Sabbatical Report

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Alaska: Ecosystems, Sustainability and Native Cultures

Introduction

In summer and fall of 2010, I studied the ecology of Alaska. This included the current ecosystems, the area's paleohistory, and human impacts. I divide my report into the following sections: 1) ecosystem descriptions, 2) recent evolution, 3) salmon: a keystone species, 4) a comparison to Oregon ecosystems, 5) changes resulting from human activity, 6) conservation efforts, and 7) native Alaskan cultures as parts of Alaskan ecosystems. Much of the material is written from memory, so rather than exact citations, I include a list of materials from which information was garnered.

Alaskan Ecosystems

Alaska's natural environments fall into three broad categories. These form sequential latitudinal bands. From south to north, we find first temperate rain forest, then boreal forest (taiga) and at the northernmost latitudes, tundra. Within these broad categories, there is considerable variation, and tundra, especially, can be found in more southerly areas, especially at higher elevations.

Temperate Rainforest

The most biodiverse of these is the rainforest. It is dominated by hemlock (*Tsuga* sp.) and *S*itka spruce (*Picea sitchensis*), with a wide variety of other coniferous and broad-leaved trees. The understory includes many woody and herbaceous plants, including ferns, devil's club (*Oplaplanax horridum*) and wild ginger (*Asarum caudatum*). It extends north to about the line where the ground is underlain by permafrost. The temperate rain forest is under heavy pressure from the logging industry and most of the old growth Sitka spruce forest has been cut. Cedar is now the most commonly targeted tree, and these forests are quickly falling to the chain saw.

Taiga

The boreal forest is not threatened by logging because the trees tend to be too small to be of commercial value. The predominant trees are white spruce (*Picea glauca*) and black spruce (*P. mariana*). The small size of these trees results from generally cold temperatures (limiting the rate of photosynthesis) and the short growing season. Broad-leaved trees are found in isolated stands depending on micro-climate, moisture and recency of fire. These are primarily alders (*Alnus* sp.), birches (*Betula* sp.), and members of the family Salicaceae (genera *Populus* and *Salix*).

Boreal forests are fairly open stands of trees, with a thin understory and a thick, spongy mat of mosses and spreading shrubs. They are found in areas where permafrost is discontinuous.

Tundra

Tundra can form under a variety of conditions. Most broadly, tundra can be arctic (northern) or alpine (in mountains). Tundra vegetation is marked primarily by what it lacks, namely trees. A variety of plant types are present, depending on moisture and temperature, including grasses, sedges, mosses, woody shrubs (mostly willow) and lichens. In the low tundra of the far north, cotton grass (*Eriophorum,* actually a sedge) is abundant and conspicuous. These plants, and some other grasses and sedges, form rounded tussocks, generally surrounded by standing water. Although the relatively flat, wide-open arctic tundra looks like a perfect place for a stroll, the tussocks that cover most of the ground make walking treacherous. One can either walk on the tussocks themselves, risking a sprained ankle with each step, or in the wedge-shaped spaces between, slogging through icy water.

The reason the tussocks are surrounded by water is not because of frequent rain. In fact the climate of the arctic is quite dry. Instead, the continuous permafrost just a few centimeters below the surface slows or prevents water run-off.

Alpine tundra, on the other hand is a pleasure to walk through. One does need to watch for rocks of many sizes. In addition, it is hoped that most hikers in this ecosystem will avoid stepping on the fragile lichens and other low plants.

Alpine Tundra, Brooks Range

Arctic tundra forms over ground that contains continuous permafrost which is associated with a lack of trees (see below). The alpine tundra is treeless because of cold temperatures at altitude.

