Nesting Behaviour and Reproductive Success of Sprague's Pipit (*Anthus spragueii*) and Vesper Sparrow (*Pooecetes gramineus*) during Pipeline Construction

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Industrial activity occurs in the breeding habitat of several species at risk, including the federally threatened Sprague's Pipit (*Anthus spragueii*). To evaluate whether oil pipeline construction reduces the productivity of this species, we examined (a) noise levels in relation to distance from the pipeline right-of-way (ROW), (b) the extent to which noise and song frequencies overlapped, (c) the distribution of Sprague's Pipit nests relative to the ROW, and (d) Sprague's Pipit reproductive success during exposure to pipeline construction and clean-up activity. We also examined the songs, nest locations, and reproductive success of the Vesper Sparrow (*Pooecetes gramineus*) for comparison. Study plots (400 × 400 m, $n = 30$) were established in grassland adjacent to the pipeline ROW or 600 m away from the ROW in similar habitat. Mean maximum noise levels during pipeline activity included frequencies that overlapped the song range of both species and were louder than the recommended 49 dB threshold up to 250 m from the ROW. Sprague's Pipit nests were evenly distributed across close and distant plots, whereas Vesper Sparrow nests were more abundant within 50 m of the ROW. Sprague's Pipit daily nest survival rate and the number of young surviving to day 8 both increased with increasing distance from the ROW; and Vesper Sparrow daily nest survival decreased slightly with exposure to pipeline activities. Our findings validate the restricted activity period and indicate that the recommended setback distance of 350 m is a reasonable guideline for pipeline projects.

Key Words: Sprague's Pipit; *Anthus spragueii*; breeding success; industrial activity; pipeline; Vesper Sparrow; *Pooecetes gramineus*; noise; setback distance

Introduction

Industrial activity is a major source of disturbance that can affect the abundance, reproductive success, and survival of breeding birds (Bayne *et al.* 2008; Ludlow 2013). Direct impacts involve visual or acoustic disturbances that alter breeding behaviour (Lyon and Anderson 2003), spatial distributions (McClure *et al.* 2013), or rates of predation (Francis *et al.* 2009). Indirect effects range from large-scale habitat fragmentation (Herkert *et al.* 2003) to local changes in habitat structure (Forman and Alexander 1998; Ingelfinger and Anderson 2004). Regulators must anticipate both types of impacts when they develop guidelines for industrial activities, even in situations where information is lacking or incomplete.

In this study, we evaluate whether pipeline construction reduces the productivity of Sprague's Pipit (*Anthus spragueii*; hereafter "pipit") and the Vesper Sparrow (*Pooecetes gramineus*). The pipit is a federally threatened grassland songbird (COSEWIC 2010; Government of Canada 2016) that is typically associated with native mixed-grass prairie at both the patch and landscape scales (Davis 2004; Davis *et al.* 2013). The Vesper Sparrow is a habitat generalist (Best and Rodenhouse 1984) that is considered "secure" in Canada (NatureServe 2015).

Federal guidelines recommend that high-disturbance activity should not occur within 350 m of pipit nests from 1 May to 31 August, to avoid disturbing breeding birds and to reduce potential effects on nest survivorship (Environment Canada 2011). Unusual sights and noises may distract or scare away breeding birds. Similarly, noises that interfere with calls and songs may make it difficult for displaying males to hear or communicate with their prospective mates and competitors (Habib *et al.* 2007) and may affect communication between parents and their young (Leonard and Horn 2012; McIntyre 2013). Compared with continuous industrial noise, pipeline construction and clean-up noises are more sporadic, intermittent, and occur over a wider range of amplitudes.

The opportunity to investigate the effects of this activity arose with the construction of the Alberta Clipper, a 1080-km long, 914-mm diameter oil pipeline that extends from eastern Alberta to southwestern Manitoba. For the purposes of this study, the Canadian Wildlife Service granted special permits that relaxed the restricted activity period and allowed the pipeline company (Enbridge Inc., Calgary, Alberta, Canada) to construct within the setback distance for pipit nests during the breeding season.

To assess the potential for acoustic interference from pipeline activities, we compared the frequency ranges of construction and clean-up noise to the frequencies of pipit and Vesper Sparrow songs. To assess impacts on reproduction, we located and monitored nests up to 1000 m away from the pipeline right-of-way (ROW). We tested whether nesting success was reduced closer to the ROW and with increased exposure to activity. We predicted that pipits would avoid nesting near the ROW and that, as generalists, Vesper Sparrows would be unaffected by the ROW and, therefore, exhibit a random nesting pattern.

Methods

Study design

We collected data from 10 May to 31 August 2009 along portions of the Alberta Clipper pipeline route (Figure 1). Most (98%) of the pipeline route is adjacent to an existing pipeline corridor, which has been in use since the early 1950s. Pipeline construction and clean-up activities are generally carried out by crews that may spend a few hours to a few days in a given area, using heavy equipment. They focus on a portion of the pipeline called a “spread” and their work is part of a short-term, discontinuous process, where discrete events are separated by longer periods of inactivity. Construction activities include surveying, grading, clearing, pipe-stringing, trenching, welding, pipeline lowering, backfilling, and reclamation. Clean-up activities include grade replacement, topsoil replacement, and seeding.

