

Refuge Notebook

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A splash of yellow on the winter landscape

by Todd Eskelin



A three-toed woodpecker rattles away on a beetle-killed spruce. The yellow staining is apparent on the tail, wingtips, breast, and throat. The gold cap on its head is the normal coloration (Matt Bowser, USFWS, Jan 28, 2017).

A few years ago I received a call about an odd, unidentifiable bird. This is not an abnormal call to our office and we are glad to help whenever we can. This call piqued my interest as the caller described a woodpecker with yellow on the belly and face, but the rest of it was black and white. I asked for a photo and in fact the caller could do one better. Her cat had killed the bird and she held on to it for me. Normally, I would ask the person to return it to the wild in a place that it would not be consumed by their pets. In this case I had a clear vision that this was a Yellow-bellied Sapsucker.

Yellow-bellied Sapsuckers have been making a push into the southcentral area since about 2013 so this was not a stretch, but it would provide an important data point. Upon inspection of the bird I realized my vision was totally off and this was “just” a Three-toed Woodpecker with yellow staining on the belly, face, tail and wingtips. Curiously, the bird did not have the

yellow staining down the back. While not the exciting bird I thought it to be, it turns out to be even more of a mystery.

Stained feathers in birds are not uncommon. Waterfowl arrive at the Kenai Flats in spring with orange-colored feathers. Snow Geese, Northern Pintails and Sandhill Cranes get stained as they plunge their faces into the iron-rich mud in search of emergent vegetation. Staining in songbirds is much less common. The only significant examples I found in the literature were several bird species that were stained by coal soot from air pollution during the start of the Industrial Revolution from 1880 to 1929. The museum specimens ranged from a dark gray to white based on the amount of coal soot that was being pumped into the air and then lightened in subsequent years as regulations began curbing our air pollution problems.

Over the next several years after viewing the

yellow-stained woodpecker, I noticed yellowing in Gray Jays, Red-breasted Nuthatches and Boreal Chickadees at my feeder, but never in Black-capped Chickadees or Common Redpolls. Having inquired of fellow birders from around the state, it appears that the yellowing of certain species is restricted to the Kenai Peninsula. This phenomenon has been reported from Homer to Nikiski, but not from Anchorage or Fairbanks.

We next surmised that whatever birds were encountering that was causing the aberrant coloration was probably coming from spruce and likely not a dietary thing. All the species affected had a strong affinity for spruce forest while the black-capped chickadee that prefers deciduous or mixed forests was not affected. Also, since the backs of woodpeckers would rarely contact the tree it would have to be something on the trunk of the tree as opposed to an airborne stain like pollen floating all around the tree. We ruled out diet as that should affect all feathers equally.

Based on observations and speculations the mystery coloration appears to be the product of the Green Stubble Lichen, *Calicium viride*. This lichen has bright yellow to green soredia (granular outgrowths formed on the surface of the lichen that form a powdery dust). These soredia contain everything needed to land somewhere new and form a new lichen. The Green Stubble Lichen also produces short spore-producing stalks called apothecia. The lichen can spread via spores carried on the wind or by insects and animals to a new site or from soredia carried by insects and animals.

This species is found across the Western Hemi-

sphere from Argentina to the Canadian Arctic. It is also quite common in Europe and Scandinavia. While most commonly found growing on coniferous wood and bark, it can be found on deciduous species.

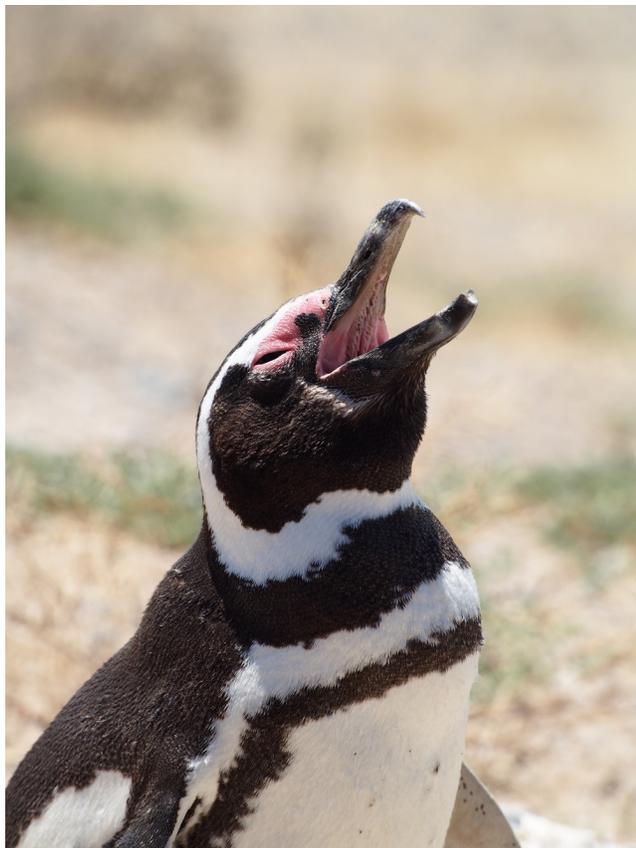
The next step will be to confirm from one of our yellow birds if the coloration is indeed caused by contact with this lichen. We may be able to do this with microscopy or through chemical methods. If we can connect the dots to this lichen, a flood of new questions begin. Why is the Kenai Peninsula the only place that is seeing yellowed birds? There are plenty of other places in the world where this lichen occurs, so why are yellowish birds not being reported elsewhere? What has changed on the Kenai Peninsula as there is no mention of yellowing by previous bird surveys? We have had large, old spruce and presumably this lichen since Wilfred Osgood surveyed the Kenai Peninsula in the early 1900s.

If you would like to help with this exploration, we need to better document how prevalent yellowed birds are on the peninsula. We are looking for high-quality photos that clearly show yellowing in these spruce-dwelling bird species. You can email your photo, along with the coordinates or address and the date to todd_eskelin@fws.gov. Watch for an update as we try and sort out the mystery of yellowing birds across the Kenai Peninsula.

Todd Eskelin is a Wildlife Biologist at the Kenai National Wildlife Refuge. He specializes in birds and has conducted research on songbirds in many areas of the state. Find more information at <http://www.fws.gov/refuge/kenai/> or <http://www.facebook.com/kenainationalwildliferefuge>.

Lessons learned from Tierra del Fuego

by John Morton



Magellanic Penguins are only found along the coast of southern South America, not Antarctica. They are named after Ferdinand Magellan, the first European (Portuguese) to navigate around the tip of South America in 1520.

People recreationally travel for many reasons, but most often it's to see new places, do new things, eat new foods or encounter new cultures. I enjoy those experiences as well, but sometimes I get my most enlightening moments when I see something familiar out of context.

As a case in point, I traveled around Tierra del Fuego and Cape Horn at the tip of South America over the holidays. Tierra del Fuego means the “land of fire”, in deference to the many small campfires seen by early Spanish explorers that native Yamanas clustered around at night. Here, at the “end of the world” as local Argentinians have branded their provincial capital of Ushuaia, it is different.

Even though you can look at Google Earth or a globe anytime you want to, it didn't really occur to me how different southern South America is from northern North America. First of all, there isn't a “tip” to North America. Our continent fans broadly into the Arctic Ocean, its waters lapping onto Alaska's North Slope 70 degrees north of the equator. In contrast, South America really does come to a narrow tip, following the backbone of the Andes Mountains. Tierra del Fuego is actually an island archipelago, separated from mainland South America by the Strait of Magellan, but it only reaches south to 55 degrees in latitude, still 600 miles from Antarctica. Consider that all of Interior Alaska is farther north than Cape Horn is south from the equator.

What this means is that although the climate is more benign than most of Alaska's, its narrow geography results in a depauperate biological community. Only 90 bird and 20 mammal species (and no amphibians) inhabit Tierra del Fuego, but this list includes some very cool and unique animals like Guanacos in the camel family, huge (18 inches long!) Magellanic Woodpeckers, and Magellanic Penguins. On the adjacent mainland, I saw ostrich-like Greater Rheas and the Patagonian Cavy, a jackrabbit-like rodent.

But walking through the forest composed of several species of southern beeches (*Nothofagus* spp.), unique to South America and only distantly related to beeches (*Fagus* spp.) in the Northern Hemisphere, I was stunned to recognize two plants that I know from previous work in two very different places of the world that seemed incongruous growing together. The first was a native evergreen shrub called Diddledee (*Empetrum rubrum*) that I mistook initially for our crowberry (*E. nigrum*) that grows here on the Kenai Peninsula except that it has red rather than black berries. The second was a small native tree called Pickwood or *Maytenus magellanica*—the last time I had seen a *Maytenus* was in the Mariana Islands where I had studied Mariana Crows on Guam and Rota. How does a genus from boreal and arctic Alaska take root next to a genus that is widely distributed mostly in tropical and subtropical locales of the southern hemisphere?

Before I get to this question, however, I need to

point out that Pleistocene glaciation and, in particular, Beringia frame how evolutionary ecologists think about speciation and our contemporary species assemblages in Alaska. Beringia was the large grassland that straddled the Bering Strait, stretching from the Lena River in Russia to the Mackenzie River in Canada. Beringia was a refugium for many plants and animals during the last ice age, sustaining beaver, moose, Dall Sheep, and spruce at a time when much of the northern latitudes were encased in ice. Some Beringian species like mammoths went extinct, but others like steppe bison evolved into our contemporary wood and plains bison. Still others, like humans, crossed the Bering land bridge that connected the two continents as recently as 30,000–11,000 years ago.

What blows me out about *Maytenus* is that its global distribution is not the outcome of something as relatively recent as Beringia, but resulted when the supercontinent Pangaea split into two continents 180 million years ago, one of which was Gondwana when the climate was much warmer than it is today. *Maytenus* presumably speciated as Gondwana broke up into what is now South America, Africa, India, Australia, New Zealand, Antarctica and Micronesia, persisting in some far-flung locales like Tierra del Fuego and Guam.

The equally incredible story is that *Empetrum* really did originate in the Northern Hemisphere, geographically disjunct from the species that appears much later in South America. A 2011 paper published in the *Proceedings of the National Academy of Sciences* found that *E. rubrum* in southern South America is most closely related to the crowberry that grows in northwestern North America (that is, Alaska!). The authors went so far as to suggest that a single seed dispersal event perhaps a half-million years ago by a bird, such as a whimbrel that eats crowberries in Alaska and migrates nonstop to Tierra del Fuego where it defecates, could well explain the ancestral origin of Diddledee in South America. I love science.

The shock of seeing two familiar plants in an unfamiliar landscape prompted me to explore their biogeography. And a little bit of research into Pickwood and Diddledee just made my travels that much richer.

Dr. John Morton is the supervisory biologist at Kenai National Wildlife Refuge. Find more information about the Refuge at <http://www.fws.gov/refuge/kenai/> or <http://www.facebook.com/kenainationalwildliferefuge>.



Jam made from the red berries of Diddledee, the most common shrub in the Falklands and a species closely related to crowberry, a common plant on the Kenai Peninsula. Scientists suggest that the random act of a whimbrel migrating from Alaska (where it ate crowberry) to Tierra del Fuego (where it defecated) may have been the ancestral origin of Diddledee in southern South America.

Magical moments

by Matt Conner



Participants in the Kenai National Wildlife Refuge’s “Stick & String Naturalist Camp” canoe across Dolly Varden Lake in hopes of catching rainbow trout or arctic char on flies that they tied themselves.

I have a collection of outdoor memories I carry around in my mind at all times. These are magical and unforgettable moments I have experienced in the outdoors. One of my favorite memories occurred while working as a Ranger at Glacier National Park in Montana. I had hiked up to the top of a ridge and sat down to watch the sunset. Looking over at an adjacent ridge to my left, I saw a grizzly bear saunter up the hill, sit down, and look towards the sunset as well. I wondered what the bear was doing sitting on top of a ridge like that. Later someone told me that bears climb to the high peaks like that to roll rocks over searching for moth larva and other insects, but I prefer to believe that the bear was just enjoying the view.

Another time I was collecting forest ecology data in northern Wisconsin and, as I took a compass heading for my next research plot, I looked up just in time

to watch a large paper birch fall 100 feet in front of me. I didn’t find this moment to be frightening. Rather, I was awed by the randomness of standing at that exact location at that exact moment when a tree fell of natural causes right in front of me. There wasn’t any wind nor other apparent reason for the tree to fall other than this tree’s life happened to end just as I looked up from my compass. I was present the exact second this 80-year-old tree fell.

Why is this magical? Consider this. There are 86,000 seconds in one day. Multiply this by 365 and you see there are 313,390,000 seconds in a year. Multiply this by the tree’s age (80 years) and you get 2,511,200,000 seconds. Do you see my point? I had less than a 1 in 2.5 billion chance to see this happen and I was lucky enough to be there at that exact time.

Several years ago, I worked with a community col-

lege in Arkansas to develop the “Business of Birding” program. Designed to increase tourism to the Delta area and encourage local hunting lodge owners to cater to birders after the hunting season, this program had the goal of offering year-round tourism and outdoor experiences to people from around the world. Driving down a gravel road, the group I was working with spotted a great blue heron eating a frog. The van pulled over and we practiced using our binoculars and field guides to observe the bird.

As we watched the heron, we noticed a loggerhead shrike, about the size of a robin but with a black mask similar to a chickadee’s, flying towards us. I told the group that the loggerhead shrike was a hunter like a red-tailed hawk, but because it was a smaller bird with much weaker feet, it had adapted its hunting strategy. Shrikes are neither able to kill their prey with crushing talons nor tear apart its catch with their feet. Instead, this small bird catches grasshoppers or even prey as large as mice and flies them straight into a thorn on a bush, impaling its prey and then returning later to feed on it.

Even as I said this, the shrike dove into the bushes, jumped back on the branch it had been sitting on it, and stuck a mouse on the adjacent branch. We sat there and watched the exact moment unfold that I had just described. The bird ate the mouse as we took pictures from the van. We all watched the bird’s activity in silence, aware that this was a special moment, and one that made a group of beginner birders hooked on

wildlife observation forever after.

The best part of my job is the moment when I have the privilege of sharing nature with someone and provide them with the skills to start a new outdoor pursuit for the rest of their lives. At Kenai National Wildlife Refuge, we strive to provide visitors with these opportunities through ranger programs, nature camps and presentations at the Visitor Center.

One of my favorite activities is to host a camp called “The Stick and String Naturalist” where we spend several days with teenagers, teaching every aspect of fly-fishing and nature journaling. The camp begins with an aquatic macroinvertebrate lab where we discover the insects living in the water. The campers focus on details, sketching their discoveries to help us mimic these insects as we tie our own flies.

Many of our campers have never caught a fish on a fly rod and some have never been fishing before. As I sit in my office today, I can’t help but daydream about the potential magic moments this summer might bring. Perhaps I will be able to teach a camper how to catch their first fish with a fly they tied. Maybe we will glimpse a lynx or wolf while hiking to one of the Refuge’s lakes. Or maybe we will just get to spend some time together exploring Kenai Refuge—and that, in itself, is a magical thing.

Matt Conner is the Visitor Services Manager at Kenai National Wildlife Refuge. You can find more information about the Kenai Refuge at <http://kenai.fws.gov> or <http://www.facebook.com/kenainationalwildliferefuge>.

Contact with the natural world benefits our well-being

by Ted Bailey



Following tracks left by American marten in the Kenai Lowlands can be a great way to experience the outdoors in winter (credit: Andy Baltensperger)

I read in a recent newspaper article how even a brief contact with the natural world, or nature, can benefit our well-being. Researchers found that just hearing a bird sing, or seeing trees and the sky, was enough to boost one's mental health. Other research has shown how contact with the natural world can lower blood pressure and improve other aspects of a person's physical health.

Contacts with the natural world can also change a person's philosophy about life. I just read a book titled *Zulu Wilderness: Shadow and Soul* by the late South African game ranger, later turned world-renowned conservationist, Ian Player—who helped save the white rhinoceros from extinction. Most of the book's storyline takes place in the formerly Umfolozi Game Reserve in South Africa. It is about

Player's forty-year friendship working with Magqubu Ntombela, a native Zulu game guard, whose life was closely in touch with the natural world and how their friendship changed Player's outlook on life. Player subsequently started the Wilderness Trails program in Umfolozi in 1959 and told how many of his trail clients' exposure to the natural world during just three or four days often beneficially changed their outlooks on life, especially the importance of maintaining natural places and wildlife.

I identified with many of the places mentioned in the book because my family and I were fortunate to spend time in Umfolozi. I participated in the live capture of two white rhinoceros and observed other wildlife there in the early 1970s while conducting research on leopards in South Africa.

I mention these stories on the health benefits of contact with the natural world because I often I think how fortunate we are on the Kenai Peninsula to have the Kenai National Wildlife Refuge and other public lands nearby, so close that many of us can reach them in less than an hour. We have many opportunities to experience nature here in our own preferred way to help us cope with today's increasingly complex and stressful lifestyles.

I also think of these advantages when I see commercial ads in magazines enticing people to come to Alaska. I realize that many people are willing to pay thousands of dollars to come here, even briefly to experience its unique natural environment, an experience many of us can have any day of the year and too often take for granted. Although we do not have rhinoceros, lions, and leopards, we have their counterparts with moose, caribou, Dall sheep, mountain goats, bears, wolves, lynx and wolverine. Many people are willing to pay large sums to see these species, perhaps only once in their lifetimes.

Moreover, I also believe one does not even have to observe wildlife to experience their presence. One of my favored winter activities is hiking on frozen lakes on the Kenai Refuge after a snowfall to observe tracks of wildlife. Tracks, unlike a brief visual observation, may reveal where a moose and her calf selectively browsed twigs on shrubs along the frozen shore-

line or perhaps where a red-backed vole defied danger and traveled across a bay hoping to reach safety on the other side. Tracks may reveal where a lynx came stealthily by, closely hugging the shoreline, perhaps with the hope of surprising an unwary snowshoe hare for a meal.

If extremely lucky, one may observe where a pack of wolves crossed a lake—find their beds where they lay curled up to rest in the snow or where they chased each other in circles like frolicking dogs. Sometimes one may encounter the trail of a river otter where it alternately loped then slid, making long furrows in the

snow as it crossed the frozen lake.

Following tracks of wildlife in the snow can be just as rewarding an experience of nature as a brief or distant wildlife visual observation. Moreover, it is a unique experience that one can only have during the winter, perhaps the most peaceful time of the year.

Dr. Ted Bailey was supervisory wildlife biologist at the Kenai National Wildlife Refuge before retiring in 2001. He has lived on the Kenai Peninsula for over 40 years. Find more information about the refuge at <http://kenai.fws.gov> or <http://www.facebook.com/kenainationalwildliferefuge>.

Winter wildlife babies

by Kyra Clark



A black bear mother and her three cubs on Skilak Lake Road in the Kenai National Wildlife Refuge (July 2017). Delayed implantation of the fertilized egg prevents pregnancy from starting until late fall, several months after mating.

Being six months pregnant in the dead of winter (as I am) has its challenges—from trying to zip up a coat that’s too small over an ever growing belly, to hobbling around in the snow without falling to open and close the driveway gate. There is also continually braving the freezing temperatures in search of the novel foods I crave. All of this got me to wondering how Alaskan wildlife handle their winter pregnancies.

Most mammals mate during the fall and give birth in the spring, but only a select few actually give birth in the late winter or early spring. Some of the earliest mammals to give birth are brown and black bears, and wolverines, because they have adapted the reproductive strategy called embryonic diapause or delayed implantation. This process allows the animals to mate early in the year without becoming pregnant right away. Instead of the fertilized egg implanting in the

walls of the uterus immediately, the egg develops into an eight-celled blastocyst that remains floating in the uterus in this dormant stage. The blastocyst eventually implants in the uterine wall if certain physiological requirements are met; at that point, it becomes a fetus.

Bears mate between May and July but implantation will not occur until October or November. If the female bear is able to gain enough weight before hibernation, the blastocysts will implant into the walls of the uterus and proceed to develop into cubs; otherwise the pregnancy will be terminated. Once she enters her den she will not eat or drink again until she emerges in June. Pregnancy demands a significant amount of energy and nutrients from the mother, and the entirety of her 6–8 week pregnancy is spent in the den.

Between January and March she will give birth to up to four cubs that are only 13 ounces when born and

will spend the next 3–5 months nursing in the den. There are eight months between mating and birth, but the female is actually pregnant for less than two months of that time.

Wolverines are solitary animals that roam around the Kenai Mountains at very low population densities. Delayed implantation allows them to take advantage of meetings by mating when they have the opportunity, anytime from May to August. Similar to bears, the embryo will not implant unless the female wolverine has gained enough weight before she burrows into a deep snow den. Pregnancy usually lasts 4–6 weeks, and babies or kits are born in February through mid-March. Wolverines typically have two but sometimes up to four kits in each litter. When born, the kits are tiny and pure white, relying on their mother's milk until they emerge in mid-May.

One of the earliest birds to nest here on the Kenai Peninsula is the great horned owl. Like most owls, these do not construct their own nests. Instead, they must find a suitable nest in tree cavities, cliff ledges, or old nests of other large birds. Great horned owls begin courting near the end of February, lay 2–5 eggs in April, which they then incubate for a month. Juvenile great horned owls rely on their parents to care and feed them until the fall.

In contrast, songbirds like orange-crowned warblers usually lay eggs in June or July and the fledglings

are ready to leave the nest within a few weeks. It's likely that great horned owls nest so early because it takes so long for their young to grow and mature. This timing also allows juveniles to practice hunting when the weather is mild and prey is plentiful.

Insects are a different story, invoking many reproductive strategies. Depending on the species, they overwinter as adults, larvae, pupae, or even eggs. To me, an insect overwintering as an egg is the closest to being pregnant. One genus (*Aedes*) of mosquito on the Kenai Peninsula overwinters as eggs and are known as "snow melt pool" insects. These eggs hatch in the icy water that forms as snow melts in April or May, emerging as adults in late May and early June. The rusty tussock moth (*Orgyia antiqua*) also overwinters as eggs that are laid on the outside of the female's cocoon. These hatch in early spring as soon as foliage appears.

Animals that birth in late winter or early spring have some interesting reproductive strategies. To be honest, though, I think bears have the right idea. I wouldn't mind spending the majority of my pregnancy sleeping in a cozy den!

Kyra Clark is a seasonal biological technician at Kenai National Wildlife Refuge. Find more information about the Refuge at <http://www.fws.gov/refuge/kenai/> or <http://www.facebook.com/kenainationalwildliferefuge>.

The “why factor” in fire management

by Mike Hill



Using a drip torch to light piled vegetation and other burnable debris to reduce fuel loads along the wildland-urban interface on Funny River Road.

In a time-compressed environment, such as during the initial response to a new wildfire, responders don't always have the opportunity to provide a thorough, in-depth explanation for the actions we take to protect lives, homes, infrastructure and natural resources. The reason for this is plain and simple—fire is dynamic. We fully understand that people deserve answers, but timing is everything. During emergencies such as these, explanations may not be as forthcoming as some folks might like.

Under a Delegation of Authority, a wildland fire

Incident Commander (IC) is authorized to carry out the expectations of the jurisdictional agent (city, borough, private, state or federal) on their behalf. The IC must delicately balance life, property, natural resources, cost and a myriad of other priority values. Sometimes during wildfires, even the IC and other decision makers are pressed for time to the point they fast-forward through the explanations, and simply act in order to protect the public and firefighters over all other values.

Emergencies are chaotic, but there are processes

available to manage those situations. After these initial actions there is time to slow down and provide a detailed and transparent description of the decision-making process, also known as the “why factor.” This “why factor” adds value, ownership, and engagement to all potentially affected stakeholders.

In contrast to wildfires, a prescribed fire is a planned event, although fire is still a very dynamic component. Foremost, fire managers who plan and execute prescribed fires are highly trained, and held to rigorous standards regarding public health and safety, and the safety of firefighters. They must possess a thorough understanding of risk, potential consequences, and technical difficulties associated with prescribed burns.

The good news is we have opportunities to control components of a fire prescription that are not necessarily under our control in a wildfire. Unlike a lightning strike, the timing of ignition is at the discretion of the prescribed fire burn boss in consultation with the planning team. The environmental conditions must be within the parameters of the prescribed fire burn plan. What does that mean? We select the day when the wind is from the right direction, the atmosphere is conducive to mixing smoke adequately, and the fuels on the ground are receptive to fire (but not so receptive as be problematic). Timing a prescribed fire before a precipitation event is every burn boss’ dream, although it doesn’t always work out that way. General weather patterns, however, are well documented for each season, and that information has a major influence on when we choose to burn.

We also examine resource needs carefully. We use computer-driven modeling to determine the prescribed fire’s rate and direction of spread under varying winds, fuels (vegetation), and topographical influences. These factors help determine the type and amount of firefighting resources needed to implement a prescribed fire. For example, a prescribed fire organization must be adequate to be able to hold (keep the fire from moving into unwanted areas) a fire under the most extreme conditions. So if modeling tells us that the maximum rate of spread for a prescribed fire may be 70 chains per hour (a chain is 66 feet), the organizational capacity must be sufficient to manage a fire that

may move at that speed. Each firefighting resource has an estimated line production rate measured in chains per hour. So if two crews plus three engines equals 100 chains of line production per hour, this would be an adequate organization to handle the proposed prescribed fire even under the most extreme conditions.

Responders to wildfires have far fewer choices. The day, the weather, the location, the atmospheric conditions, the amount of firefighting resources available, the resource type and capabilities, and a multitude of other factors have already been decided. If you contrast this to prescribed fire, ultimately we implement prescribed fires on our terms. We “plug holes in the swiss cheese model” (Google it!). There are many factors that can and should be planned, researched, and implemented to the highest standard. Prescribed fire will always have risk involved but, unlike a wildfire, we can and we should control what we have control over before we ever strike the match.

As a planned event, we have the opportunity to provide the why factor for a prescribed fire—why we’re doing what we’re doing. With fewer time constraints, it becomes practical to communicate our expectations of the outcome and describe what success looks like. We also have the opportunity to ask for feedback. All of this is done through active communication up and down the chain of command, through an organization, and with our stakeholders.

In some areas of the U.S., people live with routine prescribed fire. The Southeastern states, for example, have a culture of prescribed fire. People live with it, knowing that in the long run there are great ecological and public safety benefits. The “why” is engrained in the local culture.

Here on the Kenai Peninsula, the “why’s” of fire management may not always be fully understood, but I’ll gladly take the time to explain it. My hope is that with better understanding of our intent and expertise, whether during a wildfire or prescribed fire, you’ll feel more assured of a successful mutually-agreed-upon outcome.

Michael Hill is the assistant fire management officer for the Southern Alaska Refuges. Find more information about the Refuge at <http://www.fws.gov/refuge/kenai/> or <http://www.facebook.com/kenainationalwildliferefuge>.

How resource management has evolved on Kenai National Wildlife Refuge

by John Morton



LeTourneau tree crushers were used in the 1970s to create browse for moose on the Kenai National Moose Range.

People (including my mother) often confuse National Wildlife Refuges with National Parks, thinking they serve similar purposes. But parks are about people and refuges are about wildlife.

When you visit many refuges in the Lower 48, it's obvious a lot of active management is happening, often taking the form of diked wetland impoundments for wintering waterfowl. On Kenai National Wildlife Refuge, we do a lot of management but it may not be readily apparent. Here's how resource management has evolved on the refuge over the past eight decades.

When the refuge was first established as Kenai National Moose Range in 1941, moose populations were

declining after decades of commercial guided hunts. Caribou had already been hunted out of existence circa 1917 and wolves, too, had been wiped out by human persecution. Red fox were so heavily harvested for both pelts and to seed commercial fox farms in the 1920s that they haven't recovered even to this day. Salmon populations were so low that the Territory of Alaska offered bounties to reduce seal populations in salt waters surrounding the Kenai Peninsula.

Mining and its toxic residues were commonplace on much of what was to become refuge lands after Alexander King discovered gold in 1888. In 1951, the Sterling Highway was completed across the Moose

Range, which brought more homesteaders and visitors. Shortly thereafter, in 1957, the first oil in Alaska was discovered near the Swanson River, setting the stage for a half century of commercial oil and gas development on leased lands within the refuge.

During the early years, the Kenai National Moose Range responded to this historical legacy in multiple ways. With the Alaska Department of Fish and Game, we co-established the Kenai Moose Research Center in 1966 to research moose nutritional requirements and physiology, and the effects of habitat manipulation and browsing on carrying capacity. We used giant Le-Tourneau tree crushers to create moose browse in the Kenai Lowlands. Trumpeter swans were a high priority during the early years, and we removed or regulated commercial hunting camps, floatplane access and other sources of human disturbance. We jointly reintroduced caribou from the Nelchina herd in the 1960s and 1980s. Wolves naturally recolonized the Kenai Peninsula in the 1960s, only to find that coyotes had also colonized the peninsula during their absence.

In 1980, the Alaska National Interest Lands Conservation Act established the Kenai National Wildlife Refuge with one of its two primary purposes to “conserve fish and wildlife populations and habitats in their natural diversity”. Responding to this new mandate, we broadened our resource management.

