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SPATIAL RELATIONSHIPS OF NESTING GOLDEN EAGLES IN CENTRAL UTAH

by
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Abstract
    We examined the distribution of Golden Eagle (*Aquila chrysaetos*) nest sites in the
eastern Great Basin using the Clark-Evans nearest-neighbor method of analysis. Distri-
bution values indicated uniform spacing of nest sites within the hills and ridges, which
provided all of the potential nesting sites in the study area. Analysis of Golden Eagle
nest site distribution with three other large raptors suggested a tendency toward uni-
form spacing between diurnal raptor species and aggregation with the Great Horned
Owl (*Bubo virginianus*).

Introduction
    Odum (1971) suggested that populations exhibit one of three distribution patterns: (1)
random, where habitat is homogenous and individuals do not normally interact; (2) uni-
form, where habitat is homogenous and individuals compete for one or more resources;
(3) aggregated, that may result from either heterogenous habitat or a tendency to aggre-
gate socially. Newton (1979) noted that many species exhibit uniform distribution of ter-
ritories and nest sites except where available sites are limited and concentrated, such as
in the Snake River Birds of Prey Natural Area. Our observations of Golden Eagles in the
eastern Great Basin Desert revealed a concentration of nest sites in high, north-south
oriented ridges and hills but none in intervening broad, flat valleys. Herein we examine
this distribution using the Clark-Evans nearest-neighbor model (1954).

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Study Area

We began long term raptor studies on a 7700 km² portion of the eastern Great Basin Desert in 1966. Data used herein are from a 120 km² segment of the area which includes portions of Utah and Tooele Counties. We have described the climate, topography and major vegitation of the study area previously (Smith and Murphy 1973).

Methods

Our studies were from 1966–1970. Details of methods are provided in Smith and Murphy (1973).

The Clark-Evans model is a measure of the ratio (R) of the distance between nearest-neighbor sites ($\bar{r}_A$), in this case active eagle nests, to the theoretical nearest-neighbor distance ($\bar{r}_E$) expected if all nests were in fact uniformly distributed:

$$R = \bar{r}_A/\bar{r}_E$$

where r_A is the average of the observed distances, $\bar{r}_A = \Sigma$ distances/N and N is the total number of distances sampled. The theoretical value, $\bar{r}_E$, is determined, $\bar{r}_E = 1/2\sqrt{p}$ where p is the population density expressed as the number of active nests per unit of area. The calculated R indicates the spatial pattern of distribution. If random, R equals or approaches 1; if aggregated R equals or approaches O; if uniform R equals or approaches 2.15. The significance of the calculated R is tested by the following:

$$C = \bar{r}_A - \bar{r}_E/\sigma\bar{r}_E$$

where C is the standard variate of the normal curve and $\sigma\bar{r}_E$ is the standard error of the average distance to the nearest-neighbor in a randomly distributed population of density p. This may be determined as follows:

$$\bar{r}_E = 0.26136/Np$$

The 5% and 1% significance levels are represented by C values of 1.96 and 2.58 respectively for a two-tailed test.

The Clark-Evans model requires knowledge of the breeding density of the species. Golden Eagles and other large raptors in central Utah nested primarily in foothills and ridges and hunted in the valleys. Large tracts of these valleys were not used by the collective raptor population during the nesting season. In 1969 and 1970, we determined minimum home ranges of Golden Eagles and other raptors on a smaller 120 km² of the original study area by observation of movements of each nesting pair from blinds. We observed each pair a minimum of 10 hrs over several days. The area of the combined Golden Eagle home ranges was considered the ecological density and included in the calculations. Miller and Stephen (1966) used this method to examine spatial relationships of individuals in feeding flocks of Sandhill Cranes (*Grus canadensis*) with the Clark-Evans model.

Results and Discussion

Distribution of active nests of the Golden Eagles, Great Horned Owl, Ferruginous Hawk (*Buteo regalis*), and Red-tailed Hawk (*Buteo jamicensis*) on the 120 km² area are shown in Figure 1.

In 1969 and 1970, nearest-neighbor distances between the 34 active Golden Eagle nests averaged 4.3 ± 1.33 km and ranged from 1.7 km to 5.1 km.

