

ADDITIONAL OBSERVATIONS ON WINTER BALD EAGLE  
POPULATIONS: INCLUDING REMARKS ON  
BIOTELEMETRY TECHNIQUES AND  
IMMATURE PLUMAGES

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BETWEEN 29 September 1962 and 9 April 1963, my assistants and I spent 850 hours obtaining new as well as supplemental data on the Bald Eagles (*Haliaeetus leucocephalus*) wintering near Savanna, Illinois. The study area as delineated previously (Southern, 1963), was used again this year and, in general, the objectives were the same: to record behavior, live-trap, color-mark, and determine the movements of Bald Eagles during winter and early spring. I also spent considerable time studying the plumage patterns of immature eagles and attempted to categorize them into age-groups. In addition to color-marking eagles, I attached miniature transmitters to some and followed their movements with radio-tracking equipment.

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POPULATIONS AND FLUCTUATIONS

This year I started field work earlier (29 September) and recorded the first Bald Eagles on 21 October. More immatures than adults were present until 15 December. The indication was that immatures, particularly first-year birds, moved southward earlier than adults. They either concentrated at waterfowl wintering areas (e.g., Horseshoe Lake Refuge) and other suitable feeding sites or dispersed and fed over a larger area. The number of immatures increased again during February and early March. Fewer immatures were observed in spring than in fall and it appeared that northbound birds were not necessarily the ones observed at Savanna during the fall. More 3-, 4-, and 5-year-old birds were recorded during late winter and early spring (see Fig. 1).

Figure 2 presents the population fluctuations of adult and immature Bald Eagles during the 1962-63 winter. Our census methods were the same this year as last. One indication that we obtained an authentic picture of the number of eagles in our area was given when Alexander Sprunt, IV, carried out an aerial census of the Mississippi River population on 3 February. He

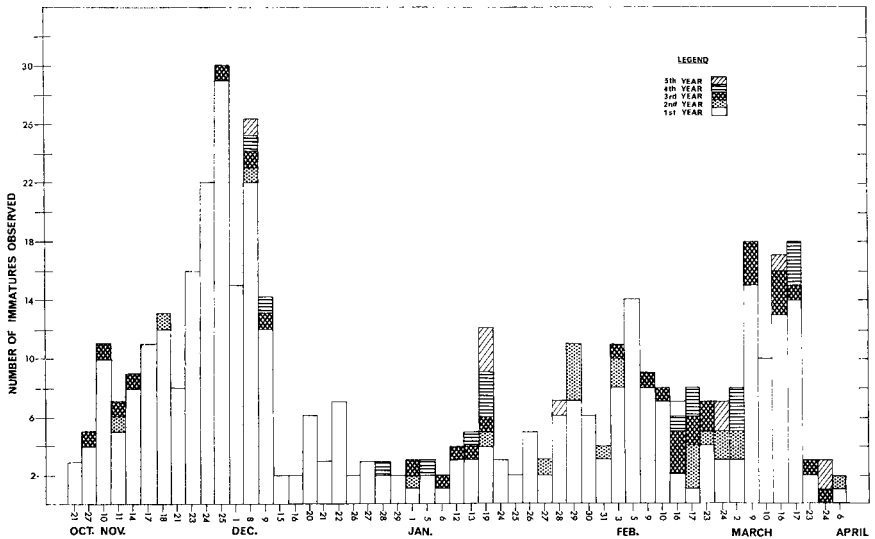


FIG. 1. Fluctuations in immature Bald Eagle population by age-groups during the winter of 1962-63.

reported a population of 158 in our area, 12 of which were immatures, while our ground count for that day was 156, 11 of which were immatures. The counts were made at about the same time and I saw Sprunt's plane pass over.

Two new localities, in addition to the four reported last year, had eagle concentrations. Both were along small sloughs; one resulted from spring seepage and the other from a swifter flow of water. Shad concentrated at each site at some time during the winter and attracted eagles. The winter was severe with a low of  $-32^{\circ}\text{F}$  recorded in the area. Prolonged periods of subzero temperatures were recorded and the high for one day was  $-19^{\circ}\text{F}$ . Nevertheless, the open areas in the river and backwaters maintained their size. Fluctuations in ice conditions occurred but not necessarily during the periods of extreme cold as might be expected.

#### FOOD AND FEEDING HABITS

As during last year small Gizzard Shad supplied the major portion of the eagle's diet. They appeared in small numbers by 28 December, became abundant by 13 January, and remained abundant, at least at one or two areas, until 23 February when shad, except for a few dead ones, were scarce.

