Quantifying and Mitigating Avian Collisions with Transmission Lines in Pincher Creek, Alberta, Canada

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Collisions with transmission lines are a source of avian mortality. In January 2014, AltaLink L.P. (AltaLink) learned of dead birds, presumably from collisions, under a 240 kV transmission power line near Pincher Creek, Alberta. AltaLink subsequently conducted mortality surveys and interviews with local contractors, followed by a one-year monitoring study. Initial mortalities (n = 345) appeared to have occurred when cold temperatures and strong winds (> 100 km/hr) constrained waterfowl to limited roosting areas frequented by avian predators. AltaLink's goal in this study was to identify factors influencing collisions year-round. Two key findings emerged. First, the number of waterfowl observed was the only variable measured which correlated with the probability of finding a carcass. Specifically, when < 1,000 waterfowl were observed during a survey, a carcass was unlikely to be found. When > 1,000 waterfowl were observed, a carcass was likely. Second, duck carcasses were more likely to be found than expected due to chance. Thus, the initial incident was hypothesized to be attributable to large numbers of overwintering waterfowl with flight paths constrained by limited unfrozen roosting habitat, strong west winds, and predation. AltaLink installed 4,700 line markers in response to the incident, which remained in place for the duration of this study.

Keywords: Alberta, avian, bird, collision, line marker, raptor, transmission line, waterbird, waterfowl.

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INTRODUCTION

Avian collisions with overhead power lines are an ongoing concern in many areas of North America (Avian Power Line Interaction Committee [APLIC] 2012, Sporer et al. 2013). Avian collision risk varies as a function of local avian populations, local environments, and line design (Bevanger and Brøseth 2001, Mojica et al. 2009, Rollan et al. 2010). In general, large, heavy-bodied birds such as herons, cranes, swans, and pelicans with low aspect ratio wings or high wind loading are more susceptible to collisions because of these species' large wingspans and poor maneuverability (Janss 2000, Crowder and Rhodes 2002, Rubolini et al. 2005). Relatively small and maneuverable ducks also are vulnerable because of their high flight speeds, routine low flight altitudes, and flocking behavior. Flocking behavior, in particular, increases collision risk because birds' views of obstacles may be obscured by other members of the flock. Thus, collisions often are associated with habitats where concentrations of waterfowl occur. Power lines bisecting daily movement corridors, such as those located between roosting and foraging sites, have historically been associated with the most prominent avian collision incidents (Faanes 1987, Bevanger and Brøseth 2004, Stehn and Wassenich 2008), with risks exacerbated during low light, fog, and inclement weather (Savereno et al. 1996, APLIC 2012, Hüppop and Hilgerloh 2012). Disturbances from humans or animal predators may increase collision risk when flocks are flushed suddenly (Murphy et al. 2009, APLIC 2012).

Avian collision with electric infrastructure has been reported primarily on high voltage transmission lines where birds appeared to avoid the large-diameter energized wires (conductors) by adjusting flight altitudes upward, subsequently colliding with the smaller, less visible overhead shield wires (OHSWs) or optical fiber composite overhead ground wires (OPGWs) located above the conductors (Murphy et al. 2009, Ventana Wildlife Society 2009, Martin and Shaw 2010).

Figure 1. Example of Mallard remains observed during AltaLink's January 2014 post-collision field survey near Pincher Creek, Alberta, Canada.

For example, Faanes (1987) reported 85% of 46 and 93% of 102 observed avian collisions with a transmission line involved the OHSWs, and Murphy et al. (2009) reported 65% of 71 observed avian collisions involved the OHSWs. Pandey et al. (2008) using Bird Strike Indicators (BSIs; EDM International, Inc. (EDM), Fort Collins, CO) to remotely monitor lines found 68% of 154 collisions involved the OHSWs. Consequently, a common strategy for mitigating collision risk is to install visibility enhancing devices, commonly called bird markers or line markers, on OHSWs and OPGWs. Multiple studies in North America have found that bird diverters reduce collisions by half, on average, and by up to 80% in some cases (reviewed in APLIC 2012).

