GLOBAL CHANGE IMPACTS IN THE COLORADO ROCKIES BIOGEOGRAPHICAL AREA FINAL REPORT, 1999-2003

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INTRODUCTION

Phase I of our global change research program (1992 to 1998) consisted of three integrated studies designed to: (1) develop an understanding of the abiotic and biotic controls on forest distribution and productivity as a basis for assessing potential vegetation change for a range of projected climate scenarios; (2) project a range of possible scenarios of future climate change for the Colorado Rockies; and (3) evaluate potential responses of hydrologic and aquatic ecosystem processes to climate change at watershed, drainage basin, and regional scales. Phase II of our research program (1999 to 2003) focused directly on how rapid environmental change affects key natural resources and processes in Rocky Mountain National Park and the surrounding region. We used our interdisciplinary, ecosystem science approach to identify high priority issues as identified by Park resource managers, including: (1) providing better climate change scenarios to land managers to assess the vulnerabilities of ecosystems to rapid environmental change; (2) assessing how climate change influences natural watersheds (e.g., Loch Vale, Rocky Mountain National Park); (3) developing GIS-based disturbance history maps (fire and insect outbreaks) to aid the Park’s Fire Management Program; and (4) determining how climate change, vegetation management practices, and disturbance affect the spread of non-native plants and aspen regeneration.
OVERVIEW OF PROGRESS AND RESULTS

We have made substantial findings in our integrated study of Global Change in the Colorado Rockies (COLR) Biogeographical Area. Our research provides important ecological information of direct use to the US Global Change Research Program, Department of the Interior bureaus, and the public. For example, Tom Veblen’s team completed a GIS map of fire history in over 30,000 hectares of subalpine forests in the southern two-thirds of Rocky Mountain National Park. He reported that years of widespread fire in the subalpine zone are limited to years of exceptional drought, which are statistically associated with La Niña events (i.e., the positive phase of the Southern Oscillation). La Niña events tend to be followed by dry springs in the northern Front Range. Contrary to popular belief, tree-ring reconstructions of spruce budworm outbreaks in Douglas fir forests show that outbreak frequency during the 20th century period of fire exclusion was not atypically high in comparison with the previous four centuries.

Baker’s team found that a mixture of crown fires, mixed-severity fires, and surface fires occurred in the ponderosa pine forest of Rocky Mountain National Park prior to Euro-American settlement. However, quantitative targets for how frequent prescribed fires should be, how much land area should be burned in a particular year, or how much fuel reduction is appropriate, cannot be specified for restoration efforts because of large uncertainty in the pre-Euro-American fire regime. In addition, in spite of significantly changed climate since the middle 1800s, there is no compelling evidence at the present time that the alpine tundra zone in Rocky Mountain National Park is in danger of disappearing because of the upward movement of trees. Long-term monitoring of forest-tundra ecotones will be needed to detect significant movement in future years.

Stohlgren and Binkley’s team found that elk herbivory did not greatly threaten populations of aspen and other native plant species in Rocky Mountain National Park and fears of such threats may have been exaggerated. Aspen regeneration is far greater and more widely distributed than previously measured, and understory species richness is very resilient to current patterns of herbivory. The cumulative effects of multiple stresses on biodiversity, the key focus of our research, suggests that invading non-native plants, animals, and diseases may be a far more urgent threat to native biodiversity in the coming decades and century compared to climate change. Combined with direct loss of key habitats associated with land use change, invasive species pose a significant and urgent challenge to land managers and policymakers.

Pielke’s team showed that the spatial variability of greenness and land use is also implicated in the significant variation of long-term temperature data in eastern Colorado. The local teleconnection (over distances of tens to hundreds of kilometers) of weather effects from land-use change are now well documented, leading to a more integrated framework of climate variability and change.

Baron’s team showed that increases of up to 4 degrees centigrade will change the timing, but not the amount of snowmelt runoff from high elevation watersheds. RHESSYS’s modeling of Loch Vale under GCM climate scenarios suggests warming over the next century could lead to more frequent low flow years. They also have found strong species response to climate (the elevation link) and to nitrogen concentrations.
(specifically for algae). This is important evidence that will be used as Rocky Mountain National Park decides whether to pursue air quality emissions regulations.

