Ninth Biennial Conference of Research on the Colorado Plateau

du Bois Center, Northern Arizona University

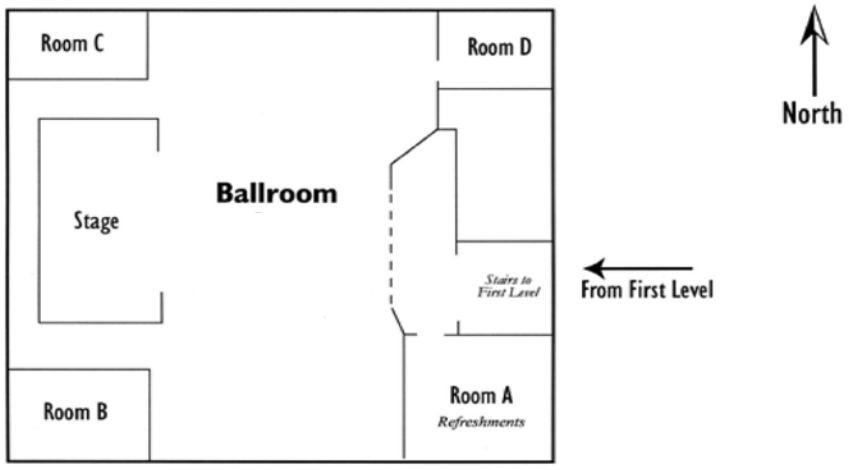
29 October – 1 November 2007

Program and Abstracts of Presented Papers and Posters

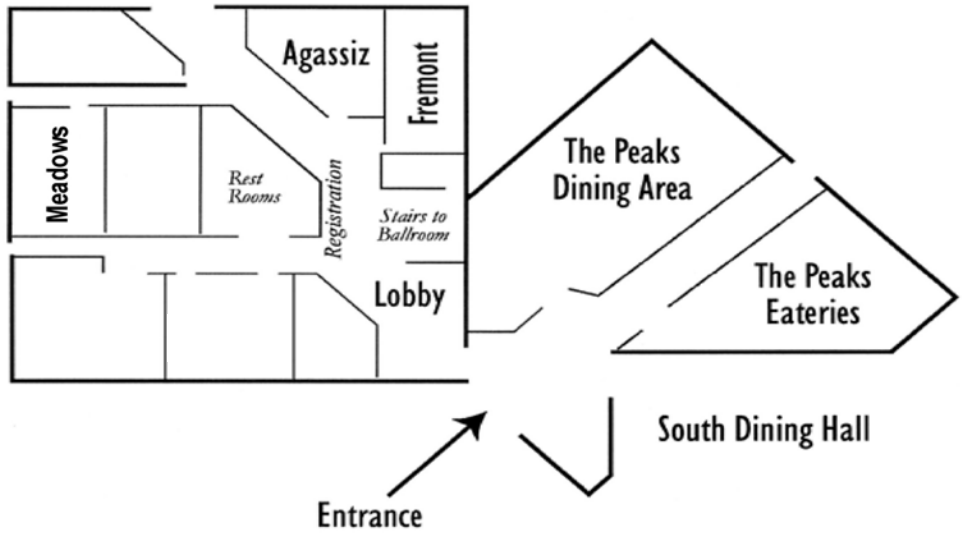
Sponsored by:
USGS Southwest Biological Science Center
USGS Colorado Plateau Research Station
Ecological Monitoring & Assessment Program & Foundation
NAU Center for Sustainable Environments
NAU Merriam-Powell Center for Environmental Research
NPS & NAU Colorado Plateau Cooperative Ecosystems Studies Unit
National Park Service
Diablo Trust