Fire management was refocused on ensuring a natural wildfire regime, particularly within Congressionally-designated Wilderness. We co-established the Interagency Brown Bear Study Team in 1984 to collect data useful for managing brown bears across jurisdictional boundaries peninsula-wide. We co-developed the Kenai River Comprehensive Management Plan in 1986 to ensure interjurisdictional management of fishery and wildlife resources, sensitive habitat areas, recreation, and development activities within the Kenai River Special Management Area. Our 1988 Furbearer Management Plan mandated annual reporting by permitted trappers for better harvest management. We completed an interagency caribou management plan in 1994, subsequently revised to recognize the four re-established herds. A 1996 Moose Habitat Management Plan provided guidelines for prescribing fire to enhance habitat, established management objectives for population composition, and recommended assessing mortality including those by predators and vehicle collisions.

We protected vegetation by prohibiting snowmachines above treeline in alpine areas and elsewhere on

the Refuge when snow was sparse—we prohibited all-terrain vehicles all together. Remediation of oil spills, accidental release of xylene, PCBs released from a compressor plant explosion, and other industrial accidents on leased lands within the refuge were (and still are) a management priority.

More recently, the urbanizing landscape outside our western boundary that runs 175 miles from Point Possession to the Fox River has become a new management focus. We can now use prescribed fire in Wilderness, primarily to reduce fuels loads along the wildland-urban interface. We have practiced early detection and rapid response for exotic and invasive plant species since 2005. We helped apply Rotenone™ and fluridone for the first time in 2012 and 2014, respectively, to eradicate northern pike and elodea, one deliberately and the other accidentally introduced to the peninsula.

We restore (including boardwalks) banks on the Kenai River heavily used by recreational anglers. We replace culverts to improve fish passage. We work with the Alaska Department of Transportation to construct wildlife underpasses as part of the ongoing Sterling Highway MP58–79 improvement project. We co-developed the Kenai Mountains to Sea partnership that aims to maintain riparian corridors outside the refuge along some of our most important waterways.

In the not-so-distant future, we expect the dramatic effects of rapid, human-caused climate change will challenge our ability to conserve natural diversity. The peninsula was the epicenter of a spruce bark beetle outbreak that killed 4 million acres of spruce forest in southcentral Alaska over 15 years, sustained by consecutive summers of above-average temperatures. As climate has warmed over the past half century, treeline in the Kenai Mountains rose 165 feet, wetlands decreased 6–11% per decade, the Harding Icefield lost 11% of its surface area and 70 feet in elevation, and available water declined almost 60%. Spring fires in bluejoint grasslands now replace late summer canopy fires in spruce. Water temperatures in nonglacial streams already exceed salmon physiological thresholds during July. Modeling suggests forests and more snow will likely replace alpine tundra in the not-so-distant future, but forecasts for lower elevations range from more hardwood to almost catastrophic deforestation, and less snow.

Whether the cumulative changes are dire enough for us to consider planting trees or transplanting novel wildlife or prescribing grassland fires to sustain

ecosystem functions and biodiversity remains to be seen, but we've begun collecting the data that will allow us to think intelligently about this new management paradigm. I suspect new wildlife diseases, increasingly introduced to Alaska due to a warming climate and by domestic animals, will also eat our lunch as the 21st century unfolds.

So the next time you recreate on Kenai Refuge, I

hope you'll appreciate more than the cabins, campgrounds, trails, and boat launches. There's a lot of behind-the-scenes work to help Mother Nature in a world where Man has an increasingly heavy hand.

Dr. John Morton is the supervisory biologist at Kenai National Wildlife Refuge. Find more information about the Refuge at <http://www.fws.gov/refuge/kenai/> or <http://www.facebook.com/kenainationalwildliferefuge>.



Terrestrial and aquatic invasive plant management has become increasingly more complex since herbicides were first used on Kenai National Wildlife Refuge in 2005.

Vacation through the eyes of a naturalist

by Todd Eskelin



A male Wilson's Warbler bathes in a small waterfall, Santa Elena, Costa Rica February 20, 2018 (T. Eskelin).

First let's paint a picture. I am sitting at a concrete table sipping the best cup of coffee I have ever tasted. It was slow dripped through a coffee sock and the beans were grown, hand-picked, dried and roasted in the hills surrounding my current location. After an incredible morning of toucans, motmots, and trogons, I position myself next to the tilapia pond with a small cascading waterfall. Almost nothing could draw me from the bliss of this cup of coffee. The Costa Rican national bird, Clay-colored Thrush, is foraging in the underbrush near me and I catch a flash of yellow bathing in the pools of the waterfall. This has to be a Euphonia

or some other tropical gem that will further bolster my bird list that is growing daily by the dozens.

It is not a Central American endemic, but a bird I have banded in Alaska, a striking male Wilson's Warbler or WIWA in the American Ornithological Union banding code list. I would guess it ranks in the top 5 of the 20,000+ birds I have banded in the state. I am so struck by the connection that I even looked for a band to make sure it was not a bird I had handled before. As I myself struggle to acclimate to temps in the upper 80's in Santa Elena, I look back at my Alaskan adventures with Wilson's Warblers. On the

Alaska Peninsula I banded a few thousand WIWA's in a "mosquito rich" swamp with alder and willow shrubs on all the ridges. High temps of 60's and lows in the 40's and 50's throughout the nesting period dominated the landscape. Occasional hurricane force winds and sideways rain were common place as these fledglings fattened up for the journey to this tropical paradise.

How strikingly different is Alaska from this species' wintering grounds? Plasticity is a term often used in discussing biological systems or components of those systems. It is often thought of in terms of a species' ability to adapt to a changing environment or a change in the timing or phenology of the requirements of a species to successfully breed and replace themselves before expiring. Can a species change its migratory path or timing if the food sources needed along the route are shifted to another place or occur two weeks earlier?

Rarely do we think about plasticity in terms of an individual that makes radical shifts twice a year for its entire life. Mostly, we are talking about a species that changes from generation to generation. In this case the birds are emerging from a nest in a gray, cold, damp, windy environment. Then they successfully navigate over 5,500 miles to a lush, green, tropical climate and repeat in the opposite direction six months later. This is an incredible feat.

I was just happy to make it through customs in Los Angeles and these birds cross up to eight international borders twice a year. Another thing I noted from my view at 31,000 feet while traveling from Liberia, Costa Rica to Los Angeles, California was the frequency of fires. They were all small fires at least from my vantage point and looked as though the fires were likely

being used as land clearing techniques. This requires another level of individual flexibility. Not only do you have to make the change between Alaska and Central America twice a year, you may have to adapt from the lush tropical forest that was cleared and replaced with a homogeneous date palm or banana plantation. Option two would be to deviate from your hard wired sense of where you are "supposed" to be migrating and pick a new wintering ground that still provided the habitat you were accustomed to.

Again, this would be a demonstration of extreme individual plasticity as opposed to a new generation randomly locking in on a new spot and then being more successful at passing on their genes at the new site than ones locked in on the site that became a date palm plantation. It is astounding when you begin to stack these hurdles collectively, to imagine a scenario where any of these species are able to return to Alaska year after year and provide splashes of color across our summer landscape.

On my last day at the tilapia pond, I realized I had become very acclimated to the Costa Rican environment, culture, and climate. I found myself wondering if I had enough plasticity to migrate back to the winter environment and work that awaited us in Alaska. How do birds maintain enough plasticity to be resilient and not so much that they just don't migrate at all?

Todd Eskelin is a Wildlife Biologist at the Kenai National Wildlife Refuge. He specializes in birds and has conducted research on songbirds in many areas of the state. Find more information at <http://www.fws.gov/refuge/kenai/> or <http://www.facebook.com/kenainationalwildliferefuge>.

A willow, a fly, and a moose

by Matt Bowser



A willow rose on a Barclay willow near the Sterling Highway in Soldotna, February 28, 2018. Note in the background a stem from the same willow that was browsed by a moose; the rose gall was not eaten (credit: USFWS/Matt Bowser).

While traffic rushed incessantly up and down the Sterling Highway on a glorious June day, a male Barclay willow flourished in the full sun on the road shoulder, reaching up his leafy, tender new stems to escape the shade of the lush grass and fireweed.

Eight months later on a crystalline February morning well before the sun rose, a cow moose relentlessly hungry for calories to keep her fire burning made quick work of the willow's tasty, young stems, munching his branches back down to the snow line, then moving along to the next willow.

As snowmelt wetted the soil and the sun warmed the willow's branches in spring, he prepared to make another run toward the sky. Buds burst, pushing off their brown bud scales that had protected them over the winter. Last summer when each willow bud had formed, it had already divided into all the structures of a willow stem. Inside that tiny bud were the beginnings of a central stem and a spiral of leaves all around it, ready to expand rapidly at the beginning of the short growing season.

A tiny, hairy midge named *Rabdophaga* emerged

from her winter hiding place at just this time. Now she flitted about the willow. In her few days as a winged fly she sought the most vigorous, fastest-growing buds for her offspring, selecting this willow in the sunshine that had been browsed by a moose over the winter. Here she alighted, depositing one egg on each chosen bud before flying off to find the next willow.

Days later the eggs hatched and the miniscule larvae immediately began feeding, but somehow they had been programmed to eat in a special way. Each larva nipped only the central tissue of the bud, the part that would have elongated to become a new length of stem. This caused the stem to cease growing while allowing the leaves to develop. On this foreshortened stem the leaves overlapped one another, forming a rose-like home around the growing midge larva. Inside this rose gall the larva ate and grew.

In June a tiny wasp named *Gastrancistrus* took flight in search of *Rabdophaga* midges. Upon finding one she injected an egg through the still small and fleshy gall into the young midge larva. The egg hatched, releasing a voracious wasp larva within the developing midge. If there was more than one *Gastrancistrus* larva, they killed each other until only one remained.

A dazzlingly metallic wasp named *Torymus* appeared later in the summer, also searching restlessly for midge larvae. With her long ovipositor she pierced the now mature rose gall, laying an egg alongside the fat midge larva. From this egg came a larva that slowly consumed the midge from the outside, also eating any *Gastrancistrus* that happened to be inside the midge larva.

A midge larva overlooked by wasps grew, molting twice over the course of the summer. The vigorous bud his mother had chosen formed a large gall that afforded him more protection from wasps than a smaller gall would have. As the frosts came he spun a silken cocoon around himself.

Snow fell and days shortened while *Gastrancistrus*, *Torymus*, and *Rabdophaga* rested in their willow rose homes. A young bull moose meandered through the willow patch, chomping nearly every new willow stem but leaving the rose galls. He disliked something about those dry, papery galls.

One night a snowshoe hare nibbled willow stems left by the moose. She bit off and chewed up most of the stem, but like the moose she rejected the willow roses, letting them drop onto the snow.

After wintering as a plump larva, the midge became a pupa as he felt the warmth of spring. Soon he would exit his willow rose. He would spend his short time as a winged fly looking for a female of his species. Meanwhile, *Gastrancistrus* and *Torymus* larvae were finishing their meals of gall midges. Soon they, too, would be winged adults.

I chose here to use a narrative form, but the relationships portrayed reflect our understanding of reality. Studies have indicated that moose and hares avoid rose galls, meaning that gall midges are competing with these mammals for the same food resource. Willows do exist as separate male and female plants and both are galled by *Rabdophaga* flies.

Our local willow rose insects make one of the better study systems to share with children. They can be reared simply as follows. Clip galled willow stems late in winter. Bring them inside to dry for a day or two. Once they are dry on the outside, place the galls in resealable plastic bags. After about a month at room temperature most of the gall midges and wasps will have emerged and can be examined.

Matt Bowser serves as Entomologist at the Kenai National Wildlife Refuge. Much of what we know about local willow rose gall insects is due to the work of local naturalist Dominique Collet. Find more information at <http://www.fws.gov/refuge/kenai/> or <http://www.facebook.com/kenainationalwildliferefuge>.

TEK: another way of understanding our natural world

by John Morton



Tribal elders, educators and scientists engage in a workshop about Traditional Ecological Knowledge last week at the Alaska Maritime National Wildlife Refuge visitor center.

I had the privilege last week to participate in an interesting workshop hosted by Chugachmiut, an Alaska Native non-profit agency that serves seven villages in the Chugach region: Port Graham, Nanwalek, Qutekcak, Chenega Bay, Valdez, Tatitlek and Eyak. It was originally planned to be a meeting between tribal elders and Local Education Coordinators to discuss how best to introduce Traditional Ecological Knowledge (TEK) into school curricula. However, several local scientists, including a few from Outside who happened to be at the Kachemak Bay Science Conference

in Homer, were invited to review their work.

Particularly in a world with global warming, where data sets for ecological systems are rarely long enough to address what is real change over long-term natural variation, TEK is advocated as a body of observational knowledge that can complement scientific knowledge. Western science is typically argued to be more rigorous, but consider that TEK is learned through trial-and-error over thousands of years. And, occasionally, if you get it wrong, you end up dead. Outcomes that severe are likely to pass whatever test

for rigor you might come up with.

Sure enough, the natural resource issues brought up by elders were very much in-line with ones that a group of ecologists would likely have discussed for our local area. Tribal Chief Pat Norman from Port Graham discussed the importance of maintaining forested buffers along streams for salmon and around muskegs for moose when logging. Bill Smith, an Eyak elder, pointed out that the Valdez Glacier was once visible from the airport in Valdez, but it has now retreated too far up its terrestrial fjord to be seen. And hooligan used to run in that river but reportedly don't anymore.

Patrick Selanoff, both tribal elder and commercial fisherman, mentioned that the mesh size of his net is now 4.25 inches for sockeye salmon, rather than the 5.25 inches he used not so long ago. Whether fish are getting smaller from harvest management or changing conditions at sea remains to be seen, but those kind of observations can serve as a working hypothesis in a more conventional scientific investigation to answer the why.

This same elder also mentioned his concern about marine ballast dumping from visiting cargo and cruise ships. He told a good story about a 125-pound grouper that showed up in the waters around Valdez, far north of its normal range...and how good it tasted. Mark King, from Cordova, spoke of a sighting of a sunfish in Hinchinbrook Pass, another fish species normally in the tropics. And last February, Salmonberry was blossoming along with Devil's Club in the Cordova area, both species out of phenological sync with each other and the season.

Western science sometimes struggles with these place-based observations because it is difficult to know if these anomalies are part of a larger spatial pattern or temporal trend. One way to call attention to all of these observations is by tracking them through an Alaska-centric online database such as the Local Environmental Observer (LEO) Network (<https://www.leonetwork.org>). In 2012, the Alaska Native Tribal Health Consortium launched the LEO Network to help the tribal health system and local observers share information about climate and other drivers of environmental change. In 2015, the LEO Network was recognized by the U.S. Chairmanship of the Arctic Council as a model program to help raise awareness and improve communication about climate change in the circumpolar region. Consider joining this network—data can be submitted via your smart phone through the LEO Reporter mobile app.

These are indeed strange times. We need to be receptive to other ways of knowing, such as TEK, particularly as communities and society at large adapt by necessity to a rapidly changing climate. Asked what message needs to be passed to the younger generation, Chief Norman suggested that we “use traditional values in our responsibilities toward the environment” rather than money as the primary metric. What a great lesson to learn and share!

Dr. John Morton is the supervisory biologist at Kenai National Wildlife Refuge. Find more information about the Refuge at <http://www.fws.gov/refuge/kenai/> or <http://www.facebook.com/kenainationalwildliferefuge>.

When the Kenai and Kasilof Rivers flowed backward

by Ted Bailey



Looking south over the outwash delta at the head of Tustumena Lake showing where water and sand erupted from the ground and fractured the ice 54 years ago. Photograph taken shortly after the March 27, 1964 earthquake by Ave Thayer, Kenai National Moose Range.

It must have been an alarming sight to see these two Kenai Peninsula rivers temporarily flow backward into the outlets of Kenai and Tustumena Lakes. But it also had been a most disturbing day.

That evening (5:36 PM) on Good Friday, March 27, 1964 the great Alaskan Earthquake struck southcentral Alaska. It was the strongest earthquake (9.2 on the Movement Magnitude Scale) measured in North America and the second strongest in the world, surpassed only by the 9.5 Valdivia earthquake off the coast of Chile on May 22, 1960.

For comparison, the destructive earthquakes off the east coast of Japan (2011) and west coast of Suma-

tra (2004) were both 9.1 earthquakes. The Great Alaskan Earthquake lasted four minutes and thirty-eight seconds compared to the recent January 23, 2018 earthquake off the coast of Kodiak, which seemed to last a long time, but lasted only about a minute and was registered at 7.9. The 1964 earthquake was a destructive subduction zone quake where two tectonic plates converge. The 2018 Kodiak earthquake was a strike-slip quake, which is less destructive, caused by horizontal motion across a fault.

Of the many destructive effects of the Great 1964 Alaskan Earthquake, the temporary reversals of flow of the Kenai River out of Kenai Lake and the Kasilof

River out of Tustumena Lake were relatively benign from a human damage perspective. Reports later published by the U.S. Geological Survey attributed the temporarily change in the direction of flow to the tilting of the basins of Kenai and Tustumena Lakes, both of which were frozen at the time. The tilting of the lake basins, about three feet at Kenai Lake and a foot or less at Tustumena Lake, caused the water in the lakes to slosh back and forth (seiching), temporarily reversing the flow of the rivers at the mouths of both lakes.

According to the above reports, several witnesses saw the Kenai River reverse and flow back into the outlet of Kenai Lake. One witness, John Ingram of Cooper Landing, could see logs on the bottom of Kenai Lake and the Kenai River rapidly rushing back into Kenai Lake. The lake level was later estimated to have temporarily dropped 15 feet. Damage to trees along the shoreline from the sloshing water extended to about 30 feet above the lake level.

Flow in the Kasilof River was so low after the earthquake that it almost ran dry. The late Joe Secora, then living at the upper end of Tustumena Lake, reported that the lake level rose and fell for about two hours after the earthquake as the water sloshed back and forth in the basin. The day following the earthquake, a biologist from the Alaska Department of Fish and Game reported he was able to walk in its channel wearing only overshoes.

A photograph of upper Tustumena Lake taken a couple of days later by Ave Thayer, Assistant Refuge Manager and pilot of the then Kenai National Moose Range, shows where water and sand erupted out of fis-

tures in the outwash delta at the head of the lake. Later in June the late Joe Magargl from Kasilof reported the level of Tustumena Lake was well below normal seasonal levels. By late autumn 1964, it was estimated to be five feet below normal level.

One effect of the earthquake on the Refuge's fish and wildlife occurred when the sloshing of water and ice back and forth in frozen lowland lakes destroyed beaver lodges and bank dens or left them exposed above the water line. Water levels in the Finger Lakes area dropped about five feet. Such abrupt changes undoubtedly affected resident fish populations. Faults and fissures occurred in the ground throughout the Refuge. One such fissure can still be seen 54 years later on the trail to Silver Lake near the trailhead.

A later (1993) radiocarbon study, which dated layers of buried organic material in the Kenai and Kasilof River Flats, Chickaloon Bay and other similar sites in the Cook Inlet region, suggested that in the past 5,000 years there have been six to nine major subsistence events associated with major, probably great, earthquakes. This gives an average reoccurrence interval of roughly 600 to 800 years between major earthquakes, but this is only an average. Who knows for certain when the next big earthquake may happen?

Dr. Ted Bailey, supervisory wildlife biologist at Kenai National Wildlife Refuge before retiring in 2001, has lived on the Kenai Peninsula for over 40 years. Find more information about Kenai Refuge at <http://kenai.fws.gov> or <http://www.facebook.com/kenainationalwildliferefuge>.

A partnership approach to protecting fish habitats

by Kyle Graham



The Kenai Peninsula Fish Habitat Partnership works to protect spawning and rearing habitats for salmon and other fish species across jurisdictional boundaries.

What is being done collaboratively to ensure the Kenai Peninsula's aquatic habitat remains healthy for fish? The Kenai Peninsula hosts a number of non-profit organizations, borough, state and federal agencies all tasked at some level with ensuring the Peninsula's aquatic habitat remains healthy and intact. Imagine if there was a way for organizations to come together and leverage individual talents, share knowledge and develop a mutual vision and purpose. Fortunately, the Kenai Peninsula is host to one of the twenty National Fish Habitat Partnerships, an innovative and

collaborative model for conservation supported by the U.S. Fish and Wildlife Service.

First, a little history. Roughly 17 years ago, a group of people gathered to discuss the concept of developing a partnership for fish habitat similar to what exists for waterfowl and their habitats through the North American Waterfowl Management Plan. The vision was simple—locally driven partnerships scattered across the U.S galvanized into action by the threat of aquatic habitat losses, a coalition of anglers, conservation groups, scientists, state and federal agencies,

tribes, and industry leaders, all on the same page.

In a short time this concept gained traction as fisheries professionals and other stakeholders recognized the need for a unified effort to conserve aquatic habitats. The National Fish Habitat Action Plan was drafted, funding arrived and the implementation phase began. The strategy includes a network of Fish Habitat Partnerships, selected based on important aquatic habitats, distinct geographies, fish species, or system type such as a lake or estuary. In 2008, the Kenai Peninsula was chosen as a candidate Fish Habitat Partnership and ultimately approved full partnership recognition under the early leadership of Robert Ruffner.

Since 2011, the Kenai Peninsula Fish Habitat Partnership (KPFHP) represents a partnership driven approach that includes a non-regulatory, science-based strategy developed by a locally-led steering committee and supported by broad-based membership. The strategy includes a systematic approach of focusing on what is important to conserve along with potential threats that could negatively affect fish habitats.

Each fall, the KPFHP solicits proposals for projects that address both a target ecosystem as well as potential threats to either the freshwater or marine environment that are characterized in a Conservation Action Plan. In freshwater systems, the most significant threats are aquatic invasive species, warming climate, and residential development in riparian areas. Highest rated potential threats to the marine environment include incompatible shoreline development, beach alteration, and large scale oil spills. The types of projects funded by the KPFHP include the Kenai Watershed Forum's Streamwatch program, Cook Inlet Keeper's stream temperature monitoring, as well as the Alaska Department of Fish and Game's use of environmental DNA as a way to detect invasive northern pike.

Other KPFHP activities include hosting a biennial Science Symposium where the public is invited to learn, share and exchange ideas about fish habitat science and conservation. Partner organizations share their work through presentations covering a wide range of topics pertinent to fish habitat on the Kenai Peninsula.

Nationally, the National Fish Habitat Partnership

annually publishes "Waters to Watch," a collection of rivers, streams, estuaries, lakes and watershed systems that need a collective effort to restore, enhance, or protect. These waters represent the best of the best, voluntary habitat conservation efforts in progress, where local Fish Habitat Partnerships are supporting on-the-ground work. Numerous waters throughout Alaska have been highlighted and the work of a partnership effort is showcased on a national stage. Most recently, the Anchor River was highlighted as an example of a waterway where the trifecta of research, restoration, and protection has resulted in a system more resilient to a warming climate and increased development.

Other larger efforts include nationwide assessments of human driven impacts on fish habitat throughout the United States. Twenty-two percent of inland stream miles in the Lower 48 states are at high or very high risk of habitat degradation; predictably, watersheds in or near urban areas or areas with intensive agriculture are most at risk.

Fortunately, the assessment found the risk of stream habitat alteration in Alaska is generally low, mostly as a result of land ownership that limits development. However, developing areas (such as the Kenai Peninsula) are showing signs of habitat alteration, especially when rivers flow from protected areas to areas where riparian areas are less protected, habitat stress can increase due to development. Protection of existing intact habitat was identified as key strategy in Alaska to make the best use of limited people and money resources as it is far less expensive to protect habitat than rehabilitate once damaged.

In 2018, the KPFHP will kick off the year with a full membership meeting that will include 33 organizations from across the Kenai Peninsula, gathering to discuss current topics regarding fish habitats. Organizations or individuals interested in the KPFHP should contact Coordinator Jack Sinclair at jack@kenaiwatershed.org or 907-260-5449.

Kyle Graham is a Fish & Wildlife Biologist at the Kenai Fish & Wildlife Conservation Office. Find more information about Kenai National Wildlife Refuge at <http://www.fws.gov/refuge/kenai/> or <http://www.facebook.com/kenainationalwildliferefuge>.

Goodbye snow

by Dawn Robin Magness



One of the aerial markers used to monitor snow depth on the Kenai National Wildlife Refuge.

The longer days and sun warming my office have me thinking somewhat disappointingly about trading out my skis for my bike. I am one of the many people on the Kenai Peninsula who loves snow. When the snow is good, we can ski, snowshoe, snowmachine, and mush dogs on the Kenai National Wildlife Refuge. Each year's snowfall pattern is different, so refuge staff monitor snow depths from December to April.

Federally-coordinated snow monitoring began in the 1930s because Congress needed information about mountain snowpack to forecast water supply for the western U.S. The SNOTEL (SNOWpack TELEmetry) program was born and federal workers began to standardize and validate data collection. The first surveys, called Snow Courses, require a person to visit each site to measure snow depth and weigh the snow to estimate how much water is being held. Aerial

markers were also used as a quicker method to gauge snow depth from a plane (see photo). The Natural Resources Conservation Service (NRCS), an agency within the U.S. Department of Agriculture, currently coordinates the SNOTEL program (<https://www.wcc.nrcs.usda.gov/snow/>). Manual surveys are conducted during a 5-day window at the beginning of each month because snow levels can change quickly. Storms can dump snow over a couple days or a warm spell can cause significant melt.

In the 1980s, automated SNOTEL stations were added to the network. These stations have sensors to collect more information such as precipitation, soil temperature, and soil moisture. Measurements, taken several times a day, are remotely-transmitted to a central database. NRCS staff crunch the data into products and reports to help us understand snowpack and water availability.

Currently there are 15 SNOTEL stations in Alaska that collect snow and soil information including five on the Kenai Peninsula. One is located in the Kenai Moose Research Center at the end of Swan Lake Road. This April, the amount of water available as snow is 74 percent of normal levels, while precipitation accumulation is 111 percent of normal. In other words, this SNOTEL station had more water available as rain than snow this winter when compared to the last 30 years.

The Kenai Refuge is almost two million acres, of which a large portion is accessible only by aircraft, so we use aerial markers to measure how much snow is on the ground. Our refuge pilot recently flew over 17 markers and recorded how many panels were covered with snow. Caribou Hills had nearly 5 feet of snow in December and currently has over 6 feet. In contrast, the Kenai Lowlands had patchy snow in December, but had a foot of snow by February.

Another 25 locations are monitored by other agencies for snow depth elsewhere on the Kenai Peninsula. Collectively, these 42 sites are among the more than 200 locations in Alaska where snow depth information is collected as part of the NRCS program.

Snow insulates the ground during the very cold months. Subnivean habitats, which occur under the snow, remain around 32 degrees even when out-

side temperatures become bitterly cold. Small mammals find shelter and food here, which increases their chances of surviving the winter. Snow insulation is also important for plants. Freeze events when snow is not present can damage plant tissue and this can stunt growth over the next year. For example, a study in Scandinavia linked a loss of snow followed by freezing temperatures to a loss of nearly 90% of summer growth for a crowberry species. The plant damage was so extensive it was visible in satellite imagery.

The impetus for the SNOTEL program was to understand water availability. When and how much water is available is also important to ecosystems here on the Kenai. Snow acts as a storage bank for water.

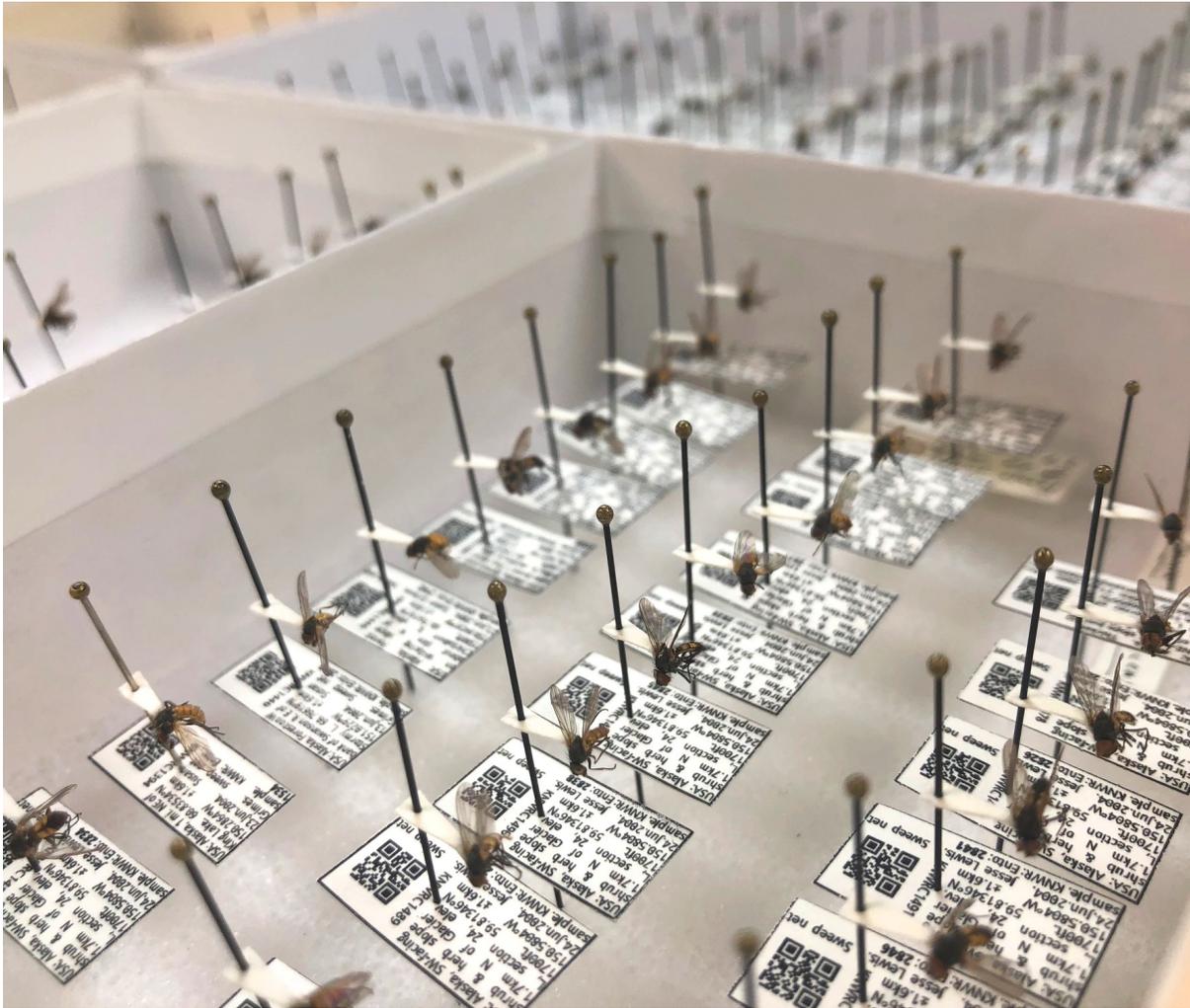
Snow melt releases water slowly and can be a reliable source for plants and animals throughout the spring into the summer. For example, snowpack is a major source of water for both glacial and non-glacial salmon rivers. However, when winter precipitation occurs as rain, most of the water flows over frozen earth and ends up in the ocean.

