

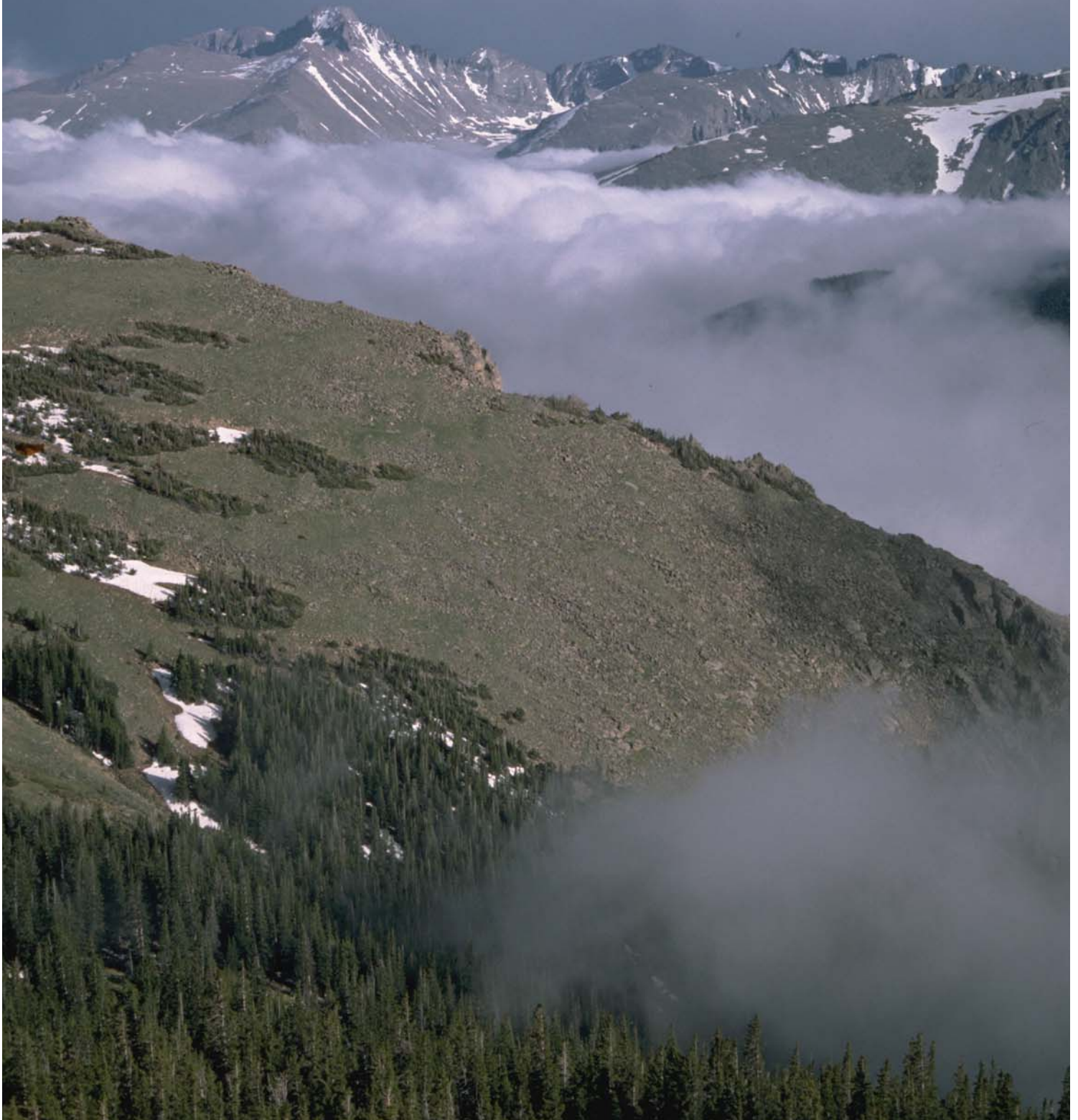
National Park Service
U.S. Department of the Interior

