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Differences in the Distribution of Adult and Immature Bald Eagles at an Autumn Concentration in Montana

Abstract

During the autumns of 1983 and 1984 we compared the relative abundance of adult and immature Bald Eagles (*Haliaeetus leucocephalus*) at two foraging sites along Lower McDonald Creek in Glacier National Park, Montana. The ratio of adults to immatures differed between the locations. The proportion of adults was higher during both years at a public viewing area compared to a site 1 km downstream in an area closed to public access. We examined four hypotheses related to migration timing, human disturbance, behavioral exclusion, and food availability that could account for these differences. There were temporal differences in adult and immature migration, but they were insufficient to explain age-ratio dissimilarities at a given time. The ratio of adults to immatures did not change in response to the number of people at the public viewing area. Adults displaced immatures from perch sites and food less frequently than expected. Live salmon were more abundant at the public viewing area, but the downstream site had greater opportunity to scavenge accumulated carcasses. Our results suggest that food availability was the primary factor influencing the distribution of adult and immature eagles during this study.

Introduction

The spatial distribution of adult and immature Bald Eagles (*Haliaeetus leucocephalus*) often differs among and within geographic locations (Hancock 1964, Stalmaster and Newman 1978, Fisher *et al.* 1981, LaBonde 1981, Fisher and Hartman 1982, Millsap 1986). Several explanations of age-related differences in distribution have been suggested, but data have been insufficient to test specific hypotheses.

We compared the ratio of adult to immature Bald Eagles at two locations along Lower McDonald Creek (LMC) during the autumns of 1983 and 1984 in Glacier National Park, Montana. We then examined differences in these ratios with respect to four hypotheses: age-related differences in the distribution of Bald Eagles results from (1) *migration timing*—adult and immature Bald Eagles differed in their arrival or departure dates at the concentration (Sprunt and Ligas 1966, Steenhof 1976, Fitzner and Hansen 1979); (2) *human disturbance*—dissimilar response of adults and immatures to human presence (Stalmaster 1976, Stalmaster and Newman 1978); (3) *behavioral exclusion*—aggressive interactions between adult and immature Bald Eagles resulted in a greater degree of exclusion of immatures from one site (Fisher and Hartman 1982, Craighead 1979); and (4) *food availability*—adult and immature eagles responded differently to the quantity, quality, and accessibility of food (LaBond 1981, Fisher *et al.* 1981).

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Study Area

Glacier National Park is adjacent to the Canadian border in northwestern Montana and is the United States' portion of Waterton-Glacier International Peace Park. Each autumn in recent years several hundred migrating Bald Eagles have been attracted to LMC to feed on spawning kokanee salmon (*Oncorhynchus nerka*) (McClelland 1973, Shea 1978). LMC flows 4 km from the outlet of Lake McDonald to the confluence with the Middle Fork of the Flathead River. The average creek width during autumn is approximately 25 m. The creek generally ranges from 10 to 60 cm deep and is interspersed with deeper pools and riffles. Salmon spawning occurs in shallow areas (<20 cm) with gravel beds.

Vegetation along LMC consists of black cottonwood (*Populus trichocarpa*), riparian shrubs, and mixed coniferous forest. Plant species composition along the creek was described in detail by Habeck (1970).

Methods

During the autumns of 1983 and 1984, weekly counts of all Bald Eagles at LMC were conducted in accordance with the procedures described by McClelland *et al.* (1982). Eagles with a predominantly white head and tail were classified as adults and all others as immatures. We

conducted site-specific counts of adult and immature Bald Eagles from 10 October through 20 November 1983 and from 20 October through 1 December 1984. Counts were conducted 4 d per week at 2 locations along LMC: Apgar Bridge and the oxbow blind (Figure 1). Apgar Bridge was a public viewing area where >2500 people viewed Bald Eagles on some autumn days. The oxbow blind was approximately 1 km downstream from Apgar and within an area closed to the public during the eagle concentration. The blind, used for observations at the oxbow, had a covered walkway which allowed entry without disturbing eagles. The differences in dates of our surveys between the two years reflects the dates that eagles were present at LMC.

