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Oil development in the grasslands: Saskatchewan's Bakken formation and species at risk protection

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Abstract: This paper considers the possible impacts of oil development on wildlife in the grasslands ecosystem, particularly in the province of Saskatchewan. The Bakken formation, a major North American shale play, overlaps with one of the largest areas for grassland birds in Canada the US. Access to the oil is made possible through fracking and horizontal drilling, which are controversial techniques that have been regulated and banned in other parts of North America and the world. Drawing on analysis of recovery documents for listed species at risk, this paper illustrates that oil development is impacting species through habitat destruction, oil and noise pollution, invasive species, and road infrastructure. Current wildlife policy in Saskatchewan is inadequate to protect species at risk in the Bakken formation.

Subjects: Conservation - Environment Studies; Energy Policy; Environmental Politics; Federalism

Keywords: species at risk; oil development; Bakken formation; grassland conservation

1. Introduction

The Saskatchewan prairies lie at the northern edge of the North American Great Plains, which is an eco-region that stretches from Canada through the United States and down into Mexico. Saskatchewan's prairie includes mixed grasslands and aspen parklands as well as a plethora of flora and fauna (see Savage, 2011). From a global perspective, Saskatchewan prairie is important habitat for grassland and migratory birds (Henwood, 2010; Savage, 2011). For example, there are two Western Hemisphere Shorebird Reserve Network sites in the prairies, Chaplin Lake and Quill Lakes, and the oldest bird sanctuary in North America, known as Lake Mountain Bird Sanctuary (Savage,

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PUBLIC INTEREST STATEMENT

The Canadian prairie province of Saskatchewan is home to the grasslands ecosystem and a large oil reserve known as the Bakken formation. In the past decade, Saskatchewan has become a significant producer of oil due to new technological advances in recovering oil from shale rock. However, oil development in this region is impacting species at risk through habitat destruction, oil and noise pollution, invasive species, and road infrastructure. Current wildlife policy in Saskatchewan is inadequate to protect species at risk in the Bakken formation.

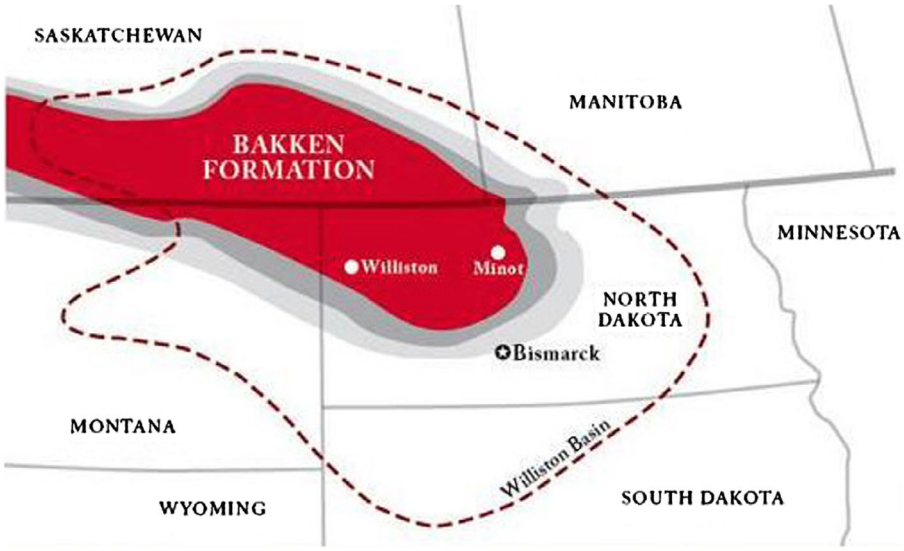

Figure 1. Map of the Bakken formation in Canada and the US.

Source: United States Geological Survey (n.d.).

Figure 2. Stages in shale hydraulic fracturing.

2011). Today the grasslands are in jeopardy as they "are one of the most significantly modified landscapes in Canada" (Nasen, Noble, & Johnstone, 2011, p. 195) and "constitute one of the most endangered ecosystem types on Earth" (Roch & Jaeger, 2014, p. 2506).

Saskatchewan is also home to the Bakken formation, which is an area of shale rock with vast oil potential (see Carter, Fraser, & Zalik, 2017; Zink & Eaton, 2016). This shale play extends through North Dakota and Montana into the southeast corner of Saskatchewan and the southwest corner of Manitoba. See Figure 1. For the past 15 years, the region has been producing immense quantities of oil—enough to make North Dakota the second largest producer of oil in the US, after Texas, and Saskatchewan the second largest producer of oil in Canada, after Alberta (Carter et al., 2017). The United States Geological Survey suggests potential for up to 503 million barrels of oil in the Bakken formation (Langdon, 2008).

There has been limited research on the direct impacts posed by oil development in the Bakken region to flora and fauna (as exceptions, see Braun, Oedekoven, & Aldridge, 2002; Hill & Olson, 2013; Thompson, Johnson, Niemuth, & Ribic, 2015). More generally, however, research shows a link between oil and gas development and the decline of grasslands species in North America (see, for example, Bernath-Plaisted & Koper, 2016; Hill & Olson, 2013; Nasen et al., 2011; Northrup & Wittemeyer 2012). Nasen et al. (2011) conducted a cumulative impact assessment of oil and gas development in the mixed grasslands of southwestern Saskatchewan, and found significant long-term, and spatially long-range, impacts. Notably, there were changes in soil structure around well sites, which can have ripple effects across the ecosystem. Unfortunately, no similar research has been conducted in the Bakken region.

This paper examines the potential impact of oil production on prairie grassland biodiversity. Specifically, the main focus is species at risk with range in Saskatchewan's Bakken region. The paper begins with a brief overview of the oil development process as well as the regulatory frameworks for oil and wildlife in Saskatchewan. The next section presents the research questions and

methodology. The data, taken from government documents for listed species, is given in detail before a discussion regarding the main impacts of oil in the grasslands.

