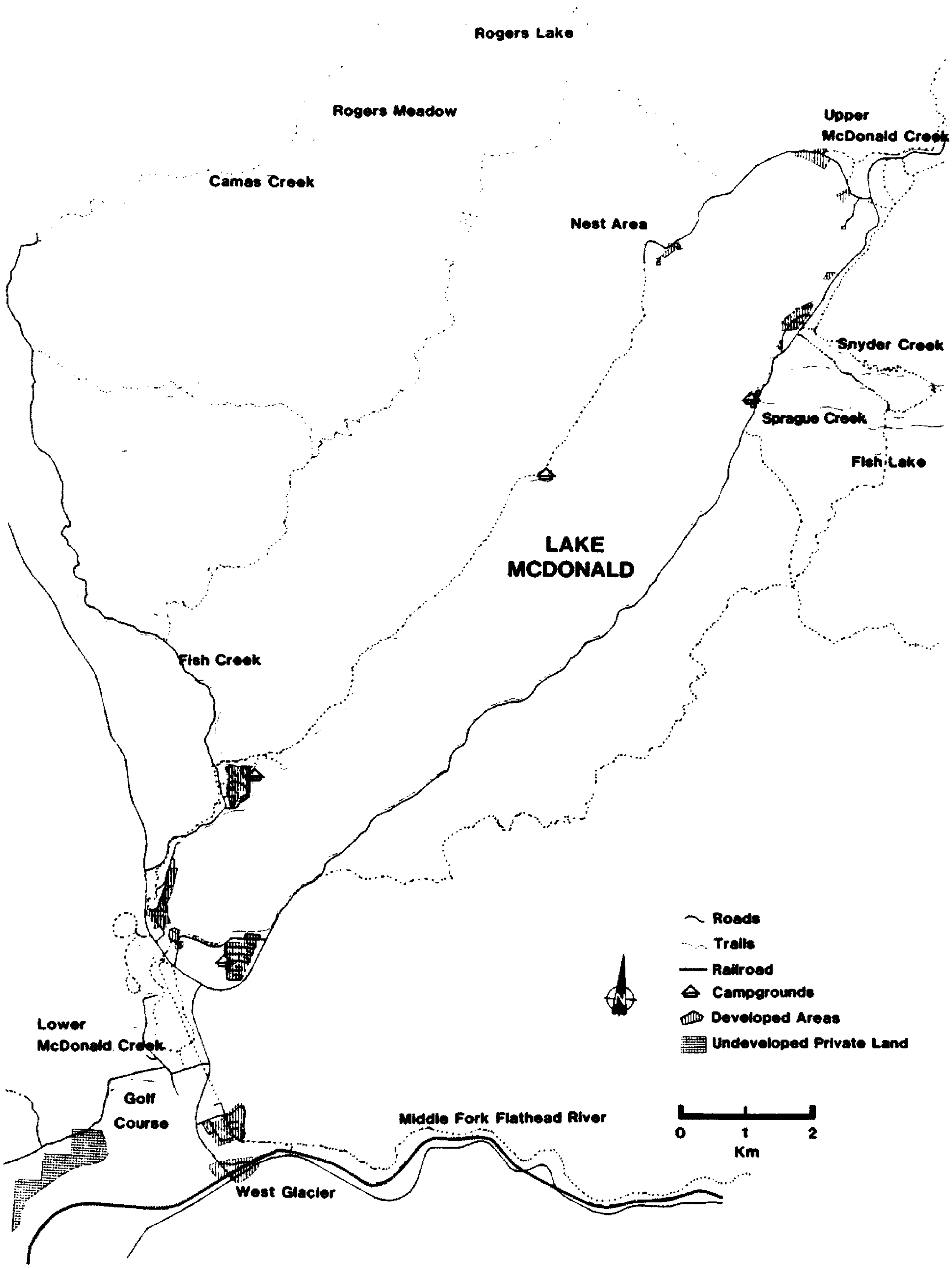

Upper
McDonald Creek
Kelly Creek
Nest Area
Snyder Creek
Jackson Creek
Sprague Creek
Fish Lake
LAKE
MCDONALD
Fish Creek
Lower
McDonald Creek
Going-to-the-Sun
Road
N
0
1
2
Km

Figure 2. Facilities and roads in the LM area.

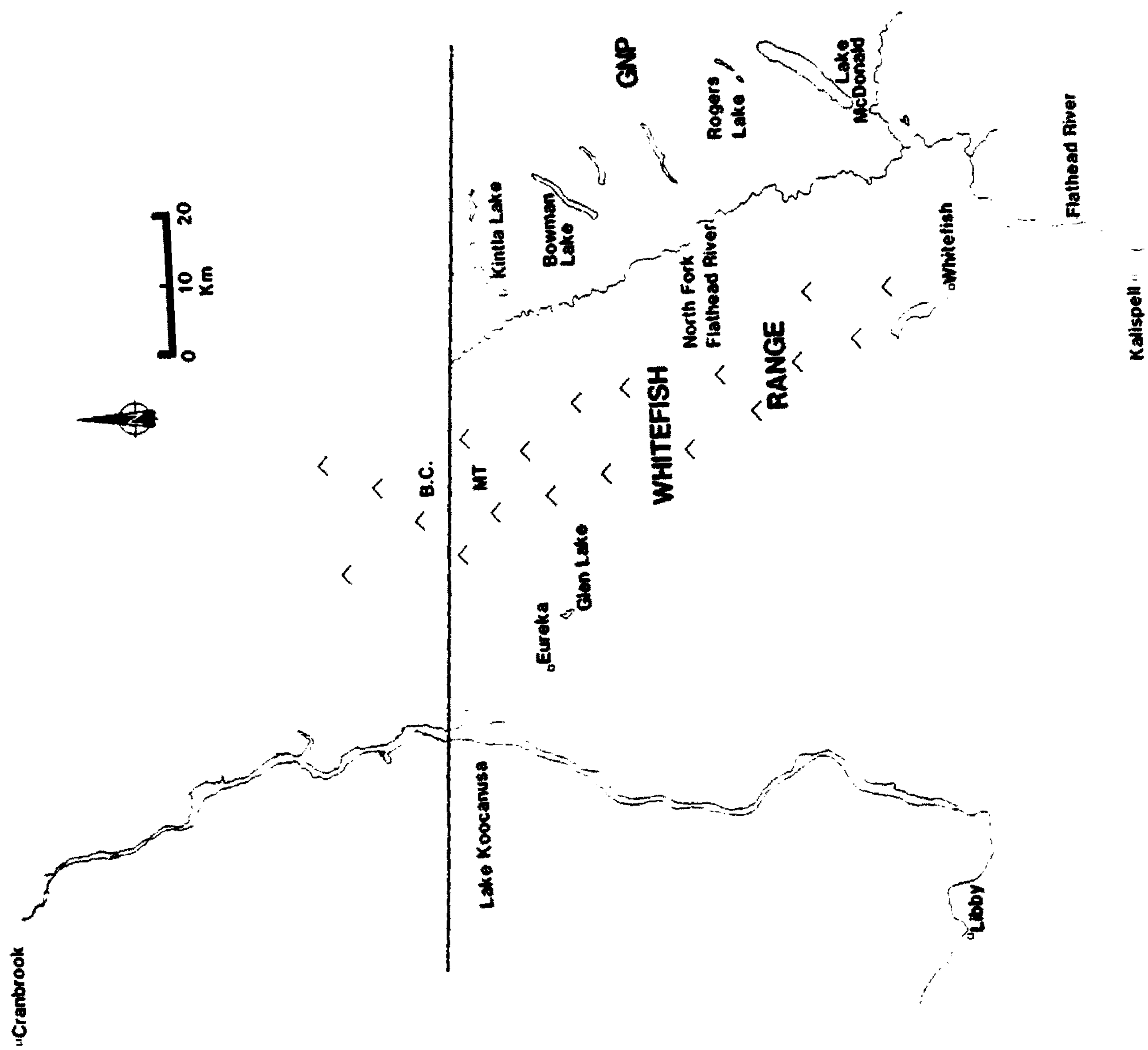

Rogers Lake
Rogers Meadow
Upper
McDonald Creek
Camas Creek
Nest Area
Snyder Creek
Sprague Creek
Fish Lake
LAKE
MCDONALD
Fish Creek
Roads
Trails
Railroad
Campgrounds
Developed Areas
Undeveloped Private Land
Lower
McDonald Creek
Golf
Course
Middle Fork Flathead River
0
1
2
Km
West Glacier

the LM Lodge complex at Snyder Creek. Apgar Village and numerous private homes are adjacent to the LM outlet.

My study area originally included the lower McDonald Valley, extending from Lower McDonald Creek (LMC) to UMC. After the onset of field work, expansion of the study area became necessary to include all areas frequented by the resident pair of bald eagles. These additions are: a) the Middle Fork of the Flathead River (MFFR) and Lake Five, near West Glacier; b) the North Fork of the Flathead River (NFFR) including Bowman and Kintla Lakes; c) Rogers Lake and the Camas Creek drainage, west of the McDonald Valley; d) Lake Koocanusa and its headwaters extending from near Eureka, Montana across the United States/Canada Border almost to Cranbrook, British Columbia; and e) Glen Lake and nearby Lick Lake in the Tobacco Valley, southeast of Eureka, Montana (Fig. 3).

The common plant communities of GNP have been described in detail by Habeck (1970). Prevalent old-growth tree species in the LM Valley include western white pine (Pinus monticola), lodgepole pine (Pinus contorta), black cottonwood (Populus trichocarpa), western redcedar (Thuja plicata), western larch (Larix occidentalis), western hemlock (Tsuga heterophylla), Douglas-fir (Pseudotsuga menziesii), and Engelmann spruce (Picea engelmannii). Vegetation along LMC was described by Shea (1973), Young (1983), Crenshaw (1985), and

Figure 3. Expanded study area, including southeastern British Columbia.



Cranbrook
Lake Koocanusa
Libby
B.C.
MT
Eureka
Glen Lake
WHITEFISH
RANGE
Kintla Lake
Bowman Lake
North Fork Flathead River
GNP
Rogers Lake
Lake McDonald
Whitefish
Flathead River
Kalispell
0 10 20
Km
N

Bennetts (1986).

Near West Glacier, LMC joins the MFFR (part of the Wild and Scenic Rivers System) as it flows westward. Stands of black cottonwood along the River provide perching and roosting sites for bald eagles. Parts of the River remain ice-free throughout much of the winter, and spawning kokanee salmon (Oncorhynchus nerka) migrate up the River from Flathead Lake to LMC each autumn. U.S. Highway 2 and the Burlington Northern Railroad (BNRR) parallel the River. Lake Five is located 5 km southwest of West Glacier between the BNRR and U.S. Highway 2. It is a small, shallow lake bordered by private homes.

The NFFR (also part of the Wild and Scenic Rivers System) flows south from British Columbia through the North Fork Valley and remains relatively undeveloped. Stands of lodgepole pine, Douglas-fir, Englemann spruce, western larch, and black cottonwood are interspersed with natural meadows along the riparian corridor. Kintla and Bowman are the largest lakes in the North Fork drainage; both are accessible by automobile and have public campsites. Their outlet areas are forested with lodgepole pine and Douglas-fir; mosaics of old-growth forest occur near the Lakes. Neither lake has supported a bald eagle nesting territory in recent years.

Rogers Lake lies between Trout Lake and Rogers Meadow in the Camas Creek drainage. The lake has an average depth of 25 m (Morton 1968). It is surrounded by western white pine, Englemann spruce, Douglas-fir, and lodgepole pine. The Camas Creek drainage is characterized by open avalanche slopes, small lakes, and extensive meadows.

Fish Lake is a small, shallow, sphagnum-bog lake located 300 m above LM on Snyder Ridge. It has no outlet and is considered an unique area for plants and wildlife (Morton 1968).

Lake Koocanusa is a large reservoir behind Libby Dam on the Kootenai River near Libby, Montana. The reservoir extends north into British Columbia and is considered productive habitat for introduced kokanee salmon (M. Aderhold, Mont. Dept. Fish, Wildl., and Parks, pers. commun.). Much of the reservoir's shoreline is severely eroded; high cut-banks of grassland mixed with ponderosa pine (Pinus ponderosa) sluff into the wind-driven water.

The Tobacco Valley is characterized by expansive grasslands and is bounded to the east by the Whitefish Range. Glen Lake is a small man-made lake (average depth 12 m) located 10 km southeast of Eureka, Montana. It was originally developed for irrigation purposes in the 1930's and is stocked with kokanee salmon each year, providing excellent fishing for summer residents (B. Haworth, Glen Lake resident, pers. commun.). Nearby, Lick Lake is surrounded by dense forest stands of Englemann spruce, Douglas-fir, and western larch, and has no public access.

METHODS

Historical Literature Search

GNP files, LM ranger logbooks, and publications related to the LM area were reviewed to document the history of bald eagles at LM. I relied on interviews with long-term LM residents to document the presence of eagles during summer months over a 6 decade period.

Nest-Site Characteristics

Nest and nest-tree dimensions and heights were measured in conjunction with a climb to band a single nestling in 1985; a rope suspended from the nest to the ground was used to measure actual nest height. A diameter tape was used to measure nest-tree DBH and a Relascope was used to estimate basal area around the nest tree. Distances from the nest to human habitations and to water were measured on USGS 7.5 min topographic maps. Disturbances of eagles by human activity were documented whenever possible.

Nesting Activity

Nesting activity was documented by ground observation. Nest occupancy and activity were recorded to the nearest day because nest observations were made daily during the nesting seasons (see Postupalsky 1974 for nesting terminology). Eagle nesting behavior was recorded in field notebooks and summarized on data forms (Appendix 1). Identification of the resident female was based on size disparity (Newton 1979); when the eagles were away from the LM territory I assumed that a larger adult perched in proximity to the marked male was his mate.

Prey Base

Composition, abundance, and availability of the aquatic prey base was assessed using previous studies of LM, Rogers Lake, and Fish Lake (Wasem 1964, Morton 1968, Wasem 1970, Marnell 1987, Marnell 1988). Information from ongoing studies of LM also were used (L. Marnell, Natl. Park Serv., pers. commun.). Bald eagle prey items were identified in conjunction with other observations as time permitted.

Food Habits

Methods used to determine seasonal food habits during the 20 month study included: observation of prey items delivered to the nest during the nesting season (Ofelt

1975, Rettig 1978), collection of prey remains and pellets from feeding sites (Todd et al. 1982), and observation of successful foraging attempts (Frenzel 1984a). Prey species were identified to the most specific taxonomic level possible.

Capture, Banding, Marking, and Radio Telemetry

Bald eagles can fly 400 km or more in one day (Young 1983) and radio telemetry is essential to document these far-ranging movements. Precise determination of local movements and home range also requires the use of radio transmitters (Griffin 1978, Frenzel 1984a). The adult male was captured at LM for the purpose of attaching a radio transmitter on 15 March 1986 using a floating fish device (Cain 1985). The snared eagle was immediately retrieved by 2 researchers in a canoe. The bird was hooded and the wings were restrained with a cravat secured around the body and folded wings. This technique calms the eagle and prevents injury to the wings and feathers. The feet were tethered with a nylon cord and placed in a leather talon bag. Body measurements, such as weight and wing-spread, were taken for comparison with measurements of migrating bald eagles (McClelland et al. 1984).

Orange, vinyl wing-markers coded with black characters (A-01) were attached around the patagium of each wing (Young 1983) and a USFWS band was placed on the right leg. The eagle is hereafter referred to as 01. A Telonics Inc. (Mesa, Ariz.) backpack transmitter with an activity tip-switch, (weight 56 g; guaranteed battery life 14 months) was attached by fitting a Teflon harness around the eagle's body. The harness was placed to avoid inhibiting wing movement and the 4 ends were connected with cotton thread over the eagle's breast (a method previously used by D. Garcelon, Inst. for Wildl. Stud., Arcata, Calif., pers. commun.). After several years the cotton thread should rot, allowing the harness and transmitter to fall from the eagle.

Home Range

Considerable transmitter signal bounce has been experienced in the the mountain valleys of GNP (Crenshaw 1985) and location error may be great if dependent solely on triangulation. For this reason, radio locations were used mainly as an aid to obtaining visual locations of eagle 01. Observations were made with binoculars and variable-power telescopes at distances of 0.5 to 5 km so that observers would not disturb the eagles or influence their activity. Observations of nesting and foraging activities, near the head of LM, were made from the lakeshore adjacent to the LM Ranger Station and from pullouts along the Going-to-the-Sun Road.

Individual locations of 01 were plotted daily on USGS 7.5 min. topographic maps. A modified-minimum-area-polygon method (Harvey and Barbour 1965) was used to map the nesting home range by connecting outer perching and soaring locations within the study area. Other information recorded at the time of location included: weather, time spent at each location, specific behavior of individual eagles, identification of food items, and observation time (Appendix 1).

Perch-Site Frequency Calculation

Mapped perch sites were digitized with UTM coordinates to the nearest 10 m using the "Digit" program (developed by Natl. Park Serv. geographer C. Key) and a Numonics digitizer (tablet size 36 X 48 inches). All UTM locations were then imported into a dBase III+ (copywrite by Ashton Tate 1986) database file containing date, duration, and activity information for each specific location of eagle 01 (Appendix 2). Locations were sorted by UTM for specific seasonal observation periods. Perch durations were aggregated from within 25 m of a representative perch site. Total minutes of eagle presence for each aggregate point was divided by the total observation time to yield a standardized index of eagle use per unit observation time for each seasonal observation period. These values were used to scale circle sizes around each aggregate point on the seasonal study area maps. Perch sites were mapped using circles, where circle size is proportional to the relative amount of time spent at that perch location. Summed times of 1 to 10 min were assigned the same scaling value for the smallest circle size. Circle sizes on the Long-Range Movements map represent only perch locations and do not indicate frequency of perch use during the summer period.

Study area drainages and lakes were plotted on maps prior to the plotting of scaled circles. Digitized UTM information for the drainages and lakes was obtained from GNP's Geographic Information System (Wherry et al. 1985). The aggregate site points and their corresponding scaled circles were plotted using the "Plot" program developed by C. Key.

Maps covered the following seasonal periods: a) Winter 1986 (10 Jan to 14 Mar, prior to transmitter attachment), b) Nesting Period I (1986 Female) (15 Mar to 18 Jun 1986, and 9 Mar to 18 Mar 1987), c) Long-Range Movements (Summer) (19 Jun to 24 Aug 1986 and 25, 26 Aug 1987), d) Autumn 1986 (25 Aug 1986 to 7 Jan 1987), e) Winter 1987 (8 Jan to 8 Mar), f) Mate Replacement Period (19 Mar to 5 Apr 1987), g) Nesting/Courtship, Near-Adult Female (6 Apr to 18 Jun 1987), and h) Summer, Non-Nesting (19 Jun to 13 Aug 1987). Maps of roost-site use were generated using number of roost nights at a specific location relative to the total number of roost nights documented. A map of the Primary Use Zone (MBEMP 1986), the area where the eagles did most of their foraging and loafing, was prepared using a 20-month compilation of perch sites in the LM area, and does not indicate seasonal shifts in habitat use by O1.

RESULTS AND DISCUSSION

History of Bald Eagles at Lake McDonald

Bald eagles have been observed in the LM area during summer months since at least 1915 (Saunders 1921). J. Brewer (LM shoreline resident for over 75 years, pers. commun.) described watching adult bald eagles "flying about" near the inlet of UMC as early as the 1920's.

Consistent bald eagle sightings from the 1930's through the mid-1950's occurred along the west shore of LM between the Chadbourne cabin site and the Trout Lake trailhead (J. Athern, LM shoreline resident, pers. commun.). At least 1 active bald eagle nest was reported in this area throughout the 1930's.

J. LaDow (another long-time LM shoreline resident, pers. commun.) recalled an active bald eagle nest at the

UMC inlet during the 1950's and early 1960's. The large black cottonwood nest tree was located immediately west of the inlet, approximately 200 m from Mr. LaDow's summer home. The nest tree fell during the 1964 flood, but Mr. LaDow has continued to occasionally see bald eagles foraging near the inlet since that time.

R. Gaynor (Natl. Park Serv. fire guard, pers. commun.) reported seeing an active bald eagle nest along the east shore of LM approximately 1 km south of the UMC inlet in the mid-1970's.

In 1957 the National Park Service aerial-sprayed DDT along UMC to control an infestation of the black-headed budworm (Acleris variana). The full impact of this activity on bald eagle and aquatic prey-base productivity is unknown, but a substantial fish kill in LM followed the spraying and aquatic insect numbers were expected to have been suppressed (Ruder 1957).

The location of the LM bald eagle nest used through 1988 was first documented in 1982 when 2 nestlings, near fledging, were observed (R. McClelland, Natl. Park Serv., pers. commun.). In 1985, one crippled nestling fledged from the nest but it did not survive (see Chapter II). Discounting the 1985 fledgling, productivity at the LM nest from 1983 through 1987 was zero.