On 7 January 2014, AltaLink L.P. (AltaLink) was notified of avian carcasses under a transmission line near Pincher Creek, Alberta, Canada. AltaLink dispatched a team of biologists familiar with avian-power line collision risk to investigate. AltaLink biologists arrived and found scavengers had consumed carcasses, leaving only wings or skeletal remains (Figure 1). Carcass estimates were subsequently determined based on a wing count, where 1 wing = 0.5 carcass. Using this methodology, biologists estimated 345 fatalities from 3 days of survey data. On 19 February 2014, AltaLink again received reports of further avian carcasses along Highway 785, the same area investigated following the January reports. Based on information from three companies working in the area, these bird fatalities occurred between 0615 and 0815 on 19 February 2014. AltaLink biologists arrived approximately 24 hours later on 20 February 2014 and noted 32 Mallard (*Anas platyrhynchos*) carcasses, 31 of those already scavenged (i.e., only wings and some skeletal remains) (AltaLink unpub. data 2014). On 20 February 2014, Mallard remains also were documented under the adjacent 138 kV single-circuit F-Line, which is oriented north-south east of Highway 785 (Figure 4C). Mallard carcasses of varying stages of decomposition were observed, but counts were limited to 10 Mallard carcasses documented between spans 36-39 believed to be associated with the 19 February collision event based on the condition of the remains (AltaLink unpub. data 2014). Local contractors interviewed during these investigative early 2014 surveys indicated predation by Bald Eagles (*Haliaeetus leucocephalus*) also may have caused flocks to fly erratically, contributing to the waterfowl collisions.

Following these collision mortality events, EDM was contracted to carry out an avian review and field assessment. EDM is an independent environmental firm with over 30 years of experience working to assess and resolve avian interactions with electric infrastructure. EDM's assessment was completed March 3 to 8, 2014, representing a snapshot of bird use relative to AltaLink's electrical infrastructure in the Pincher Creek, Alberta, Canada area during a six-day late winter period. AltaLink and EDM then collaborated to develop recommendations to reduce avian collision risks; and developing a study plan to monitor future bird use and movement patterns and line marker retention (EDM 2014). Based on the recommendations provided by EDM, AltaLink implemented line marking in the Pincher Creek area and a one-year monthly monitoring program.

The objective of the monthly monitoring program was to identify patterns in avian collisions that would contribute to AltaLink's understanding of collision within the AltaLink service area in particular, and thus to increase collision awareness and develop applicable mitigation, where warranted, in the AltaLink electric system. We hypothesized that each of three factors: local populations, local environment, and line design would influence collision rates in the Pincher Creek area. To evaluate these hypotheses we sampled local avian populations and weather monthly for one year and compared these factors, together with line design, to known and presumed avian collisions. We surveyed contractors working in the area to identify factors relevant to collision that might not have been detectable given our coarse-scale monthly monitoring scheme, and we installed line markers to mitigate future collision events.