*Rocky Mountain Futures: An Ecological Perspective* was published in 2002 and reviews were excellent. The book summarizes the past, present, and future human disturbances to Rocky Mountain ecosystems, by giving background information on natural processes, a series of contemporary case studies, and syntheses of ecosystem integrity and environmental disturbances. The overwhelming conclusion is that the Rocky Mountains are today a profoundly human-influenced landscape, with few areas where natural processes dominate.

Overall, this project has produced 115 peer-reviewed publications, 15 reports, 76 presentations, 11 theses, and 9 dissertations in the past four years. The following final report details our specific accomplishments and our final deliverable products.
SPECIFIC ACCOMPLISHMENTS AND RESULTS

GIS-based disturbance history map of fire in subalpine forests to aid in Rocky Mountain National Park’s Fire Management Program. – A GIS map of fire history in over 30,000 hectares of subalpine forests in the southern two-thirds of Rocky Mountain National Park was completed. We found that, within subalpine forests, the natural fire regime was dominated by stand-replacing fires killing most (> 90%) of canopy trees over areas of 1000s of hectares. In contrast, the total surface area determined to have had a history of non-lethal surface fires was less than 2%. Large areas of spruce-fir forest burn only at very long intervals (> 200 years) in association with extreme drought, often coinciding with La Niña events. The frequency and extent of burning during the post-1915 fire suppression period is not outside the historic range of variability of the past c. 400 years.

Relevance to resource managers: Our results show land managers and the public that extremely large fire events have occurred in this landscape in the past and that they are likely to occur again in the future in association with extreme drought. Our results show that modern fire suppression has not resulted in a landscape that departs significantly from the range of landscape conditions that occurred in the Park over the past c. 400 years. Fires in the subalpine zone were largely stand-replacing fires, and, consequently, proposals to mechanically thin subalpine forests to mimic a pre-settlement fire regime of widespread surface fires are not consistent with knowledge of the historic range of variability of these forests.

This study supports Question and Product: Q3,P3; Table – Feasibility of Milestones, Products, and Payoffs.

Climatic influences on fire and insect outbreaks in montane forests in the Front Range of Colorado. - We used tree rings to reconstruct the occurrence of fire and spruce budworm outbreaks in the montane forests of ponderosa pine and Douglas-fir in and nearby Rocky Mountain National Park in the Colorado Front Range. We found that within montane
forests of the Park and surrounding areas, conditions for widespread fire are favored by drought and by high year-to-year variability in moisture availability statistically associated with El Niño-Southern Oscillation events. Spruce budworm outbreaks were associated with periods of above-average moisture availability and also with periods of high year-to-year variability in moisture availability during the growing season.

Figure 2: Increased burning in the late 19th century left a legacy of dense even-aged stands over much of the montane landscape of northern Colorado. This was primarily due to climate, but it was also due to Euro-American settlement.

Relevance to resource managers: The understanding of the relationships of major fire years to moisture variability associated with both the negative and positive phases of the El Niño-Southern Oscillation allows managers significant lead time to plan for years of extreme fire hazard. Based on our results, land managers can expect increased budworm activity during wetter decades and periods of high year-to-year variability in climate. Furthermore, the frequency of budworm outbreaks during the 20th century period of fire suppression is not significantly different from the previous 300 years, and such outbreaks should not be regarded as a departure from the historic range of variability.
This study supports Question and Product: Q2,P10; Table – Feasibility of Milestones, Products, and Payoffs.

How fires and suppression affect ponderosa pine densities. – Fires vary in severity of low, mixed, and high-severity fires. Tree regeneration follows fires of different severities, especially high-severity fires. High density of trees after high-severity fires is a natural mode of regeneration (up to 3,000 trees/ha). Fire suppression since Euro-American settlement has led to decreased tree regeneration and mortality. Therefore, restoring fire would likely increase density of small trees and so increase ladder fuels.
Relevance to resource managers: As managers seek to restore fire to previously fire-suppressed ecosystems, it is important to know the consequences of such actions. This study has shown that restoring fires would likely increase the density of small ponderosa pine trees, thereby increasing ladder fuels and the possibility of high-severity crown fires.

This study supports Question and Product: Q3,P3; Table – Feasibility of Milestones, Products and Payoffs.

