University of Colorado
Boulder

Interpretive Trails

University of Colorado

Mountain Research Station

818 County Rd 116

Nederland, CO 80466


YOU ARE HERE
NEED A MAP? TAKE A PHOTO!
To Nederland
ch Sites and Climate Stations
University of Colorado Boulder
INSTAAR
PUBLIC ACCESS
Please stay on trail (F.S. Rd 506)
INTERPRETIVE TRAILS
TRAIL 3
RESEARCH AT THE MRS
SUBALPINE FOREST TRAIL
TRAIL 2
You are here
COMO CREEK RIPARIAN ZONE
TRAIL 1
Thank you to our project partners!
University of Colorado Boulder Office for Outreach and Engagement
INSTAAR
OPEN TO PUBLIC
FOOT TRAFFIC ONLY - Please Stay on Trail
NO dogs, NO bicycles
Interpretive Trail Content Creator
William (Bill) D. Bowman, MRS Station Director 1991-2021
Special thanks to Bill Bowman for developing content for the MRS interpretive trails, and for his contributions to our community. Bill served as the Director of the Mountain Research Station from 1991 to 2021. In addition to serving as Director of the MRS, Bill was a Professor in the CU-Boulder Department of Ecology and Evolutionary Biology, and served as Editor of the journal Arctic, Antarctic, and Alpine Research. His work has contributed to our understanding of how nitrogen deposition impacts ecosystems and assisted with setting air quality standards across mountain regions through extensive research in the areas of resource use by plant communities, abiotic and biotic constraints on primary production, and nutrient cycling in alpine ecosystems. Bill has positively impacted thousands of students, researchers, and colleagues during his career and advanced the study of mountain ecosystems through his leadership at the MRS.

Trail #1

COMO CREEK / RIPARIAN ZONE

Forest Diversity

The diversity of plants and animals is influenced by multiple factors, including the amount and spatial patterning of resources like water and nutrients, disturbances like fires and floods, and how organisms interact with each other, including competition for resources and consumption like predation and herbivory. The zone around Como Creek is characterized by relatively high diversity reflecting the steep gradients of soil moisture and disturbances such as tree falls from high wind events.

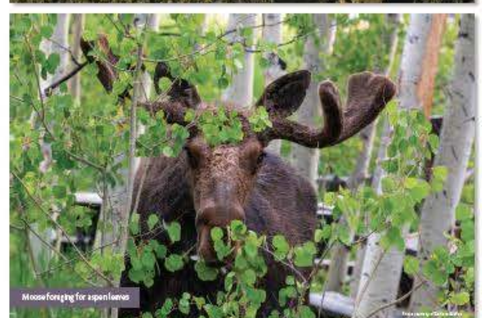
University of Colorado Boulder

Understory plants in an aspen forest

On the slope in front you can see the transition from pine dominated forest to aspen dominated forest. Aspen trees are more common in moist habitats, often in areas that have experienced severe fires. Note the greater amount and diversity and abundance of plants in the forest floor in the aspen stand than under the pines. This difference is associated with greater early season light penetration and higher nutrient and water availabilities in the soil under the aspen trees. In turn, the diversity of some animals, such as birds, is higher in the aspen stands than the pine stands.

Clones of aspen in fall color in Como Creek valley

Reproduction in aspen trees occurs primarily by the spread of underground stems that establish genetically identical trees. These groups or "clones" of aspen can be quite large- indeed, the world's largest individual organism is thought to be an aspen clone in Utah covering 106 acres (43 hectares). The size of a clone is indicated by the simultaneous leaf appearnce of trees in the spring as well as the timing of leaf color change in the fall. The beautiful fall colors of aspen leaves result when chlorophyll (green pigment) is broken down into its constituent molecules and stored for later use, and the remaining leaf pigments becoming more apparent, including xanthophylls (yellow), carotenoids (orange), and anthocyanins (red).



