



**Proceedings of the  
Fifth Biennial Conference of  
Research on the Colorado Plateau**

*Editors*

Charles van Riper III

Kathryn A. Thomas

Maureen A. Stuart

Fifth Biennial Conference  
of Research on the Colorado Plateau  
Northern Arizona University  
Flagstaff

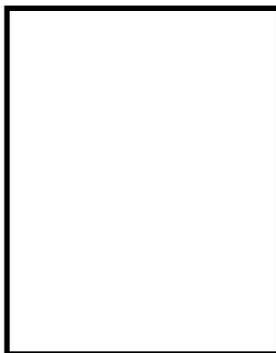
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**DEDICATION  
TO  
DR. DENNIS B. FENN**



This book, 'Proceedings of the Fifth Biennial Conference of Research on the Colorado Plateau,' is dedicated to Dr. Dennis B. Fenn. Born and raised near Benson, AZ, in 1969 Denny (as his many colleagues call him) completed his undergraduate degree at the University of Arizona, Tucson. In 1973 he graduated with a Ph.D. in soil chemistry and clay mineralogy from Michigan State University. From December 1972 - February 1995, Dr. Fenn was involved with National Park Service research, and from 1993-1995 served as Acting Associate Director for Natural Resources Management. In 1995, he was appointed Western Regional Director for the newly created National Biological Service, then from April to September 1996 served as Deputy Director. Today, Denny serves as Division Chief of the U.S. Geological Survey Biological Resources Discipline. As the Associate Director for Biology, he is the biological science advisor to the USGS Director and oversees science programs conducted at 17 major research centers, 102 field stations, and 39 cooperative research units. In addition, he has the responsibility for executing a budget of over \$220 million and managing a work force of 1,700 employees.

Denny Fenn has been an integral part of the growth and success of USGS/FRESC Colorado Plateau Field Station. In 1989, he approached Northern Arizona University (NAU) regarding the possibility of placing a National Park Service Cooperative Park Studies Unit (CPSU) on campus. Denny's vision resulted in a Colorado Plateau ecosystem-based entity, rather than being bounded by traditional state lines. This ecosystem-based unit continues today at the USGS/FRESC Colorado Plateau Field Station (CPFS). In the fall of 1993, the CPSU was transferred to the newly-created National Biological Service, and then in 1997 to the U.S. Geological Survey. Denny Fenn met each change with the same enthusiasm and continued support of science that he directed toward establishment of the NAU CPSU. From 1991-1999, he devoted additional time and energy to the Colorado Plateau Biennial Conference, providing introductory materials for three former proceedings. Without Denny's support, the Colorado Plateau Field Station and its Biennial Conference Proceedings would not have been a reality. It is because of his commitment to quality science that we dedicate the 'Proceedings of the Fifth Biennial Conference of Research on the Colorado Plateau' to Dr. Dennis B. Fenn.

## CONTRIBUTORS

**Gregory H. Aplet**

Center for Landscape Analysis  
The Wilderness Society  
7475 Dakin Street, Suite 410  
Denver, CO 80221

**John Duff Bailey**

College of Ecosystem Science  
and Management  
School of Forestry  
Northern Arizona University  
POBox 15018  
Flagstaff, AZ 86011-5018

**Jill L. Bright**

Arizona Game and Fish Department  
1910 Avenue A, #28-B  
Yuma, AZ 85364

**Timothy E. Crews**

Environmental Studies Program  
Prescott College  
220 Grove Avenue  
Prescott, AZ 86301

**Ben Dowler**

Department of Biology  
College of Science and Allied Health  
Grand Canyon University  
3300 West Camelback Road  
Phoenix, AZ 85061-1097

**Charles A. Drost**

USGS/FRESC  
Colorado Plateau Field Station  
Northern Arizona University  
POBox 5614  
Flagstaff, AZ 86011-5614

**Mechelle Eacret**

Department of Biology  
College of Science and Allied Health  
Grand Canyon University  
3300 West Camelback Road  
Phoenix, AZ 85061-1097

