Exploring the Ecological Impacts of Oil Development on Alaska's North Slope Bird Species

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Final Project for GEOG 574
Geospatial Database Design and Development
Spring 2020

INTRODUCTION

The American Arctic, also known as Alaska's North Slope, is both the heart of Alaska's oil industry and "America's Bird Basket" (Sullender & Smith, 2016). Recent legislation allows for oil exploration and, ultimately, drilling to commence in the Arctic National Wildlife Refuge, the North Slope's easternmost region, later this year. This law has heightened existing concerns about the environmental impacts of oil development on the North Slope due to the Arctic's, "fragile, undisturbed ecosystems and the difficulty of monitoring and responding to spills due to remote locations, long, cold winters, and the lack of an Arctic deepwater port to handle emergency response vessels and equipment" (Allison & Mandler, 2018, p. 1). Given the region's unique importance to birds—millions of individuals that migrate along all four of North America's major flyways spend their summers on the North Slope—we seek to better understand the existing and potential impacts of development on birds in the region.

Location and Ecosystems

Alaska's North Slope is the region on the northern slope of the Brooks Range along the coast of two marginal seas of the Arctic Ocean: the Chukchi Sea to the north and west and the Beaufort Sea to the north and east. The region encompasses approximately 25,000 square miles, up to 40% of which are classified as wetlands (Herlugson & Parnell, 1996). The North Slope consists of three ecoregions: the coastal plain, Brooks foothills, and Brooks Range north of the range's crest (Nowacki et al., 2001). The primary area of study for this assessment is the coastal plain ecoregion, with minor review of the Brooks foothills ecoregion.

During the brief summer, only the surface layer of the North Slope tundra thaws; thus a key feature of the coastal plain ecoregion is standing water, which is prevented from draining by the frozen ground underneath (Herlugson & Parnell, 1996). Though frozen for nine months out of the year, in summer the coastal plain contains thousands of "thaw lakes, tundra ponds, streams and rivers, and tens of thousands of smaller [water] features," similarly associated with permafrost (Herlugson & Parnell, 1996, para. 1). In fact, thaw lakes cover up to 50% of the coastal plain (Trammell et al., 2015). The coast itself is replete with bays, lagoons, barrier islands, and river deltas (Herlugson & Parnell, 1996).

Bird Populations

The North Slope supports an abundance of diverse seabirds, shorebirds, waterfowl, and passerines, including more than 250 species of birds altogether. Of those 250 species, 183 are known to breed in the region (Herlugson & Parnell, 1996). The Alaskan polar arctic tundra is known to be both nationally and internationally important to shorebirds, supporting the bulk of the U.S. populations of at least six species (Alaska Department of Fish and Game, 2015). The National Petroleum Reserve- Alaska (NPR-A), found in the western region of the North Slope, is said to support more than 6 million breeding individuals (Alaska Department of Fish and Game, 2015). Eleven of Alaska's more than 200 Important Bird Areas (IBAs) are found on the North Slope, eight of which are recognized as globally important, and the remaining three have this same designation pending.

Oil Development and Other Threats

While Arctic ecosystems, including the North Slope, are largely considered to be pristine, they are also expected to, and are already demonstrating, some of the "most rapid and dramatic changes" due to a warming climate (Trammell et al., 2015). Moreover, Arctic environments are inherently fragile and slow to return to undisturbed states (Trammell et al., 2015). While more than 90% of the coastal plain ecoregion is believed to remain intact, most of the development is related to oil and gas exploration and extraction, particularly in the oil fields at Prudhoe Bay and Kuparuk (Alaska Department of Fish and Game, 2015). However, since oil was discovered at Prudhoe Bay in 1968 and production began in 1977 (Herlugson & Parnell, 1996), oil, gas, and mining industries have expanded rapidly, building extensive permanent infrastructure and releasing high levels of contamination into the surrounding environments (Trammell et al., 2015). Prudhoe Bay and more than 25 other producing fields cross 1,000 square miles of the North Slope, and oil spills from these fields and the Trans-Alaska Pipeline System (TAPS) are responsible for, on average, 504 oil spills per year since 1996 (The Wilderness Society, 2004). More than 4,500 spills between 1996 and 2004 led to some 1.9 million gallons of toxic substances, primarily diesel, crude, and hydraulic oil, contaminating the region (The Wilderness Society, 2004). Oil spills on the North Slope, even the largest ones, often take hours or days to discover and even longer to clean up due to sub-zero temperatures common throughout the

Arctic winter (Barringer, 2006). The worst spill in North Slope history went undetected for five days, spilling oil over nearly two acres of tundra (Barringer, 2006). At least 135 contaminated sites on the North Slope still have not been completely remediated.

Land Management and Monitoring

The United States government manages approximately 73% of the coastal plain, including the parts of this ecoregion found within the NPR-A and Arctic National Wildlife Refuge (Alaska Department of Fish and Game, 2015). Another 18% is owned by the State of Alaska, which comprises much of the existing oil and gas infrastructure (Alaska Department of Fish and Game, 2015). Exploration and development within the NPR-A has been largely limited to the last decade, though currently some 2.6 million acres have been leased to companies for future development. Moreover, the Arctic Refuge's 1.5-million-acre "1002 Area" was reopened for oil development by the Trump Administration as part of the Tax Cuts and Jobs Act of 2017 (Allison & Mandler, 2018).

Of course, "as in any ecological system, change is not always proof of an adverse effect" (Herlugson & Parnell, 1996, para. 4). However, it is important to monitor and assess these changes in order to understand their effect on the environment. Last year marked the 30-year anniversary of the Exxon Valdez spill, which dumped approximately 11 million gallons of North Slope crude into the Prince William Sound (Exxon Valdez Oil Spill Trustee Council, n.d.), and this year is the 10th anniversary of the Deepwater Horizon oil spill, which dumped 210 million gallons into the Gulf of Mexico (National Museum of Natural History, 2018). As we look to expand oil development into previously untouched regions, it is more important than ever to understand the impact of these types of events on Arctic habitats and its vulnerable species.