Moose foraging for aspen leaves

Aspen are an important resource for animals as food and shelter. The leaves and catkins (flowers) provide a nutritious food source for many animals, including insects, deer, elk, and even bears. Moose will strip the leaves off the terminal stems of young trees, often cracking the leading stem in half. Cavities in the trees of mature aspen are excavated by flickers and sapsuckers for nests. These cavities may later be used by other birds, including tree swallows, owls, and wrens. *Do you see any indications of animal use of aspen for food or shelter in the forest around you?*

Trail #1

COMO CREEK / RIPARIAN ZONE

Hydrology and Aquatic Ecology

Como Creek provides an important setting to study the hydrology and ecology of a mountain stream. Long-term measurements of stream flow and chemistry help us to better understand the amount and quality of water draining from streams in the Colorado Front Range. Aquatic organisms, such as stream invertebrates and trout are also good indicators of water quality.

University of Colorado Boulder

Stream weir on Como Creek

Stream flow provides information on the hydrology of the ecosystems from which it drains, as well as an indication of the supply of water to downstream communities. In the arid western U.S. water supply from mountains is critical for people living in surrounding lowland areas. Water chemistry provides information about ecological function in the stream and surrounding terrestrial areas. The chemistry of precipitation (rain and snow) and stream water are measured regularly, giving an indication of the uptake and transformations of air pollutants in the subalpine forest ecosystem.

Aquatic insects found in Como Creek

Aquatic organisms in Como Creek include midges, mayflies, caddisflies, leeches, stoneflies, and trout, which respond to a variety of factors that determine their presence and abundance in different areas of a stream. These environmental factors include water temperature, dissolved oxygen, and chemistry, the presence of rocks or sand, and how fast the water is flowing. Some organisms such as aquatic insects including mayflies and caddisflies prefer the zone near the bottom where flows are lower and they can scavenge for food more easily. Other organisms, such as trout, are more likely to be found in the more rapidly flowing waters which have higher oxygen concentrations. There are few aquatic plants and algae in high elevation streams like Como Creek—most of the energy supporting organisms comes from the surrounding terrestrial ecosystem in the form of organic matter (leaves, stems, and dissolved organic matter).

Como Creek in the early summer

Water flows not only on the surface, but also through the substrate of soil, sand and rocks below the creek, called the hyporheic zone. Stream water interacts with the soil and the organisms that live in the hyporheic zone. As a result stream chemistry can be altered as it flows downstream, associated with the removal of some elements such as pollutant nutrients like nitrogen, or with increases in elements such as those derived from rock weathering including calcium and silicon. In the upper reaches of Boulder Creek changes in streamwater chemistry suggest that remnant permafrost patches and rock glaciers are melting as a result of climate change.

Trail #1

COMO CREEK / RIPARIAN ZONE

Geomorphic Setting

Como Creek drops steeply from its origin on the southern flank of Niwot Ridge through subalpine ecosystems and across remnants of large glaciers that once flowed down the surrounding valleys. Below the Mountain Research Station, Como Creek flows through aspen forests then cuts a small canyon before joining North Boulder Creek near the Peak to Peak highway below Caribou Ranch.

Como Creek is fed by a combination of snowmelt and groundwater springs. The creek exhibits a typical seasonal pattern of water flows for mountain streams, with the highest volumes in early-June, and lowest volumes during the winter. Portions of the higher parts of the creek may not carry water in very dry years, but below the MRS surface water flow is consistent. Como Creek flows mostly through subalpine forest, but just above the MRS it runs through a wetland with sedges and willow and birch shrubs in terrain leveled out by the Arapaho glacier around 16,000 years ago. During high flows the water may be brownish from dissolved organic matter carried from the wetland. The creek cuts through a deposit of rocks (moraine) that were pushed up by the Arapaho glacier at its maximum expansion, and then flows steeply downhill toward the aspen forest below.

University of Colorado Boulder

Measurements of the snow depth and distribution, streamflow, groundwater, plants, and climate along Como Creek have provided important information on the hydrology of mountain streams. These streams are critically important to the water supply of towns and cities on the plains, and the research on Como Creek has helped determine the controls on the amount and quality of the water for these communities.

