Environment

The Arctic National Wildlife Refuge is a diverse but fragile ecosystem. The 1002 region in particular, a coastal strip caught between the Brooks Range Mountains and the Beaufort Sea, is an intricate network of species and their surroundings that stand to be severely damaged by human activities. It is essential to establish a baseline of the ANWR ecosystem in order to create an assessment of the effects of oil drilling on its well-being and to take the proper precautions to preserve it.

In order to create a comprehensive model of the ecosystem, we have to set up the important parameters and components that define an ecosystem. Based on ecological models from multiple references, we have determined the main constituents of an ecosystem to include the following: geography structure and relief, climate, soils, hydrology, producers and consumers, decomposition and soil processes, energy and nutrient cycling, and interaction between terrestrial and aquatic communities (if relevant to the area of study). By developing a descriptive and quantitative model for each constituent we can compile the information for the structure and function of the ANWR ecosystem.

Surface Operations

Physical Environment

Biodiversity

Terrestrial

Avian

Plants

Decomposers

Environmental Implications - Surface Operations

Impact Report: Surface Operations

Of all the aspects of surface operations (pad construction, camp construction, personnel, dining, lodging, maintenance shops, water plants, waste water plants) the largest impact will be caused by the physical existence of the drilling pad. However, all activity has impact, just varying in terms of duration and geographic scope. The impacts of this are listed below, along with a rating of significance. The rating of significance is based on the intensity (magnitude, geographic scope, and frequency/duration) and the probability of occurrence, with the scale being high, moderate, or low. Probability of biological impacts is extremely difficult to predict. Thus, the probability should be evaluated in the context of professional judgment and past occurrences of impacts. In ANWR this is complicated because there has been no prior development to reference to.

ELEVATED PLATFORM

- Support: Steel poles

o Direct impact on permafrost.

> Depending on metal used and extent of insulation from high temperature drilling equipment, thawing may occur.

o Attraction for curious, nesting, or hiding animals.

> :: Significance:

o Intensity

> Magnitude: (LOW) Animals might be scared away from the poles, but since the poles would not block migration, feeding or breeding it is unlikely that it would directly change the size or geographic range of an animal or plant population. The permafrost melting could be minimized with the correct insulation and/or materials.
>
> Geographic Scope: (LOW) The effect would be site specific at a few locations.
>
> Frequency: (HIGH) The poles would be permanently in place
>
> Duration: (LOW) The poles will be removed after the extraction of oil is complete, and therefore will have a finite life of impact

- Operating Surface: Aluminum sheets
o Damage to tundra vegetation by oil leaks
o Damage to tundra vegetation by shading

> Could be reduced by having slots or small holes in the pad, allowing some light to get through
>
> :: Significance:

o Intensity

Magnitude: (LOW) This depends on the amount of oil leaked. But since the tundra beneath the platform is already (at least nearly) dead it seems that the effects from oil spills would be a minimal addition to any unavoidable vegetation damage. Animals might come in contact with some leaking oil, but very minimal amounts, and not likely enough to alter an entire population.

Geographic Scope: (LOW) The effect would be site specific at a few locations.

Frequency: (HIGH) The platform would be permanently in place

Duration: (LOW) The pad will be removed after the extraction of oil is complete, and therefore will have a finite life of impact

CONSTRUCTION

- Transportation of the pieces: Helicopter

o Flight will create noise that may be detectable to animals on the ground surface, and occasionally wintering birds

Increased flight elevation will significantly diminish the severity

o No landing pad will be needed as the pieces are to be lowered into place.

Will be increased by holes in pad

:: Significance:

o Intensity

Magnitude: (MODERATE) The impact from the period of construction and removal is understood to be very harsh on both tundra and animals. However, it would not be enough to directly change the size or geographic range of an animal or plant population.

Geographic Scope: (LOW) If the parts are flown in by helicopter, the impact will be site specific at a few locations. If land transport is used then a larger impact might occur.

Frequency: (HIGH) Personnel or equipment would most likely be at the site throughout the construction period

Duration: (LOW) Construction will be very small in terms of the life of the pad, and therefore will have a finite time of impact. The use of the aluminum platform allows for an even smaller construction period, than gravel pads, because gravel pads must wait for the completion of ice roads.

REQUIREMENTS OF PERSONNEL

- Sewage Disposal

o Transport of solids will have noise effects and need for further development of helicopter/plane landing and pumping facilities

> This will also be a constant need for gasoline (defeating the purpose of drilling)

o Disposal in or on the tundra will impact the chemical composition of the tundra, and could be especially harmful if water sources are affected.

> Possibilities for reuse/recycling should be considered

- Fresh Water

o Fresh water for human use is scarce on the North Slope. Any large needs would deplete fresh water sources for animals, thus possibly beginning a chain of impact through the ecosystem
o Wetland ecosystems would be disturbed by the collection or piping of water from them

> Possibilities for desalinization should be considered

- Food

o Transportation of food would cause impacts. See below.
o Storage of food might attract animals.
o Disposal of trash. Might attract animals. Must be flown out eventually (See below).
Note: Possibility in all this for introduction of an invasive species of plant or animal.

- Transportation: People and supplies

o Noise effects from air travel
o Tundra and animals impacted from landing pad/equipment

> Ideally a helicopter landing-pad would be on the housing platform adjacent to the drilling platform, to minimize direct tundra impact.

1. Non-seismic exploration

Due to the fact that magnetic and gravitation exploration do not give off magnetic waves, the only effects produced by this method are caused by the service operations associated with the method.
The effects are:
Due to the airplanes used, there will be noise pollution. In addition to that, the nitrous oxides and carbon monoxide produced will reduce the air quality. Mild, wide-spread, short-term.
Any surface operations necessary will be conducted by attaching the magnetic exploration equipment to seismic exploration trucks thus requiring no extra vehicles of transport.

2. Seismic Exploration

A very useful tool that we relied on when conducting our evaluation is the Seismic exploration that was conducted along the coastal plain of the Arctic Refuge during the winters of 1984 and 1985.

Also note that 3-Dimensional subsurface image creation requires a much denser grid than that required for 2-D. The 1984-85 trails were usually four miles apart, whereas the 3-D seismic trails that are currently impacting areas where they are in use are about half a mile (or less) apart. This means that the tracked vehicles will basically blanket the area. 3-D crews are twice the size of 2-D crews, so more than twice the tracked vehicles are out on the tundra (more equipment and more bulldozers to transport the camps). Furthermore, the turns that the heavy equipment need to make are much tighter in 3-D seismic than they are in 2-D seismic, so the damage made to vegetation and the tundra in general is greater.