Nest-Site Characteristics

The LM nest was 47 m above the ground in a 52-m-tall western white pine (diameter = 134 cm). The nest tree was on a southeast exposure 0.5 km upslope from the northwest shore of LM. The base of the co-dominant nest tree was 92 m above the surface of LM and was surrounded by western white pine and western hemlock. Basal area at the nest tree was 420 sq ft. Large snags within 100 to 200 m of the nest tree were used as frequent perch-sites mainly associated with nesting activity. No alternate nests were found on the territory. Several private homes, a secondary road, and hiking trails occurred within 1 km of the nest tree.

The historical presence of a bald eagle breeding area near the head of LM suggests that this was the preferred site for a nest. The availability of prey at the head of LM early in the nesting season probably is the most important factor that had lead to its continued use as a bald eagle breeding area (Swenson et al. 1986). However, the location of the nest 0.5 km from the lakeshore may be a result of disturbance at LM. Anthony and Isaacs (1984), and Swenson et al. (1986) found that as recreational use of water increased, the distance from bald eagle nests to water tended to increase. The distance of the LM nest from the lakeshore limited visability of foraging areas for the pair when they were in attendance at the nest. If the nest were located at a prime foraging site (e.g. the UMC inlet, as it formerly was), an adult could forage while guarding the nest and young.

Nesting Activity

failure of incubation

Summary of Lake McDonald Nesting Chronology.--Both adults were first observed near the nest on 3 March 1986 and on 8 March 1987. The territory was considered occupied on those dates, when nest repair and courtship also were initiated. In 1986, incubation began on 28 March when at least one egg was laid, and continued for 18 days until the nest failed on 14 April. No eggs were produced in 1987. The adults stopped frequenting the nest area on 19 June in 1986, and on 11 June in 1987.

Copulation.--In 1986, 27 copulations were observed; 23 were timed (mean duration = 11.4 sec, SD = 2.0 sec). Four of 5 attempted copulations (i.e. 01 fell from the female's back) were timed (mean duration = 5 sec, SD = 0.8 sec). Copulations were documented almost daily from 16 March until an egg was laid on 27 March; 2 copulations were observed on 28 March after the initiation of incubation. A maximum of 5 copulations were recorded in one day (16 March). After the nest failed on 14 April, 4 copulations were observed during the next 3 weeks (1 copulation on each of the 2 days immediately following the failure). One copulation was observed on 27 October when the resident adults began to frequent the LM territory to feed on spawning kokanee salmon near the head of LM. Migrating adult eagles were present at this time.

In the spring of 1987, 11 copulations were observed, but none were timed. Four were with the female that I assumed was 01's previous mate (8 to 11 March), and 7 were with a near-adult female after mate replacement (6 April to 1 May). Three copulations were recorded on 12 April. No copulations were observed with the first female after 11 March; however, she did not disappear from the territory until 19 March. Copulations took place on the nest, in the nest tree, in the sentinel snag, in perches near the inlet of UMC, and on the lake ice near the Snyder Creek inlet.

Incubation.--Incubation began on 28 March 1986, when the male was first observed in an incubating posture. After 18 days of incubation (28 March to 14 April), the egg was eaten by a raven while the nest was unattended. During these 18 days, I observed 231 (92.5%) of the 250 daylight hours (i.e. the amount of time the nest could be seen through a spotting scope). The male incubated for 31.1% of the observation period, which was 98.3% of the time that he was alone in nest attendance. Cain (1985) documented a male bald eagle in Alaska incubating an average of 42% (range 22-68%) of the daylight hours during the last 15 days of the 35 day incubation period. The LM female incubated or was in attendance at the nest 66.7% of the observation period; her percentage of actual incubation time was less than 66.7%. The egg was not incubated for 2.2% of the observation period as a result of the adults being off the nest during substitutions. I know precisely how much time 01 spent in an incubating posture because of the tip-switch on the radio transmitter, but exact duration of female incubation could not be observed because of a shortage of personnel. When 01 did not incubate during his periods of attendance he stood at the nest edge or left the nest for brief periods near the end of an incubation bout. This behavior may have been a signal to the female that he was ready to be relieved from incubation. Twice after he left the nest (for 1 and for 5 min) the female returned to the nest from out of view within the next 10 min and assumed incubation.

Eagle 01 did not incubate at night. His daylight incubation bout lengths averaged 115.5 min, SD = 70.4 min (n = 33). The female's complete incubation bouts during daylight hours averaged 172.6 min, SD = 123.5 min (n = 16). I recorded fewer observations of complete incubation bouts for the female (where she was observed arriving at and departing from the nest) during daylight hours because she spent more time incubating and her bouts often were extended from and into night hours. In Alaska, incubation bouts averaged 164 min (range 76-273) for a male, and 144 min (range 82-261) for a female bald eagle (Cain 1985). Duration of the LM female's incubation bouts was shortest during the first 2 days of the incubation period. The longest period the female incubated extended from 1426 H on 9 April to 1752 H on 10 April (27 h 26 min, including night hours). Early in the incubation period 01 usually relieved the female shortly after sunrise, but as food became scarce he spent morning hours foraging and there were fewer incubation substitutions per day. Extended incubation bout duration and infrequent substitutions may indicate that the adults were food stressed.

In 1986, false incubations by the female were recorded on 16, 22, and 26 March (mean length = 8.75 min, SD = 4.03 min, n = 4). Although no egg was produced in 1987, the near-adult female false-incubated 3 times on 25 April and once on 1 May (mean length = 34.25 min, SD = 9.91 min, n = 4).

Nest Failure.--Almost continuous observation of 01's activities documented only 1 prey delivery to the nest during the first 2 weeks of incubation in 1986. The female's unusually long incubation bouts, without food why food stressed - far from food

delivery or replacement by 01, probably did not allow her adequate foraging time. I believe she was food-stressed during the second week of incubation and that the failure of the LM nest was ultimately due to this condition.

At 1420 H on 14 April, 01 was perched in a frequently-used tree near the inlet of UMC; he had been at this perch since 1308. There were several small flocks of waterfowl nearby. The female had been incubating since at least 0530, probably since 1938 of the previous evening. At 1421, 01 left his perch to circle and stoop upon a lone female mallard (Anas platyrhynchos) swimming close by. After several unsuccessful stoops by 01, a 2-year old subadult bald eagle flew to join in circling the prey. Eagle 01 pounced on the duck several times, holding it below the water, but he could not fly from the water while grasping the duck. After several more unsuccessful stoops by both eagles, the subadult finally took the duck at 1426 and flew laboriously toward the northwest lakeshore. Eagle 01 caught up with the subadult at 1427 and, in midair, took the duck from it. By 1428, 01 had flown to the lakeshore, where he went into dense vegetation and began feeding on the duck. A second subadult arrived and both perched near 01. The female left the nest and flew to the area at 1427; she was aggressive toward the subadults. At 1434 she flew to 01 and he relinquished the duck carcass to her. She began to feed on it voraciously while warding off pirating attempts by the subadults.

I turned to view the nest at 1438 and saw a raven (Corvus corax) standing in the nest center eating the egg or eggs. The raven fed for at least 8 min before flying from the nest. Neither of the adult eagles could view the nest from their perch sites on the lakeshore. I observed crows (Corvus brachyrhynchos) or ravens at the LM nest 6 times prior to egg laying in March 1986. The raven was probably searching for prey remains when it discovered the egg on 14 April. Cain (1985) documented a raven depredating a single egg at one of his camera-monitored nests in Alaska.

The female fed on the duck until 1451, when she flew directly back toward the nest. She arrived at the nest by 1453 and stood peering into the cup for 6 min before settling on the egg remnants at 1459. She remained in incubating position for 20 min before walking to the nest edge at 1519. She appeared agitated, walking about the nest and nuzzling at the cup for 2 min. At 1521 she settled on the cup again and incubated for 8 min before standing and walking around the cup while vocalizing. She flew to the sentinel snag at 1530 and perched. The male flew to the nest at 1532, and stood facing the cup for 15 sec before hopping into the air and flapping his wings. After nuzzling at the cup, he settled into incubation posture at 1533. At 1536 the female left her perch and began to soar westward; she was lost from view at 1551 soaring west over Howe Ridge.

Eagle 01 continued to incubate for 1 hr 41 min. At 1714 he stood and began to nuzzle the nest material for 2 to 3 min before returning to incubation posture at 1717. He stood for 2 min at 1750, but again resumed incubating until 1838. At this time he stood and began to preen and to nuzzle the nest material near the cup. He defecated at 1842 and continued to preen and nuzzle at the nest for the next 11 min. Eagle 01 again settled on the cup with a rocking motion at 1853. This incubation bout lasted until 1919 when he again stood briefly. After resettling for 2 min, 01 stood and began to nuzzle nest material along the northern edge of the nest. He again settled in the nest at 1923 for 3 min then flew from the nest to roost.

The nest remained unattended until 1947, when the female returned and began to nuzzle nest material. By this time it was nearly dark and I ended observation without seeing the female settle into an incubating posture.

The nest was first visible the next morning at 0544. The female was in incubating posture and she may have remained on the nest the entire night. At 0613 the female flew from the nest and circled above the forest canopy for about 20 sec before returning to resume an incubating posture. She left the nest again at 0657, flew across LM, captured a fish, and flew to perch along the east shore at 0702. The nest was left unattended until the female returned to it at 0716; she did not assume an incubating posture until 0727.

Gradually the female began to spend more time away from the cup with incubating bouts lasting from 10 to 15 min. She left the nest and flew to the sentinel snag 4 times within the next 2 hrs. At 1006 she flew from the sentinel snag across LM to the east shore, where she was lost from view at 1011. I did not observe any further incubation activity, although both eagles returned to the nest at 1307 and vocalized profusely. They copulated at 1529 in the sentinel snag. During the next several weeks, the pair added material to the nest and copulated 3 times, but they did not produce another egg.

Prey Base

Fish species indigenous to LM include westslope cutthroat trout (*Salmo clarki lewisi*), bull trout (*Salvelinus confluentus*), Rocky Mountain whitefish (*Prosopium williamsoni*), largescale sucker (*Catostomus macrocheilus*), longnose sucker (*C. catostomus*), northern squawfish (*Ptychocheilus oregonensis*), peamouth chub (*Mylocheilus caurinus*), redside shiner (*Richardsonius balteatus*), and pygmy whitefish (*Prosopium coulteri*).

Non-native fish species known to occur in LM are rainbow trout (Salmo gairdneri), brook trout (Salvelinus fontinalis), Yellowstone cutthroat trout (Salmo clarki bouvieri), lake trout (Salvelinus namavcush), Lake Superior whitefish (Coreponus clupeaformis), and kokanee salmon (Marnell 1988).

A decline in the native salmonids and an increase in non-native species such as lake trout can have a negative effect on bald eagle foraging potential. Lake trout occupy the pelagic zone where they are not available to eagles and they prey on cutthroat trout (Salmo clarki) which are more available because they occupy the shallow littoral zone (Morton 1968).

Shallow lakes are the most productive areas for fish in the McDonald basin (Hazzard 1939, in Morton 1968). Cutthroat trout spawning begins in May, but the fish may not leave these areas until July. Shallow water spawners in Fish, Rogers, and Trout Lakes and in Camas Creek are most vulnerable to foraging bald eagles from May to July. Angling for cutthroat trout in Fish and Rogers Lakes is considered poor; in Trout Lake and Camas Creek it is considered good (Kinnie 1960, in Morton 1968). At LM, cutthroat fishing is now poor, but Kinnie (1960, in Morton 1968) stated that it was best between 15 June and 10 July at the inlets of UMC, Snyder Creek, and Sprague Creek. However, during that time the inlets are unavailable to bald eagles because of human activity. Suckers (*Catostomus spp.*) constitute an important prey species at LM because they spawn early (April) in shallows where they are accessible to foraging eagles. In the Greater Yellowstone Ecosystem, Swenson et al. (1986) documented suckers spawning in shallow bays as an important food source to nesting bald eagles. Grubb and Eakle (1984) found that suckers were a major prey item for nesting bald eagles in Arizona, and in California, BioSystems Analysis (1985) determined that suckers contributed the greatest biomass to bald eagle diets. Other sources of food at LM include ungulate carrion, small mammals, and waterfowl. Carrion is available to bald eagles after avalanche chutes begin to melt out in the spring, or at kills made by large predators such as mountain lions (*Felis concolor*), coyotes (*Canis latrans*), grizzly bears (*Ursus horribilis*), and gray wolves (*Canis lupus*). Ungulate carrion is also available as a result of collisions near the BNRR tracks and near roads. Columbian ground squirrels (*Citellus columbianus*) inhabit open grassy areas within the home range and are a possible prey species (Frenzel 1984a). Migrating waterfowl make rest stops on LM; some sick and injured birds become available to foraging eagles. American coots (*Fulica americana*) are probably the easiest waterfowl for eagles to take, especially when a pair hunts cooperatively (Gerrard and Bortolotti 1988). A decline in waterfowl populations over the last decade may have had a deleterious effect on food availability to bald eagles at LM by reducing the number of prey and the extent of the migatory season.

LM is a "worst case" example of human impact on a natural aquatic system in GNP (Marnell 1988). Impacts include: introduction of non-native fish; developments such as parking lots, campgrounds, and buildings; loss of spawning habitat in UMC, Snyder, Sprague, and Fish Creeks due to scouring of the creeks by floods; improper sewage disposal at Sperry and Granite Park chalets and private homes; and intensive recreational activity (Marnell 1988).

Food Habits

Seasonal shifts in the diet of the resident pair were apparent. During summer the pair fed almost exclusively on fish, only occasionally taking waterfowl. During autumn the pair fed exclusively on kokanee salmon until the spawners were depleted. Winter food was mainly ungulate carrion; however, the eagles were consistently observed near open water. The spring nesting season brought an increase in food requirements and a more varied diet. During nesting the eagles remained opportunistic, feeding on carrion, fish, and waterfowl depending on what food was most accessible near the nest site.

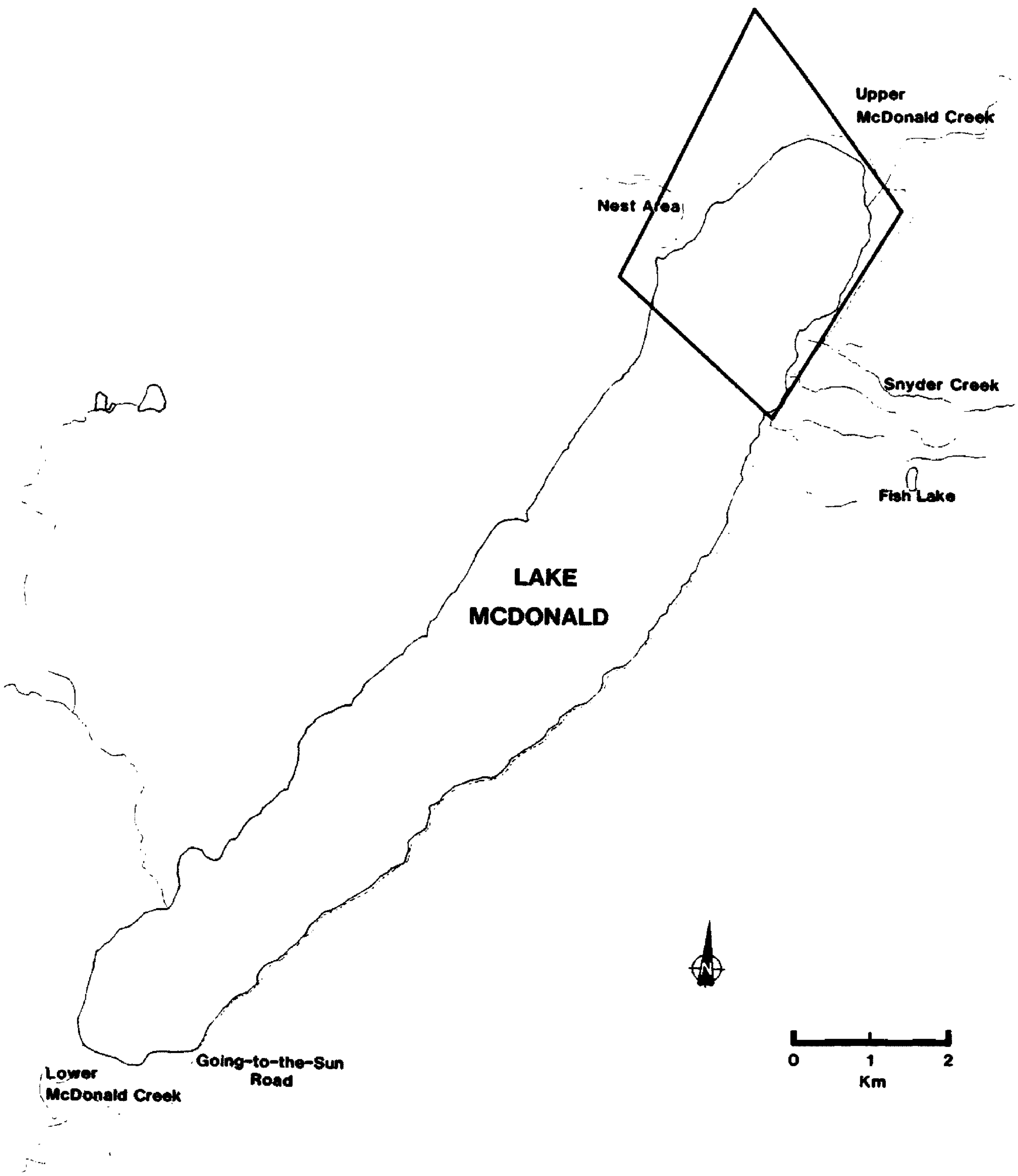
Frenzel (1984a) and Harmata (1984) documented seasonal shifts in diets of bald eagles. These shifts occurred as a result of prey species availability which was influenced by weather conditions and season. Waterfowl are prevalent at LM during spring and fall migration, but few nest at LM in summer. Fish were most available during spawning in spring and summer and when kokanee spawned in the autumn. Carrion was available in winter and early spring due to winter-kill and collision deaths.

Territory, Home Range, and Regional Range

I captured 01 at the onset of courtship in 1986. Five copulations were observed at the nest the day after capture. No more than 5 copulations were observed on any day; therefore, the capture did not appear to substantially effect courtship behavior. However, for 5 days 01 did not return to the perch used prior to his capture.

The nesting territory, the area actively defended by the resident pair against conspecifics (Alcock 1984), covered 12.6 sq km, including all 5 perennial stream inlets near the head of LM (Fig. 4). Nesting territories of 1.5, 6.0, and 1.1 sq km were documented in Michigan by Mattsson (1974), in Saskatchewan by Gerrard et al. (1980),

Figure 4. Defended territory of the LM resident pair.


Upper
McDonald Creek
Nest Area
Snyder Creek
Fish Lake
LAKE
MCDONALD
Lower
McDonald Creek
Going-to-the-Sun
Road
N
0
1
2
Km

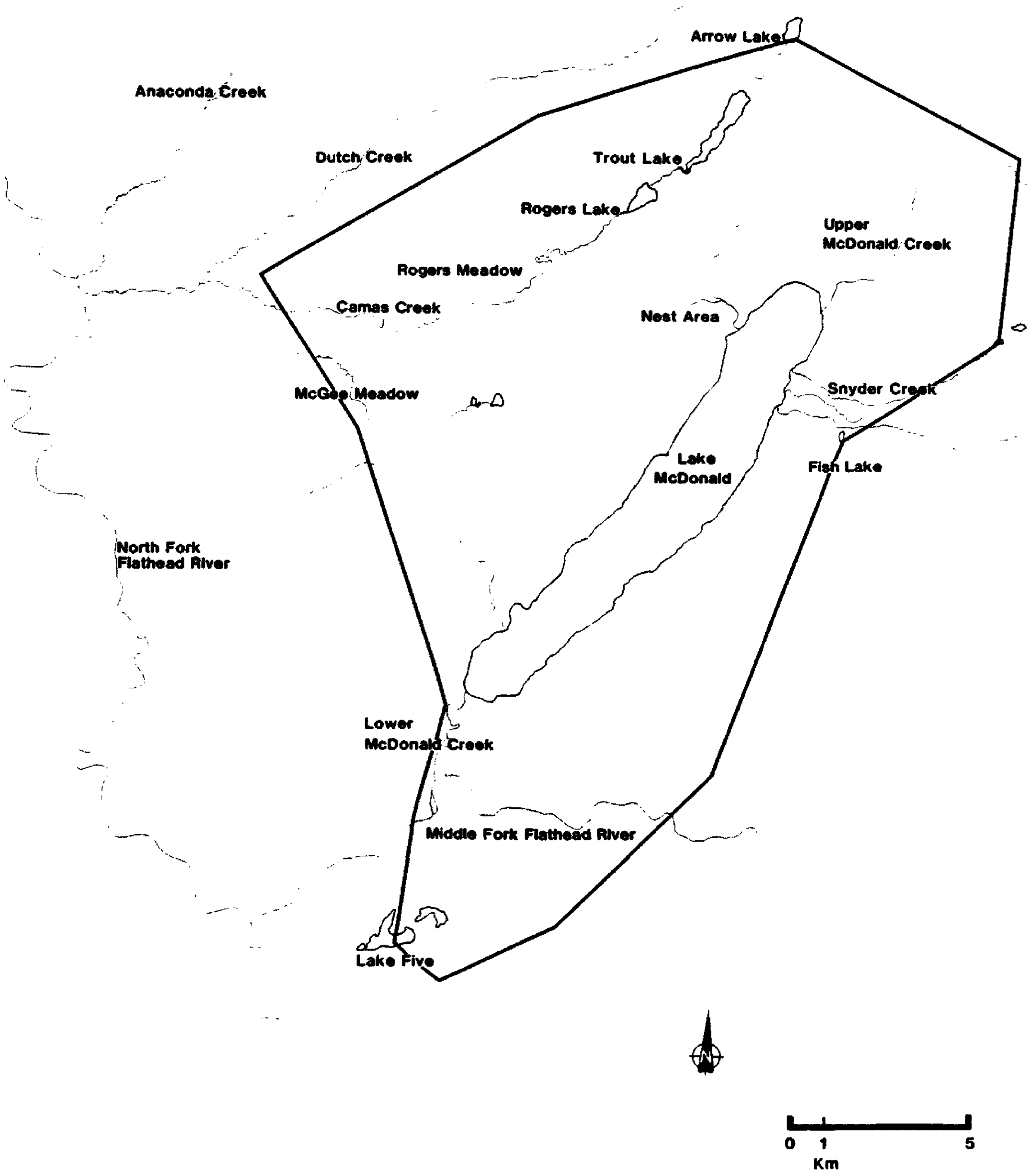
and in Minnesota by Mahaffy (1981), respectively.