Trail #2

SUBALPINE FOREST

A Dynamic Forest

Sandwiched between the alpine tundra and lower elevation montane forests, subalpine forests are shaped by many ecological forces, notably by fire, wind, bark beetles, and humans, which influence the abundances of tree species found in this zone (lodgepole pine, limber pine, Engelmann spruce, subalpine fir, and aspen).

University of Colorado Boulder


Cold Springs fire near Nederland, CO

Fires occur in subalpine forests at intervals of 200–400 years, associated with cycles of fuel build up and droughts. Lodgepole pine and aspen recover more quickly than other species following a fire. Aspen have underground stems that form new trees following fires, and lodgepole pines have closed cones that open following a fire. Do you see any evidence of fire in the forest around you? *Do you see any closed pine cones that would aid recovery following a fire?*


Tree fall on Niwot Ridge

Wind is a regular feature in the subalpine, particularly in the winter, when wind speeds can exceed 100 miles per hour. Winds knock over both live and dead trees. This makes the surrounding trees more likely to topple over, and increases attacks by beetles. In 1997 a massive windstorm near Steamboat Springs blew down over 6 million trees. *What factors do you think would make trees more likely to blow over in a windstorm?*


Mountain pine beetle caught in pine resin

Bark beetles, including mountain pine beetles and spruce beetles, occur naturally. Populations of these beetles have increased tremendously since the 1990s, resulting in the deaths of tens of millions of subalpine trees in western North America. These beetle outbreaks have been linked to hotter temperatures and droughts associated with climate change, which have weakened tree defenses, and increased beetle population growth rates.


Historic Colorado sawmill

Humans have impacted the subalpine forest in this region through tree harvesting and mining since the late 1800s and early 1900s. A sawmill was built half a mile northwest of here in the 1890s, and a significant amount of forest on the hill above here was cut to produce lumber. A railroad line existed half a mile to the southeast that hauled the lumber to the nearby mining camps and towns. *Do you see any evidence of tree cutting in the nearby forest?*

Trail #2

SUBALPINE FOREST

Friend or Foe? Biological Interactions

Trees of the subalpine interact with many animals, microorganisms, and plants. Some interactions enhance tree growth and reproduction, while others can inhibit growth and even kill the trees. Knowing whether there is a benefit or harm involved with an interaction is not always clear—what may seem like a negative interaction may actually benefit the tree.

University of Colorado Boulder

Clark's nutcracker extracting limber pine seed

Seed eaters like red squirrels and Clark's nutcrackers decrease the potential reproduction of evergreen conifer trees by consuming some seeds. However these animals may also transport the seeds to areas where the plants will have a greater chance of surviving and growing to maturity, such as recently burned areas with higher light and nutrient levels. The seed caches of animals may benefit other animals that consume the seeds, increasing the diversity of animals nearby. *As you walk through the forest look for piles of intact and dismantled cones (caches or middens) left over from red squirrels foraging for seeds.*

King bolete, a mycorrhizal symbiont of conifers

Microorganisms such as fungi are often associated with decomposition and sometimes plant and animal infections. For example, one contributor to tree death associated with bark beetles is a fungus carried by the beetle. The fungus spreads through the tissues that carry sap and water, blocking off their transport. The fungus may color the wood of beetle-killed trees blue. Some fungi are beneficial for plants—for example some fungi are actually required for conifer trees to grow. These fungi form an association with the roots called mycorrhizae, which increase the ability of the tree to obtain water and nutrients from the soil. *Look for evidence of fungi on the surface of the forest after the snow melts out in the spring, as well as for fruiting bodies (mushrooms) in the late summer and fall.*

Coralroot orchid

Plants also have positive and negative interactions with each other. Needles from the trees increases the organic matter in the soil which helps retain water and increases nutrients. However the trees also compete with each other for these soil resources, as well as for sunlight. Some plants parasitize the trees for their sugars produced by photosynthesis and the water and nutrients that they obtain from the soil. Examples of these plant parasites include dwarf mistletoe, which taps into the vascular tissues in branches of the pine trees, and coralroot orchid, which obtains its resources from mycorrhizal fungi associated with the pine trees. *Look for these plant parasites as you walk through the subalpine forest.*

