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HABITAT AND SPATIAL RELATIONSHIPS OF NESTING SWAINSON'S HAWKS (*BUTEO SWAINSONI*) AND RED-TAILED HAWKS (*B. JAMAICENSIS*) IN NORTHERN UTAH

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ABSTRACT.—A total of 28 Swainson's Hawk (*Buteo swainsoni*) and 30 Red-tailed Hawk (*B. jamaicensis*) nests were found in Cache Valley, Utah, during the summers of 1992 and 1993. All nests were in trees, but only Red-tailed Hawks nested in dead trees (30%). In the intensive study area, nesting densities were 0.10 nests/km^2 for Swainson's Hawk and 0.08 nests/km^2 for Red-tailed Hawk. Nearest-neighbor nest distances were significantly shorter among Swainson's Hawks (1.74 km) than among Red-tailed Hawks (2.83 km). Congeneric nearest-neighbor distances were significantly shorter than conspecific distances for Red-tailed Hawks (1.59 vs. 2.83 km) but not for Swainson's Hawks (1.52 vs. 1.74 km). GIS analysis of habitat types was made for 2-km radii around nest sites. Cropland was the dominant land cover type at nest sites of both species and no significant difference was found between species. Swainson's Hawk nest sites contained significantly more pasture, whereas Red-tailed Hawk nest sites contained significantly more juniper, maple, and sagebrush. Only Red-tailed Hawk nests (n = 8; 27%) were found on the periphery of the valley at the base of foothills of the Cache Mountains. This preference resulted in a significantly higher elevation for Red-tailed Hawk nest sites. Swainson's Hawk nests occurred only on the valley floor on level terrain. Distance to the nearest paved road and building was very similar for both species, implying that little difference exists in tolerance levels for human activities. Overall, multivariate niche overlap for habitat was high (0.89), indicating a lack of habitat partitioning between these 2 *Buteos* in Cache Valley.

Key words: Swainson's Hawk, Red-tailed Hawk, Buteo, *nest sites, habitat, GIS.*

Relatively few studies have included a comparison of nest sites, habitat, or densities of Swainson's Hawks (*Buteo swainsoni*) and Red-tailed Hawks (*B. jamaicensis*). Rothfels and Lein (1983) and Bechard et al. (1990) examined nearest-neighbor distances of these 2 species in Alberta and Washington, respectively, and Bechard et al. (1990) also compared habitats. Janes (1985) examined habitats associated with sightings of these 2 *Buteos* in Oregon. Considering that these species are sympatric throughout much of their range in western North America, further information on their habitat use and nesting density in overlapping regions would be useful for understanding patterns of coexistence.

The present study is also important because the Swainson's Hawk is considered to be declining in Utah, Nevada, and Oregon, and its status is listed as a "species of special concern" in Utah, Nevada, Oregon, and Washington, and "threatened" in California (Harlow and Bloom 1989). Conversely, Red-tailed Hawks are considered to be increasing (Harlow and Bloom 1989) due to an increase in perching habitat, at the expense of Swainson's Hawks (Janes 1985, 1987). Therefore, a comparative approach to the nesting ecology of these 2 species is not only of ecological importance but has implications for the future conservation of Swainson's Hawks.

STUDY AREA AND METHODS

The study was conducted in the Cache Valley portion of Cache County in northern Utah (Fig. 1). The valley comprises cropland (alfalfa, hay, winter wheat, corn), pasture, grassland, marsh, sagebrush-grassland, barnyards/feedlots, residential areas, and commercial complexes. During the summers of 1992 and 1993, we conducted a vehicle survey of the entire valley by driving on primary and secondary (dirt) roads along the valley floor and lower benches. Searches did not extend into mountainous terrain.