2. Oil and fracking process and policy

Saskatchewan has been producing oil since the 1950s, but more recent technologies in hydraulic fracturing (fracking) and horizontal drilling have caused a boom in oil production in the Bakken (Carter et al., 2017; Zink & Eaton, 2016). Thanks to the technique, which involves injecting high-pressure water and chemicals deep underground to unlock stores of trapped oil, Saskatchewan produced 527,000 barrels of oil per day on average in 2015 (National Energy Board, 2016). Unlike other shale plays in North American, such as the Marcellus on the East coast or the Barnett in Texas, which are rich in natural gas, the Bakken is predominately oil rich. Between 2006 and 2012, over 2000 new wells were drilled in Saskatchewan's Bakken area (Zink & Eaton, 2016, p. 19).

Since most of the oil is trapped in shale rock, fracking is the predominate method of oil extraction. This is a process that can occur in six stages as illustrated in Figure 2.

After an oil firm determines a suitable location and obtains the mineral rights (stage 1), a well is drilled. Most oil sites contain as many as five well heads and infrastructure like solution tanks and disposal facilities for waste water (Nasen et al., 2011). These sites also require access roads for trucks and equipment. In stage 2, the oil firm installs a permanent well-head and the necessary infrastructure to beginning hydraulic fracturing. Hydraulic fracturing takes place in stage 3 where water and a chemical mixture are injected at high pressure into the well. This pressure causes the shale to fracture. In stage 4, the well is completed and a permanent wellhead is installed so that oil can be pulled to the surface. During the production stage, oil, gas, and water (including the chemicals and sand) flow from the surface wellhead through the flow lines to tanks that separate the oil from the rest of the mixture. Oil is often stored in large containers until it is ready for pick-up and delivery to a pipeline or refinery. The water used in fracking is either recycled for use at another well location or it is stored and disposed of according to government regulations. After all the economically viable oil has been recovered from the well, the final stage is well abandonment. Often wells are filled with cement and surface equipment is removed from the landscape. For a detailed description of the process see Lade and Rudik, 2017, Shrestha, Chilkoor, Wilder, Gadhamshetty, & Stone, 2017 or the Petroleum Services Association of Canada, 2018).

Environmental degradation occurs unevenly across the stages of fracking. Most scientific research has focused on water quality and quantity impacts across the different stages (see Shrestha et al., 2017 for an example of water impacts in the Bakken formation) or greenhouse gas emissions across the stages (see Jiang et al., 2011; for example). Other research has focused more broadly on the general environmental impacts, which range from altered land use (Fore, Overmore, & Hill, 2015; Moran, Cox, Wells, Benichou, & McClung, 2015), chemical and air pollution (Prenni et al., 2016; Rabe, 2014), human health risks (Webb et al., 2014), and stressed transportation infrastructure (Rahm, Fields, & Farmer, 2015). In the scientific literature, these risks are not examined systematically across the different stages of the fracking process.

2.1. Governing oil in Saskatchewan

Saskatchewan has taken a hands-off approach to regulating oil development, largely because it depends on the industry for revenue and job creation (Carter & Eaton, 2016). According to Carter et al. (2017), "over the 2009–2014 period, Saskatchewan's oil sector directly contributed 13 to 24 percent of the province's total revenue" (p. 64). The oil and gas sector is regulated by the Saskatchewan Ministry of the Economy, whereas the Ministry of Environment has little to no role in decisions concern oil development in the province (Carter et al., 2017). Saskatchewan has chosen not to regulate fracking as a "distinct and specifically risky practice," and instead relies on general oil and gas development rules (Carter & Eaton, 2016). There is no regulatory distinction between conventional and unconventional oil development. Most wells are approved in Saskatchewan without undergoing an environmental impact assessment (Carter & Eaton, 2016). This is because each application for

individual lease sites are "rarely considered significant enough to trigger a formal EA" (Nasen et al., 2011, p. 196). And all oil and gas exploration activities are exempt from environmental assessment (Bowden, 2010; Carter & Eaton, 2016). These exemptions are part of the government's "results-based regulatory regime," which the government describes as one that "establishes clear performance expectations while eliminating ineffectual scrutiny and attention to process, especially for routine, well understood, and low-risk activities" (Government of Saskatchewan, 2014). This hands-off approach creates a regulatory atmosphere that is favorable for oil and gas industry.

3. Wildlife policy in Saskatchewan

In Canada, wildlife is co-managed by the provinces and federal government, with the former holding the bulk of responsibility (Olive, 2014a). Since the federal government, under the Constitution of Canada, has some jurisdiction over navigable waters and federal lands as well as transboundary issues, that government is responsible for some aquatic species, wildlife on federal lands (such as national parks or First Nation reserves), and migratory birds that are part of the Canada–US Migratory Birds Convention Act 1917. Everything else is predominately provincial responsibility as all provinces have jurisdiction over their own natural resources (such as oil), private lands, and provincial crown lands.

Species at risk are subsequently managed at two levels of government. The federal government has a longer and more global relationship to biodiversity loss and species at risk. In 1976, Canada established a non-government scientific body, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), to assess the status of all flora and fauna across the country.[1] In 1992 the federal government signed the UN Convention on Biodiversity and set about creating a national biodiversity strategy for the country. The federal government passed the Species at Risk Act (SARA) in 2002, which makes it illegal to kill or harm listed species and alter critical habitat. However, the main legal provisions of the law extend only to listed species on federal lands, some aquatic species, and some migratory birds (see Olive, 2014a).