Permafrost

Because permafrost plays an important role in determining the type of vegetation found at different latitudes in Alaska, it seems appropriate to discuss this phenomenon. Essentially, permafrost is ground that remains frozen year-round. During warm summer months, a layer of soil at the top will thaw. This is called the active layer. Beneath the active layer, the layer of frozen earth is either continuous or patchy. As noted above, the change from continuous to discontinuous describes the boundary between taiga and tundra. However, the correlation is not entirely direct. That is, the real change is in terms of temperature and growing season. The degree of cold needed to form a continuous layer of permafrost is also the degree preventing photosynthesis from proceeding rapidly enough to allow for tree growth. In addition, the thickness of the active layer varies, and where it is thinnest (in the tundra) trees can't root strongly enough and will be blown over by the wind.

Alaskan Land Animals

Alaska is known for its large mammals and birds. It is home to a variety of nesting waterfowl, shorebirds, and raptors and passerines. The arctic tundra is well known as a nesting area for waterfowl and shorebirds. I will discuss some of the mammals below.

Only one amphibian, the wood frog, *Lithobates sylvaticus,* lives in Alaska. It is uniquely adapted to life in the north because it can literally freeze in the fall and thaw out the flowing spring. It survives this unusual means of dealing with freezing temperatures by having evolved to manifest several adaptations. What generally destroys living tissue when it freezes is the growth of ice crystals. The wood frog avoids this problem by moving much of its water into the coelom and other cavities where ice crystals have less opportunity to cause damage. It also fills its cells with glucose that separates water molecules so they won't build crystals and the glucose can be fermented anaerobically to provide a trickle of energy through the cold months.

The most conspicuous invertebrates are the mosquitoes and their primary predators, the dragonflies.

A number of large mammal species are important components of Alaskan ecosystems. These are the brown bears (*Ursus arctos*), the wolves (*Canis lupus*) and such ungulates as Dall sheep (*Ovis dalli*), caribou (*Rangifer taranus*), moose (*Alces alces*), and muskoxen (*Ovibos moschatus*).

Grizzly Bear

Muskox

Wolves and brown bears are the two important large predators. While there is some evidence that wolves feed primarily on young (calves), old and sick individuals, they are known to feed on healthy adults as well. Some studies suggest that wolf predation may keep caribou and moose populations below their carrying capacities (Smith 2008), but it must be remembered that these were season to season studies and it is clear that what appears to be the carrying capacity for an herbivorous species may be unrealistic because the herbivores will deplete their food supplies only after many years.

This is an important issue because the extent to which wolves compete with humans for caribou and moose is a polarizing subject in Alaska. For example, despite strong opposition, Sarah Palin helped implementation of a number of highly controversial wolf hunts during her short tenure as governor of Alaska. Some of these involved shooting wolves from state supplied helicopters right outside the boundaries of National Wildlife Refuges.

As far as moose are concerned, it is likely that grizzly bears kill far more (mostly calves) than do wolves, but there is no bear killing program to enhance the sizes of moose herds.

In general, grizzly bear diets are far more varied than those of wolves, and I will consider their role, through salmon feeding, in the discussion of the nitrogen cycle below.

The muskoxen now living in the tundra are the result of a successful reintroduction from Greenland in 1930. These animals had been extirpated by the mid 1800's and only remnant populations survived into the 20th century in northern Canada and Greenland. After the initial reintroduction of 34 animals into Alaska, their offspring were introduced into various locations across the arctic coastal plane.

Snowshoe Hare

A critical primary consumer (herbivore) in the boreal forest is the snowshoe hare. These are well known for their large paws (especially the hind feet) and their seasonal color changes. In the spring, the white hares turn mostly brown and they browse on bushes relatively low in fiber and high in protein content. This is the opposite of the favorite browse of moose, an example of resource partitioning. In the fall, the hares turn white to camouflage them against the winter snow. Their large feet allow them to run across the surface of the snow, rather than sinking into it. They are also restricted to browsing on shrubs that extent out of the snow. In spring, one can see the average depth of the winter's snow fall by checking the level at which hare browsing occurred.

