BIODIVERSITY
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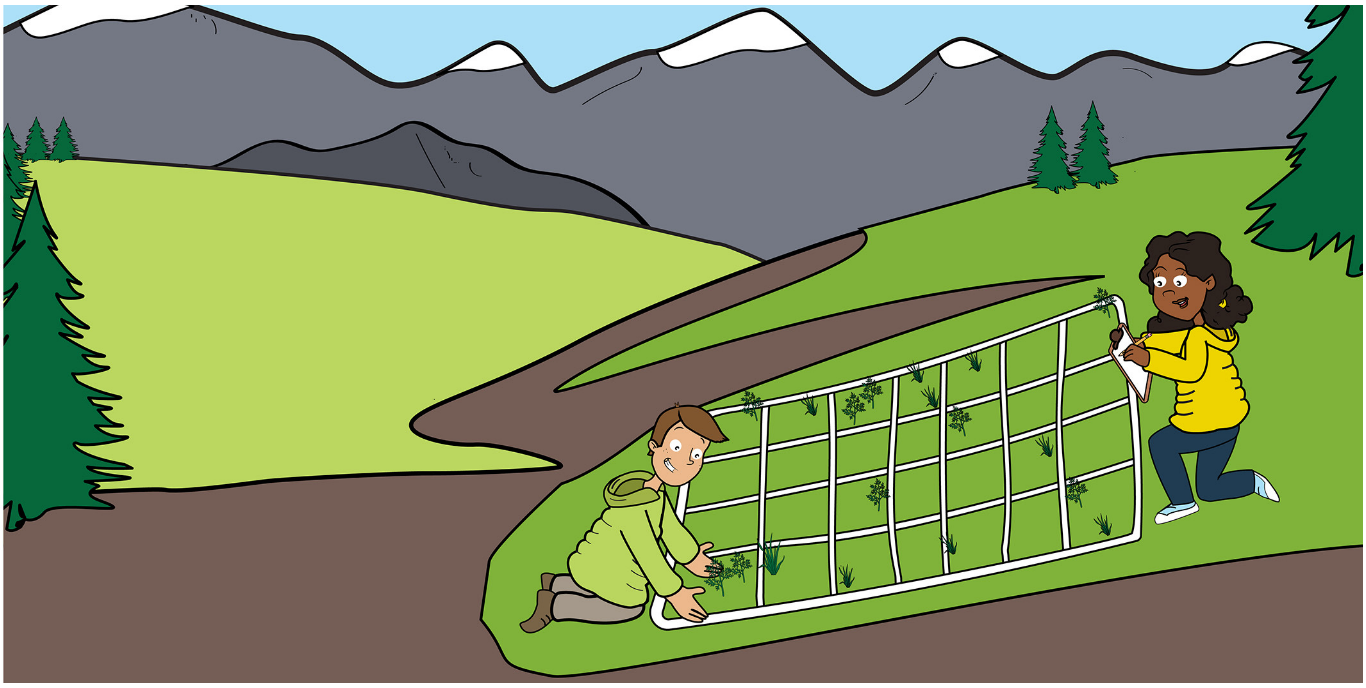

# A RECIPE FOR PLANT DIVERSITY IN SUBARCTIC ALASKA

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YOUNG REVIEWERS

SLEEPING GIANT MIDDLE SCHOOL

AGES: 12–14

Hungry for a little plant diversity? Let us mix some up! First, we gather available ingredients—a bit of soil, a few nutrients, and a selection of nearby plants. Then, we add them together, pour them onto a landscape and let our concoction sit. Sound easy enough? But wait... was that soil we used too acidic? Did we add enough liquid? Was our landscape flat or tilted? How can we adjust our recipe to grow the most plant species in one place? As plant ecologists, we travel to remote places in subarctic Alaska to look at which species grow there. At each place, we record the condition of the environment and tally the number of plant species we find. Over 1,000's of visits, we now have a pretty good recipe for cooking up plant diversity! By learning about where plant diversity is high now, we can help protect it into the future.

