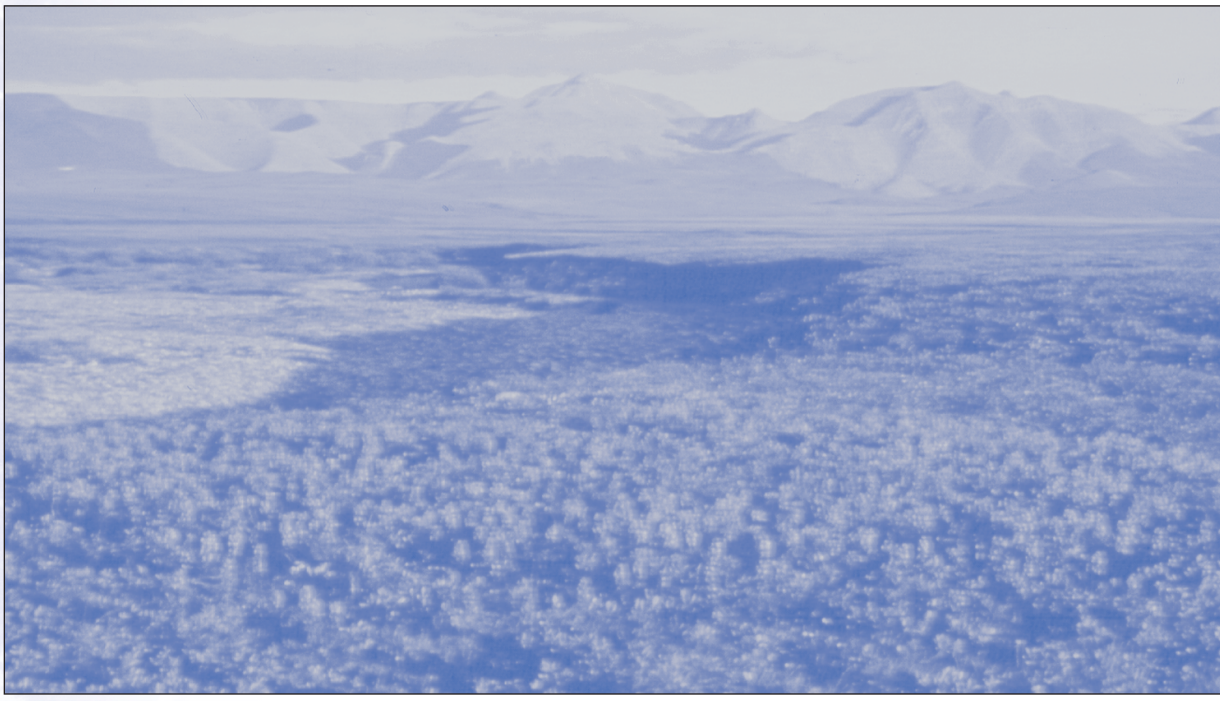
THE ARCTIC ENVIRONMENT

Background

Imagine a cold, windy place where at times the sun hardly shines and at other times of year barely sets. It is a place with frozen ground, making it very difficult for trees to grow. Instead of walking through the forest, in the Arctic tundra, you walk *on* the forest, as plants may only grow a few inches to perhaps one foot tall. At certain times of the year a visitor might think the tundra appears barren, but during the sunny summers, the land bursts with wildlife and activity.

What is the Arctic region? Literally defined, it is the area within the Arctic Circle, including the icy North Pole and the Arctic Ocean. One interesting feature of the Arctic is its many **glaciers**, rivers of ice formed from snow falling over thousands, even millions, of years. Glaciers spread and move with freezing and thawing temperatures and by the force of their own weight and gravity. Glaciers form on land, near lakes, and along the coast. When the tip of a glacier reaches the edge of the sea, it breaks off and forms an iceberg in a process called **calving**.

The Arctic region also includes the **tundra**—meaning "treeless plain"—**ecosystem**. One defining characteristic of the arctic tundra is its



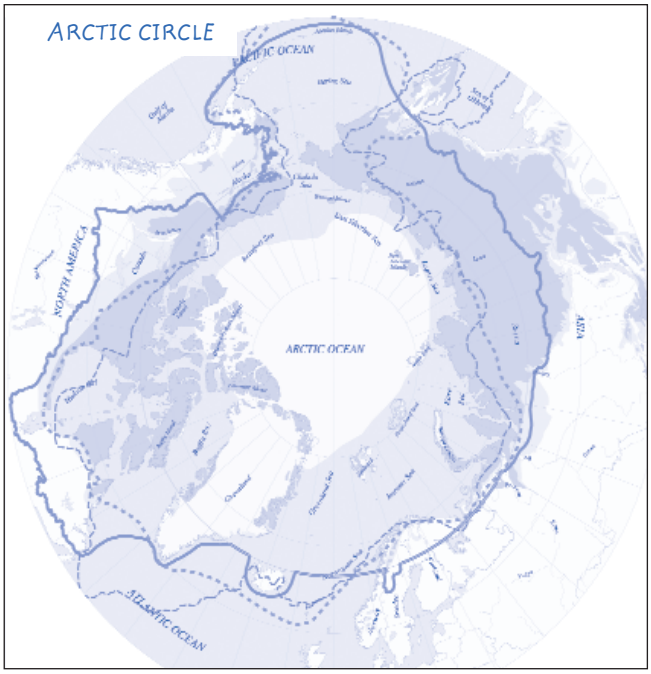
permafrost, permanently frozen ground that occurs from several inches below the surface to depths of more than 1000 feet. Permafrost, combined with a long season of cold and high winds, are the primary reasons for a nearly treeless zone in the arctic. Trees are unable to spread roots in the permafrost, and leaves and branches would catch the wind and be blown down.

The northern boundary of the arctic tundra is the northern ice cap (ice cover, which includes the North Pole). The **taiga**, also called boreal (meaning northern) forest, is a zone of scattered evergreen trees, and is the southern boundary of the arctic tundra. The imaginary line where the treeless tundra changes to taiga is called the **tree line**.

Arctic tundra is found in Asia, North America, and eight northern countries within Europe. Tundra also occurs in other places around the world, where cold and high winds inhibit or prevent tree growth. Generally this kind of tundra is found at high elevation and is thus known as alpine tundra.

The arctic is an amazing and unique place. This activity guide will lead you and your students through explorations of the arctic region, its wildlife, people, and conservation challenges, focusing on its North American component. This guide will help you explore the following questions:

- Where is the arctic?
- What is tundra?
- What characteristics define it?
- What species of wildlife live in the North American arctic region? What adaptations do arctic wildlife have to survive the extreme conditions?
- What peoples live in the North American arctic? How do they live?
- What are some of the conservation challenges facing the North American arctic regions? What can be done to address them?



Location and Climate

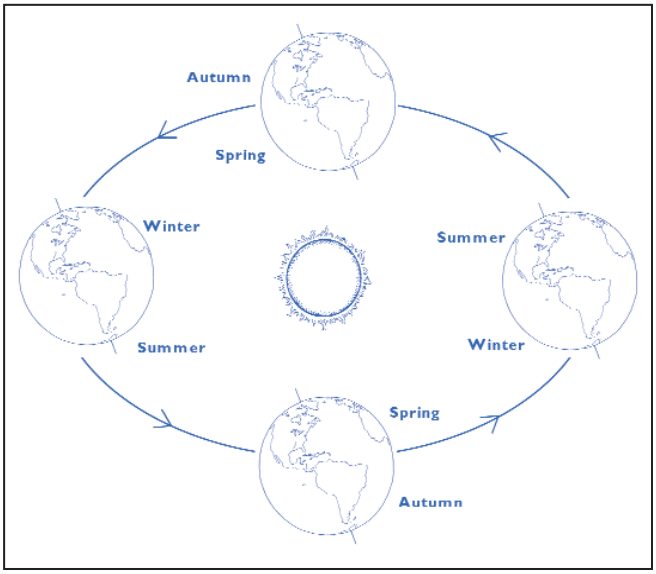
The arctic tundra is **circumpolar**, meaning that it is an ecosystem surrounding the polar region, above roughly 60 degrees north **latitude**. The Arctic circle occurs at 66 degrees north latitude.

In the arctic tundra, short days for much of the year and the harsh cold climate result in a brief growing season of 50-60 days. By contrast, the growing season in temperate forests is about six months long and in tropical forests lasts the entire year. Furthermore, strong winter winds challenge the stability of any plants that grow more than an inch or two above ground surface. Below a thin layer of soil that thaws every summer is ground that remains frozen year-round, called permafrost. The permafrost may be incredibly deep, reaching more than 1000 feet thick in some locations. Although the tundra receives less than ten inches of precipitation each year, (which is why it is some-

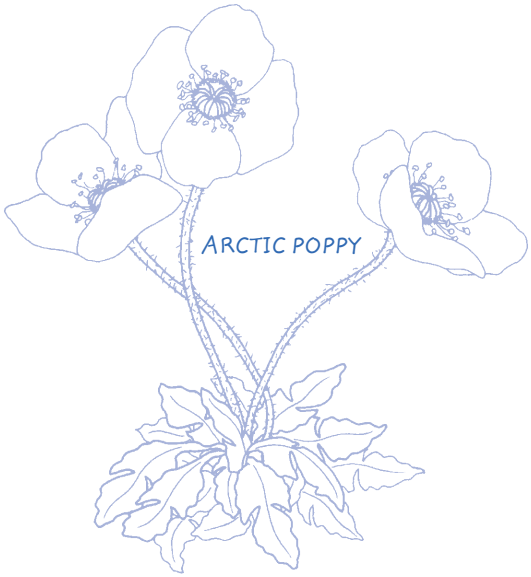
times referred to as an arctic desert), there can be plenty of standing water when the upper layer of soil thaws each summer. During this thaw, water is trapped at the surface by the always-frozen permafrost below, forming extensive seasonal wetlands. Roads, which trap the sun's heat, must be specially insulated to prevent them from melting the permafrost, which could cause their collapse. Since buildings also trap heat, to avoid this problem, many buildings are constructed on stilts and insulated pipes run above ground.

Flora and Fauna

Due to its high latitude and the tilt of the earth, the arctic experiences light and temperature extremes throughout the calendar year. Temperatures range from 60°F (50° C) in the winter to 77° F (25° C) in the summer. In Barrow, Alaska, on the northern coast, there is a 67-day-long period of darkness beginning November 18. May 10 starts an 84-day-long period of light. The plants and animals of the tundra must be adapted to face these challenges, including not only extremes of day length and temperatures, but also harsh winter winds, long periods of below freezing temperatures, and permanently frozen ground.



Hundreds of plant species have adaptations allowing them to thrive in the arctic region. Plants that grow in the arctic are adapted to grow very quickly in the short window of prime growing conditions each summer. Plants with low growing, small, compact forms are the most successful in the arctic—mosses and lichens, grasses and low bushes are good examples. They are adapted this way not so much to conserve heat, as animals do, but to conserve water. When surface area is lower, water evaporation is also lessened. The form



or shape of a plant plays a role in its overall ability to function in its environment; in other words, form follows function. Small, waxy leaves help some tundra plants retain moisture, and vertical leaves (such as a blade of grass) help others get more light when the sun is very low on the horizon. Tundra plant roots tend to spread horizontally through the thin soil layer above the permafrost, rather than vertically.

The form of a plant is one type of adaptation, but arctic plants have many others. For example, some plants contain chemicals which serve as natural antifreeze, enabling them to continue photosynthesizing in freezing temperatures (water is a necessary part of the process of **photosynthesis**). Furthermore, all plants must reproduce and many cannot rely

largely on insect pollinators since insects' period of activity in the arctic is limited. Many arctic plants therefore reproduce from pieces of themselves, such as a bulbil or root runner below the ground.

Interestingly, the very condition that challenges the overall survival of arctic plants so much, the wind, is essential to many of them for spreading their pollen. Sometimes plants have to "cooperate" with each other to survive. This is called a **symbiotic relationship**. **Lichens** are organisms that are made up of two coexisting organisms, each helping the other to survive. Each lichen is a combination of a fungus, which stores water and collects minerals, and an algae, which photosynthesizes, providing energy for the lichen using the water collected by the fungus.

Tundra conditions—especially permafrost and high winds — prevent trees from growing to the heights found naturally in many other parts of the world. This is because the root system of the tree has limited soil penetration with the near-surface permafrost, and a low growing form is less likely to catch the wind and become uprooted. Only very low-growing dwarf willows and birches survive on the tundra, and they may only reach a few feet in height.

