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GOLDEN EAGLE (AQUILA CHRYSAETOS) POPULATION ECOLOGY IN EASTERN UTAH

J. William Bates and Miles O. Moretti

ABSTRACT.—Golden Eagle population ecology was studied from 1982 to 1992 in eastern Utah where over 47% of 233 territories monitored during the study period were active. Golden Eagle use of four habitat types was compared. Talus territories were used less often than expected; valley, aspen-conifer, and pinyon-juniper territories were used as expected. Number of young produced per territory averaged 0.612 and was correlated with rabbit abundance. Observations on the impacts of coal mining at two locations are discussed.

Key words: Aquila chrysaetos, Golden Eagle, population, habitat use, prey relationships.

The Golden Eagle (Aquila chrysaetos) is a year-round resident of eastern Utah but is most common during the nesting season. Golden Eagle nests in the area are found at elevations of 1546 m (5070 ft) to 3000 m (9800 ft). Most are located on cliffs, while others are located in cottonwood (Populus fremontii) and Douglas fir (Pseudotsuga menziesii) trees. Golden Eagle eyries are found in riparian areas, shadscale-clay hills, pinyon-juniper hills with sandstone cliffs, steep talus slopes with large cliffs, and aspen-conifer areas in trees or on smaller cliffs (Jensen and Borchert 1981).

Many nests are located on prominent escarpments found in the Castle Valley area. These escarpments are part of the Castle Gate and Hiawatha formations, which are rich in coal deposits (McGregor 1985). Coal mining is a major industry in the area, and mining activities have the potential to impact nesting Golden Eagles. As a result, federal land-management agencies have required mining companies to monitor eagle nests on their properties.

The primary objective of this project was to monitor Golden Eagle and eagle prey populations in a variety of habitats in eastern Utah. The secondary objective was to summarize data collected by mining companies required to monitor raptor nests.

STUDY AREA

Golden Eagle nests monitored during this study were located in Carbon and Emery counties in eastern Utah (Fig. 1). The study area includes territories from Scofield and Emma Park south to Quitchipah Creek, and from Horse Canyon on the east to Huntington Canyon on the west. Elevations in the study area range from 1546 m (5070 ft) to 3000 m (9800 ft). Vegetative zones include riparian, saltbush (Atriplex sp.), sagebrush (Artemisia sp.), pinyon-juniper (Pinus edulis, Juniperus osteosperma), and mixed aspen-conifer.

The study area was classified into four habitat types that typify eagle use in the area: (1) valley territories, located on saltbush flats, on clay hills, or along riparian areas, with nests in cottonwood trees, on conglomerate pinnacles, or on clay ledges; (2) pinyon-juniper territories, with nests found on sandstone cliffs; (3) talus territories, where eyries were located on thick sandstone cliffs; and (4) aspen-conifer territories, where one nest was located in a Douglas fir and all others were on sandstone cliffs.

METHODS

The U.S. Fish and Wildlife Service, in cooperation with the Utah Division of Wildlife Resources (UDWR), conducted extensive helicopter surveys in 1981 and 1982 to locate Golden Eagle nests in the area. Over 250 nests were located and monitored during these surveys. Beginning in 1986 several mining companies were required to monitor approximately 26 territories within a 10-mile radius of the areas affected by mining to assess the impacts of coal mining on the local Golden Eagle population. In 1990 the UDWR began monitoring
an additional 13 territories beyond the 10-mile radius impact area. A total of 39 territories were monitored in 1992.

A Bell Jet Ranger helicopter with a pilot and two observers was used to check all known nests in the area affected by mining. Previously unknown nests occasionally were found and recorded during these flights. Normally, the helicopter was able to fly close enough to allow direct observation of the nest. Adult eagles usually would remain in the nest as the helicopter passed, although occasionally they flushed. Adult eagles also left the nest area when they were viewed from the ground.

