The Ecological Interactions of Sanak

Nancy Huntly, Utah State University
Spencer Wood
Roly Russell

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CHAPTER THREE
THE ECOLOGICAL INTERACTIONS OF SANAK
Sanak Island

Elma Island

Sisters Island
CONNECTIONS AND MOVEMENTS THAT MOLD THE ECOLOGY OF THE SANAK ARCHIPELAGO

Nancy Huntly, Spencer Wood, and Roly Russell

Ecology is not only about the interesting biology of organisms, as described for Sanak Island in the last chapter, but also about interactions: interactions between animals (including people), plants, microbes, the habitats that they live in, and the environments that surround them. The ecology of Sanak Island today reflects not only today’s conditions, but also shows the imprint of the distant history of interactions of the island, especially, as we will see below, the imprint of the Aleut people that have made this island their home.

The islands of the Sanak Archipelago, despite being so close together, differ greatly in appearance. For instance, Elma Island has a mix of lush tall plant communities and shrubby heather-dominated tundra; it looks much like the lower Alaska Peninsula, 50 km away. Sanak Island also has upland tundra, but is ringed with meadows of low-growing plants, especially grasses and sedges interspersed with abundant dandelions. Sisters Island looks like many of the more distant western Aleutian Islands and is dominated by beach grass (*Leymus mollis*).

In sharp contrast to the terrestrial communities with their distinct vegetation, the marine communities of seaweeds, invertebrates, and other animals that live in the waters immediately surrounding the islands are similar to each other and to marine communities of the Alaska Peninsula. Why are the intertidal communities of the Sanak Archipelago so similar and the terrestrial communities so different?

One reason that Sanak, Elma, and Sisters Islands have unique ecologies is that they are at least partly isolated from each other by the surrounding water, which reduces or blocks movements of many land-living organisms. This isolation allows different sets of plants and animals to accumulate on each island, so the islands come to provide local snapshots of the range of ecologies that are possible in the region. In contrast, most ocean-living species are able to move freely among the islands in the

The sites of ancient villages on Sanak Island have a characteristic topography, with depressions indicating the locations where semi-subterranean houses once were. Here, an archaeologist in the foreground is standing near the center-bottom of a house pit, to the right of a small excavation.
continuous waters that surround them. Some move as adults and others release their eggs or other propagules to be moved by ocean currents; thus, they form a continuous marine ecological community.

The particular histories of people on each island also have played a major role in the between-island differences in plants, animals, and interactions that are seen today. All of these islands were homes to the Aleut in the past, as shown by the ancient village-sites and house-pits that the Sanak Biocomplexity Project discovered and studied; however, the islands have had somewhat different economic histories.

In historic times, Sanak Island has had cod stations, cattle ranches, and fox farms, in addition to the traditional fishing and harvesting of marine mammals that occurred for thousands of years (see Chapter 5 for more details). Cattle and foxes have been major players in the ecosystems of the island in the past century.

In contrast, Sisters Island has had neither cattle nor foxes for any significant length of time. Although Sisters Island had fox farms for a short time, foxes did not persist on this tiny island, and it remains an island without mammals. Without native or introduced mammals, Sisters Island resembles the Aleutian Islands that are more distant from large land areas. It has abundant beach grass (*Leymus mollis*) and many nesting seabirds.

Elma Island, like Sanak Island, has been inhabited by foxes, but cattle never lived on this island. Thus, the ecological interactions on Elma Island have created an ecosystem more like the mainland of the Alaska Peninsula, where herbivores (such as voles and lemmings, ground squirrels, and caribou) and carnivores (such as bears and foxes) are major parts of the ecology.
The biology and ecology of the Sanak group of islands today reflect not only current, but also past, interactions between species, particularly interactions of people with some of their major food and economic resources. A general message is that what the Aleut have cultivated, harvested, or otherwise used has shaped the ecologies of the islands.
Foxes and Birds

Foxes were introduced to the Sanak Islands, and many other Aleutian Islands, many times during the 19th and 20th centuries, to support a fur-harvesting economy (Murie, 1959; Bailey, 1993; for more information, see Chapter 5). However, research made it clear that foxes were greatly reducing the abundance of ground-nesting birds, especially by eating eggs from the nests. To stop the loss of seabirds from Aleutian Islands, the United States Fish and Wildlife Service (USFWS) began eradicating foxes from islands in 1949. The removal of foxes from many of the Aleutian Islands has resulted in recovery and increase of many nesting waterfowl and sea birds.

