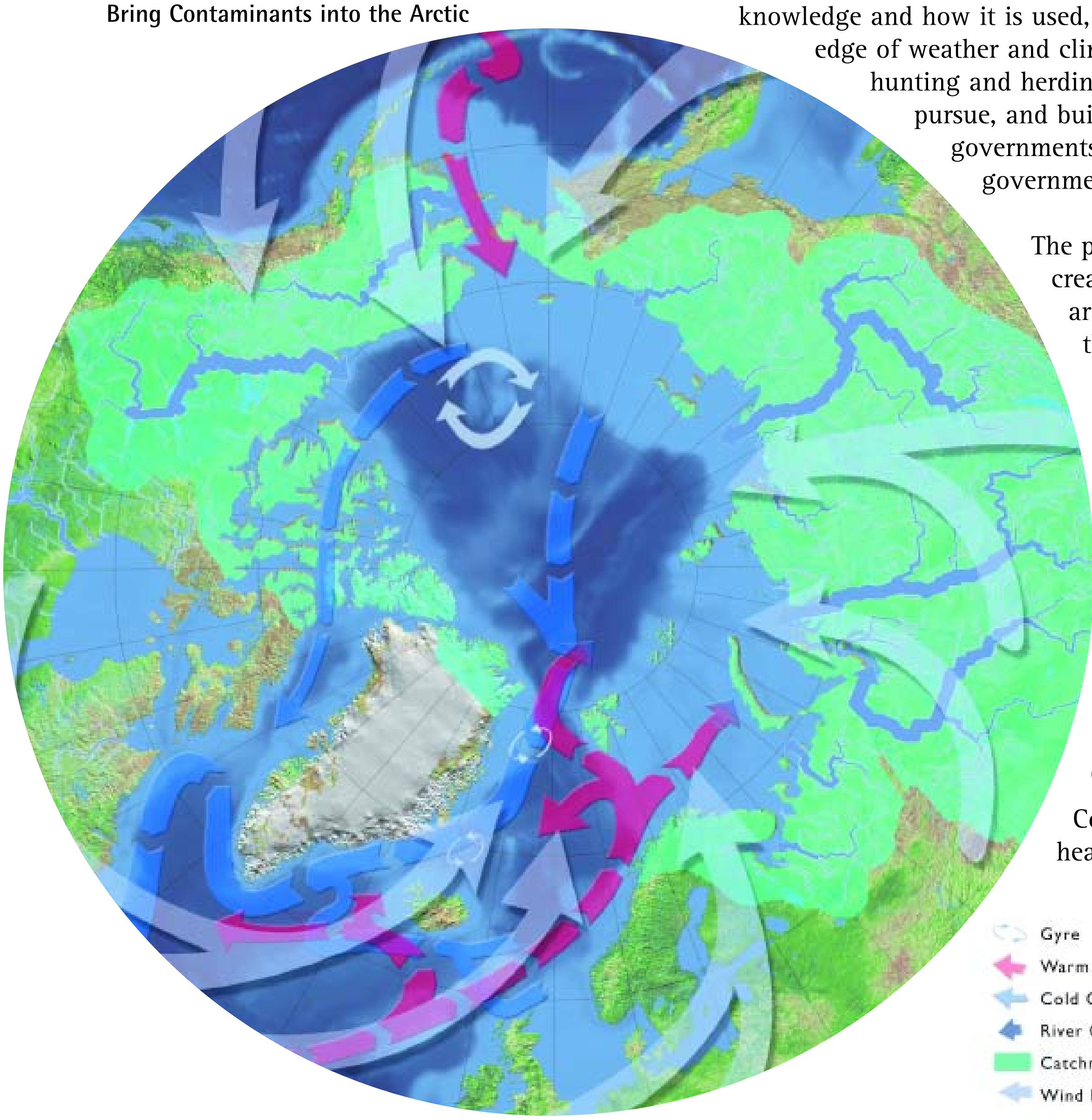
# 10 Multiple influences interact to cause impacts to people and ecosystems.

Climate change in the Arctic is taking place within the context of many other changes, such as chemical pollution, increased ultraviolet radiation, and habitat destruction. Societal changes include a growing population, increasing access to arctic lands, technological innovations, trade liberalization, urbanization, self-determination movements, increasing tourism, and more. All of these changes are interrelated and the consequences of these phenomena will depend largely on interactions among them. Some of these changes will exacerbate impacts due to climate change while others alleviate impacts. Some changes will improve peoples' ability to adapt to climate change while others hinder their adaptive capacity.