The historic range of variability in the fire regime of ponderosa pine stands within Rocky Mountain National Park. – A mixture of crown fires, mixed-severity fires, and surface fires occurred in the ponderosa pine forests of Rocky Mountain National Park prior to Euro-American settlement. Therefore, thinning (e.g., mechanical, prescribed burns) of these forests, the removal of dead trees and downed wood, and other programs to lower the risk of mixed or high-severity fires in ponderosa pine forests may satisfy sociopolitical objectives, but should not be labeled as restoration. Longer fire rotations and spatially patchy fires also suggest that a greater diversity of forest structures probably existed in the pre-Euro-American ponderosa pine landscape, possibly leading to some crown fires. Dense thickets of regenerating trees or dense old patches of trees may have been a part of the ponderosa pine forest landscape at that time.

Relevance to resource managers: A historic range of variability in fire regimes is needed for managers using fire as a restoration practice. Although it is known that a mixture of crown fires, mixed-severity fires, and surface fires occurred in the ponderosa pine forests of the Park prior to Euro-American settlement, quantitative targets for how frequent prescribed fires should be, how much land area should be burned in a particular year, or how much fuel reduction is appropriate cannot be specified for restoration efforts because of large uncertainty in the pre-Euro-American fire regime. Managers of parks and adjoining areas may have a difficult task given the natural spatial and temporal variability within these forests.

This study supports Question and Product: Q3,P3; Table – Feasibility of Milestones, Products and Payoffs.

The treeline environment and how it has been affected by climate change. – Below treeline, there is abundant tree regeneration in subalpine meadows interspersed with patches of subalpine trees, and this regeneration dates primarily to a warm, wet period in the 1950s and 1960s. There is also significant change in growth form near treeline, where krummholz growth forms have grown up to become tree height. This height growth occurred in a continuous process since the middle-1800s, a period associated with warmer and wetter conditions since the end of the Little Ice Age. There is no present evidence of abundant tree regeneration in alpine tundra, although scattered clumps of small trees occur. Our data suggest that it is possible that if warming continues without significant increases in precipitation, tree regeneration will not necessarily be favored in tundra or in subalpine meadows because this regeneration was favored only during warm and wet conditions in the past.
Relevance to resource managers: In spite of significantly changed climate since the middle 1800s, there is no compelling evidence at the present time that the alpine tundra zone in Rocky Mountain National Park is in danger of disappearing because of the upward movement of trees. Managers may wish to monitor the treeline environment by setting up permanent photographic points, but our work suggests that these points need to only be observed and evaluated approximately every 25 years to be able to detect significant movement in the forest-tundra ecotone.

This study supports Question and Product: Q3,P2; Table – Feasibility of Milestones, Products and Payoffs.

Determine how climate change, vegetation management practices, and disturbance affect the spread of non-native plants. – Non-native plant species have systematically invaded rare habitat types and lowland mesic areas in Rocky Mountain National Park and elsewhere. However, only a small percentage of non-native plant species are invasive, and only a small portion of the Park is heavily invaded. In addition, species traits of successful invaders are far less predictable than the vulnerability of habitats to invasion. Fire suppression in forests may suppress invasions by non-native plant species indirectly with increased canopy cover, but post-wildfire habitats are particularly vulnerable to plant invasions. The interactions between climate, fire, and plant invasions will help develop better predictive spatial models for the early detection and rapid response of non-native plants.

Relevance to resource managers: The cumulative effects of multiple stresses on biodiversity suggests that invading plants, animals, and diseases may be a far more urgent threat to native biodiversity in the coming decades and century compared to climate change. Combined with direct loss of key habitats associated with land use change, invasive species pose a significant and urgent challenge to land managers and policymakers.

This study supports Question and Product: Q2,P6; Table – Feasibility of Milestones, Products and Payoffs.

