

CUMULATIVE ENVIRONMENTAL EFFECTS OF OIL AND GAS ACTIVITIES ON ALASKA'S NORTH SLOPE

Since the 1968 discovery of huge oil reserves in Prudhoe Bay, Alaska's North Slope has been a site of oil exploration and production that, by the end of 2002, had produced about 14 billion barrels (558 billion gallons) of crude oil. North Slope oil currently averages about 15% of total annual domestic oil production of approximately 3.3 billion barrels and 7% of the annual domestic consumption of approximately 7 billion barrels. Active exploration on the arctic coastal plain is now expanding incrementally westward into the National Petroleum Reserve-Alaska, eastward toward the Arctic National Wildlife Refuge, and south toward the foothills of the Brooks Range (see Figure 1).

Northern Alaska's environment and culture have already been significantly affected by oil infrastructure and activities. There have been many benefits to North Slope residents including more jobs and improved medical care and schools. These economic benefits have been accompanied by environmental and social consequences, including effects of the roads, infrastructure and activities of oil exploration and production on the terrain, plants, animals and peoples of the North Slope and the adjacent marine environment.

Although a large body of research has assessed actual and potential effects of oil and gas activities and infrastructure, no integrated, comprehensive analysis of *cumulative* effects has previously been attempted. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time or within an area. In response to a request from Congress, the National Academies convened the Committee on Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope to assess probable cumulative effects of oil and gas activities on various receptors—that is components of the physical, biological, and human systems of the region. The committee's consensus report assesses both present and likely future cumulative effects on the North Slope and adjacent marine waters for the time period of 1965 to 2025 (in some cases to 2050).



Figure 1. The North Slope (the Arctic Slope) extends from the crest of the Brooks Range to the Arctic Coast, from the Canadian border to Point Hope. Industrial activity has grown from a single operational oil field at Prudhoe Bay to an industrial complex stretching from the Alpine field near the mouth of the Colville River on the west to Badami on the east.

Accumulated Effects To Date

Alaska's North Slope is underlain by permafrost—a thick layer of earth material that stays frozen year round. The permafrost is covered by a thin active layer that thaws each summer and supports plant growth for a brief period. If permafrost thaws, the ground surface and the structures it supports will settle. To minimize disruption to the ground surface, the North Slope industrial infrastructure is specially built—pipelines are generally elevated rather than buried, and roads and industrial facilities are raised on thick gravel berms.

For a variety of reasons, nearly all of the roads, pads, pipelines and other infrastructure ever built are still in place. The environmental effects of such structures on the landscape, water systems, vegetation, and animals are manifest not only at the “footprint” itself (physical area covered by the structure) but also at distances that vary depending on the environmental component being affected. The petroleum industry continues to introduce technological innovations to reduce its footprint, for example, directional drilling and the use of ice roads and pads, drilling platforms, and new kinds of vehicles.

For some areas of concern, the committee found no evidence that effects have accumulated. For example, despite widespread concern regarding the damaging effects of frequent oil and saltwater spills on the tundra, most spills to date have been small and have had only local effects. Moreover, damaged areas have recovered before they have been disturbed again. However, a large oil spill in marine waters would likely have substantial accumulating effects on whales and other receptors because current cleanup methods can remove only a small fraction of spilled oil, especially under conditions of broken ice.

For other areas of concern, effects have accumulated, although in some cases efforts by the petroleum industry and regulatory agencies have reduced them. The committee identified the following areas in which there was evidence of effects that have accumulated.

Roads. Roads have had effects as far-reaching and complex as any physical component of the North Slope oil fields. In addition to their direct effects on the tundra, indirect effects are caused by dust, roadside flooding, thawing of permafrost, and roadside snow accumulation. Roads and activities on them also alter animal habitat and behavior and wildland values and can increase access of hunters, tourists, and others to previously inaccessible parts of the region; enhance communication among communities; and increase contacts between North Slope communities and those outside the area.

Damage to Tundra from Off-Road Travel.

Surface erosion, water flow and tundra vegetation on the North Slope have been altered by extensive off-road travel. Some damage has persisted for decades. The current 3-dimensional survey method requires a high density of seismic-exploration trails. Networks of these trails now cover extensive areas and are readily visible from the air, degrading visual experiences of the North Slope. Despite technological improvements and increased care taken by operators, the potential for damage to the tundra still exists because of the large number of vehicles and camps used for exploration.