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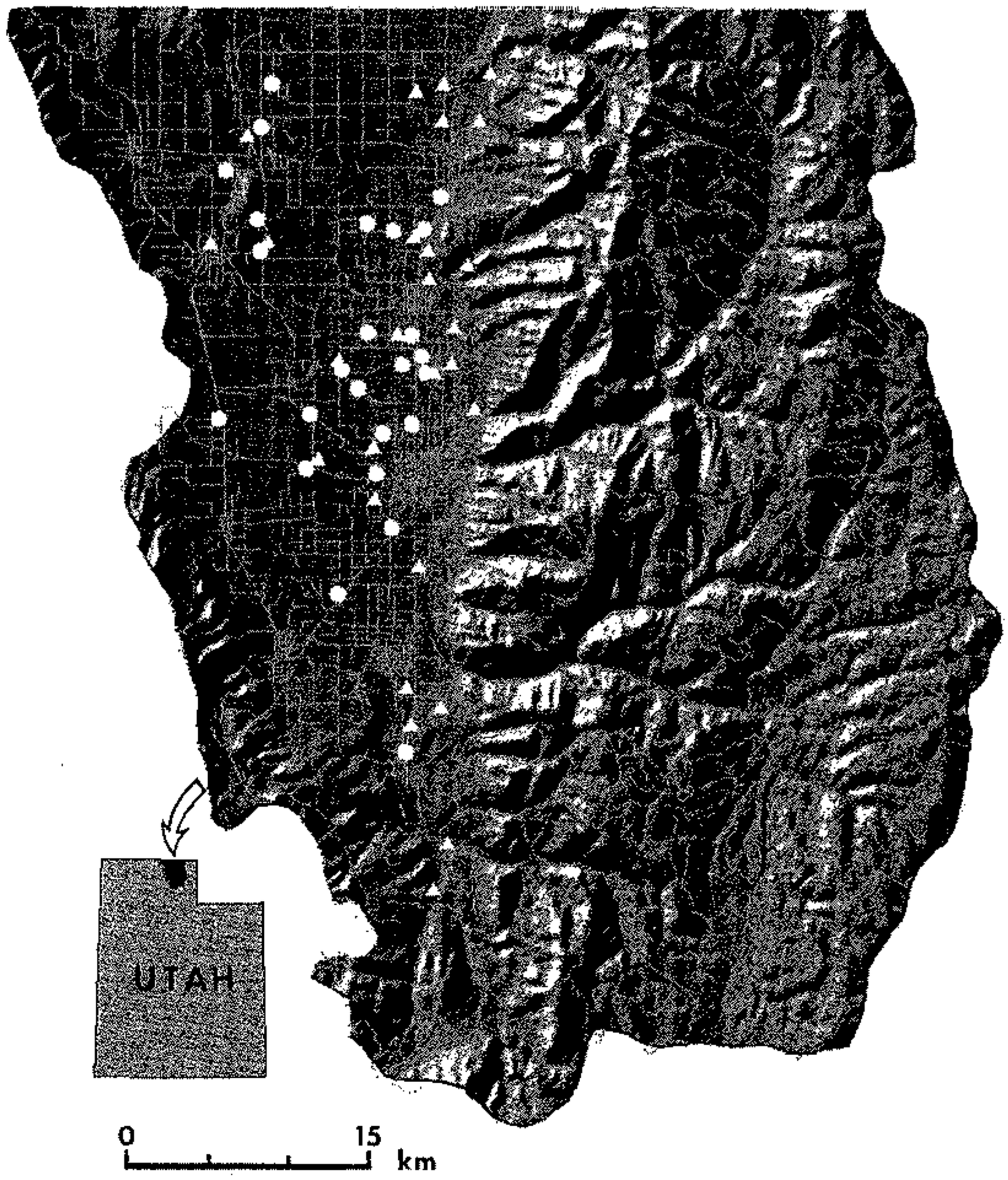

Fig. 1. GIS shaded relief map of the Cache Valley study area in northern Utah showing the distribution of Swainson's Hawk (circles) and Red-tailed Hawk (triangles) nests for 1992 and 1993 nesting seasons combined. Light lines indicate primary and secondary roads.

Occupied nests were found by scanning likely trees, especially if adults were seen nearby or protested our approach. A nest was considered occupied only if an incubating or brooding female and/or young were present. Nests were not examined for the presence of eggs. Because of the low density of trees (<1/ha) in the valley, we found nests relatively easily and could effectively search large areas by vehicle surveys. Although there were undoubtedly some nests that were missed in the valley, we felt there was a similar probability of detecting either species on all surveys, so comparisons should not be biased. Locations of all nests were plotted onto 7.5-min USGS topographic maps (1:24,000 scale quadrangles). Elevations of nest sites were obtained from the topographic maps. Slope was not calculated since the vast majority of nest sites occurred on level ground.