**M. Lisa Floyd**

Environmental Studies Program  
Prescott College  
220 Grove Avenue  
Prescott, AZ 86301

**Jennifer Gillis**

Department of Biology  
College of Science and Allied Health  
Grand Canyon University  
3300 West Camelback Road  
Phoenix, AZ 85061-1097

**Randy Gimblett**

School of Renewable Natural Resources  
The University of Arizona  
Tucson, AZ 85721

**Kerry L. Griffis**

Department of Fisheries and Wildlife  
Utah State University  
Logan, UT 84341-5210

**David D. Hanna**

Environmental Studies Program  
Prescott College  
220 Grove Avenue  
Prescott, AZ 86301

**Dawn Hartley**

Center For Landscape Analysis  
The Wilderness Society  
1424 Fourth Avenue, Suite 816  
Seattle, WA 98101

**Timothy L. Hoffnagle**

Oregon Department of Fish and Wildlife  
Eastern Oregon University  
211 Inlow Hall  
La Grande, Oregon 97850

**Christina Hudenko**

Center for Environmental Sciences  
and Education  
Northern Arizona University  
POBox 5694  
Flagstaff, AZ 86011

**Tim Jackson**  
Department of Biology  
College of Science and Allied Health  
Grand Canyon University  
3300 West Camelback Road  
Phoenix, AZ 85061-1097

**Sarah R. Jacobs**  
USGS/FRESC  
Colorado Plateau Field Station  
Northern Arizona University  
POBox 5614  
Flagstaff, AZ 86011-5614

**Matthew R. Loeser**  
Center for Environmental Sciences  
and Education  
Northern Arizona University  
POBox 5694  
Flagstaff, AZ 86011-5694

**Sheri S. Mann**  
Agriculture, Health, and  
Natural Resource Extension  
American Samoa Community College  
Pago Pago, American Samoa 96799

**Craig Moran**  
Center for Environmental Sciences  
and Education  
Northern Arizona University  
POBox 5694  
Flagstaff, AZ 86011-5694

**Erika M. Nowak**  
USGS/FRESC  
Colorado Plateau Field Station  
Northern Arizona University  
POBox 5614  
Flagstaff, AZ 86011-5614

**Gary P. Nabhan**  
Center for Sustainable Environments  
Northern Arizona University  
POBox 5765  
Flagstaff, AZ 86011-5765

**Kurt Olsen**  
Center for Environmental Sciences  
and Education  
Northern Arizona University  
POBox 5694  
Flagstaff, AZ 86011-5694

**Trevor B. Persons**  
USGS/FRESC  
Colorado Plateau Field Station  
Northern Arizona University  
POBox 5614  
Flagstaff, AZ 86011-5614

**Catherine A. Roberts**  
Department of Mathematics and  
Computer Science  
College of the Holy Cross  
Worcester, MA 01610

**Gary Salamacha**  
Arches National Park  
Moab, Utah 84532

**Thomas D. Sisk**  
Center for Environmental Sciences  
and Education  
Northern Arizona University  
POBox 5694  
Flagstaff, AZ 86011-5694

**Jonathan J. Smith**  
College of Ecosystem Science  
and Management  
School of Forestry  
Northern Arizona University  
POBox 15018  
Flagstaff, AZ 86011-5018

**John R. Spence**  
National Park Service  
Resource Management Division  
Glen Canyon National Recreation Area  
POBox 1507  
Page, AZ 86040

**Maureen A. Stuart**  
USGS/FRESC  
Colorado Plateau Field Station  
Northern Arizona University  
POBox 5614  
Flagstaff, AZ 86011-5614

**Kathryn A. Thomas**  
USGS/FRESC  
Colorado Plateau Field Station  
Northern Arizona University  
POBox 5614  
Flagstaff, AZ 86011-5614

**Charles van Riper III**  
USGS/FRESC  
Colorado Plateau Field Station  
Northern Arizona University  
POBox 5614  
Flagstaff, AZ 86011-5614

