POWER LINE USE BY NESTING RAPTORS

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THUNDER BAY, ONTARIO
2018

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An undergraduate thesis submitted in partial fulfillment
of the requirements for the degree of
Honours Bachelor of Environmental Management
Lakehead University

NRMT 4010 Thesis II
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May 2018.

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ABSTRACT

Citation: Cockhill, S. 2018. Power line use by nesting raptors.

Keywords: aerial imagery, monitoring, power pole, raptor, stick-nest

Raptors represent an important species group often targeted in wildlife monitoring efforts. Incidental raptor stick-nest observations were recorded in SaskPower power line aerial imagery. Analyses were conducted to determine if the nest location were chosen at random along the power line infrastructure. It was determined that raptors may non-randomly select nest sites to avoid anthropogenic features. This data source does not seem to be valuable for future wildlife monitoring studies

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ACKNOWLEDGMENTS

I would like to thank Zachary Long, for without him I would not have been able to do any of this. Thank you Dr. Crowe for being supportive with my decisions for the thesis and through the bumps in the road. I am grateful to KBM Resources Group for providing me with access to the data, and for the overall idea of using the incidental observations for the thesis. Thank you to SaskPower for granting me permission to use their data through KBM. Finally, thanks to my friends for supporting me through this process, and accepting my absences while I locked myself away to work on this research.

1.0 INTRODUCTION

Wildlife monitoring is an important part of sustainable land-use practices. Monitoring programs provide valuable information on the effects of land-use and on the effects of larger-scale issues such as climate change. Such programs are necessary to avoid conflicts with species at risk, which are afforded legal protection. Further, information on indicator species, which indicate the state of an ecosystem, can be used to monitor ecosystem health. However, wildlife monitoring data are often scarce. The most readily accessible sources are public citizen-science databases, although observations in these data sets tend to be biased towards areas with dense human populations.

SaskPower, Saskatchewan's power electricity company, uses aerial surveying to monitor and assess their power line infrastructure. It was noted that there were many incidental observations of wildlife, particularly birds of prey, *i.e.* raptors, using power poles as nesting habitat for their stick-nests. Since SaskPower annually assesses the lines using aerial imagery, these data have the potential to be used as part of a wildlife monitoring plan in Saskatchewan. The objective of this thesis is to explore whether these observations might be useful to monitor wildlife populations, particularly in remote areas. This objective will be pursued by: a) cataloguing stick nest observations in the SaskPower aerial imagery data set, and b) inferring how the various raptor species are currently using the power poles. Once the potential of the data set is evaluated it may be possible to apply it to other research questions.

Monitoring raptor interactions with power lines is beneficial for SaskPower. This information can be used to determine whether power poles function as new habitat for raptors, or whether the overall interactions are detrimental (*e.g.*, raptor mortality due to collision or electrocution, and damage to infrastructure).

The data used in this thesis may have value for a range of research topics. For example, the information could be used to track changes in the abundance and distribution of raptors over time resulting from climate change, or to compare the relative abundance of raptor species across a variety of ecosystems. Even questions relating to management practices, like the effectiveness of buffers in forestry might be addressed.

The monitoring of raptor populations is a significant problem. Several species of raptors in Canada have been listed as species at risk, *e.g.*, *Buteo regalis* and several owl species (Government of Canada 2018), primarily caused by habitat loss. Raptors represent top food-chain predators, and as such often reflect overall ecosystem health. Hence, they are strong indicators. Further, many raptor species are wide-ranging, breeding in North America and wintering in South America. Hence, they are afforded protection under the Migratory Birds Convention Act (1994).

1.1 OBJECTIVE AND HYPOTHESIS

The incidental wildlife observations may represent additional value in the SaskPower aerial imagery database, beyond simply monitoring infrastructure. This study is intended to explore and evaluate whether these observations can be used as part of a plan for the monitoring of wildlife. It is presently unknown how the birds are using the power poles and in what regions. To be able to assess this statistically with the provided data, two hypotheses will be used.

H1) Raptors that nest on power line infrastructure non-randomly select their nest sites.

1.2 LITERATURE REVIEW

The purpose of this literature review is to present the state of knowledge on raptor species present in Saskatchewan, as well as how they interact with power lines.

1.2.1 Monitoring Methods

Current wildlife monitoring methods are often limited in their range, though there's multiple methods. One of the more common monitoring methods is through citizen-science observations and reports. The Saskatchewan Breeding Bird Atlas (Bird Studies Canada 2017) has many online tools and resources. The website allows people to submit bird sightings that are then added to the database. The atlas provides data summaries for the province as a whole and for its sub-regions. There is also a species list summary that provides each species recorded in a given region (Bird Studies Canada 2017). The Government of Saskatchewan has a publicly available Geographic Information System (GIS) database of hunting, angling, and biodiversity information. The database includes information for hunters and anglers, such as wildlife management zones, game preserves, fisheries management zones and bird sanctuaries. The database also contains wildlife observations, including data from the Saskatchewan Bird Atlas (HABISask 2016).

Another monitoring method is aerial surveying. This can be done through free or privately-owned satellite imagery (Regos *et. al*. 2017), or privately flown imaging (Kochert and Steenhof 2002). Satellite imagery can only be used for monitoring larger species or larger stationary features such as stick nests (Regos *et. al*. 2017). Flown imagery is much costlier, though beneficial for higher resolution imagery. Helicopter assessments reap slightly higher identification of raptor species compared to fixed-wing aircraft, but are four-times more expensive; fixed-wing aircraft are the more precise option for raptor surveying (Olson *et. al*. 2015). Aerial surveys conducted over a 10-year period (average life span for prey species) would help to monitor how changes in prey affect the raptors. Sampling methods, like random transects, are easily replicable and cost-effective. Aerial surveying is becoming more affordable with decreased cost from technological innovations (Kochert and Steenhof 2002).

SaskPower's aerial surveys are conducted using fixed-wing planes. Though the flights are not conducted specifically for wildlife monitoring, the incidental observations may be beneficial. Though this thesis does not evaluate citizen science data sources, it is important to note the current public data availability when assessing this potential new data source. No previous studies were found examining imagery from utility surveys for wildlife monitoring.