Habitat generally consisted of flat or gently rolling native mixed-grass or planted pasture, with a varying number of shrubs and the occasional wetland or stand of small trees. We set up 30 400-m × 400-m study plots along portions of the pipeline that follow the existing corridor, focusing on a 165-km construction spread and a 75-km clean-up spread (Figure 1). On the construction spread, the 40-m wide ROW had been mowed in winter 2008–2009. Construction had been completed on the clean-up spread in 2008, but the ROW was not vegetated and topsoil was still stored in windrows as of May 2009.

Plots were established prior to the start of construction activity in locations where pipits were observed during point count surveys conducted from 10 to 14 May 2009. We paired plots adjacent to the ROW (close) with others that were 600 m away from the ROW (dis-

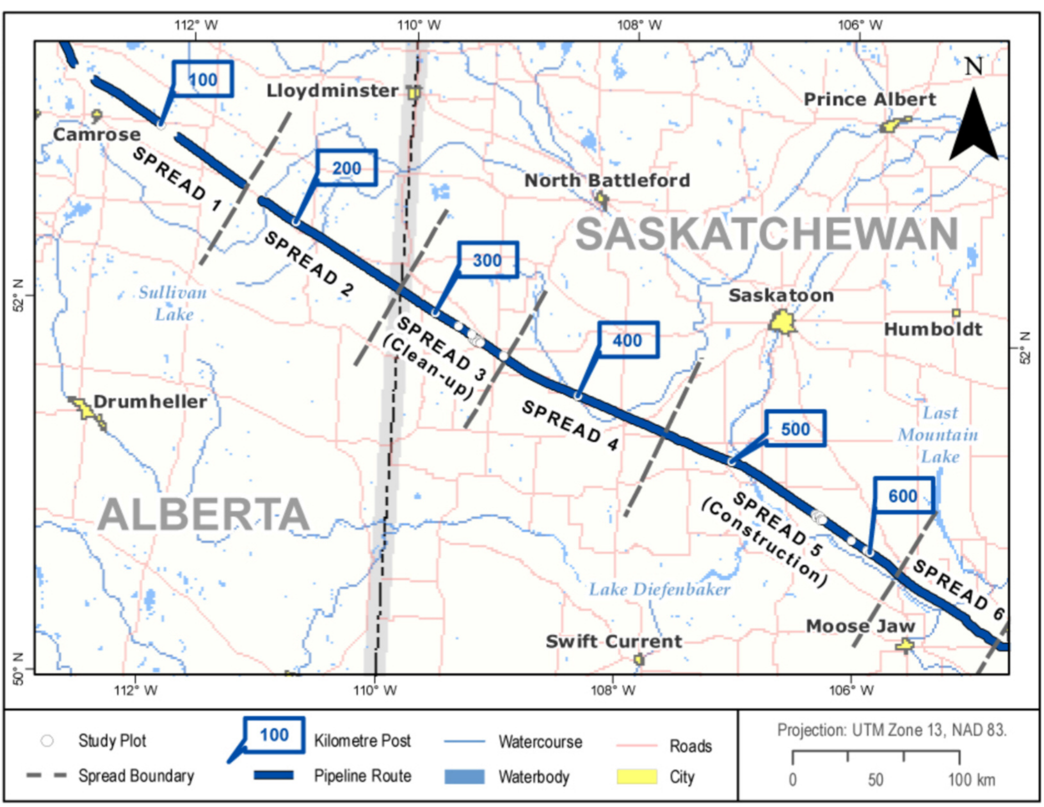

FIGURE 1. Location of the Alberta Clipper pipeline route across portions of Alberta and Saskatchewan, Canada, showing study plots (n = 30). The numbers in boxes refer to the length of the pipeline in kilometres at that point.

tant), where possible. We were not able to establish the same number of close and distant plots because pipits were not always present at distant locations. We separated each pair of plots by at least 1 km to ensure biological and statistical independence.

We focused our nesting studies on 23 plots that were located on grassland dominated by native vegetation to reduce confounding effects of habitat type and pipeline activity, given that pipits are less abundant in planted pasture (Davis and Duncan 1999; Davis *et al.* 1999; Fisher and Davis 2011). Of these, 7 close and 3 distant plots were on the construction spread and 7 close and 6 distant plots were on the clean-up spread. Three of the close plots included a portion of the existing reclaimed pipeline corridor, which was 7–20 m wide within these plots (mean 12.5 m). Eleven plots (4 distant and 7 close) had areas of scattered low-growing shrubs, including Pasture Sage (*Artemisia frigida* Willdenow), Western Snowberry (*Symphoricarpos occidentalis* Hooker), silverberry (*Elaeagnus* spp.), and wild rose (*Rosa* sp.). Grassland contained scattered shrubs covering from 15% (1 plot) to 60–70% (3 plots, mean 65%) on distant plots, and from 40–65% (4 plots, mean 55%) to 75–80% (3 plots, mean 78%) on close plots, with the remainder being open grassland. Of these 11 plots, 4 (2 distant and 2 close) had stands of tall brush, e.g., willow (*Salix* sp.), and in 1 case small Trembling Aspens (*Populus tremuloides*), that made up an additional 10–20% (mean 14%) of the cover. These 11 plots were included because at least 1 pipit was detected there during point counts and they contained Vesper Sparrow nests. Pipit nests were not found in 5 plots that were 55–80% grassland with scattered shrubs (3 close and 2 distant plots on the construction spread). We used all but 1 of the 30 plots for noise measurements and analyses because we would not expect a difference in noise transmission related to vegetation for these species.

