

WINTERING BALD EAGLE TRENDS IN NORTHERN ARIZONA, 1975–2000

TERYL G. GRUBB*

United States Department of Agriculture, Forest Service, Rocky Mountain Research Station,
2500 South Pine Knoll Drive, Flagstaff, AZ 86001-6381

*Correspondent: tgrubb@fs.fed.us

ABSTRACT—Between 1975 and 2000, 4,525 sightings of wintering bald eagles (*Haliaeetus leucocephalus*) were recorded at Mormon Lake in northern Arizona. Numbers of wintering eagles fluctuated little in the 20 years from 1975 through 1994 (5.5 ± 3.0 mean sightings per day). However, during the winters of 1995 through 1997 local record highs of 59 to 118 eagles increased mean sightings per day to 22.4 ± 9.6 . This dramatic population increase led to a major change in social behavior favoring consistent communal roosting; maximum roost counts of 2 to 8 eagles scattered among 11 roosts in prior years shifted to maximums of 33 to 45 eagles regularly using 2 roosts during 1996 and 1997. Winter population averaged 58% adults and 42% immatures, but during 5 recent years of greatest numbers (≥ 40 eagles in 1989, 1995 through 1997, and 2000), the proportion of immatures increased to 58%. Local increases in the wintering eagle population at Mormon Lake were largely attributable to this greater proportion of immature bald eagles. Both age classes peaked in February, with adults more abundant during October through December and immatures more abundant from January through April. Weekly maximum counts for 1995 through 1997 indicated changing weather and prey conditions resulted in annual variation in local numbers and habitat use of wintering bald eagles.

RESUMEN—Entre 1975 y 2000, 4,525 avistamientos invernales de águilas calvas (*Haliaeetus leucocephalus*) fueron registrados en Mormon Lake en el norte de Arizona. Los números de águilas invernales fluctuaron poco en los 20 años entre 1975 y 1994 (5.5 ± 3.0 avistamientos promedio por día). Sin embargo, durante los inviernos de 1995–1997 altos registros locales de 59–118 águilas incrementaron el promedio de avistamientos por día a 22.4 ± 9.6 . Este aumento dramático de la población condujo a un cambio importante en el comportamiento social que favorecía pasar la noche en un sitio comunal consistentemente; las cuentas máximas de 2–8 águilas durmiendo juntas en 11 sitios en años anteriores cambiaron a un máximo de 33 a 45 águilas regularmente usando 2 sitios para dormir durante 1996 y 1997. La población del invierno promedió 58% adultos y 42% inmaduros, pero durante cinco años recientes de números altos (≥ 40 águilas en 1989, 1995–1997, y 2000), la proporción de inmaduros aumentó a 58%. Los aumentos locales en la población invernal del águila en Mormon Lake se atribuyeron en gran parte a esta mayor proporción de águilas calvas inmaduras. Ambos grupos de edad alcanzaron su máximo en febrero, con los adultos más abundantes desde octubre hasta diciembre y los inmaduros más abundantes desde enero hasta abril. Las cuentas semanales máximas de 1995–1997 indicaron que las condiciones cambiantes de clima y de presa resultaron en variación anual de números locales y el uso de hábitat de águilas calvas invernantes.

Consideration of bald eagle (*Haliaeetus leucocephalus*) winter ecology has been an important factor in the protection and recovery of this species in the contiguous United States (Spencer, 1976). Surveys of wintering eagles in Arizona began in the late 1970s and were conducted by various private, state, and federal organizations (Pramstaller et al., 1980; Todd, 1981; Grubb and Kennedy, 1982a, respectively). However, long-term trends and status of

wintering populations in Arizona, as in many western states, remained uncertain (Gerrard, 1983). In recent years, the Arizona Game and Fish Department (AGFD) has coordinated annual statewide counts of wintering bald eagles each January, with an average of 288 eagles (range = 186 to 363) tallied from 1992 through 1998 (Beatty and Driscoll, 1999).

