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METHODS OF CONTROLLING GOLDEN EAGLE DEPREDATION ON DOMESTIC SHEEP IN SOUTHWESTERN MONTANA

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ABSTRACT.—Potential for extensive Golden Eagle (*Aquila chrysaetos*) depredation on lambs of Domestic Sheep (*Ovis aries*) exists when jackrabbit (*Lepus* spp.) populations are low and/or lambing seasons are cool or wet. Such conditions were present during 1974 and 1975 on two ranches near Dillon, Montana, when eagle depredation on lambs was high. Golden Eagles were trapped on the ranches from 1975 through 1983 and translocated to areas where chances of depredation were deemed small. The translocation program was expensive, had little demonstrated effect on depredation and may have functionally transplanted the problem, not solved it. Harassment of eagles by chasing with a small airplane, discharging rifles and firing explosive shotgun shells failed to stop depredation, to reduce the number of birds present or to alter distribution. Human-like scarecrows placed on high knobs and ridges, accompanied by harassment, appeared to reduce depredation and displace eagles from the lambing sheep bands during 1984. We tested the hypothesis that eagles avoided scarecrows and that scarecrows, combined with harassment and increased human activity, reduced depredation. This combination kept eagle sighting rates to a minimum, redistributed birds and reduced depredations. No single predator control technique will always work in every situation, but we conclude that scarecrows, combined with harassment, offer the most feasible means of protecting lambs under range lambing conditions in southwestern Montana.

The topic of Golden Eagle (*Aquila chrysaetos*) depredation on lambs of Domestic Sheep (*Ovis aries*) is controversial. Raptor enthusiasts and sheepmen are often at odds over the severity of depredations or the fact that they even occur. Golden Eagles are efficient predators known to kill lambs (Glover and Heugly 1970; Nesse et al. 1976; Tigner and Larson 1977, 1981; Foster and Crisler 1978, 1979; O'Gara 1978, 1981; Wade and Livingston 1978, 1979). Reportedly, Golden Eagles have killed domestic calves (*Bos taurus*), Mule Deer (*Odocoileus hemionus*), Bighorn Sheep (*Ovis canadensis*), Dall's Sheep (*Ovis dalli*), Mountain Goats (*Oreamnos americanus*), and even Coyote (*Canis latrans*) (McLean 1925; Dixon 1934; Allen 1939; Couey 1944; Wood 1946; Boyer 1948; Clawson 1948; Kennedy 1948; Brown and Couey 1950; Casebeer et al. 1950; Riney 1951; Ford and Alcorn 1964).

Most depredation problems occur at lambing time (Arnold 1954; Murphy 1977; U.S. Dept. Int., Fish and Wildl. Serv. 1983) and are relatively short-term conflicts, although economic losses can be great. Lit-

tauer and White (1981) estimated lamb losses due to eagle depredation at \$87 000 in New Mexico from 1 January–1 May 1981. Lamb losses to eagle depredation on two ranches in southwestern Montana were estimated at \$38 000 in 1974 and \$48 000 in 1975 (O'Gara 1978). Arnold (1954:30) concluded from his studies of eagle depredation on sheep in Colorado, Wyoming and Texas that depredations were "spasmodic . . . and may vary considerably under changing local conditions."

Factors that influence the severity of Golden Eagle depredation on sheep include: natural prey densities, availability of carrion, weather, ranching practices, vegetative cover, and topography as well as Golden Eagle age, behavior, densities and distribution (Arnold 1954; Lockie and Stephen 1959; Snow 1973; Bolen 1975; Brown 1975; Tigner and Larson 1977, 1981; O'Gara 1978, 1981; Gober and Lockhart 1979). Interaction of these factors in combination with economic, social and political values contributes to emotionally charged, opinionated and highly contested conflicts.

