

BERRIES IN ALASKA'S CHANGING ENVIRONMENT SERIES: *EMPETRUM NIGRUM*

Crowberry in a Changing Climate: Threats and Opportunities

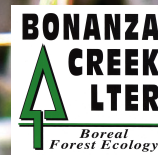


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WELCOME!

In late summer, berry picking is on the to-do list of many Alaskans. Alaska's wild berries provide delicious and highly nutritional food, and for communities not connected to the road system they are a crucial source fruit. For Alaska Native peoples, berries are an important part of the culture, reflected in stories and recipes. Berry picking is a traditional and recreational activity for rural and urban Alaskans alike. But all across the state people have observed changes in the timing and predictability of fruiting for many berry species, and wonder if a changing climate is having an influence. A shifting climate has led to many changes that could influence berry species, including rising temperatures, longer growing seasons, shorter

snow-covered seasons, and altered precipitation patterns. It can also lead to changes in the pollinators that our berry plants depend on, and in the populations of the animals and **microbes** that consume or protect the plants. The effects of those changes are complicated, and the overall impact can be positive or negative.

In "Berries in Alaska's Changing Environment" series, we examine what we know about the impacts of climate change on our berry species based on scientific research and observations by community members across the state. We identify potential threats to the growth, health, and fruit production of each species. We also look at opportunities: ways that Alaskans may be able to preserve

or even expand the availability of fruits. And third, we identify gaps in our knowledge that limit our current abilities to predict what will happen with our berry species. Some potentially unfamiliar words are bold, colored, and defined in the **glossary** at the end of the booklet. We hope this information will inspire berry lovers to find ways to take advantage of opportunities, protect what we have, and adapt when that is not possible.

The series will look at growth, flowering, pollination, fruits and seeds, mutualists (like fungi that help plants obtain nutrients), herbivores, and pathogens, briefly discuss human use, and highlight threats and opportunities for each aspect of the plant life cycle under a changing climate.

TEXT: Lindsey V. Parkinson, Christa P.H. Mulder, Katie Spellman

GRAPHICS AND PHOTOS:

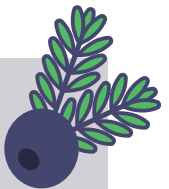
Molly Putman, Anne Ruggles, Christa Mulder, Emily Sousa, Rachel Culpovich, Kourak Nakak, Becky Knott, Ingeborg van Leeuwen, Jacob W. Frank, H. Halbritter, Kristen Schroder

MORE INFORMATION:

For more information and to download copies of this booklet visit the Alaska Berry Futures website at <https://casc.alaska.edu/changingberries>

ADVISORY AND REVIEW TEAM:

N. Fresco, M. Muscarella



Suggested citation: Parkinson, Lindsey V; Mulder, Christa PH; Putman, Molly; Ruggles, Anne; Sousa, Emily; Spellman, Katie L. (2024). Crowberry in a Changing Climate: Threats and Opportunities. Berries in Alaska's Changing Environment Series: *Empetrum nigrum*. Institute of Arctic Biology and International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, Alaska, USA.



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CROWBERRY

Crowberry (scientific name: *Empetrum nigrum*, in the Ericaceae family) is known by many names across Alaska including: *asiavik*, *paungaq* (Inupiaq)¹; *dineech'uh* (Gwich'in)²; *paurngaq* (Inuktitut)³; *auryaq*, *uryaq* (Alutiiq/Sugpiaq)⁴; *aangsu-x*, *kidnga-x*, *qanglaagimm aangsuu* (Tunuu/Aleut)⁵; *niṭanht'asr* (Y), *niṭonht'as* (K) (Deg Xinag)⁶; *ts'neht'ida* (Dena'ina)⁷; *dotson' geega'*, *deenaalt'as* (Denaakk'e)^{8,9}; *giznaey* (L), *giznae* (C), *naht' aezi* (M) (Ahtna)¹⁰; *xéel'i* (Lingít)¹¹; *maaym ggaagg*, *maaym k'awk'aw* (Shm'algyack)^{12,13}; *xa skáawaa* (Haida)¹⁴; as well as mossberry, curlewberry, and blackberry (English).¹⁵ This species is not to be confused with several *Rubus* (raspberry-like) species that grow outside Alaska that are also commonly referred to as "blackberry". Crowberry is a popular berry to harvest in Western Alaska and some regions in northern Europe.

