Interim evaluation of breeding bird response to oak woodland restoration at Indian Cave and Ponca state parks, Nebraska, USA

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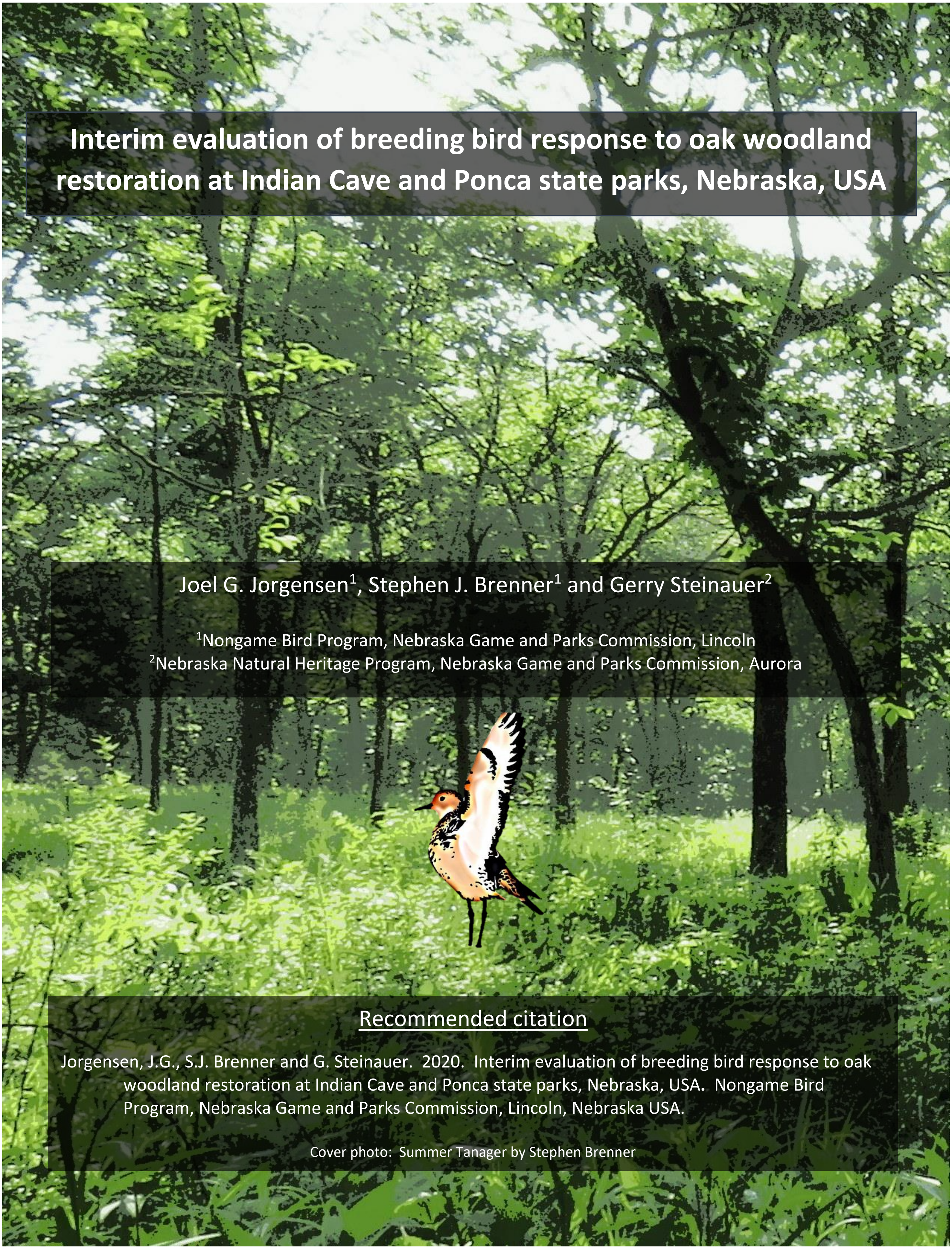

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Cover photo: Summer Tanager by Stephen Brenner

Oak (*Quercus* spp.) forests and savannas (hereafter woodlands) in the Midwestern United States are disturbance-mediated ecosystems that historically were maintained by periodic fires (Apfelbaum and Haney 1991, Dey and Kabrick 2016). Fires burn understory, foster oak regeneration and increase the density and diversity of ground-layer herbaceous vegetation (Hart and Buchanan 2012). Changes in fire regimes since settlement by Euro-Americans have altered these systems (Apfelbaum and Haney 1991, Hart and Buchanan 2012). Specifically, fire suppression promotes development of dense woody understory of shade-tolerant trees and shrubs, which hinders oak regeneration and the system will ultimately transition to a different state (Taft 2009, Brewer 2014, Dey and Kabrick 2016). Increasingly, land managers and conservation practitioners are using prescribed fire and mechanical tree thinning to mimic historical disturbance regimes in order to restore altered oak woodlands (Hart and Buchanan 2012, Dey and Kabrick 2016, Harrington and Kathol 2009)