We might not all love snow, but I think we probably all can find something we love that relies on snow.

Dr. Magness is a landscape ecologist at Kenai National Wildlife Refuge. Find more information at <http://kenai.fws.gov> or <http://www.facebook.com/kenainationalwildliferefuge>.

Making Kenai Refuge data discoverable through Arctos

by Kyra Clark



Pinned, labeled and barcoded Fannia subpellucens from the insect collection at Kenai National Wildlife Refuge. Find the online record in Arctos by simply typing “KNWR:Ento:2838” in the “Any Identifier” search bar and press enter!

In December I started a project I had hoped would be over rather quickly. But to my surprise, I’m still enjoying it. After three months of inputting specimen data from our herbarium and insect collection into the online database [Arctos](#), I find that I really appreciate what I thought was going to be a tedious task.

Here at Kenai National Wildlife Refuge, we have thousands of plant and insect specimens in our collection, some dating back to 1949. For years, these sat in our lab, occasionally pulled out of cabinets by bi-

ologists seeking to identify a new sample or to see if a species had been found here previously. Otherwise, these specimens weren’t used all that often.

Our pressed or pinned specimens are housed in the “specimen room”, which contains several cabinets, numerous drawers and countless folders. Although organized taxonomically, it takes effort to locate a specific specimen, not knowing if we actually have a given species without searching through the collection. To be honest, the effort to search for a specimen that may

or may not be there was not always worth it. Beyond that, our collections were only accessible to those who were physically present at the Refuge.

So how does inputting these specimens into Arctos make our collection more useful? Well, most of us understand that it's good to have an online record of important documents or samples, but this project is so much more than just inventorying and archiving data.

Arctos requires a lot of additional information beyond simply identification including names of the collectors and ID determiner, date of collection and determination, habitat, specific location and GPS coordinates, and a unique barcode label. Before each specimen is entered, I add that unique barcode label to the herbarium sheet or insect label which is then used to "track" the specimen. Each element of our specimen room (building, room, cabinet, drawer or folder) also has its own barcode so that once entered into Arctos, we can scan a specimen into its correct location. Now, when we search for a specimen, we know exactly where it is located and find it easily!

Currently, the Kenai Refuge has over 10,300 plant, insect, and other invertebrate records in Arctos and we are still inputting more. Our Arctos records are now discoverable to anyone! Although an interested party can't physically get their hands on them (unless we arrange a loan), our specimens have tangible value since all of the data associated with each record is accessible and useable anywhere, anytime!

These records are used to determine species distributions, historical ranges, and countless other things. They can be cited in publications and referenced for research. One of the coolest features of Arctos is that it is linked to third party databases such as [The Global Biodiversity Information Facility](#) or GBIF. Through GBIF, Kenai Refuge data are now accessible internationally!

Arctos isn't the only database we use to track species on the Refuge. While out in the field, we

can log observations without taking an actual sample through [iNaturalist](#). This database has its own app that lets you simply enter a photo of the specimen while it automatically records the time, date, and GPS coordinates! You can enter an identification or, if you're uncertain what it is, leave it blank—other users then correct the identification based on your photos and their knowledge of the area. An observation will change from the designation "Needs ID" to "Research Grade" when more than two thirds of identifiers agree on a taxon. As one my favorite tools, I've used it both personally and professionally whenever I come across a new organism.

Another database we use is the [Alaska Exotic Plants Information Clearinghouse](#) or AKEPIC. Every year we log all of the invasive species we observed on and off the Refuge with dates, GPS coordinates, and any management actions taken. AKEPIC tracks the whereabouts of all invasive species observed in Alaska, including a plant profile and its invasiveness ranking. This information is used by numerous agencies and universities.

It is one thing for the Kenai Refuge to have a bunch of data on its own, but it is so much more valuable to have our data be discoverable and used by others. That is what we are striving to do here at the Refuge—after all, we are a public agency. We continuously acquire new data and work to make it all accessible as soon as possible.

If you are curious and want to explore our specimen records, go to the websites of Arctos, iNaturalist, and AKEPIC to easily find more data than you might imagine.

Kyra Clark is a seasonal biological technician at Kenai National Wildlife Refuge. Find more information about the Refuge at <http://www.fws.gov/refuge/kenai/> or <http://www.facebook.com/kenainationalwildliferefuge>.

Getting ready for Spring Fever

by Steve Miller



Even though the Swanson River has a slow current, canoeists smartly wear life jackets.

It doesn't take too many warm sunny days, coupled with almost three additional hours of daylight gained over the last month, for Spring Fever to arrive. You go into stores and they have gardening materials out and, just to heighten your desire to get more stuff and do something with it, this year's Kenai Peninsula Sport, Rec & Trade Show is coming up in a week. In preparation for the busy season that is fast approaching, here are some tips for preparing you and your gear for outdoor activities.

First, get mentally prepared. When staff at Kenai National Wildlife Refuge are getting ready to take on a

task, we pause to take time for a "tailgate safety meeting". These meetings are intended to ensure we have thought of the important details to safely complete the mission. All participants engage in describing the objective and talking through the details of our planned day. During our discussion, we identify potential obstacles or unsafe activities that may occur.

The next step is to be sure we have the proper state of mind and the gear appropriate for all the possible conditions we might encounter. Often we come up with scenarios we may be unprepared for, so we add the proper gear and define safe practices to help us

handle what would have been unexpected had we not had the tailgate meeting.

One consideration for first-of-the-season trips, especially for those who did not spend all winter out on Tsalteshi Trails or Headquarters Lake skiing and staying in shape (such as myself), is to take it easy! Plan to make that first hike after a long winter a short one that is not too steep. Skyline Trail and Fuller Lakes Trail still have quite a bit of snow, so why not start with Hidden Creek Trail or drive out Swanson River Road and take Drake/Skookum Trail as a start for this year's outdoor adventures? If you do decide to go up high on a hike somewhere on the Peninsula, just be prepared for post-holing through some deep snow spots...and, remember, avalanches are still a danger!

For those who are just now pulling the boat out to prepare for your upcoming fishing, rowing or paddling season, make sure you take the time to go over trailer brakes, lights, hitches and tie-downs. Check your trailer tires and wheel bearings as well, since you don't want to be that person we have all seen sitting by the roadside in the wee hours of the morning with a flat or missing tire, and losing out on that perfect early-morning uncrowded fishing spot. Is your vehicle and boat registration up-to-date? Also, take the time now to replace that fishing line still on your reel from last year so that you don't have to do it out on the river.

On those upcoming days on the water or out hiking, please make sure you take the time to go over safety for the day with your family members, friends or visitors who may be with you. Check the weather forecast but be prepared for unexpected precipitation. Let your guests know those spots where they can usually get a cell phone signal in the area just in case they get stranded or there's some other emergency. Review

with your guests and family what to do if you spot a bear or a moose while hiking—carry bear spray and know how to use it. Remember to wear a personal flotation device while out on the water.

It's also time to start preparing yourself for—you guessed it—crowds. We've spent all winter driving in town and not having a problem turning left onto the Sterling and Kenai Spur Highways. That is about to change. Keep in mind that those businesses that stay open all year for us now depend on these few busy summer months to keep going for another year and make a living. Also, that slow rented motorhome, the one you've been following for what seems like 20 miles on the Sterling Highway and unable to pass, may be carrying a family that has saved up for a once-in-a-lifetime trip to visit the place that we all get to call home. So, take a deep breath and be thankful that we live year-round in a place that some folks will visit once or twice for a week or two at most.

With all of those folks out driving, always wear a seatbelt to guard against the distracted driver who is more focused on the view than the road. Watch out for those visitors who land in Anchorage on a red-eye flight and insist on driving down half-asleep so they won't miss a day of fishing. And wait to have that conversation or text on your cell phone once you reach your destination, or perhaps pull over at a scenic lookout!

Get out and enjoy the long days and great views on the Kenai Peninsula and wherever else you may be going this summer. Most of all...be safe out there.

Steve Miller is the Deputy Manager at Kenai National Wildlife Refuge. Find more information about the Refuge at <http://kenai.fws.gov> or <http://www.facebook.com/kenainationalwildliferefuge>.

Ent-draughts and birch sap

by John Morton



Birches offer up free brew this time of year on the Kenai Peninsula.

In *Lord of the Rings*, the two hobbits, Merry Brandybuck and Pippin Took, grow taller as their hair curls after downing a few Ent-draughts between chasing and being chased by orcs. This drink is provided by the Ents, the tree-like shepherds of their arboreal kindred in Middle Earth.

As fictitious as this story may be, Ent-draught sounds very reminiscent of birch sap. I've been drinking sap from the birch trees in my yard this past week as I have every April for the past decade. I tapped maple trees as a boy in Wisconsin to make syrup, so extracting birch sap is an easy enough task.

Where I've failed miserably is in my one and only attempt several years ago to boil down the sap to make birch syrup. I knew that it takes 100 gallons of birch sap to make 1 gallon of syrup, a ratio 2 1/2 times greater than that required to make maple syrup.

So the bad news is I turned the heat up on my stove to speed things up a bit, only to burn the sap. I found out later this was due to the high fructose content in birch sap (as opposed to sucrose in maple sap), which requires a lower evaporation temperature to prevent the scorched smell. Some commercial producers in Alaska even use reverse osmosis to distill birch syrup rather than heat.

The good news is I discovered birch sap, a traditional health elixir that was apparently well known to native Americans, Russians, Scandinavians, Chinese, and Japanese living wherever birch grows around the globe. The fact that I was a bit late in rediscovering this medicinal tonic and delightful drink doesn't detract from its history of being used to treat hypertension, urinary and gastroenteric disorders, gout, arthritis and scurvy!

The sap "rises" in the spring as the birch tree prepares itself for leaf-out, typically a period from mid-April to early May on the Kenai Peninsula. It flows through the system of vascular "pipes" that we call the xylem (if a biologist) or sapwood (if everybody else). Not surprisingly, birch sap is mostly water and minerals carried from the roots to the embryonic leaves hiding in the buds.

More specifically, birch sap is about 98% water, 1–2% sugars (fructose, glucose and sucrose), and some maltic, citric, fumaric and succinic acids. One website reported that one liter of sap contains 410 mg of calcium, 350 mg of potassium, 78 mg of magnesium, 27 mg of manganese and 50 mg of phosphorus. Thiamin (vitamin B1), riboflavin (vitamin B2), vitamin C, iron and copper can also be found in the sap.

An unusual sugar found in birch sap is xylitol, used as a low-calorie sweetener in chewing gum. Xylitol actually inhibits tooth decay by suppressing *Streptococcus* bacteria and so has been used in toothpastes. And xylitol is absorbed more slowly than table sugar so it has been used by diabetics because it doesn't contribute to high blood sugar. It isn't surprising that one article I read on birch sap calls paper or white birch the "white gold of the boreal forest".

With such rich blood coursing through the vascular system of a birch in spring, you would think

that wildlife would have figured this out as well. Perhaps because birch sap rises for such a brief period in Alaska, only three weeks in our area and as short as 10 days in the interior, wildlife don't seem to have cued in on it.

A known exception are sapsuckers, a group of woodpeckers that includes two species in Alaska. Yellow-bellied sapsuckers have been recorded only a few times in Alaska, mostly in the interior but twice in Seward. Red-breasted sapsuckers breed in south-east Alaska but have been found more frequently on the Kenai Peninsula in recent years. Sapsuckers drill small, square holes in rows around a tree trunk, which then act as miniature wells that fill with sap. They use their long tongues with their special brush-like tips to lap up the sap, and then eat insects attracted to the sap.



American three-toed woodpeckers on the Kenai Peninsula drill horizontal rows of “sap wells” into birch trees from which they feed on sap.

Here on the Kenai Peninsula, Ted Bailey, retired biologist from Kenai National Wildlife Refuge, published a [short note](#) in *Western Birds* in 2008 that described his observation of American three-toed woodpeckers feeding at horizontal rows of sap wells in Kenai Birch. He suggested that sap feeding on birches by three-toed woodpeckers may be more widespread than previously realized.

One of the most common insects to feed on birch sap are aphids. Large infestations of these small, pear-shaped bugs can drink so much sap from birch leaves that the branches may start to die back. A more lethal insect, the bronze birch borer, can interrupt sap flow by burrowing into the inner bark of the birch, essentially girdling the tree. This beetle currently exists only in small numbers in Alaska, but the [Arctic Climate Impact Assessment](#) forecasts it may become more prevalent as boreal Alaska warms. So even as sapsuckers extend their range northward into birch forests in response to a warming climate, so will some insects harmful to birch.

In the meantime, while it may not be Ent-draught, I encourage you to enjoy this spring-time treat that's healthy, free, and running NOW! Contact the University of Alaska Cooperative Extension Service or Alaska Birch Syrup Makers Association about how best to tap birch trees or to make birch syrup.

Dr. John Morton is the supervisory biologist at Kenai National Wildlife Refuge. A [version of this article](#) was published by the Clarion in May 2011. Find more information about the Refuge at <http://www.fws.gov/refuge/kenai/> or <http://www.facebook.com/kenainationalwildliferefuge>.

Good birding etiquette isn't for the birds

by John Morton



A buff-breasted sandpiper stops to feed near Anchor Point during migration (T. Eskelin).

Spring is a rough time for migratory birds, particularly for arctic nesting shorebirds and waterfowl. They're busy making their way ever north to get to their breeding grounds. In our local area, hot spots to see birds are the Kenai River Flats, particularly waterfowl, and the Kasilof River Flats, where shorebirds tend to congregate.

Some pass through very early, like black brant, which often arrive on their breeding grounds when snow is still on the ground. Other geese and some ducks, such as mallards and northern pintails, also wing north in early spring, chasing the retreating

snow line. Gadwalls and lesser scaup are among some of the last ducks to fly through.

Many shorebirds pass through early as beaches and estuaries are scraped free of snow and ice by tidal action. Many of the nondescript “peeps”—western, least and semipalmated sandpipers—stage along the way to ensure they don't arrive too early or too late on the breeding grounds. Arrive too early, and that first nesting attempt might be wasted in a late winter storm. Arrive too late, and the best nest sites are already occupied and the opportunity is lost to raise their broods before ephemeral wetlands go dry later

in the summer.

Whatever their migration chronology, most waterfowl and shorebirds need to feed along the way. Females, in particular, need to put on the body reserves that will allow them to produce eggs and to incubate for long periods. It's often relatively easy to get close to birds during their spring feeding frenzies as they are more focused on eating than on you trying to do a little birding.

We love birds and we like to watch them, perhaps from Bridge Access Road or perhaps while walking our dogs along Cook Inlet beaches. And there's the rub of it. Poor birding etiquette and other human behaviors can really stress birds, far more than you might expect.

As anybody who has ever dieted knows, your body weight is a function of energy expenditure (exercise) versus energy intake (food). Birds are no different. During spring migration, birds try to minimize their expenditure while maximizing their food intake so they can put on body fat, even while trying to maintain their muscle mass after long flights from the Lower 48 or perhaps Tierra del Fuego.

Anytime we disturb birds, accidentally or otherwise, we are negatively impacting that energy balance. Consider that a duck expends 10–12 times more energy in flight than it does at rest. In contrast, a walking or swimming duck expends only 1.4–1.8 times more energy than when at rest. So when we do disturb birds and make them flush, not only do they stop feeding, it also increases their energy expenditure several fold. Multiply this event by all the humans and dogs and ATVs that birds encounter during their long flight north, and you begin to understand the problem. This is a recipe for weight loss, not weight gain.

In the early 1990s, I studied the effects of recreational disturbance on sanderlings wintering at Asateague Island National Seashore off the coast of Maryland. Sanderlings disturbed by beach goers or dogs or off-road vehicles spent 177% more time preening and stretching (agitated), 151% more time in flight, and 42% less time roosting than undisturbed sanderlings. These behavioral changes upped their energy expenditure by 50%, something you'd think sanderlings would try to avoid. Sure enough, population densities were 60% less on disturbed than undisturbed beach segments. These are not trivial impacts.

Here's some tips if you want to make life a little easier on our feathered friends, especially if you're a birder:

- Vehicles are usually less disturbing than people on foot, so view from your car with a window-mounted scope if the birds are nearby.
- Stop trying to take pictures with your smart phone. Invest in a decent camera with a long lens so you don't have to approach too closely to get a good photograph.
- Like airplanes, birds like to launch into the wind. You'll get a lot closer to birds without making them flush if you approach from downwind so their escape route isn't cut off.
- Similarly, don't ride a fat tire bike or ATV between feeding birds and water, as that makes them skittish and likely to flush.
- Birds see color so wear neutral colors like browns and greens, and even camouflage, something all duck hunters know.
- Bring your dog to heel or leash it when you see a flock of peeps on the beach. Better yet, leave your dog at home.

Good birding etiquette isn't something that's just nice to do. It's also smart to do if you make your living off wildlife viewing. Todd Eskelin, a Kenai Refuge biologist, was in Costa Rica recently. When something cool like a bananaquit or spiny green lizard was spotted along the trail during guided wildlife trips, his group chose to back away and use their scopes and binoculars to view the animal. It made life easier for the animal and allowed others following to have the same viewing opportunity.

We have two big birding festivals coming up on the Kenai Peninsula. The Kachemak Bay Shorebird Festival is May 10–13, and the Kenai Peninsula Birding Festival is May 17–20. Enjoy the birds, but give them the respect they deserve after their long flights.

Dr. John Morton is the supervisory biologist at Kenai National Wildlife Refuge. Find more information about the Refuge at <http://www.fws.gov/refuge/kenai/> or <http://www.facebook.com/kenainationalwildliferefuge>.

Underestimate ravens nevermore

by Todd Eskelin



A Common Raven watches from a safe perch and seems to be apprising friends of what I am doing.

I recently had an opportunity to make a quick dash up the Alcan. It has been 25 years since I last drove it and I am always up for an adventure. The trip was exactly as I remembered it—long hours driving, road in “great shape”, Stone Sheep and Wood Bison on the roadways, and scenic views like nowhere else.

It was all the same until we got to a random, snow-covered roadside stop in the middle of the Yukon Territory. We stopped to dig out some snacks when about 100 yards ahead a large bird erupted from the ditch and began flying alongside the road toward us. Immediately following behind was a large Common Raven.

At first the escaping bird looked like a grouse, but as it got closer I saw it was an adult male American Widgeon. I was expecting to see the duck zoom away from the raven but, just as the pair winged closer to our vehicle, the raven closed the gap and grabbed ahold of the duck’s wing with its beak.

This was stunning as I have never seen a raven go after a bird this size. They tumbled and hit the ground, with the raven standing on the duck’s back and the duck squirming to get away. The rest of this story may be graphic, but this is truly what transpired and probably the only time in my life that I will ever see such

an event. The raven began pecking at the back of the duck's neck with powerful thrusts. Then it would stop, and pick and twist some skin and feathers off, before resuming the piercing jabs. The duck was beginning to look a little worse for wear but certainly not dead.

The raven dismounted and grabbed the duck in the middle of the neck and began thrashing it back and forth with incredible strength and violence. After flopping the body back and forth 4 or 5 times, it managed to rip the duck's head off.

That was it for the duck, but the raven had another crafty plan. It walked over into the woods about 30 feet away and stashed the head. It covered it with leaves, moss and snow and then walked back to the remaining carcass. It picked at the open end of the carcass for a few minutes and then flew up to an adjacent tree.

At this point we had to hit the road again, and I am left to guess at what was going through the raven's mind. In that desolate country where there is such a thin line between life and death, it appeared the raven had previously experienced losing a good portion of its prized catch to other scavengers. In anticipation, it decided to hide the most important part—the brain. I have read that some societies consider brains somewhat of a delicacy, but never thought I would see this behavior from non-human life forms.

So when did Raven the Trickster become Raven the Killer? I have read about ravens as nest predators and scavengers, but have never seen accounts of ravens being able to take down a healthy adult duck capable of sustained flight. In searching for answers to these questions, I find that I may have underestimated the intelligence of the raven. They are considered one of the smartest animals we know, right up there with Chimpanzees and dolphins. Ravens in captivity have been able to talk better than some parrots.

There is something very creepy about hearing a raven say "Nevermore".

In one account, the author described how a raven had hid food in a very obvious way. It turned out the raven was being watched by another raven, so it hid food where it could be seen by the other raven, and then stashed better food in another place while the would-be thief was distracted by the initial, obvious hiding spot. They have also been known to play dead by a beaver carcass in hopes of scaring off other ravens from a delicious find.

Beyond the typical intelligence tests involving tools and complex problems, recent research has found that ravens are capable of planning ahead. Captive birds will select tools they need to solve problems for a large reward in the future rather than select a smaller reward at the time. They even choose delayed gratification and will pass on smaller less-tasty kibble, instead picking a token that can be traded later for a better treat. Hearing them speak human words and plan for a future reward is mind-blowing.

So while I completely underestimated ravens, that encounter at a rest stop in the Yukon has significantly changed my expectations of ravens. Forget my excitement of a raven taking a duck out of mid-air, the bar is set much higher now. I fully expect to see a raven sitting out at my duck blind mimicking duck calls, and either killing the duck itself or waiting for me to do it, knowing its reward will come when I dress the bird out later.

Todd Eskelin is a Wildlife Biologist at Kenai National Wildlife Refuge. He specializes in birds and has conducted research on songbirds in many areas of the state. Find more information at <http://www.fws.gov/refuge/kenai/> or <http://www.facebook.com/kenainationalwildliferefuge>.

Why I like Devil's club

by Matt Bowser



A Devil's club bud ready for harvest, May 14, 2018 (credit: USFWS/Matt Bowser).

If your only interactions with Devil's club have involved needle-sharp prickles poking into your legs, arms, or hands, then I can understand your disdain for this plant. I enjoy getting poked no more than anyone else, but I truly do like Devil's club. As a black bear endures stinging yellow jackets to get at a nest full of protein-rich larvae, I put up with those Devil's club prickles because it is worth the trouble. I think of it like a pineapple: prickly on the outside but good on the inside.

Devil's club has long been regarded as a useful medicinal plant by the Outer Inlet Dena'ina, who

know it as *heshkeghka'a* (literally "big, big prickle"). The Dena'ina prepared a tea from the inner bark of the roots to treat infections, fever, tuberculosis, coughs, and colds. A topical treatment from the root bark was used for boils, sores, and topical infections. Beyond the Kenai Peninsula, Devil's club was likely the most important medicinal and spiritual plant to most indigenous peoples in the Pacific Northwest wherever the plant occurs. A 2004 [article](#) in the journal *Herbal-Gram* listed 34 broad categories of medicinal uses by 38 linguistic groups of indigenous peoples in the Northwest.

In recent years, Devil's club root and extracts from Devil's club have been increasingly marketed in the herbal and dietary supplement industry as "Alaskan ginseng" or "Pacific ginseng," suggesting similarities to ginseng, to which Devil's club is closely related. However, the chemical makeup of Devil's club differs from that of ginseng, so it cannot be assumed that the two plants have similar medicinal uses. At this point the pharmacology of Devil's club has not been thoroughly investigated, but there is evidence that some components of extracts from Devil's club have antimicrobial and anticancer properties.

I do not take Devil's club medicinally, but I do harvest the buds every spring to eat in soups, stir-frying, and pesto. They have an excellent, unique, strongly aromatic flavor. I think they are best used like cutting celery tops: a little too strong to eat much by itself but wonderful as a flavorful component of a meal.

The spring buds are typically ready for harvest as they are just starting to expand in the middle of May. The key is to catch them after they have expanded beyond the surrounding bracts and before the prickles begin to harden, typically a one- to two-week window just after the fern fiddleheads have begun to unfurl. As for harvesting pineapples, you should wear sturdy pants, a long-sleeved shirt, good boots, leather gloves, and eye protection. The buds can simply be pinched off by gloved hands and placed into a basket.

At home, the buds should be separated from any hardened prickles, bits of branches, and other debris. I usually (but not always) remove the purplish, slightly papery bracts on the outside of each bud. The cleaned buds can be used fresh in stir-frying or pesto or served blanched with butter as a side dish.

To preserve Devil's club buds I either dehydrate

them or blanch and freeze them. Dehydrated buds are easiest to store and work especially well for soups. For freezer storage, the buds must first be blanched for two minutes or so by steaming or placing them in boiling water; otherwise they will turn brown when frozen. I think they would be great pickled like artichoke hearts, but I have not tried this yet.

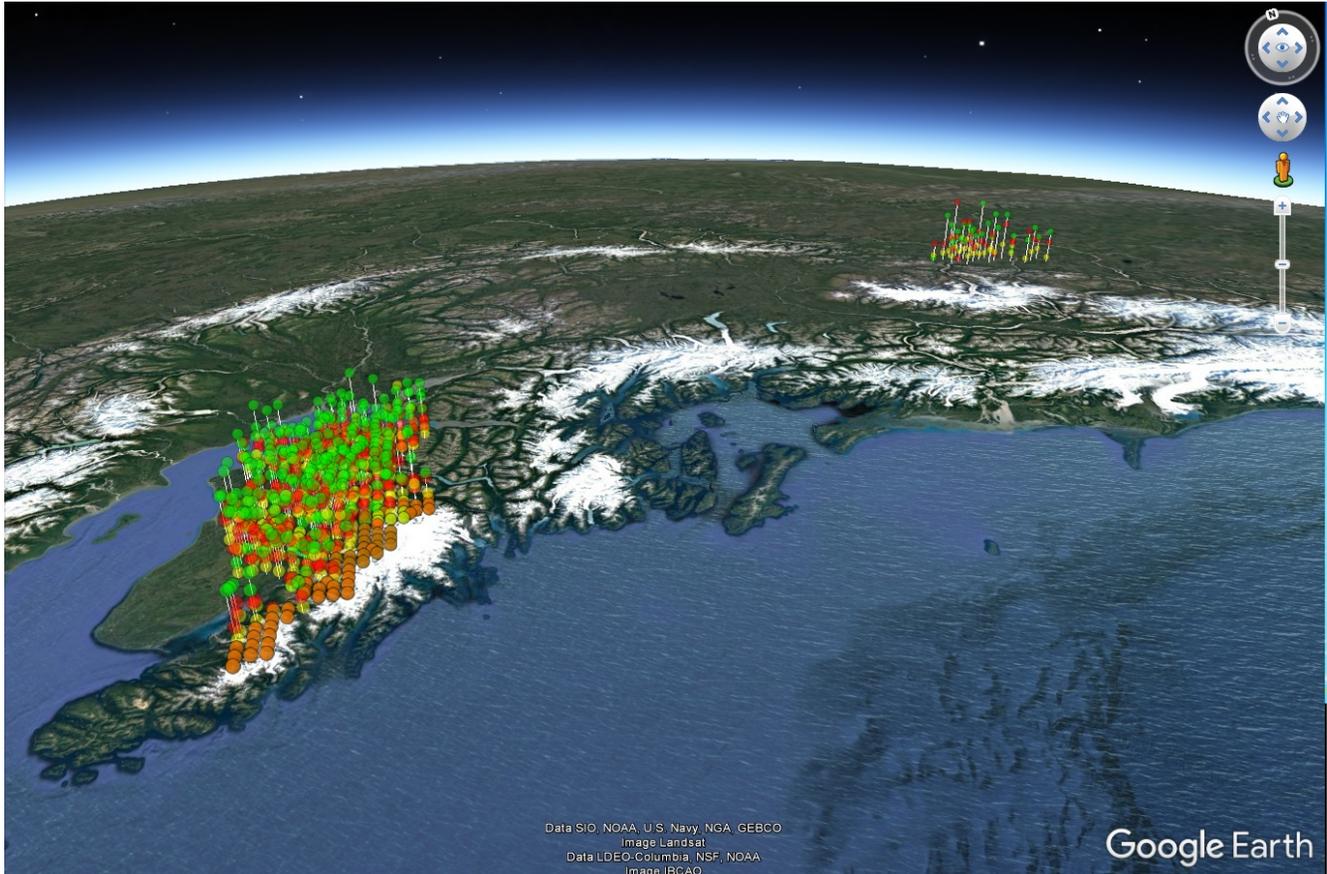
Devil's club is also important to wildlife. A [study](#) on the lowlands of the Kenai National Wildlife Refuge in the 1980s found that the berry-like fruits of Devil's club were the most important food for black bears in summer and fall. In late summer, black bears migrated to mature forests where Devil's club grows. In these forests, fruits of Devil's club were present in 90–100% of bear scats and made up more than 70% of the bears' diets, providing ample nutrition for the bears to overwinter. Devil's club's broad foliage provides shade and cover over salmon streams. Birds and small mammals use Devil's club for protection. The inconspicuous, greenish flowers are highly attractive to pollinating insects.