To examine nesting density, we completely searched an intensive study block (100 km^2) for nests during a single breeding season (1992) using the methods of Craighead and Craighead (1956). Since the intensive study area was completely flat and relatively treeless, spotting all territorial birds and nests in trees was not difficult. In the intensive study area, nest searching occurred from April through July, and all territorial birds were accounted for with occupied nests. This fact, combined with a lack of rocky outcrops and cliffs, assured us that there were no ground-nesting birds in the intensive study area. Nesting density was calculated as the absolute density of nests per total area of the intensive study block. Nearest-neighbor distances

were calculated according to the method of Clark and Evans (1954).

Land-use/land-cover maps of Cache Valley were generated and field-checked from aerial photographs by Utah Division of Water Resources (1991). These maps were subsequently digitized into a vector-based (ARC/INFO) geographic information system (GIS) and were used as a base layer to determine habitats of the 2 *Buteos* in Cache Valley. Nest site locations on USGS quadrangles were subsequently digitized into the GIS. Habitat areas were calculated within a 2-km (1.2-mile) radius of nest sites. This represented a circular area of 1257 ha, which was about midway between the mean home range size reported for Swainson's Hawk (Fitzner 1980) and Red-tailed Hawk (U.S. Department of Interior 1979). Because some hawks built a new nest in the same territory the following year (1993), only 1 occupied nest per territory over the 2-yr period was used in the habitat analysis to avoid pseudoreplication. Distances to the nearest paved road and buildings were measured by pacing (<200 m) or using a vehicle odometer (>200 m). Habitats were classified by the Utah Division of Water Resources (1991) into 11 major habitat types: cropland, fallow field, grassland, pasture, sagebrush, juniper (*Juniperus* spp.), maple (*Acer grandidentatum*), riparian (wetlands, temporary marshes, mud flats), open water, residential, and commercial (non-residential buildings, industrial structures, junkyards, and parking lots).

Statistical analysis was performed on NCSS software (Number Cruncher Statistical Software, Kaysville, UT). Prior to analysis, habitat variables were tested for normality (D'Agostino 1990). A number of data transformations were attempted (Zar 1984), but none were able to normalize all variables. Therefore, a non-parametric rank test (Mann-Whitney *U*-test, 2-tailed) was selected for all habitat comparisons. To calculate habitat overlap from the GIS data variables, a full-model (all variables included) discriminant function analysis (DFA) was run to determine the extent of habitat partitioning between the 2 species. Multivariate niche overlap for habitat was calculated with log-transformed variables with the following formula presented by Maurer (1982):

$$\text{overlap} = \exp(-d^2/S1 + S2);$$

where d = the difference between mean discriminant scores for species 1 and 2, and S = the standard deviation of the discriminant scores. Maurer (1982) and Klopfer and Ganzhorn (1985) suggested that stepwise procedures that eliminate variables always result in a biased underestimation of niche overlap. Therefore, we used a full-model DFA instead of stepwise DFA because it considers the whole spectrum of habitat variables available for partitioning.

RESULTS AND DISCUSSION

We located 58 occupied nest sites during 1992 and 1993 field seasons: 28 Swainson's Hawk nests and 30 Red-tailed Hawk nests. In a single breeding season (1992), a maximum of 22 occupied nests were found for Swainson's Hawks and 23 for Red-tailed Hawks. All nests were in trees, although a few cliff sites were available in the study area but not occupied. Only Red-tailed Hawks nested in dead trees (9 of 30 trees), which was statistically significant because Swainson's Hawks nested only in live trees (Fisher Exact Test, 2-tailed, $P = 0.002$). Red-tailed Hawks nested higher aboveground and in taller trees, but tree diameter was not significantly larger (Table 1).

The intensive study area was completely searched for occupied nests in 1992 and contained 10 Swainson's Hawk nests and 8 Red-tailed Hawk nests (Fig. 2). Absolute nesting density in this area was 0.10 nests/km^2 for Swainson's Hawks and 0.08 nests/km^2 for Red-tailed Hawks. Gilmer and Stewart (1984) reported a nesting density of 0.055 nest/km^2 for Swainson's Hawk, which was almost half the density found in Cache Valley. Luttich et al. (1971) reported a nesting density of 0.145 red-tailed nests/km^2, which is higher than our study area. Rothfels and Lein (1983) reported nesting densities of 0.238 nests/km^2 for Swainson's and 0.508 nests/km^2 for Red-tailed Hawks, which were much greater than the density for Swainson's and Red-tailed Hawks in Cache Valley. This difference probably reflects the fact that hawk nests can be dispersed because of areas of unsuitable and marginal habitat (e.g., note that nests were not located within areas of dense suburban road networks in Fig. 2).

