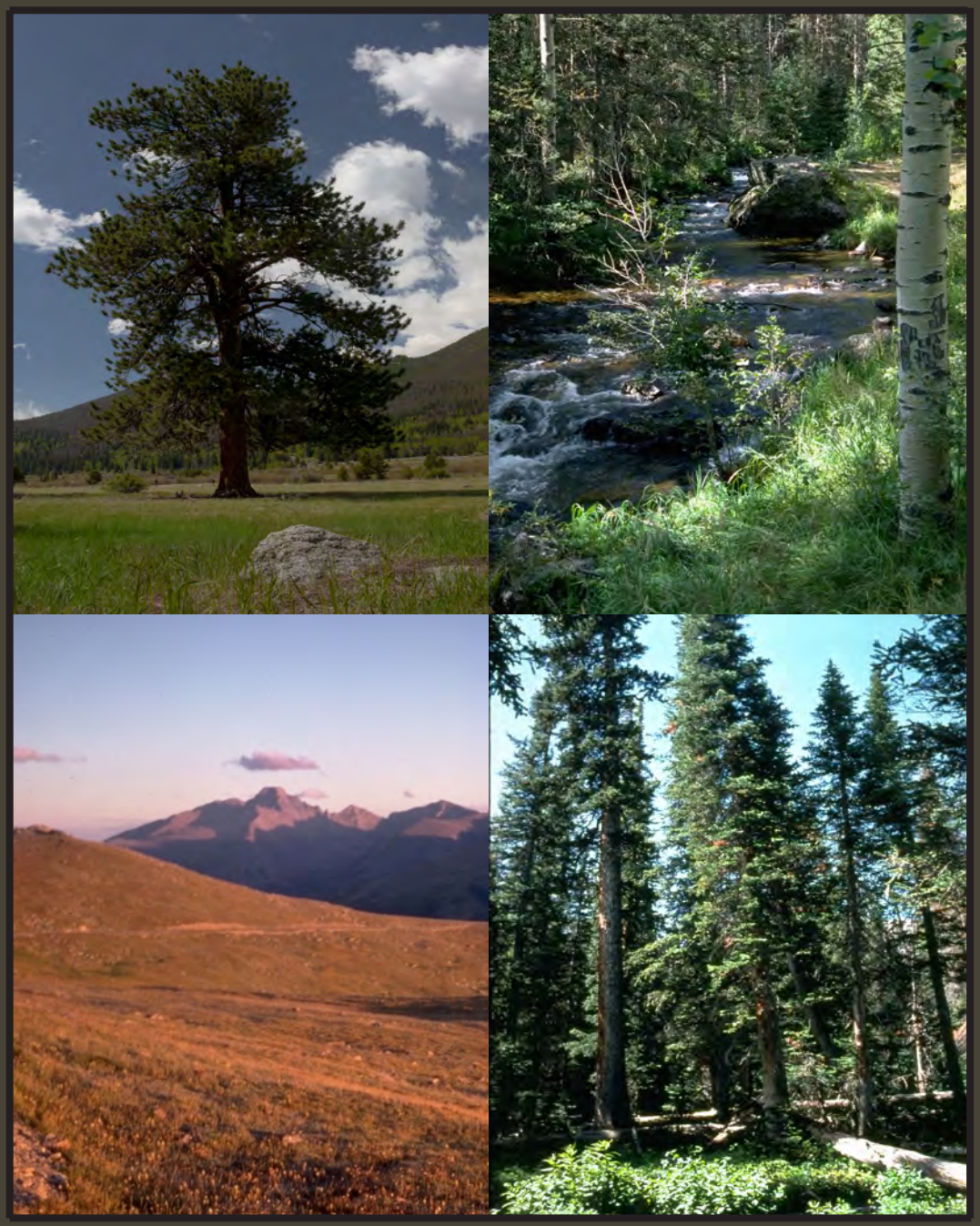
Rocky Mountain

National Park Service
U.S. Department of Interior
Rocky Mountain National Park

Ecosystems of Rocky Teacher Guide



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Rocky Mountain National Park

Rocky Mountain National Park (RMNP) is defined by the rugged Rocky Mountains that cut through the heart of the park from north to south. These mountains have shaped the landscape and created the conditions for the ecosystems we find within the park. Three of the park's ecosystems, the montane, subalpine, and alpine tundra are delineated by elevation, with the montane ecosystem comprising the lowest elevations in the park (5,600 – 9,500 ft.) and the alpine tundra ecosystem comprising the highest elevations in the park (11,000 – 14,259 ft.). This fragile alpine tundra, which comprises 1/3 of the park, is one of the main scenic and scientific features for which the park was established and is one of the largest and best preserved examples of this ecosystem in the lower 48 states.

Environmental Education was formalized at RMNP with the inception of the Heart of the Rockies program in 1992. Our curriculum is built on the principles of RMNP's founding father, Enos Mills. Mills felt children should be given the opportunity to explore and learn in the outdoors, for nature is the world's greatest teacher, a belief that is kept alive today through every education program.

RMNP was established on January 26, 1915 through the efforts of local residents, especially Enos Mills, Abner Spague, and F.O. Stanley. Today the park covers 415 square miles of beautiful terrain, most of which is designated Wilderness.

Lessons Written and Compiled By
Rocky Mountain National Park Environmental Education Staff

Teacher Guide Created by Rachel Brooks 5/2013; Updated by Christie Wilkins 3/2021

Teacher Guides

Teacher guides have been developed by the education staff at RMNP, and each focuses on a topic of significance to the Park. These guides serve as an introductory resource to the topic, and the information provided is used by park educators to develop curriculum-based education programs. Guides benefit teachers by providing the background information necessary to build a strong foundation for teaching students about specific park-related topics; they may also be used as a resource for preparing students for field trips to RMNP. Each guide contains a resources and references section to provide for more in-depth study.