1.2.2 Raptors

There are several raptor species in Saskatchewan that potentially build stick-nests on power poles. These species include, but are not limited to: Northern Saw-whet

Owls (*Aegolius acadicus*), Golden Eagles (*Aquila chrysaetos*), Great Horned Owls (*Bubo virginianus*), Ferruginous Hawks (*Buteo regalis*), Turkey Vultures (*Cathartes aura*), Bald Eagles (*Haliaeetus leucocephalus*), Ospreys (*Pandion haliaetus*), and Barred Owls (*Strix varia*). Raptor-power pole interactions of some of these species are further discussed below.

Raptors are great indicator species for many habitats. Resident species (year-round) are better indicators than migrant or nesting species (Grossman *et. al*. 2008). Raptors often have a high-tolerance to anthropogenic change and able to quickly adapt to these changes (Rodriguez-Estrella *et. al*. 1998, Grossman *et. al*. 2008). This makes them a poor choice for indicator species in habitats with little human activity such as the low precipitation, scrub species habitat of the dessert in Baja, California (Rodriguez-Estrella *et. al*. 1998). Grossman *et. al*. (2008) found that Great Horned Owls did well in a range of habitats (both forest and non-forest), while Barred Owls and Northern Saw-whet Owls preferred continuous forests and/or corridors.

Raptors are indicators for bioaccumulation of chemicals and toxins as well (Rodriguez-Estrella *et. al*. 1998, Reiter-Marolf *et. al*. 2017, Provencher *et. al*. 2014). Both Bald Eagles and Ospreys indicated bioaccumulation of the pesticide dichlorodiphenyltrichloroethane (DDT) in the mid-20thth century. Both species have undergone incredible population recovery since the ban of DDT (Reiter-Marolf *et. al*. 2017, Bierregaard *et. al*. 2014). Eagle fecal samples have since been assessed for bioaccumulation effects of micronutrients and other environmental contaminants. The study found that several micronutrients registered above quantitation limit (minimum amount that can be accurately measured). There were also higher levels of micronutrients and chemicals such as manganese found in spring nesting feces over wintering samples (Reiter-Marolf *et. al*. 2017). Mercury is a natural trace element, however is toxic in methylated form. Marine birds are used to monitor ecosystem health through mercury concentrations in the Canadian arctic. Most species contain tolerable levels of methylmercury, but some species have begun to experience reproductive problems (*e.g.* egg shell weakening or embryo development issues) caused by the biomagnification of mercury (Provencher *et. al*. 2014).

There are several potential stick-nest building raptor species that have ranges in Saskatchewan. Raptor are larger birds of prey that typically hunt small mammals, fish, or scavenge carcasses. The ranges of raptors in Saskatchewan may be strictly migratory, breeding, or year-round use (Degregorio *et. al*. 2016, Mitch Waite Group 2013). Some of these species are described below.

Figure 1. Turkey Vulture range map (Mitch Waite Group 2013).

Turkey Vultures use a variety of man-made structures for nesting (*e.g.*, abandoned houses). This behaviour was first described in 1982 in the boreal transitional and aspen parkland ecoregions (Houston *et. al*. 2011). Nests established in deserted buildings studied from 2003 through 2006 showed similar survival rates of young survival rates as nests established in more natural settings elsewhere in the Turkey Vulture's range (Houston *et. al*. 2007). Their breeding ranges in Saskatchewan were tracked, between 2005 and 2009, using Global Positioning System (GPS) satellite transmitters. Breeding ranges sizes varied between 371 km^2 and 648 km^2, depending on the method of analysis. Variation in range size can be influenced by food availability and territory overlap, as well as the Turkey Vulture's ability to easily soar long distances (Houston *et. al*. 2011). Their range is shown in Figure 1. Turkey Vultures spend their summers in Saskatchewan, during the breeding season (Mitch Waite Group 2013). Adult vultures would rest overnight up to 38 km away from their home nest in order to search for food for their young (Houston *et. al*. 2011).

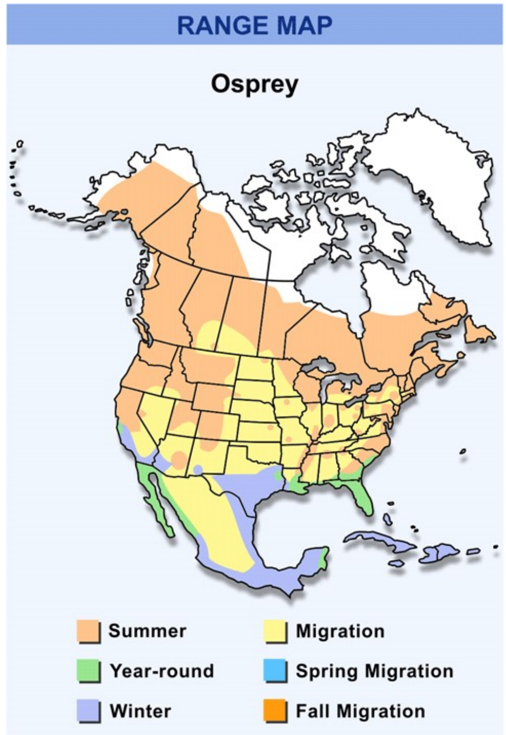

Figure 2. Osprey range map (Mitch Waite Group 2013).

Ospreys can survive in a wide range of habitats at varying proximity to humans (Bierregaard *et. al*. 2014). They breed and migrate throughout the summers in Saskatchewan, as seen in Figure 2 (Mitch Waite Group 2013). Osprey primarily feed on fish and have evolved to catch fish in water. Unlike most other raptor species, Ospreys can be used as indicators for aquatic environments. In the 1960s and 70s, the discovery of DDT bioaccumulation in Osprey food-chain helped justify the banning this substance (Bierregaard *et. al*. 2014). Many subsequent studies monitored the species to aid in their recovery. Migration studies are easily conducted through nearly effortless banding of Ospreys. Satellite transmitters simplified migratory studies once the technology was more readily available. Studies on Osprey-human interaction show North America providing habitat (nesting platforms and perches), meanwhile Europe historically participates in Osprey hunting and egg collecting, though rarely today. Ospreys have exhibited increased population sizes and expanded ranges in the 21st century. This has caused some conflicts with power lines and fish farms. Continued monitoring has been suggested as a method to ensure adequate data for future analyses (Bierregaard *et. al*. 2014).