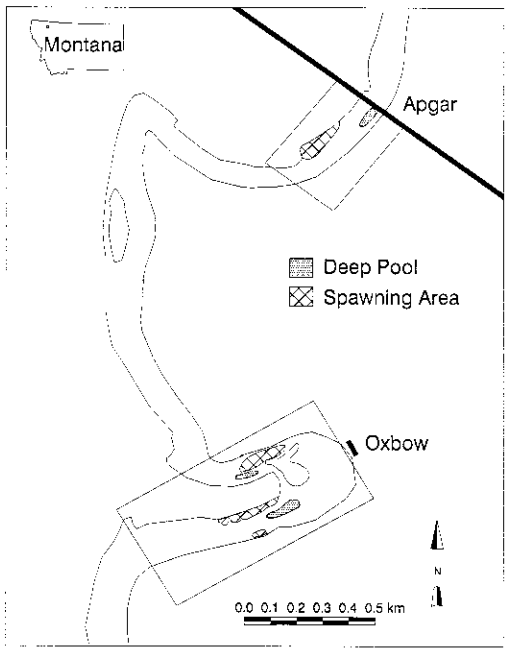

Figure 1. Lower McDonald Creek showing the areas visible from Apgar Bridge and the Oxbow Blind (rectangles). Deep pools used by salmon for staging and salmon spawning areas are shown for each observation area.

Because eagles moved throughout the day, 2 to 4 censuses were conducted each day with a minimum of 2 h between censuses. The 2 h minimum was based on prior sampling (during 1983) in which no eagles remained at a given perch longer than 1.5 h (pers. observ.). Observation of 114 wing-marked and 57 transmitter-equipped Bald Eagles at LMC over a 10 yr period also revealed that individuals seldom remained in the same location longer than 2 h (pers. observ.). Although we felt that 2 h was sufficient to avoid double-counting eagles at the same location, we could not be certain that samples were independent because all individuals were not marked.

The white head and tail of adult Bald Eagles makes them more conspicuous than subadults against a dark background (e.g., foliage), thereby affecting adult to immature ratios (Hancock 1964, Joseph 1977, Stalmaster and Newman 1979, Pannetier 1980, LaBonde 1981). This bias would be most pronounced for surveys done quickly, from a distance, or while moving (e.g., aerial surveys). Our sampling was done from stationary vantage points in proximity to the eagles (<200 m) and with spotting scopes. Consequently, we assumed that detectability bias did not influence our results.

We partitioned each season into three equal time periods (early, mid, and late season) to assess whether the proportions of adult and immature eagles differed during the 1983 and 1984 seasons. We used chi square tests of independence to test the association between age and location for each season and year.

Prey abundance was estimated bi-weekly by two Montana Department of Fish, Wildlife and Parks (MDFWP) biologists. While snorkeling, they independently estimated the number of live salmon at each riffle and pool and these estimates were averaged for a final count. We used two-way analysis of variance, blocked by survey date, to test for differences between observers and location. Salmon abundance prior to October of each year was excluded from this analysis because the fish were still moving upstream and migrating Bald Eagles had not arrived by this time.

A displacement attempt was defined as an eagle attempting to supplant another eagle from its perch site or food. Only successful perch-site displacements were recorded because it often was difficult to distinguish an attempted perch-site displacement from simply perching proximal to another eagle. To compare the frequency of aggressive encounters between adult and immature eagles we used the procedure described by Hailman (1975) (see also Griffin 1981), which derives expected values of a chi square goodness-of-fit test by using relative abundance of each age class. We used the overall proportion (combined counts) of each age class at each location during each year to derive expected values.

We recorded all foraging attempts observed during 2-hour time periods conducted 3 times per d, 4 d per week during each year. The morning observation period each day began 30 min after sunrise. An evening observation period ended 30 min before sunset, and a mid-day period was evenly arranged between the morning and evening periods. Observation periods alternated between locations. For each foraging attempt observed we recorded the age class of the eagle and the foraging method used. Each attempt was assigned to 1 of 3 foraging methods: stooping, piracy, or scavenging.

In 1986 we examined whether the proportion of adults to immatures changed in response to the number of people at Apgar Bridge. From 27 October through 9 November we recorded the number of adult and immature eagles at Apgar and the number of people present at the viewing area at 2-hour intervals throughout each day. We used Spearman's rank correlation for this analysis.