Territorial behavior exhibited by the resident adults included: chasing and displacing other adult bald eagles, vocalizations directed toward intruding adults, wing-shuddering and vocalizing while perched in the presence ofintruding adults, chasing and displacement of crows and ravens, copulation during the autumn 1986 bald eagle concentration, and addition of green sprigs to the nest (Newton 1979). Also, Newton (1979) described conspicuous perching in prominent trees as a type of territorial display for raptors. Swenson et al. (1986), and Gerrard and Bortolotti (1988) noted that resident bald eagles used conspicuous perches as a signal to migrant eagles that a territory was occupied. At LM, the resident eagles were observed in non-foraging, conspicuous perches at Snyder Creek, along the west shore of the Lake, on the ridge southeast of the nest area, and in prominent trees adjacent to the UMC inlet. During courtship and when the nest was inactive the resident adults frequently were together in conspicuous perches. A large western white pine snag 100 m from the nest tree was used as a conspicuous perch as well as a sentinal and guard perch for the nest site.

Much of the territorial behavior was observed during spring courtship and nesting, and during the autumn 1986 bald eagle concentration when competition for kokanee salmon occurred at the head of LM. During spring migration as many as 15 eagles were observed on the nesting territory competing for limited food resources. Increased competition for food and energy expenditures in territorial displays, can have a negative influence on bald eagle productivity (Hansen 1984). The LM residents were most defensive at food and near the active nest site, but other adults were occasionally tolerated on the territory. Subadult bald eagles were tolerated within the territory (Swenson et al. 1986), sometimes within 100 m of the nest tree. However, subadults generally followed a soaring resident from the territory after closely approaching the active nest.

Eagle 01's nesting home range covered 235 sq km; it included most of the lower McDonald Valley, a section of the MFFR, and much of the Camas Creek drainage (Fig. 5). The southern extent of the nesting home range was near Lake Five and the eastern boundary paralleled a ridge that forms the eastern edge of the LM Valley. Frenzel (1984b) found maximum home ranges of 14 sq km (mean = 7 sq km) for nesting bald eagles in Oregon. Gerrard et al. (1980) described home ranges of 10 to 15 sq km for nesting bald eagles in Saskatchewan. Garrett et al. (1988) described maximum home ranges of 47.5 sq km for bald eagles nesting on the Lower Columbia River in Oregon. The extensive home range at LM indicates limited food resources in this

Figure 5. Eagle 01's home range during the nesting season, spring 1986.


Arrow Lake
Anaconda Creek
Dutch Creek
Trout Lake
Rogers Lake
Upper
McDonald Creek
Rogers Meadow
Camas Creek
Nest Area
McGee Meadow
Snyder Creek
Lake
McDonald
Fish Lake
North Fork
Flathead River
Lower
McDonald Creek
Middle Fork Flathead River
Lake Five
N
0 1 5
Km

breeding area.

Eagle 01's documented regional range during non-nesting summers and winter extended over 3,000 sq km from LM and the west slope of GNP to Lake Koocanusa (near Eureka, Mont.) and the southeastern corner of British Columbia, Canada (Fig. 3). The southern extent of the regional range was along the Flathead River 10 km east of Whitefish, Montana.

Seasonal Perch Use Frequency

Perch-site frequency maps (Figs. 6-15) are presented chronologically and are based on 3266 hrs of observation (Table 1). Although 01's perching time near the nest area is included on the maps, the nest area provided few foraging opportunities. Circles near the nest site represent the relative amount of time 01 spent courting, nest-building, and incubating. A large circle or cluster of circles in proximity to a geographic feature, such as a stream inlet, indicates that the area was important foraging habitat for 01. However, small circles, which represent less frequent use, may indicate areas of seasonal importance.

Winter 1986.--Winter 1986 observations of the resident pair were made prior to the attachment of a radio

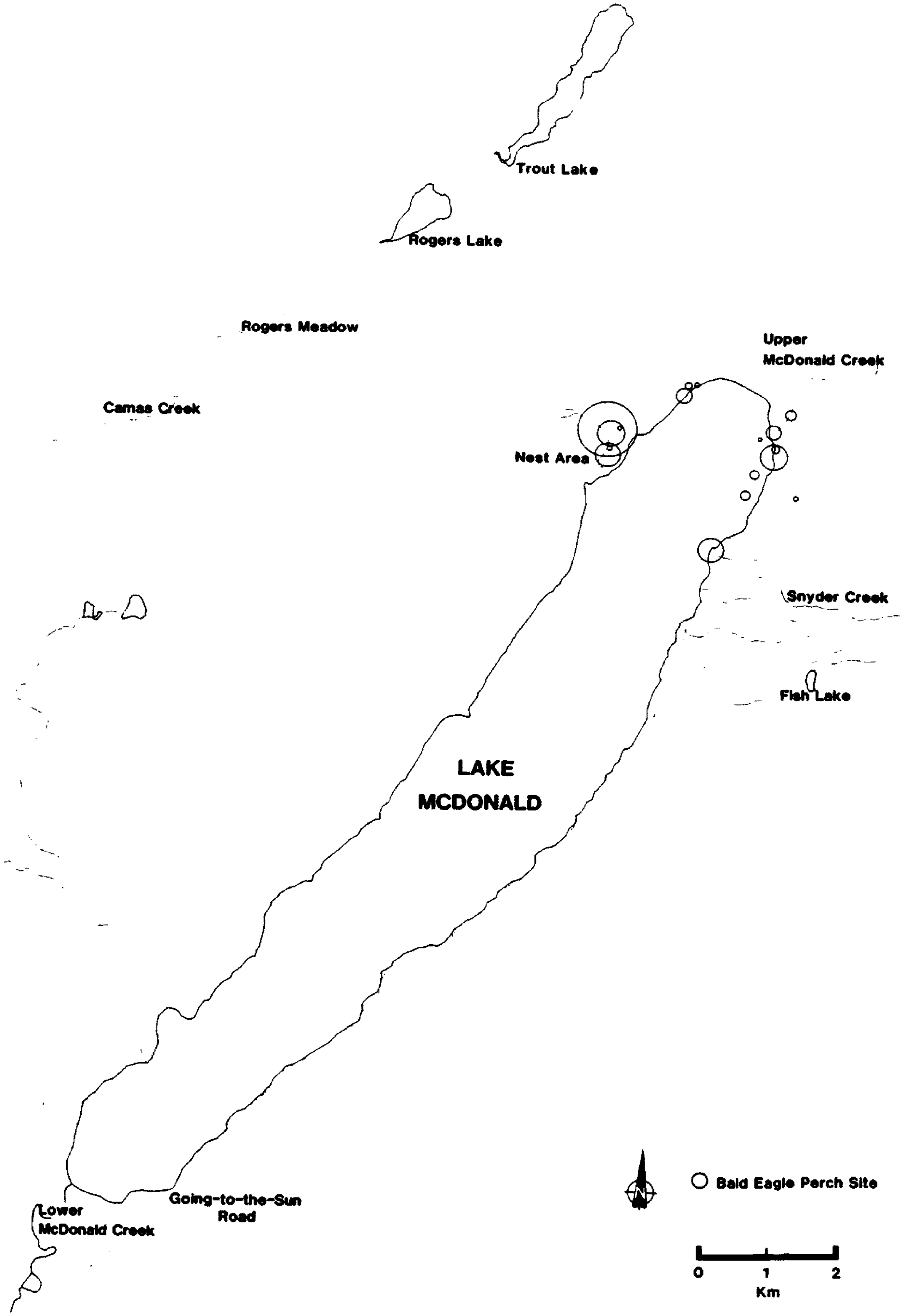
Table 1. Description of seasonal perch-site frequency periods, reference to figures, and hours of observation.

Seasonal Period	Figure	Dates	Hours
Winter 1986	(Fig. 6)	10 Jan-14 Mar	94
Nesting Period I	(Fig. 7)	15 Mar-18 Jun 1986 and 9-18 Mar 1987	1184
Long-Range	(Fig. 9)	19 Jun-24 Aug 1986 and 25-26 Aug 1987	229
Autumn 1986	(Fig. 10)	25 Aug 1986-7 Jan 1987	750
Winter 1987	(Fig. 11)	8 Jan-8 Mar 1987	270
Mate Replacement	(Fig. 12)	19 Mar-5 Apr 1987	101
Courtship/Nest Activity (Female 2)	(Fig. 13)	6 Apr-18 Jun 1987	420
Summer Non-Nesting	(Fig. 14)	19 Jun-13 Aug 1987	153
Primary Use Zone	(Fig. 17)	10 Jan 1986-13 Aug 1987	3266

transmitter on 01. LM was completely frozen during this observation period, with intermittant freezing of UMC and other tributaries. The resident pair was periodically observed near the head of LM on 10, 17, 19, and 21 January; 8, 9, 10, and 26 February; and on 3 and 7 March. In January and February, the eagles often perched 100 m south of the UMC inlet in black cottonwoods adjacent to an unoccupied summer cabin and at the Snyder Creek inlet (Fig. 6) adjacent to the LM Lodge. Perch-sites along the northwest shore were used as guard sites while the eagles were feeding on white-tailed deer (*Odocoileus virginianus*) carrion in that area. On 13 March the pair began to occupy the nest area consistently, which accounted for the high frequency of use at that location. Winter perch-sites also were used during the subsequent nesting period.

Nesting Period I (1986 and part of 1987).--After capture of 01 on 15 March, all locations through 19 June 1986, and from 9 to 18 March 1987 were characterized as Nesting Period I. I assumed that the same female from 1986 returned to the LM territory on 8 March 1987. However, she disappeared after 10 days and was later replaced by a near-adult female. I lumped 01's 1987 "original" female courtship locations in with the 1986 nesting locations because I assumed that the same female was involved. With

Figure 6. Perch-site frequency map for Winter 1986. Circle size represents the relative amount of time O1 perched at specific sites.


Trout Lake
Rogers Lake
Rogers Meadow
Upper
McDonald Creek
Camas Creek
Nest Area
Snyder Creek
Fish Lake
LAKE
MCDONALD
Bald Eagle Perch Site
N
Lower
McDonald Creek
Going-to-the-Sun
Road
0
1
2
Km

the addition of telemetry, I was better able to document 01's movements and exact perch locations. Knowledge of the territory and home range expanded almost daily as the movements of 01 were tracked over a 260 sq km area. Perch use was concentrated along the east shore of LM in proximity to the mouths of UMC, and Snyder Creek, and south of the Sprague Creek inlet (Fig. 7). Along the west shore, areas of concentrated use occurred near the northwest corner of LM, adjacent to the nest area, and 2 km south of the nest area along a secluded section of shoreline. The two large circles at the nest area represent use of the nest tree and a nearby snag, and the smaller circles in that vicinity represent perches associated with nesting activity. Circles on LM are perch sites used by 01 prior to the breakup of lake ice on 2 April 1986. Large circles at Rogers Meadow, Rogers Lake, and Fish Lake result from lumping together signal locations. Representative points were visually identified at these areas, but I relied mostly on signal locations because of the disturbance potential associated with attempting to obtain visual locations at these secluded sites. LMC received an inordinate amount of use during this period even though it is 12 km from the nest. Except for stream inlets, LMC was the nearest open water when LM was frozen. Perch use also occurred along the MFFR and at Lake Five, 20 km from the active nest (Fig. 8). Use in

Figure 7. Perch-site frequency map for the Nesting Period I (LM area only).

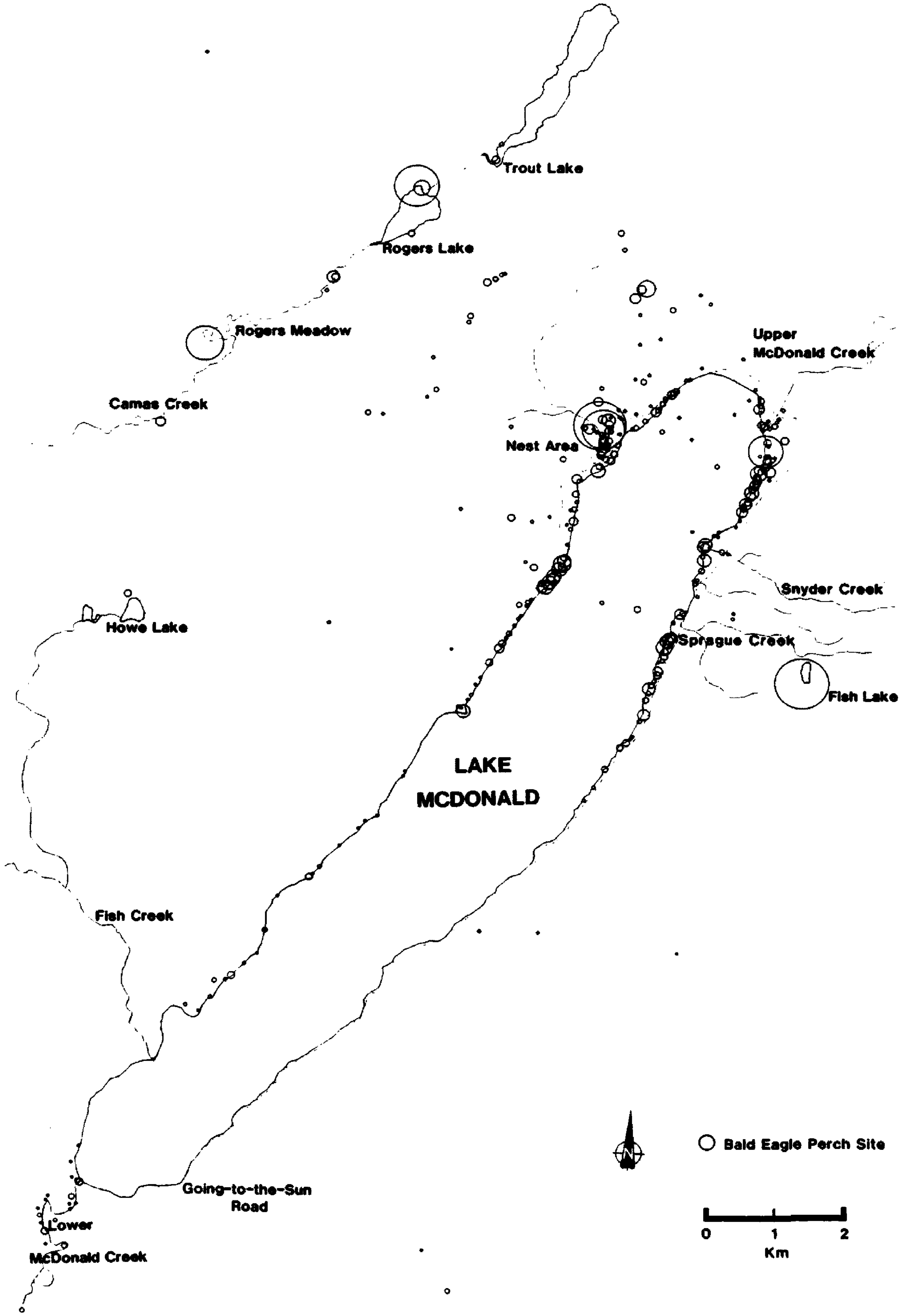
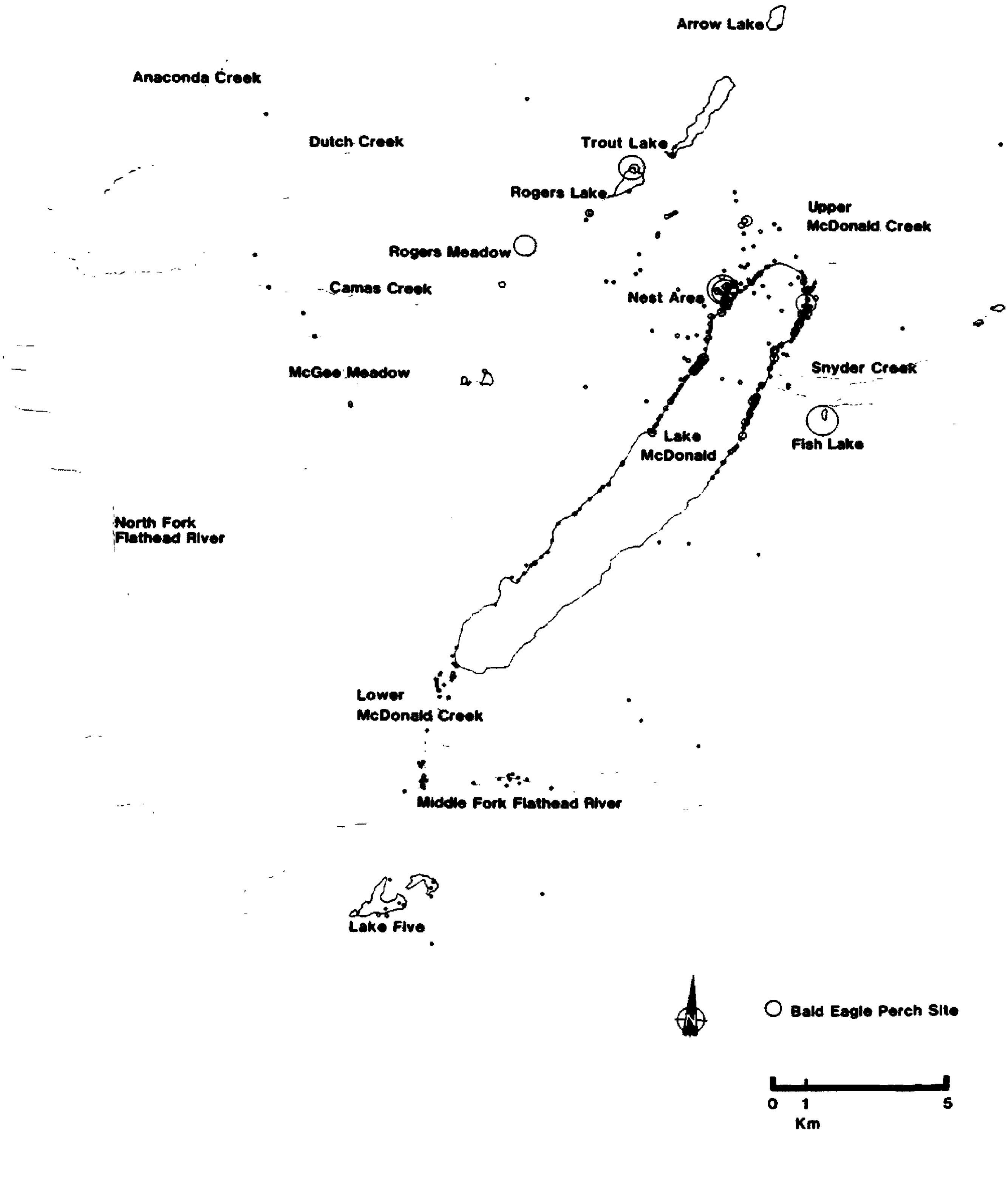

Trout Lake
Rogers Lake
Rogers Meadow
Camas Creek
Upper McDonald Creek
Nest Area
Snyder Creek
Sprague Creek
Fish Lake
Howe Lake
LAKE MCDONALD
Fish Creek
Going-to-the-Sun Road
Lower McDonald Creek
Bald Eagle Perch Site
0
1
2
Km

Figure 8. Perch-site frequency map for Nesting Period I (entire home range area).