Trail #2

SUBALPINE FOREST

Mammals of the Subalpine Forest

The subalpine forest is home to many mammals, ranging in size from tiny shrews (4 inches long, weighing 0.01 pounds) to moose (9 feet long, 6 feet high, weighing 900 pounds). The most abundant mammals include red squirrels, mule deer, elk, moose, deer mice, and meadow voles. The forest serves as shelter and provides food for these mammals. Some subalpine mammals are primarily predators, hunting other animals, some are herbivores, eating plants, while others are omnivores, consuming both animals and plants.

University of Colorado Boulder

Cow moose

Mountain lion

Coyote hunting

Herbivores rarely eat the needles of conifers despite their abundance, as the needles are not a nutritious food source. Instead most herbivores consume the leaves of plants on the forest floor or in meadows, aspen leaves, or plant seeds and fruits. A few such as porcupines eat the bark of trees. During the winter herbivorous mammals are forced to rely on poorer quality food sources, such as the willow stems that moose and deer consume. Some mammals will store food sources for the winter, such as the seed caches of the pine squirrels, while others including chipmunks may hibernate to minimize their need for food. Some mammals such as deer and elk may migrate to lower elevations to take advantage of the lower amount of snow and greater availability of grass.

Predators tend to be less abundant than herbivores (why do you think that is true?). Some tend to eat just a few different species of prey, such as Canada lynx which mainly hunt snowshoe hare. However most predators are generalists, and eat a diversity of prey. Most mammalian predators may hunt prey by stalking them, as exemplified by bobcats and mountain lions. Both predators and prey avoid detection in a variety of ways, including blending in with the background, hiding under the surface of the ground or among the needles in the trees, or being active at dawn or dusk when the light levels are low. Both predator and prey use their keen senses of sight, smell, and hearing to detect the other.

Omnivores consume both animal and plant items in their diet. This provides an obvious benefit by taking advantage of a wide diversity of food types. Examples of omnivores of the subalpine include coyotes, foxes, and skunks. One of the best studied omnivores in Colorado is the black bear. Despite being large and ferocious, black bear diets consist of around 90% plant tissues, including leaves, fruits, and seeds, with only 10% animal material, usually insects and carrion. Being opportunistic black bears have also learned that they can raid houses, cars, and trash containers to get food, though this option poses a serious threat to the individual bear's long-term survival.

Trail #2


SUBALPINE FOREST
Identifying Mammals by Their Signs
Mammals are generally shy, and not often seen by humans. They see, hear, or smell us, and often run off before we see them. However we can determine their occurrences and identities using their signs: tracks and scat (poop). Shown here are the tracks and scat of many of the common mammals found near the Mountain Research Station.
University of Colorado
Boulder

Trail #3

RESEARCH AT THE MRS

Environmental Monitoring

The Mountain Research Station has fostered several long-term environmental monitoring programs. Since the mid-twentieth century climate measurements have been made as part of the Mountain Climate Program, started by John Marr. Additionally two programs evaluating human influences on the environment have been maintained for multiple decades, both part of larger nationwide or global monitoring systems: greenhouse gas measurements and measurements of atmospheric nitrogen and mercury pollution.

University of Colorado Boulder

Servicing the D1 climate station on Niwot Ridge in the 1950s

Collecting flask samples on Niwot Ridge for NOAA greenhouse gas monitoring

Collecting sample for precipitation chemistry on Niwot Ridge

Weather is the most fundamental physical environmental feature—it controls the distribution of organisms and their functioning. Standard weather measurements include air temperature, humidity, wind speed and direction, and precipitation. These variables have been measured as part of the Mountain Climate Program at multiple sites along an elevational gradient in the Front Range since the mid-1950s. The program uses standard meteorological instruments, including some on display here. Keeping these instruments running and calibrated requires substantial effort, particularly in the winter when temperatures may be well below freezing and the winds can gust to over 100 miles per hour (45 meters per second). These climate data allow us to understand how climate influences the functioning of organisms and ecosystems, as well as to track how climate is changing regionally.