Management actions that alter vegetative community and structure of an ecosystem, either directly or indirectly, will affect the avian species and communities that occupy them. This includes resident birds that occupy sites over their lifetime, migrant species that may inhabit sites for short periods during spring and fall and breeding birds that use habitats and resources to mate, nest and rear young during the warmer months. In the case of oak woodlands, decisions to suppress and reintroduce historical disturbance regimes affect avian communities. In general, ground- and shrub-nesting species have been observed at lower densities in managed woodlands, but bark-gleaners (e.g., woodpeckers), late-successional, edge and some canopy-nesting species have been observed at higher densities at managed sites compared to unmanaged sites (Davis et. al. 2000, Rodewald and Smith 1998, Artman et al. 2001). Many species show no apparent changes in abundance and adapt to changes in woodland structure. For example, Artman and Downhower (2003) showed neither Wood Thrush (see Appendix for scientific names of all species) density nor nest success were different between recently burned and unburned sites in Ohio. However, Wood Thrushes used different habitat niches in recently burned compared to unburned sites. Nonetheless, woodland restoration presents trade-offs for avian conservation (Vander Yacht et al. 2016, Roach et al. 2018, Brawn 2006).

Indian Cave State Park (ICSP) and Ponca State Park (PSP) are important conservation properties in Nebraska that are owned and managed by the Nebraska Game and Parks Commission (NGPC). Both parks border the Missouri River and are two of the largest continuous tracts of undeveloped upland deciduous oak woodland in the state (Kaul and Rolfsmeier 1993). ICSP totals 1,336 hectares (ha) and is located in northeast Richardson and southeast Nemaha counties (Figure 1). PSP totals 813 ha and is located in northeast Dixon County. Flora, fauna and communities of conservation concern are found within both parks, which are part of Biologically Unique Landscapes identified by the Nebraska Natural Legacy Project (Schneider et al. 2011). Fire was absent at both ICSP and PSP for most of the 20th Century and into the early 2000s. A dense understory of trees and shrubs developed on both properties. Furthermore, the understory was also invaded by non-native plants such as common buckthorn (*Rhamnus catharitica),* honeysuckles *(Lonicera spp.)* and garlic mustard *(Allaria petiolata)*.

Since 2008, NGPC has implemented management actions, specifically prescribed fire and tree thinning at ICSP and PSP (Figure 2-3). The management goals at both parks are to reduce the abundance of shade-tolerant shrubs and mid-canopy trees, promote oak regeneration, increase native plant (groundlayer) diversity and abundance, and control invasive plant species. The overall goal is to reestablish a mosaic of plant communities that were present at the sites prior to settlement by Euro-Americans including: 1) dense forests of basswood (*Tilia americana*) and other fire-intolerant trees in bottoms and on north- and east-facing slopes, 2) oak woodlands primarily on mid–slopes and 3) tallgrass prairie and oak savanna on some higher ridgetops and upper south- and west-facing slopes. It is expected to take several decades of management to fully achieve these objectives.

ICSP and PSP provide important habitat for numerous breeding birds, including several species of conservation concern. Woodland management at ICSP and PSP will alter the breeding bird communities, but alterations are expected to be positive overall based on studies in similar habitats in the region (Brawn 2006, Vander Yacht et al. 2016, Roach et al. 2018). However, there remains a need to evaluate management and its impacts on the breeding bird community at ICSP and PSP over time. Starting in 2012, the Nongame Program at NGPC implemented breeding bird monitoring at ICSP and PSP in order to address this need (Jorgensen et al. 2014). Surveys were conducted in 2012, 2013 and 2014. These initial three years were completed to establish a baseline reference of breeding bird communities and species' densities. It was envisioned that the surveys would be replicated periodically in subsequent years as a way to monitor breeding bird response to woodland restoration over meaningful timescales. Species of conservation concern would be a focus of monitoring. In 2019-20, the breeding bird surveys were repeated. In this report, we summarize results from the breeding bird surveys, compare trends to the baseline years and discuss the consequences of management at this point in time.

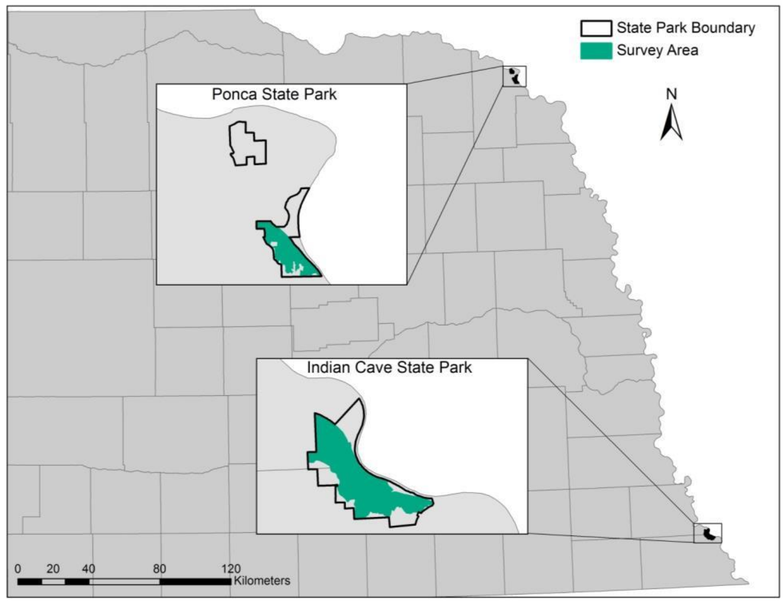

Figure 1. Indian Cave and Ponca State Park location, boundary, and survey areas in eastern Nebraska.