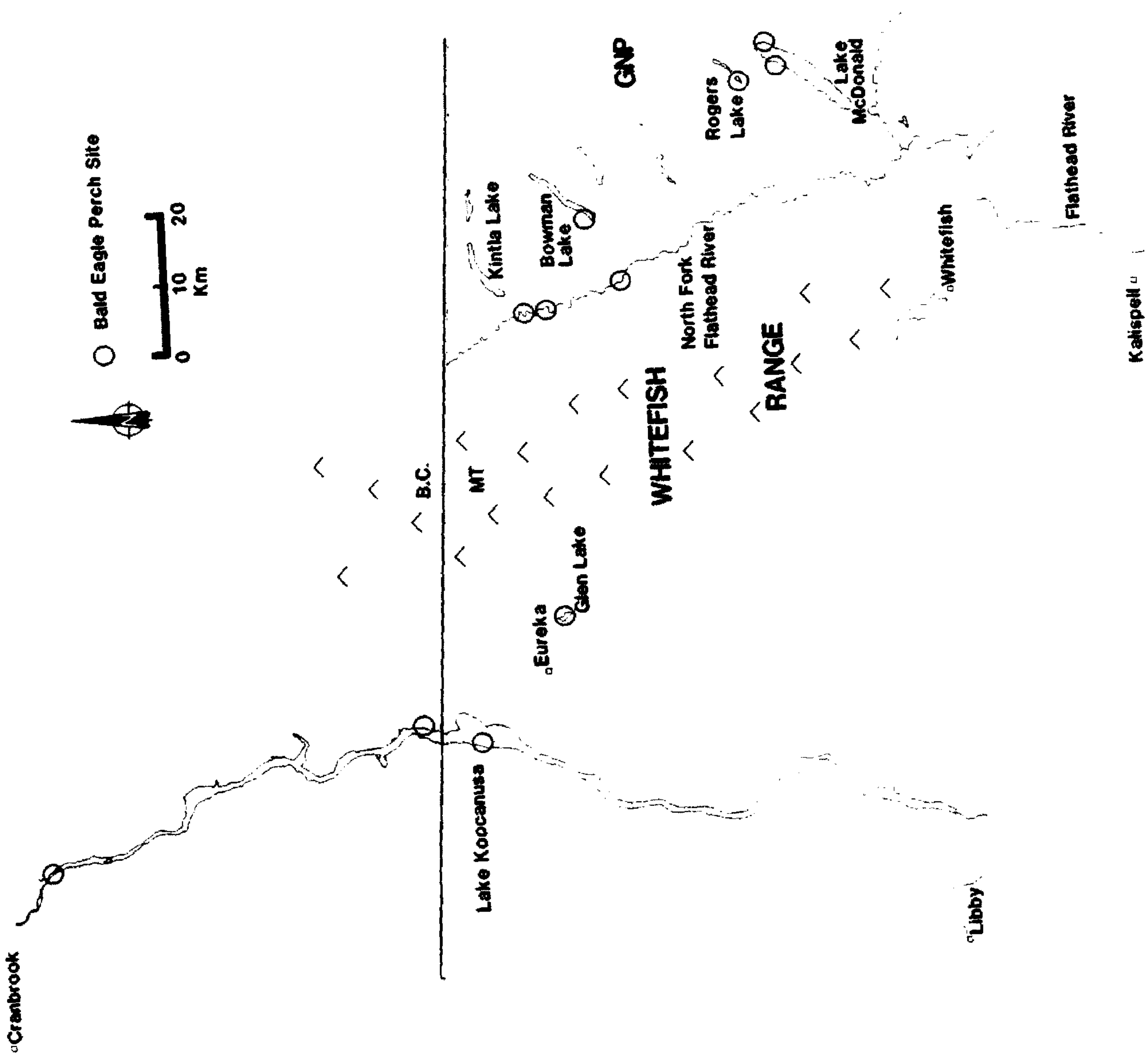

Arrow Lake
Anaconda Creek
Dutch Creek
Trout Lake
Rogers Lake
Upper
McDonald Creek
Rogers Meadow
Camas Creek
Nest Area
Snyder Creek
McGee Meadow
Lake
McDonald
Fish Lake
North Fork
Flathead River
Lower
McDonald Creek
Middle Fork Flathead River
Lake Five
N
Bald Eagle Perch Site
0 1 5
Km

these areas also occurred when LM was frozen.

Maintaining the availability of tributary inlet areas to nesting bald eagles (especially in years when LM is frozen) is one of the most important types of habitat enhancement that managers can accomplish at the LM breeding area. The importance of ice-free areas with available fish and waterfowl near an active bald eagle nest in early spring was discussed by Steenhof et al. (1980) and Barber et al. (1983). According to Swenson et al. (1986), an available food source in early spring is the most important factor in nest-site selection by bald eagles.

Long-Range Movements (Summer 1986 and 1987).--In 1986, the resident pair remained in the LM area after nest failure (14 Apr) until 19 June, when E. Caton tracked 01's transmitter signal as he soared from the Camas Creek drainage westward over the North Fork Valley and the Whitefish Range. After losing the signal, Caton and I spent the next several days searching for 01 along the NFFR and MFFR. At a later date I learned that a homeowner at Glen Lake, in the Tobacco Valley, observed 01 and another adult bald eagle on 21 and 22 June. Glen Lake is located 10 km southeast of Eureka, Montana, and 96 km northwest of LM (Fig. 9). The mountains of the Whitefish Range separate the expansive North Fork and Tobacco

Figure 9. Long-range movements of eagle 01 (summer 1986 and 1987). Circles represent 01's perch sites and not time spent at each site.


Bald Eagle Perch Site
0
10
20
Km
B.C.
MT
GNP
Kintla Lake
Bowman Lake
Rogers Lake
Lake McDonald
North Fork Flathead River
WHITEFISH
RANGE
Whitefish
Flathead River
Kalispell
Eureka
Glen Lake
Lake Koocanusa
Libby
Cranbrook

Valleys but do not pose an obstacle to bald eagles. The Lake Koocanusa reservoir dominates the Tobacco Valley and is considered to be an excellent kokanee salmon fishery (M. Aderhold, Mont. Dept. Fish, Wildl., and Parks, pers. commun.) I flew to Lake Koocanusa on 26 June and found 01 perched along the east shore of the reservoir in extreme southeastern British Columbia, 3.5 km north of the US/Canada Border. On 28 June I found 01 perched near the mouth of Young Creek, on the west shore of Lake Koocanusa, 8 km south of the border. On 30 June, 01 was again perched with another adult at Glen Lake. They fed at this lake and nearby Lick Lake for the next several days before flying back across the Whitefish Range to the NFFR on 1 July. On 2 July, E. Caton obtained a roost location for 01 near the foot of Bowman Lake in GNP (Fig. 9).

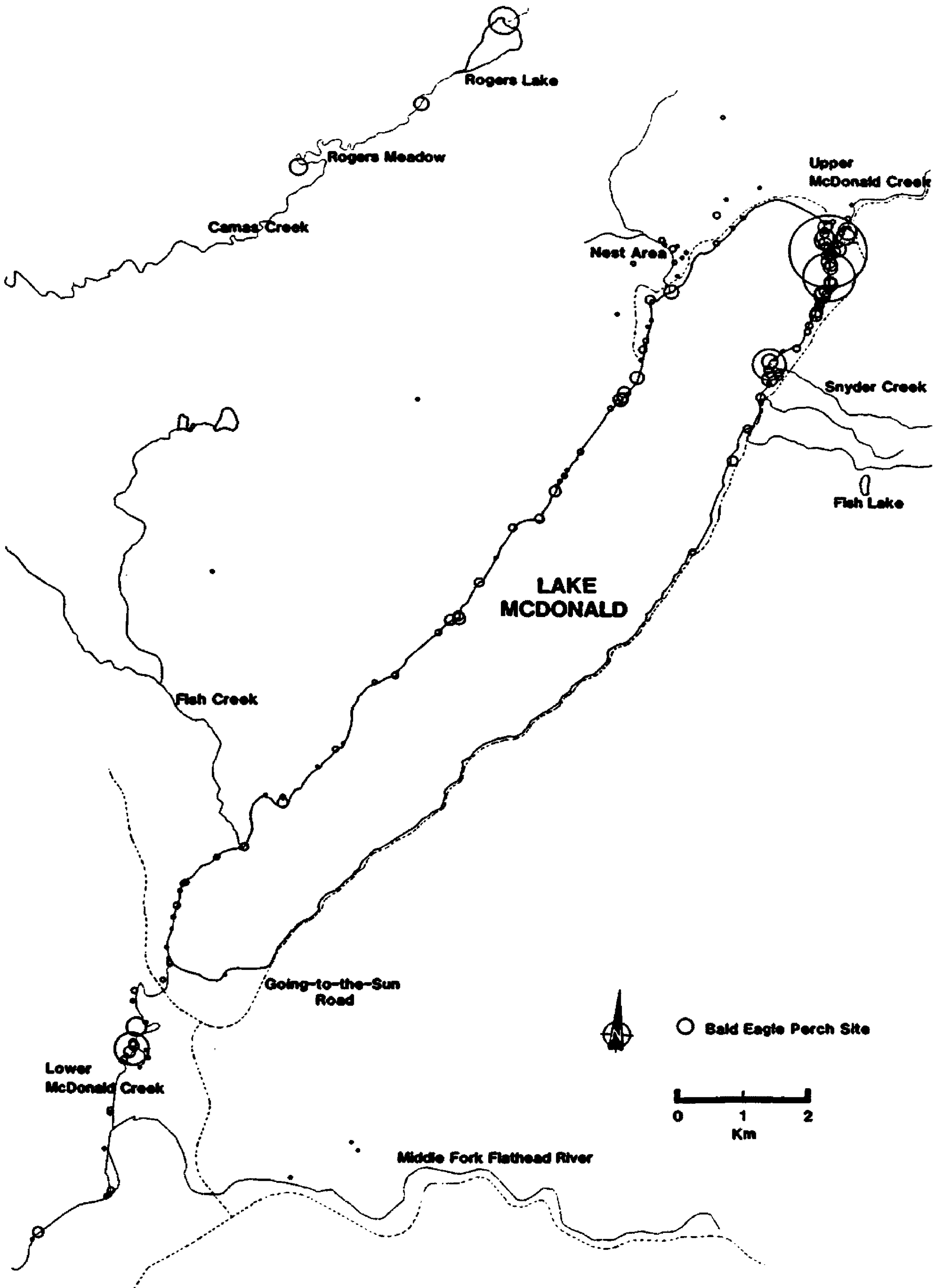
Eagle 01 was observed near LM on 5 and 6 July; he then left the McDonald Valley and was again located at Glen Lake on 14 July. The pair remained at Glen and Lick Lakes until 17 July. On 18 July, 01 was located near Kintla Lake, in GNP, by wolf researcher D. Boyd. During the next week there were no locations of 01 in the North Fork or McDonald Valleys. A shortage of personnel at this time did not allow for monitoring in the Tobacco Valley. On 25 July, I located 01 at Rogers Lake, in the Camas Creek drainage northwest of the McDonald Valley. He may have remained in the area until 27 July, when he was briefly observed at LM before again leaving the park.

I flew to Lake Koocanusa on 8 August and found the pair perched along the western shore at the confluence of the Kootenai and Elk Rivers near Cranbrook, British Columbia. This location was 144 km northwest of LM and the farthest documented long-range movement. One week later, on 15 August, 01 was on the NFFR near Kintla Creek. He remained in this area until 17 August and was found at Rogers Lake 2 days later. There were no further locations of 01 in GNP until 24 August, when he returned to the LM area.

On 25 and 26 August 1987, 01 and another adult were again observed near Cranbrook, B.C., at the same 8 August 1986 location, by P. and R. McClelland.

<u>Autumn 1986</u>.--After returning to the LM area in August 1986, 01 was not observed with a mate until 17 September. On 28 September, 01 and an unmarked female were the first bald eagles to exploit spawning kokanee salmon in LMC during the 1986 bald eagle concentration (Fig. 10). The pair fed on the kokanee along LMC throughout the remainder of September and most of October. During this period they maintained a close pair bond and defended their foraging areas along LMC against a steady influx of migrating bald eagles. As the number of migratory eagles and the competition for food increased, the resident pair shifted

Figure 10. Perch-site frequency map for Autumn 1986.

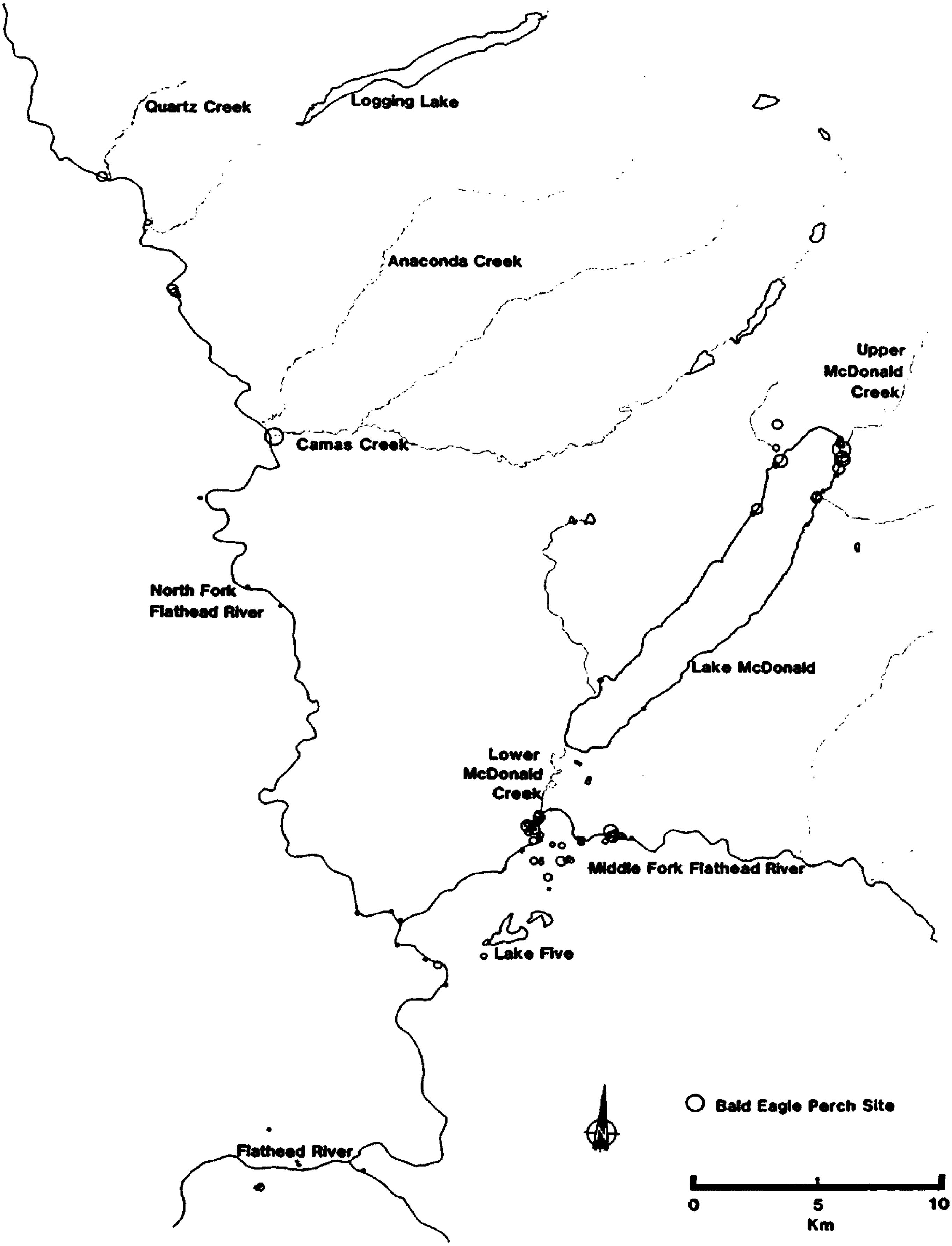

Rogers Lake
Rogers Meadow
Camas Creek
Upper McDonald Creek
Nest Area
Snyder Creek
Fish Lake
LAKE MCDONALD
Fish Creek
Going-to-the-Sun Road
Bald Eagle Perch Site
Lower McDonald Creek
0 1 2
Km
Middle Fork Flathead River

from defending foraging areas to defending specific foraging and feeding perches.

On 26 October, when the number of bald eagles along LMC reached approximately 100, the pair retreated to their home territory near the head of LM. A small run of kokanee salmon had begun to spawn along the shore of LM between Snyder Creek and UMC. The pair began to exploit the salmon and for several weeks were successful in defending the 3 sq km area against other bald eagles as well as crows and ravens. As the number of salmon in LMC dwindled, more migrant bald eagles moved to the head of LM and competed for those salmon. As on LMC the residents reduced their defended area to a favored tree at the UMC inlet. The bald eagle concentration at the head of LM peaked on 1 December when 43 eagles were counted. Throughout December the number of migrants at LM gradually decreased allowing the resident pair to expand their defended area to Snyder Creek and the west shore of the lake. By 7 January (1987) the salmon prey base was exhausted and all nonresident eagles had moved on. Eagle 01 and his mate moved downlake to the MFFR.

<u>Winter 1987</u>.--Eagle 01 and the female remained along the MFFR and NFFR corridors throughout most of the winter (Fig. 11). He frequented the MFFR adjacent to the West Glacier Golf Course and GNP Headquarters on 8 and 9

Figure 11. Perch-site frequency map for Winter 1987.



Quartz Creek
Logging Lake
Anaconda Creek
Camas Creek
Upper
McDonald
Creek
North Fork
Flathead River
Lake McDonald
Lower
McDonald
Creek
Middle Fork Flathead River
Lake Five
Bald Eagle Perch Site
Flathead River
0
5
10
Km
N

January, and moved 25 km downriver, where M. McFadzen observed him feeding on white-tailed deer carrion from 10 through 12 January. He was not found on monitoring searches near the Flathead River, LM, or in the northern Flathead Valley between 13 and 16 January, but was found on LMC on 17 January. He remained along the MFFR, near West Glacier, for 3 days, moved 15 km downriver to the main stem Flathead River for 3 days, then traveled 30 km up the NFFR for 5 days. Eagle 01 went as far north as Quartz Creek and was observed feeding on ungulate carrion along the NFFR on 22 January. He returned to the West Glacier area on 28 January and was seen with the adult female on 30 January and 3 February near the MFFR, where they fed on ungulate carrion. Eagle 01 flew to the UMC inlet by 9 February and stayed 3 days before returning to the MFFR and the carrion for another 3 days. On 16 February 01 again flew to the UMC inlet and remained for 4 days before returning to the MFFR on 20 February. He stayed along the River for 3 days, but was not located between 24 February and 3 March. He returned to the LM territory on 4 March and remained in the area until joined by a mate on 8 March.

Swenson et al. (1986) found that bald eagles in the Greater Yellowstone Ecosystem wintered primarily along major rivers near ungulates and open water where food was available, and that 93% of the bald eagles wintering in

Yellowstone and Grand Teton National Parks used ungulate carrion. Eagle 01 and his mate fed on ungulate carrion along the North Fork Road, U.S. Highway 2, and the BNRR tracks. Several of these deer (*Odocoileus sp.*) and elk (*Cervus canadensis*) had been killed by collisions with vehicles and trains. During winter 1987, LM did not freeze but 01 and his mate visited the head of the lake only briefly for a few days every 2 to 2.5 weeks.

Spring 1987 - Female 1.--On 8 March, 01 was observed copulating at the nest. Throughout the courtship, nest repair, and copulation activity over the next 10 days, 01 and the female made periodic forays downlake. That female was last seen on the territory on 18 March when she was with 01 at the nest. The lost female may have been killed or injured in a collision because she had been frequenting the BNRR tracks feeding on ungulate carcasses, or she may have abandoned the territory due to poor food conditions (Newton 1979).

Mate Replacement Period.--On 19 March, 01 flew to the BNRR tracks near West Glacier, where he and the female had earlier fed on ungulate carrion. He traveled from the LM territory to the West Glacier area again on 20, 21, and 22 March, but remained on the LM territory from 23 to 27 March. Eagle 01 roosted along the MFFR near the West

Glacier Golf Course on the night of 27 March and frequented the BNRR tracks and the old West Glacier dump area on 28 March before returning to the territory later that day. From 28 March through 5 April he mostly remained on the territory, but made occasional forays to the BNRR tracks and the MFFR near West Glacier (Fig. 12). Other adult and subadult bald eagles were seen on the territory during this period, but 01 was not observed with another adult at the nest until 6 April, when he was with a near-adult female.

Hansen (1984) stated that mates lost by resident bald eagles in southeast Alaska were quickly replaced. Eagle 01's mate was replaced within 2.5 weeks, but the replacement apparently occurred too late in the nesting season for an egg to be laid. A paucity of food resources during mate replacement and courtship also may have negatively influenced nesting.

<u>Courtship/Nest</u> <u>Activity</u> <u>(Female 2)</u>.--Observation of plumage on the near-adult replacement female indicated that she was different from the previous female that disappeared on 19 March. The male seemed to attract the new female to the nest area by capturing fish, perching near her on the shoreline, and then flying with the fish 2 km upslope to the nest. The clusters of perch locations near the nest site (Fig. 13) may be a result of 01's

Figure 12. Perch-site frequency map for Mate Replacement Period.