Vegetation Killed by Browsing of Snowshoe Hares

The populations of snowshoe hares is highly cyclical with peaks every ten years or so. At the bottoms of these cycles, there are very few hares and their favorite browse plants typically show a burst of growth. At the opposite end of a population cycle, hares are abundant and the dense populations can cause considerable mortality among browse species, especially as a result of winter foraging.

Snowshoe hares represent an important source of food for many predator species, including the lynx. Lynx populations tend to follow those of the hare, with peak lynx populations occurring one or two years after peak hare populations. Other predators that feed on snowshoe hares include the canids: wolves, coyotes and foxes; mustelids like wolverines, otters and minks and even rodents like red squirrels and ground squirrels. In addition, a variety of birds take hares, including snowy and great-horned owls, golden eagles, red-tailed hawks and gryfalcons.

Freshwater Fish

First, there are no fish in the tundra regions of Alaska. This is because, during winter, the above-ground water north of the tree-line freezes all the way to the bottom or so far down as to become anoxic. There are many insect larvae, especially those of mosquitoes and dragonflies, but their presence is seasonal.

Salmon

Further south, in taiga streams and lakes, the most conspicuous fish is the grayling. It is related to the lake trout and other salmonids. It is found further north than salmon and is an important food source for bears living north of the range of the salmon.

Sockeye Salmon

In southern and central Alaska we find the salmon species. These are critical to the functioning of their ecosystems. Not only do they provide food for orcas, bears, otters and eagles, the carcasses of salmon return critical nutrients, especially nitrogenous compounds, to the forests surrounding their spawning streams and lakes.

Salmon are anadromous. This means they hatch in fresh-water streams, migrate to the ocean to mature, and, as adults, return to freshwater to spawn. This return voyage can be long and difficult, sometimes requiring that the fish swim up against fast running mountain streams. All of the salmon in a population return at about the same time, and the streams are so full of fish, one could imagine walking across the stream on their backs. When they arrive on the gravel banks where they were born, females use their tail fins to scrape out a depression. They release eggs into this redd, or nest, and then a male of the female's choosing covers the eggs with his milt, a fluid containing his sperm. A few hours or a day after spawning, the adults die.

Both before and after this reproductive act, the salmon are preyed upon by mammalian and avian carnivores. Bears, eagles and others often carry salmon carcasses inland, where large parts of them are dropped and some of the rest eliminated in urine and feces. This transport of the salmon inland means that they fertilize not only the stream beds, but also the surrounding forests. Thus, the release of nutrients (especially nitrates) represents a critical link between the ocean (where the nutrients were ingested) and the land (where they are released).

Some Recent Paleohistory of Alaska

Ecosystems in Alaska today are the products of a long and interesting evolutionary history. During the course of this history, Alaska's climate has undergone a number of shifts between relatively warm and cold periods. For example, the terrane (small plate) making up Alaska's North Slope on the shore of the Arctic Ocean was clearly much warmer at some time in the past to allow for the growth of dense vegetation that would produce today's oil fields in the area. While the location was likely to be somewhat further south at the time, the temperatures still would have been warmer than we would expect at such latitudes today.

Another warm period existed about 70 million years ago when northern Alaska was actually a bit closer to the north pole, but was home to a variety of dinosaur species, the fossilized remains of which can be found in several areas in Alaska.

More recently, the alternate warming and cooling of the Pleistocene most strongly affected the modern biota of Alaska. During each of several ice ages, so much of the world's water was locked up in glaciers and ice sheets that the ocean surface dropped as much as 120 m below today's level. This exposed a wide band of ocean floor that connected Alaska and Siberia. The connection made it possible for plants and animals from Asia to migrate to Alaska, and subsequently to the rest of North America. Some of these went extinct over time, such as the mammoths, lions and the camels (though the latter gave rise to modern llamas and alpacas). Of course, humans are among the new arrivals, as well.