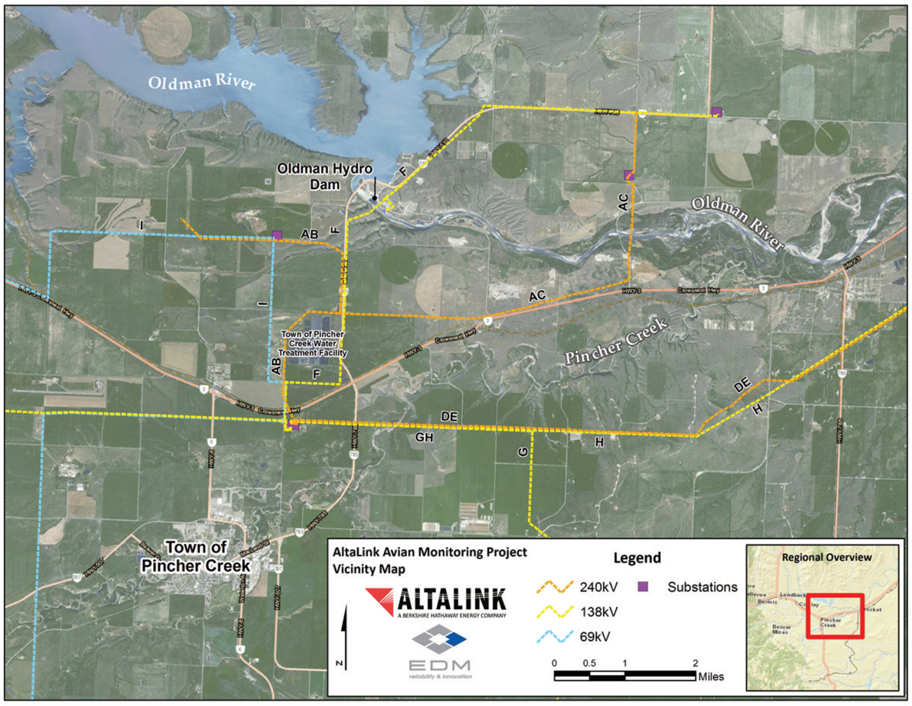

Figure 2. AltaLink avian monitoring project study area map.

Line ID	Line Description	Line Configuration	# of Horizontal Planes of Wires
AB	240 kV double circuit	Vertical	4
AC	240 kV double circuit	Vertical	4
DE	240 kV double circuit	Vertical	4
F	138 kV single circuit with 25 kV underbuild	Vertical	5
G	138 kV single circuit	Horizontal	2
H	138 kV single circuit	Horizontal	2
I	69 kV single circuit	Horizontal	2

Table 1. AltaLink transmission infrastructure occurring within the Pincher Creek, Alberta, Canada study area.

METHODS

AltaLink is Alberta's primary electric transmission service provider, operating and maintaining over 12,000 km of transmission lines and over 280 substations within a service territory located in southern and central Alberta, Canada. Pincher Creek is located in the southeastern corner of Alberta where thousands of waterfowl overwinter. The study area was located within the Municipal District of Pincher Creek, approximately 3.5 km north of the town site. The area included developed transmission infrastructure to support several wind facilities and the Oldman River Hydro Dam. Transmission lines include three double-circuit 240 kV lines, three 138 kV lines, one 69 kV line, five substations (Figure 2, Table 1), and distribution power lines not owned or operated by AltaLink. Thousands of Mallard ducks and Canada Geese (*Branta canadensis*) overwinter in the area, feeding in nearby grain fields and roosting in open water areas. Potential predators, Common Ravens (*Corvus corax*), Bald Eagles and Golden Eagles (*Aquila chrysaetos*) also overwinter in the area.

Based on the recommendations from the March 2014 Assessment conducted by EDM, AltaLink implemented a one year monthly field monitoring program beginning in July 2014 and ending in June 2015 to encompass multiple seasons and weather scenarios. Monitoring consisted of surveys conducted at seven sites (Table 2) identified by EDM as being potentially high-risk areas for avian collisions, or areas where waterbirds were likely to form flocks, facilitating quantification of monthly numbers of potentially at-risk species. The purpose of the field surveys was to quantify monthly indices of abundance of waterbirds and raptors in the Pincher Creek area and to document collisions, if collisions occurred. Surveys were conducted during the last week of each month, or as close to the end of the month as possible, to ensure consistent temporal separation between surveys year-round.

During each survey the following information was recorded:

- Weather Data: Collected when the first site was visited and every hour on the hour thereafter through the time the survey was completed. To ensure consistency, weather variables (i.e., temperature, wind speed, and wind direction) were recorded from the internet-based Weather Network electronic smart phone application.
- Avian Abundance: Recorded the species or species group (if exact species could not be determined) at each site.
- Avian Movement: Observed for 30 minutes at each site, recording spans crossed, flight direction, and any observed collision events.
- Carcass Searches: Conducted a minimum of one carcass search along the ROW and/or road allowance under AB-Line Spans 14 – 16 following the avian movement monitoring. Cultivated areas within the ROW were not searched from May through September. If a bird fatality was observed along these spans, additional carcass searches were conducted under adjacent spans.