COSEWIC assesses a species and grants it a scientific status: endangered, threatened, species concern, not at risk, or data deficient. The federal government has nine months to accept the status and add the species to SARA or can ask COSEWIC for more data. If nine months elapse without a decision, the species is automatically listed on SARA with the status granted by COSEWIC (see Mooers et al., 2010; Olive, 2014b). For endangered and threatened species, the government has 2 and 3 years, respectively, to write a recovery plan, which outlines the biological description and needs of the species, it geographical range, and the major threats or reasons for decline. After a recovery plan is finalized and made public, the government is required to write an action plan for the species, which is a document intended to the recovery process into policy guided actions with economic considerations. For species listed as special concern on SARA, the government must prepare a management plan, which is similar to a recovery plan but not supported by the force of law (see Mooers et al., 2010; Olive, 2014b). Special concern species are excluded from the main legal provisions of SARA. Overall, SARA protects COSEWIC designated endangered and threatened species and makes it illegal to harm said species, but the federal government can only implement policy and work toward the protection and recovery of these species on federal lands.

Saskatchewan is one of only four provinces in Canada to lack stand-alone species-at-risk legislation (Olive, 2014a). Instead, the province uses its 1998 Wildlife Act to regulate all flora and fauna. Under the Act, native wild species can be designated as vulnerable, threatened, endangered, or extirpated from the province.[2] While similar to COSEWIC's categories, these designations in Saskatchewan are at the discretion of the provincial Minister of Environment. The province uses a conservation status ranking system through its own Saskatchewan Conservation Data Centre. This center is responsible for maintaining a centralized database for all scientific information pertaining to the native species (see Saskatchewan Conservation Data Centre, 2017).

Table 1. List of species at risk with habitat range in the Bakken formation

	Latin name	Taxon	COSEWIC status	SARA status	SK wildlife act status
Alkaline Wing-nerved Moss	*Pterygoneurum kozlovii*	Mosses	Threatened	Threatened	No status
American Badger taxus subspecies	*Taxidea taxus taxus*	Mammal	Special Concern	No status	No status
Baird's Sparrow	*Ammodramus bairdii*	Bird	Special Concern	Special Concern	No status
Bank Swallow	*Riparia riparia*	Bird	Threatened	No status	No status
Barn Swallow	*Hirundo rustica*	Bird	Threatened	No status	No status
Black-tailed Prairie Dog	*Cynomys ludovicianus*	Mammal	Threatened	Special Concern	No status
Bobolink	*Dolichonyx oryzivorus*	Bird	Threatened	No status	No status
Buff-breasted Sandpiper	*Tryngites subruficollis*	Bird	Special Concern	Special Concern	No status
Buffalograss	*Bouteloua dactyloides*	Vascular Plant	Special Concern	Special Concern	No status
Burrowing Owl	*Athene cunicularia*	Bird	Endangered	Endangered	Endangered
Chestnet-collared Longspur	*Calcarius ornatus*	Bird	Threatened	Threatened	No status
Chimney Swift	*Chaetura pelagica*	Bird	Threatened	Threatened	No status
Common Nighthawk	*Chordeiles minor*	Bird	Threatened	Threatened	No status
Dakota Skipper	*Hesperia dacotae*	Arthropod	Endangered	Threatened	No status
Eastern Whip-poor-will	*Antrostomus vociferous*	Bird	Threatened	Threatened	No status
Eastern Yellow-bellied Racer	*Coluber constrictor flaviventris*	Reptile	Threatened	Threatened	No status
Ferruginous Hawk	*Buteo regalis*	Bird	Threatened	Threatened	No status
Great Plains Toad	*Anaxrus cognatus*	Amphibian	Special Concern	Special Concern	No status
Greater Sage Grouse urophasianus subspecies	*Centrocercus urophasianus urophasianus*	Bird	Endangered	Endangered	Endangered
Greater Short-horned lizard	*Phrynosoma hernandesi*	Reptile	Endangered	Endangered	No status
Greenish-white Grasshopper	*Hypochlora alba*	Arthropod	Special Concern	No Status	No status
Hairy Prairie-clover	*Dalea villosa*	Vascular Plant	Special Concern	Special Concern	No status
Horned Grebe Western Population	*Podiceps auritus*	Bird	Special Concern	Special Concern	No status
Loggerhead Shrike Prairie subspecies	*Lanius ludovicianus excubitorides*	Bird	Threatened	Threatened	No status
Long-billed Curlew	*Numenius americanus*	Bird	Special Concern	Special Concern	No status
Monarch	*Danaus plexippus*	Arthropod	Endangered	Special Concern	No status
Mormon Metalmark Prairie Population	*Apodemia mormo*	Arthropod	Special Concern	Threatened	No status
Nine-spotted Lady Beetle	*Coccinella novemnotata*	Arthropod	Endangered	No status	No status
Pale Yellow Dune Moth	*Copablepharon grandis*	Anthropods	Special Concern	Special Concern	No Status
Piping Plover circumcinctus subspecies	*Charadrius melodus circumcinctus*	Bird	Endangered	Endangered	Endangered
Plains Bison	*Bison bison bison*	Mammal	Threatened	No Status	No status
Prairie Rattlesnake	*Crotalus viridis*	Reptile	Special Concern	No status	No status
Red Knot rufa subspecies	*Calidris canutus rufa*	Bird	Endangered	Endangered	No status
Red-headed Woodpecker	*Melanerpes erythrocephalus*	Bird	Threatened	Threatened	No status
Red-neck Phalarope	*Phalaropus labatus*	Bird	Special Concern	No status	No status
Short-eared Owl	*Asio flammenus*	Bird	Special Concern	Special Concern	No status
Sprague's Pipit	*Anthus spraguelli*	Bird	Threatened	Threatened	No status
Western Tiger Salamander Prairie population	*Ambystoma mavortium*	Amphibian	Special Concern	No Status	No status

Under the Wildlife Act, all flora and fauna is protected from "being disturbed, collected, harvested, captured, killed, sold or exported without a permit." For species deemed at risk, "the den, house, nest, dam, or usual place of habitation" is also protected from disturbance and destruction. As of 2018, the Wildlife Act designates five species as extirpated, nine species as endangered, and one as threatened. The list of species has not changed since the original list was created in 1999. However, according to COSEWIC, in 2018, there are 39 special concern species, 33 threatened, 21 endangered, and 2 extirpated species with range in Saskatchewan. The federal government, using COSEWIC data, is adding species to SARA and creating regulatory obligations for that level of government.