I encourage you to get to know Devil's club a little better and learn to appreciate it. The lush, green foliage and contrasting, bright red fruits have led to intentional planting of Devil's club as an ornamental. I think it is beautiful, but I still choose to walk around it when I am trying to get somewhere in the woods. Fittingly, Devil's club has been considered for use as a natural and visually appealing security barrier to deter people from walking through sensitive areas.

Matt Bowser serves as Entomologist at the Kenai National Wildlife Refuge. Find more information at <http://www.fws.gov/refuge/kenai/> or <http://www.facebook.com/kenainationalwildliferefuge>.

International Day for Biological Diversity

by John Morton



A Google Earth image showing stacked assemblages of plant (green), arthropod (orange) and bird (red) species found on Kenai and Tetlin National Wildlife Refuges.

Unbeknownst to most folks, this past Tuesday was the International Day for Biological Diversity. The United Nations declared May 22 as the day to help make people aware of the importance of biodiversity, 25 years after the Convention on Biology Diversity was approved as a multilateral treaty in late 1993 by 196 countries. The Convention has three main goals: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising from genetic resources.

Given that one of the primary legislative purposes of the Kenai National Wildlife Refuge is to “conserve fish and wildlife populations and habitats in their natural diversity”, it is not surprising we have taken this

message to heart. In 2004, 2006 and 2008, we collaborated with the US Forest Inventory and Analysis (FIA) program to survey species diversity on 259 plots spaced at 5-km intervals across the 2 million-acre Kenai Refuge. It was not an exhaustive survey, but it was comprehensive in its taxonomic scope. Just as importantly, it gave us good spatial data for over 1,000 species of birds, invertebrates, and plants!

Refuge staff continue to build our species inventory. We now have documented 2,138 species including 207 vertebrates, 826 invertebrates, 523 vascular plants, 182 mosses and liverworts, 370 fungi and 30 unicellular organisms. Of these, more than 95% are considered native species. One hundred species are

nonnative, but the good news is that we believe 19 were extirpated from the Refuge. What has really sped up our inventorying of biodiversity in recent years is the use of Next Generation Sequencing (NGS) to identify species through genetic “barcodes”.

We recently had the opportunity to apply our survey approach on Tetlin National Wildlife Refuge near Tok. Again collaborating with the FIA, we identified 229 species of birds, invertebrates and vascular plants on just 26 plots.

Here’s where the story gets more interesting. Tetlin and Kenai Refuges are ecologically similar (or so it would seem) in many respects. They are both part of the boreal biome, heavily forested by white and black spruce, white birch and aspen and inhabited by moose, caribou, lynx, wolves and bear. Fire is a big ecological driver in both systems.

So you’d think species diversity on both refuges would be similar—but that turned out to be only partially true. Of 80 bird species detected during the two surveys, 29 percent were found on both refuges. Of 370 vascular plant species, 16 percent occurred on both refuges. So quite a bit of commonality between the two boreal systems, at least among those taxonomic groups.

But of 338 invertebrates found in total during these surveys, only four species (1 percent) were shared by both Kenai and Tetlin Refuges! This is a stunning outcome if you’re an ecologist. Within the discipline of conservation biology, ecologists and managers often assume that if habitat is provided for an “umbrella” species that needs large landscapes, such as brown bears, then other species which require smaller areas are protected as well. Our finding suggests that while this may be true for each conservation unit, in this case a national wildlife refuge, it isn’t safe to assume that both units conserve the same biodiversity despite their similar appearance.

Admittedly, the methods used were different. When we surveyed the Kenai Refuge with the FIA more than 10 years ago, genetic identification using

NGS was not a viable method. So Matt Bowser, our refuge entomologist, had to resort to morphological identification. This is a tried-and-true method, but it is painfully laborious and slow, and generally requires adult specimens in good condition. In contrast, at Tetlin Refuge, we used NGS to identify insects and other invertebrates quickly from sweepnet samples stored in RV antifreeze. The samples are homogenized (ground up) anyways for genetic analysis, so neither their age nor condition matters for identification purposes.

Still, our work suggests there is much more to discover about biodiversity in Alaska. These two surveys resulted in the identification of 1,249 species over a combined acreage of 2.5 million acres, which represents less than 0.6 percent of the state.

What’s the big rush? A [paper](#) published just this week in the *Proceedings of the National Academy of Sciences* reveals that farmed poultry today makes up 70% of all birds (by weight) on the planet, with just 30% being wild. The picture is even more stark for mammals—60% of all mammals on Earth are livestock, mostly cattle and pigs, 36% are human and just 4% are wild animals.

And as we enter a geologic age that some scientists now call the Anthropocene, many predict we are entering a sixth great extinction event, driven by a rapidly warming climate that could cause the loss of 40 percent of species worldwide. This is a big deal. The last big extinction was 66 million years ago when dinosaurs were snuffed out by rapid climate change in the aftermath of an asteroid cratering the Yucatan Peninsula.

So pause just for a moment to appreciate that almost 200 countries think enough of this looming problem to declare the International Day for Biological Diversity. Bottoms up!

Dr. John Morton is the supervisory biologist at Kenai National Wildlife Refuge. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/refuge/Kenai/community/refuge_notebook.html.

Being bear aware and sustaining our wild-lifestyle

by Courtney Breest

Most Alaskans treasure the wild-lifestyle we lead, living side-by-side with wildlife. I know I do. On any given day, we will see eagles overhead flying to their nests with food in their mouths for their chicks, are impressed by massive bear tracks on a trail as we go hiking, and sometimes are late for work because there is a moose hanging out between us and our vehicle—I mean, we've all been there, right? With these wondrous Alaskan perks, however, comes the responsibility of creating a safe environment where humans and wildlife can coexist peacefully.

Every spring, we Alaskans begin to prepare for a fun and adventurous summer. We dust off the camping gear, plant our gardens, and make sure our fishing gear and other outdoor recreation toys are in working order. But we must not forget to check in with our wildlife safety plans. Springtime is an especially crucial time to be more aware of our actions and how they may affect the behavior of the wildlife that surrounds us. Bears are waking up ready to forage after a long hibernation, and moose calves are being born by their protective mothers.

In thinking through our wildlife safety plans, consider two main areas: preparing for travel in bear country, and securing bear attractants like garbage, bird seed, pet food, or compost piles around our homes and backyards. Bears can easily become habituated to human sources of food, leading to unsafe human-bear interactions and unwanted bear killings. By addressing these two areas, we will keep ourselves safe, as well as the bears.

Check out below for some FREE events this June where you can learn about how best to live and recreate in bear country, refresh your bear aware skills, and help maintain the wild-lifestyle that we Alaskans enjoy:

June 8th—Stewardship Day at the Russian River 10:00 a.m.–4:00 p.m. at Russian River Campground

Get hands-on at this hotspot for human-bear interactions. You'll get to help with the behind-the-scenes preparations for the bears, fishermen, and tourists that flock to the river to enjoy the annual salmon migration. Defenders of Wildlife and the Forest Service in-

vite you to come out and help keep all the river visitors safe by putting up seasonal fences and informational signage that will help protect important wildlife habitat during this busy time of the year. Volunteers will be provided a T-shirt and pizza at the end of the day, plus free camping opportunities on Thursday, June 7th and Friday, June 8th at the Russian River Campground. RSVP required, email cbreest@defenders.org.

June 9th & 10th—Kenai River Festival Bear Awareness Booth

11:00 a.m.–5:00 p.m. at Soldotna Creek Park

Come find the Bear Awareness booth at the Kenai River Festival hosted by the Kenai Watershed Forum. Learn more about the distinct species of bears on the Kenai, how to travel safely in bear country, and how to avoid attracting and food conditioning bears.

June 11th—Free Bear Spray Training

5:30 p.m.–7:30 p.m. at the Kenai National Wildlife Refuge Visitor Center

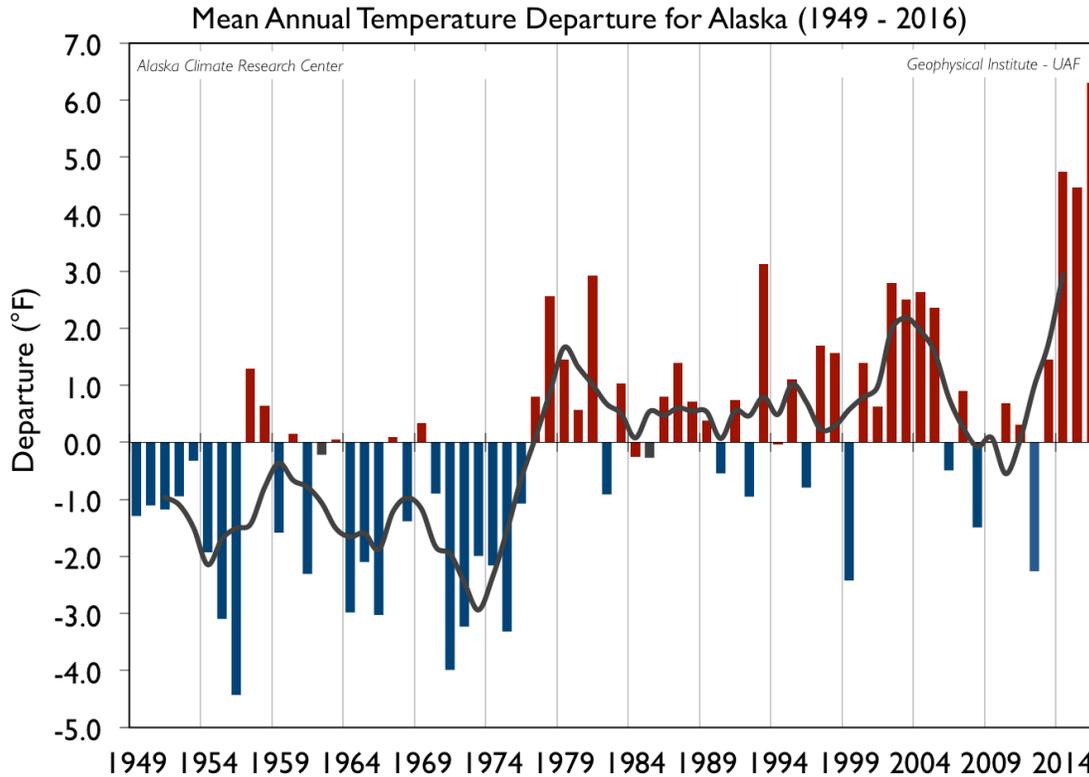
Learn how to properly use bear spray so you are prepared for a possible bear encounter when out in bear country. You will get to practice deploying bear spray after a brief presentation. Whether you're hiking, fishing, camping, or hunting, bear spray is the most effective and important tool to have at your disposal.

We must remember that preparedness and vigilance year after year is key, even if we haven't experienced any negative wildlife interactions in the past or heard about incidents in recent summers. Incident-free summers are due to residents and tourists taking appropriate precautions and securing the attractants around their homes every year. Let's maintain these good habits and encourage others to do the same if we want to continue avoiding negative encounters, which could lead to harming ourselves or the bears.

Courtney Breest is the Outreach Coordinator at Defenders of Wildlife—Alaska. Find more information about these events at <https://www.facebook.com/groups/121800611819412> or by emailing Courtney at cbreest@defenders.org. To learn more about Defenders of Wildlife in Alaska, visit <https://defenders.org/alaska/our-alaska-office>.

Soil: a complex ecosystem under your feet

by Dawn Robin Magness



Annual departures from mean annual temperature in Alaska (°F) from 1949–2016. Figure credits to the Alaska Climate Science Center (<http://akclimate.org/ClimTrends/Change/TempChange.html>)

Soil has a unique place in the history of the National Wildlife Refuge System. Farming practices coupled with drought in the 1930s caused the Dust Bowl. Dust storms, large enough to engulf entire communities and lasting for weeks, blew away soil and destroyed wetlands. In 1937, President Franklin D. Roosevelt wrote a letter to the State Governors that stated “The Nation that destroys its soil destroys itself.” President Roosevelt’s multi-faceted response included appointing a presidential committee to conserve ducks affected by the Dust Bowl. The committee included wildlife leaders, such as Thomas Beck, Aldo Leopold, and “Ding” Darling, and their recommendations led to the Duck Stamp Act of 1934. Waterfowl hunters are required to buy Duck Stamps as part of their license and the revenue is directly used to purchase or lease wetlands. The land purchases helped to build your Na-

tional Wildlife Refuge System. Refuges conserve and manage habitat for ducks along their Continental fly-way routes.

As stated so eloquently by President Roosevelt, soil loss is destructive because soil develops very slowly as rock is broken down by weathering. On the Kenai Peninsula, we have young soils due to glaciers scouring much of our landscape during the last ice age. Here, soils have only had several thousand years to develop. Soils are described in layers, called horizons, that have different properties. The bottom layers reflect the parental geology. The dark surface layer and lighter colored subsoil layer just below the surface are biologically active. In Alaska, plant roots only survive and anchor into the top 6 inches.

The biologically active layer is known as mineral soil. Mineral soil consists of mineral particles, air,

and water, generally in equal proportions, and a small amount (about 5%) of organic materials. The organic material consists of diverse microbe and fungal communities and the plant and animal parts they are decomposing. The process of decomposition is both complex and important because it converts minerals, such as nitrogen and phosphorous, into compounds that can be used by plants.

According to the Alaska Climate Research Center, Alaska's annual temperature has increased by 3.7° F over the last 70 years. There are seasonal differences with average winter temperatures increasing by 6.7° F and average summer temperatures by 2.3° F. Average temperatures are variable across years and there is a regional temperature shift in 1977 that corresponds to the Pacific Decadal Oscillation (see Figure). Soil temperatures are tightly linked with air temperatures. What can we expect with warming soils?

Warming soil temperature increase decomposition rates and, therefore, the nutrients that are available to plants. Soil nitrogen has been extensively studied because it strongly limits plant growth. Nitrification, the process where bacteria converts nitrogen into a usable form, is highly dependent on temperature. In cold soils, slower nitrification rates slow plant growth. When soils are experimentally warmed, nitrification increases on average of 50% and plant productivity increases. If not used quickly by plants, nitrogen is

highly water soluble and easily flushed out of the soil in runoff.

Microbial communities also change when exposed to warmer soil temperatures. Often microbial communities increase in warmer temperatures. But in boreal black spruce forests, a soil warming experiment changed the composition and reduced the abundance of bacteria and fungus in the soil. The decrease was thought to be linked to the soils dying out.

Cold soil temperatures slow enzymatic processes in the soil microbial communities that cycle nutrients and in the growing plant tissues. Plants species have minimum temperatures that they can tolerate. Once soil temperature falls below this threshold their root growth is severely limited. For example, paper birch trees require soil be 39° F to grow roots. Trees and other plant species also have specific soils temperature and water requirement for their seeds to successfully germinate.

Soil properties interacting with warming temperatures have the potential to change vegetation. We are starting to measure soil temperatures on the Kenai National Wildlife Refuge and to understand the complex interactions between soil, microbes, and plants.

Dr. Magness is a landscape ecologist at Kenai National Wildlife Refuge. Find more information at <http://kenai.fws.gov> or <http://www.facebook.com/kenainationalwildliferefuge>.

The mystery of agates

by John Morton



Translucent agates of many colors are found along Kenai Peninsula beaches with patience and luck (credit: Donna Brewer).

Almost everyone I know likes to search for agates along our Cook Inlet beaches. Some folks have a better search image than others, keying in quickly on these translucent (sometimes opaque) stones that vary from blood-red to amber to almost clear in color. Most are small, less than a small pea, but I've occasionally found golf-ball sized agates on Salamatof Beach and along the beach north of Bishop Creek.

When I decided to write a story about agates, I thought it would be an easy Wikipedia search. But the more I probed, the more mysterious agates be-

came. Dr. Dick Reger, retired from the Alaska Division of Geological & Geophysical Surveys, tells me that agates found on our local beaches don't originate from the Kenai Peninsula. And Dr. Peter Heaney, a mineral sciences professor at Penn State University and an agate expert, wrote me that "agate are one of the few gem materials that have not been successfully synthesized, even today. So nobody knows exactly how agates formed. After many decades of studying crystal growth, I regard agates as the most complex example of hierarchical pattern formation in minerals, and

most of the complex patterning is not even visible to the naked eye.” Here’s what I found out from these two experts.

The secret to making agate is how silica (SiO_2) dissolves in water. An agate starts with a cavity or void in rock, which could be sedimentary, metamorphic or igneous. But the best rock, for agate formation, is young volcanic rock in which vesicles are formed by the expansion of a gas bubble trapped inside the lava. Like Swiss cheese, as water containing dissolved silica percolates through the rock, the minerals begin to crystallize out within these cavities.

Ninety percent of an agate is quartz, but Heaney found the other 10 percent is moganite, a transparent mineral with the same chemical composition as quartz but a different structure. The quartz is encapsulated by an outer layer of very fine-grained chalcedony, which is a mixture of quartz and moganite. As the crystal grows under low pressure and temperatures, agate fibers twist in a helical fashion, even as the outer chalcedony fibers grow inward like spokes on a wheel. Further, Heaney believes the silicate has to be a little bit polymerized, with repeated units of five to ten molecules that will give a banding pattern sometimes found in agates from our local area, the color of the bands coming from trace elements like iron or manganese.

Because of their microcrystalline structure, agates are extremely resistant to weathering. So eventually the matrix in which they are imbedded (whether rock or even dinosaur bone!) erodes away and they are set free. The outer surface of an agate may be pitted and rough initially, a consequence of removing the original coating which formed the cavity. The agates then remain as nodules in the soil or are deposited as gravel in streams and along shorelines where they are polished over time. Agate colors are generally the result of staining by the waters in which they are transported or by mineralized groundwater after they are buried.

Dick Reger believes agates were ferried to the northwestern Kenai Peninsula by glaciers during the last ice age from the west side of Cook Inlet. There, agates formed less than 2 million years ago in chalcedony-rich hydrothermal deposits associated with faults in volcanic rocks deep in the Mount Spurr complex west of Tyonek. They were then scoured out by intensively-eroding ice streams flowing down the nearby Chakachatna-McArthur River corridor, carried by glacier to the Salamatof-Nikiski area, and ultimately deposited in sub-estuarine fans that jut from our coastal bluffs on the northwestern peninsula. Not surprisingly, a good time to search for exposed agates is after a winter storm erodes those bluffs.

Here on the Kenai, Kenaitze called lucky agates *nudech’ghela*. Peter Kalifornsky wrote that “the lucky agate stone brings good luck to whoever finds it. Sometimes they would be walking on the beach and would find the marks left by the lucky agate when it fell from the sky. They followed the trail and found it. And it gave them luck.” Dr. Alan Boraas, anthropologist at the Kenai Peninsula College, tells me that luck to Dena’ina was not a random event, but “an essence that was everywhere, soothing like gravity. To obtain luck of this type one had to have a ‘good heart’, meaning a proper attitude toward nature and particularly toward hunted animals.”

Elsewhere in the world, agates ended up being carried to the shoreline of the River Achates (now called Dirillo) in present-day Sicily, where they were found and given their name 3,000 years ago by Theophrastus, a Greek philosopher and naturalist. Just as early Greeks and Alaskan Natives recognized the uniqueness of agates, we continue to appreciate their mystery when we find one during our beach walks.

Dr. John Morton is the supervisory biologist at Kenai National Wildlife Refuge. Find more Refuge Notebook articles (1999-present) at https://www.fws.gov/refuge/Kenai/community/refuge_notebook.html.

Estuaries on the Kenai Peninsula are special places

by Angelica Smith



Beluga Slough in Homer is one of several estuaries on the Kenai Peninsula.

Growing up in Homer was an experience that I am incredibly happy to have had. From playing outside in the summers until midnight or helping out my grandpa at the Beluga Lake ice races to fishing in Kachemak Bay and cheerleading for the Homer Raiders.

Driving out to The Spit, my family and I would always ensure the windows were rolled up when we passed by Beluga Slough because that drive was most often accompanied by breezes of rotten egg. Even though I didn't always appreciate its lovely aroma, I was still happy to tromp around in my "tufts" looking at the little pools of sticklebacks and pointing out gulls and ducks. I looked past its little faults to enjoy the bigger picture of Beluga Slough, its uniqueness, and the fun creatures it housed that were so in reach.

On the Kenai Peninsula, Beluga Slough is among

our estuaries that include Chickaloon Flats, Kenai Flats, Kasilof Flats, and the Fox River Flats at the headwaters of Kachemak Bay. Acting as transition zones or gradients at the interface of land and sea, estuaries and the surrounding areas are wetlands where fresh water meets salt water. This brackish water sets the stage for some of the most highly productive habitats.

These coastal wetlands serve a variety of functions and values for us including flood alleviation through water storage and slow release, educational opportunities, enhanced water quality through filtering and phytoremediation, and as recreational areas. Though wetlands have not always been viewed in as positive a light as this, it seems estuaries on the Kenai are highly valued by people for everything from the annual shorebird festivals in Homer to waterfowl production and fisheries. Those who hold even more value in these estuaries are the plants and animals that inhabit them.

Prime land for food, habitat, and nursery grounds of many bird and fish species throughout the world, estuaries are sometimes dubbed the "nurseries of the sea". A unique community of plants and animals arise in this brackish habitat adapted to high and varying water salinity, tidal inflows and outflows, and hydrophobic soils in anaerobic conditions that occur in estuaries and other wetlands.

Wetland plants have adaptations to uptake nutrients, minerals, and chemicals considered toxic in other situations like sulfur, methane, and excess nitrogen. When plants (like sedges) die back, the microorganisms in the soil get to work decomposing the tissues and releasing the plant's stored sulfur and methane. This process produces that rotten egg smell some of us are far too familiar with. An example of these specially adapted plants native to the Kenai is the Lyngbye's Sedge. This grass-like plant has a high tolerance for anaerobic conditions that occur in estuaries, and a medium tolerance for salinity and slightly acidic waters.

Adaptations unique to wetlands in the animal kingdom are brackish-water-tolerating euryhaline organisms that can take advantage of estuaries as permanent or semi-permanent residents. Among these are

mollusks like the Baltic Macoma, a permanent bivalve resident of estuaries and intertidal zones in sandy and muddy soils. This oval-shaped clam, up to 1.5 inches long, is polymorphic with coloration variations, and serves as a food source for visiting birds. The Coho Salmon is considered a euryhaline species, too. Estuaries act as brackish nurseries where Coho spend time from alevin to smolt (1–3 years) before heading out to open sea where they mature.

Of course, there is the famous annual shorebird festival in Homer where visitors (human and avian alike) come from all over to enjoy and admire estuaries like Beluga Slough. Western Sandpipers and Pacific Golden Plovers are two of the more common avian visitors that make a stop on the peninsula during their migrations. Larger mammals like moose, bears, and coyotes also forage for the unique food sources available in these estuaries that do not occur elsewhere (or in the same abundance).

Estuaries only constitute about 1 percent of the

Kenai Peninsula. However, they provide habitats for many species while providing unique opportunities for recreation, education, and economic gain. Because of their great value and the limited land area they occupy, some estuaries like Fox River Flats are designated Critical Habitat Areas by the Alaska Department of Fish and Game, and are managed with special regulations. Chickaloon Flats, the largest estuary on the Kenai Peninsula, is under the care of the Kenai National Wildlife Refuge.

Next time you are near an estuary, take the time to admire everything they provide for you and for the wildlife that is precious to our way of life.

Angel Smith is a biological intern this summer at Kenai National Wildlife Refuge. She is a junior in Wildlife Biology at Missouri State University during the rest of the year. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/refuge/Kenai/community/refuge_notebook.html.

This moss grows in what?

by Anthony Holzhauser



The red stalks and whitish-yellow caps of Yellow moosedung moss growing by Headquarters Lake on the Kenai National Wildlife Refuge, July 28, 2014 (credit: Matt Bowser/USFWS).

When you think about where moss grows, where do you think of? Perhaps on a tree or a stump or just directly on the ground. Well, that's not the case with the infrequently seen moss *Splachnum luteum*, commonly referred to as yellow moosedung moss. This moss finds its home in, as the common name implies, moose dung!

One might mistake this moss for a flower due to its simple structure and bright colors. A thin red-yellow stem extends upward from the small, green, leafy base to reach the cap. The bright yellow, umbrella-shape

cap is branded in the scientific name "luteum", the Latin word for yellow.

Mosses are plants, but function very differently when it comes to obtaining nutrients and reproduction. Mosses are non-vascular, which means they simply absorb nutrients through their stem and leaves instead of through vascular tissues. This is why most mosses are small and live in moist environments.

Mosses also reproduce much differently than most other plants. The familiar, leafy, green gametophyte phase of the moss produces sperm and eggs. The

sperm and the egg form a zygote and the zygote is housed in what's called the sporophyte or, in this case, the yellow cap on top of the red stalk. Then, the zygote produces spores that can travel to a different, suitable habitat and produce new individuals.

Splachnum luteum is part of the family Splachnaceae, which contains several unique mosses commonly referred to as the dung mosses. What is interesting about this family is that almost half of these species of mosses are entomophilous, which means that their spores are dispersed by insects. Reproducing through entomophily has yet to be observed in any other moss family.

Most mosses reproduce solely by relying on the wind or water to transport their spores. Entomophilous species attract their “pollinators”, mostly flies, by using both bright colors and odors that simulate decaying organic matter. Yellow moosedung moss is no exception to these unique reproductive maneuvers—it attracts the blue bottle fly (*Calliphora vomitoria*), a species found on the Kenai National Wildlife Refuge, with the seductive double whammy of odor from a butyl compound and the bright yellow color of its spore cap. The moss' spores are sticky enough to stick to the fly, and then the fly carries the spores to another pile of droppings.

As previously mentioned, *Splachnum luteum*, and other mosses in the family Splachnaceae, require a very unique habitat. Species in the genus *Splachnum* grow exclusively in herbivore dung. In addition to being restricted to growth in plant-eaters' feces, yellow moosedung moss is also confined to bogs. Another species in the same family found on the Kenai Refuge, *Tetraplodon mnioides* or “entire-leaved nitrogen moss”, specializes in carnivore dung, old bones and owl pellets.

With such a constrained habitat type, it makes

sense for this moss to develop additional reproductive methods to supplement wind or water dispersal. Other than reproducing through entomophily, dung mosses may also be unwittingly eaten by foraging herbivores. Its spores might then be excreted as part of the animal's waste, hopefully leading to a new individual.

These mosses picked a strange medium to set up home in, but they did it for a couple of reasons. Moose droppings contain about 2.5% nitrogen, which is more nitrogen than cow dung! Nitrogen is an important element for plants as it is a component of chlorophyll, which is essential to complete the photosynthetic process. Water is also a critical piece of photosynthesis, and is contained as moisture within moose scat.

Yellow moosedung moss is a rarely seen moss on the Kenai Peninsula, probably due to its limited habitat and reproductive methods. Even though this moss can transport its spores through flies to another pile of dung, they still have to have a pile of dung nearby for the fly to land on. Droppings don't stay in the ecosystem very long either, typically 1 to 3 years, which means that habitat for the yellow moosedung moss is constantly changing and ultimately disappearing.

This moss is rare, but that doesn't mean you should dismiss it. Keep an eye out for piles of moose droppings here and there and see if you can find it! Rare things are fun to find, and this little guy is no exception. If you do encounter it, take a second to appreciate the complexity of its lifecycle because, as Aristotle said, “In all things of nature, there is something of the marvelous.”

Anthony Holzhauser is a biological intern this summer at Kenai National Wildlife Refuge. He is a junior in Wildlife Biology at Unity College during the rest of the year. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/refuge/Kenai/community/refuge_notebook.html.

Our national bird more than meets the eye

by Todd and Leah Eskelin



Breakfast time! This snapshot from the City of Kenai Eagle Cam shows mom feeding the two eaglets pieces of a bird she brought back to the nest on May 26, 2018.