Methods

We defined study areas within ICSP and PSP property boundaries. The ICSP study area was based on existing management units and totals 907 ha. The PSP study area was delineated manually by excluding peripheral areas of the park that are not wooded. The PSP study area totals 327 ha. We used a random sampling design using point transects and distance sampling to survey birds at ICSP and PSP. We initially established 200 and 90 point transects at ICSP and PSP, respectively (Jorgensen et al. 2014). We used a random point generator utility in ArcMap to locate point transects. Distance sampling is a method used to survey birds where density, rather than relative abundance, is estimated and adjusted for detectability (Buckland et al. 2001). Three keys of distance sampling are 1) objects directly on the line or point are always detected, 2) objects are detected at their initial locations, prior to any movement in response to the observer, and, 3) distances are measured accurately.

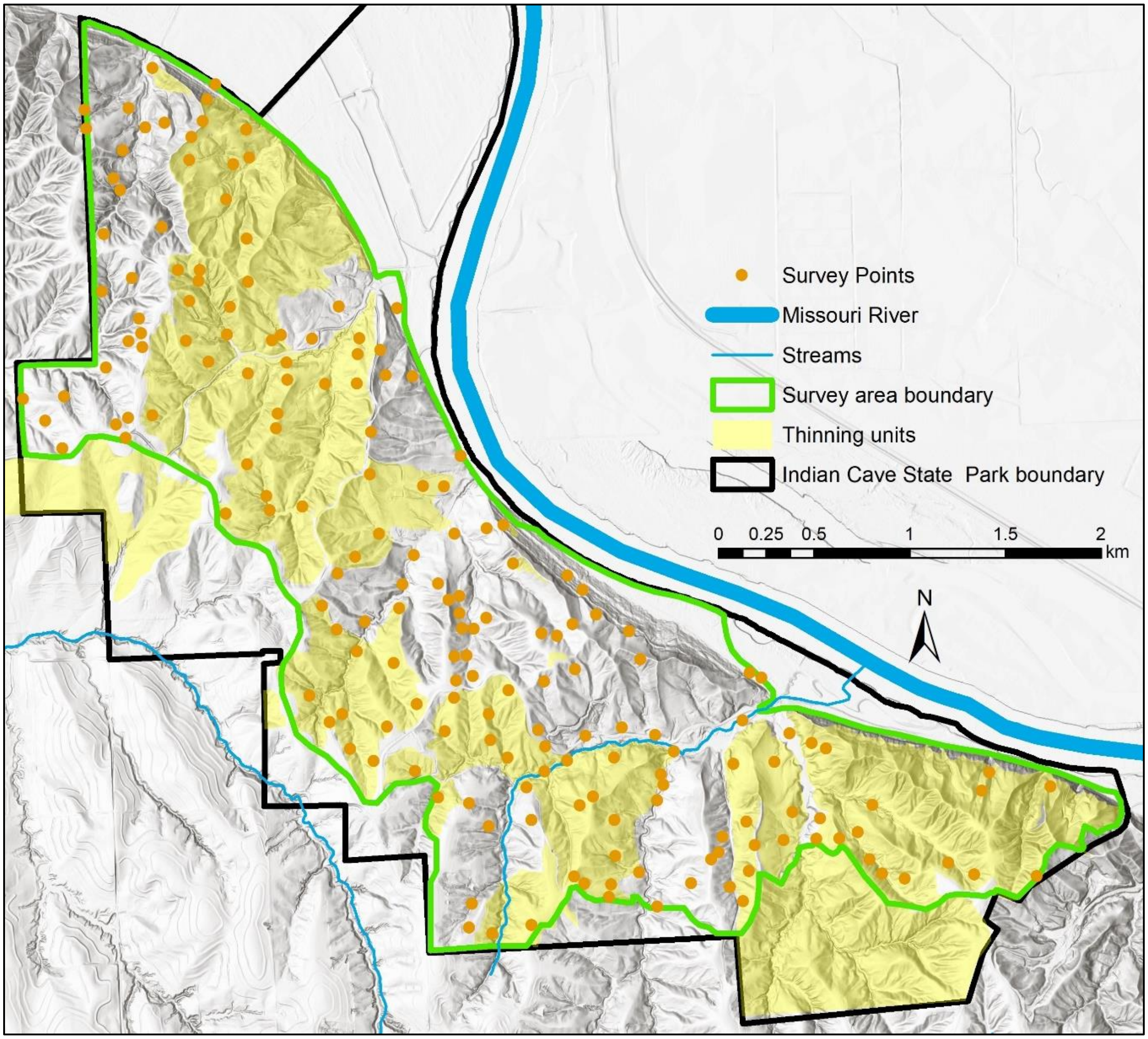

Figure 2. Indian Cave State Park boundary (black line), study area (green line), study survey points (orange dots) and areas where mechanical thinning has occurred.

All surveys were conducted from 26 May–30 June in all years. Surveyors used hand-held global positioning system (GPS) units to navigate to point transects. All point transects were conducted between sunrise and 11:00 a.m. Surveys were not conducted during heavy precipitation or when wind speeds were > 20 kph. Surveyors conducted five-minute point transect surveys in which they located and identified all birds seen or heard from the point transect. Visual detections were distinguished from auditory detections. Distances to all visual detections were measured using a laser range-finder. Distances to all auditory detections were estimated. Detections involving species considered to be late spring migrants were excluded. Not all points were completed in all years and our analysis only used points that were surveyed all four years.