During June 1974, the Director of the U.S. Fish and Wildlife Service (USFWS) received two applications from Peter and George Rebish and from Rebish and Helle, Inc. requesting a permit to kill Golden Eagles that were killing lambs. Law enforcement agent E. Cofer (USFWS), who had extensive experience identifying predator kills, was dispatched to Dillon. Cofer found 16 fresh, eagle-killed lambs within two hr. Service biologists, animal damage control agents and a representative of the National Audubon Society met in Dillon to discuss the situation. The applicants were willing to cooperate in an eagle live-trapping and removal program or a documentation study. Thus began an 11 yr research/management program on Golden Eagle-lamb depredation in southwestern Montana. This paper summarizes research results and describes management practices.

STUDY AREA

Rebish Brothers/Rebish-Konen and Rebish and Helle, Inc., ranches are located about 40 and 25 km southeast of Dillon, Montana, respectively. The former covers about 9300 ha of rolling grassy hills near the head of Rock Creek at about 2100 m elevation. Steep hills and deep valleys associated with strong winds and thermal updrafts provide ideal flying conditions for eagles.

Rebish and Helle, Inc., ranch consists of about 3000 ha of sagebrush (*Artemisia* spp.) and scattered grasslands with pockets of aspen (*Populus tremuloides*) and conifers along the North Fork of Sweetwater Creek. Large boulders and rock outcrops are common, providing ideal perches for eagles.

Rebish-Konen ranch was divided into two areas to test scarecrow efficacy during 1985. The two areas, Rock Creek (2000 ha) and Little Rock (3000 ha), were adjacent and had similar vegetation and topography. Rock Creek had high eagle use during previous years (J. Konen, pers. comm.) and many eagle kills were found there (O'Gara 1978, 1981, 1983). Eagles also used Little Rock and were trapped in both areas from 1975 through 1983 (Niemeyer 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983). Sheep stocking rates were similar to past years with 1400 lambing ewes on Rock Creek and 500 lambing ewes and 600 yearling ewes on Little Rock.

Lambing Practices. Range lambing begins on both ranches during mid- to late May and is completed by early July. The ranchers minimize human disturbance of the sheep during lambing in efforts to prevent lamb abandonment by ewes. Ewes and lambs are moved to mountain rangelands during July and remain there through September. Golden Eagle depredation occurs primarily on lambing grounds during May and June. Ranchers report no problems from eagles on summer ranges.

After lambing is completed, tails of lambs are removed (docked) and animals are prepared for movement to summer ranges. Accurate counts are made at docking time. The number of lambs divided by the number of ewes,

multiplied by 100, is referred to as the docking percentage. Docking percentages are frequently used, erroneously, as indicators of predation severity. During years of severe depredation, bad weather, high disease incidence or combination of a myriad of other mortality factors, docking percentages will be low. Nevertheless, docking percentages can be used as a relative indicator of lamb production.

METHODS

Carcass Searches, Depredation Rate and Identification of Eagle-killed Lambs. Sheep carcasses were located with cursory drives around each ranch and by sighting groups of eagles or Common Ravens (*Corvus corax*) (White and White 1985). Many carcasses were located during aerial surveys and examined later on the ground. If cause of death was not immediately discernible, carcasses were skinned to examine any wounds and dissected to examine internal organs if present. Some carcasses were brought in by field crews and ranchers for necropsy. Eagle depredation rate during 1985 was calculated by dividing the number of eagle-killed lambs found by the number of adult ewes on a given study area. The number of ewes present was our best indicator of number of lambs available. Depredation rate differences between study areas were evaluated with a proportional test using a Z statistic (Zar 1984).

O'Gara (1978, 1981) outlined methods for identification of eagle-killed lambs. Additional characteristics of predator-killed animals were given by Rosko (1948), Rowley (1970), Wiley and Bolen (1971), Bowns et al. (1973), Davenport et al. (1973), Brown (1976), Nesse et al. (1976) and Tigner and Larson (1977, 1981). Subcutaneous hemorrhage at talon wounds was the primary indicator for eagle-killed lambs. Evidence of arterial spurts also indicated a kill. Large amounts of blood originating from eye wounds generally indicated a raven kill. Ravens sometimes pecked the eyes of young lambs and "pecking bruises" were often noted when these kills were skinned.