At the southern edge of the arctic tundra, in what is called the transition zone between evergreen taiga forest and the nearly treeless land of the tundra, there are trees growing that look like they are walking across the tundra. These **krummholz**, or "twisted wood," are trees that grow on one side, the side away from the wind. On this side, they have branches that reach out and touch the ground, eventually taking root there. Wind hitting the tree on the other side causes it to lean in the direction of growth. This gives the krummholz the appearance of moving, almost crawling across the tundra. These trees may be only several inches to a few feet tall, (generally not taller than the amount of snow that falls each

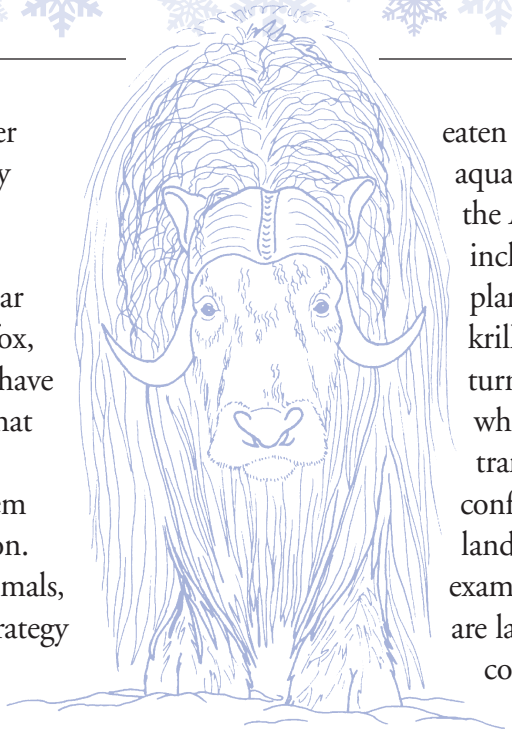
FOOD WEB POLLUTION IMPACTS IN THE ARCTIC

Lichens absorb and store radioactive materials very easily because these chemicals mimic potassium, a mineral important for lichen growth. The Chernobyl nuclear power plant accident affected lichens of the Norwegian arctic, which impacted reindeer that rely on lichens as their main food source. Scientists found that these reindeer had radiation levels above government safety levels, and could no longer safely be eaten by people.

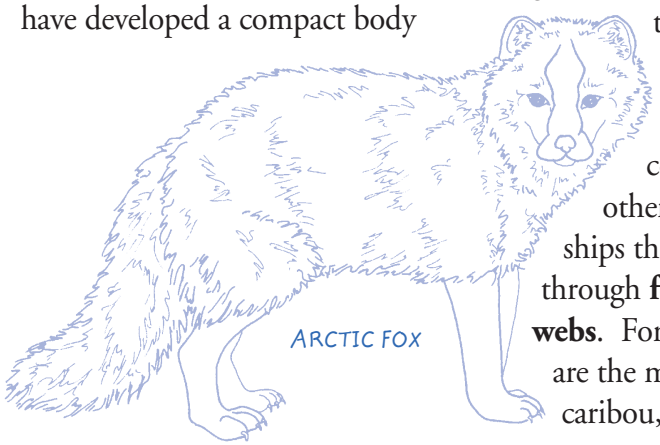
year), but they can live for several hundred years!

Like plants, animal species inhabiting the arctic tundra have special **adaptations** that enable them to survive in an ecosystem that is dramatically different in the summer than in the winter. Many species have thick layers of fat and heavy fur coats. Several arctic species change color with the seasons to blend in with the changing ground cover — arctic fox and rock ptarmigan, which turn white in winter, for example. Some species hibernate, including ground squirrels and grizzly bears. Insects lay eggs in summer when the ground is soft and larvae are adapted to survive freezing temperatures. During the winter, some insects survive by going into a dormant state, called **diapause**. In this state, they can live despite being nearly frozen, due to naturally occurring antifreeze-like compounds in their bodies.

Other species, like musk oxen, have developed a compact body shape to better conserve body heat. Several mammals, including polar bears, arctic fox, and caribou, have hollow hair that traps air, providing them with insulation. For many animals, the coping strategy is to **migrate** seasonally, taking advantage of the tundra's long summer days and explosion of food sources in the short summer season, and finding more suitable warmer habitats in the winter. Animal adaptations like these take thousands of years to develop, through **natural selection**. Relatively sudden changes in an animal's ecosystem, such as increased temperatures caused by global warming, challenge a species' ability to survive.



MUSK OXEN



ARCTIC FOX

Plants and animals of the arctic are connected to each other by feeding relationships that transfer energy through **food chains** or **food webs**. For example, lichens are the major food of caribou, which in turn are eaten by wolves. An aquatic food chain of the Arctic Ocean includes phytoplankton eaten by krill, which are in turn eaten by whales. Energy transfers are not confined to either land or sea. For example, polar bears are land dwellers that consume seals feeding entirely on oceanic organisms (such as herring and other fish). It is important to remember that conditions in neighboring ecosystems to the arctic, including the Arctic Ocean, do have an impact on tundra life via food webs. Pollution introduced into the air and water of far-flung areas of the globe can eventually reach arctic wildlife as well. Also, because migrating species have ranges that include multiple ecosystems, including some far removed from the arctic tundra. The tundra can be affected by changing conditions in these ecosystems and their respective food webs.

CASE STUDY

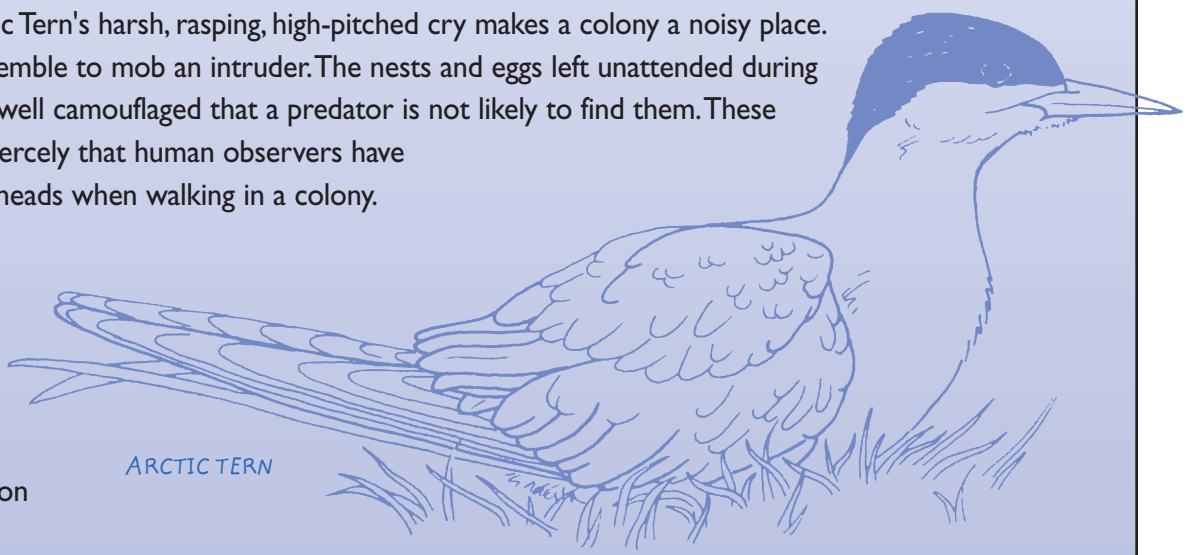
ARCTIC TERN
Sterna paradisaea

Habitat: Coastal islands and beaches throughout North America, Europe and Africa; also on tundra in summer.

Nesting: 2 spotted olive-buff eggs in a shallow depression in the ground, sometimes lined with grass or shells. Nests in colonies, usually on islands or protected sand spits.

Range: Breeds from Aleutians, northern Alaska, and northern Canada east to Ellesmere Island and Newfoundland, and south to northern British Columbia, northern Manitoba, Quebec, and Massachusetts. Winters at sea in Southern Hemisphere. Also breeds in northern Eurasia.

These terns annually perform spectacular migrations, every fall heading eastward across the Atlantic and down the west coasts of Europe and Africa to winter in the Antarctic Ocean. In spring they return north, following the East Coast of South and North America, a round-trip that can total 22,000 miles (35,000 kilometers). They see more daylight than any other living creature since they are in both the arctic and Antarctic during the periods of longest days. During the northern winter, this species is more truly oceanic than its close relatives, feeding chiefly on small seagoing shrimp and other planktonic animals. The arctic Tern's harsh, rasping, high-pitched cry makes a colony a noisy place. All members assemble to mob an intruder. The nests and eggs left unattended during an attack are so well camouflaged that a predator is not likely to find them. These terns attack so fiercely that human observers have to protect their heads when walking in a colony.



Threats:
Human disturbance of breeding habitat, habitat degradation

CASE STUDY

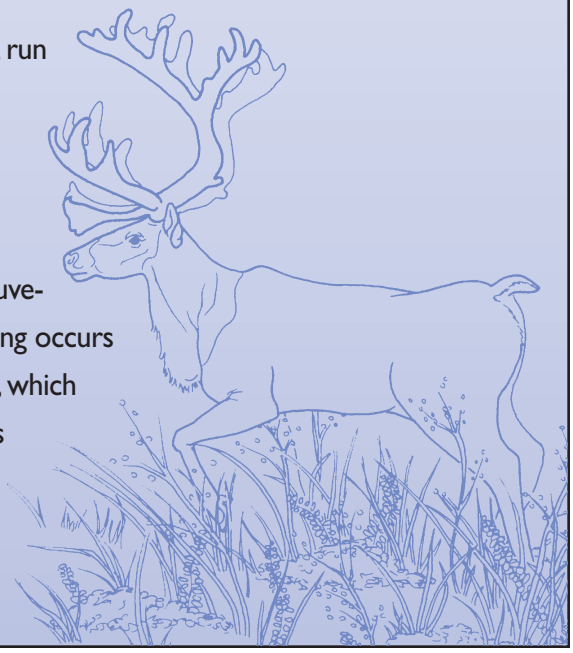
CARIBOU

Rangifer tarandus

Habitat: Tundra and taiga; farther south, where lichens are abundant in coniferous forests in mountains.

Range: Alaska and much of Canada south through British Columbia to Washington and Idaho; also Alberta and northern two-thirds of Manitoba and Saskatchewan; in the East, most of Canada south to Lake Superior and east to Newfoundland.

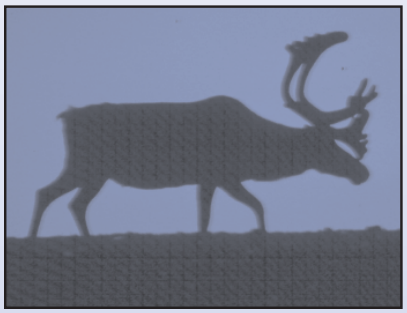
The caribou of North America, now considered to be the same species as the reindeer of Europe and Asia, is among the most migratory of all mammals. It is the only member of the deer family that lives year-round north of the tree line in some of the harshest ecosystems in North America. The gregarious caribou usually forms a homogeneous band of bulls, or of cows with calves and yearlings, but may also gather in groups numbering up to 100,000 of both sexes and all ages in late winter before the spring migration. As spring proceeds, herds begin to move northward. Females move more rapidly, and soon some of the juveniles drop back, especially if the snow is deep; they will join the bulls, who travel more slowly. The cows spread out as they reach the area for calving, which takes place in mid-May through early July. The newborn calf is well developed, able to stand in about 30 minutes, run some distance after 90 minutes, and keep up with the herd within 24 hours. It begins to eat solid foods at two weeks, but may continue to nurse into the winter.



In October and November, mating begins; the bulls join the cow/juvenile groups, where they remain until cows become receptive. Mating occurs either at that time, in the early stages of the southward migration, which varies with location, or immediately after fawning. The polygamous bull chases the female, who flees ahead of him. Pursuit is often interrupted by fights with other males. A male may rush about among several cows, thrashing bushes with his antlers and

battling other bulls. However, a male actually pursues only one female at a time. After the rut, the animals move south to the winter range; adult bulls often separate at this time from the cow/juvenile group. Different herds move in different ways in order to reach summer, winter, calving, and rutting grounds with adequate food, water, and protection from predators. The most impressive migrations are by the caribou living on the tundra in the northwest, often called the "Barren Ground Caribou."

Especially active in the morning and the evening, the caribou can run at speeds of nearly 50 mph (80 km/h), but cannot maintain such a pace for very long. The animal's spongy footpads provide traction and good weight distribution on boggy summer tundra; in winter, when the pads have shrunk and hardened, and are covered with tufts of hair, the hoof rim bites into ice or crusted snow to prevent slipping. The caribou is also a good swimmer. It swims with nearly a third of its body above water, the air-filled hollow hairs of its coat giving it great buoyancy. In summer, to avoid heat and insects, the caribou often lies on snowbanks on the north side of hills; in winter, it suns on frozen lakes. In early spring, the antlers begin to grow; they are lost shortly after rutting. The female retains her antlers through the winter and loses them about the time the calves