Site	Descriptor	View from	Waterbird Habitat
1	Intersection of AC-Line and Oldman River	South bank of river	Roosting
2	Oldman River Picnic Area	Boulder Run road at river crossing	Roosting
3	Oldman Dam Tailrace	Boulder Run road at tailrace gate	Roosting
4	Windy Point Picnic Area	Shore of picnic area	Roosting
5A	Water Treatment Facility	AB-Line Structure 23	Foraging
5B	Water Treatment Facility	AB-Line Structure 16	Foraging
6	Pincher Creek Crossing	Private pasture	Foraging

Table 2. Survey sites for evaluating avian numbers of collisions at Pincher Creek, AB, Canada, from July 2014-June 2015.

To evaluate factors affecting collisions, we recorded the number of waterbirds (waterfowl and gulls), and raptors observed during each survey, the maximum wind speed and average direction, and the proportion of surface freezing of water treatment facility ponds in the area as an indicator of monthly weather patterns. We used t-tests and chi-square tests to compare surveys where collisions were found to surveys where collisions were not found. These tests allowed use of relatively coarse-scale (monthly) sampling to identify correlations between measured variables and avian collisions. A weakness of this approach is that multiple comparisons can increase the risk of Type 1 error (incorrectly rejecting a null hypothesis). We used a Bonferroni correction (0.5/6) to reduce the risk of Type 1 error, and considered tests significant at = 0.008. Because in the interest of efficiency, we surveyed for carcasses only under non-randomly selected spans where we believed carcasses to be most likely based on January and February 2014 collision locations, we could not statistically analyze the effects of line design or line marking, so we address these topics only qualitatively.

We compared the proportions of the three most abundant species or species groups observed crossing power lines in our study, to their proportions in our observations of mortality. Proportions are typically compared via chi-square analyses, but because our observations did not meet the assumptions of a chi-square framework (i.e., we did not know the total number of birds crossing the power lines, and we had mortality values < 5 in some cells), we calculated 95% confidence intervals on proportions to identify whether proportions overlapped. Theoretical and simulation tests indicate that when 95% confidence intervals overlap by < 85%, statistical significance at = 0.05 is implied (Payton et al. 2000). When confidence intervals do not overlap at all, this test is particularly conservative (Payton et al. 2003). Thus, if the 95% confidence intervals for the proportions did not overlap, we considered differences significant.

RESULTS

AltaLink contractors reported that at the time of the January 2014 collisions, when 345 carcasses were found (Table 3), the majority of open water in the area was frozen except for a small area of open water immediately below and adjacent to the Oldman Dam, and a small area of open water at the Pincher Creek water treatment facility. Overwintering waterfowl were unusually concentrated in these two areas, and strong west winds were blowing, when multiple (4-10) Bald Eagles attacked the roosting flocks at the water treatment facility. Panicked flocks of waterfowl attempting to evade the Bald Eagles subsequently collided with the lines around the water treatment facility and with the lines perpendicular to the most direct line of flight from the water treatment facility to the Oldman Dam.

During monthly surveys, we observed daily flights of waterfowl occurring primarily at dawn and dusk, between feeding and roosting areas. Waterfowl were observed feeding in grain fields east and north of Pincher Creek during the day, and flying northwards to the Oldman River at dusk, crossing multiple power lines in transit. Waterfowl species also were documented roosting at the Pincher Creek water treatment facility, which is bordered by the AB-Line to the west and north, and the F-Line to the south and east. We observed one gull (Family Laridae) collide with the line and continue to fly, and found 11 carcasses, four Mallards, one Northern Pintail (*Anas acuta*), four unidentified duck (Family Anatidae), one unidentified gull, and one unidentified passerine (Order Passeriformes) under monitored spans.