Capture, Translocation, Radio Instrumentation and Monitoring. From 1975 through 1983 eagles were captured for translocation using the Lockhart method (Niemeyer 1975). Padded, steel, leg-hold traps (No. 3 or 4) were baited with dead rabbits or lambs, placed at visible locations and observed from a distance. A live decoy eagle was usually staked near the traps. Four, unanchored, concealed traps chained together to form two pairs surrounded each bait. Sometimes a length of rope was attached to each trap pair. When an eagle was captured, the weight of the traps and their tendency to snag on surrounding vegetation allowed ground crews to contain the eagle and remove the trap. Captured eagles were transported to holding facilities and then to release sites (Niemeyer 1975).

Nine eagles were captured for radio instrumentation during 1985 using a helicopter and Coda (Coda Enterprises, Inc., Mesa, AZ) net gun (O'Gara and Getz 1986). Radio-transmitters (SB2, AVM Instruments, Livermore, CA), were attached ventrally on the most recently molted central rectrix approximately 2 cm distal to the follicle. Transmitters were attached to the feather with three pairs of nylon string that were embedded in the transmitter potting material. Anterior and posterior string pairs were tied around the feather shaft, and one of the middle strings

was passed through the feather shaft using a needle, and then tied around the transmitter. String tails were tied together forming a "net" around the transmitter. The antenna was attached to the remaining distal portion of the feather at four equally spaced intervals. Surgical knots were used throughout and super glue (Duro) was applied to each knot. Transmitter packages weighed approximately 26 g. Eagles were radio-tracked from a Piper Super Cub utilizing a rotating H antenna and Telonics (Telonics, Inc., Mesa, AZ) receiver. A few locations were recorded from the ground on an opportunistic basis.

Eagle Surveys. Aerial and ground counts and age classifications of eagles were made during 1975 and 1976 (Niemeyer 1975, 1976). Notes on relative abundance and age of eagles observed during trapping efforts were made from 1977 through 1982 (Niemeyer 1977, 1978, 1979, 1980, 1981, 1982). Age, sex and total number of eagles captured was also recorded annually between 1975 and 1983.

Parallel strip transects approximately 1 km wide were flown at an altitude of about 100 m across the entirety of both ranches from 1983 through 1985. The pilot and observer looked for eagles within 0.5 km of the aircraft on 2-4 d intervals from May through July. Total numbers of eagles observed and approximate locations were recorded during 1983 and 1984. During 1985, the number of eagles observed from aircraft, vehicle, and horseback, and eagle activity, age and exact location (Universal Transverse Mercator coordinates within 100 m) were recorded. Search effort (flight survey time or time and km driven/riden) was also noted during 1985.

Eagle Harassment and Frightening Techniques. Eagle harassment consisted of discharging explosive shotgun shells (crackershells), discharging a rifle near perched birds and approaching birds via vehicle, foot, or horseback causing them to move. Taped eagle "chitter" and alarm calls were used during 1983 in attempts to frighten eagles from sheep carcasses. Eagles were also harassed using a Piper Super Cub during 1983 by "buzzing" them, attempting to force them to fly and by chasing birds with the aircraft and firing shotshells or crackershells (O'Gara 1983).

Human-like scarecrows and suspended eagle carcasses were placed on high points and ridges late in the lambing season of 1983 in attempts to discourage eagles from lambing areas. Scarecrows were hung with wire on a pipe, allowing movement in the wind and were also used during 1984 and 1985 (O'Gara et al. 1984; O'Gara and Matchett 1985). Shiny tin pans were tied to each scarecrow with string after they had been in place for about two wk in efforts to increase visibility and retard eagle habituation to scarecrows.