On Sanak Island, arctic foxes (*Vulpes lagopus*) were common during the twentieth century. With no tall trees to nest in, the birds of the island laid their eggs directly on the ground or in burrows, where foxes could easily consume them. Although people also hunted ground-nesting birds and their eggs, they did not do it at the scale or with the intensity of the introduced foxes. Consumption of bird eggs by foxes decimated ground-nesting seabird populations on Sanak Island. Breeding colonies of Cassin’s Auklet (*Ptychoramphus aleuticus*) and Ancient Murrelet (*Synthliboramphus antiquus*) vanished from the Sanak Islands after the introduction of foxes (Murie, 1959). In response, the USFWS and Sanak Corporation collaborated to remove the foxes from Sanak and Elma Islands. In the fall of 2006 and Spring of 2007, 119 arctic foxes were removed, by trapline and gun, from Sanak Island and 17 foxes were removed from Elma Island. A few remaining foxes were removed from Sanak Island in Fall 2007.

An arctic fox (*Vulpes lagopus*) in the intertidal zone. Foxes have been responsible for a cascade of ecological changes on Aleutian Islands where they have been introduced by people. They have especially reduced the abundance of ground-nesting birds.
Only time will tell what the result of removing foxes from Sanak and Elma Islands will be, but some observations just before and just after their removal suggest there will be many changes. More individual birds and more bird species were seen on Sanak and Elma Islands in 2007 than in 2006, particularly along the shores of lakes. Gull nests were seen along the shorelines of some inland lakes, though these were seen only on small fox-free islets within those lakes in 2006. Several bird species were seen in 2007 but not 2006, including Black Scoter, Goldeneye, and Western Sandpiper. Least and Rock Sandpipers, which nest in the tundra, are common on Sanak Island, but more of their nests, eggs, fledgling sandpipers, and adult sandpipers displaying to distract predators from their nests were seen after foxes were removed from the island. There are nesting seabirds both on Sisters Island and the small Bird Island that is near Pauloff Harbor, so seabirds may soon return to nesting on the newly fox-free islands. Sisters Island also suggests that gulls may nest on Sanak and Elma Islands in the future: during nesting season, the beaches of fox-free Sisters Island are strewn with gull nests and eggs.

**Cows and their Many Interactions**

Cattle were brought to cod camps on Sanak Island in the late 1800s. They have been abundant on Sanak Island since the early twentieth century, when they began to be ranched and sold as beef. Cattle have roamed free on Sanak since the 1980s, when the last modern community, Pauloff Harbor village, was abandoned as the inhabitants moved to larger communities on other islands or the Alaska Peninsula. Hundreds of cattle remain feral on the island. An aerial survey of Sanak in 2003 estimated that 800–850 cattle and 38–40 horses were present (A. Morris, Sanak Corporation, 2008). Their effects are most apparent in the coastal meadows that ring the island, but the effects of cows on vegetation, soils, streams, lakes, and other animals are visible across the island.
Cows and Plants

Much of Sanak Island does not look like most of the Aleutian Islands. Among other differences, it is ringed by low grassy meadows and there are active dunes, particularly on the south side of the island (see also Chapter 1). Much of the interior of the island is maritime tundra, dominated by heathers, particularly crowberry (*Empetrum nigrum*) and sub-shrub willows (*Salix* spp.). Heavily traveled cow trails permeate the tundra and often are eroding. The slow-growing heathers and lichens of tundra do not survive heavy trampling by cattle, which leaves space open for more rapidly growing and short-lived or disturbance-resistant species to take root. Non-native plant species, those which were brought to the island from other places in recent times, such as Kentucky blue grass (*Poa pratensis*) and dandelions (*Taraxacum officinale*), are found along these trails. Together, trampling by cows and introduction of non-native species degrade tundra.