Besides feeding on shad in the methods referred to previously (Southern, 1963:46) the eagles occasionally fed on other fish when available. During

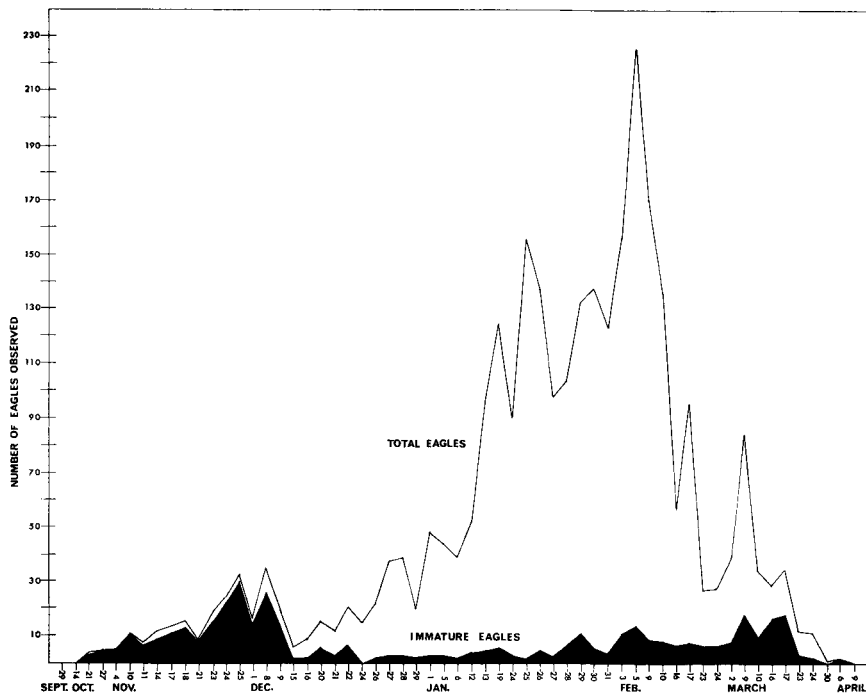


FIG. 2. Population fluctuations of adult and immature Bald Eagles during the winter of 1962-63.

mid-January about 200 fish representing 11 species were trapped in shallow water at Burning Ground Slough (Site 4, Fig. 1, of Southern, op. cit.:43). Eagles fed on several species of fish but appeared hesitant to feed on species larger than shad. Eagles fed most readily on fresh fish but occasionally consumed frozen ones. Twice we watched eagles capturing fish after commercial fishermen pulled their nets. During the fall (24 and 25 November) fishermen pulled their nets near North Point Island (Site 2, Fig. 1, *ibid.*). Each time they returned to the water a number of White Bass (*Roccus chrysops*), some of which were apparently injured and remained near the surface. Gulls were attracted first, but after the fishermen left an adult eagle arrived and shortly thereafter six immatures appeared. They circled the water, swooped down, and picked up fish weighing about 2 or 3 pounds. Successful birds carried the fish to a perch far from the other birds before eating it. Two birds carried their catch across the river to the Iowa side. The adult and each of two immatures ate three fish in about 30 minutes. The next day the nets were pulled again and four eagles were attracted. Later activities of the fishermen

failed to attract eagles. The feeding activities of crows sometimes attracted eagles to a feeding site. Occasionally eagles chased crows from such sites before feeding, but it was not uncommon to find eagles and crows feeding at the same open hole.

We witnessed the attempts of seven eagles, all immatures (three color-marked), trying to capture a female Mallard (*Anas platyrhynchos*). The duck was in a small open hole under a fallen tree. The eagles hopped about among the branches, occasionally fell into the water, and attempted in every fashion to get at the duck. All attempts failed and after about 50 minutes the last eagle departed. During the ordeal the Mallard swam about and occasionally quacked or flapped her wings. After this observation we tried live and dead Mallards as trap bait, but the eagles were not attracted to them.

On 18 December at Horseshoe Lake near Cairo, Illinois we counted 38 eagles of which 29 were immatures. We observed adults and immatures feeding on dead ducks and geese. Groups of eagles moved from one area of goose concentration to another and consumed dead birds. Generally one or two eagles started the feeding activity, and then others gradually moved into the area. New arrivals perched high in cypress trees (*Taxodium*) and slowly worked into the feeding area. Nineteen eagles were concentrated in one area, but all did not feed on one animal. No fewer than six dead birds were consumed at this locality. The eagles jumped on dead birds that were in the open water and pulled them out onto the ice. Live geese remained in the area although they behaved a little nervously. During our stay we saw numerous dead geese, as well as piles of feathers, evidence of previous eagle feeding activity in the fields and on the ice. Most, if not all, of the dead waterfowl resulted from hunting activities bordering the refuge. Twice we saw crippled geese fly or glide to the refuge and die. After the hunting season the abundance of such food decreased, although the death of some cripples is probably prolonged. So long as dead waterfowl were available the eagles showed no interest in live birds. Most of the lakes in southern Illinois were frozen over and the only open areas at the refuges were those maintained by waterfowl. When the lakes are open fish probably supplement the eagle's diet.

As a result of our observations we placed two traps, each baited with a dead goose, in fields near goose concentrations at the Union County Refuge. Within an hour an adult eagle was at one trap and an immature at the other. Each consumed about half of the goose before we frightened them. Neither bird was captured since each had stood on the carcass while feeding and failed to step on the platform snare beside the bait.

