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# DISTRIBUTION AND NESTING SUCCESS OF FERRUGINOUS HAWKS AND SWAINSON'S HAWKS ON AN AGRICULTURAL LANDSCAPE IN THE GREAT PLAINS

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ABSTRACT—We studied land-cover associations at nest sites and reproductive success of two *Buteo* species of conservation concern on the southern Great Plains, USA. The study area was in Cimarron County, Oklahoma, where land use is dominated by row-crop agriculture, livestock grazing, and grasslands enrolled in the Conservation Reserve Program (CRP). Ferruginous hawks (*B. regalis*) were uncommon and nested primarily in and around the Rita Blanca National Grassland. Swainson's hawks (*B. swainsoni*) were common and nested throughout the study area. Territories of ferruginous hawks contained more sandsage (*Artemisia filifolia*) habitat and less cropland and CRP lands than random sites, whereas territories of Swainson's hawks mirrored proportions of available landcover. Our results suggest that proportion of nearby sandsage habitat is an important factor in determining Swainson's hawk reproductive success. In addition, ferruginous hawk nest sites were located in areas that contained significantly more sandsage habitat than randomly selected sites in the study area. Nest-site availability may have constrained the distribution of buteos in our study area and is probably a major factor limiting nesting density of ferruginous hawks. Ferruginous hawks typically nest on man-made platforms (e.g., nest platforms and windmills) that in the study area were most common in and around the Rita Blanca National Grassland. Our results suggest that conversion of native grasslands to cropland may have negative consequences for ferruginous and Swainson's hawks. This relationship has been previously demonstrated in several studies of ferruginous hawks, but not for Swainson's hawks. In particular, loss of sandsage habitat on the southern Great Plains may have contributed to range declines in ferruginous hawks and decreased breeding success for Swainson's hawks.

RESUMEN—Se estudiaron las asociaciones de la cubierta vegetal en los sitios de anidación y el éxito reproductivo de dos especies de *Buteo* de interés para su conservación en las Grandes Planicies del sur, Estados Unidos. El área de estudio fue el condado de Cimarrón, Oklahoma, donde el uso del suelo es predominantemente agricultura de filas de cultivos, pastoreo de ganado y praderas inscritas en el Programa de Conservación de Reservas (CRP, por sus siglas en inglés). Los halcones *B. regalis* fueron poco frecuentes y anidaron principalmente en y alrededor de la Pradera Nacional Rita Blanca. Los halcones *B. swainsoni* fueron comunes y anidaron en toda el área de estudio. Los territorios de *B. regalis* contenían más hábitat de artemisa (*Artemisia filifolia*) y menos tierras de cultivo y tierras del CRP que los sitios al azar, mientras que los territorios de *B. swainsoni* fueron un reflejo de la proporción de cubierta vegetal disponible. Nuestros resultados sugieren que la proporción de hábitat cercano de artemisa es un factor importante para determinar el éxito reproductivo de *B. swainsoni*. Además, los sitios de anidación de *B. regalis* fueron localizados en áreas que contenían significativamente más hábitat de artemisa que zonas seleccionadas al azar en el área de estudio. La disponibilidad de sitios de anidación puede haber restringido la distribución de buteos en nuestra área de estudio y es probablemente un factor importante que limita la densidad de anidación de *B. regalis*. El *B. regalis* suele anidar en plataformas creadas por el hombre (por ejemplo, plataformas de anidación y molinos de viento) que en el área de estudio fueron más comunes en y alrededor de la Pradera Nacional Rita Blanca. Nuestros resultados sugieren que la conversión de pastizales nativos en tierras de cultivo puede tener consecuencias negativas para *B. regalis* y *B. swainsoni*. Esta relación ha sido previamente demostrada en varios estudios de *B. regalis*, pero no para *B. swainsoni*. En particular, la pérdida de hábitat de artemisa en las Grandes

Planicies del sur puede haber contribuido en la disminución de la distribución geográfica de *B. regalis* y en la reducción del éxito reproductivo de *B. swainsoni*.