The number of waterfowl observed during surveys was the only variable we measured, which correlated with the probability of finding a carcass (Table 4). Specifically, we found at least one carcass during only one of nine surveys where we observed < 1,000 waterfowl, and we found at least one carcass during each of three surveys where we observed > 1,000 waterfowl. Among waterbirds, ducks were more likely to be found dead than expected due to chance, gulls were found as expected, and Canada Geese were found less than expected (Figure 3). All detected carcasses were found under vertically configured lines. Very high Mallard concentrations were observed only once during monthly surveys during the January 2015 survey, when approximately 3,000 Mallards were observed. During this observation, one Bald Eagle and seven Common Ravens also were observed harassing part of the Mallard flock.

In March 2014, AltaLink installed approximately 1,500 line markers from structures 8 to 23 on the AB-Line where

Line	2014 Survey Dates	Potential Collision Event (Date or Period)	Span Numbers w/Bird Remains	Estimated Bird Carcasses (Species Composition)
AB	8, 13, 16 January	December 2013	Spans 8-23	345 total (Mallard=341, Gray Partridge=3, Canada Goose=1)[a]
AB	20 February	19 February	Spans 11-18	32 total (Mallard=32)
F	20 February	19 February	Spans 36-39	10 total[b] (Mallard=10)

Sources: AltaLink unpub. data. (2014)
[a]Mallard, Gray Partridge (*Perdix perdix*), Canada Goose (*Branta canadensis*). Approximately 25% of bird remains could be identified to species. Based on size, shape, and correlation to identifiable Mallard carcasses, the unidentified remains were attributed to Mallards.
[b]Additional older Mallard carcasses also were observed, but counts were limited to those associated with the 19 February collision event.

Table 3. AltaLink's results from bird carcass searches conducted January and February 2014 along circuits AB-Line and F-Line.

Variable	t	D.F.	P	No Carcass Found	SE	No Carcass Found	SE
Waterfowl count	3.76	10	0.004	358	71.8	1023	125.5
Gull count	0.902	10	0.39	60	36	149	74.3
Ponds frozen	0.774	10	0.46	37.5	14.2	17.5	11.1
Max Wind	0.693	10	0.5	36.3	7.2	44.8	3.6
Raptor count	0.623	10	0.55	3.4	0.9	4.5	0.8
Wind Direction	0.188	1	0.66	west	NA	west	NA

Table 4. Univariate test results comparing variables measured monthly at Pincher Creek, Alberta, Canada, June 2014 through July 2015 to the identification of avian carcasses below monitored transmission lines.

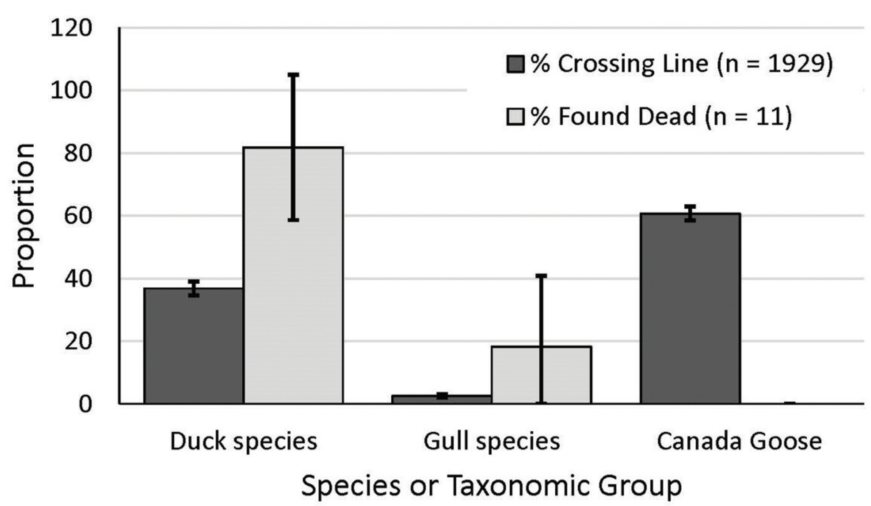

Figure 3. Proportions of species groups observed in flying past power lines and found dead beneath power lines during monthly surveys at Pincher Creek, Alberta, Canada, June 2014-July 2015.