We received several reports from the vicinity of Mt. Carroll and Savanna that eagles (one on each occasion) had fed on dead livestock (chickens and

hogs) dumped in fields by farmers. At the depot we found the remains (hair only) of a fox squirrel (*Sciurus niger*) killed after daybreak in an area of eagle concentration. There were eagle tracks and wing prints on the snow. Since there were no squirrel tracks on the ground, it had apparently been killed and eaten in a tree. It is possible, however, that one of the many Red-shouldered Hawks (*Buteo lineatus*) in the area killed the squirrel.

#### CENSUS METHODS AND RESULTS

The same census route and procedures were followed this year as last. We censused the population during 60 of the 65 days spent in the area between 29 September 1962 and 10 May 1963. Census results are presented in Fig. 1. There was a noticeable decrease in the number of adults on 16 February 1963; thereafter, although with fluctuations, there was a tendency toward a decline. During early February (beginning 3 February) the immature population became more constant and showed a gradual increase until mid-March when a sharp decline was noted. No eagles were recorded after 6 April. The sharp decline in adults is similar to that witnessed in 1961-62 when there was a sharp drop about 16 February. We assumed that the eagles had either moved north (most likely) or south along the river. However, this was not the case. About the same date, there was also a decrease in eagle numbers to the south at Keokuk, Iowa (Lock and Dam Number 19). We traveled along the river between the two areas and recorded only four eagles. Likewise, there was no noticeable increase in eagles to the north of Savanna along the Mississippi. Such an increase should have been evident since few eagles wintered in that area. The remaining conclusion to be drawn is that the birds dispersed or at least followed a course, other than that along the river, to the north toward the breeding grounds. The increased number of immatures during both years probably indicated a similar movement although it is possible that the immatures followed the river to the north of Savanna.

The fluctuations in eagle numbers (see Fig. 1) were somewhat correlated with the availability of shad, but ice conditions also affected the population. By 15 December most of the main channel was frozen at Savanna and probably farther to the north as well. Soon after this date the number of adult eagles started to increase while the number of immatures decreased. When the ice broke up in the spring (river opened on 23 March) the number of adults had decreased and that of immatures increased. Undoubtedly the departure of adults in mid-February was correlated with the nesting cycle.

My data indicate that the heaviest movements of immatures occurred earlier in the fall and later in the spring than the peak movements of adults.

Although immatures of all ages were observed throughout the winter, a larger proportion of the birds present during early winter (through Decem-

ber) were one year old; later in the winter a larger proportion of older sub-adults was observed (see Fig. 2). The plumage patterns of the various age-groups will be discussed later in this paper.

During both years the peak population occurred during early February. In 1962, on 2 February, 268 eagles were present; in 1963, on 5 February, 225 eagles were present. The fluctuations were similar during both seasons.

#### ROOSTS

Few additional data were gathered about roosts. Recent data suggest that many, and perhaps most, eagles roosted singly or, at least, in small groups. Several times we flushed single birds from wooded islands bordered by sloughs. The birds were in dense stands of large trees and roosted about halfway down in the crown. Generally the sites we located were near feeding areas since this is where most of our predaylight activity was concentrated. Most birds did not, however, roost in close proximity to their early morning feeding area. It was not uncommon for them to fly long distances, perhaps several miles, and often past other suitable feeding sites to reach a particular area. I am convinced that some eagles frequented particular feeding areas, perches, and loafing areas with more than accidental regularity.

#### TRAPPING METHODS AND RESULTS

We used similar trapping methods this year as last. Seven immatures were caught in platform snares and two adults in a cannon net. Three of the immatures were captured at one time, one in each of three traps in one area, and the next day four were caught simultaneously in the same three traps. Other immatures were on the beach near the trapped birds and attempted to steal the bait fish. After these occasions this method, for some reason, failed. The eagles would not walk on the traps, and once some birds walked around platforms baited with carp and attempted to pull fish from the nooses. Their talons pierced the fishes' operculum during these attempts. Bait was also taken from three floating fish traps by immatures but none were captured.

The cannon net appeared to be the best method for capturing adults. More than one net is necessary, however. We were constantly plagued by our net covering too small an area or by the fact that our time should have been spent checking a series of nets. A rapid method of firing, such as a radio-firing device, would be helpful. The main reason for failure to capture more eagles (one which could be solved by the radio-firing device) was the extreme wariness of adult eagles while feeding. We had to conceal our detonator about one-quarter mile from the feeding area where the birds would not see us stop. This necessitated setting the net at a location distant, yet visible, from the

road. When we sighted eagles at the net we drove to the detonator and fired the net. Sometimes sight of the slow-moving vehicle disturbed the birds and they left before the net was fired. The maximum number of birds before the net at one time was three. We tried using walkie-talkies but they would not function properly at low temperatures. We also constructed blinds at trap areas, but an observer could withstand the low temperatures for only a few hours.

The weights and measurements for 10 of the eagles we captured are given in Table 1. The sexes were determined by cloacal examination and are questionable.