Determine how climate change, vegetation management practices, and disturbance affect aspen regeneration. – About half of the aspen in the Front Range of Colorado is found in patches smaller than 200 m², which have been largely overlooked in previous studies that had larger minimum mapping units. Thus, aspen regeneration is far greater and more widely distributed than previously measured. Aspen regeneration has been relatively strong in recent decades, except in the areas of the heaviest winter-time use by elk (where little to no regeneration has been successful), but it appears that understory species richness is very resilient to current patterns of herbivory. Conifer invasion and competition have more severe effects on aspen regeneration (especially preventing it) than on aspen growth.
Figure 5: Aspen patches ranged in size (left) from less than 10 m² to more than 1 hectare (10,000 m²), but the most common patch size was 100 to 1000 m². Although most patches of aspen were small, the large patches of aspen comprised the majority of the total cover of aspen in the Park (right); more than half the total aspen area was found in patches > 1 ha in size.

Relevance to resource managers: Contrary to some reports, aspen forests are not in immediate threat of disappearance from the central Rockies. Opportunities for enhancing aspen on the landscapes include reducing the intensity of winter-time elk use in high-density areas, and reducing conifer dominance through increased fire or other disturbances.

Figure 6: Aspen trees are commonly mixed with conifers; only about one-quarter of aspen trees are found in stands with no conifers (where aspen accounts for 100% of the canopy).

This study supports Question and Product: Q3,P3; Table – Feasibility of Milestones, Products and Payoffs.
Figure 7: Percent of aspen stands with a successful young cohort (> 2m tall) in the past 20 years. N=number of stands mapped from photos; n = number of stands sampled.

Figure 8: Number of aspen regenerating in a ha for each 10 year period as a function of conifer basal area. A conifer basal area of 10 m²/ha equals about 50 trees with a 15 cm diameter.

Figure 9: Aspen basal area growth appeared to be unaffected by the presence of understory conifers.
The productivity of old-growth forests and how it is related to stand structure and environmental resource supplies. – Overall, the structure of old-growth forests (including the size of the forest canopies) had a greater influence on forest growth than did the supply of nutrients, light, or water. We now expect that the response of old-growth forests in the Rockies to changing climate will depend less on the direct environmental changes (such as precipitation) and more on the changing timing and severity of disturbances that develop stand structure. Future rates and intensities of disturbances will be the key driver in the fate of old-growth forests in the Rocky Mountains, probably much more important than direct effects of temperature or precipitation changes.

Relevance to resource managers: Under a changing climate, it is important for resource managers to know what the consequences of global change will be to a particular system. This study found that increased disturbances that affect stand structure will have the most impact on old-growth forests that dominate much of the subalpine landscape of the Central Rocky Mountains.
This study supports Question and Product: Q2,P2; Table – Feasibility of Milestones, Products and Payoffs.

Provide better climate change scenarios to land managers to assess the vulnerabilities of ecosystems to rapid environmental change. – We documented the significant role of vegetation greenness on maximum and minimum temperatures in northeastern Colorado, and found that greenness is directly affected by irrigation and previous precipitation. The spatial variability of greenness and land use is implicated in the significant variation of long-term temperature data in eastern Colorado. Through this research, it was shown how snow cover and lack of snow cover substantially influence temperature and atmospheric dispersion. The local teleconnection (over distances of tens to hundreds of kilometers) of weather effects from land-use change are now documented, dictating the need for an integrated framework of climate variability and change.

Relevance to resource managers: Among our most significant accomplishments is that we have shown that the assessment of vulnerability of resources to climate and environmental variability and change is more comprehensive and useful to policymakers than a limited modeling based prediction of future conditions. The use of historical- and paleo- records of past environmental conditions (such as drought), but with the today’s and expected future human residence in a region, provides a particularly robust approach to assess vulnerability.

This study supports Question and Product: Q2,P9; Table – Feasibility of Milestones, Products and Payoffs.

Evaluating regional and local trends in temperature within eastern Colorado: - Many climate change studies tend to generalize regional patterns by examining data from single stations, single seasons, or a few parameters over a short time scale by averaging data from dissimilar stations or by using coarse-scale general circulation models. Therefore, we explored the potential shortcomings of these studies by evaluating long-term trends in average maximum and minimum temperatures, threshold temperatures, and growing season in eastern Colorado. This study found that finer-scale spatial and temporal variation must be considered when evaluating climate change because of the improbability that a few weather stations represent regional climate trends or that coarse-scale general circulation models will accurately portray trends at subregional scales.

Relevance to resource managers: This study provides a reasonable robust procedure to evaluate climate trends and variability by assessing a group of weather stations for consistent, more qualitative trends.