Rocky Mountain National Park Education Program Goals

1. Increase accessibility to Rocky Mountain National Park for students from our gateway communities and under-served students who otherwise would not have the opportunity to visit the Park.

2. Develop a variety of internal and external partnerships with other park operations, school districts, universities, professional educational organizations, agencies, friends groups, and various funding organizations.

3. Conduct workshops to train teachers to take a larger role in their students' experience at Rocky Mountain National Park.

4. Develop distance learning opportunities to serve students from outside our visiting area.

Schedule an Education Program with a Ranger

Field trips to national parks offer unique opportunities for studying and experiencing natural and cultural resources. Field trips are a great way to make abstract concepts from the classroom concrete. RMNP is an ideal outdoor classroom. It has a diversity of natural resources, easy spring and fall access, and is in close proximity to Front Range and Grand County communities.

Rocky Mountain National Park, like many national parks, offers ranger-led education programs. Heart of the Rockies, Rocky's education program, provides free field and classroom-based education programs, aligned to Colorado education standards. School groups should make reservations at least 6 months in advance. National Park entrance fee waivers may also be available for school visits. For further information or to schedule a program please contact the Education Program Manager, at (970) 586-1338.

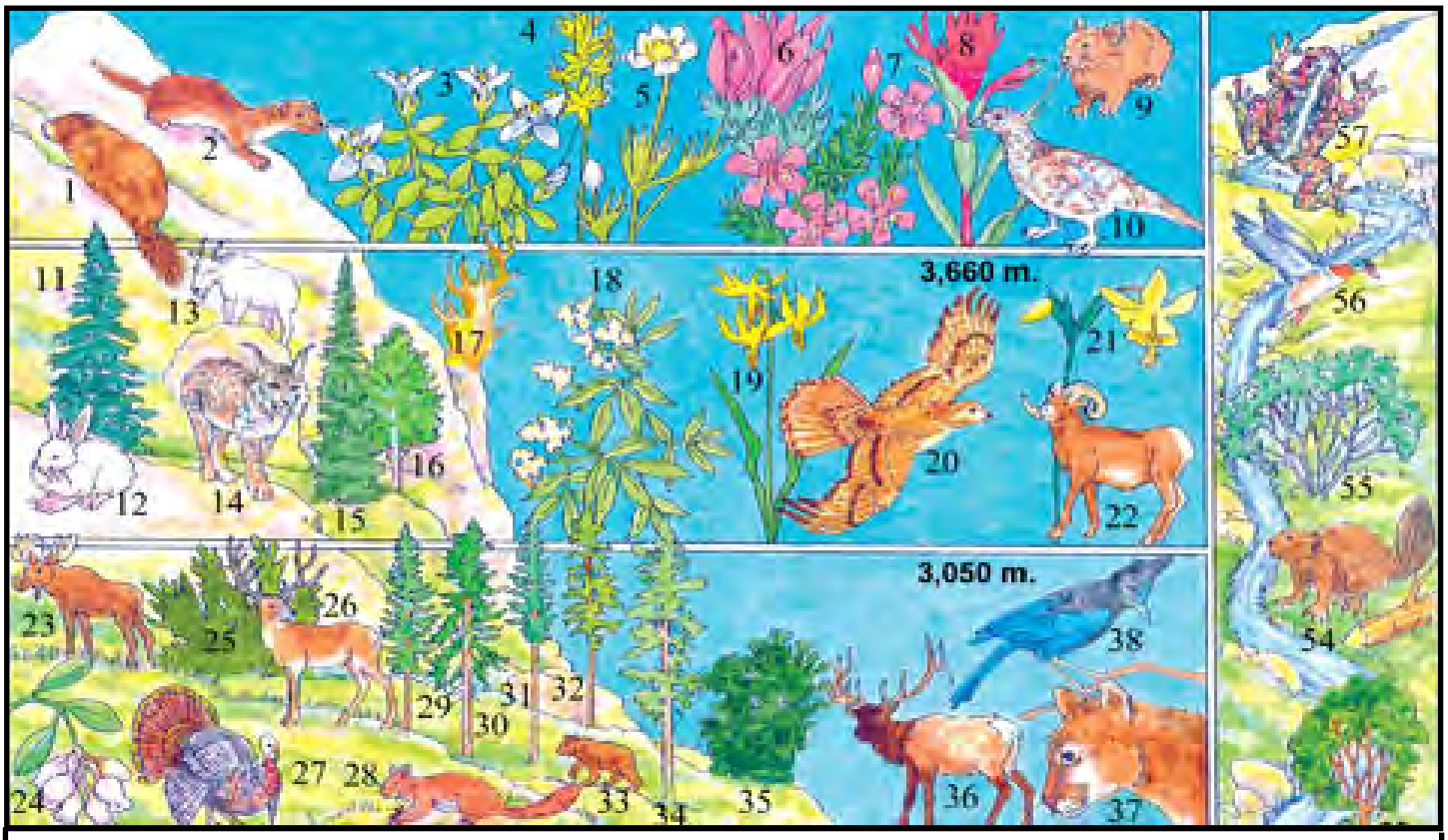
A variety of ranger-led education programs are offered seasonally. Programs in the spring and fall are generally similar focusing on a variety of park topics; programs in the winter are limited to snowshoeing programs and classroom programs focusing on winter. To see a list of the latest available programs please visit http://www.nps.gov/romo/forteachers/planafieldtrip.htm.

Ecosystems of Rocky Background Information

Introduction

An ecosystem, an interaction of biologic communities with the surrounding physical environment, can be as small as a cubic centimeter of soil or as big as the ocean floor. The four ecosystems of Rocky Mountain National Park (RMNP) have distinctions that make them uniquely important to life. Like other ecosystems, the ones found in RMNP include both biotic (living) and abiotic (non-living) components, their interactions, and a source of energy, usually the sun.