**Michael R. Wagner**  
College of Ecosystem Science  
and Management  
School of Forestry,  
Northern Arizona University  
POBox 15018  
Flagstaff, AZ 86011-5018

**Brian F. Wakeling**  
Arizona Game and Fish Department  
Research Branch  
2221 West Greenway Road  
Phoenix, AZ 85023

**Sally Weimann**  
Department of Biology  
College of Science and Allied Health  
Grand Canyon University  
3300 West Camelback Road  
Phoenix, AZ 85061-1097

## PREFACE

The Colorado Plateau is one of the richest ecoregions in North America in terms of its high rates of plant endemism, and its species richness of invertebrates and vertebrates. It is also a region that has come under unprecedented levels of human use, in terms of the diversion of its water resources and dramatic increases in eco-tourist activities located in back-country settings. Combine this natural richness with new stresses on plant and animal communities, and you have a justified need for more investment in science-based management of species and habitats. The Colorado Plateau Biennial Conference has become the premiere means of bringing ground-breaking science on the Colorado Plateau into public discussion, particularly among federal land managers.

The Colorado Plateau Biennial Conference series of publications focus on providing information to a diversity of land management agencies and organizations on the Colorado Plateau, and throughout the southwestern United States. The 13 papers in this fifth proceedings volume are contributions of researchers from the federal, state, and private sectors, who come together at Northern Arizona University every other year to share scientific information relevant to land management decisions affecting the Colorado Plateau. These papers contribute to our increasing pool of fresh data, providing baseline scientific information pertinent to physical, cultural, and biological resources of the Colorado Plateau.

Support for many of these studies have come from a spectrum of federal, state, and private partners concerned about the well-being of the Plateau's resources. I applaud the effort of the contributors in accomplishing such excellent studies on often-limited financial resources, under sometimes challenging field conditions. Nevertheless, their modest funding is compensated for by their broad base of public and institutional support. These authors are already making an impact in demonstrating more effective means of managing the fragile lands and scarce waters of the arid southwestern states, especially in Arizona, Utah, New Mexico and Colorado.

There remains much to be done. As a people, we face the prospect of extensive local and global environmental changes that continue to perturb the physical, cultural, and biological resources of the terrestrial and freshwater ecosystems of the Colorado Plateau. As the research branch for the Department of the Interior, the USGS is committed to identify, in a sound scientific manner, information that can be used by land managers to protect our resources from detrimental change due to modern human influences. We must broaden our collaborations to develop the information necessary to alert our managers, leaders, and the public to the importance of their natural surroundings as elements of those basic resources that sustain us, inspire us, and represent our natural biological and environmental heritage. Our task has just begun.

**GARY P. NABHAN**

*Director  
Center for Sustainable Environments  
Northern Arizona University*

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*(Insert sketch: Introduction)*







# Introduction to the Proceedings of the Fifth Biennial Conference of Research on the Colorado Plateau

The 13 chapters in this book were selected from 105 research papers presented at the Fifth Biennial Conference of Research on the Colorado Plateau. Held 15-18 October 1999 in Flagstaff, Arizona, the conference was hosted by USGS Forest and Rangeland Ecosystem Science Center Colorado Plateau Field Station (CPFS) and Northern Arizona University. The meeting theme centered on research, inventory, and monitoring of lands over the Colorado Plateau, with a focus on the newly created Cooperative Ecosystem Studies Unit (CESU) at Northern Arizona University.

This is the fifth volume in a planned series of Colorado Plateau Proceedings, highlighting research and resource management efforts related to physical, cultural and biological resources within the biogeographic province of the Colorado Plateau. Many of the protocols and management techniques presently being utilized in land management units over the Colorado Plateau are a result of collaborative work among the USGS Colorado Plateau Field Station staff, university and agency scientists, with land managers. The scientific work published in this Proceedings Series contributes significantly to those collaborative efforts. It has been clearly demonstrated that, because of similarities across the Colorado Plateau, techniques that work in one management unit are applicable to many other areas throughout the ecoregion, and to other locations in the country that have similar habitat and climatological conditions.