duBois Conference Center Floor Plan

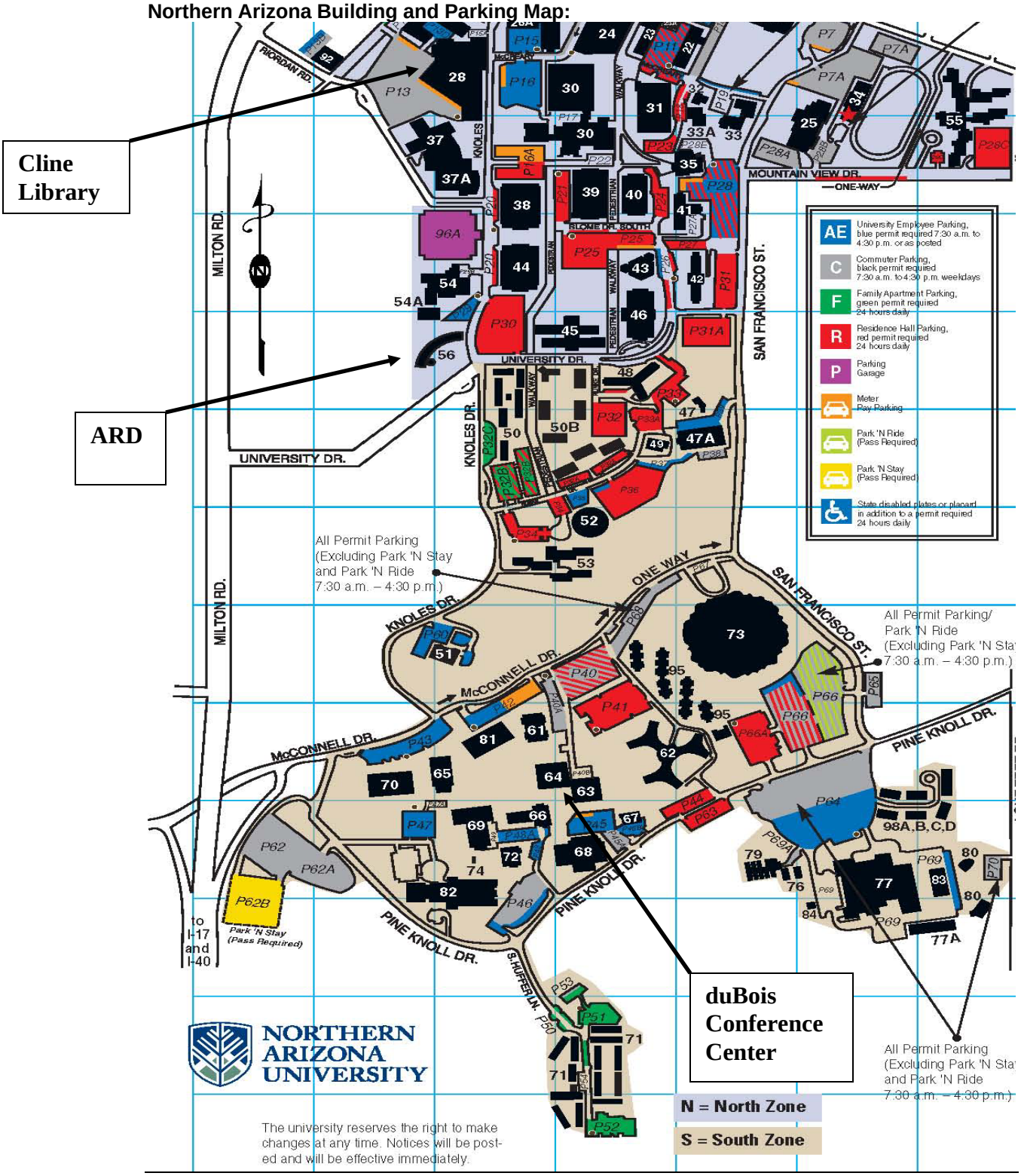
Second Level



First Level



Northern Arizona Building and Parking Map:



Biennial Conference: duBois Conference Center, 64
Parking: Lots P40 and P66 (no permit needed at any time)

A River Reborn Documentary: Cline Library, 28
Parking: Lot P13 (no permit needed after 4:30 p.m.)

Poster Session: Applied Research & Development Building (ARD) 56
Parking: Garage Lot P96A (no permit needed after 4:30 p.m.)

Conference Coordinators

Conference Chairs	Scott Durst and Mark Sogge
Program Chairs	Scott Durst and Mark Sogge
Registration Managers	Marie Saul and Sparrow Adson
Food and Promotion	Scott Durst
Audio-Visual	Chris Calvo
Information Technology	Chris Taesali
Poster Session Chair	Matthew Johnson

Special Session Developers

Cave Research in the Western United States	J. Judson Wynne
Climate Change and Ecosystem Impacts	Neil Cobb, Kirsten Ironside and Ken Cole
Colorado Plateau Cooperative Ecosystems Studies Unit Faciliation of Cross-boundary Research and Management on the Colorado Plateau	Ron Hiebert
The Legacy and Future Visions of Conservation Biology on the Colorado Plateau	Matthew Johnson and the Colorado Plateau Chapter of the Society for Conservation Biology
Native Plant Production and Seed Increase	Judy Springer and Susan Nyoka
Restoration and Conservation at the Landscape Scale: The Kane 2 Mile Ranch Project	Tom Sisk and Eli Bernstein
The Restoration of Fossil Creek: Result of Research and Monitoring	Michele James
Tribal Lands of the Colorado Plateau: Scientific Assessment of Climate Change Impacts to Landscapes and Ecosystems	Diana Anderson and Amy Whipple
Using Native Plants in Ecological Restoration	Judy Springer and Susan Nyoka

REGISTRATION

Registration and information tables, located in the lobby of the du Bois Conference Center, will be open at the following times:

1:00 p.m. – 5:00 p.m.	Monday, October 29th
7:30 a.m. – 4:00 p.m.	Tuesday, October 30th
7:30 a.m. – 4:00 p.m.	Wednesday October 31st
7:30 a.m. – 9:00 a.m.	Thursday, November 1st

GENERAL INFORMATION

Messages: Telephone messages will be posted on a message board near the registration table as they are received from the du Bois Conference Center Information Desk (928-523-1594).

Dining: Meals are available at several locations at the du Bois Conference Center or at nearby off-campus restaurants.

Conference Parking: Follow the posted signs to Biennial Conference parking. Conference participants can use Parking Lots 40 and 66 (north and northest, respectively, of the duBois Center. Refer to the NAU Campus map in the registration folder or program. Permits will not be necessary to park in these two lots. However, cars parked in metered spots must "feed the meter." Restricted space (e.g. handicapped) regulations will be enforced. Cars parked in lots other than these will be cited.

Poster Session Parking: Parking is available in the Parking Garage Lot (P96Q) ½ block to the north of the the ARD (B56) building after 4:30 p.m. (no permit needed).

Submissions for the Proceedings of the 9th Biennial Conference of Research on the Colorado Plateau

We invite interested individuals to publish research presented at the 9th Biennial Conference of Research on the Colorado Plateau in the 9th volume of the Biennial Conference Proceedings Series. The paper would be refereed and peer reviewed. University of Arizona Press will publish the Proceedings as a book. The previous eight volumes of the Biennial Conference Proceedings have gained international recognition, being reviewed and summarized in journals such as *Conservation Biology*, *Ecology*, and the *Southwest Naturalist*. Many of the Proceedings Chapters are frequently cited by fellow professionals and documented by Science Citation Index.

AUTHOR INSTRUCTIONS can be found at:
http://sbsc.wr.usgs.gov/cprs/news_info/meetings/biennial/2007/authorsguide.asp

Questions can be directed to the editors of the 8th volume: Dr. Charles van Riper (520-626-7027; charles_van_riper@usgs.gov) or Mark Sogge (928-556-7194; mark_sogge@usgs.gov)

DEADLINE FOR SUBMISSIONS: 15 December 2007

SUBMIT PAPERS TO: Dr. Charles van Riper, USGS Sonoran Desert Research Station, 125 Biological Sciences East, The University of Arizona, Tucson, AZ 85721.

8th volume of the Biennial Conference Proceedings Series

A proceedings of the 8th Biennial Conference of Research on the Colorado Plateau has been published as a book, entitled "The Colorado Plateau III: Conservation of Resources through Integrating Research into Resources Management", by The University of Arizona Press. UA Press will be present and taking orders for the book at the 9th Biennial Conference.