To learn more about the park as a whole, and how all its living organisms thrive, it is best to learn about the characteristics of each ecosystem and to compare them in order to see the story of survival and beauty in RMNP. The four distinct ecosystems of RMNP are: the montane, the subalpine, the alpine tundra, and the riparian. Each ecosystem is composed of organisms interacting with one other and with the surrounding natural environment. Living organisms (biotic), the dead organic matter produced by them, and the abiotic (non-living) environment that impacts the biotic life (water, weather, rocks, landscape) make up the members of an ecosystem.



A sample of plants and animals found in each ecosystem:
Montane - (5,600 to 9,500 ft): (23) moose; (24) bearberry; (25) mountain mahogany; (26) mule deer; (27) wild turkey; (28) pine squirrel; (29) grand fir*; (30) Douglas fir; (31) western larch*; (32) lodgepole pine; (33) grizzly bear*; (34) ponderosa pine; (35) Gambel oak*; (36) elk; (37) cougar; (38) Stellar's jay. **Subalpine** - (9,000 to 11,000 ft): (11) Engelmann spruce; (12) snowshoe hare;(13) mountain goat; (14) lynx; (15) subalpine fir; (16) aspen, also common in montane; (17) bristlecone pine; (18) black elderberry; (19) yellow glacier lily; (20) red-tailed hawk; (21) yellow columbine; (22) bighorn sheep. **Alpine** - (11,000 ft): (1) yellow-bellied marmot; (2) weasel; (3) moss gentian; (4) bog sedge; (5) alpine anemone; (6) dwarf clover; (7) moss campion; (8) scarlet paintbrush;(9) pika; (10) white-tailed ptarmigan. **Riparian (occurs in each ecosystem)** - (50) trumpeter swan; (51) water birch; (52) mallard duck; (53) cottonwood; (54) beaver; (55) mountain alder; (56) wood duck; (57) boreal toad. Note: "*" for organisms not found in RMNP, but similar ecosystems elsewhere.

There are three categories to organize the biotic members of each ecosystem: producers (plants), consumers (animals), and decomposers. Each of these three depend on energy exchanges, the cycling of elements, and the abundance and occurrence of nutrient rich soil, water, and other abiotic factors. Within an ecosystem, both living and non-living elements are connected to create a web of life that can be specific and unique to a continent,area, elevation, and/or a cubic centimeter.

Producers

The producers provide a foundation for all other life. Just as humans depend on plants for food, clothing and much more, each ecosystem functions because of the abundance and growth of plants. Plants including trees, shrubs, grasses, forbs, and mosses depend closely on the abiotic factors of sunlight, soil, and water. The adaptive capabilities of plants that live in RMNP are countless, and the differences between abundance and distribution of species in each ecosystem are fascinating.

Consumers

Consumers play a key role in the predator-prey cycle and include herbivores, carnivores, and of course omnivores. Secondary consumers eat the primary consumers that eat plants in order to survive. The predator prey cycles of each ecosystem are supported by abiotic factors and the balance of natural processes. Each ecosystem is a part of a larger biome of RMNP, and the migrating consumers can play a part in each ecosystem depending on the season and the climate conditions for that current year.

Decomposers

To return nutrients to the soil and clean up animal and plant remains, each ecosystem relies on a workforce of decomposers. Their job is to eat the plant and animal remains and return vital nutrients to the soil for the process to begin again. On every level, the decomposers (including fungi, bacteria, invertebrates, and scavengers) play a vital part in the cleanup crew and are part of symbiotic relationships with plants and animals. While the species and process are different, decomposition is a vital part of each ecosystem.

Elevation

Elevation is one of the abiotic factors that has determined the ecosystems ofRMNP. The Rocky Mountains create a gradient of temperatures from their peaks to the low-lying meadows and valleys. Generally, as the elevation increases 1000 feet, the temperature will decrease 3.5° F. Therefore, plant distribution is determined by temperature as well as moisture availability, soil type, or disturbance by humans, wildlife, fire, avalanche, landslides, or other causes.

The ecosystems within RMNP are expansive and are on display for visitors to see, whether on a drive up Trail Ridge Road or gaining elevation on a hike. Starting at the bottom, the montane presents itself at approximately 5,600 feet and extends to roughly 9,500 feet. Elevation ranges of each ecosystem are approximate due to the intricacies ofthe land and the factors at work in a particular area. As one ecosystem transforms into another, the overlapping zone is called an ecotone. These areas show characteristics, plants, and animals of two ecosystems and are rich in species diversity.

At 9,000 feet the subalpine begins, continuing up to 11,000 feet. Near this elevation, the trees are stunted and the alpine tundra begins and includes the highest peak in the park, Longs Peak at an elevation of 14,259 feet. The riparian ecosystem runs through all the others and creates a foundation for life especially for species that thrive next to streams, rivers, and lakes. The local climate can vary between these ecosystems because the temperatures become cooler as elevation increases. Climatic variables affect plant growth in all of the ecosystems in RMNP, which in turn affects the populations of animals. The relationship between plants, animals, and decomposers is very important in each ecosystem, and this can be seen through the interaction of each ecosystem member with one another.

The Diamond of Longs Peak, the highest point in RMNP, basks in the morning sun.

The Montane

The montane ecosystem is the lowest in elevation at RMNP and encompasses mountain meadows, ponderosa, lodgepole, and Douglas fir forests. Generally ranging from 5,600 – 9,500 feet , this ecosystem is warmer and drier than the other ecosystems. There is a 10° difference in temperature within the montane ecosystem as the species shift from ponderosa pines, which thrive in wide stands, to lodgepole pines, which grow close together. The average temperatures range from 43° - 75° F in the summer and 19° - 42° F in the winter. Generally, the soil in the montane is dry and rocky and supports plants that are drought tolerant and sun-loving.