#### BIOTELEMETRY AND COLOR-MARKING

The same methods were used to color-mark adult eagles this year as last. Immatures were marked with back-tags constructed from yellow Coverthin (a laminated plastic-nylon upholstery material). Black numerals were painted on the tags with Ramcote paint. The tags were fastened to the bird by means of two straps, one of which was wrapped around the base of each humerus and stapled. The tags were conspicuous and easily observed on flying or perched birds.

In addition to the back-tags, six eagles (four immatures and two adults) were equipped with radio transmitters and tracked electronically. This aspect of our work represents a relatively new procedure in field ornithology and will, therefore, be covered in some detail.

Numerous investigators are involved in the development and application of wildlife-tracking systems. Several, including LeMunyan et al. (1959), Lord et al. (1962, 1963), Marshall (1962), and Cochran et al. (1963) published papers regarding certain aspects of their studies. To my knowledge, no one has published results from tracking wide-ranging birds.

Field biologists have long been plagued with the problems encountered in determining the range of individual animals and the necessity of drawing conclusions from scanty data. A means by which marked individuals could be followed continuously or relocated at will was necessary to alleviate, at least in part, these problems. The radio-tracking system herein discussed is an attempt at a solution. While problems still exist, it is now possible to obtain more accurate data as well as larger quantities of data over a shorter period of time.

I first developed an interest in radio-tracking during 1959. Progress was slow and it was not until my discussions with members of the Illinois Natural History Survey that a workable system evolved. The equipment was tested in the field on Herring (*Larus argentatus*) and Ring-billed Gulls (*L. del-*

TABLE I  
WEIGHTS AND MEASUREMENTS OF 10 LIVE BALD EAGLES

Band number	Age	Sex	Weight in pounds	Measurements in millimeters						Date captured	
				Wing measurements		Tail	Exposed culmen	Tarsus	Total spread		
				Manus	Spread wing						
528-98106	Adult	male	—	590	—	—	—	—	—	—	17 Feb. 1962
509-52601	Adult	female	14.5	623	927	2,125 (83.75 in.)	318	116	116	116	4 Mar. 1962
509-52602	Immature 1st yr	male	8.5	577	825	1,930 (75.5 in.)	343	76	95	95	10 Nov. 1962
509-52603	Immature 3rd yr	female	11.75	660	940	2,080 (82 in.)	343	89	116	116	10 Nov. 1962
509-52604	Immature 1st yr	male	9	623	903	2,020 (79.5 in.)	345	89	89	89	10 Nov. 1962
509-52605	Immature 2nd yr	male	9.9	628	927	2,030 (80 in.)	356	76	89	89	11 Nov. 1962
509-52606	Immature 1st yr	female	12.75	641	965	2,145 (84.5 in.)	343	76	89	89	11 Nov. 1962
509-52607	Immature 1st yr	female	11	647	940	2,095 (82.5 in.)	381	89	95	95	11 Nov. 1962
509-52608	Immature 1st yr	female	10.5	635	940	2,070 (81.5 in.)	324	76	82	82	11 Nov. 1962
509-52609	Adult	female	12.6	620	929	2,035 (80.25 in.)	330	91	89	89	5 Jan. 1963



*warensis*) during the summer of 1962. Further development readied the equipment for use on Bald Eagles in the fall of 1962.

#### DESCRIPTION OF THE RADIO-TRACKING SYSTEM

*Transmitters.*—The transmitter circuitry is similar to that described by Cochran and Lord (1963). The 7-inch diameter loop antenna used on eagles was constructed from aluminum wire (number nine) or aluminum tubing (one-quarter inch inside diameter). A Philco T2399 transistor which is very stable during temperature fluctuations, performs uniformly, and has small size was used in most transmitters. Weights of completed eagle transmitters averaged 80 grams. Heavy encapsulation (Epoxy 346 or Silastic RTV 82) was necessary to protect the transmitter parts from the eagles. The cost of components for each transmitter was about \$9.00. Minimum life expectancy was 3 months, but longer life (about one year) is possible by altering battery load or switching to a pulsed signal. The first transmitters included regular mercury cells (E 630) as the power source, but at temperatures below 20 F these transmitters failed to operate properly. Tests in a deep freeze at subzero (down to -30 F) temperatures indicated the batteries were at fault. Alkaline cells were substituted and worked satisfactorily. Later Mallory low-temperature mercury cells were adopted. Characteristics regarding power drain and milliwatt hours/gram are most favorable for mercury cells.

As stated by Cochran and Lord (1963:20), "Building these transmitters is an art, not a science." The reader is referred to their article for instructions. Certain components vary according to the animal's size. The eagle transmitter has a 7-inch diameter wire loop antenna. Resistance values ranged between 68,000 and 390,000 ohms. The tuning capacitor values ranged between 75 and 82 picofarads.

Transmitters were attached to birds by means of a two-strap harness constructed from Coverthin. Each strap encircled the bird's body, one anterior and one posterior to the wings, and was fastened with staples at the back. The transmitters rested against, or under, the feathers of the upper breast. While the bird was aware of the transmitter and occasionally worried it, the radio apparently did not interfere with normal movements or behavior.