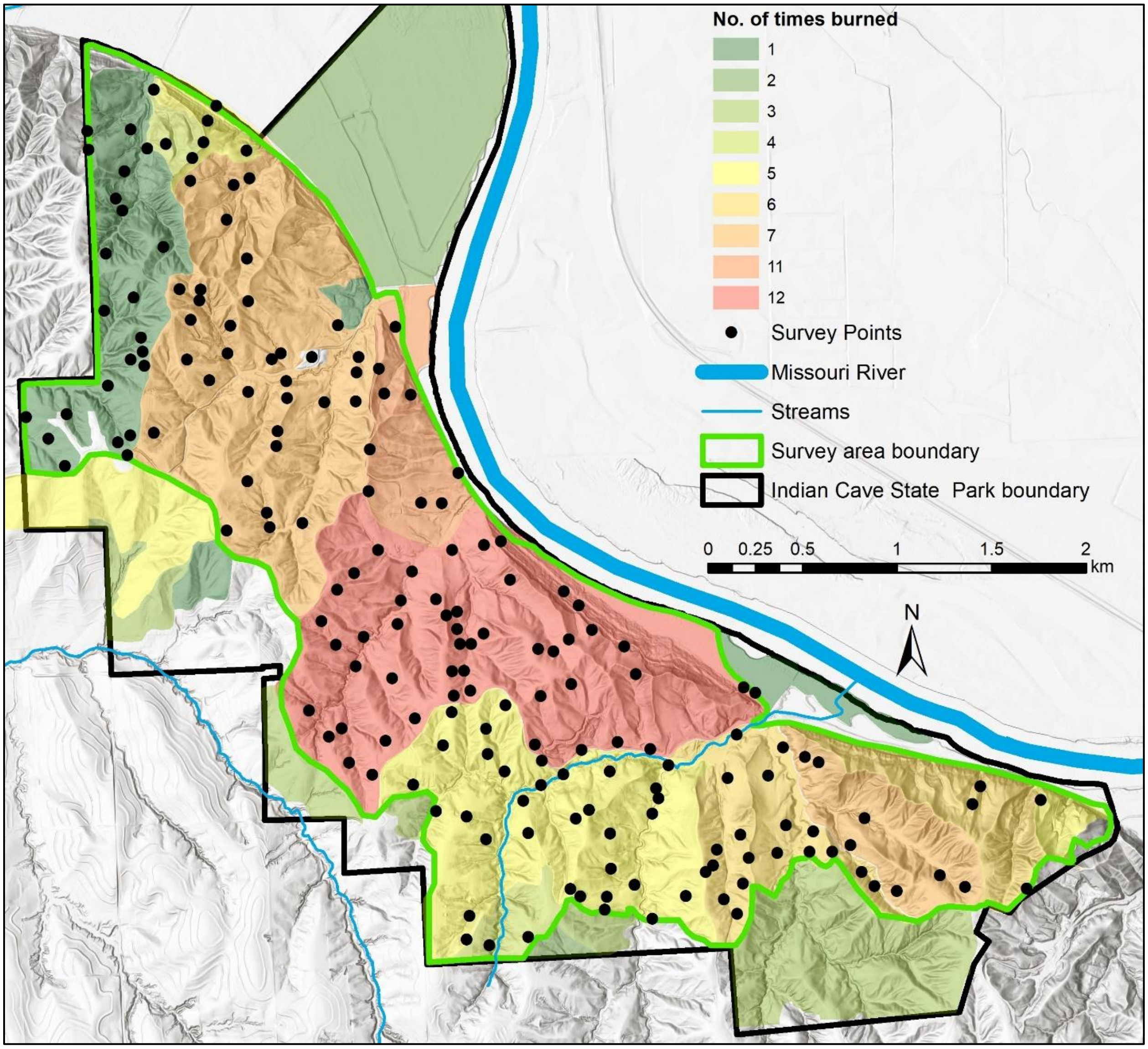

Figure 3. Indian Cave State Park boundary (black line), study area (green line), study survey points (black dots) and burn units (color-shaded areas). The number times each unit has been burn since 2008 indicated by color.

We used Program DISTANCE 7.3 (Thomas et al. 2010) and the Distance package in Program R (Miller et al. 2019, R Core Team 2019) to estimate individual species' density by year. Both Program DISTANCE and the corresponding R companion package estimates density by fitting observer detection as a function of distance to a set of models. We truncated 10% of the maximum detection distances. We used the six candidate models suggested by Buckland et al. (2001, p. 42-50) to analyze data. Akaike's Information Criterion (AIC) was used to determine relative fit of models. The model with the lowest AIC value was selected and goodness-of-fit tests were used to support model selection decisions. We then visually examined density estimates to determine if species have increased, decreased or remained stable. We considered a species to have increased or decreased if the recent survey was higher/lower than all estimates from the baseline years, and if the CV for all estimates was < 0.35. We only modeled annual species' density for species where we had > 75 detections across all years, unless noted otherwise. We refer to surveys conducted from 2012-2014 as baseline surveys and the iteration completed in 2019/2020 as the recent survey. The recent surveys cover two years because a small number (17) of points were not completed in 2019, as originally planned, because of logistical challenges.