If you have not checked out the City of Kenai Eagle Cam you are missing out. This is among the best in the world of online nest cameras. We watched the adults fix up the nest in April. Then we got to see a few unwanted guests come and check out the already claimed nest. Hundreds of people watched in real time as the first and then a second egg were laid. After what seemed like an eternity, but barely more than a month, both eggs eventually hatched a few hours apart.

Now almost six weeks old, the rapidly growing chicks are checking off their milestones one after another. Pin feathers have replaced their baby down. They are able to feed themselves from the smorgasbord of birds and fish that mom and dad bring back to the nest. They back up and defecate out of the nest without falling. They have begun exercising their wings. At this point, each eaglet is the size of a volleyball with gangly wings and legs.

They will continue to use the nest until mid-August, so if you want to watch them grow and follow their progress, check out the live webpage at <http://www.kenai.city/eaglecam>. From there you can also look at highlights that were saved to the City of Kenai's YouTube channel.

As you celebrate the Fourth of July, we hope you'll reflect about what the Bald Eagle represents as our national bird. It is a sign of strength and power depicted on every seal representing the United States of America. The Bald Eagle is also one of our greatest conservation success stories—a nation coming together to ensure wild populations persist for future generations to enjoy.

The Bald Eagle was clearly headed down the path of extinction, at least in the Lower 48. Dichlorodiphenyl-trichloroethane or DDT was developed in the 1940s as one of the first synthetic insecticides. It was

very effective, and its use became popular across the country to combat insect-borne human diseases like malaria and typhus. Unfortunately, it contaminated fish and other prey that eagles consumed. Although not lethal to adult birds, DDT ultimately caused the egg shells of eagles and many other raptors to become too thin. The eggs literally cracked before the chick was fully developed.

At the same time as this rapid increase in nest failures, the American population was growing and expanding the urban footprint into forested lands. In previous decades, waterfowl and shorebirds were hunted to dangerously low numbers making it difficult for eagles to find appropriate food while nesting. On top of all these hurdles, eagles were being shot as it was believed incorrectly that they preyed upon calves and lambs from the growing livestock industry.

The combination of these factors happening simultaneously was the perfect storm, devastating to Bald Eagles. In the early 18th century, Bald Eagles probably numbered between 300,000 and 500,000 birds. By the 1950s, after the extensive use of DDT and habitat loss, there were only 412 nesting pairs in the 48 contiguous states!

While the Migratory Bird Treaty Act of 1918 provided some protection for the species, it clearly was not enough. In 1940, the Bald and Golden Eagle Protection Act made it illegal to take, possess, sell, purchase, offer to sell, transport, or import/export live or dead eagles or eagle parts including any part, nest, or egg unless a permit is issued.

Native Americans are able to apply for permits to possess eagle parts used in their cultural traditions. Alaska plays a key role in this process as all dead eagles

are sent to the National Eagle Repository near Denver for distribution to successful applicants, thereby giving people the opportunity to maintain traditions even in areas where few eagles now reside. In fact, Bald Eagles killed on the Kenai Peninsula from electrical transformers or vehicle collisions are sent by Kenai Refuge staff to this repository.

In the 1950s and 1960s, the U.S. Department of Agriculture began regulating the use of DDT. Additional regulations followed with the establishment of the Environmental Protection Agency in 1972. Bald Eagles in the Lower 48 were also listed following enactment of the Endangered Species Act in 1973.

Fast forward almost four decades and the Bald Eagle was officially delisted in 2007 due to these new laws and regulations. The number of nesting pairs in the Lower 48 now approaches 10,000!

Now, as “our” eaglets approach taking flight from the nest in mid-August, we wish to highlight another event focusing on Bald Eagles. On Saturday, August 4, beginning at 2:00 pm, the Kenai National Wildlife Refuge is presenting “Bald Eagle Exploration Stations,” a hands-on guided discovery lab for participants of all ages. Join our rangers and be a biologist for a day while exploring eagle anatomy, flight, nesting habits, and more in a rotating series of activity stations. Call the Refuge Visitor Center for more details at 907-260-2820.

Todd Eskelin is a Wildlife Biologist and Leah Eskelin is a Visitor Services Park Ranger, both at Kenai National Wildlife Refuge. Find more information at <http://www.fws.gov/refuge/kenai/> or <http://www.facebook.com/kenainationalwildliferefuge>.

A big year for spruce tip rust

by Matt Bowser



Bright orange spores are released from rupturing needles of a spruce tip infected with spruce tip rust on the Skyline Trail, July 5, 2018 (credit: USFWS/Matt Bowser).

“What is that?” asked my coworker, pointing down to where it looked like someone had marked the ground beside the Skyline Trail with neon orange spray paint. It turned out to be an orange powder coming from a fallen spruce cone. As we looked around we saw strangely stunted, bright orange spruce tips that dropped copious orange powder whenever they were touched. These were spores of a rust fungus.

Rust fungi, named for the rust-colored spores of some species, include thousands of species, all of them parasites wholly dependent on their plant hosts. Each kind of rust fungus usually infects only one to a few species of plants.

Rusts are familiar diseases on our local spruces, with multiple species of spruce rusts known in our area, but these bright orange spruce tips were different

than anything I could find in field guides. I sent pictures to Dr. Lori Winton, Forest Pathologist at the U.S. Forest Service's Forest Health Protection office in Anchorage. She quickly identified the photos as spruce tip rust, *Chrysomyxa woroninii*.

Although this fungus was described in 1903, the details of its biology have been worked out only recently. To complete its life cycle, spruce tip fungus requires two host plants: a spruce and bog Labrador tea (*Ledum groenlandicum*), a shrub common in wetlands and woods in our area.

By the time this article is printed, infected spruce tips will have released most of their spores and have started to change from orange to brown to black as the tips die and release a special kind of spore called aeciospores. In the case of spruce tip rust, the aeciospores are incapable of re-infecting spruce. They must be spread by wind, water, or animals to bog Labrador tea, their primary host.

The aeciospores germinate on Labrador tea, sending out filaments that penetrate and ramify through the host plant's tissues. The fungus grows by extracting nutrients from its host's cells. The infection causes a stunted, irregular growth of dense branches called a "witches' broom." The rust lives through the winter inside the leaves of Labrador tea. In spring, spore-producing structures erupt from undersides of infected leaves, releasing a different kind of spore called teliospores.

The teliospores are dispersed by wind and rain. They germinate and release yet another kind of spore called basidiospores, which can only infect spruce. Basidiospores that germinate on spruce send out filaments that penetrate the spruce, presumably through microscopic holes on the needles called stomata. This leads to a local systemic infection, where the fungus grows within the tissues of a new spruce tip bud that develops in the late summer.

The spruce tip rust fungus overwinters in the spruce buds. As the tips begin to elongate in the spring, infected tips develop into spore-producing factories, with all needles in the spruce tips eventually bursting with spores. This life cycle takes two years to complete, so the infected spruce tips we see this year were infected last summer.

Female cones of spruce can be infected by *Chrysomyxa woroninii*, basically hijacking the cones so that they produce orange fungal spores instead of viable seeds. (Locally, spruce cones can also be infected with spruce cone rust, another species of *Chrysomyxa* that alternates between wintergreens and spruce cones.)

Although spruce tip rust is strikingly conspicuous this year on black, white, and Lutz spruce on the Kenai Peninsula (I have not yet investigated Sitka spruce), its effects on spruces appear to be quite inconsequential. Most trees that I see lack any obviously affected tips and infected trees usually have few orange tips, perhaps one in one hundred tips.

Spruce tip rust is generally not an important disease of spruce, usually causing little slowing of growth, but sometimes causing a significant reduction in viable seed production. The fungus does not continue living in its spruce host but dies as the infected tips dry up, requiring Labrador tea to complete another round of its life cycle and re-infect spruce the following summer.

Throughout its range in the boreal forest of the Old World and New World where both spruces and Labrador tea occur, *Chrysomyxa woroninii* tends to be seldom seen. It appears that even where it is present, this fungus requires a specialized set of conditions to complete its life cycle. There is some evidence that infections of spruce are more frequent following rainy summers, with the spores apparently having a better chance of infecting developing spruce buds in wet conditions. This year's comparatively high incidence of spruce tip rust on spruce is likely related to the wet, rainy summer of 2017.

If you have not yet seen spruce tip rust fungus, have a look at this phenomenon soon before these orange tips turn completely brown and are only a memory. It is likely that *Chrysomyxa woroninii* will again be rarely seen in our area for some time as we move past the most conspicuous phase of this one of many cycles of nature.

Matt Bowser serves as Entomologist at Kenai National Wildlife Refuge. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/refuge/Kenai/community/refuge_notebook.html.

Restoring nature one gravel pad at a time

by Amber Robbins



Kenai National Wildlife Refuge interns Angel Smith and Laura Bashor help Hilcorp Alaska restore a retired gas pad east of the Swanson River Field (credit: Lorene Lynn).

What happens to old oil and gas pads when they are no longer useful? This June, I was given the opportunity to find out.

As a biological intern at the Kenai National Wildlife Refuge, I was asked to help restore the Sunrise pad east of the Swanson River Field. This retired pad, originally built by Marathon Oil Corporation in 2008 in hopes of meeting commercial gas needs, was abandoned when production levels didn't pan out. A decade later, Kenai Refuge and Hilcorp Alaska LLC devised a strategy to remedy the problem. Hilcorp hired restoration specialist Lorene Lynn, of Red Mountain Consulting LLC (RMC), to develop a plan and lead the in-field execution with exceptionally well-thought-out

details that can only be described as creative restoration.

I and three other interns were anted up by Kenai Refuge as help for the project, to which Lorene eagerly agreed. Our first day on the job, we toured the 2.75-acre gravel pad, reviewing the different methods the team planned on using to restore the pad. The team included Moore's Landscaping, a local contractor, who over the next few days would transform the flat and compacted gravel pad using heavy machinery to "dimple" the ground, creating a rough and loose ground surface that emulated the complexity of microtopography and microclimates found in nature. I learned that this method is more ideal than tilling as it does not

destroy soil cohesion and the outcome more closely resembles a natural landscape.

Together we transplanted tree seedlings from the surrounding area into the dimpled areas. We chose young spruce trees, avoiding deciduous trees such as willow or birch upon which moose love to snack. This increased the likelihood of a successful restoration by aiming to reduce potential losses from winter moose browsing.

The trees we transplanted were originally surrounded by a mat of vegetation. These vegetation mats are composed of several herbaceous plant species as well as mosses and a complex soil system that will support the health and recovery of the pad. A bobcat was used to scoop up these mats so that the root mass remained intact. Unlike many other restoration projects, we did not bring in any outside plants or material—instead, we simply transplanted nearby native vegetation. Not only does this approach save money, but it also reduces the potential of accidentally introducing invasive or other unwanted species as part of the restoration effort.

Something that Lorene reminded the team of throughout the project is that bioengineering is a matter of creating complexity across the landscape. By the end of the project, this ideal was clearly met across the entire pad—the dimpled ground, diversity in vegetation, and boulders and logs left sporadically. We also worked hard to choose young trees that really varied in size, ranging from a couple inches to a couple feet in height.

Although the pad is just a small portion of the area currently leased by Hilcorp for commercial oil and gas extraction, this particular project could provide a

solid framework for future restorations. The success of the Sunrise Pad’s restoration will ultimately be judged five years down the road through meticulous measurements of vegetation cover, plant species diversity, and tree density. If it proves to meet the performance standards prescribed in the restoration plan, then these unusually thoughtful methods could be used by others to restore degraded lands to more natural conditions.

I loved being able to see how individual people take extra steps to do a quality job. For example, Lorene recommended reflective mylar sheeting in response to a suggestion by Hilcorp project manager Kelley Nixon that birds be deterred from nesting in the area before the project got underway. Together, Lorene and Kelley tied mylar to the surrounding trees, and removed them once the project started, to promote a “leave no trace” ethic. It is inspiring to be surrounded by people who view their work as more than just a job.

The chance to work on this project is not an experience lost on me. It was an incredible opportunity to see different parties interacting to make a difference. The Refuge, Hilcorp, RMC, Moore’s Landscaping, and even we interns helped transform a barren gravel pad into a natural-looking field that is now on a fast trajectory to grow into a native forest. It’s a project I can be proud to have worked on—knowing I’ve planted hundreds of trees that will outlive myself and one day support a complex ecosystem is truly special.

Julie “Amber” Robbins is a biological intern this summer at Kenai National Wildlife Refuge. She will be a senior in Wildlife Ecology and Conservation Sciences at Washington State University this fall. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/refuge/Kenai/community/refuge_notebook.html.

How Elodea became “explosive” in its growth

by John Morton



Elodea was introduced to Sports Lake in Soldotna sometime after 2013, but exploded onto the scene in May 2017 (credit: Ben Boettger).

Early last week, we applied another round of herbicide to ensure that *Elodea*, a highly injurious invasive plant, was eradicated from Sports Lake. *Elodea* was discovered here 19 months ago when a state fisheries biologist augered holes through the ice in preparation for a youth fishing derby. Partners in the Kenai Peninsula Cooperative Weed Management Area responded quickly, applying herbicide in May and July of 2017. By the end of that summer, *Elodea* had declined from 32% to 4% of sampled sites. After maintaining the herbicide at lethal levels (~5 ppb) all winter, *Elodea* has yet to be detected in Sports Lake this summer.

What’s remarkable about this success story is that

when the ice went out on May 1 last year, *Elodea* was so abundant that long strands had wracked along the shoreline, making it difficult to wade through! Several lakeside homeowners commented they had not seen anything like this before. Yet, when Sports Lake was surveyed in 2013, *Elodea* was not found. So sometime in the intervening three years, *Elodea* was introduced before the population exploded in 2017.

This happened in another Alaskan lake. In 2014, *Elodea* was found in Alexander Lake in the MatSu. A few scattered plants over 10 acres were growing in front of a lakeside cabin owned by a floatplane pilot who commuted between there and then-*Elodea*-infested Sand Lake in Anchorage. By the time biol-

ogists returned to apply herbicide in 2016, Elodea had exploded over 500 acres of Alexander Lake.

Contrast these two explosive stories (pun intended) with how Elodea has infested other lakes in Alaska. Elodea was first discovered in Alaska in 1982 when it was incidentally collected during an aquatic plant survey of Eyak Lake in Cordova. It languished, unappreciated, as a pressed herbarium specimen at the University of Alaska Fairbanks for almost three decades.

In 2009, a second specimen was added to the herbarium when botanist Al Batten collected Elodea in Chena Slough, which flows through Fairbanks. The following year, a floating fragment was found in Chena River, downstream of its confluence with Chena Slough, by two Forest Service ecologists who recognized that this was the first submersed freshwater invasive plant to establish in Alaska.

With this new awareness, detections around the state came quickly. Established Elodea infestations were found in Anchorage lakes in 2011, six remote waterbodies on the Copper River delta, and Stormy and Daniels Lakes near Nikiski in 2012.

In Fairbanks, Anchorage and initially on the Kenai Peninsula, Elodea was probably introduced to local waters through aquarium dumping. Elodea is commonly used in the commercial aquarium trade and, in fact, was sold by Petco in Soldotna as recently as 2013. A likely scenario is that an aquarium owner, tired of their pet fish but not willing to flush them down the toilet, frees them (and Elodea) into the nearest waterbody.

Here on the Kenai Peninsula, ground zero was Beck Lake based on the abundance and distribution of Elodea before herbicide treatments. A tropical fish shop on Halbouty Road, near Beck Lake, reportedly went out of business in the mid-1990s and it seems probable that this is when Elodea was introduced.

We have good evidence that initial introductions around Alaska were independent events. Genetic analysis indicates that *Elodea nuttallii* occurs in Fairbanks, *E. canadensis* in Anchorage and Cordova, and their hybrid in the Nikiski lakes. The hybrid is common in the commercial aquarium trade, more support that these populations arose from independent aquarium dumps.

When a plant is first introduced to a novel system, it may die or survive, but it typically has to adapt to local conditions to thrive. Both Elodea species are na-

tive to the mid-continent, and so are adapted naturally to warmer waters, and Elodea raised for the aquarium trade are growing in an even warmer and more thermally-stable environment. So if Elodea survives that initial dump into Alaskan waters, it'll take several generations (aka years) to adapt to the colder waters.

But adapt it did. Our best evidence is a case of "reverse engineering". When we first determined that Elodea in Stormy Lake was a hybrid, I sent live specimens to Fort Collins, Colorado, where SePRO Corporation, the manufacturer of the herbicide we use, has a laboratory. Here, Andrew Skibo planned on conducting experiments to assess the herbicide's efficacy on the hybrid.

However, when Dr. Skibo tried propagating the Elodea we sent him, it only limped along in his room-temperature tanks. He figured that the sample we sent him had been stressed during shipping, so I sent him another live sample. When he still couldn't grow that, he realized something wasn't right. Skibo came up with the bright idea of dropping the water temperature in the tanks, and that's when the Elodea exploded. Our Elodea from the Kenai Peninsula had become cold-adapted—but it took perhaps two decades of struggling in the waters of Beck Lake before it too became explosive in its growth.

And that's why I think Elodea has exploded in Sports and Alexander Lakes. Instead of introducing warm-adapted plants from aquarium dumps, we are now accidentally moving cold-adapted plants from established populations around the state by floatplanes and motorboats. Elodea in Alexander Lake was likely introduced from Sand Lake by floatplane, and the Elodea in Sports Lake was presumably brought in by floatplane or via the public boat launch.

The bad news is Elodea is more viral than ever. The good news is that the Alaska Department of Natural Resources maintains a quarantine on importing Elodea into the state. And, as we've demonstrated in Beck, Daniels, Stormy and now Sports Lake, there is a viable means to kill it.

Dr. John Morton is the supervisory biologist at Kenai National Wildlife Refuge. For more information about Elodea at <http://peninsulaclarion.com/outdoors/2017-07-13/refuge-notebook-your-photo-can-save-salmon-kenai-peninsula>. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/refuge/Kenai/community/refuge_notebook.html.

Why do moose cross the road? Wildlife underpasses on the Sterling Highway

by John Morton



Aerial photo of longest of five culverts being installed under the Sterling Highway (credit: Shaun Combs, DOT&PF).

Why do moose cross the road? To get to the other side, of course—as do other wildlife like lynx, caribou, bears and wolves. The nature of the beast is that dens and calving areas and salmon and hardwood browse and berries don't all occur in the same place. Here on the Kenai National Wildlife Refuge, it seems reasonable that we like wildlife to move freely around to access these sometimes patchily-distributed resources.

The problem is that it's not that simple. Almost 1.4 million vehicles per year travel down the Mile-post 58–79 section of the Sterling Highway that bisects the Refuge between Jim's Landing and Sterling. That traffic volume translates to a vehicle every 22 seconds, making this a formidable (albeit moving) barrier

to wildlife like wolves and bears that tend to avoid traffic. For animals like moose that are sometimes attracted to the roadside hardwood browse, road salts or plowed roadways, this translates to 225–250 collisions with vehicles annually on the Kenai Peninsula, 90 percent of which are cows and calves. This mortality approximates the number of moose (mostly bulls) legally harvested on the peninsula every year!

In addition to this waste of meat and hunting opportunity, moose-vehicle collisions average \$36,000 in vehicle damage, lost wages, and towing, medical and investigation costs. That's \$9 million per year! And sometimes people die, for which there is no price tag.

Needless to say, the Refuge is just as interested in

public safety as it is in ensuring wildlife movement. The answer clearly isn't to prevent moose from crossing the highway. Thomas McDonough and Sean Farley, two local biologists with the Alaska Department of Fish and Game, coauthored a [2015 journal article](#) in which their research showed that moose populations in Anchorage were genetically different on either side of the Glenn Highway because of the restricted gene flow (movement) caused by fencing and heavy traffic. While they didn't find any detectable effect due to the Sterling Highway, it's clear that this is a looming issue as traffic volumes increase on the Kenai Peninsula.



A new bridge over the East Fork of the Moose River will provide a very natural wildlife underpass after the existing small culvert and roadbed are removed (credit: John Morton)

Instead, the Refuge worked closely with an Alaska Department of Transportation & Public Facilities (DOT&PF) planning team to develop six underpasses for wildlife passage on this 21-mile section of the Sterling Highway. Perhaps the most noticeable underpass is the new bridge over the East Fork of the Moose River. This almost-140-foot bridge will provide a 104-foot wide × 18-foot high opening for moose and the Kenai Lowland caribou herd, eventually replacing the small culvert and very high road bed that currently exists there.

The other five underpasses are large culverts ranging in height from 8 feet for bears and lynx to twin culverts for moose, each 16 feet high. This latter structure anchors the west end of 1.5 miles of fencing on either side of the highway section that runs between there and the new East Fork bridge. This area is known to have a high moose-vehicle collision rate, in part because moose travel there, but also because of a large

bend in the highway near Lily Lake that hides crossing moose until the last second.

We've made every effort to ensure this fence is porous to other wildlife. It's 8 feet high to stop moose, but it starts 1 foot off the ground so smaller wildlife can pass under. In addition, 22 "jump-outs" are being installed every eighth of a mile to allow moose that might accidentally walk around the fence to escape. These are dirt ramps that lead up to large gaps in the fence that allow moose to step through and away from the road corridor, but don't allow moose to return because of a 7-foot vertical drop.

Will wildlife use these underpasses? We already know that overpasses are a better design for moose and caribou. Unfortunately, the cost of overpasses were more than this particular project could afford, but we have ensured that the culverts are as high and as short as they can be to minimize the "tunnel" effect. All but one of the structures pass under two lanes, and they have all been placed in areas of frequent wildlife crossings based on GPS collar data from moose and caribou, moose vehicle collision reports, and wildlife observations.

As these structures are new for Alaska, we'll be monitoring their use by wildlife for several years after construction. We fully expect moose and other wildlife to still cross over open pavement, but our interagency goal is to reduce those opportunities for vehicle collisions as much as possible. The Refuge's goal is to ensure that widening of the road to allow for passing lanes and a wider shoulder doesn't restrict wildlife movement.

This project will have other tangible benefits that those who use the Kenai Refuge will appreciate when the construction dust settles next year. A pedestrian underpass will connect the parking lot for the Skyline Trail with its trailhead on the other side of the road. The gravel pit at MP 63.5, an open wound on the landscape for several decades, will finally be remediated. The access to Mystery Creek Road will be realigned to make it safer and to provide public parking. And this is the first DOT&PF project in Alaska to use certified weed-free gravel.

Why moose cross the road is no surprise. But the "how" is perhaps the more interesting question. We should find out over the next few years!

Dr. John Morton is the supervisory biologist at Kenai National Wildlife Refuge. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/Refuge/Kenai/community/Refuge_notebook.html.

Hummingbirds take migration to a new level

by Todd Eskelin



An adult male Calliope Hummingbird captured and banded near Inkom, Idaho. This is the smallest breeding bird in North America (credit: Todd Eskelin).

In my career as a bird bander I have banded over 20,000 birds and probably closer to 30,000 birds. I have banded small ones like the 6 gram Ruby-crowned Kinglet, up to Bald Eagles measured in pounds. Recently, I was humbled when I went to Boise, Idaho to get my hummingbird banding certification. Initially I felt like a gorilla with a bunch of bananas for fingers, trying to safely handle hummingbirds that weighed 2.5 to 4 grams or the weight of a single penny.

It was no easy feat to get this qualification. Candidates must band with a certified trainer and handle enough birds to demonstrate competency in safe banding, measuring, aging and sexing hummingbirds. Fred Basset, one of the best trainers in the country bands in Idaho and I arranged to travel across southern Idaho on a 3 day road banding trip with him. I banded nearly 200 hummingbirds and the experience was incredible.

I banded 4 different species, but the highlight was handling 50 Rufous Hummingbirds, a migratory

species found back on the Kenai Peninsula. Now the trick will be to capture and band Rufous Hummingbirds here with the hope of continuing to understand where our birds are wintering and what route they are taking to get there. Banding these birds will also give us insights about range expansion here like what is seen in other areas of the country.

The last week in July in Alaska is epitomized by the craziness of returning salmon runs, flower beds at peak color and fireweed blooms reaching for the sky to catch the last blast of full sunshine. It is also a time on the Kenai where our smallest bird is fattening up and beginning a LONG journey south. The Rufous Hummingbird is by far our smallest breeding bird and until recently all we knew was the direction was south and the timing was late July and early August.

In 2010, a Rufous Hummingbird banded in Tallahassee, Florida was recaptured in Chenega Bay, Prince William Sound. Since then there have been additional band returns linking Prince William Sound to Texas, Colorado, and California. This is an incredible distance for a bird that only weighs 3.5 to 4 grams (slightly smaller than a nickel). For more perspective, these birds are only about $\frac{1}{3}$ the weight of a chickadee.

In addition to Rufous, and increasingly common visitor to the Kenai Peninsula is the Anna's Hummingbird. They also have been expanding their range and tend to show up in late fall after the Rufous have long departed. They have even seemingly overwintered in Homer, surviving at least through February. I can't wait to band some of the Anna's and see if they are returning each fall or if a new crop is finding their way to Homer and Seward each Fall.

There are a lot of myths about feeding hummingbirds so I asked the experts while on my banding trip. They are very adamant that the presence of hummingbird feeders does not convince hummers to halt migration. They have already made choices and while the feeders and warming lights may extend their survival beyond what would have been normal, they will not convince birds to overwinter.

Also, hummingbirds are surprisingly cold tolerant. We have this idea that with their high metabolic requirements and comfort in hot tropical climates,

they just can't survive when the temperature dips. In Homer, Seward, and Cordova we have repeatedly watched Anna's Hummingbirds survive down to single digit temperatures. They utilize a special ability to enter a nightly torpor or temporary hibernation. They lower their body temperature to just above a set point they could not recover from. This reduces their metabolism up to 50 times slower than when they are active and feeding.

When the nighttime temperatures and darkness retreat, Anna's Hummingbirds simply warm their body back up by shivering for about 20 minutes and resume normal daytime activity. Their average daily caloric requirements transferred to a human body weight would equate to a 155,000 calorie diet each day! We can marvel about these statistics for days, but I am excited to track their occurrence on the Kenai Peninsula and add to their remarkable migration statistics.

If you see a hummingbird hanging around your flower garden and have a hummingbird feeder, go ahead and fill it up. No food coloring is needed, just 1 part sugar to 4 parts water. If you do get lucky enough to have a hummingbird stick around, get a photo and give me a call (907) 260-2817. Maybe we can put a little jewelry on these awesome birds and hope they reveal some of the still unclear mysteries of where they are heading each winter.

Todd Eskelin is a Wildlife Biologist at Kenai National Wildlife Refuge. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/Refuge/Kenai/community/Refuge_notebook.html or other info at <http://www.facebook.com/kenainationalwildliferefuge>.



An adult Male Rufous banded near Inkom, Idaho. Currently Rufous Hummingbird is the only known breeding hummingbird on the Kenai Peninsula (credit: Todd Eskelin).

Mycorrhizae: the fungus among us

by Laura Bashor



An edible Alaskan scaber-stalk mushroom grows on the Keen Eye Trail on the Kenai National Wildlife Refuge, September 5, 2014. The scaber-stalks form mycorrhizal relationships with roots of trees and shrubs, but the mycorrhizal partners of the Alaskan scaber-stalk are not yet known. Credit: Matt Bowser/USFWS.

What do gardeners and biologists have in common? We both want plants to grow! From the native trees and plants on the 2 million acres of the Kenai National Wildlife Refuge to the vegetables, flowers and berries in your garden, the healthy growth of plants is important to all of us.

Biologists and gardeners alike know that most plants need sunlight, water and nutrient-rich soil to grow. However, many plants depend heavily on another support system, one that is microscopic and hid-

den underground or even inside the cells of the plant itself. Composed of mycorrhizae, a group of symbiotic microbial fungi, this system coexists in the soil among and within plant root systems.

What seems like a long, difficult-to-pronounce name can be simplified by breaking it down into its Greek roots—"myco" for fungus, and "rhiza" for root. Essentially, mycorrhizae consist of a fungus-root relationship.

This fungus-root relationship is a form of symbi-

otic relationship. Symbiotic relationships occur between two different organisms that live together. A symbiosis is not always mutually beneficial, but the majority of mycorrhizal fungi benefit the plants they are associated with in addition to receiving a benefit themselves.

At the (literal) root of this beneficial exchange is the increased efficiency of water uptake and nutrient absorption from the soil for plants. In return for their help, many fungi receive carbon that their host plant removes from the atmosphere in the form of sugars. Mycorrhizae associated with trees and woody plant species commonly form a sheath around the root, which can also help to protect the roots from disease.

Mycorrhizal fungi are present throughout Alaska in a wide variety of environments. In fact, mycorrhizae have been around since plants first evolved, and many scientists believe that beneficial relationships between plants and microbial fungi were instrumental in allowing the first plants to colonize land from the ocean millions of years ago.

Some mycorrhizae are even considered “living fossils,” as scientists have found fossils of ancient plants associated with fungi that appear to be structurally identical to today’s mycorrhizae. They are also crucial to the health of a plant much beloved by Alaskans, the blueberry.

Although much remains unknown about these tiny underground organisms, their importance to the healthy functioning of ecosystems is not doubted. Scientists are still discovering amazing things about their relationships with plants. Consider that mycorrhizal fungi and their host plants talk to each other! They communicate with each other via signaling hormones, responding to each other’s signals with distinct behavioral changes.