The effects of cattle on Sanak Island are especially evident in the coastal meadows. These meadows, which are most apparent on the sites of ancient Aleut villages, have high densities of low-growing grasses, abundant dandelions, and an occasional lush and upright lupine (*Lupinus nootkatensis*, a native plant that was among the root-foods used by the ancient Aleut). Lupines persist in these heavily grazed meadows, growing taller than the other, very short, grazed vegetation because cows prefer to eat other plants. These meadows look much like the moist-meadow pastures found in northerly and temperate areas, and that is exactly what they are: grazing lawns, produced by the heavy use of ancient village sites by cattle. Cow trails cross the island nearly everywhere except for the higher parts of Sanak Peak. However, cattle are most often in these meadows, where they graze and where their dung, hair, and hoof-prints

The meadows of Sanak Island have a beautiful and unusual mix of flowers, including here the widely distributed dandelion (*Taraxacum officinale*), which is not native to the islands, and the native purple bog orchid (*Dactylorhiza aristata*), which has a long history of association with and use by the Aleut, both as a root food and as a lovely decorative flower.
are seen in abundance. Consequently, the village sites are heavily grazed and trampled and so have come to have low grassy vegetation.

Cows seem to be largely responsible for the wide distribution and high abundance of non-native plants on Sanak Island. During the ranching era, hay was imported for winter feed (Black, 1999) and likely brought with it the seeds of common pasture weeds, including dandelions and Kentucky blue-grass. Dandelions are not seen on cow-free Elma and Sisters Islands, which have only native plant species. Nearby Izembek National Wildlife Refuge has a few species that are not native to the area, including dandelion and Kentucky blue-grass, but only where people lived in modern settlements (Talbot et al., 2006). In contrast, these species are widespread on Sanak Island and among the most abundant in the grazing lawns of ancient village sites.
Cascading Interactions of Cattle—the Food Webs of Dandelions, Dung, and Carrion

Sometimes a single species has effects that spread to other species and cause cascading changes to many organisms and interactions. Cows create novel habitats that are exploited by other creatures that, in turn, become more abundant than they could be without those habitats. Cows have created the unique grazing lawn habitat of Sanak Island’s coastal meadows, which has abundant dandelions that themselves provide food and shelter for many arthropods such as spiders and insects. Cows also create novel habitats in the form of their dung pats and, when they die, their carcasses.

Dandelions can be the most noticeable feature of the heavily grazed coastal meadows in early spring. When they are in flower, the meadows are awash in yellow blossoms. These bright flowers produce abundant nectar and pollen that are foods for many insects. The flowers also may provide warm spots where insects can rest and raise their body temperature during windy and cold Aleutian days.

Although dandelion is a comparatively new plant species to Sanak Island, dandelion flowers are visited more frequently and by more species of insects than the flowers of many other plants that bloom at the same time. At least 30 insect species visit the flowers of dandelions on the island, including nectar and pollen feeders, some of which are also pollinators, insects that use the flowers as places to sun themselves and warm up enough to fly in the cool windy skies, and insects that prey on other flower visitors.
The dandelions also provide food for many of the larger animals on Sanak Island. Tundra voles harvest the leaves, flowers, and seed-heads of dandelions. Many birds, such as the Lapland Longspur, Savannah Sparrow, Fox Sparrow, and Gray-crowned Rosy Finch, consume the seeds.

Cows are themselves a food resource for other creatures on Sanak Island. Cows produce dung, and cow dung is abundant on the island. Dung is a waste product for cows, but is a nutrient-rich windfall for many insect species. Many kinds of flies and beetles feed on dung or on the microbes that also decompose dung. By feeding on the dung left by cows and other animals, these insects speed up decomposition and cycling of the nutrients in the ecosystem.