Results

Indian Cave State Park (ICSP)

We completed 164 survey points each of the four years and we detected 79 different species. Across all years, we recorded 4,814 individual detections, with 996 in 2012, 1,209 in 2013, 1,122 in 2014, and 1,487 in 2019/2020. For the models we used to estimate density by year (birds/ha), the hazard rate polynomial or half-normal polynomial had lowest AIC and/or best fit. In some years and in some species the confidence intervals were large, mostly due to a small number of detections of a particular species in a given year. Species with the highest estimated densities across all years at ICSP were Rose-breasted Grosbeak, Eastern Wood-Pewee, and American Redstart.

Out of 19 species for which we calculated density for all years, 5 showed apparent increases, three showed apparent declines and 11 remained relatively stable. For most species with > 75 detections, estimated density were similar between at least two of the three years during baseline surveys (Table 1). At ICSP, most species' densities were similar between baseline and recent surveys. Notable apparent increases included Yellow-billed Cuckoo (mean density from ~0.26 to 1.05), Great Crested Flycatcher (~0.59 to 1.1) and Indigo Bunting (~0.48 to 0.94; Table 1). The most notable apparent declines were for American Redstart (~1.02 to 0.28) and Tufted Titmouse (~0.83 to 0.23; Table 1). The Tier I and Tier II species in which there were sufficient detections to estimate density were Wood Thrush, Acadian Flycatcher, Kentucky Warbler, Yellow-billed Cuckoo, Tufted Titmouse, and Summer Tanager (Figure 4). Acadian Flycatcher densities in 2019/2020 declined slightly from 2012 and 2013 numbers, but were higher than 2014 densities (Figure 4).

There were four additional Tier I and Tier II species detected that did not have enough detections across years for us to estimate density. However, all of these species have always been rare and localized within the study area. The species with corresponding total detections across all years () were; Louisiana Waterthrush (8), Pileated Woodpecker (31), Ruby-throated Hummingbird (12), and Yellow-throated Vireo (34). We recorded each of these species at least once in the recent survey period.

Ponca State Park (PSP)

We completed 72 survey points across each of the four years and we detected 68 different species. Across all years, we recorded 1,678 individual detections, with 488 in 2012, 324 in 2013, 352 in 2014, and 514 in 2019/2020. For the models we used to estimate density by year (birds/ha), the hazard rate polynomial or half-normal polynomial had lowest AIC and/or best fit. In some years and in some species the confidence intervals were large, mostly due to small number of detections of a particular species in a given year.

Table 1. Estimated species' densities (birds/ha) at Indian Cave State Park (ICSP) by year. Lower and upper 95% confidence intervals are presented in parenthesis along with model coefficient of variation (LCL-UCL; CV). Species that have showed apparent increases in density between baseline and recent surveys are shaded green, species that have showed apparent declines are shaded orange and species whose densities were relatively stable are unshaded. Species names are matched with alpha codes in the Appendix.

Species	2012	2013	2014	2019/2020
MODO	0.08 (0.04-0.16; 0.34)	0.31 (0.17-0.57; 0.32)	0.10 (0.06-0.17; 0.28)	0.25 (0.19-0.33; 0.14)
YBCU[2]	0.13 (0.07-0.27; 0.33)	0.26 (0.09-0.74; 0.52)	0.43 (0.27-0.65; 0.22)	1.05 (0.67-1.60; 0.23)
RBWO	0.46 (0.20-0.68; 0.18)	0.40 (0.15-1.04; 0.51)	0.34 (0.25-0.45; 0.14)	0.29 (0.15-0.45; 0.48)
EAWP	0.23 (0.16-0.32; 0.17)	0.88 (0.35-2.20; 0.48)	0.82 (0.51-1.30; 0.24)	1.07 (0.70-1.60; 0.21)
ACFL[2]	0.61 (0.38-1.00; 0.25)	0.94 (0.51-1.70; 0.31)	0.32 (0.18-0.57; 0.30)	0.75 (0.47-1.20; 0.24)
GCFL	0.67 (0.42-1.10; 0.23)	0.59 (0.32-1.10; 0.31)	0.56 (0.34-0.90; 0.24)	1.18 (0.73-1.90; 0.24)
REVI	0.55 (0.41-0.74; 0.15)	0.86 (0.64-1.20; 0.15)	0.68 (0.42-1.10; 0.25)	0.79 (0.43-1.46; 0.31)
BLJA	0.26 (0.19-0.36; 0.17)	0.79 (0.28-2.20; 0.54)	0.23 (0.15-0.34; 0.21)	0.24 (0.19-0.32; 0.14)
TUTI[2]	0.24 (0.17-0.33; 0.17)	1.41 (0.97-2.04; 0.19)	0.83 (0.58-1.19; 0.18)	0.23 (0.13-0.39; 0.27)
WBNU	1.29 (0.91-1.81; 0.30)	0.56 (0.29-1.10; 0.33)	0.35 (0.18-0.68; 0.34)	0.54 (0.26-1.12; 0.37)
WOTH[1]	0.15 (0.10-0.22; 0.19)	0.20 (0.13-0.29; 0.20)	0.19 (0.09-0.40; 0.36)	0.26 (0.17-0.40; 0.21)
EATO	0.23 (0.10-0.52; 0.42)	*NC	0.18 (0.07-0.45; 0.49)	0.54 (0.31-0.95; 0.28)
BHCO	0.25 (0.18-0.35; 0.17)	0.82 (0.60-1.12; 0.16)	0.36 (0.27-0.48; 0.15)	1.02 (0.61-1.70; 0.27)
KEWA[2]	0.13 (0.08-0.21; 0.26)	0.20 (0.09-0.43; 0.38)	0.21 (0.10-0.45; 0.37)	0.21 (0.13-0.35; 0.26)
AMRE	1.10 (0.73-1.57; 0.20)	1.02 (0.64-1.64; 0.24)	0.73 (0.43-1.23; 0.27)	0.34 (0.17-0.66; 0.34)
SUTA[2]	0.23 (0.12-0.43; 0.32)	0.28 (0.15-0.50; 0.30)	0.09 (0.05-0.14; 0.25)	0.28 (0.14-0.57; 0.34)
NOCA	0.90 (0.51-1.60; 0.29)	1.06 (0.70-1.60; 0.21)	0.65 (0.46-0.93; 0.18)	0.47 (0.30-0.75; 0.24)
RBGR	1.76 (0.74-4.20; 0.46)	1.59 (0.95-2.60; 0.26)	1.39 (1.00-1.90; 0.16)	1.29 (0.59-2.82; 0.41)
INBU	0.45 (0.26-0.77; 0.27)	0.72 (0.42-1.20; 0.27)	0.66 (0.41-1.10; 0.25)	0.94 (0.55-1.60; 0.27)