A large percentage of bird species endemic to the Great Plains have undergone notable population declines in the past century (Knopf and Samson, 1997; Brennan and Kuvlesky, 2005). The widespread nature of declines suggests factors associated with changes in land use may be largely responsible. While it has proven difficult to link changes in land-use practices to changes in the population densities of Great Plains birds, abundance of ferruginous hawks (*Buteo regalis*) has declined in areas of the Great Plains where grasslands have been converted to crop production (Schmutz, 1984; Bechard and Schmutz, 1995).

The shortgrass region of the western Great Plains is a semiarid environment of sparse grasslands dominated by shortgrasses (*Bouteloua gracilis* and *Buchloe dactyloides*) on loamy soils, and a mixture of sagebrush (*Artemisia filifolia*), soapweed (*Yucca glauca*), midheight grasses (e.g., *Sporobolus cryptandrus*), and shortgrasses on sandy soils (Lauenroth et al., 1999). Approximately 50% of historical native grasslands and shrublands in the region have been converted to cropland (Samson et al., 2004). Conversion of shortgrass prairie began in the early 1900s and peaked in the 1960s and 1970s. However, conversion of grassland to cropland remains a threat to remaining grasslands as water extracted from the Ogallala aquifer is being used to irrigate land otherwise unsuitable for crops. Sandsage prairie (i.e., dominated by *Artemisia filifolia*), an important component of the shortgrass ecotone, has undergone extensive decline, primarily due to conversion to irrigated cropland (see Rodgers and Sexson, 1990).

The United States Fish and Wildlife Service (2002) has designated several grassland raptors as "Birds of Conservation Concern" in the shortgrass prairie region (ferruginous hawk), as well as nationally (ferruginous hawk; Swainson's hawk, *Buteo swainsoni*). In addition, the United States Forest Service (2007) has designated several species of grassland birds as "Sensitive Species," for which management activities should be directed. Several of the sensitive species, including the ferruginous hawk, nest on National Grassland units within the southern Great Plains and on adjoining private lands. Although both the ferruginous hawk and Swainson's hawk have undergone recent population declines in some areas of the Great Plains, it is unclear how land-use patterns and land-management practices may have contributed to population declines. In Alberta, conversion of native grasslands to cropland and degradation of native grasslands are the primary contributing factors to long-term declines in breeding ferruginous hawks (Schmutz, 1984; Bechard and Schmutz, 1995).

Ferruginous hawks have declined in abundance in Oklahoma over the past 50 years and are now largely restricted as breeding species to Cimarron and Texas counties in the western portion of the Oklahoma Panhandle (Smith, 2004*a*). Although widespread as a breeding species in the state, Swainson's hawks have shown significant declines (−4.5% per year) in abundance in Oklahoma since 1966 (Smith, 2004*b*). Previous work by McConnell et al. (2008) quantified land cover around *Buteo* nests in Cimarron and Texas counties in Oklahoma, but did not include the Rita Blanca National Grassland, an area of high nesting density of ferruginous hawks. We mapped and monitored nests of ferruginous and Swainson's hawks, recorded nest-site habitat associations, and measured breeding success within an agricultural and shortgrass prairie mosaic in the western third of the Oklahoma Panhandle. Our objective was to assess how current land use in predominantly agricultural areas may be affecting distribution and nesting success of ferruginous and Swainson's hawks on the southern Great Plains.

Materials and Methods—From 2006–2008, field surveys were conducted in Cimarron County, Oklahoma, during the period from late April–early July. Nest searches were concentrated around the Rita Blanca National Grassland in southwestern Cimarron County and on private lands in the remainder of the county. The Rita Blanca was a focal point of the study and, as a consequence, private land with similar vegetation and topography (primarily flat grassland areas) was surveyed to provide a comparative data set. The Black Mesa area in northwestern Cimarron County and the Beaver River drainage in the south-central portion of the county were not surveyed during this study (see Fig. 1). In addition, southeastern Cimarron County was not surveyed due to logistical constraints.