As part of long-term research on seasonal changes in population dynamics, roosting hab-

itat, and foraging ecology (Grubb and Kennedy, 1982*b*; Grubb et al., 1989; Grubb et al., 1994), I have recorded and collected wintering bald eagle sightings on the Coconino National Forest (CNF) in northern Arizona since the mid-1970s. An average of 22% (range 17 to 26%) of the Arizona January count occurs on the CNF, and more than half of the CNF sightings come from Mormon Lake (Grubb, 1996). Mormon Lake (~1,000 ha) is the largest lake on the CNF and it, along with several nearby smaller lakes, is a focal point for wintering eagles. Nearly continuous winter sighting data for Mormon Lake since 1975 provided a unique opportunity to evaluate long-term wintering bald eagle trends in northern Arizona.

METHODS—Study Area—The 728,000-ha CNF lies within Coconino and Yavapai counties on the Colorado Plateau. Elevation ranges from 1,000 to 2,500 m in gentle to steep mountainous terrain (Chronic, 1983). Dominant vegetation is Rocky Mountain Montane Conifer Forest comprised of ponderosa pine (*Pinus ponderosa*) associations, with mixed conifer associations of Douglas and white fir (*Pseudotsuga menziesii* and *Abies concolor*) at higher elevations, and Great Basin Conifer Woodland/pinyon-juniper associations (*Pinus edulis-juniperus scopulorum*) at lower elevations (Brown, 1982). Located 34 km south of Flagstaff, Arizona, Mormon Lake lies in a shallow depression surrounded by mountainous, forested terrain. Habitat surrounding Mormon Lake is primarily ponderosa pine forest with some grassland to the east; elevation is 2,134 m. Size and depth of this shallow lake (<2 m) vary annually.

Because of extensive emergent vegetation, the lake is used by waterfowl in the late fall and early spring, and sporadically through the winter depending on surface freezing and thawing. Until Mormon Lake completely dried prior to the winter of 1997, several species of warm-water fishes (including perch, *Perca flavescens*; catfish, *Ictalurus*; bluegill, *Lepomis macrochirus*; northern pike, *Esox lucius*) and the feral fathead minnow (*Pimephales promelas*) were also present. The lake only partially refilled before the winter of 1998 and was devoid of fish. By the winter of 2000, fathead minnows had become reestablished in the lake, but the water level remained low (<25% capacity).

Study Design—Sighting data were recorded during 26 winters from 1975 through 2000. A winter was defined as October from the preceding year through April of the designated year. A sighting was an observation of one bald eagle within 2.2 km of Mormon Lake (distance to farthest associated roost) during any continuous period of observation. When

sightings were recorded for more than one time period in a day, or when more than one observer reported different numbers for the same time period, I used the maximum count for each age class (adult, immature, unknown) within the time period. White-headed bald eagles were classified as adults, all others as immatures. I eliminated duplicate sightings among multiple observers on the basis of time and location. Because the entire lake was visible from the main road and a favored observation overlook, sightings for each discrete time period were assumed to represent complete coverage regardless of observer. Most data were recorded by or reported to United States Department of Agriculture, Forest Service personnel, incidental to other research and management activities. Early AGFD survey data supplemented limited sighting records for 1977 and 1979 through 1981 (Todd, 1980, 1981). No eagles were observed in 1979 on only one recorded observation day. Otherwise, observation days without sightings were not recorded in years when eagles were present.

Sighting totals were unstandardized for the actual number of eagles present and variable observation efforts. However, numbers of days when eagles were recorded gave a relative indication of observation effort, and mean sightings per day indicated the average number of eagles seen on any given day during the associated winter. Maximum counts represented my best estimate of actual numbers of eagles present. Highest maximum counts per day within the designated time frame facilitated comparisons among years, months, and weeks. I calculated annual proportions (%) of adults and immatures by dividing maximum counts for each age class for each year by the sum of the immature and adult maximum counts for that year. Eagles of unknown age class were excluded from these calculations. I used notched box and whisker plots to verify apparent differences in maximum counts between peak and non-peak years (Chambers et al., 1983), a Chi-square test to compare variations in age-class proportions, and Spearman's rank correlation coefficient (r_s) to evaluate the association between the proportion of immatures and overall numbers of eagles (SPSS, 1999). Means are reported \pm standard deviations (*SD*).