*Receivers.*—The receivers were constructed by Sidney Markusen, of Cloquet, Minnesota. One was a portable, crystal-controlled, battery-operated, transistorized double-conversion superheterodyne. Its sensitivity is such that it will give good bearings with a signal input of less than one-tenth microvolt. The receiver is powered by 10 "C" cells, weighs 6.5 pounds, and is 12 × 7 × 6 inches. A 24-inch hand-held loop (aluminum wire) antenna with a 4-foot coaxial lead was attached to the receiver. The receiver was carried by means of a shoulder strap. It covers 100 kc of the 26-mc band in 20 switched channels with tunable subranges.

The second receiver was a mobile unit constructed from a surplus Army command receiver (BC 453) and converted in a manner similar to that described by Cochran and Lord (1963:15). The range of this receiver was slightly superior to that of the portable model. A hand-held (copper tubing) loop antenna was used with this receiver. The loop on an aluminum pole was mounted on the side of an auto during tracking. Plots were taken from a compass rose included in the mounting.

The location of a transmitter-bearing eagle was determined by plotting the intersects of two or more azimuths obtained as nulls with the loop antennas. Accuracy was within about one degree at a distance of 2 miles. Positions were plotted on aerial photographs

of the area. A transistorized tape recorder and a spring-wound Curtiss Wright strip-chart recorder were used to record signals and variations therein.

#### FIELD RESULTS FROM RADIO-TRACKING

No differences in behavior between transmitter-bearing eagles and color-marked eagles were noticed at release time. All but one immature flew over the river and landed in the water. The one not doing so was released on a hill farther from the river. It fluttered across the road and remained concealed in tall grass for about 15 minutes. The period of time spent in the water ranged from 15 to 35 minutes. The birds mostly drifted about but exhibited swimming ability when they were once directed toward shore. The birds apparently used simultaneous strokes of wings and legs. The wing strokes were made by partially extended wings being directed forward and then forced back so that the breast was lifted from the water and projected forward. Progress was good and strokes were often repeated at regular intervals. After reaching the shore the birds preened, shook themselves, and soon thereafter headed for a perch higher than the beach such as a stump, log, or tree.

The transmitters continued to emit a somewhat weaker signal of a slightly different frequency while the bird was in the water. Swimming motions also altered the signal in a recognizable way. As a result, forward motion of the wings was recorded. When the bird emerged from the water the signal returned to normal. Flight movements also produced a particular variation in signal. As a result it was possible to determine when an eagle was in flapping flight or soaring. Preening movements and attacks on the transmitter were also detectable by variations in signals.

We successfully followed an eagle at a distance of 28 miles from the receiver but generally the tracking range did not exceed 2 or 3 miles. The location of an eagle perched in a tree or standing on ice could be determined at a maximum distance of about 2 miles. During soaring or flapping flights at various altitudes the range increased significantly. Continuous tracking of an eagle flying at an altitude of approximately 800 feet was possible in one instance. By taking a series of plots, we followed the bird for a distance of about 38 miles before we were stopped by the depot boundary fence. On two occasions immature eagles left our area and flew at least 30 miles north along the river. One of these was Number 15 which was caught by a muskrat trapper. It appeared, therefore, that even though food was abundant in our area, the birds took advantage of suitable thermals and flew to other areas, possibly remained there for a few days, and fed.

One immature was periodically relocated and tracked during a 5-week period. Batteries failed at this time because of low temperatures. On occasion we followed a radio-bearing eagle for an entire day, thus recording its feeding areas, periods of flight, and roosting site.

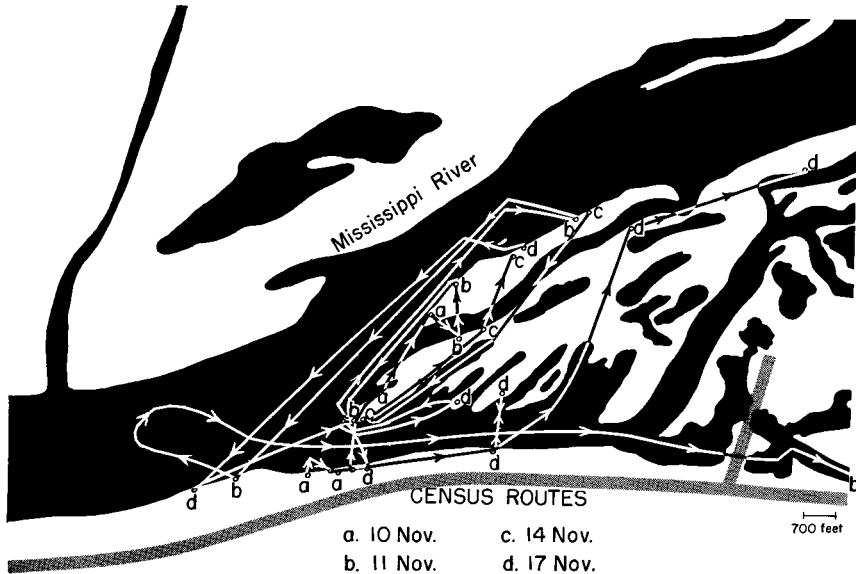


FIG. 3. Movements of Eagle Number 11 during four days of radio-tracking. On the second day the bird left the study area and travelled at least 15 miles north along the river. On 10 Nov. the bird was tracked from 1410 to 1645 hours; on 11 Nov. from 0825 to 1340 when it left the study area; on 14 Nov. from 0745 to 1300; on 17 Nov. from 0715 to 1629.