We conducted surveys in four intensive periods each year: late April and early May (when ferruginous hawks were incubating and when Swainson's hawks were establishing territories); late May; mid- to late June (when ferruginous hawks were fledging); and early July (when Swainson's hawk young were large enough for us to see and count in the nest). We made attempts to access each nest to determine nest contents and the outcome of each breeding effort. We quantified reproductive success by recording the number of nestlings in nests at $\geq$30 days of age (ferruginous hawks) or $\geq$25 days of age (Swainson's hawks). We defined successful nests as those that fledged at least one young. In cases where the number of young could not be accurately determined from afar, we used an extendable mirror pole to count the number of fledglings. However, because Swainson's hawks often nested higher than the reach of our extendable mirror, we sometimes were unable to establish the exact number of young in nests. Consequently, in 2007 and 2008, we spent significantly more time observing Swainson's hawk nests to determine reproductive success. In addition, we normally did not record clutch size because it would have required more frequent nest checks and disturbance during the laying and incubation stages; such activities are known to cause desertion in some *Buteo* species (Smith and Murphy, 1973; Bechard and Schmutz, 1995).

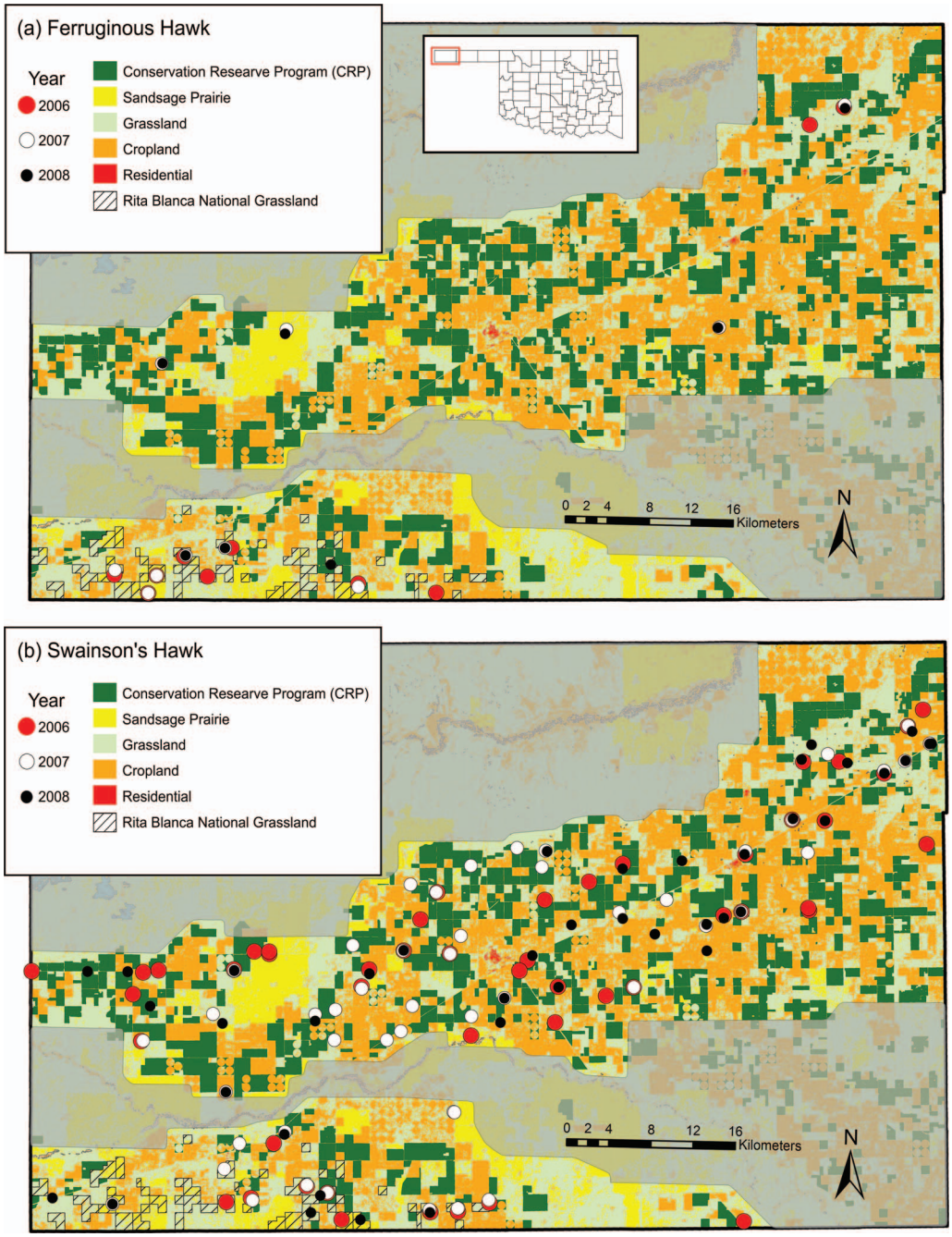


FIG. 1—Location of active nests in Cimarron County, Oklahoma, during 2006–2008 breeding seasons of (a) ferruginous hawks (*Buteo regalis*) and (b) Swainson's hawks (*B. swainsoni*). Overlapping circles indicate nesting attempts at the same next site. Inset in panel *a* indicates location of Cimarron County in Oklahoma. Grayed-out areas of Cimarron County were not surveyed.