Since the onset of the industrial revolution in the mid-nineteenth century humans have been emitting substantial quantities of greenhouse gases (mainly carbon dioxide—CO_2, methane—CH_4, and nitrous oxide—N_2O) into the atmosphere. Accurately measuring these gases and the change in their concentrations is critical to evaluating future climate change. The National Oceanic and Atmospheric Administration (NOAA) has established a global network of stations that regularly measure greenhouse gases. Niwot Ridge is unique in being one of a few sampling stations that is in the middle of a continent not far from a major urban location (Denver). However the reliably windy conditions help to assure well mixed air, representative of the region, is being collected. The flasks seen here are similar to those used to collect air samples once a month at over a hundred sites in the monitoring network.

Burning fossil fuels and agricultural activities emit air pollutants that can travel long distances and impact remote ecosystems. The fall-out or "deposition" of these air pollutants is measured across the U.S. as part of the National Atmospheric Deposition Program. Three deposition collectors are maintained by the MRS, two on Niwot Ridge and one on Sugarloaf Mountain. The data from these collectors have been important for linking inputs of pollutant nitrogen to environmental impacts in high elevation ecosystems, including soil and water acidification and changes in the composition of plants.

Trail #3

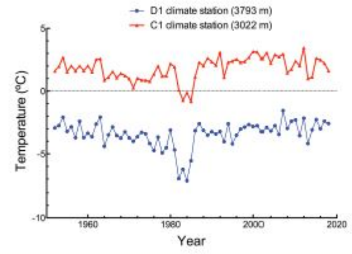
RESEARCH AT THE MRS

Long-term Data

Changes in the environment can occur at a variety of time-scales, for example daily to seasonal changes in temperature associated with the amount of sunshine. To detect significant directional changes in the environment, such as climate change, we need long-term measurements that allow us to account for the many factors that influence environmental phenomena. As a result, the data sets collected at the MRS have become more important for interpreting environmental change through time.

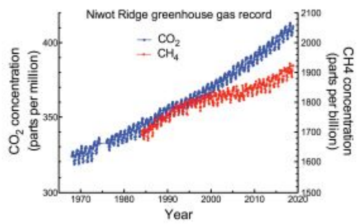
University of Colorado Boulder

Annual average temperatures for the C1 (subalpine) and D1 (alpine) climate stations



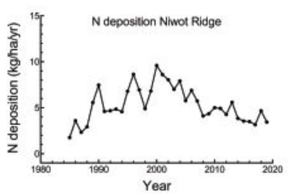
Weather changes predictably from day to night and summer to winter. Natural phenomena, such as major atmospheric pressure cells, can influence our weather over periods lasting up to two decades. Thus it is important to have long-term weather data to detect trends in the weather that would indicate climate change is occurring. The Mountain Climate Program has provided one of the world's best long-term data sets covering a gradient in elevations. Warming trends are clear for the stations below 10,000 feet/3000 meters, particularly since 1990. The alpine weather stations lack a strong annual warming signal, but there is significant warming in the spring and summer, with earlier snow melt through time. The warming at both alpine and subalpine sites is driven by higher maximum temperatures, which is likely to have large potential impacts on the biology of the systems.

Increases in the greenhouse gases carbon dioxide (CO_2) and methane (CH_4) measured on Niwot Ridge



Greenhouse gas concentrations have increased substantially in the atmosphere over the past century. Monitoring the concentrations and rates of increase of these gases are important to understanding their influence on the observed climate warming that is occurring, as well as predicting future climate change. In 1968 Niwot Ridge was established as a site within NOAA's global monitoring network. In 50 years of monitoring at Niwot Ridge (second longest record in the world) the carbon dioxide concentration has risen 26%, from 325 parts per million in 1968 to 411 parts per million in 2019. Over the 35 years that methane has been measured the concentration has increased 17%. The magnitude of increase in concentrations of both of these greenhouse gases at Niwot Ridge is similar to the average global increases for both gases. Atmospheric scientists have concluded with high certainty that Earth's climate is warming as a result of the increase in these and other greenhouse gases.