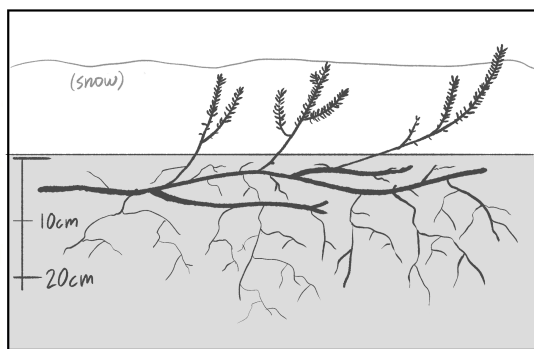
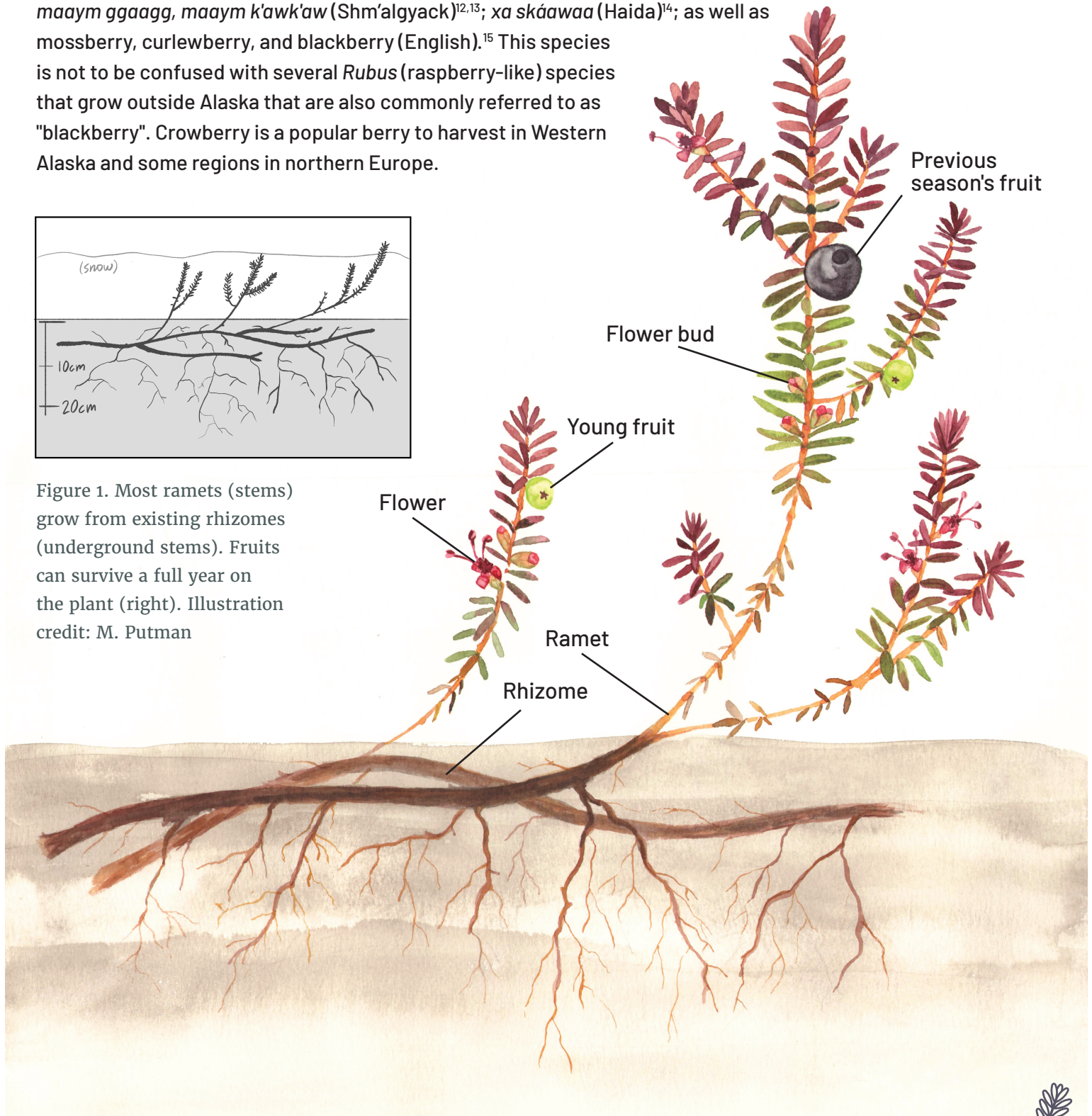


Figure 1. Most ramets (stems) grow from existing rhizomes (underground stems). Fruits can survive a full year on the plant (right). Illustration credit: M. Putman





Crowberry pie. Photo credit: Becky Knott, Eagle River

Crowberries are gathered by Alaskans all across the state, especially in western Alaska (Figure 2).^{9,15-17} The berries are valued as a source of food and for their medicinal properties, and the act of picking berries is an important cultural activity for many communities. All these benefits are particularly important where access to fresh food is scarce, such as Alaskan and Canadian communities that are not

on the road system.¹⁸ The plants and fruits are an important source of traditional food and medicine in many cultures around the circumpolar north, including indigenous peoples in Alaska and Canada as well as throughout Eurasia.

The fruits may be eaten fresh¹⁹, used with other berries in baked goods, jams, or *akutaq*,²⁰ frozen for later, or stored in and enjoyed with seal oil.^{16,19} Crowberries can even serve as a source of water when out hunting in dry regions of interior Alaska during the summer.⁹ They are often picked in the fall after the first hard frost because then they're sweeter;

pickers can also put them in the freezer for a while to get the same effect.²⁰

Crowberries are a superfood: they have very high levels of antioxidants as well as chemicals that suppress inflammation and fight cancer.^{21,22} The cancer-fighting power of crowberry extract is thought to come from its ability to protect human skin cells against damage from solar UV radiation.²¹ One study found that eating 2 g (0.07 oz.) of powdered crowberries every day for four weeks lowered cholesterol.²³

Teas and extracts of crowberry stems and leaves are antifungal

“ Black berry picking usually occurs after first frost. ”
– Benny, Kotlik²⁹



Crowberry jam. Photo credit: Rachel Culpovich

and antibacterial.²¹ In the Upper Tanana region, colds were historically treated with a drink of crowberry leaves mixed with Labrador tea (*Rhododendron* species), and spruce tips (*Picea* species), while an extract of the roots was used as an eyewash.²⁴ A tea of the leaves or stems was used to treat diarrhea or kidney problems as well.²⁴

The leaves have even more phenolic compounds (which reduce disease) than the berries!²⁵ In the lab, an extraction from the branches blocked the growth of *Mycobacterium tuberculosis*, the **bacterium** responsible for tuberculosis.²⁶

CLIMATE IMPACTS ON HUMAN USE

At least ten Alaskan communities mention crowberry in their climate adaptation plans. Many are concerned with changes in the timing of fruit ripening, which affects the harvest schedule, or express concerns about reduced abundance due to factors such as berry patches drying out.²⁷ The community of Pilot Point reports in their Climate Adaptation Plan that berry harvests have been unreliable in recent years,

including a total failure in 2012, which has had serious impacts on local diets.²⁸ And the community of Kotlik reported that flooding led to a lost season of crowberries.²⁹