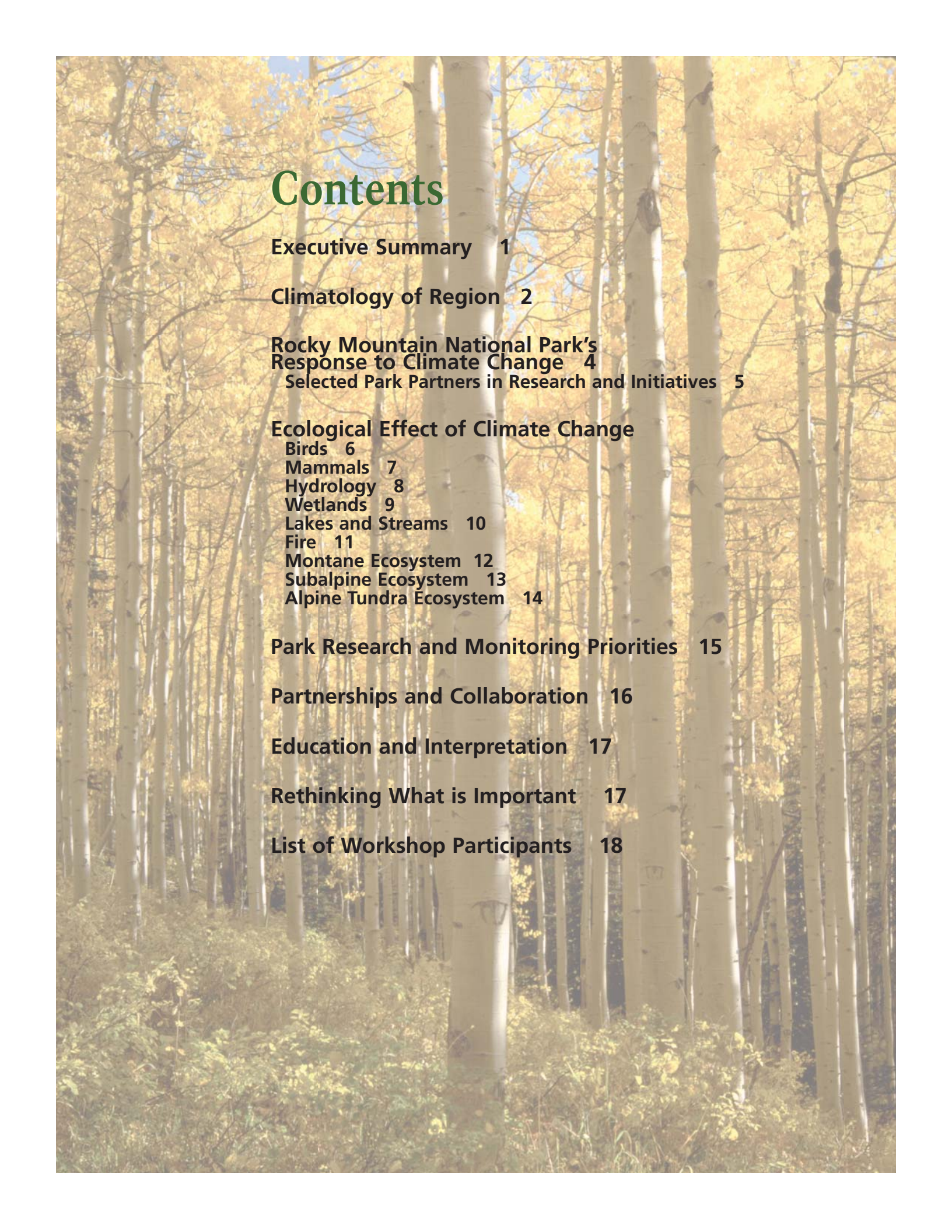
Rocky Mountain National Park
Continental Divide Research Learning Center



Climate Change in Rocky Mountain National Park:

Preservation in the Face of Uncertainty





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Climatology of the Region

based on presentation by Jason Vogel, Stratus Consulting, Inc.

