

Impacts of Climate Change on Rocky Mountain National Park and its Gateway Community

Project Scope

Anticipated changes in temperature and precipitation in the Central Rockies may have profound effects on the ecosystems and hydrologic processes of Rocky Mountain National Park (RMNP), and the economy of its gateway community, Estes Park. RMNP contains the headwaters of the Colorado and Platte Rivers, providing irrigated agriculture, sustenance, and livelihoods to millions. The protected area is home to numerous endangered and endemic species and hosts over 3 million visitors per year.

The objectives of this research were to:

- Assess the potential consequences of changing land-use and climate for landscape structure, aquatic biota, terrestrial wildlife and native plant communities;
- Extend these biotic effects to predict likely changes in visitation and the implications of those changes for the local economy; and
- Help stakeholders identify and evaluate potential ways to respond to a changing landscape and climate.

Approaches for fulfilling these objectives generally centered on determining the historical correlation between the variables of interest and climate, then projecting potential future outcomes based on the climate predictions of two Global Climate Model (GCM) simulations. Both models predict increased temperatures of 1° to 7° F over 30 years. Regional effects on precipitation are less consistent, however. The Canadian Climate Centre (CCC) simulation predicts a decrease in precipitation ranging from 5 to 25 percent, while the Hadley model anticipates an increase in precipitation of 10 to 25 percent.

Hydrological, ecological, and economic impacts were considered in collaboration with decision makers and local stakeholders in order to provide a comprehensive assessment of the most salient impacts of climate change to this National Park, the region, and downriver interests.

Grant Title and Principal Investigator

An Integrated Assessment of the Effects of Climate Change on Rocky Mountain National Park and its Gateway Community: Interactions of Multiple Stressors
N. Thompson Hobbs, Colorado State University

Key Findings and Implications

Analytical Accomplishments:

- The application of retrospective historical correlation between climate and ecological variables demonstrates that local climate is a significant predictor of impacts to wildlife and ecosystem function, while large-scale climate patterns alone may be insufficient.
- The comprehensive, integrative adaptation of numerous tools and methods for evaluating the economic and environmental effects of climate change provides a necessary basis for adaptive management.

Impacts of Results:

- Increased fire frequency will lead to increased landscape diversity.
- Larger numbers of park visitors should be anticipated.
- Local extinction of sensitive species is likely.
- Overpopulation of elk with increased injury to vegetation is likely to become more pronounced.
- Alpine tundra and the organisms it supports will diminish.
- The possibility for the reestablishment of the endangered greenback cutthroat trout exists under climate change.

Implications of Research:

- Results suggest implications and provide decision support for the management of public reserve lands, particularly for issues related to water allocation, economic development, fire regulation, habitat, endangered species, and elk populations.

Publications include eleven peer reviewed journal articles, one dissertation, and six conference presentations.

Project Period: October 1999 to September 2002

Relevance to ORD's Multi-Year Research Plan

This project serves ORD's research strategy for EPA by addressing the long term goals of (1) determining the implications of climate change on national environmental and economic priority areas in the context of other non-climate stressors, (2) providing approaches and methods that allow for quantitative assessment of global change impacts and allow for adaptive responses, (3) applying tools to integrate the evaluation of global change effects across environmental media, and (4) assessing impacts to aquatic ecosystems.

This study represents a comprehensive and integrated evaluation of the environmental effects of climate change on Rocky Mountain National Park, with implications to the region and downstream communities across the country who depend on hydrologic flows from the Colorado and Platte Rivers. The study applied the results of these environmental evaluations to surmise changes in visitation and subsequent economic impacts on Estes Park, its gateway community.

Project Results and Implications

Beginning with the GCM projections, RHESSys (the Regional Hydrologic Ecological Simulation System), a GIS-based hydroecological modeling framework, was applied to the study of RMNP's hydrological function. Under the CCC projection, shorter winters and drier summers resulted in no change in streamflow for forested watersheds, but in higher-altitude, unforested areas, diminished streamflow was directly proportional to reduced precipitation; snowfield coverage was diminished by almost half. Under the Hadley projection, shorter winters meant that more rain than snow fell in the Park, increasing soil penetration and streamflow. Under both projections, snowmelt occurred two to eight weeks earlier than under current conditions.