Strong winds usually blow the snow into depressions, leaving the higher areas with thinner snow cover and making them much more susceptible to impacts from vehicle tracks. After the 1984-85 seismic exploration 1400 miles of trails that have been made by drill, vibrator and recording vehicles impacted the tundra. In addition to the trails left by the exploration equipment, trails were also created by D-7 Caterpillar tractors that pulled ski-mounted trailer-trains between work camps. In 1999, 15 years after the exploration conducted a significant amount of the trails persisted. Some of them became troughs that are visible from the air (all vegetation removed). In other trails, the amount and type of vegetation present changed. This implies that the entire food-web dependant on this vegetation is affected and altered. Animals can be displaced out of their original habitats if their source of food is no longer available. In other areas, permafrost melted and the trails remained wetter than they previously were. Severe, localized, long-term.

Even though the caribou and birds are usually absent from the 1002 Area during the winter months, there are several species that are adapted to the harsh conditions and that remain in the area during the winter. These species are likely to be affected by the seismic exploration activities. They include primarily muskoxen and polar bears, but there are also other species including wolverine, arctic fox and arctic grayling. In addition, the sensitive arctic tundra vegetation is affected. Moderate, localized, short-term.

3. Transportation:

a. Rolligons:
Exerts pressure of about 3psi that is relatively less than an ordinary vehicle. They would, however, still leave a small footprint on the ground. Mild, localized, short term.
Atmospheric pollution caused by the use of diesel fuel (see airplanes).

b. Helicopter:
Noise pollution caused by the propellers of the helicopter will affect bird migration, polar bears, and other animals. Mild, localized, short-term.
Hazard of encountering birds in the air which would increase bird mortality and decrease the efficiency of the helicopter. Mild, localized, short-term.
At times air travel will not be possible due to extreme weather conditions which can persist for days. As a result, local storage needs would increase and more pad area would be required. (see environmental impact of surface operations). Mild, localized, short-term.
Degradation of air quality: see airplanes.

c. C-130 Hercules
Landing on snow cover may put pressure on the surface. Moderate, localized, short-term.
May affect air quality. Moderate, wide-spread, short-term.
If an ice strip was used, this would put a strain on water resources since one million liters are required per air strip. Severe, localized, long-term.
The option of using synthetic materials could be a problem if they are not biodegradable or if they are toxic. Severe, localized, long-term.

4. Drilling

Permafrost destroyed when drill bits driven into the ground. The area around the drill hole thaws. Severe, localized, long-term.

The flooding technique of recovering oil from the wells will have two effects:

- It will use up excess H20 Mild, localized, short-term.
- Chemicals will circulate into the ground material. Moderate, localized, long-term.

Benefits of drilling plan:

- Directional drilling and coiled tubing are the best choice: they will provide a minimal impact on the environment. Directional drilling allows for the installation of infrastructure beneath these areas without affecting the delicate ecosystem; animal habitats and sensitive areas can be avoided as a result.

- Coiled tubing reduced the amount of waste produced and results in a smaller footprint. Because the joint connection operations of a convenient drill string are not required, noise levels are reduced as well.

5. Pipeline

Permafrost thaws around pole-support structure. Mild, localized, short-term.

Vegetation does not grow underneath sunlight due to lack of sunlight. Mild, localized, long-term. Potential fragmentation of habitats. Ex. Caribou might not want to cross underneath pipeline, and although they are not highly active around this area, their migratory route still runs through there. Moderate, wide-spread, long-term.

Impacts of Oil Exploration and Drilling on Permafrost

Examining the soil and water cycles of the 1002 region, one cannot ignore the presence of permafrost, or permanently frozen soil,¨ which underlies 80% of Alaska and remains a central issue in the debate about oil drilling. Permafrost has been defined as frozen ground in which a naturally occurring temperature below 0æ C (32æ F) has existed for two or more years (A). On the North Slope, permafrost ranges in thickness from about 700 to as much as 2,240 feet thick, and may be as cold as -8° to -10° C.

Permafrost can be either thaw-stable or non thaw-stable, depending on the type and percentage water of the soil it is made of. Permafrosts in more fine-grained soils like loess (silty) tend to thaw, sink, and create thermokarsts more often. Permafrost thaws from heat input, such as global warming or human activity, as well as the clearing of vegetation which insulates the ground.

Permafrost is affected by road dust generated by traffic on unpaved roads; snow melt due to dust deposition can lead to flooding, ponding, and hydrological changes in oil. Continuing oil and gas exploration, development, and production, construction of a natural gas pipeline, the operation and maintenance of facilities, and other activities requiring road travel would add cumulatively to the volume of road dust generated on unpaved roads (A). Regions of ice which have been wind-dusted are likely to undergo localized melting earlier than the neighboring non-dusted ice (A).

There are three approaches to dealing with the permafrost problem in the construction practice. The first and most obvious is to avoid it entirely. The second is to destroy it by stripping the insulating vegetative cover and allowing it to melt over a period of years. This has the obvious drawback of requiring a considerable period of time to elapse before construction can begin, and even then, it is a good idea to excavate the thawed ground and replace it with coarse material.

The third approach, and one which is becoming more widespread, is to preserve it. This can be accomplished by building on piles to allow cold air to circulate beneath heated structures, by building up the construction site with gravel fill which insulates and protects the permafrost below, or by refrigeration to maintain low ground temperatures. This is done by utilizing thermal piles or freeze tubes, such as those used by the trans-Alaska pipeline. These devices are filled with a non-freezing liquid and act like coffee percolators. They are cooled during the winter months and draw heat from the ground to retard thawing during warm weather (A).

In nearshore areas, ice-bonded permafrost is probably present and must be considered in the design of an offshore pipeline. But nearshore ice-wedge permafrost under shallow water, particularly along a rapidly receding coastline, is even more critical for design. Oil pipelines placed in areas of ice-bonded or ice-wedge permafrost must be heavily insulated to limit thawing of permafrost. The best location for an offshore platform is at water depths of 6.5-65 feet, to minimize ice gouging. Beyond the 6.5 foot water depth the top of the ice-bonded permafrost generally is below the surface of the seabed. Inshore of the 18-foot bottom-depth contour, ice gouging is typically less than 1.6 feet (Y).