The degree to which people are resilient or vulnerable to climate change depends on the cumulative stresses to which they are subject as well as their capacity to adapt to these changes. Adaptive capacity is greatly affected by political, legal, economic, social, and other factors. Responses to environmental changes are multi-dimensional. They include adjustments in hunting, herding, and fishing practices as well as alterations in the political, cultural, and spiritual aspects of life. Adaptation can involve changes in knowledge and how it is used, for example, using newfound knowledge of weather and climate patterns. People can alter their hunting and herding grounds and the species they pursue, and build new partnerships between federal governments and Indigenous Peoples' governments and organizations.

The particular environmental changes that create the greatest stresses vary among arctic communities. For example, threats to human health from persistent organic pollutants (POPs) and the reduction in sea ice are extremely serious for Inuit in northern Canada and western Greenland, but not as important to Saami in northern Norway, Sweden, and Finland. For the Saami, freezing rain that coats reindeer forage with ice is of great concern, as is the encroachment of roads on grazing lands.

**Wind, Rivers, and Ocean Currents Bring Contaminants into the Arctic**




Contaminants emitted in northern industrial areas are transported to the Arctic where they may become concentrated as they move up the food chain.

## Climate Change and Contaminants

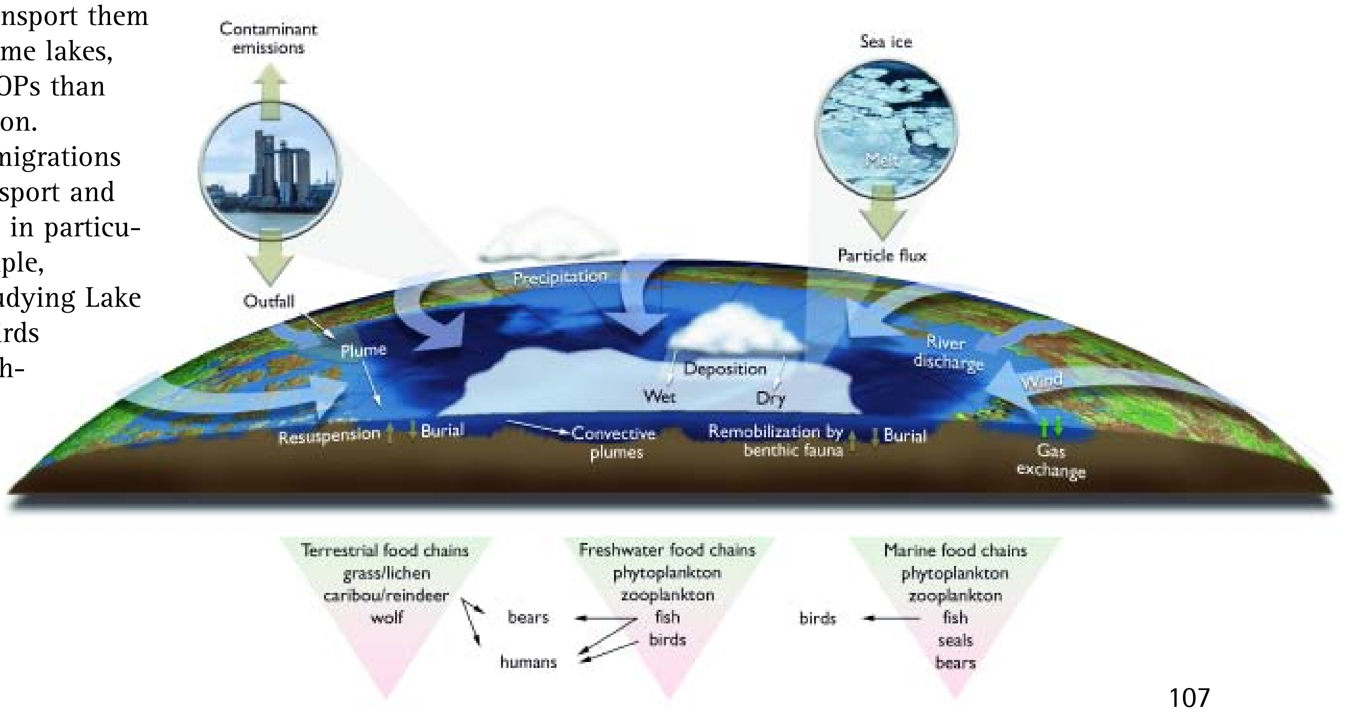
Contaminants including POPs and heavy metals transported to the Arctic from other regions are among the major environmental stresses that interact with climate change. Certain arctic animal species, particularly those high on the marine food chain, carry high levels of POPs such as DDT and PCBs. Global use of these chemicals peaked in the 1960s and 1970s and their manufacture has since been banned in most countries. However, pollutants emitted prior to these controls persist in the environment and are transported, primarily by air currents, from industrial and agricultural sources in the mid-latitudes to the Arctic where they condense out of the air onto particles or snowflakes or directly onto earth's surface.