Universal Transverse Mercator coordinates of nest sites were recorded with a portable Garmin GPS, and later entered into ArcGIS (version 10.0, ESRI, Redlands, California). We collected and plotted data using North American Datum of 1927 projections. We projected the nest-site layers onto maps depicting land use in Cimarron County taken from the 2001 National Land Cover Database for the county, as well as a layer showing lands enrolled in the Conservation Reserve Program (CRP; provided by Cimarron County Farm Service Agency).

To examine land use around nests, we quantified land codes in 2-km buffers around each nest (cf. Schmutz, 1984; McConnell et al., 2008). Because of similarity and spatial proximity of two habitat types, we used ArcGIS to reclassify sandsage savanna and sandsage prairie (data derived from the National Land Cover Database, http://www.mrlc.gov/nlcd2001.php) into a single habitat type that we refer to as sandsage prairie. To assess whether either raptor species was selecting or avoiding particular land-use types, we computed land use within 2-km radii of 100 random points in the study area for comparison to land use adjacent to hawk nests. Using Minitab 16 (Minitab Inc., State College, Pennsylvania), we employed a nonparametric two-sample rank test (i.e., two-sample Wilcoxon rank sum test) to

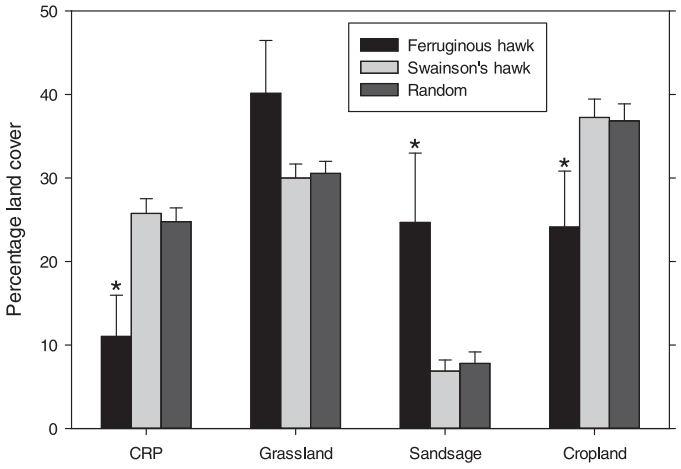


FIG. 2—Mean (+ 1 *SE*) percentage of land-cover types within 2-km radii of nests of ferruginous hawks (*Buteo regalis*) and Swainson's hawks (*B. swainsoni*), and within 2-km radii of random points in study area in Cimarron County, Oklahoma, from 2006–2008. Asterisks denote significant differences between nest sites of ferruginous hawks and random points with respect to land-cover values (Wilcoxon rank sum test, $P < 0.05$). CRP = grassland enrolled in the Conservation Reserve Program.

