Migrating Swainson's Hawk (*Buteo swainsoni*) occurrence at spring controlled burns in the central Great Plains

Platte River Natural Resource Reports eJournal 3:1-17

Andrew J. Caven[1, 2], Joshua D. Wiese[1,*], Kelsey C. King[1,3], Emma M. Brinley Buckley[4,5], Brice Krohn[1], Hannah B. English[1], Bruce Winter[1], and Timothy J. Smith[1]

[1]The Crane Trust, 6611 W Whooping Crane Drive, Wood River, NE 68883, USA.
[2]Current Address: International Crane Foundation, E11376 Shady Lane Rd, Baraboo, WI 53913, USA.
[3]Current Address: Department of Biological Sciences, Washington State University-Vancouver, Science (VSCI) 230, 14204 NE Salmon Creek Ave, Vancouver, WA, 98686, USA.
[4]Department of Communications, University of Nebraska-Kearney, 2504 9th Avenue, Kearney, NE 68849, USA.
[5]Current Address: Appalachian Highlands Inventory and Monitoring Network, Big South Fork National Recreation Area, 4564 Leatherwood Road, Oneida, TN 37841, USA.
[*]Corresponding author; email: jwiese@cranetrust.org

MIGRATING SWAINSON'S HAWK (*BUTEO SWAINSONI*) OCCURRENCE AT SPRING CONTROLLED BURNS IN THE CENTRAL GREAT PLAINS

Andrew J. Caven, Joshua D. Wiese, Kelsey C. King, Emma M. Brinley Buckley, Brice Krohn, Hannah B. English, Bruce Winter, and Timothy J. Smith

Abstract.—The Great Plains ecosystem was historically structured by periodic natural disturbances including drought, wildfire, and pulses of grazing, to which endemic wildlife would have had to adapt. Agricultural and industrial developments have created firebreaks disrupting the ability of wildfires to carry across contiguous grassland habitats. A body of research has demonstrated habitat and ecosystem level benefits from the replication of these historic wildfires through prescribed controlled burning. However, most recognized benefits to wildlife species come in the form of improved habitat in the months and years following a controlled burn. Less studied is the ability of wildlife to immediately exploit natural disturbances such as fire.

We recorded the occurrence of raptor species, in particular Swainson's Hawks, using active controlled burns during the spring of 2016 and 2017. Controlled burns took place on conservation-managed prairies in Hall and Buffalo counties along the Platte River in central Nebraska, USA. To examine whether migrating Swainson's Hawks were differentially drawn to controlled burns, we compared their rate of presence from surveys conducted during the latter portion of controlled burns to their rate of presence from systematic long-term biological monitoring efforts for the duration of their spring migration period (15 March to 31 May) in 2016 and 2017. Swainson's Hawks *(Buteo swainsoni)* were more likely to occur during controlled burns as compared to long-term monitoring surveys ($P < 0.001$). Golden Eagles (*Aquila chrysaetos*), Bald Eagles (*Haliaeetus leucocephalus*), Red-tailed Hawks (*Buteo jamaicensis*), and Turkey Vultures (*Cathartes aura*) were also recorded during or immediately after controlled burns. These findings suggest a likely behavioral adaptation to fire for Swainson's Hawks, and potentially other raptor species, and provide some insights into the natural history of the central Great Plains.

Keywords.—Swainson's Hawk, prescribed fire, disturbance ecology, Great Plains, grasslands, Golden Eagle

INTRODUCTION

The tall and mixed-grass prairies of the central Great Plains evolved under the pressure of relatively cyclical and interrelated natural disturbances including severe droughts, wildfires, and large migrating herds of grazing ungulates (Anderson 1990; Briggs et al. 2005; Anderson 2006). Before large-scale habitat fragmentation and fire suppression beginning with European settlement, lightning-caused wildfires were a natural disturbance that historically structured the ecosystem by limiting the cover of woody species and returned phosphorus and other nutrients to the soil, creating prime forage for migrating Bison (*Bison bison bison*) and other grazers (Bragg and Hulbert 1976; Anderson 1990; Collins 1990; Helzer 2009). Flora and fauna endemic to the Great Plains are variously adapted to these disturbance cycles, with some species benefiting from habitat improvements resulting several years after fire occurrence, while other species benefit relatively soon after a burn through increased foraging opportunities (Gibson and Hulbert 1987; Fussman 1997; Reinking 2005; Fuhlendorf et al. 2009; Caven et al. 2017).

Swainson's Hawks (*Buteo swainsoni*) are grassland specialist raptors that migrate from their wintering grounds in the pampas of Argentina to breed in the grassland ecosystems of the Great Plains and Interior Mountain West of North America (England et al. 1997). In recent years, they have adapted to life in an increasingly agricultural landscape (Bechard 1982; England et al. 1997, Inselman et al. 2015, Insleman et al. 2016). Swainson's Hawks will use anthropogenic agricultural disturbances, such as crop harvesting, flooding, and burning to opportunistically forage; however, they do not use crops that are significantly taller than native grasslands (Bechard 1982; England et al. 1997).

Research has documented the attraction of raptor species to wildland fire for foraging opportunities, particularly in the southwestern United States (Tewes 1984; Dodd 1988). Murphy and Smith (2007) documented that Swainson's Hawks were 2-3 times more common than other raptor species foraging in over 150 prescribed burns over a 20-year period (1983-2002) in mixed-grass prairie of the Northern Great Plains in northwest North Dakota. They documented Swainson's Hawks at every spring and summer burn (April-July) throughout their study period, noting Swainson's Hawks were more numerous during spring burns. Hovick et al. (2017) recently documented an increase in raptor abundance during controlled burns in Oklahoma, driven primarily by a surge of Swainson's Hawks' use of burn areas following the ignition phase of prescribed burns. Hovick et al. (2017) suggests that Swainson's Hawks are attracted to the plumes of smoke, which likely signal exploitable resources resultant from fires. However, this behavior has not been rigorously documented in Nebraska within the central Great Plains.