“...all drowned
—even black
berries didn’t grow.”
– Winnie, Kotlik



OPPORTUNITIES FOR HUMAN USE

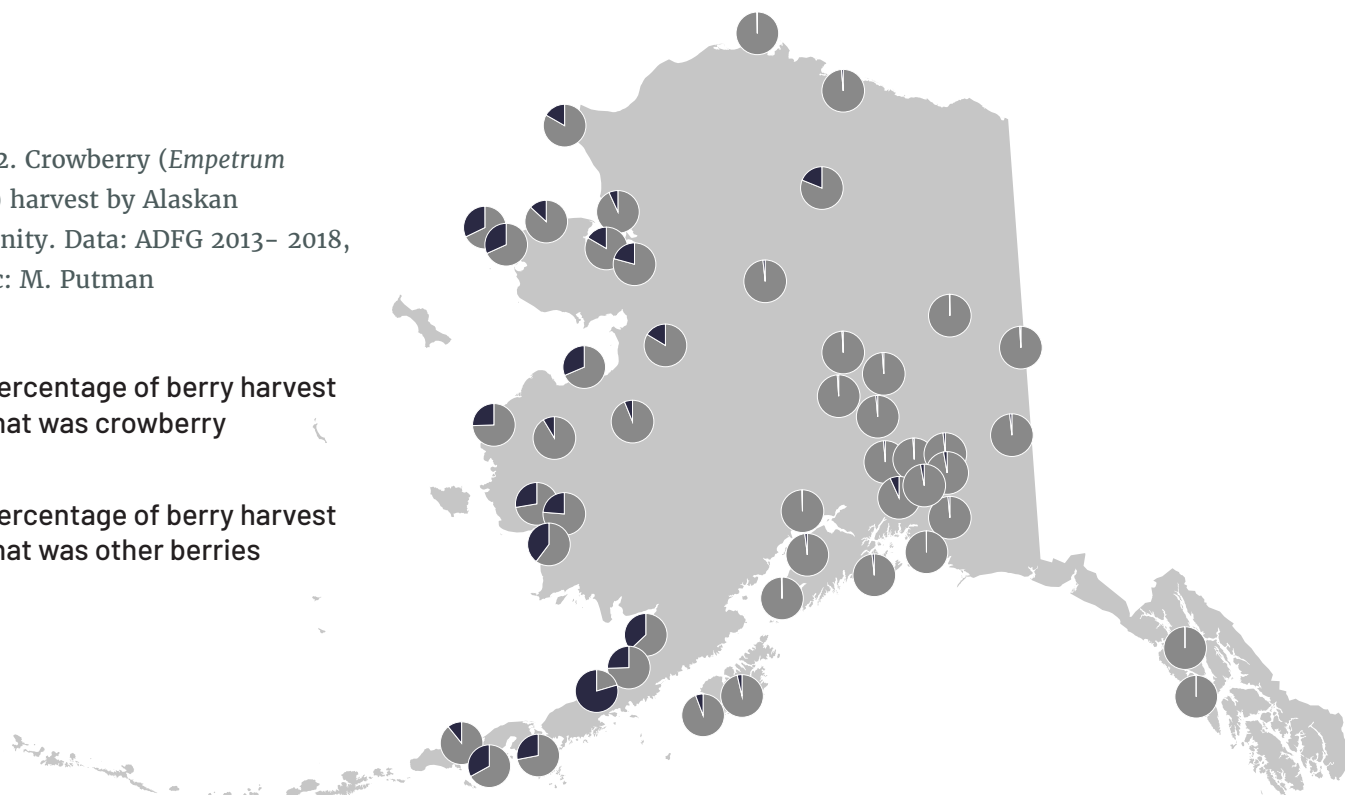
Crowberries are not commercialized in Alaska but are in Newfoundland, Iceland, and elsewhere in the boreal and Arctic regions. The berries are sold in jams,³⁰ used as an ingredient in schnapps,³¹ and the leaves and the berries are used in teas.³²



Blackberry comb and sifter made by the late Lincoln Millibrock for his wife Emily. Still in use several generations later. Photo credit: Kourak Nakak, Nome

Figure 2. Crowberry (*Empetrum nigrum*) harvest by Alaskan community. Data: ADFG 2013– 2018, Graphic: M. Putman

-  Percentage of berry harvest that was crowberry
-  Percentage of berry harvest that was other berries





Crowberry growing on moss. Photo credit: Christa Mulder, near Fairbanks.

Crowberry is a low, creeping evergreen shrub (up to about 6 inches or 15 cm in height) with small, needle-like leaves (Figure 1). Its scientific name, *Empetrum nigrum*, comes from a combination of the Greek for “upon a rock” (en, upon + petros, rock) and the Latin word for black (niger).³³ Crowberry can form thick mats of clones by growing many stems from a shared root system. Compared to other shrubs in the same environment the stems grow quite slowly, around 3 – 6 inches (7-15 cm) per year, depending on the location.^{34,35} But the plant can live to at least 140 years.³⁶

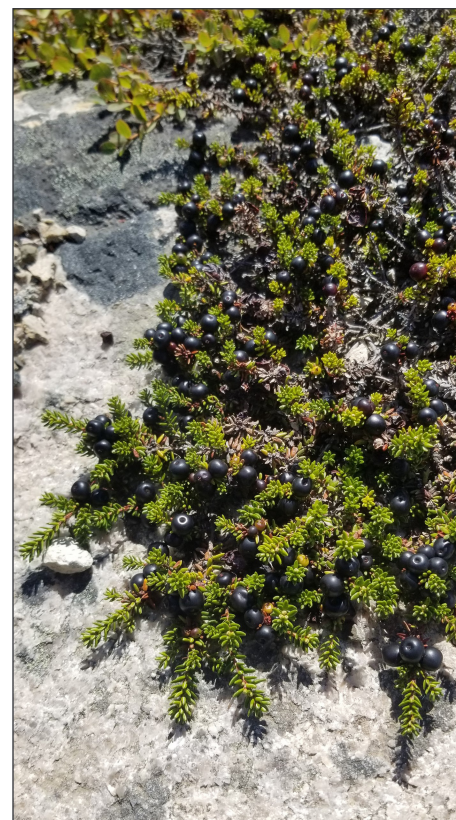
Crowberry shrubs grow all over the arctic and boreal regions of the world, and as far south as northern California and central Europe. They can grow in very acidic to neutral soil (pH 2.5 – 7.7) but not basic soil (pH > 8).³⁶ They are especially common in black spruce (*Picea mariana*) forests and

peat bogs – hence the common name “mossberry”. However, they don’t produce as many branches in *Sphagnum* moss beds as they do at drier sites.^{35,37}

Like other plants in this family (for example, lowbush cranberry), in the fall they produce high levels of anthocyanins which turn them red (Figure 3). In spring the leaves slowly turn green again. It’s not known exactly why some evergreen plants redden in winter, but it may provide protection from UV light so that they can continue to function during the shoulder seasons (spring and fall).³⁸