Between 10 November and 19 December we plotted 118 locations (511 timed fixes at 5-minute intervals) for the four immature Bald Eagles carrying radios. In addition, individuals birds were often tracked continuously for long periods (15 minutes to 4 or 5 hours). The minimum time that lapsed between plots was 5 minutes and sometimes hours or days elapsed before we attempted to locate a particular bird. Usually tracking was done on weekends, and as a result several days were interspersed between tracking periods. This presented a serious problem to successful tracking during this particular study.

Eagle Number 11 was released on 10 November and was tracked periodically through 19 December. The bird was not located on 23 November and only twice thereafter. A total of 200 5-minute positions were taken. On 2 days the bird was followed from daylight until midafternoon, when it left the area. Several times these birds were added to census figures solely on the basis of radio contact. On several occasions we observed transmitter-bearing eagles and their behavior appeared identical to that of "normal" individuals near them. Following are my abbreviated notes describing the movements

of Number 11 on 11 November. Figure 3 illustrates these movements within a part of our study area.

- 0825 Good signal received from roosting site where we left bird last night (west side of island out from R 5.5).
- 1008 Moved to west side of outermost island in R 5.5 area.
- 1040 Flew directly south-southeast to west side of North Point Island which is nearly opposite trap site.
- 1100 Same location.
- 1150 Flying north-northwest in direct flight. Perched directly out from Coast Guard landing on main channel. Signal rather weak. Probably low in trees or on ice.
- 1212 Bird has moved—no signal.
- 1240 Eagle located on east side of river at R 4.5.
- 1255 Took flight about 5 minutes ago and is soaring in a large circular pattern in general area of R 4. Circles take bird about 1.5 miles to the south of us.
- 1258 Soaring to NNW now in a more direct flight. Occasionally circles but in smaller arcs. Flying about parallel to Crooked Slough.
- 1305 Bird moving rapidly to north. Soaring eagle sighted with 10× glasses by directing vision through antenna when null was received. Probably our bird! Good signal with flight variation.
- 1315 Still receiving signal from north. Bird too far away to see with binoculars. Bird about 10 miles north of us.
- 1325 Number 11 is now about 15 miles to our north along river. Still in flight.
- 1330 Lost signal.
- 1640 Tried periodically to pick up Number 11 but no signal received. Bird still outside our area.

Eagle Number 12 was released on 11 November and tracked through 18 November. A total of 128 5-minute locations were obtained.

Eagle Number 15 was tracked between 11 and 25 November. No signals were received on 23 or 24 November. In all, 165 5-minute locations were obtained. The maximum number of locations taken during a single day was 63. We tracked this bird during the morning of 25 November until after 1000 hours. It was one of a group (including Numbers 8 and 14) that attempted to capture a Mallard near the Coast Guard landing (Site 2, Fig. 1, Southern, loc. cit.). We left the area and did not return until 1 December when we failed to relocate this bird. Possibly the bird had already moved north of our area since it was caught in a muskrat trap along the Mississippi River near Galena on 2 December.

We trapped two adults in a cannon net at Burning Ground Slough and attached transmitters to them. The first, Number 16, was captured on 5 January at 1000 hours. It was released at 1200 and flew north from the release point, Coast Guard landing, back to the trap site. At 1210 it flew to an island west of the Burning Ground area and there it remained until 1400 or so. At 1445 we failed to locate it. On 12 January the bird fed during the afternoon at the mouth of the Maquoketa River (Site 1, Fig. 1, Southern, *ibid.*). We did not find it after that date.

The second adult was captured on 26 January. It was released at 1400 hours. We followed it for the remainder of the afternoon. It was not located again.

Three of the back-tagged immature eagles were sighted a total of six times. One, the first bird released (Number 8), was observed with Numbers 14 and 15 (released on 11 November) on 25 November. Number 10 was the only back-tagged eagle observed more than once. It was reported four times within the area after its release on 10 November. During the morning of 8 December it was observed perched in a tree on a small island near the Coast Guard landing. There it remained for about an hour. On 21 December it was found during the early morning on North Point Island and at 0845 it flew south. We observed it near the mouth of the Maquoketa River on 22 and 27 December. It was not reported thereafter. No reports were received from outside the area. One band recovery was reported (immature killed near Galena).

Last year I received two validated reports of color-marked eagles. Thus on the basis of color-marking, I obtained a total of eight reports of eagle locations during 2 years. The value of radio-tracking as a tool in home range studies is obvious—118 locations in about 5 weeks as compared with eight sightings in 2 years.