Relation of oil drilling, permafrost and vegetation:

Permafrost layer restricts the drainage of water through the soil, making it moist in the short summer growing season. It is easily broken by road construction or the seismic explosions used in oil exploration, changing the water drainage patterns of the soil and thus retention of moisture. Melting permafrost has also led to widespread damage of buildings, costly road repairs, and increased maintenance for pipelines and other infrastructure impacts that will continue to grow in magnitude.

Permafrost also stores large amount of ancient carbon and methane; thawing is likely to release some of this stored carbon and methane back into the atmosphere, amplifying the risk of further climate change. The boreal forest will advance northward into present coastal plain tundra, and mixed forest into present boreal forest. Forest fires and insect outbreaks, both of which have increased sharply in recent years, will further increase. If the permafrost thaws, the vegetation will in the long term dries out, altering plant communities and use by wildlife.

It has been observed that in areas where the permafrost thaws, there is a sudden rapid growth of plants, which attract more animals to feed on. However, this is only momentary. Once the permafrost thaws, temporarily there is much water for plants to grow well for like a month or two, but then the water is continuously used up and drained away as there is no layer to prevention drainage now; yet the permafrost, once destroyed, take years to resume. Therefore, a few months after destruction, water will finally be deficient and no plants can grow well even during summer when water has already been used up, drained away but no permafrost exists to trap them for the growing season. This detrimental effect on vegetation is permanent, while the vast growth of plants is just transient.

Impacts of Seismic Exploration:

Seismic exploration involves a large number of vehicles driving across the tundra in a grid or network. The snow covering the vegetation in teh 1002 area is often shallow and therefore it doesn't provide great protection to the vegetation and soil underneath. The impact from the seismic grid will depend on the following:

a. Type of vegetation. Trails in shrub-dominated tundra have the slowest rate of recovery, whereas trails in sedge-dominated tundra recover well.

b. Texture and ice content of the soil.

c. The shape of the surface.

d. the depth of the snow; snow depths of at least 25 cm are required to minimize disturbance.

e. Type of vehicle. Surprisingly enough, camp move trails persist much longer and produce a more scarring effedct than seismic trails, due the great pressure exerted by camp move trails.

Studies conducted by the US Fish and Wildlife Service (USFWS) after the 1984-85 exploration showed the following effects:

a. The depth to permafrost was greater on disturbed sites than nearby controls.

b.Increased thaw depths.

c. Increased trail subsidence.

d.Shifts to wetter conditions.

e.Formation of distinct ruts.

f. Invasion of grasses

g. Decreases in shrub cover.

h. Longterm disruption of the soil thermal regime.

Reference:

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Environmental Implications - Polar Bears

ANWR is an important place not only because of the wide variety of species that it shelters but also because this "coastal tundra is America's only land denning habitat for polar bears" (2). "According to studies of radio-collared polar bears of the Beaufort Sea population between 1981 and 2000, 53 dens were located on the mainland coast of Alaska and Canada. Of these 53 dens, 22 (42%) were within the Arctic Refuge's 1002 Area" (4)† Over the past two decades the polar bear population has been steadily increasing, growing at more than 3% per year from 1967 to 1998, to reach an estimated number that could be as high as 2500 animals in 2001 (3). This rapid population growth of this species has "spanned the entire history of petroleum development in arctic Alaska" (3) as the polar bear population is thriving and thus will not likely be decimated even if drilling is to negatively affect the bears. In fact in a study (Amstrup and Durner) conducted in 1995, 85% of documented deaths of adult female polar bears were a result of hunting and not of environmental changes or natural factors. Although polar bear population is nearing "historic heights" caution must be taken as "possible changes in human activities, including hunting and habitat alterations could precipitate further declines" (3). This point will be clarified in the next section that discusses bears in general (of which polar bears are a part).

Yet, according to WWF report on ANWR, polar bears are especially sensitive to disturbance during denning. The Agreement on the Conservation of Polar Bears committed the arctic nations to "protect the ecosystems of which polar bears are a part, with special attention to habitat components such as denning and feeding sites and migration patterns." Females may abandon their dens if disturbed, and early den abandonment may be fatal to cubs unable to fend for themselves. In 1985, a female polar bear abandoned her maternity den in the Arctic Refuge coastal plain after seismic exploration vehicles tracked within 700 feet of it ¡V even though regulations at the time required a 0.8-kilometer buffer from known dens. This occurred despite the most extensive monitoring program ever in place for seismic exploration on the North Slope. Most maternity den sites are never known, and therefore cannot be avoided. Their natural curiosity and keen sense of smell often places polar bears in harm¡œs way ¡V they can be attracted to drill rigs, garbage dumps, and contaminants.

Polar bears are especially sensitive to oil spills because they search for food in the open leads or broken ice where oil accumulates. Laboratory experiments showed that oil ingested during grooming caused liver and kidney damage.† One bear died 26 years after oiling and another was euthanized.† However, as far as is known, neither ringed seals or polar bears have been affected by oil spilled as a result of North Slope industrial activities.† Yet, drilling in 1002 may have a greater effect on polar bears as 1002 is a much more important habitat for polar bears as discussed above.

Interactions between polar bears and humans are often lethal. A young bear was shot in Prudhoe Bay by an oil industry employee during the winter of 1968-69, and in 1990 a bear was killed when it approached an offshore rig in Camden Bay, off the Refuge. (WWF's paper titled "Protection of the Artic National Wildlife Refuge: Key to Managing one of the World's Most Biologically Valuable Ecoregions, the Arctic Coastal Tundra")

Parameter:

Polar Bears: "A female polar bear abandoned her maternity den in the Arctic Refuge coastal plain after seismic exploration vehicles tracked within 700 ft of it even though regulations at the time required a 0.8 kilometer (0.5 mile) buffer from known dens. "(WWF "Protection of the Arctic National Wildlife Refuge: Key to Managing one of the world's most biologically valuable ecoregions, the arctic coastal tundra") Therefore exploration and production activity should be kept at least 0.8 km away from all known areas of polar bear dens.

As previously mentioned, seismic exploration involves the movement of vehicles in grid patterns all across the tundra. Maternal polar bears with their newborn cubs can be chased out of their winter dens by the noise and vibrations and all of the human activities that come along with the exploration activities (particularly the explosives).

Anticipated negative effects include:

a. Human-bear encounters that can be fatal to either party on many occasions.

b. Increased mortality of cubs due to harsh winter conditions that they're not prepared for.