This study supports Question and Product: Q2,P9; Table – Feasibility of Milestones, Products and Payoffs.

Mountain hydrologic and ecosystem responses to climate scenarios. – These climate scenarios have been addressed with the RHESSys (Regional HydroEcological Simulation System) model, which is a series of ecosystem and hydrologic models run on a GIS
platform. Climate change scenarios for Loch Vale watershed (a mostly unvegetated catchment at the highest elevations) and Big Thompson watershed (85% forested) strongly suggest that hydrology is directly related to winter precipitation amounts. For the Big Thompson watershed, streams are fed by snow that accumulates high above treeline in mountain basins, and precipitation to the east-facing slopes is used for evapotranspiration instead of stream flow. Temperature changes mostly affect the timing of snowmelt, but when winter and spring temperature warm to 4°C, snowmelt begins to occur throughout the winter, leading to strong changes in soil moisture (and thus nutrient cycling), snowpack duration, and primary productivity. In addition, RHESSYSs modeling of Loch Vale under GCM climate scenarios suggests that if warming over the next century occurs, this could lead to more frequent low flow years.

Figure 12: 1993 RHESSys streamflow models for Big Thompson (top) and Loch Vale (bottom) watersheds. Timing of snowmelt is dependent on temperature.
Relevance to resource managers: Ecosystem models are the only way to forecast future ecological and hydrological conditions, but when built upon long-term measurements and understanding of ecosystem processes, they present plausible scenarios that managers can use to prepare and plan for. Our modeling efforts over the past eight years have shown the potential for climate change to drastically change the timing of spring snowmelt runoff, affecting regional water supply. They have also highlighted possible changes to vegetation under climate change scenarios and the potential for extended periods of prolonged drought if GCM scenarios come about.

This study supports Question and Product: Q2,P10; Table – Feasibility of Milestones, Products and Payoffs.

Effects of nitrogen deposition on high elevation terrestrial and aquatic systems. – We have found significant differences in nitrogen cycling in both forests and lakes that are due to high N deposition east of the continental divide (from transportation, agricultural, and industrial emissions), compared with much lower N deposition west of the divide. Both the accumulation of N in forest soils and the change in aquatic algal communities (from paleolimnological analyses) tell us the changes began between 1950 and 1960, coincident with increases in human and livestock populations to the South Platte River Basin. Although changes to forest plant communities are not apparent, there are strong increases in soil microbial activity and foliar N concentrations. Algal communities have changed dramatically in east-side lakes, and now represent mesotrophic conditions, instead of the oligotrophic communities found in west-side lakes and in lake sediments prior to 1950. Algal community rates of change show west-side lakes are changing slowly, possibly in response to slight increases in regional N deposition, and not nearly as rapidly as east-side lakes.

Relevance to resource managers: Our nitrogen biogeochemistry work over the years has provided a wealth of information to Rocky Mountain National Park and regional national forest managers. We have shown significant changes to soil N storage, microbial activity, forest nutrient cycling, aquatic ecosystems, and lake chemistry. We have identified upward trends in N deposition along the Colorado Front Range, and the origin of their emissions. Managers have carefully used these data to alert EPA and State air quality officials of their concern that N emissions may be in violation of the NPS and USDA FS Clean Air Act Amendment and Wilderness Act requirements to maintain air quality.

This study supports Question and Product: Q2,P5; Table – Feasibility of Milestones, Products and Payoffs.

Human-driven change to the entire Rocky Mountain chain. – The overwhelming conclusion of Rocky Mountain Futures, an ecological perspective is that the Rocky Mountains are today a profoundly human-influenced landscape, with few areas where natural processes dominate. Most regions have a history of accumulated human impact that has eroded native species assemblages and altered natural rejuvenating processes such as flooding and fire. The trend toward increasing disruption of the natural
environment continues rapidly today, due to lack of regional planning and land use change. Without vision of what the Rocky Mountain environment should look like in 50-100 years, there will be no region left where natural ecosystems persist without massive management intervention. There are a few areas, however, where restoration, remediation, and protection are occurring and these should be used as models for the rest of the Rocky Mountains.