Newton (1979) stated that in continuously suitable habitat the nests of the same species are often separated by roughly equal distances. Mean nearest-neighbor distance (Clark and Evans 1954) is the measure that can be used to

TABLE 1. Nest tree and topographic variables of Swainson's and Red-tailed Hawk nest sites in northern Utah. Data represent means ± *s* with sample size in parentheses.

	Red-tailed Hawk	Swainson's Hawk	*P*[a]
Nest tree height (m)	17.3 ± 4.1 (25)	13.9 ± 2.9 (23)	0.001
Nest height (m)	14.8 ± 3.4 (23)	11.3 ± 3.3 (21)	0.002
Nest tree DBH (cm)	87.2 ± 39.4 (22)	75.5 ± 44.6 (23)	0.226
Distance to paved road (m)	393.6 ± 580.9 (30)	311.6 ± 484.2(23)	0.133
Distance to building (m)	246.1 ± 174.3 (30)	250.4 ± 174.2(24)	0.649
Elevation (m)	1401 ± 193.6 (29)	1373 ± 31.4 (27)	0.001

[a]Mann-Whitney *U*-test, 2-tailed

quantify these spacing patterns. In Cache Valley we found a significant difference (Student's *t* test, $t = 2.61$, $P < 0.02$) for this distance, which was 1.74 km for Swainson's Hawks ($n = 10$) and 2.83 km for Red-tailed Hawks ($n = 8$). In Alberta, Rothfels and Lein (1983) reported mean nearest-neighbor distances of 1.46 km for Swainson's Hawks and 0.88 km for Red-tailed Hawks. These results are similar to Swainson's Hawks in Cache Valley but are much shorter than our estimate for Red-tailed Hawks. Rothfels and Lein (1983) noted that their data on Red-tailed Hawks showed a much denser population than normal. The mean for 7 other Red-tailed Hawk studies was 1.95 km (data from Rothfels and Lein 1983), which is closer to the distance found for Cache Valley. The mean for 5 other Swainson's Hawk studies is 1.78 km (data from Rothfels and Lein 1983), very close to the mean for Cache Valley. Overall, nearest-neighbor distances from our study area were consistent with the majority of literature values, demonstrating the regular dispersion of nest sites that results from territorial behavior (Newton 1979).

Congeneric nearest-neighbor distances were significantly shorter than conspecific distances for Red-tailed Hawks (1.59 km vs. 2.83 km) but not for Swainson's Hawks (1.52 km vs. 1.74 km; Student's *t* test, $t = 2.18$, $P = 0.047$ and $t = 0.78$, $P = 0.44$, respectively). These results suggest that Red-tailed Hawks are more tolerant of close nesting by Swainson's Hawks than their own species, but Swainson's Hawks are equally intolerant to congeners and conspecifics. In Alberta, Schmutz (1977) and Rothfels and Lein (1983) found that congeneric *Buteos* nested closer together than conspecifics probably because competition among congenerics was less than among conspecifics.

With regard to distribution in the study area, only Red-tailed Hawks (27%; $n = 8$) nested above the valley floor at the base of foothills of the Cache Mountains (Fig. 1), and this difference resulted in a statistically significant increase in elevation (Table 1). Swainson's Hawks did not nest in this zone at all, possibly because many of these sites were already occupied by earlier-nesting Red-tailed Hawks or because of habitat preferences discussed below. Rothfels and Lein (1983) noted qualitatively that Swainson's Hawks usually nested on flatter terrain than Red-tailed Hawks. In this study, Swainson's and Red-tailed Hawk nests lacked a significant difference for the distance to nearest buildings or paved roads (Table 1). No previous studies of these 2 species have been conducted in areas with this much urbanization. Our data suggest that no significant differences exist in regard to tolerance of human activities and structures.