carcasses were found following the January 2014 collision event (Figure 4). Then in November 2014, approximately 3,200 additional markers were installed on the AC-, DE-, F-, G-, and H-Lines where movements of at-risk species indicated additional collisions may be of concern. All 4,700 line markers installed in response to the collision events of January 2014 remained in place for the duration of this study. Two types of line markers were used; Preformed Line Products' Swan Flight Diverter and Power Line Sentry's Avian Flight Diverter (PLS-AFD). Line markers were placed at 5 m spacing when viewed from the side. Thus they occurred every 5 m on lines with one OHSW or OPGW, and every 10 m on each of the two OHSWs or OPGWs on lines with two overhead wires. In this case, line markers were staggered on the two lines to achieve a 5-m appearance.

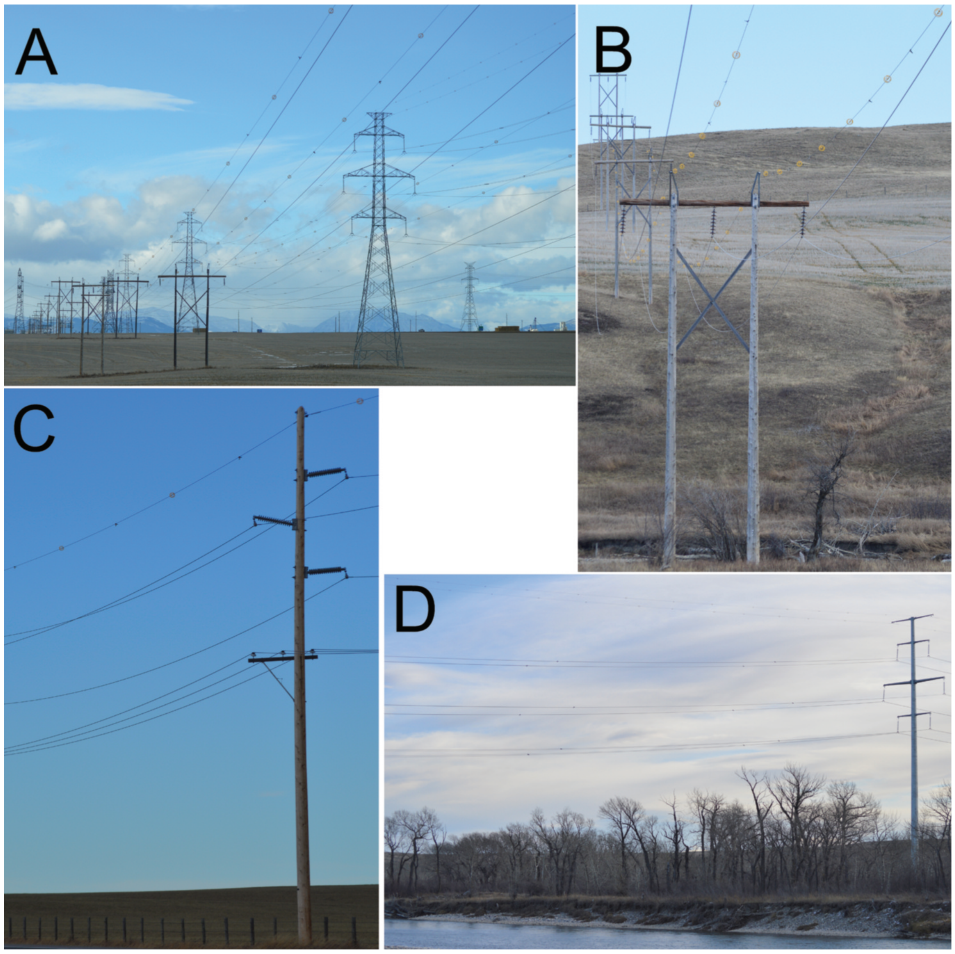

Figure 4. Transmission lines in the Pincher Creek, Alberta, Canada study area following line marking. A) AB-Line, G-Line, and H-Line (from right to left); B) H-Line; C) F-Line; D) AC-Line post-marking.