4. Research question & methodology

We know that oil development has been significantly increasing in Saskatchewan's grassland prairie region for at least the past 10 years (Carter et al., 2017; Zink & Eaton, 2016). We know the province has very few environmental regulations in place and its overall approach to oil is "hands off" so as to not impact the economic side of the industry (Carter & Eaton, 2016). What we know less about is the impact oil development has on wildlife in the province. This paper examines the extent to which oil development is thought to be impacting species at risk in Saskatchewan's Bakken region. Already at-risk species are important because they are the most vulnerable and because the federal (and provincial) government is already legally responsible for their protection. The main research question is: In what ways is oil development impacting species at risk in the Bakken formation?

4.1. Methodology

In order to establish a list of known species at risk we used the SARA Public Registry to identify every species COSEWIC categorized as endangered, threatened, or special concern with range in Saskatchewan (see Government of Canada, n.d.). This search resulted in 93 species. We examined the critical habitat and range listing for each of these species and eliminated those without range in the Bakken formation. This narrowed the list to 38 species (listed in Table 1 below).

For each species with range in the Bakken, we checked to see if the federal government published an official recovery document. Under SARA, the government is required to prepare a recovery strategy for endangered and threatened species and a management plan for special concern species (Olive, 2014b). If a published document was located, we examined it for mentions of oil development. This was done using a key word search for "fracking" or "oil" or "petroleum" or "energy." Each mention was carefully read in context for meaning. All recovery strategies and management plans are legally required to list a species' threats, according to peer-reviewed science and Aboriginal traditional knowledge. This section of each document was read and carefully analyzed to determined overall threats to each species. See Figure 2 for a depiction of our method. The goal was to determine if the federal government considers oil development to be a threat.

5. Results and discussion

Table 1 provides a list of the 38 species, as well as their taxon, and their status according to COSEWIC, as well as their standing on SARA and the Saskatchewan Wildlife Act.

Overall, 35 of these have no status on the Wildlife Act and, therefore, are not protected by the provincial government. However, 28 of the species are listed on SARA. In the case of the other 10 species, such as the American badger, the Barn swallow, or the Western Tiger salamander, these species are waiting to be granted designation on SARA. In the meantime, SARA does not protect them.

In terms of the recovery strategies, the federal government has prepared strategies for 13 of the 18 endangered or threatened species. Species like the chimney swift and the red-headed woodpecker should have a strategy in place but do not. It is not uncommon in Canada for species to be listed and the government lags in preparing a recovery strategy (Bird & Hodges, 2017; Olive, 2014a). In terms of management plans, the government has prepared 7 plans (including 2 delayed plans awaiting approval) out of 11 special concern species. See Table 2 for an overview of these findings.

Table 2. Link between species-at-risk in the Bakken and oil & gas, as established through recovery plans and peer review literature

Endangered or threatened species	Federal recovery strategy or management plan	Strategy or plan mentions oil
Alkaline Wing-nerved Moss	No	–
Burrowing Owl	Yes	Yes
Chestnet-collared Longspur	Yes	Yes
Chimney Swift	No	–
Common Nighthawk	Yes	No
Dakota Skipper	Yes	No
Eastern Whip-poor-will	Yes	Yes
Eastern Yellow-bellied Racer	Yes	Yes
Ferruginous Hawk	No	–
Greater Sage Grouse urophasianus subspecies	Yes	Yes
Greater Short-horned lizard	Yes	Yes
Loggerhead Shrike Prairie subspecies	Yes	No
Mormon Metalmark Prairie Population	Yes	No
Piping Plover circumcinctus subspecies	Yes	Yes
Red Knot rufa subspecies	Yes	No
Red-headed Woodpecker	No	–
Red-neck Phalarope	No	–
Sprague's Pipit	Yes	Yes
Special concern species		
Barid's Sparrow	No	–
Black-tailed Prairie Dog	Yes	No
Buff-breasted Sandpiper	No	–
Buffalograss	No	–
Great Plains Toad	Yes	Yes
Hairy Prairie-clover	Delayed	Yes
Horned Grebe Western Population	No	–
Long Billed Curlew	Yes	Yes
Monarch	Yes	No
Pale Yellow Dune Moth	Yes	Yes
Short-eared Owl	Delayed	Yes

In total we examined 20 documents: 13 recovery strategies and 7 management plans. As Table 2 illustrates, the federal government considers oil development to negatively impact at least 13 of these species. It is worth briefly reviewing what the government considers to be the primary threats to these species. The species are reviewed here in alphabetical order, beginning with the endangered and threatened species, followed by the management plans for the special concern species. After reviewing all the documents, threats from oil were categorized into five main threat types as illustrated in Table 3.

5.1. Reviewing recovery strategies

The recovery strategy for the Burrowing owl says "no single factor" is causing population reduction, but a cumulative impact of several factors is "likely" responsible (Environment Canada, 2012b, p. 13).

These factors include food shortages, habitat loss, loss of burrows, vehicle collisions, and environmental contaminants. These factors are linked—directly or indirectly—to oil development in the province. For example, it is noted that natural grasslands are lost through "expanding agriculture, petroleum exploration and extraction, and urban sprawl" (2012b, p. 14), but it is unclear how grassland loss directly affects the owl population. For instance, owl populations have outpaced grassland loss and been similar across Manitoba, Saskatchewan, and Alberta despite different amounts of land and oil development in those three provinces (2012b, p. 14). As an another example, the strategy also explains that vehicle collisions are a problem on roads, such as those created for oil exploration, and nests crushed by heavy machinery, including from "cultivation, highway repair, oil and gas activities, or lawn maintenance" are problematic (2012b, p. 16). Thus, while no single issue—such as oil or fracking—is causing owl populations to decrease, the government does recognize that oil development is causing habitat loss, vehicle collisions, and accidental deaths of the owls.

