GOLDEN EAGLE NESTING CHRONOLOGY IN THE SOUTHERN GREAT PLAINS

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INTRODUCTION

The Golden Eagle's (*Aquila chrysaetos*) current population stability in the western United States (US) is tentative, as increasing anthropogenic mortality may cause the population to decline (Millsap et al. 2022). If a decline occurs, significant opportunities for restoring population stability may be found in the eagle's range periphery (Channell and Lomolino 2000). In that vein, the Great Plains forms the eastern margin of the Golden Eagle's western US range. Knowledge of the eagle's ecology there could greatly influence how well regional opportunities to conserve Golden Eagles are recognized and seized. The Southern Great Plains region supports a moderately large breeding population of Golden Eagles, with 123 occupied nesting territories recently reported (Stahlecker et al. in press), but many basic facets of eagle ecology there remain understudied compared to populations in more westerly regions of the US.

Nesting chronology is one of the most fundamental aspects of avian breeding ecology and is vital to bird conservation planning. For Golden Eagles, knowledge of regional nesting chronology is critical in formulating strategies to minimize human activity near nests during periods when breeding pairs are particularly sensitive and, if disturbed, may fail to initiate nesting or abandon or reduce care of their eggs or young (reviewed in Katzner et al. 2020). Examples of such disturbance include frequent hiking, camping, and recreational rock climbing; recurrent, nearby use of off-road vehicles; and energy development and mining activities (Steenhof et al. 2014, Spaul and Heath 2016, Katzner et al. 2020). Familiarity with nesting chronology also is crucial for optimally timing surveys of raptor breeding populations (Steenhof and Newton 2007). Published, quantitative summaries of Golden Eagle nesting chronology are unavailable for the Southern Great Plains, however. Our objective was to help fill this information gap by summarizing chronology data collected during a recent study of Golden Eagle breeding distribution in the Southern Great Plains (Stahlecker et al. in press).

STUDY AREA AND METHODS

Our study area covered ~200,000 km^2 of the Southern Great Plains south of the Arkansas River (Figure 1). Nests of eagles mostly were on ledges of cliffs throughout the study area, and less frequently in eastern cottonwoods (*Populus deltoides*) along intermittent streams. Annually during late March or early April, 2015–2017, we located nests occupied by breeding pairs of Golden Eagles from the ground or via fixed- or rotary-

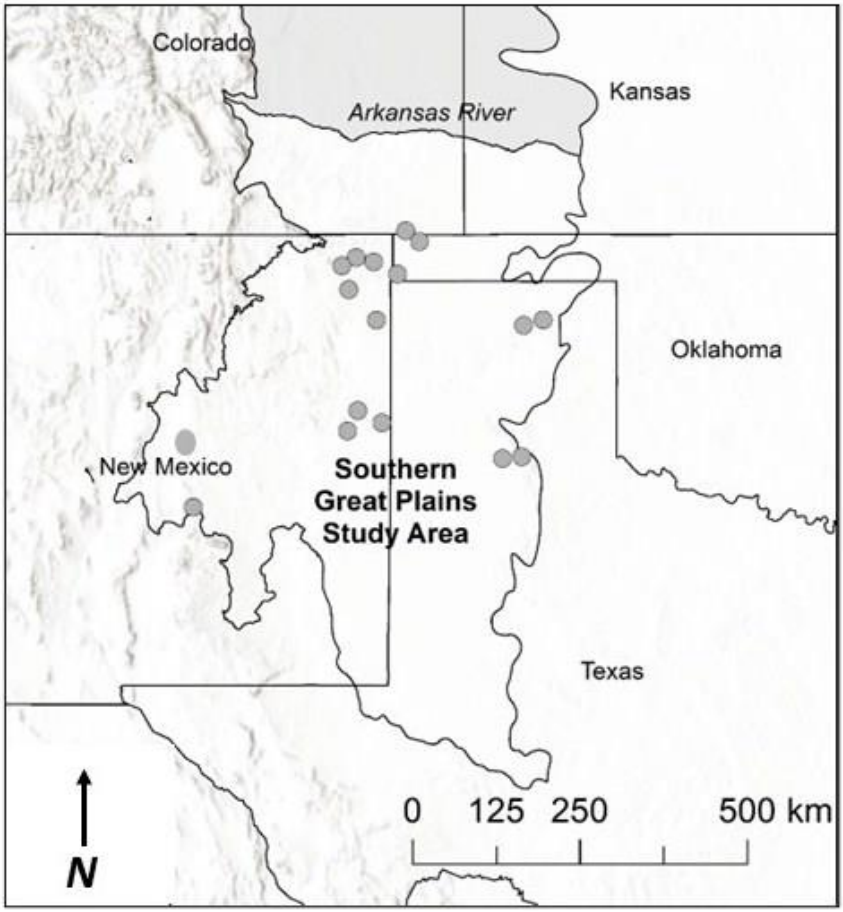

Figure 1. Distribution of Golden Eagle nesting territories in the Southern Great Plains at which nesting chronology was documented during 2015–2017.