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2. Save Alaska website
www.savealaska.com/sa_anwr.html

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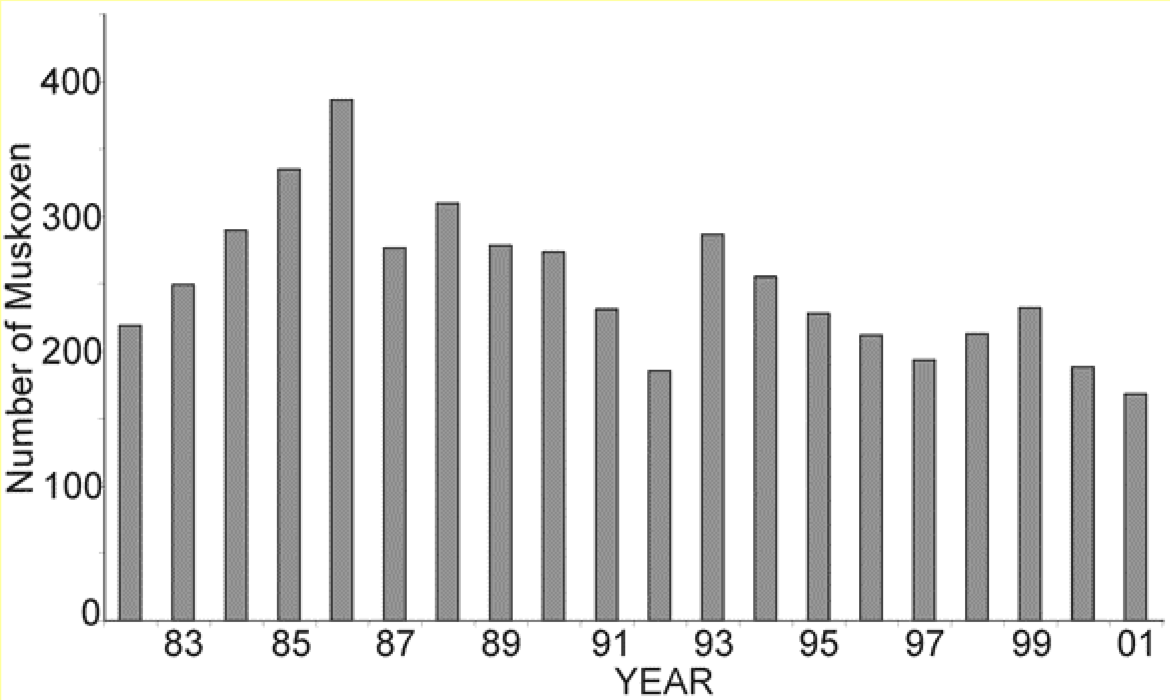
Environmental Implications - Muskoxen

Muskoxen (Ovibos moschatus) were driven to extinction before the 20th century. They were reintroduced in 1969 and their numbers reached a peak at almost 400 individuals in 1986. Since then, the muskoxen population has declined to around 200 individuals. Reasons for this population decline include emigration, increased predation by grizzly bears, and severe winters. Also, hunting by humans has increased since their reintroduction. (Patricia E. Reynolds, Kenneth J. Wilson, and David R. Klein, 2002)

Population dynamics of Muskoxen



Graph: http://www.absc.usgs.gov/1002/images/Fig07-01.gif.

Muskoxen conserve energy by limiting their movement; they tend to stick to a core area about 50 km2 in the winter and 200 km2 during the calving and summer seasons. Calving occurs from March to June, so it is especially important for mothers to build up enough reserves during the summer to last the winter and to feed the newborn. Thus, a prolonged winter would have significant negative impacts on calf survival.

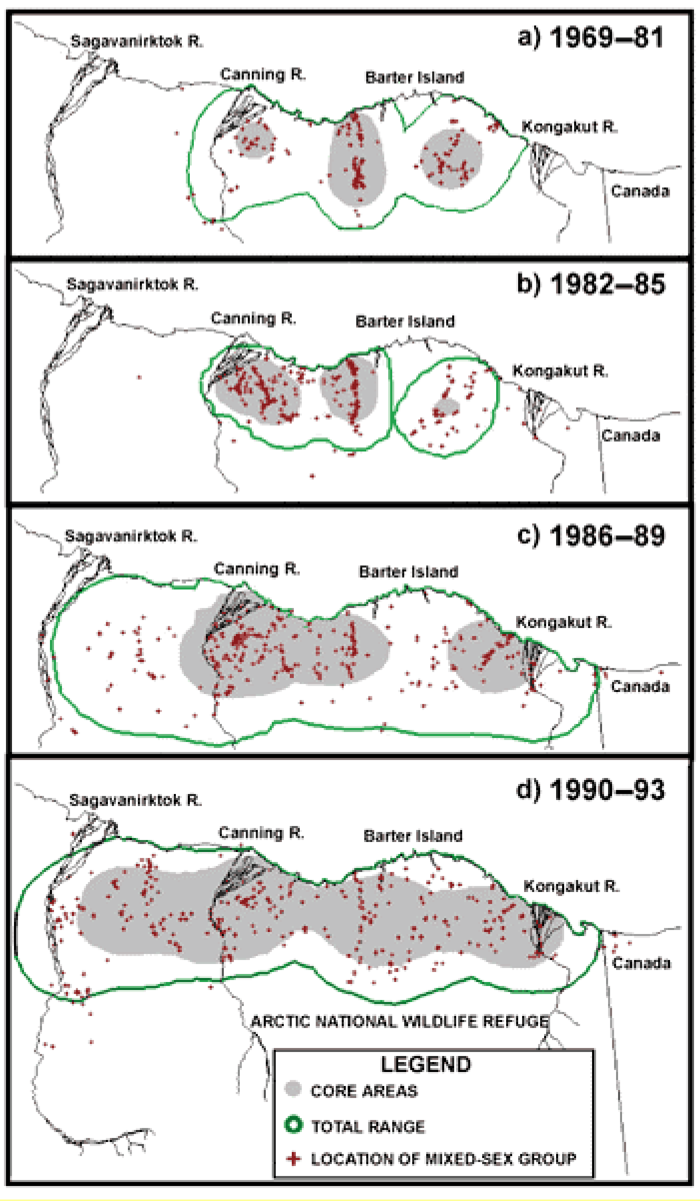
Muskoxen depend on riparian cover along river corridors, floodplains, and foothills year-round. During the winter, it seeks out areas of soft shallow snow. Its winter diet consists mainly of low-quality forage such as sedges, grasses, mosses, and forbs. In the spring, it feeds on high quality flowering sedges. Muskoxen tend to be very loyal to a particular spot, returning there year after year. (Patricia E. Reynolds, Kenneth J. Wilson, and David R. Klein, 2002)

Muskoxen herd

(Photo: http://www.saskschools.ca/%7Egregory/arctic/Amuskox.html)

Any human activity should stay away from the muskoxen habitats, including adjacent uplands. The areas that muskoxen frequent are places often used for gravel and water extraction for roads and/or platforms. Muskoxen congregate into larger groups in the winter, and large groups of animals are more likely to be disturbed by human activity because they tend to have more sensitive individuals.