For the chestnut-collared longspur oil development is named alongside farming, ranching, and invasive species as a key threat since all these factors contribute to native prairie habitat loss (ECCC, 2016c, p. iii). The strategy discusses oil extraction activities explicitly and concludes that while most research has been on natural gas development, longspurs are less abundant at sites containing active oil wells than at sites without wells (ECCC, 2016c, p. 11). Moreover, the impacts of roads are noted as longspurs are less common along roads than can be explained by the loss of suitable habitat (ECCC, 2016c, p. 12). The development of roads has been attributed to the booming oil and gas industry.

The primary threats to the Common nighthawk are unknown but "possible threats" include loss of prey, habitat loss, climate change, pollution, and invasive species (EC, 2016c, p. v). This bird is migratory and spends about 10% of its time in Canada where it's habitat ranges across the country. The species is known to breed in the prairie grasslands, but why a 49% decline in Canada has occurred over the past three generations is still unknown (EC, 2016c, p. 1). Oil development is also not mentioned in the recovery plan for the Dakota skipper. Instead, the primary threats are thought to be habitat loss due to cultivated native prairie, habitat degradation from burning, overgrazing, and haying, invasive species, pollution from pesticides and herbicides, climate change, and the collection of the species for natural history specimens (EC, 2007, p. iii).

The eastern whip-poor-will is a migratory bird that breeds in Southern Saskatchewan and other Canadian provinces. The bird's population has been steadily declining at a rate of 2.77–5.53% between 2002 and 2012 (EC, 2015c, p. iii). Energy exploration and transportation, including oil, is considered a cause of habitat loss for the eastern whip-poor-will, which is the primary threat to the species (EC, 2015c, p. 12). The recovery strategy also points out that activities associated with energy development can cause nest destruction (EC, 2015c, p. 12).

The yellow-bellied racer recovery strategy lists primary threats as habitat loss due to human activities, small population size, road mortality, and human disturbance of hibernacula (Parks Canada Agency, 2010, p. v). However, information gaps about the species are major, including the snake's overall population numbers and distribution. At present, only seven hibernacula are known. Industrial activities are minimal within those areas, but their existence in nearby areas "may" reduce snake populations (Parks Canada Agency, 2010, p. 6).

The recovery strategy for the Greater sage grouse lists the main threats as "sensory disturbance from vertical structures and noise, habitat loss and degradation, increased predator pressure, drought and extreme weather conditions, West Nile virus, alteration of natural hydrology" (EC, 2013c, p. iii). The recovery strategy discusses oil development explicitly. For example, Sage grouse avoid anthropogenic sites like oil well pads. Experiments have shown that noise alone (typical of oil/gas drilling) discourages breeding, and the species does not habituate itself to increased noise levels (EC, 2013c, p. 9). Related, tall vertical structures (power lines, oil and gas structures, wind turbines, buildings) discourage nesting nearby (EC, 2013c, p. 11). Moreover, the oil and gas industry is also

heavily implicated in the destruction of Sage grouse habitat. The recovery strategy points out that habitat conversion to cropland occurred mainly before 1981, meaning it cannot explain more recent population declines (EC, 2013c, p. 11). Habitat conversion to petroleum industry development has been closely linked temporally to Sage grouse population declines (EC, 2013c, pp. 11–12). Conversion of habitat to roads also introduces harmful noise, invasive species, and reduced natural vegetation. Sage grouse tend to avoid anthropogenic "edges" such as roads and trails (EC, 2013c, p. 12). Essentially, this means that a combination of threats is introduced by oil industry development in Saskatchewan.

The recovery strategy for the Greater short horned lizard suggests that oil development may be a problem. The listed primary threats include conversion of natural habitat to industrial infrastructure, conversion of habitat to roads, dams and irrigation, conversion of habitat to cropland, invasion of exotic plants, inclement or extreme weather, traffic and pet mortality "due to urban expansion," mortality from oil spills, and collection (EC, 2015a, p. iii). Specially, the strategy points out that oil and gas development affects habitat by clearing vegetation, stripping and mixing soil, compacting soil, "possible localized soil contamination," clearing pathways into formerly inaccessible areas, and disturbances affecting insect (prey) populations (EC, 2015a, p. 8). Above-ground infrastructure associated with wells can attract mammalian predators, snakes, and provide perches for bird predators (EC, 2015a, p. 9). Road and trail construction, associated with the oil and gas industry, "can lead to an increase in occurrence of weeds and invasive plant species"—affecting lizard movements, prey availability, micro-thermal conditions (EC, 2015a, p. 9). Importantly, the document points out that agriculture is not the threat to habitat as conversion of badlands/natural habitat to cropland has "never been a serious threat" because lizard habitat terrain/soil is not suitable to crop and forage production (EC, 2015a, p. 9).

The loggerhead shrike's recovery strategy does not focus on oil at all. Instead, the primary threats are considered land use changes on wintering grounds, cultivation of natural grasslands on breeding grounds, predation, severe weather, disease and parasitic infections. Other possible threats include pesticides, environmental contaminants and vehicle collisions (EC, 2015b). While it could be the case that oil development is contributing to these threats, such as habitat loss through roads and vehicle collisions, the recovery plan does not make that explicit connection.

Similar to other grassland birds, the primary threats facing the Mormon Metalmark are habitat loss, invasive species, pollution, and climate change. Mormon Metalmark habitat is found within the Grasslands National Park where no oil development occurs. However, the recovery strategy does point out that "oil and gas exploration and development could cause destruction and degradation of metalmark habitat" so it would become an issue if habitat is found outside the park (Pruss, Henderson, Fargey, & Tuckwell, 2008, p. 9).

The recovery strategy for the piping plover mentions oil, but the top threat has been identified as predation (Environment Canada, 2006, p. 9). Other threats include habitat loss and degradation, which can occur through "oil and gas development". However, the plan does not go on to consider this link or otherwise establish an connection between oil and piping plover populations.