Ponderosa to Lodgepole

Generally, the south-facing slopes get the most sunlight and thus have the most vegetation. The ponderosa pine, one of three types of pine trees in the park, finds its niche in the montane ecosystem. This pine is the "symbol tree" or indicator species of montane areas. The ponderosa pine is the biggest conifer in the park and can be as old as 400 years. Adapted to dry, sunny, south-facing hillsides at lower elevations, the ponderosa pine trees love space and will spread out to become giants over time. To adapt to drought conditions ponderosa pines have a wide spreading

root system with a deep taproot that is able to capture water as much as forty feet deep and a hundred feet from their trunk. Douglas fir trees tend to like cool, moist north facing slopes. As elevation increases, the species of trees shift to a mixture of Douglas fir and lodgepole pine, and an ecotone is created between the montane and subalpine. Lodgepole stands dominate many of the areas below 9,500 feet in RMNP. The lodgepole pine that is found in the upper montane got its name because tribes like the Arapaho used the long, straight trunks to build their teepees.

Plants

Grasses, wildflowers, and other herbaceous plants create colorful meadows in areas where it is too wet or dry for tree growth in the montane. These montane meadows provide food in the spring and summer months to several animals in the park, including elk, deer, Wyoming ground squirrels, Golden-mantled ground squirrels, and a variety of birds and insects. Montane shrubs include common juniper, sagebrush, and shrubby cinquefoil which is popularly planted in gardens throughout Colorado because of its bright five-petal yellow flowers. At higher elevations, mountain mahogany and mountain maple dominate the landscape.

Animals

Consumers depend closely on the abundance of plants and seeds. The seeds of the ponderosa pine are widely consumed by animals such as the Abert's squirrel, Steller's jay, and other birds. In a symbiotic way, these animals spread the seeds of the tree creating new saplings the following year. Ponderosa pines also provide shelter for the Abert's squirrel as they nest in the trees and build their middens, or trash heaps, at the base of the trees. These small rodents are food for larger consumers of the montane, including the coyote and red fox. Chickarees and martens rely on the lodgepole pines for nesting and food. The montane meadows are also prevalent in this ecosystem. Meadows provide food and habitat for deer and elk while many species use this habitat seasonally including bighorn sheep, black bear, mountain lion, and several migrating species of birds.

Female elk graze on grasses and forbs, which are the main source of food for them during summer months, in a montane meadow.

Decomposers

Decomposers, such as the bolete mushroom, have mutualistic relationships with ponderosa pines. Tan-capped and found under ponderosa pine trees, the fungi that creates these meaty mushrooms intertwines with the tree's root tips to make mycorrhizae. Mycorrhizae produce a network of new root hairs that increase the surface area of the root allowing the tree to absorb minerals more efficiently from the soil. In return, the fungi benefits from the carbon byproducts produced by the tree. This relationship may help explain how ponderosa pines thrive in areas with inhospitable soil or low amounts of water. Other decomposers include microscopic bacteria and w eb- like fungi that break down plant and animal remains. These processes happen all over the park, all the time, but are difficult to see as they are busy at work under logs. Since 2009, the mountain pine bark beetle, an invertebrate member of the decomposer community, has been at epidemic levels in the park and has been killing species of pines. To mitigate blow down of trees and fire danger, park managers have cut dead trees in high use areas and formed piles are burned in the winter months.

Organisms to Look for in the Montane Ecosystem

Ponderosa Pine	Abert's Squirrel	Bolete Mushroom
		
• Able to withstand a prolonged drought due to a long taproot that finds deep layers of moist soil. • The taproot provides stability allowing the trees to grow large in size. • Thick bark protects the tree from forest fires. • To identify, look for long needles in bunches of 2-3. The sap smells like vanilla or butterscotch.	• Relies on ponderosa forests as its prime habitat. • Food: ponderosa pine seeds, buds, inner bark, and young male cones. • Nests: built with twigs in the crotch of a branch. They will seek shelter there at night and in winter. • Distinct tufted ears and black or gray coloration.	• Grow underground until the heat and dampness of the surrounding area push them up. • Usually present underneath ponderosa stands. • Flies lay their eggs in the mushrooms, and the larvae will feast on the mushroom until grown. • The fungus enables the tree to take up more water from the soil.

The Subalpine

Between 9,000 – 9,500 feet, the subalpine begins and continues up to approximately 11,000 feet. The climate of this ecosystem consists of long cold winters, short cool summers and higher amounts of precipitation than the montane or alpine. Average annual snow accumulation can be five feet or greater in areas. Most of Colorado's ski resorts are in the subalpine ecosystem. Large drifts are common, especially with additional windblown snow from the alpine tundra. In the spring, snowmelt water soaks the ground, and snow can remain late into the spring and even into the summer in this shaded forest. The growing season is shorter than in the montane. The mean annual temperature of the subalpine is below 35°F.

Limber Pine to Subalpine Fir & Engelmann Spruce

The crowded forests of the subalpine consist mainly of Engelmann spruce and subalpine fir trees with patches of limber pine trees along ridge tops or exposed areas. The Engelmann spruce is a higher elevation tree that shares the cool temperatures with the subalpine fir. Lodgepole and aspen groves can be found in areas of disturbance. The life histories of the subalpine fir and Engelmann spruce are similar as they both are shade tolerant, making forests in the subalpine cool and crowded with trees and understory forbs and shrubs.

Organisms to Look for in the Subalpine Ecosystem

Limber Pine	Clark's Nutcracker
	
• Able to withstand high winds and live on rocky outcroppings at high elevations. • Female cones are big with large, woody scales. • Seeds provide energy and protein to winter animals like the Clark's nutcracker. • To identify, look for long needles in bunches of 5. It is the only 5 needle pine in RMNP.	• Relies on limber pine seeds to survive the winter. • Use their long bills to break cones to get seeds to cache in several places. • They have a pouch under their tongue where they can store up to 180 seeds they will cache. • They are able to relocate seed caches by recognizing objects around the cache.