RESULTS—Between 1975 and 2000, 4,525 sightings of wintering bald eagles (1,734 adult, 2,425 immature, 366 unknown) were recorded at Mormon Lake during 317 observation days (Table 1, Fig. 1). Mean sightings averaged 8.1 ± 7.8 per day. Numbers of wintering eagles fluctuated little in the 20 years from 1975 through 1994 (5.5 ± 3.0 mean sightings per day). However, during the winters of 1995

TABLE 1—Wintering bald eagle sightings, maximum counts/day, and age class composition at Mormon Lake in northern Arizona, 1975 through 2000.

| Year | Sightings | Days ^a | Mean sightings/day ^a (SD) | Maximum count/day ^b | Age class (%) | |
|--------|-----------|-------------------|---|--------------------------------|---------------|----------|
| | | | | | Adult | Immature |
| 1975 | 13 | 1 | 13.0 (—) | 13 | 81 | 69 |
| 1976 | 7 | 3 | 2.3 (1.5) | 4 | 80 | 20 |
| 1977 | 49 | 5 | 9.8 (19.7) | 45 | 75 | 25 |
| 1978 | 58 | 7 | 8.3 (7.7) | 17 | 44 | 56 |
| 1979 | 0 | 1 | 0 (—) | 0 | — | — |
| 1980 | 16 | 3 | 5.3 (4.9) | 6 | 33 | 67 |
| 1981 | 40 | 7 | 5.7 (10.3) | 31 | 45 | 55 |
| 1982 | 12 | 3 | 4.0 (2.6) | 6 | 33 | 67 |
| 1983 | 44 | 11 | 4.0 (4.0) | 14 | 75 | 25 |
| 1984 | 15 | 3 | 5.0 (4.4) | 10 | 89 | 11 |
| 1985 | 6 | 2 | 3.0 (1.4) | 4 | 60 | 40 |
| 1986 | 25 | 4 | 6.2 (7.3) | 17 | 71 | 29 |
| 1987 | 18 | 3 | 6.0 (8.7) | 16 | 19 | 81 |
| 1988 | 3 | 1 | 3.0 (—) | 3 | 67 | 33 |
| 1989 | 161 | 15 | 10.7 (10.8) | 40 | 46 | 54 |
| 1990 | 170 | 28 | 6.1 (7.0) | 28 | 61 | 39 |
| 1991 | 39 | 9 | 4.3 (3.8) | 10 | 67 | 33 |
| 1992 | 25 | 8 | 3.1 (3.4) | 10 | 91 | 9 |
| 1993 | 25 | 7 | 3.6 (3.3) | 10 | 77 | 23 |
| 1994 | 44 | 6 | 7.3 (9.3) | 26 | 76 | 24 |
| 1995 | 1,842 | 54 | 34.1 (29.3) | 118 | 41 | 59 |
| 1996 | 1,080 | 48 | 22.5 (18.9) | 66 | 52 | 48 |
| 1997 | 322 | 30 | 10.7 (15.8) | 59 | 55 | 45 |
| 1998 | 54 | 21 | 2.6 (1.6) | 7 | 71 | 29 |
| 1999 | 85 | 23 | 3.7 (3.8) | 18 | 64 | 36 |
| 2000 | 372 | 14 | 26.6 (27.0) | 75 | 22 | 78 |
| Totals | 4,525 | 317 | 8.1 ^c (7.8) | 25 ^d | 58 | 42 |

^a Days when bald eagles were present and sightings were recorded; observation dates without sightings were not recorded in years when eagles were present.

^b Includes adult, immature, and unknown age-class bald eagles.

^c Average of annual means rather than quotient of total sightings divided by total days, which was skewed unrealistically upward by the unusually high numbers of sightings in 1995 through 1997 and 2000.

^d Rounded mean of annual maximum counts, 25.1 ± 27.1 .

through 1997, local record highs of 59 to 118 eagles resulted in mean sightings per day increasing to 22.4 ± 9.6 (Fig. 2a). The 1995 February peak of 118 eagles at Mormon Lake accounted for 48% of the 248 wintering bald eagles recorded statewide a month earlier (Beatty and Driscoll, 1999). Prior to 1995, >20 eagles were recorded only 5 times, with just 2 counts ≥ 40 . Since 1995, >50 eagles were recorded in 4 of 6 succeeding years, although sightings per day dropped to 3.2 ± 0.6 during the winters of 1998 and 1999.