Pipeline activities occurred at different times on each spread and on each plot. The earliest start date was 15 June 2009 and the last day of pipeline activity was 29 July 2009. The last day that a nest was monitored was 31 August 2009.

Noise and bird songs

We measured noise levels at 19 close and 10 distant plots using a Type 2250 Hand-Held Analyzer (Brüel and Kjaer, Naerum, Denmark) held approximately 1 m from the ground, away from the body, and facing the ROW. We took measurements at 100-m intervals along a linear 1-km transect that was perpendicular to the pipeline and ran through the centre of each plot, starting at the edge of the ROW. We calibrated the sound meter each morning before use and recorded each sample as an overall A-weighted decibel reading (frequency-weighted to approximate human hearing) based on a 1-minute average. We took at least 2 baseline noise measurements during periods without any pipeline activity and 1 clean-up or construction noise measurement. We combined construction and clean-up noise measurements into 1 activity category because we had too few samples to analyze separately. We deleted measurements with obvious noise contamination (e.g., airplane noise) or paused until the noise contamination was over. We also measured wind speed with a Kestrel 2000 hand-held wind meter (Kestrelmeters, Birmingham, Michigan, USA) and excluded noise data collected at wind speeds above 18 km/h.

To examine the potential for acoustic masking, we quantified pipit and Vesper Sparrow song frequencies, using recordings from the Macaulay Library (2009), and assessed the degree of overlap between the song frequencies and the noise frequency spectra for construction and clean-up activities.

Nests

We located nests by having 2 researchers walk slowly and methodically across a plot, each holding the end of a weighted 25-m rope. As the researchers dragged the rope over the vegetation, 1 or 2 observers followed behind to watch for flushed birds. We conducted 2–5 rope-drags (mean 3.2) in each plot between 27 May and 25 July. We started rope-drags within an hour of sunrise and ended in late morning or late afternoon, stopping if the weather turned cool or rainy. We searched for nests on the ROW before initiation of construction or clean-up activity, and we also found nests opportunistically as researchers walked within or to and from the study plots.

We marked nest locations with wooden stakes or survey flags placed 5 m directly north and south of the nest. For nests found during the incubation stage, we estimated nest age by candling the eggs (Lokemoen and Koford 1996). When nests were found during the nestling stage, we based the age of the chicks on physical characteristics (e.g., eyes open or closed, feather growth; Jongsomjit *et al.* 2007). We calculated nest initiation date by back-dating from the actual or estimated hatch date, using 13 days as the incubation period for pipit (Davis 2009) and 12 days for Vesper Sparrow (Jones and Cornely 2002).

We visited nests every 3–4 days to count the number of eggs and/or chicks, to determine nest fate, and to identify the type of pipeline activity that was occurring. Field crews were instructed to stop visiting nests after day 8 if they felt there was a risk of premature fledging, based on nestling periods of 11–14 days for pipits (Davis 2009) and 7–14 days for Vesper Sparrows (Jones and Cornely 2002). Of the nests that were monitored for at least 8 days, 86% of pipit nests and 58% of Vesper Sparrow nests continued to be monitored beyond this point. We visited each nest up to 3 days after the estimated fledging date and classified nests as fledged, survived to at least day 8 (for pipits), depredated, abandoned, failed, or unknown. Given the number of days between the penultimate check and the final check, we were conservative in our assessments of nest fate, classifying 25% of pipit nests and 26% of Vesper

Sparrow nests that were monitored on or past day 8 as unknown. Given that Vesper Sparrows can fledge at 7 days from hatching (Jones and Cornely 2002), we classified Vesper Sparrow nests as fledged if nestlings were present at least 7 days after hatching, there were no signs of nest destruction at the final post-fledging nest check, and 1 of the following was observed: fledglings near the nest, adults giving alarm calls or carrying food near the nest, or the nest bowl intact but enlarged and fecal sacs present. We used the same criteria to assess the outcome of pipit nests but classified them as survived to day 8, as opposed to fledged, because pipit chicks tend to stay in the nest longer (Davis 2009). We considered nests to be depredated when eggs or nestlings were absent before their predicted fledging dates or if there were signs of nest destruction during the final post-fledging nest check. We classified nests as abandoned when eggs were cold but still intact, adults were not present during subsequent nest checks, and the eggs did not hatch when expected based on the typical incubation period. We classified nests as failed when they were destroyed by severe weather or cattle or when only Brown-headed Cowbird (*Molothrus ater*) nestlings survived. We classified nest fate as unknown if we did not visit the nest up to at least 7 days after hatching for Vesper Sparrows or to at least 8 days for pipits, or if at the final post-fledging nest check, the nest was empty, but there were no reliable clues as to the fate of the clutch.