Today prairie wildfires are simulated through prescribed burns that focus on meeting land management objectives to preserve and enhance prairie ecosystems

(Bragg and Hulbert 1976; Briggs et al. 2002). In the Platte River Valley in central Nebraska, the middle of March through the beginning of May generally serves as the main controlled burn season. Fires during this time period are effective in both limiting woody encroachment and setting back cool season invasive exotic vascular plant species (Cummings et al. 2007; Helzer 2009). This time period also largely coincides with the migration of Swainson's Hawks to their breeding grounds throughout the Great Plains (England et al. 1997; Sharpe et al. 2001). To investigate the use of controlled burns by Swainson's Hawks and other raptors we compared their frequency of occurrence during long-term avian monitoring surveys (see Caven et al. 2022) to that from surveys completed during and immediately after prescribed burns. We also report all raptor species observed during controlled burns, as well as updated detection dates for migrating Swainson's Hawks along the Big Bend of the Platte River, Nebraska.

METHODS

We conducted controlled burns and avian surveys on lowland tallgrass prairies and wet meadows along the Big Bend of the Platte River on land owned and managed by the Crane Trust, a nonprofit land conservancy aimed at protecting Whooping Crane (*Grus americana*) and other migratory bird habitat (central location: 40.795502°N, -98.445821°W, 585 m elevation) (VanDerwalker 1981; Kaul et al. 2006). During the spring of 2015, we frequently noted Swainson's Hawks attempting to forage – often successfully – during and immediately following controlled burns (Fig. 1). From March 2016 through May 2017, we recorded raptor species present within controlled burn areas during fires. The Crane Trust conducted seven controlled burns during the springs of 2016 and 2017, which averaged 35.1 ha (sd= 30.5 ha) and persisted approximately 1.5 H (+/- 0.75 H) following first ignition. Burns were conducted on days with winds below 24 kph. Similar to Hovick et al. (2017), we began surveys for raptor species after each side of the burn unit had been ignited to allow for a full smoke plume. A "backing fire" was lit, brought around the perimeter of the pasture, and allowed to burn inward toward unconsumed fuels, away from the wetted and mowed firebreaks delineating the targeted pasture (Appendix 1; NWCG 2018).

Raptor surveys were conducted for ~45 min during the "mop-up" period of the burn after ignitions were complete (Appendix 1; NWCG 2018). Due to limited staff availability, observers were also tasked with inspecting the firebreaks surrounding the burn unit. Surveys were conducted around the perimeter of each burn unit as observers checked the firebreak from a 2-person utility task vehicle (UTV) or an all-terrain vehicle (ATV) using 10x42 binoculars. One to two observers counted and identified raptor species, listed whether they were within or outside of 50 m of the observer, recorded the time and weather conditions (temperature, wind speed) during the survey period, and made descriptive notes of fire behavior and raptor foraging behavior (Gregory et al. 2004). Observers conducted several visual scans of the burn unit and the highest

recorded count of each species from a single visual pass was used to estimate the number of each species present on burn surveys, with efforts to avoid double counting (See Bibby et al. 1992; Hovick et al. 2017). We also incidentally described raptor behavior as time allowed.

Long-term avian inventory and monitoring surveys consisted of 15 min point counts followed by 15 min, 200 m moving surveys set along permanently marked transects (Bibby et al. 1992; Gregory et al. 2004; Sorace et al. 2000; Caven et al. 2022). Surveys were randomly placed within distinct ecological zones (ecotopes) delineated by soil type, land use history, and vegetative community (Nagel 1981; Naveh 1994; Herrick et al. 2009; USDA-NRCS 2015; Caven et al. 2022, Caven and Wiese 2022). We included sufficient sampling to allow for experimental control and replication in assessing the impacts of particular land management actions on the flora and avian community (Elzinga et al. 2009; Herrick et al. 2009). This process yielded a total of 60 [initial] long-term avian monitoring locations spread across approximately 2,450 ha (6,055 ac) and three prairie islands within the Big Bend of the Platte River (Mormon, Shoemaker, and Dippel Islands; eastern-most monitoring site: 40.807183° N, -98.394933° W; western-most site: 40.708052° N, -98.789932° W). All bird species identified via sight or sound were counted and recorded as within 50 m of the observer or outside of that distance; birds too far away to be accurately identified were ignored (Bibby et al. 1992; Gregory et al. 2004; Caven et al. 2022). We employed both point count and moving transect surveys at each monitoring site to maximize detection probability and maintain standardization across various environments (grassland and woodland habitats) (Gregory et al. 2004; Caven et al. 2022). A two-person team conducted each survey, consisting of an experienced observer who focused on detecting and identifying bird species and a recorder who navigated transects with a GPS device and recorded data. Spring surveys were conducted within three hours of sunrise and when weather conditions adhered to the following parameters: temperatures above 28º F (-2º C), winds below 15 mph (24 kph), skies at least “partially sunny”, no sustained rain, and no medium to heavy fog (Caven et al. 2022).