Muskoxen groups that have moved west tolerate the Trans-Alaskan pipeline and the Dalton highway, but it is due to the wider area of habitable land available to the animals. Muskoxen remaining in the 1002 coastal plain are in a more geographically constricted habitat, with the Beaufort Sea to the north and the Brooks Range to the south. Eastern muskoxen populations are likely to suffer if human activities displace their territories and there are few alternative habitats available. (Patricia E. Reynolds, Kenneth J. Wilson, and David R. Klein, 2002)



Range expansion of muskoxen in mixed-sex groups in and near the Arctic National Wildlife Refuge, Alaska, 1969-1993. Total ranges were defined by 95% adaptive kernel contours. Core areas were defined by 70% adaptive kernel contours.

(Map: http://www.absc.usgs.gov/1002/section7part1.htm)

As muskoxen populations in the far west have coexisted peacefully with the Trans-Alaskan pipeline, a similar pipeline through the 1002 region should have little impact as well-- if it is built with the same environmental precautions. For example, the Trans-Alaskan pipeline has 579 animal crossings over its 800 mile span. Helicopters and low-flying aircraft have been noted to cause some herds to stampede and abandon their calves. Some herds have been agitated by 3-D seismic exploration as far as three kilometers away; other herds seem unperturbed as close as 300 m. Generally, noise produced by traffic, etc will have a negative effect on the animals. (Patricia E. Reynolds, Kenneth J. Wilson, and David R. Klein, 2002)

Little data are available on the interaction between muskoxen and human settlement associated with oil development. This is because drilling platforms have been built in regions rarely visited by muskoxen. However, the nature of the muskoxen's normal food source is such that its scavenging among human waste is unlikely. The major concern is the gravel used for the platforms, which would have to be extracted from muskoxen habitats.The specific impacts of seismic exploration on muskoxen:

The population of muskoxen in the 1002 area is approximated to be about 250 muskoxen living all year long. The survival of muskoxen is influenced by environmental conditions such as the depth of snow, which is in turn greatly influenced by seismic exploration activities. In general, the following effects are feared if exploration is to be conducted in the 1002 area:

a. Displacement of muskoxen from their winter habitat.

b. Due to this displacement, there will be greater energy needs.
Muskoxen need to reduce their activity and movement during the winter in
order to preserve their energy and survive.

c. Decreased body fat in females. This body fat must be maintained
during the winter if they are going to rear a calf.

d. Greater chances of predation.

e. As a consequence of the above, there will be decreased calf

production and less survival of the animals. Impacts of Oil Exploration and Drilling on Lemmings and Voles Lemmings and Voles tend to be more abundant and have less survival issues than muskoxen. In the winter they live in large underground burrows that may be as close as two inches from the permafrost. They subsist on willow twigs, sedges, and stored tubers during the long winter season. Burrows of voles are often raided by native peoples, who pilfer the stored tubers for their own use. (John Whitaker Jr., 1996)

Because of their numbers lemmings and voles are not likely to be wiped out by human activity in the region. However, they are an important source of food for higher lever consumers, including polar bears, wolves, and foxes. Lemming cycles, for example, are closely tied to the population cycles of various predators. A sharp drop in their numbers could potentially cause a population decrease in many other, higher-level consumers.

(John Whitaker Jr., 1996)Reference:

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Oil or Animals report

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Environmental Implications - Other Bears

Land mammals that are "most likely to interact with or be affected by the proposed operations (drilling) are river otters, black bears, and brown bears" (4).† Brown bears use the coastal areas from April to November, relying especially on coastal meadows, beaches, and shorelines for food (4).† As they feed on salmon, and other fish, uncontaminated water sources are essential to their survival, especially during summer and early fall when brown bears "congregate along coastal streams" (4).† Therefore chemical runoff of drilling released in streams would affect the bear population. Also, if ice roads are to be built, and these deplete, the water supply would decrease the fish population in rivers, the bears would be additionally affected.†

In the case of Prudhoe Bay, it has been observed that bears are attracted to the pipelines and oil developments by sheer curiosity, food odors, or trash (4, pg. 118). These bears become food conditioned and return to these places. If this happens often enough, and this event threatens human security, these bears have to be shot. In fact in a study of Prudhoe Bay oilfields (Shideler and Hechtel 2000) , it was found that "mortality rates of all adults and subadults that fed on anthropogenic [of human origin] foods was significantly higher than for bears that fed on natural foods" (4, pg. 118).† This finding could be related to the toxicity of human wastes or to the fact that these bears had to be killed by humans, as was before mentioned, because food conditioning occurred. Additionally, it is possible that in the future, "increased access opportunities (roads and airstrips) and changes in village lifestyles or economies could result in more bears being killed for sport and subsistence" (4) especially as these animals are attracted to human settlements.

Another area of concern is the "construction of industrial facilities [that would] result in alteration or destruction of grizzly bear habitat" (4). This especially concerns disturbances created by roads or drilling that can affect the denning habitat of bears, and change food availability. This is especially dangerous if oil development is to spread into the foothills, as these provide the major habitats of bears. (4)

It also must be taken into account that bears are the predators that top the food chain, implying that any change in their dynamics would also affect that of other organisms residing in the lower branches of the food chain.†

For example, if bear population is to increase because of increase access to food coming from human wastes, or if it is to decrease as hunting prevails, this will affect other species.† The major species affected by this change in bear population would be the caribou, the main food source of brown, and black bears.†† Increased numbers of bears would decrease the number of caribou present, and likewise, a decreased number of these predators would probably allow for an increase in the number of these herbivores.