The earth has always experienced fluctuations in temperature and climate, with extremes of glacial ice and extended periods of warming and drought. Human activity is now playing a role in these fluctuations.

“The future rate of change and intensity of change for the Front Range of Colorado are not reliably predictable with current climate change models.”

*--Jason Vogel
Stratus Consulting*

Since humans began large-scale industrial activity around 1850, our emissions of carbon dioxide, methane, nitrous oxide, and other greenhouse gases have contributed to the warming of the world’s climate by trapping heat in the earth’s atmosphere. There is broad consensus that rapid climate change is a present reality, although the future rate of change and intensity of change for the Front Range of Colorado are not reliably predictable with current climate change models.

The American West is experiencing change with the rest of the globe, but the rate of warming here has been somewhat accelerated. The West’s temperatures have risen at a greater rate than the rest of the globe, with some areas of the West receiving greater rainfall and others receiving less.

Rocky Mountain National Park appears to be situated between two zones, a southern region experiencing less precipitation, and a northern one that appears likely to receive more moisture as the climate changes. It may be that this Rocky Mountain National Park region will receive

more annual precipitation, but the increase will likely arrive in infrequent, intense weather events. With the park located on this transitional latitude, climatologists are hard pressed to make reliable predictions about the effects of climate change on precipitation. Harder still is to project what these changes will mean to the park’s flora and fauna.

A complex array of interactions make climate predictions difficult and sometimes even contradictory in mountainous terrain. However, a scientific “best guess” is that this region will likely experience: an increase in temperature especially in the spring and winter and especially for minimum temperatures; reduced snowpack; earlier snowmelt; increased dryness due to increased evapotranspiration; and an increase in intense storms.

What we expect:

- an increase in temperature, especially in winter and early spring, and especially for minimum temperatures
- reduced snowpack
- earlier snowmelt
- increased dryness due to increased evapotranspiration
- increase in intense storms

For further consideration:

- Climate modeling is evolving at a rapid pace. The park can benefit from working with partners to stay apprised of model refinements and emerging trends.

Rocky Mountain National Park's Response to Climate Change

based on presentation by John Gross, National Park Service

Rocky Mountain National Park's ecosystems have been wildly different than today's. At one time the region was home to Columbian mammoths, short-faced bears, dire wolves, sabertooth tigers, American lions, and camels.

Climate change impacts are either indirect or direct. For instance, warming causes an increase in pine beetles (direct), which then kill trees (indirect). Increased dryness might cause a change in habitat (direct), which then causes changes to mammal food sources (indirect).

The passing of these species into extinction reminds us that the region is not static. However, the acceleration of change from anthropogenic climate change presents the park's caretakers with new questions and unique challenges.

A difficult aspect of addressing the impact of climate change on Rocky Mountain National Park is the broad uncertainty of what the actual climate changes will be. Even if we accept the presumption that the park's climate will likely become warmer and drier, scientists still struggle to build into their predictions all the variables that might possibly influence the outcomes for individual species and whole ecosystems. The complexity of the biological, climate, and geological matrix in which any one species lives exceeds the modeling capacity of science. Researchers at this workshop invariably prefaced their remarks with the statement that their predictions were highly speculative, and that additional monitoring and research is needed to clarify the nature and extent of the impact of climate change.

Much of climate-related research and monitoring relevant to the park is already underway, and those studies have begun to inform local climate understanding. The National Park Service Rocky Mountain Inventory & Monitoring (I&M) Network, consisting of units in Montana and Colorado, is monitoring common ecological vital signs such as air quality and wetlands health.

Park managers must also ask how the changes wrought by climate change can be managed in context of General Management Plans, existing laws, and administrative policies. Will climate change render the National Park Service incapable of meeting legislated ecosystem mandates, such as prescribed by the Endangered Species Act? The 1916 Organic Act of the National Park Service, environmental laws of the 1960s and 1970s, and the 1998 National Parks

Omnibus Management Act did not anticipate anthropogenic climate change, and in some cases their conception of the natural world may be inadequate in an era of rapid transformations.