Here at the Kenai National Wildlife Refuge, we’re just as excited about the details of mycorrhizal biochemistry as the big picture of how mycorrhizal fungi fit into the ecology and natural cycles of the refuge’s exceptional assemblages of flora and fauna.

Tracy Melvin, a doctoral student with the Refuge’s biology program, is interested in the future of the natural landscapes on the Kenai Peninsula in the face of a rapidly warming climate, in addition to the many other disturbances faced by plants and animals on the refuge including fire, invasive species, and nearby urbanization.

Tracy is very interested in mycorrhizal fungi. “The way I think about it,” she says, “is that their presence will allow or not allow things to grow. If they’re not there, it is really hard for new trees to establish.” Using her understanding of the important role mycorrhizae play in supporting forest growth, Tracy is assessing the presence and diversity of mycorrhizal fungi in the soil at a number of locations throughout the peninsula.

To identify these microscopic organisms, she collects soil samples and sends them to a partner lab for DNA sequencing. She will use her data to better understand the ability of the landscape to successfully adapt in a changing climate in the years to come.

Recently, we looked at the fungal communities from grasslands near Portage and in the Caribou Hills. These relatively simple plant communities have perhaps two dozen species of vascular plants growing above ground. But below ground, initial DNA sequencing detected 600 to 900 species of fungi in each 1½ teaspoon soil sample for a total of over 2,000 species!

By asking these big and interesting questions, we’ve been excited to get our hands dirty this summer exploring the ecological importance of mycorrhizae on the refuge. And we invite you to do the same, through finding a new respect for the network of tiny, hard-working fungi underneath your blueberry bushes. Whether you’re a gardener or a biologist, it turns out that paying closer attention to what’s happening below the ground could be more important than we realize.

Laura Bashor is a biological intern this summer at Kenai National Wildlife Refuge. She has a BA in Biology from Middlebury College in Vermont. Find more Refuge Notebook articles (1999—present) at https://www.fws.gov/refuge/Kenai/community/refuge_notebook.html.

Laying a foundation for a biologically richer world

by Tracy Melvin



Grasslands in the Caribou Hills, dominated by the native but invasive bluejoint reedgrass, support a seemingly sparse arthropod and plant community.

I spent considerable time this summer trekking around grasslands in the Caribou Hills with a giant red hula-hoop (to survey vegetation), a net and trowel (to survey arthropods above and below ground), and gallons of water mixed with mustard powder (to detect earthworms), all in the name of science. Our goal? To find out what lives there, how it all fits together, and what we might want to do to manage this evolving habitat on and around the Kenai National Wildlife Refuge.

I actually experienced vertigo out there a few times—when the wind whips around, it is as if you bob atop a fomenting green sea. This illusion is created by one extremely dominant grass, *Calamagrostis canadensis*, commonly known as bluejoint reedgrass. A native but aggressively-colonizing species, bluejoint expanded on parts of the Caribou Hills after repeated, unprecedented disturbances from both beetle kill and

human-caused wildfires in spring killed the spruce trees previously growing here.

Bluejoint is undoubtedly the ruler of this landscape, but what are its subjects and does it support a diverse biological community? We hypothesize that it actually does the opposite by excluding many species due to its thick, rhizomatous mat. If our data confirm this, our next step is to find out which species could help enrich biodiversity in this novel landscape, sustaining resilience in a rapidly warming future.

We seek to find a “foundation species”. Dr. Paul Dayton, from the Scripps Institute of Oceanography, coined the term a half century ago while conducting research at the famous McMurdo scientific base in Antarctica. Foundation species disproportionately influence the structure of their respective ecological communities by creating or maintaining the organization of a suite of interacting species that would other-

wise not persist.

Dayton discovered that beneath the ice of McMurdo Sound, a handful of species was key to laying the “foundation” for a resilient and diverse benthic community. When sewage from the research base disturbed the system, the relationships among predator (starfish), detritivore (starfish), and prey (sponges) became off-balanced with a predictive loss of other species through changes in relationships, nutrients, and habitat structure. Dayton concluded that focusing on foundation species would allow a rapid understanding of how a community as a whole would react to disturbances, rather than attempting to understand responses of all species simultaneously.

What are examples of foundation species here in the boreal biome? North American beavers directly create ecosystem structure by altering hydrology that benefits certain assemblages of vascular plant species, and altering biochemistry by slowing water currents that trap sediments and pollutants. They indirectly support vertebrate (including moose) and invertebrate populations that occupy beaver-modified landscapes. Eastern hemlock, in North America’s northeastern forests, is also a foundation species. The removal of this dominant species initially increases biodiversity as the understory changes to early-successional species but, in the longer term, simplifies structural diversity and ecosystem regulation (even the water table!) as the forest matures along a different ecological trajectory.

As a rapidly warming climate moves us towards a no-analog future with dire expectations of mass extinction, it challenges us to rethink how best to manage landscapes for wildlife. Perhaps here on the Kenai

Peninsula, could we help ameliorate the global biodiversity crisis by using foundation species as the biological engineers that they are? And how does our management response to a changing landscape fit into the larger conservation picture...300, 500, or even 3,000 miles away? These are the questions that keep me up at night.)

In the past, bison (and mammoths) might have played a role as a foundation species in much of Alaska, including the Kenai Peninsula. During the Pleistocene, the peninsula sat on the southern extent of an arid grassland that extended from Siberia to Alaska. This was a time when steppe bison roamed the Caribou Hills as horns found there carbon-date to 43,000 years ago. Like its modern descendants, woodland and plains bison, the steppe bison likely helped cycle nutrients (think poop), and created structure by digging wallows and compacting soil with their heavy hooves. They would have added species diversity and age structure with their sporadic and patchy grazing on graminoid species.

Currently, no large grazers occur on the Kenai Peninsula that can serve as a foundation species in our developing grassland complex, now spanning over 40,000 acres. If bluejoint reedgrass does indeed inhibit biodiversity with its thickening rhizomatous mat, there is much to be discussed about how to better steward this landscape by laying a strong “foundation”. We will keep you updated on the story that our data tell as it unfolds.

Tracy Melvin is a doctoral student at Michigan State University. Find more Refuge Notebook articles (1999—present) at https://www.fws.gov/Refuge/Kenai/community/Refuge_notebook.html.

Sign blindness

by Matt Conner



Lots of signs greet hikers at the trail head to Silver Lake on Kenai National Wildlife Refuge.

A couple of weeks ago, I drove a friend from Georgia around the Kenai Peninsula. He used to work as a park ranger (as do I) and remarked at how many visitors seemed to ignore signage on our tour. We watched an angler clean fish at the Kenai Lake boat launch right next to a “Do Not Clean Fish at Ramp” sign, a message that apparently did not apply to him. There was a great picture in this Sunday’s *Clarion* of a moose with a “Do Not Enter” sign wrapped around his antlers. I laughed and called my friend and said “wildlife don’t read signs either!”

I often wonder about the effectiveness of different communication styles. Perhaps the strangest is the communication of intended action through written signage. I was once asked to review a nature center and give feedback on the visitor experience. Walking from the parking lot to their visitor center, I was

greeted by several written recommendations of behaviors I was urged not to indulge or participate in. The first sign read “Do Not Park on the Grass.” Not a problem as mine was one of three cars in an ample and mostly empty parking lot, but I imagined this sign resulted from recurring times when all the spots fill and people park on the grass.

As I walked down the short trail to their visitor center, I was greeted by three more behavior modification notifications: “Do Not Pick the Flowers”, “Do Not Go Off the Trail,” and “Do Not Litter.” To be fair, each of these notifications did begin with the word, “please.” Chuckling out loud as I walked up the steps to the visitor center, I wondered how I would be greeted in person after the signage had informed me of all the ways I could fail as a visitor. To my surprise, a warm smile and a welcoming spirit greeted me, “Welcome to the Nature Center! Please feel free to ask any questions and walk the trails, enjoy the solitude, and I hope you have the opportunity to enjoy nature and wildlife during your visit.”

I hiked the trails, read the exhibits, held down a park bench for a spell before returning to their visitor center. The same friendly ranger welcomed me again with “Do you have any questions about the Nature Center before you depart?” I paused, shuffled my feet a bit, and then said, “Yes, but I do not wish to offend.” She perked up and said that now I had to share.

I answered with a question: “How many visitors this year have you had problems with parking on the grass?” Her brow contorted slightly as she explained that two years ago they hosted a special event during which the parking lot overflowed and some cars parked on the grass, prompting management to place signs to discourage that behavior.

I responded with a second question. “How many visitors do you have a year and how many of those park on the grass on average?” She replied they had 60,000 visitors annually and typically nobody parks on the grass unless there is an unusual event occurring.

I asked a third question. “So 60,000 visitors a year read the DON’T messages because on a rare occurrence, one or two people act inappropriately?” This time I offered a statement. “How about welcome to

your nature center instead of all the don'ts?"

It is easy to do. Whether it is notes in the break-room about cleaning up the microwave or reminders about cleaning out leftovers from the fridge, "signs happen." And they seem to attract more signs once we start down this path.

At the Kenai Refuge Visitor Center, we use signs to get critical information to our visitors about safety, regulations, and refuge information. However, we have learned that the more signage we put up, the fewer signs people read—a phenomenon called "sign blindness". So when our kiosks get a bit "signy", we start removing less critical information.

We have learned that tone of the message is important as well. In graduate school, we learned of a study that correlated the number of bullet holes in signs to message tone. The study showed that the more negative the message, the more bullet holes it had. Of course, nothing justifies defacing a public sign, but it is still an interesting relationship.

I think the secret to effective messaging is positive voice. We need to explain to others what we want to see them do versus what we don't want them to do.

So replace "Don't Go Off the Trail" with "Please Stay on the Trail to Protect Wildlife" or consider "Leave the Plants as They Are for Others to Enjoy" instead of "Don't Pick the Plants".

I try to use this philosophy in all forms of communication. Instead of focusing on the negative, I offer the positive of what actions we would like to see. I have noticed that the results are effective, and whether speaking to friends, family or visitors, all of us prefer to be told how to succeed rather than ways we can fail.

I think we will always have some people who disregard our suggestions by signage or verbal communication, but perhaps each of us can help protect our public lands by sharing positive messages of behavior. This can be applied to everything from proper food storage in campgrounds to protect wildlife and visitors, or to places where it is appropriate to clean fish and dispose of waste. Hopefully we can accomplish this without blanketing the roads with more signs.

Matt Conner is the Visitor Services Manager at Kenai National Wildlife Refuge. Find more information at <http://kenai.fws.gov> or <http://www.facebook.com/kenainationalwildliferefuge>.

The gift of graduate students

by John Morton



Sadie Ulman studied how shorebirds used Chickaloon Flats in 2009–10 as a graduate student at the University of Delaware-Dover. She now works for the Alaska SeaLife Center in Seward (credit: Sean Ulman).

These days, with internet search engines making information so accessible, it's easy to forget how tedious the collection of scientific data can be. Certainly in the natural world, where there is a lot of inherent variation among seasons or between years, it shouldn't be surprising that field studies usually take at least two years. And high variation across landscapes or within populations of the same species demands repeated sampling sometimes over large and remote areas, especially in Alaska.

These attributes make statistically-rigorous field work in the natural sciences so difficult for agency biologists to accomplish. Most biologists, such as myself, have other duties to juggle at our work place. We frequently research multiple issues at any given moment, respond daily to many queries from colleagues and our publics, plan workshops or public meetings, write reports and articles, apply for permits, receive

or provide training, give presentations, work on contracts, and deal with sometimes mind-numbing administrative tasks required of government employees.

The solution, at least for me, is to have graduate students. These young men and women are intelligent and motivated, whose sole purpose at this point in their life is to collect enough data to defend their master's thesis or doctoral dissertation. It is wonderful to have them around the office as their passion reminds me of why I got into Wildlife Ecology in the first place. And our intellectual discussions over coffee or beer (after hours) keep me engaged and entertained in real time.

My first graduate student at the Kenai Refuge was Caleb Slemmons from Miami University in Ohio. When he started in 2005, the Refuge was all but ignoring invasive plants. By the end of his tenure, Caleb had conducted the first of many exotic plant surveys,

produced a brochure for identifying common invasives, and helped us begin the aggressive management program we now have in place. Caleb subsequently founded the Kenai Peninsula Cooperative Weed Management Area partnership through the Homer Soil & Water Conservation District.

Matt Bowser and Dawn Magness both completed their masters and doctorate, respectively, at the University of Alaska Fairbanks (UAF) in 2009. Matt processed 15,000 arthropod specimens to help populate our current inventory of over 2,000 species. Matt is now the Refuge's entomologist and, I believe, the only one in the entire National Wildlife Refuge System (NWRS)!

Dawn's dissertation on how the NWRS, its managers and biologists are poised to address climate change was ahead of its time. She showed how risk models could be used to systematically manage the more than 500 Refuges to ensure an ecologically coherent response to climate change. Dr. Magness is now the Refuge's landscape ecologist, one of only a few in the entire U.S. Fish and Wildlife Service.

Kim Sager also earned her graduate degree in 2009 from the Alaska Pacific University. Her thesis evaluated the habitats of three passerines that nest at different forest canopy heights on the Kenai Peninsula: Yellow-rumped warbler (high), Varied thrush (medium) and Dark-eyed junco (low). Kim now works for the Alaska Department of Natural Resources.

Also in 2009, Andy Baltensperger completed his thesis at Colorado State University on why American marten colonized the Kenai Lowlands in recent years. He showed that the range expansion was likely due to warmer winters, particularly at night, which allow marten to survive even without an insulating snow pack. Dr. Baltensperger now works for the National Park Service.

As a University of Delaware graduate student, Sadie Ulman completed her thesis on shorebird use of Chickaloon Flats in 2012. As part of her study, she quantified vegetation change on this estuary as its rebounded from the 1964 Alaska Earthquake. Sadie

is now a Research Associate with the Alaska SeaLife Center in Seward.

As part of his doctoral program at UAF, Tim Mullet defended his dissertation on the ecological effects of snowmachine traffic in 2014. Along the way, Tim developed a creative approach to modeling the winter "soundscape" across the 2-million-acre Kenai Refuge, perhaps the first to model the distribution of different sounds over such a large area. Dr. Mullet is now the ecologist at Kenai Fjords National Park.

My current graduate student, Tracy Melvin from Michigan State University, works closely with me to figure out smart approaches to steward ecological outcomes in response to a warming climate. She is considering ways of not only sustaining biodiversity, but increasing it as part of her doctoral research.

Other graduate students working on the Kenai Refuge over past decades have helped answer questions about wolf pack dynamics in response to harvest management, occurrence and distribution of exotic earthworms, public perceptions of brown and black bears, moose browse regeneration in response to prescribed fire and mechanical treatments, and lichen response to caribou browsing. Graduate students helped estimate rates of drying wetlands and rising treeline, mean fire return interval in black spruce, and carbon loss in peatlands.

I hope you now appreciate that graduate students contribute much to our understanding of the ecology of the Kenai Peninsula, as well as to the broader arena of wildlife science and management. Many have ended up contributing even more by becoming part of our communities as professional biologists with local agencies and organizations. Precisely because they had to work really hard collecting scientific data to earn their degrees, we become the recipients of these gifts—it's a win-win outcome!

Dr. John Morton is the supervisory biologist at Kenai National Wildlife Refuge. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/Refuge/Kenai/community/Refuge_notebook.html.

A tale of two refuges

by Scott Johnson



Will Jenks, Christa Kennedy and Scott Johnson on fire assignment at Malheur National Wildlife Refuge last month.

This past August, I had the unique experience of traveling to Malheur National Wildlife Refuge in Princeton, Oregon. While most people visiting Malheur come to see migratory birds at Lake Malheur and its associated wetlands, I came to patrol its vast landscapes while on-call to respond to wildfires. I travelled with two others from the Kenai National Wildlife Refuge, my engine captain, Will, and another qualified

firefighter, Christa. We were dispatched to four fires altogether, with three of the four calls occurring just before or after dark.

Nearly 2,000 miles separate the Kenai Refuge from the Malheur Refuge, so it was somewhat surprising to find similarities in their geography. Both the Kenai and Malheur were shaped by glaciers. When we drove on the Steens Loop Road on Malheur, I was amazed by how much this massive fault-block mountain reminded me of hiking the alpine zones of the Kenai. The sub-alpine grassland was expansive and the valleys below stretched out for hundreds of miles. It generated a feeling of grandness that I only feel when exploring wilderness—the Steens Mountain Wilderness Area is over 170,000 acres.

But it was also very different than the Kenai. Aside from being much hotter and dryer, the Steens is home to the wild Kiger Mustangs, which are celebrated as very beautiful horses. This is much different than the wild moose that run amok on the Kenai, with their goofy gates and droopy gazes.

The main water source for Lake Malheur is the Donner und Blitzen River, which starts as an intermittent stream in Steens Mountain and finds its way through glaciated valleys and canyons as it snakes through marshes in the high desert. The river does not pass through a single town.

I looked up why the river was given a German name meaning “thunder and lightning”. In 1864, a unit of the 1st Oregon Cavalry was sent to protect settlements from the Paiute tribe. The unit was led across the river during a storm by Captain George B. Curry, who named the river and happened to be from Indiana. So I didn’t find out why it has a German name, but sometimes mystery is more powerful than truth. Malheur gets a lot of lightning, most of which is dry lightning. This, combined with persistent hot and dry weather, is the reason for severe fire danger.

It was 19:30—military time for 7:30pm. We had thirty minutes remaining in our shift and we were excited for dinner and early bed. Just then, our sister engine E-624 sent a crewmember, Phillip, over to tell us that we had a fire. It was off district and all resources there were exhausted—they were probably

tired, too, but this means we were needed to respond. We grabbed what prepared food we could find and hit the road.

At 21:30, we arrived on scene. Local volunteers had been working the fire with a dozer, several ATVs and a Unimog. The Incident Commander at that time was helitacked from Vale, Oregon, and was without transportation, as he was dropped off with a three-person crew via helicopter to help get a handle on the 80 acre blaze.

We reconfigured our radios to the new district's frequencies and began moving to where the fire activity had unexpectedly increased since our arrival. Travel in our truck along the dozer line was slow. We staffed a type-four engine which requires a CDL and carries 750 gallons of water. I had to remove rocks on several occasions that were lodged between the rear dual tires.

As we got around the fire, it was traveling towards us from the west with a 5 mph wind behind it. It was hard to see how close it was to us, as we were a couple hundred feet away from a box canyon rim, with the fire below. We decided to get a closer look on foot to check the fire's intensity. It was moving slowly but steadily up the slope toward the lip of the rim we stood on.

We returned to the engine, fired up the pump and wetted down the area surrounding the dozer. The dozer had broken down on the wrong side of the line, so our priority was to protect it. Once the fire burned over the lip of the canyon rim, the winds increased and

fire ate away at sage and cheat grass until embers were flying across the line. When the smoke became dense enough, it felt like bear spray or wasabi, eyes watered and nose ran uncontrollably.

We continued to protect the dozer and repositioned to wet down the line where fire activity was most extreme. Only a few minutes had seemingly passed, but we repositioned the engine on a steep and narrow dozer line several times before the fire quieted down.

At 0130, the Incident Commander radioed that if we thought the fire was going to be secure for the night we should try to get some sleep. But the dozer was still inoperable; one of its rods had come off the arm that holds the blade. We attempted to assist with our pneumatic jack and shovels for the next hour without success.

Before crawling into our sleeping bags, we relocated to a more solid black part of the fire—an area of the fire that had burned earlier and is not likely to burn again. We looked up at the stars above and saw lightning in the distance.

Scott Johnson is the trail crew leader at Kenai National Wildlife Refuge who has also worked wild-land fires as collateral duty for the past nine years. His favorite season is winter, where he explores the Kenai Peninsula's backcountry while skiing gnarly lines. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/Refuge/Kenai/community/Refuge_notebook.html.

Traditional hand tools maintain trails in Kenai Wilderness

by Christa Kennedy



Christa Kennedy and Izzie Giacomangeli double-buck a downed tree in July on Surprise Creek Trail within the Andrew Simons Wilderness Unit.

The Kenai National Wildlife Refuge is 1.92 million acres. What many people don't realize is that 1.3 million acres of this was designated as Kenai Wilderness by the U.S. Congress in 1980. Our designated Wilderness is divided, in turn, into three different wilderness units.

The Dave Spencer Wilderness Unit includes both the Swan Lake and Swanson River canoe systems that contain over 100 miles of lakes, portages, and small rivers. The Mystery Creek Unit, located north of the Sterling Highway from Milepost 55 to 61, plays home to the Skyline and Fuller Lakes Trails. The largest of the three units, the Andrew Simons Wilderness, embraces refuge lands south of Skilak Lake down to the Caribou Hills, including 50 miles of trails mostly on the Tustumena Benchlands.

These three units hold the majority of trail miles within the National Wildlife Refuge System. You

might expect the Refuge's trail crew would use chain saws, all-terrain vehicles and other power tools for trail maintenance, but that's not the case. The 1964 Wilderness Act tell us to protect and preserve wilderness character, specifically prohibiting the use of mechanized and motorized tools to protect lands and habitats.

We have used chainsaws in the past in Kenai Wilderness but, over the last several years, our trail crew has received training to help us better manage in ways that are more consistent with wilderness legislation and policy. In spring 2017, the trail crew completed a week-long course to help build our knowledge and skill level in using traditional hand tools to log out and brush our wilderness trails.

You might think it can't be that difficult to get into the swing of things, right? Well, we spent one and a half days just making a personal hand-crafted axe for

each crew member, ensuring that our axe heads were firmly and correctly set on their axe handle, which we custom-fitted to each individual.

The first step is getting the correct handle length for each member. We then shave the handle so its width fits comfortably in our hands. The third step is to sharpen the axe's blade. We start with a file, but eventually move on to a sharpening stone. Just squirt a little WD-40 on the stone and rub it in a circular motion on the blade's edge. Once the blade is sharp enough to cut off arm hair, the axe is almost ready for the field. In the final step, we rub linseed oil into the handle to protect it and help it last longer.

We also learned to use a crosscut saw. We quickly discovered that using a crosscut saw takes teamwork and good communication if the plan is to double buck. Just like when using a chainsaw, we have to determine what kind of bind the tree has, making sure wedges are placed at the right time and place so the saw doesn't get pinched in the tree.

There are a few golden rules to follow when double-bucking. Start your buck in a spot on the log without any knots in or around the area, but that's way

easier said than done. Never push the saw—always pull. Allow your partner to pull the saw while you just guide it. Conversely, when you pull the saw, your partner guides the saw, ensuring an even amount of wood is taken with each stroke. The bucking partners also need to decide when to place a wedge to keep the cut open. Finally, as the bucking partners approach the end of their cut, they'll have to decide if it's better to finish as a double or single buck.

With our new training, the Kenai trail crew has moved completely away from mechanized and motorized tools to using nothing but traditional tools within the three wilderness units. As we are still learning to master these tools, we are a bit slower at maintaining the trails. The trade-off is that you and other visitors will be able to enjoy the solitude of Kenai Wilderness and not see the tale-tell signs of modern machinery.

Christa Kennedy is the Trails Volunteer Coordinator for the Kenai National Wildlife Refuge. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/Refuge/Kenai/community/Refuge_notebook.html.

Why seagulls have a red dot on their bill

by John Morton



When Herring Gull nestlings peck at the red dot on their parent's bill, the parents regurgitate food. Is this an instinctive or learned behavior? (photo credit: Todd Eskelin)

There are lots of “seagulls” flying around the Kenai Peninsula. At the mouth of the Kenai River alone, more than 30,000 Herring and Glaucous-winged Gulls have taken up residence!

Have you ever stopped to really look at one? Have you noticed the red dot near the tip of the lower bill? Have you ever wondered why it is there?

If you answer ‘yes’ to these questions, then you’ve got the hallmarks of a good naturalist. If you choose to research it, you’re on the path to being a scientist. If you take it so far as to conduct experiments, you might

even win a Nobel Prize.

That’s precisely what happened to Nikolaas (Niko) Tinbergen. This Dutch ornithologist, a professor for many years at Oxford University, was co-awarded the Nobel Prize in Physiology or Medicine in 1973 partly for figuring out what that red dot does.

Gull nestlings peck at the red dot to get their parents to regurgitate food to them. But this relationship is much more complex than that. During the summer of 1946, right after WWII ended, Dr. Tinbergen and his students used gull dummies (cutouts and plaster

effigies) to investigate which stimuli gull chicks responded to the most. By varying the color, contrast, head shape, bill shape, and the position and “lowness” of the bill, Tinbergen was able to demonstrate that this innate behavior of pecking was elicited by the red color of the dot contrasted against the yellow bill.

Tinbergen used this information to see if he could improve on nature. He created a “supernormal” stimulus by painting three white rings at the end of a long red rod. This abstract dummy received 26 percent more pecks than a three-dimensional realistic plaster model of a gull’s head and bill.

“Big deal”, you might say disparagingly. Tinbergen shared this Nobel Prize with Karl von Frisch and Konrad Lorenz, who figured out how bees communicate by “dancing” and how goslings imprint on their goose parents, respectively. All three biologists showed how some behaviors are innate or genetically-programmed (as opposed to learned), triggered by specific key stimuli. Collectively, these three founded the modern field of ethology, or the study of animal behavior.

The press release for this Nobel Prize addresses the significance of these scientists and their work to the rest of humanity. “Man is [also] equipped with a number of fixed action patterns, elicited by specific key stimuli. This holds true for the smile of the infant and for the behavior of a mother to her newborn

child. Psychosocial situations leading to conflicts, for example as a result of disturbances of the social organization of an animal society, may lead both to abnormal behavior and to somatic diseases such as hypertension and myocardial infarction. Research within these fields has led to important results, for example psychiatry and psychosomatic medicine, especially as regards possible means of adapting environment to the biological equipment of man with the aim of preventing maladaptation and disease.”

In his Nobel Lecture, Dr. Tinbergen addressed the unorthodox decision of awarding this prize to three men who had previously been regarded as “mere animal watchers”. Tinbergen stated that their revival of the “watching and wondering” approach to studying behavior could indeed contribute to the relief of human suffering.

I encourage you to read *The Herring Gull’s World* (1960), a book written by Dr. Tinbergen in such an engaging way that even the nonscientist can appreciate the wonder of gull behaviors. And take notice the next time you see a gull (or a goose or a bee) in your wanderings on the Kenai Peninsula—there’s certainly more there than meets the casual eye.

Dr. John Morton is the supervisory biologist at Kenai National Wildlife Refuge. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/Refuge/Kenai/community/Refuge_notebook.html.

The next generation of conservation pilots

by Mark Laker



Some of the eleven U.S. Fish & Wildlife Service students training on the Kenai National Wildlife Refuge to become UAS pilots (credit: Brian Mullin, USFWS)

If you were out at the Marsh Lake trailhead in the Skilak Wildlife Recreation Area, perhaps you noticed several groups of people looking into the sky. I witnessed a few vehicles stop to see what everyone was looking at. Often wildlife draws attention here, but on that day in late August, folks were watching drones.

The eleven operators were students hoping to become part of the next generation of U.S. Fish & Wildlife Service pilots. However, these pilots won't be sitting in an aircraft, but will instead be flying them remotely.

The students were training to operate a small

quadcopter. It may look like a toy, but it is capable of carrying an array of sophisticated sensors, operating autonomously, and flying in conditions or places manned aircraft can't. All that said, my kids still consider it a toy that I play with at work.

The students learned to how to maneuver the Unmanned Aerial System (UAS, also known as drones), operate sensors, and respond to system failures that could affect their ability to control the aircraft. Most folks have no problem maneuvering the UAS, especially if they operated a remote control toy before. If

not, it can be a challenge to train your brain to steer it the correct way when it's facing a different direction. It's kind of like backing up a trailer using mirrors for the first time.

The UAS program within the U.S. Fish & Wildlife Service started only last year. With the millions of consumer UAS out there, it's easy to forget how quickly they have become common place. However, it was only about five years ago that the consumer and Do-It-Yourself drone industry kicked into high gear. Shortly thereafter, these inexpensive UASs were everywhere, carrying things, dropping things and taking pictures.

It didn't take long before they were eyed by biologists who viewed them as a tool instead of a toy. As tantalizing as these potential tools are, they are also fast flying objects relying on a responsible human and numerous complex systems working together to keep them from crashing and causing harm. What could possibly go wrong?

That is why the Federal Aviation Administration, the agency charged with administering our National Airspace, considers them aircraft. Fortunately, the Department of Interior (DOI) aviation folks had been engaged with the rapidly changing technology and regulations, and provided guidance and training to those human operators. The demand for training has outpaced the supply. The limiting factor has been the number of qualified instructors. As one of the initial remote pilots, I agreed to become an instructor to help build the program.

It has been great to see the wave of innovation and creativity in just the last couple years from our UAS pilots. Much like satellites provided ecologists with a landscape view, UASs are giving scientists local-scale remote-sensed data. Direct wildlife observations and measurements can change animals' behavior, potentially affecting study results. Remote sensing instru-

ments can often collect the same data without interaction or effect.

These inexpensive aircraft have delivered aviation and remote sensing to the masses and, with them, innovative solutions to a wide range of challenges. Here are just a couple examples. DOI remote pilots have been onsite at the Kilauea Volcano in Hawaii for many months providing real time information on lava flows to protect resources and search for people in harm's way. In one instance, a UAS was used to guide an individual trapped by lava flow to safety. As tools for wildland firefighting, UAS have time and again proved their mettle by both assisting firefighters and keeping them safe.