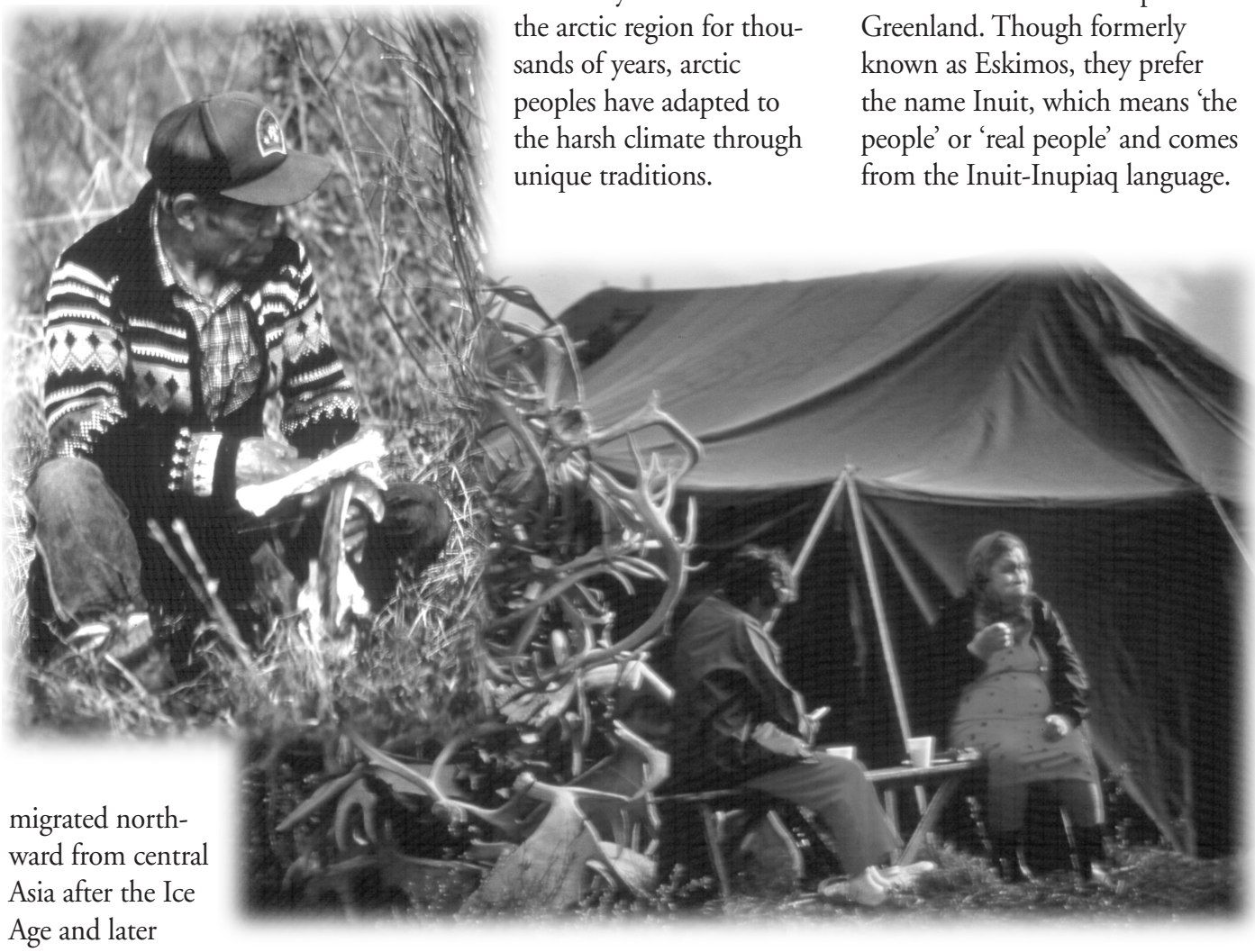
arrive. In summer, the caribou feeds on lichens, mushrooms, grasses, sedges, and many other green plants, twigs of birches and willows, and fruit; it also competes with rodents for dropped antlers, a source of calcium. In winter, lichens are the chief food, supplemented by horsetails, sedges, and willow and birch twigs. Food intake is much reduced in winter, and the animal loses weight then. The caribou needs high-quality forage in summer to supply the energy necessary for reproduction, growth, and winter survival.

Cows with insufficient energy reserves will probably not breed, but will build reserves and breed the following year. In the fall, the bull caribou fattens up to sustain himself through the rigors of the rut, when he seldom eats. Usually quiet, the caribou may give a loud snort, and herds of snorting animals may sound like pigs. Biting flies and other insects can be a major problem for caribou in some areas. In years of major outbreaks, the caribou will seek snowdrifts, windy ridges, water, or other areas with few insects. Sometimes there is nothing the animal can do but run around wildly in an attempt to avoid them. Chief predators are humans and wolves, although grizzly bears, wolverines, lynx, and golden eagles may take a few caribou, particularly the young. The caribou has been a major source of food and clothing for native people of the far north.

Threats: Development of habitat

People of the Arctic

The arctic is one of the most sparsely populated areas in the world. Its peoples are thought to be descendants of people who migrated northward from central Asia after the Ice Age and later dispersed throughout Europe and North America. There are eleven distinct Native cultures in Alaska, and dozens of sub-cultures. The North American arctic's native peoples include the Tsimshian, Aleut, Inuit (including the Inupiaq/Inupiat and Yupik), and Athabascans (also spelled Athapaskan), which include the Gwich'in (also known as Kutchin, the native language they speak).



Since they have inhabited the arctic region for thousands of years, arctic peoples have adapted to the harsh climate through unique traditions.

Hunting animals that are abundant at certain seasons of the year, such as migratory caribou, or gathering and preserving plants during the arctic summer are a few of the strategies used by native peoples to survive in the arctic.

Inuit are one group of peoples living in the arctic; their native land extends from the northeastern tip of Russia across Alaska and northern Canada to parts of Greenland. Though formerly known as Eskimos, they prefer the name Inuit, which means 'the people' or 'real people' and comes from the Inuit-Inupiaq language.

As the Inuit moved eastward from Asia, they adjusted their way of life in order to survive the harsh arctic environment. They caught fish and hunted seals, walruses and whales, caribou, musk oxen,

polar bear and other animals. They used animal skins for tents and clothes, and made tools and weapons from animal bones, antlers, horns and teeth. In summer, they traveled in kayaks and in winter, on sleds pulled by dog teams. Most Inuit lived in tents in the warmer months and in sod houses during the cold winters. When traveling in hunting parties in winter, they built snowhouses.

The Gwich'in, one of the Athabascan group of native peoples, are North America's northern most Indian Nation. They live in 15 small villages scattered across Northeast Alaska and Northwest Canada. There are about 7,000 Gwich'in people who live on or near the migratory route of the Porcupine Caribou Herd, on which they depend. For thousands of years, they have relied upon the Porcupine River Caribou Herd to meet virtually all of their needs. Each spring they watch first the pregnant cows, and later the bulls and yearlings leave their winter grounds and head north to the coastal plain of the arctic National Wildlife Refuge, which is the caribou birthing place and nursing grounds. Today, as in the past, the caribou is still vital for food, clothing, tools, and as a source of respect and spiritual guidance for the Gwich'in.

The discovery of gold in the late 1800s led to an influx of more than 30,000 prospectors to the Alaskan arctic from far-flung states and countries. The advent of World War II brought further roads, airports, harbors, and timber, fishing, and mining industries grew up in the years following World War II. The Cold War brought increased military presence to the area. Oil and gas were discovered at Prudhoe Bay on Alaska's north slope in 1968, and the Trans-Alaska Pipeline was approved for construction in 1974, bringing increasing numbers of industry personnel and with them, "Western" culture and values. Today, native peoples represent approximately 16% of Alaska's population.

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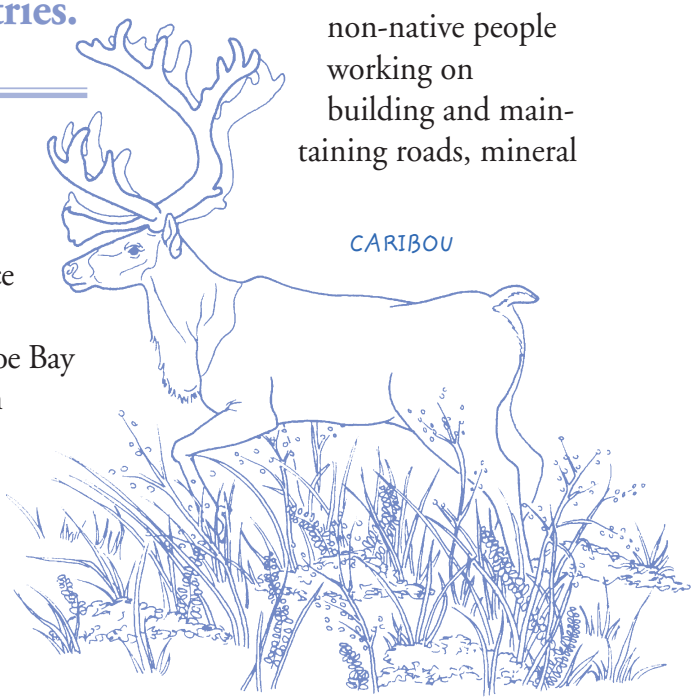
Though many Native traditions are still practiced today, the traditional way of life no longer exists for most Native peoples. Most live in wooden homes rather than snowhouses, sod houses or tents. Most wear modern clothing instead of animal skins. Most now speak English in addition to their native language. Traditionally-constructed kayaks and skinboats have been largely replaced by motor boats, and the snowmobile has largely replaced traditional dog teams. With the arctic's increasing economic and political role in the world, there has been an influx of non-native people working on building and maintaining roads, mineral



and oil extraction sites, weather stations, and military installations. This has led to increasing losses in traditional ways of life. Some Native peoples welcome the changes the last century has brought; others do not.

Oil production

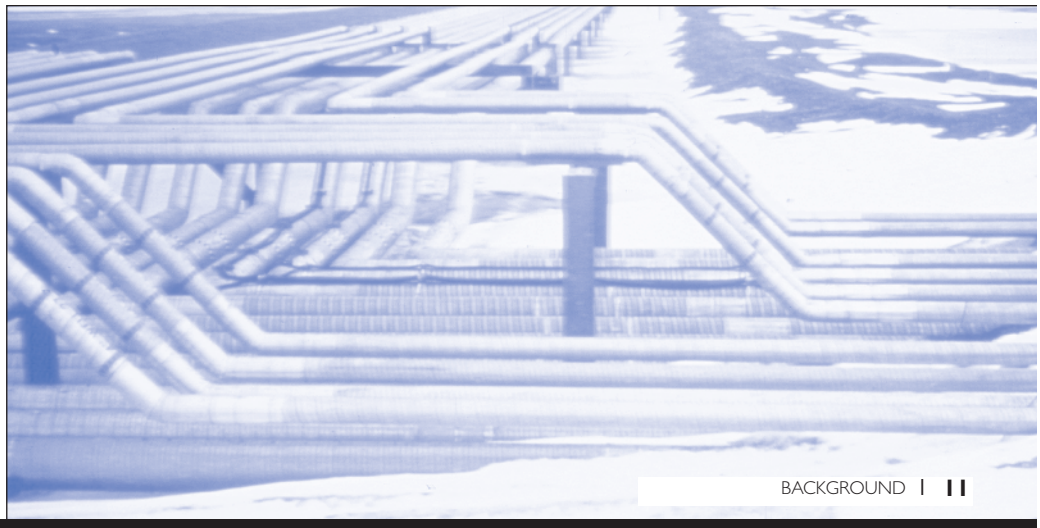
Oil, or **petroleum** (from the terms "petra" meaning rock and "oleum" meaning oil), comes from organic matter, plants and animals that died millions of years ago, their bodies accumulating and over time being covered and compacted by layers of sand and rock. Oil's ancient living origin is why it is one kind of **"fossil" fuel** (coal is another). We don't know where all of the oil in the world is located, and because known sources are finite, oil companies are always trying to find new sources, or reserves, to fill the ever-growing needs of the world's growing population. Some of these reserves are in Alaska, underneath the arctic tundra.

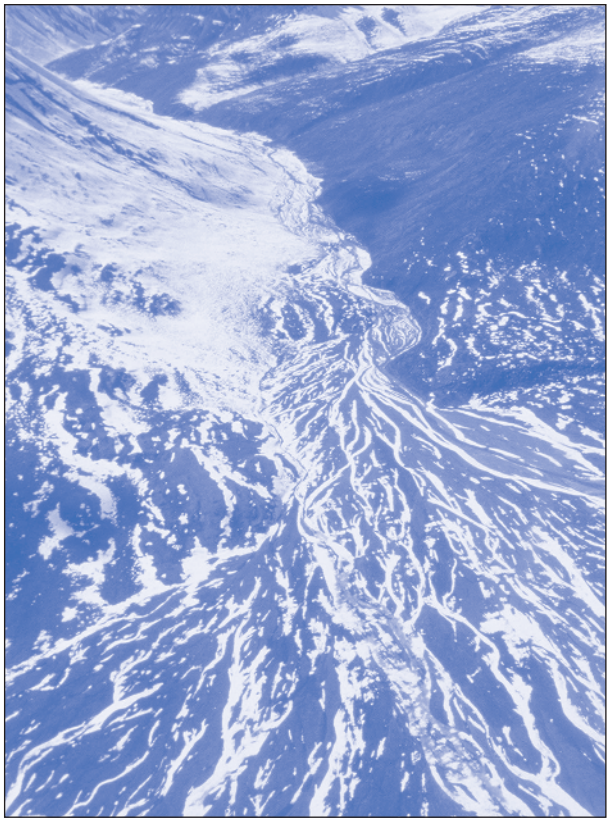
In order to take advantage of oil near Prudhoe Bay, on what is called the "North Slope" of Alaska (because it is the northern descent of the Brooks Mountains), the Trans-Alaska pipeline was approved in 1974 and completed in 1977. This is an 800 mile (1200 km), 4-foot wide pipe that transports oil from northwestern Alaska to Prince William Sound in south central Alaska. Building the pipeline was a massive project that took over 3 years to complete, and cost nearly $8 billion in 1977. Once oil passes through the pipeline, it is loaded onto ships that take it south for processing. Many special engineering considerations were necessary to build the pipeline, particularly creating a plan for transporting hot oil without melting permafrost and minimizing disturbances to wildlife which use the area. For example, because caribou tend to stay away from human structures, there was concern that the pipeline would upset caribou migration or movement. To make provisions for caribou and other wildlife, the pipeline was elevated at least 10 feet in 554 places, and buried in 23 places to create animal passageways.

Nearly 95 percent of the potential oil reserve area of the North Slope is open to exploration and drilling (the Naval Petroleum Reserve and the coast of Prudhoe Bay). The remaining 5 percent is found within the arctic National Wildlife Refuge, which was set aside by President Eisenhower in 1959 to preserve the unique wilderness and wildlife found there.