METHODS

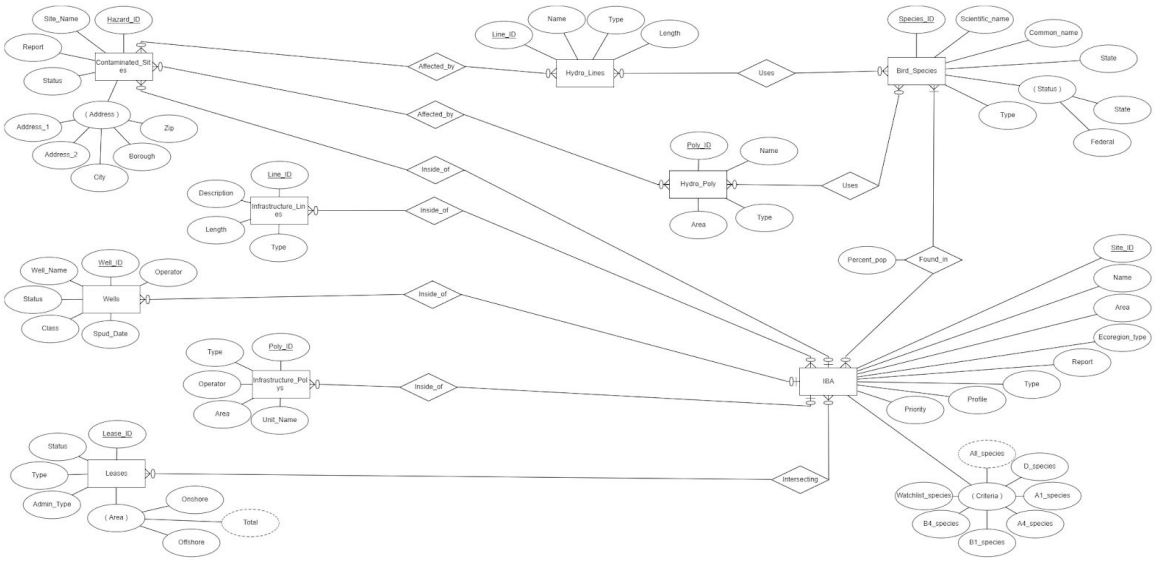
For this project we sought to gain a better understanding of which bird species are most impacted by existing oil development within their habitats on Alaska's North Slope.

Objective	Actions
To understand which species are most impacted by oil development in America's Arctic	Examine the overlap of infrastructure (roads, pipelines, pads, wells, airstrips, and contaminated sites) and bird habitat (Important Bird

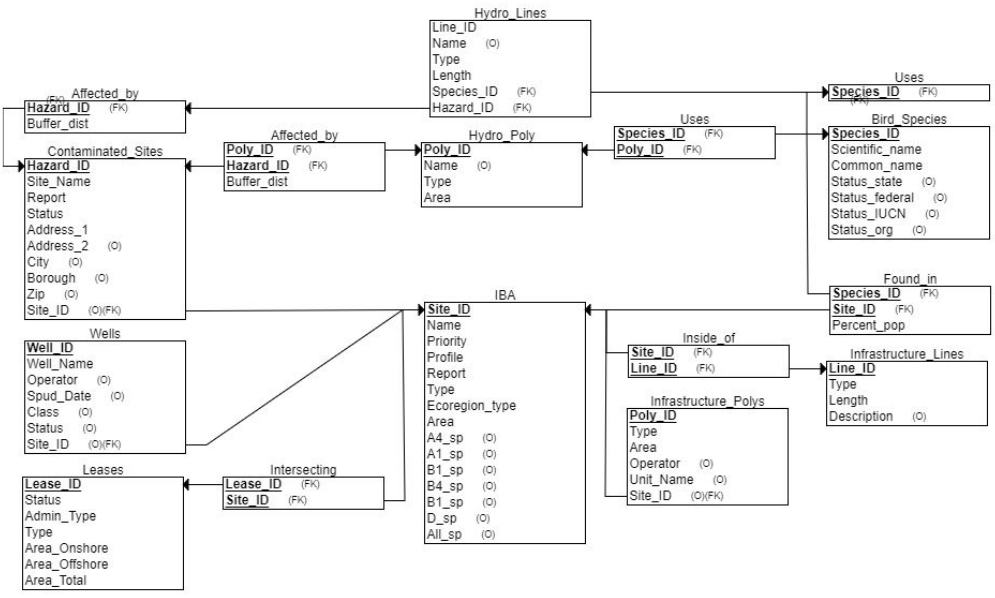
	Areas, wetlands, other water features) on Alaska's North Slope and near-shore Arctic Ocean
	Identify bird species present in the habitat areas affected by oil infrastructure

Database Design

Entity-Relationship Diagram



Relational Schema



Database Implementation

In order to run spatial queries, we created a spatial database using the PostGIS shapefile import tool. First we identified the proper projection, NAD 83 Alaska Albers, from the shapefiles' .prj files and searched spatialreference.org to obtain the spatial reference identifier (SRID): EPSG 3338. After checking all data and applying the projection, eight total datasets were loaded. The following reflects the geometries represented by our datasets: Points(contaminated_sites, wells), MultiLinestring(hydro_lines, infrastructure lines), and MultiPolygons(important_bird_areas, hydro_polys, infrastructure_polys, leases). Finally, we checked all tables for proper SRID and geometry type:

```
SELECT * FROM geometry_columns
```

We also created a geodatabase in ArcGIS desktop to corroborate our PostGIS queries and for cartography. No subtypes were included in the geodatabase.