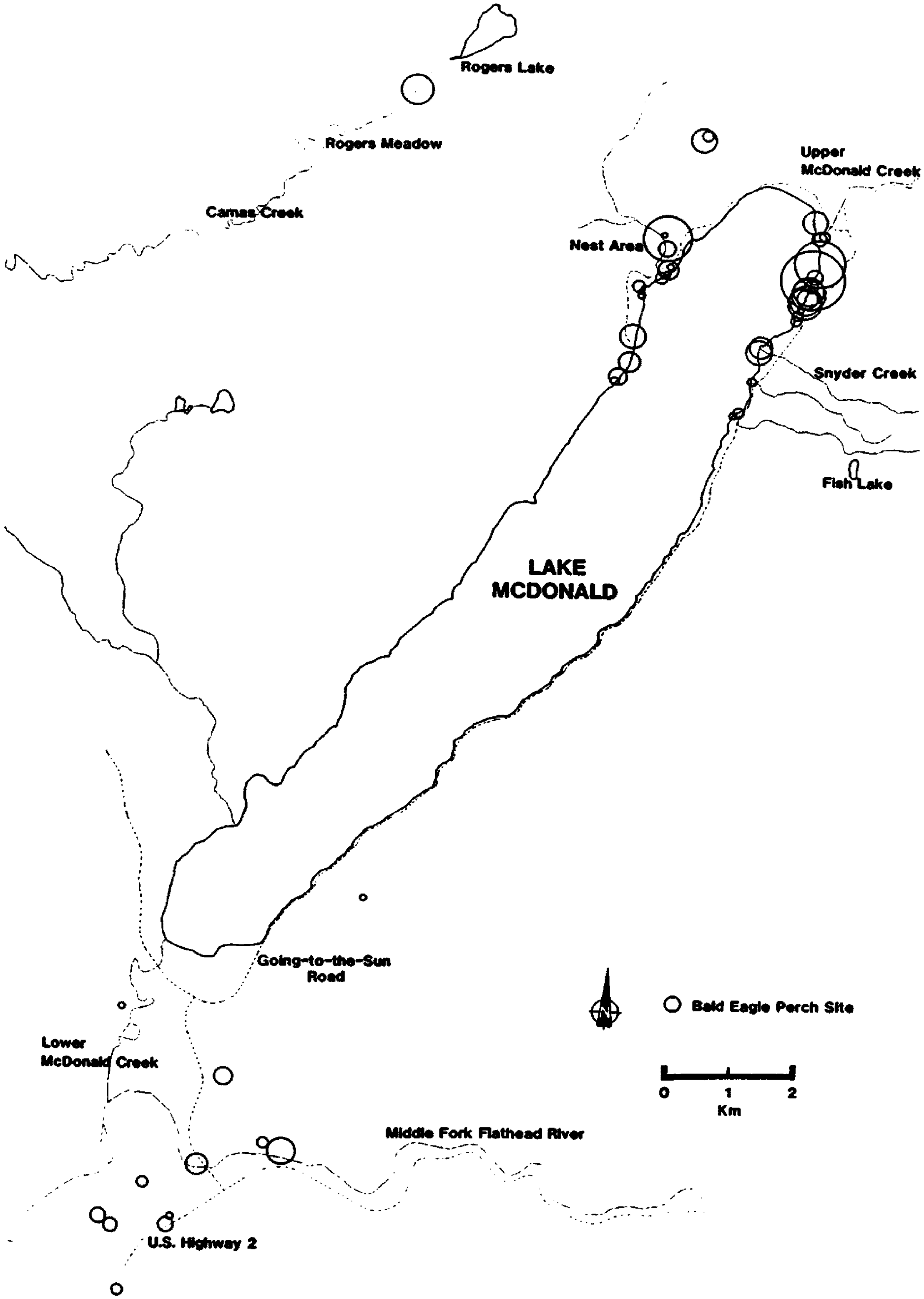
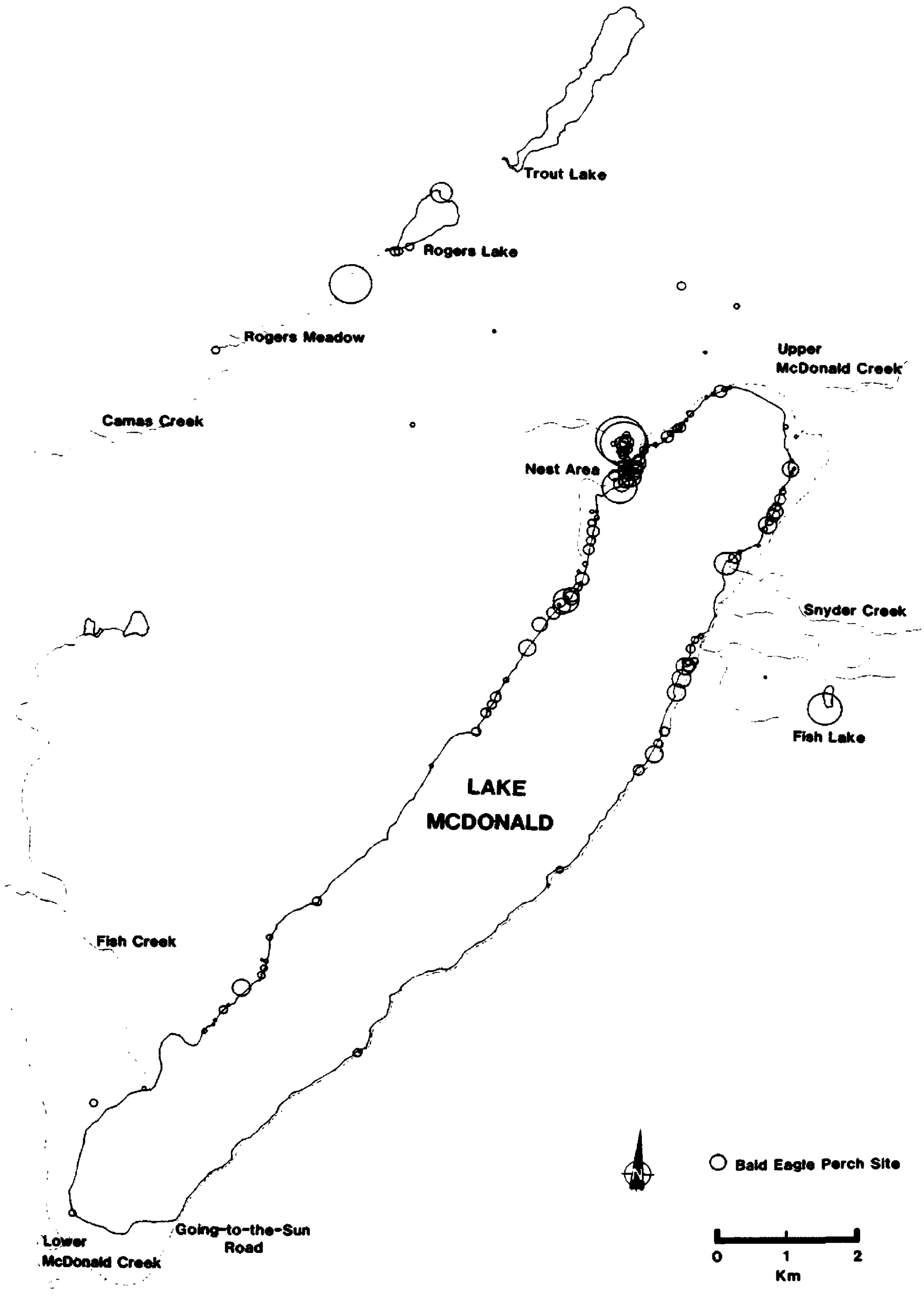

Rogers Lake
Rogers Meadow
Camas Creek
Upper McDonald Creek
Nest Area
Snyder Creek
Fish Lake
LAKE MCDONALD
Going-to-the-Sun Road
Bald Eagle Perch Site
0 1 2
Km
Lower McDonald Creek
Middle Fork Flathead River
U.S. Highway 2

Figure 13. Perch-site frequency map for Courtship/Nest Activity (Female 2).

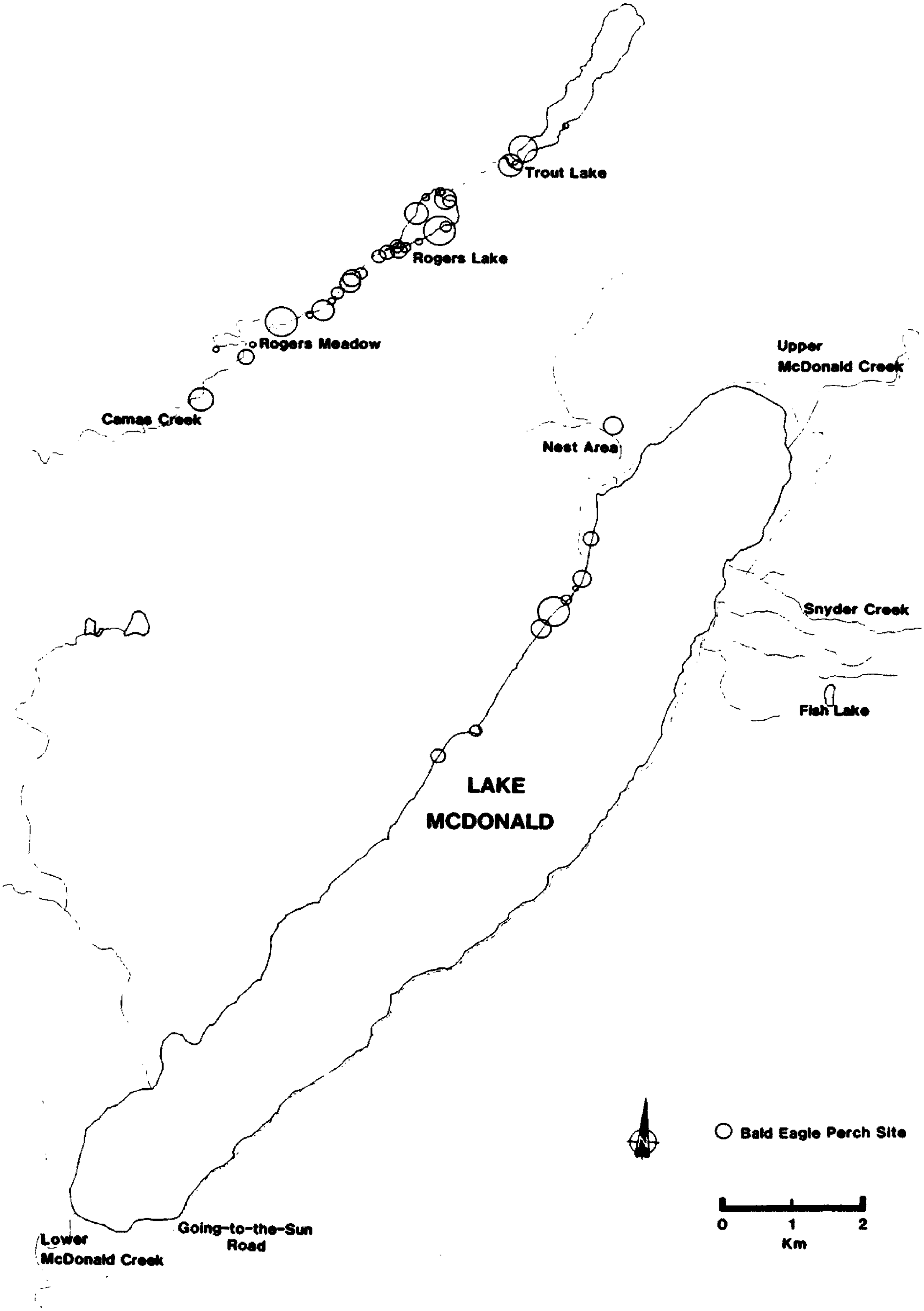

Trout Lake
Rogers Lake
Rogers Meadow
Camas Creek
Upper McDonald Creek
Nest Area
Snyder Creek
Fish Lake
LAKE MCDONALD
Fish Creek
Bald Eagle Perch Site
0 1 2
Km
Lower McDonald Creek
Going-to-the-Sun Road

attempts to attract a new female to the nest. During this period important foraging sites were identified at Snyder Creek, south of Sprague Creek, and along the west shore near the nest area. Limited eagle use near the UMC inlet may have resulted from extensive use of the area by fishermen, beginning on 1 April.

Eagle 01 and the female made nest repairs and copulated until early May. By 3 May the pair began to spend more time away from the nest area but remained on the territory until 10 June, when they began to frequent the Camas Creek drainage more often than the McDonald Valley (Fig. 13).

Summer 1987, Non-Nesting.--Except for occasional returns to the west shore of LM, 01 and the female remained in the Camas Creek drainage for the next 2 months (Fig. 14). They perched along Camas Creek near Rogers Meadow, where fishing for cutthroat trout is very good according to Kinnie (1960, in Morton 1968). The eagles also frequented Rogers and Trout Lakes throughout the remainder of June, July, and most of August. By 24 August the pair left GNP and flew to the headwaters of Lake Koocanusa near Cranbrook, B.C.

Figure 14. Perch-site frequency map for Summer 1987, Non-Nesting Period.


Trout Lake
Rogers Lake
Rogers Meadow
Camas Creek
Upper
McDonald Creek
Nest Area
Snyder Creek
Fish Lake
LAKE
MCDONALD
N
Bald Eagle Perch Site
0
1
2
Km
Lower
McDonald Creek
Going-to-the-Sun
Road

Roost-Site Use Frequency

Roosts adjacent to the NFFR, MFFR, and main stem Flathead River were used during summer 1986 and winter 1987 (Fig. 15). Roost sites along the MFFR near the West Glacier Golf Course were concentrated in a tract of undeveloped private land (GNP Land Protection Plan 1985). Roost sites near the southern end of LM's west shore occurred within old-growth larch stands. These sites were used during September and October 1986, when the pair frequented LMC (Fig. 16). The scattering of roost sites along the west shore of LM, near the upper end of the Lake, were documented in late-winter, spring, and autumn. These sites were within mature stands of mixed conifers adjacent to lakeshore riparian vegetation. The most used roost area, near the nest site in mature mixed conifer, was associated with nest activity during spring and summer. A roost near the UMC inlet was within old-growth mixed conifer and riparian vegetation very near the Going-to-the-Sun Road. Most of its use was in autumn months when the resident eagles fed on spawning kokanee salmon near the inlets of UMC and Snyder Creek. Use frequency of the roost near UMC probably is correlated with the frequency of use of the nearby feeding area (Harmata 1984, Keister et al. 1987). Specific roost-sites at Fish Lake were not documented, but the number of nights spent at

Figure 15. Eagle 01's roost-site use frequency in GNP (Mar 1986 through Aug 1987).

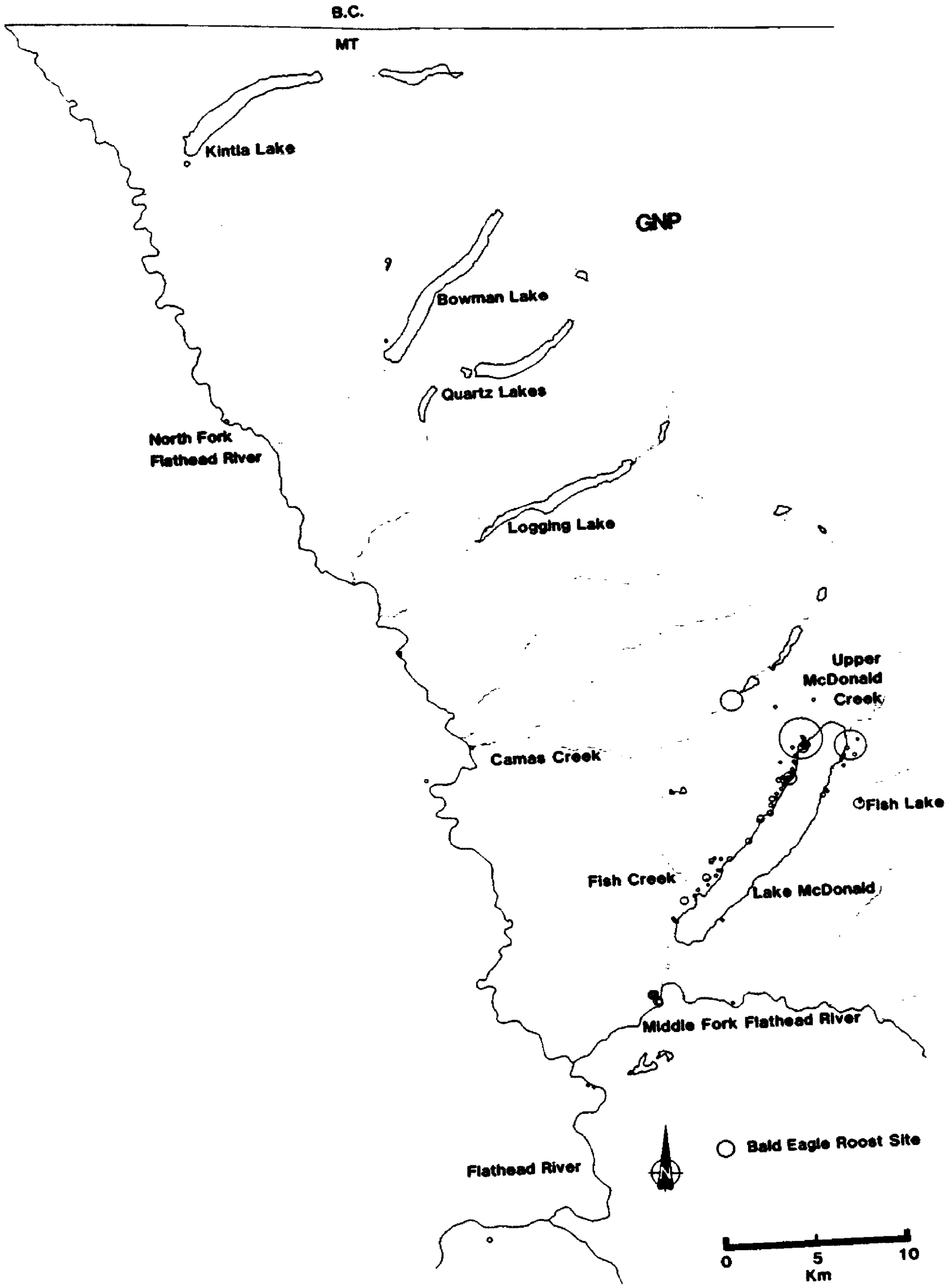
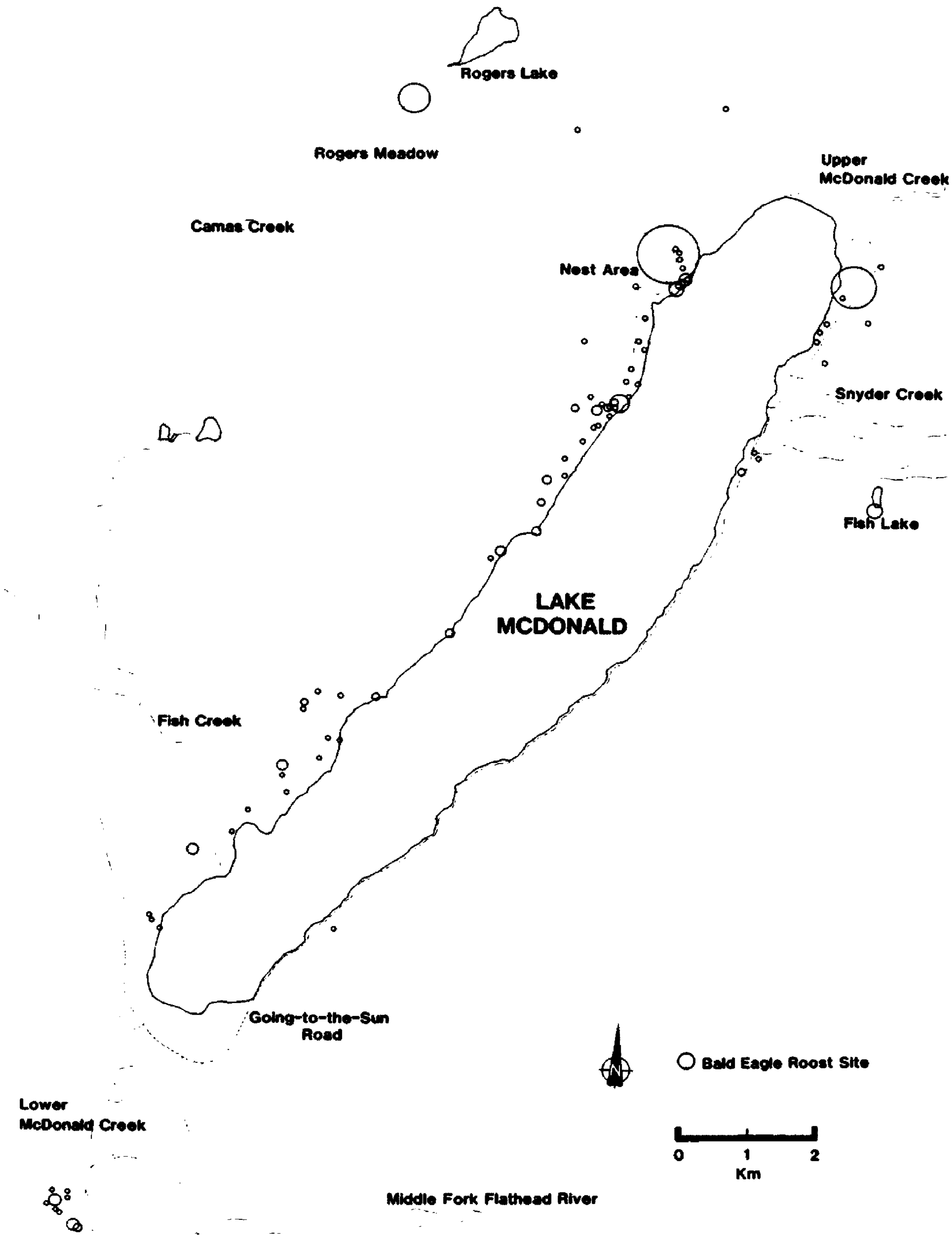

B.C.
MT
Kintla Lake
GNP
Bowman Lake
Quartz Lakes
North Fork
Flathead River
Logging Lake
Upper
McDonald
Creek
Camas Creek
Fish Lake
Fish Creek
Lake McDonald
Middle Fork Flathead River
Bald Eagle Roost Site
Flathead River
0
5
10
Km

Figure 16. Eagle 01's roost-site use frequency in the LM area (Mar 1986 through Aug 1987).