Results

During 1983 we conducted 33 censuses at Apgar and 36 at the oxbow. The mean number of eagles per census was 14.6 ± 9.1 SD at Apgar and 8.5 ± 5.3 SD at the oxbow. During 1984 we conducted 82 censuses at Apgar and 86 at the oxbow. The mean number of eagles per census was 19.9 ± 12.9 SD at Apgar and 21.4 ± 14.2 SD at the oxbow. Overall (combined locations), adults comprised 63 percent and 67 percent of the total population during 1983 and 1984, respectively. The proportion of adults was higher at Apgar and lower at the oxbow during both 1983 ($X^2 = 289.8$, $P < 0.001$, 1 df) and 1984 ($X^2 = 330.9$, $P < 0.001$, 1 df). This relationship also persisted within each period of the season during 1983 ($X^2 = 130.65$, $P < 0.001$, 1 df; $X^2 = 93.96$, $P < 0.001$, 1 df; and $X^2 = 69.11$, $P < 0.001$, 1 df, early, mid, and late seasons, respectively) and 1984 ($X^2 = 9.80$, $P = 0.002$, 1 df; $X^2 = 80.29$, $P < 0.001$, 1 df; and $X^2 = 225.23$, $P < 0.001$, 1 df, early, mid, and late season, respectively) (Table 1).

Migrating adult and immature Bald Eagles are not synchronous in their patterns of arrival and departure at LMC in some years. The number of immatures tends to peak earlier than adults. The number of adults often increases and then decreases more rapidly, and within a shorter time period, than the number of immatures (McClelland *et al.* 1982) (Figure 2).

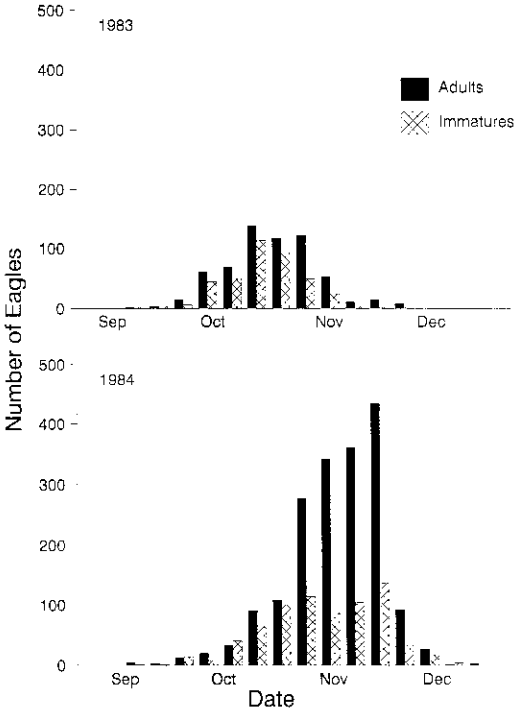

Figure 2. Weekly censuses of adult and immature Bald Eagles along LMC during the 1983 and 1984 concentration periods.

TABLE 1. The number (percent) of adult land immature Bald Eagles counted at Apgar and Oxbow during ealry, mid, and late season of 1983 and 1984.

	Early		Mid		Late		Total	
	Apgar	Oxbow	Apgar	Oxbow	Apgar	Oxbow	Apgar	Oxbow
1983								
Immatures	20 (11)	144 (68)	66 (19)	144 (56)	30 (18)	76 (68)	116 (17)	364 (63)
Adults	162 (89)	68 (32)	290 (81)	112 (44)	134 (82)	36 (32)	586 (83)	216 (37)
1984								
Immatures	2 (9)	28 (47)	10 (12)	164 (68)	44 (9)	300 (53)	56 (10)	492 (57)
Adults	20 (91)	32 (53)	76 (88)	78 (32)	432 (91)	264 (47)	528 (90)	374 (43)

During our 1986 study the number of people at Apgar at a given time ranged from one (the observer) to 205 ($\bar{x}$ = 38.7, ± 48.0 S.D.; n = 63). The ratio of adult to immature eagles was not significantly correlated with the number of people present (Spearman r = −0.16, P = 0.21).

The frequency of perch-site displacements by immature and adult eagles did not occur in proportion to the relative abundance of each age class in 1983 at the oxbow (X^2 = 15.32, P < 0.001, df = 1, n = 84), 1983 at Apgar (X^2 = 13.31, P = 0.004, 1 df, n = 72), 1984 at the oxbow (X^2 = 29.65, P < 0.001, 1 df, n = 74), or in 1984 at Apgar (X^2 = 118.77, P < 0.001, 1 df, n = 109). In all cases immatures initiated successful displacements against adults in frequencies greater than expected (Figure 3). Conversely, adults initiated successful perch-site displacements against immatures less frequently than expected in 3 of 4 cases.