CONFERENCE SCHEDULE

	Rooms			
Time	*BALLROOM*	*FREMONT*	*MEADOWS*	*AGASSIZ*
Tuesday Morning	**OFFICIAL INTRODUCTION** **Climate Change and Ecosystem Impacts I**	**CPCESU Facilitation of Cross-boundary Research and Management on the Colorado Plateau**	**Animal Ecology I**	
Tuesday Afternoon	**Climate Change and Ecosystem Impacts II**	**The Legacy and Future Visions of Conservation Biology on the Colorado Plateau**	**The Restoration of Fossil Creek: Result of Research and Monitoring**	
	ARD Atrium			
Tuesday Evening	**Poster Session at the Applied Research and Development Building, NAU**			
	BALLROOM	*FREMONT*	*MEADOWS*	*AGASSIZ*
Wednesday Morning	**Conservation, Management, and Planning**	**Tribal Lands of the Colorado Plateau: Scientific Assessment of Climate Change Impacts to Landscapes and Ecosystems**	**Ecosystems and Communities; Aquatic Resources**	**Using Native Plants in Ecological Restoration** **Native Plant Production and Seed Increase I**
Wednesday Afternoon	**Drought and Climate**	**Cave Research in the Western United States**	**Restoration and Preservation**	**Native Plant Production and Seed Increase II**
	MNA			
Wednesday Evening	**Social at the Museum of Northern Arizona**			
	BALLROOM	*FREMONT*	*MEADOWS*	*AGASSIZ*
Thursday Morning	**Forests and Fire Ecology**	**Animal Ecology II**	**Invasives**	**Restoration and Conservation at the Landscape Scale: The Kane 2 Mile Ranch Project**

PROGRAM SYNOPSIS

MONDAY, 29 October 2007

Side-Meetings

10:00 -12:30 Colorado Plateau All Taxa Biodiversity Inventory Program

1:30 – 5:30 Colorado Plateau All Taxa Biodiversity Inventory Program (Continued)

1:00 – 4:00 Developing Research Collaborations with Tribal Colleges

1:00 – 5:00 Cross Boundary Major Colorado Plateau Issue

7:00 – 9:00 Colorado Plateau Cooperative Ecosystem Studies Unit Mixer (by Invitation)

7:00 – 9:00 A River Reborn Documentary (Cline Library, NAU)

TUESDAY, 30 October 2007

8:00 – 8:15 **Official Introduction**

8:15 – 12:00 Climate Change and Ecosystem Impacts I **(Special Session)**

8:20 – 12:00 CPCESU Facilitation of Cross-boundary Research and Management on the Colorado Plateau **(Special Session)**

8:20 – 12:00 Animal Ecology I **(General Session)**

12:00 – 1:00 Lunch

1:00 – 5:00 Climate Change and Ecosystem Impacts II **(Special Session)**

1:00 – 4:40 The Legacy and Future Visions of Conservation Biology on the Colorado Plateau **(Special Session)**

1:20 – 4:40 The Restoration of Fossil Creek: Result of Research and Monitoring **(Special Session)**

5:00 – 6:00 Society of Conservation Biology Members Meeting – Applied Research and Development (Building 56) Large Pod

7:00 – 9:00 Poster Session – Applied Research and Development (Building 56) Atrium

PROGRAM SYNOPSIS (Continued)

WEDNESDAY, 31 October 2007

8:00 – 12:00	Conservation, Management, and Planning **(General Session)**
8:00 – 12:00	Tribal Lands of the Colorado Plateau: Scientific Assessment of Climate Change Impacts to Landscapes and Ecosystems **(Special Session)**
8:00 – 12:00	Ecosystems and Communities; Aquatic Resources **(General Session)**
8:00 -10:00	Using Native Plants in Ecological Restoration **(Special Session)**
10:20 -12:00	Native Plant Production and Seed Increase I **(Special Session)**
12:00 – 1:00	Lunch
1:00 – 4:40	Drought and Climate **(General Session)**
1:00 – 4:40	Cave Research in the Western United States **(Special Session)**
1:00 – 5:00	Restoration and Preservation **(General Session)**
1:00 – 2:00	Native Plant Production and Seed Increase II **(Special Session)**
2:00– 2:40	Native Plant Production and Seed Increase – Roundtable Discussion
3:00 – 5:00	Colorado Plateau Native Plant Initiative/Northern Arizona Native Seed Alliance Meeting
7:00 – 9:00	Mixer/ Social at the Museum of Northern Arizona

THURSDAY, 1 November 2007

8:00– 12:00	Forest and Fire Ecology **(General Session)**
8:00 – 12:00	Animal Ecology II **(General Session)**
8:00 – 12:00	Invasives **(General Session)**
8:00 – 12:00	Integrating Restoration and Conservation at the Landscape Scale: The Kane 2 Mile Ranch Project **(Special Session)**

SIDE MEETINGS – Monday October 29th

10:00 –12:30 Colorado Plateau All Taxa Biodiversity Inventory Program
Ecological Networks
AGASSIZ ROOM
Organizer: Neil Cobb

1:30 – 5:30 Colorado Plateau All Taxa Biodiversity Inventory Program (Continued)
Ecological Networks
AGASSIZ ROOM
Organizer: Neil Cobb

1:00 – 4:00 Developing Research Collaborations with Tribal Colleges
FREMONT ROOM
Organizer: Amy Whipple, Diana Anderson, Marnie Carroll and Barb Cline

1:00 – 5:00 Cross Boundary Major Colorado Plateau Issue
HUMPHREYS ROOM
Organizer: Dave Ostergren

7:00 – 9:00 Colorado Plateau Cooperative Ecosystem Studies Unit Mixer / Social
(by invitation only)

ZANE GREY BALLROOM at the Weatherford Hotel
in historic downtown Flagstaff (23 N. Leroux)
Organizers: Dave Ostergren and Ron Hiebert

7:00 – 9:00 A River Reborn Documentary

CLINE LIBRARY, Northern Arizona University

DETAILED SCHEDULE

Official Welcome & Introduction

Tuesday Morning 8:00-8:15 a.m.
BALLROOM

8:00-8:05	SCOTT DURST, *Biologist, USGS Southwest Biological Science Center* – Conference Chair Welcome
8:05-8:10	LAURA HUENNEKE, *Dean, College of Engineering and Natural Sciences* – Northern Arizona University Welcome
8:10-8:15	ANDREA ALPINE, *Center Director, Southwest Biological Science Center* – USGS Welcome

Climate Change and Ecosystem Impacts I

Tuesday Morning 8:20 a.m.-12:00 p.m.
BALLROOM
Moderator: Neil Cobb, *Merrian Powell Center for Environmental Research, Northern Arizona University and* Mark Miller, *USGS, Southwest Biological Science Center, Colorado Plateau Research Center*