Overall, the GIS indicated that habitat around nest areas was dominated by cropland and pasture for both *Buteos* (Fig. 3). Swainson's Hawk nest sites had significantly more pasture (22.4% vs. 12.3%) but not cropland, fallow field, or grassland. In eastern Washington, Bechard et al. (1990) noted that Swainson's Hawks utilized wheatland and grassland more than Red-tailed Hawks. In this study Red-tailed Hawks nested in areas with significantly more tree cover (maple and juniper) and sagebrush, which predominated uplands along the edge of the valley floor. The importance of trees to Red-tailed Hawks was noted by Houston and Bechard (1983), who documented the increase in nesting by this species after the expansion of trees into the prairie regions of Saskatchewan. Similarly, Knight et al. (1982) found that Red-tailed Hawks nested exclusively in riverine forest land along the Columbia River, even though suitable cliff nesting areas were available. Janes (1985) noted that Swainson's Hawks depended more on aerial foraging and occurred in habitats containing few or no perches. In this study Red-tailed Hawks probably nested more in tree habitats because of greater perch availability/

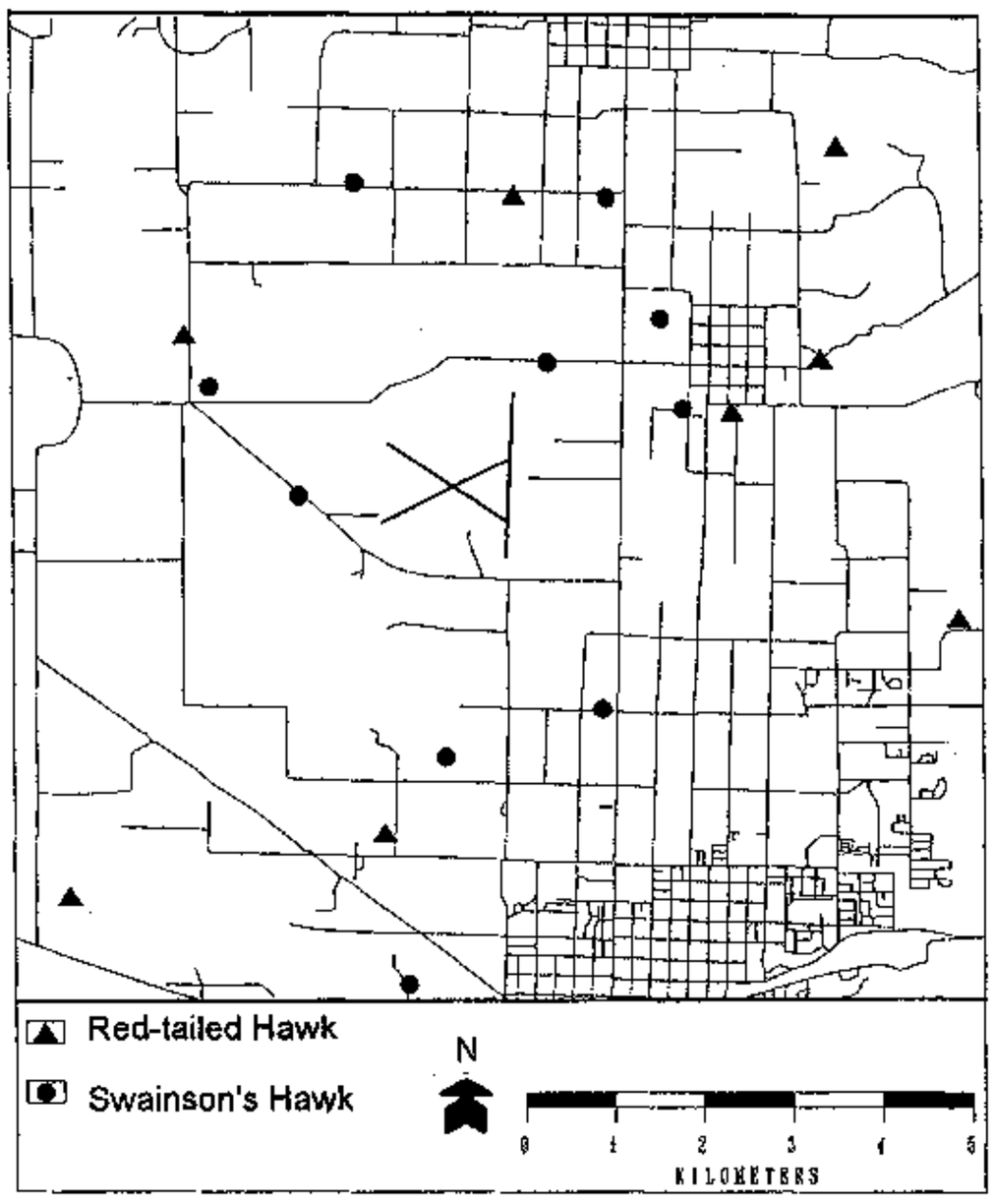

Fig. 2. GIS road map of 100-km^2 intensive study area centered at Logan Municipal Airport showing nest site locations for Swainson's and Red-tailed Hawks during the 1992 breeding season.

use, although other factors such as larger prey species may also be a factor.