Oil and gas is not acknowledged as a threat to the Red knot. The recovery strategy is for three subspecies of the bird. The main threats are residential and commercial development, agriculture and aquaculture, energy production and mining, human intrusions and disturbance, natural system modifications, invasive and problematic species and genes, pollution, and climate change (ECCC, 2016a, p. iv). These threats apply to all three subspecies, whereas threats from oil drilling and mining/quarrying are described only for the Arctic subspecies (ECCC, 2016a, p. 16).

Lastly, the recovery strategy for the Sprague's pipit reveals key threats as the loss and degradation of breeding habitat, including through the encroachment of invasive species or shrubs/woody vegetation (EC, 2012a). The species requires large areas of open grassland, which is associated with

low-moderate grazing, or periodic haying or burning (EC, 2012a, p. iv). Pipits breed in higher numbers in native grasslands compared to non-native grasslands (EC, 2012a, p. 6). As of 2001, 75% of native grasslands on the Canadian prairies had been lost, "primarily to cultivation, succession, road construction, gravel extraction, petroleum exploration and extraction, and settlement" (EC, 2012a, p. 6).

5.2. Reviewing management plans

The black tailed prairie dog's management plan indicates the primary threat is sylvatic plague. Other listed threats in the management plan include natural diseases (tularemia), habitat loss and degradation, predation, pest control, drought, floods, and severe winters (p. v). The plan does not discuss oil production explicitly.

The primary threat to the Great Plains toad is habitat loss in the prairies from the drainage of wetlands and the cultivation of native grasslands. Other threats listed include pesticides and fertilizers, overgrazing, oil and gas development and operations, traffic, disease, and climate change (EC, 2013b, p. ii). Oil and gas development is considered a threat because of habitat loss, chemical pollution, and traffic collisions (EC, 2013b).

The management plan for the hairy prairie-clover is the only document in this study to specifically mention the word "fracking." The document points out that "sand and gravel extracted from sand dunes is used for road construction, oil and gas activities (e.g. fracking), agriculture (e.g. potato farming), and personal use" (Environment & Climate Change Canada, 2017, p. 12). The plant is found mainly in Manitoba and its range likely extends into southeastern Saskatchewan. More of a concern is that other locations of known hairy prairie-clover in the sands dunes of Saskatchewan are under potential threat because sand is being extracted to support fracking in the Bakken formation and in Alberta (Environment & Climate Change Canada, 2017). Fracking requires large amounts of sand to blast into the shale rock in order to extract oil.

Oil development is cited as a major threat to long-billed curlew. The management plan lists major current threats as conversion of grasslands to agriculture, fire suppression resulting in forest and shrub encroachment, urbanization (for curlews in British Columbia), energy development, human developments in wintering habitat (US/Mexico), predation, and invasive plant species. The plan suggests that energy development in Alberta and Saskatchewan reduces habitat, and "may enhance other threats"—such as introducing invasive plant species, increasing traffic, and vehicle collisions (EC, 2013a, p. 10).

Monarch butterflies are under threat from "degradation and loss of overwintering habitat in Mexico and along the Californian coast, the widespread use of pesticides and herbicides throughout their breeding grounds, climate change, severe weather events, succession and conversion of breeding and nectaring habitat, and for the Eastern population, the impacts of Bark Beetles on overwintering habitat" (ECCC, 2016b, p. iii). Oil development is not considered at all in the management plan of the Monarch. The only form of energy mention is wind energy can be a threat if wind mills are placed in the migratory pattern of the Monarch.

Similar to the hairy prairie clover, the pale yellow dune moth is also threatened by sand extraction. The management plan points to a low-level concern over the "construction of roads and energy infrastructure and sand extraction in sand dunes" (EC, 2016b, p. 11). It is thought that "suitable habitat will likely decrease and/or degrade" over the long term given these threats (EC, 2016b, p. 11).

Lastly, energy and mining exploration are considered a threat to short-eared owls. Specifically, the plan suggests that oil, gas, coal, and hydroelectricity contribute to habitat loss but that the "direct impacts of these threats on the Short-eared owl populations have not yet been demonstrated" (EC, 2016a, p. 13). These owls breed in all Canadian provinces, but are found most commonly in the

Table 3. Summary of the impact of conventional oil and fracking on SARA listed species in the Bakken formation according to federal recovery documents

Habitat loss & destruction	Oil & noise pollution	Invasive species (from oil industry)	Road infrastructure/ vehicle collisions
Burrowing Owl	Greater short horned	Greater Sage Grouse	Burrowing Owl
Chestnut-collared	lizard	Greater short horned lizard	Chestnut-collared longspurs
longspur	Greater Sage Grouse	Loggerhead Shrike	Yellow-bellied racers
Eastern Whip-poor-will	Sprauge's Pipit		Greater Sage Grouse
Greater Sage Grouse			Greater short horned lizard
Greater short horned lizard			Great Plains toad
Piping Plover			Loggerhead Shrike
Sprague's Pipit			
Great Plains Toad			
Hairy Prairie Clover			
Loggerhead Shrike			
Pale Yellow Dune			
Moth			
Short-eared Owls			

prairies. Unfortunately, the species has experienced a 23% decline in the last decade with lost of habitat considered to be the primary threat to the owl (EC, 2016a).

5.3. Summary of threats

We reviewed 20 federal recovery documents for species listed on the Species at Risk Act with range in Saskatchewan's Bakken Formation. The documents suggest that oil development impacts 13 species in 4 main ways: habitat loss, oil and noise pollution, invasive species, and road infrastructure. Table 3 categorizes these threats and lists the species that are impacted by each threat based on our document analysis.