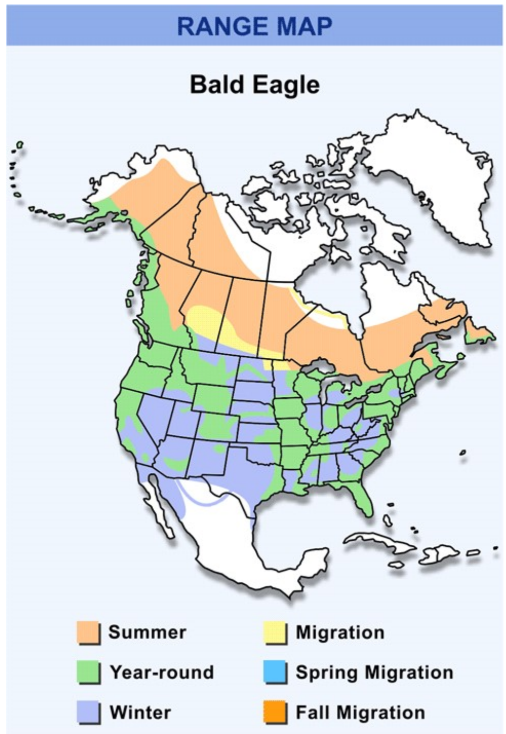

Figure 3. Bald Eagle range map (Mitch Waite Group 2013).

Bald Eagles near Besnard Lake, Saskatchewan, were studied for trends in population size and reproduction from 1968-2012 (Mougeot *et. al*. 2013). Bald Eagles range all throughout Saskatchewan, as seen in Figure 3. The population near Besnard Lake are there during the summer to breed (Mitch Waite Group 2013). Population size and climactic factors were analysed to describe population growth rate and recruitment. Fledging success increased until 1977, and then remained fairly consistent. Nesting success decreased throughout the entire study. Meanwhile, annual recruitment increased until 1970 before declining. This area most likely reached its carrying capacity for Bald

Eagles around 1977. Reproductive success ranged widely across the study as a function of population density, and nesting success was loosely related to milder spring conditions (Mougeot *et. al*. 2013).

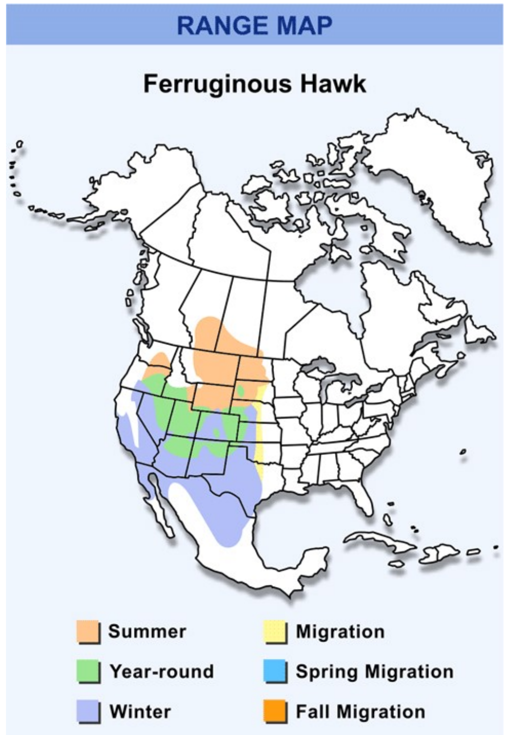

Figure 4. Ferruginous Hawk range map (Mitch Waite Group 2013).

Urban expansion is leading to increased interaction with animals. Animals behave differently when around human activity, which is possibly detrimental to the animal. Behavioural changes depend on the nature of the anthropogenic disturbances as well as each individual animal's experience. The 'flight' instinct (*i.e.*, fleeing when encountering a human) of nesting Ferruginous Hawks studied in southern Alberta and Saskatchewan, in relation to an individual's history and nesting proximity to human activity. This nesting population range is displayed visually in Figure 4 (Mitch Waite Group 2013). Approaches on foot induced more flight responses compared to vehicle approaches; low traffic roads had higher flight rates than higher traffic roads. Greater numbers of previous approaches increased the flight frequency. Over time, the hawks became accustomed to vehicle activity (Wallace *et. al*. 2016, Nordell *et. al*. 2017).

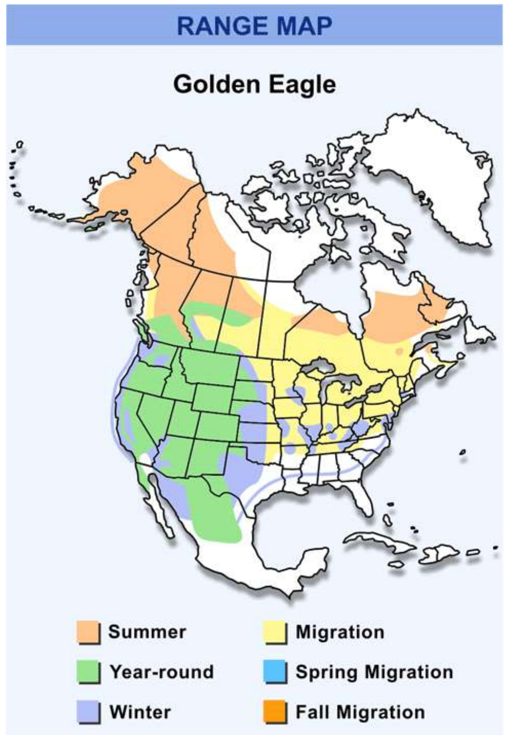

Figure 5. Golden Eagle range map (Mitch Waite Group 2013).

Golden Eagles are found across North America. Northern nesting populations (ranges shown in Figure 5) are stable in Canada and Alaska, but other nesting populations are in decline due to anthropogenic disturbances (urbanization, vegetation and prey species decrease). Eastern migration populations were in decline from the 1930s to 1970s but have been stable or increasing since then; western migrations show no trends since the 1980s. Monitoring migration pathways (Rocky Mountains at the border) can increase trend analysis potential in western Canada (Kochert and Steenhof 2002).