The short stature of the crowberry plant doesn’t allow it to overgrow other plants very easily but it is excellent at controlling space once it has it, and expanding from there.³⁴ Its dense mats make it difficult for other plants to gain a foothold. Also, because almost all of its growth is sideways, even though it grows slowly crowberry

can sometimes crowd out other plants that haven’t grown very large yet.³⁴



Crowberry on rock, Photo credit: Rachel Culpovich, near Skagway



This control of space is helped by the crowberry's leaves, which have special glands that release a complicated liquid chemical mixture (Figure 4).³⁹ The liquid harms other plants that try to grow underneath or among them (**allelopathy**). Even the dead leaves release a chemical that prevents seedlings of other plants from establishing.³⁴ However, some plant species are more susceptible to the toxins than others.⁴⁰

While experts at controlling space, crowberry shrubs do not recover quickly once disturbed, whether the disturbance is human-induced (logging) or natural (fire). Crowberry showed no signs of recovery two years after clearcutting and subsequent burning near Fairbanks.⁴¹

Figure 3. Winter-reddened leaves in springtime. New leaves are just emerging at the tips of the branches. Over the next few weeks the leaves will turn green again. Photo credit: Anne Ruggles



THREATS TO GROWTH FROM CLIMATE CHANGE

Fire sensitivity:³⁴ Unlike species like bog blueberry (*Vaccinium uliginosum*) that rapidly invade or expand in an area after a fire, crowberry's slow growth puts it at a disadvantage when competing for newly available territory. This is especially problematic in interior Alaska, where fires are becoming more frequent, larger, and more intense.⁴²⁻⁴⁴

Large tundra fires are new and historically unprecedented in Alaska.^{45,46} They present a new challenge for crowberry.⁴⁷

Loss of snow: Crowberry is usually covered by snow in winter and is dependent on the insulation the snow provides to protect it from extreme winter temperatures and dehydration.^{33,34} In areas of the state where snow cover is reduced by mid-winter thaws or by increased wind, damage to leaves in winter may increase.

RESISTANCE TO CLIMATE IMPACTS

Crowberry shrubs grow almost entirely sideways, and allocate very few resources towards upward growth. As shrubs like alder and willow attempt to invade tundra areas, crowberry's dense mats of branches and allelopathic chemicals may prevent the taller shrubs from establishing in some areas, thereby slowing down "shrubification".



Figure 4. Trichomes (small hairlike glands) on the surface of crowberry leaves. These structures produce a range of chemicals that reduce the growth of seedlings underneath the plant. Photo credit: Anne Ruggles

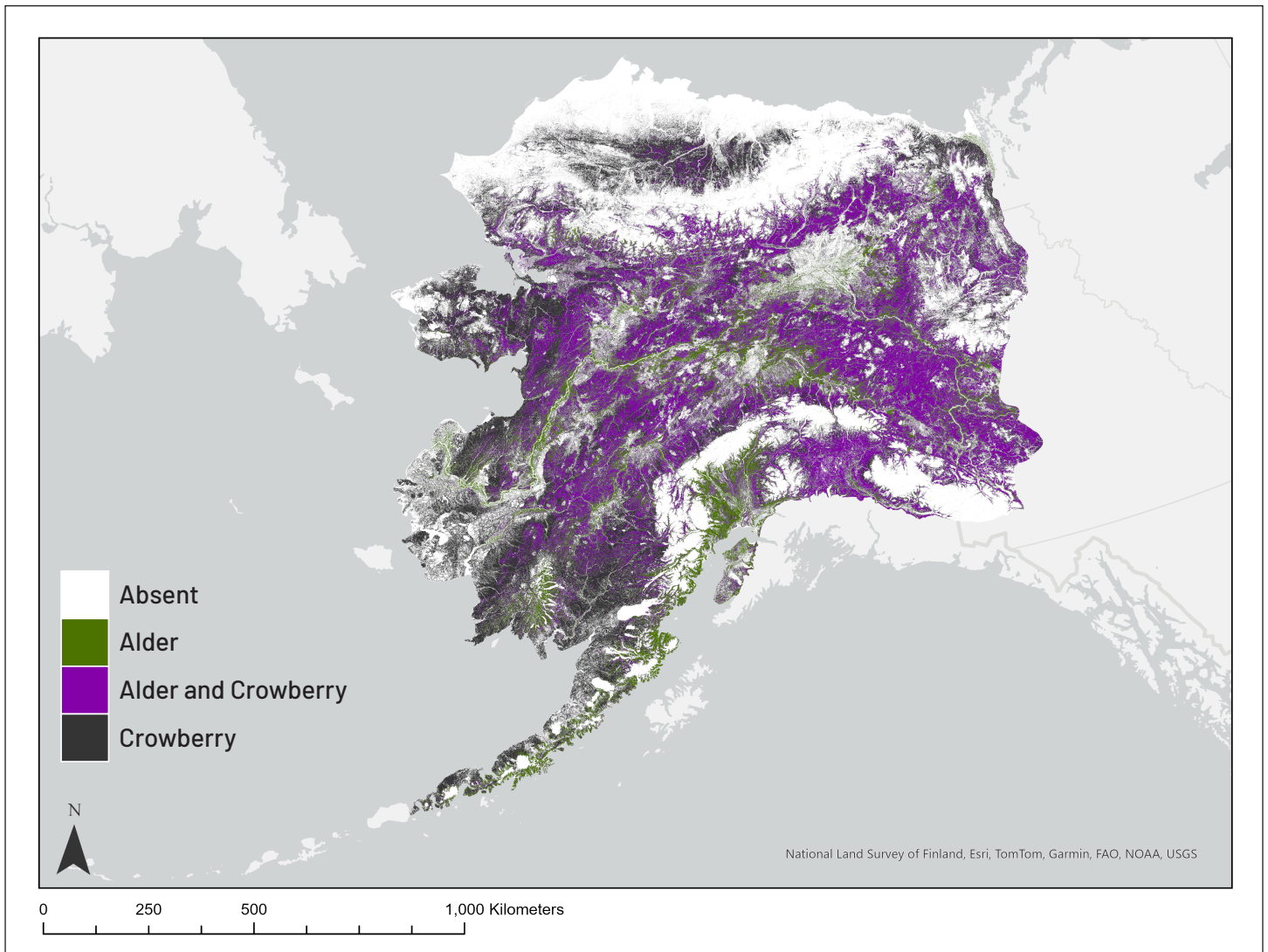


Figure 5. Crowberry and alder (*Alnus*) shrub distribution. As shrubs begin to invade formerly shrub-free tundra regions (grey areas), there may be a quiet fight for space as the overshadowing alder competes with the toxin-producing crowberry. Map: E. Sousa, Data: Nawrocki et al. 2021.