Data analysis

We used Sigma Plot version 11.0 (Systat Software, San José, California, USA) to analyze noise data, testing for effects of distance (1-way ANOVA followed by Holm-Sidak post-hoc test) and comparing activity levels with baseline levels (paired *t*-tests, $\alpha = 0.05$).

We tested for differences in nest locations with respect to the ROW by generating frequency distributions with 50-m distance classes and using χ^2 tests to compare the observed percentage of nests in each class with the percentage that would be expected if the nests were evenly distributed, i.e., 1/8 or 0.125.

We used SAS version 9.3 (SAS Institute, Inc., Cary, North Carolina, USA) for all analyses related to reproductive success. We used the logistic exposure method (Shaffer 2004) to determine the extent to which daily survival rate (DSR) varied as a function of nest age (Age), date (Date), distance from the ROW (Distance), whether or not an active nest overlapped with any days of construction or clean-up activity (Activity), and the number of days an active nest overlapped with construction or clean-up activity, determined by examining field crew activity logs (Exposure). The total number of days that the nest was exposed to pipeline activity was unique to each nest-visit interval, whereas 1 value for Activity was assigned to a nest. For nests with known fate, we used the halfway point between the last visit when the nest was active and the final visit to calculate the final interval length. For nests whose fates were unknown, we included nest-visit intervals only up to the last visit that the nest was active (Manolis *et al.* 2000).

We determined whether nest age or date influenced daily survival rates before examining the effects of pipeline activity on nest survival. However, we found no evidence of age or date effects for either species (null was the top-ranked model) and, therefore, tested for treatment effects by considering the following models: Distance, Activity, Exposure, Distance + Activity, Activity + Exposure, Distance + Exposure, and a Distance × Exposure interaction. We also compared the best models with a null (constant survival) model. We calculated Akaike information criterion scores corrected for small sample size (AIC_c) and used AIC_c weights to derive model-averaged estimates for DSR (Burnham and Anderson 1998).

We used generalized linear mixed models (PROC GLIMMIX) to assess the effects of nest initiation date (Initiation), Activity, and Distance on the number of Vesper Sparrow young that fledged and the number of pipit young that survived to at least 8 days post-hatch. We used the square root of the number of nests in each plot as a weighting factor and assigned plot as a random effect to account for multiple nests in each plot. We modeled the number of Vesper Sparrow fledglings and the number of pipit young surviving to at least day 8 as a Poisson distribution with a log link and used a Laplace approximation to derive AIC_c values. We used AIC_c to rank 10 models composed of a main and additive effect of Initiation, Activity, and Distance, along with an interactive effect of Initiation and Activity, and a null model.

Results

Noise and bird songs

Activity noise levels decreased exponentially with increasing distance from the pipeline ROW (1-way ANOVA, $F_{10, 126} = 23.35$, $P \leq 0.001$), reaching 49 dB at approximately 250 m (Figure 2). Noise readings were asymptotic after 500 m from the ROW but remained significantly higher than baseline levels (paired *t*-tests, *P* range < 0.001–0.03). The rate of decrease was frequency specific ($y = 42.4642 + 25.1351e^{(-0.005x)} - 0.0025x$, $r^2_{adj} = 0.99$), and the range of noise frequencies from both construction and clean-up activities (6.3–20 000 Hz) overlapped with pipit (3150–8000 Hz) and Vesper Sparrow (2000–18 000 Hz) song frequencies (Macaulay Library 2009).

Nests

We found 69 pipit and 53 Vesper Sparrow nests, including 20 pipit and 13 Vesper sparrow nests that were outside the study plots. We used 49 pipit and 40 Vesper Sparrow nests for nest location analyses (nests outside the study plots were excluded as they were found opportunistically), 57 pipit and 42 Vesper Sparrow nests for nest survival analyses (nests that did not overlap with pipeline activity were excluded), and 50 pipit

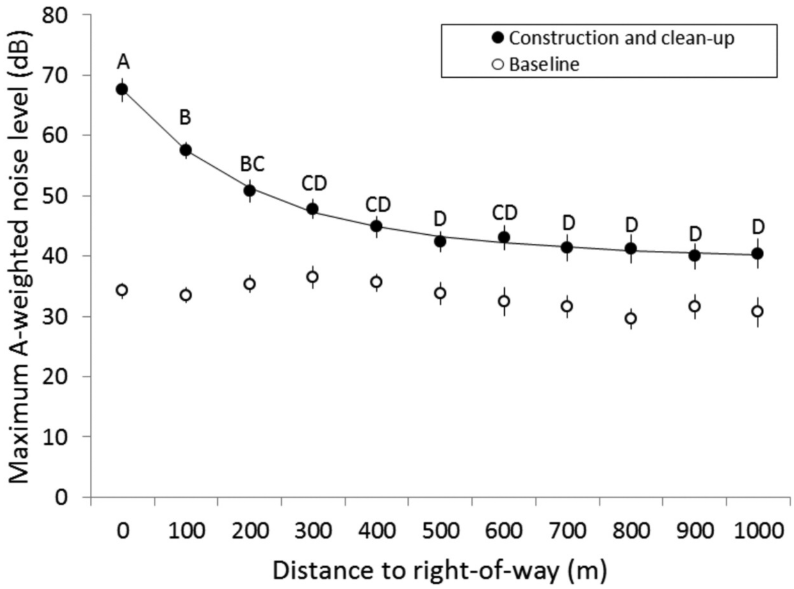

FIGURE 2. Relation between maximum A-weighted noise levels and distance from the pipeline right-of-way under pre-activity conditions (baseline) and during construction and clean-up activities. Values are means ± standard errors. Means with the same letter are not significantly different, and all differences between means for baseline and construction/clean-up conditions are significant ($P < 0.05$).