## WELCOME TO THE SUBARCTIC KITCHEN

The **subarctic** is the area of the world that is not quite "arctic" and not quite "temperate." It has long, cold, dark winters, and brief, warm summers. The subarctic can be a difficult place to be a plant. The sun hits the ground at a low angle and is less powerful than at the equator. Even worse, the summer season lasts only 3 months! Most plants do not have a long time to grow each year and must produce all their energy in only a few months. As a result, many plants have adapted a life strategy in which they take more than one season to grow a flower, set fruit, and develop seeds. Even the small plants you see could be many (even 100's!) years old.

**SUBARCTIC**

An area of the world with warm but short summers, and very cold winters. The subarctic contains many habitats including forest, shrublands, and tundra.

**Plant ecologists** are scientists interested in how plants interact with their environments. They observe where plants grow, how species got there, and the tricks plants use to survive. One way plant ecologists learn is by going to a place of interest, looking around, and recording all the plant species they see. They also record information about the site itself, such as whether it is on a steep slope, and the temperature of the soil. But how do they study plant ecology in a place that is enormous?

**PLANT ECOLOGISTS**

A scientist who studies how plants relate to and interact with their environment, including other plant or animal species.

## TAKING A "BITE" OF PLANT DIVERSITY

Denali National Park and Preserve, in Alaska USA, contains about 2.4 million hectares (9,500 square miles) (Figure 1). It is a bit bigger than the state of New Hampshire in the United States or the country of Belize. To gather information about plants there, plant ecologists have visited over 1,000 different sites and measured plots. A plot is like a bite of land—an area that they can survey in a few hours. Surveying these bite-sized plots makes the job of learning about where plant species grow in a large wilderness area possible.

Plant ecologists aim to measure each plot in the same way. That way, they can compare the data collected among plots and can repeat measurements in the future (Figure 1). By seeing species many times in many places, scientists can get to know plant "preferences," for example, where certain plants like to grow and which other plants grow near them.

## WHAT ARE PLANT COMMUNITIES? WHY LOOK FOR DIVERSITY?

Plant communities form as particular plant species associate with each other. Sometimes they align with environmental conditions. For example, at a dry site, there may be a gathering of plant species that have evolved structures that make them suited to dry conditions, like long roots or hairy leaves. Other times there are gatherings of species

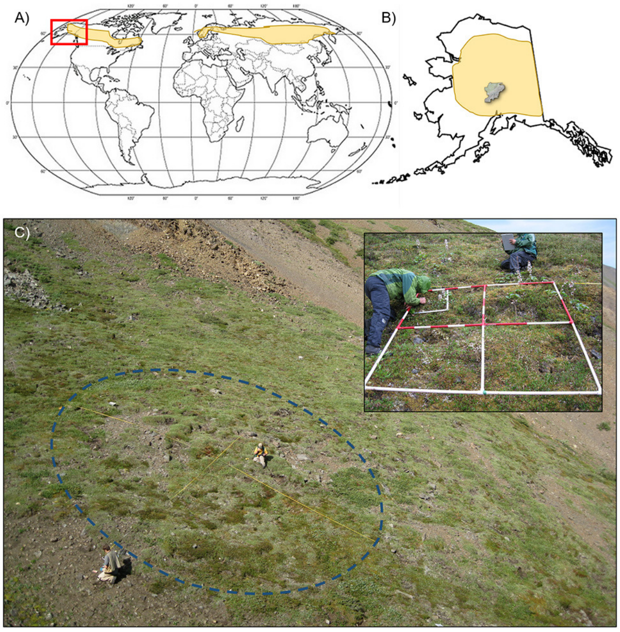


Figure 1

**Figure 1**

**(A)** This map shows the approximate location of the subarctic climate zone in yellow. The red box shows where Alaska is. **(B)** Denali National Park and Preserve is located in central Alaska and considered part of the subarctic. **(C)** Plant ecologists use tools to take a "bite" of the landscape. This system of measuring a site can be repeated at many places on the landscape. The yellow lines are tapes laid out to measure 16 m across the ground. The blue circle is added to show the area in which we record plot characteristics and count plant species.