Eyries in nonimpacted areas were observed from a distance to determine whether eagles were present. If adult eagles, greenery, or fresh mutes were present, the nest site was classified as occupied. If young or eggs were present, it was classified as active. The nest was classified as inactive if no sign of eagle use was present. If eggs were present but failed to hatch, or if all nestlings were observed to die before fledging, it was classified as failed. Due to commitments to other projects, we had insufficient time to return to each territory to determine the number of successfully fledged young. Therefore, these data cannot be interpreted to indicate Golden Eagle recruitment or nesting success.

Rabbit populations were monitored in the area to determine prey base trends during 1986–91. Eleven 5-mile transects were completed each year in the study area. Transects were conducted just after dusk or just before dawn by mounting a spotlight on a vehicle and recording all rabbits seen on one side of the road. Transects were completed in desert shrub, pinyon-juniper, sagebrush, and aspen-conifer habitat types.

Data were analyzed using descriptive statistics, contingency table analysis, and linear regression in the Number Cruncher Statistical System (Hintze 1990). The Bonferroni Z test (Neu et al. 1974) was used to analyze utilization data.

RESULTS

Habitat Use

Of 233 Golden Eagle territories checked from 1981 to 1992 (average/year = 26), 109 (47%) were active and produced young. Almost 78% of the territories were occupied. The year with the most active territories (56%) was 1990 (Fig. 2). In that same year 94% of monitored territories were occupied. The year with the fewest known active territories (33%) was 1988.
Of 185 territories checked in consecutive years, over 28% (52) were active. Five territories were observed to produce young for 3 consecutive years. One territory was active 4 consecutive years, while another produced young 5 consecutive years. One territory failed 3 years in a row. Generally, eagles use different nest sites within the same territory in consecutive years, but in our study eagles used the same nest as the previous year 11 times (21%).

Golden Eagle nesting activity was analyzed by habitat type. A significant difference was found between the four habitat types (chi-square = 20.6, $P < .015$). The number of active territories in each habitat type was compared to the expected number active using the Bonferroni Z statistic (Neu et al. 1974). Talus territories were active less frequently than expected, accounting for almost 37% of available habitat, but only 24% of active territories (Table 1, Fig. 3). The number of active nests in valley, pinyon-juniper, and aspen-conifer territories did not differ significantly from the number expected.

Talus eyries had their highest incidence of use in 1982, 1987, 1990, and 1991, with over 40% of territories active. In 1989 only one of nine talus territories was active. Over 75% were active in 1986, 1987, 1989, 1991, and 1992. Six of nine were active in 1990, seven of nine in 1991 (although two eyries failed), and seven of nine in 1992. Two or fewer valley territories were checked in 1981, 1982, and 1988. Over 57% of aspen-conifer territories were active each year, with the exception of 1982, 1986, and 1992, when only one of three, one of four, and three of nine, respectively, were active.

Nesting was relatively late in 1991 because of an unusually wet and cold spring; precipitation was 4.34 cm (1.71 in) greater than normal and temperatures were 1.65°C (3°F) cooler than the 30-year average at the Hiawatha weather station. Golden Eagles also showed a shift in habitat use in 1991. All known valley tree nests were active ($n = 9$). Talus territories were used less than expected and were initiated up to 4 weeks later in 1991 than in 1990. In spite of the cool spring, all four known aspen-conifer territories over 2400 m in elevation near Joe's Valley Reservoir were active and began incubation earlier than lower talus territories and close to the time incubation began at this elevation in previous years.
TABLE 1. Active Golden Eagle eyries by habitat type in eastern Utah, 1982–92.

<table>
<thead>
<tr>
<th>Habitat type</th>
<th>Sample points</th>
<th>Proportion of habitat</th>
<th>Territories active</th>
<th>Expected territories</th>
<th>Prop. of active territories</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valley</td>
<td>51</td>
<td>0.219</td>
<td>32</td>
<td>24</td>
<td>0.294</td>
<td>0.196 &lt; p &lt; 0.392</td>
</tr>
<tr>
<td>Pinyon/juniper</td>
<td>41</td>
<td>0.176</td>
<td>22</td>
<td>19</td>
<td>0.202</td>
<td>0.116 &lt; p &lt; 0.288</td>
</tr>
<tr>
<td>Talus</td>
<td>85</td>
<td>0.364</td>
<td>29</td>
<td>26</td>
<td>0.266</td>
<td>0.171 &lt; p &lt; 0.361*</td>
</tr>
<tr>
<td>Aspen/conifer</td>
<td>56</td>
<td>0.241</td>
<td>26</td>
<td>40</td>
<td>0.239</td>
<td>0.147 &lt; p &lt; 0.331*</td>
</tr>
<tr>
<td>Total</td>
<td>233</td>
<td>1</td>
<td>109</td>
<td>109</td>
<td>1.001</td>
<td></td>
</tr>
</tbody>
</table>

* Fewer territories active than expected.