and 33 Vesper Sparrow nests for productivity analyses (14 of 64 useable pipit nests had an unknown number fledged). Nests used for productivity analyses can also be used for nest survival analyses because the data are truncated to the last day they were visited with known fate.

Pipit nests were evenly distributed with respect to distance from the ROW in close ($\chi^2 = 5.4$, df = 7, $P = 0.61$) and distant plots ($\chi^2 = 9.3$, df = 7, $P = 0.23$, Figure 3). Vesper Sparrow nests were also evenly distributed, but only in distant plots ($\chi^2 = 4.3$, df = 7, $P = 0.74$). In close plots, Vesper Sparrow nests were unevenly distributed ($\chi^2 = 23.5$, df = 7, $P = 0.001$), and the number of nests within 50 m of the ROW was higher than expected ($\chi^2 = 17.0$, df = 1, $P < 0.05$).

Median clutch initiation was 26 June for pipits ($n = 69$) and 14 June for Vesper Sparrows ($n = 53$). For both species, the range of clutch initiation dates (23 May to 30 July for pipits; 13 May to 17 July for Vesper Sparrows) fell within the restricted industrial activity period for pipits (1 May to 31 Aug).

Of the 58 pipit and 42 Vesper Sparrow nests with known fate, 41% of pipit nests and 40% of Vesper Sparrow nests survived, with predation accounting for 85% of unsuccessful pipit nest and 88% of unsuccessful Vesper Sparrow nests. Daily survival rates tended to be lower during incubation than during the nestling period for pipits and were nearly equal for Vesper Sparrows (Table 1). Assuming incubation and nestling periods of 13 and 12 days, respectively, for pipits (Davis 2009) and 12.5 and 10 days for Vesper Sparrow (Jones and Cornely 2002), overall nest success (product of incubation and nestling DSR) tended to be lower for pipits than for Vesper Sparrows (Table 1). On average however, more pipits per nest and per successful nest survived to at least day 8 compared with the number of Vesper Sparrow fledglings (Table 1), likely a result, in part, of their larger clutch sizes (4.8 ± 0.1 for pipits vs. 3.9 ± 0.1 for Vesper Sparrows). One pipit nest and 2 Vesper Sparrow nests were parasitized by Brown-headed Cowbirds. The pipit nest and 1 of the Vesper Sparrow nests contained 1 cowbird egg; the other Vesper Sparrow nest contained 2 cowbird eggs.

In total, 32 pipit and 39 Vesper Sparrow nests that were within 100 m of a plot were active during pipeline construction or clean-up. Distance and Exposure were considered the most parsimonious models for pipits and Vesper Sparrows, respectively, but no models were more than 2.6 AIC_c units away from the null (Table 2). Pipit DSR increased as a function of distance from the ROW, and Vesper Sparrow DSR declined with increasing exposure (Figure 4), but a high degree of variability was associated with proximity to the ROW and longer periods of exposure.

The number of pipit young that survived to at least day 8 was influenced mainly by distance from the ROW. In pipit nests further from the ROW, more young tended to survive to day 8 ($\beta = 0.001$, 85% CI = 0.0003–0.0017; Figure 5), although the underlying model was only 1.3 AIC_c units from the null (Table 3). The number of Vesper Sparrow fledglings was influenced mainly by an interaction between distance and activity (Table