Oregonian Ecosystems by Comparison

Because of latitudinal differences, and consequent climate differences, Oregon ecosystems are generally different from those in Alaska. Nevertheless, there are two environment types that are similar. Like the temperate rainforests of southeastern Alaska, the rainforests Oregon’s coast are dominated by sitka spruce, cypress, and hemlock. A diverse understory of ferns and shrubs includes species found in both environments, including devil’s club. Both living and dead trees are festooned with mosses and lichens.

Oregon Rainforest

Oregon does not have ecosystems equivalent to Alaska's taiga or arctic tundra, but there are alpine tundra stretches at higher elevations in the Cascade Mountains.

Alpine Tundra on Mt. Hood

Human Impacts on Alaskan Ecosystems

Global Pressure on Alaska's Resources

As with ecosystems around the world, Alaska's biodiversity is being degraded by human activity. As the human population continues to grow at a ruinous rate, these impacts get more profound individually and synergistically. Indeed, many of Alaska's environmental problems result from human overpopulation in other parts of the world. These global stressors are at the root of the unsustainable resource use in Alaska.

Oil is the most obvious of these. Large quantities of oil are pumped out of Alaska, not just from the North Slope, but also from wells surrounding Cook Inlet and a variety of other places. Virtually all of this oil goes to satisfy energy needs outside of Alaska.

A variety of minerals, including such metals as gold, copper and lead are also sold outside the state. These forms of extraction are not sustainable by definition, as the resources do not replenish. While the harvest of trees could be sustainable, it is not currently so. Very few old-growth forests remain in the bottomlands of the southeastern rainforests and only in less economically valuable stands do we still see trees more than 150 years old (young for most trees).

The sizable salmon harvest is also mostly consumed elsewhere.

Even the pollution in Alaska's air comes mostly from outside the state. Remote Point Barrow can have very high levels of particulate pollution that has blown over from Europe, North America and Russia. Interestingly, air pollution in northern Alaska has declined in recent years because of lower industrial output from Russia and improved pollution controls in western Europe and North America. There is concern that this trend will be reversed by the accelerated industrialization of China, especially because of that country's heavy reliance on coal as a source of energy.

Oil

As noted above, the global demand for petroleum is at the root of the extensive extraction of oil from Alaska. This extraction has had a number of negative impacts on the state's arctic tundra. Of course, the burning of fossil fuels contributes to the increase in greenhouse gases in the atmosphere, and so providing Alaskan oil as an energy source also contributes to the resultant rise in global temperatures.

In addition, the extraction process affects temperature at a more local level. Gravel roads and pads, and metal buildings absorb more heat than tundra vegetation, which acts as an insulator. The permafrost underlying developed areas typically melts, causing subsidence and the need for additional gravel. The heat also moves to surrounding landscape by conduction and convection.

Deadhorse (Adjacent to Prudhoe Bay)

An interesting phenomenon of some arctic tundra landscapes is the presence of polygons with either raised or lowered centers. When frozen ground continues to cool, it shrinks and cracks. Often the cracking forms very regular patterns (as in drying mud). In spring, these cracks fill with water which, being below the active layer of soil, then freezes and thereby expands. The expansion of these ice wedges pushes surrounding soil up to form low banks around the low-center polygon. Water often pools in these polygons and the resulting ponds are important nest sites for tundra swans and other birds.

When temperatures rise, the ice wedges melt, leaving ditches around the polygons instead of banks. The resulting raised center polygons do not hold water. The area around Prudhoe Bay is occupied by such raised-center polygons, presumably because of the localized increase in temperature form gravel beds, buildings and energy-intensive activity.

Raised-Center Polygons Outside Prudhoe Bay

Another impact on the environment surrounding an oil drilling operation is the extensive dumping of garbage. Although the operation at Prudhoe Bay has greatly lowered this impact, the ravages of several decades of careless waste disposal remain evident, even many miles south of the installation.