Adults outnumbered immatures in 18 of the 26 years of data collection (Table 1). The average proportions of adults and immatures

were 58% and 42%, respectively. However, during 5 of the 6 years of greatest eagle numbers (≥ 40 in 1989, 1995 through 1997, and 2000; age class was not recorded in 1975), the average proportion of immatures increased to 58% (Fig. 2b; $\chi^2 = 10.5$, $df = 1$, $P < 0.01$). Local increases in wintering bald eagle numbers at Mormon Lake were largely attributable to greater proportions of immatures ($r_s = 0.53$, $P < 0.01$).

On a seasonal basis, adult wintering bald eagles outnumbered immatures from late fall through early winter, whereas immatures usually occurred in greater numbers from mid-winter through spring departure (Fig. 3). Max-

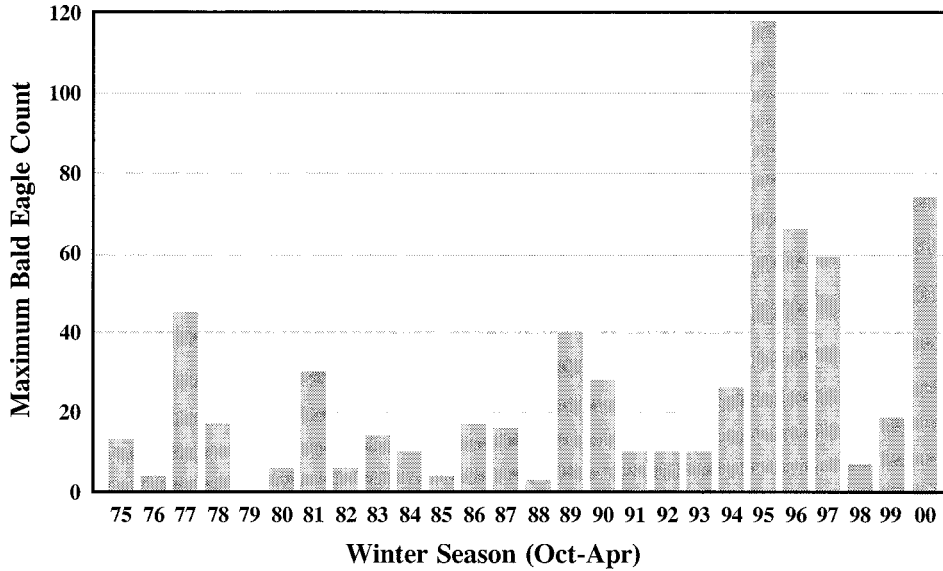


FIG. 1—Annual variation in maximum counts of bald eagles at Mormon Lake in northern Arizona during winters (October through April) of 1975 through 2000.

imum counts tended to level off during December and January as the predominant age class shifted from adults to immatures. The largest differences between age classes occurred in February and March, when imma-

tures comprised 59 and 61% of the population. Total numbers of wintering eagles at Mormon Lake generally increased from the second week of October to a peak in February, then sharply declined until all were gone by the