Database Design			
Feature Dataset	**FeatureClassType**	**Name**	**Alias**
Base	POLY	AK_bndy	Alaska boundary
	POLY	NPRA_bndy	NPRA boundary
	POLY	ANWR_bndy	Arctic Refuge boundary
	POLY	NS_bndy	North Slope boundary
Infrastructure	PNT	Contaminated_sites	Contaminated sites
	PNT	Wells	Wells
	L	Infrastructure_lines	Roads and Pipelines
	POLY	Infrastructure_polys	Pads, airstrips, gravel mines, etc.
	POLY	Leases	Leases
Habitat	L	Hydro_line	Rivers and streams
	POLY	Hydro_poly	Laks, ponds, and wetlands
	POLY	Important_Bird_Areas	IBAs

	tabular	Bird_species	Bird species

Datasets								
Featureclass or table name	**Field name**	**Field type**	**Length**	**AliasName**	**Description**	**Domain Name**	**Default Value**	**IsNullable (Y/N)**
AK_bndy	Area_sqmi	Float		Square miles	Area in square miles			N
NPRA_bndy	Area_sqmi	Float		Square miles	Area in square miles			N
ANWR_bndy	Area_sqmi	Float		Square miles	Area in square miles			N
NS_bndy	Area_sqmi	Float		Square miles	Area in square miles			N
Contaminated_Sites	Hazard_ID	LI		Hazard ID	Unique ID			N
	Site_Name	String	254	Site name	Site name			N
	Site_Repor	String	254	Site report	URL to site report			N
	Status	String	25	Status	Cleanup status	Site_status		N
	Address_1	String	254	Address 1	Street address			Y
	Address_2	String	254	Address 2	Building/apt number			Y
	City	String	25	City	City			Y
	State	String	2	State	State		AK	N
	Zipcode	LI	5	Zipcode	Zipcode			Y
	Borough	String	25	Borough	Borough			Y
Wells	Well_ID	LI		Well ID	Unique ID			N
	Well_Name	String	254	Well Name	Name of well			N
	Operator	String	254	Operator	Name of operator			Y
	Spud_Date	Date		SPUD date	Date drilling began			Y

	Class	String	25	Class	Type of well	Well_class		Y
	Status	String	25	Status	Operational status	Well_status		Y
Infrastructure_Lines	Line_ID	LI		Line ID	Unique ID			N
	Type	String	10	Type	Road or pipeline	Inf_line_type		N
	Length	Float		Length in miles	Length in miles			N
	Description	String	254	Description	Notes and data source			Y
Infrastructure_Polys	Poly_ID	LI		Poly ID	Unique ID			N
	Type	String	50	Type	Type of feature	Inf_poly_type		N
	Area_ac	Float		Acres	Area in acres			N
	Operator	String	50	Operator	Feature operator			Y
	Unit_Name	String	25	Unit Name	Name of unit			Y
Leases	Lease_ID	LI		Lease ID	Unique ID			N
	Status	String	25	Status	Available, leased, or unavailable	Lease_status		N
	Admin_Type	String	10	Admin type	State or federal	Admin_type		N
	Type	String	10	Type	Onshore or offshore	Lease_type		N
	Area_onshore	Float		Onshore area	Acres onshore			N
	Area_offshore	Float		Offshore area	Acres offshore			N
	Area_total	Float		Acres	Total acres			N
Hydro_Lines	Line_ID	LI		Line ID	Unique ID			N
	Name	String	25	Name	Name			Y
	Type	SI		Type	Type	Hydro_line_type		N
	Length	Float		Length	Length in miles			N
Hydro_Poly	Poly_ID	LI		Poly ID	Unique ID			N
	Name	String	25	Name	Name			Y
	Area	Float		Area	Area in acres			N

	Type	String	50	Type	Type	Hydro_poly_type		N
IBA	Site_ID	LI		Site ID	Unique ID			N
	Name	String	50	Name	IBA name			N
	Area	Float		Area	Area in acres			N
	Ecoregion_type	String	25	Ecoregion type	Ecoregion type	Ecoregion_type		N
	Report	String	254	Report URL	URL to site report			N
	Type	String	25	Type	IBA type	IBA_type		N
	Profile	String	254	Profile URL	URL to site profile			N
	Priority	String	25	Priority	Priority	IBA_priority		N
	A4_sp	String	100	A4 species	A4 criteria species			Y
	A1_sp	String	100	A1 species	A1 criteria species			Y
	B4_sp	String	100	B4 species	B4 criteria species			Y
	B1_sp	String	100	B1 species	B1 criteria species			Y
	D_sp	String	100	D species	D criteria species			Y
	All_sp	String	100	All criteria species	All criteria species			Y
Bird_Species	Species_ID	String	4	Species ID	Unique ID			N
	Scientific_name	String	50	Scientific name	Scientific name			N
	Common_name	String	50	Common name	Common name			N
	Status_state	String	25	State Status	State conservation status	Status_st		Y
	Status_fed	String	25	Federal Status	Federal Conservation status	Status_fed		Y
	Status_IUCN	String	25	IUCN Status	IUCN conservation status	Status_IUCN		Y