Connell (1980) explained that resource partitioning (or low overlap) is due to the "ghost of competition past" (past competition), which has created evolutionary changes in morphology and behavior to avoid current competition. Since raptors are at the top of the food pyramid and occur at extremely low breeding densities (Newton 1979, Scheoner 1984), resources are likely to be limiting, and high overlap in resources between species is likely to result in current competition (except in rare cases such as vole plagues). Despite some significant differences for 4 of the 12 habitat types, we calculated a multivariate (DFA) niche overlap of 0.89 for habitat. Niche theory suggests that overlap values higher than 0.6 are needed to cause interspecific competition, while lower values indicate underutilization of the resource continuum resulting in intense intraspecific competition (see reviews by Bosakowski et al. 1992, Bosakowski and Smith 1992).

Prey overlap data were not collected in our study area, but Smith and Murphy's (1973) data from northern Utah showed a high prey overlap value of 0.80 for Red-tailed and Swainson's Hawks (as calculated by Jaksic 1983). In Montana, Restani (1991) found an even higher food overlap (0.93) for these 2 *Buteos*. Considering the findings of high overlap for food (Jaksic 1983, Restani 1991) and habitat (this study), competition between these *Buteos* should be expected whenever the species occur in close proximity. As further evidence, Schmutz et al. (1980) found that reproductive performance was significantly reduced in cases where these *Buteos* nested at close range.

Due to man-made alterations, few of the native plant communities presently exist in Cache Valley. Not surprisingly, we did not observe significant habitat partitioning between these 2 *Buteos* for the existing habitat types. Elsewhere, investigators have claimed that significant habitat partitioning (non-overlap) occurred between these *Buteos* in Oregon (Janes 1985) and Washington (Bechard et al. 1990), but the extent of habitat overlap was not previously quantified. Our results indicate that statistical tests can show differences among several habitat variables, while the overlap value can still remain critically high.

Competition for habitat has also been demonstrated by behavioral observations of Swainson's Hawks frequently usurping portions of Red-tailed Hawk territories with lower perch densities (Janes 1994). Alternately, Janes (1985, 1987) noted that the increase in perching habitat, caused by the spread of junipers, homesteads, and utility poles, "favors the Red-tailed Hawk at the expense of the Swainson's Hawk." In addition, Janes (1994) also reported that territorial Swainson's Hawks are occasionally displaced by Red-tailed Hawks.

Bednarz (1988) noted that availability of nest trees could be a limiting factor for Swainson's Hawks because of their affinity for open grassland and desert habitats that are often devoid of trees. Similarly, Houston and Bechard (1983) reported the expansion of Red-tailed Hawks in Saskatchewan following the spread of trees into prairie regions. In our study area the western portions of the valley floor were often treeless and usually supported little nesting for either species (note lower density of nests in Fig. 1). For such situations Schmutz et al. (1984) recommended installation of artificial nest platforms for Swainson's Hawks, which significantly increased nesting density in his experiments. However, if artificial nest platforms are used, we recommend caution and close monitoring so as not to give advantage to the more