The 13 contributed papers each constitutes a chapter, with the book being divided into three subsections: I. **Cultural Resources**; II. **Biological Resources**; and, III. **Physical Resources**. Each paper selected for publication in this Biennial Conference Proceedings represents original research, not published in another location, and that has been peer reviewed by scientists from that research discipline.

## I. CULTURAL RESOURCES

This book opens with a chapter by Loeser et al., focusing on a cultural/social controversy that presently has center-stage on the Colorado Plateau — public lands grazing management. In the past, research information that has provided a foundation for determining levels of public lands grazing has been based on biomass and species composition of aboveground plant assemblages. Loeser et al. argue

that measurements at multiple trophic levels offer additional information and provide a tractable approach for investigating grazing impacts on underlying ecosystem processes. They feel that the present grazing controversy should move beyond the simplistic approach of grazed-verses-ungrazed comparisons, and address a wider range of potential grazing practices. One focus of this chapter is that, not only should plant biomass and species composition be considered, but we also need to examine below ground grazing impacts. Preliminary data from Loeser and his colleagues' ongoing study suggest that cryptogammic crusts and diatoms below the soil-surface are most greatly affected by intense grazing pressures. In conclusion they argue that we need to frame the grazing debate into an assessment of what are the best overall socio-economic returns, when balanced with environmentally sensitive practices for the Colorado Plateau.

The second chapter illustrates another cultural/social challenge on the Colorado Plateau, that being regulating use of remote locations to maintain/enhance the value of solitude. Roberts and Gimblett provide readers with a background on challenges facing regulation of rafting traffic on the Colorado River. This paper provides managers with a model that presents options for regulating river-rafting traffic along one of the premier white-water rivers in the world. The authors, after conducting interviews with guides who had undertaken Colorado River trips, add artificial-intelligence algorithms developed from the interview process. The resulting simulation engine uses elements of fuzzy logic in the model's decision structure. The fuzzy logic theory employed by the authors provides a robust and full-range of decision-making tools that are suitable for capturing much of the nuances inherent in making complex decisions in a natural environment. Roberts and Gimblett then utilize actual river-trip data, and compare their model predictions to 15-day trips and to trips of longer duration. The focus of the authors' modeling effort is to provide for a balance between solitude required by visitors, with increased demands for a greater number of permits for Colorado River trips. They feel that this balance can be accomplished, while still minimizing impacts on natural resources along the river corridor.

## II. BIOLOGICAL RESOURCES

This section comprises the next 10 chapters of this book, first covering animals, then vegetation, and closing with two modeling chapters on wildlife/habitat associations. Chapter #3 examines the influences of habitat types, water sources and movement barriers to pronghorn antelope in northern Arizona. Utilizing a Geographic Information System and data collected from 17 radio-collared animals captured within the environs of Wupatki National Monument in northern Arizona, the authors show that pronghorn antelope movements were most greatly affected by fencing along main thoroughfares, historical presence of animals, forage succulence and permanently available water sources. They conclude the chapter by

encouraging management agencies to enhance communication and to consider managing pronghorn antelope across a broader landscape than just their individual land units.

In Chapter #4 Brian Wakeling compares mule deer demographic responses to weather variables throughout Arizona. Utilizing data from Arizona Game and Fish Department winter mule deer surveys, monthly precipitation, and Palmer drought severity index values, the author examines weather relationships with fawn:doe and buck:doe ratios among game management units throughout the state. He demonstrates that statewide mule deer population estimates show only a modest relationship with weather patterns, but that it does explain 40-50% of the variation. Habitats at climatic extremes (e.g., desert and montane) had a better fit in his model than did more moderate habitat types (e.g., grassland-pinon juniper woodland habitats). Wakeling concludes by suggesting six other confounding variables that contribute to changes in deer numbers, but argues that climatic regimes still have the largest influence on overall mule deer abundance throughout Arizona.