8:15-8:20	INTRODUCTION, Ken Cole
8:20-8:40	SHIFTING LANDSCAPES IN MOUNTAIN ENVIRONMENTS: HOW CLIMATE CHANGE HAS INFLUENCED GLACIER NATIONAL PARK. **FAGRE**, DANIEL B.
8:40-9:00	CLIMATE MODELING AND PROJECTION IN SUPPORT OF SOCIETAL IMPACTS ASSESSMENTS **DUFFY**, PHILIP B.
9:00-9:20	FINE-SCALE PROCESSES REGULATE THE RESPONSE OF EXTREME EVENTS TO GLOBAL CLIMATE CHANGE. **DIFFENBAUGH**, NOAH S., Jeremy S. Pal, Robert J. Trapp and Filippo Giorgi
9:20-9:40	POTENTIAL IMPACTS OF CLIMATE CHANGE ON THE COLORADO PLATEAU. **NEILSON**, R.P., R. Drapek and J.M. Lenihan
9:40-10:00	SIMULATED VEGETATION RESPONSE TO FUTURE CLIMATE CHANGE IN THE WESTERN UNITED STATES. **SHAFER**, SARAH L. and Patrick J. Bartlein
10:00-10:20	BREAK
10:20-10:40	DOWNSCALED CLIMATE CHANGE PROJECTIONS FOR THE SOUTHERN COLORADO PLATEAU. **GARFIN**, GREGG M. and Jon K. Eischeid
10:40-11:00	VEGETATION CHANGE ON THE COLORADO PLATEAU FOLLOWING PAST CLIMATE WARMING EVENTS: AN ANALOG FOR THE PRESENT AND FUTURE. **COLE**, KENNETH L.

Climate Change and Ecosystem Impacts I - continued

11:00-11:20 EXPLORING MODELING APPROACHES FOR PREDICTING CLIMATE CHANGE IMPACTS ON DOMINANT PLANTS; EXTREMES VS. MEANS AND COMMUNITIES VS. SPECIES. **IRONSIDE**, KIRSTEN E., Kenneth L. Cole and Neil S. Cobb

11:20-11:40 MODELING THE IMPACTS OF CLIMATE CHANGE – CHANGES MADE IN A SPECIES SPECIFIC MODELING SYSTEM. **CHEW**, JIMMIE, Kirk Moeller and Kirsten Ironside

11:40-12:00 CONCEPTUAL MODELING OF CLIMATIC INFLUENCES ON UPPER-ELEVATION PLANT COMMUNITIES ON THE COLORADO PLATEAU. **VANKAT**, JOHN L.

CPCESU Facilitation of Cross-boundary Research and Management on the Colorado Plateau

Tuesday Morning 8:20 a.m.-12:00 p.m.
FREMONT
Moderator: Ron Hiebert, *National Park Service, Colorado Plateau Cooperative Ecosystem Studies Unit, Northern Arizona University*

8:20-8:40 WATERSHED RESTORATION ON THE COLORADO PLATEAU: A META-ANALYSIS OF PROJECTS AND EVALUATION PROCEEDURES. **HENN**, AVI, David M. Ostergren and Ron Hiebert

8:40-9:00 NATIVE PLANT RESTORATION ACTIVITIES ON THE COLORADO PLATEAU. **SMITH**, VERLIN and Ronald B. Bolander

9:00-9:20 DEVELOPMENT OF NATIVE PLANT MATERIALS FOR NATIONAL PARKS: AN INTERAGENCY PLANT MATERIALS PROGRAM. **HAAS**, RUSSELL J. and Sarah Wynn

9:20-9:40 RESTORATION IN THE NATIONAL PARK SERVICE; PROGRAMS, FUNDING, AND ASSESSMENT. **HIEBERT**, RON

9:40-10:00 RESTORATION OF TAMARIX-DOMINATED XERIC RIPARIAN AREAS. **BEAUCHAMP**, VANESSA B.

10:00-10:20 BREAK

10:20-10:40 STREAM RESTORATION ON THE COLORADO PLATEAU: CHALLENGES AND OPPORTUNITIES. **MOODY**, TOM O.

10:40-11:00 RIPARIAN RESTORATION WITHIN A CULTURAL LANDSCAPE AT HUBBELL TRADING POST NHS. **WORTHINGTON**, ANNE

11:00-12:00 PANEL DISCUSSION

Animal Ecology I

Tuesday Morning 8:20-11:40 a.m.
MEADOWS
Moderator: T. J. Fontaine, *USGS, Sonoran Desert Research Station, University of Arizona*

8:20-8:40 IMPORTANCE OF JUNIPER *(JUNIPERUS OSTEOSPERMA)* TO BIRDS NESTING IN PIÑON-JUNIPER WOODLANDS IN NORTHWEST NEW MEXICO. **FRANCIS**, CLINTON D., Catherine P. Ortega and John Hansen

8:40-9:00 EFFECTS OF GAS WELL COMPRESSOR NOISE ON NESTING BIRDS IN PIÑON-JUNIPER *(PINUS EDULIS-JUNIPERUS OSTEOSPERMA)* WOODLANDS OF RATTLESNAKE CANYON MANAGEMENT AREA (BLM) IN NORTHWEST NEW MEXICO. **ORTEGA**, CATHERINE P., Clinton D. Franacis, Ryan I. Kennedy, Peter J. Nylander, and John Hansen

9:00-9:20 SURVIVORSHIP ACROSS THE ANNUAL CYCLE OF A MIGRATORY PASSERINE: CONSERVATION IMPLICATIONS FOR THE WILLOW FLYCATCHER. **PAXTON**, EBEN H., Scott L. Durst, Mark K. Sogge and Thomas J. Koronkiewicz

9:20-9:40 IMPLICATIONS OF MICROCLIMATE ON NEST PREDATION OF THE SOUTHWESTERN WILLOW FLYCATCHER. **STUMPF**, KATIE J., Tad C. Theimer, Mary Anne McLeod and Tom J. Koronkiewiz

9:40-10:00 USING ECOSYSTEM PRODUCTION BUDGETS TO ASSESS RESOURCE LIMITATION OF NATIVE AND NON-NATIVE FISHES IN COLORADO RIVER, GRAND CANYON. **CROSS**, WYATT F., Colden V. Baxter, Robert O. Hall Jr., Theodore A. Kennedy, Scott Rogers, Emma J. Rosi-Marshall and Michael D. Yard

10:00-10:20 BREAK

10:20-10:40 YELLOW-BILLED CUCKOO DISTRIBUTION, BREEDING STATUS AND HABATAT USE ALONG THE LOWER COLORADO RIVER. **STEWART**, LAURA, R., Matthew J. Johnson, Christopher M. Calvo and Geoffrey Bland

10:40-11:00 PEREGRINE FALCON *(FALCO PEREGRINUS)* A SUMMERY OF NESTING / OCCUPANCY SURVEYS ON THE COLORADO PLATEAU 1991-2007 FOR THE NATIONAL PARK SERVICE AFTER THE PEREGRINES RECOVERY. **HETZLER**, BRENT C.