Near the upper zone of the subalpine, hardy limber pine trees inhabit rocky outcroppings and manage to survive the fierce winds of the Rocky Mountains. Here, a mutualistic relationship can be seen between the limber pine and the Clark's nutcracker. The limber pine is the only five-needled pine in RMNP, and its seeds are consumed by a black, white, and gray bird called the Clark's nutcracker named for Captain William Clark of the Lewis and Clark expedition. These birds pry open the cones of the pine in the fall and cache the seeds in several locations. The seeds are highly nutritious and help the bird survive the harsh winter.

In turn the nutcracker buries many more seeds than it could possibly eat, or remember. The remaining forgotten seeds germinate and continue the cycle of the limber pine and the Clark's nutcracker. This relationship is a good reminder to not feed wildlife because they are part of an important cycle. Near treeline the subalpine forest becomes shorter as the land becomes more exposed and colder. Limber pines are more adapted to the rocky, dry soil, but spruce and fir trees adapt as well. Some appear one-sided as banner or flag trees due to the intensity of the wind.

Plants

These thick forests are present directly beneath treeline, and the forest floor can be quite lush with shade and moisture-loving plants, such as blueberry and broom huckleberry. In general, the diversity of plant types is low; however, they create a carpet of dense plants. Forbs and wildflowers that live in the forest include broadleaf arnica and a few types of lousewort. These flowers tend to have pale colors. In forest openings wildflowers like monkshood and Parry's primrose pop up. Deep within the dense stands a passerby might stumble upon different species of orchids, including the fairy slipper or brownie lady's slipper.

The bright Colorado Columbine is the state flower and grows on the lush forest floor of the subalpine ecosystem.

Animals

Indicator species of animals include the snowshoe hare, American marten, long-tailed weasel, southern red-backed vole, blue grouse, mountain chickadee, and Clark's nutcracker. Larger animals that are rare in the park presently are the Canada lynx and the wolverine. Several migrating animals including mule deer, moose, and elk stop and graze or seek shelter from warm temperatures in the subalpine during the summer months. All animals that live in the subalpine have adaptations that allow them to cope with both the cold and the deep snow. The snowshoe hare has large, broad back feet that allow it to stay afloat and glide across the snow in search of forage or to escape a predator. Ungulates (hoofed animals) generally stay below the subalpine during the winter because it requires too much energy to get through the snow. Animals in the subalpine, like the snowshoe hare and the long-tailed weasel, also molt their fur to white to blend into the snowy surroundings.

Decomposers

In the moist understory of the subalpine other decomposers are present including a myriad of fungi, bacteria and invertebrates that work together to return nutrients to the soil by breaking down woody material as well as acquiring water for trees. The floor of the spruce-fir forest is crisscrossed with dead trees and it is the job of the saprophytic mushrooms to break down and recycle the woody material. An example of a saprophytic mushroom is subterranean mycorrhiza, another group of fungi, which soaks up the moisture in this ecosystem and plays a vital role in the survival of conifer trees (these relationships are similar to the bolete mushroom and the ponderosa pine in the montane ecosystem).These important members of this ecosystem can be found by looking closely under rotting stumps or in the soil layers. A truly spectacular decomposer of the subalpine that can be found shooting up through the forest floor are the fungus known as purple fairy fingers.

Organisms to Look for in the Subalpine Ecosystem

Snowshoe Hare	Fairy Slipper Orchid
	
• Extra-large feet that spread their body weight over a larger area so they will not sink into the snow. • Shorter ears that help them retain heat in the winter. • Brown, summer fur turns white in the winter to blend into the snow. • In the winter they change their diet from grasses and forbs to woody material like twigs and shrubs.	• Germination requires help from a fungi that aids seedling establishment. • Each stalk supports a single fragrant flower that attracts bees. • The orchid momentarily traps the bee in the floral pouch to ensure the bee picks up plenty of pollen to take to the next flower.

The Alpine Tundra

The alpine tundra or alpine ecosystem is a place of intense contrast. From afar, it appears to be a rolling desert on top of the world, but up close it is a diverse forest of tiny microhabitats. The extreme abiotics include high amounts of solar radiation, high winds, and cold temperatures. More than 200 species of tiny grasses, forbs, and mosses create a colorful display in the spring and summer. Alpine tundra is described as the land above the tree line and the word tundra means "land of no trees". Found at approximately 11,000 feet, summer temperatures in this ecosystem are generally 20° cooler than those in the montane.

In winter the temperatures are below freezing, and the wind has been recorded as reaching over 100 mph. The winter season can last from October to May, and the majority of the annual precipitation, 40 inches, falls as snow. Remnants of snow can be seen in the summer months. The summer season may last from June to September, and the growing season averages less than 40 days. Plants and animals living in the alpine zone have adapted to these harsh conditions. RMNP is 1/3 alpine tundra: Trail Ridge Road and Old Fall River Road give visitors a chance to see and experience this unique ecosystem. In 1976, RMNP was designated as a biosphere reserve to continue the conservation of the tundra, promote environmentally sound economic growth, and to support research, monitoring, and education.

Trees like this limber pine seek shelter from the harsh winds by growing next to boulders.

The alpine tundra is an area of concern because of the impact of global climate change. Current studies involving pikas, ptarmigan, and the hardy tundra plants show an uncertain future as the climate warms. Species that depend on cooler temperatures will eventually shift to higher, cooler elevations, but at some point species will have to adapt to this area or find another home. Research continues in RMNP as more and more information becomes available about climate change.