**DIVERSITY**

Referring to the variety found within a given community. For plant diversity, this would be a measure of the number of different plant species or species types.

that complement each other. For example, where tall trees grow, their dense canopies limit the amount of sunlight that reaches the ground. Smaller plants, tolerant of shade, may thrive under the canopy. The dense canopy excludes other species that need lots of sunlight.

Some plant communities have high **diversity**, meaning they contain many different species. Other plant communities are less diverse, hosting only a few. In human neighborhoods and schools, diverse perspectives enhance creativity and improve problem solving. Diversity in plant communities provides similar benefits. Diverse plant communities provide a variety of habitats for other creatures. Diverse plant communities also tend to include unique species that are not found in other places on the landscape. By understanding where and when diverse plant communities develop, we can better protect them.

## TIME TO GET COOKING!

How can we find diverse plant communities on the landscape? To start, let us follow the cooking steps below for hints on where and when diverse subarctic plant communities may develop (Table 1). Then we will look at some data to see where the greatest plant diversity has developed.

### Step 1: Gather the Ingredients

In our recipe for plant diversity, the primary ingredients are plant species. Do you think there are tropical flowers that can grow in

| Procedures | Information needed | Why? |
|---|---|---|
| Step 1: Gather the ingredients | Available plant species | The possible plant species come from the species pool, which is dependent on the biogeographic history of the region. |
|  | Soil type and age | Soils are developed over time and depend on the rock type and climatic conditions, as well as how often the soils are disturbed (like by flooding or wildfire). |
| Step 2: Choose a baking pan and adjust the oven | Site characteristics | Landscape characteristics of a site generally include elevation, slope, and aspect, which together provide a lot of information about how much sunlight and warmth a site receives. |
|  | Climate and micro-climate | Additional information about warmth and moisture specific to plant communities can be found by investigating the patterns of temperature and precipitation experienced by the plants, both at larger (hillslope, for example) and smaller (under a forest canopy, for example) scales. |
| Step 3: Mix, pour, and let sit | Order of species arrival and level of competition | Some species have traits that allow them to compete with other species for resources, while others do better on their own, when they do not have to compete. |
|  | Patterns of disturbance | Some portions of the landscape are likely to be disturbed, and their plant communities restarted many times. An example is near a river prone to flooding. Other portions of the landscape are more stable, like gentle slopes. |

Table 1

**Table 1**

A recipe for plant diversity. The "Information needed" column includes some of the most important items to consider when investigating diversity at a particular place. Note that this table is most relevant to places in the subarctic [1]. For determining diversity in other regions, additional information may be needed.

Alaska? Or piles of seaweed sitting atop the tall mountains? No, that is unlikely. In cooking up plant diversity in the subarctic, we are somewhat limited by the plants currently found in and around the subarctic region. This is called the **species pool** and it contains the greatest number of species that could survive in an area *and* are in that area currently or have been there in the recent past. For a plant species to be part of a plant community, that species must be there already or be able to arrive there.

**SPECIES POOL**

All the species that could colonize and survive in a particular area. The species pool is based on the history of an entire region over 1,000's of years.

Another important ingredient is soil. Soil is the foundation for how most plants interact with their environments. Soil conditions vary due to the rock type the soil came from, climate-related heat and moisture inputs, and how long the soil has been developing. In the subarctic, young soils (younger than 100 years) tend to be rocky and warm. Older soils (older than 5,000 years) tend to be full of organic muck and are frozen [2]. Individual plant species have different tolerances of these soil conditions. Thus, soils play a critical part in influencing how diverse a plant community in a specific area may be.

### Step 2: Choose a Baking Pan and Adjust the Oven

When baking, the type of cookware you use makes a difference in how the batter receives heat from the oven. Applied to our quest for plant diversity, this means we must consider the shape of the landscape. Even when beginning with the same set of plant species and other ingredients, the land where the plants grow affects their survival.