11:00-11:20 NEST SITE SELECTION OF THE COMMON BLACK-HAWK *(BUTEOGALLUS ANTHRACINUS):* CONSERVATION IMPLICATIONS. **ETZEL**, KENNETH E., Matthew Johnson and Thomas G. Whitham

11:20-11:40 A CASE STUDY WITH BIRDS AT PETRIFIED FOREST NATIONAL PARK: IMPLEMENTING RESOURCE MANAGEMENT DECISIONS FROM SCIENTIFIC FINDINGS. **VAN RIPER**, CHARLES III

Climate Change and Ecosystem Impacts II

Tuesday Afternoon 1:00-5:00 p.m.
BALLROOM
Moderator: Neil Cobb, *Merrian Powell Center for Environmental Research, Northern Arizona University and* Mark Miller, *USGS, Southwest Biological Science Center, Colorado Plateau Research Center*

1:00-1:20 CLIMATE CHANGE AND DUST: WHAT DOES THE FUTURE HOLD? **BELNAP**, JAYNE, Richard L. Reynolds, Jason C. Neff, Thomas H. Painter and Marith Reheis

1:20-1:40 RESPONSES OF COLORADO PLATEAU DRYLANDS TO CLIMATE CHANGE: VARIABILITY DUE TO LAND USE AND SOIL-GEOMORPHIC HETEROGENEITY. **MILLER**, MARK E. and Jayne Belnap

1:40-2:00 THE ROLE OF CLIMATE AND LAND USE IN PINYON PINE RECRUITMENT AND GROWTH. **BARGER**, NICHOLE, Henry Adams and Connie Woodhouse

2:00-2:20 DISSECTING THE CAUSES AND EFFECTS OF A CLIMATE-INDUCED REGIONAL-SCALE TREE MORTALITY EVENT. **WHITE**, AMANDA B., Donatella Pasqualini, Paul M. Rich and David D. Breshears

2:20-2:40 CARBON DIOXIDE AND ENERGY EXCHANGE IN DISTURBED SOUTHWESTERN PONDEROSA PINE FORESTS. **KOLB**, THOMAS E., Sabina Dore, Mario Montes-Helu, Benjamin W. Sullivan, Wesley W. Winslow, Steve C. Hart, Jason P. Kaye, George W. Koch and Bruce A. Hungate

2:40-3:00 BREAK

3:00-3:20 SIGNATURES OF VEGETATION CHANGE IN A STRATEGIC INVENTORY AND MONITORING SYSTEM. **SHAW**, JOHN D.

3:20-3:40 INSTITUTING THE HYDROCLIMATIC INDEX IN MONITORING DROUGHT ACROSS THE COLORADO RIVER BASIN. **ELLIS**, ANDREW W.

3:40-4:00 WHAT'S DYING IN SOUTHERN CALIFORNIA'S MOUNTAINS: REPEAT SURVEYS AND MICROMETEOROLOGICAL MEASUREMENTS ALONG AN ELEVATION GRADIENT. **GOULDEN**, MICHAEL L., Anne Kelly, Gregory Winston and Aaron Fellows

4:00-4:20 CLIMATE-RELATED TRENDS IN NORTHERN NEW MEXICO ECOSYSTEMS: LONG-TERM MONITORING, THRESHOLD EFFECTS, AND DISTURBANCE INTERACTIONS. **ALLEN**, CRAIG D., Kay L. Beeley and Rebecca Oertel

4:20-4:40 A CLIMATE CHANGE VULNERABILITY ASSESSMENT FOR BIODIVERSITY IN NEW MEXICO: RECENT CLIMATE DEPARTURES & CONSERVATION IMPLICATIONS. **ENQUIST,** CAROLYN A.F.

4:40-5:00 A CURRENT PERSPECTIVE ON OUR DEVELOPING UNDERSTANDING OF DROUGHT-INDUCED DIE-OFF AND ITS CONSEQUENCES. **BRESHEARS**, DAVID D.

The Legacy and Future Visions of Conservation Biology on the Colorado Plateau

Tuesday Afternoon 1:00-5:00 p.m.
FREMONT
Moderator: Tad Theimer, *Department of Biology, Northern Arizona University and* Matthew Johnson, *USGS, Southwest Biological Science Center, Colorado Plateau Research Center*

1:00-2:40 PANEL DISCUSSION: To begin, we will educate ourselves on historical conservation efforts across the Plateau, addressing what strategies have forwarded or hindered the protection of structural, compositional, and functional biodiversity. Panel Members: Jan Balsom, Paul Beier, Jim Catlin and Charles van Riper III

2:40-3:00 BREAK

3:00-5:00 PANEL DISCUSSION: In this session we will travel forward in time to develop visions of a future for conservation biology within the context of challenges such as a changing climate, and shifting human demands for natural resources. Special emphasis will be paid to "the passing of the torch", as seminal thinkers in the field help us explore what skills the future leaders of conservation on the Plateau will require to face these challenges. Panel Members: Ethan Aumack, Jayne Belnap, Tom Fleischner, Ed Grumbine and Dave Mattson

The Restoration of Fossil Creek: Result of Research and Monitoring

Tuesday Afternoon 1:20-4:40 p.m.
MEADOWS
Moderator: Jane Marks, *Department of Biology, Northern Arizona University*

1:20-1:40 NATIVE FISH POPULATION INCREASE FOLLOWING FLOW RESTORATION AND EXOTIC FISH REMOVAL IN FOSSIL CREEK, ARIZONA. O'Neill, Matthew W., CINNAMON M. **PACE**, G. Allen Haden and Jane C. Marks