	Status_org	String	25	Audubon Status	Audubon conservation status	Status_org		Y

Domains						
Domain name	**Description**	**Field type**	**Length**	**Domain type**	**Coded values/Range Code (Min)**	**Desc(Max)**
Well_status	Operational status of well	Text	25	Coded values	Abandoned	Abandoned well
					Injector	Injecting
					Producer	Producing
					Suspended	Suspended
					Other	Other not listed
Well_class	Type of well	Text	25	Coded values	Delineation Well	Delineation Well
					Development Well	Development Well
					Exploratory Well	Exploratory Well
					Relief Well	Relief Well
					Service Well	Service Well
					Test Hole	Test hole
					Other	Other not listed
Site_status	Cleanup status of contaminated site	Text	25	Coded values	Active	Active site
					Cleanup complete	Cleanup complete
					Cleanup complete with institutional controls in place	Cleanup complete with institutional controls in place
					Informational	Informational
Inf_line_type	Infrastructure line type	Text	10	Coded values	Road	Road
					Pipeline	Pipeline
Lease_status	Status of lease	Text	25	Coded values	Available	Available for lease
					Unavailable	Not leased or offered for lease

					Leased	Currently leased
Admin_type	Administration type for leases	Text	10	Coded values	Federal	Federal
					State	State
Lease_type	Type of lease	Text	10	Coded values	Offshore	Offshore lease
					Onshore	Onshore lease
Hydro_line_type	Type of river	SI		Coded values	1	Minor river
					2	Major river
Hydro_poly_type	Type of hydrology polygon	Text		Coded values	Estuarine and Marine Deepwater	Estuarine and Marine Deepwater
					Estuarine and Marine Wetland	Estuarine and Marine Wetland
					Freshwater Emergent Wetland	Freshwater Emergent Wetland
					Freshwater Forested/Shrub Wetland	Freshwater Forested/Shrub Wetland
					Freshwater Pond	Freshwater Pond
					Lake	Lake
					Riverine	River
					Other	Other not listed
Ecoregion_type	Type of ecoregion	Text	25	Coded values	Marine ecoregion	Ocean-based IBA
					Terrestrial ecoregion	Land-based IBA
IBA_type	Type of IBA	Text	25	Coded values	Coastal	Land-coastal
					Colony	Bird colony
					Interior	Land-interior
					Marine	Ocean
IBA_priority	IBA priority	Text	25	Coded values	Continental	Recognized Continental
					Global	Recognized Global
					State	Recognized State

					Potential Continental	Proposed Continental
					Potential Global	Proposed Global
					Potential State	Proposed State
Status_st	State conservation status	Text	25	Coded values	Endangered	Endangered Species
					Special Concern	Species of Special Concern
					None	None
Status_fed	Federal conservation status	Text	25	Coded values	Endangered	Endangered Species
					Threatened	Threatened Species
					Proposed	Proposed for protection under ESA
					None	None
Status_IUCN	International conservation status	Text	25	Coded values	EX	Extinct
					EW	Extinct in the wild
					CR	Critically endangered
					EN	Endangered Species
					VU	Vulnerable Species
					NT	Near threatened
					LC	Least concern
					DD	Data deficient
					NE	Not evaluated
Status_org	Audubon's conservation status	Text	25	Coded values	RL	Red List
					YL	Yellow List
					WL	Watchlist
					None	None

Database Manipulation

Once the proper SRID was attributed to the data and tables were loaded in PostgreSQL, queries were run to answer the problems. We focused on spatial queries composed of inner joins. There were two main types of queries used in this study. A full list of queries and their results can be found in Appendix A (page 23).

The first type aimed to quantify data that lies inside of Important Bird Areas and therefore relied on spatial functions. Important query results consisted of contaminated sites, wells, and various other infrastructure and features located within IBAs. These queries relied on joining the corresponding data to the IBA spatial data and then using the ST_Within spatial function.

The second type relied mainly on measuring how far contaminated sites were from hydrologic features, infrastructure, or IBAs. After choosing a distance of 100 meters, we then grouped results according to the contaminated sites' status.

RESULTS AND DISCUSSION

The North Slope is home to 11 Important Bird Areas (IBAs), nine of which contain some type of oil infrastructure, site of contamination, and/or lease. These nine IBAs are the Teshekpuk Lake Area, Kasegaluk Lagoon, Lower Coleville River, Beaufort Sea Nearshore, Northeast Arctic Coastal Plain, Barrow Canyon and Smith Bay, Chukchi Sea Nearshore, and Colville River Delta. The two remaining IBAs, Ledyard Bay to Icy Cape and Lisburne Peninsula Marine, which are untouched by oil development, are the most remote IBAs in the study area.

Roads and Pipelines

Only two of the IBAs contain roads and pipelines: Colville River Delta and Beaufort Sea Nearshore. They contain a combined total of 45.6 miles of pipelines and 38.4 miles of roads. The Colville River Delta, however, has 81% of the pipelines and 88% of the roads, with 37.1 and 33.6 miles, respectively.

Airstrips, Gravel Pads, and other Oil Infrastructure

Three IBAs contain airstrips, gravel pads, and/or other oil infrastructure polygons. The Chukchi Sea Nearshore IBA contains 1,633.2 acres of infrastructure polygons, while the Barrow Canyon and Smith Bay IBA contains 1,500 acres, and the Beaufort Sea Nearshore IBA contains 747.6 acres.

Wells

Eight of the ten IBAs contain wells. The Beaufort Sea Nearshore IBA contains 462 wells representing 55% of all wells in North Slope IBAs, while the Colville River Delta IBA contains 329 wells representing another 39%; the Teshekpuk Lake Area IBA contains 22 wells representing just 3%; the Lower Colville River IBA contains 14 wells; the Barrow Canyon and Smith Bay IBA contains six, the Northeast Arctic Coastal Plain IBA and Chukchi Sea Nearshore IBAs each contain three, and the Kasegaluk Lagoon contains one.