We compared the raptor sightings data from spring controlled burns with systematic long-term avian monitoring data to examine whether Swainson’s Hawks and other raptor species occurred at a differential frequency during controlled burns. As Swainson’s Hawks are diurnal migrants that take advantage of rising thermals (England et al. 1997), it is possible that our long-term monitoring surveys underrepresent abundance during migration as they were conducted within 3 hours of sunrise (before 09:47 H based on 21 April (mean Swainson’s Hawk detection date) sunrise time). Long-term raptor monitoring stations are often operated between 08:00 and 17:00 H (Bednarz et al. 1990), and research aimed at collecting monitoring data on Swainson’s Hawks specifically recommends conducting surveys between 09:00 and 16:00 H. (BCN 2006). Though our long-term monitoring data collection efforts overlapped with

raptor sampling time periods, we included incidental observational data collected throughout the day in our analysis to assure sufficient temporal coverage. Incidental observations of migratory birds are taken by Crane Trust researchers while en route to field research sites. We recorded the time, date, current weather, the number of individuals of a species of interest observed, predominantly between 05:00 and 20:30 H, depending on time of year. These efforts were aimed at documenting rare migrants on the Crane Trust's property that may not have been frequently detected during long-term monitoring efforts.

We used a two-way Z-test for independent samples to make pairwise comparisons between the proportion of surveys in which Swainson's Hawks were detected in each particular context (controlled burn surveys, long-term monitoring surveys, incidental surveys). We restricted all observations used for the analysis to those within the known spring migration period for Swainson's Hawks in Nebraska, from 15 March to 31 May (Sharpe et al. 2001). In total this included seven controlled burn surveys, 40 long-term avian monitoring surveys, and 861 incidental detections of spring migrants within the mid-March to end of May time window across both 2016 and 2017. Additionally, we summarized all detections of raptor species present during spring controlled burns. We also summarized all spring and fall migration detection dates of Swainson's Hawks recorded on Crane Trust properties from the fall of 2015 through the spring of 2017.

RESULTS

During their migration period, we observed Swainson's Hawks at all seven controlled burns, totaling 35 Swainson's Hawks with a mean of five observations per burn (Table 1). We observed a maximum of 14 Swainson's Hawks at a burn on 21 April 2017 (Fig. 2). By contrast, in the same period, no Swainson's Hawks were encountered during long-term avian monitoring surveys and only two of the 861 incidentally recorded detections of migrating species included Swainson's Hawks (Table 1). We found that the proportion of controlled burn avian surveys detecting Swainson's Hawks (100.0%) was significantly higher than the proportion of spring long-term avian monitoring surveys detecting Swainson's Hawks (0%) as well as the proportion of incidental detections of migrating species including Swainson's Hawks (0.2%; Table 1).

Of the 37 total spring detections, 35 were detected during prescribed burns. Fall detections of Swainson's Hawks were made independently of controlled burns through both regular monitoring and incidental observations while moving between research sites (n=8). The early, late, and mean detection dates of Swainson's Hawks were determined for both spring and fall migrations (Table 2). The mean date for spring detection was 21 April (range: 31 Mar to 2 May), while the mean for fall detection was 25 September (range: 24 Aug to 20 Oct). In 2016, we noted the highest number of Swainson's Hawks observed on April 13, while in 2017 the highest count was on April 21 (Figure 2). Timing of

controlled burn implementation likely had an influence on our estimation of mean and peak Swainson's Hawk temporal occurrence.

Other raptor species that occurred during controlled burns were noted along with the dates of the burns on which they were detected (Table 3). A total of 10 observations of four additional raptor species were made: the Bald Eagle (*Haliaeetus leucocephalus*), Golden Eagle (*Aquila chrysaetos*), Red-tailed Hawk (*Buteo jamaicensis*), and Turkey Vulture (*Cathartes aura*). With the exception of the Golden Eagle, all species were regularly detected during long-term avian monitoring research during appropriate times of the year (N= 242 systematic surveys and N= 1,941 incidental species observations recorded from Mar 2015 - May 2017). Bald Eagles (n=192 across 91 surveys, 13 Jan - 20 Dec) and Red-tailed Hawks (n= 102 across 79 surveys, 18 Jan - 20 Dec) were regularly detected throughout the calendar year, while Turkey Vultures were commonly observed from the spring to early fall (n= 89 across 29 surveys, 6 Apr - 8 Oct). However, the Golden Eagle was only detected once (7 Apr 2017) outside of the two presences recorded during controlled burns.

DISCUSSION

The significantly higher frequency at which Swainson's Hawks were detected at controlled burn surveys may suggest that they are attracted to the plumes of smoke created by prairie fires, which may signal foraging opportunities (Hovick et al. 2017). Though opportunistic foraging at wildfires has only recently been documented regarding Swainson's Hawks in the northern and central Great Plains (Murphy and Smith 2007; Hovick et al. 2017), fire and smoke's capacity to attract foraging raptors is noted throughout ornithological literature (Stoddard 1963; Parker 1974; Dodd 1988, Hingtgen 2000). White-tailed Hawks (*Geranoaetus albicaudatus*), a similar species in appearance, foraging habitat, and prey preference to the Swainson's Hawk (Stevenson and Meitzen 1946), are particularly noteworthy as a common forager during prescribed burns in Texas (Tewes 1984).

Smallwood et al. (1982) recorded American Kestrels (*Falco sparverius*) and Cattle Egrets (*Bubulcus ibis*) foraging within an active controlled burn in Florida. Hingtgen (2000) also noted potential foraging behavior by vultures (Cathartidae), swallow-tailed kites (*Elanoides forficatus*), hawks (*Buteo* spp.), and Bald Eagles in Florida as well. American Kestrels foraged on flying insects as they fled the fire, while the egrets and other raptors took advantage of various small vertebrates and invertebrates remaining on the ground after the fire passed (Smallwood et al. 1982; Hingtgen 2000). Grasshoppers (Orthoptera: Acrididae) are abundant and ecologically important defoliators in grassland systems and have demonstrated various adaptations to fire, including effectively moving in mass ahead of oncoming flames (Komarek 1969; Joern 2005). Interestingly, White-tailed Hawks, American Kestrels, and Swainson's Hawks, which have demonstrated pyric-carnivory, all regularly exploit insect communities, particularly grasshoppers, as an important food source (Stevenson and