It should be noted that descriptions of the area affected by drilling for oil do not take these and other factors into consideration. It is said that a new development for oil in the Alaskan National Wildlife Refuge would cover 'only' 2000 acres of tundra. (2000 acres is equivalent to 52 airport runways.) The issue is that those acres would not be contiguous and the total affected area would be much larger. It is estimated that an area the size of Rhode Island is directly, negatively affected by the Prudhoe Bay site.

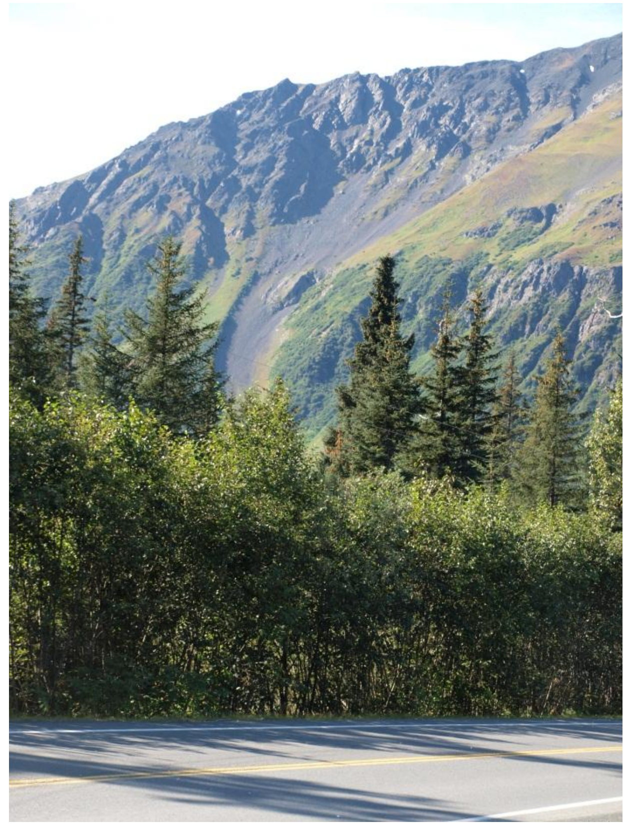
Global Warming

Global impacts are many and varied, but the one of greatest concern is global climate change. The impacts of rising atmospheric and ocean temperatures are felt most strongly near the poles. In Alaska, there are both subtle and obvious changes taking place in the natural environment. The tree line is moving: northward into the arctic tundra, and upslope on mountains. In Denali National Park, for example, the tree line has moved up several meters in the last ten years. This is bad news for Dall's sheep, an animal that resembles big-horn sheep, except that it is white instead of gray-brown. Dall's sheep fall victim primarily to wolf predation, but by foraging above the tree line, they can keep an eye out for approaching wolves. Their agility makes this possible even on steep craggy slopes. As these become more heavily forested, wolves have an easier time catching the sheep.

Across central Alaska (and many other taiga environments) warming temperatures and changes in rainfall have caused an increase in frequency and intensity of wildfires. Animals that depend on taiga for protection and browse face population declines as a result. This includes the caribou that spend their winters in the boreal forest and the snowshoe hare that finds little to eat above the level of the snow in burned out forests.

Burned Taiga, North of Fairbanks

Perhaps the most noticeable effect of global warming is the loss of glaciers. It is estimated that Alaskan glacial melt is responsible for 9% of the global rise in sea level. One glacier in Prince William Sound receded 12km (7.4 miles) in the last 20 years. Currently, about $96km^3$ of Alaskan glacial ice melt every year.



2008 2010

Loss of a glacier outside Seward, Alaska.

(Both pictures were taken in August)

Sustainability and Resilience Based Management

There is considerable tension in Alaska between advocates of environmental conservation and those who support rapid economic development of the state. A wide variety of resource extraction projects are envisioned, including a copper mine in the watershed feeding Bristol Bay, and a pipeline to bring natural gas from Prudhoe Bay to the lower forty-eight.