A small sample size (n = 8) precluded an analysis of food displacements during 1983. During 1984 the frequencies of food displacements by immatures and adults was not proportional to their relative abundance at Apgar (X^2 = 190.40, P < 0.001, df = 1, n = 67); however, this difference was not detected at the oxbow (X^2 = 2.52, P = 0.472, 1 df, n = 83). The pattern of food displacements was similar to perch-site displacements; immatures initiated displacements more frequently than expected against adults (Figure 4). The success of food displacements also was not dependent on age (X^2 = 1.07, P < 0.1, 1 df).

Salmon, the nearly exclusive food source of Bald Eagles at LMC, were consistently more abundant at Apgar than at the oxbow during both 1983 and 1984 (Figure 5). Estimates of salmon abundance did not differ between observers (F = 0.03, P = 0.86), but differed significantly between locations (F = 26.7, P < 0.001) and among dates (F = 5.25, P < 0.001). Since 1979, when biweekly salmon counts began, a staging pool at Apgar consistently supported the highest number of salmon in LMC (J. Fraley, pers. comm.).

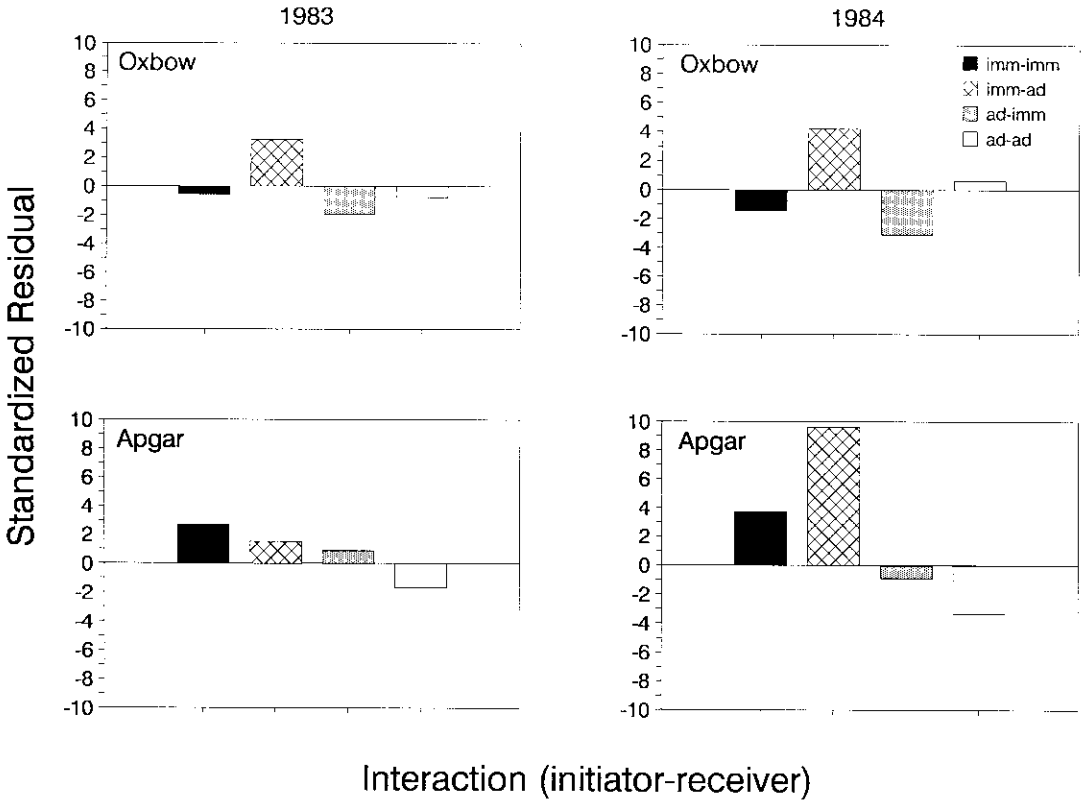

Figure 3. Standardized residuals (Haberman 1973) from chi square goodness-of-fit test of perch-site displacements between immature and adult Bald Eagles during 1983 and 1984 at the oxbow and Apgar.