The next chapter (#5) moves from the large mammal arena to work on amphibians and reptiles. Drost et al. summarize their 1997-98 study that inventoried the herpetofauna of Petrified Forest National Park. Utilizing pit fall traps, visual encounters, artificial cover boards and night driving, the authors identified over 1.5 thousand individual reptiles and amphibians. Their data show that the herpetofauna at Petrified Forest NP is comprised of 16 reptile and seven amphibian species, of which one is a first record for northeastern Arizona and another a new record within the state of Arizona. This diverse assemblage of species is a result of individuals from three biogeographic regions (Southern desert/grassland, Great Plains, and Great Basin) that overlap at the park. The authors point out that Petrified Forest NP is one of the few large tracts of protected short-grass prairie on the southern Colorado Plateau, that still remains in semi-pristine condition, and as such supports regionally rare grassland herpetofauna species.

Chapter #6 examines the potential influence of changing water temperature on native fish within the Colorado River corridor. Timothy Hoffnagle compares differences in temperature, turbidity, dissolved oxygen and pH of backwaters between fluctuating vs. short-term steady flows that result from discharges of Glen Canyon Dam. The author cautions managers that they should more closely examine the potential impacts of a steady flow regime on native fish, prior to implementation of this discharge regime. He raises this caution because of decreases in dissolved oxygen and increases in turbidity of backwaters that he found under steady flow regimes.

Chapter #7 of the Biological Resources section provides a transition into terrestrial wildlife management, where Wakeling et al. examine the selection of roost trees by Merriam's turkeys in north-central Arizona. The authors compare 13

known roosting trees with 13 paired random trees >40 cm dbh. They found that turkeys selected significantly older and larger trees that had greater height to first limb in addition to greater surrounding basal area. From their data, Wakeling et al. develop a model that, utilized in conjunction with other existing models, should allow land managers to more accurately rank and prioritize potential Merriam's turkey roosting habitat.

Chapters #8 and #9 move into a closer examination of impacts resulting from ponderosa pine stand treatment, dealing with butterfly densities and forest health, respectively. In Chapter, #8 Griffis et al. document changes in adult butterfly populations among unmanaged, mechanically thinned, prescribed burned, and wildfire-affected stands of ponderosa pine near Flagstaff, Arizona. Although they did not detect a significant effect of stand treatment on butterfly densities, they suggest that important treatment effects may have been masked by several factors including butterfly movement among plots. In the next chapter (#9) Bailey et al. examine landscape-level silviculture affects on ponderosa pine forests around Flagstaff, AZ. Testing among the four forest-treatment types outlined in the previous chapter, the authors found that unmanaged stands had a higher density of smaller diameter, suppressed ponderosa pine. Burned treatments had a significantly greater number of dead stems/ha, but seedling density did not differ among the four treatments. Bailey and his coworkers argue that the greater density of small diameter trees in unmanaged forest represent a condition that would enhance stand replacing wildfires, especially during drought years.

The final vegetation chapter by Floyd, Hanna and Salamacha deals with ecosystem response to fire at Mesa Verde National Park, focusing on post-fire invasion by 'noxious weeds.' Of the major habitat types in Mesa Verde they found that, following a fire, old-growth pinon-juniper woodlands were the most susceptible to noxious weed invasion. The authors then evaluated the effectiveness of mechanical removal, herbicide application and native grass seeding on inhibiting noxious weed expansion following two fire events (1989 and 1996). They conclude this chapter by suggesting that native perennial grass seeding within 3-years of a fire is the most effective way to reduce noxious weed proliferation.