We utilized what we learned from last year's pilot survey of nesting Aleutian terns here at Headquarters Lake to develop new techniques that will allow biologists to greatly increase the efficiency and quality of nest surveys. Remote pilots on National Wildlife Refuges across the country have been pioneering new methods to survey a wide variety of wildlife. The use of UAS is energizing ecological studies by providing new data from a bird's eye view.

You may be wondering how those students did. Everyone passed—it was almost disappointingly uneventful, not even a broken propeller! In past classes I've had to dive out of the way, grab the controls, and witness some dramatic crashes.

With these 11 next generation pilots, the U.S. Fish and Wildlife Service has 47 remote UAS pilots, eight of which are in Alaska. I'm confident they will continue to innovate and find creative and effective ways to conserve our wild lands.

Mark Laker is an ecologist at the Kenai National Wildlife Refuge. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/refuge/Kenai/community/refuge_notebook.html.

Where two cottonwood mix

by Dawn Robin Magness



Cottonwood bark and leaves. Photo credit: Jason Grant; iNaturalist (<https://www.inaturalist.org/photos/20118013>).

The natural landscapes of the Kenai Peninsula host about 60% of Alaskan tree species, but when it comes to *Populus*, we have it all. Three species in this genus occur in Alaska and on the Kenai, quaking aspen (*Populus tremuloides*), balsam cottonwood (*P. balsamifera*), and black cottonwood (*P. trichocarpa*). *Populus* trees are deciduous, meaning they have broad leaves that are lost each winter. Young trees have smooth bark.

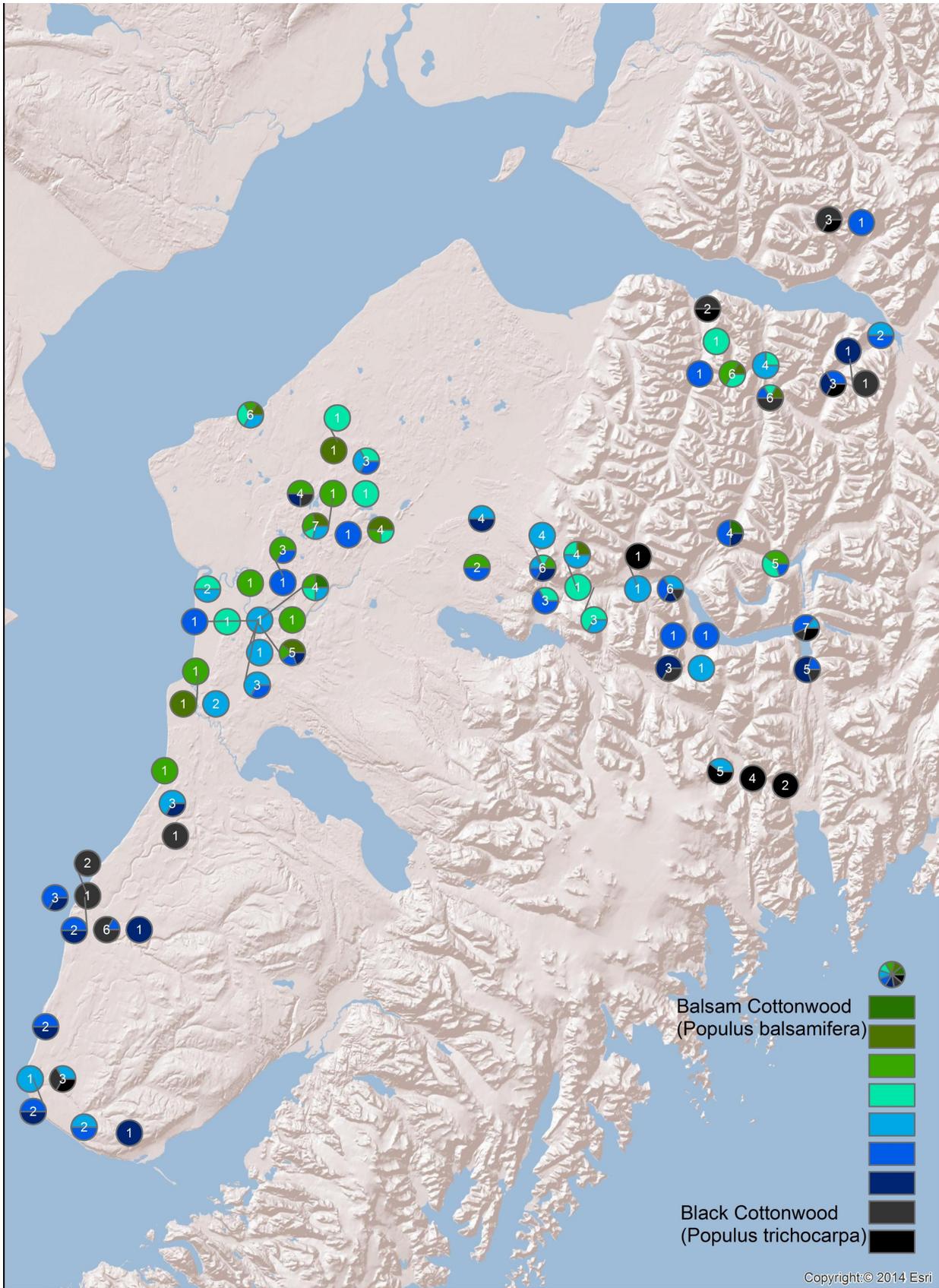
Aspen are easily distinguishable from the cottonwoods. The species name, *tremuloides*, alludes to the unique qualities of the leaves. Aspen leaves are round and thin, yet slightly stiff. The stems are flattened. A slight breeze will cause the entire tree to tremble or

quake. The bark tends to remain smooth as the tree ages. Aspen can send out clone shoots and form large stands that are interconnected by a huge root system.

Balsam and black cottonwood are much harder to tell apart from one another. They look identical, except for minor differences in the flowers. Both are large trees that grow quickly with bark that becomes furrowed with age. Both have sticky leaf buds and the female trees unleash cottony seeds from their long catkins. They are so similar that botanists sometimes lump them together as subspecies. More often, they are considered separate species because of geographic separation. Balsam cottonwood is distributed across the boreal forest of Interior Alaska. Black cottonwood runs along the coasts through Southeast Alaska up to the Kenai.

Balsam and black cottonwood also have genetic differences. Genetic evidence linked to information about each species' ecological niche supports the hypothesis that balsam and black cottonwood diverged about 75,000 years ago in the late Pleistocene. At that time, ice rapidly expanded and the ancestors of these two species appear to have been geographically separated. Now that the ice has retreated, their distributions have expanded and touch along the margins. Balsam and black cottonwood can hybridize in the regions where they meet, such as, the Kenai Peninsula.

In the 1970s, Leslie Viereck and Joan Foote collected cottonwood flowers in Alaska to map and describe the hybrid zone. They created a key to score if a flower was pure balsam, pure black or a hybrid. Cottonwood trees are either male or female. Each cotton-producing catkin on a female tree consists of many small flowers. Balsam flowers are oval shaped, leathery, and split into two pieces (have two carpels) to release the seeds. Black cottonwood flowers are round, hairy and split into three or four parts hence the name *trichocarpa*. Viereck and Foote coarsely mapped the western lowlands of the Kenai to be a hybrid zone and the eastern side of the Kenai Mountains to be within the range of black cottonwood.



Pie charts depict the hybrid score of cottonwood trees. Green indicates balsam cottonwood, blue represents hybrids, and black is black cottonwood. The number of trees sampled is noted in each pie.

This summer, I collected catkins from nearly two hundred trees across the Kenai to get a more detailed understanding of what and where cottonwoods currently occur. The map shows pie charts of the hybrid scores of trees for each location I sampled. Within a stand, balsam and black individuals can be side by side with hybrids. Cottonwood pollen is wind born, so I expected that balsam and black trees would have no problem mixing together.

From my samples, the Kenai Lowlands north of Tustumena Lake tended to have balsam and hybrids transitioning to hybrids and black cottonwood south of Tustumena around Ninilchik. Seward tended to have black cottonwoods and hybrids. This pattern aligns with the distribution of the coastal rainforest biome (black cottonwood) and the boreal biome (balsam) that meet around the Kenai Mountains. Interestingly, Cooper Landing and the highway corridor along Six-mile Creek hosted the whole spectrum of cottonwood.

The Kenai National Wildlife Refuge has a congressionally mandated purpose “to conserve fish and

wildlife populations and habitats in their natural diversity”. Biological diversity is an important theme in conservation. Aldo Leopold, the father of game management, believed our land ethic as natural resource managers should include “keeping every cog in the wheel”. He believed it was crucial for “intelligent tinkering” because we may not understand how each species contributes to the whole ecosystem or how they may contribute as conditions change. The Kenai sits where two biomes meet and this unique geography blesses us with more cogs. My hope is the diversity we have here on the Kenai will help our landscape be resilient and adaptive long into the future. Understanding the patterns of diversity today is a prerequisite to understanding which species are winning and losing in the hybrid zone as our climate changes.

Dawn Robin Magness is an ecologist at the Kenai National Wildlife Refuge.

Previous Refuge Notebook articles can be viewed on our website <http://kenai.fws.gov/>. You can check on new bird arrivals or report your bird sighting on the Kenai National Wildlife Refuge Birding Hotline (907) 262-2300.

The impermanence of permafrost

by John Morton



A telltale sign of thawing permafrost plateaus is when black spruce growing in the overlying soil starts to tilt, eventually to fall over (photo credit = Ed Berg).

Ohio experienced a record high temperature of 89 degrees last week as I was driving from Cleveland to Vermont. Strangely enough, I was listening to a podcast about thawing permafrost in Fairbanks, specifically in a tunnel at the Cold Regions Research and Engineering Laboratory. This tunnel is roughly 50 feet underground and 360 feet in length.

Named the Permafrost Tunnel Research Facility, this tunnel literally carves through 40,000 years of the tail end of the Pleistocene and all of the Holocene. You can see intact willows and grass, frozen timelessly,

alongside the remains of steppe bison and mammoths. I encourage you to peak at the photos and videos on [their website](#).

This facility was dug during 1963–1969 to study underground excavation methods in permafrost. However, it didn't take long before scientists realized that this underground perspective also lent itself to studying geology and paleoecology in a “living” laboratory. Seriously. A bacterium, now called *Carnobacterium pleistocenium*, sat frozen for 32,000 years until 2005, when it started swimming around after being

thawed from this tunnel.

What is permafrost? It is simply ground that remains at or below freezing for at least two consecutive years. Twenty-four percent of the Northern Hemisphere has permafrost, but 80 percent of Alaska has permafrost. However, the distribution of permafrost within a landscape varies—it can be continuous (>90%), discontinuous (50–90%), sporadic (10–50%) or isolated (10%). North of the Brooks Range, the ground is continuous permafrost, frozen to a depth of 2,000 feet or more. Most of Interior Alaska has discontinuous permafrost.

Why care about permafrost? After all, it's just frozen ground. But if you've paid any attention to concerns about thawing permafrost in Alaska, you'll realize that it's a big deal. A 2007 study conducted by the University of Alaska Anchorage's Institute of Social and Economic Research estimated damage from climate change, primarily thawing permafrost effects on road and rail infrastructure, could cost the state \$6 billion by 2030. Thawing permafrost along the Beaufort and Chukchi Seas is accelerating coastline erosion. And, if you think the climate is warming rapidly now, consider that the amount of carbon in permafrost, released as carbon dioxide or methane, is twice what is currently in the atmosphere!

Here on the Kenai Peninsula, permafrost is almost nonexistent. A statewide mapping effort by Torre Jorgenson and his colleagues in 2008 indicates that permafrost is absent from the western peninsula except for isolated patches in the Nikiski area. Retired Kenai Refuge ecologist Ed Berg described finding a permafrost pocket in the Kenai Lowlands northeast of Sterling in 2009.

That's what makes a [2016 study](#) published in the journal, *The Cryosphere*, so interesting. Authored by Ben Jones at the USGS Science Center in Anchorage and his colleagues, it documents the dynamics of small permafrost plateaus around Browns Lake (east of Funny River) on the Kenai National Wildlife Refuge. They showed that the ice encountered was indeed permafrost, but barely so, maintaining its temperature just below freezing at -0.04 to -0.08 degrees Celsius. The permafrost depth ranged from 1 foot to almost 21 feet!

What's fascinating about this work is that this

residual permafrost from a colder era exists in our part of the world where the mean annual air temperature is above freezing, 1.5 degrees Celsius to be exact. What allows the permafrost to persist in our warming environment is the insulating vegetation layer, composed mostly of black spruce and *Sphagnum*, that now grows in the unfrozen soil overlaying the permafrost.

Just how insulating this vegetation can be was best demonstrated at the permafrost tunnel in Fairbanks. There, three experimental plots were laid out in 1946. One plot was left undisturbed, the second was cleared of trees but their roots and organic material left, and the third plot was stripped of all vegetation and surface organic material. The findings after 25 years suggest that partial clearing degraded the permafrost to 15 feet below the surface, while complete stripping degraded permafrost to 22 feet below the surface. In a more recent study, the partially cleared plot had grown back its vegetation and the degradation has stabilized, but the completely stripped site has continued to degrade to 32 feet!

Back on the Kenai, Dr. Jones and his colleagues examined historic aerial photographs. One of the tell-tale signs of the thawing of permafrost plateaus is that the black spruce growing there starts to tilt, eventually falling over. They found that 60 percent of the permafrost plateaus present around Browns Lake in 1950 severely degraded by 2010, leading to replacement of black spruce forest by *Sphagnum* fens or bogs. This loss translates to 1 percent of surface area per year, the second fastest change rate reported to date in the scientific literature on boreal peatlands.

The Kenai Fire burned the Browns Lake area in 1947, which certainly removed some of the insulating vegetation and contributed to loss of these permafrost plateaus. But the rapid thawing of these pockets of permafrost is clearly linked to a warming climate, particularly increasing nighttime temperatures during the winter in recent decades. We can still freeze the ground several feet deep in a cold winter, but we get it all back in the summer and permafrost never gets started nowadays.

Dr. John Morton is the supervisory biologist at Kenai National Wildlife Refuge. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/Refuge/Kenai/community/Refuge_notebook.html.

Alaska blackfish on the Kenai

by Matt Bowser



An Alaska blackfish from a stream in Kenai (credit: Lucas Byker, ADF&G).

Recently I stopped by a shallow, scuzzy pond by Candlelight Drive in Kenai to look for Alaska blackfish. I had heard that they had been found in the stream that runs through the Kenai Golf Course downstream of this little pond. The fish were not hard to find. As I walked along the squishy shore, a few 6-inch long blackfish darted from the shoreline. One dove into the mud by the shore, a typical behavior for this remarkable species.

The Alaska blackfish is the only air-breathing fish in the arctic and one of only three fish species in the world that obtain atmospheric oxygen through a mod-

ified esophagus. This ability to breathe air allows them to thrive in shallow, weedy, mucky wetlands where other fish would die due to lack of oxygen. Blackfish reportedly can burrow into wetland moss when water levels drop temporarily, surviving as long as they remain moist. In winter, blackfish sometimes breathe air through holes in the ice made by muskrats.

The cold-hardiness of Alaska blackfish is legendary, with multiple reports of these fish apparently coming back to life after having been frozen. Subsequent studies demonstrated that blackfish cannot survive being completely frozen. Nonetheless, they are

extremely hardy and can remain active under the ice in oxygen-poor lakes and ponds where other fish may not survive.

Known in the Iñupiaq language as *iluuqiniq*, which describes it as a dark-skinned bottom dweller, and in the Koyukon language as *oonyeeyh*, which means “the one you survive on,” the blackfish has long been harvested by Alaska’s indigenous peoples as food for themselves and their dogs. In late winter when other fresh food sources were scarce, these fish were caught in specially designed traps where they gathered under openings in the ice to gulp air. Though blackfish are only 7–8 inches in length, they can be taken in large quantities and are considered to be extremely nutritious.

In the geologic past, Alaska blackfish ranged over a broad area from eastern Russia to southcentral Alaska. A fossil specimen found in the Homer area shows that blackfish were once present on the Kenai Peninsula. In recent times this species occurs naturally in eastern Russia and western, northern, and Interior Alaska.

Until lately, blackfish had long been absent from southcentral Alaska. Bob Chlupach, a retired Alaska Department of Fish & Game (ADF&G) biologist who studied blackfish in the 1970s, told me that blackfish were accidentally transported to Anchorage in the 1950s. The story was that a U.S. Fish & Wildlife Service Grumman Goose seaplane had flown into Lake Hood from Bethel. As the plane was brought out of the water onto a concrete ramp and drained, live blackfish were discharged from the plane into the lake. There is also a 1959 article in the *Fairbanks Daily News-Miner* detailing how 300 Alaska blackfish were temporarily kept in bins in Lake Hood on their way to the National Aquarium in Washington, D.C.

From Lake Hood, blackfish made their way through connected wetlands to other Anchorage water bodies. Later, blackfish were transported intentionally or unintentionally to waters in the Palmer and Wasilla area, where they flourished.

By the 1970s, Alaska blackfish were suspected of causing declines of sportfish in Anchorage lakes. In 1972 an attempt was made to eradicate blackfish in Anchorage’s Jewel Lake using rotenone, a poison that interferes with respiration, but the air-breathing blackfish persisted.

In the 1990s, ADF&G biologists Terry Bendock and

Jeff Breakfield found Alaska blackfish in the City of Kenai. The fish now occupy two streams: the unnamed creek that flows through the Kenai Golf Course and the unnamed stream that runs under the Spur Highway between Walmart and the Kenai New Life Assembly of God. Both streams drain into the brackish waters of the lower Kenai River that is not good habitat for blackfish. This barrier has apparently kept them from spreading to other streams in the Kenai River drainage, but blackfish have reportedly showed up farther north in the string bog off of Marathon Road.

Local biologists do not know how Alaska blackfish were brought to the City of Kenai. We also cannot say how long the Kenai blackfish population will remain contained within the two aforementioned streams and surrounding wetlands. We do know that blackfish are hard to get rid of and that their presence will change things.

How introduced blackfish will fit in to the Kenai River system is difficult to forecast, but we can make a few predictions. This exceptionally tough air breather will be able to colonize currently fishless swamps and small ponds. Larger fish, river otters, mink, loons, grebes, terns, and people eat blackfish, so these predators may benefit.

As they do in other places, blackfish will voraciously consume aquatic insects and tiny crustaceans, perhaps eating so much that they leave less food for other fish species. There is some anecdotal evidence from the Wasilla and Anchorage areas that introduced blackfish have led to diminished populations of sticklebacks and rainbow trout, both native species, through competition for the same invertebrates for food.

While I thoroughly enjoyed seeing these hardy, unfamiliar blackfish at that little pond in Kenai, I am concerned about how they might affect other species—especially other fish—in the Kenai River system.

Matt Bowser serves as Entomologist at Kenai National Wildlife Refuge. He thanks Bob Chlupach, Lucas Byker, Dr. Michael A. Bell, and Jeff Breakfield for sharing information on blackfish in Southcentral Alaska; Celia Rozen and Sharon Prien for library sleuthing; and Ronald H. Brower for providing the meaning of the Iñupiaq name for blackfish. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/refuge/Kenai/community/refuge_notebook.html.

Anna's Hummingbird banded in Homer

by Todd Eskelin



This hatching-year male Anna's Hummingbird was banded in Homer, Alaska, on October 17, 2018. This is the westernmost banding record for this species in North America. (credit: Aaron Lang).

October 17, 2018 will be one for the record books. The day began like many others, dealing with an injured Bald Eagle that needed transport to Bird Treatment and Learning Center in Anchorage for evaluation and hopefully rehabilitation. After wrestling

10 pounds of muscle-bound male eagle into a pet carrier for transport, I turned my truck south and headed for Homer.

In August, I wrote about my trip to Idaho to get certified for banding hummingbirds. So I was glad

to apply my new skill set as there was a report of two Anna's Hummingbirds at a private residence in Homer. It didn't take long after arriving to find the hummingbird. He intermittently sang from his alder perch when not scolding me for messing with "his" feeder. I let him get comfortable with the setup of his feeder hanging inside my trap for about 20 minutes while I prepped the rest of my banding equipment.

When I sprung the trap on him, he only seemed slightly concerned, even resuming his feeding inside the trap. He was far from happy when I actually got hold of him and he jacked his little wings out and up as hard as he could. When I folded them in place next to his body to keep him safe, it almost felt as if I were going to break something.

After placing the leg band on his right leg and taking several measurements, I concluded it was an immature male Anna's Hummingbird born sometime this summer. But where did it come from? Anna's supposedly do not breed here yet, but for the past five years or so they have regularly showed up in Homer and Seward in late fall.

With an additional permit, I was allowed to collect one tail feather that will grow back in 2 or 3 weeks. That tail feather will be part of a study being conducted by Jessica Pollock from Boise State University. She is looking at the proportion of several stable isotopes to determine where the bird was when that feather was grown. Unfortunately, this male Anna's had just replaced its tail while here in Homer so the isotope signature will be from Homer rather than helping to unravel the mystery of its birthplace.

All is not lost, however, as this will give us the isotopic profile for Homer. If future sampled birds with retained juvenile feathers have that same signature, we will know that Anna's breeding range has now reached south-central Alaska.

I initially believed this was the all-time northernmost banding record for the species, with Cordova being the other banding location in Alaska. I was quickly corrected that this record was the furthest west, but Cordova is actually further norther than Homer so they still have that claim. A quick glance at the map and you'll see that the City of Kenai is less than a mile

north of Cordova, so Cordova has Homer beat by a long shot.

It was also quite a diverse day for me bird wise. I handled both the Bald Eagle, which is arguably the largest bird on the peninsula at roughly 4500 grams, and Anna's Hummingbird, which is 1,000 times smaller at 4.7 grams. I am still struck by the power in that little wing as he held it up not wanting me to close it next to his body. How do they have so much strength holding their wings out? I've banded thousands of birds, but I have never felt that kind of power on the upstroke, only on the downstroke.

A little digging and it totally makes sense. We all know about the breast muscles in birds, also called the pectoralis major, which is what we like to eat in chickens, turkeys, grouse and waterfowl. The pectorals are big and powerful, pulling the wings down and providing lift.

But directly underneath that muscle, separated by a thin membrane, is the supracoracoideus muscle. It is the shiny little muscle that peels out when you breast out a chicken and is sold as chicken tenders. It has a large tendon at the forward end that forms a unique rope-and-pulley system. From the breast side of the bird, the tendon wraps over the shoulder blades and out the top of the wing. When contracted, this muscle pulls the wing on the upstroke and allows birds to hold the wing in place while soaring.

In most birds, the supracoracoideus is about one-fifth the size of the pectoralis muscle. In hummingbirds, however, their supracoracoideus is half the size of the pectoralis because they are tasked with much more than just upstroke recovery. Hummingbirds can back up, hover and perform aerobatic maneuvers that other birds cannot. So the pound-for-pound strength of this 4 gram bird holding its wing up was not a figment of my imagination, but rather the result of a sophisticated mechanism giving them superior maneuverability. Who knew?

Todd Eskelin is a Wildlife Biologist at Kenai National Wildlife Refuge. Call him at (907) 260-2817 if you have interesting bird sightings. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/Refuge/Kenai/community/Refuge_notebook.html.

Elodea partnership recognized

by John Morton



Looking for a spawning bed? Sockeye salmon navigate through elodea-infested Alexander Lake in the MatSu this past summer (credit = Bob Pence).

In August, at the 2018 Industry Appreciation Day in Kenai, the elodea partnership on the Kenai Peninsula was acknowledged for Outstanding Fish Habitat Conservation. The United Cook Inlet Drift Association (UCIDA) nominated the partnership and I was the face that accepted this very nice award.

The elodea partnership, a subcommittee of the Kenai Peninsula Cooperative Weed Management Area, has been unusually motivated and successful in eradicating elodea from the Kenai Peninsula. Elodea is the first aquatic invasive plant to establish in Alaska and it has already shown itself to be quick at spreading and able to cause great harm.

Dr. Toby Schwoerer, with the UAA Institute of Social and Economic Research, estimates elodea will likely cost \$100 million annual loss in revenue to commercial sockeye fisheries and charter floatplane operators if it disperses throughout Alaska. In some lakes,

like Chena Lake in Fairbanks, it is thick enough to hinder canoe paddling. Walt Nesbett, a Sucker Lake landowner in the MatSu, believes beaver abandoned his lake because they could no longer drag branches through elodea-infested waters.

Here on the Kenai Peninsula, the partnership pioneered the use of aquatic herbicides and was the first to successfully eradicate elodea from an Alaskan waterbody. Of five known infestations on the Kenai, four were successfully eradicated (Beck, Daniels, Stormy, Sports Lakes) and the fifth is likely to be gone by next summer.

What is so unusual about the elodea partnership is that local, state and federal agencies and NGOs came together to work voluntarily on a problem with no funding available, and then not only made it work, but in a short time frame.

Mike Navarre, our former borough mayor, re-

marks, “This collective effort is a great example of how to responsibly deal with public policy issues. A problem was identified and everyone came together with the goal of addressing the problem and educating the public on the issue. The focus was on resolving the problem rather than placing blame or claiming credit.”

As with most partnerships, it wasn’t the organizations and agencies involved that made the difference—it was individuals. Early on, shortly after elodea was found in Stormy Lake in 2012, Brianne Blackburn and later Heather Lescanec (Alaska Department of Natural Resources), Matt Steffy (Homer Soil & Water Conservation District) and myself (Kenai National Wildlife Refuge) organized the first public meetings in Nikiski, as well as the partnership itself. We were also the heavy hitters in the permitting process and in raising funds, and later during the actual herbicide treatments when others such as Matt Bowser and Todd Eskelin from Kenai Refuge also weighed in.

Mike Navarre, as former mayor, provided \$40,000 to initially seed the effort. With help from Michele Aranquiz, former assistant to the mayor, the borough assembly later approved a \$400,000 request for state capital funding that provided critical momentum for eradication efforts eventually costing more than twice that amount.

As this battle with elodea has played out, everyone has had roles to play. Jack Blackwell (Alaska State Parks) agreed to close Stormy Lake’s public boat launch to reduce the risk of more spread. Later, Tammy Davis and Jeff Breakfield (Alaska Department of Fish & Game) helped close Sport Lake’s public boat launch, even while providing staff to inspect for elodea on boats and trailers when it was open.

Cheryl Anderson (Kenai Fish & Wildlife Field Office) and Dr. Libby Bella (Kenai Refuge) surveyed many lakes in 2013. Edgar Guerron-Orejuela and Jen

Hester, with the Kenai Watershed Forum, continued those surveys, and rounded up funds to evaluate the use of eDNA to detect elodea and the degradation of residual herbicide in lake sediments. Lisa Ka’aihue and others at the Cook Inlet Aquaculture Association were quick to install nets to prevent elodea from washing downstream, and more recently to survey MatSu lakes. Janice Chumley (UAF Cooperative Extension Service) was always quick to help with public outreach.

Several Daniels Lake landowners, Bill Haese, Bill and Michele Hartline, and Stacy Oliva, enthusiastically contributed their personal time to this planning effort. Craig Ralston and Susan Stockdale graciously provided boat access to Beck Lake.

Outside experts provided free consultation. Dr. Lars Anderson (University of California-Davis) helped launch us down the right planning path. Scott Shuler and Dr. Andrew Skibo (SePRO Corporation) provided support during the early days when we really didn’t understand technical aspects of the herbicides or application equipment. Dr. Don Les (University of Connecticut-Storrs) identified elodea from the Nikiski lakes as a hybrid species.

This partnership has successfully won five battles, but it may lose the war with elodea as that ultimately depends on the success of other partnerships elsewhere in Alaska. Elodea is so viral in its ability to spread by floatplane that it needs to be eradicated from MatSu and Anchorage lakes if we want to protect the Kenai.

But I’m glad UCIDA recognized that our local partnership really has set the bar for how to be successful.

Dr. John Morton is the supervisory biologist at Kenai National Wildlife Refuge. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/Refuge/Kenai/community/Refuge_notebook.html.

Wildfire apprentice catches the fire bug

by Allie Cunningham



Allie Cunningham above a burnout operation on the Copper King Fire in Montana (credit: Parker Anders).

Let's go back to the beginning.

On a day in late August 2016, I found myself on a steep slope in Lolo National Forest near Plains, Montana. I had a Stihl MS038 on my shoulder, and I was listening intently to my hand-held radio. About 500 feet below me on the opposite side of a logging road, a hotshot crew was conducting a burnout operation. Burnouts have many functions. In this case, it was a mitigation strategy—the burnout created a piece of “solid black”—allowing the main fire to work its way steadily downhill without putting containment lines at risk.

Or, at least, that was the plan. I was tasked with “spinning” weather and reporting my findings to the division supervisor. During critical operations, such as firing, fire personnel take weather observations at least every hour, including relative humidity measurements with a sling psychrometer. Burning conditions transitioned from favorable to a little too favorable in

just a few hours. As a “holding” resource, we were standing in unburned vegetation across the road from the burnout operation, extinguishing any embers that crossed into the “green”. This is a vulnerable position, as any fire that crossed the road could jeopardize our safety.