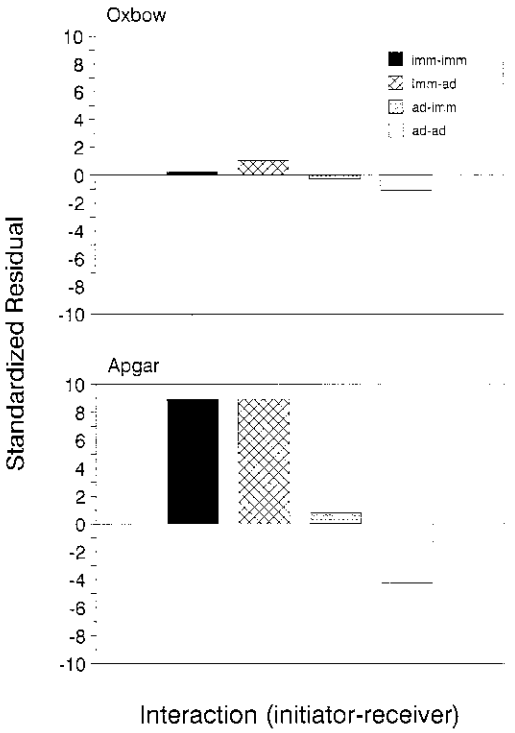

Figure 4. Standardized residuals (Haberman 1973) from chi square goodness-of-fit test of food displacements between immature and adult Bald Eagles during 1984 at the oxbow and Apgar.

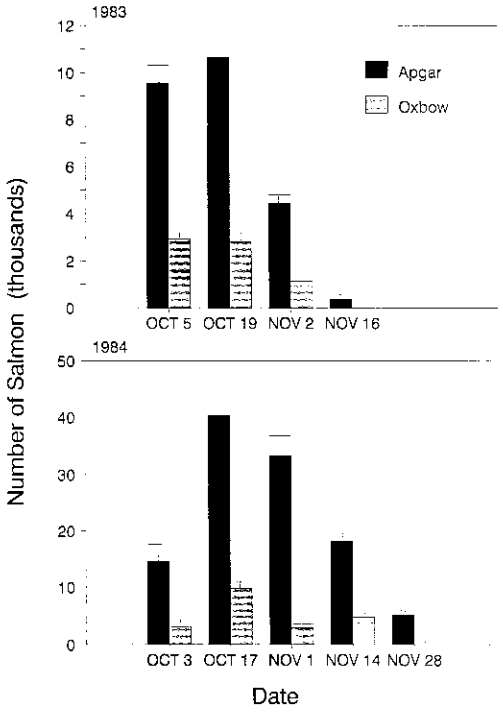

Figure 5. The average number of salmon counted at Apgar and the oxbow during 1983 and 1984. Crossbars represent the high count of the two observers (the range).

Kokanee salmon weakened and died within 2 to 3 weeks after spawning at LMC (pers. observ.). Although surveys of salmon abundance were of live salmon, differences in carcass accumulations between locations were apparent. Because of the relatively straight stream course at Apgar, dead salmon accumulated primarily in deep pools and were unavailable to eagles. At the oxbow, however, dead salmon accumulated in the relatively shallow backwater or along the shoreline.

Foraging methods were age dependent during 1984 ($X^2 = 121.4$, $P < 0.001$, 2 df). Adults stooped more frequently than expected and immatures scavenged and pirated more frequently than expected. In 1983 we had an insufficient sample for statistical analysis.

Discussion

Differences in migration timing clearly influenced the adult/immature ratio during each season. However, our surveys were conducted throughout the entire season and consistently higher proportions of adults at Apgar and immatures at the oxbow persisted. Therefore, we rejected the hypothesis that migration timing accounts for the age-related distribution differences at LMC. These results do, however, illustrate that timing can greatly influence the results of surveys.

Adult Bald Eagles are more sensitive than immatures to human activity (Edwards 1969, Shea 1973, Stalmaster 1976, Stalmaster and Newman 1978, Fisher and Hartman 1982). Because of the high level of human activity at Apgar (sometimes >2500 people per day), we predicted that adult Bald Eagles would avoid Apgar if human disturbance were a primary influence on distribution. Adult Bald Eagles, however, were found in higher proportions than immatures at Apgar.