wing aircraft. If we observed an adult eagle in an incubating-brooding position on a nest, we returned in May to observe each such nest from > 400 m away to confirm presence of nestlings and estimate their ages via photographic guides (Hoechlin 1976, Driscoll 2010). We returned to nests when, based on our initial estimates of age, nestlings would be roughly 50 to 55 d old and almost completely feathered as they neared fledging age (roughly 64 d of age but variable; Katzner et al. 2020). We entered the nests to band and attach transmitters to nestlings as part of another study and thus had opportunity to closely examine and more accurately estimate nestling ages. Golden Eagle nestlings exhibit distinct sequential changes in plumage characteristics as they grow, making it

relatively easy to determine their age (Driscoll 2010). Each of us estimated the age of a given nestling independently. We found our estimates to be within 2 d of one another and recorded the mid-point between our estimates in cases where our estimates were not identical. Hatching date for each nestling was determined by backdating from our estimate of age on the date of nest entry. We estimated date of nest initiation (i.e., laying of first egg) by backdating another 42 d, the species' approximate incubation period (Katzner et al. 2020). Last, we estimated fledging dates of nestlings by adding 64 d to their respective hatching dates. At some nesting territories we documented ages of nestlings in more than one breeding season. For each of these territories, our database entry included only the mid-point between or among estimated annual hatching dates, to maintain statistical independence among samples. Thus, each nesting territory was represented by only one hatching date.

RESULTS AND DISCUSSION

We assessed Golden Eagle nesting chronology at 17 territories. The estimated median date of nest initiation was 2 March, but the mean was 6 d earlier (Table 1). About one-half of nests were initiated during only a 16-d period (interquartile range), but estimated initiation dates ranged from 28 January to 23 March. Estimated median hatching and fledging dates were 13 April and 16 June. Although each nesting territory was represented only once in our dataset, we estimated nestling ages at three territories in two breeding seasons and at another in three breeding seasons; in each of the four cases, differences in estimates of age between years differed by only 1–3 d.

We acknowledge that our sample size is not large, but the interquartile ranges we report encompassed relatively short periods (16 d), suggesting that we captured the peak period of nest initiation, hatching, and fledging reasonably well. Although we are unaware of other published, quantified documentation of Golden Eagle nesting chronology in the Southern Great Plains, there are miscellaneous anecdotal or qualitative descriptions including observations of individual nests. For example, a note by Stahlecker et al. (2010) that Golden Eagles in New Mexico begin incubation by the end of February included some nests in the Southern Great Plains portion of the state. The closest comparative data come from a study by Murphy et al. (2017) in the southern Rocky Mountains and Colorado Plateau regions, extending from about 250 km to 500 km west of our study area but at roughly the same latitudinal range. The authors reported 14 April as the estimated median date of hatching for 66 Golden Eagle juveniles at 53 nesting territories, which was practically identical to the estimated median hatching date of 13 April in this study. North of our study area, in the Central Great Plains region, Olendorff (1973) reported that hatching dates ranged from 21 April to 13 May for 11 Golden Eagle nests in northeastern Colorado, and Schmalzried (1976) reported that hatching at seven Golden Eagle nests in southeastern Wyoming occurred during 2–31 May.

Table 1. Golden Eagle nesting chronology in the Southern Great Plains: summary statistics based on estimated ages of nestlings observed at 17 nesting territories during 2015–2017.

	Calendar Date			
Nesting Stage	**Median**	**Mean (SE)**	**Range**	**Interquartile Range**
Initiation[1]	2 March	24 February (3.5)	28 January–23 March	18 February–5 March
Hatching[2]	13 April	7 April (3.5)	11 March–4 May	1–16 April
Fledging[3]	16 June	10 June (3.5)	14 May –7 July	4–19 June

[1]Forty-two days before hatching date.
[2]Determined by backdating from estimate of age on the date of nest entry by investigator.
[3]Sixty-four days after hatching date.

Many species of raptors can be sensitive to anthropogenic disturbance during the breeding season especially during courtship through incubation periods (Newton 1979). For Golden Eagles, this extends through the early nestling period; human disturbance may trigger reduced parental care (Katzner et al. 2020). In regions of the coterminous western United States where Golden Eagle pairs remain on nesting territories year-round, courtship, including selection and refurbishing of nests, is likely to be underway at least 1 mo before nest initiation (Katzner et al. 2020). Using the earliest date of nest initiation (28 January) that we estimated, Golden Eagle breeding pairs in the Southern Great Plains likely begin courtship by late December. Based on the latest date of hatching (4 May) that we estimated, the early nestling period could extend through late May. Thus, based on a liberal interpretation of our data, the sensitive period of the Golden Eagle's breeding season in the Southern Great Plains may extend from late December through late May (about 5 mo). Based on a conservative interpretation, using interquartile ranges reported herein, the corresponding period would extend from mid-January through early May (about 4 mo).

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potentially could glide far away and escape as we entered nests. We especially thank C.W. Boal of the U.S. Geological Survey's Cooperative Fish and Wildlife Research Unit at Texas Tech University who, as co-researcher on related studies in the region, aided with access to and logistics of nest entries, organized volunteers, and was particularly helpful in handling of the eagles we aged. Our work in the field would not have been possible without permissions for access granted by many gracious landowners. We thank Kristin Madden and Jean-Luc Cartron for comments that improved our manuscript.

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