Meitzen 1946; White 1966; Johnson et al. 1987; England et al. 1997; Granzinolli and Motta-Junior 2007; Hovick et al. 2017). As Erwin and Stasiak (1979) note, controlled burns in the central Great Plains commonly result in the mortality of prairie rodent and snake species, which may provide attractive forage for migrating Swainson's Hawks as well. We noted Swainson's Hawks flying through the smoke ahead of the fire, consistent with other descriptions of avian insect foraging during controlled burns, as well as landing in the black to pick up recently killed or injured vertebrate prey (Smallwood et al. 1982; Fig. 1). It is beyond the scope of this study to comprehensively assess Swainson's Hawk foraging behavior during prairie fires, but this would be a valuable pursuit for future research.

Historically, prairie fires were responsible for setting back woody encroachment within tallgrass prairies (Fussman 1997; Briggs et al. 2005; Hovick et al. 2017), subsequently maintaining large open tracts of grassland with isolated trees, which are preferred habitats for Swainson's Hawks (Estep 1989; England 1997; Sharpe et al. 2001; Inselman et al. 2015). The high frequency of occurrence and general abundance of Swainson's Hawks (>35 observations in 7 prescribed burns) we detected at controlled burns suggests that Swainson's Hawks may not only be adapted to the grassland ecosystem but also to the disturbances, in particular fire, that maintain it. These same adaptions serve them today to successfully navigate cyclic anthropogenic disturbances within agricultural systems as they simulate natural disturbances, reducing vegetative cover and exposing prey (Bechard 1982; Smallwood 1995).

Several raptor species, such as Ferruginous Hawks, have experienced declining numbers with increased cultivation (Schmutz 1984; Schmutz 1987; Wiggins et al. 2014; Inselman et al. 2016). Although populations of Swainson's Hawks have remained stable, anthropogenic activities that limit natural disturbances (e.g., fire suppression) and promote woodland development (e.g., shelter belts, orchards, etc.) may favor species that prefer higher perch densities, such as Red-tailed Hawks (Janes 1994). Hovick et al. (2017) noted that the increase in Swainson's Hawk abundance following the ignition phase of prescribed burns was most pronounced in late April. The mean spring detection date of Swainson's Hawks in our study (about 650 km north of the Oklahoma State University Research Range) was also in late April. Lighting strike fires have been documented from March through November in Nebraska, with the natural burn season generally from May to September, and a majority of wildfires occurring in July and August (Knapp et al. 2009). Swainson's Hawk occurrence in the central Great Plains would have historically overlapped with the seasonality of lighting caused wildfires (Sharpe et al. 2001; Knapp et al. 2009). However, wildfires may have been most common historically just after the Swainson's Hawk breeding season (Sharpe et al. 2001; Knapp et al. 2009).

All other raptor species detected during prescribed fires demonstrate highly flexible diets, including scavenging behavior, and

can be categorized broadly as opportunistic (Olendorff 1976; Lingle and Krapu 1986; Sheffield and Jobe 1996; Stolen 2003). By contrast, the general abundance of Swainson's Hawks observed foraging at controlled burns suggests that they are fire specialists or fire adapted, similar to the White-tailed Hawk and potentially American Kestrels (Tewes 1984; Hovick et al. 2017). Swainson's Hawks avoid dense stands of forest as they need open habitats to forage, and overgrazing and fire suppression have been associated with the eventual abandonment of some habitats (Bechard et al. 1982; England et al. 1997; Estep 2009; Bechard et al. 2010). It is possible that, in addition to the negative impacts of row crop expansion and grassland habitat loss (Schmutz et al. 1987; England et al. 1997; Estep 2009), the disappearance of brush and prairie fires from large areas of the Great Plains and Interior Mountain West during last century may have negatively impacted habitat for Swainson's Hawks.

During our three years (2015-2017) of long-term avian monitoring research at the Crane Trust we have recorded a notable fall Swainson's Hawk migration (n=8) in addition to a comparatively robust spring migration (n=37; Table 2). However, it is noteworthy that aside from avian surveys conducted during controlled burns, spring detections of migrating Swainson's Hawks were relatively rare (n=2). This suggests that migrating Swainson's Hawks may be drawn from a rather long distance toward rising columns of smoke as the detection rate of Swainson's Hawks appears consistently low during their spring migration in the absence of fire.

We acknowledge it is possible that the difference in survey effort (30 min vs. ~45 min (mop-up period)) and timing (before 10:00 H compared to between 11:00 and 14:00 H) of long-term avian monitoring surveys and prescribed fire raptor surveys may have partially accounted for the differences in Swainson's Hawk abundance. However, we feel our hypothesis that Swainson's Hawks are fire-adapted is supported given the extreme contrast of our results (100% occurrence at fires vs. 0.0% across monitoring surveys), especially when coupled with the findings of Murphy and Smith (2007) and Hovick et al. (2017). Furthermore, data from our incidental avian observation database, which includes robust coverage through the middle of the day, corroborates the general finding that Swainson's Hawks are not particularly abundant (or at least are very hard to detect) in the Big Bend of the Platte River during their spring migration. This parallels Lingle and Hay (1982), who listed the Swainson's Hawk as a "rare" spring migrant during their two-year inventory of the birds of Mormon Island, documenting just two or fewer sightings per migration season (48 spring surveys conducted 1980-1981). Lingle and Hay (1982) did not detect Swainson's Hawks migrating through Mormon Island during the fall.