Krummholz

As elevation increases, the subalpine fir and spruce trees huddle and become islands called krummholz (German for "crooked wood"). Long ago, the prolonged warming of the climate allowed the trees to establish at this ecotone elevation, and now these trees have adapted to the cooler climate by sending out lower branches that take root close to the ground to grow horizontally instead of vertically. These ragged-looking stands signify the drastic boundary between the high elevation ecosystems. Over years and years these islands of trees will slowly march across the tundra in the direction they are pushed by the harsh winds.

Plants

Alpine plants are usually small, low growing, and well adapted to the cold, short growing season. Due to the cold, most plants are perennials and grow and reproduce slowly. Plants on the tundra include flowering dwarf shrubs, grasses, lichens, mosses, and sedges, all creating a mosaic of microhabitats. The colors of alpine plants are vibrant in the short summer months where the pollination and growth of these plants has to happen very quickly. The rate of respiration and photosynthesis is much faster than a plant at a lower altitude.

Plants to Look for in the Alpine Tundra Ecosystem

Alpine Avens	Sky Pilot	Clover
		
• One of the most common alpine wildflowers. • When fall arrives, a buildup of anthocyanins turns the plants a deep red color. • Pikas use the alpine avens, which has a chemical that helps keep hay piles fresh during the winter.	• Also called sticky polemonium because it has sticky leaves. • Individual plants have a sweet smell to attract bumblebees or a skunk-like smell to attract flies. • Its bloom is determined by elevation, and it grows in meadows and rocky slopes that get plenty of sun.	• There are 3 types of clover; Parry's, dwarf, and alpine. • Taproot can be more than 1 meter deep. • Clover species are important to the alpine tundra due to their nitirogen fixing capabilities that increase the amount of N in the soil.

Each tundra plant has its own survival story to tell. The old man of the mountain, for instance, utilizes a spectrum of adaptations to survive and thrive as it is east facing, soaking up the sun's rays and storing food in its roots for years until it has enough energy to bloom into yellow flowers before the entire plant dies after the seed matures. Below are summaries of the remarkable adaptations that many plants, like old man of the mountain have to thrive in the alpine tundra.

Size

Small plants are well adapted to conserve water and to stay warm; most energy is used to form the root system that is usually 2-8 times bigger than the above ground part of the plant itself. The above ground plants find protection by hugging the ground. Being close to the warm, absorbent soil helps keep plants from freezing. Taller plants or trees are more susceptible to the high winds and freezing temperatures. A great way to feel the temperature difference on the tundra is to lie down, gently so the plants are not destroyed, and then sit up to feel the temperature and wind differences.

Hairy Wonders

The stems, leaves, and buds of these plants are highly vulnerable and often have extra waxy protection or tiny hairs that cover the plant. These hairs provide protection against the very strong UV rays, create a layer of insulating warm air, and reduce water loss by protecting the plant from high winds.

Xeric Adaptations

Plants have also adapted to the dry (xeric) conditions of the alpine. Many of these are small, stunted versions of species found in lower ecosystems, but they are all good at finding microclimates where there is water, plenty of sunlight, nutrients, and protection from the wind. Plants put out rhizomes, or shoots, to aid in reproduction and nutrient finding in times of drought.

Growth Formations

Some plants have adapted to the environment by growing in a cushion formation like moss campion and alpine phlox. Cushion plants grow in clusters over the rocks of the tundra. Plants in clumps remain 20° warmer than the surrounding air. Staying low to the ground, they grow in an aerodynamic shape which allows the wind to flow right over them. The foliage of these plants grows to allow the maximum amount of photosynthesis while blocking out the most wind possible.

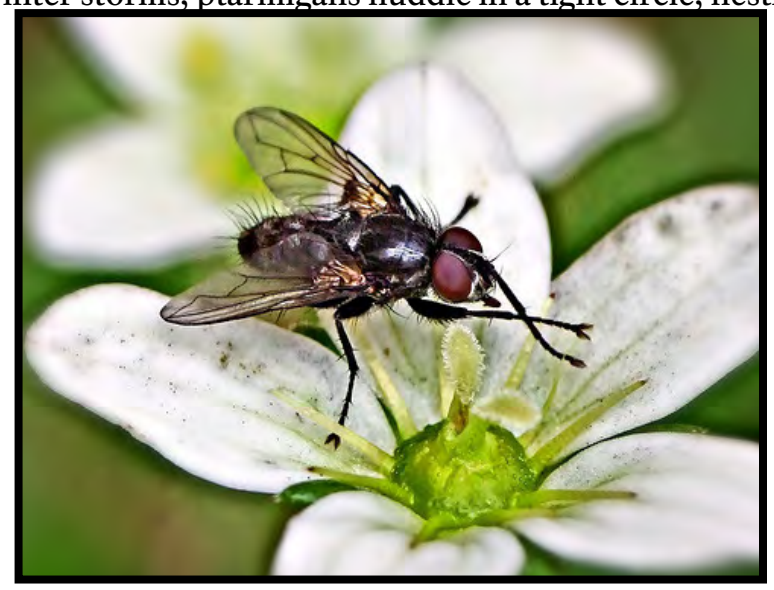
Snow Warmth

The snowfalls provide water and insulation to the plants and soil beneath. These plants are so specially adapted to the tundra's climate, snow can be considered beneficial and necessary for the plants' survival.

Animals & Insects

Animals, like the marmot, White-tailed Ptarmigan and the pika depend on these plants for survival. Elk will migrate to the tundra to find cool temperatures and a smorgasbord of delicious grasses to eat. With such extreme conditions, inhabitants of the alpine tundra are well adapted and sensitive to changes in the environment. Conservation of the alpine tundra is an area of concern; the careless hiker can trample years of growth without knowing, and climate change will have numerous impacts on the inhabitants of this incredible place.