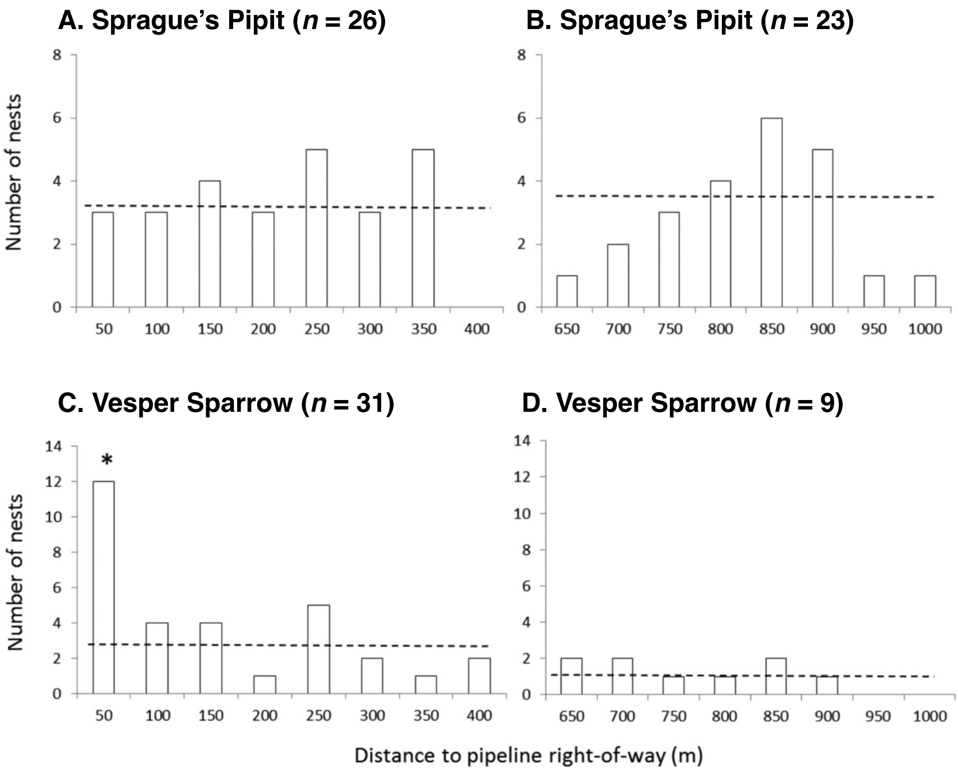

FIGURE 3. Distribution of Sprague's Pipit (*Anthus spragueii*, A–B) and Vesper Sparrow (*Pooecetes gramineus*, C–D) nests in relation to the pipeline right-of-way. Dashed line is the number of nests expected with even distribution and asterisks denote a significant ($P < 0.05$) difference between observed and expected. Numbers on the X axis refer to the tops of 50-m distance classes, and n = number of nests.

TABLE 1. Breeding success of Sprague's Pipit (*Anthus spragueii*) and Vesper Sparrow (*Pooecetes gramineus*) based on 58 pipit and 42 sparrow nests with known fate.

Parameter	Sprague's Pipit	Vesper Sparrow
Incubation DNS (95% CI)	0.930 (0.765–0.982)	0.957 (0.939–0.970)
Nestling DNS (95% CI)	0.969 (0.946–0.982)	0.959 (0.941–0.972)
Overall nest success, % (range)	27.0 (1.6–63.5)	38.0 (24.8–51.4)
Chicks surviving to day 8 ± SE	2.2 ± 0.3	1.4 ± 0.4
Chicks per successful nest ± SE	3.6 ± 0.2	2.7 ± 0.4

Note: CI = confidence interval, DNS = daily nest survival, SE = standard error.

TABLE 2. Comparison of daily nest survival model results for Sprague's Pipit (*Anthus spragueii*) and Vesper Sparrow (*Pooecetes gramineus*). Corrected Akaike information criterion (AIC_c) scores and their weights are shown for the top model, for models within 2 AIC_c units of the best model with the same or fewer number of parameters, and for the null model.

Species (effective sample size, no. nests)	Model	k	AIC_c	Δ AIC_c	AIC_c weights
Sprague's Pipit (765, 57)	Distance	2	205.5	0.0	0.25
	Exposure	2	207.5	2.0	0.09
	Null	1	208.1	2.6	0.07
Vesper Sparrow (398, 42)	Exposure	2	115.1	0.0	0.23
	Null	1	115.5	0.5	0.18

Note: k = number of parameters, Δ AIC_c = change in score compared with top model.