Raptors are vulnerable to human activity (Kochert and Steenhof 2002, Degregorio *et. al*. 2016). Humans cause 76% of raptor deaths from sources such as road/fence/wind turbines collisions, electrocution and lead poisoning (from eating hunting game shot with lead bullets). Nest predation is often carried out by red-squirrels in the boreal forest (Degregorio *et. al*. 2016). Nesting on power poles may reduce predation caused by the inability of squirrels to climb the metal structures.

1.2.3 Power Lines

There are several studies documenting cases of raptors occupying power poles as nesting sites. Power poles increase the variety and density of birds where other nest sites may be limiting (Dixon *et. al*. 2013). Structure designs that provide shelter and support may be favoured over other structures (Dixon *et. al*. 2013). Depending on the region, utility companies may remove problem nests during non-breeding or migratory periods of the year. This is often in combination with deterrent installation or the construction of nearby artificial platforms to induce breeding and increase populations while maintaining power line infrastructure by reducing occupants and collisions. Some species are more accepting of nest removal, like Ospreys, whose nests can be removed once the bird has left the area for migrations. There may be socio-political consequences associated with removing nests in populated areas, but these most be balanced with the risk of power outages. Public education of better monitoring and management methods are key to reducing conflicts (Washburn 2014).

Nesting eagles in South Africa cause frequent power outages, reducing the power quality and increasing costs for the main power supplying company. A study was conducted from 2002 to 2006 via aerial surveys of eagle nests through over nearly 100 eagle territories. Detailed breeding activity was recorded for three eagle species, and about one hundred breeding pairs across 1,400 km of power lines. Specific structure designs were more prone to outages when an active nest was present. This study offered a management plan to promote eagle nesting while reducing eagle induced outages. The plan included three steps. The first step is to provide platforms for nesting near high-risk conductors. High-risk conductors are those that have higher voltages and less insulated sections. Step two is to install deterrents on and surrounding high-risk conductors, so eagles are encouraged to nest on the nearby platforms. Third step is to monitor eagle well-being before and after these installations to ensure population success. This approach reduced outages with no evident detriments to the eagle welfare. Power lines can provide habitat for raptors, but the large birds can create significant power concerns. Alternative installations and management practices can reduce these concerns while maintaining the raptor populations (Jenkins *et. al*. 2013).

Power lines can be very dangerous for raptors. Avian power line electrocutions happen worldwide and are a conservation concern for a variety of species. Power companies often only collect data to monitor utility outages. These outages are the only possible records for bird mortalities on power lines (Kemper *et. al*. 2013, Dwyer *et. al*. 2017). A study focused on mortalities within a three-month period in east-central Alberta. Transformer poles experienced the highest rate of mortality. Three-phase corner dead-end poles showed higher than expected rates of raptor mortality compared to transportation poles. Only about 6% of electrocutions caused a power outage, indicating that utility outage records do not sufficiently represent raptor mortalities caused by electrocutions. The results from this study can be used to improve existing and future structure designs to minimize potential raptor electrocutions (Kemper *et. al*. 2013).

Collisions between power lines and raptor are a common occurrence that do not always result in electrocutions. Mortality rates caused by power line collisions are difficult to determine. Estimates in Canada are difficult because a lack of literature, and the range of habitats and species. Injuries from collision may also lead to mortality, but there are few studies on this subject. Collision range estimates were made from existing data primarily in Canada's boreal forest. Mortality rates ranged from 2.5 million to 25.6 million deaths per year over 231,966 km of transmission line. Population increases of sensitive species suggest that collision mortalities are not sufficient to influence population growth. However, there are species at risk for which collisions may be contributing to their population declines (Rioux *et. al*. 2013).

Another study by Luzenski *et. al*. (2016) was conducted on a set of power lines that were originally 20-25 m tall, extended to 55-60 m tall and with markers for better visibility for birds. This study was conducted within a southward raptor migration route. When encountering the line raptors were presented with the option to fly at the same height and avoid collisions with the wire, fly at the same height and collide with the wire, or change their height and fly over or under the wire. The heights of raptor flights were recorded in this region prior to installation of the larger towers, and then compared to the flight heights following construction. Prior to construction, most raptors (72%) flew higher than 60 m, a small number (4%) flew below 55 m, and the rest (24%) flew through the future power line zone. After construction of the power line, nearly all raptors flew above the lines, and no collisions were observed. Future studies may focus on areas with less wind protection, or lines without visibility markers (Luzenski *et. al*. 2016).

Electrocution is common for raptors that frequent power lines and poles. Insufficient insulation on the energized components and the relative proximity of these parts contribute to the risk of electrocution. These issues are not easily fixed for some power pole designs (Dwyer *et. al*. 2016). Several studies assessed retrofitted power poles and their interaction with various raptors like Golden Eagles (Dwyer *et. al*. 2017, 2016). Retrofits can include increasing component separation, increased insulation, or installing perches. One study by Dwyer *et. al*. (2017) focused on retrofitted poles with a known history of causing electrocutions. These poles were identified through the presence of burns on the poles and carcasses. Flaws in the pole retrofits inappropriate mitigation plans most likely contributed to the electrocutions. Flaws included insufficient insulation and lack of full coverage of all energized components. These flaws are often missed by electricity companies until outages occur or carcasses are discovered. Reinstallations cause additional expense to the companies (Dwyer *et. al*. 2017).

Proper retrofit installation decreases the risk of electrocution for raptors, and also reduced expenditure in the long-term (Dwyer *et. al*. 2017). Another study by the same group of people (Dwyer *et. al*. 2016) assessed how the installation of perches may be a suitable alternative to refitting power lines. A perch is a cheaper alternative to some retrofitting efforts and would encourage raptors to keep their distance from the dangerous portions of the poles. There is a variety of perch designs, however their relative effectiveness is unknown. Raptor response to perch designs was initially tested in a rehabilitation facility. Birds were presented with perches installed above a cross-arm, as well as a control non-perch cross-arm. The raptors primarily used the perch (63%), but many still used the control cross-arms (33%), illustrating the adaptability of raptors to use perches as opposed to energized areas of power poles (Dwyer *et. al*. 2016). Supplying nesting barrels as habitat alternative was also assessed in a study. However, only cavity nesting birds, such as Kestrels, favoured these options (Dixon *et. al*. 2013).