appraise differences between medians when comparing percentages of different land-cover categories between successful and unsuccessful nest sites. Given that land-cover categories remained relatively static during the study period (D. A. Wiggins, pers. observ.), we pooled data for the 3 years when analyzing effects of land cover on reproductive success.

Human disturbance during nesting has been shown to be a significant factor affecting the reproductive success of some *Buteo* species (e.g., White and Thurow, 1985). Although we could not measure disturbance directly, we estimated the distance to the nearest road (to the nearest 10 m) as a surrogate measure of potential disturbance (cf. Bechard et al., 1990); we evaluated the difference in the median for failed and successful nests using the two-sample Wilcoxon rank sum test.

RESULTS—*Nest-Site Distribution and Land-Use Patterns*—In all years of the study, we found the highest concentration of breeding ferruginous hawks in and around the Rita Blanca National Grassland in southwestern Cimarron County (Fig. 1a). We located nests of ferruginous hawks on artificial nesting platforms (five sites), in isolated trees (six sites), and on old windmills (two sites). Sites outside of the Rita Blanca included two nests on windmills in landscapes dominated by CRP lands and sandsage habitat, another nest in a tree in sandsage habitat, and a nest in a tree in an area of primarily cropland.

TABLE 2—Number of nests and reproductive success of Swainson's hawks (*Buteo swainsoni*) in study area in Cimarron County, Oklahoma, from 2006–2008.

| Year | Active nests | Nests with young | Failed nests | Nests with unknown outcome | Breeding success[a] at nests with known outcome |
|---|---|---|---|---|---|
| 2006 | 69 | 11 | 2 | 56 | 85 |
| 2007 | 41 | 26 | 2 | 13 | 93 |
| 2008 | 36 | 21 | 15 | 0 | 58 |
| Total | 146 | 58 | 19 | 69 | 75 |

[a] Percentage with young.

Swainson's hawks nested throughout the study area in a wide variety of habitats, including sandsage, grazed grasslands, CRP lands, and fields of row crops (Fig. 1b). Nests of Swainson's hawks typically were in Siberian elms (*Ulmus pumila*) on abandoned homestead sites or along roadsides, or in isolated plains cottonwoods (*Populus deltoides*).

Analysis of land cover within 2-km radii around nest sites indicated that ferruginous hawks nested in areas with a high proportion of sandsage habitat and with a low proportion of CRP grassland and cropland (Fig. 2). In contrast, land cover around Swainson's hawk nests was nearly identical to that found at random sites.

*Nesting Success*—Nesting success of ferruginous hawks (i.e., percentage of active nests that fledged at least one young) was ≥50% in each of the 3 years (Table 1). Swainson's hawk reproductive success ranged from 58–93%, with a mean of 75% over the 3 years (Table 2). Sites with successful nests of Swainson's hawks encompassed a higher proportion of nearby sandsage habitat than did those with unsuccessful nests (Table 3). Although many nests of Swainson's hawks were located relatively close to roads, we found no significant effect of mean distance to nearest road on breeding success (failed nests, mean = 71 ± 21 m, $n = 14$; successful nests, mean = 51 ± 12 m, $n = 25$; Wilcoxon rank sum test, $W = 422$, $P = 0.28$). We did not carry out similar analyses of nesting success for ferruginous hawks, as the high degree of between-year

TABLE 1—Number of nests and reproductive success of ferruginous hawks (*Buteo regalis*) in study area in Cimarron County, Oklahoma, from 2006–2008.

| Year | Active nests | Nests with young | Failed nests | Nests with unknown outcome | Minimum[a] brood size at fledging (*n*) | Number of fledglings per active territory (*n*) | Percentage of active nests that were successful |
|---|---|---|---|---|---|---|---|
| 2006 | 9 | 6 | 1 | 2 | 3.8 (6) | 2.6 (9) | ≥66 |
| 2007 | 10 | 5 | 4 | 1 | 3.0 (5) | 1.5 (10) | ≥50 |
| 2008 | 7 | 6 | 0 | 1 | ≥2.2 (6)[b] | ≥1.7 (7)[b] | ≥86 |

[a] Successful nests only.
[b] Estimates made at three nests.