FLOWERS



Figure 6. Crowberry buds and flowers in various stages of development. From left: in bud, in early flowering stage (with the stamens just lengthening), and in a later flowering stage with spent anthers and fully receptive stigmas. These flowers are hermaphroditic (have both male and female parts in the same flower). Photo credit: Anne Ruggles

Flower buds begin to develop in July of the year before they open.^{35,48} The buds overwinter and bloom the next growing season – around early to mid-May in interior Alaska (CPH Mulder, pers. obs.).⁴⁹ This makes them one of the earliest species to flower in Interior Alaska.⁵⁰ Because the flowers are so tiny they are often overlooked, so there is not a lot of good information about when they flower in other parts of the state.

Crowberry shrubs are unusual in that they can have three different

possible combinations of sexes in a flower: they can have female flowers only, male flowers only (Figure 7), or hermaphroditic flowers (both male and female components in each flower) (Figures 5 and 6).⁵¹ The vast majority of crowberry plants have hermaphroditic flowers.

The flowers grow at the base of leaves, directly off the stem. While they are quite small, $\frac{1}{8}$ - $\frac{1}{4}$ in. (3-6 mm), the petals and **stamens** are a dark pink to purple color that stands out against the green shrub. The color must be

distinctive for pollinators to find them since they don't produce any scent. The flower is divided into threes: **3 sepals** (the structures that enclose and protect the buds), **3 petals**, and **3 stamens** (the male part of the flower) (Figure 8).⁴⁹ The number of ovules ranges from 6 to 9 and each ovule can become one seed.⁴⁹

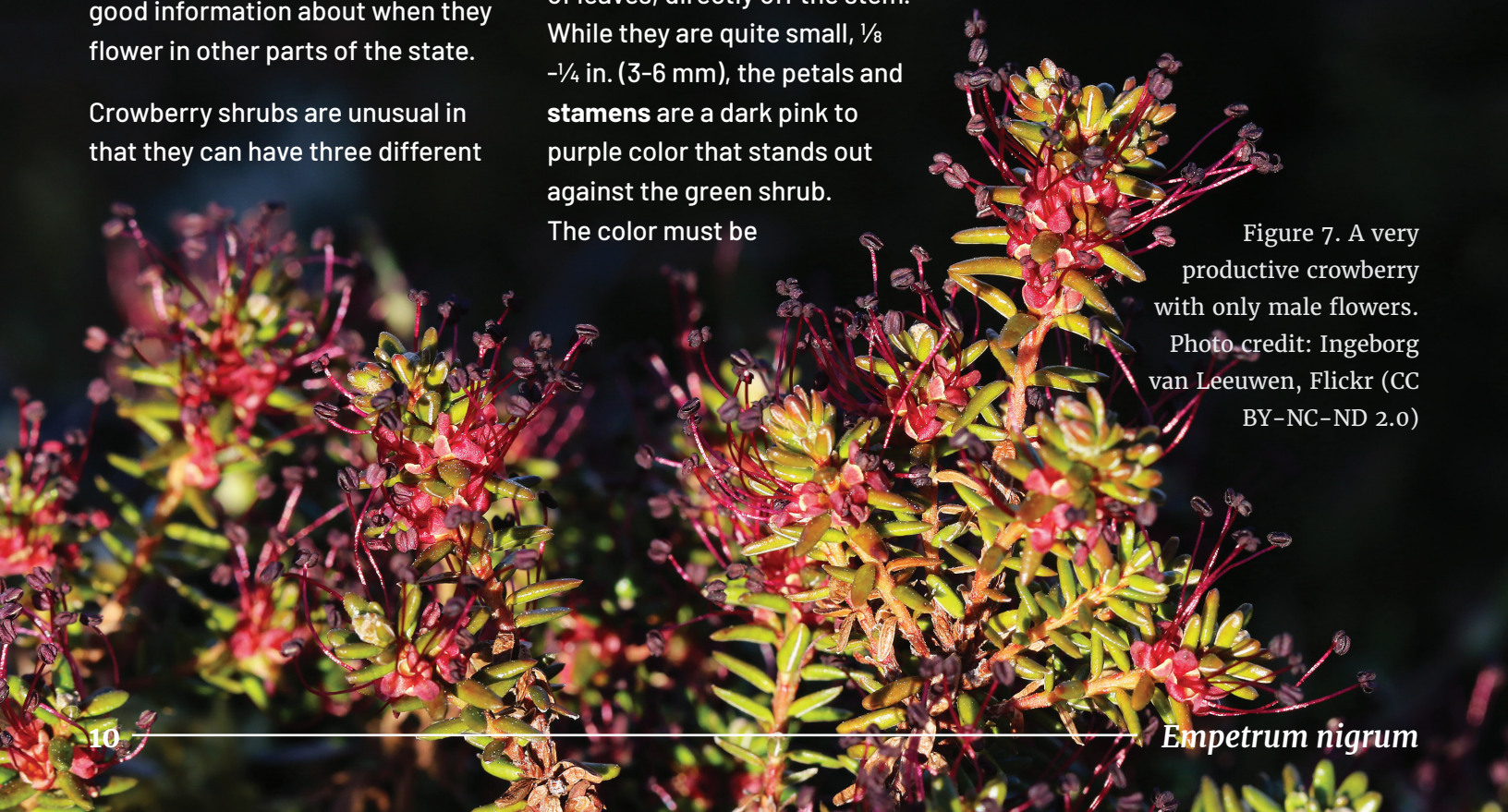


Figure 7. A very productive crowberry with only male flowers. Photo credit: Ingeborg van Leeuwen, Flickr (CC BY-NC-ND 2.0)

POLLINATION

The flowers of crowberry plants have some traits that are typical of wind-pollinated flowers, like little or no scent and small pollen grains. Crowberry pollen is about 25 – 50 microns (μm) wide, or about $\frac{1}{4}$ to $\frac{1}{2}$ the thickness of a piece of paper.⁵³ However, the flowers also have traits that are more common in plants that are pollinated by insects: purple color, maybe some nectar production,³⁵ and pollen grains clustered in groups of four (called tetrads, Figure 9). It is likely that this species uses a combination of wind and generalist insects like flies and beetles to move pollen between flowers.^{33,34}