The proposed mine (the Pebble Mine) is of grave concern not only to conservationists but also to sport and commercial salmon fishers. Bristol Bay supports one of the largest populations of salmon along the Pacific Coast of Alaska. The history of metal mines indicates that it is very difficult to avoid all heavy metal pollution form the tailings of such a mine. Heavy metal pollution is especially insidious in that heavy metals do not degrade over time, and they tend to accumulate in the predators, especially in adipose (fat) tissue. Salmon are known for their high fat content.

Since the influx of Alaska Pipeline workers in the 1960's, '70's and 80's, the general political atmosphere in Alaska has turned decidedly conservative, and pro-development lobbies are especially strong. Nevertheless, many Alaskans are concerned about the loss of their state's wild character as a result of uncontrolled development. In addition, many of the proposed resource extractions in Alaska face stiff opposition from the federal government and a wide variety of NGO's.

Whether or not resources can be extracted in a sustainable manner may depend on the extent to which all Alaskans (and other stakeholders) are ready to incorporate notions of resilience based management into resource use and conservation projects.

Resilience based management is a new paradigm for considering environmental management. The idea is that instead of trying to return natural systems to some historical ideal, we must accept that change is happening and work to incorporate change in our plans in an optimal way. Thus, instead of trying to maintain the biodiversity of the arctic tundra as it is today, we must accept that much of the tundra will become forested and work to assure that these new boreal forests contain healthy and biodiverse ecosystems. To do so, we need to manage the tundra in a way that best accommodates the natural resilience of the ecosystem, fostering components that adapt to change and allowing less resilient parts to expire. For example, many willow species will thrive in a warmer climate, but some sedges will not survive.

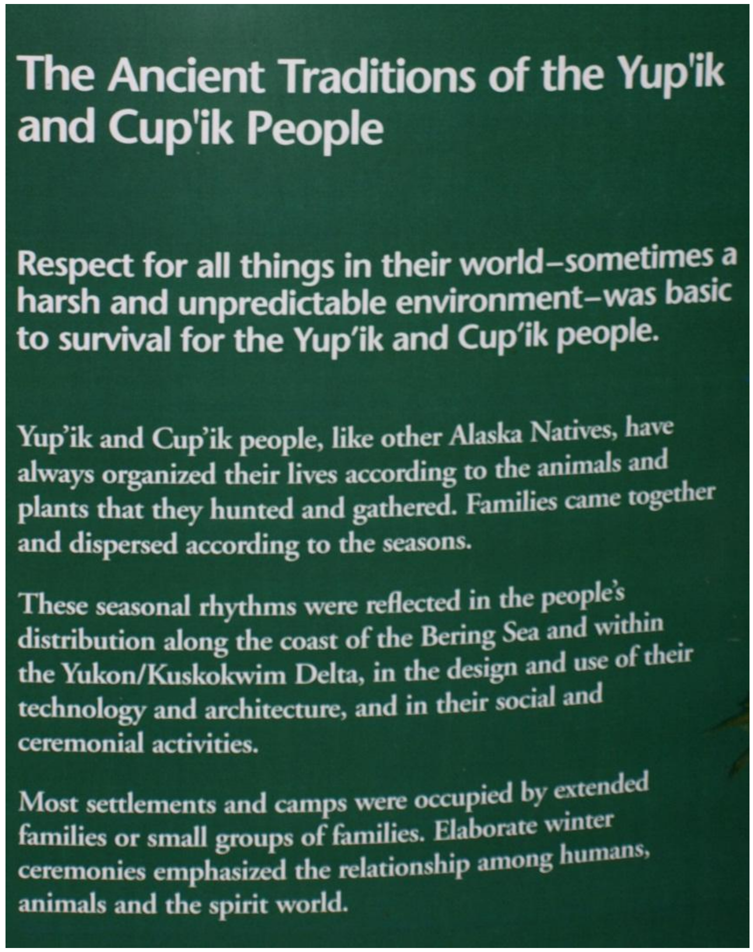
An important component of resilience based management is that it requires long-term planning. This in turn requires that the plans be flexible because future changes are unpredictable. Long-term, flexible planning would represent salutary innovations. Instead of reacting to toxic dumps with super-fund clean-ups, for example, we can proactively prevent or mitigate against toxic waste accumulation. This might, for example, include introduction of bacteria that metabolize toxins right at the beginning of a project, in anticipation of toxin production.