TABLE 3—Mean percentage (*SE*) of land in different land-cover categories within 2-km buffers around nests of Swainson's hawks (*Buteo swainsoni*) for failed and successful nests in Cimarron County, Oklahoma, from 2006–2008.

| | | | Wilcoxon rank sum test | |
|---|---|---|---|---|
| Land-use type | Failed ($n = 14$) | Successful ($n = 25$) | Wilcoxon $W$ | $P$ |
| Conservation Reserve Program grassland | 26.3 (4.6) | 24.6 (2.7) | 298 | 0.61 |
| Grassland | 30.8 (5.2) | 25.0 (1.7) | 296 | 0.65 |
| Sandsage | 3.2 (1.8) | 10.9 (3.3) | 206 | 0.03 |
| Cropland | 39.7 (5.6) | 39.4 (3.9) | 272 | 0.82 |

nest reuse and relatively high nesting success precluded meaningful statistical analysis.

DISCUSSION—Ferruginous hawks are a species of conservation concern due to loss of breeding habitat throughout their North American range and because they are highly sensitive to disturbance while nesting (Bechard and Schmutz, 1995). Available data on long-term population trends show no discernible range-wide change (Collins and Reynolds, 2005), but declines in local populations are apparent on the fringes of its range in Kansas (Busby and Zimmerman, 2001) and in Canadian prairies (e.g., Schmutz, 1999; Downey 2006). In addition, the species generally is considered more at risk on the Great Plains due to the large percentage of land in private ownership, prevalence of crop production in this area (relative to livestock grazing in other parts of the range of the species), and decline in numbers of prairie dogs (*Cynomys*) on the Great Plains (Miller et al., 1994).

Our results suggest that conversion of native grasslands to cropland has had a long-term negative effect on ferruginous hawks on the Great Plains. In particular, a significantly higher percentage of territories of ferruginous hawks were in sandsage habitat relative to random sites. Schmutz (1987) noted a significant negative correlation between density of breeding ferruginous hawks and percentage of land in active cultivation, apparently resulting from a decrease in abundance of their primary prey (e.g., pocket gophers, ground squirrels) in croplands. However, Schmutz (1987) also recorded that ferruginous hawks flushed from nest sites at an average of 110 m (from observer) when approached, which suggests that disturbance due to agricultural activities also may play a role in nest-site choice and nesting success. In our study, cropland constituted an average of 25% of the landscape surrounding nest sites of ferruginous hawks, and nesting success in this type of landscape was $\geq$50% in all 3 years. Cropland comprised an average of 40% of the landscape surrounding nest sites of Swainson's hawks, both for successful and unsuccessful nests. These findings suggest that agricultural landscapes can support populations of both ferruginous and Swainson's hawks (see also Schmutz, 1989).

Other factors may also play a significant role in determining local abundance of breeding ferruginous hawks. Efforts to eradicate prairie dogs have led to an estimated 98% population decline in the black-tailed prairie dog (*Cynomys ludovicianus*) on the Great Plains (Kotliar et al., 1999). Although not explicitly quantified in this study, more than half of all ferruginous hawk nests were located within 2 km of an active prairie dog town (D. A. Wiggins, pers. observ.). A similar affinity for prairie dog colonies was documented for ferruginous hawks breeding in New Mexico (Cook et al., 2003). Prairie dog towns are more common on the Rita Blanca National Grassland than on private land in Cimarron County (D. A. Wiggins, pers. observ.), which may contribute to the higher densities of ferruginous hawks on the Rita Blanca. Ferruginous hawks also typically nest in isolated, single trees on the Great Plains, and the availability of such sites may play a significant role in determining local nesting density.