The last two biological chapters deal with modeling studies of wildlife/habitat associations over portions of the Colorado Plateau. Chapter #11 provides the reader with an introduction to the Southwest Regional Gap Analysis Program that is a second generation GAP analysis of the five states (Arizona, Colorado, Nevada, New Mexico and Utah) that comprise the Colorado Plateau. Jacobs et al. explain how, using a cooperative approach, their new program will develop new Geographic Information Systems (GIS) data themes for land cover, vertebrate species distributions, and land stewardship across five states. These GIS layers will be seamless across state boundaries and of finer (5 ha) resolution than previous GAP data. The authors plan to utilize these new data layers to better evaluate habitats of

concern and conservation status of vegetation types and vertebrate species over the 5-state region. They believe that these new GIS products will allow land managers, policy makers, and planners to make better-informed land-use decisions over the Colorado Plateau.

Chapter #12 by Hartley and Aplet presents a newly developed model that projects potential wildlife habitat corridors in the Greater Grand Staircase-Escalante ecosystem. Utilizing principles of island biogeography, the authors apply a model developed for grizzly bears in Montana to habitat surrounding Grand Staircase-Escalante in southern Utah. They point out that the model is based on four assumptions: 1) good corridors are primarily composed of good habitat; 2) humans pose problems for successful wildlife transit; 3) current human developments are permanent; and, 4) least-cost paths constitute the best routes of transit. The authors import Utah GAP GIS data into their model and produce a cost surface grid for each species of concern. Areas that they identify as potential important corridors are the East Fork of the Virgin River and the Dixie National Forest northeast of Bryce Canyon National Park.

### III. PHYSICAL RESOURCES

The final chapter of the Fifth Biennial Conference Proceedings deals with recent trends of climate change over the Colorado Plateau. In this 13<sup>th</sup> chapter John Spence focuses on characterizing recent trends in climate changes within the central Colorado Plateau. Utilizing long-term weather station data from southern Utah and northern Arizona, he demonstrates that climate patterns over the past half-century have changed in this region. Annual minimum temperatures have increased significantly in most areas. Maximum temperatures have declined some at higher elevation climate stations. Spence also points out that precipitation has changed little except for a slight increase during the winter. He also found no evidence for a strengthening of the summer monsoon, a prediction of some global warming models. The chapter concludes with a discussion of how these changing weather patterns might potentially impact vegetation and rare plant species on the Colorado Plateau.

Any Proceedings is never a single effort, but a direct result of work by many individuals. This Fifth Proceedings is no exception. The dedicated Colorado Plateau Field Station staff (T. Arundel, K. Cole, C. Drost, J. Hart, S. Jacobs, M. Johnson, E. Kee, T. Koronkiewicz, D. Mattson, E. Nowak, E. Paxton, T. Persons, M. Rasmussen, M. Sogge, R. Stevens, M. Stuart, K. Thomas) provided much needed assistance during the conference. I would especially like to thank the following reviewers: Craig Allen, Sam Arundel, Chuck Avery, Don Bertollette, Dean Blinn, Matt Brooks, Bruce Bury, Ken Cole, Tom Edwards, Peter Gogan, Tom de Gomez, Tim Graham, Linda Jalbert, Dave Mattson, Jim Mead, Karen Mock, Barbara Phillips, David Pyke, Peter Rowlands, Cecil Schwalbe, J. Michael Scott, Harley G. Shaw, Tom

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This book, like the products of other symposia that are centered around a particular theme, should help to focus attention on research presently being conducted over lands of the Colorado Plateau. In particular, it is hoped that the many new BLM and NPS National Monuments will be able to utilize some of the ideas and concepts presented within the Biennial Proceedings, to launch efforts toward management and stewardship of their newly created lands in the Southwest. Finally, if the material in this volume, as that contained in previous Biennial Conference Proceedings, can act as a stimulus for future support of research and management of cultural, natural and physical resources over the Colorado Plateau, it will make the organizational and editorial work of the past two years a worthwhile and productive effort.

**CHARLES VAN RIPER III**

*Station Leader, USGS/BRD  
Forest and Rangeland Ecosystem Science Center  
Colorado Plateau Field Station*



*(Insert sketch: Cultural Resources)*