Experimental Test of Scarecrow Efficacy. Scarecrows were erected on Rock Creek study area and Little Rock study area served as a control area without scarecrows or harassment during 1985. Both areas were similarly surveyed for eagles and lamb carcasses. Expected results were that Rock Creek and Little Rock would have similar eagle sighting and predation rates before placement of scarecrows. If scarecrows deterred eagle depredation, rates would be expected to decrease on Rock Creek and stay the same or increase on Little Rock.

Number of eagles observed were evaluated on a per unit

effort basis (number of eagles observed/min or km of search effort) for pre- and post-scarecrow placement time periods. Differences between mean sighting rates during pre- and post-scarecrow placement time periods and between Rock Creek and Little Rock Creek study areas were evaluated with Student's *t*-Tests using separate variance estimates (Sokal and Rohlf 1981; Nie 1983).

Measurements of distances between scarecrow sites and both eagle radio-locations and sightings of unmarked eagles before and after scarecrow placement were used to quantify potential eagle avoidance of scarecrows. Mean distances were calculated for pre- and post-scarecrow time periods. Our hypothesis was that eagles would be closer to individual scarecrow sites before scarecrows were placed and would avoid scarecrows and be farther from scarecrow sites after placement. We tested our hypothesis using Mann-Whitney *U*-Tests and Student's *t*-Tests on differences in eagle distance from scarecrow sites during pre- and post-scarecrow time periods (Sokal and Rohlf 1981; Nie 1983).

RESULTS AND DISCUSSION

Lamb Mortality and Circumstances Related to Eagle Depredation. Little depredation documentation was attempted during 1975-1982 and 1984. Compared to 1974 and 1975, depredations were evidently low from 1976 through 1985 (Table 1). Eagle-killed lambs were easily found with minimal search effort during 1974 and 1975, but relatively few eagle-killed lambs were found from 1977-1985. Many of the carcasses necropsied between 1977 and 1982 were brought in by ranchers and field crews. Selection for suspected eagle-killed lamb carcasses was a possibility. Docking percentages approached normal (rancher acceptable) levels from 1976-1985. If significant depredations were occurring during this period, larger numbers of eagle-killed lambs would have been found and docking percentages would have been lower.

An apparent decline in jackrabbit (*Lepus* spp.) populations throughout the West appeared to be an important factor leading to extensive sheep depredation during 1974 and 1975 (O'Gara 1978, 1981, 1983). Conclusive data were unavailable, but communications with biologists from 17 western states indicated that jackrabbit populations crashed during 1972-1973 and that jackrabbits were scarce during 1974 and 1975. Lambing seasons of 1974 and 1975 were unusually cool and wet on the study areas (U.S. Dept. Comm. 1974, 1975) and Richardson's Ground Squirrels (*Spermophilus richardsonii*) and Yellow-belly Marmots (*Marmota flaviventris*) were relatively inactive due to cool temperatures (O'Gara 1981). Few alternative prey species were available to eagles, whereas lambs were abundant.

Table 1. Domestic sheep docking percentages and summary of predator-killed lambs found on the Rebish brothers/Rebish-Konen and Rebish and Helle, Inc., ranches near Dillon, Montana from 1974 through 1985.

| YEAR | TOTAL CARCASSES EXAMINED | TOTAL PREDATOR KILLS | TOTAL EAGLE KILLS | % OF EXAMINED CARCASSES KILLED BY EAGLES | DOCKING ^a PERCENTAGE |
|------|--------------------------------|----------------------------|-------------------------|--|------------------------------------|
| 1974 | 58 ^b | 47 | 44 | 76 | 56 |
| 1975 | 17 ^c | 15 | 15 | 88 | 48 |
| 1976 | 0 | 0 | 0 | 0 | 76 |
| 1977 | 31 | 2 | 1 | 3 | 78 |
| 1978 | 11 | 0 | 0 | 0 | 77 |
| 1979 | 32 | 19 | 15 | 47 | 78 |
| 1980 | 13 | 6 | 1 | 8 | 78 |
| 1981 | 17 | 3 | 0 | 0 | 90 |
| 1982 | 21 | 13 | 11 | 52 | 81 |
| 1983 | 287 | 36 | 16 | 6 | 87 |
| 1984 | 37 | 17 | 5 | 13 | 73 ^d |
| 1985 | 416 ^c | 37 | 10 | 2 | 72 ^d |

^a Docking percentages represent the average of both ranches combined.