Rogers Lake
Rogers Meadow
Upper McDonald Creek
Camas Creek
Nest Area
Snyder Creek
Fish Lake
LAKE MCDONALD
Fish Creek
Going-to-the-Sun Road
Bald Eagle Roost Site
0 1 2
Km
Lower McDonald Creek
Middle Fork Flathead River

roost in that vicinity are represented by a single circle at a documented perch site. Specific roost sites were not documented within the Camas Creek drainage due to potential encounters with grizzly bears. The relative frequency of 01's roosts in the Camas drainage are represented by a single circle located along Camas Creek, centered between documented forage sites at Rogers Meadow and Rogers Lake. Actual roost sites in this drainage are probably upslope from Camas Creek.

Primary Use Zone

The resident bald eagle Primary Use Zone (Fig. 17) is based on a composite map (Fig. 18) of 01's perch-sites and frequency of use near LM from 10 January 1986 through 13 August 1987. Within the home range, areas of lakeshore and riparian habitat showing nearly contiguous forage perch use by 01 were outlined as the Primary Use Zone. Nearly 3000 locations of 01 were used to determine the Primary Use Zone. This delineated zone masks important seasonal variations in 01's perch-site use, but it is useful in identifying the area within which most foraging and perching occurs.

Areas of bald eagle/human conflict are defined when the Primary Use Zone map (Fig. 17) is compared with the map of human developments in the LM vicinity (Fig. 2).

Figure 17. Primary Use Zone for the LM breeding area.

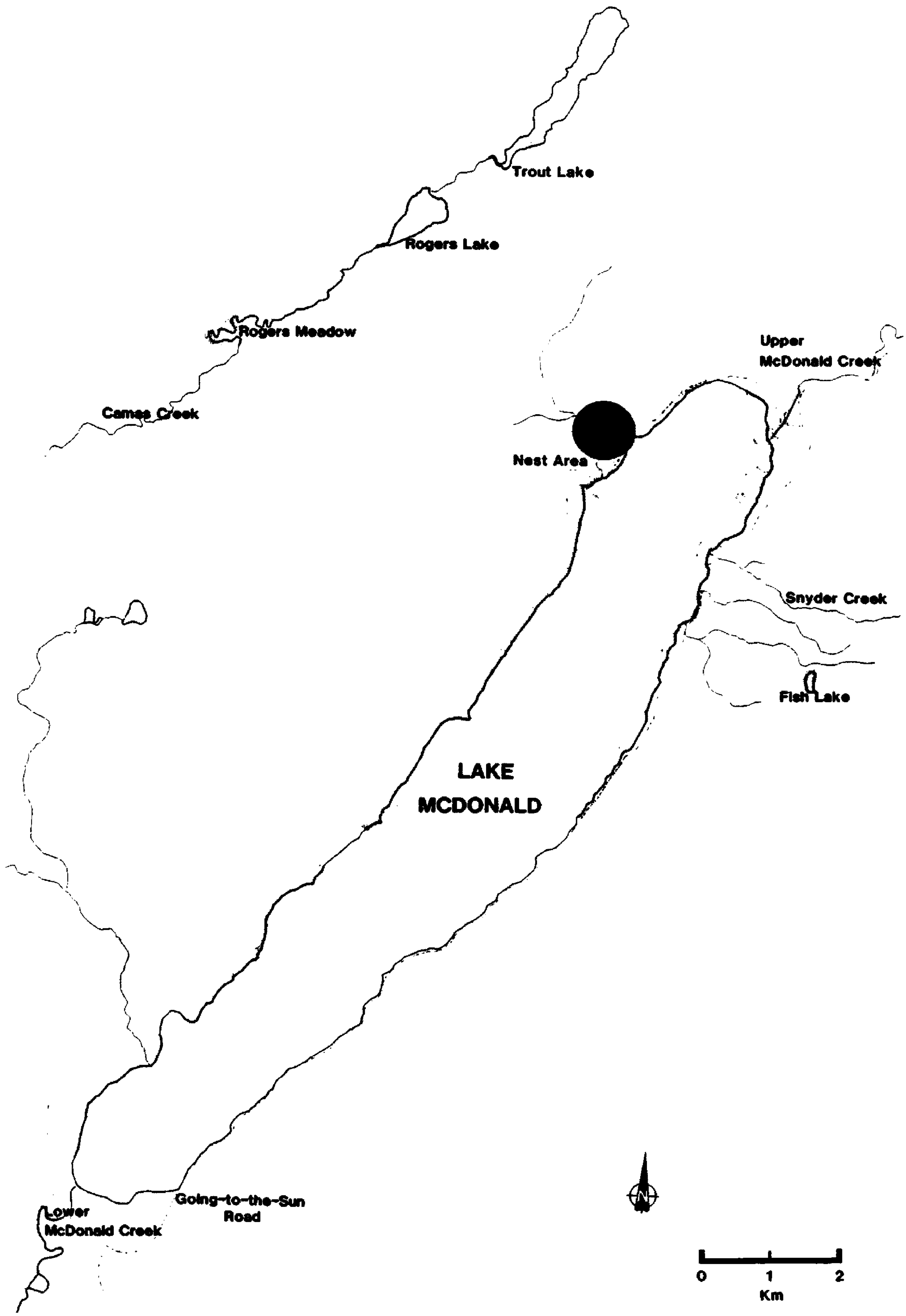
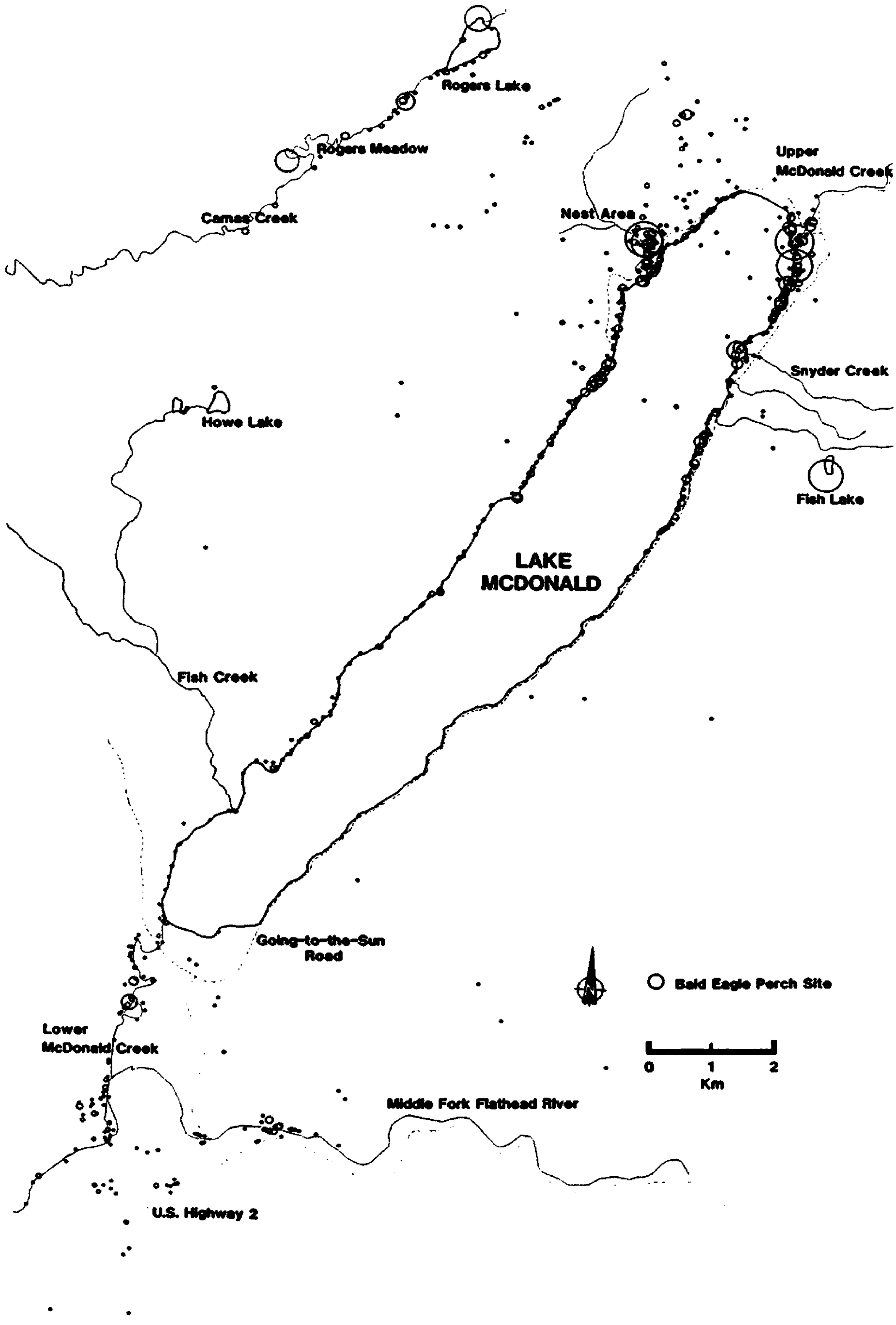

Trout Lake
Rogers Lake
Rogers Meadow
Camas Creek
Upper
McDonald Creek
Nest Area
Snyder Creek
Fish Lake
LAKE
MCDONALD
Lower
McDonald Creek
Going-to-the-Sun
Road
N
0
1
2
Km

Figure 18. Composite map of O1's perch-site use frequency in the LM area (Jan 1986 - Aug 1987).


Rogers Lake
Rogers Meadow
Camas Creek
Upper
McDonald Creek
Nest Area
Snyder Creek
Howe Lake
Fish Lake
LAKE
MCDONALD
Fish Creek
Going-to-the-Sun
Road
Bald Eagle Perch Site
Lower
McDonald Creek
0
1
2
Km
Middle Fork Flathead River
U.S. Highway 2

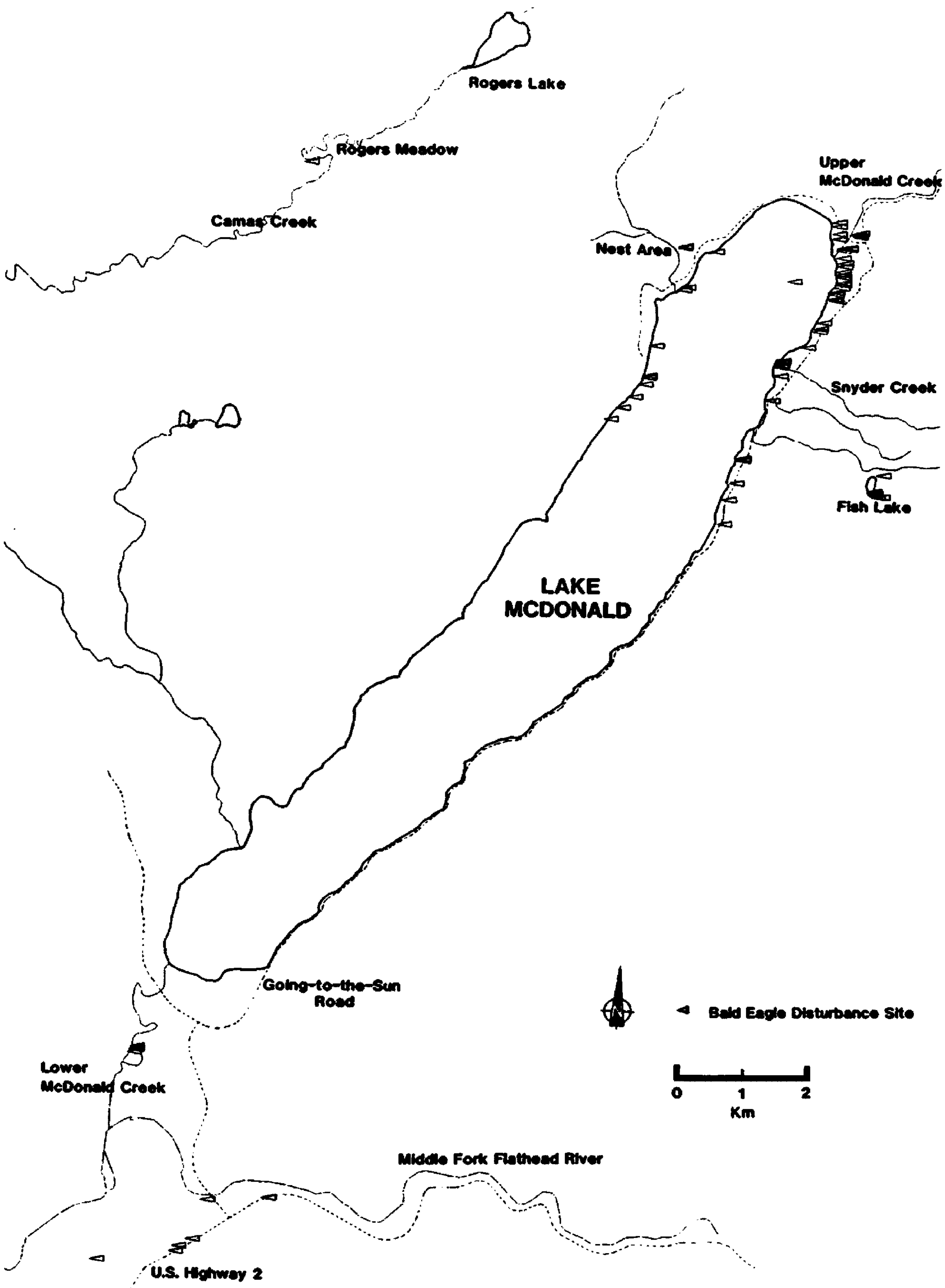
Most conflict areas occur at stream inlets, areas important to foraging bald eagles.

Threats to the LM Resident Pair

Disturbance.--During 1985, 1986, and 1987, 71 documented disturbances occurred to one or both of the LM resident eagles; 29 were caused by humans on foot, 22 by motorboats, canoes, and rowboats, 6 by vehicles on roads adjacent to the lakeshore, 6 by heavy construction equipment near the lake and near inlet and outlet creeks, 4 by trains near West Glacier, and 4 by aircraft (2 of which were sonic booms). Disturbances by researchers were at times unavoidable, but when we knew where an eagle was perched, we did not approach that area. Of the 71 documented disturbances, 6 were inadvertently caused by research personnel. Documented disturbance sites (Fig. 19) illustrate only where the resident eagles were flushed from perches by human activity and do not indicate when or where eagles were excluded from foraging sites by people already in an area.

Areas of frequent disturbance (Fig. 19) were: 1) UMC, where disturbances were caused by vehicular and foot traffic at and near the UMC bridge and by people on foot and boats at the UMC inlet area and adjacent lakeshore; 2) Snyder Creek, where automobiles, heavy equipment, and

Figure 19. Resident bald eagle disturbance sites in the LM area during 1985, 1986, and 1987.


Rogers Lake
Rogers Meadow
Camas Creek
Upper
McDonald Creek
Nest Area
Snyder Creek
Fish Lake
LAKE
MCDONALD
Going-to-the-Sun
Road
Bald Eagle Disturbance Site
0
1
2
Km
Lower
McDonald Creek
Middle Fork Flathead River
U.S. Highway 2

people on foot caused the disturbances; 3) Fish Lake, where hikers approaching the lake flushed eagles; 4) the west shore of LM, where disturbances resulted from boats and low-flying aircraft; 5) LMC, where all disturbances were caused by loud noises from GNP maintenance operations using heavy equipment and gravel trucks.

Sources of disturbance at LM, in decreasing order of disturbance potential, include: humans on foot, boats, construction equipment, and passenger vehicles. Boat activity on LM increased during the 1988 summer season, and was encouraged by the placement of a new boat dock at Apgar. Fishermen account for most of the boating activity on LM in spring and fall and boats anchored at inlets or near shallows were the most disruptive to foraging eagles. Although fishermen may exclude bald eagles from some foraging areas they also wound fish making them more available to bald eagles at a later time (Swenson et al. 1986).

Human activity resulting in disturbance may contribute to the low bald eagle productivity at LM. Some bald eagles habituate to human presence in certain areas over time, but persistent human activity may preclude eagle use and act as an insidious form of habitat destruction (Fraser 1983). Bald eagle productivity is adversely affected by such habitat loss. Smith et al. (1987) found that bald eagles in North Carolina concentrated in areas used infrequently by people, and that eagles shifted their use to less accessible areas during periods of increased human activity. Skagen (1980) reported that bald eagle use of an area decreases for 30 min or more after human activity has occurred. Resident eagles at LM avoided areas for several hours or even for the remainder of the day after they were disturbed.

Disturbance causes eagles to use energy unnecessarily when they are flushed from perches. Exclusion from frequently-used foraging sites can result in an inability to maintain energy levels (Stalmaster 1983). At LM, the marginal prey base provides few alternative foraging sites for displaced eagles. Parts of the lakeshore (especially near inlets) are unavailable to foraging eagles during summer months because of human activity. If eagles are flushed or excluded from prime locations at UMC and Snyder Creek they may not have other opportunities to acquire fish that day.

Vegetative buffer zones are essential components of bald eagle foraging habitat in areas subjected to human activity. Perched eagles flush at greater distances when approached by humans on foot than when approached by humans in vehicles, and eagles on the ground are flushed at greater distances than those perched in trees (Skagen 1980, Knight and Knight 1984). On Besnard Lake, Saskatchewan, bald eagle breeding drastically decreased at

4 nests within 4 km of newly constructed tourist access sites (Gerrard et al. 1983). The LM nest is within 2.5 km of a proposed parking lot and tourist access site immediately adjacent to a prime foraging area at UMC. Increased tourist access and expansion of the visitor season at LM Lodge are proposed in the Lake McDonald Development Concept Plan (U.S. National Park Service 1986). Increases in park visitation and expansion of the visitor season to include spring and autumn will lead to an increased disturbance potential on the LM territory. The lodge is adjacent to an important inlet foraging site (Snyder Creek) and is within 2.3 km of the LM nest. Maintaining buffer zones will effectively allow an increase of human activity nearer to bald eagles by reducing flushing distances (Knight and Knight 1984). LM Lodge and adjacent trees screened bald eagle perches at the Snyder Creek inlet and allowed eagle use of the site with people less than 120 m away. Twenty-five old-growth trees adjacent to the lodge were removed in September 1988 to improve views of the lodge from the parking area. As a result, bald eagle flushing distances probably will increase at that site.

Maintenance of at least 100 m wide vegetative buffers substantially reduces disturbance to foraging bald eagles (Stalmaster 1976, Stalmaster and Newman 1978) and will partially offset development impacts in sensitive areas.

In Oregon, McGarigal et al. (1987) studied bald eagle reponses to human activity and found that eagles avoided an area within 300 to 800 m of disturbance sites. I documented eagles flushing from humans on foot and from boats at distances of 300 to 400 m across open areas. Eagles at LM most often were flushed by slow moving boats within 200 to 300 m of the shoreline. Knight and Knight (1984) recommended a boating restriction zone of at least 450 m to protect bald eagles feeding on the ground.