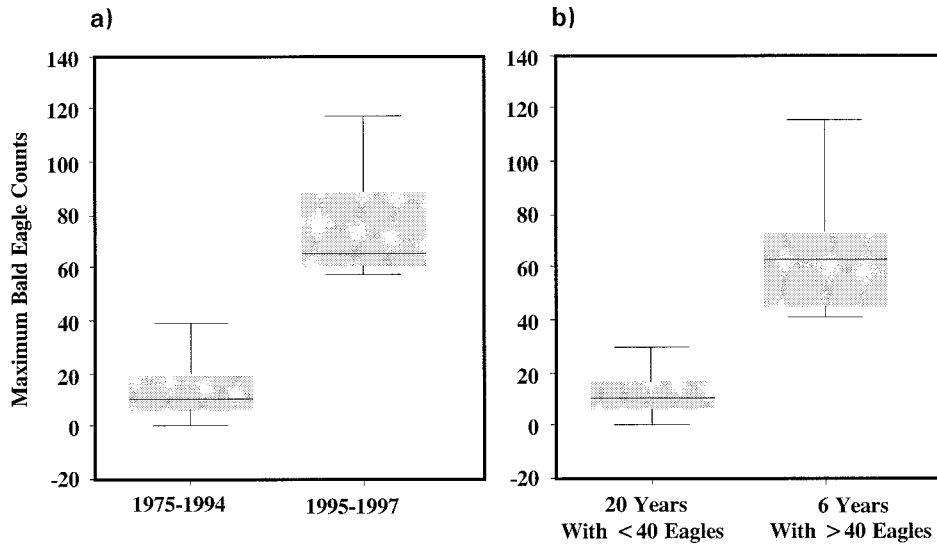


FIG. 2—Notched box and whisker plots (Chambers et al., 1983) showing median, 25–75% interquartile range (shaded boxes), and range of values that fall within 1.5 times the box length (whiskers) for maximum counts of wintering bald eagles at Mormon Lake in northern Arizona for a) 1975–1994 versus 1995–1997 and b) 6 years of highest numbers, i.e., ≥ 40 eagles versus 20 years with maximum counts < 40 eagles. Non-overlapping plots indicate significant differences ($P < 0.05$).

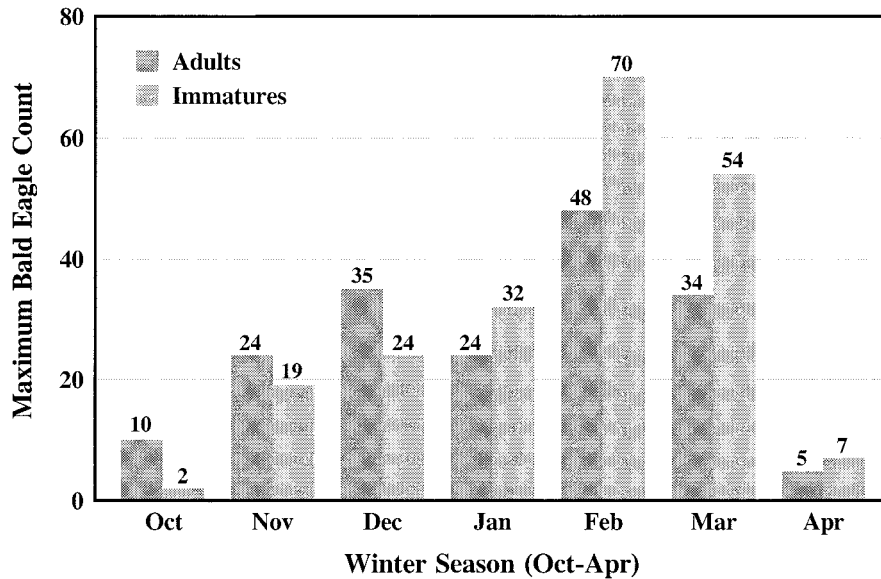


FIG. 3—Monthly variation in maximum counts of adult and immature bald eagles at Mormon Lake in northern Arizona during winters (October through April) of 1975 through 2000.

third week of April. However, the ranges of weekly maximum counts were highly variable within months: October 1 to 10, November 6 to 45, December 17 to 59, January 22 to 54, February 44 to 118, March 16 to 66, and April 1 to 11.

Weekly maximum counts for 1995 through 1997 indicated changing weather and prey conditions resulted in annual variation in local numbers of and habitat use by wintering bald eagles (Fig. 4). Cold temperatures in November and December led to complete freezing of Mormon Lake early in the winter of 1995, with a subsequent unusual and massive die-off of fathead minnows (Grubb and Lopez, 1997). Scavenging dead minnows from lake ice, wintering eagles peaked at 38 in late December before essentially disappearing from the frozen lake through much of January. By early February as the lake surface thawed and dead minnows accumulated along shore, bald eagle numbers increased from 7 to 118 in 9 days and remained unusually high through mid-March.