Each pile of dung has its own small and specialized food web that includes not only dung-feeders, but also fungi and bacteria, along with fungus- and bacteria-feeders, as well as predators and parasites of the animals that eat the dung and its microbial consumers. On Sanak Island, the insects found in a dung pat might include dung beetles (Agolimax congregatus), which are specialized feeders on the dung of mammals, along with scuttle flies (Phoridae), blow flies (e.g., Cynomya mortuorum—the fly of the dead), tiny fungus-feeding featherwing beetles (Ptiliidae), and rove beetles (Staphylinidae).

Cows also provide carrion, which is a prime source of nitrogen, a precious ecological commodity. In a place like Sanak Island, where the largest native terrestrial animals other than humans once were voles, a cow carcass is a major food resource for scavengers and decomposers. The death of a cow sets in motion a dramatic course of ecological interactions as carrion is consumed and decomposed. Many cows die during winter on Sanak Island, and their carcasses dot the landscape each
The many cows that die on Sanak Island are relatively quickly returned to the soil by the actions of decomposers, including the larvae, and sometimes the adults, of numerous flies and beetles that make their living from carrion. Spring. This is especially true of the south side of the island, where cows congregate during the warmer growing season and graze in the extensive coastal meadows. Often, the carcasses lie below low cliffs or dunes, the edges of which sometimes collapse under a cow’s weight, particularly in the sandy eroding areas.

As with cow dung, a suite of ecological interactions develops as many organisms form food webs that collectively decompose the carcasses of cows. The larvae and adults of insects that feed on carrion, like the northern carrion beetle (*Thanatophilus lapponicus*) and the blue-bottle fly (*Protophormia terraenovae*), can be super-abundant on cow carcasses. The carcass food web also includes a variety of other insects, especially flies and beetles, such as cheese skippers (Piophilidae), dung flies (e.g., *Crumomyia annulus*), and predatory rove beetles.

It is not clear how long the dung- and carcass-specialist beetles have lived on Sanak Island. They may have a long history on the island or may have been introduced to Sanak more recently, along with the large animals on which they now depend for their existence. Both dung beetles and carrion beetles have a long history in Alaska and the Beringian region; both groups have been recorded in prehistoric deposits in the region. For instance, the dung beetle *Agoliinus congregatus*, which is the common dung beetle on Sanak, was found with mammoth dung in a fossil sample further north in Alaska (Elias and Crocker, 2008).

Cascading interactions in food webs also occur in the intertidal and in the sea. A notable example that has been studied in the Aleutian region is the interaction of otters, sea urchins, and the other organisms that form food webs with them (see Otters, Urchins and Food Webs).
Otters, Urchins and Food Webs

Historically, sea otters were abundant around Sanak Island and along the entire west coast of North America. This changed following the voyages of Vitus Bering in 1741 and James Cook in 1778, when demand for sea otter fur increased and ships were sent from Russia, England, and America to collect their pelts. During the late 1700s and early 1800s, well over one million otters were killed in Alaska alone, and by the 1900s only one population of less than 1,000 individuals persisted in the central Aleutian Islands. C.L. Hooper wrote in 1897 that “the otter are now nearly extinct on the Sannak grounds.”

Sea otters prey on a broad array of marine species including fish, chitons, mussels, urchins, and clams. In the absence of sea otters, urchin populations grow larger and, in turn, consume more seaweed. As a result, following the extirpation of sea otters in the 1800s, urchin abundances increased and there was a widespread loss of kelp. This shift from an ecosystem with sea otters and rich kelp forests to one with large populations of urchins was caused by a cascade of trophic interactions among species in the food web. The recent restoration of sea otters, and corresponding return of kelp forests, has had positive effects on species throughout the food web. Kelp-associated fish like the rock greenling are benefiting, as are harbor seals and bald eagles that feed on fish from higher in the food web.

Hooper, CL. 1897. US Treasury Department Document No. 1977. Office of Secretary, Division of Revenue Cutter Service.