Impacts of Oil Exploration

There is great debate over the impacts of oil exploration and extraction in Alaska. Many argue that oil development has significantly altered Alaska's North Slope region. Since drilling was authorized in the region more than 30 years ago, oil operations have led to an average of 409 spills of crude oil, diesel fuel, and other pollutants each year, including a spill of 64 million

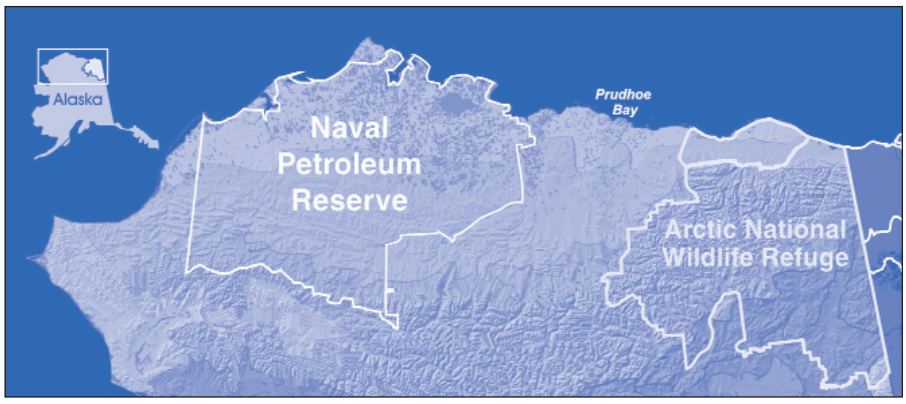




gallons of toxic drilling waste in the Prudhoe Bay area in 1986. In addition, the heavy equipment necessary for oil extraction leaves long-term impact on tundra soil and plants. Recovery and re-growth are especially slow in the cold arctic climate. Wildlife activities are disrupted by the presence of humans; arctic wildlife are sensitive to the presence of human structures and often need undisturbed areas to meet their habitat needs. Furthermore, oil extraction activities have left abandoned drill sites and waste areas, and have created hundreds of miles of roads and pipelines through these sensitive areas. The 1989 11-million-gallon Exxon oil spill in Valdez, Alaska affected 1,500 miles of shoreline along Prince William Sound, an area as vast as the distance from Massachusetts to North Carolina.

However, people all over the world rely on petroleum products to heat their homes, drive their cars, and produce the many plastic products we have come to rely upon every day. Oil has also had a major impact on the people who live in the arctic region. Since oil was discovered in 1968, the industry has brought jobs, modernization and economic incentives to the arctic region's peoples. Instead of paying state income tax, all residents of Alaska receive oil dividend checks yearly from the Alaska Permanent Fund, allowing Alaskans to share the wealth from publicly owned natural resources. Oil and gas revenues provide Alaska with 85% of its yearly income and provide 25% of total U.S. production. The oil industry provides more than 5,000 jobs in drilling, pipeline operations, cargo transportation and a range of other support positions in the Prudhoe Bay region.

In addition to the direct environmental impacts of oil exploration, the arctic is considered to be particularly vulnerable to global warming, temperature changes caused in part by carbon dioxide emissions that result from the burning of oil and other fossil fuels. Average surface temperatures in Alaska have risen over the past 30 years, and scientists project that the average temperature in the region will continue to warm twice as quickly as the



global average. There is growing scientific evidence that the region may already be feeling the effects of this warming: glaciers are retreating, icebergs are melting, sea level is rising, and vast areas of permafrost are thawing.

Arctic National Wildlife Refuge

The political spotlight has recently shone on the Arctic National Wildlife Refuge, largely due to the debate regarding whether or not to open it up for oil and gas exploration.

The Arctic National Wildlife Refuge is located entirely north of the Arctic Circle. The refuge features rolling foothills, towering mountains, much forest land, and a vast 1.5-million-acre coastal plain.

The Arctic National Wildlife Refuge is located entirely north of

TIMELINE OF ARCTIC NATIONAL WILDLIFE REFUGE EVENTS 1903-1997

1903
President Theodore Roosevelt established the National Wildlife Refuge System, designating Pelican Island in Florida as its first unit.

1949
The National Park Service began a recreational survey in Alaska to identify areas with special natural values.

1954
The National Park Service recommended that the undisturbed lands in the northeastern corner of Alaska be preserved for their wildlife, wilderness, recreation, scientific, and cultural values.

1957
The Department of Interior announced plans to ask Congress to establish an 8,000 square-mile wildlife reserve in the area identified by the National Park Service study.

1960
After Congress debated but failed to create the wildlife reserve, the Secretary of Interior signed a Public Land Order establishing the 8.9 million acre arctic National Wildlife Range.

1964
President Lyndon Johnson signed the Wilderness Act, establishing the National Wilderness Preservation System and policies for wilderness management.

1968
President Lyndon Johnson signed the Wild and Scenic Rivers Act, establishing the National Wild and Scenic Rivers System, which protects designated rivers as either wild, scenic, or recreational.

1969
The first manager was hired for the arctic National Wildlife Range.

1971
President Richard Nixon signed the Alaska Native Claims Settlement Act. The Act gave the Kaktovik Inupiat Corporation surface rights to 69,000 acres along the arctic coast within the Range.

1980
President Jimmy Carter signed the Alaska National Interest Lands Conservation Act. The Act expanded the arctic Range to 18 million acres, renamed it the arctic National Wildlife Refuge, designated eight million acres as Wilderness, designated three rivers as Wild, and called for wildlife studies and an oil and gas assessment of 1.5 million acres of the Refuge coastal plain.

1983
Nearly one million acres were added to the south side of the Refuge when the State of Alaska decided not to retain control of lands it had selected under the Statehood Act.

1987
The governments of the United States and Canada signed an international agreement for management and long-term protection of the Porcupine Caribou herd.

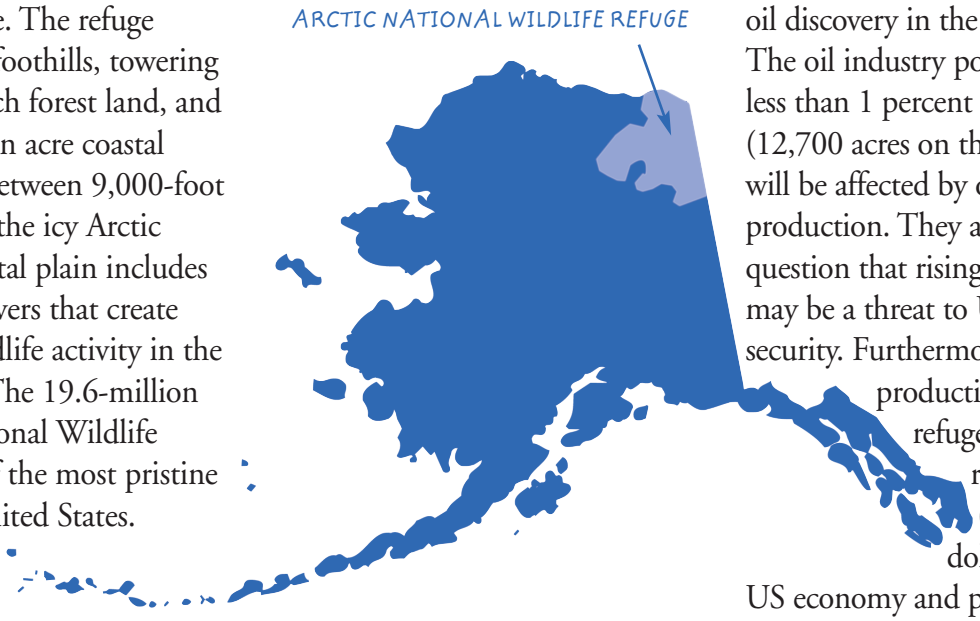
1988
Congress added 325,000 acres to the south side of the Refuge, bringing its total size to19.8 million acres.

1997
President William Clinton signed the "National Wildlife Refuge System Improvement Act." This Act provides specific guidance to the Refuge System, and establishes the mission of the National Wildlife Refuge System "to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans."

1997
The U.S. Supreme Court reaffirmed that the lagoons bounded by barrier islands along the northeast coast of Alaska are within the boundaries of the arctic Refuge. The State of Alaska had hoped to claim ownership of these lagoons to make oil leasing available.

Source: US Fish and Wildlife Service

the Arctic Circle. The refuge features rolling foothills, towering mountains, much forest land, and a vast 1.5-million acre coastal plain. Nestled between 9,000-foot mountains and the icy Arctic Ocean, the coastal plain includes low lakes and rivers that create the heart of wildlife activity in the Arctic Refuge. The 19.6-million acre Arctic National Wildlife Refuge is one of the most pristine places in the United States.



Many scientists believe that the refuge's combination of sweeping landscapes and high biological diversity, especially in its sensitive coastal plain, is unmatched anywhere in the circumpolar North. This diversity is a result of the presence of high mountains which curve north near the arctic coast in northeast Alaska, compressing many arctic and subarctic landscapes and ecosystems into close proximity and lending themselves to the existence of diverse wildlife habitats and niches. According to the U.S. Fish and Wildlife Service, the refuge provides home to more than 180 species of birds, and numerous mammals including polar bears, musk ox, wolves, wolverine, moose, arctic and red foxes, black bears, brown bears, and the white Dall sheep. It is also the site where more than 100,000 snow geese prepare for their fall migration. The Refuge also supports the northernmost breeding populations of golden eagles and arctic peregrine falcons.

The coastal plain of the Arctic Refuge is also the birthplace and nursery grounds of the Porcupine (River) caribou herd, of more than 130,000 individuals. The extensive international migrations of the Porcupine caribou herd have caused some to compare the area to Africa's fabled Serengeti, or to the now-gone buffalo movements across America's Great Plains more than 100 years ago.

Other scientists and the oil industry point to the possibility that the Coastal Plain of the arctic Refuge contains one of the best remaining prospects for significant oil discovery in the United States. The oil industry points out that less than 1 percent of the Refuge (12,700 acres on the coastal plain) will be affected by oil drilling and production. They also raise the question that rising oil imports may be a threat to US national security. Furthermore, new oil production in the refuge will infuse revenue (billions of dollars) into the US economy and provide increases in employment nationwide. The oil industry believes that oil extraction technology has improved since development of the North Slope, so that the impact of new development will be limited to a small area.

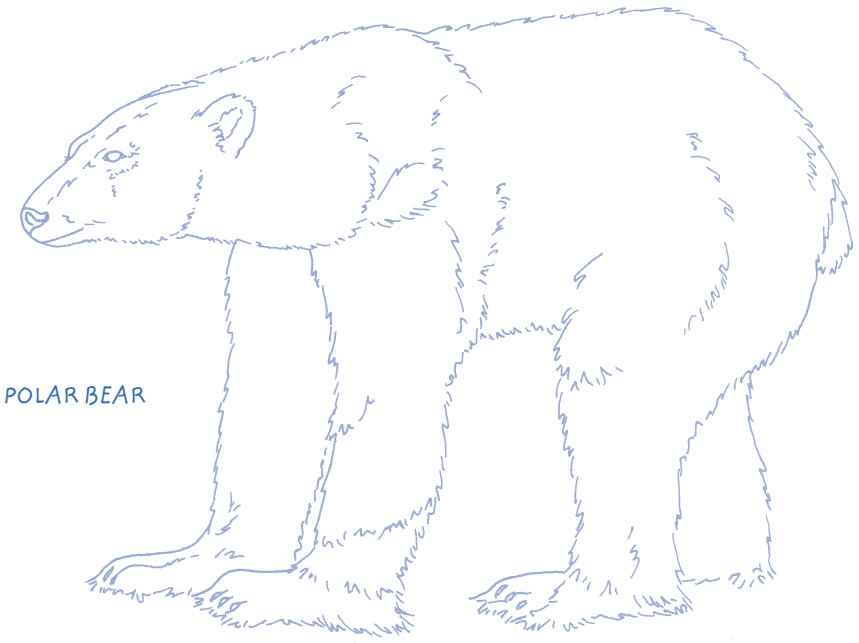
A recent U.S. Geological Survey report estimates the technically recoverable oil within the refuge area is between 4.3 and 11.8 billion barrels (95- and 5-percent probability range). This latest government figure is being challenged as overly conservative by those supporting oil development.

By contrast, conservation organizations point out that oil is a non-renewable resource. Once oil and gas is extracted from the land, it is gone. If the government's estimates are correct, many who support protection of the

refuge believe that the amount of oil available for extraction will provide the United States with just nine months' supply of oil, and it will not be available for at least 7 years after exploration begins. Supporters of the refuge's protected status also believe that if the government's national security objective is to limit reliance on foreign oil imports and create a sustainable long-range energy policy, there are better ways of achieving it—such as improving the fuel efficiency of cars and other motor vehicles and implementing renewable energy strategies. Holding relatively constant the production of automobiles, they believe that a gradual change in corporate average fuel economy (CAFE) standards from the present average of 27.5 miles per gallon to 40 mpg could reduce US oil demand by two million barrels a day by the year 2005 - far more than can be produced in the same period by extracting oil from the coastal plain of the Arctic Refuge. Furthermore, they argue that although development technology may have improved, the area targeted for drilling is the most sensitive portion of the reserve for wildlife.

Native Alaskan peoples are also divided on the value of oil drilling in the refuge. The Gwich'in are highly concerned about drilling's potential impact on the caribou herds on which they depend for subsistence and a large part of their culture. The Inupiat peoples, on the other hand, are coastal dwellers who stand to gain substantially from the leasing of their potentially rich coastal land to the oil companies. This split is likely to contribute to heightened conflicts between those native groups who rely on hunting and fishing for their sustenance, and those who look to oil-generated employment as their most important means of economic livelihood.