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$FILE/Forest%20Oil%20EA%20Section%2003A%20Affected%20(Baseline)%20Environment.pdf

Environmental Implications - Migratory Species

Throughout the year, hundreds of species migrate to the 1002 region of the Arctic National Wildlife Refuge. These include birds, mammals and fish which migrate to this region for a multitude of purposes generally between the months of May and October. This region has proven to be a center of biological activity throughout these months due many factors including nutritional benefits, increased safety from predators and a more favorable climate. Thus, a method to extract oil should carefully take into consideration these species and the impact on their habitat and livelihood in order to preserve the current ecosystem. Because the area has been left untouched for centuries, the impact of oil drilling could be severe if the migratory species are not taken into consideration.

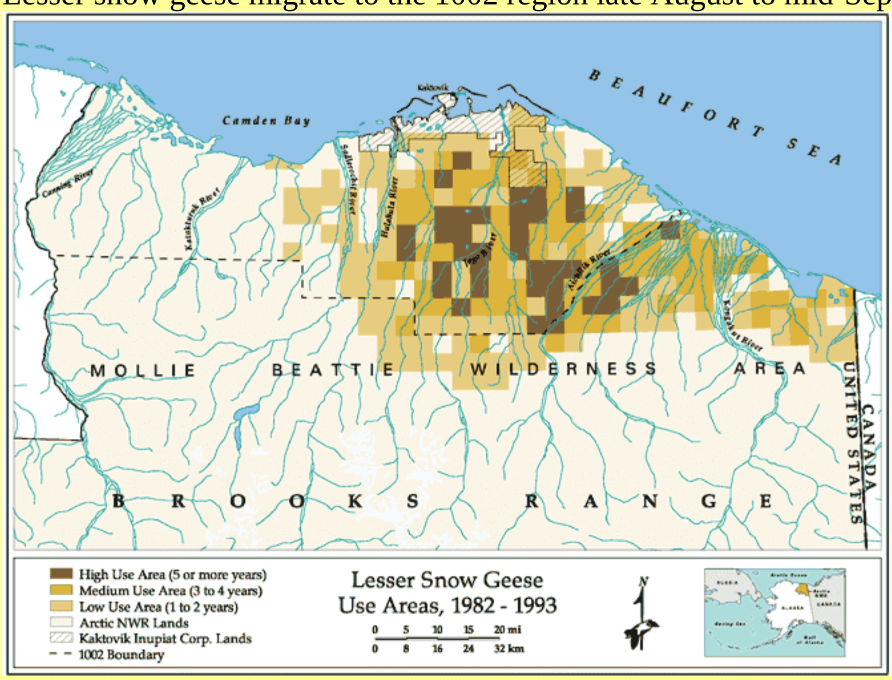
For many species, the 1002 region is not a critical stopover along their migratory paths. For example, over 135 bird species visit the area each year, but only a small percentage stay significant periods of time, while even fewer use the area for breeding purposes. For land species, this also holds true. For example, the moose population would be minimally impacted by oil drilling because its calving grounds is in the Old Crow Flats in Canada and their stay in the 1002 region is brief. However, for the few species that do spend a significant amount of time in the region, the environmental impact of oil drilling can be devastating. Disturbances such as roads and noise pollution could potentially affect the survival rates of species which breed and calve in the area, as well as species which depend on the region for nutrition. For instance, the preservation of the 1002 region is essential to the survival of the porcupine caribou herd, which calve there. This is an extremely critical time period for the calves because of their vulnerability to predators and great nutritional need. Therefore it is necessary to identify critical time periods during the year in which the most damage would occur so that oil drilling could be planned accordingly. Also, the impacts of permanent structures and disturbances caused by oil extraction should be properly assessed and evaluated. In order to comprehensively consider the consequences of oil production, this report will present an analysis of major species, the potential impact of drilling, and propose methods of minimizing this impact.

Environmental Implications - Snow Geese

This species migrate to the 1002 region of ANWR every year for two to four weeks before continuing on a 1300 mile journey to Northern Alberta. Their time spent on the north slope is critical to their survival since they need to store nutrients for their long migration path. As many as 500,000 species migrate to the region each year (Hupp et al, 2002). These birds are herbivores, feeding on cotton grass. A major predator is the arctic snow fox. The North Slope supports over 60% of the Pacific population (National Research Council, 2003).

(Photo: www.saskschools.ca/~gregory/arctic/Abirds.html)

Critical Time Periods
Lesser snow geese migrate to the 1002 region late August to mid-September



(Hupp et al, 2002) Density Distribution of Lesser Snow Geese
(Map: Jerry W. Hupp, Donna G. Robertson, and Alan W. Brackney, Artic Refuge Coastal Plain Terrestrial Wildlife Research Summaries, http://www.absc.usgs.gov/1002/section9.htm)

Reference:
1.   Hupp, Jerry W., Donna G. Robertson, and Alan W. Brackney. (2002). Arctic Refuge Coastal Plain Terrestrial Wildlife Research Summaries, http://www.absc.usgs.gov/1002/section9.htm
2.   National Research Council. (2003). Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope. Washington: The National Academics Press, 2003.

Environmental Implications - Other birds

Sea Duck

Sea ducks visit the 1002 region for 2 to 4 weeks every year. While they do not breed here, they use the area for molting purposes. Anywhere from 10,000 to 30,000 birds visit the region each year. Predators include the arctic fox and glaucous gulls.

Critical Time Periods
Sea ducks visit the 1002 region from mid-July to mid-September.

Sensitivities
There has been a decline in the number of sea ducks and other marine birds in the area, which raises concern about the impact that oil drilling will have on them, especially if there is a spill. Sea ducks are especially vulnerable during their stay on the North Slope because the time they spend there is for molting. This leaves them unable to fly for 3-4 weeks. Molting also requires a large amount of protein to grow new feathers. Oil drilling could potentially disrupt the ducks' foraging capabilities, depriving them of much needed nutrients. However, one study showed that the ducks' foraging patterns are not significantly altered by minor disturbances, which perhaps suggests that oil drilling will not have a large impact on them. Another study that was performed showed that seismic activity does disturb ducks. Their results show a decline in population in a certain area where seismic activity starts, although underwater seismic activity had no effect on them.

Buff Breasted Sandpiper

General Information

Buff-breasted Sandpipers migrate to their wintering grounds in groups from 500-2200; their populations suffered from development of agriculture in the Great Plains of North America and the Pampas of South America. The Sandpiper's key wintering sites must be protected.

Critical Time Periods
The Buff-Breasted sandpipers arrive in their Alaskan breeding grounds in mid-April and vacate their breeding grounds in mid-July.