While the theoretical framework for resilience based management are well established, there is, as yet, little evidence that people are adopting this forward looking strategy. To improve this situation, a program at the University of Alaska, Fairbanks trains graduate students to become resilience based managers. As part of their work, they intern with various government and non-government organizations, both in the U. S. and abroad, working on projects where the integrated approach of resilience based management promises to improve results. For example, one student worked with the Newtok Planning Group on a project to move the village of Newtok in western Alaska. Newtok is on a river that is eroding its banks and will eventually cause the entire village to fall into the river. While this movement of the river is natural, it has accelerated to such a degree that fortifying the banks is not a practical option. This acceleration is attributed to global warming: less sea ice increases eroding waves that travel up the river and is also melting permafrost that would otherwise help stabilize the soil.

Newtok is a village of native Alaskan Indians of Yup'ik origin. The moving project is an example of how resilience based management incorporates not only natural environmental sustainability, but also social and economic components. Village members were offered the opportunity to relocate individually to such towns as nearby Bethel or more distant Anchorage. The people of Newtok did not want to break up their society and wanted to stay near their traditional hunting and fishing grounds that are critical for their subsistence economy.

The moving program faces challenges, particularly in terms of financing, but it is proceeding and represents the spirit of resilience based management. Rather than attempting a costly technological fix to the erosion, the project accepts the inevitable and instead relies on the resilience of the people of Newtok. The new village will be better situated and will provide residents with modern facilities including sewage systems.

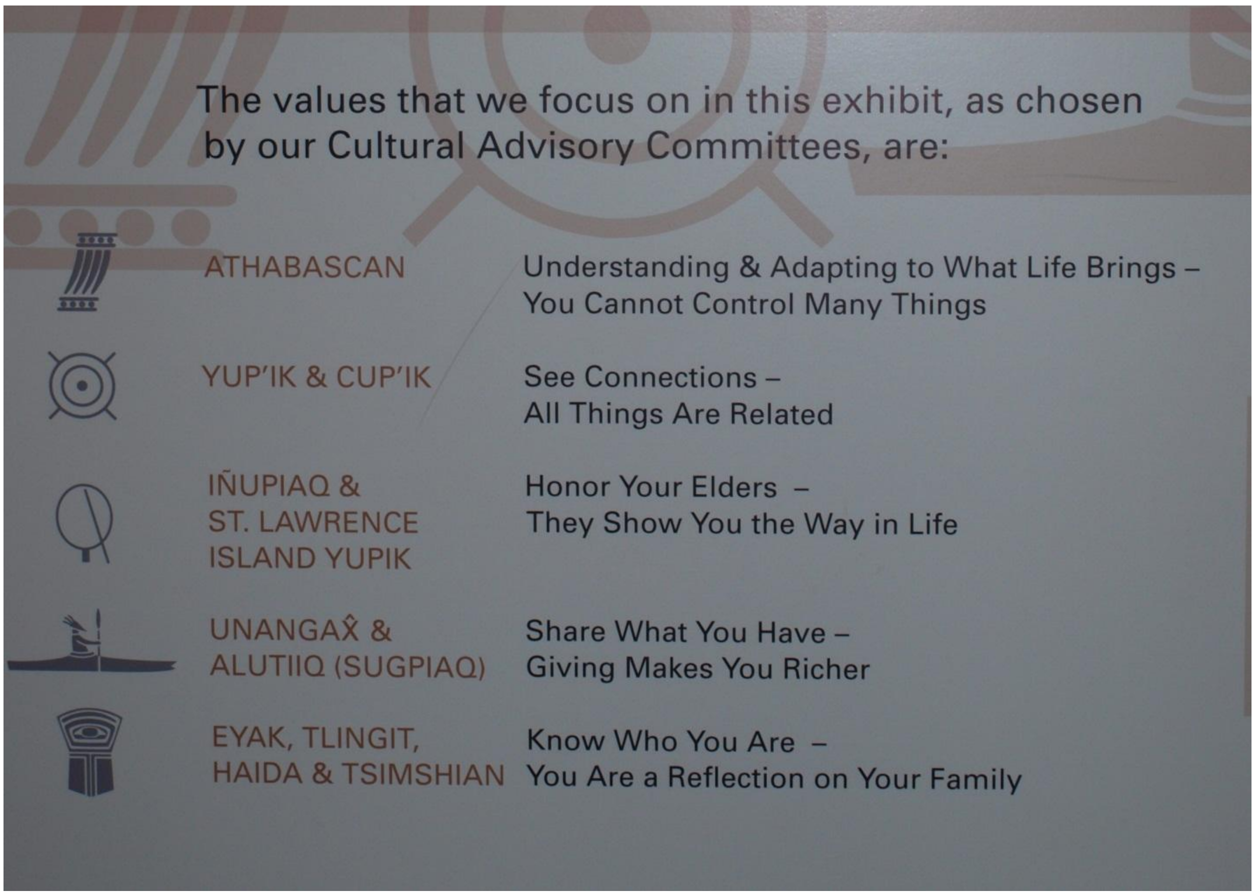
From the Alaska Native Heritage Center, Anchorage