We offer 2 explanations for the adult's failure to avoid Apgar. First, eagles may have become habituated to people at Apgar where visitors have been restricted to a viewing area (McClelland 1981) (see also Grier 1969, Edwards 1969, Stalmaster and Newman 1978, Russell 1980,

Hansen *et al.* 1984, Harmata 1984). However, the process of habituation needs further testing (Knight and Knight 1984). Secondly, the highest concentration of food on LMC was at Apgar. This may have outweighed the effect of disturbance (see also Knight 1981, Skagen 1981); however, this hypothesis has not been tested.

Behavioral exclusion implies an influence on distribution when "dominant" eagles exclude "subordinate" eagles from preferred areas. Some researchers have reported that adult Bald Eagles are dominant over immatures (e.g., Lish 1973, Stalmaster and Gessaman 1984); others have shown that size is a more important determinant of dominance than age (Hansen 1986, Knight and Skagen 1988). We predicted that if dominance were age-related, adult Bald Eagles would exclude immatures from preferred areas. Griffin (1981) also suggested that conditioning from previous encounters could encourage a dominant-subordinant relationship favoring adults. Neither our prediction nor Griffin's suggestion were supported at LMC. Our data showed that immatures successfully displaced adults from both perch sites and food more often than the reverse. Additionally, eagles that were displaced from perch sites or food seldom left the area, but more often returned to a nearby perch site. It is possible that behavioral exclusion may influence distribution at other locations, under conditions different than those depicted in our study, or is based on attributes other than age (e.g., size). Our data, however, do not support behavioral exclusion as an important influence on age-related distribution at LMC.

Food availability may have an important influence on the distribution of wintering Bald Eagles and may differentially influence the distribution of adult and immature eagles (Stalmaster *et al.* 1979, Fisher *et al.* 1981). Stalmaster (1976), LaBonde (1981), and Fielder and Starkey (1987) suggested that immature eagles were found in greater proportion in areas where food was more abundant and accessible. This leaves unanswered why adults in these areas did not concentrate at these "abundant and accessible" food sources since through greater experience they presumably would have been more aware than immatures of these locations.

We suggest that the type or condition of food may have major influence on its availability to Bald Eagles. Immatures are less effective at capturing live prey and may be more dependent than adults on scavenging or piracy (Shea 1973, Sherrod *et al.* 1976, Joseph 1977, Fisher and Hartman 1982, Harmata 1984). Our data at LMC were consistent with these reports: adult Bald Eagles stooped more frequently than expected and immatures scavenged and pirated more frequently than expected. The opportunities for immatures to scavenge carcasses in the shallow waters of the oxbow may have been more attractive than the more abundant, but more difficult to capture, live prey at Apgar.

We offer 3 explanations for the higher proportion of immatures at the oxbow: (1) adults seem to have little difficulty obtaining the more abundant live salmon at Apgar (i.e., scavenging was not necessarily easier for adults) (see also Shea 1973); (2) the energy content of salmon decreases as decomposition progresses (i.e., carcasses at the oxbow may be of lesser quality) (Stalmaster and Gessaman 1984); and (3) adults appeared much more reluctant than immatures to land on the ground. Given the opportunity, adults usually stooped on prey (carcasses or live salmon) rather than landing (see also Knight and Knight 1986). Wading often was necessary to take available carcasses at the oxbow.

Anecdotal evidence supporting the food availability hypothesis was found in a change of the age-class distribution of eagles following a loss of spawning habitat at the oxbow. A flood during 1975 resulted in diversion of the main flow of LMC away from the oxbow. The backwaters created by this diversion resulted in increased siltation, decreasing spawning habitat and numbers of salmon. Concomitantly, the proportion of adult Bald Eagles decreased at the Oxbow (pers. observ.).

In summary, our results suggest that food availability, particularly the condition of food, has an important influence on age-related distribution of Bald Eagles on LMC. Differences in migration timing occurred and influenced the overall ratio of adult to immature eagles, but was insufficient to explain why adult and immature Bald Eagles were distributed disproportionately between locations at any given time. Human disturbance and behavioral exclusion may be important influences on age-related eagle distribution in other areas or under different conditions. Our results, however, indicate that they were not important influences of distribution at LMC.

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