Contaminated Sites

There are 77 total contaminated sites within all North Slope IBAs. Forty-five have Cleanup Complete, 27 are Active, three have Cleanup Complete with Institutional Controls, and two are Informational. These sites fall within eight different IBAs. Teshekpuk Lake Area IBA contains 19 total sites, one of which is Active and 18 of which are Cleanup Complete. The Kasegaluk Lagoon has 17 total sites, with 10 Active and four Cleanup Complete. The Lower Colville River IBA has 16 total sites, 13 Active and three Cleanup Complete; Beaufort Nearshore IBA has 11 total, one Active, and nine Cleanup Complete; Northeast Arctic Coastal Plain IBA has 10 total sites, one Active and eight Cleanup Complete; Barrow Canyon and Smith Bay IBA had two total sites, both of which are Cleanup Complete; Chukchi Sea Nearshore IBA has one total site that is Cleanup Complete, and the Colville River Delta IBA had one total site that remains Active.

In terms of likely contamination sources, 213 sites fall within 100m of a road or pipeline: 182 within 100 meters of a road and another 35 within 100 meters of a pipeline. Of the 213 sites, 94 are Cleanup Complete, 84 are Cleanup Complete with Institutional Controls, and 35 remain Active. Another 343 contaminated sites fell within 100 meters of a well, with 126 of them

Cleanup Complete, 122 of them Cleanup Complete with Institutional Controls, 65 of them Active, and 35 of them Informational.

Regarding contamination impacts, 684 contaminated sites fell within 100 meters of a lake, pond, wetland, or other polygon water feature. Nearly one-half of these sites, 340 of them, were Cleanup Complete, while another 170 were Cleanup Complete with Institutional Controls. A full 159 sites were Active, and another 15 were Informational. Another 49 total sites fell within 100m of a river or stream. Of these, 21 were Cleanup Complete, 13 were Active, 10 were Cleanup Complete with Institutional Controls, and five were informational.

Leases

Active leases totaling more than 1.5 million acres are present across six of ten IBAs. The Beaufort Sea Nearshore IBA contains 521,216 acres, approximately one-third of all active leases within IBAs. Teshekpuk Lake Area IBA contains 388, 434 acres of active leases, with the Colville River Delta IBA close behind at 276,713 acres. The Lower Colville River IBA contains 226,700 acres of active leases; the Barrow Canyon and Smith Bay IBA contains 56,550 acres; and the Northeast Arctic Coastal Plain IBA contains 16,125 acres.

All of the queries documenting infrastructure within IBAs also yielded a list of species that are either 1) found within those IBAs in large numbers or 2) are threatened or endangered at the state, federal, or global level. A full list of these species can be found in Appendix B (page 31).

CONCLUSION

While few studies have been done exploring the legacy of change that gravel roads leave on the surrounding environment, they have been shown to cause “apparently permanent geophysical changes to the landscape, altering permafrost freeze-and-thaw cycles and creating topographic features known as thermokarst” (Sullender, 2017). Though the effects of thermokarst on species are “not well understood” (Sullender, 2017), they have been observed to include the destruction of habitat for terrestrial birds and the formation of new habitat for aquatic

birds (Rowley & Pritek, 2015). The long term ecological impacts of pipelines are equally concerning as they are frequently a source of contamination. In 2001, a drunken hunter shot a hole in the Trans-Alaska Pipeline System near Fairbanks: within 36 hours 285,000 gallons of crude oil was spilled into the surrounding environment (The Wilderness Society, 2005). In 2009, a pipeline in Prudhoe Bay ruptured, spilling an estimated 46,000 gallons of oil and other contaminants, contaminating approximately 8,400 square feet of tundra (National Research Council, 2003).

The impacts of roads and pipelines are of particular importance in the Colville River Delta IBA. Sixty-eight species regularly breed in the delta, which is of particular importance to Black Brant (as much as 5% of the Pacific population is supported by the delta) and Spectacled Eider (a threatened species under the United States Endangered Species Act) as well as Yellow-Billed Loon, American Golden-Plover and Stilt Sandpiper. The development of more roads and pipelines has been proposed within this IBA as part of ConocoPhillips Alpine West/CD5 project expansion.

Wells and contaminated sites are yet another reason for concern. A study from the early 2000s "observed that 177 spills of greater than 50 gallons to the tundra totaled 691,173 gallons associated with the oil and gas operations on the North Slope" (The Wilderness Society, 2005). Meanwhile, the cold temperatures, slow growth rates, and long life spans of animals associated with North Slope ecosystems mean that they take longer to recover from contamination (The Wilderness Society, 2005). The presence of 77 contaminated sites within North Slope IBAs is therefore particularly troubling. Of particular importance is the impact of contamination on the Teshekpuk Lake Area IBA. The Teshekpuk Lake wetlands are one of the most important goose

molting habitats in the Arctic: as many as 35,000 Greater White-fronted Geese and 37,000 Brant have been known to molt in this region annually. Teshekpuk Lake is also important to several threatened species, including Spectacled Eiders, King Eiders, Red-throated Loons, Dunlins, and Buff-breasted Sandpipers. While Teshekpuk Lake has remained off-limits to oil development for several decades, the existence of wells and contaminated sites within its boundaries suggest that nearby development may be encroaching on this important region.

The impacts of active leases are perhaps least clear. Many active state leases contain infrastructure, as represented by the Beaufort Sea Nearshore IBA, which not only contains one-third of all active leases but also the largest number of wells. The Beaufort Sea Nearshore IBA is notable for its large populations of Glaucous Gull and Long-tailed Duck. An estimated 20,000 Glaucous Gulls and 300,000 Long-tailed Ducks breed within this IBA, representing significant percentages of the global populations of both species. As this region lies primarily in open water, it is an important region in which to consider the impacts of existing and proposed offshore oil drilling. Most active federal leases, particularly those within the NPR-A, however, remain undeveloped. As such, active federal leases may serve as a predictor of future development.