The issue of whether to drill or not to drill in the refuge is controversial and complicated. It is likely to be an issue carefully watched by the entire nation in the context of broader US energy, environmental, security, and economic policies of the early 21st century.



ACTIVITY 1

WHERE IN THE WORLD IS THE ARCTIC?

Summary:
Students map the arctic in relation to their home in order to learn the location and countries of the arctic.

Grade Level:
3-4; 5-8; K-2

Time
one class period.

Subjects:
geography, language arts, math, science

Skills
application, comparison, analysis

Learning Objectives
Students will be able to:

- ✔ Identify the arctic region on a world map.
- ✔ Calculate the distance between where they live and the arctic region.
- ✔ Record prior knowledge and perceptions of the arctic and compare these to what they know about their own community.

Materials

- ✔ Colored pencils
- ✔ Three maps showing different perspectives/orientations (included)
- ✔ Copies of Student Activity Sheet (included)
- ✔ Reference maps and atlases

Background

Latitude lines are imaginary lines that run east/west on the globe in concentric circles. They are useful in determining the distance a given point is north or south of the equator. The arctic tundra is circumpolar, meaning it is an ecosystem that spans the globe around the pole. It is found in Asia, North America, and eight northern countries within Europe, generally above 60 degrees north latitude. The arctic Circle occurs at 66 degrees north latitude.

The arctic tundra is a nearly treeless zone of land found between the northern ice cap and the taiga, a zone of scattered evergreen trees.

The arctic tundra is a nearly treeless zone of land found between the northern ice cap and the taiga, a zone of scattered evergreen trees. The imaginary line that distinguishes the treeless tundra from the taiga is called the tree line.

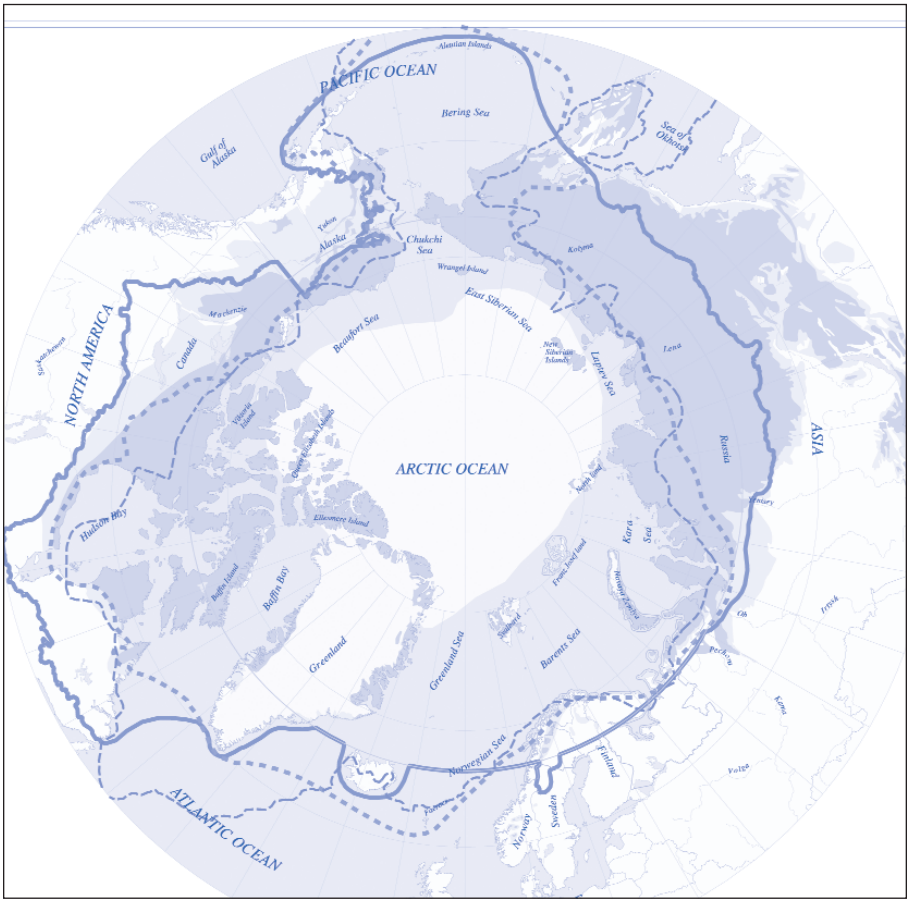
Because the arctic is geographically far away from most of North America's population, it is a location that may be difficult for students to understand. This activity, and those that follow, will help students to identify the location of the arctic circle and its relationship to their own community.

Procedure

1. Hand out the world maps provided and have students look them over. Ask the class, *Have you ever thought about which way is "up" on the earth? Does it feel like you are at the "top?" Are you at the top? How do you think people in Australia might feel about their location on North American world maps? Why would different maps be oriented in different ways? Discuss How do the maps differ? What seems most important in each map, and why?* Have students locate the continents and oceans on each map. *Which map is easiest to use? Why?*
2. Focus on the map with the North Pole at the center (map#3). Note the location of the arctic Circle at 66° north latitude. This is the imaginary

line that is commonly used to mark the boundary of the arctic region. *Which countries of the world are located within the Arctic Circle?* Using colored pencils and a world map or atlas for reference, and working in small groups, fill in the map of the arctic using Map I (p.19). Include the names of countries or continents, the location of the Arctic Circle, the North Pole and the ice cap, the Arctic Ocean, and the tundra. Student maps should be saved so they can be used again in other activities in this guide.

3. Determine the latitude of your school. *How many degrees is your school from the Arctic Circle? How many miles or kilometers is your school from the Arctic Circle? The North Pole?* Calculate the distances based on the scale of the map you are using. To illustrate the distance of the Arctic Circle from your school, take the class outdoors and, (using an appropriate scale, for example, one foot on your schoolyard equals 250 miles.) measure the simulated distance from the school to the Arctic Circle (or North Pole). When outside, choose a point that will serve as the location of your school and mark it. Then, determine where the Arctic Circle would be based on your chosen scale and mark that. Next, pick a familiar landmark (i.e., the state capitol, a museum, zoo, or park) and measure how far that landmark is from your school using a map and the map's scale. Then use the same outdoor scale and mark where that landmark would be on the schoolyard. Have students observe and compare the three distances.



SOURCE: UNEP

4. The arctic is probably a long distance from your school. Explain that the arctic is usually a very cold place. Ask students to imagine what life is like on the cold, windy tundra of the arctic. *What plants, animals, and people likely live there?*

5. Have each student fill in the Arctic Comparisons worksheet based on their preconceptions and existing ideas of the arctic. This is not a research project; rather, students are just recording their initial ideas. More advanced students can write a paragraph about what they think the arctic would be like—*what might they see in*

terms of plants and animals? What would the weather feel like? What might they eat? (All of these questions are answered in the other activities in this guide, and the chart can be completed again at the end of your unit.) Below the arctic row on their worksheets (or a separate page), students should fill in the corresponding information for their own school community. *What similarities and differences do they observe? Why do these differences exist between your school area and the arctic?*

Modifications for Younger Students (K-2)

Help students to identify their location on a world map. Point out the arctic's location. Explain to students how far away this is, relative to the size of your state or the size of the country. For the Arctic Comparisons worksheet, have students draw pictures in each box of the chart and explain their drawings to each other.

Modifications for Older Students (5-8)

After identifying the arctic on several maps, ask students what kinds of challenges arctic explorers may have faced in mapping this area? Have students investigate the history of arctic exploration and try to find early maps of the area. How did they change over time?

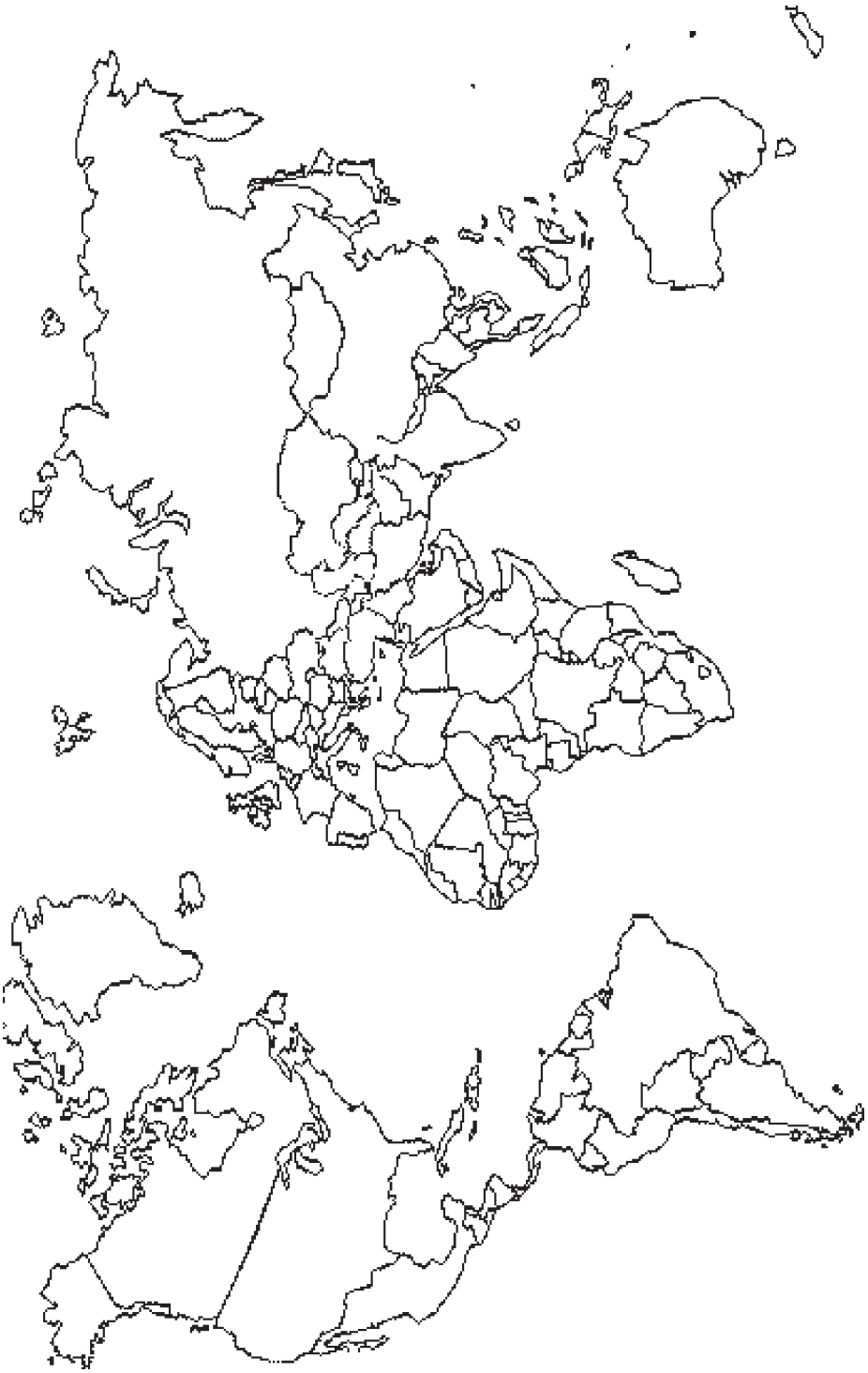
Assessment

Have students write a report or essay on how their lives would be different if they lived in the arctic region.