[1]Nebraska Natural Legacy Project Tier I species
[2]Nebraska Natural Legacy Project Tier II species
*NC - models did not converge

Out of 8 species in which we calculated density for all years, three showed apparent increases and 5 remained relatively stable. The species with the highest estimated densities across all years at PSP were House Wren, American Redstart, and Eastern Wood-Pewee (Table 2). Based on comparisons of baseline and recent surveys, Rose-breasted Grosbeak, House Wren, and Red-eyed Vireo densities appeared to increase, Eastern Wood-pewee increased slightly, and most species had similar estimates as previous years. It is unclear if Black-capped Chickadee densities at PSP are declining, holding steady, or showing some other trend compared to baseline estimates, as all years showed large confidence intervals and high coefficients of variation (> 0.35) for density models (Table 2).

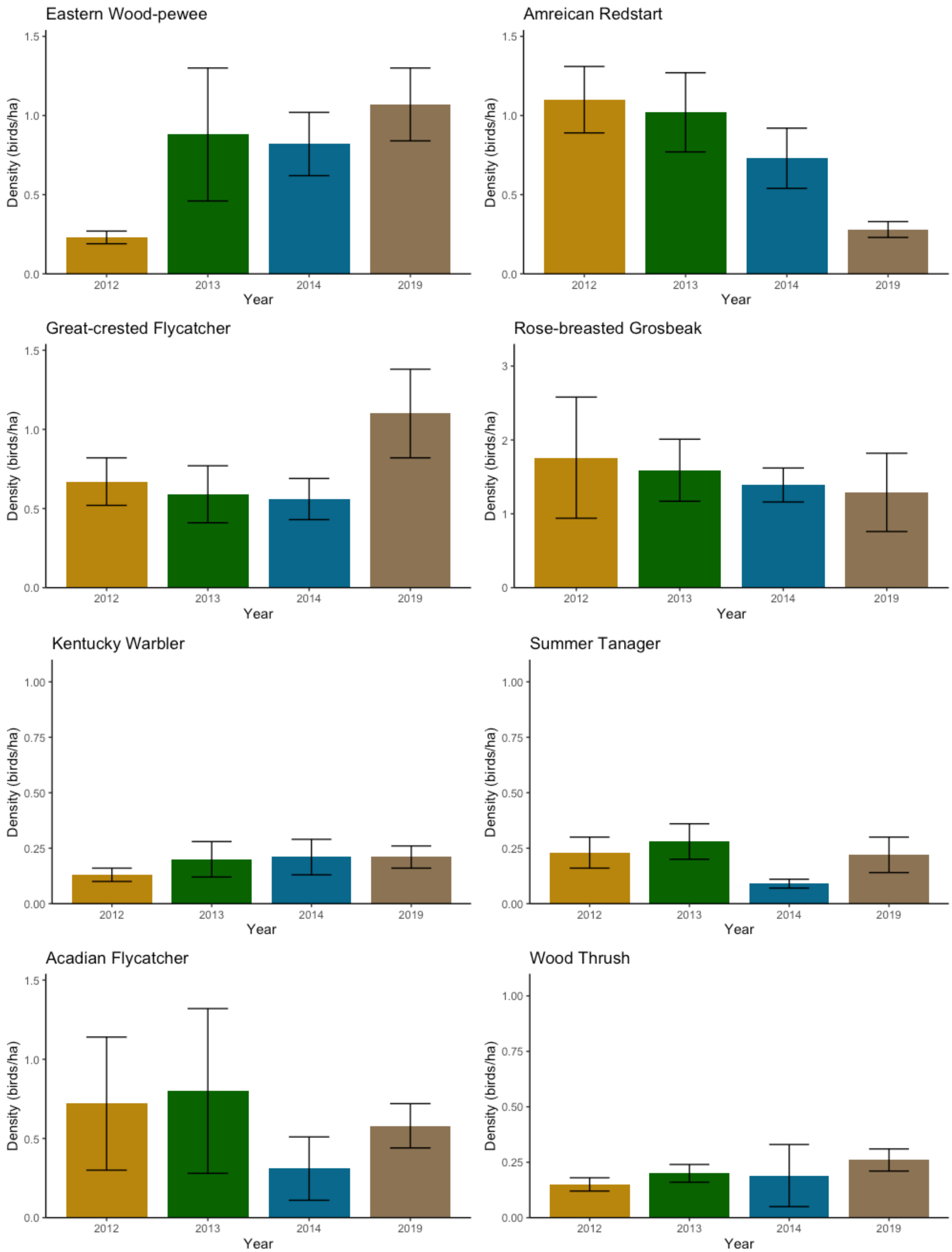

Figure 4. Density estimates of focal species in ICSP by year (continued on following page).

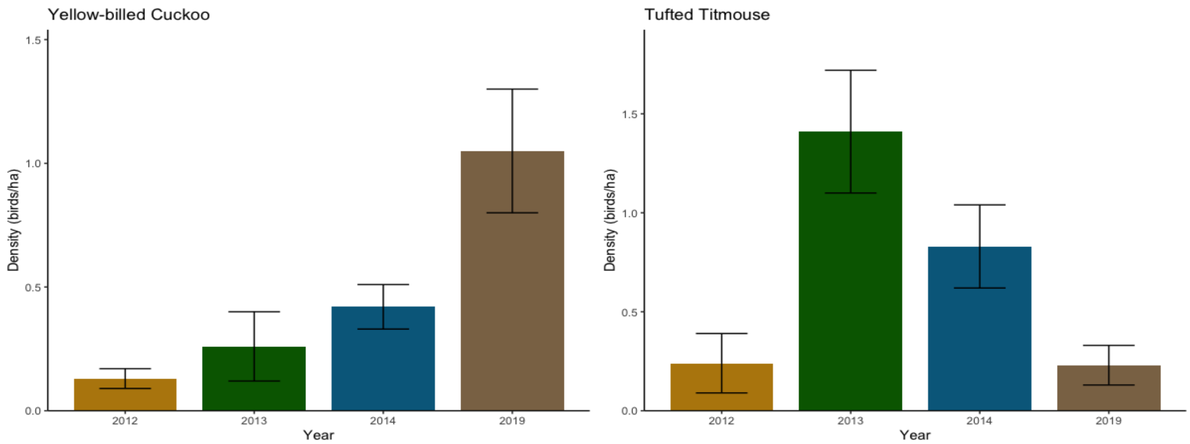

Figure 4. (continued). Density estimates of focal species in ICSP by year.

Table 2. Estimated densities (birds/ha) at PSP by year. Lower and upper 95% confidence intervals are presented in parenthesis along with model coefficient of variation (LCL-UCL; CV). Species that have showed apparent increases in density between baseline and recent surveys are shaded green, species that have showed apparent declines are shaded orange and species whose densities were relatively stable are unshaded. Species names are matched with alpha codes in the Appendix.