In conclusion, the current wildlife monitoring methods throughout Saskatchewan are limited. There are gaps in this information in which this thesis may potentially fill (power pole occupation and more northern data sources). There are several raptor species that are present in Saskatchewan that may potentially occupy the power poles. These populations may be monitored long-term through the data provided in this study, but this study will only discuss raptors as a population group because individual species cannot be identified through the provided imagery. Raptor-power pole interactions are well documented throughout the world, however it is unknown how and why raptors chose their poles in Saskatchewan. This study will provide insight to Saskatchewan-specific raptor nesting habitat selection. The indirect health risks (from low-level electromagnetic fields) of high-voltage power lines on inhabitant raptors are unknown.

2.0 MATERIALS AND METHODS

Aerial imagery of all the power lines in Saskatchewan were collected annually from 2014-present, by KBM Resources Group (KBM) for SaskPower. Access to this aerial imagery was granted through KBM for the purpose of this study. The imagery was queried through a user-friendly online tool (HabiSask, not open to the public) to locate all identified raptor stick-nests. This distance is commonly used when monitoring nesting bird disturbance reactions (OMNR 1987) and is also the average ground width from power lines in the aerial imagery. The distance to the nearest forest patch (greater than 0.5 ha in size) was recorded, as well as the presence water (area greater than 0.5 ha in size) within the 400m area, and anthropogenic features (*e.g.*, buildings, roads and agriculture). The presence of water may be an indication of osprey and bald eagle nesting habitat (who hunt fish) as opposed to other raptor species. Presence of anthropogenic features can be used to assess how raptors select nesting sites. To assess H1, control sites were selected at random and catalogued for the same features as described above. The controls were selected at a 3:1 ratio to the nest sites as there is a far greater number of non-nested power poles in Saskatchewan. Once all this information was recorded, analysis of variance (ANOVA) was conducted to examine the relationship of these features to nested sites.

2.1 AERIAL SURVEY AND STUDY AREAS

Aerial photographs were reviewed for presence of raptor stick nests. The SaskPower aerial surveys covered a total length of 13,463 km, which includes 68,745 structures of assorted designs, and imagery width averaging 500 m. Power lines are more concentrated in the south of the province, while several power lines extend to the north but at greatly reduced densities. The north of Saskatchewan is boreal forest. These two regions define the study areas. The forested (boreal) is defined by proximity to forest patches from the power poles. Lack of forest patches within the 400 m radius was inferred to be prairie/agriculture for this study. Figure 6 shows the nest locations without displaying the line locations (at the request of KBM Resources Group for the privacy of SaskPower). The surveys conducted using orthoimagery and high-resolution obliques. Orthoimagery provide the base imagery, shot directly downward and corrected for scale variations caused by factors like camera tilt and terrain (USGS 2015). Oblique images are clearer and display a smaller scale at an angle either forwards or backwards from airplane (not directly downwards). The oblique imagery, however, was not made available for this study. The omission of oblique imagery restricted the potential of the study; nest occupancy, identification, even species identification can be made using oblique imagery if it is available in future studies. However, the availability of the ortho imagery can be assessed in other ways, like methods conducted in this study.

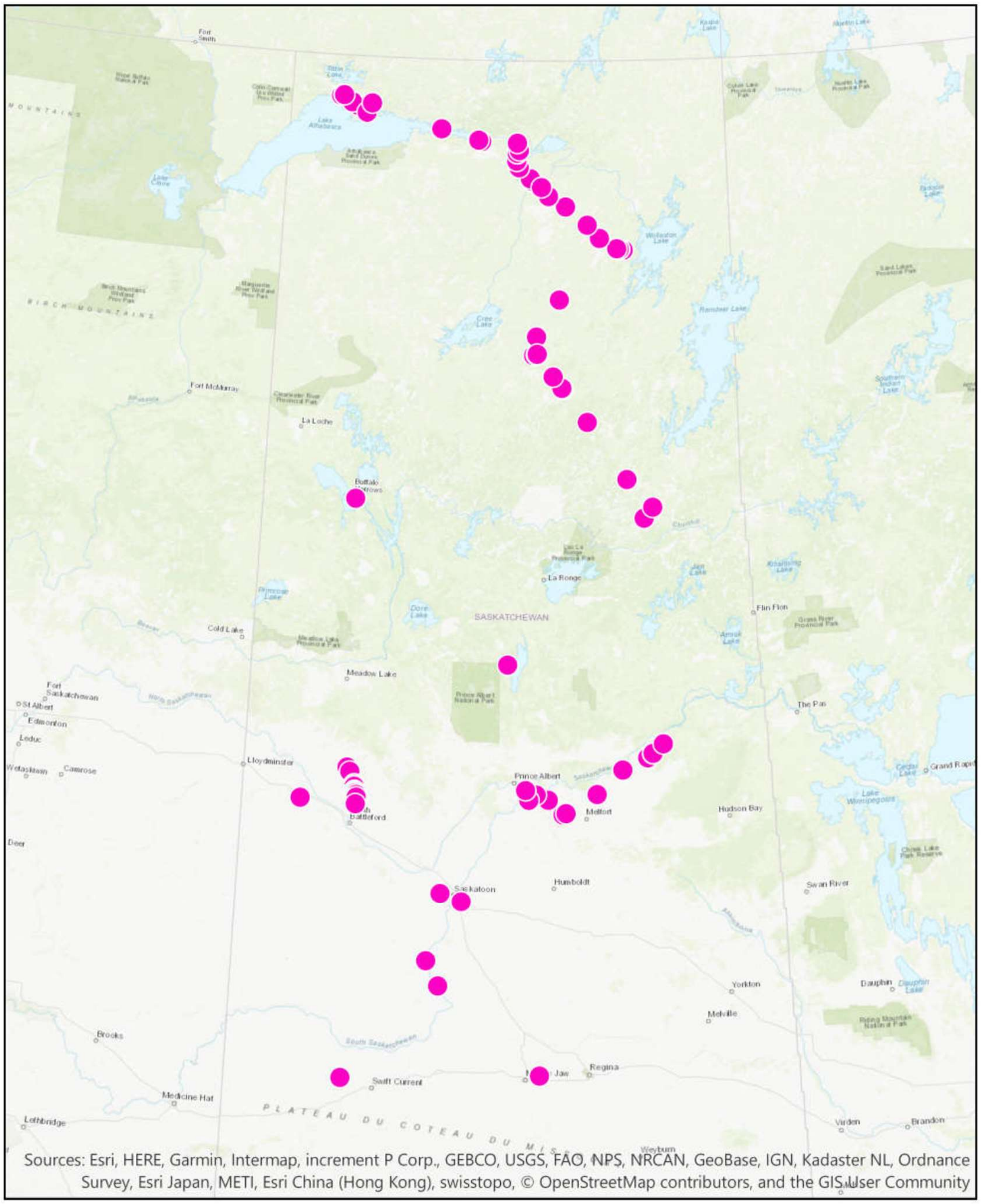

Figure 6. Stick-nest locations in SaskPower imagery.

