Effects of oil and gas development on grassland birds

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BACKGROUND

Grassland bird populations have declined significantly over the past century, largely due to anthropogenic habitat loss and degradation. It is estimated that approximate 20% of original native grassland remains in Canada. The quantity and quality of remaining grassland is threatened by habitat loss and degradation through cultivation, urban expansion, industrial development, exotic species invasion, woody vegetation encroachment, and inappropriate management practices. The amount of oil and gas development in south-western Saskatchewan and south-eastern Alberta has increased dramatically over the past 15 years, but its impact on grassland species is poorly understood. Our project will determine the extent to which oil and gas development influences density and reproductive success of grassland songbirds in south-west SK and south-east AB. We will quantify density and reproductive success of grassland songbirds listed by the Committee On the Status of Endangered Wildlife In Canada (COSEWIC) in areas with high levels of disturbance (increased number of oil and gas wells, pipelines, roads, trails, and exotic grass species) and areas with low, to no levels of disturbance. Additionally, we will determine whether noise from compressor stations affect the singing behaviour and song characteristics of Sprague's Pipit and Chestnut-collared Longspur.

METHODS

Study areas and sites – We conducted the study on the Antelope Creek Habitat Development Area in southeastern Alberta and on native pastures in southwestern Saskatchewan in the Agriculture Agri-food Canada/Agri-Environment Services Branch (AAFC/AESB) pastures in 2010 and 2011. We located our 300 x 600 m study plots in each study area using ArcGIS and satellite imagery. The percent disturbance for each plot was determined by measuring the area of the plot and the area that encompassed each of the disturbance features in ArcGIS. In each study area, the study was conducted on 12 plots in 2010 and an additional 4 plots the following year. Each plot was divided into a 50 m grid using survey flags to facilitate nest location and monitoring.

Nest searching and monitoring - Nest searching and monitoring were carried out from early May to late July. Between 0600 and 1200 hours, we systematically located nests by flushing adult birds using weighted 25m nylon rope with aluminum can attached every 1 m, pulled between two people (Davis 2003). Each study plot was systematically searched 4-5 times during the breeding season. We also located nest fortuitously while conducting other activities. Nests were marked with the same survey flags as the 50m grid, at 5m north and south of the nest. Nests were monitored every 2-4 days until the young fledged or the nesting attempt failed. We candled the eggs (Lokemoen and Koford 1996) to determine egg age to help determine hatching dates and assist with calculating daily nest survival rates. Nest attempts were considered successful if at least one nestling of the parental species fledged the nest. Cues such as minimal nest disturbance, presence of feces and feather scales in the nest and adults uttering alarm calls nearby were used, along with nestling age, to determine nest fate.

Density - Breeding density was determined by spot-mapping (Svensson 1979). Each plot was visited several times (7-10) over the breeding season and the location of all territorial birds observed was mapped. All rounds of spot-mapping were conducted between 0500 and 0800 (MST) when wind was < 20 kph and no precipitation. For each round of spot-mapping, field staff recorded the location of singing males within the 50m x 50m grid within the plots. Territory clusters were identified by creating a composite territorial map based on all visits.

We quantified vegetation by estimating the percent ground cover of live and standing dead vegetation (dead vegetation that remains attached to the ground), forbs, shrubs, lichen, bare soil, abiotic features (dung, rocks) and litter within a 50 cm x 50 cm quadrat to the nearest 5% (Daubenmire 1959). Percent cover of crested wheatgrass was also included in the vegetation measurements in Alberta. We also measured litter depth (unattached dead vegetation on the ground; Fisher and Davis 2010) and average vegetation height in each quadrat. The distance to nearest perch was also recorded. Vegetation volume was measured by the degree of visual obstruction of a Robel pole (Robel et al. 1970). Vegetation surveys were evenly distributed across each plot, at random distances between 1-50 m from each systematically chosen grid flag in each of the four cardinal directions. At each survey area, we conducted 72 vegetation surveys per plot and 4182 vegetation surveys for all plots over both survey years.