ACTIVITY

WORKSHEET 1

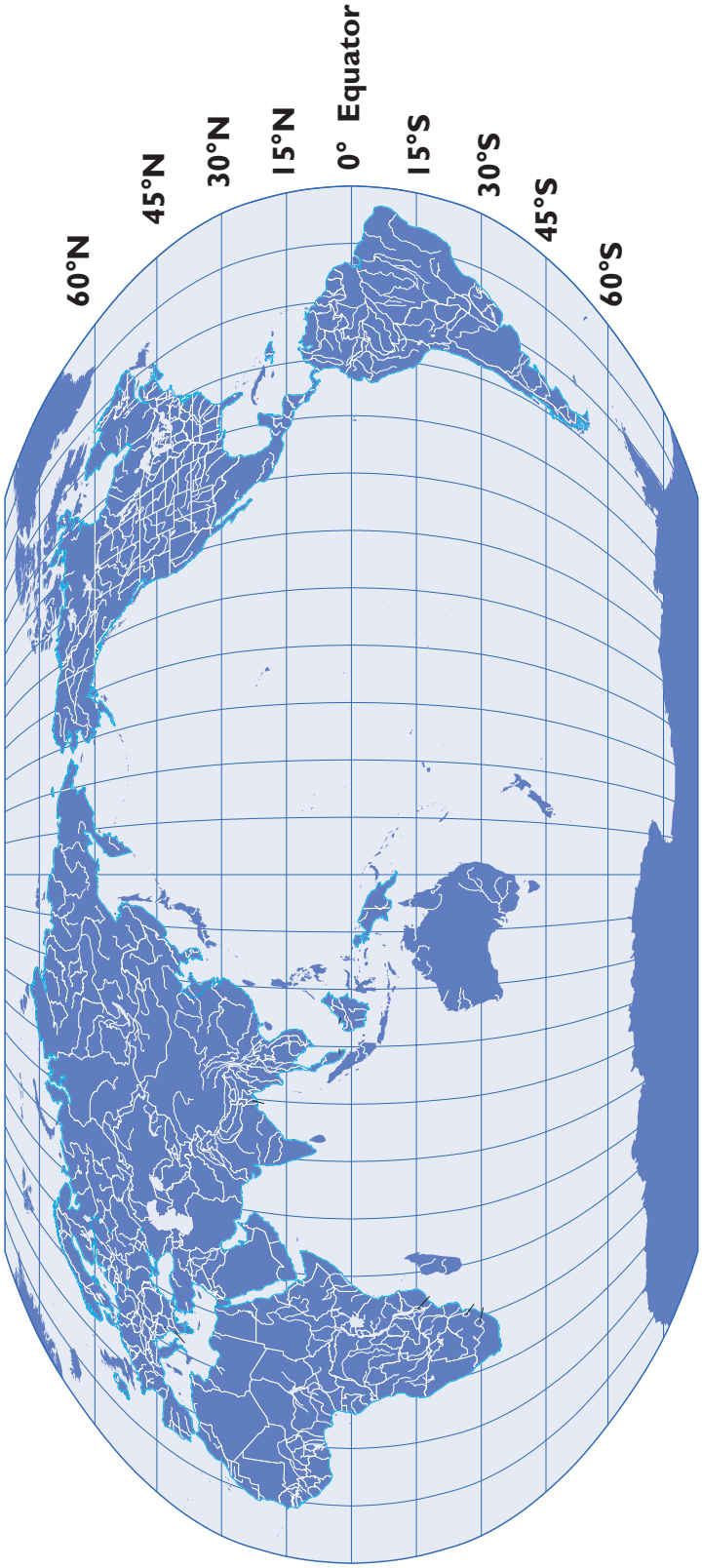
WORLD MAP I



ACTIVITY

WORKSHEET 1

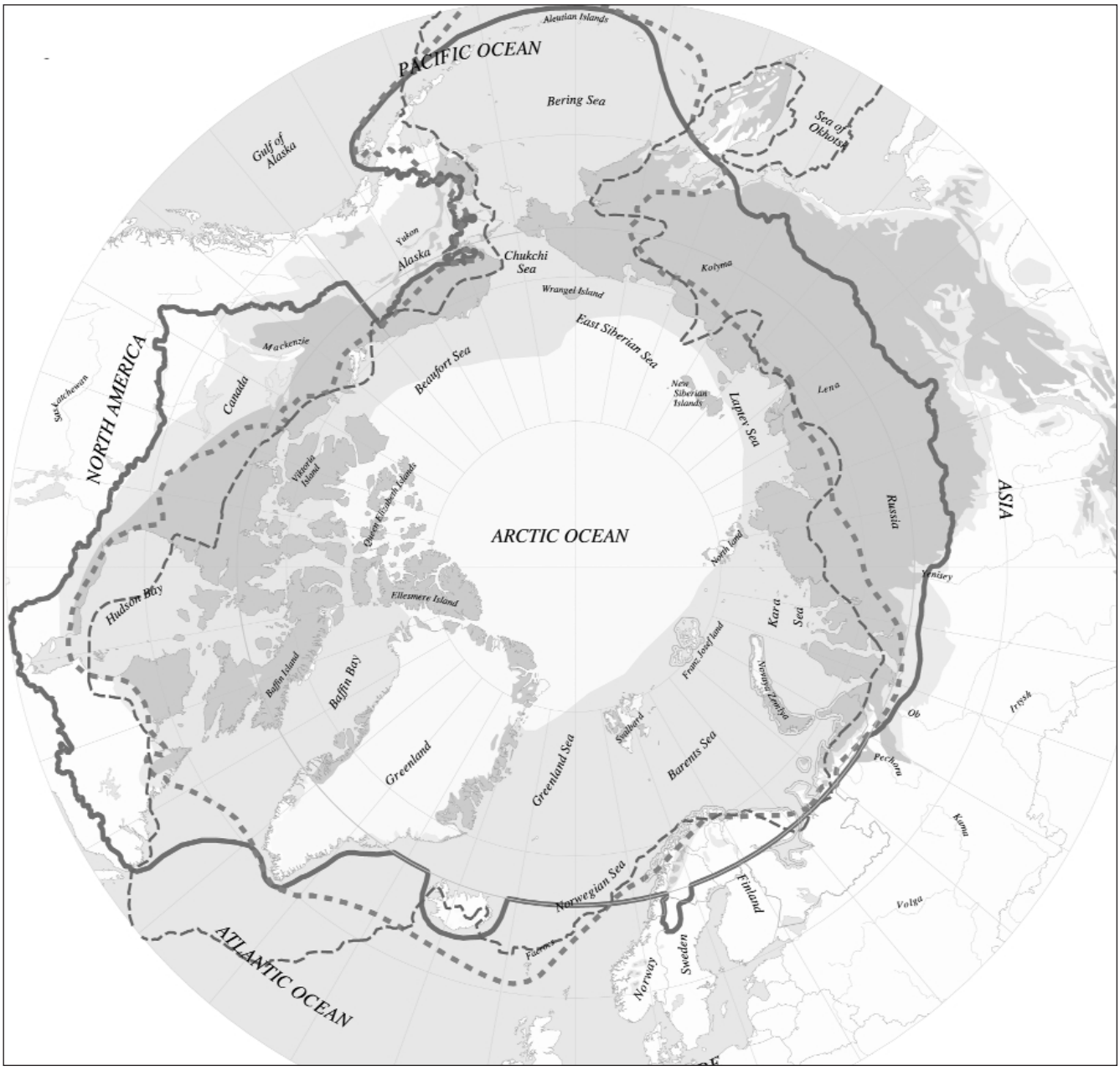
WORLD MAP II



ACTIVITY

WORKSHEET 1

MAP III



Map courtesy of United Nations Environment Program

ACTIVITY

WORKSHEET 1

ARCTIC COMPARISONS

	ARCTIC	YOUR SCHOOL'S COMMUNITY
People		
Plants		
Animals		
Weather		

ACTIVITY 5

PLANTS AND ANIMALS OF THE ARCTIC

Summary

Students create an arctic food web to understand the feeding connections and social relationships between tundra plants and animals.

Grade Level:

3-4; K-2; 5-8

Time:

one to three class periods.

Subjects:

science, creative arts, physical education

Skills:

analysis, comparison, construction, critical thinking

Learning Objectives:

Students will be able to:

- ✔ Explain the relationships between several arctic plants and animals.
- ✔ Identify a number of arctic plants and animals and their role in arctic food chains.

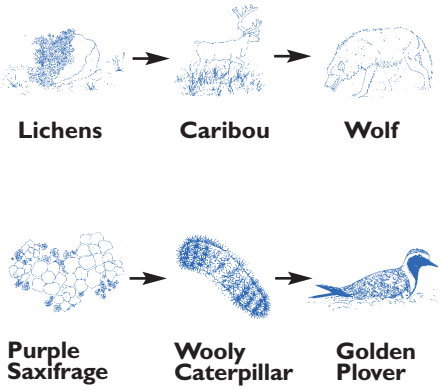
Materials:

- ✔ One rag, bandana or cloth for each student, using three different colors for the class,
- ✔ Arctic Species cards (included)

Background

The arctic is home to plants and animals adapted to take advantage of its unique climate. On the following pages are examples of plants (producers), **herbivores** (**primary consumers**, plant-eaters), **omnivores** (eat both plant and animal matter), and **carnivores** (primarily meat-eaters). Your students will use these relationships to create their own food chains and food webs in this activity. Your class can learn more about the plants and animals of the arctic ecosystem by reading Arctic Summer by Downs Matthews (1993; New York: Simon & Schuster).

Sample food chains:



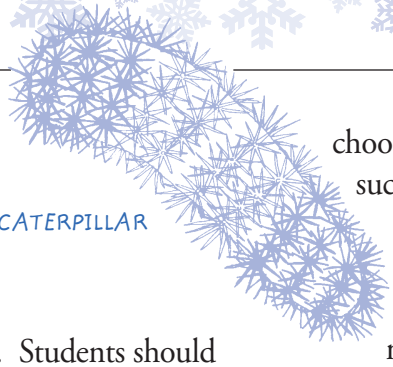
Procedure

1. With your class, review or introduce the terms **producer**, **herbivore**, **omnivore** and **carnivore**. Explain that they will begin by examining some arctic food chains to learn about the feeding connections of tundra species, and will ultimately construct an arctic food web. Ask your students, *What is the main source of energy for all living things? (the sun) How does the energy get from one organism to another? (through food chains)* Discuss the role of decomposers in recycling nutrients.

2. To practice making food chains, organize your students into small groups. To practice, distribute the Arctic Species cards for them to line up

in logical feeding order, making one or more food chains. Ask students to look at each other's food chains and identify any problems. *How does each food chain start? Where does it end? How does it recycle?* Help students identify links in the chain they may have forgotten, such as starting with the sun or including decomposers, etc.

3. Collect the square cards then re-distribute an assortment of them to the class, one for each student. Distribute only one sun. Students should familiarize themselves with their card, then attach it to the front of their shirt using masking tape. To illustrate the concept of the food web, move the students to an open area. Have students circulate around the area and join hands with other students forming natural arctic food chains. Students should join fingers when it is necessary to accommodate more than one other student onto that end of their chain. In the case of an herbivore, for example, one hand should be dedicated to producers, and the other hand dedicated to omnivores.



WOOLY CATERPILLAR

4. Once they have completed their food web, have them stop and look around. They will likely be well interconnected. Ask, *How are you all connected? Why is it important that there are so many links? How would removing one species from the web impact other species? What would happen if we removed caribou from the web?* Before letting go of one another, choose only one individual, such as a caribou or a mosquito, and explain to the students that there has been an environmental disaster, causing the extinction of the caribou. With all other students remaining in place, remove the caribou from the group. Next, ask any students who were connected to the caribou and relying on it for food, to leave the group. Explain that if the caribou (for example) are no longer eating the lichen, lichen populations could grow out of control. When this happens, habitat occupied by other plant species may be overtaken. To demonstrate, remove a "moss" or "grass" from the web. Any student who is relying on moss for its food source should then leave the group. Continue in this fashion for as long as is reasonable, then have the students evaluate the web that remains. This exercise should serve to illustrate the complexities of the relationships between organisms in any ecosystem.

PURPLE SAXIFRAGE

Modifications for Younger Students (K-2)

Have students pick Arctic Species cards from a bag or box and color them in. Then select student volunteers to hold up their card. Ask them, *What does this animal eat? What eats it?* Assist students to identify another student with a card that is predator or prey of their animal. Have them stand next to this new animal. After several rounds of moving students around to stand next to predators and prey, point out to students that all these animals and plants are interconnected. *What does that mean? What would happen if one disappeared?*

Modifications for Older Students (5-8)

✔ Have students work in small groups to make their own arctic species cards and food webs based on the plants and animals provided, or they can research several arctic species, determine what they eat and what eats them, and then create their own cards and food webs.

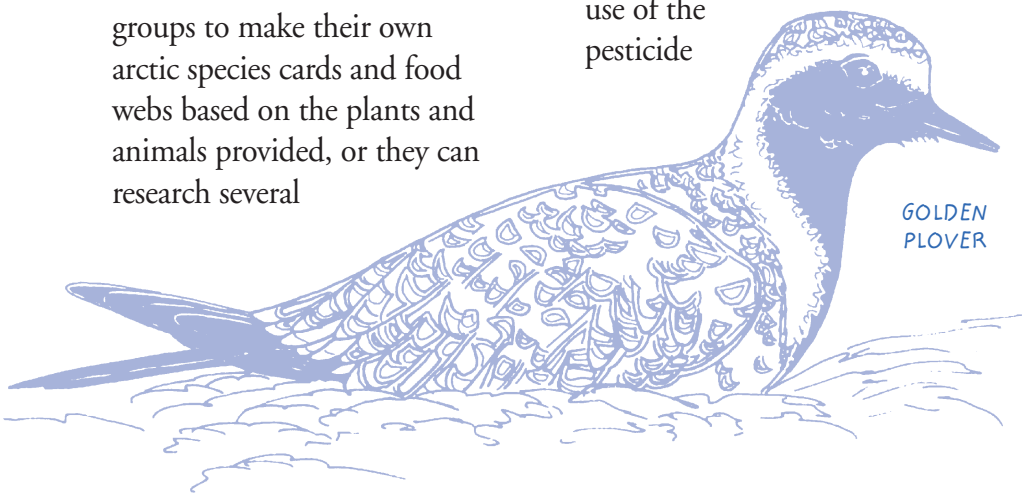
Extensions

✔ Research real-life situations in which a pollutant moved through a food chain or web. Discuss with the students the fact that pollutants are sometimes initially taken in by one organism, but may have serious consequences to an organism further along the chain. Examples would be the use of the pesticide DDT, or fallout from the Chernobyl nuclear power plant accident. *How did this pollutant affect the food web?*

✔ *Which arctic species can also be found in your region?* Have students research and report their findings to the class, including the food webs to which they belong.

Assessment

✔ Have students research the predator/prey interactions of their chosen arctic species (from Activity 2) and create a food web highlighting that species. Alternatively, have students create a food web for local species or a species found on their schoolyard. Students can then create a predator-prey mini-drama, and present their creation to the class.