Native Cultures and Sustainability: an Intersection

An interesting anecdote to arise from the Newtok moving project involves crossing the rough waters of the Ninglick River. Soldiers working with the Army Corps of Engineers almost tipped over their moving barges on several occasions, until members of the village gave them some tips on safe navigation of the river. This illustrates, on a very local level, an important aspect of resilience management and sustainability planning: the importance of incorporating traditional native knowledge in project plans.

An important reason for this is that resilience based management (and sustainability in the broad sense) deal not with separate natural and social units but with integrated social-ecological systems. Indeed, in native Alaskan traditions (as well as those of most indigenous peoples) the concept of separate natural and anthropic systems is unheard-of: people are parts of the natural ecosystems they live in.



From the Alaska Native Heritage Center, Anchorage

Unfortunately, most planners do not readily heed the wisdom of native peoples. Worse, the needs of people are not always considered in management plans. One example involves the native peoples of the Kenai Peninsula. In a treaty with the U. S. government, the people were given lands surrounding their village on which they could hunt and gather berries and other plant material. They were not permitted, however to build on land outside the village. This restriction led to friction, with several villagers constructing a hunting cabin on land that was supposed to be off-limits. The plan was to rent the cabin to tourists as a source of income. The federal government proposed instead that a private firm would build a hotel on a different parcel of land. The hotel, when completed, could provide employment for many of the villagers. This proposal was, of course, rather insulting. The Indians told the feds they'd build their own hotel.

Conclusion

Alaska is still a very wild place. This provides an opportunity to test our collective resolve to maintain biodiversity and move toward a more forward looking and sustainable approach to how we live on our planet.

Resources

The information in this report was gleaned from the sources listed below, from personal observations and from discussions with a number of individuals I would like to thank. They are listed below in no particular order.

Terry Chapin, University of Alaska, Fairbanks

Gary Kofinas, University of Alaska, Fairbanks

Bud Johnson, Tetlin National Wildlife Refuge

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Kelly Smith, Alaska Pacific University

David Tomeo, Murie Science and Learning Center

Ellen Weiser, University of Alaska, Fairbanks

Heidi Schoppenhorst, Boreal Lodging

Tom Meier, Denali National Park biologist

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