Compressor station noise - Six compressor stations were chosen based on native pastures on at least three directions from the station. Three of the six compressor stations were on study sites where nest monitoring occurred.

The sound pressure level was recorded using a Bruel and Kjaer 2250 sound meter. We followed specifications outlined in the International Standard 8297 to determine the sound power level of multisource industrial plants. A measurement surface for each compressor station was determined based on the size of the plant, which determined the closed path around the compressor. Measurements were done early in the morning when access to the compressor station was allowed and monitored by compressor station staff. We did not conduct measurements if it was raining or if wind speed was >15km/hr.

Sprague's Pipit and Chestnut-collared Longspur singing males were located while walking meandering transects through pastures located around the chosen compressor stations between 0500 and 1300 MST. Most of the transects started from the compressor station but when transects had to end prematurely due to weather or other reasons, the transect was restarted from the farthest possible distance away and moved towards the compressor. All males encountered along each transect were recorded for 2-5 minutes. We only recorded a singing male that was within 200 m of a previously recorded individual if displays of both individuals were heard at the same time to avoid recording an individual twice. Singing males were recorded when there was no precipitation and wind speed was below 15km/hr. When a singing male was located, it was recorded by placing the microphone in the direction of the singing male. For each recording, the temperature, average wind speed, max wind speed and % humidity was recorded using a Kestrel 3000 weather meter. A GPS location was also taken for each singing male to calculate the distance from the male to the nearest compressor station. The songs were recorded with a Sennheiser MKH 20-P48 microphone and a 68 cm diameter parabola onto a Tascan HD-P2 portable stereo audio recorder. I randomly chose two songs from each male and digitized them using Raven 1.3 (The Cornell Lab of Ornithology, Bioacoustics Research Program © 2008). The background noise was removed from the digitized recordings using the Noise Reduction Process in Adobe Audition CS5.5 (Adobe Systems Inc © 2011). Song length, high frequency, low frequency, frequency range and peak frequency were measured using the measurement function in Raven 1.3.

Statistical analysis - All analyses were conducted using SAS ver. 9.2 (SAS Institute 2008). We used the logistic exposure method (Shaffer 2004) to determine if nest survival varied as a function of disturbance features. We used PROC GENMOD in SAS to run a generalized linear model (using a Poisson regression) to determine whether fledging and hatching rates varied with proximity to disturbance features. Significance is assumed at $\alpha \geq 0.05$.

RESULTS

South-east Alberta

Overall, we found 533 nests representing 23 species over the two years of the study. Most nests were passerines (n = 332), followed by waterfowl (n = 152) and shorebirds (n = 32). We also found 12 Short-eared Owl nests, one Northern Harrier nest, and one Sora nest. Among the passerines, only species for which we found 20 or more nests were included in the analyses; this resulted in 325 nests of five species of grassland songbirds (Savannah Sparrow, Baird's Sparrow, Vesper Sparrow, Sprague's Pipit, and Western Meadowlark). The proportion of grassland songbird nests that successfully fledged young was 37%. The remaining nests failed due to predation (41%), desertion (12%), or other factors, such as inclement weather, trampling by cattle, or unknown causes (10%).

Preliminary analyses indicate that the effects of oil and gas development on grassland songbirds vary by species and with type of disturbance. For example, Baird's Sparrow and Western Meadowlark nest survival was higher closer to trails than further away due to increased predation in these areas. Nest survival of Vesper and Savannah sparrows was minimally affected by proximity to trails. In contrast, Sprague's Pipit nest survival increased with distance from trails due to increased nest predation rates closer to trails. Differences in predation rate among species and at varying distances to trails may be due to differences in the type, behaviour, or activity of predators, as well as variations among the songbird species in terms of nest concealment and behaviour at the nest. Western Meadowlark nest survival was lower closer to gravel roads and may have resulted from increased nest abandonment rates we found in these areas. Traffic on gravel roads could interrupt the typical behaviour and activities of birds at the nest, such as incubation and feeding of young, subsequently increasing nest desertion rates. Well proximity had minimal effects on the nest survival of all five study species whereas distance to crested wheatgrass patches had stronger effects. Western Meadowlark nest survival was higher closer to crested wheatgrass while Baird's Sparrow nest survival was lower. Upon further examination, we found that both predation and desertion were lower for nests situated farther from crested wheatgrass and likely explains the lower nest survival of Baird's Sparrow in these areas. Proximity to crested wheatgrass did not appear to influence nest survival rates of Savannah Sparrow Vesper Sparrow, or Sprague's Pipit.