There are a number of different flies which live on the alpine tundra and serve as important pollinators for plants. Insects are able to adapt to the cold climate by producing glycerol which has antifreeze abilities, allowing their body fluids to dip below freezing temperatures while not killing the insect. Some insects are able to extend their life cycle to more than a year to make sure they can grow and reproduce. The number of birds found on the alpine tundra is limited due to the cold conditions and limited food. However, the ptarmigan lives there all year round. During the harsh winter storms, ptarmigans huddle in a tight circle, nestling into the snow, to retain their heat.



In addition, their legs and feet are covered completely in feathers during the winter to provide insulation from the cold. Other birds such as the sharp-shinned hawk and golden eagle soar and hunt at the high elevations but prefer trees and lower, protected elevations for nesting. There are 19 species of mammals that live above tree line all year; all others are only visitors since food becomes almost impossible to find during the seven month winter. The pika, a member of the rabbit family, lives on the alpine tundra year round. Pikas use the short summer months to harvest grasses to store for winter food, as they do not hibernate. In contrast, the marmot spends the short summer months eating until it can eat no more and then they hibernate all winter long. The largest mammals in the alpine zone, such as bull elk, bighorn sheep, coyotes, and mountain lions, leave the tundra during the winter and move down to the subalpine or lower.

Decomposers

The clean-up crew on the tundra consists of ants and other invertebrates that assist the plants in pollination and breaking down dead material from the previous year. Nutrients are sparse on the rocky surface of the tundra, and most plants take advantage of the thin layer of soil, outcompeting many fungi species that thrive in more moist environments.

Animals to Look for in the Alpine Tundra Ecosystem

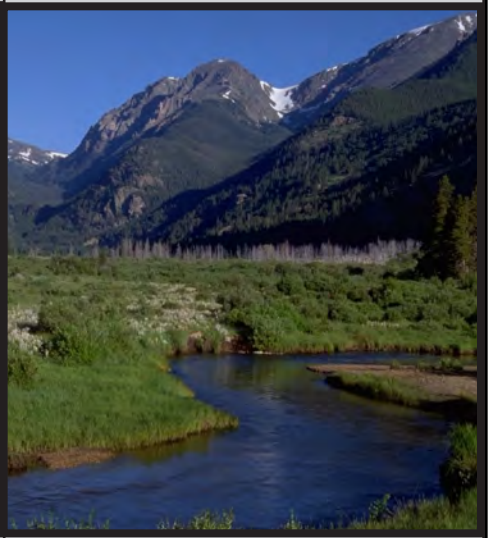
Pika	White-tailed Ptarmigan	Yellow-bellied Marmot
		
• Extremely vocal animals that are usually seen running from rock to rock collecting plants for the long winter. • Talus slopes on the tundra are the year round home and possibly mark underground water reservoirs or springs. • Sometimes called a “rock rabbit,” it is the smallest member of the rabbit family.	• Main food in winter is the alpine willow. In the summer they eat green leaves and flowers. • Largely restricted to the alpine tundra and are being studied extensively due to the changing climate. • Feathered from head to toe and change from brown to white from summer to winter. • Burrow in snow to escape from harsh winter winds.	• Largest of the ground-dwelling squirrels, that lives in the tundra all year. • Unlike the pika, the marmot hibernates for up to 7 months of the year and then eats for the remainder of the year. • Vocalizations include a high pitched whistle that gives the marmot the nickname "whistle pig." • They live in social groups on rocky outcroppings.

The Riparian

This ecosystem is found flowing through all of the other ecosystems of RMNP. Riparian areas include communities surrounding lakes, ponds, streams, and rivers. Water is the life-giving force around which aquatic and terrestrial plants and animals thrive. Often, these areas have increased biodiversity and an abundance of life. This ecosystem can be found in all three of the elevation-determined ecosystems of RMNP. Four major rivers begin in RMNP and drain several watersheds that are highly important to plant and animal (including human) survival. These River carry water vast distances. The headwaters of the Colorado are located on the west side of the park. The Colorado provides water to many states and eventually passes through the Grand Canyon. On the east side three rivers begin: Fall River, Cache la Poudre and Big Thompson. Just like the other ecosystems in RMNP, the riparian is affected by the climatic variables of temperature and precipitation, as well as elevation. Generally, riparian areas in valleys will have cooler temperatures than communities on slopes and ridge tops. Depending on elevation there is more or less precipitation, and this creates a shift in the types of plants and animals found at a particular elevation.

Fourth Lake, Spirit Lake and Lake Verna are part of the many lake riparian ecosystems of RMNP.

Riparian Ecosystems of RMNP

Alpine	Subalpine	Montane
		
Alpine Natural Spring	Tyndall Creek	Fall River in Horseshoe Park

Willow & Cottonwood

Willows and cottonwoods are predominate species in wetland areas because they have roots that need close contact with water. Riparian species are able to withstand the periodic flooding that is common in a single growing season by maintaining roots which assist with gas exchange and possess the ability to replace damaged roots quickly. There are several types of shrub and tree willows in RMNP, and they are highly adapted for life along the river. The seeds of the willow are lifted by the wind as white puffs, and they land on moist soil and germinate. Both tree and shrub willows produce new sprouts by the creation of suckers that the tree sends up to sprout. The willow therefore is successful at colonizing a streambed and in turn keeps soils and nutrients from being washed away during spring runoff.

Willow shrubs grow along the banks of rivers and provide habitat for many animals in RMNP.

Plants

Other wetland shrub species include bog birch, river birch and mountain alder. A variety of forbs occupy these areas as well including: cow parsnip, chimingbells, and monkshood. All three species thrive in these wet areas and are indicators of moist soil. Water loving plants find homes on the banks of rivers, lakes and ponds in RMNP and provide food for many species of animals and insects.