Only 2 of the maximum 39 territories monitored in any one year were documented as being impacted by mining activities. Energy West Mining applied for and received a permit from the U.S. Fish and Wildlife Service to 'take' eagle nests in Newberry Canyon. This was necessary because of coal removal directly under a major escarpment that had four eagle nests on it; a major spauling was a possibility. Plateau Mining faced a similar situation at Star Point and also obtained a U.S. Fish and Wildlife Service permit to take two nests because of escarpment failure.

To keep Golden Eagles from using the two nests at Star Point, both nests were covered with chain-link fencing in 1989. From 1985 to 1988 this territory was active twice, occupied once, and inactive one year. In 1989 the eagle pair built a new nest in a pine tree about 300 m from the cliff nests but produced no young. In 1990 and 1992 the pair used an alternative cliff nest about 500 m from the fenced cliff nests and produced one young each year. In 1992 this nest was tended, but nesting did not occur. This territory produced young 2 of 4 years before and 2 of 4 years after the nests were fenced.

Escarpment failure in Newberry Canyon resulted in the loss of three nests in 1989. One nest remained in 1989 and was used to produce two young. This nest fell before the spring of 1990. This territory produced young

![Fig. 3. Active Golden Eagle eyries by habitat type in eastern Utah.](image-url)
2 of 4 years before the nests were lost and 1 of 4 years after the escarpment failure. Five other Golden Eagle territories are located within 8 km airline distance of Newberry Canyon. These territories produced young 39% of the time before the spauling, compared to 55% after. Although Newberry Canyon territory was not active again until 1993, these territories averaged 2.25 pairs active/year producing young before the nests fell, and 3 active/year after the spauling.

Productivity

Rabbit transects were conducted in the area from 1986 to 1991 (Bates 1989). Data on rabbit populations prior to 1986 are available through harvest statistics compiled by the UDWR (Mitchell and Roberson 1992). Number of cottontail rabbits harvested per hunter day was highest in 1982 and declined dramatically in 1984 (Table 2). Rabbit populations remained low until 1987, when they began to increase.

Average number of eaglets produced per territory was 0.612 (SE = 0.059) over the period 1981–92. Number of young produced per territory was above average in 1982, 1989, 1990, and 1991 (Fig. 4), although there was not a significant difference in number of young produced among years (P = .27). Except for 1991, these years coincided with increased rabbit populations (Table 2). Years with the highest number of young produced per active territory were 1982 and 1989, which were years with peak rabbit numbers. Although, based on transects, rabbit populations declined in 1990 and 1991, the number of young per territory was above average (Fig. 4) because the percentage of active territories was above average (Fig. 2).

<table>
<thead>
<tr>
<th>Year</th>
<th>Cottontails per hunter day</th>
<th>Cottontails and jackrabbits/mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>1.81</td>
<td></td>
</tr>
<tr>
<td>1983</td>
<td>1.79</td>
<td></td>
</tr>
<tr>
<td>1984</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>0.33</td>
<td>0.17</td>
</tr>
<tr>
<td>1987</td>
<td>1.37</td>
<td>0.39</td>
</tr>
<tr>
<td>1988</td>
<td>1.35</td>
<td>0.75</td>
</tr>
<tr>
<td>1989</td>
<td>0.93</td>
<td>0.86</td>
</tr>
<tr>
<td>1990</td>
<td>1.28</td>
<td>0.56</td>
</tr>
<tr>
<td>1991</td>
<td>1.5</td>
<td>0.43</td>
</tr>
</tbody>
</table>