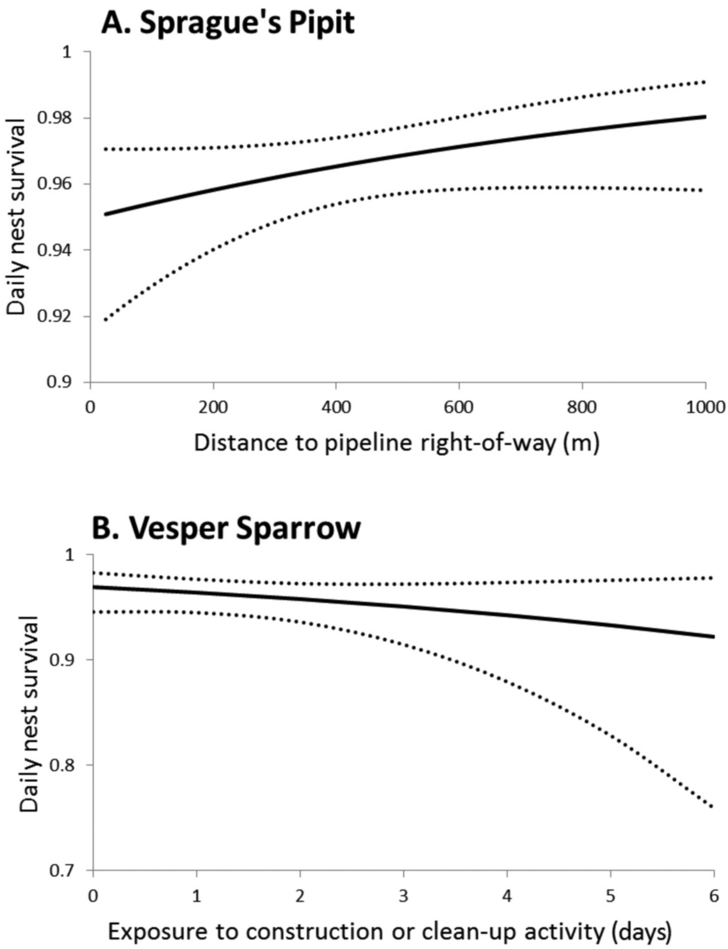

FIGURE 4. Model-generated estimates of daily survival of (A) Sprague's Pipit (*Anthus spragueii*) nests as a function of distance from the pipeline right-of-way and of (B) Vesper Sparrow (*Pooecetes gramineus*) nests as a function of exposure to pipeline construction or clean-up activity. Dotted lines denote 85% confidence limits.

3). The Distance × Activity parameter had confidence limits that did not include 0 ($\beta = 0.010$, 85% CI = 0.004–0.016) and the number of Vesper Sparrow fledglings also increased with distance from the ROW, but only in the absence of construction or clean-up activities. When activity was occurring, Vesper Sparrow nests closer to the ROW tended to fledge more young.

Discussion

Pipeline construction and clean-up had some effect on nest-site selection and reproductive success of both Sprague's Pipit and Vesper Sparrows. Although the overall distribution of pipit nests was fairly even with respect to the ROW, Vesper Sparrow nests were more abundant than expected close to the ROW. These results suggest that differences in the vegetation close to the ROW may have been an important factor in Vesper Sparrow nest-site selection. Also, as predicted, pipit nest survival increased with distance from the ROW, compared with a slight decline for Vesper Sparrows with increased exposure to pipeline activities. Pipit nests that were further from the ROW also tended to have more young survive to 8 days, whereas distant Vesper Sparrow nests tended to fledge fewer young in the presence of pipeline activity.

Noise and bird songs

Next to the ROW, maximum construction and clean-up noises were far above the 49 dB suggested as an upper limit for continuous noise within the breeding habitat of listed songbird species (Nicholoff 2003; Environment Canada 2011). Maximum noise levels were still above this threshold 250 m from the ROW and were only 3 dB below it at the 350-m setback distance. Pipeline construction and clean-up noises occurred at

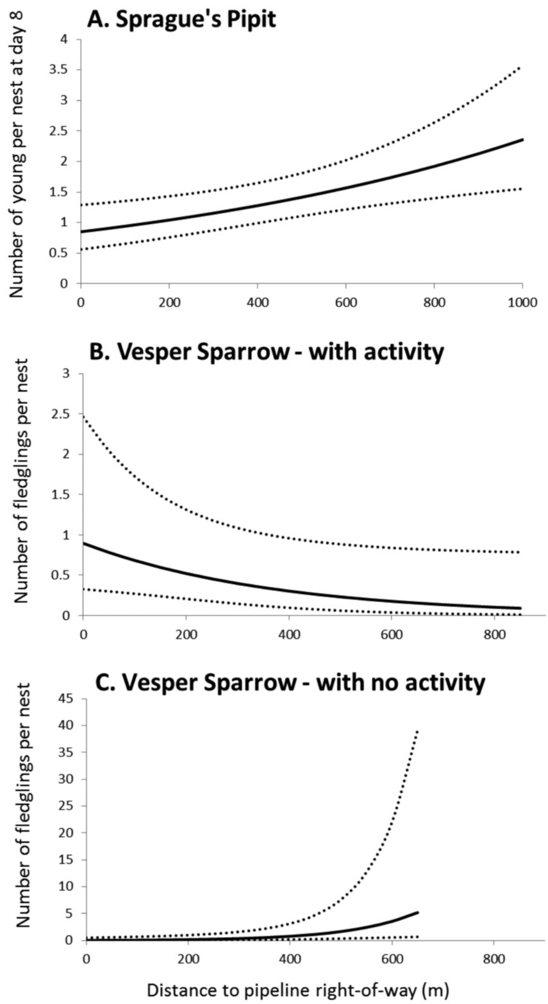

FIGURE 5. Model-generated estimates of the number of Sprague's Pipit (*Anthus spragueii*) young per nest that survived to at least day 8 (A), and the number of Vesper Sparrow (*Pooecetes gramineus*) young per nest that fledged with (B) and without (C) construction or clean-up activity, as a function of distance to the pipeline right-of-way. Dotted lines denote 85% confidence limits.

TABLE 3. Comparison of model results for the mean number of Sprague's Pipits (*Anthus spragueii*) per nest that survived to a least 8 days post-hatch and the mean number of Vesper Sparrow (*Pooecetes gramineus*) young per nest that fledged. Corrected Akaike information criterion (AIC_c) scores and their weights are shown for the top model, for models within 2 AIC_c units of the best model with the same or fewer number of parameters, and for the null model.