This project has largely sought to quantify the various types of oil infrastructure on Important Bird Areas and other habitat features, such as rivers, streams, wetlands, and tundra ponds on Alaska's North Slope. It is our recommendation that future research focus on the direct and indirect effects of this infrastructure, including roads, pipelines, wells, airstrips, and gravel pads on both the North Slope environment and its unique array of species.

Acknowledgements

The authors would like to thank Audubon Alaska for granting us access to their data.

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Appendices

Appendix A: Database Manipulations

A.1: Miles of Pipeline Located in Important Bird Areas and Impacted Species

```
SELECT iba.name, iba.all_sp, SUM(length_mi) AS "miles_of_pipeline"
FROM infrastructure_lines AS i
JOIN important_bird_areas AS iba
ON ST_WITHIN(i.geom, iba.geom)
WHERE i.type = 'pipeline'
GROUP BY iba.name, iba.all_sp
ORDER BY SUM(length_mi) DESC;
```

Important Bird Area	Bird Species ID	Miles of Pipeline
Colville River Delta	AMGP; BLBR; BLSC; GLGU; GOEA; GWFG; LTDU; PALO; RTLO; SAGU; SPEI; STEI; TUSW; YBLO	37.08992119374
Beaufort Sea Nearshore	ARTE; BLBR; BLKI; BLSC; COEI; GLGU; KIEI; LTDU; PALO; REPH; RTLO; SUSC; WWSC; YBLO	8.5532995040626

A.2: Miles of Roads Located in Important Bird Areas and Impacted Species

```
SELECT iba.name, iba.all_sp, SUM(length_mi) AS "miles_of_road"
FROM infrastructure_lines AS i
JOIN important_bird_areas AS iba
ON ST_WITHIN(i.geom, iba.geom)
WHERE i.type = 'road'
GROUP BY iba.name, iba.all_sp;
```

Important Bird Area	Bird Species ID	Miles of Roads
Beaufort Sea Nearshore	ARTE; BLBR; BLKI; BLSC; COEI; GLGU; KIEI; LTDU; PALO; REPH; RTLO; SUSC; WWSC; YBLO	4.8287680363787
Colville River Delta	AMGP; BLBR; BLSC; GLGU; GOEA; GWFG; LTDU; PALO; RTLO; SAGU; SPEI; STEI; TUSW; YBLO	33.626569649492

A.3: Wells Located in Important Bird Areas and Impacted Species

```
SELECT iba.name, iba.all_sp, COUNT(w) FROM wells AS w
JOIN important_bird_areas AS iba
ON ST_CONTAINS(iba.geom, w.geom)
GROUP BY iba.name, iba.all_sp
ORDER BY COUNT(w) DESC;
```

Important Bird Area	Bird Species ID	Number of Wells
Beaufort Sea Nearshore	ARTE; BLBR; BLKI; BLSC; COEI; GLGU; KIEI; LTDU; PALO; REPH; RTLO; SUSC; WWSC; YBLO	462
Colville River Delta	AMGP; BLBR; BLSC; GLGU; GOEA; GWFG; LTDU; PALO; RTLO; SAGU; SPEI; STEI; TUSW; YBLO	329
Teshekpuk Lake Area	AMGP; ARTE; BBPL; BBSA; BLBR; BLSC; BTGO; CACG; CAGO; DUNL; EMGO; GLGU; GOEA; GWFG; LBDO; LTDU; NOPI; PALO; PESA; REPH; RNPH; RTLO; SAGU; SEOW; SESA; SNGO; SPEI; STEI; STSA; TUSW; YBLO	22
Lower Colville River	GYRF; PEFA; YBLO	14
Barrow Canyon & Smith Bay	ARTE; BLBR; BLKI; COEI; GLGU; KIEI; LTDU; PALO; POJA; REPH; RTLO; SAGU; YBLO	6
Northeast Arctic Coastal Plain	AMGP; BBSA; DUNL; GOEA; PESA; REPH; RNPH; RTLO; RUTU; SEPL; SESA; SNGO; STSA; WHIM	3
Chukchi Sea Nearshore	ARTE; BLKI; COEI; GLGU; LTDU; POJA; REPH; RTLO; SAGU	3
Kasegaluk Lagoon	ALTE; BLBR; COEI; DUNL; GLGU; GWFG; LTDU; RTLO; SPEI	1

A.4: Number of Contaminated Sites by Status Located in Important Bird Areas

```
SELECT c.status, COUNT(c)
FROM contaminated_sites AS c
JOIN important_bird_areas AS iba
ON ST_Contains(iba.geom, c.geom)
```

```
GROUP BY c.status;
```

Status	Number of Contaminated Sites
Cleanup Complete	45
Active	27
Cleanup Complete - Institutional Controls	3
Informational	2

A.5: Number of Contaminated Sites Within Important Bird Areas and Impacted Species

```
SELECT iba.name, iba.all_sp, COUNT(*) AS "number_contaminated"
FROM contaminated_sites AS c
JOIN important_bird_areas AS iba
ON ST_Contains(iba.geom, c.geom)
GROUP BY iba.name, iba.all_sp
ORDER BY COUNT(c) DESC;
```