Research has demonstrated that many wildlife species are adapted to take advantage of habitats created by various successional stages following fire. For instance, Bison and Elk (*Cervus canadensis*) have been documented to prefer forage resulting from recently burned habitats (Pearson et al. 2005; Fuhlendorf et al. 2009).

Likewise, the habitats and ecological niches of many prairie songbird and insect species exist within relatively limited time-intervals or stages of ecological succession following controlled burns (Fussman 1997; Fuhlendorf et al. 2009; Caven et al. 2017). However, little information exists regarding individual species' immediate responses to prairie fire or the ability of particular species to exploit these natural disturbances for foraging opportunities (Komarek 1969; Lyon et al. 1978).

Avian species, particularly raptors, represent the vast majority of North American vertebrates documented exploiting wildland fires for foraging opportunities; this is particularly true of records during and immediately following controlled burns (Komarek 1969; Lyons 1978; Lyons et al. 2000; Hovick et al. 2017). North American bird species recorded foraging during controlled burns include: Swainson's Hawks, White-tailed Hawks, Red-tailed Hawks, Red-shouldered Hawks (*Buteo lineatus*), Broad-winged Hawks (*Buteo platypterus*), Rough-legged Hawks (*Buteo lagopus*), Cooper's Hawks (*Accipiter cooperii*), Sharp-shinned Hawks (*Accipiter striatus*), White-tailed Kites, Mississippi Kites (*Ictinia mississippiensis*), Northern Harriers (*Circus cyaneus*), American Kestrels, Crested Caracaras (*Caracara cheriway*), Black Vultures (*Coragyps atratus*), Turkey Vultures, Great-Horned Owls (*Bubo virginianus*), Short-eared Owls (*Asio flammeus*), Cattle Egrets, American Crows (*Corvus brachyrhynchos*), and Purple Martins (*Progne subis*) (Stoddard 1963; Komarek 1969; Parker et al. 1974; Cowner 1979; Smallwood et al. 1982; Tewes 1984; Dodd 1988; Hovick et al. 2017). Bald Eagles and Golden Eagles have previously been documented scavenging in the days and weeks following a wildfire (Lyon et al. 2000). However, this account marks the first records, to our knowledge, of Golden Eagles using active controlled burns. Golden Eagles are considered an uncommon spring visitor in the central and western portion Nebraska with reports as late as mid-May (Lingle and Hay 1982, Sharpe et al. 2001). It is notable that during our study period we recorded just one Golden Eagle on monitoring surveys but two during prescribed fires. Their overall rarity in the region may suggest an attraction to smoke plumes for this species as well, but further data is needed to validate this hypothesis.

These observations provide a better understanding of the foraging behavior and natural history of Swainson's Hawks and other raptors in relation to the disturbance ecology of the Great Plains. It also provides corroboration of the findings of Hovick et al. (2017), suggesting that Swainson's Hawks may be particularly drawn toward prescribed prairie fires during their spring migration period. Further investigation is needed to describe the foraging behavior and prey selection of Swainson's Hawks in relation to controlled burns and wildfires. Future research should also investigate the characteristics of prairie fires in relation to Swainson's Hawk use, particularly whether the size of a prairie fire and its smoke plume are correlated with the number of attending Swainson's Hawks and other raptors. The attraction to and utilization of controlled burns by Swainson's Hawks for foraging opportunities demonstrates a behavioral

adaptation to an important natural disturbance that historically structured the Great Plains ecosystem.

ACKNOWLEDGEMENTS

We would like to thank the Crane Trust land management team past and present, specifically J. Salter and M. Morton for their expert handling of the controlled burns involved in this study. We appreciate the help of R. P. McLean, I. Vilella, K. Leung, and T. Phillips for their help completing avian monitoring surveys. Finally, we thank Carson Schultz for his critical review of this manuscript as well as Melissa Mosier for editorial support and production.

LITERATURE CITED

Anderson, R. C. 1990. The historic role of fire in the North American grassland. In: Collins SL, Wallace LL, editors. Fire in North American tallgrass prairies. Norman (OK): University of Oklahoma Press. p. 8-18

Anderson, R. C. 2006. Evolution and origin of the Central Grassland of North America: climate, fire, and mammalian grazers. The Journal of the Torrey Botanical Society. 133:626-647.

Bechard, M. J. 1982. Effect of vegetative cover on foraging site selection by Swainson's Hawk. Condor. 84:153-159.

Bechard, M. J., C. S. Houston, J. H. Sarasola, and A. S. England. 2010. Swainson's Hawk (*Buteo swainsoni*). In The birds of North America online (A. Poole, Editor). Cornell Lab of Ornithology. Ithaca, NY, USA, No. 265.

Bednarz, J. C., D. Klem Jr, L. J. Goodrich, and S. E. Senner. 1990. Migration counts of raptors at Hawk Mountain, Pennsylvania, as indicators of population trends, 1934-1986. The Auk 107: 96-109.

Bibby, C. J., Burgess N. D., and D. A. Hill. 1992. Bird Census Techniques. Academic Press, San Diego, CA, USA.

Bird Conservancy Network (BCN). 2006. Illinois Swainson's Hawk project: Fieldwork instructions, pp. 7. http://bcnbirds.org/shp/SHPinstructions.pdf

Bragg, T. B., and L. C. Hulbert. 1976. Woody plant invasion of unburned Kansas bluestem prairie. Journal of Range Management. 29:19-24.

Briggs, J. M., G. A. Hoch, and J. C. Johnson. 2002. Assessing the rate, mechanisms, and consequences of the conversion of tallgrass prairie to *Juniperus virginiana* forest. Ecosystems 5:578-586.

Briggs, J. M, A. K. Knapp, J. M. Blair, J. L. Heisler, G. A. Hoch, M. S. Lett, and J. K. McCarron. 2005. An ecosystem in transition: causes and consequences of the conversion of mesic grassland to shrubland. BioScience. 55:243–254.