DISCUSSION

This study suggests that the single most important driver of avian collision risk in the Pincher Creek area is the number of individuals of collision prone species in the area, but that numbers alone do not tell the whole story. Risk is exacerbated by limited roosting sites when cold temperatures freeze water bodies, by strong winds reducing flight control, and by predators forcing flocks in atypical directions. Though intuitive, these results have not previously been demonstrated and provide important insight into designing effective mitigation strategies. Specifically, in areas where > 1,000 at-risk birds occur, at least low levels of collision may be likely if transmission lines bisect feeding and roosting habitat, and acute collision incidents may occur if flocks are flushed unexpectedly by potential predators. Potential effects to local populations depend on interactions between populations, line design, and local environment. All of the carcasses we were notified of or found were associated with vertical configurations, but did not appear to be randomly distributed throughout vertically configured spans when evaluated qualitatively. Rather, collisions were focused primarily where lines crossed perpendicularly to the top of a gully linking the Oldman River to agricultural fields surrounding a water treatment center. It appears birds trying to stay low under strong west winds flew up the gully from roosting sites on the Oldman River and encountered the transmission lines at the top. These observations suggest that marking relatively few high-risk spans likely addresses the vast majority of predictable collision risk.

In general, weather is considered an important contributing factor in avian collisions, but we found no effects of weather in this relatively coarse-scale study. Regular monthly surveys never led to the detection of carcasses on the order of those found in January and February 2014. Based on comparison of observations, contractors present in January and February 2014, and AltaLink's subsequently monthly observations, we believe this difference to have been driven primarily by an extended period of low temperatures during the winter of 2013/2014, leading to freezing of nearly all roosting habitats. For example, the average monthly temperature in February 2015 was -8.1 degrees Celsius compared to -18.5 degrees Celsius in February 2014 (Government of Canada 2015). This concentrated ducks in two areas in the winter of 2013/2014 where predation pressure from wintering eagles was believed to be high. Similar low temperatures and concentration never occurred in the winter of 2014/2015, allowing waterbirds to disperse throughout the Oldman River corridor, eliminating concentrations immediately adjacent to transmission lines, and thus substantially reducing collisions through the winter.

To reduce avian collision risk in the Pincher Creek area, AltaLink responded to the initial 2013/2014 incidents by marking the AB-Line as quickly as possible, and responded to monthly observations of avian movements by marking additional lines. In total, marking consisted of approximately 4,700 devices on 6 transmission lines in the area. Though we cannot quantify the subsequent reduction in collision risk, line marking tends to reduce collision by at least 50% across studies. The general expectation of reduced collision following line marking, combined with the observation that a unique weather scenario contributed to the 2013/2014 events suggests that similar incidents are less likely to occur in the future.

Suggestions for Future Research

Future research should investigate triggering factors that lead to avian collisions. For example, sudden disturbances of roosting, loafing, or foraging birds can be a contributing factor to avian collisions (Brown et al. 1984, APLIC 2012). Sudden disturbances can flush concentrated waterfowl, causing panic flights, into the overhead power lines in restrictive flocks with limited visibility. Disturbances can include vehicles, pedestrians, farm equipment, hunters, and predators (e.g., eagles, ravens). In 2014, contractors working near the water treatment facility observed ducks colliding with the overhead lines, as a result of Bald Eagle harassment (AltaLink unpub. data 2014). During the January 2015 routine survey, while driving north from Site 1, approximately 3,000 mallards were observed in a grain field. One Bald Eagle and seven Common Ravens were observed in the field with them and at one point the eagle and ravens flew into the flock causing panic flights. Although anecdotal, these observations suggest that predators, such as eagles and ravens, do cause panic flights in flocks of mallards, which could increase the risk of collisions with the power lines in the area. Mitigating these factors, in addition to marking lines to reduce collision and covering energized equipment to reduce electrocutions, would likely further reduce negative impacts of power lines to avian populations.