Park managers will also have to consider how to interpret climate change for their visitors. As the park gains and loses species and as its forests and other habitats evolve, the park will be challenged with making these changes comprehensible to a public that might be shocked or dismayed. This need to educate the public on the effects of climate change will challenge interpreters to make a complex, multivariate phenomenon understandable.

Budgetary constraints will likely prevent the park from single-handedly undertaking more than a few of the research and monitoring projects important to understanding climate change impacts. Given this limitation, the sharing of resources within a consortium, such as the Rocky Mountain I&M Network, and benefiting from knowledge gained at other locations, such as the University of Colorado's Mountain Research Station, will be essential.

Policy guidance is needed to determine to what degree NPS efforts will be devoted to protecting individual species, and current ecological communities, versus embracing newly arrived species and evolving species assemblages.



A modeling study suggests ptarmigan will become less abundant in RMNP as the climate warms. (NPS-RMNP photo)

Birds

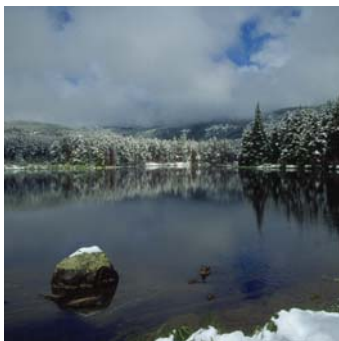
Climate change will have a mixed impact on the 258 bird species in the park, favoring some and adversely affecting others.

What we expect:

- Some species will likely use their flight mobility to move to higher elevations and more northern latitudes.
- Decreased food availability due to drying will affect nesting and breeding rates. Because plants and birds may be using different environmental cues, food availability may not coincide with time of need during nesting.
- The most vulnerable bird species are expected to be those with long migration patterns, those dependent on a narrow range of plants and climate conditions, and those which are physiologically more sensitive to environmental change.
- Warmer temperatures may expose birds to new diseases such as the West Nile virus.

For further consideration:

- As an aid to education and management, classify birds according to their expected sensitivity to climate change. Use this information to help prioritize monitoring and potential management actions.
- Working closely with partners such as the Rocky Mountain Bird Observatory, consider enhancing avian monitoring along elevational gradients using an expanded cadre of park “birder” volunteers.



More precipitation will likely fall as rain rather than snow.
(NPS-RMNP photo)

Hydrology

On average, the onset of spring snowmelt and runoff in Colorado is beginning about two weeks earlier than in the late 1970s.

What we expect:

- More precipitation is expected to fall as rain instead of snow, significantly decreasing snowpack.
- Glaciers and perennial snowfields are believed to have recently shrunk back to around their 1940s extent.
- In the short term, melting permafrost may supplement stream flows during dry periods. Over time, this “stored water” will diminish and streams will dry.
- Spring flooding may negatively affect trails, bridges, roads, and visitor safety.

For further consideration:

- There are few high-quality climate recording stations at high-elevations in the western United States. Collect more precipitation and temperature data to better understand park microclimates and patterns of change.
- Improved climate models are needed to assess future trends in snowpack water content and summer precipitation, particularly the summer monsoon.
- Assess the contribution of melting permafrost to stream flow. Determine how changing patterns of spring run-off will affect water capture by the Grand Ditch.
- Jason Vogel, Stratus Consulting, Inc., notes that there are more than ten models that provide useful information on predicted patterns of climate change. The top ones include: CCCMA, MRI, ECHO, CCSM3, GFDL2.0, GFDL2.1, HadCM3, MIROCmed, ECHAM5, HadGEM.



Greenback cutthroat trout may adapt to warmer stream temperatures, but they may have difficulty surviving in shallower waters. (Chris Kennedy, USFWS photo)

Lakes and Streams

Lake and stream temperatures will rise along with warmer air temperatures.