Important Bird Area	Bird Species ID	Number of Contaminated Sites
Teshekpuk Lake Area	AMGP; ARTE; BBPL; BBSA; BLBR; BLSC; BTGO; CACG; CAGO; DUNL; EMGO; GLGU; GOEA; GWFG; LBDO; LTDU; NOPI; PALO; PESA; REPH; RNPH; RTLO; SAGU; SEOW; SESA; SNGO; SPEI; STEI; STSA; TUSW; YBLO	19
Kasegaluk Lagoon	ALTE; BLBR; COEI; DUNL; GLGU; GWFG; LTDU; RTLO; SPEI	17
Lower Colville River	GYRF; PEFA; YBLO	16
Beaufort Sea Nearshore	ARTE; BLBR; BLKI; BLSC; COEI; GLGU; KIEI; LTDU; PALO; REPH; RTLO; SUSC; WWSC; YBLO	11
Northeast Arctic Coastal Plain	AMGP; BBSA; DUNL; GOEA; PESA; REPH; RNPH; RTLO; RUTU; SEPL; SESA; SNGO; STSA; WHIM	10
Barrow Canyon & Smith Bay	ARTE; BLBR; BLKI; COEI; GLGU; KIEI; LTDU; PALO; POJA; REPH; RTLO; SAGU; YBLO	2
Chukchi Sea Nearshore	ARTE; BLKI; COEI; GLGU; LTDU; POJA; REPH; RTLO; SAGU	1

Colville River Delta	AMGP; BLBR; BLSC; GLGU; GOEA; GWFG; LTDU; PALO; RTLO; SAGU; SPEI; STEI; TUSW; YBLO	1

A.6: Active Contamination Sites Located in Important Bird Areas and Impacted Species

```
SELECT iba.name, iba.all_sp, COUNT(*) AS
"number_active_contaminated"
FROM contaminated_sites AS c
JOIN important_bird_areas AS iba
ON ST_Contains(iba.geom, c.geom)
WHERE c.status = 'Active'
GROUP BY iba.name, iba.all_sp
ORDER BY COUNT(c) DESC;
```

Important Bird Area	Bird Species ID	Number of Active Contamination Sites
Lower Colville River	GYRF; PEFA; YBLO	13
Kasegaluk Lagoon	ALTE; BLBR; COEI; DUNL; GLGU; GWFG; LTDU; RTLO; SPEI	10
Beaufort Sea Nearshore	ARTE; BLBR; BLKI; BLSC; COEI; GLGU; KIEI; LTDU; PALO; REPH; RTLO; SUSC; WWSC; YBLO	1
Colville River Delta	AMGP; BLBR; BLSC; GLGU; GOEA; GWFG; LTDU; PALO; RTLO; SAGU; SPEI; STEI; TUSW; YBLO	1
Northeast Arctic Coastal Plain	AMGP; BBSA; DUNL; GOEA; PESA; REPH; RNPH; RTLO; RUTU; SEPL; SESA; SNGO; STSA; WHIM	1
Teshekpuk Lake Area	AMGP; ARTE; BBPL; BBSA; BLBR; BLSC; BTGO; CACG; CAGO; DUNL; EMGO; GLGU; GOEA; GWFG; LBDO; LTDU; NOPI; PALO; PESA; REPH; RNPH; RTLO; SAGU; SEOW; SESA; SNGO; SPEI; STEI; STSA; TUSW; YBLO	1

A.7: Number of Completed Cleanup Sites Located in Important Bird Areas and Impacted Species

```
SELECT iba.name, iba.all_sp, COUNT(*) AS
"number_cleanup_completed_sites"
FROM contaminated_sites AS c
JOIN important_bird_areas AS iba
ON ST_Contains(iba.geom, c.geom)
WHERE c.status = 'Cleanup Complete'
GROUP BY iba.name, iba.all_sp
ORDER BY COUNT(c) DESC;
```

Important Bird Area	Bird Species ID	Number of Completed Cleanup Sites
Teshekpuk Lake Area	AMGP; ARTE; BBPL; BBSA; BLBR; BLSC; BTGO; CACG; CAGO; DUNL; EMGO; GLGU; GOEA; GWFG; LBDO; LTDU; NOPI; PALO; PESA; REPH; RNPH; RTLO; SAGU; SEOW; SESA; SNGO; SPEI; STEI; STSA; TUSW; YBLO	18
Beaufort Sea Nearshore	ARTE; BLBR; BLKI; BLSC; COEI; GLGU; KIEI; LTDU; PALO; REPH; RTLO; SUSC; WWSC; YBLO	9
Northeast Arctic Coastal Plain	AMGP; BBSA; DUNL; GOEA; PESA; REPH; RNPH; RTLO; RUTU; SEPL; SESA; SNGO; STSA; WHIM	8
Kasegaluk Lagoon	ALTE; BLBR; COEI; DUNL; GLGU; GWFG; LTDU; RTLO; SPEI	4
Lower Colville River	GYRF; PEFA; YBLO	3
Barrow Canyon & Smith Bay	ARTE; BLBR; BLKI; COEI; GLGU; KIEI; LTDU; PALO; POJA; REPH; RTLO; SAGU; YBLO	2
Chukchi Sea Nearshore	ARTE; BLKI; COEI; GLGU; LTDU; POJA; REPH; RTLO; SAGU	1

A.8: Number of Contaminated Sites Located Within 100 meters of Pipelines

```
Select c.status, COUNT(c)
FROM contaminated_sites AS c
JOIN infrastructure_lines AS il
ON ST_DWithin(c.geom, il.geom, 100)
WHERE il.type = 'pipeline'
```

```
GROUP BY c.status;
```

Status	Number of Contaminated Sites Within 100 Meters of a Pipeline
Cleanup Complete - Institutional Controls	14
Cleanup Complete	9
Active	7
Informational	1

A.9: Number of Contaminated Sites Located Within 100 meters of Roads

```
Select c.status, COUNT(c)
FROM contaminated_sites AS c
JOIN infrastructure_lines AS il
ON ST_DWithin(c.geom, il.geom, 100)
WHERE il.type = 'road'
GROUP BY c.status;
```

Status	Number of Contaminated Sites Within 100 Meters of a Road
Cleanup Complete	94
Cleanup Complete - Institutional Controls	84
Active	35

A.10: Number of Contaminated Sites by Status Located Within 100 Meters of a Well

```
SELECT c.status, COUNT(c)
FROM contaminated_sites AS c
JOIN wells AS w
ON ST_DWithin(w.geom, c.geom, 100)
GROUP BY c.status;
```