POPs become increasingly concentrated as they move up the food chain, resulting in high levels in polar bear, arctic fox, and various seals, whales, fish, seabirds, and birds of prey. Arctic people who eat these species are thus exposed to potentially harmful levels of these pollutants. Levels of concern have been measured in blood samples from people in various arctic communities, for example, in eastern Canada, Greenland, and eastern Siberia, with strong variations observed around the region.

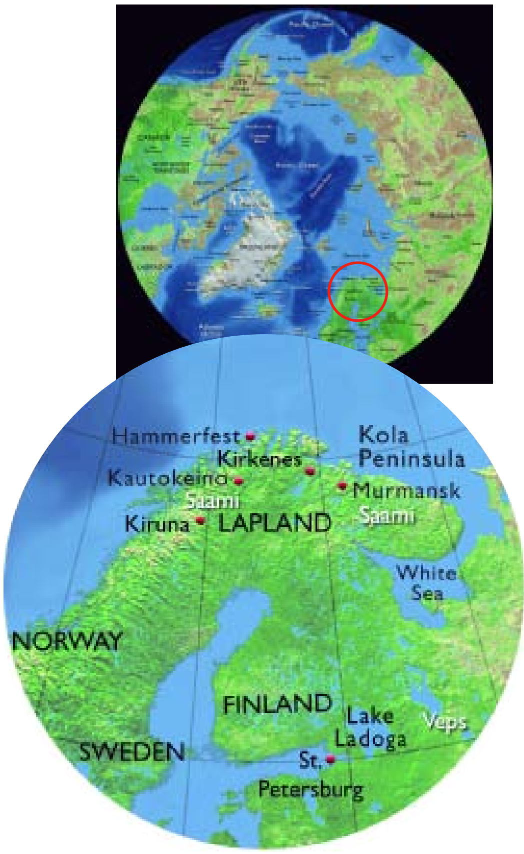
Mercury is the heavy metal of greatest concern in parts of the Arctic. Mercury from distant sources is deposited onto snow in the Arctic where it is released to the environment when the snow melts in springtime, at the onset of animal and plant reproduction and rapid growth, when living things are most vulnerable. Coal burning, waste incineration, and industrial processes are the major sources of global mercury emissions. Current mercury levels pose a health risk to some arctic people and animals, and because mercury is so persistent, mercury levels are still increasing in the region, despite emissions reductions in Europe and North America.

Winds carry contaminants, and precipitation deposits them onto the land and sea. Temperature plays a role in determining the distribution of contaminants between air, land, and water. Projected climate change-related alterations in wind patterns, precipitation, and temperature can thus change the routes of contaminant entry and the locations and amounts of deposition in the Arctic. More extensive melting of multi-year sea ice and glaciers results in the rapid release of large pulses of pollutants that were captured in the ice over years or decades.

There are several other ways that climate change can alter contaminant pathways into the Arctic. Recent evidence suggests that salmon migrations undergo large, climate-related variations and that Pacific salmon may respond to change by moving northward into arctic rivers. These salmon accumulate and magnify contaminants in the Pacific Ocean, and transport them into arctic waters. For some lakes, fish may bring in more POPs than does atmospheric deposition. Similarly, changing bird migrations have the potential to transport and concentrate contaminants in particular watersheds. For example, Norwegian researchers studying Lake Ellasjoen found that seabirds serve as an important pathway for contaminants (in this case POPs) from marine to freshwater environments.