It was 1500, the middle of the critical burn period when fires spread most rapidly. Over the radio came a warning to all fire personnel—a thunder cell had formed over Plains and was expected to impact the fire area within thirty minutes. Wind gusts could reach 45 mph. The relative humidity values would plummet ahead of the cold front. We heard this. We kept watch—as did the Bitterroot Hotshots below us on the hill.

A few minutes later we felt the winds pick up as the cell passed over. Trees began torching in groups and embers were blown far across the logging road below. Someone on the road found a spot fire ahead of

us, in the green. Bitterroot moved to the road and we followed.

Our crew boss counted personnel as we lined out, giving instructions to hike up the road to a safety zone identified earlier in the day. My squad boss led the crew. In that moment, my chainsaw seemed to weigh only ten pounds instead of its usual thirty. We reached the safety zone in minutes and circled up to take our collective breath.

This was the moment that I caught “the fire bug”. There have been many others since then, with varying levels of intensity. Needing to escape to a safety zone is not commonplace. This one sticks in my memory as the first of many times that we leaned upon a network of trust and communication. Our foundation was tested...and it held.

I fought fire as a member of the Kenai National Wildlife Refuge trail crew for two seasons before the opportunity arose to turn collateral work into primary duty. The Wildland Firefighter Apprenticeship Program (WFAP) was started in 1989 with staff from the U.S. Forest Service and Bureau of Land Management. Although the National Park Service and U.S. Fish and Wildlife Service (USFWS) also partnered in 1997, I am the first WFAP apprentice for the USFWS!

The WFAP is an educational and experiential program designed to develop future fire and aviation managers. The program accomplishes this task by utilizing training, education, and paid work experience to take an entry-level wildland firefighter to the “journey-level” (certified Firefighter Type 1).

The training and education include up to two academies hosted each spring and fall, as well as on-the-job training through six required experience categories. These categories span fireline suppression duties (engines, dozers, handcrews, aviation) to time in dispatch, wildland fire prevention/education, local

unit planning and preparedness, fuels management, fire business practices, and wildland fire safety.

The academies consist of classes that support progression in fire management through both fireline (field) duty qualifications and leadership skills. Apprentices are also held to a national fitness standard, expected to meet the minimum of 25 pushups, 45 situps, 2–7 pullups, and a 1.5 mile run in 10.5 minutes. Each callisthenic must be completed within three minutes. The Work Capacity Test (aka pack test) is also required at “arduous” level: 3 miles in 45 minutes with a 45 lb. weight vest.

In a nutshell, the WFAP is like going to college for a degree in wildland fire but being paid to do so. At the Kenai Refuge, this is a term position, which means I work year-round for up to four years while I progress through the program. When I’m not fighting fire, I work at refuge headquarters maintaining our fire caches and chainsaws, assisting with fuels work, collecting vegetation data from the Sterling fuel break, helping other refuge programs like trails and cabins, and a myriad of other things.

We have a unique situation at the Kenai Refuge, as most of our fuels work is completed in the winter rather than summer. We typically burn piles of slash derived from other thinning projects accomplished by hand or machine. It will be an adjustment for this lifelong seasonal worker to relinquish some of my former adventure time to working time, but it is part of the path and I will do my best to accept the change gracefully.

I have the fire bug, after all.

Alexandra “Allie” Cunningham is a Wildland Firefighter Apprentice at Kenai National Wildlife Refuge. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/Refuge/Kenai/community/Refuge_notebook.html.

Species packing into Biosphere 2

by Tony Burgess



Dr. Tony Burgess in the Biosphere 2 desert biome in 1993. The desert began transforming into chaparral scrubland after receiving extra rain for more than a year to increase carbon dioxide uptake.

In 1991, Biosphere 2 was launched in Oracle, Arizona. It is a 3-acre structure built to enclose seven biomes or habitats: rainforest, coral reef, mangrove wetlands, savanna grassland, fog desert, an agricultural system, and living space for eight humans who called themselves biospherians. It remains the largest closed system ever created.

Biosphere 2 was originally designed to discover how closed ecological systems could maintain human life in outer space. The first attempt to live for two years within these hopefully self-sustaining systems went awry when food and oxygen became scarce. The second attempt was aborted after a few months by a management dispute.

Earth, too, has experienced changes in atmo-

spheric composition and climate in its past. Most shifts have been slow enough to allow plants and animals time to adapt and evolve as they generally became more taxonomically diverse. But five times in the past 450 million years, more than 75% of known species disappeared from the fossil record when climates changed too quickly.

Many scientists agree we are sliding into the sixth mass extinction, driven by human activities such as logging, farming, overharvesting, and polluting, but also by a climate rapidly warming in response to greenhouse gas emissions. The designers of Biosphere 2 did not envision their grand experiment might have more relevance to our warming Earth than to colonizing space.

I was an ecological designer of the Biosphere 2 desert and savannah biomes, and later helped manage them. Now I live in Homer.

The biomes inside Biosphere 2 were to evolve within nearly total material closure for 100 years, with occasional modifications, and humans would inhabit almost continuously as involved observers, rotating crews every two years. A century is a long time for humans; however, it's only enough time to grow a young forest or form a weakly developed soil.

Why did we design so many biomes into Biosphere 2? More opportunities to learn. All we knew for certain was that the only known biosphere, Earth, has many biomes which interact in creating air and water chemistries that foster life. Mostly powered by sunlight, our planetary biosphere consumes incoming energy to create complex, evolving, carbon-based life, diversifying in interacting ecosystems that continuously recycle essential nutrients.

We didn't know which biomes would be best, and there were few clues. What became clear was that an agricultural biome alone would not be adequate—current agricultural technology causes rapid fluxes of carbon dioxide that destabilizes atmospheric chemistry. For example, every time the soil was tilled, a large burst of carbon dioxide was released into the air.

The question that challenged us was how to create a biosphere that evolved as quickly as possible, while sustaining as much diversity as possible. Fortunately, a theory of island biogeography offered hints about maximizing species richness in closed ecosystems. The most species-rich islands tend to be those that had once been connected to continents rather than islands that arose from volcanoes or coral reefs. After becoming isolated by rising sea level, these continental fragments (now islands) with higher species richness adjust to the more limited resources of an island.

Similarly, we assumed well-adapted species would accumulate more rapidly in Biosphere 2 if we overpacked our small biomes with lots of plants and animals, an idea we called “species packing.” As the famous ecologist Howard Odum advised us, “shovel the species in, and let extinction sort it out.”

Choosing which species to colonize each biome proved controversial. Each biome had different designers with differing ecological ideas. For example, the mangrove biome was constructed by transporting large, intact chunks of soil with growing mangroves from the Florida coast into Biosphere 2. In contrast, I

used a synthetic approach for the humid desert biome, populating it with plants from several coastal deserts in Baja California, Israel, Namibia and Chile.

Microbial communities are the critical foundation for a biosphere, yet they are the least understood. In the 1980s when we were designing Biosphere 2, technology for assessing microbes was too crude for detailed inventories. However, we were certain that if there were diverse environments inside Biosphere 2, inoculated with soils and waters from diverse places, there would soon be well-adapted microbial communities to recycle nutrients and stabilize air and water chemistry. A similar process occurs in aquariums and aquaponics systems, when their ecosystem “pops” into a state that can process fish waste into plant nutrients.

Establishing adaptable populations of plants and animals posed greater challenges. Space and light energy were limited in our ‘island’, hence the number of individual organisms had to be limited. However, more individuals of each species meant fewer species could be included. So we developed a compromise design strategy. We emphasized species richness in plants and smaller invertebrates such as roaches and ants. In contrast, we included only a few vertebrate species such as coqui frogs and Solomon Island skinks, but we stocked enough individuals to ensure breeding populations.

Management changes cancelled the goal of a century of observation and evolution. Yet even during the few years of closure, community adaptation was evident. During the first closed mission, condensation on the glass dripped extra moisture into the soil, and rainfall in the desert biome was substantially increased to offset oxygen loss. Within two years, the desert vegetation structure changed from open shrubland to denser chaparral. Many desert plant species died, but those favored by the wetter climate allowed a rapid transition to better adapted vegetation. Surveys discovered two species new to science, a protozoan and a soil nematode, indicating that novel communities were forming rapidly from diverse inoculations. The invertebrate food web began to organize with crazy ants (*Paratrechina*) as keystone predators, similar to islands where this ant has been introduced.

How might such concepts apply in Alaska where climate is warming at twice the rate of the Lower 48? Unlike previous mass extinctions, powerful technologies currently alter the land and its ecology. New species are pouring in with global trade, tourism, and gardeners' desires for ornamental plants. Some of

these species, including earthworms, pasture grasses, and agricultural weeds, have become invasive in Alaska. Interactions among economic globalization, technological evolution, cultural evolution, climate change and human population growth are certain to cause major, disruptive changes in Alaska's ecology.

Might Alaskans want to learn how to assist ecological adaptation that could sustain healthy environ-

ments in boreal and arctic regions? The basic questions are the same as those that confronted us in designing Biosphere 2.

Dr. Tony Burgess, now retired, continues to grow many different plants on his small farm outside of Homer. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/refuge/Kenai/community/refuge_notebook.html.

Kenai blackfish came from Bethel

by Matt Bowser



An Alaska blackfish lurks in the shallows of an ice-rimmed pond in Kenai, November 27, 2018 (credit: Matt Bowser/USFWS).

Since learning that Alaska blackfish had been found in two small streams in the City of Kenai, I have wondered how they got here. Like northern pike, Alaska blackfish are native to Western and Interior Alaska, but they have been historically absent from Southcentral Alaska, including the Kenai Peninsula.

I wondered whether introduced blackfish in Southcentral Alaska get around like northern pike, which spread in our area through intentional introductions, or more like the invasive aquatic plant *Elodea*, which has spread mostly accidentally through boat and float-

plane traffic.

I related in an October 26 *Refuge Notebook* article the historical account of how blackfish were unintentionally transported from Western Alaska to Lake Hood in Anchorage on an amphibious aircraft. From there, the fish made their way through streams and wetlands, and were later spread by people to other water bodies in Anchorage and the Mat-Su.

Given the Anchorage story, it seemed possible that Alaska blackfish could have arrived in the City of Kenai by floatplane. The floatplane basin at the

Kenai Airport has been there for some time and, judging from old topographic maps, was historically connected to two streams close to where blackfish now occur.

I looked for blackfish in waterbodies currently and historically connected to the Kenai Airport floatplane basin, but I found none. Jennifer Hester from the Kenai Watershed Forum set out a minnow trap, a good method for catching blackfish, in the floatplane basin. She caught only sticklebacks. Based on this recent work and historical fish sampling records, it looked like blackfish did not get to Kenai via the floatplane basin.

We still had one more tool at our disposal for learning more about where these fish came from. Matthew Campbell and Dr. J. Andrés López, both at the University of Alaska Fairbanks at the time, had investigated the geography and genetic diversity of Alaska blackfish, reporting [their findings](#) in the *Journal of Fish Biology* in 2014. They had obtained DNA barcode sequences from 169 blackfish taken from 22 populations over much of the species' range and published their data, providing a reference library of blackfish DNA barcodes from known locations. Campbell and López found that their one specimen from the Mat-Su was most similar to fish from Western Alaska, consistent with the historical account of how blackfish first arrived in Southcentral Alaska.

Thanks to Jennifer Hester, who collected blackfish for me in October from a pond in Kenai, I was able to send in two tissue samples for DNA barcoding. When I compared the sequences we obtained to the available library, I found that those from the Kenai population closely matched populations from the vicinity of Bethel. The Kenai sequences were also quite distinct from the Mat-Su population.

It now appears, based on genetics and where blackfish occur in the City of Kenai, that the progenitors

of the Kenai population were brought from the Bethel vicinity by aircraft to the road system and released here.

Why would someone make this effort to transplant blackfish to Kenai? This hardy species is harvested for food in Northern and Western Alaska, so the intent may have been to stock a pond with harvestable fish. Along similar lines, someone might have been trying to bring pike or something else from Bethel using minnow traps, with the blackfish coming along as bycatch. It seems unlikely that blackfish would have been brought all the way from Bethel for a fish tank and later released.

Whatever the original reasoning by whoever brought them here, the decision to have blackfish in the Kenai River system has been made for all of us and is practically irreversible. Northern pike have been eradicated from many water bodies in Southcentral Alaska using the piscicide rotenone, but treating lakes in Anchorage with this chemical led to increases in blackfish after other fish species were killed.

The only reason we have not seen blackfish spread in the Kenai River system as quickly as they did in Anchorage is that these two small streams in which blackfish now occur both drain into brackish water near the mouth of the Kenai. This is poor blackfish habitat and appears to have been a real barrier to their further spread to date. It should be obvious, however, that the small distance separating blackfish in Kenai from productive salmon streams like the Moose and Swanson Rivers is much less of an obstacle to dispersal than the Alaska Range that lies between Southcentral and Western Alaska, a barrier that blackfish have crossed twice now.

Matt Bowser serves as Entomologist at Kenai National Wildlife Refuge. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/refuge/Kenai/community/refuge_notebook.html.

Machines are learning about wildlife

by Dawn Robin Magness



A Sandhill crane in flight. Photo Credit: Created by Steven R. Emmons and published by USFWS in NCTC Image Library.

Over the weekend, I was curious about where Golden-crowned Kinglets spend winters. I pulled out my cell phone and instantly found range maps, beautiful pictures, and detailed information about the natural history of this small bird. I am sometimes wonderstruck by the advances in technology that have occurred just within my lifetime. Prior to the 1980s, ecologists often hand drew maps and used calculators to labor through tedious statistical equations. The average person didn't have access to much computing power.

We now have amazing computers, immense data storage, and software to harness information. What can I, an ecologist who is interested in natural resource management, do with these innovations? I've been pondering this question over the past couple years while co-editing a recently published book titled *Machine Learning for Ecology and Sustainable Natural Resource Management*.

The idea of machine learning came into being after WWII when Alan Turing creatively suggested that computers could learn and communicate new information to us humans. Turing's work first had to demonstrate that computers could indeed learn from data. Throughout the 1960s, there was some work on computer perception; for example, the military tried

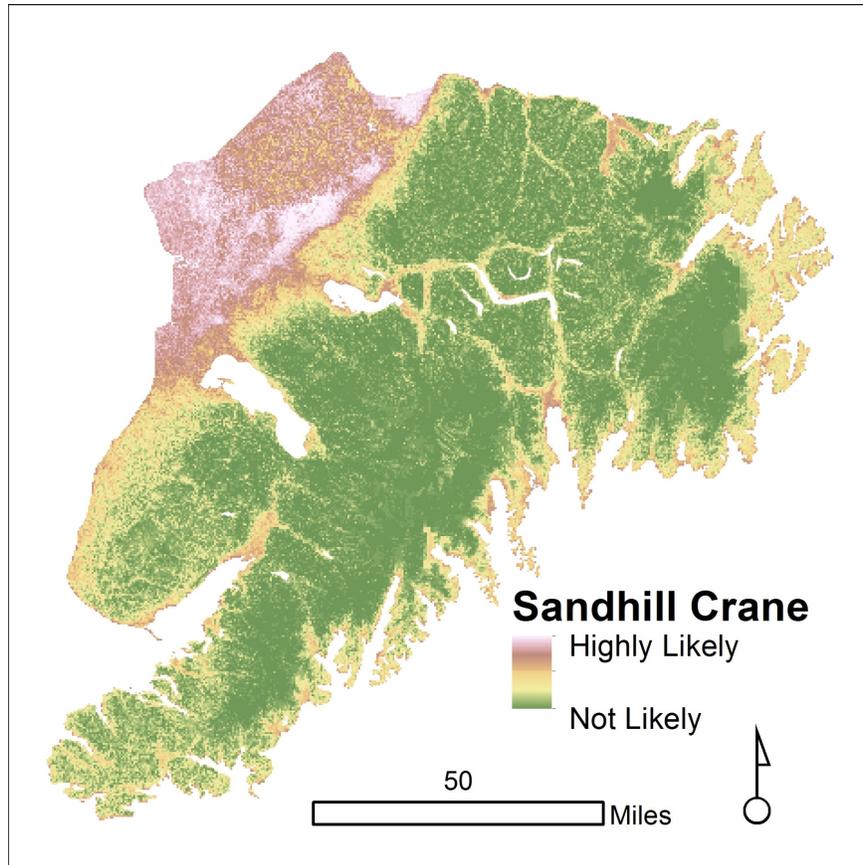
getting computers to identify enemies in radar images. However, machine learning was largely fodder for science fiction until computing power became widely accessible. These days machine learning is being implemented by a wide variety of disciplines, including ecology.

I was first introduced to machine learning algorithms while working on my Ph.D. at the University of Alaska, Fairbanks. Algorithm is just a fancy word that means, according to Merriam-Webster, "a step-by-step procedure for solving a problem or accomplishing some end". The field of machine learning is dedicated to creating, testing, and refining algorithms that computers use to learn and communicate information to humans.

At that time, I had just finished a master's degree at Texas A&M University where I used data to map where birds were likely to live. The State of Texas was interested in paying ranchers to clear brush on their land, but wanted information to incentivize practices that benefited wildlife species. I visited ranchers to collect data on where birds occurred, but had a hard time translating my data into maps that could communicate the information that Texas needed.

Fortunately, about the time I started mapping where birds occurred on Kenai National Wildlife Refuge, computing power and software made this task easier to do well. I used a machine learning algorithm to link where I found birds on the Kenai to vegetation and landscape features such as elevation, proximity to water and human development. Then, I could predict whether a bird would like places that I had not visited to make a map. We can assess how well the algorithm does by comparing how well it predicts a subset of withheld data versus the data from which it learned to predict.

Natural resource managers use information about where animals live to conserve and enhance habitat. Before these technological advances, we only had coarse, hand drawn range maps to work with. Machine learning and other computing advances give us the capacity to compile and translate vast datasets into useful products for conservation.



A machine learning algorithm was used to create this map of Sandhill Crane nesting habitat on the Kenai Peninsula.

For example, scientists at the Cornell Lab of Ornithology take the observations from eBird (www.ebird.org), a website where volunteer birders add sightings, and use machine learning algorithms to deliver detailed information, such as a week-by-week animation of where Sandhill Cranes are in North America (<https://ebird.org/science/status-and-trends/sancra/abundance-map-weekly>). Knowing if a bird has a restricted winter range, and when and where migration pathways occur can help us sustain populations for our children to enjoy.

Machine learning algorithms have also been developed that allow computers to “see or hear” animals, which is very useful for monitoring populations. Computers can help researchers go through vast amounts of data collected by camera stations or sound recorders. Researchers in South Africa have developed a fully automated monitoring program for an African penguin colony. African penguins use “penguin highways” as pathways between the sea and their nests. As the penguins walk these trails each day, they are photographed and a computer identifies the individual penguin based on their unique belly spots! This

information is used to count colony size and estimate survivorship as accurately as older methods that relied on physically attaching a band to their flippers.

In Alaska, researchers are using computers to listen to thousands of hours of recorded sounds to identify birds. Teaching bird sounds to computers has been difficult because birds tend to call over one another in the summer. Computers need to have processes to discriminate the sounds and then identify them.

However, progress is being made on this problem. Recently, a paper was published in the journal *Science Advances* aptly titled “[Eavesdropping on the Arctic](#)” which outlines a machine learning approach that successfully detects birds and is useful for tracking shifts in nesting phenology and ranges.

My hope is that computers will help us learn how to be good stewards of the environment. Each day of innovation could bring new and previously unimaginable approaches to conservation.

Dr. Dawn Magness is the landscape ecologist at Kenai National Wildlife Refuge. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/Refuge/Kenai/community/Refuge_notebook.html.

77 years of conservation in our neighborhood

by Leah Eskelin



Kenai National Wildlife Refuge was established in 1941 after a grass-roots effort by big game hunters to protect dwindling wildlife populations (credit: USFWS).

What happened in 1941? So many events are tied to that year, some small and others enormous in their lasting impacts. The first paid network TV commercial aired that year. The National Gallery of Art opened in Washington, D.C. The first organ music was played at a baseball stadium.

More somber, Pearl Harbor's bombing marked the entry of the United States into World War II. On the heels of that sad event, President Roosevelt signed an executive order creating the Kenai National

Moose Range on December 16th. Here's a link to a more detailed account of how the refuge came to be: https://www.fws.gov/refuge/Kenai/what_we_do/Community/09302011.html.

Since its establishment, the Kenai National Moose Range, now Kenai National Wildlife Refuge, has actively contributed to the way of life found on the Kenai Peninsula: public access to lands and waters conserved for fishing, hunting, hiking, camping, canoeing, solitude, green space. It's hard to imagine life

on the Kenai without our homes backing up to the forest, our families having short drives to free campgrounds, or our boats slipping into the water at free boat launches.

How has the Kenai National Wildlife Refuge been your neighbor this year?

Have your kids explored the outdoors on a field trip or at summer camp? The Refuge hosted four weeks of camp and months of school programs, partnered with Alaska Geographic and Kenaitze Indian Tribe for three other summer camps, and visited the library and local preschools for some indoor fun.

Has your family hiked a trail with a Ranger? Discovery Hikes were back and stronger than ever. Ranger Amber and Volunteer Hosts Gail and Bill gathered quite a following on their weekly guided walks in the Skilak Wildlife Recreation Area. Missed the fun in 2018? More hikes, on more trails and designed for all fitness levels are scheduled for Fridays in summer 2019.

The Refuge opened a new trail off Skilak Lake Road in 2018, broke ground on a second one in town along Ski Hill Road, and partnered with the local horsemen's association to improve a historic trail to access land near Tustumena Lake. If you haven't checked out the new Marsh Lake Trail, add it to your plans! Growing out of a rehabilitation project after fighting the Card Street Fire in 2015 and after contributions of skill from every department of the Refuge, this trail opened to the public in a weekend event called Termination Dust Celebration. Marsh Lake Trail is great for hiking, skiing or snowshoeing in every season and it's just three short miles from Sterling!

Quiet evenings aren't ideal for everyone. Thankfully the long days of summer can help the more spirited outdoorsman find adventure on the refuge. Have you fished for salmon at the Russian River Ferry? Finding that perfect hole by the powerline or wading out to the confluence island as the river runs red with sockeye is perfection to many of the refuge's neighbors. Seasonal rangers and volunteer hosts piloted a new program for visitors at the ferry landing this year. They offered interactive educational programs on bear safety, fishing tips, and even "How not to poop in the woods" guidance to reduce human waste. These programs will return for summer 2019, along with our daily ranger visits to help folks enjoy their day safely. Rangers are a wealth of local knowledge, too.

If day trips aren't enough, you can be a refuge neighbor overnight. Have you stayed at a Refuge

Public-Use Cabin? Sitting by a warm fire, looking out at soft lake waves while a loon calls out an evening song can't be beat. Fourteen cabins can be reserved online at the newly redesigned www.recreation.gov. Two other cabins are first come, first served. A dedicated cabin crew works year-round to keep these buildings looking their best. Front-country cabins include a row boat in the summer months but don't be scared off from a winter stay. Some of the most happy and rejuvenating visits have been recorded in the cabin journals by winter guests.



Participants at the 2018 Termination Dust Celebration took aim at invasive species like ticks and earthworms while learning archery skills (credit: Leah Eskelein/USFWS).

New in 2018 was a partnership with Kenaitze Indian Tribe's Daggeyi Internship Program. This summer-long internship brought cultural programs to the Kenai Refuge Visitor Center in Soldotna and a new guided walk to the Russian River in the Squilantnu Archaeological District. Interested in learning more about the rich cultural history of the Kenai Peninsula? Watch for more hands-on programming in town and out in the Skilak area in 2019!

The history of this place, the land now called Kenai National Wildlife Refuge and held in trust for all future generations, began well before 1941. As neighbors who are each drawn to its majesty, its wildlife, its diverse landscapes, we each play a role in writing the next chapter in the Kenai's story.

This weekend marks the 77th year of conservation for Kenai Refuge. Please join Refuge managers and staff for refreshments, free interactive family activities, and more at a Visitor Center Open House this Sat-

urday, December 15, from noon until 4pm. Our Visitor Center is located at 33398 Ski Hill Road in Soldotna. Call 907-260-2820 for more information.

Leah Eskelin is a Visitor Services Park Ranger at

the Kenai National Wildlife Refuge who loves bringing fun hands-on nature programs to the public every month. Check out the events schedule at kenai.fws.gov or www.facebook.com/kenainationalwildliferefuge.



Autumn arrives on Skilak Lake Road in October 2018 (credit: Leah Eskelin/USFWS).

Building new trail builds community

by Erin Mckittrick



In late May, snow can still be thick on the top of 1200' Lunch Mountain. Looking west towards Tutka Bay (credit: Andy Banas).

From Lunch Mountain, on Kachemak Bay State Park's Tutka Backdoor Trail, Mount Iliamna appears perfectly framed between the fjord's forested slopes. We wrapped up our last day of trail work this year on September 27, enjoying lucky fall weather and this incredible view. Behind us, a trail wound through unnamed mountains before spilling onto the remote coast of Taylor Bay.

A dozen volunteers stood atop a retaining wall of unreasonably heavy and painstakingly-placed rocks that replaced a bit of trail which had previously been a shimmy on a 4-inch wide ledge. We snapped a photo, then hiked four miles back to the beach, rock bars and generator in tow. It was good we now knew how

to build a proper rock wall, and just as good that we hadn't known much of anything in 2016, when we set out to build the Tutka Backdoor Trail. If we had, we might never have started.

On a small point a mile from the tidal flats at the head of Tutka Bay, streamers of blue and orange flagging decorate a small forest opening. The trail begins there, following the deep rainforest valley eastward before popping out onto Lunch Mountain. It winds through deer cabbage meadows, past ponds and lakes, through a braided valley of willows, into a playground of tundra and peaks. That's eight miles that anyone can follow.

Beyond that, the trail crosses the river twice, be-

fore leaving hikers to make their own way through a 4-mile mountain pass, picking up the rest of the marked trail on the eastern side of the Kenai Peninsula. This half of the trail is more remote and rugged, climbing and descending constantly to avoid impassable cliffs, crossing the Taylor River and ending on the beach in Taylor Bay. Since the route was completed at the end of 2017, nearly all through-hikers have done the 20-mile route one way only, most beginning with a float-plane ride to Taylor Bay.



The newly-constructed Tutka Backdoor Trail treks 20 miles between Tutka Bay and Taylor Bay on the southern tip of the Kenai Peninsula. The dotted line shows a portion of the trail that is not maintained (credit: Bretwood “Hig” Higman)

In those three seasons, I have spent 80 days living along that 20-mile stretch, with a rotating cast of dozens of volunteers. Seventy individuals have joined us, from babies to grandmothers. They have endured days-long deluges, toiling for weeks on the promise of nothing more than free beef jerky and granola bars. The adults among them have put in 626 person-days of work, nearly all of it with hand tools and sweat.

Why?

As one of the trail’s three parents, my initial reasoning was mostly along the lines of “Hey, wouldn’t that be cool?” It was a route Hig (my spouse) and I had roughed out in our pre-kid high-speed bushwhacking days. Beautiful alpine valleys, endless stretches of tundra, and a route to the stunning and rarely-visited eastern side of the state park. So when the park was

mulling over drafts of its new management plan, we drew a few lines on the map. All we had to do was cut a few bushes, and we’d open up a path for all the adventurers who weren’t quite willing to brave the devil’s club to get there.

We did have to brave the devil’s club. I spent a whole day in 2017 with an intrepid volunteer, crawling through devil’s club and salmonberries on the side of a cliff above Taylor River, while a half dozen other people fanned out in equally improbable directions, all looking for a single possible route. We crawled through all the bad ways and all the good ways, multiple times, with flagging tape and inclinometers and pouring rain. We had to uproot devil’s club, hand saw miles of alder, hack tread into long steep traverses, haul rocks, and smash other rocks.

Along the way, each of those hard-won miles acquired its own stories. I remember the pond where I surprised a moose, the salmonberry thicket where I sawed through a can of pepper spray, and a debate over the first steep hill that nearly caused us scouts to mutiny. Volunteers leave new names where none were known before. Ugh Hill...Whiskey Knob...Heart Lake Pass.

I didn’t know how to build a trail when we started. We learned about grade, controlling drainage, trail psychology, and stone-setting from Eric Clarke, the park trail guru, from other experts, and from our own mistakes. Eventually we found ourselves repeating the very same advice we’d chafed at when we started. I was surprised by how much work building 16 miles of trail turns out to be. I was even more surprised by how many people were eager to do that work. Who would have thought we would collectively spend more than a year and a half volunteering labor?

The first time a stranger hiked up the half-built trail to encounter our work crew, I was thrilled. We’d built something others could follow. Something that existed without us. And as I’ve worked on the trail, I realize that we’ve built two things: A line on the ground, and the community that came together to make it.

Erin Mckittrick is a writer, adventurer, and scientist, who lives in Seldovia with her husband and two kids. See http://www.groundtruthtrekking.org/tutka_backdoor/ for more information including how to get trail maps. Find more Refuge Notebook articles (1999–present) at https://www.fws.gov/Refuge/Kenai/community/Refuge_notebook.html.