Species	2012	2013	2014	2019/2020
EAWP*	1.50 (0.80-2.80; 0.30)	1.27 (1.20-1.40; 0.03)	1.27 (1.20-1.50; 0.04)	1.98 (1.67-2.40; 0.08)
REVI	0.38 (0.20-0.69; 0.32)	0.83 (0.41-1.70; 0.36)	*NC	1.98 (1.14-3.40; 0.28)
BCCH	1.35 (0.91-2.00; 0.20)	0.65 (0.31-1.37; 0.38)	0.28 (0.12-0.63; 0.42)	0.59 (0.24-1.45; 0.46)
WBNU	1.19 (1.03-1.28; 0.25)	0.46 (0.31-0.61; 0.39)	0.26 (0.19-0.38; 0.26)	0.74 (0.51-0.97; 0.39)
HOWR	1.50 (1.05-2.13; 0.18)	0.88 (0.58-1.20; 0.14)	0.85 (0.68-1.10; 0.11)	3.00 (2.54-3.50; 0.16)
AMRO	0.44 (0.26-0.71; 0.60)	0.61 (0.45-0.85; 0.42)	0.73 (0.51-0.98; 0.33)	0.34 (0.24-0.45; 0.30)
AMRE	0.86 (0.46-1.60; 0.32)	1.07 (0.54-2.15; 0.23)	0.74 (0.38-1.40; 0.33)	1.02 (0.73-1.43; 0.17)
RBGR	1.07 (0.33-1.97; 0.87)	0.56 (0.38-0.82; 0.19)	0.78 (0.47-1.28; 0.14)	1.44 (0.87-2.40; 0.26)

*There were fewer than 75 detections for Eastern Wood-Pewee (70).
*NC – models did not converge

Discussion

The purpose of our breeding bird monitoring program is to track long term changes in abundance (density) of breeding birds at two important NGPC properties dominated by oak woodlands that are actively managed with prescribed fire and tree thinning. We detected minimal changes in breeding bird abundance between baseline and recent surveys at both ICSP and PSP. Perhaps most importantly, we observed no declines in abundances of the Tier I and Tier II species at ICSP, except for Tufted Titmouse. We also observed more species increasing in abundance than species declining in abundance. The steady to slightly positive overall trends support the notion that recent and ongoing management strategies at ICSP and PSP are favorable to the overall breeding bird community.