5.4. Habitat destruction

Habitat destruction caused by oil development is mentioned in a recovery document for twelve species in this study. Essentially, the federal government—using peer-reviewed science—is acknowledging that oil development is destroying important habitat for species in the Bakken formation. In some cases, like the Greater sage grouse, the connection between habitat and oil/fracking is very clear. In fact, for the Greater sage grouse this link was so clear that in 2013 the federal government invoked the "safety net" clause in SARA to protect the bird inside the provinces of Alberta and Saskatchewan, where it was otherwise not being adequately protected (SAR Public Registry, n.d.). The federal government has used the safety net only twice since the law was enacted in 2003, thus demonstrating how severe the situation is for the Greater sage grouse in the prairies. While the Saskatchewan Wildlife Act does list the bird as endangered, the province has done very little in the form of regulation to protect or recover the Grouse. Instead, the 2014 provincial conservation plan discusses various voluntary management practices that could be implemented and suggests that the best habitat for the sage grouse is in the federal Grasslands National Park (Weiss & Prieto, 2014, p. 14), thereby passing the responsibility back to the federal government.

The relationship between oil development and habitat destruction and fragmentation is less clear in other cases, such as the eastern yellow bellied racer or the long-billed curlew. It is important to point out that habitat destruction (in general) is considered a threat for all species with a recovery strategy in this study. In some cases, oil or energy development is not specifically mentioned, but it could be because no peer review science yet exists for the specific species in Saskatchewan. For

example, recent studies in the Bakken area have confirmed that "avoidance of unconventional oil wells and roads" is making habitat loss more severe for many species, such as the Sprague's Pipit, which was found to be more sensitive to oil and gas activity, avoiding them more than some other grasslands birds (Thompson et al., 2015). The case of the short-eared owl or the Mormon Metalark are other examples of species threatened by habitat loss and fragmentation, but where oil has not been directly named as a cause of that habitat loss.

Related, there are data that discuss changes in the landscape that alter species behavior. Very recent scientific studies have illustrated that for grassland songbirds oil and gas structures are an ecological trap, providing structures for the birds but also for their predators (Bernath-Plaisted & Koper, 2016). One study observed more loggerhead shrikes in areas with high levels of oil field development, then in no or low development areas (Fiehler, Cypher, & Saslaw, 2017). Shrikes were observed using power lines as perches, as well as other anthropogenic structures such as fences. The combination of structures with prey availability (insects, lizards) "may facilitate shrike persistence in highly disturbed oil production landscapes" (Fiehler et al., 2017, p. 139).

5.5. Pollution

For oil and noise pollution, the federal government suggests an impact on at least three species. In the case of the greater short-horned lizard mortality from oil spills is explicitly mentioned as well as localized soil contamination. For the Greater Sage Grouse, noise pollution is problematic because it discourages breeding and because species do not want to be near increased noise levels.

However, none of the recovery documents mention water pollution from oil or fracking. This is somewhat surprising given all attention to water pollution in fracking literature (see Lauer, Harkness, & Vengosh, 2016; Olive & Delshad, 2017; Rozell & Reaven, 2011). Peer review literature does suggest that water pollution from oil development poses a threat to grassland birds and other species (Daigh & Klaustermeier, 2016). Trail (2006) addresses the dangers of "oil pits," or open tanks and areas with accessible waste fluids, that can resemble water and trap birds. Some birds may be killed in the pits, or otherwise harmed by "oiling" or exposure to toxic chemicals if they escape (Trail, 2006). In a more recent study, oiling was found to impede flight and cause more frequent stops, which could result in landing in areas of poor food quality—relevant for long-distance migrating birds such as red knot (Perez, Moye, Cacela, Dean, & Pritsos, 2017). While the recovery strategies for species in the Bakken do not mention water pollution, this is an area where more data are needed.

5.6. Invasive species

Invasive species, introduced through oil development and activity, is considered a threat to at least three species in the Bakken, according to recovery strategies. In these cases, trucks and other equipment introduce new species into the area and/or wellpad and road construction creates ideal conditions for invasive species. This points back to the cumulative impact assessment done in southwestern Saskatchewan where Nasen et al. (2011) found that changes to soil structure around well sites can "favor the establishment of fast-growing, weedy, and often invasive plants" (Nasen et al., 2011, p. 201). For sage grouse, short-horned lizards, and loggerhead shrikes changes in habitat are linked directly to invasive species and overall harm.

5.7. Roads and infrastructure

Lastly, roads created by the oil industry are a threat to at least seven listed species in the Bakken. As mentioned, the construction of roads destroys habitat and opens up new areas for invasive species to thrive. But the existence of roads also introduces traffic that can cause collisions with wildlife, such is the case for burrowing owls. Roads can also put prey at risk as it creates unprotected spaces were some species become vulnerable to predators, such as loggerhead shrikes who expose themselves to prey in order to gain access to insects or lizards on roads.

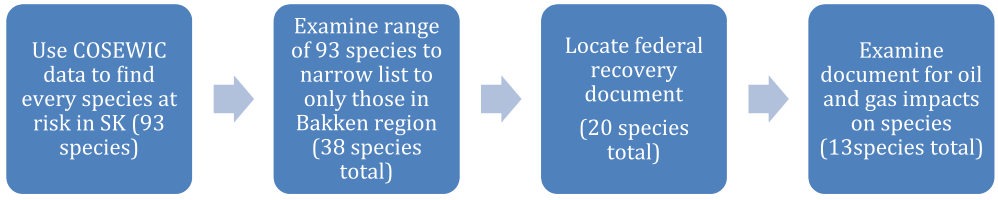

Figure 3. Process used to determine impact of oil development on Saskatchewan species at risk.

6. Limitations and future research

This paper has not considered the link between oil development and climate change, which is another possible driver of biodiversity loss and species at risk in the grasslands. Indeed, oil is double-linked to climate change in the grasslands because when "native grasslands are converted to other land use types, carbon is released contributing significantly to greenhouse gas emissions" (Roch & Jaeger, 2014, p. 2506). Thus, oil production involves both the destruction of a carbon sink as well as the simultaneous production of more greenhouse emissions—through oil production and use as well as through methane production in the flaring of excess natural gas produced through the fracking process (see Carter & Eaton, 2016). Future work could examine recovery documents for links between climate change and grassland species.