What we expect:

- Changing water temperature, water chemistry, longer ice-free periods, changing run-off patterns, and light availability along riparian banks, among other factors, will affect fish and other aquatic species.
- Cutthroat trout may benefit from warmer water temperatures, but other factors, such as habitat loss at lower elevations and new diseases, may offset this advantage.
- As in other ecosystems, problems may arise due to prey responding to temperature changes in one way, while predators respond in another. This may result in insufficient food at a key time in a predator's life cycle.
- Native species are likely to persist under climate change, but the associative effects of warming may increase opportunities for invasive species, diseases, and parasites in lakes and streams.

For further consideration:

- Consider ways to bring interdisciplinary teams together in order to facilitate integrated physical, chemical, and biological studies of lakes and streams.
- Support the Rocky Mountain I&M Network efforts to conduct long-term monitoring of lakes and streams to understand, and potentially mitigate, climate change impacts.



Non-native plants and animals will likely have more opportunities to invade the montane life zone. (NPS-RMNP photo)

Montane Ecosystem

The timing of natural annual events such as snowmelt run-off; plant, insect, and animal reproduction; spring green-up; and first frost in the fall will change.

What we expect:

- Climate change will have complex ramifications for the ecological interactions of plant, insect, and animal species.
- Invasive non-native flora and fauna will likely find more opportunities to invade and thrive.
- Animals may move to higher elevations before plant communities shift.
- Climate change will create hybrid ecological communities consisting of new mixes of species, dubbed “novel” ecosystems.

For further consideration:

- Learn more about the synchronicity and symbiosis between plant and insect species. How will berry crops, important to wildlife, fare in climate change?
- Develop models for the evolution of the structure and composition of forests, especially as they undergo stresses and disturbances.



The extent of the park's tundra will likely shrink with warmer temperatures. (NPS-RMNP photo)

Alpine Tundra Ecosystem

Warming is most likely to occur in winter and early spring, and in minimum temperatures; that is overnight low temperatures will not be as cold.

What we expect:

- Permafrost area will shrink even with minimal warming. This may impact vegetation communities and park visitor facilities.
- Potential encroachment of trees may be slowed by lack of moisture.
- New plant and animal species will likely encroach into the tundra as growing season lengthens and soil becomes saturated with nitrogen. Grasses are expected to increase.
- Tundra animal and insect species, living on mountaintop "islands," are especially vulnerable to extirpation.
- In the short term, changes in plant species due to nitrogen pollution from urban and agricultural sources will likely be more significant than changes due to warming.
- Perennial plants of the tundra are long-lived and communities have a type of ecological inertia, making them slow to change.

For further consideration:

- Monitor pikas, ptarmigans, and flowering plants, and share findings about these popular species with the park's visitors.
- Conduct field investigations of permafrost and determine its relationship to vegetation communities.
- Identify symbiotic plant and insect relationships and synchronous events that will be disrupted by climate change.
- Revisit plots from a previous climate change study to determine if records and field markers are sufficient to conduct follow-up work.

Partnerships and Collaboration

The generous and open participation of the representatives from federal and state agencies, the private sector, and non-profit entities in this workshop demonstrated the great potential for future cooperation. Here were a few ideas that emerged from this complement of park stakeholders:

- **Because of their shared boundary, the park and the Forest Service have the opportunity to continue to strengthen ties. The park in particular stands to learn from the Forest Service's ambitious and coherent forest ecology research program.**
- **Rocky Mountain National Park is fortunate in having one of the world's premier alpine research institutes, the University of Colorado at Boulder Mountain Research Station (MRS), less than twenty miles to the south. Although researchers from MRS have worked in the park, and some research results filter back to park staff, this information flow can be improved so that valuable insights are not lost and so that park staff does not duplicate research efforts.**
- **For most visitors, large mammals continue to represent the essence of the park. Although the Colorado Division of Wildlife and the National Park Service have worked together in the past, holding more frequent joint workshops could benefit both agencies. Likewise, the Denver Zoo brings expertise in mammal conservation biology and a connection to our urban neighbors that are quite valuable.**
- **The park has the opportunity to involve park volunteers in tracking and publicizing the emerging patterns of climate change. For instance, the ten-year, volunteer-led study of park butterflies is a model for future efforts.**

These highlights are offered as examples rather than a comprehensive list.

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