Changes in nitrogen deposition on Niwot Ridge



Air pollution in remote mountain areas such as Niwot Ridge is somewhat unexpected. However the removal of pollutant compounds from the atmosphere involves precipitation (wet deposition), which is higher in mountain areas than in the surrounding lowlands. Annual precipitation on Niwot Ridge is more than double that in Boulder, and thus the removal of air pollutants by wet deposition is also higher. The deposition of pollutant nitrogen increased five-fold from the 1980s into the late 1990s. During this period changes in the composition of plants and algae as well as soil chemistry were recorded that were symptomatic of higher pollutant N inputs. The inputs of pollutant nitrogen have decreased over the past two decades, although they remain considerably higher than background levels. Even modest levels of pollutant nitrogen can build up in an ecosystem and cause soil acidification and loss of biodiversity.

Trail #3

RESEARCH AT THE MRS

History of Environmental Monitoring at MRS

The roots of research programs at the Mountain Research Station date back to the end of the nineteenth century with the establishment of a mountain laboratory in Tolland, as well as field camps along North Boulder Creek and Como Creek at its present location. Along the way the research themes and teaching foci have changed, but the emphasis on the special characteristics of mountain science has remained.

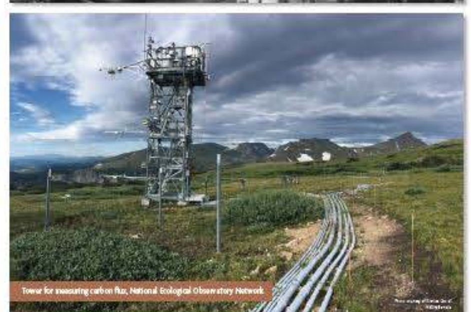
University of Colorado Boulder

CU Biology field excursion led by Drs. Ramaley and Caldwell near Tolland, July 1909

The potential to use the local mountains as a laboratory to study environmental science was realized more than a century ago. Faculty from CU Boulder, including Francis Ramaley, capitalized on the mountain laboratory concept in the 1890s by establishing a field camp at Tolland on the rail line headed over the Continental Divide. The camp held field courses and fostered research in botany and zoology. A few years later a recreational camp for CU faculty and students was established along Boulder Creek in what is now the City of Boulder watershed. Eventually both the lab in Tolland and camp in the watershed were vacated and a new camp for education, research, and recreation was established at the present site of the MRS in 1920. For the next two decades the emphasis was primarily on geology and geomorphology, reflecting the academic expertise of the camp directors.

John Marr in front of the original Science Lodge in 1957

John Marr, a plant ecologist and faculty member in the Biology Department at CU Boulder, established two major research programs in the 1950s that became the core of many subsequent research efforts at the Mountain Research Station. The first was the Mountain Climate Program, which established weather stations at four major life zones along the elevational transect from the plains to the Continental Divide. The second was the Front Range Ecology Project, designed to describe the major mountain biological zones (lower and upper montane, subalpine, and alpine) and determine the environmental features associated with them. Marr's efforts provided a legacy of knowledge and data that make Niwot Ridge one of the best known mountain research sites in the world.



Tower for measuring carbon flux, National Ecological Observatory Network

Several major programs have used Niwot Ridge as a site for monitoring and experimental research over the past five decades. Two notable examples include the Long Term Ecological Research (LTER) program, started in 1980, and the National Ecological Observatory Network (NEON), started in 2013. Both programs are funded by the U.S. National Science Foundation and include multiple sites that represent the range of ecosystem types found in the U.S. The Niwot Ridge LTER program has provided critical knowledge of high elevation ecosystems and the factors that influence their functioning and biodiversity. In particular through a combination of experiments and long-term observations the LTER program has focused on how environmental change, including air pollution and climate change, influence alpine and subalpine ecosystems. NEON focuses on monitoring key ecological features, including carbon exchange and terrestrial and aquatic biodiversity, at spatial scales varying from the soil particle to the continent.