1:40-2:00 NATIVE FISH REBOUND IN FOSSIL CREEK. **STEFFERUD**, SALLY E., Jerome A. Stefferud, Paul C. Marsh and Robert W. Clarkson

2:00-2:20 STOCKING THREATENED AND ENDANGERED NATIVE FISHES INTO FOSSIL CREEK. **CARTER**, CODEY

2:20-2:40 TRACKING THE VERTICAL GROWTH OF TRAVERTINE DAMS FOLLOWING THE RESTORATION OF FLOW TO FOSSIL CREEK, ARIZONA. **FULLER**, BRIAN M., Leonard S. Sklar, Zacchaeus G. Compson, Kenneth J. Adams and Jane C. Marks

2:40-3:00 BREAK

3:00-3:20 DEVELOPMENT OF A COLLABORATIVE RESEARCH MODEL TO FACILITATE INTERDISCIPLINARY RESEARCH ON DAM DECOMMISSIONING PROJECTS. Schott, Nathan D. and RODERIC A. **PARNELL**

The Restoration of Fossil Creek: Result of Research and Monitoring - continued

3:40-4:00 IMPLEMENTATION OF AN ADAPTIVE MANAGEMENT STRATEGY FOR SPECIAL STATUS SPECIES: LOWLAND LEOPARD FROGS IN FOSSIL CREEK. **HEDWALL**, SHAULA J., Janie Agyagos, Cecelia Overby and Susan MacVean

4:00-4:20 FOSSIL CREEK: FOSTERING STEWARDSHIP AND ENGAGING LOCAL RESIDENTS AS PARTNERS. **HANCOCK**, PAUL and Marty Lee

4:20-4:40 TRAVERTINE DAMS INCREASE PRODUCTIVITY AND NUTRIENT RETENTION: IMPLICATIONS FOR RIVER RECOVERY. **MARKS**, JANE, Leonard Sklar, Cathy Gibson and Jeff Muehlbauer

Poster Session

Tuesday Evening 7:00-9:00 p.m.
APPLIED RESEARCH AND DEVELOPMENT ATRIUM, NAU Posters are listed in order of their location.
(Posters will be available for viewing in the Ballroom at the duBois Center on Wednesday and Thursday of the conference)

1 BIOSPHERE 2: TESTING THE INFLUENCE OF GLOBAL CHANGE DYNAMICS ON KEY INTERACTIONS BETWEEN PLANTS AND WATER. **ADAMS**, HENRY D., Juan C. Villegas, David D. Breshears, Maite Guardiola-Claramonte', Chris B. Zou, Greg A. Barron-Gafford, Travis E. Huxman

2 REPRESENTATIVENESS OF THE OLDEST PERMANENT PLOTS IN NORTHERN ARIZONA PONDEROSA PINE FORESTS. Bell, David M., PABLO F. **PARYSOW**, Margaret M. Moore

3 HISTORICAL STEM-MAPPED PERMANENT PLOTS INCREASE PRECISION OF RECONSTRUCTED REFERENCE CONDITIONS IN PONDEROSA PINE FORESTS OF NORTHERN ARIZONA. Sánchez Meador, Andrew J., PABLO F. **PARYSOW**, Margaret M. Moore

4 FIRE REHABILITATION EFFECTS ON BIRDS AND HABITAT IN A BURNED PINYON-JUNIPER WOODLAND. **CLEMENTS**, AMANDA, Kelly Hutton

5 DECLINE OF NORTHERN LEOPARD FROGS IN NORTHERN ARIZONA. **DROST**, CHARLES A., Lisa Gelczis, Karen E. Mock, Michael J. Sredl, Susan R. MacVean, Tad Theimer

6 FACTORS INFLUENCING EXOTIC SPECIES RICHNESS AND ABUNDANCE WITHIN PONDEROSA PINE FORESTS NEAR FLAGSTAFF, ARIZONA. **ENGEL**, E. CAYENNE, Scott R. Abella

7 INCORPORATING GENETIC DIVERSITY INTO RIPARIAN RESTORATION: THE IMPORTANCE OF MERGING RESTORATION WITH LANDSCAPE LEVEL EXPERIMENTS. **FERRIER**, SHARON M., Randy K. Bangert, Gerard J. Allan, Laura E. Hagenauer, Karla Kennedy, Carri Leroy, Dylan Fischer, Eric Lonsdorf, Tom G. Whitham

8 BUNCHGRASS TRANSPLANTS FOR SOUTHWESTERN PONDEROSA PINE UNDERSTORY COMMUNITIES. **FOWLER**, JAMES F., Carolyn Hull Sieg

9 EFFECTIVENESS OF LITTER REMOVAL IN PREVENTING MORTALITY OF YELLOW BARKED PONDEROSA PINE IN NORTHERN ARIZONA. **FOWLER**, JAMES F., Carolyn Hull Sieg, Linda Wadleigh, Sally Haase

10 EFFECTS OF SPACING AND IRRIGATION ON SEED PRODUCTION OF NATIVE PERENNIALS. **GODIN**, RON, Steve Monsen, Kim Schultz

11 VEHICLES IN STREAMS: EFFECTS OF DRIVING THROUGH POOLS ON *BUFO WOODHOUSII* (WOODHOUSE TOAD) EGG SURVIVAL. **GRAHAM**, TIM B.

12 DEVELOPMENT OF NATIVE PLANT MATERIALS FOR NATIONAL PARKS: AN INTERAGENCY PLANT MATERIALS PROGRAM. **HAAS**, RUSSELL J., Sarah Wynn

13 CONSERVATION AND RESTORATION RESEARCH AT THE ARBORETUM AT FLAGSTAFF. Haskins, Kristin E., SHEILA **MURRAY**

Poster Session - continued

14 ORAIBI WASH ARROYO CUTTING — THE ROLE OF CLIMATE VARIABILITY AND EFFECTS ON CULTURE. **HEREFORD**, RICHARD, Sharon Masek Lopez

15 PEREGRINE FALCON (*FALCO PEREGRINUS*) A METHOD OF USING DIGITAL RECORDING EQUIPMENT AND VIDEO CAMERAS FOR EARLY CONFIRMATION OF EYRIE LOCATIONS AND TO RELIEVE LONG OBSERVATIONS BY OBSERVERS. **HETZLER**, BRENT C.