Arguably, the most notable change in abundance we observed involved Yellow-billed Cuckoo, which increased markedly at ICSP between baseline and recent surveys. Yellow-billed Cuckoo is a Tier II species under the Nebraska Natural Legacy Project (Schneider et al. 2018) that has shown declines regionally. Mollhoff (2016) noted a 7% decrease in the proportion of BBA blocks reporting Yellow-billed Cuckoos between the first (1985-1989) and second (2006-2012) BBA projects. Furthermore, Breeding Bird Survey (BBS) trend analysis shows a -1.83 (95% C.I.; -3.13, -0.50) annual decline during the years 1966-2015 (Sauer et al 2015).

Great Crested Flycatcher, Eastern Wood-Pewee and Indigo Bunting densities increased at ICSP between baseline and recent surveys. Previous research (Wilson et al. 1995, Vander Yacht et al. 2016) also showed these species' densities increased in oak-woodlands and forested savannah ecosystems where prescribed fire was reintroduced. Acadian Flycatchers, a Tier II Legacy species, density remained relatively stable, which is notable because other research (Roach et al. 2019) showed this species responding negatively to management. Brown-headed Cowbird, a brood parasite, also increased at ICSP. This species prefers open-early successional habitats, and it is possible that as management-related disturbance increases, cowbird abundances will follow suit, especially given the landscape surrounding ICSP is dominated by agriculture (Hoover and Brittingham 1993). Whether increases in Brown-headed Cowbird density results in increased rates of nest parasitism is an important question that should be considered for future research.

The only clear declines we observed at ICSP were for American Redstart. Redstarts are generally a mid-successional or secondary forest species; therefore, the response to management is not unexpected. However, redstart densities remained relatively stable at PSP. Tufted Titmouse and Northern Cardinal at ICSP, as well as Black-capped Chickadee at PSP, also showed some suggestion of declining, but results are ambiguous, as it is difficult to discern normal variation in species' density from response to management or the influence of other factors. For example, West Nile Virus has likely negatively affected Black-capped Chickadees in the region (Brenner and Jorgensen 2020). Thus, it is important to use caution when interpreting and making inferences between the baseline and recent surveys, as our monitoring program is in nascent stages. Additional years of surveys over longer periods will be required to determine actual trends for each species. Annual variations in abundance and potential single-year aberrations, as we observed in some species between 2012, 2013, or 2014, may be misleading.

There were some changes in the baseline years' density estimations in this report compared to previous analysis (See Jorgensen et al. 2014). This is due to two factors: 1) we eliminated ~25 points used during the previous years for various reasons, including being located slightly outside of oak woodlands or being in close proximity of other point transects and 2) because some points were not completed during all four sampling efforts, we changed some aspects of our analyses. Slight changes in methodology changed some estimates from the baseline years, none of the changes was significant enough to alter our understanding of the breeding birds in the study area or change any of our conclusions from the first report.

This latest iteration of surveys and analysis at ICSP and PSP is a deliberate shift toward a long-term monitoring strategy for the breeding bird populations at these parks. Documenting the long-term trends in species' abundances can also be used to assess the impacts of management (mainly prescribed fire and thinning) on overall trends of breeding birds. However, given the current nature and implementation of management activities at ICSP, direct comparisons between bird abundances in burned and unburned portions of the park are difficult. However, long-term monitoring will still illuminate any apparent trends that may be related to management, particularly as a) more survey efforts are added over time and b) active management continues or shifts over time.

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Appendix A. Common and scientific bird names and corresponding alpha code for all species mentioned in text.

Species	Alpha Code
Ruby-throated Hummingbird (*Archilochus colubris*)	RBHU
Pileated Woodpecker (*Dryocopus pileatus*)	PIWO
Eastern Wood-Pewee (*Contopus virens*)	EAWP
Acadian Flycatcher (*Empidonax virescens*)	ACFL
Great Crested Flycatcher (*Myiarchus crinitus*)	GCFL
Yellow-throated Vireo (*Vireo flavifrons*)	YTVI
Red-eyed Vireo (*Vireo olivaceus*)	REVI
Black-capped Chickadee (*Poecile atricapillus*)	BCCH
Tufted Titmouse (*Baeolophus bicolor*)	TUTI
White-breasted Nuthatch (*Sitta carolinensis*)	WBNU
House Wren (*Troglodytes aedon*)	HOWR
Wood Thrush (*Hylocichla mustelina*)	WOTH
American Robin (*Turdus migratorius*)	AMRO
American Redstart (*Setophaga ruticilla*)	AMRE
Louisiana Waterthrush (*Parkesia motacilla*)	LOWA
Kentucky Warbler (*Geothlypis formosa*)	KEWA
Summer Tanager (*Piranga rubra*)	SUTA
Eastern Towhee (*Pipilo erythrophthalmus*)	EATO
Northern Cardinal (*Cardinalis cardinalis*)	NOCA
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)	RBGR
Indigo Bunting (*Passerina cyanea*)	INBU
Brown-headed Cowbird (*Molothrus ater*)	BHCO