Caven, A. J., K. C. King, J. D. Wiese, and E. M. Brinley Buckley. 2017. A descriptive analysis of Regal Fritillary (*Speyeria idalia*) habitat utilizing biological monitoring data along the big bend of the Platte River, NE. Journal of Insect Conservation 21:1-23.

Caven, A. J., J. D. Wiese, B. L. Ostrom, K. C. King, J. M. Malzahn, D. M. Baasch, and B. Krohn. 2022. Landscape-level

long-term biological research and monitoring plan for the Crane Trust. Zea Books, University of Nebraska-Lincoln Libraries, Lincoln, NE, USA, 117 pp.

Caven, A. J., and J. D. Wiese. 2022. Reinventory of the vascular plants of Mormon Island Crane Meadows after forty years of restoration, invasion, and climate change. Heliyon 8:e09640.

Collins, S. L. 1990. Introduction: Fire as a natural disturbance in tallgrass prairie ecosystems. In Fire in North American tallgrass prairies (S. L. Collins, L. L. Wallace, Editors). University of Oklahoma Press, Norman, OK, USA, pp. 3-7.

Cowner, A. W., and G. W. Barrett. 1979. Effects of fire on the small mammal component of an experimental grassland community. Journal of Mammalogy 60:803-813.

Cummings, D. C, S. D. Fuhlendorf, and D. M. Engle. 2007. Is altering grazing selectivity of invasive forage species with patch burning more effective than herbicide treatments? Rangeland Ecology and Management 60:253-260.

Dodd, N. L. 1988. Fire management and southwestern raptors. In: Glinski RL, Pendleton BG, Moss, MB, editors. Proceedings of the southwest raptor symposium and workshop. National Wildlife Federation Technology Series 11; 21-24 May 1986. National Wildlife Federation, Tucson, AZ, pp. 341-347.

Elzinga, C. L., D. W. Salzer, J. W. Willoughby, and J. P. Gibbs. 2009. Monitoring plant and animal populations: a handbook for field biologists. John Wiley and Sons, Hoboken, NJ, USA

England, A. S., M. J. Bechard, and C. S. Houston. 1997. Swainson's Hawk (*Buteo swainsoni*). In: Poole A, Gill F, editors. The birds of North America. The Birds of North America, Inc. Philadelphia, PA, USA, No. 265.

Erwin, W. J., and R. H. Stasiak. 1979. Vertebrate mortality during the burning of a reestablished prairie in Nebraska. American Midland Naturalist 101:247-249.

Estep, J. A. 1989. Biology, movements, and habitat relationships of the Swainson's hawk in the Central Valley of California, 1986-1987. California Department of Fish and Game, Wildlife Management Division, Nongame Bird and Mammal Section Sacramento, CA, USA.Report W-64-R-2.

Estep, J. A. 2009. The influence of vegetation structure on Swainson's Hawk (*Buteo swainsoni*) foraging habitat suitability in Yolo County, California. Prepared for Yolo Natural Heritage Program.

Fuhlendorf, S. D, D. M. Engle, J. Kerby, and R. Hamilton. 2009. Pyric herbivory: rewilding landscapes through the recoupling of fire and grazing. Conservation Biology 23:588-598.

Fussman, J. L. 1997. Foraging ecology of Kirtland's warblers in managed and natural breeding habitat. Dissertation. The Ohio State University, Columbus,OH, USA.

Gibson, D. J., and L. C. Hulbert. 1987. Effects of fire, topography, and year-to-

year climatic variation on species composition in tallgrass prairie Vegetation 72:175-185.

Granzinolli, M. A. M., and J. C. Motta-Junior JC. 2007. Feeding ecology of the White-tailed Hawk (*Buteo albicaudatus*) in south-eastern Brazil. Emu 107:214-222.

Gregory, R. D., D. W. Gibbons, and P. F. Donald PF. 2004. Bird census and survey techniques. In: Sutherland WJ, Newton I, Green R, editors. Bird Ecology and Conservation: A Handbook of Techniques. Oxford University Press Inc., New York, NY, USA.

Helzer, C. 2009. The ecology and management of prairies in the central United States. Bur Oak Books. University of Iowa Press, Iowa City, IA, USA.

Herrick, J. E., J. W. Van Zee, K. M. Havstad, L. M. Burkett, and W. G. Whitford. 2009. Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems: Volumes I and II. USDA Agricultural Research Service, Jornada Experimental Range, Las Cruces, NM, USA.

Hingtgen, T. 2000. Prescribed burning: Observations on the interaction of wildlife and fire in state parks of Southwestern Florida. *In* W. Keith Moser and Cynthia F. Moser (eds.). Fire and forest ecology: innovative silviculture and vegetation management. Tall Timbers Fire Ecology Conference Proceedings. No. 21. Tall Timbers Research Station. Tallahassee. FL.

Hovick, T. J., D. A. McGranahan, R. D. Elmore, J. R. Weir, and S. D. Fuhlendorf. 2017. Pyric-carnivory: Raptor use of prescribed fires. Ecology and Evolution 7(21): 9144-9150.

Inselman, W. M., S. Datta, J. A. Jenks, K. C. Jensen, and T. W. Grovenburg. 2015. Buteo Nesting Ecology: Evaluating Nesting of Swainson's Hawks in the Northern Great Plains. PloS one 10(9): e0137045.

Inselman, W.M., S. Datta, J.A. Jenks, R.W. Klaver, and T.W. Grovenburg. 2016. Spatial Ecology and Survival of Swainson's Hawks (*Buteo swainsoni*) in the Northern Great Plains. Journal of Raptor Research 50(4): 338-350.