Although the effects of well proximity on nest survival were minimal, other reproductive parameters were more affected. For example, the mean number of young fledged from Savannah Sparrow nests was higher closer to wells than farther away (p=0.01). Greater fledging rates closer to wells may be due to reduced predation in these areas. Predators may avoid wells due to traffic associated with their maintenance or changes in the structure and composition of the vegetation, which alters food availability. Hatching success was lower closer to wells than further away for Baird's Sparrow (p=0.001). Traffic associated with well maintenance may disrupt incubation patterns of birds nesting nearby, thereby increasing nest abandonment and reducing hatching success as a result.

The mean number of young fledged from Baird's Sparrow nests increased with distance to crested wheatgrass (p=0.01) while Sprague's Pipit fledging rates were higher closer to patches of crested wheatgrass than further away (p=0.05). As mentioned previously, rates of predation and desertion were higher for Baird's Sparrow nests situated closer to crested wheatgrass than further away, which explains reduced fledging success in these areas. Although not significant, clutch size of Savannah Sparrow, Vesper Sparrow, Sprague's Pipit, and Western Meadowlark increased with increased cover of crested wheatgrass. Baird's Sparrow clutch size decreased with increased cover of crested wheatgrass; however this was also not statistically significant.

Baird's Sparrow density declined with increasing cover of crested wheatgrass and the species was not detected on plots with ≥ 25% cover of crested wheatgrass. Sprague's Pipit density also decreased with increased cover of crested wheatgrass up to 45% cover, after which no Sprague's Pipits were detected. These results suggest that a threshold of percent cover of crested wheatgrass exists, whereby Baird's Sparrow and Sprague's Pipit will no longer occupy or nest in an area. Savannah and Vesper sparrow densities decreased with increased cover of crested wheatgrass. Despite this decline, Savannah and Vesper sparrows were found across the entire range of crested wheatgrass cover measured in this study (0-60%), indicating that if a threshold exists for these species, it occurs at >60% cover. The density of Western Meadowlarks and Brown-headed Cowbirds were not affected by crested wheatgrass cover.

South-west Saskatchewan

Overall, 437 nests of 21 species were located over the two years of the Saskatchewan study. Most of the nests were passerines (n=405), followed by shorebirds (n=18) and waterfowl (n=12), along with one Short-eared Owl (*Asio flammeus*) nest and one Mourning Dove (*Zenaida macroura*) nest. Among the passerines, only species with more than 20 monitored nests were included in the analyses with the exception of Western Meadowlark (n=19); this resulted in 392 nests of seven species of grassland songbirds: Chestnut-collared Longspur (*Calcarius ornatus*, n = 212), Vesper Sparrow (*Pooecetes gramineus*, n = 56), Sprague's Pipit (*Anthus spragueii*, n =

33), Savannah Sparrow (*Passerculus sandwichensis*, n = 27), Baird's Sparrow (*Ammodramus bairdii*, n = 23), Horned Lark (*Eremophila alpestris*, n = 23) and Western Meadowlark (*Sturnella neglecta*, n = 19). The proportion of grassland bird nests that successfully fledged young was 36%, while the remaining 64% were unsuccessful due to predation (56%), desertion (4%) and failure due to inclement weather or unknown causes (4%).

The distance to disturbance features examined in south-western Saskatchewan included distance to natural gas compressor station, natural gas well and pipeline, fence, gravel road and trail. None of these features were strongly correlated. Unlike the Alberta study, there were only a few areas with crested wheatgrass on the plots or it occurred in small patches.