Figure 8. View of crowberry flowers under a dissecting scope. Photo credit: Kristin Schroder

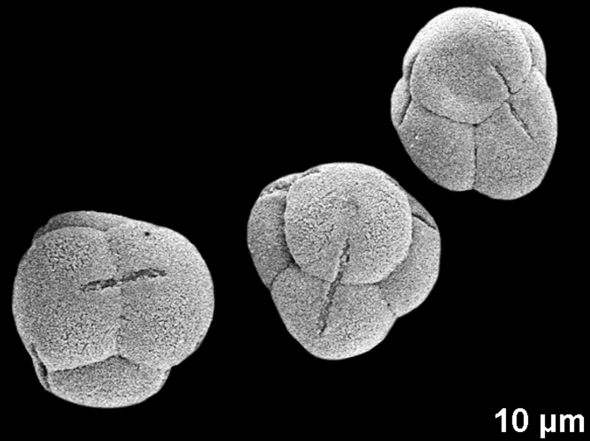
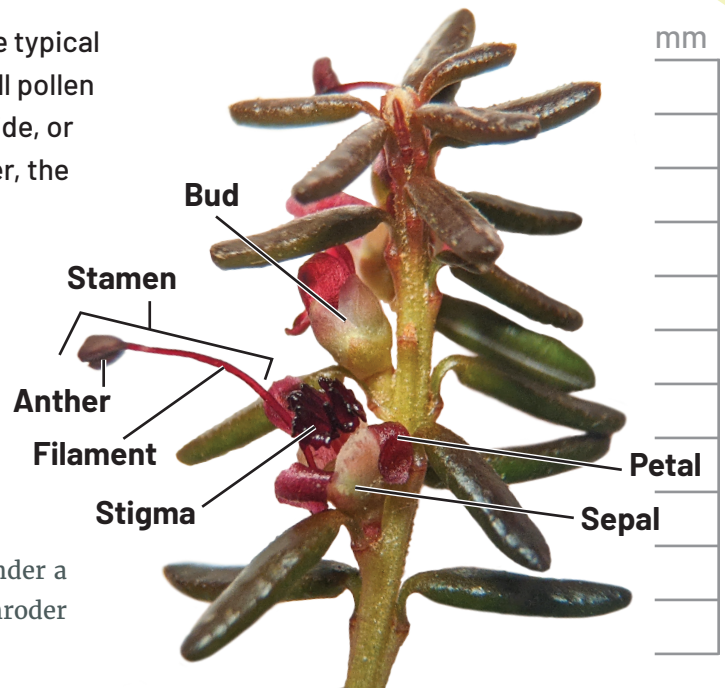


Figure 9. *Empetrum nigrum* pollen tetrads under a scanning electron microscope. Image credit: H. Halbritter, courtesy of PalDat (2000 onwards, www.paldat.org)⁵²

RESILIENCE TO CLIMATE CHANGE

The crowberry flowers' flexibility in how it gets pollen (using insects or wind) makes the plant less vulnerable to changes in insect numbers than other Alaskan berry species. It can likely still reproduce when it is wet and windy – conditions under which insects struggle to fly. This makes them much less vulnerable to mismatches with timing of pollinator activity under climate change than some other species.



FRUITS AND SEEDS

Crowberries are round, about $\frac{3}{16}$ – $\frac{3}{8}$ inch (5–10 mm) wide with shiny, dark blue-black skin. Some plants produce many berries but male plants produce none. Because crowberry shrubs are clonal, an entire patch may be male and never produce berries.

Fruits are generally ripe by the middle of July in interior Alaska⁵⁰ and, based on herbarium specimens²⁷, in much of Alaska, though likely later at high elevations. In interior Alaska crowberry fruits are available earlier than many other fruits⁵⁰, making them an important resource for animal species in late summer.

On average across Alaska, about 38% of crowberry fruits are still on the plant by the beginning of winter.⁵⁴ However, there is a lot of variability across the state in the rate at which fruits disappear from the plants. Places that are cool in spring and summer and have a lot of snow but not much rain (such as Scammon Bay and Saint Paul) lose fruits a lot faster in fall than places that are warm in summer and have many months of rain but little snow (such as Fairbanks and Sitka), possibly because there are fewer other types of berries available. Crowberry fruits are well protected against pathogens such as bacteria and fungi²¹ and remain edible for long periods of time,

with > 80% of fruits still in good shape by the end of the fall, and of these, >80% are still edible in spring in interior Alaska (but much lower percentages in other parts of the state).^{54,55} Many other berries in Alaska, such as blueberries and cloudbberries, do not survive the winter, which makes crowberries an important winter food source to many creatures.⁵⁶ For example, in northern Yukon, Canada, crowberries were one of the main foods for grizzly bears in the fall and the overwintered berries were one of the only foods available in spring.⁵⁷ Red-backed voles in the Yukon also rely on crowberries as a winter food.⁵⁶