Effects on Animal Populations. Bowhead whales' fall migrations have been displaced by the noise of seismic exploration. Garbage and food provided by people working in oil fields have resulted in higher than normal densities of predators (such as brown bears, arctic foxes, ravens, and glaucous gulls) that prey on the eggs, nestlings, and fledglings of birds. As a result, the reproduction rates of some bird species such as black brant, snow geese, eiders, and probably some shorebirds in industrial areas are, at least in some years, insufficient to balance death rates. These populations may persist in the oil fields only because of immigration of individuals from source areas where birth rates exceed death rates.

The combined effects of industrial activity and infrastructure and the stress imposed by insects in some summers reduced calf production in the Central Arctic caribou herd and may have contributed to the reduction in herd size from 1992 through 1995. In contrast, the herd increased in size from 1995 to 2001, when insect activity was lower. Although accumulated effects have not prevented an increase in the overall size of the Central Arctic Herd, the spread of industrial activity into other areas caribou use for calving and insect relief, especially to the east where the coastal plain is narrower, would likely affect reproductive success, unless the degree to which it disturbs caribou can be reduced.

Interactions of Climate Change and Oil Development.

Global and regional climates have changed throughout the Earth's history, but climate changes during the past several decades on the North Slope have been unusually rapid. If recent warming trends in climate continue, as many projections indicate, the effects will accumulate over the next century to alter the extent and timing of sea ice, affect the distribution and abundance of marine and terrestrial plants and animals, and affect permafrost as well as the usefulness of current oil-field technologies and how they affect the environment.

Interference with Subsistence Activities. The Inupiat Eskimo people of the North Slope have a centuries-old nutritional and cultural relationship

with the bowhead whale. Most view offshore industrial activity—both observed effects and the possibility of a major oil spill—as a threat to the bowhead whale and, thereby, to their cultural survival. Because noise from exploratory drilling and marine seismic exploration have caused fall migrating bowhead whales to change their movements, subsistence hunters have been forced to travel greater distances to find whales, increasing their risk of exposure to adverse weather and the likelihood that a whale’s tissues will have deteriorated before the carcass can be landed. Recent agreements concerning the timing and placement of exploration in the fall have reduced the effects on subsistence hunters.

The Gwich’in Indians of northeast Alaska and northwest Canada have a centuries-old nutritional and cultural relationship with the Porcupine Caribou Herd. Most Gwich’in oppose any oil development that would threaten the herd, especially on the calving ground, which they consider sacred, and thereby threaten their cultural survival. These threats have accumulated because repeated attempts to develop areas used by the herd have occurred and will probably continue to occur.

Social Changes in North Slope Communities. Most North Slope residents have positive views of many of the economic changes that have resulted from revenue generated by petroleum activities, such as access to better medical care, availability of gas heat for houses, improved plumbing, and higher personal incomes. At the same time, however, balancing the economic benefits of oil activities against the accompanying loss of traditional culture and other societal problems that can occur is often a dilemma for North Slope residents. Without this revenue, the North Slope Borough, the Alaska Native Claims Settlement Act, and hence the Arctic Slope Regional Corporation, would not exist or, if they did, would bear little resemblance to their current form. This discovery of oil and its development on the North Slope has resulted in major, important, and probably irreversible changes to the way of life in communities. These effects accumulate because they arise from several ongoing, interacting causes.

Cumulative Aesthetic, Cultural, and Spiritual Consequences. Many activities associated with oil development have compromised wildland and scenic values over large areas. Some Alaska Natives told the committee that they violate what they call “the spirit of the land,” a value central to their relationship with the environment. These consequences have increased in proportion to the area affected by development, and they will persist as long as the landscape remains altered.

Future Accumulation of Effects

The committee assessed possible future accumulation of effects, assuming conditions favorable to continued expansion of oil and gas activities using technology and regulatory oversight at least as good as those currently used.

Response of North Slope Cultures to Declining Revenues. For North Slope residents, the current way of life of North Slope communities made possible by oil and gas activities will be more difficult to maintain when these activities cease as oil is depleted because other sources of funds appear to be modest. Eventual adjustments to reduced financial resources are unavoidable. Their nature and extent will be shaped by adaptations North Slope communities have made to the accumulated effects of the cash economy.