Comparatively, nearest-neighbor distances between the 34 active Golden Eagle nests located on the entire 1170 km² area from 1967–1970, were slightly, but not significantly less, averaging 3.71 ± 1.1 km (range 1.12 km to 10.3 km). Nearest active nests were usually located on opposite sides of high ridges and pairs hunted primarily in opposite valleys. For example, in 1968, nests of 3 pairs in the foothills south of Lake Mountain formed a triangle 1.12 km, 2.4 km and 2.4 km on the three sides. Caminzand (1969) noted that the 2 nearest nests of this triangle were separated by a ridge 38.1 m higher than either nest site. Adults at these 3 nests reportedly occupied separate hunting ranges. These observations coupled with the distribution patterns illustrated in Figure 1
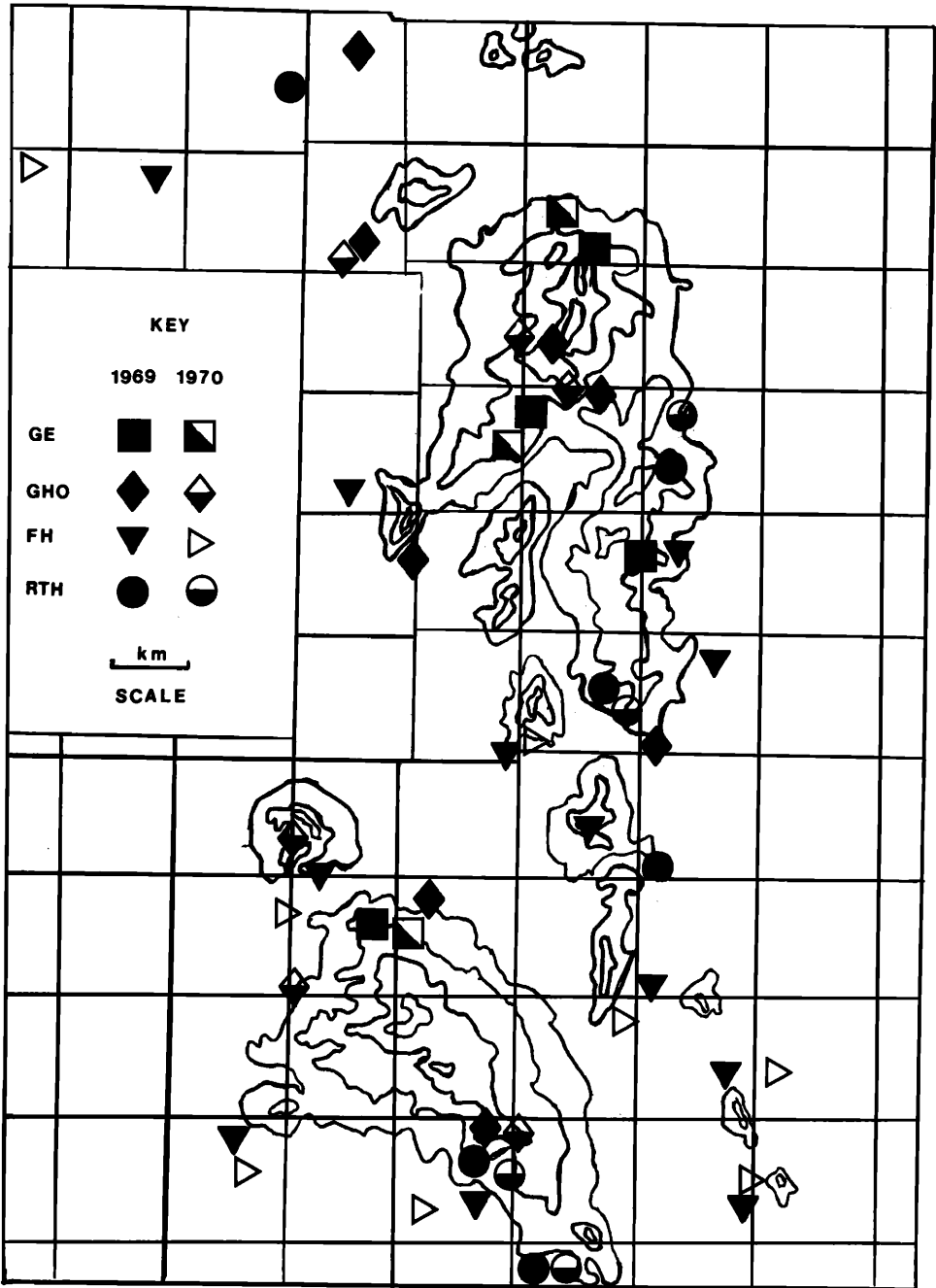
KEY

	1969	1970
GE	■	◨
GHO	◆	◇
FH	▼	▷
RTH	●	◖

km
SCALE

Figure 1. Distribution of active nests of Golden Eagles (GE), Great Horned Owls (GHO), Ferruginous Hawks (FH) and Red-tailed Hawks (RTH) on a 120 km² portion of the central Utah study area in 1969 and 1970.

suggest an aggregated pattern of nest placement resulting from the limited potential nest site habitat. Results of nearest-neighbor analysis of Golden Eagle nest distribution do not however indicate an aggregated pattern (Table 1). For comparison, we have included analysis of Golden Eagles with 3 other large raptors nesting on the study area.