^b Sixteen found by E. Cofer in 2 hr and the remainder found by O'Gara in just a few days. Additionally, 36 carcasses heavily fed upon by eagles were found, but cause of death could not be identified.

^c All found on the Rebish-Konen ranch within 6 hr.

^d Values from the Rebish-Konen ranch only.

^e Search effort totaled 2039 km via truck, 56 hr via aircraft and 173 km via horseback.

Aerial and ground censuses during 1975 and 1976 showed that eagle numbers declined steadily from January through April (Niemeyer 1975, 1976). Natural dispersion of wintering birds from, or movement of migrants through the area, and eagle removals from trapping undoubtedly accounted for the decline (Niemeyer 1975, 1976). In May 1975 and 1976 during the peak of the lambing season numbers of eagles, 50–75% juveniles and subadults, suddenly increased. Trapping success increased markedly with the influx of birds. Numbers of eagles fluctuated thereafter, but were highest during lambing (Niemeyer 1975, 1976).

Boeker and Ray (1971) aerially censused Golden Eagles across a 26 000 km² area in east-central New Mexico from 1964 through 1969 and found that an average of only 31% of the general population was composed of immature birds between November and April. Counts between 1973 and 1984 in the Birds of Prey Area in southeastern Idaho indicated that the proportion of immatures fluctuated but did not exceed 50% (M. Kochert, pers. comm.). In contrast high proportions of immature birds were observed during trapping efforts in Montana (Niemeyer 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983).

Seventy-six percent of the eagles captured on the study area were immature birds. Similarly, Foster and Crisler (1978) reported that 77% of their sightings were of immature eagles during a Golden Eagle-sheep depredation study in Oregon.

Young eagles appeared to be responsible for killing more lambs in this study than adult eagles (O'Gara 1981). Young eagles or birds in poor condition do not defend territories and may congregate in areas of food abundance (Gober and Lockhart 1979). Fourteen Golden Eagles, predominantly immature birds, were observed feeding simultaneously on one sheep carcass during 1985.

Evaluating Depredation Severity. Golden Eagle food habit studies have been used as indicators of livestock depredation severity, and livestock is generally considered a minor diet component (Olendorff 1976). Prey remains at nest sites are frequently used as indicators of prey taken (e.g., McGahan 1967; Mollhagen et al. 1972; Bloom and Hawks 1982; Collopy 1983). Presence of lamb remains at nest sites is not a good indicator of eagle depredation. Non-territorial or non-breeding eagles do not maintain a nest but may account for most of the depredation. Lamb remains at nests are generally fed upon

extensively and are difficult if not impossible to classify as kills or carrion. One Golden Eagle nest was located on the Rebish-Konen ranch and was occupied during most years of the study. Lamb remains were frequently found at the nest, but cause of death could not be determined. Eagles undoubtedly carry more small (less than 2 kg) than large prey items to nests. Eagle-killed lambs in the present study typically weighed more than four kg. Even with ideal flying conditions, eagles could not carry such lambs to a nest (Cameron 1908; Seton 1937; Walker and Walker 1939, 1940; Arnold 1954; Olendorff 1972). Prey items at nest sites only represent animals eaten during the nesting season. Food habit studies based on castings or crop/stomach analyses are also limited and distinction between kills and carrion is impossible.