# 10 Multiple influences interact to cause impacts to people and ecosystems.




## Case Study of Interacting Changes: Saami Reindeer Herders

Observed and projected increases in temperature and precipitation and changes in the timing of the seasons affect reindeer herding in numerous ways. Increases in the frequency of rain on snow, and in periods of winter melting, result in the formation of ice crust layers that make forage less accessible. Increasing autumn temperatures might lead to a later start of the period with snow cover. Rising temperatures and precipitation could increase the frequency of snow falling on unfrozen ground. An increased number, density, and distribution of birch trees in grazing areas has already begun to decrease the availability of forage plants for reindeer in winter. Shifts of forest vegetation into tundra areas are likely to further reduce traditional pasture areas.

The characteristic seasonal pattern of moving herds between winter and summer pastures reflects the herders' knowledge of seasonal changes in the availability of key resources such as forage and water. In the warm winters of the 1930s, for example, when conditions were sometimes difficult owing to heavy precipitation, herds were moved to the coast earlier than normal in the spring. Similarly, the movement of herds from poorer to better grazing areas, including the "trading of good snow" by neighboring herders, reflects thorough knowledge of forage conditions. In every case, the success of the herders is contingent upon the freedom to move.

A variety of factors, including government policies in the past few decades, have constrained the ability of Saami reindeer herders to respond to and cope with climate warming and other changes. One important stress has come from the encroachment of roads and other infrastructure on traditional reindeer grazing lands. Another stress comes from conflicting objectives among parties. Norway's mountain pastures are an important resource for herders, but pastureland management is complicated by the

*"The world has changed too much now. We can say nature is mixed up now. An additional factor is that reindeer herding is being pressured from different political, social, and economic fronts at all times now. Difficulties are real. A way of living that used to support everything is now changing."*

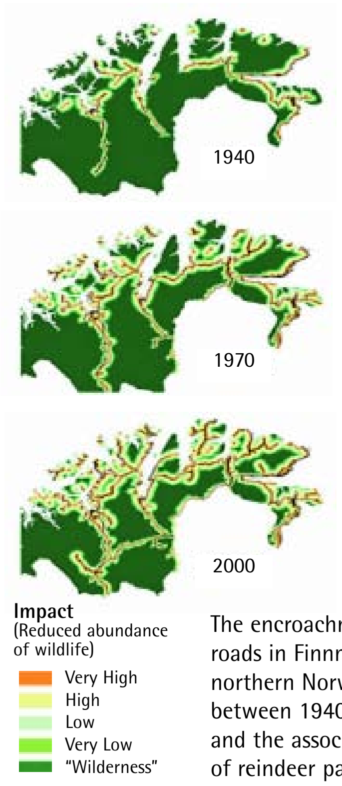
*Veikko Magga*
*Saami Reindeer Herder*
*Vuotso, Finland*



presence of predators such as lynx, wolf, and wolverine, which are a major threat to the survival of reindeer calves, but are protected by wildlife conservation efforts.

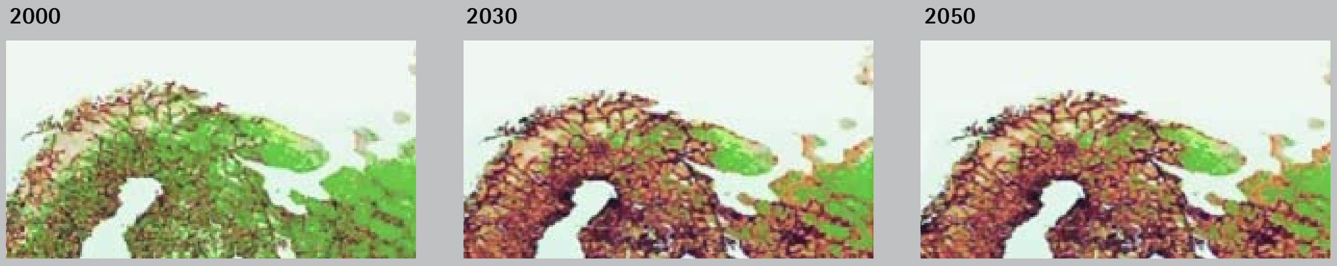
Other changes come from laws that emphasize meat production, encouraging active breeders and discouraging small herds. These laws favor larger herds, which have thus increased from around 100 to 700 animals. These laws also favor herds dominated by females and calves (the calves are slaughtered for meat) and have resulted in a change in structure from a traditional herd consisting of about 40% bulls, to herds with only 5% bulls. In traditional Saami herding practices, the bulls are important because their superior ability to dig through deep or poor quality snow make forage plants available to the entire herd. The reduced proportion of bulls may become more of a problem in the future if snow conditions altered by climate change make grazing even more difficult for smaller reindeer.