Similarly, it would be helpful to break-down the impacts of oil development by stage of the fracking process. Hydraulic fracture is a multi-stage process (see Figure 2 above) and impacts on species would vary across the different stages of the production cycle. For example, the relative contributions of oil production at the site identification stage would be different than the production stage. Namely, landscape changes, road construction, noise, and traffic could be potentially harmful in stage 1, whereas water pollution, oil spills, soil contamination, and traffic could be problematic in stage 5. A systematic analysis of the fracking process and its potential impacts on listed species should be conducted (Figure 3).

Next steps for expanding this research could also include examining peer-reviewed literature and Aboriginal Traditional Knowledge on all 38 listed species at risk. This paper was limited to examining only the 20 species with documents prepared by the federal government. Opening the search up to all existing knowledge on each species would create a more precise understanding of the relationship between oil development and grassland species. Moreover, future work could examine species in the Bakken formation that are not listed as a species at risk by COSEWIC. All species in the grassland ecosystem are important and oil development could be having cumulative impacts on the ecosystem that cannot be discovered by a species-by-species analysis (see Nasen et al., 2011).

Lastly, research must examine why the oil industry in Saskatchewan is not being regulated so as to protect these known species at risk under threat from oil development. This research suggests the federal government knows oil and fracking is a threat to at least 13 species in the Bakken formation. We already know that part of the answer is federalism and the federal government cannot protect species in the Bakken because SARA only extends to federal lands. In southern Saskatchewan there is only one federal park, the Grasslands National Park, which lies at the extreme western end of the Bakken formation. The federal government has created a *Multi-Species Action Plan for Grassland National Park of Canada*, but there is no oil development in the park and, thus, no oil industry that the government could regulate.

From the provincial government's standpoint, it is only illegal to kill or harm the burrowing owl, greater sage grouse, and piping plover on provincial lands or private lands. Those are the only species the Wildlife Act regulates. All the other species discussed in this paper are not legally protected on private lands or provincial crown lands, which comprise most of the land in Saskatchewan. It appears that Saskatchewan's "hands off" regulatory approach to fracking and oil development is also a "hands off" approach to species at risk. More research is needed into the rationale for Saskatchewan's lack of policy as well as the long-term impacts for the grasslands ecosystem. Interviews with government officials, non-government organizations, and scientists should be conducted to gain better insight into the regulatory regime in the province.

Related, regulations and technologies to minimize environmental and ecosystem impact risks should be examined in the context of Saskatchewan's regulatory system. For example, Small et al. (2014) argues that environmental risks can be "mitigated significantly" through technologies and procedures like wastewater recycling, the addition of tracers to injection fluids, methane migration, contamination monitoring programs, and other best practices for the industry (pp. 8290–8291). The extent to which the Saskatchewan government is encouraging these practices is unknown. There use is not discussed in federal recovery documents. However, if oil is impacting species in the Bakken then these solutions, as well as others, are worth serious government consideration and more analysis.

7. Conclusion

The grasslands are one of the most threatened ecosystems on earth and "one of the least protected biomes, with only 4% under protection" (Roch & Jaeger, 2014, p. 2506). Oil development, such as that occurring in the Bakken formation, poses significant potential challenges to native grassland species. The national scientific committee that assesses Canadian wildlife, COSEWIC, designates 38 species at risk—as endangered, threatened or special concern—in the Bakken formation. This determination was made using the best available science, Aboriginal Traditional Knowledge, and local knowledge. The federal government accepted COSEWIC's designation for 28 of these species and placed them on the federal Species at Risk Act. The province of Saskatchewan, using its own Conservation Data Centre, has listed only 3 of the species on its Wildlife Act. Thus, 28 species are being protected by the federal government, 3 species are being protected by both the federal and provincial government, and there are 10 species without protection by either level of government. Moreover, there are potentially more species at risk in southeastern Saskatchewan, but they have yet to be assessed by COSEWIC or the Conservation Data Centre.

While our scientific understanding of the cause–effect relationships between oil and the grasslands is still in its early stages, we do have a plethora of data to suggest that oil development is potentially negatively impacting species at risk. As this paper has illustrated, data collected by the federal government links oil to at least four main threats: habitat destruction, oil and noise pollution, invasive species, and road infrastructure. For 12 of the 20 examined species, one or more of these threats is having a negative impact on the long-term health and viability of the species.

The governments of Canada are failing to adequately protect species from expanding oil development in the Bakken. The oil industry in Saskatchewan is one of the least regulated in North America (Carter & Eaton, 2016). The provincial government offers little in the way of environmental protections (Carter et al., 2017) and has shown limited interest in regulating and protecting wildlife from the oil industry. Despite the federal governments' acknowledgment of the link between oil and species at risk, it can do very little to regulate the oil industry in Saskatchewan. The federal government does not have the jurisdiction to do so. Instead, it can prevent oil development in the Grasslands National Park and other federal wildlife sanctuaries. The other option is for the federal government to invoke the "safety net clause" of SARA for Bakken Species, as it did for the Greater sage grouse in 2013. This would likely be an unpopular move by the federal government, as it does not regularly infringe on areas under provincial jurisdiction. Instead, Saskatchewan needs to step up and do the dirty work of balancing the environment with the oil economy.

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Notes
1. Once assessed, using science, Aboriginal Traditional Knowledge, and local knowledge, a species is determined to be data deficient, not at risk, special concern,

threatened with extinction, endangered with extinction, extirpated from Canada, or extinct in the wild.

2. Vulnerable means a species has low and/or declining numbers but is not threatened or endangered. Threatened means a species is likely to become endangered is the factors causing its decline are not reversed. Endangered means a species is threatened with imminent extirpation or extinction. And extirpated means a species no longer exists in Saskatchewan, but still exists in the wild.

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