Studies are limited in their ability to accurately quantify actual eagle depredation. Proportions of eagle kills identified by examining carcasses are often reported but are likely biased by carcass search effort, ability to locate carcasses and carcass selectivity. Hence, the relationship between data on examined eagle kills (Glover and Heugly 1970; Wiley and Bolen 1971; Klebenow and McAdoo 1976; Nesse et al. 1976; Tigner and Larson 1977, 1981; Foster and Crisler 1978, 1979; Wade and Livingston 1978, 1979; O'Gara 1981, 1983; O'Gara et al. 1983, 1984; O'Gara and Matchett 1985) and actual eagle depredation rate is unknown.

Eagle Trapping and Translocation. The USFWS personnel in Montana were committed by the Director of the USFWS to trap and translocate eagles from 1975-1983. No data were gathered on dispersal or fate of translocated birds. Eagles were released in Flathead and Swan Valley in northwestern Montana (approximately 325 km northwest of the study areas) and north-central Colorado (approximately 750 km southeast of the study areas) during 1975. All translocated eagles were released in Yellowstone National Park (approximately 160 km southeast of the study areas) from 1976 through 1983. One hundred forty-five eagles were captured and removed during 1975 at a cost of \$23 600 (Niemeyer 1975; O'Gara 1981). Even so, docking percentages were lower in 1975 than in 1974 (Table 1). Translocated eagles totaled 432 between 1975 and 1983 and cost of the project totaled \$112 771. Number of eagles captured generally decreased from 1976 through 1983, as did relative depredation severity as indicated by docking percentages.

Jackrabbit populations were apparently increasing during and after 1976 (U.S. Dept. Int., Bur. Land Manage. 1972-1980; Stoddart 1977; Knowlton 1980; Johnson and Peek 1984), and weather during lambing seasons was warmer compared to 1974 and 1975 (U.S. Dept. Comm. 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983). Eagles were not censused from 1977 through 1982 because so few appeared on the ranches (Niemeyer 1977, 1978, 1979, 1980, 1981, 1982). Low numbers of eagles on the ranches could have resulted from the translocation program, but most likely resulted from an increase in natural prey and mild weather. We suspect that eagle numbers in southwestern Montana did not change dramatically between 1977 and 1985, but rather eagles were concentrated in lambing areas during 1974 and 1975 and more dispersed after 1976. Captured eagles totaled 145 in 1975 and 69 in 1976, yet the capture rate averaged only 31 between 1977 and 1983 with a high of 48 in 1978 (Niemeyer 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983). Eagles killed lambs after 1976, but impacts were minor compared to 1974 and 1975. Translocation did not stop depredation during 1975, and by 1983 the program was determined not to be the solution. Translocation was expensive and had little demonstrated effect on depredation rates. In addition translocated eagles might continue to kill lambs in other areas or eventually return to the original depredation area as was evident in 1977 (Niemeyer 1977).

A helicopter-net gun capture technique provided a more efficient and selective method for removing depredating eagles compared to the Lockhart method as birds could be selectively removed from carcasses. Pit traps and cannon nets might also be effective methods (P. Bloom, pers. comm.). Eagle translocation is a reactionary measure, does not prevent depredation, could be expensive if large numbers of eagles were involved and may only transplant the problem, not solve it.

Harassment and Scarecrows. Law enforcement agent E. Cofer (USFWS) estimated that 40 eagles were on the Rebish and Helle, Inc., ranch when he found 16 fresh eagle-killed lambs on 6 June 1974. Cofer counted 20 Golden Eagles in the air at one time. Use of rockets and crackers failed to disperse the eagles or reduce depredation (O'Gara 1978).

Harassment of eagles from an airplane during 1983 failed to stop depredation, to reduce the number of birds present or to alter their distribution (O'Gara

1983). Eagles could not be flushed more than twice, even when "buzzed" about 1 m from the wheel of the aircraft. The use of taped eagle "chitter" and alarm calls failed to frighten eagles from sheep carcasses (O'Gara 1983). Eagles simply looked towards the source of the taped calls and resumed feeding. Capture and handling of eagles for radio-instrumentation could be considered harassment. Refusal by radio-marked birds to leave the area indicates that harassment alone will not cause birds to abandon lambing areas.