**Road Expansion Reduces Reindeer Pasture**




The encroachment of roads in Finnmark, in northern Norway, between 1940 and 2000, and the associated loss of reindeer pasture.

**Projected Infrastructure Development**




Projected development of infrastructure including roads, houses, and military training areas in northern Scandinavia 2000-2050. The scenario illustrated here is based on the historical development of infrastructure, distribution and density of the human population, existing infrastructure, known location of oil, gas, mineral and forest resources, distance from coast, and vegetation type.

# 10 Multiple influences interact to cause impacts to people and ecosystems.

## Human Health

Climate change will continue to affect human health in the Arctic. The impacts will differ from place to place due to regional differences in climate change as well as variations in health status and adaptive capacity of different populations. Rural arctic residents in small, isolated communities with a fragile system of support, little infrastructure, and marginal or non-existent public health systems appear to be most vulnerable. People who depend upon subsistence hunting and fishing, especially those who rely on just a few species, will be vulnerable to changes that heavily affect those species (for example, reduced sea ice and its impact on ringed seals and polar bears). Age, lifestyle, gender, access to resources, and other factors affect individual and collective adaptive capacity. And the historic ability to relocate to adapt to changing climatic conditions has been reduced as settlements have become permanent.

There are likely to be both adverse and beneficial outcomes of climate change on human health in the Arctic. Direct positive impacts could include a reduction in cold-induced injuries such as frostbite and hypothermia and a reduction in cold stress. Death rates are higher in winter than in summer and milder winters in some regions could reduce the number of deaths during winter months. However, the relationship between increased numbers of deaths and winter weather is difficult to interpret and more complex than the association between illness and death related to high temperatures. For example, many winter deaths are due to respiratory infections such as influenza, and it is unclear how higher winter temperatures would affect influenza transmission.

Direct negative impacts are likely to include increased heat stress and accidents associated with unusual ice and weather conditions. Indirect impacts include effects on diet due to changes in the access to and availability of subsistence foods, increased mental and social stresses related to changes in the environment and lifestyle, potential changes in bacterial and viral proliferation, mosquito-borne disease outbreaks, changes in access to good quality drinking water, and illnesses resulting from sanitation system problems. Health effects may also arise from interactions between contaminants, ultraviolet radiation, and climate change.

Indigenous people in some parts of the circumpolar North are reporting incidences of stress related to high temperature extremes not previously experienced. Impacts include respiratory difficulties, which, in turn, can limit an individual's participation in physical activities. However, fewer cold days associated with the warming trend in many regions during the winter are reported to have the positive effect of allowing people to get out more in the winter and alleviating stress related to extreme cold.

Climate-related changes in fish and wildlife distribution are very likely to result in significant changes in access to and the availability of traditional foods, with major health implications. A shift to a more Western diet is known to increase the risks of cancer, obesity, diabetes, and cardiovascular diseases among northern populations. Decreases in commercially important species, such as salmon, are likely to create economic hardship and health problems associated with reduced income in small communities.

Climate stress and shifting animal populations also create conditions for the spread of infectious diseases in animals that can be transmitted to humans, such as West Nile virus.

Safe drinking water and proper sanitation are critical to maintaining human health. Sanitation infrastructure includes water treatment and distribution systems, wastewater collection, treatment and disposal facilities, and solid waste collection and disposal. Permafrost thawing, coastal erosion and other climate-related changes that adversely affect drinking water quality, limit efficient delivery, or cause direct damage to facilities are likely to lead to adverse impacts on human health.