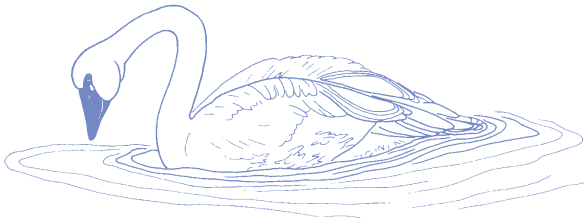


ACTIVITY

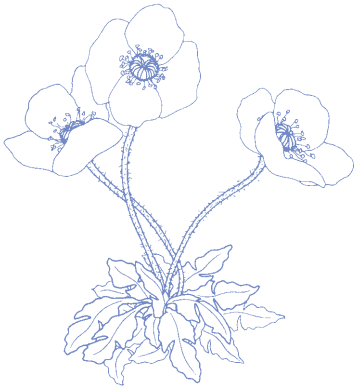
WORKSHEET 5

ARCTIC SPECIES CARDS

Plankton

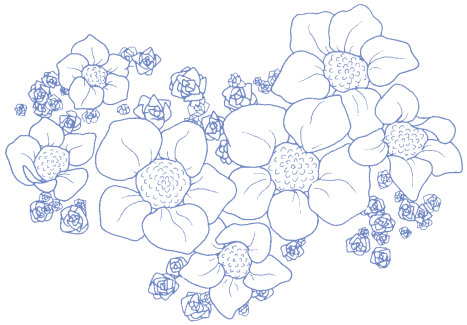


Tundra Swan

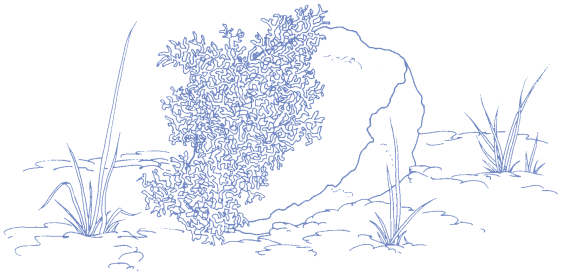


Arctic poppy

Blueberry Bush



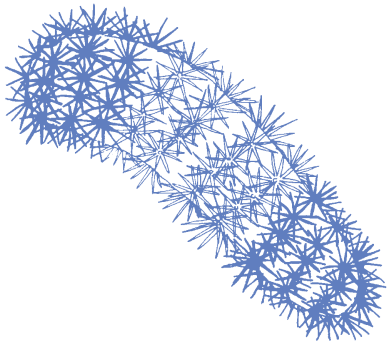
Purple Saxifrage



Lichen

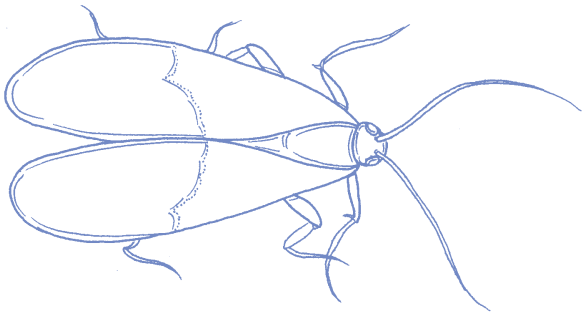
ACTIVITY

WORKSHEET 5



Wooly Bear Caterpillar

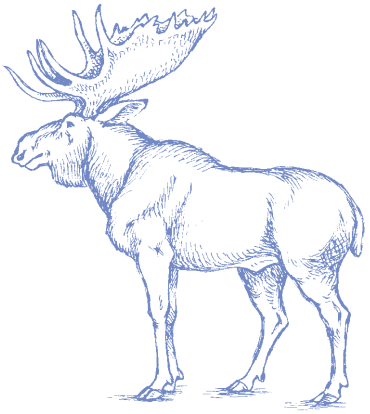
Lemming



Lichen Moth

Caribou

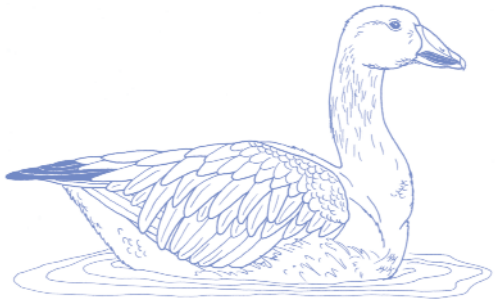
Musk Oxen



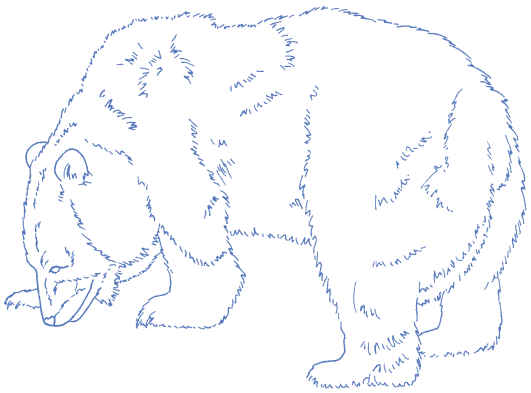
Moose

ACTIVITY

WORKSHEET 5



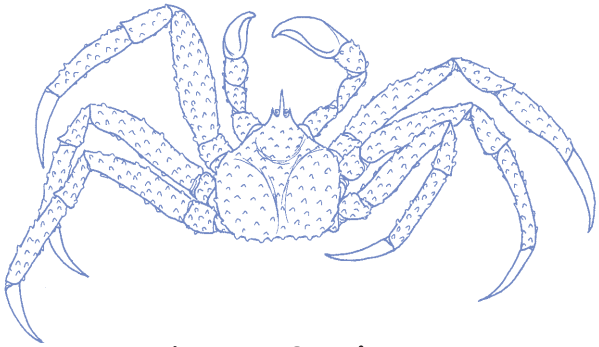
Snow Goose



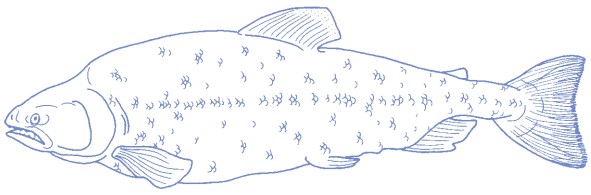
Grizzly Bear

Snowshoe Hare

Ptarmigan



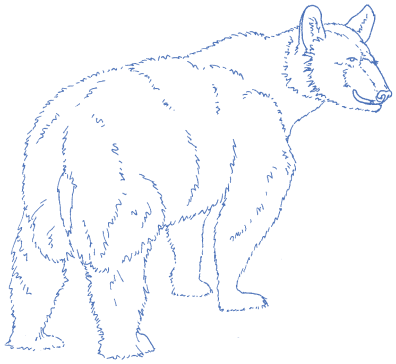
King Crab



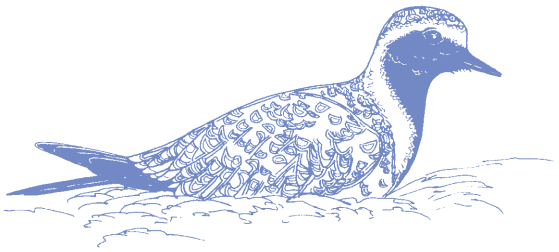
Salmon

ACTIVITY

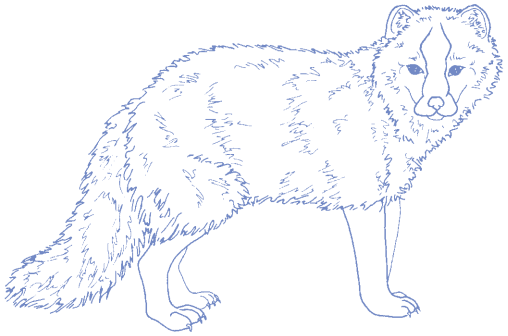
WORKSHEET 5



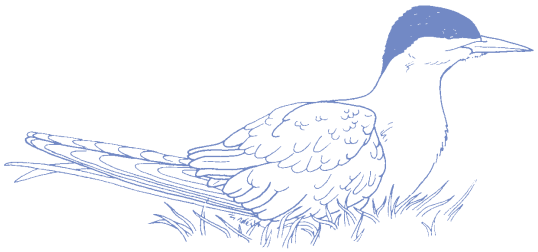
Black Bear



Golden Plover

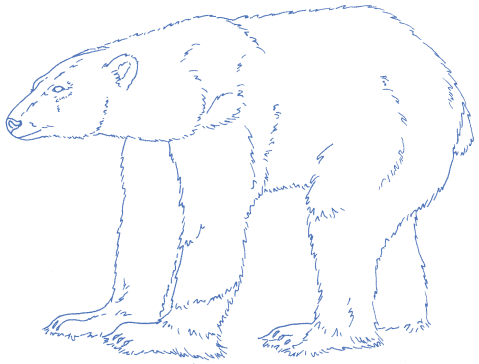


Arctic Fox



Arctic Tern

Walrus

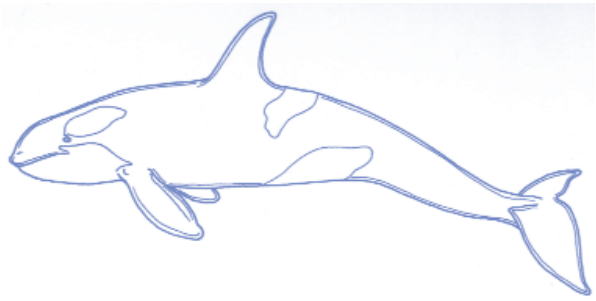


Polar Bear

ACTIVITY

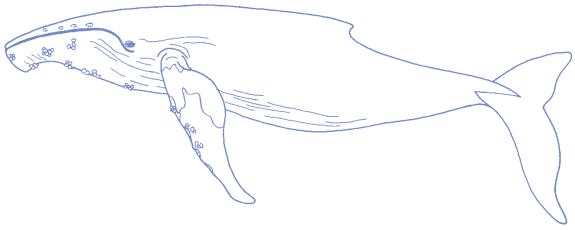
WORKSHEET 5

Wolf

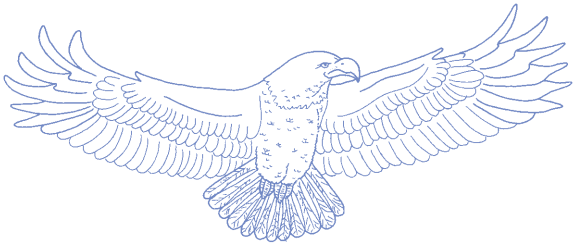


Orca

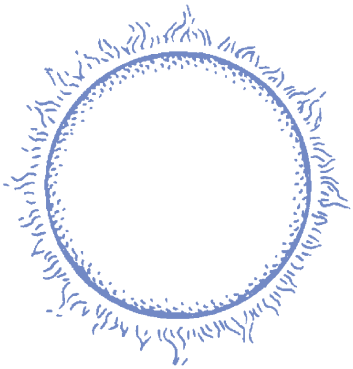
Snowy Owl



Humpback Whale



Eagle



Sun

ACTIVITY 6

MASSIVE MIGRATIONS

Summary

Students map and calculate the migration routes of arctic species to learn that animals that spend part of their lives in the arctic are connected to other parts of the world for food and shelter.

Grade Level:
3-8; K-2

Time:
one class period

Subjects:
geography, science

Skills:
research, synthesis

Learning Objectives:
Students will be able to:

- ✔ Measure the distances traveled by migratory arctic bird species.
- ✔ Identify arctic species that spend parts of the year in their own local areas.
- ✔ Explain how migratory arctic species meet their habitat requirements in various regions.

Materials:

- ✔ World map, computer with internet connection (if possible);
- ✔ North America Map worksheet, (included)
- ✔ Migration route map if computers not available (included)

Background

A habitat is the place where a species' requirements for food, water, cover, and places to raise young are found (distinguished from an ecosystem, which is the set of interactions between living and nonliving components in the environment). Migratory birds require three different habitat types: breeding and nesting areas, where they lay their eggs; non-breeding areas (often used to find food, water, and cover); and migratory stopover locations as the birds move from the breeding to the non-breeding areas. Some animals, such as caribou, migrate to areas where food is more plentiful and where they can safely have offspring. The caribou migrate from southern, inland areas of Alaska and Canada to the arctic coastal plain in the summer. High winds on the coastal plain help keep away mosquitoes and warble flies which are parasites of the caribou.

Most arctic wildlife species are temporary residents; they move to more favorable climates during the harshest times of the year. However, some species spend the entire year in the arctic ecosystem. Year-round resident birds such as the ptarmigan, raven, ivory gull, bald eagle, and dovekie have thicker feathers than

migrants such as arctic terns, snow geese, eiders, and sandhill cranes. The best time of year for birds to live in the arctic is during the summer months with long days in which to find food, warm temperatures, and plenty of insects! In May, thousands of birds descend upon the thawing tundra to begin their reproductive cycle. As the top soil layer of the tundra thaws, the remaining permafrost below the surface prevents the melt waters from draining, creating standing pools, called "thaw lakes," and marshy soil. For migratory birds, the process of egg-laying and rearing of young must be a fast one, as the summer months are few and quickly pass.

Most tundra birds lay their eggs directly onto the ground, in a slight depression. Some, like the golden plover, line their nests with vegetation such as moss, grass and leaves. American golden plovers and black-bellied plovers have their young in the arctic during the summer months, then travel about 6,000 miles each winter to South America! They use Texas and other states on the way as a stop-over, to take advantage of warm temperatures and plentiful food before completing their long journey. Flight of the Golden Plover: The Amazing Migration

Check this list to see which bird is an example of a species that summers in Alaska and winters in your state. In addition to these, there are likely many other local species in your area with similar migration patterns.