Other outcomes based on RHESSys simulations—earlier spring runoff, lower flows from late spring to fall, decreased snowpack, and decreased soil moisture—lead to a longer and drier summer in the riparian corridor, causing increased willow seedling mortality due to water stress. Additionally, decreased peak flows lead to diminished opportunities for willow establishment. It is possible that the return of the beaver to RMNP might mitigate water table and soil moisture declines, improving willow establishment and riparian ecosystems overall, though this hypothesis has not been evaluated.

Fires produce the most immediate and dramatic changes to landscape patterns. Using historical correlation between past climate variables and fire, researchers determined that under predicted climatic changes, fire frequency and extent is expected to increase substantially. Ignitions from lightning will increase by 50 to 92 percent, human-caused ignitions will increase by 3 to 30 percent, the probability of fires exceeding 10 acres in extent will increase by 30 to 100 percent, and the fire rotation period for the Park will decrease from a 6000-year interval to 2000 years. This may be of ultimate benefit to the Park, as aspen-covered areas are likely to be the most highly impacted forest type (with an increased fire frequency of 400 to 700 percent). Aspen have been in decline due to fire exclusion, but make a substantial contribution to local biodiversity and are valued by Park visitors.

Substantial reductions will occur in tundra habitat as treeline creeps upslope in response to changing climate. Tundra ecosystems, occurring on high mountaintops above treeline, contribute disproportionately to regional biodiversity given the relatively small area they cover. According to this study, a 1° F temperature increase had little effect on tundra coverage, while a 3° F increase corresponded to over 50 percent reduction in area, and a 6° F temperature increase eliminated virtually all tundra from RMNP. As habitat patches shrink and become further separated from one another, extinctions of endemic species are expected.

The white-tailed ptarmigan (a small ground bird) is one tundra species that has demonstrated sensitivity to climatic factors. Retrospective historical correlation showed that hatching times have shifted to earlier in the year with increased temperatures, and that high winter minimum temperatures retard population

growth. However, this work has demonstrated that the local responses of wildlife populations may not be adequately explained by large scale climate patterns. Attempts to apply a larger scale climate pattern, in this case the North Atlantic Oscillation, to the prediction of ptarmigan population size, showed no significant relationship. Local climate, however, was a good predictor of ptarmigan population dynamics.

Another example of the necessity of including localized conditions in the prediction of wildlife population dynamics is the threatened greenback cutthroat trout, whose survivability in response to warmer air temperatures varied from stream to stream. Overall, because fewer lakes became fully inundated with ice during the winter months under anticipated changes in climate, climate change effectively increased the available suitable habitat for the trout, and the number of populations increased.

Two species of boreal toad in RMNP have been in decline in recent decades. While climate does exert an influence on recruitment and survival of individuals within the population, this study determined that climatic factors are not the cause of the toads' demise.

Managers at RMNP currently rely on weather to regulate the elk population, viewed by many as overabundant at its current size. This study suggest that the elk population will become 1.5 to 2 times larger under changed climate, thereby magnifying the stresses it creates, particularly on vegetation in the elks' limited winter range, as well as on aspen and willow communities. However, because visitors to the Park place a high value on viewing wildlife, increased elk populations may not be interpreted as a negative impact by all stakeholders.

Surveys and focus groups were conducted in order to determine how climate might affect visitation to RMNP and the economy of its gateway community, Estes Park. Visitation increased under both GCM predictions. The CCC scenario would increase the number of annual visitor-days by 1,357,888; the Hadley scenario resulted in 1,002,080 additional visitor-days per year. Incorporating this information into IMPLAN, a local-scale economic model, showed that new local sales resulting from increased visitation would range from \$32.1 to \$43.5 million, and between 725 and 981 new jobs would result. Not all stakeholders viewed this positively, as local development and planning would be stressed under these circumstances. Additionally, these results cannot be extrapolated linearly. Under an "extreme heat" scenario, where temperatures exceeded 80°F at least 50 days of the year in Estes Park, the local economy would be expected to contract by \$25.2 million and 592 jobs.

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For More Information

An Integrated Assessment of the Effects of Climate Change on Rocky Mountain National Park and its Gateway Community (Project URL): <http://www.nrel.colostate.edu/projects/star/>

NCER Project Abstract and Reports:

http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/286/report/0