Species (no. observations)	Model	k	AIC_c	ΔAIC_c	AIC_c weights
Sprague's Pipit (50)	Distance	3	199.5	0.00	0.28
	Null	2	200.8	1.30	0.14
Vesper Sparrow (33)	Distance × Activity	5	74.4	0.00	0.42
	Activity × Initiation	5	75.1	0.71	0.29
	Null	2	77.4	3.01	0.09

Note: k = number of parameters, ΔAIC_c = change in score compared with top model.

pipit and Vesper Sparrow song frequencies, making these activities a potential source of acoustic interference. It is not known whether pipits or Vesper Sparrows vary the pitch or intensity of their songs in response to industrial activities, but other species adjust their songs in noisy urban and forested environments to ensure their signals travel far enough to maintain territories and attract mates (Warren *et al.* 2006; Nemeth and Brumm 2009), even if this leads to increased energy and fitness costs (Brumm 2004; Patricelli and Blickley 2006). More research is needed to examine whether, or how, grassland birds adjust their songs in the presence of industrial noise and if this carries any fitness costs.

Nest-site selection

The fact that over half (52%) of our plots had 15–80% shrub cover likely affected the distribution of pipit nests, given that this species tends to avoid shrubby habitat (Davis *et al.* 1999; Grant *et al.* 2004). All close plots were also located in areas where some habitat modification had occurred (i.e., the ROW was mowed on the construction spread and not vegetated on the clean-up spread) and along an existing pipeline corridor that had been established in the 1950s. In this light, the even distribution of pipit nests with respect to the ROW is at odds with the tendency for this species to occur in lower numbers near anthropogenic edge habitats (Koper and Schmiegelow 2006; Koper *et al.* 2009; Sliwinski and Koper 2012) and to avoid compressor stations and well sites (Bogard 2011; Hamilton *et al.* 2011; Gaudet 2013).

In comparison, the high proportion of Vesper Sparrow nests within 50 m of the ROW suggests that suitable habitat for this species occurred along and in close proximity to the existing pipeline corridor during nest-site selection. This is consistent with Vesper Sparrows' high tolerance for vehicle traffic (Best and Rodenhouse 1984). Vesper Sparrows also have a much broader habitat niche than pipits and occupy many different types of anthropogenic habitats, including hayfields, cropland, abandoned fields, and roadsides (Jones and Cornley 2002).

Nest success

Nest survival and survivorship for pipits and Vesper Sparrows were similar to observations in southeastern Alberta (Ludlow *et al.* 2014), southern Saskatchewan (Davis 2003; McMaster *et al.* 2005), north-central North Dakota (Grant *et al.* 2005), and north-central Montana (Jones *et al.* 2010), and our findings suggest that pipit reproductive success is negatively affected by proximity to the ROW. However, given that we have data for only 1 year and nest success can fluctuate among years (Davis 2003; Jones *et al.* 2010), our nest success results should be interpreted with caution. The fact that we found only a weak effect of distance supports Ludlow *et al.* (2015), who found no effect of oil and gas infrastructure on pipit reproductive success. Jones and White (2012) also reported no reproductive effects associated with distance to a range of habitat edges, including an active railroad ROW. Species nesting near roads, ROWs, and trails may experience lower reproductive success because some predators hunt and scavenge along these linear disturbances, especially when there are medium to low volumes of traffic (Pescador and Salvador 2007). Barton and Holmes (2007) reported high rates of nest abandonment because of predation near trails, and Ludlow *et al.* (2014) found lower reproductive success and evidence of avoidance near trails for pipits and Baird's Sparrows (*Ammodramus bairdii*), whereas Vesper Sparrows nested closer and fledged more young closer to trails.

Given that nest failure was primarily a result of predation, the fact that the number of Vesper Sparrows that fledged during pipeline activities was relatively high close to the ROW suggests that these activities were reducing the number of predators or their foraging ability. Further research is required to identify mechanisms that might account for this, including studies that characterize the nest predator community and clarify how industrial development affects parental care and predator density and behaviour.

Management Implications

Setback distances and periods of restricted activity are designed to address a range of issues noted in Canada's Species at Risk Act, including prohibitions related to harming or harassment. Environment Canada (2011) considers the construction and clean-up of large-diameter pipelines to be high-level disturbance activities, in the same category as the construction of permanent structures, such as roads, buildings, and compressor stations. Our results suggest that the restricted activity period from 1 May to 31 August and the 350-m setback distance are reasonable guidelines.

Our noise measurements indicate that construction and clean-up noises are above the 49 dB guideline up to 250 m from the ROW and only slightly below this level at 350 m. In terms of reproductive success, distance from the ROW tended to affect pipit nest survival rates and the number of young surviving to day 8: our estimates of pipit DSR at 0 m, 350 m, and 1000 m from the ROW (0.950, 0.965, and 0.980) translate into nest success estimates of 29%, 43%, and 62%, respectively, assuming constant survival. These are similar to rates found in other pipit studies in Saskatchewan (24%; Davis 2003), Montana (27%; Jones *et al.* 2010); and southwest Manitoba (47%; Davis and Sealy 2000), but the higher rates that occurred further from the ROW suggest that 350 m should be viewed as a minimum setback distance. To protect pipit populations, we recommend that the current guideline be applied until further research determines the demographic consequences of nesting near sites that are, or have been, exposed to industrial development and whether tolerance thresholds exist that might further inform land-use policy and regulations.

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