(Information from: US FIsh and Wildlife Service, (www.fws.gov.), www.r7.fws.gov/nwr/arctic

Alabama - Ruby-crowned Kinglet
Alaska - Redpoll
Arizona - Fox Sparrow
Arkansas - Mallard
California - Snow Goose
Colorado - Bohemian Waxwing
Connecticut - Greater Scaup
Delaware - Black-bellied Plover
Florida - Peregrine Falcon
Georgia - Gray-checked Thrush
Hawaii - Golden plover
Idaho - Short-eared Owl
Illinois - Northern Flicker
Indiana - Dark-eyed Junco
Iowa - Sharp-shinned Hawk
Kansas - Smith's Longspur
Kentucky - Merlin
Louisiana - Long-billed Dowitcher
Maine - Least Sandpiper
Maryland - Tundra Swan
Massachusetts - Golden Plover
Michigan - Oldsquaw
Minnesota - Red-throated Loon
Mississippi - Norther Waterthrush
Missouri - American Pipit
Montana - Golden Eagle
Nebraska - Wilson's Warbler
Nevada - Green-winged Teal
New Hampshire - Dunlin
New Jersey - Canvasback
New Mexico - Sandhill Crane
New York - Semipalmated Sandpiper
North Carolina - Semipalmated Plover
North Dakota - Rough-legged Hawk
Ohio - American Tree Sparrow
Oklahoma - Savannah Sparrow
Oregon - Brant
Pennsylvania - Lapland Longspur
Rhode Island - Horned Grebe
South Carolina - Ruddy Turnstone
South Dakota - Northern Shrike
Tennessee - Yellow-rumped Warbler
Texas - White-fronted Goose
Utah - White-crowned Sparrow
Vermont - Snow Bunting
Virginia - Lesser Scaup
Washington - Varied Thrush
West Virginia - Rusty Blackbird
Wisconsin - Snipe
Wyoming - Townsend's Solitaire

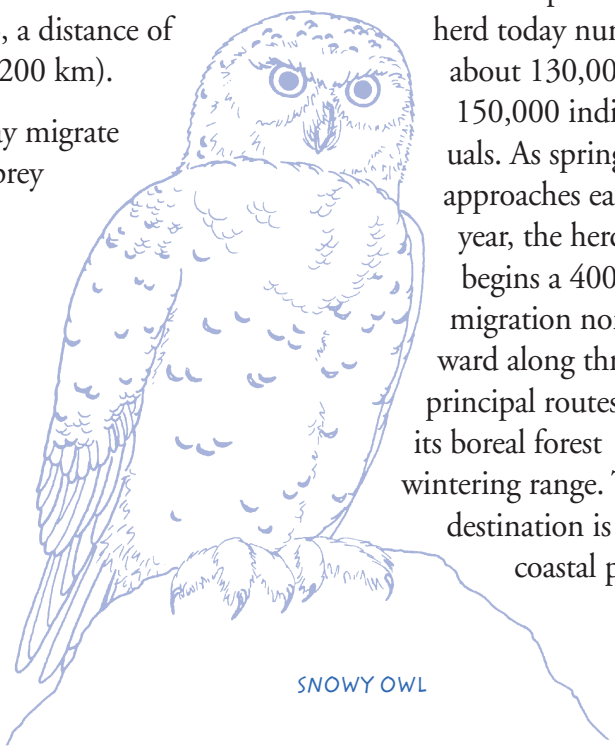
between Alaska and Hawaii, by Debbie S. Miller (1996) is an informative illustrated book about the impressive migration of the golden plover (for grades K-6).

Arctic terns make the longest migration of any species on earth, traveling from the northern arctic to the southern Antarctic each year, a distance of 25,000 miles (40,000 km) total (or about 11,000 miles or 17,700 km each way).

Arctic loons breed on tundra lakes and winter mostly on the U.S. Pacific coast.

Snow geese nest in the arctic during the summer, traveling from their winter homes in the Gulf of Mexico, a distance of 2,000 miles (3,200 km).

Snowy owls may migrate depending on prey availability—if there is enough prey in their home habitat, they don't need to migrate, but if there isn't enough prey, they will migrate south. Alaska's snowy owls tend to spend autumns in the prairies and marshlands of Canada.



SNOWY OWL

Sandhill cranes breed and lay their eggs mainly in the marsh grasses of the arctic and winter in grasslands throughout the southern and mid-western U.S.

Caribou are well-known travelers across the tundra. These herbivores are attracted to the abundant lichens and grasses of the arctic, and spend winter farther south in the shelter of the taiga's trees. They are excellent swimmers, which is essential since there are many rivers to cross along their way.

The Porcupine caribou herd today numbers about 130,000 to 150,000 individuals. As spring approaches each year, the herd begins a 400-mile migration northward along three principal routes from its boreal forest wintering range. Their destination is the coastal plain of the Arctic National Wildlife Refuge. By mid-May, the first pregnant cows arrive, followed soon by the rest of the herd. Calving reaches a peak in early June. The narrow coastal plain between the Brooks Mountain Range to the south and the Arctic Ocean to the north is ideal for calving and the early nurturing of the young. Thick fields of protein-rich cottongrass provide nourishment. Ocean breezes deter swarms of mosquitoes. Predators in this season are few. The coastal plain is so well-suited for calving that, although it is only one-fifth the size of the calving area used by the Central arctic caribou herd, six times as many Porcupine caribou inhabit it. By early September, the young calves are strong enough to initiate their migration southward and the cycle begins again.
A Caribou Journey, by Debbie S. Miller (1994) is a story of caribou migration, including information on the natural history of caribou, which would complement this activity for grades 3-6.

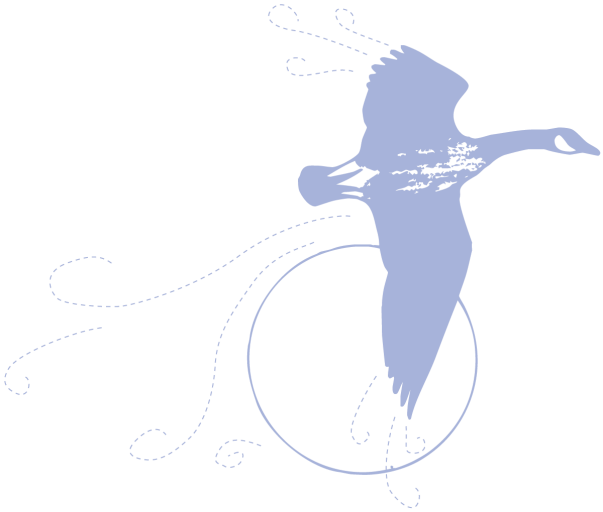
Procedure

1. Divide students into small groups and have them visit the FWS's arctic National Wildlife Refuge website

(http://www.r7.fws.gov/nwr/arctic/) to find your state and others around it and discover which bird species winter in your area and summer in the arctic (if no website access is available, refer to the background section's list of states and migratory bird species or use library resources). Have each group choose one species, and make sure each group has a different species to research. *What does their species eat? What are its habitat requirements for food, water, and cover, and places to raise young? How far does it migrate? What challenges do they face?*

2. Have students, in their groups, calculate the distance traveled by the species they have selected and make a list of the places it travels through. *What are the habitat requirements that are met by each place/stopover?* On the map of North America provided to students on the worksheet and using colored pencils, have students chart the path that their species travels on its route to and from the arctic region.

3. Compare the distances of different species' migration routes. This could be done by creating charts and graphs, or to scale outside, using string and tape measures. For example, one foot on the schoolyard could equal 100 miles (or whatever increment makes the most sense) traveled by the selected species. Have students lay out their migration route on the schoolyard to compare. *Which species has the longest migration? The shortest? What kinds of ecosystems do they pass through? Why do you think birds would travel on these long journeys? What makes the journey worthwhile for them? Why not just stay?*



4. Have each group of students demonstrate their species' migration route to the class. Students may create props or geographic landmarks to symbolize what their species might encounter on their migration. Give them time to create skits or mime acts to illustrate all the challenges and activities their species will encounter along the way. For example, to illustrate the difficulty of the journey, students may perform their migration hopping on one foot. Or at each stopover point, students could perform a task such as arranging leaves into the shape of a nest or attempting to reproduce the call of their species. Encourage the non-performing students to ask questions of each group during and after their presentation.

5. Explain that in addition to birds, other kinds of animals migrate as well. If time allows, have students research the migration route of the arctic's caribou herds. For more information, visit NWF's Arctic Refuge page: (www.nwf.org/arcticrefuge/)

Modifications for Younger Students (K-2)

✔ Have students cut out tracks of migrating species. You may find these in field guides. These can be taped to the floor, perhaps in a gymnasium. Have small groups of students follow the trail of one or more species, performing tasks that their species might need to do along the way, for example catching fish using a play fishing set, and building shelter/dens by stacking square cardboard boxes. They could imitate the appropriate bird calls or songs along the way. If possible, they can answer questions or learn more about a related topic (such as nest making) along their migration.

Extension

✔ Research the habitat requirements of migratory species found in your area. Check your schoolyard to see if there are migratory species present, and what microhabitats exist that meet this species' needs. *In which seasons are you most likely to see these species? How could you change your schoolyard to make the habitat more inviting for visiting migratory species? Does your local migratory species have adequate habitat is the size of its habitat growing or declining? Why? What environmental quality challenges do these species face?*

✔ Discuss and investigate how disruptions along a migratory route could affect the survival of the species. A common problem for migrating birds is development, and thus loss of habitat. This concept could be built into the activity above, by introducing obstacles along the students' migratory route, or eliminating one of the students' critical habitats along the path to see what would happen.

✔ Discuss and investigate how birds know when and where to migrate. *What are the signals they look for? How do they navigate?*

Assessment

✔ Assign students different migratory arctic species from the ones they originally studied. Have them determine their routes of migration, calculate the approximate distances they have to travel, and describe how they meet their habitat requirements along the way.

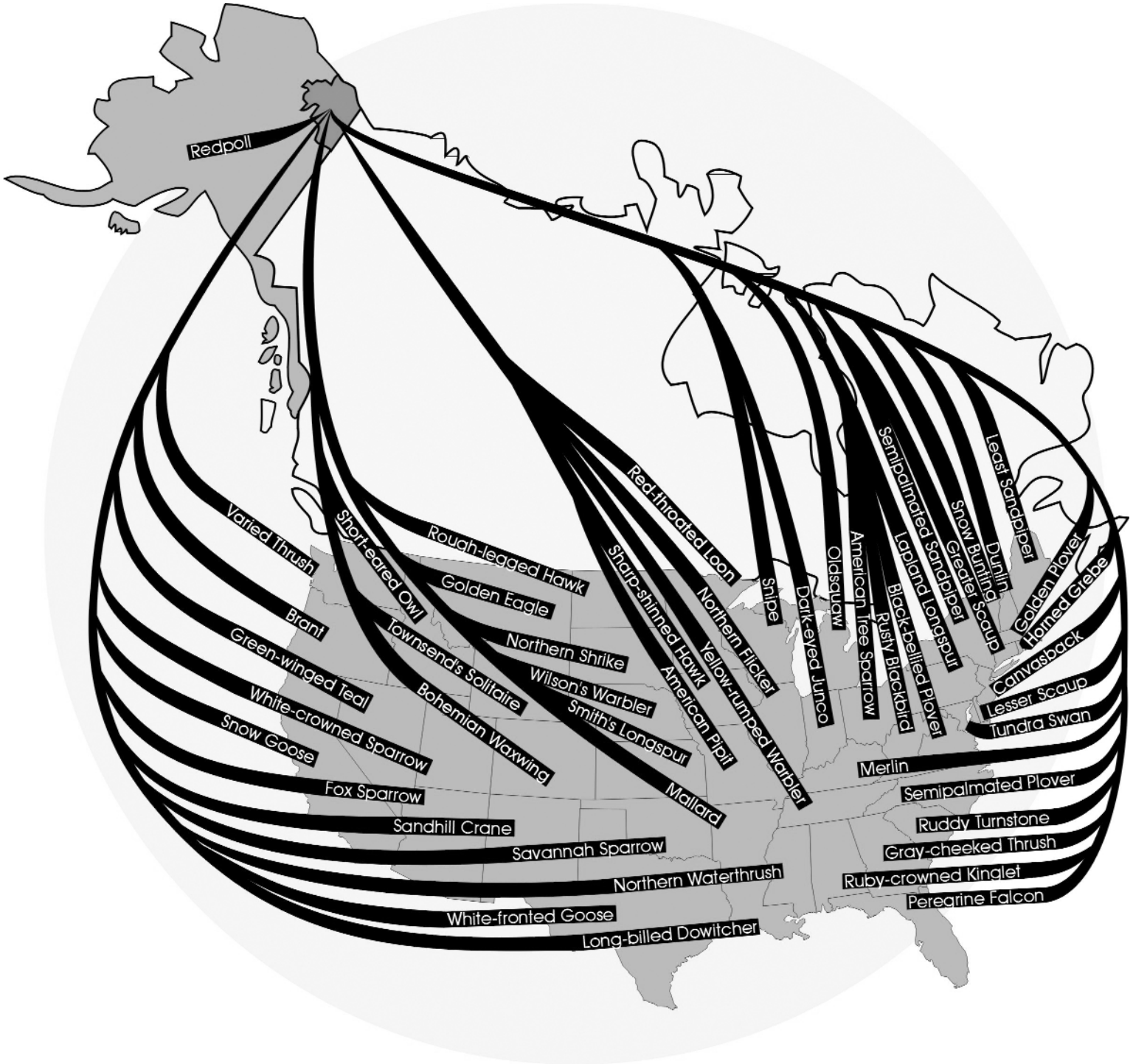
ACTIVITY

WORKSHEET 6

ACTIVITY

WORKSHEET 6

SAMPLE ARCTIC MIGRATORY BIRD SPECIES



SOURCE: U.S. FISH AND WILDLIFE SERVICE