#### GENERAL BEHAVIOR

On the basis of radio-tracking and direct observations, it is possible to point out some general patterns of eagle behavior. A condensation of these observations follows: The first eagle usually arrived at a particular feeding site at the first sign of dawn or shortly thereafter. Soon other birds started to appear individually. The arrival of birds at particular sites continued until after sunrise. Usually there was much calling as the birds arrived, particularly in the cases of dawn arrivals. The flight to the area was of the direct, flapping type alternated with only a few short glides. Seldom were birds very active at this early hour, and usually they remained perched in trees near the feeding area. Occasionally a bird circled over the open water, if it had not done so upon arrival, and soon returned to a perch. Once in a while a late arrival landed on the ice near the water. The birds usually started feeding about 20 or 30 minutes after the first birds had arrived. The early morning method of feeding was generally that of flying over the hole and swooping, attempting to take fish with the talons. About this time some birds landed on the ice near the larger open areas (e.g., mouth of the Maquoketa River). Usually the birds on the ice were rather far apart and a number of them were immatures. Occasionally they reached into the water with beak or talons after fish but usually the ice simply served as a landing place after a fishing flight. At smaller holes (e.g., Burning Grounds) the eagles were more

hesitant to get onto the ice, apparently because of limited visibility. Some birds remained perched while others fed. The feeding period extended throughout the day with a few birds always attempting to catch fish. Sometimes a number of eagles concentrated on the ice or along beaches where spring seepage opened the shallow water. Some waded in the water after fish while others remained perched in trees and became startled at the slightest disturbance. At these sites eagles also swooped down after fish, provided the hole was large enough.

Eagles, particularly immatures, were attracted to small holes, wet areas, or patches of slush ice. In such areas they were seen standing or walking about on the ice. Prior to the formation of ice on the river one immature walked about 300 yards along the beach, apparently looking for food. It was not uncommon for an eagle to land 20 or 30 feet from a somewhat hidden feeding area and walk cautiously to it.

About 0900 to 1000 hours, after feeding, some birds left the feeding areas. If it were foggy or snowing the birds generally remained perched and also tended to group together. During such conditions we occasionally found 50 or 60 eagles perched in one cluster of trees near feeding sites. During clear days, particularly when the wind was blowing at about 15 mph, the eagles took to the air and soared about. During afternoons of such days the population was usually low. Temperatures below zero also resulted in the birds' being inactive. They perched low in the trees, rather than on high dead stubs, and remained farther back in the sloughs, behind banks, or in other protected places. During these periods we recorded eagles where they had not been previously.

Once in a while, apparently after wading for food or after falling through the ice, an eagle got on a high perch, and with its back to the sun, spread or drooped its wings, and apparently dried its feathers. Sometimes the eagle panted. This posture suggested that the bird was injured.

After soaring about or feeding during the afternoon the birds gradually left for roosting sites. There was not an obvious flight, but the number visible at a given area slowly decreased. Some remained perched along the census route until almost dark. These birds probably roosted close by on one of the islands.

Insufficient data are available to permit determination of the winter range of individual eagles. I believe, however, that there was a change in the daily population. Some new birds came into the area (or simply returned to it) and others left. Our tracking indicated that the birds ranged over a 3- to 4-mile area for a few days and then possibly wandered outside of the study area (perhaps 30 miles or more). Sometimes they returned after a few days. I doubt that many eagles remained for the entire winter in a given area. Our

records for two eagle flights to the north of our area and a banding return from Galena tend to substantiate my suspicion. The fluctuation in the daily number of individuals representing each age-group further suggests that the birds wander about.

AGE-GROUPS AND PLUMAGES

In each census report we differentiated between the number of adults and immatures at each check station. Striking variations in subadult plumages were noted. As a result I recorded each variation and the number of times I saw it. I noted similarities suggesting a distribution according to age. On the basis of plumage characters I suggest that six age-groups of subadults are distinguishable. My grouping differs somewhat from that of Bent (1938: 326-327). Specimens examined at The University of Michigan Museum of Zoology represented four of the six groups. The plumage patterns, based on the more conspicuous markings, were grouped as follows:

*First-year plumage.*—Dorsal and ventral sides uniformly dark brown except for an occasional white portion on one or more feathers. Primaries, secondaries, and coverts as dark or darker. Crown sometimes darker than rest of body. Rectrices brown, often with grayish-white varying from a sprinkling to a coverage of about 60% of the central rectrices. Less white visible on dorsal side of tail. Mandibles horn brown. Tarsi yellowish. Iris light brown. UMMZ specimens 91379, 59255, 36916, 113761, 84214. Numbers 59255 and 113761 were birds of known ages, 3 and 4 months, respectively.

*Second-year plumage.*—Belly and lower breast generally light, tawny brown. Upper breast darker, appearing as a band or bib. Dark brown dorsally in most cases. Occasionally a few white feathers on belly and throat (possibly incoming feathers of third-year plumage). Some white in tail, perhaps more than in first year. Beak and iris brown. Tarsi yellow. UMMZ specimens 47152 and 56479.