Janes, S. W. 1994. Partial loss of Red-tailed Hawk territories to Swainson's Hawks: relations to habitat. The Condor 96:52-57.

Joern, A. 2005. Disturbance by fire frequency and bison grazing modulate grasshopper assemblages in tallgrass prairie. Ecology 86:861-873.

Johnson, C. G., L. A. Nickerson, and M. J. Bechard. 1987. Grasshopper consumption and summer flocks of nonbreeding Swainson's Hawks. The Condor 89:676-678.

Kaul, R. B., D. Sutherland, and S. Rolfsmeier. 2006. The flora of Nebraska. School of Natural Resources, University of Nebraska-Lincoln. Lincoln, NE, USA.

Knapp, E. E., B. L. Estes, and C. N. Skinner. 2009. Ecological Effects of Prescribed Fire Season: A Literature Review and Synthesis for Managers. United States Department of

Agriculture, Forest Service, Pacific Southwest Research Station. General Technical Report PSW-GTR-224.

Komarek, E. V. 1969. Fire and animal behavior. In: Komarek E. V., editor. Proceedings of the Tall Timbers Fire Ecology Conference 9. Tall Timbers Research Station. Tallahassee, FL, USA, pp. 160-207.

Lyon, L. J., H. S. Crawford, E. Czuhai, R. L. Fredriksen, R. F. Harlow, L. J. Metz, and H. A. Pearson. 1978. Effects of fire on fauna: a state-of-knowledge review. USDA, Forest Service, General Technical Report WG-6.

Lyon, L. J., M. H. Huff, R. G. Hooper, E. S. Telfer, D. S. Schreiner, and J. Kapler-Smith. 2000. Wildland fire in ecosystems: effects of fire on fauna. USDA, Forest Service, Rocky Mountain Research Station, Ogden, UT, USA. General Technical Report RMRS-GTR-42 Vol. 1.

Lingle, G. R., and M. A. Hay. 1982. A checklist of the birds of Mormon Island Crane Meadows. Nebraska Bird Review 50:27-36.

Lingle, G. R., and G. L. Krapu. 1986. Winter ecology of Bald Eagles in central Nebraska. Prairie Naturalist 18:65-78.

Murphy, R. K., and K. A. Smith. 2007. Swainson’s Hawks gather to forage at fires on a Northern prairie. Blue Jay 65(2):78-81

Nagel, H. G. 1981. Vegetation ecology of Crane Meadows. Report to the Nature Conservancy and the Platte River Whooping Crane Critical Habitat Maintenance Trust. Grand Island, NE, USA.

National Wildfire Coordinating Group (NWCG). 2018. NWCG glossary of wildland fire. Data Standards and terminology subcommittee of the National Wildfire Coordinating Group, PMS No. 205. https://www.nwcg.gov/glossary/a-z

Naveh, Z. 1994. From biodiversity to ecodiversity: a landscape ecology approach to conservation and restoration. Restoration Ecology 2:180-189.

Olendorff, R. R. 1976. The food habits of North American Golden Eagles. The American Midland Naturalist 95:231-236.

Parker, J. W. 1974. Activity of red-tailed hawks at a corn stubble fire. Kansas Ornithological Society 22:17-18.

Pearson, S. M., M. G.Turner, L. L.Wallace, and W. H. Romme WH. 1995. Winter habitat use by large ungulates following fire in northern Yellowstone National Park. Ecological Applications. 5:744-755.

Reinking, D. L. 2005. Fire regimes and avian responses in the central tallgrass prairie. Studies in Avian Biology 30:116.

Schmutz, J. 1984. Ferruginous and Swainson's Hawk abundance and distribution in relation to land use in southeastern Alberta. The Journal of Wildlife Management 48:1180-1187.

Schmutz, J. 1987. The effect of agriculture on Ferruginous and Swainson's Hawks. Journal of Range Management 40:438-440.

Sharpe, R. S., W. R. Silcock, J. G. Jorgensen. 2001. Birds of Nebraska: Their distribution and temporal occurrence. University of Nebraska Press. Lincoln, NE, USA.

Sheffield, S. R., and N. Jobe. 1996. Winter carrion feeding of Red-tailed Hawks in Oklahoma. The Journal of Raptor Research 30:43-44.

Smallwood, J. A., M. Woodrey, N. J. Smallwood, and M. A. Kettler. 1982. Foraging by Cattle Egrets and American Kestrels at a Fire's Edge. Journal of Field Ornithology 53(2):171-172.

Smallwood, K. S. 1995. Scaling Swainson's hawk population density for assessing habitat use across an agricultural landscape. The Journal for Raptor Research 29:172-178.

Sorace, A., M. Gustin, E. Calvario, L. Ianniello, and S. Sarrocco. 2000. Assessing bird communities by point counts: repeated sessions and their duration. Acta ornithologica 35(2): 197-202.

Stevenson, J. O., and I.H Meitzen. 1946. Behavior and food habits of Sennett's White-tailed Hawk in Texas. The Wilsons Bulletin 58:198-205.

Stoddard, H. L. Sr. 1963. Bird habitat and fire. Proceedings of the Tall Timbers Fire Ecology Conference 2. Tall Timbers Research Station, Tallahassee, FL, USA, pp. 163-175.

Stolen, E. D. 2003. Turkey Vultures carrying carrion. Florida Field Naturalist 31:22.

Tewes, M. E. 1984. Opportunistic feeding in White-tailed Hawks at prescribed burns. Wilson Bulletin. 96:135-136.

USDA-NRCS. 2015. Monitoring Manual – Natural Resources Conservation Service. 206 p.