Elevation, slope, and **aspect** are important landscape characteristics in determining plant diversity. Slope is the steepness of the land and aspect is the direction the land faces. Together, they determine how much sunlight a site receives and how much moisture it can hold. At the high latitudes of the subarctic, the sun hits the earth at a low angle, so it is not, by itself, very powerful. But, if the land slopes to meet the sun, its warming effects can be greater.

**ASPECT**

The direction in which a surface faces. For a plot, the aspect is measured with a compass and influences the amount of sun exposure received.

Speaking of sun and warmth, when baking, the temperature of the oven matters! Have you ever followed a recipe that says to place your pan on the top rack only? Or to rotate the pan partway through baking? **Microclimate** is a term used to describe small parts of a landscape (or oven) that experience a different climate. A diversity of microclimates allows for a wider variety of plants to thrive there.

**MICROCLIMATE**

The usual weather conditions specific to a small area. For example, the temperature, moisture, and wind under a forest canopy may differ from those of the hill the forest grows on.

### Step 3: Mix, Pour, and Let Sit

As any good cook knows, there is more to a recipe than a list of ingredients! The order that you add ingredients often matters. In plant communities, the plant species that arrive first often have a competitive advantage over the ones arriving later. In other cases, certain species cannot survive unless those early arrivers have done some work to the site to make it more inhabitable.

Occasionally a site is disturbed by a wildfire, a landslide, a flood, or even a bear digging a den. When that happens, it is a bit like spilling the bowl of ingredients. Sometimes the recipe is salvageable and can be prepared as expected. Other times, a critical piece is lost, and the resultant concoction comes out different. When a disturbance “restarts” a plant community, a different set of species may take over. This restart may change the plant diversity of an area for many years to come [3].

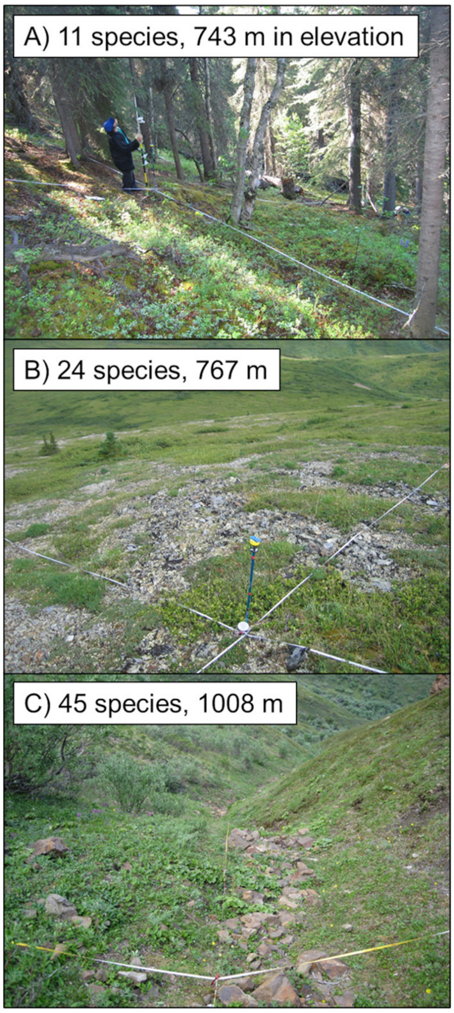


Figure 2

**Figure 2**

These sites in Denali National Park and Preserve display **(A)** low (11 species, 743 m in elevation), **(B)** medium (24 species, 767 m), and **(C)** high (45 species, 1,008 m) plant diversity. Can you match any of the site characteristics you see to our recipe for plant diversity?

## A SUBARCTIC SURPRISE? DENALI'S DIVERSE ALPINE

The open alpine tundra contains the most diverse plant communities in subarctic Alaska [1]. This may seem strange because you may envision the top of a mountain being cold, snowy, and windy. But high elevations allow for the perfect combination of ingredients, baking pan, oven, and procedures (Figure 2).