The Swainson's hawk is a species of conservation concern due to loss and degradation of suitable breeding habitat in some areas (Houston and Schmutz, 1995; England et al., 1997) and because of susceptibility to pesticide use on the wintering grounds (southern South America; e.g., Woodbridge et al., 1995). In some areas of the Great Plains, gradual loss of nesting trees has been cited as a primary cause of declining abundance of Swainson's hawks (Olendorff and Stoddart, 1974; Gilmer and Stewart, 1984; Houston and Schmutz, 1995). Lack of nest sites did not appear to be a major constraint in our study area, where abandoned homesteads and roadside shelterbelts provided the bulk of nest sites.

Our data indicate that in Cimarron County territories of Swainson's hawks are associated with a diversity of land-cover types dominated by grassland and CRP lands, but also included a significant percentage (37%) of cropland. Our analysis shows higher percentages of CRP lands and cropland, and a lower percentage of grassland compared to a similar analysis by McConnell et al. (2008) in the same general study area (Cimarron County, Oklahoma). Differences in findings of the two studies likely are a result of the study areas for the two investigations not being precisely the same; McConnell et al. (2008) included high-relief, grassland-dominated areas (e.g., northwestern and north-central Cimarron County) not included in our study.

Unlike ferruginous hawks, Swainson's hawks did not appear to avoid areas of cropland. Studies of land cover around Swainson's hawks' nests in other areas also have shown that a variety of habitats are used. In the northwestern portion of their range, 43% (California; Woodbridge, 1991) and 50% (Washington; Bechard et al.,

1990) of foraging habitat around Swainson's hawks' nests was in active agricultural production (i.e., cropland), whereas in North Dakota, only 18% was in cultivated crops (Gilmer and Stewart, 1984). In southeastern Alberta, Schmutz (1989) found that the density of breeding Swainson's hawks increased as the percentage of land under cultivation increased, up to a limit of 30% cropland. These results suggest that in some areas of the Great Plains, habitat diversity may be an important factor determining breeding densities of Swainson's hawks.

*Nest Success*—Nesting success of ferruginous hawks was ≥50% in each of the 3 years. Comparable studies elsewhere within the geographic range of the species have shown nest success averaging 59% in Idaho (Lehman et al., 1998), 72% in Utah (Smith and Murphy, 1973), and 75% in southeastern Colorado (D. A. Wiggins, in litt.). Nesting success of Swainson's hawks also was high in our study, with >85% of nests producing young in 2006 and 2007. However, the lower success rate we observed in 2008, when we made greater effort to verify nesting success, is probably more representative of a typical year. Usually, we were unable to determine the cause of nest failure for Swainson's hawks. In most cases, formerly active nests were found empty and abandoned on a subsequent visit. Although numerous studies have shown a significant effect of prey availability on fledging success, such an effect probably does not explain the total nest failures (i.e., complete brood loss) noted in our study. Despite a large number of investigations of breeding ecology of Swainson's hawk, there remains relatively little information on the causes of nest failure (but see England et al., 1997). Although considered to be relatively tolerant of disturbance near the nest (England et al., 1995), some pairs abandon nests when disturbed during egg-laying and incubation (Bent, 1937; Houston, 1974). This could be a problem in our study area, where many nests are located in trees close to roadways, thus increasing chances of human disturbance. However, for our sample of nests with known outcomes, we found no evidence that distance from roads affected breeding success.