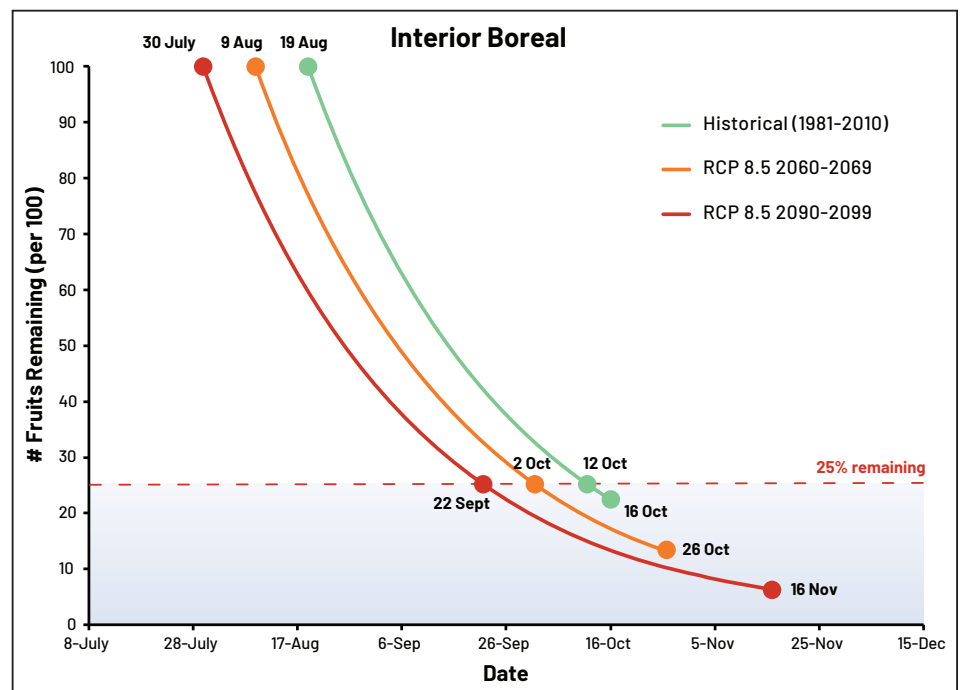
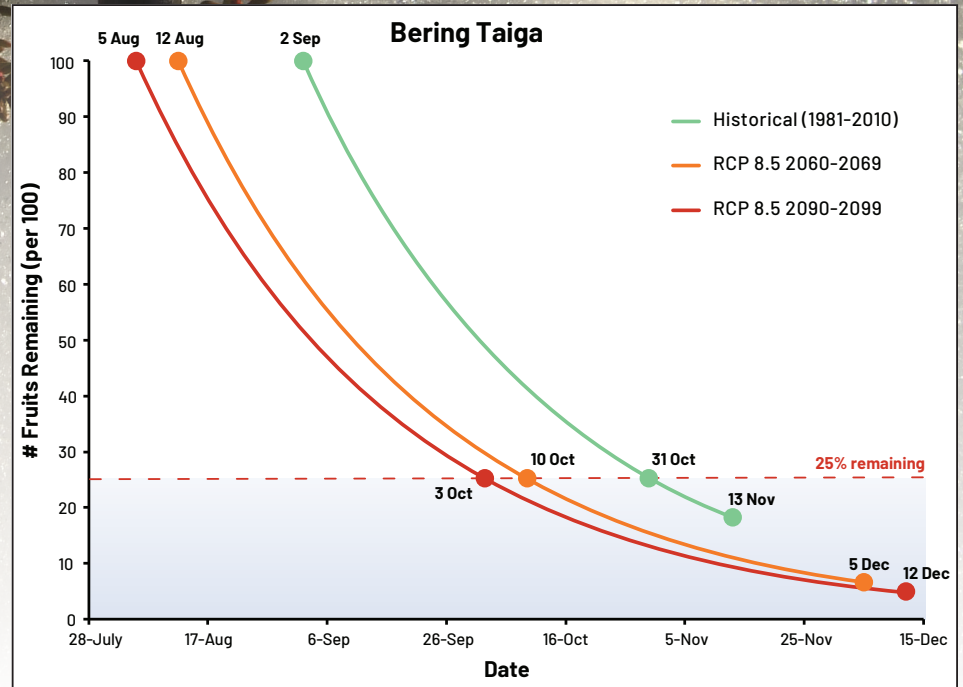
Ripening (left) and fully ripe (right) crowberries. Photo credits: Christa Mulder (left) and Anne Ruggles (right).



THREATS TO FRUIT FROM CLIMATE CHANGE

Earlier springs will lead to berries ripening earlier⁵⁸ with a greater chance that fruits will be removed before the snow falls, especially in the years with later onset of snow in winter (Figure 10). This change in growing season length will not necessarily reduce the number of fruits produced but it may reduce the number of crowberries available for animals in the winter and spring, when other sources of food are scarce.

Figure 10. Predicted changes in the timing of fruit loss in the Bering Taiga and Interior Boreal ecoregions due to shifts in the start and end of the growing season. Green lines show the % fruits remaining under historical conditions, while the orange and deep red lines show the % fruits remaining by the middle and end of the century.⁵⁹ Projections are based on the Intergovernmental Panel on Climate Change (IPCC) Representative Pathway 8.5. The large dots point to the dates by which 25% of fruits are still remaining under each of the scenarios. Image credit: C. Mulder and M. Putman.



“ We had absolutely no berries this year [2012], neither black, blue or cranberries. There were lots of dead patches in the berry bushes. ”

– Sue Evanoff, Pilot Point²⁸



SEED DISPERSAL AND GERMINATION



Golden-crowned sparrow (*Zonotrichia atricapilla*) eating a crowberry in Wrangell St. Elias National Park, Alaska. Photo credit: Jacob W. Frank.

If fully pollinated, and with enough access to resources, there are 6-9 seeds per crowberry. While most often the crowberry plant reproduces by growing new clonal shoots, the seeds can help the species recover after a disturbance or can travel to new territory in animal scat.

Crowberries make up at least a small portion of the diet of many animal species across Alaska and northwestern Canada. Fruits are eaten by foxes (*Alopex lagopus*); black, grizzly,⁵⁷ and polar⁶⁰ bears (*Ursus arctos*, *U. horribilis*, *U. maritimus*); caribou (*Rangifer tarandus*)^{61,62}; and many bird species including crows (*Corvus brachyrhynchos*), ptarmigan, spruce grouse (*Canachites canadensis*),⁶³ ruffed grouse

(*Bonasa umbellus*),⁶⁴ golden-crowned sparrow (*Zonotrichia atricapilla*), gulls (family Laridae), teals (family Anatidae), and more. In the Russian Far East, over 60 bird species have been documented eating the berries.⁶⁵ Migratory waterfowl have been observed eating crowberries in Scammon Bay, Alaska.⁵⁵

Ants and snails have been observed eating crowberry fruits in the Interior and Aleutians, respectively,⁵⁵ but invertebrates are unlikely to contribute to long-distance seed dispersal because they don't go very far.

Whichever way they get to the ground, crowberry seeds can survive in the ground for at least four years.³⁵ Many seeds need



Four seeds inside of a crowberry fruit. Crowberries can have 3-9 seeds per fruit. Photo credit: Anne Ruggles.

some way to break the seed coat before they can start the growing process. For some species it is fire, for others it's the scarring from the digestive juices of an animal's gut. While crowberry seeds seem to germinate a little more often if overwintered in scat (50% germination v. 33% without the poo, Figure 11),⁶⁶ the most important trigger to start germination is a distinct, extended cold period of weeks or months followed by warmth and moisture.