Ecology is about organisms with unique biologies, the interactions that link them, and also their movements, which create linkages among habitats and food webs. Indeed, many of the species of Sanak Island move over vast areas as they forage for food or move between seasonal homes. These species that use many or distant habitats, whether on a daily, yearly, or even longer basis, can move materials and organisms between habitats, fundamentally changing their character. The migratory and predatory birds of the island are examples of species that move between and link habitats, as are salmon (which link the sea and inland lakes), and ultimately the Aleut themselves, who linked land and sea through their use of algae, marine fish and mammals, and intertidal invertebrates for food and other purposes (see How Sanak Aleut Fit into the Intertidal Food Web).

The birds of Sanak have influenced the ecology of the island over time and through space. Although Sanak Island no longer has dense seabird colonies, some smaller islands such as Bird Island in Pauloff Harbor have colonies of Puffins and Ancient Murrelets. This tiny island serves as an example of how dramatically seabirds can change an island: the high density of nesting birds on Bird Island has reduced the diversity of common plants to only a few species that are weedy and short-lived, especially yellow rocket (Barbarea orthoceras) and foxtail brome (Vulpia bromoides), and a few small prostrate and succulent forbs. Bird Island also has much more nitrogen in the soil than Sanak or Elma Island, which lack bird colonies. The higher
soil nitrogen is undoubtedly caused by the high density of seabirds and the massive amounts of nutrients they move to the island as marine fish are caught in the sea and brought to the island by the birds.

The influence of birds on spatial variety of habitats also is seen on Sanak Island. The coastal landscape of the Island is dotted by mounds of earth known as “bird mounds” (Bank, 1953). These features begin as rocks or other small local highpoints, then grow larger over time thanks to the long-term accumulation of organic matter and waste brought by raptors (such as eagles, hawks, or falcons) and other birds. Eventually bird mounds become prominent features that are covered by fertile soils and vegetation. The nitrogen-loving green alga, *Prasiola*, which grows in both fresh and marine water, can also be found on some sea-side rocks that form bird mounds, where many of the tiny plants, each with a simple small blade on a short stalk, grow together and form a miniature bright-green turf. The *Prasiola* turfs growing on bird mounds tell us that these areas have been fertilized with nitrogen from remains of the prey of the roosting raptors.

Less prominent features than bird mounds also show evidence of the importance of birds and their movements to the local ecologies of Sanak Island. Raptors that forage or scavenge in the ocean or intertidal and return to their nests with marine animals link the marine and the terrestrial ecosystems. The remains of the prey of the raptors can be observed on and around their nests and perches, sometimes as regurgitated pellets. And the soils in these areas, where raptors feed and perch, are especially rich in nitrogen that chemical analyses show is, in part, from the sea.

Many other species also function as nutrient conduits and create local fertile habitats. For instance, salmon transport nitrogen from the sea to streams and lakes, and this fertilizes the plants growing in and along them.
Red salmon return in great numbers to inland lakes and streams to spawn (below left). When their eggs hatch, the young salmon rear in the lakes, then return down the rivers to the ocean to mature. The adult salmon die after spawning, leaving large numbers of carcasses in the inland waters to decompose (above left). These carcasses provide abundant nutrients to the lakes, streams, and the plants that grow along the waterways. Thus, salmon fertilize the waters in which their young grow and provide significant nutrient subsidies to inland ecosystems (photos courtesy of Sarah Klain).

People who lived long ago can leave strong imprints on today’s ecology. Effects of the long-ago actions of people on today’s plants, animals, and habitats are called “landscape legacies.” There are strong landscape legacies on Sanak, Elma, and Sisters Islands. On Elma Island, and even tiny Sisters Island, village sites have more kinds of plants and these plants are larger, greener, and more nitrogen-rich than in nearby areas outside of the village boundaries. Even on Sanak Island, where feral cattle roam and ancient village sites have become “grazing lawns,” those village sites still are distinct from the nearby areas, and they remain highly productive.

In addition to the special plant community, different animals are seen in areas where there were villages long ago. In the Sanak Archipelago, the best place to see the landscape legacy of the Aleut villages of hundreds and thousands of years ago is Elma Island, which has not been affected by introduction of cows. Voles, which eat plants and tend to live in tall and dense vegetation, are abundant in the luxurious vegetation of village sites of Elma Island, but are not common in nearby tundra communities. Some birds, such as Golden-crowned Sparrows, are seen and heard more in the ancient village areas. Even on Sanak Island, where the ancient
Young bald eagles are often seen in nests along the cliffs that surround parts of Sanak Island.