Legacy of Abandoned Infrastructure and Unrestored Landscapes. The network of roads, pads and pipelines, and infrastructure that support production will likely remain in place for many years to come. The oil industry and regulatory agencies have made dramatic progress in reducing the effects of new gravel fill by reducing the size of the gravel footprint required for many types of facilities and substituting ice for gravel for certain types of roads and pads. However, much less attention has been directed to restoring already disturbed sites. To date, only about 1% of the habitat on the North Slope affected by gravel fill has been rehabilitated.

With the exception of well-plugging and abandonment procedures, state, federal, and local agencies have largely deferred decisions regarding the nature and extent of restoration that will be required. Because the obligation to restore sites is unclear, and the costs of dismantlement, removal, and restoration are likely to be very high, the committee judges it unlikely that most disturbed habitats on the North Slope will be restored. Because natural recovery in the Arctic is slow, the effects caused by abandoned and unrestored infrastructure are likely to persist for centuries and could accumulate further as new structures are added.

Expansion of Activities into New Areas. Expansion of oil and gas exploration is spreading into hillier terrain and into coastal plain areas with soils, vegetation and aquatic environments that differ substantially from current areas of activity. To assess effects in these environments, they should be characterized through description of topography, permafrost conditions, sand, gravel, and water availability, hydrological conditions, and a description of the biotic communities present. In

addition, future exploratory activity will probably be carried out in a warming climate, with milder winter temperatures and shorter periods of freezing conditions.

Filling Knowledge Gaps

As industrial activities proceed, it is vital to continue collecting and analyzing information on the North Slope's physical, biological, and human environments to help decision makers in developing and implementing effective natural resources management. Advantage should be taken of opportunities to learn from these activities (adaptive management).

Decisions about where, when, and under what conditions and requirements industrial activities are permitted on the North Slope are made by many different federal, state, regional, and municipal government agencies. To date, decisions have generally been made without a comprehensive slope-wide plan and regulatory strategy that identify the scope, intensity, direction and consequences of industrial activities judged acceptable. A comprehensive framework and plan should be developed for the North Slope so that actions can be evaluated with respect to their compatibility with overall goals, the likely effects of individual activities on all receptors that might be affected by them, and the likelihood that the activities will result in long-term or difficult-to-reverse undesirable effects. Knowledge gaps should be addressed through the following:

- Ecosystem-level research in addition to local ecological studies.
- Studies to understand the types of effects that exist at varying distances beyond the footprint of industrial structures.
- Studies of air pollution that provide a quantitative baseline of spatial and temporal trends in air quality over long periods across the North Slope.
- Studies of effects of seismic exploration and other off-road use on the tundra.
- Research on habitat requirements of caribou, their reproductive physiology and movements, and how natural and anthropogenic disturbance affects them.
- Studies of the effects of noise on the migratory and acoustic behavior of bowhead whales and on their feeding habits in the Alaskan portion of the Beaufort Sea.
- Studies of effects of taking water from lakes on the North Slope for ice roads, pads, and other purposes.
- Studies of methods to reduce effects of oil spills including non-mechanical methods of cleaning up oil spilled in the sea, especially in broken ice.
- Research on the specific benefits and threats that North Slope residents perceive.
- Studies of effects of oil and gas activities on human health including studies of increased use of alcohol and drugs, increased obesity, and other societal ills.

This summary was prepared by the National Research Council based on the committee's report. For more information: Contact the National Research Council's Board on Environmental Studies and Toxicology at 202-334-3060. *Cumulative Environmental Effects of Oil and Gas on the North Slope* is available from the National Academies Press, Fifth Street, NW, Washington, DC 20001; 800-624-6242 or 202-334-3313 (in the Washington area); <http://www.nap.edu>.

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Firsthand Input to the Report

To gain diverse views and perspectives, the committee traveled to Alaska several times during the course of its two-year study. The committee heard from federal and state agencies, representatives of the oil and gas industry, environmental organizations, and officials and community members of the North Slope Borough and the municipalities it visited: Barrow, Kaktovik, and Nuiqsut. It also visited Arctic Village and toured oil facilities at Prudhoe Bay, Endicott, and Alpine, and flew over Kuparuk, the offshore Northstar facility, the National Petroleum Reserve-Alaska and the Arctic National Wildlife Refuge.