Figure 11. Bear scat (poo) full of crowberries. Photo credit: K. Schroder

THREATS TO SEED DISPERSAL AND GERMINATION FROM CLIMATE CHANGE

Crowberry seeds need a long period of cold to help start the process of germination. **Warmer winter temperatures** in the southern end of its range may mean it does not get cold enough in winter. But at the same time, **loss of insulating snow cover** in some regions like the North Slope makes it hard to predict the temperatures crowberry seeds will get exposed to across the state. In some places where the insulating snow is lost, the temperatures in the winter might be too cold for the seeds to survive.

RESILIENCE TO CLIMATE CHANGE

A study in subarctic Quebec, Canada, found much of the local population of crowberries (belonging to the closely related species *E. hermaphroditum*) seemed to be successfully using sexual reproduction, reproducing with seeds, more often. Researchers proposed it was a response to climate change: a higher percentage of the seedlings could survive and were filling in the gaps.⁶⁷

PLANT FUNGAL ASSOCIATES

Crowberry roots host ericoid **mycorrhizae** species, a group of fungi that attach and insert themselves directly into the cells and tissues of plant roots.⁶⁸ Through this close connection, the mycorrhizal fungi expand the

reach of crowberry roots, helping the plants get more nitrogen and phosphorus from the soil in return for sugars from the plant.³⁵ The mycorrhizal fungi (in the groups ascomycetes and basidiomycetes) may connect many different plants

and even other plant species, like lowbush cranberry, together.⁶⁹ The berries also have fungi and bacteria living in and on them, some that cause problems and some that do not.⁷⁰



HERBIVORES AND PATHOGENS

The leaves of the crowberry are not easy to digest and thus not a favorite of many or maybe any herbivores. However, they sometimes will get eaten in the winter or incidentally along with the berries. Willow ptarmigan⁷¹ and ruffed grouse⁶⁴ will eat the shrubs.³⁵ Arctic ground squirrels (*Spermophilus parryii*) will sometimes eat them too but prefer herbaceous plants because they are easier to digest.⁷²

Crowberry fruits are generally resistant to pathogens and don't seem to attract very many insects either. For about 2700 crowberry plants monitored in Alaska, only 3% of the fruits showed signs of damage by fungi or insects and only about 2% dried out.⁵⁵ So, of the berries that stay on the bush, almost 95% of the fruit remains in an excellent state, not damaged or dried out, for an entire year. It doesn't seem like insect herbivores or pathogens are responsible for many berry losses.^{55,73} However, observations in part of western Alaska in 2017 found many crowberries that were rotting on the plant (Figure 12). This was an unusual occurrence and the cause is unknown.

RESILIENCY

Between the unpalatable leaves and the berries that aren't heavily consumed except by some migratory birds, there is not a lot of damage most years from herbivores and pathogens.



Above: Figure 12. Crowberry shrubs in western Alaska in 2017 with rotting berries.

Below: A crowberry hollowed out by ants. Photo credit: C. Mulder



Crowberry shrubs are remarkably resilient. They can produce toxins to protect their habitat from invading plants, be pollinated by both wind and insects, and have fruits that are resistant to rot. While we could identify few “opportunities” for crowberries from climate change, we identified several ways crowberry plants are resilient and resistant to changes. The likeliest threat for crowberries in a warming climate comes from disturbance due to fire. Fire is increasing in size and severity throughout Alaska, including in the tundra where wildfires are a new, growing phenomenon.

BUILDING RESILIENCE TO CHANGES IN LOWBUSH CRANBERRIES

Cutting back shrubs that are overtaking the crowberry patches can increase the availability of light and nutrients.

Avoiding heavy disturbances to the ground around favored crowberry patches can also help plants.

KEY KNOWLEDGE GAPS

We don’t know how much of the crowberry flower’s reproduction happens through insect pollinators. **Insect communities** are already changing around Alaska and will likely continue to change as the climate warms.⁷⁴ Whether this will affect crowberries is unknown.

We don’t know how warmer conditions will affect damage by **fungal pathogens** to plants, fruits, and seeds. While heavy damage is currently very uncommon, it has occurred under some conditions, but we don’t know what those conditions are.

Competition between crowberry plants and other plants is difficult to predict. Crowberry can defend space through the use of allelopathic chemicals but if other plants can grow faster in the warmer climate, or survive fire, the chemicals may be less helpful. The relationship between crowberry and overstory plants like alders or even *Sphagnum* moss (which can overgrow the crowberry plant) may shift.

GLOSSARY

Allelopathy - when a plant produces a toxin to suppress growth of nearby competing plants.

Anthocyanin - natural plant pigments that make red, blue, and purple colors in many fruits and vegetables. They are antioxidants, which have health benefits for people

Herbivore - an animal that eats primarily plants

Microbe - a microscopic organism or microorganism — especially bacteria and fungi

Mycorrhizae - A beneficial fungal partner that grows around many plant roots

Pathogens - bacteria, fungi, or viruses that cause disease

Sepals - small structures to the outside of the petals that enclose the flower buds and protect them.

Stamen - pollen producing, male part of a flower; includes the filament (stalk) and the anther (where the pollen is produced and released)

Stigma - part of the female portion of a flower; catches pollen



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A close-up photograph of several dark, round berries, likely Arctic huckleberries, growing on a shrub. The berries are dark purple to black and are surrounded by green and brown foliage. The background is blurred, showing more of the same plant and some sunlight filtering through the leaves.

Photo credit: Western Arctic National Park

Funding Acknowledgement: This report is part of the Alaska Berry Futures project of the Institute of Arctic Biology and International Arctic Research Center at the University of Alaska Fairbanks. Major funding is provided by the US Geologic Survey through the Alaska Climate Adaptation Science Center (G17ACOO213) and additional support is provided by Arctic Harvest- Public Participation in Scientific Research project (NSF Award AISL-1713156) and the Bonanza Creek Long Term Ecological Research program (NSF Award DEB-163476 and USDA USFS award RJVA-PNW-01-JV-1161952-231)