Six scarecrows and 11 eagle carcasses were placed at prominent points near lambing grounds late during the lambing season of 1983. These devices did not immediately reduce the number of eagles on the ranches, but both showed potential for altering the distribution of eagles relative to lambing bands (O'Gara 1983). Depredation ceased after scare device placement, but other factors (human activity, harassment, movement of sheep to summer range) may have contributed (O'Gara 1983).

Twenty-two scarecrows were placed on prominent points during 1984. Harassment associated with scarecrows seemed to keep eagles away from lambing bands during 1984 (O'Gara et al. 1984). Numbers of eagles observed on census flights decreased after scarecrow placement, and the distribution of eagles apparently shifted (O'Gara et al. 1984). Lack of search effort and exact eagle location data precluded rigorous analysis of the apparent change in eagle numbers or shift in use areas (see following results for 1985). Eagles were observed near scarecrows within two wk of scarecrow placement. Ground harassment was then initiated. In addition to harassment of eagles during 1984 efforts were made to kill Common Ravens, but only two were actually killed. Eagles apparently took cues from ravens on the presence of danger (O'Gara 1983; O'Gara et al. 1984).

Eagle-killed lambs were easily found from the air during 1983 (O'Gara 1983), but none were observed on 21 flights or during visits on the ground during 1984 (O'Gara et al. 1984). O'Gara verified five eagle-killed lambs brought in by ranchers before scarecrows were erected in 1984.

Sheep characteristically bed on high knobs and ridges, and many eagle-killed lambs were found near sheep bedding areas. Placement of scarecrows at or near bedding grounds made them visible and in close proximity to sheep during morning hours. If lambs were "protected" for the first few hours of daylight,

eagles would usually kill some alternative prey before sheep left the vicinity of the scarecrows. Scarecrows are inexpensive to construct, place and maintain and should be erected just prior to lambing and removed immediately after to minimize eagle habituation.

Experimental Evaluation of Scarecrow Efficacy. Scarecrows (11 on Rock Creek and 18 on Rebish and Helle, Inc.) and harassment helped to prevent eagle depredation on lambs during 1985 (O'Gara and Matchett 1985). Sighting rates (eagles observed/min of search time) decreased slightly on Rock Creek when scarecrows were erected and remained relatively low throughout the lambing season (Fig. 1). Sighting rates increased on Little Rock after scarecrows were placed on Rock Creek and remained relatively high throughout the remainder of the lambing season (Fig. 1).

Analyses of aerial observation rates (eagles observed/min search time) supported the hypothesis that eagles avoided scarecrows. Mean eagle observation rates were 0.1445 on Rock Creek and 0.2427 on Little Rock for 24 d prior to scarecrow placement and 0.1497 and 0.5283, respectively, for 24 d post-scarecrow placement. Sighting rates between study areas did not differ significantly prior to scarecrow placement (Student's *t*-Test, $P > 0.05$). Sighting rates were also similar before and after scarecrow placement on Rock Creek (Student's *t*-Test, $P > 0.05$). Sighting rates increased significantly in Little Rock after scarecrow placement on Rock Creek (Student's *t*-Test, $P < 0.005$). Sighting rates were significantly higher on Little Rock than on Rock Creek during the 24 d post-scarecrow placement (Student's *t*-Test, $P < 0.001$).

Twenty-four d pre- and post-scarecrow placement was the maximum time in the field prior to scarecrow placement. Results of comparisons of 24 d prior to scarecrow placement with 55 d post-scarecrow placement were virtually identical to those described above. The trend from ground sighting rates was similar, but more variable than for aerial surveys. Relatively few data were available for ground sighting rates prior to scarecrow placement.