In our species pool, there are many small and hardy plants well-adapted to alpine conditions. Over many **periods of glaciation**, these species survived in the alpine as the valleys below filled with ice [4]. Mountain tops are made of exposed bedrock or otherwise young soils. These are better for growth than the frozen, acidic soils common in the lower elevations [1]. Some mountain slopes tilt to the south and allow more warmth to accumulate earlier in the season. This lengthens the potential period of growth. Where the land slopes, there are small-scale soil differences due to mini-landslides. These small disturbances create microclimates that attract species in the species pool [5]. Many of these species are tolerant of alpine conditions. The

**PERIOD OF GLACIATION**

An interval of time, generally 1,000's of years, when glaciers covered larger portions of the landscape than they do today.

wind and cold keep out larger shrubs and trees that would take up a lot of growing space and soil nutrients.

## REFINING THE RECIPE

The arrangement of plants on the landscape is a phenomenon that occurs over many years. It is the result of a complex series of predictable and unpredictable events. Plant diversity is likely to change as global-scale climate changes alter the landscape. For example, in the subarctic, we have found trees and shrubs growing into higher elevations. They take space away from the diverse, open alpine tundra communities [1]. If those communities are lost, how will the recipe for plant diversity change?

It is important to learn about where individual plant species, and the communities they form, exist on the landscape today. This information helps plant ecologists predict how those species may be able to adapt to changes in the future. By monitoring plant communities as they respond to changes over time, ecologists can refine the "recipe" for plant diversity. Have you noticed what influences the diversity of plants and animals where you live? What elements of the climate, history, and community development may contribute? Time to wash up, gather your ingredients, and get cooking!

## REFERENCES

1. Roland, C. A., Stehn, S. E., and Schmidt, J. H. 2017. Species richness of multiple functional groups peaks in alpine tundra in subarctic Alaska. *Ecosphere* 8:1–18. doi: 10.1002/ecs2.1848
2. Viereck, L. A. 1966. Plant succession and soil development on gravel outwash of the Muldrow Glacier, Alaska. *Ecol. Monogr.* 36:181–99.
3. Roland, C. A., Stehn, S. E., Schmidt, J. H., and Houseman, B. 2016. Proliferating poplars: the leading edge of landscape change in an Alaskan subalpine chronosequence. *Ecosphere* 7:1–30. doi: 10.1002/ecs2.1398
4. Roland, C. A., and Schmidt, J. H. 2015. A diverse alpine species poll drives a "reversed" plant species richness-elevation relationship in interior Alaska. *J. Biogeogr.* 42:738–50. doi: 10.1111/jbi.12446
5. Roland, C., Sadoti, G., Nicklen, E. F., McAfee, S., and Stehn, S. 2019. A structural equation model linking past and present plant diversity in Alaska: a framework for evaluating future change. *Ecosphere* 10:e02832. doi: 10.1002/ecs2.2832

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Students at Sleeping Giant Middle School, Livingston, Montana, USA: Mathew, Alexis, Bella, Brooklin, Caen, Chase, Chloe, David, Ed, Freddy, Grace, Haggen, Hunter, Isabella, Jackson, Kinzey, Lexi, Lily, Mathew, Matine, Nevaeh, Neve, Rose, and Weston. We are two classes of students comprised of girls and boys who are interested in science and reading—in our free time some of us like video games, skiing, watching anime, drawing, shooting, running, technology, biking, soccer, board games, softball, hunting, reading, writing, and cooking.

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Sarah E. Stehn works on a team of passionate place-based scientists in the US National Park Service. They aim to understand and conserve the ecological communities they live in. As a botanist, her focus is on the plants, particularly the often-overlooked mosses, liverworts, and lichens. She strives to contribute knowledge on how "the little guys" affect ecosystem function and adaptation to change. Examining data from an extensive network of long-term monitoring plots, she is often amazed at both the resilience and vulnerability of subarctic plant life. *sarah_stehn@nps.gov

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Carl A. Roland is a botanist/ecologist who has studied the flora and vegetation of Alaska since 1990. Each year, he cultivates a large garden and a small orchard in the Fairbanks area during the short (but increasing) subarctic growing season. He serves as plant ecologist for Denali National Park and leads the botany program for the Central Alaska Inventory and Monitoring Network for the NPS. Sometimes, he only knows where he is based on the plants that are growing there!