Food Stress.--The large nesting home range of the LM eagles probably is indicative of a limited food resource. Other indications that the LM eagles are food-stressed during nesting include low productivity, the nest failure in 1986, and the possible abandonment of the territory by the mated female in 1987 (Newton 1979). If there were adequate food during the nesting season, severe weather and human disturbance might be less significant factors influencing productivity. Zande and Verstrael (1985) found that human disturbance in The Netherlands had the most negative impact on kestrel (*Falco tinnunculus*) nesting success during years of low prey abundance. Hansen (1984) found that bald eagle productivity in southeast Alaska was reduced when food was not abundant. Minimal food may be the most important factor limiting bald eagle productivity at LM. Even when productivity is low, bald eagles may continue to show a tenacity to their breeding area (Swenson et al. 1986). If both individuals of the LM pair died at the same time, the territory might not be reoccupied by other eagles because of the limited food resources.

Habitat Loss.--A major threat to identified and potential bald eagle habitat at LM is posed by the removal of vegetation, particularly old-growth trees. Trees are threatened by vista-clearing projects along the Going-to-the-Sun Road, proposed road realignment and widening, and facility construction projects at LM Lodge. Removing old-growth trees and screening vegetation eliminates perch, roost, and potential nest trees and their associated buffer zones (Fraser 1983). A roost-site near UMC is threatened by proposed trail construction and road reconstruction. Three roost-sites near Sprague Creek are adjacent to the Going-to-the-Sun Road and may be threatened by road reconstruction.

During May 1985, GNP crews removed numerous old-growth trees from the lakeshore to improve vistas for passing motorists. The decisions to remove trees then and in 1988 at LM Lodge were made by GNP managers and planners with full knowledge of possible irreversible negative impacts to resident and migrant bald eagles.

Collision, Shooting, and Trapping.--Direct threats include the possibility of the eagles colliding with automobiles or trains while feeding on ungulate carrion along roadways or the BNRR tracks. In February 1987, 01 was flushed from an elk carcass by a train and narrowly missed colliding with it. Many bald eagles are shot each year. Bald eagle feathers and body parts fetch prime prices on the black market (Marler 1986), and mutilated eagles are found near GNP almost yearly. Eagles also are inadvertently trapped by furbearer trappers; many of these eagles die of exposure or injuries (Durham 1981). Trappers heavily use public and private lands adjacent to GNP.

Site-Specific Management Recommendations

The following recommendations are in accord with the goal of the National Park Service to preserve, protect, and enhance the habitat of endangered species. They are designed to reverse the current trend of increasing disturbance, loss of prey base, and negative habitat alterations that jeopardize the continued existence of the LM bald eagle territory. These recommendations are based on 20 months of study of a single pair of bald eagles at LM; the findings from LM should not be extrapolated to other pairs or other areas. A longer term study at LM would provide more insight into variations in bald eagle food habits and use areas.

Recommendations Implemented in Spring 1988.--In March 1988 several recommendations were implemented to help mitigate the loss of bald eagle foraging opportunities at Snyder Creek as a result of construction activities at LM Lodge. These management actions included:

1. Boating closure of the upper 1/3 of LM from 1 March through 27 May. This action offered eagles and migrating waterfowl some protection from boating disturbances.

2. Closure of the shoreline area near LM Lodge to human activity in April. This action may have benefitted some migrant bald eagles, but the residents did not use the area possibly because of continued construction activity at the lodge. There was an insufficient number of personnel to properly enforce the closure.

3. Restriction of construction activity before 1000 H on the west (lake) side of LM Lodge during April. This action was ineffective due to loud noises and human activity on the east side of the lodge beginning at 0730 H.

4. Movement of the Going-to-the-Sun Road winter closure

from UMC to Avalanche Creek on 19 March. This action opened the Going-to-the-Sun Road beyond LM at least 2 weeks earlier than normal. It had the most positive effect on reducing the number of shoreline disturbances to the resident eagles by moving the center of human activity 10 km from the UMC inlet area.

5. Supplemental feeding of the LM resident bald eagles from 31 Mar to 15 May to compensate for lost foraging opportunities near Snyder Creek as a result of LM Lodge construction activity. This action ensured that the eagles got food during the early nesting period and may have been partly responsible for the production of eggs. However, a long-term feeding program will not solve the problems of unnaturally low prey species populations and high occurrence of disturbance; continuance of a long-term feeding program is not recommended (Fraser 1983).

Recommendations for Immediate Implementation.--GNP managers can control the amount of human disturbance allowed on the territory. Disturbances should be reduced in order to maximize foraging opportunities for bald eagles at LM. The most critical seasons to protect from disturbance are spring (1 Mar to 15 May) and autumn (1 Nov to 31 Dec); the most critical time of the day to protect from disturbance is the first 5 hrs of daylight.

1. Do not remove trees or shrubs (especially old-growth trees) within the defined Primary Use Area at LM (Fig. 17). This vegetation is essential for the preservation of documented foraging and roosting habitat, potential habitat, and buffer zones. Nest, perch, and roost-sites must be protected and the buffer zones associated with these sites must be maintained and enhanced (BioSystems Analysis, Inc. 1985). It is particularly important to leave all vegetation at inlet areas.

2. Enact the boating closure at the head of LM in the autumn (1 Nov to 31 Dec), in addition to the spring closure, to reduce disturbances associated with the fishing season.

3. Identify and protect post-fledging and potential post-fledging areas used by the young eagles along the LM shoreline.

4. Identify and preserve potential bald eagle habitat so that replacement forage, roost, and nest sites are available to the birds (Steenhof and Isaacs 1984) in case of blowdown or catastrophic fire in the McDonald Valley.

5. Visitor seasons at Sprague Creek Campground and LM Lodge should be as brief as possible, i.e. maintain months

of operation from June through early September. Developed areas at these and other inlets should not be expanded.

6. Aircraft overflights in the McDonald Valley should be restricted, especially near the Howe Ridge nest site. Helicopters should never be allowed to fly over the McDonald Valley and should not be used to survey bald eagle nests. Sonic booms should not be allowed over GNP.

7. The McFarland property (tract 12-101 in the GNP Land Protection Plan, 1985) should be acquired to protect an important bald eagle roost and foraging site.

8. The LM Campground at Long Point should be removed to provide a larger area of continuous undisturbed eagle habitat along the west shore of LM.

9. No toxic chemicals, heavy metals, or pesticides should be introduced into the LM water or air sheds.

10. Runoff from construction projects should be controlled to prevent siltation of streams and LM.

11. Timing of construction and maintenance activities should be considered in the planning process so that projects are not disruptive to bald eagles during critical

times of the year. Habitat needs of bald eagles should be considered before construction projects are initiated.

12. Fire managers should be familiar with the location and status of the bald eagle nest at LM so that the nest or surrounding trees are not cut during fire-line construction, or targetted for retardent drops during a wildfire in or near the nest zone (Fig. 16). No supression efforts should be undertaken within the 400 m nest zone. In an attempt to save eaglets directly threatened by wildfire, low impact suppression efforts (hand line) should be positioned outside of the nest zone, or eaglets should be removed from the nest by a climber. All large trees should be left standing. No helicopter-bucketing should be allowed within the defined territory at the head of LM (Fig. 3). Attempts to frighten eagles out of the territory (for the purpose of "saving" them from the fire) by low-level helicopter flights are unwarranted, and probably would be ineffective and more dangerous to the birds than the fire. No fire-related helicopter flights should be allowed on the territory when the nest is active. If a fire is man-caused and threatens the nest area, efforts should be made to rescue nestlings in the LM nest without using helicopters. Natural fires should be allowed to burn in the McDonald and Camas drainages to enhance ungulate habitat (potential carrion

prey for bald eagles). Wildfire does not pose a long-term threat to bald eagle habitat as long as groups of large trees are left standing (Swenson et al. 1986).

13. Trail maintenance activities that involve chainsaws, punjaars, power-brushers, or blasting should not be conducted along the Trout Lake or Howe Ridge trails from 1 March to 1 September in years when nesting occurs.

14. Recommendations for reducing tour-boat disturbance to bald eagles at LM (Appendix 3) were submitted to GNP Resources Management and Concessions Management personnel in the winter of 1988. Tour-boat cruises should not be allowed during the first 4 hours of daylight and the number of cruises per day should not be increased. The boat concession at LM Lodge should phase out motor-boat rentals. Perched eagles are frequently disturbed by these numerous boats because they slowly travel the shoreline where eagles perch.

15. Continued closure of the UMC inlet area in autumn will help protect resident and migrant eagles as they feed on kokanee salmon.

16. Permanently move the Going-to-the-Sun Road winter closure to Moose Country *if* an assessment of fauna

determines that wintering animals will not be significantly affected by the increased human presence.

17. Work with inholders to eliminate construction activity at private dwellings near the head of LM during the identified sensitive times in spring and autumn.

18. Require utility companies to coordinate their work in sensitive areas with GNP Resource Management personnel to reduce disturbances to eagles.

19. Construction activity at LM Lodge should not be performed between 1 March and 15 May or between 1 November and 31 December (i.e. the critical periods identified for bald eagles).

20. Do not improve or further develop the north-shore McDonald road. The road closure at Theef's driveway should be maintained year round to prevent vehicle access to the shoreline of LM at the old Chadbourne cabin site. Autumn closure of the road at the Trout Lake trailhead should also continue, and the road should not be plowed past Fox's driveway in winter and spring.

21. Maintain the option of a short-term supplemental feeding program as a mitigation measure when eagles are

excluded from parts of their habitat.

22. Placement of an informational sign at the Apgar boat ramp requesting recreationists to avoid designated areas of bald eagle use.

<u>Recommendations</u> <u>for</u> <u>Long-Term</u> <u>Management</u>.--These recommendations provide long-term management goals which would benefit resident and migrant bald eagles at LM by reducing disturbance potential and increasing foraging opportunities.

What limits forage ?
People on the habitat

1. Eventually acquire the Kelly Camp inholdings and close the north-shore McDonald road beyond the LM ranger station.

2. No bike trail (as previously proposed) should be constructed along the west shore of LM.

3. No additional trails or campgrounds should be developed in the Camas Creek drainage. Off-trail use in this drainage, especially between Rogers Meadow and Trout Lake, should be discouraged and all social trails eliminated.

4. Close fishing at Fish Lake to preserve it as an unique

wildlife lake (Morton 1968) and to reduce disturbance to foraging bald eagles. Recent discovery of an unique genetic evolutionary process occurring in the Yellowstone cutthroat trout at Fish Lake also supports the closure of this lake to fishing (L. Marnell, Natl. Park Serv., pers. commun.). Rogers Lake also should be closed to fishing due to its remoteness from an established trail and importance as a foraging site to nesting osprey (Pandion haliaeetus) and resident bald eagles. Trout Lake provides good fishing, but fishing pressure should not be increased and the current fly-fishing only restriction should be maintained.

5. All inlet areas should eventually be returned to a natural condition by eliminating developments and allowing reestablishment of native vegetation.

6. Motorboat use on LM should not be increased or encouraged, and should eventually be eliminated.

Research Questions Concerning Eagle Productivity:

1. What are the levels of organochlorine pesticides, heavy metals, or other toxins in the LM environment and in the tissues of adult and nestling bald eagles in GNP?

2. Does cold, wet spring weather negatively impact bald eagle productivity in GNP as it does in the Greater Yellowstone Ecosystem (Swenson et al. 1986)?

3. Do harsh winters increase the amount of ungulate carrion available to GNP eagles in the spring?

4. What is the actual bald eagle prey base at LM? What prey species are available to bald eagles and what factors regulate food abundance in the breeding area (Hansen 1984)?

6. What is the survivorship of locally-produced young? Which areas of LM are important to fledgling bald eagles? Are locally-produced young eventually recruited into the GNP bald eagle population?

CONCLUSION

The LM ecosystem has been irreversibly altered by human intervention during the past 100 years. Water quality, species diversity, and shoreline vegetation have been affected. Natural fires have not been allowed to burn on Howe or Snyder Ridges, adjacent to LM, and numerous old-growth trees near the lakeshore have been removed as hazards or to improve vistas. Motorboats have made all of LM easily accessible for unlimited recreational activity. Resident bald eagles have been subjected to almost continual conflicts with humans within the LM territory because of numerous developments. The extensive nesting territory and home range, nest failures in 1986 and 1987, and consistent low productivity indicate that food is a major limiting factor at LM. Persistent exclusion from foraging sites as a result of human disturbance compounds the food stress problem. If the goal of GNP managers is to preserve an active bald eagle breeding area at LM, human disturbance must be minimized and foraging opportunities maximized, especially at inlet areas. Cummulative impacts to bald eagle habitat should be considered for the entire LM area when facility maintenance and development projects are planned. Heightened sensitivity to the need for habitat protection could improve bald eagle productivity and assure the perpetuation of the historic LM breeding area. A continuation of traditional resource management could lead to an extirpation of bald eagles from LM.

LITERATURE CITED

Alcock, J. 1984. Animal behavior an evolutionary approach. Sunderland, Massachusetts: Sinauer Associates, Inc.

Allen, G. T. and R. L. Knight. 1984. Vegetation and topography of bald eagle nest sites in northwestern Washington, p. 14 in R. G. Anthony, F. B. Isaacs, and R. Frenzel (eds.). Proceedings of a Workshop on Habitat Management for Nesting and Roosting Bald Eagles in the Western United States. Oregon Cooperative Wildlife Research Unit. Oregon State Univ., Corvallis.

Anthony, R. G. and F. B. Isaacs. 1984. Characteristics of nesting habitat -- mixed habitat type, Oregon. p. 16 in R. G. Anthony, F. B. Isaacs, and R. Frenzel (eds.). Proceedings of a Workshop on Habitat Management for Nesting and Roosting Bald Eagles in the Western United States. Oregon Cooperative Wildlife Research Unit. Oregon State Univ., Corvallis.

Barber, S., H. A. Stelfox, and G. Brewster. 1983. Bald eagle ecology in relation to potential hydro-electric development on the Churchill River, Saskatchewan. in J.M. Gerrard and T.N. Ingram (eds.). The Bald Eagle in Canada. Proceedings of Bald Eagle Days, 1983. Winnipeg, Manitoba.

Bennetts, R. E. 1986. Age-related differences in spatial distribution and behavior of bald eagles during the autumn concentration at Glacier National Park, Montana. Undergraduate Thesis. Univ. of Montana, Missoula. 112pp.

BioSystems Analysis, Inc. 1985. Pit 3, 4, and 5 project bald eagle and fish study. Pacific Gas and Electric Co. Final Report. Univ. of Ca., Davis. pp.

Cain, S. L. 1985. Nesting activity time budgets of bald eagles in southeast Alaska. M. S. Thesis. Univ. of Montana, Missoula. 47pp.

Craig, R. J., E. S. Mitchell, and J. E. Mitchell. 1988. Time and energy budgets of bald eagles wintering along the Connecticut River. J. Field Ornithol. 59(1):22-32.

Crenshaw, J. G. 1985. Characteristics of bald eagle communal roosts in Glacier National Park, Montana. M.S. Thesis. Univ. of Montana, Missoula. 85pp.

Durham, K. 1981. Injuries to birds of prey caught in leghold traps. Int. J. Anim. Prob. 2(6):317-328.

Flath, D. and R. Hazelwood. 1986. Up, up, and away - Montana's soaring eagles. Montana Outdoors. May/June 1986. Vol 17 No 3.

Fraser, J. D. 1983. The impact of human activities on bald eagle populations - a review. in J.M. Gerrard and T.N. Ingram (eds.). The Bald Eagle in Canada. Proceedings of Bald Eagle Days, 1983. Winnipeg, Manitoba.

______., L. D. Frenzel, and J. E. Mathisen. 1985. The impact of human activities on breeding bald eagles in north-central Minnesota. J. Wildl. Manage. 49(3):585-592.

Frenzel, R. W. 1984a. Environmental contaminants and ecology of bald eagles in southcentral Oregon. Ph.D. Thesis, Oregon State Univ., Corvallis. 143pp.

Frenzel, R. 1984b. Spacing of nest sites and foraging areas of bald eagles. p. 18 in R. G. Anthony, F. B. Isaacs, and R. Frenzel (eds.). Proceedings of a Workshop on Habitat Management for Nesting and Roosting Bald Eagles in the Western United States. Oregon Cooperative Wildlife Research Unit. Oregon State Univ., Corvallis.

Garrett, M., R. G. Anthony, J. W. Watson, and K. McGarigal. 1988. Ecology of bald eagles on the lower Columbia River. Final report to the U.S. Army Corps of Engineers. Portland, Oregon. 189pp.

Gerrard, J. M., and G. R. Bortolotti. 1988. The bald eagle, haunts and habits of a wilderness monarch. Washington and London: Smithsonian Institution Press.

Gerrard, J. M., P. N. Gerrard, and D. W. A. Whitfield. 1980. Behavior in a nonbreeding bald eagle. Canadian Field-Naturalist 94:391-397.

Gerrard, P. N., J. M. Gerrard, and G. R. Bortolotti. 1983. The impact of road development on a bald eagle population at Besnard Lake, Saskatchewan. pp.160-165 in J.M. Gerrard and T.N. Ingram (eds.). The Bald Eagle in Canada. Proceedings of Bald Eagle Days, 1983. Winnipeg, Manitoba.

Grier, J. W. 1982. Ban of DDT and subsequent recovery of reproduction in bald eagles. Science 218:1232-1234.

Griffin, C. R. 1978. The ecology of bald eagles wintering at Swan Lake National Wildlife Refuge, with emphasis on eagle-waterfowl relationships. Ph.D. Thesis, Univ. Missouri. 185pp.

Grubb, T. G., and G. T. Allen. 1984. Methodology, available information, and research needs for nesting habitats. pp.26-28 in R. G. Anthony, F. B. Isaacs, and R. Frenzel (eds.). Proceedings of a Workshop on Habitat Management for Nesting and Roosting Bald Eagles in the Western United States. Oregon Cooperative Wildlife Research Unit. Oregon State Univ., Corvallis.

Grubb, T. G., and W. L. Eakle. 1984. Characteristics of bald eagle nesting habitat in the Sonoran desert type of Arizona. p. 19 in R. G. Anthony, F. B. Isaacs, and R. Frenzel (eds.). Proceedings of a Workshop on Habitat Management for Nesting and Roosting Bald Eagles in the Western United States. Oregon Cooperative Wildlife Research Unit. Oregon State Univ., Corvallis.

Habeck, J. R. 1970. The vegetation of Glacier National Park. Univ. Montana, Dep. Botany, Missoula. 132pp.

Hansen, A. J. 1984. Behavioral ecology of bald eagles along the Pacific Northwest Coast: a landscape perspective. Ph.D. Dissertation, Univ. of Tennessee, Knoxville. 162pp.

Harmata, A. R. 1984. Bald eagles of the San Luis Valley, Colorado: their winter ecology and spring migration. Ph.D. Thesis, Montana State Univ., Bozeman. 222pp.

Harvey, M. J. and R. W. Barbour. 1965. Home range of Microtus ochrogaster as determined by a modified minimum area method. J. Mamm. 40(3):398-492.

Juenemann, B.G. 1973. Habitat evaluation of selected bald eagle nest sites on the Chippewa National Forest. M.S. Thesis, Univ. Minnesota, St. Paul. 170pp.

Keister, G. P., R. G. Anthony, and E. J. O'Neill. 1987. Use of communal roosts and foraging areas by bald eagles wintering in the Klamath Basin. J. Wildl. Manage. 51(2):415-420.

Knight, R. L., and S. K. Knight. 1984. Responses of wintering bald eagles to boating activity. J. Wildl. Manage. 48(3):999-1004.

Lehman, R. N., D. E. Craig, P. L. Collins, and R. S. Griffen. 1980. An analysis of habitat requirements and site selection criteria for nesting bald eagles in California. Rep. by Wilderness Research Inst. for U.S. Forest Service. 90pp.

Mahaffy, M. S. 1981. Territorial behavior of the bald eagle on the Chippewa National Forest. M.S. Thesis, Univ. Minnesota, St. Paul. pp.

Marler, S. 1986. Bald eagles and poaching: threat to an American symbol. Western Wildlands 11(4):2-6.

Marnell, L. F., R. J. Behnke, and F. W. Allendorf. 1987. Genetic identification of cutthroat trout, Salmo clarki, in Glacier National Park, Montana. Canadian Journal of Fisheries and Aquatic Sciences 44(11):1830-1839.

Marnell, L. F. 1988. Status of the westslope cutthroat trout in Glacier National Park, Montana. In Biology and management of interior cutthroat trouts. American Fisheries Society, Western Division, Special Publication.

Mathisen, J. E. 1968. Effects of human disturbance on nesting of bald eagles. J. Wildl. Manage. 32(1):1-6.

Mattsson, J. P. 1974. Interaction of a breeding pair of bald eagles with subadults at Sucker Lake, Michigan. M.S. Thesis, St. Cloud State College, Minnesota.

McClelland, B. R., P. T. McClelland, and J. G. Crenshaw. 1984. Ecology of bald eagles associated with the autumn concentration in Glacier National Park, Montana. 1982-1983 Progress Report and Basic Data Summary. U.S.D.I. National Park Service and School of Forestry, unpubl. Univ. of Montana, Missoula. 85pp.

McEwan, L. C. and D. H. Hirth. 1979. Southern bald eagle productivity and nest site selection. J. Wildl. Manage. 43(3):585-594.

McGarigal, K., R. G. Anthony, and F. B. Isaacs. Experiments on bald eagle response to human activity.