Sensitivities
The Buff-breasted Sandpiper mates in leks, or an area of ground approximately 8 acres in size, each containing about 10 males. Therefore the ground taken up by a mating Buff-breasted Sandpiper flock is fairly extensive. Human development of winter habitats infringes on land, disrupts the mating pattern and also attracts predators to the area.

Tundra Swan

General Information

Twice a year, Tundra Swans migrate 6,000 km between breeding areas in Alaska and The Canadian Arctic and wintering areas in eastern and western North America. Approximately 150 pairs of tundra swans nest on the coastal plain. Tundra swans feed on the following plants: foxtail and other grasses, wild celery, pondweeds, smartweeds, square-stem spike rush , arrowhead, coontail, mermaid weed, muskgrasses, bulrushes, horsetail, wigeon grass, and bur reed. Rice and barley are eaten in stubble fields. Tundra swans also feed on waste corn in both dry and flooded fields and upon harvested potatoes. These swans commonly fly as far as 10 to 15 miles (16-24 km) inland to glean waste corn and soybeans and to browse upon shoots of winter wheat. Animals that prey on tundra swans include: Golden Eagles, jaegers, wolves, foxes, and bears.

Critical Time Periods

Tundra swans start nesting between May and late June, depending on location and weather. During fall migration, tundra swans leave their major breeding grounds in the 1002 area in late September and early October. For their spring migration, tundra swans leave their central California winter grounds in mid-February, and most of the birds have departed within 3 weeks. By early April almost all of them have migrated north to Alaska and Canada.

Sensitivities

Scientists believe that new Tundra swan pairs are less likely to establish themselves on lakes where humans reside. They are extremely sensitive to noise pollution and as a result, inadvertent disturbance can cause adult swans to abandon their nests and cygnets.

Environmental Implications - Plants

“Due to the extreme cold, short growing season and nutrient-poor soils, Arctic vegetation is extremely fragile. Plant communities scarred by bulldozer tracks, oil spills and other human activities can take decades to recover.”
Source: http://oz.plymouth.edu/~lts/conservation/Ecosystems/northslope.html

1. Sedges and willows for nutrition

There are two major types of plants that are very important in providing the herbivores (caribou, muskoxen, etc) with high quality and nutritious food: tussock cottongrass (Eriophorum vaginatum) and diamond-leaf willow (Salix planifolia ssp. pulchra). Surveys by US Geological Survey have shown that disturbed areas by petroleum development in other parts of Alaska exhibit significant decreasing quantity and quality of these two plants. In disturbed areas, they have lower biomass, lower nutritional values and higher fiber and lignin concentrations which decrease digestibility. This in turn significantly adversely affects reproduction and calving success of caribou that highly depend on them.
(Janet C. Jorgenson, Mark S. Udevitz, and Nancy A. Felix, 2002)

2. Sedges and willows for inhabitation

Willows in riparian areas are important nesting habitat for migratory birds. Willows will be reduced in amount by heavy tracked vehicles for seismic studies. They will also be affected in the long term by thawing of permafrost, which would be discussed in greater details in the latter part of this essay. Loss of nesting places means unsuccessful calving for birds and higher chances of predation. Successful rehabilitation techniques are yet to be developed for these areas.
(World Wide Fund for Nature, 2000)

Flame orange dwarf birch and golden willow
Photo: Subhankar Banerjee

3. Mosses and lichens for nutrition

While sedges and willows are important food source for herbivores during summer, the growing and calving seasons, mosses and lichens are more important for local herbivores during the bitter winter as they can still grow well during the winter, though they have lower nutritional values. Construction of drilling site, roads and tracked vehicles all directly destroys the delicate mosses and lichens, lowering the energy source for the herbivores such as muskoxen.
(Sarah J. Woodin & Mick Marquiss, 1997)

4. Mosses and lichens for carbon and nutrient cycling

Mosses and lichens have a major influence on nutrient cycling in tundra and other northern ecosystems through their role in nitrogen fixation, and the ability of mosses to accumulate and retain elements from precipitation. They restrict the draining away of nutrients and help trap them during the summer and avail the nutrient for the herbivores during the winter. Slow decomposition of mosses allows the mosses to contribute significantly to the Arctic carbon sink. By photosynthesis, they "fix" carbon from the atmosphere to organic compounds and by slow decomposition they help trap the carbon instead quickly releasing them back to the atmosphere. This helps soothing global warming. Destruction means that all these functions cannot carry on.
(Sarah J. Woodin & Mick Marquiss, 1997)

5. Mosses and lichens for maintaining the permafrost

Mosses and their under-composed remains are particularly efficient in thermal insulation when dry, thus restricting heat penetration into arctic soils in summer. Thermocarst resulting from destruction of the vegetation by the summer use of tracked vehicles during early stages of arctic oil exploration demonstrated the importance of the moss layer in maintaining permafrost. This caused extensive thawing of permafrost. The importance of permafrost on arctic ecology will be discussed in the next paragraphs.
(Sarah J. Woodin & Mick Marquiss, 1997)

Summary

“The effects of winter seismic trails on tundra vegetation were studied on the Coastal Plain of the Arctic National Wildlife Refuge. Plant cover was lower on most disturbed plots than on their adjacent controls, with decreases as high as 87% the first summer following disturbance. The species most sensitive to disturbance were evergreen shrubs, followed by willows, tussock sedges, and lichens. Willow height in riparian shrubland plots was significantly reduced by 5 to 11 cm (from an average of 16 cm, $p < 0.05$). Little recovery of plants occurred in the second or third summers after disturbance; only four plots in river floodplain habitats (Dryas terrace and riparian shrubland) showed improvements in cover of a few species.”
(Felix NA, Raynolds MK, 1989)

Reference:

1. Janet C. Jorgenson, Mark S. Udevitz, and Nancy A. Felix, (2002). Arctic Refuge Coastal Plain Terrestrial Wildlife Research Summaries, http://www.absc.usgs.gov/1002/section5.htm

2. World Wide Fund for Nature. (2000). Protection of the Artic National Wildlife Refuge: Key to Managing one of the World's Most Biologically Valuable Ecoregions, the Arctic Coastal Tundra, http://www.worldwildlife.org/arctic-refuge/anwr_position.pdf

3. Sarah J. Woodin & Mick Marquiss. (1997). Ecology of Arctic Environment

4. Felix NA, Raynolds MK. (1989). Arctic and Alpine Research, vol. 21, no. 2, pp., http://www.csa.com/hottopics/ern/01aug/01aug16.html