Village sites are now grazing lawns rather than diverse and verdant "gardens," these areas that were villages long ago are used differently by animals. For instance, a more diverse group of songbirds is seen on the village sites. Also, although not the most abundant summer songbird on the island, the Gray-crowned Rosy Finch was the most commonly observed bird at ancient villages. The Gray-crowned Rosy Finch was used by the Aleut to decorate the necklines of cloaks (Jochelson, 2002).

It has been hundreds to thousands of years since most of the village sites of the Sanak archipelago were inhabited. Often, human-caused changes to an ecosystem tend to dissipate and disappear after much shorter periods of time, years to decades. It is somewhat of a mystery how the ecosystems of these village sites can stay so distinct for so long, continuing to reflect the long-past interactions of the Aleut people and their environment. The long-term persistence of special "Aleut village communities" or "Aleut gardens" on Sanak and the surrounding islands may be related to their soils, to the activities of the animals that use the villages today, or to the soil biota, including the soil microbes, whose many ecological roles are noted in Chapter 2.

The Aleut people who lived on Sanak Island moved large quantities of fish, marine mammals, shellfish, seabirds, and kelp from the sea to the land, and the soils today bear witness to that. The soils where there once were Aleut villages are enriched with nitrogen that is derived from the sea. This no doubt reflects the incorporation of wastes from the many sea animals that were important to the diet and culture of the people. It might also reflect incorporation of marine plants (seaweeds); if so, this would suggest deliberate fertilization of villages, as was done in places further south along the coasts of Alaska, British Columbia, Washington, Oregon and California.
Aleut Gardens

One of the most notable features of the Aleutian region is the lush vegetation that is found growing on the sites of ancient villages. These unique and lovely plant communities may be regarded as “Aleut gardens.” Although there is no indication in the ethnographic literature that Aleut people used row-crop agriculture before Russian contact, the ancient Aleuts may nevertheless have had close relationships with many plants that provided foods, medicines, and textiles.

The unusual and distinct vegetation of prehistoric village sites in the Aleutians was noticed by the early explorers of the region. The mid-twentieth century explorer and ethno-botanist Theodore Bank II described this vegetation in more detail and suggested that village sites have a characteristic plant community that is the result of use by the Aleut people of a wide variety of plants that otherwise grow in a similarly wide variety of physical habitats (Bank, 1953). Bank suggested that continued collection of often-used plants by the Aleut people resulted in development of a characteristic community that was uniquely associated with village sites. On Elma and Sisters Islands in the Sanak Archipelago, ancient village sites have the characteristic plant community described by Bank.

The plant community of these ancient villages has especially high numbers of plants that were traditionally used by the Aleut people as foods or medicines. The plants most commonly reported as important traditional foods include rice-root (also called chocolate lily, *Fritillaria camschatcensis*), putschki (also called cow parsnip, *Heracleum lanatum*), petruski (also called beach lovage, *Ligusticum scoticum*), purple orchid (*Dactylorhiza aristata*), lupine (*Lupinus nootkatensis*), white bog orchid (*Platanthera dilitata*), sea coast angelica (*Angelica lucida*), and wild rhubarb (*Rumex fenestrate*). The most common and abundant plants on village sites on Elma and Sisters Island include putschki, rice-root, spring beauty, sea coast angelica, and lupine.

These unique plant communities, and their long-lasting strong association with village sites, suggest that the ancient Aleut may have had effective “gardens.” Such gardens could be deliberate, with people actively working to have the plants that they used grow near their homes. Or they could be incidental: if people bring home plants again and again, their roots, bulbs, or seeds may establish, grow, produce seeds, and eventually these plants may come to grow especially well in villages. Either scenario could explain why ancient village sites are so notably enriched in plants that were important to the people who lived there long ago.