*Land-Management Recommendations*—Our results show that Swainson's hawks are relatively widely distributed in Cimarron County across a variety of habitats and can breed successfully in landscapes with up to 40% cropland. Ferruginous hawk nests were more restricted in distribution, primarily occurring within or near the Rita Blanca National Grassland in southwestern Cimarron County. In this area, ferruginous hawks nested often on man-made nesting platforms erected in the late 1970s. In areas away from the Rita Blanca, density of ferruginous hawks was notably lower. We suspect this could result either from lack of suitable nest sites and/or lack of suitable foraging habitat. Although we did not quantify size and location of prairie dog colonies in this study, at least two of the four nest sites outside the Rita Blanca were within 1 km of an active prairie dog colony, and most nest sites on the Rita Blanca were also within 1 km of an active colony. During our study, density and year-to-year persistence of prairie dog colonies was notably higher on the Rita Blanca National Grassland relative to private lands (D. A. Wiggins, pers. observ.). An epizootic outbreak of plague decimated colonies in the county to the north of our study area during 2006 and 2007 (Augustine et al., 2008) and, in 2008, most prairie dog colonies (>50%) located on adjacent private lands in Cimarron County (away from the Rita Blanca National Grassland) were inactive. These observations are consistent with findings of Cook et al. (2003), who cited proximity to prairie dog colonies as positively affecting breeding density and nesting success of ferruginous hawks in grasslands of New Mexico, and with Smith and Lomolino (2004), who found a significant association between ferruginous hawks and prairie dog colonies in Oklahoma. Protection or creation of nest sites in isolated areas and sustaining populations of prairie dogs may help maintain or increase densities of ferruginous hawks in the Oklahoma Panhandle.

*Sandsage Habitat*—Ferruginous hawks selected breeding territories with significantly more sandsage prairie than typically occurred in the landscape. Sandsage habitat also was positively associated with nesting success of Swainson's hawks. One explanation for the positive influence of sandsage prairie on *Buteo* nesting is that small-mammal prey are typically more abundant and/or more accessible in sandsage prairie relative to other habitats. Typically, small-mammal abundance is greater in shrublands of the southwestern Great Plains (i.e., sandsage prairie and other shrubland types) compared to native grasslands (Stapp et al., 2008; Thompson and Gese, 2013). In nearby southwestern Kansas, small-mammal abundance was higher in native sandsage prairie than in nearby cropland (Fleharty and Navo, 1983). Although Hall and Willig (1994) found no difference in species diversity between native grassland and CRP grasslands in Texas, they determined that small-mammal abundance was significantly higher on native grasslands (including sandsage prairie). Kaufman and Kaufman (1990) and Navo and Fleharty (1983) noted that diversity and abundance of native small mammals was lower in wheat fields than on adjacent native prairie in Kansas. Taken together, these studies suggest that native grasslands, including sandsage habitat, support a higher diversity and abundance of small mammals, especially larger taxa (e.g., *Spermophilus*, *Dipodomys*) that are the preferred prey of ferruginous and Swainson's hawks. For ferruginous hawks, this link likely is even stronger given the close association between native grassland habitats and prairie dogs, a primary food source in our study area (Giovanni et al., 2007).

Sandsage habitat has declined across the western Great Plains, and extensive areas of sandsage prairie in

Cimarron County have been converted to cropland during the past century. For example, in southwestern Kansas, Rodgers and Sexson (1990) reported a 60% loss of sandsage habitat in Finney County. In addition, sandsage often is chemically treated with 2,4-dichlorophenoxyacetic acid (to eliminate *Artemisia*) in an attempt to improve grasslands for grazing livestock; such practices have been and continue to be carried out on sandsage habitats in Oklahoma (Donaldson, 1969; Gunter et al., 2012). Similar eradication efforts have occurred on the Cimarron National Grassland in neighboring Morton County, Kansas (Cable and Seltman, 2011), and *Artemisia* removal has been widely practiced across the western United States (Pechanec et al., 1965). Previous studies have shown that removal and degradation of sandsage habitat can have direct impacts on local avian diversity on the southern Great Plains (e.g., Rodgers and Sexson, 1990). Our results show that percentage of local sandsage prairie habitat may influence breeding distribution (ferruginous hawks) and breeding success (Swainson's hawks).

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