16 IMPLICATIONS OF EPISODIC DEFOLIATION OF TAMARISK BY THE SALTCEDAR LEAF BEETLE ON THE COLORADO PLATEAU. **HULTINE**, KEVIN R., Pamela L. Nagler, Jason B. West, James R. Ehleringer

17 DOES RIPARIAN VEGETATION INFLUENCE TAMARISK ESTABLISHMENT? **JOHNSON**, TYLER D., Kolb, Tom E., Medina, Alvin L.

18 TREE MORTALITY FOLLOWING THE EXTREME 2002 DROUGHT AT THE PONDEROSA PINE/PINYON-JUNIPER ECOTONE IN NORTHERN ARIZONA: BIOTIC AND ABIOTIC INFLUENCES. **KOEPKE**, DAN F., Thomas E. Kolb

19 TASSEL-EARED SQUIRREL USE OF RESTORATION TREATED FOREST MOSAICS. **LOBERGER**, CHAD D., Catherine S. Wightman

20 EVALUATION OF THINNING TECHNIQUES IN A PINYON-JUNIPER ENCROACHED SHRUBLAND. **MATCHETT**, J. R., Matt Brooks, Curt Deuser, Helen Smith

21 A COMPARATIVE STUDY OF PLANT NICHES AT ZION NATIONAL PARK. **OTT**, JEFFREY E.

22 COMPARING TRAPPING METHODS FOR SAMPLING BEETLE DIVERSITY AND MONITORING EFFECTS OF OFF-ROAD VEHICLES IN SALT CREEK CANYON, CANYONLANDS NATIONAL PARK, UT. **PECH**, LOUIS L. Tim B. Graham

23 VARIATION IN NEAR-GROUND SOLAR RADIATION AS A FUNCTION OF TREE COVER: A PRELIMINARY ASSESSMENT ALONG A WOODLAND GRADIENT. **ROYER**, PATRICK D., David D. Breshears, Chris B. Zou, Neil S. Cobb

24 IDENTIFICATION AND CHARACTERIZATION OF ARIZONA HERITAGE WATERS. Springer, Abe, Lawrence Stevens, Robert Glennon, Gary Paul Nabhan, Carl Olson, Laura Monti, Everett Shock, JANET C. **LYNN**, Catherine Woodwell

25 A NEW COLORADO PLATEAU RIPARIAN HEALTH ASSESSMENT METHOD: THE *RAPID STREAM-RIPARIAN ASSESSMENT* (RSRA) PROTOCOL. **STACEY**, PETER B., Taylor Jones, Allison Jones

26 EFFECTS OF ECOLOGICAL RESTORATION TREATMENTS ON THE HOME RANGE SIZES OF TASSEL-EARED SQUIRRELS *(SCIURUS ABERTI)* WITHIN THE WILDLAND URBAN INTERFACE SURROUNDING FLAGSTAFF, ARIZONA. **STEFFEN**, NIKI, Kristen Pearson, Catherine Wightman, Chad Loberger

27 POTENTIAL SPREAD OF A NON-NATIVE BARK BEETLE: ECOLOGICAL AND ECONOMIC CONSEQUENCES. **WARING**, KRISTEN M., Danielle M. Reboletti, Lauren A. Mork, Richard Hofstetter, Amanda M. Garcia, Peter Z. Fulé, T.S. Davis

28 THE EFFECTS OF GRAZING REGIME ON THE ABUNDANCE OF NATIVE WILLOW SPECIES. **WATKINS**, SENSA L., Cynthia E. Dott, Ben D. Wolcott

29 CLIMATE AND PHENOLOGY DURING THE 1950S AND 2000S DROUGHTS IN THE SOUTHWESTERN U.S.A. **WEISS**, JEREMY L. Jonathan T. Overpeck

30 CULTURAL RESOURCES PRESERVATION USING HYDROLOGIC MONITORING AND GIS AT AZTEC RUINS NATIONAL MONUMENT, NEW MEXICO. **WHITE**, W. SCOTT, Heather J. Hormell, Colleen Filippone, Larry Martin

31 WESTERN BLUEBIRDS COMPENSATE FOR INFLATED ECTOPARASITE INFESTATIONS IN A RESTORATION-TREATED FOREST. **WIGHTMAN**, CATHERINE S., Maria L. Wessel

32 THE SECRET LIFE OF A VELVET ANT (HYMENOPTERA: MUTILLIDAE): CRYPTIC PATTERNS OF DIVERSITY ON THE COLORADO PLATEAU. **WILSON**, JOSEPH S., James P. Pitts

33 IS INVASIVE SPECIES ABUNDANCE AFFECTED BY GRAZING INTENSITY? **WOLCOTT**, BEN D., Cynthia E. Dott, Sensa L. Watkins

34 TEMPORAL RESPONSES OF MULE DEER TO PONDEROSA PINE FOREST RESTORATION TREATMENTS. **YARBOROUGH**, R. FENNER, Catherine S. Wightman, Steven S. Rosenstock

35 EFFECTS OF TOPOGRAPHY AND WOODY PLANT CANOPY COVER ON NEAR-GROUND SOLAR RADIATION: IMPLICATIONS FOR VEGETATION GRADIENTS AND DYNAMICS ON THE COLORADO PLATEAU. **ZOU**, CHRIS B., Greg A. Barron-Gafford, David D. Breshears

Conservation, Management, and Planning

Wednesday Morning 8:00 a.m.-12:00 p.m.
BALLROOM
Moderator: Charles van Riper III, *USGS, Southwest Biological Science Center, Sonoran Desert Research Station*

8:00-8:20 PRACTICAL ASPECTS AND IMPLICATIONS OF SELECTING SITES FOR LONG-TERM MONITORING OF SOILS AND VEGETATION AT NATIONAL PARKS. **LAUVER**, CHRIS, Jodi Norris, Lisa Thomas and Jim DeCoster

8:20-8:40 MAPPING ECOLOGICAL SITES FOR LONG-TERM MONITORING IN NATIONAL PARKS. **GARMAN**, STEVEN L., Dana Witwicki and Aneth Wight

8:40-9:00 RESULTS AND MANAGEMENT IMPLICATIONS FROM WATER QUALITY MONITORING IN NORTHERN COLORADO PLATEAU PARKS. **THOMA**, DAVID and Dustin Perkins

9:00-9:20 TREE-RING SAMPLING OF HISTORIC NATIVE AMERICAN WOODEN STRUCTURES, GRAND CANYON NATIONAL PARK, AZ. **HOUGH**, IAN and Tom Windes

9:20-9:40 50 YEARS OF SCIENTIFIC RESEARCH PERMITTING AT GRAND CANYON NATIONAL PARK: WHAT HAVE WE LEARNED? **BENENATI**, EMMA and Diana Pennington

9:40-10:00 FINDING GAPS IN THE PROTECTED AREA NETWORK IN THE COLORADO PLATEAU: A CASE STUDY USING VASCULAR PLANT TAXA IN UTAH. **FERTIG**, WALTER F.