The lines were flown throughout the summer months, which represents the breeding season for most migratory bird species. However, it is unknown whether the imagery was taken during the breeding period. This could potentially limit the number of nests observed on the lines if the flights were conducted just before breeding season.

The images may have been taken just after the breeding season, during nest vacancy period, and so it is unknown whether they were recently in use because stick nests are often used over many years.

2.2 DATA AND LIMITATIONS

Power lines are present across a range of ecosystems in Saskatchewan, from boreal forest to wetlands to open agriculture. All power lines have a 15 m buffer (right-of-way) cleared on both sides of the power lines and structures (30 m total width) to prevent damage to these structures from contact with vegetation. Data used in this study concentrated on the power pole corridor. Raptors within the interior boreal forest or prairies were not assessed or considered in this study. Information regarding the surrounding land-uses of the poles was monitored for potential interactions.

The lack of other land-use data weakens the potential for similar studies. It means that only the raptor populations that have potential to dwell on power poles can be assessed. Usually only stick nest building species would occupy power poles, so this eliminated potential studies for cavity nesting raptors such as Kestrels or some owls. The focus of the study area is on the power poles themselves. Only nests on the poles were recorded in the database, so these potential nests are present else where in the imagery but not assessed in this study as the area of imagery is too large to assess in this study. The data provided represent a comprehensive data set in terms of power pole data and were treated as such in this study.

There was also the potential for human error in the data collection. When the aerial images were catalogued, some nests on the power poles may have been missed. When measuring and assessing for the landscape feature of the study, it is possible that they may have been miscalculated or incorrected recorded. All measures were taken to avoid human error where ever possible.

2.3 DATA HANDLING

The data were supplied through an online database by KBM. The information in the database included a base map with roads and basic landscape features, the power line aerial imagery placed superficially on the base map, and the power line features relevant to SaskPower. The imagery captured power line features (*e.g.*, georeferenced line path, power pole locations and labels) and the 30-m right-of-way (Figure 7). The online database also included a query tool that was used to locate and review all structures with nests.

Figure 7. Data viewer containing base map, aerial imagery, and power line features.

This database was still in it’s beta form (incomplete and working through bugs) and produced many errors during datamining. As it was an online tool hosted on the KBM servers, all query tools were non-functional when the servers were experiencing issues. This meant that nest sites had to be searched for manually, starting from the provincial map and zooming into the specific line and pole. The control locations were more difficult to assess. After randomly selecting the control poles (discussed further in the section 2.4 Controls and Variables), there was no search tool for these data. Each pole had to be found manually. This was time consuming as many of the line names were difficult to find.

2.4 CONTROLS AND VARIABLES

Variables were collected using a measuring tool in the online database. Distances to forests patches greater than 0.5 ha in size were recorded. The size was measured using an area tool in the online database. Any forest patches a greater distance than 400 m away from the power pole (control or nest) were grouped as not present. The presence of water features (lakes or rivers) greater than 0.5 ha in size within the 400 m area were recorded. This was also done for anthropogenic features.

Control sites were selected at a 3:1 ratio to nest sites, since there was a far greater number of non-nested power poles in the dataset. This resulted in a total of 50 nest locations and 150 controls (Appendix I and II). Control locations were selected using the random number generator function in Microsoft Excel.

2.5 ANALYSIS

After data collection, the distance variable (distance to nearest forest patch with 400 m) was split into 15 m distance categories ending with +405 m group. This last group accounted for all the data within non-forested areas (prairies). The data were analysed using ANOVA statistical analysis in the program SPSS (Statistical Package for the Social Sciences). This test compares all variables within each treatment (control or nests) to each other to see if there are any significant correlations. The single ANOVA test addresses all the treatments, variables, and both hypotheses. An ANOVA test is a robust and well rounded test to determine significance. Due to the 3:1 ratio of controls to nests, it was an unbalanced ANOVA. Any significant interactions were graphed to better visually represent the trends in the results.

3.0 RESULTS

The ANOVA statistical analysis resulted in only one significant result (Table 1). The significant feature was the presence of anthropogenic features. This indicates that H1 (raptors that nest on power line infrastructure non-randomly select their nest sites) is accepted. Raptors non-randomly select their nest sites on power poles to avoid other anthropogenic features like roads, buildings, and farm fields.

Table 1. SPSS ANOVA results.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Forestdistancegroup	5.225	25	0.209	1.431	0.098
WaterPresent	0.467	1	0.467	3.196	0.076
AnthroPresent	0.660	1	0.660	4.522	**0.035**
Forestdistancegroup * WaterPresent	3.254	13	0.250	1.714	0.063
Forestdistancegroup * AnthroPresent	1.959	7	0.280	1.916	0.071
WaterPresent * AnthroPresent	0.104	1	0.104	0.711	0.400
Forestdistancegroup * WaterPresent * AnthroPresent	0.688	2	0.344	2.357	0.098
Error	21.758	149	0.146		
Total	350.000	200			
Corrected Total	37.500	199			

a. R Squared = .420 (Adjusted R Squared = .225)

Almost all of the control sites had anthropogenic features nearby (Figure 8). The nest sites were almost a 2:1 ratio of anthropogenic features present to not present. This analysis may suggest raptors non-randomly select power poles nest sites.