Animals & Insects

There are a mixture of terrestrial and aquatic insects and animals that depend on riparian areas for survival. When healthy, these areas provide abundant food, protection, and homes for permanent and migrating species. Some species are aquatic or semi-aquatic while others live and reproduce in the willow shrubs of the bank communities. The riparian areas create high numbers of niche spaces. A niche is a particular job an organism does in a functioning ecosystem. There are many jobs to fill and therefore a greater number and diversity of species. This creates plenty of habitat for the indicator animal, the beaver. Beavers, with the help of several adaptations including webbed feet and waterproof fur, are experts of the water and are excellent at creating their own habitat by building dams.

3-tailed Mayfly larva are found in lakes and streams.

Decomposers

Although fungi are present in the riparian ecosystem, macro invertebrates have a specialized job that recycles nutrients through the system. The area at the bottom of lakes and ponds is called the benthic zone and is home to several detritus feeders that eat the remains of plants and animals that are decomposed by aquatic fungi and bacteria. The diversity of these insects is rich, and many have specific roles within the aquatic ecosystem to keep it functioning as a natural filter for water and soil (To learn more about aquatic ecosystems please see the Aquatic Ecology Teacher Guide).

Animals to Look for in the Riparian Ecosystem

Beaver	Western Chorus Frog	Red-winged Blackbird
		
• Alter riparian areas to make prime habitat for itself and a myriad of other species. • There are few beavers in RMNP due to the decrease (caused by over-browsing by elk) of willow and aspen habitat near bodies of water. • They have valves that allow them to close their ears and nostrils. They are also able to see and chew on trees under water.	• Tiny frog that has a stripe along its back. • Can occur at up to 12,000 feet in riparian areas. • They have a loud, recognizable chorus that is a slow trill. • They hibernate during the winter. • A tadpole becomes an adult in approximately 78 days.	• Common year round bird of wetlands. • Males have a loud, gurgling conk–ka-ree call that ends in a trill and is used to establish territory. • The male has bright red shoulder patches with a yellow border that determine his social status. • Females are dusky white with brown streaks.

Ecosystems of Rocky Resources

Classroom Book List

These books are not endorsed by the National Park Service. They are intended to serve as classroom resources for students. Please be sure to preview books to ensure that they are appropriate for your classroom. This list is by no means inclusive of every book available on the topic.

Elementary Level Books

And Then It's Spring by Julie Fogliano

Antlers Forever! by Francis Bloxam

Farewell to Shady Glade by Bill Peet

Grandpa Tree by Mike Donahue

If You Were a Bear by Rachel Mazur

Little Friends by Mike Logan

National Geographic Book of Animal Poetry: 200 Poems with Photographs that Squeak, Soar, and Roar! by J. Patrick Lewis

The Beetle Book by Steve Jenkins

The Glaciers are Melting! by Donna Love

Time to Eat by Steve Jenkins and Robin Page

Who Pooped in the Park? Rocky Mountain National Park: Scat and Tracks for Kids by Gary D. Robson and Elijah Brady Clark

Middle/High School Level Books

Alpine Flowers of the Rocky Mountains by Bettie E. Willard and Michael T. Smithson

Field Guide to Wildlife Viewing in Rocky Mountain National Park by Wendy Smith

Plants of the Rocky Mountains by Linda J. Kershaw, Andy MacKinnon & Jim Pojar

Rocky Mountain National Park: The Complete Hiking Guide by Lisa Foster

Rocky Mountain National Park Natural History Handbook by John C. Emerick

Rocky Mountain: The Story Behind the Scenery by Michael T. Smithson

The Naturalist's Guide to the Southern Rockies: Colorado, Southern Wyoming, and Northern New Mexico by Audrey DeLella Benedict

Glossary

Anthocyanin – various pigments that produce blue to red coloring in flowers and plants.

Biome - A large naturally occurring community of plants and animals occupying a major habitat.

Cache – Hidden storage for equipment or food.

Carnivore – Organism that consumes only meat.

Climate – The average of prevailing weather conditions at an area over a long period of time.

Conifer – A plant that is part of the Coniferales order that use cones or similar structures to reproduce. These plants include evergreen trees and shrubs that have needles or scales.

Consumer – Organism that consume other organisms. Primary consumers are herbivores or omnivores and secondary consumers are carnivores.

Decomposer – Any of a variety of organisms (fungi, bacteria, and invertebrates) that return organic substances and nutrients to soils by feeding on and breaking down dead materials.

Detritus – Waste or debris of any kind.

Ecosystem – A complex community of producers, consumers, and decomposers that interact with abiotic factors to form a functioning network of life.

Ecotone – The zone where ecosystems transform into another. These zones occur between ecosystems where characteristics of both communities are present.

Evergreen – A plant that retains green leaves or needles throughout the year.

Herbivore – An organism that consumes only plant material.

Life History – Characteristics of a species that describe how and when important events (i.e. maturation) happen during its lifetime.

Midden – A food stash containing pine cones and dried fungus along with piles of scales from eaten cones by a rodent.

Mutualism – An interaction between species that is beneficial to both.

Mycorrhiza – Literally means “fungus root” and describes the fungus that grows on tree roots and increases the surface area to create a mutualistic relationship.

Niche – A specific role of an organism in an ecological community.

Omnivore – An organism that consumes both meat and plant material.

Organism - An individual entity that embodies the properties of life.

Producer – An organism that produces its own food through the process of photosynthesis.

Saprophytic – Wood eating.

Symbiosis – The relationship between two different species that are interdependent.

Talus - Pile of rocks that forms when other rocks break apart like at the base of a cliff.

Treeline – The edge of the habitat where trees are not capable of growing.

Weather – The immediate and short term state of atmospheric conditions.

Wetland – Areas of land that are intermittently covered with shallow water or have soils that are saturated with water.

Xeric - An environment or habitat containing little moisture; very dry.

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