Relevance to resource managers: This book has begun to be a catalyst for planners, managers, and regional citizens to change how we view and act on the landscapes, processes, and ecosystems that make the Rockies unique. Book reviews have been quite favorable, but more importantly, the message from the book has been in great demand, augmenting a growing regional momentum to act in order to direct future environmental conditions in the Rocky Mountains. Rocky Mountain National Park, along with the Arapaho-Roosevelt Forest, is developing a task force to produce future scenarios under different management and climate scenarios that will be presented to decision makers in the future. Similar plans are beginning in the Southern Rockies as part of the Southern Rockies Ecosystem Project and Wildlands Initiative, as well as through Colorado College. USGS is moving forward with stakeholder-driven establishment of Indicators of Condition for the Colorado Front Range through the Science Impact program.

This study supports Question and Product: Q3,P1; Table – Feasibility of Milestones, Products and Payoffs.
PRODUCTS

Data Sets

Tom Stohlgren, Principal Investigator
Data available at:
http://www.nrel.colostate.edu/projects/stohlgren/_projects/gcts2.html
Supports Question and Product: Q2,P6; Q3,P3; Table-Feasibility of Milestones, Products, and Payoffs.

William L. Baker, Principal Investigator
No data sets are available.

Jill Baron, Principal Investigator
Loch Vale Watershed Research Project Data available at:
http://www.nrel.colostate.edu/projects/lvws/pages/accesstodata/accesstodata.htm
National Atmospheric Deposition Program Data available at:
http://nadp.sws.uiuc.edu/ (site number CO98)
Supports Question and Product: Q2,P5; Q2,P10; Table-Feasibility of Milestones, Products, and Payoffs.

Dan Binkley, Principal Investigator
BinkleyOldGrowthConifer.xls. Contains data on tree species, numbers, diameter, leaf area, growth and biomass for old forests in Rocky Mountain National Park, and adjacent Neota Creek Wilderness. Data set is complete, not documented in any database. Available at:
Supports Question and Product: Q2,P2; Table-Feasibility of Milestones, Products, and Payoffs.

BinkleyExclosureNSupply.xls. Contains data on net N mineralization and resin-bag N for old and young exclosures in and near Beaver Meadows in Rocky Mountain National Park. Data set is complete, not documented in any database. Available at:
Supports Question and Product: Q2,P2; Table-Feasibility of Milestones, Products, and Payoffs.

BinkleyOldExclosureSoil.xls. Contains data on soil bulk density, total N and C, and available cations and phosphorus for the 3 old exclosures in Beaver Meadows in Rocky Mountain National Park. Data set is complete, not documented in any database. Available at:
Supports Question and Product: Q2,P2; Table-Feasibility of Milestones, Products, and Payoffs.

BinkleyRMNPAspenAges.xls. Contains data on tree numbers, diameters, and ages for pure aspen stands in Rocky Mountain National Park and Roosevelt National Forest.
Data set is complete, not documented in any database. Available at: http://www.nrel.colostate.edu/projects/stohlgren/_projects/gcts2.html. Supports Question and Product: Q3,P3; Table-Feasibility of Milestones, Products, and Payoffs.

Timothy G.F. Kittel, Principal Investigator
No data sets are available.

Roger A. Pielke, Sr., Principal Investigator
No data sets are available.

Tom Veblen, Principal Investigator
Fire-scar data set. The fire-scar data set is currently in progress for submission to the International Multiproxy Paleofire Database, NOAA. The contact person is T. Veblen, Geography, CU-Boulder. After September 1, 2004 the fire-scar data may be accessed at: http://www.ngdc.noaa.gov/paleo/impd/ Supports Question and Product: Q3,P3; Q2,P10; Table-Feasibility of Milestones, Products, and Payoffs.

Fire history map data set. The GIS map of fire history of the southern two-thirds of Rocky Mountain National Park is in progress. It will be submitted to the Park by July 2005. In the meantime the contact person is T. Veblen, Geography, CU-Boulder. Supports Question and Product: Q3,P3; Table-Feasibility of Milestones, Products, and Payoffs.

Tree-ring data set on insect pest outbreaks. The tree-ring data set on insect pest outbreaks is in progress for submission to the International Tree-ring Data Archive, NOAA. Currently, the contact person is T. Veblen, Geography, CU-Boulder. Supports Question and Product: Q2,P10; Table-Feasibility of Milestones, Products, and Payoffs.