One hundred eighty-one observations of eagles were made during 24 d prior to scarecrow placement and 256 observations during 24 d post-scarecrow placement. The apparent influx of eagles was similar to that described for 1975 and 1976. Scarecrows likely caused newly arriving eagles to avoid Rock Creek and use Little Rock instead. Immature birds

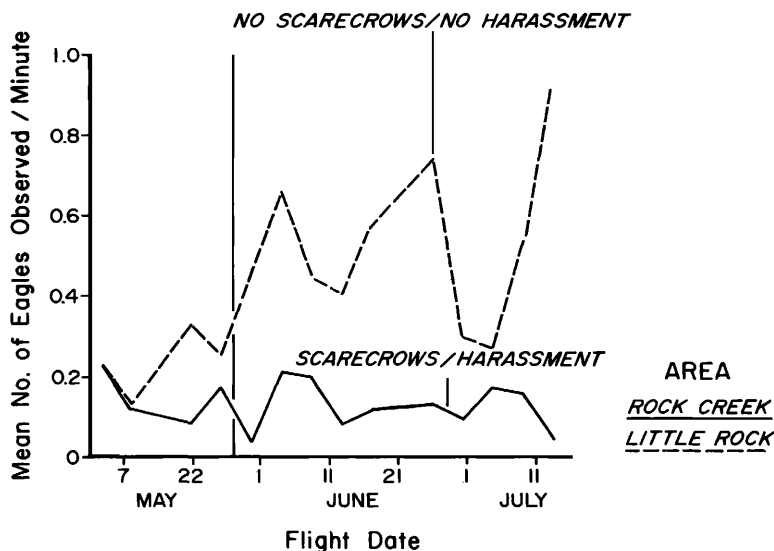


Figure 1. Golden Eagle sighting rates from flight surveys during 1985 on the Rebish-Konen ranch near Dillon, Montana. Means were based on 4 d groups. The reference line from the X-axis indicates scarecrow placement date.

comprised 64% of 204 eagle observations where age class was determined (Rock Creek and Little Rock combined).

Little Rock contained relatively few lambs and little carrion. Rock Creek contained nearly three times the number of lambing ewes as Little Rock and thus would be expected to attract more eagles. The contention that eagles avoided scarecrows and harassment was further supported by sighting rates remaining relatively low on Rock Creek after scarecrow placement, even with the potentially strong attractant of many lambs and abundant carrion. Routine removal of carrion near range lambing bands would minimize a potential eagle attractant.

Eagle depredation rate (number of eagle-killed lambs found/total number of ewes) during 1985 was significantly higher on Little Rock (0.01) than on Rock Creek (0.001) ($Z = 3.34$, $P < 0.001$). Examined lamb carcasses totaled 213 on Rock Creek and 51 on Little Rock. Two eagle-killed lambs were found on Rock Creek and five were found on Little Rock. Search effort was similar in both areas. Scarecrows were erected at the onset of lambing and there was little opportunity for eagle depredation prior to scarecrow placement.

Although not statistically significant, the distance between eagles and the nearest scarecrow site increased after scarecrows were erected (O'Gara and

Matchett 1985). Only 9 d of radio-tracking were available prior to scarecrow placement. Mean (SE) distances between eagle radio locations and nearest scarecrow sites were 3.72 (0.61) km, 4.36 (1.30) km, and 6.09 (0.74) km, respectively, during the 9 d pre-, 9 d post-, and 55 d post-scarecrow placement time periods. Median distances between eagle radio locations and nearest scarecrow sites were 2.93 km, 4.46 km, and 5.65 km, respectively, for the same time periods.

Most harassment during 1985 was directed at Common Ravens shortly after scarecrows were erected (five were killed). Eagles and ravens soon learned to take flight upon sighting a moving person or a truck (O'Gara and Matchett 1985). Our presence alone often caused ravens and eagles to leave the area during the last two-thirds of the lambing season. McAdoo and Klebenow (1978) also noted that human activity, in itself, is a deterrent to predation.

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