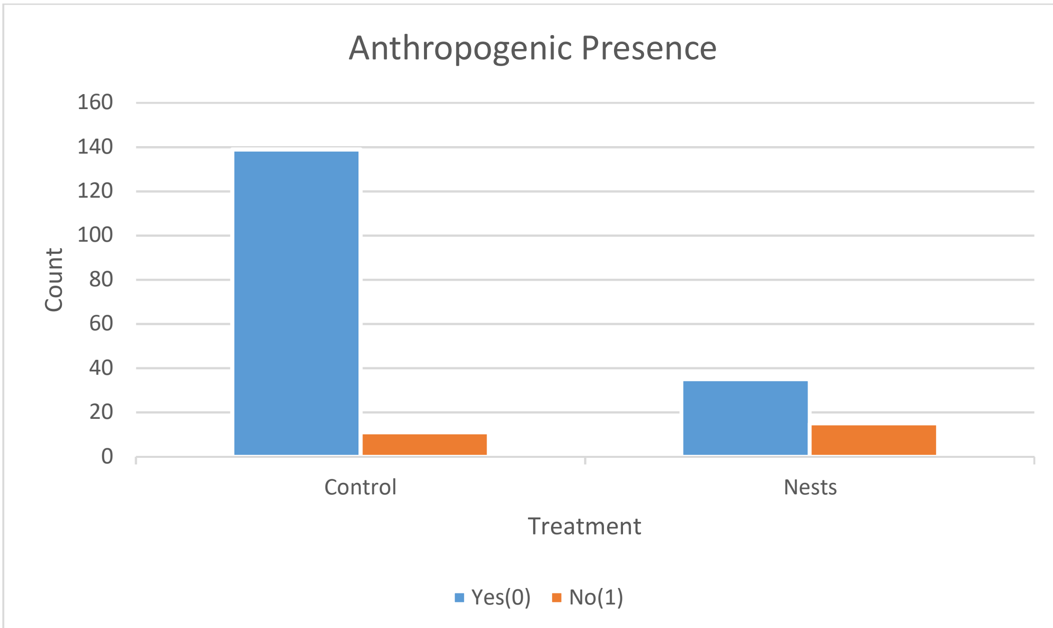

Figure 8. Anthropogenic presence graphed to display the counts with nests and controls.

Figure 9. Raptor stick nest located directly on a dam (shown as the red pointer).

Raptors typically avoid anthropogenic features when finding nesting sites. The nest sites with anthropogenic features, however, tended to be around large bodies of water. There were even three of the nest sites within 500 m of dams. Some nest locations were immediately surrounded by anthropogenic features, like dams, and were used several years in a row, as evident through the 2014 to 2017 aerial imagery (Figure 9).

4.0 DISCUSSION

The objective of this study was to explore whether the incidental raptor nest observations might be used to monitor wildlife populations, particularly in remote areas. This objective was pursued by: a) cataloguing stick nest observations in the SaskPower aerial imagery data set, and b) inferring how the various raptor species are currently using the power poles. Failing to reject H1 proves that raptors may non-randomly select their nest sites on power lines to avoid anthropogenic features.

Raptors, like all other predators and species, establish themselves near food sources. They rotate nest sites every few years to access the more plentiful food sources. The raptors may not significantly use the power poles in any particular ecozone (around forest patches or not), so it cannot be said that the power poles are producing nesting habitat in the prairies where nesting trees may be more lacking. They also do not nest particularly around water sources, so it cannot be suggested that osprey are the primary raptor species nesting on power poles.

Aerial surveys are used to monitor several wildlife monitoring studies (Kochert and Steenhof 2002, Regos *et. al*. 2017). Fixed-wing airplanes are the ideal method, however random transect selection is the best way to effectively monitor an area. The power lines cover fairly evenly the southern portion of the province, but do not evenly assess the northern portion into the boreal. This database is good for a non-random assessment, but is not an ideal wildlife monitoring method system.

This study fell short in several aspects. First, the online database was a great way to access the data remotely (through the internet), but the tools it provided had many issues. As the study was first suggested with the working tools in mind, it was difficult to adapt the study to the non-functioning tools. This caused several time delays in the study. The entire website being down during server shutdowns also increased these delays. As many KBM employees do not work with the online database daily, the issues often went unnoticed, and therefore took even longer to get fixed.

As the technological issues noted above, it complicated detailed data collection. This study would have been more thorough and beneficial if all variables were measured for distance rather than just the forest patches. If the issues with the search tool were to be fixed, these measurements could be done very quickly.

Another issue noted in this study is the statistical test. Though an ANOVA analysis is robust and well-rounded, other tests could have been done to further prove and reinforce the statistical significance.

Wildlife monitoring programs are very important to quickly detect any changes in populations, ranges, and habitats. Though this tool is very useful for monitoring the structural integrity of the power poles and the clearance of the corridors, it is not an effective wildlife monitoring tool. As a result of the shear quantity of power poles, more than 60,000, and there only being 50 poles identified with nests, it is a very insignificant population. It was a valuable study to assess the possibility of using the incidental observations as data in future studies, but they do not seem to be a good data source.

5.0 CONCLUSION

In conclusion, very few individual raptors use power poles as nesting sites. When they do use power poles, they prefer sites with no other anthropogenic features. Features such as water and distances to forest patches yield no significant correlation with nest site selection. Though there are ways to improve this particular study (through improved methods and database tools), the insignificant number of nest sites to power poles in this region make future studies of this type invaluable.

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APPENDICES

Appendix I. SaskPower nest identification by case and structure number, and their surrounding features.

Case Number	Structure ID	Distance to Forest	Water Present	Anthro Present
1	8	N/A	Yes	Yes
2	406	N/A	Yes	Yes
3	129	N/A	Yes	Yes
4	423	40m	No	No
4	536	Within	No	Yes
4	412	Within	No	No
4	258	Within	No	No
5	250	200m	Yes	Yes
5	216	80m	Yes	Yes
5	204	100m	No	Yes
5	196	30m	No	Yes
5	191	130m	No	Yes
5	187	20m	No	Yes
5	183	20m	No	Yes
5	160	20m	No	No
5	152	250m	No	No
5	149	20m	No	Yes
5	79	15m	Yes	Yes
5	55	40m	Yes	Yes
5	53	15m	Yes	Yes
5	184	15m	Yes	Yes
6	217	20m	Yes	Yes
7	1	N/A	Yes	Yes
8	195	N/A	No	Yes
9	87	N/A	Yes	Yes
10	305	N/A	Yes	Yes
11	261	140m	Yes	No
12	946	Within	Yes	Yes
12	641	60m	Yes	No
12	682	50m	Yes	No
12	762	50m	Yes	No

12	764	50m	Yes	Yes
13	23	15m	Yes	Yes
14	24	85m	Yes	Yes
14	20	15<	Yes	Yes
15	742	30m	Yes	No
16	46	20m	Yes	Yes
17	5	15m	Yes	No
18	610	15m	Yes	Yes
19	23	N/A	Yes	Yes
20	1048	20m	Yes	No
21	22	N/A	No	Yes
22	22	400m	Yes	Yes
23	591	N/A	No	Yes
24	567	Within	Yes	No
25	156	200m	No	Yes
26	97	Within	Yes	Yes
27	87	15m	Yes	Yes
27	59	15m	Yes	No
27	31	15m	Yes	No

Appendix II. SaskPower control identification by case and structure number, and their surrounding features.