VanDerwalker, J. G. 1981. The Platte River Whooping Crane Critical Habitat Maintenance Trust. In Proceedings of the North American Crane Workshop. (J. C. Lewis, Editor. National Audubon Society, Tavernier, FL, USA, pp. 4-6.

White, C. M. 1966. Notes on the food of Swainson's Hawks. Kansas Ornithological Society Bulletin. 17: 10.

Wiggins, D. A., G. D. Schnell, and D. J. Augustine. 2014. Distribution and nesting success of Ferruginous Hawks and Swainson's Hawks on an agricultural landscape in the Great Plains. The Southwestern Naturalist. 59(3):356-363.

Table 1. Frequency of Swainson's Hawk (SWHA) occurrence during spring controlled burns as compared to systematic long-term monitoring and incidental surveys from 15 March to 31 May 2016 and 2017.

	Controlled Burns	Monitoring Surveys	Incidental Observations
N	7	40	861
SWHA present	7	0	2
SWHA Total	35	0	2
Percent (%)	100.0*	0.0	0.2
Max Count	14	0	2
Min Count	1	0	0
mean ($\bar{x}$)	5.0	0	0.0
standard dev. (*sd*)	4.5	0	0.0

*The proportion of controlled burn surveys in which SWHAs were detected differed significantly from both the proportion detected during systematic monitoring surveys and the proportion of incidentally detected migrants identified as SWHAs.

Table 2. First, last, and mean spring and fall migration presence dates for Swainson's Hawks, including all Crane Trust avian monitoring databases 2015 to 2017, Hall and Buffalo Counties, Nebraska, USA.

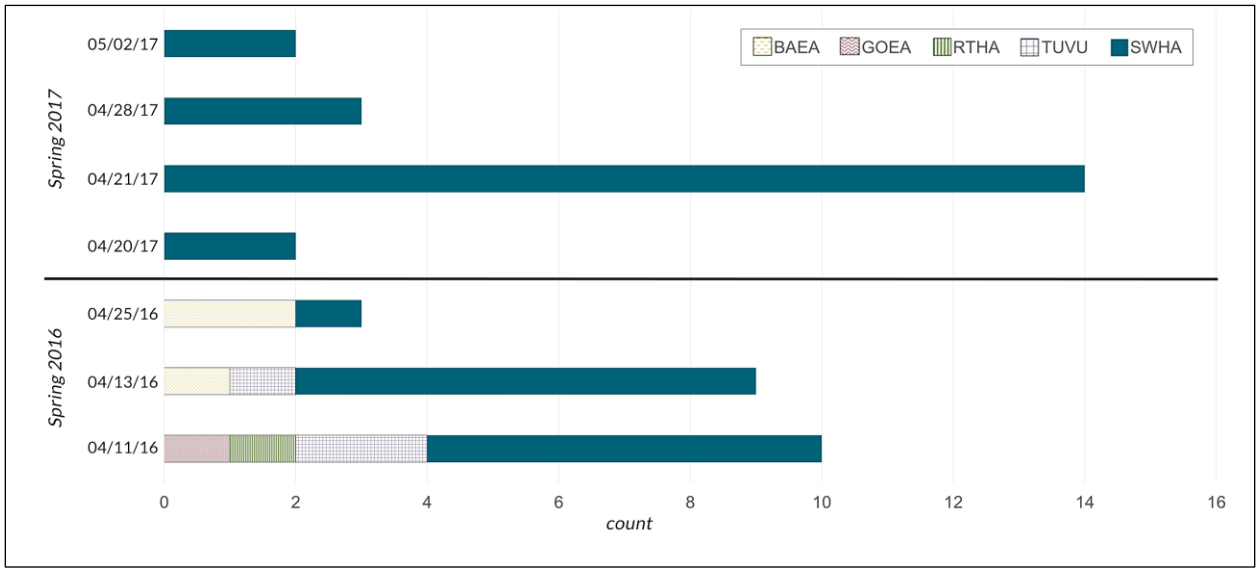
Date Metric	Spring (n=37)	Fall (n=8)
First Detection	31 March	24 August
Last Detection	2 May	20 October
mean ($\bar{x}$) date	21 April	25 September
standard dev. (*sd*) days	+/- 10.4	+/- 20.0

Table 3. Counts and detection dates of raptors aside from Swainson's Hawks detected during or immediately following controlled burns.

Species	Date of Burn	Count
Golden Eagle (*Aquila chrysaetos*)	11 April 2016	1
	21 April 2017	1
Bald Eagle (*Haliaeetus leucocephalus*)	13 April 2016	1
	25 April 2016	2
Red-tailed Hawk (*Buteo jamaicensis*)	11 April 2016	1
	20 April 2017	1
Turkey Vulture (*Cathartes aura*)	11 April 2016	1
	13 April 2016	2

Figure 1. Swainson's Hawks (SWHA) detected foraging following an 82 ha controlled spring burn focused on controlling woody species and exotic cool season grasses. Left, SWHA tears at prey/carrion pulled from the fire. Right, SWHA perches atop a grazing enclosure before swooping down into the post-burn black earth to forage.

Figure 2: Count of raptors present during spring prescribed fires in 2016 and 2017 by species (Bald Eagle (BAEA), Golden Eagle (GOEA), Red-tailed Hawk (RTHA), Turkey Vulture (TUVU), and Swainson's Hawk (SWHA)).



Appendix 1. Controlled burn terminology used in this manuscript quoted from the National Wildfire Coordinating Group (NWCG 2018) "glossary of wildland fire."

Backing Fire	"Fire spreading, or ignited to spread, into (against) the wind or downslope."
Firebreak	"A natural or constructed barrier used to stop or check fires that may occur, or to provide a control line from which to work."
Mop Up	"Extinguishing or removing burning material near control lines…to make a fire safe…."