Fig. 4. Average number of young per territory in eastern Utah.
Linear regression was used to determine if there was a relationship between number of rabbits seen per mile during rabbit transects in 1986–91 and number of eaglets per territory. A weak relationship was found ($R^2 = .33, P = .24$), indicating that part of the variability in Golden Eagle productivity was explained by rabbit population levels. The data indicated a lag effect, with productivity higher the year after rabbit populations increased (Fig. 5). By using linear regression to test this hypothesis, we found a near-significant relationship between number of rabbits the previous year and number of eaglets per territory ($R^2 = .63, P = .058$; Fig. 6). A significant relationship was also found between number of rabbits/mile and number of young produced per active territory in the same year, indicating higher production in years when rabbits were more abundant ($R^2 = .83, P = .01$; Fig. 7). These data demonstrate that Golden Eagles produce more young in the same year that rabbit populations increase, but a higher proportion of territories are active the year following an increase in rabbits (Fig. 5).

**DISCUSSION**

Number of young produced per territory and proportion of active territories in southeastern Utah were similar to those of other studies. Phillips et al. (1990) found 0.78 young produced per occupied territory in Montana and Wyoming from 1975 to 1985, compared to 0.82 in this study. They also found 1.46 young produced per successful territory, compared to 1.39 per active eyrie in this study. Results from southeastern Utah are inflated as the Phillips study was based on number of fledged birds and this study recorded only the number present in nests. However, most eaglets in this study were approaching fledging age when observed. Murphy (1975) found 0.69 young fledged per occupied territory in central Utah.

Number of eaglets produced was associated with rabbit population densities in the study area. Although other prey, such as white-tailed prairie dogs, are available, correlations with rabbit populations were quite high. High rabbit populations seemed to influence Golden Eagle nesting in two ways. First, number of young produced per active nest was...
affected by number of rabbits in the area that year; i.e., more eaglets were produced in years with higher rabbit populations. This relationship has also been found in other studies (Murphy 1975, Phillips et al. 1990). Second, there appeared to be a lag effect on number of eagles that attempted to nest. There was a significant correlation between number of young produced per territory and number of rabbits the previous year. High rabbit populations may have allowed more pairs in the area to nest, or enticed more eagles into the area, resulting in an increased number of active territories.

Use of valley territories increased in years with higher rabbit populations. Golden Eagles may have selected nest location to minimize the energy required to obtain food. In years with higher rabbit populations, eagles may have spent more time hunting in valley locations. The 2 years with the fewest active talus eyries, 1988 and 1989, were years of relatively high rabbit abundance. Eagles possibly avoided talus eyries in years of high rabbit populations because they were too far from an abundant food source. In years with fewer cottontail and jackrabbits they may have used these territories to take advantage of other prey, such as snowshoe hares or woodrats.

Data on mining impacts caused by cliff spaulings are too few to draw empirical conclusions. However, we offer some observations. When ample suitable habitat is nearby, there appeared to be no net loss in production. The territory at Star Point was active 2 of 4 years before and after the escarpment failure. Although the pair at Newberry Canyon did not re-nest in the canyon for 3 years after the original nests fell, they may have been using alternate nests of adjoining pairs. The five territories in the area averaged 2.25 pairs active/year before and 3 active/year after the escarpment failure.

In consideration of these observations, we offer several recommendations to protect against loss of birds or territories. First, if spauling can be controlled, it should be done in the nonnesting season. Otherwise, physically fencing may help prevent loss of nestlings. The two fenced nests were not used; however, the pair built a new nest below a fenced nest on a cliff that was failing. The pair did not attempt to raise young in that nest. Second, there must be ample suitable nesting habitat to allow other nests to be built. In Newberry Canyon a sheer wall was the result of escarpment failure and may not provide suitable nesting structure. This pair built a new nest 150 m east of a
Fig. 7. Eaglets per active eyrie as a function of rabbits, eastern Utah.

fallen nest on a ledge that did not fail. Loss of nesting structure could be a consideration in areas with limited cliff habitat where the whole face fails.

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LITERATURE CITED


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