In contrast to 1995, the winter of 1996 was generally mild, with only three 10-day to 14-day cold cycles. Waterfowl used Mormon Lake most of the winter, often becoming concentrated in small openings during the several cold periods from mid-December through late

February. Bald eagle numbers at the lake cycled up and down from <10 to >60 as waterfowl numbers and their vulnerability increased and decreased. By early winter 1997, Mormon Lake was dry with no fish or waterfowl present. The early peak of wintering eagles was unexplained. However, through the remainder of the typically cold winter, foraging was primarily on mammalian carrion (Grubb and Lopez, 2000) and eagle numbers at Mormon Lake were low.

Eleven winter roosts have been identified around Mormon Lake with no more than 2 to 8 eagles recorded using any 1 roost at a time through 1994 (Grubb et al., 1989; Dargan, 1991; Grubb et al., 1994). However, in 1995, when large numbers of opportunistically foraging eagles gathered at the lake, roosting behavior became more traditional (Keister et al., 1987) with consistent, concentrated use of 2 large communal roosts. Between 7 February and 3 March 1995, 21 early morning counts of eagles flying out of these 2 roosts accounted for 62% (range 28 to 95%) of the 19 to 101 wintering eagles present at the lake the same day. The number of eagles using the same roost ranged from 6 to 33, with 4 roost counts ≥ 20 and 3 counts ≥ 30 . Only 6 of the 21 roost counts recorded <10 eagles. Between 25 Jan-

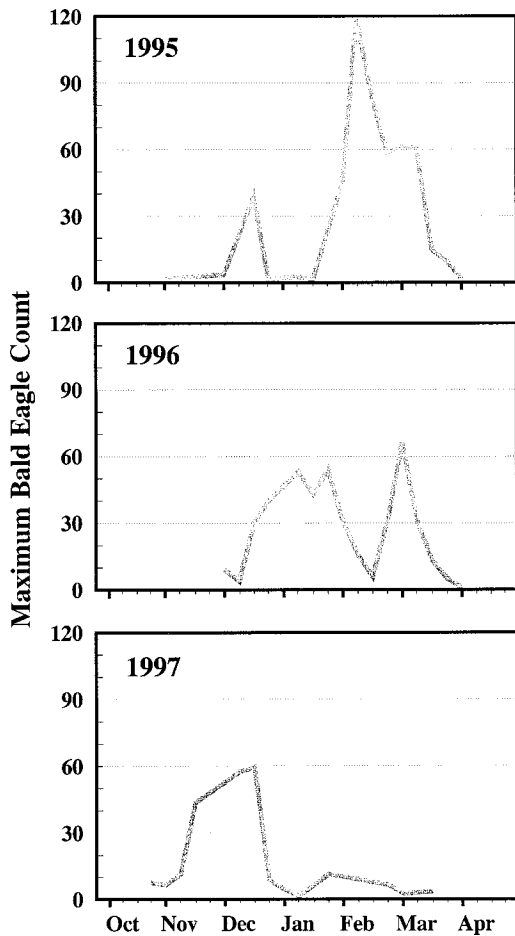


FIG. 4—Seasonal variation in weekly maximum counts of bald eagles at Mormon Lake in northern Arizona during winters (October through April) of 1995 through 1997. Foraging in 1995 was primarily on dead minnows caught in lake ice, in 1996 on live waterfowl in patches of open water, and in 1997 on mammalian carrion away from the dry lake.

uary and 8 March 1996, 17 early morning flyout tallies at the same 2 roosts accounted for 84% (range 45 to 100%) of the 12 to 62 eagles present at the lake. The number of eagles using the same roost ranged from 3 to 45, with 12 roost counts >20, 5 counts >30, and 3 counts >40. Only 3 of the 17 roost counts recorded <10 eagles. No roost data were collected from 1997 through 2000.

DISCUSSION—With minor fluctuations from 3 to 17 and occasional peaks > 20, maximum counts of wintering bald eagles at Mormon

Lake were generally consistent in the 20 years from 1975 through 1994. The unusual peak counts in 1995 through 1997 appear to have been local phenomena. Neither Arizona statewide January counts for 1981 through 1985 and 1992 through 1996 (Beatty and Driscoll, 1996) nor national midwinter count data for 1979 through 1996 (K. Steenhof, United States Geological Survey, Biological Research Division, unpubl. data) showed corresponding peaks. The proportion of immatures for Arizona during this period (32%) was similar to the national average (33%). However, at Mormon Lake from 1975 through 2000, immatures averaged 42%, thus suggesting this northern Arizona area might be important wintering habitat for young bald eagles.