*Third-year plumage.*—Throat with some white; breast brown resulting in an obvious but perhaps narrow band on upper breast. Belly and lower breast whitish to white. Sometimes white area very large, other times small and flecked with brown. Dark brown dorsally except for an occasional white patch or scattered white feathers (may have brown tips). The most common location for a white patch of feathers is between the wings on the back where it resembles a solid white V on a perched bird. Coverts often spotted with white. Crown generally dark brown, sometimes tawny tips to feathers. White may begin to show on sides of head or throat (usually throat first), but crown and nape most often dark. Little yellow at base of mandible; iris brown. UMMZ specimens 36915, 61233, 71862, 107478, 122068.

*Fourth-year plumage.*—Body primarily brown dorsally. Breast brown; possibly some dull-white on belly. Throat light brown or whitish; sides of head and possibly forehead dull-white; crown and nape often dull-white with brown-tipped feathers (sometimes largely brown). Light superciliary line and occasionally a dark line before and behind eye. Beak showing yellow on proximal one-half. Iris still brownish. UMMZ specimens 74304, 93904, 118574, 122072.

*Fifth-year plumage.*—Similar to adult plumage but with a sprinkling of brown on most of the white rectrices which may not be visible except with high power binoculars. Generally brown tips on some crown and nape feathers; sometimes entire crown still

brown. Iris yellowish. At a distance, without binoculars, an observer might mistake such a bird for an adult although the head appears somewhat darker.

At some time during development there was a change in the location of brown and white on some contour feathers. During the second and third years the bases were usually brown and the tips white; later they are reversed.

*Sixth-year plumage.*—Head white but a sprinkle of brown still present on rectrices and occasionally on the nape. This condition possibly persists for some time. Since this plumage pattern is difficult to distinguish in the field from the full adult plumage, birds in this plumage were censused as adults. This variation may simply represent a variation of the fifth-year plumage.

Considerable variation was evident in the third-year plumage. Possibly the birds with a sprinkling of white were second-year birds showing signs of molt. In the spring we noticed a few more birds in this condition. Although we found a few dropped brown contour feathers in the area, there was no indication of a heavy molt. Immatures trapped in the fall were all in fresh plumage.

This grouping of eagles into age-groups served the purpose of providing categories to be used in censusing the population. Although I feel that I viewed the variations with a fair degree of accuracy, there is no guarantee that I am correct. Much more data are necessary from birds of known ages before my grouping can be properly validated.

#### SUMMARY

Between 29 September 1962 and 9 April 1963, I continued my study of the winter eagle populations in northeastern Illinois. In addition to methods used previously, I introduced radiotelemetry techniques to the eagle research.

Immatures arrived in the area before adults and remained more abundant until mid-December. The adult population increased to 225 by early February. No eagles were present after 6 April.

Gizzard Shad continued to supply the main portion of the eagles' diet. The eagle population fluctuated according to the abundance of shad, with ice conditions, and with the advent of the breeding season. Sometimes eagles fed on fish discarded by commercial fishermen, on dead waterfowl, possibly on dead livestock, and on one occasion attempted to capture a live duck.

Eagles roosted singly or in small groups usually some distance from their feeding sites.

Nine eagles were captured in platform snares and a cannon net. Weights and measurements were taken.

Adult eagles were color-marked with dyes but plastic back-tags were used on immatures. In addition, six birds were equipped with miniature radio transmitters. The transmitter weighed about 80 grams, had a life of about 3 months, and enabled the investigator to follow the bird with radio-tracking equipment. Besides knowing the animal's location I could determine when it was soaring, flapping its wings, or preening. One eagle was tracked periodically for about 5 weeks. Occasionally a bird was tracked from the time it left the roost in the morning until it returned at night. One bird was tracked continuously for a distance of about 38 miles.

During about 5 weeks 118 locations were received by radio-tracking four birds in contrast to eight reports for 12 color-marked birds in 2 years.

Considerable variation was noted in immature plumages. On the basis of my observations and the examination of specimens at The University of Michigan Museum of Zoology I grouped the plumage patterns into six age-groups.



LITERATURE CITED

- BENT, A. C.  
1937 Life histories of North American birds of prey. Part 1. *U. S. Nat. Mus. Bull.* 167.
- COCHRAN, W., AND R. LORD  
1963 A radio-tracking system for wild animals. *J. Wildl. Mgmt.*, 27:9-24.
- LORD, R. D., F. C. BELLROSE, AND W. W. COCHRAN  
1962 Radiotelemetry of the respiration of a flying duck. *Science*, 137 (3523):39-40.
- LEMUNYAN, C. D., W. WHITE, E. NYBERG, AND J. CHRISTIAN  
1959 Design of a miniature radio transmitter for use in animal studies. *J. Wildl. Mgmt.*, 23:107-110.
- MARSHALL, W. H., G. W. GULLION, AND R. G. SCHWAB  
1962 Early summer activities of porcupines as determined by radio-positioning techniques. *J. Wildl. Mgmt.*, 26:75-79.
- SOUTHERN, W. E.  
1963 Populations, behavior, and seasonal dispersal of Bald Eagles wintering in northwestern Illinois. *Wilson Bull.*, 75:42-55.

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