Reports, Abstracts, and Presentations

Reports:


Appropriate Time. USDA Forest Service Proceedings XXXX. Fort Collins, CO: Rocky Mountain Research Station.


Presentations:


Baron, J.S. Denver Zoo (Southern Rockies Ecosystem Project, Feb 2004).


Baron, J.S. Rocky Mountain Futures Forum, Rocky Mountain National Park April 2004.


Baron, J.S. University of Denver seminar May 2004.


Nydick, K.R. 2003. The role of nitrogen in high elevation lakes. Aquatic, Watershed, and Earth Resources Department seminar, Utah State University, Jan. 27, Logan, UT.


Baron, J.S.  EPA Region 8 May 2003.


Baron, J.  Gore Range Natural Science School, July 2003.


Alley, T., N.W., R.O. Coleman, T.J. Stohlgren, P.H. Evangelista, and D.A. Guenther. Integrating various data layers and multi-media in a comprehensive format for land


Nydick, K., B. Moraska, J. Baron, B. Johnson. 2001. Mesocosm experiments to determine if subtle nitrogen additions can alter primary production in small mountain lakes, Snowy Range, WY. American Society of Limnology and Oceanography (ASLO) Annual Meeting, Feb 11-16, Albuquerque, NM.


Nydick, K., B. Moraska, J. Baron, B. Johnson. 2001. Simulation of N deposition to small mountain lakes, Snowy Range, WY. Front Range Student Ecology Symposium, March 14-15, Fort Collins, CO.


Nydick, K., B. Moraska, J.S. Baron, J. Sickman, and B. Johnson. 2001. Sensitivity of western mountain lakes to N deposition. Symposium on N deposition in the West, Ecological Society of America (ESA) Annual Meeting, Aug. 6-10, Madison, WI.


**Stohlgren, T.J.**. Invasive species threats to National Parks. National Park Service’s Discovery 2000 Conference in St. Louis, MO (Sept. 11-14, 2000). (PRESENTED)


**Peer-Reviewed Publications**


Wolfe, A.P., A.C. van Gorp, and J.S. Baron. 2003a. Assessing the ecological consequences and spatial trends of nitrogen deposition in alpine lakes of Rocky
Mountain National Park (Colorado USA): an application of paleolimnology. Ecological Applications In press.


Other

Theses/Dissertations


Algal and zooplankton species lists are available in a video library on the Loch Vale website. Vegetation lists are also available, as well as long-term stream discharge, water quality, and climatic data (http://www.nrel.colostate.edu/projects/lvws/). These species lists are the first comprehensive lists of aquatic algae and invertebrates within Rocky Mountain National Park.
GEOSPATIAL REFERENCE TO THE STUDY AREA

Rocky Mountain National Park
The bounding box of the park (all in Latitude/Longitude decimal degrees):
West: -105.911926
East: -105.493031
North: 40.553807
South: 40.158081

Centroid (approximate): -105.414143 W, 40.201766 N
WEB PAGE REVIEW

Tom Stohlgren, Principal Investigator
Main Project Page: http://www.nrel.colostate.edu/projects/stohlgren/index.html
National Institute of Invasive Species Science home page:
http://kiowa.colostate.edu/cwis438/niiss/index.html

William L. Baker, Principal Investigator
Main Project Page: http://www.uwyo.edu/geog/people/wbaker.html

Jill Baron, Principal Investigator
Loch Vale Watershed Research Project:
http://www.nrel.colostate.edu/projects/lvws/pages/homepage.htm
User interface for running the RHESSys model:
https://www.nrel.colostate.edu/~lkc/rhessys_dist/rhessys.cgi
Link to calibration of the RHESSys model:
https://www.nrel.colostate.edu/~lkc/rhessys_calibration/calibration.cgi

Dan Binkley, Principal Investigator
Main Project Page: http://lamar.colostate.edu/%7Ebinkley/research.htm

Timothy G.F. Kittel, Principal Investigator
Main Project Page: http://culter.colorado.edu/~kittel/

Roger A. Pielke, Sr., Principal Investigator
Main Project Page: http://blue.atmos.colostate.edu

Thomas T. Veblen, Principal Investigator
Main Project Page:
http://www.colorado.edu/geography/news_events/facilities/biolab/biolab.html