The effects of natural gas development on grassland songbirds varied by species and with type of disturbance (compressor station, well, pipeline, roads, trails and fence). All distance to disturbance features had an effect on the nest survival of Chestnut-collared Longspur, Vesper Sparrow and Sprague's Pipit. Nest survival of Western Meadowlark, Horned Lark and Savannah Sparrow, was not affected by any of the distance to disturbance features. The only distance parameter that varied with nest survival for Baird's Sparrow was trails. Like in Alberta, Baird's Sparrow nest survival decreased with increased distance to trails. However, unlike Baird's Sparrow in Alberta, nest predation was similar regardless of proximity to trails in Saskatchewan.

Compressor station proximity strongly influenced nest survival of Chestnut-collared Longspur, Vesper Sparrow and Sprague's Pipit, and was higher near compressor stations. Nest survival may be higher closer to compressors if predation is lower in these areas. For Vesper Sparrow and Chestnut-collared Longspur, nest predation and desertion was indeed lower near compressor stations. The loud, constant noise from compressor stations may cause predators to avoid areas near compressors. However, for Sprague's Pipit, nest predation was similar regardless of proximity to compressor station. This result may be due to pipits avoiding areas near compressor stations as we did not find a nest closer than 170m from the station. In contrast, Vesper Sparrow and Chestnut-collared Longspur nests were as close as 20m to the station. Proximity to natural gas wells also had a large effect on nest survival of these three species. Vesper Sparrow and Chestnut-collared Longspur nest survival was higher near natural gas well which corresponded to nest predation and desertion being lower near wells. Nest survival of Sprague's Pipit was lower near gas wells. Like the effect of distance to compressor stations on pipit nest survival, predation was similar regardless of gas well proximity.

Roads and trails had a large effect on nest survival for three species. Nest survival of Chestnut-collared Longspur was lower near roads and trails, a result of higher nest predation in these areas. Reduced nest survival of Vesper Sparrows away from roads and trails was explained by nest abandonment and predation being higher further from these linear features. Sprague's Pipit nest survival was higher near roads but lower near trails. Nest survival of all three species appears to be affected differently by proximity to roads and trails. Increased predation rates in areas away from roads and trails may be caused by habitat interior predators that avoid road- or trail-side habitat. Predators of grassland songbirds are varied and tend to be opportunistic generalists (Pietz and Granfors 2000, Davis et al. In press). Longspur nests may be easier to find by predators travelling near roads and trails because their nests consist of an open cup in short, sparse vegetation, whereas pipit and sparrow nests tend to be better concealed in somewhat taller vegetation (Davis 2005).

Distances associated with pipelines and fences had an effect on nest survival. Chestnut-collared Longspur and Vesper Sparrow nest survival decreased with increased distance from pipelines and fences due to increased predation and desertion in areas further away from these linear features. In contrast, Sprague's Pipit nest survival increased with increased distance from pipelines and fences.

The effects of disturbance proximity on nest survival were strong, but other reproductive parameters were not affected. The number of young fledged per successful nest did not vary significantly with increased distance to disturbance features for any of the focal species.

The effect of plot level disturbance on songbird territory density varied for our focal grassland species. The density of Sprague's Pipit ($p=0.04$), Savannah Sparrow ($p<0.0001$), Vesper Sparrow ($p<0.0001$), and Western Meadowlark ($p<0.0001$) increased with increased percent disturbance. Density decreased with increased percent plot disturbance for Chestnut-collared Longspur ($p<0.0001$) and Horned Lark ($p<0.0001$). There was no effect of percent plot disturbance on Baird's Sparrow density ($p=0.319$). There was a trend between the effect of disturbance on density and songbird habitat requirements as the four species that increased in density are all associated with taller, denser vegetation whereas Chestnut-collared Longspur and Horned Lark are associated with shorter, sparser vegetation. Future analyses will take vegetation structure and composition into account, allowing us to determine whether territory density is affected by plot disturbance or presence of suitable habitat on the plot.

Anthropogenic noise

Songs from 40 pipit and 17 longspur males were recorded at distances ranging from approximately 150 m to >3000 m from a compressor station. The songs have been digitized and song components have been measured but have not been thoroughly analyzed.

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