Relatively large numbers of duck carcasses were found during January 2014 (n = 383), and during monthly surveys (n = 9). Relatively few carcasses of Canada Geese were found during these same periods (n = 1, and n = 0, respectively), even though Canada Geese were also abundant during both surveys. Future research should evaluate whether the discrepancy in the mortality rates could be attributed to their different potential predation risk, or flight behaviors, or whether Canada Geese are more likely to continue flying after a collision, leading to carcasses beyond typical survey transects.

CONCLUSION

A large-scale incident of avian collision mortality at Pincher Creek occurred when a unique combination of large numbers of overwintering waterfowl were present and very low winter temperatures eliminated most open water roosting sites. Simultaneously, strong west winds caused waterfowl to select a single geographically shielded path between the only two available open water roosting sites in the area. Bald Eagles pursuing these waterfowl are thought to have caused flocks of panicked birds to attempt to pass between transmission line wires, resulting in collisions. The combination of AltaLink marking overhead wires in the area, and of the low likelihood of a similar perfect storm of factors occurring regularly in the future, make similar incidents less likely in the Pincher Creek area.

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AUTHOR PROFILES

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Nikki has a master's degree from the faculty of Environmental Design at the University of Calgary where her thesis work was conducted on avian collisions with transmission lines. She is a Professional Biologist with over 10 years of experience, working in the electric utility industry in Alberta, Canada. She is employed by Alberta's primary transmission service provider, AltaLink where she wrote, implemented, and manages Canada's first Avian Protection Plan.

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Mr. Harness has a master's degree in Fishery and Wildlife Biology from Colorado State University (Raptor electrocutions caused by rural electric distribution lines). He is a Certified Wildlife Biologist at EDM with over 25 years of experience managing projects associated with wildlife and energy facilities. His areas of strength include mitigating avian-power line electrocutions and collisions, and managing perching and nesting on poles and towers, and animal intrusions and outages in substations. Mr. Harness has completed over 100 Avian Protection Plans from Alaska to Florida, including plans for Investor Owned Utilities, Electric Cooperatives, Municipalities, the U.S. Fish and Wildlife Service, and Military bases. He also has worked on these issues in Mongolia, Hungary, Israel, Mexico, and South Africa. Mr. Harness works regularly with utility manufacturers to develop new products to reduce avian electrocutions and collisions, and routinely publishes written and videographic records of his work.

Melissa Landon

Ms. Landon has a master's degree in soil science from Montana State University. She is an EDM biologist and project manager with 20 years of experience specializing in environmental analyses and spatial data collection and management. EDM's work nationally and internationally, assessing and resolving bird electrocution and collision issues with manmade infrastructure, has resulted in the Environmental Division developing over 100 site-specific Avian Protection Plans throughout the U.S. and Canada. Ms. Landon's focus is to combine knowledge in utility infrastructure, biological resources, and regulatory requirements to develop approaches and strategies to address avian issues.

Lori Nielsen

Ms. Lori Nielsen has a Bachelor of Science in Wildlife, Ecology and Management from Oklahoma State University. She is a research biologist and project manager with WEST, based in Cheyenne, Wyoming. She has 29 years of experience specializing in environmental and wildlife analyses with over 14 years of experience assessing avian interactions with power lines (transmission and distribution) and communication towers. Ms. Nielsen has managed or contributed to over 50 Avian Protection Plans and other avian studies in the U.S. encompassing both conventional and renewable power generation and Department of Defense installations. Projects have ranged in size from a statewide initiative for small electric cooperatives to large, interstate analyses for investor-owned utilities.