Case Number	Structure ID	Distance to Forest	Water Present	Anthro Present
1	222	N/A	Yes	Yes
2	572	N/A	No	Yes
3	29	N/A	No	Yes
4	99	75m	No	Yes
4	126	230m	Yes	Yes
4	363	Within	Yes	Yes
5	237	N/A	Yes	No
5	427	150m	Yes	Yes
5	456	5m	Yes	Yes
6	53	N/A	No	No
7	141	Within	Yes	No
7	395	Within	Yes	No
7	409	40m	Yes	No
7	509	15m	No	Yes
8	118	N/A	No	Yes
9	189	15m	Yes	Yes
9	338	145m	Yes	Yes
9	361	100m	Yes	Yes
10	38	N/A	Yes	Yes
10	299	N/A	Yes	Yes
11	146	85m	Yes	Yes
12	118	N/A	Yes	Yes
12	185	N/A	Yes	Yes
12	486	60m	Yes	Yes
13	86	375m	Yes	Yes
13	142	380m	No	Yes
14	69	N/A	No	Yes
15	4	525m	Yes	Yes
16	60	N/A	No	Yes
17	241	N/A	Yes	Yes
17	439	65m	No	No
18	59	150m	Yes	Yes
19	404	Within	Yes	Yes
20	216	N/A	No	Yes
20	375	200m	Yes	Yes

21	131	N/A	No	Yes
22	532	260m	Yes	Yes
23	66	N/A	Yes	Yes
24	377	435m	Yes	Yes
25	8	N/A	No	Yes
26	227	N/A	No	Yes
27	2	N/A	No	Yes
28	188	15m	Yes	Yes
29	291	20m	No	Yes
30	36	185m	No	Yes
31	164	435m	No	Yes
32	29	N/A	No	Yes
33	235	230m	Yes	Yes
33	245	15m	No	Yes
34	24	N/A	No	Yes
35	181	220m	Yes	Yes
35	243	200m	Yes	Yes
36	269	Within	Yes	Yes
37	92	Within	Yes	No
37	253	Within	Yes	No
38	52	Within	Yes	Yes
39	38	70m	Yes	Yes
40	52	115m	Yes	Yes
41	43	N/A	No	Yes
42	101	Within	No	Yes
43	264	Within	No	Yes
44	324	Within	No	Yes
45	197	30m	No	No
46	7	Within	Yes	Yes
46	10	64m	Yes	Yes
47	300	70m	Yes	Yes
47	367	100m	Yes	Yes
47	554	220m	No	Yes
48	274	80m	No	Yes
49	196	65m	Yes	Yes
50	289	N/A	Yes	Yes
50	546	140m	No	Yes
51	52	N/A	Yes	Yes
52	220	N/A	Yes	Yes
53	16	160m	Yes	Yes
54	189	Within	Yes	Yes

54	352	130m	Yes	Yes
55	1091	N/A	Yes	Yes
56	20	80m	Yes	Yes
57	40	N/A	No	Yes
58	64	470m	No	Yes
59	58	15m	No	Yes
60	213	N/A	Yes	Yes
61	13	110m	Yes	Yes
62	30	N/A	No	Yes
63	100	N/A	No	Yes
63	331	N/A	No	Yes
64	27	N/A	No	Yes
65	8	83m	Yes	Yes
66	796	N/A	No	Yes
66	927	25m	No	Yes
66	1136	60m	No	Yes
67	27	N/A	No	Yes
68	478	N/A	Yes	Yes
69	31	N/A	No	Yes
70	3	N/A	No	Yes
70	121	90m	Yes	Yes
70	226	43m	Yes	Yes
70	689	Within	No	Yes
70	983	Within	Yes	No
71	218	N/A	Yes	Yes
72	76	N/A	Yes	Yes
72	97	N/A	Yes	Yes
73	129	360m	Yes	Yes
73	140	N/A	No	Yes
74	215	N/A	No	Yes
74	293	285m	No	Yes
75	99	N/A	No	Yes
76	9	470m	No	Yes
77	229	N/A	No	Yes
77	316	150m	Yes	Yes
77	466	N/A	Yes	Yes
78	77	Within	Yes	Yes
79	2	50m	Yes	Yes
80	83	15m	Yes	Yes
81	1249	50m	Yes	Yes
81	1268	10m	Yes	Yes

81	1615	Within	No	Yes
82	109	30m	No	Yes
83	274	30m	Yes	Yes
84	106	N/A	No	Yes
84	144	N/A	No	No
84	187	350m	Yes	Yes
84	377	220m	Yes	Yes
85	77	380m	Yes	Yes
86	66	N/A	No	Yes
87	90	N/A	No	Yes
88	481	85m	Yes	Yes
88	526	115m	Yes	Yes
88	559	225m	Yes	Yes
88	677	N/A	Yes	Yes
88	895	240m	Yes	Yes
88	1090	270m	Yes	Yes
88	1199	300m	Yes	Yes
89	56	225m	Yes	Yes
90	125	15m	Yes	Yes
92	139	130m	No	Yes
92	154	170m	Yes	Yes
93	206	N/A	No	Yes
93	445	N/A	No	Yes
94	70	10m	Yes	Yes
95	198	180m	Yes	Yes
96	875	N/A	No	Yes
96	1073	10m	Yes	Yes
96	1429	210m	Yes	Yes
96	1516	165m	Yes	Yes
97	577	15m	No	Yes
98	311	Within	Yes	Yes
98	334	150m	Yes	Yes
99	140	145m	No	Yes