Status	Number of Contaminated Sites Within 100 Meters of a Well
Cleanup Complete	126
Cleanup Complete - Institutional Controls	122
Active	65

Informational	35

A.11: Number of Contaminated Sites by Status Located Within 100 Meters of Lakes or Wetlands

```
Select c.status, COUNT(C)
FROM contaminated_sites AS c
JOIN hydro_poly AS hydro
ON ST_DWithin(hydro.geom, c.geom, 100)
GROUP BY c.status
ORDER BY COUNT(c) DESC;
```

Status	Number of Contaminated Sites Within 100 Meters of Lakes or Wetlands
Cleanup Complete	340
Cleanup Complete - Institutional Controls	170
Active	159
Informational	15

A.12: Contaminated Sites Located Within 100 Meters of Rivers or Streams

```
Select c.status, COUNT(c)
FROM contaminated_sites AS c
JOIN hydro_line AS r
ON ST_DWithin(r.geom, c.geom, 100)
GROUP BY c.status;
```

Status	Number of Contaminated Sites Within 100 Meters of Rivers or Streams
Active	13
Cleanup Complete	21
Cleanup Complete - Institutional Controls	10
Informational	5

A.13: Acres of Active Leases Located in Important Bird Areas and Impacted Species

```
SELECT iba.name, iba.all_sp, SUM(l.area_total) AS "Total Leased
Area"
FROM Leases AS l
JOIN important_bird_areas AS iba
ON l.status = 'leased' AND ST_OVERLAPS(iba.geom, l.geom)
GROUP BY iba.name, iba.all_sp;
```

Important Bird Area	Bird Species ID	Total Acres of Active Leases
Barrow Canyon & Smith Bay	ARTE; BLBR; BLKI; COEI; GLGU; KIEI; LTDU; PALO; POJA; REPH; RTLO; SAGU; YBLO	56550.07
Beaufort Sea Nearshore	ARTE; BLBR; BLKI; BLSC; COEI; GLGU; KIEI; LTDU; PALO; REPH; RTLO; SUSC; WWSC; YBLO	521215.8
Colville River Delta	AMGP; BLBR; BLSC; GLGU; GOEA; GWFG; LTDU; PALO; RTLO; SAGU; SPEI; STEI; TUSW; YBLO	376712.9
Lower Colville River	GYRF; PEFA; YBLO	226700.4
Northeast Arctic Coastal Plain	AMGP; BBSA; DUNL; GOEA; PESA; REPH; RNPH; RTLO; RUTU; SEPL; SESA; SNGO; STSA; WHIM	16125
Teshekpuk Lake Area	AMGP; ARTE; BBPL; BBSA; BLBR; BLSC; BTGO; CACG; CAGO; DUNL; EMGO; GLGU; GOEA; GWFG; LBDO; LTDU; NOPI; PALO; PESA; REPH; RNPH; RTLO; SAGU; SEOW; SESA; SNGO; SPEI; STEI; STSA; TUSW; YBLO	388434.7

Appendix B: Bird Species ID and Conservation Status

Species_Name	Species_ID	Status_State	Status_Federal	Status_IUCN	Status_Audubon
American Golden-Plover	AMGP			Least Concern	Red List
Buff-breasted Sandpiper	BBSA			Near Threatened	Red List
Pectoral Sandpiper	PESA			Least Concern	Red List
Yellow-billed Loon	YBLO			Near Threatened	Red List
Glaucous Gull	GLGU			Least Concern	
Pomarine Jaeger	POJA			Least Concern	
Black-legged Kittiwake	BLKI			Vulnerable	Red List
Black Brant	BLBR				
Common Eider	COEI			Near Threatened	
King Eider	KIEI			Least Concern	Yellow List
Long-tailed Duck	LTDU			Vulnerable	Watch List
Red-throated Loon	RTLO			Least Concern	Watch List
Surf Scoter	SUSC			Least Concern	Watch List
White-winged Scoter	WWSC			Least Concern	
Sabine's Gull	SAGU			Least Concern	
Arctic Tern	ARTE			Least Concern	Watch List
Red Phalarope	REPH			Least Concern	
Black-bellied Plover	BBPL			Least Concern	
Dunlin	DUNL			Least Concern	Red List
Greater White-fronted Goose	GWFG			Least Concern	Yellow List
Long-billed Dowitcher	LBDO			Least Concern	
Red-necked Phalarope	RNPH			Least Concern	Watch List
Semipalmated Sandpiper	SESA			Near Threatened	

Stilt Sandpiper	STSA			Least Concern	Watch List
Tundra Swan	TUSW			Least Concern	
Black Scoter	BLSC			Near Threatened	Red List
Steller's Eider	STEI		Threatened	Vulnerable	Red List
Emperor Goose	EMGO			Near Threatened	Yellow List
Snow Goose	SNGO			Least Concern	
Whimbrel	WHIM			Least Concern	Yellow List
Cackling Goose	CACG			Least Concern	Yellow List
Peregrine Falcon	PEFA			Least Concern	
Spectacled Eider	SPEI		Threatened	Near Threatened	Red List
Bar-tailed Godwit	BTGO			Near Threatened	Red List
Short-eared Owl	SEOW			Least Concern	Watch List
Gyrfalcon	GYRF			Least Concern	
Golden Eagle	GOEA			Least Concern	
Ruddy Turnstone	RUTU			Least Concern	
Semipalmated Plover	SEPL			Least Concern	
Pacific Loon	PALO			Least Concern	Watch List
Canada Goose	CAGO			Least Concern	Red List
Northern Pintail	NOPI			Least Concern	
Aleutian Tern	ALTE			Vulnerable	Red List