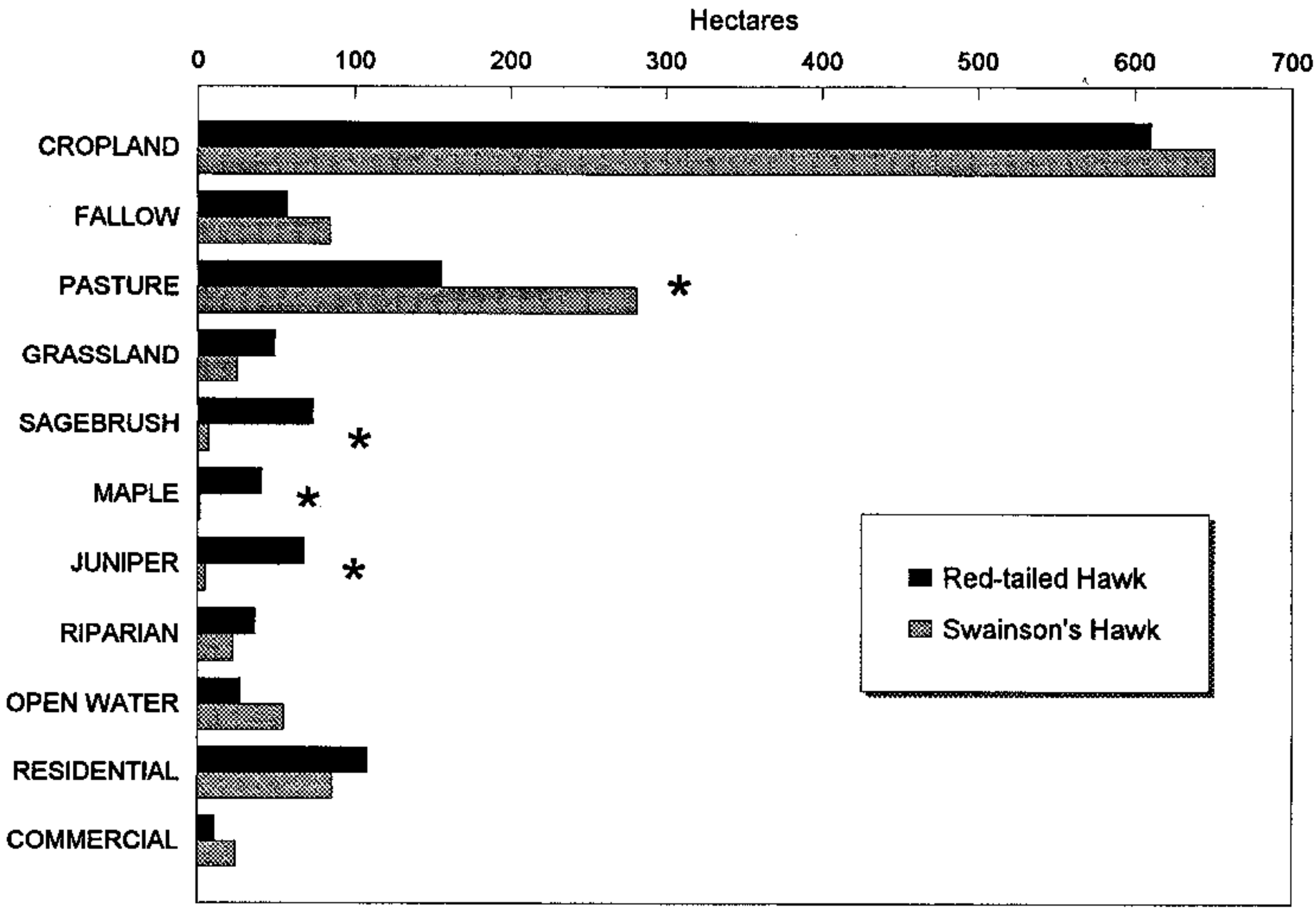

Fig. 3. Habitat areas around nest sites (2 km radius) of Swainson's ($n = 26$) and Red-tailed Hawks ($n = 28$) from Cache Valley, Utah, as determined from GIS analysis. Bars represent the mean and stars indicate that a significant difference was observed between species (Mann-Whitney U-test, 2-tailed, $P < 0.05$).

common Red-tailed Hawks. In our study area only Red-tailed Hawks nested in snags (30% of occupied nests) and may be more likely to use an open-topped artificial platform than Swainson's Hawks, which always nested in green trees. Many of the snags used by Red-tailed Hawks in Cache Valley were caused by failure to irrigate croplands during recent drought conditions, thus changing the suitability of nest sites in favor of Red-tailed Hawks.

In the future close attention to irrigation and surveillance of land-use changes are likely to be the most important factors in conserving Swainson's Hawks in Cache Valley. Economic conversion of agrarian land use to commercial and residential real estate is currently in progress, and impacts to future Swainson's Hawk populations need to be carefully monitored. Due to the rapid human population growth in Cache Valley, we recommend annual monitoring for Swainson's Hawk territories and nests, which may be impacted by future development or land-use changes. This monitoring management will require frequent updating of the GIS database to track habitat changes in the future so that necessary mitigation steps can be evaluated.

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