Plentiful food supplies at Mormon Lake during the winters of 1995 and 1996 (Grubb and Lopez, 1997; Grubb and Lopez, 2000) at least partially explain this local increase in immatures, who tend to concentrate around easily accessible, abundant prey sources (Stalmaster, 1987; Bennetts and McClelland, 1991). The massive die-off of minnows in 1995 was apparently unprecedented and might have precipitated the record numbers of eagles at Mormon Lake. The short period of rapid increase in eagle numbers, along with the lack of communal roosting in large numbers prior to this foraging assemblage, suggest observation of flight behavior associated with food finding (Knight and Knight, 1983) as the likely mechanism for communicating this unusual food source among eagles scattered across northern Arizona. Because of their excellent vision, bald eagles might be able to spot a distant soaring group, or individual eagles flying purposefully, from 24 to 65 km away and thus be attracted to a new foraging area (McClelland et al., 1982).

The still high yet declining frequencies of immatures in 1996 and 1997 might have resulted from migrant bald eagles returning to previously good wintering areas in northern Arizona (Gerrard et al., 1978; McClelland et al., 1994) and being hampered by different weather and foraging conditions. In 1996, waterfowl were abundant and concentrated, but easily scavenged minnows were lacking. In 1997, a dry lake with no available prey led to rapid dispersal after the initial exploratory or perhaps social gathering in December. Low wa-

ter and no prey explain the paucity of eagles at Mormon Lake in 1998. In 1999, despite abundant waterfowl through most of the winter, eagle numbers remained low after an early freeze-over when no lake prey was available. By 2000, a combination of low water, alternate freezing and thawing conditions, and a rejuvenated fathead minnow population might have led to increased numbers of wintering bald eagles that included a high proportion of immatures.

Variations in the proportion of immatures at Mormon Lake might reflect population changes tracing back to the breeding grounds, or simply represent local variations in winter habitat use. Wintering populations with low relative frequencies of immatures can follow years of poor productivity induced by limited prey, which in turn can lead to a higher proportion of adults migrating to the wintering area (Newton, 1979). Alternatively, variations in weather and prey availability on the wintering grounds (Fisher and Hartman, 1983; Craig et al., 1988) might be causing local movements resulting in lower overall numbers as well as fewer immatures. Fluctuations in 1995 through 1997 sighting data for Mormon Lake tend to support this latter explanation.

My 26-year data set indicates wintering bald eagles at Mormon Lake have generally increased, which is consistent with statewide (Beatty and Driscoll, 1999) and national trends (K. Steenhof, U.S. Geological Survey, Biological Research Division, unpublished data). Local increases were mostly due to higher proportions of immature eagles. As the wintering population increased at Mormon Lake, roosting behavior became more traditional (Kiester et al., 1987), suggesting a density-dependent social dynamic. Despite this increasing trend, local weather and prey conditions dramatically affected numbers and habitat use of wintering bald eagles in the area. Thus, this study demonstrates the utility of opportunistic sightings for monitoring general trends and habitat use (see also Grubb and Kennedy, 1982*b*), especially when sightings are the only available data. Nonetheless, well-defined surveys standardized over time and space provide better data for analyzing population trends of wintering bald eagles and are recommended whenever possible.

Field data were recorded by K. and D. Aitken, W. Eakle, M. Coffey, N. Dodd, J. Ganey, J. Hernandez, R. Lopez, M. Nixon, R. Prigge, P. Stefanek, J. Werner, and J. Yazzie. N. Dodd and T. Britt, AGFD, provided early sighting records. Contributing CNF personnel included J. Bradley, C. Dargan, G. Goodwin, H. Green, S. Nagiller, T. Randall-Parker, L. Schaal, C. Taylor, and M. Whitney. J. Yazzie assisted with data entry and R. King with statistical analyses. P. Beier, R. Bennetts, J. Ganey, and R. McClelland provided constructive reviews of the manuscript.

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