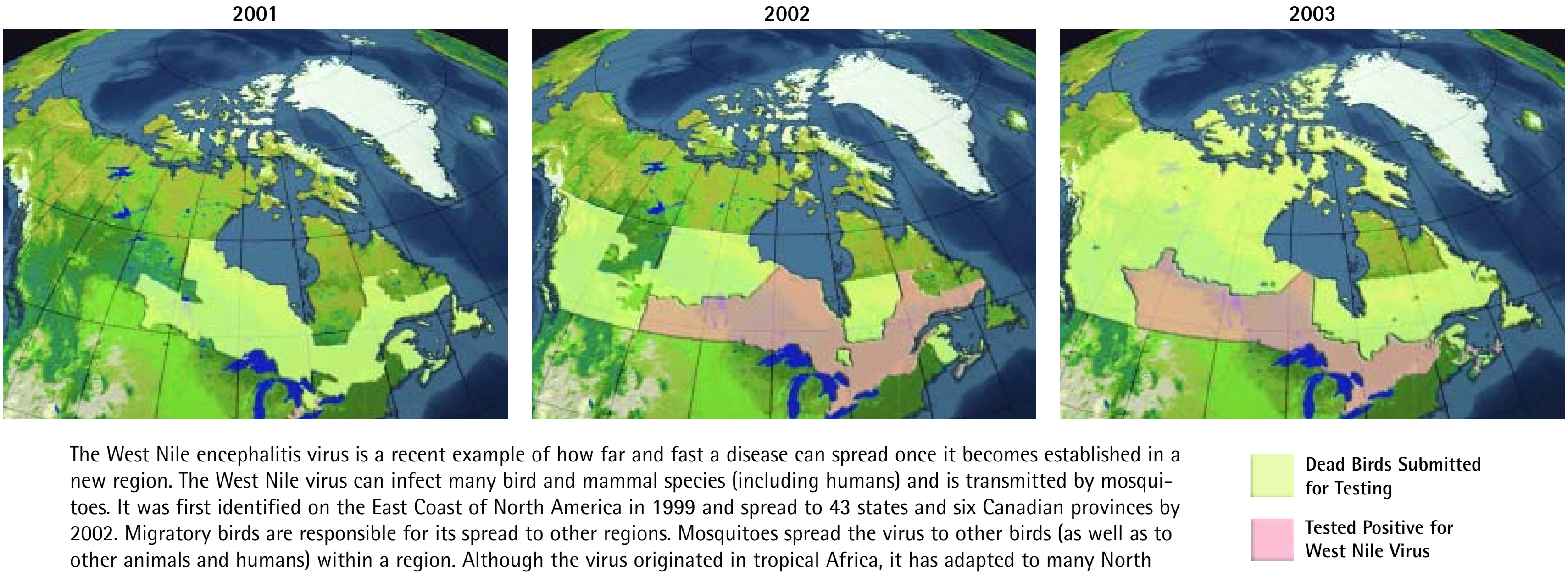
Increases in extreme events such as floods, storms, rockslides, and avalanches can be expected to cause an increase in injury and death.  In addition to such direct impacts of these events, indirect effects could include impacts on the availability of safe drinking water.  Intense rainfall events can also trigger mosquito-borne disease outbreaks, flood-related disasters, and, depending on existing water infrastructure, contamination of the water supply.

Mental health is also likely to be affected by climate related changes in the Arctic. Reduced opportunities for subsistence hunting, fishing, herding, and gathering are likely to cause psychological stresses due to the loss of important cultural activities. Flooding, erosion, and permafrost thawing related to climate change can negatively affect village habitability and infrastructure, and result in population dislocations and community disruption with resultant psychological impacts.



*Rural arctic residents in small, isolated communities with a fragile system of support, little infrastructure, and marginal or non-existent public health systems appear to be most vulnerable.*

**West Nile Virus Change in Canada**




The West Nile encephalitis virus is a recent example of how far and fast a disease can spread once it becomes established in a new region. The West Nile virus can infect many bird and mammal species (including humans) and is transmitted by mosquitoes. It was first identified on the East Coast of North America in 1999 and spread to 43 states and six Canadian provinces by 2002. Migratory birds are responsible for its spread to other regions. Mosquitoes spread the virus to other birds (as well as to other animals and humans) within a region. Although the virus originated in tropical Africa, it has adapted to many North American mosquitoes, and so far, to over 110 species of North American bird, some of which migrate to the Arctic. Mosquito species known to transmit the virus are also found in the Arctic. Climate has historically limited the range of some insect-borne diseases, but climate change and adaptive disease agents such as the West Nile virus tend to favor continued northerly expansion. Some arctic regions, such as the State of Alaska, have initiated West Nile virus surveillance programs.