Significance of bryophytes and lichens in arctic coastal plain

Nutrient cycling

The soil under bryophyte and lichen mats tends to be cold and moist. Lichens and mosses affect nutrient cycling of the ecosystem by intercepting aerial deposition and leaching from dripping aboveground vascular plant parts(Cowles, 1984; Rosswall and Granhall, 1980). Lichens with cyanobacterial symbionts and bryophytes with cyanobacterial associations provide the main input of nitrogen into the ecosystem(Alexander et al., 1978; Baselier et al., 1978,; Kallio, 1975)

Arctic ecosystems receive a higher proportion of nutrients input from precipitation and nitrogen fixation than do temperate systems, because chemical weathering is inhibited by low temperature and permafrost. Mosses and lichens have a major influence on nutrient cycling in tundra and other northern ecosystems through their role in nitrogen fixation, and the ability of mccosses to aumulate and retain elements from precipitation. Retention of precipitation by bryophytes is also likely to redice losses by leaching of nutrients already existing in the soil. The general role of mosses and lichens in nitrogen fixation bases on that the cyanobacteria growing on their stems and roots help transfer the nitrogen nutrients to the mosses and lichens themselves and also to the other plants, enriching the nitrogen content of the whole vegetation. (Sarah J. Woodin & Mick Marquiss, 1997)

Bryophytes act as efficient filters of nutrients arriving in precipitation, throughfall or litter and from the soil by absorbing them directly into their tissues, or retaining them externally in solution in capillary spaces. The annual growth increment of the moss layer at an Alaskan taiga site was found to contain nutrients in excess of inputs from throughfall. The mosses, and also the lichens, help increase the nirtogen concentration in the soil. Their absorption from the soil retains large amount of phosphorous and potassium in their cytoplasm. Mosses alone account for 75% of the annual accumulation of phosphorous in an Alaskan black spruce (Picea mariana) forest. Other nutrients such as calcium and magnesium are also intensively retained in the tissues of mosses and lichens. (Sarah J. Woodin & Mick Marquiss, 1997)

Nutrient immobilization in slowly decomposing bryophyte phytomass may thus have a major influence in restricting recycling, and therefore in controlling ecosystem development and productivity. In mires, absorption of nitrogen and other elements by Sphagnum reduces availability to other plants. Bryophytes therefore may increase the pools of nutrients in the Alaskan ecosystems, but reduce availability to other organisms. (Sarah J. Woodin & Mick Marquiss, 1997)

Arctic tundra domonated by mosses and lichens
Photo: http://www.r7.fws.gov/nwr/arctic/issues1.html

Maintenance of permafrost

Mosses and lichens are important in the structure and function of the ecosystems because of their effects as insulators and filters. Their insulating properties is partly from increased reflectance and partly from the numerous air pore space when dry. They as an effective mulch, retaining moisture in the upper layers of the soil. Mosses and their undercomposed remains are particularly efficient in thermal insulation when dry, thus restricting heat penetration into arctic soils in summer. When wet and frozen in winter, their effect in reducing heat flux away from the soil is reduced. The net effect of mosses in decreasing soil temperatures in summer is generally greater than the converse effect in winter, and over much of the Arctic the distribution of permafrost is positively correlated with that of mire vegetation underlain by mosses. Thermocarst resulting from destruction of the vegetation by the summer use of tracked vehicles during early stages of arctic oil exploration demonstrated the importance of the moss layer in maintaining permafrost, which is an important habitat for many other species naturally occuring in Alaska as well as ANWR. Destruction of such vegetation can lead to extensive melting of permafrost, both directly and by accelerating the decomposition of organic matter. (Sarah J. Woodin & Mick Marquiss, 1997)

Apart from maintaining the natural permafrost habitat, mosses, and also lichens, provide microenvironments of vital importance for invertebrates, and in some communities for the establishment of vascular plants although the relationships may be complex. Lichens release compounds capable of supressing the growth of associated vascular plants and bryophytes. Sphagnum spp. control the environment of mires by lowering pH, by releasing H+ ions in exchange for other cations, and creating waterlogged, anaerobic conditions to which only a characteristic range of other organisms is adapted. (Sarah J. Woodin & Mick Marquiss, 1997)

Reference:

1. Sarah J. Woodin & Mick Marquiss. (1997). Ecology of Arctic Environment

Environmental Implications - Decomposers

Likely effects from oil drilling

At this time, more detailed soil profile descriptions and soil climate data are needed for more accurate characterizations of patterns and net change in decomposition. However, the big picture implies that “environmental changes may have little impact on plant productivity unless average nutrient availability also changes” (Reynolds etc. al). This statement emphasizes the importance of decomposer species in any given ecosystem. Since they control the nutrient availability to an environment, they control not only plant productivity, but the competition that consequently occurs between plants for the nutrients, which affects evolution (according to survival of the fittest), and in turn the nutrition of herbivores and the carnivores that feed on the herbivores, etc. In essence, the entire food web of an ecosystem depends upon the availability of nutrition.}

That said, the impact of road dust to decomposer species is as follows:

The influence of road dust results in higher soil pH levels (moving along the scale from acidic to basic), lower soil moisture, and greater thaw depth; although there are yet to be experimental studies of the impact on decomposer species specifically, the combination of the previously mentioned conditions when applied to simulations and past studies have shown that “soil enzyme activities in surface organic materials were found to be affected by dust loading: Activity increased rapidly with increased distance from the road” (Reynolds etc. al).

Even so, the biggest effects to decomposer species are likely to be those caused by changes in soil moisture. Reynolds etc. al found that “areas with moist tundra where water in channeled (water tracks) have higher vascular productivity and nitrogen availability than areas that do not.” Basically, decomposition rates are higher and nutrient uptake is easier. Yet, without moving water—i.e. under more stagnant conditions—wet soils relate to low nitrogen availability due to the anaerobic, decomposition inhibiting circumstances (Reynolds etc. al).

One of the problems that arise in evaluating the effects of disturbance in the Arctic is that there is a major lack of information describing the dynamic response of ecosystems to altered hydrological regimes and accompanying change in water quality. Therefore, it is my opinion that before conclusions concerning the impact of specific development strategies can be drawn, more experiments need to be performed.

Furthermore, in reference to decomposer species only, most of the impacts that I have discussed tend to operate on a more local scale. They would likely not affect an ecosystem as a whole unless there were many such local areas subjected to those impacts.

Reference:

1. Sarah J. Woodin & Mick Marquiss. (1997). Ecology of Arctic Environment