Paper presented at Raptor Research Foundation, Inc. Annual Meeting, Boise, Idaho; 1987.

Montana Bald Eagle Working Group. 1986. Montana bald eagle management plan. U.S.D.I. Bureau Land Manage.; Billings, Mont. 61pp.

Morton, W. M. 1968. Fishery management program, McDonald unit, Glacier National Park. U.S. Fish and Wildlife Service Review report No. 7. Unpubl. Glacier National Park files. 196pp.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, S.D. 399pp.

Oakleaf, R. and G. Silovsky. 1984. Management plans for nest sites and nesting populations. pp. 29-33 in R. G. Anthony, F. B. Isaacs, and R. Frenzel (eds.). Proceedings of a Workshop on Habitat Management for Nesting and Roosting Bald Eagles in the Western United States. Oregon Cooperative Wildlife Research Unit. Oregon State Univ., Corvallis.

Ofelt, C. H. 1975. Food habits of bald eagles in southeast Alaska. Condor 77(3):337-338.

Postupalsky, S. 1974. Raptor reproductive success: some problems with methods, criteria, and terminology. Pages 21-31 in F. N. Hamerstrom, Jr., B. E. Harrell, and R. R. Ohlendorff (eds.). Management of Raptors. Proc. Conf. Raptor Conserv. Tech., Raptor Research Rep. No. 2, Raptor Research Found., Vermillion, S.D.

Rettig, N. L. 1978. Breeding behavior of the harpy eagle (*Harpia harpyja*). AUK 95:629-643.

Ruder, M. Planes spray McDonald forest in Glacier. The Hungry Horse News. 1957 July 26:12(1):ppl and 4.

Saunders, A. A. 1921. A distribution list of the birds of Montana with notes on the migration and nesting of better known species. Pacific Coast Avifauna. Cooper Ornithol. Club. Berkeley. 194pp.

Shea, D. S. 1973. A management-oriented study of bald eagle concentrations in Glacier National Park. M.S. Thesis, Univ. Montana, Missoula. 78pp.

Skagen, S. 1980. Behavioral responses of wintering bald eagles to human activity on the Skagit River, Washington. Pages 231-242 in R. L. Knight, G. T. Allen, M. V. Stalmaster, and C. V. Servheen (eds.). Proceedings of the Washington Bald Eagle Symposium. The Nature Conservancy, Seattle, Wash.

Smith, T. J., D. N. Chester, J. D. Fraser, and D. F. Stauffer. Effects of human activities on bald eagle distribution and abundance at Jordan Lake, North Carolina. Paper presented at Raptor Research Foundation, Inc. Annual Meeting. Boise, Idaho; 1987.

Stalmaster, M. V. 1976. Winter ecology and effects of human activity on bald eagles in the Nooksack River Valley, Washington. M.S. Thesis, Western Washington State College, Bellingham. 100pp.

______. 1983. An energetics simulation model for managing wintering bald eagles. J. Wildl. Manage. 47:349-359.

______. 1987. The bald eagle. New York: Universe Books.

______., and J. R. Newman. 1978. Behavioral responses of wintering bald eagles to human activity. J. Wildl. Manage. 42(3):506-513.

Steenhof, K., and F. Isaacs. 1984. Identification of potential habitat. pp.37-40 in R. G. Anthony, F. B. Isaacs, and R. Frenzel (eds.). Proceedings of a Workshop on Habitat Management for Nesting and Roosting Bald Eagles in the Western United States. Oregon Cooperative Wildlife Research Unit. Oregon State Univ., Corvallis.

Steenhof, K., S. S. Berlinger, and L. H. Fredrickson. 1980. Habitat use by bald eagles in South Dakota. J. Wildl. Manage. 44(4):798-805.

Stuwe, M., and C. E. Blowhowiak. 1986. Micro computer program for the analysis of animal locations. Conserv. and Res. Cent. Natl. Zool. Park, Smithsonian Inst., Washington, DC. 18pp.

Swenson, J. E., K. L. Alt, and R. L. Eng. 1986. Ecology of bald eagles in the Greater Yellowstone Ecosystem. Wildl. Monogr. 95, 1-46. The Wildlife Society.

Todd, C. S., L. S. Young, R. B. Owen, Jr., and F. J. Gramlich. 1982. Food habits of bald eagles in Maine. J. Wildl. Manage. 46:636-645.

U.S. National Park Service. Land protection plan Glacier National Park. Unpubl. Rep., Natl. Park Serv., Glacier National Park. 1985. 60pp.

______. 1986. Development concept plans for Lake McDonald, Sun Point/Rising Sun/St. Mary, and the Many Glacier/Swiftcurrent areas of Glacier National Park, Montana. U.S. Government Printing Office, Washington, D.C. 773-038/40,013. USDI. 91pp.

U.S. Fish and Wildlife Service. 1980. Fishery investigations Glacier National Park 1980 progress document. Unpubl. Rep., Northwest Montana Fishery Center, Kalispell, Montana. 352pp.

______. 1986. Recovery Plan for the Pacific Bald Eagle. U.S. Fish and Wildlife Service, Portland, Oregon. 160pp.

Wasem, C. R. 1964. A brief history of fish management in Glacier National Park. Unpubl. Rep. to the Superintendent, Glacier National Park. Glacier National Park files. 15pp.

______. 1970. Identification and general distribution of the eleven sport fish species of Glacier National Park. Special Fishery Res. Report No. 2.

Wherry, D. B., J. A. Hart, C. H. Key, and S. A. Bain. 1985. An operational interagency GIS: the Glacier National Park/Flathead National Forest project. pp.58-67 in Proceedings for PECORA 10 Remote Sensing in Forest and Resource Management. Ft. Collins, Colo.

Young, L. S. 1983. Movements of bald eagles associated with autumn concentrations in Glacier National Park. M.S. Thesis, Univ. of Montana, Missoula. 102pp.

Zande, A. N. van der, and T. J. Verstrael. 1985. Impacts of outdoor recreation upon nest-site choice and breeding success of the kestrel. Ardea 73(1):90-99.

APPENDICES

Appendix 1. Data form for bald eagle locations and activities.

BALD EAGLE ACTIVITIES FORM

YEAR	DAY	LOC.	BEGIN OBS.	END OBS.	TOTAL OBS.	OBS. LOC.	TEMP	PRECIP.	CLOUD	WIND SP.	WIND DIR.	FORM

BEGIN TIME	INDIVIDUAL	MAIN ACT.	LOCATION	CON. ACT.	CAPT. SUCC.	PREY SPP.	END TIME	TOTAL TIME	COMMENTS:

WILDLIFE OBSERVATIONS:	TIME	SPECIES	#	LOC.	

Appendix 2. Dbase III+ file structure for 01's perch-site locations.

Structure for database: D:a01loc.dbf
Number of data records: 3662
Date of last update : 02/09/88

Field	Field Name	Type	Width	Dec
1	YEAR	Numeric	2	
2	REC_NO	Numeric	5	
3	DAY	Numeric	3	
4	UTMN	Numeric	9	
5	UTME	Numeric	9	
6	LOC_NAME	Character	5	
7	TIMEINITI	Numeric	4	
8	DURATION	Numeric	4	
9	BIRD	Character	2	
10	COMMENT	Character	10	
** Total **			54	

Appendix 3. Management recommendations for tour-boat operation on LM.

United States Department of the Interior
NATIONAL PARK SERVICE
GLACIER NATIONAL PARK
WEST GLACIER, MONTANA 59936

IN REPLY REFER TO:

C3801
xN1621

July 25, 1988

Mr. Art Burch, Jr.
Glacier Park Boat Company
P.O. Box 5262
Kalispell, Montana 59903

Dear Art:

Researchers and resource managers monitoring bald eagle activities on lakes within Glacier National Park have observed that eagles will fly from the perch site when approached too closely or directly by boats. Food requirements of eagles are very high, especially when nesting, and flushing a perched eagle results in unnecessary energy expenditure. While certain periods may be more critical than other periods, we request that the procedures outlined below be followed throughout the operating season. These procedures should be implemented immediately if you have not done so already.

Tour boats should never directly approach a perched eagle. The boats should pass the eagle by traveling parallel to the lakeshore, without stopping, at a minimum distance of 200 meters from the perched eagle(s). This manner of operation will minimize the disturbance to foraging eagles while still providing visitors opportunities to view eagles. Please explain to your passengers the eagles' food requirements and how maintaining some distance will help this endangered species.

These procedures are especially applicable to your Lake McDonald operation, but may also apply on St. Mary Lake. Your manner of informing visitors that there are nesting eagles in the Lake McDonald valley, without specifically pointing out the nest site, is well done and very much appreciated. Your cooperation regarding these procedures will be much appreciated as well.

Sincerely,

Sandra H. Key
Assistant Superintendent

bcc: Resource Mgt. Spec., Lange
Supv. Park Ranger, Seeley
Supv. Park Ranger, Koehn
Supv. Park Ranger, Bellamy
Supv. Park Ranger, Decker
Research Biologist, McClelland

Unusual Leg Injury in a Nestling Bald Eagle: Effects on Behavior, and Relationship to a Sonic Boom

by

Richard E. Yates

Chapter II

Note: This paper was submitted to the Journal of Raptor Research for publication as a Short Communication in May 1988.

ABSTRACT

An unusual tarsometatarsal joint dislocation occurred in a nestling Bald Eagle (*Haliaeetus leucocephalus*) at Lake McDonald in Glacier National Park, Montana in 1985. The deformed leg was first noticed when the 8-wk-old nestling was banded; however, the mechanical dislocation probably occurred during the first 2 wk after hatching. When the nestling was 8 d old a sonic boom disturbed the brooding adult and its sudden movement may have caused the injury. The dislocation may have contribuated to late fledging (15 wk).

In this paper I report a tarsometatarsal joint dislocation and its subsequent effects on a nestling Bald Eagle (Haliaeetus leucocephalus); I also speculate about the cause of the injury. Leg joint dislocations in raptors are uncommon; most occur at the hip joint in tethered, captive raptors (P. Redig, Raptor Research and Rehabilitation Program (RRRP), University of Minnesota, pers. comm.). The RRRP has treated only 2 tarsometatarsal joint dislocations within the past 15 years and at the National Wildlife Health Lab (Madison, Wisconsin) this type of injury is rare (N. Thomas, pers. comm.).

None of the following Bald Eagle banders have documented a tarsometatarsal joint luxation: R. Anthony and associates, after banding 150 nestlings in Oregon; S. Cain, 175 nestlings in Alaska; J. Grier, 1000 nestlings in Ontario; T. Grubb, 300 nestlings in Arizona and Washington; A. Harmata, 135 nestlings in Wyoming; S. Postupalsky, 1500 nestlings in Michigan; and C. Sindelar and D. Evans, 3100 nestlings in Wisconsin.

Observations during prenesting, incubation, and the nestling period, 16 March-29 August, and during post-fledging, 30 August-4 September 1985, totaled 1038 hr at the Lake McDonald Site in Glacier National Park (GNP), Montana. Observations were made with a spotting scope 2-3 km from the nest, a distance which did not interfere with adult nesting and foraging activity.

Incubation commenced on 11 April and 35 d later changes in adult behavior indicated that at least one egg had hatched (Bortolotti, G.R., J.M. Gerrard, P.N. Gerrard, and D.W.A. Whitfield. Minimizing investigator-induced disturbance to nesting Bald Eagles. pp. 85-103 in J.M. Gerrard and T.N. Ingram (editors). The Bald Eagle in Canada-proceedings of Bald Eagle days, 1983). I was unaware that the eaglet was crippled until I banded the 8-wk-old nestling on 10 July. This first close look revealed that the bird's right leg was deformed. The tarsus and foot were rotated 90 deg with the hallux pointing inward, and the tarsometatarsal joint was noticeably swollen. Although the young bird could sit on the crippled leg, it could not extend the leg to a normal standing position. The foot and talons were useless for perching, or grasping prey (Fig. 1).

The eaglet's dislocation probably occurred within 14 d after hatching, when distorting forces would likely cause a separation at the distal cartilaginous growth plate (P. Redig, pers. comm.). Such forces could have resulted from the brooding adult inadvertantly stepping on the eaglet, or from the eaglet trying to extract its leg from between nest sticks.

Only one disturbance was recorded during the 14 d post-hatching. When the chick was 8 d old (24 May at 1053

H), an extremely loud sonic boom originated approximately 10 km from the nest. The noise caused the brooding adult to vault to a standing position and look toward the disturbance source. I could not see the nestling, but the unusual brooding and feeding activity subsequent to the disturbance indicated that the adults were greatly disturbed and may have inadvertently injured the chick during that time.

Prior to 24 May, continuous brooding was observed and feedings averaged 0.4 bouts per hr. Immediately after the sonic boom, the attending adult moved to the nest edge for 20 min but returned to feed the nestling 3 times in the next 45 min. This was the most frequent feeding observed. The third feeding bout lasted 18 min, the longest bout recorded during the first 26 d of the nestling period. Just prior to the third feeding bout, the adult left the nest for 1 min (the first record of the chick being unattended for even a brief period). The adult did not return to a brooding posture during the entire 3.5 hr observation interval following the disturbance. This was the most extended non-brooding period until 31 May. Later, between 1800 and 2107 H, the adults exchanged brooding and young-tending 3 times. I did not record any other brooding substitutions that were made as frequently. Brooding time during this period ranged from 1-23 min; no other broodings as brief were recorded. The frequent feedings and brooding exchanges, and the adults' agitated behavior following the sonic boom were dissimilar to observations made prior to the sonic boom. I observed similar agitated behavior the following year, 14 April 1986, after a raven (Corvus corax) consumed at least one eagle egg at the same nest.

Considering the unusual behavior of the Lake McDonald adults immediately following the sonic boom, I believe that the boom probably resulted in the eaglet's injury. I recognize that the evidence linking this eaglet's injury to a sonic boom is circumstantial. However, T. Grubb (pers. comm.) found that nesting Bald Eagles in Arizona reacted to sonic booms (N=77) 58% of the time by becoming alert or by flying. Ellis (Responses of raptorial birds to low level military jets and sonic booms. unpubl. U.S. Air Force-U.S. Fish and Wildlife Service Study. 59pp, 1981) determined that sonic booms were disruptive to nesting Peregrine Falcons (Falco peregrinus) in Arizona and caused some adults to flee their nests. He also stated that eggs or tiny young may be dislodged from a nest by a fleeing adult.

The injured leg was an obvious handicap to the eaglet during the late nestling period when it could be seen hobbling across the nest. The eaglet often balanced on its normal leg, with the crippled leg held close to the abdomen (Fig. 2). The only leg movement was to flex toes, and the eaglet had difficulty feeding itself. The eaglet first attempted to feed itself at 6 wk post-hatching; the adults continuined to feed it intermittently until 13 wk post-hatching (2 wk prior to fledging). Cain (Nesting activity time budgets of Bald Eagles in Southeast Alaska. M.S. Thesis. University of Montana, Missoula. 47 pp, 1985) reported that nesting Bald Eagles in Alaska fed young until they fledged.

Exercise bouts (wing-flapping and bounding) increased in frequency during July and August, with the highest number of bouts (26) occurring on the day of fledging, 29 August. At 1712 H the eaglet fell from the nest during a flapping bout, clung to the edge of the nest with its normal leg, and finally flapped back into the nest several seconds later. Wing-flapping continued every 15-20 min for the next hr. At 1857 H the eaglet returned to the center of the nest and remained in a resting posture until 1945 H. It then hopped to the northwest rim of the nest in a single bound, extended its wings, and flew at 1946 H. Only a few wing-flaps were observed as the fledgling glided over the trees for 10-15 s before dropping out of view into the surrounding old-growth forest canopy. Normal fledging of bald eagles occurs at 10-12 wk (Brown, L.H., and D. Amadon. Eagles, hawks and falcons of the world. 2 vols. New York. 1968). The crippled eaglet fledged from the Lake McDonald nest 15 wk (105 d) after hatching.

The adults were not seen in the McDonald Valley for 2 d prior to the fledging date and the eaglet had not fed for 35 hr before it left the nest. At 0715 H on 30 August we found the bird on the ground, about 200 m east of the nest tree. The adults returned to the nest area at 1412 H and flew into the forest near the fledgling. They left the area 1 hr 43 min later, and were not observed on the territory again until 12 October.

By 1430 H on 1 September the fledgling arrived at the Lake McDonald shoreline 400 m directly downslope from the nest tree. The eaglet made a 30 m flight and hobbled to the lakeshore through thick undergrowth after crossing a nearby road. It appeared exhausted as it flew to a tree along the shore and tried to perch. By 1330 H on 2 September the eaglet moved 400 m downshore near several private homes. It could fly up to 100 m but could not perch in a tree; instead, it hung from branches by its wings, eventually tumbling to lower branches or to the ground.

On 3 September I captured the juvenile and relocated it near one of the adults' frequently used perches, 1 km south of the private homes. I hoped that the adults would return to this more secluded spot and care for the young bird. When the adults did not return to the territory by 1400 H on 4 September, I recaptured the eaglet, convinced that it could not survive in the wild, and prepared to ship it to the RRRP.

The eagle was fed for 2 d at GNP Headquarters and inspected by a local veterinarian before shipment on 6 September. Dr. Pat Redig, RRRP, determined that the injury could not be corrected and the fledgling was euthanized. A necropsy revealed that the eaglet had a severe luxation of its right tarsometatarsal joint and was emaciated. The specimen was donated to the University of Montana Zoological Museum (Missoula).

Acknowledgments

I thank R. McClelland, E. Caton, P. McClelland, and R. Bennetts for field work, support, and suggestions. The National Park Service provided partial funding support. GNP Rangers D. O'Brien and M. Ober helped with logistics. Northwest Orient Airlines shipped the injured eaglet without charge. G. McFarland prepared illustrations. Dr. P. Redig contributed valuable advice and I appreciated his efforts to save the injured eaglet. Constructive comments on an earlier draft were made by R. Dunsmore, R. Hutto, K. Keating, C. Key, R. McClelland, P. Redig, and H. Zuuring.

Figure 1. Nestling Bald Eagle (8 wks) showing rotated right foot and tarsus (arrow points to rotated hallux).

Figure 2. Fledgling Bald Eagle (16 wks) showing rotated right foot and tarsus, and elevated position of leg (arrow points to rotated hallux).

Fig. 1.

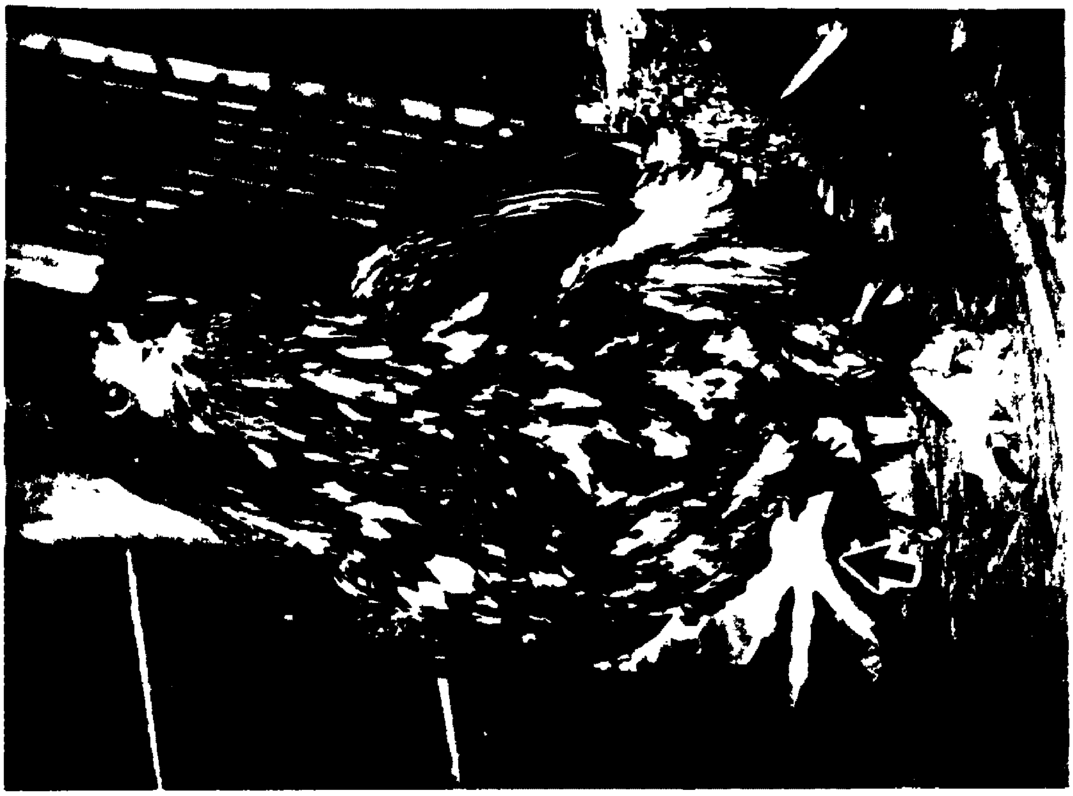


Fig. 2.