Table 1. Analysis of nest site distribution of Golden Eagles and other large raptors in central Utah.

	Golden Eagle		Golden eagle X Great Horned Owl		Golden Eagle X Ferruginous Hawk		Golden Eagle X Red-tailed Hawk	
	1969	1970	1969	1970	1969	1970	1969	1970
N	4	3	8	6	12	7	6	4
$\bar{r}_A$	3.28	2.57	0.82	1.26	1.98	2.29	2.32	2.28
r_E	2.20	3.15	1.43	1.58	2.34	1.41	1.86	1.81
R	1.49	0.82	0.57**	0.79*	0.84	1.62*	1.24*	1.15

*Significant at P < 0.05
**Significant at P < 0.01

Distribution values of Golden Eagle active nests in 1969–1970, were R = 1.49 and R = 0.82 respectively. The 1969 value indicates a trend towards uniform spacing of nests while the 1970 value shows random spacing. The analysis does not suggest aggregation, even with the restricted area of potential nest sites.

Distribution of active Golden Eagle and Great Horned Owl nests had values of R = 0.57 in 1969 and R = 0.79 in 1970. Both values are statistically significant (p<0.05) and indicate a trend towards aggregation, undoubtedly a function of similarity in choice of nest sites by the two species plus lack of interaction because of differing daily activity patterns. Distribution of active Golden Eagle and Ferruginous Hawk nests had values of R = 0.84 in 1969 and R = 1.62 in 1970. These values indicate random nest location in 1969 and a trend towards uniform spacing in 1970. Comparative values of Golden Eagle and Red-tailed Hawk nest distribution were R = 1.24 in 1969 and R = 1.15 in 1970. Both values suggest a trend towards uniform spacing.

Golden Eagles nested in cliffs or rock outcrops at elevations ranging from 1460–1910 m, although most were located at elevation greater than 1680 m. Great Horned Owls nested in cliffs and junipers at elevations ranging from 1485–1890 m. Distances between active Golden Eagle and Great Horned Owl nests averaged 1.12 km. The nearest active nests were 0.08 km apart in the same quarry cliff face while the most distant was 2.45 km. Red-tailed Hawks selected nest sites in several cliff types and trees at elevations ranging from 1508–1847 m. Distances between active nests of Golden Eagles and Red-tailed Hawks ranged from 1.34 km to 4.26 km and averaged 2.45 km, considerably greater than those between Great Horned Owls and Golden Eagles.

Nests of Ferruginous Hawks were located on rock outcrops and in a variety of tree and ground sites at middle and lower elevations. A total of 85.1% were found between 1511–1660 m and none were at elevations higher than 1710 m. Distances between active nests of Golden Eagles and Ferruginous Hawks averaged 2.45 km and ranged from 0.88 km to 4.04 km.

There is an apparent correlation between daily activity patterns of the four raptor species and distribution of active nests. Thus the two raptors with the least similar daily activity patterns, Golden Eagles and Great Horned Owls show an aggregated distribution pattern when considered together. The two raptor species with the greatest similarity in daily activity patterns, Golden Eagles and Red-tailed Hawks, show a trend towards uniformity of distribution of active nests, suggesting interaction to at least some degree during nest site selection. The spacing of Golden Eagle and Ferruginous Hawk active nests is more random and may reflect the somewhat crepuscular activity of the Ferruginous Hawk.

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OBSERVATIONS OF GOLDEN EAGLES NESTING IN WESTERN WASHINGTON

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Nesting of the Golden Eagle (*Aquila chrysaetos*)west of the Cascade Mountains in Washington State generally has been considered rare, and more commonly has been identified with the open habitats of the arid country of eastern Washington (Dawson and Bowles 1909, Jewett *et al.* 1953, Alcorn 1978). However, Laing (1956) recorded nesting Golden Eagles on Vancouver Island, British Columbia, and Thomas (1977) noted

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