10:00-10:20 BREAK

10:20-10:40 BUILDING AGREEMENT ON AND ESTIMATING THE SUPPLY OF RESTORATION-BASED SOURCES OF SMALL DIAMETER WOOD IN NORTHERN ARIZONA. **HAMPTON**, HAYDEE, M., Steven E. Sesnie, Brett G. Dickson, Jill M. Rundall, Gary B. Snider, John D. Bailey, Thomas D. Sisk

10:40-11:00 DESIGN, LOCATION AND TRAFFIC VOLUME: A CONCEPTUAL MODEL OF HIGHWAY EFFECTS ON WILDLIFE. Gagon J., N. Dodd and T. **THEIMER**

11:00-11:20 FIELD-TO-DESKTOP: BUILDING WIRELESS CYBERINFRASTRUCTURE FOR ENVIRONMENTAL MONITORING. **YAMAMOTO**, KENJI, Yuxin He, Paul Heinrich, Alex Orange, Bill Ruggeri, Holland Wilberger and Paul Flikkema

11:20-11:40 THE CHALLENGE OF BUILDING NEW CITIES IN MOHAVE COUNTY WITHOUT A RENEWABLE WATER RESOURCE. **DAVIDSON**, KEVIN A.

11:40-12:00 REDEFINING THE WILDLAND-URBAN INTERFACE AS AN ECOLOGICAL CONCEPT. **DRUM,** RYAN G., Tom Sisk, John Prather and Greg Aplet

Tribal Lands of the Colorado Plateau: Scientific Assessment of Climate Change Impacts to Landscapes and Ecosystems

Wednesday Morning 8:00 a.m.-12:00 p.m.
FREMONT
Moderator: Diana Anderson, *Environmental Sciences, Northern Arizona University*

8:00-9:00	HUMAN-ENVIRONMENT INTERACTION ON THE SOUTHERN COLORADO PLATEAU DURING THE LAST TWO MILLENNIA. **DEAN**, JEFF
9:00-10:00	PROJECTED CLIMATE CHANGES AND THEIR POTENTIAL IMPACTS ON NATIVE AMERICAN LANDS OF THE SOUTHERN COLORADO PLATEAU. **GARFIN**, GREGG M., Rachael Novak and Jeremy Weiss
10:00-10:20	BREAK
10:20-10:40	LISTENING TO THE LAND: GEOARCHAEOLOGICAL RESEARCH ON THE NAVAJO NATION. **ANDERSON,** KIRK C.
10:40-11:00	IMPACTS OF CLIMATE CHANGE AND LAND USE ON THE NAVAJO NATION IN THE SOUTHWESTERN UNITED STATES. **HIZA REDSTEER**, MARGARET
11:00-11:20	CLIMATE CHANGE AND VARIABILITY ON THE DEFIANCE PLATEAU: IMPACTS AND THE INTERSECTIONS OF WESTERN SCIENCE AND TRADITIONAL KNOWLEDGE. **NOVAK**, RACHAEL
11:20-11:40	SPATIAL DISTRIBUTION OF PRECIPITATION ON THE NAVAJO NATION AND GAUGE DENSITY. **SELOVER**, NANCY J.
11:40-12:00	THE STATE OF STREAM FLOW MEASUREMENT, DATA QUALITY AND ADEQUACY IN THE NAVAJO NATION. **TECLE**, AREGAI, Greg Garfin, Michael Crimmins, Nancy Selover, Andrew Ellis, Diana Anderson, Neil Cobb, Paul Heinrick, Elisabeth Alden, John Leeper, Jolene Tallsalt-Robertson and Teresa Showa

Ecosystems and Communities; Aquatic Resources

Wednesday Morning 8:00 - 10:00 a.m.
MEADOWS
Moderator: John Hamill, *USGS, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center*

8:00-8:20	COVARIANCE BETWEEN ECOSYSTEM PROCESSES AND SOIL MICROBIAL COMMUNITY STRUCTURE ALONG THREE MILLION YEARS OF ECOSYSTEM DEVELOPMENT IN NORTHERN ARIZONA. **HART**, STEPHEN C., Gregory S. Newman, Paul C. Selmants, Karen L. Adair, Egbert Schwartz, Kristin Haskins, and Andrew Kowler
8:20-8:40	N MINERALIZATION INCREASES MICROBIAL 15N ENRICHMENT IN INCUBATED GRASSLAND SOILS. **LAVIOLETTE**, CORINNE M., Paul Dijkstra, Stephen C. Hart, Egbert Schwartz, Richard R. Doucett and Bruce A. Hungate

Ecosystems and Communities: Aquatic Resources - continued

8:40-9:00 DIFFERENT COTTONWOOD GENOTYPES SUPPORT DIFFERENT ABOVEGROUND FUNGAL COMMUNITIES. **LAMIT**, L.J., C.A. Gehring, S.C. Wooley, C.M. Sthultz, N. Lojewski, R.L. Lindroth and T.G. Whitham

9:00-9:20 DIFFERENT AGED STANDS INCREASE LANDSCAPE HETEROGENEITY AND SUPPORT GREATER BIODIVERSITY. **HAGENAUER**, LAURA E. and Thomas G. Whitham

9:20-9:40 COMMUNITY STRUCTURE OF FLIES IN THE GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT: DIFFERENCES IN OCCURRENCE AND ABUNDANCE AT TWO SITES, SPRING 2000 AND SPRING 2005. **GRAHAM**, TIM B. and Sarah J. Foltz

9:40-10:00 ALLOCHTHONOUS ORGANIC MATTER FROM TRIBUTARY FLOODS DOMINATES ORGANIC MATTER INPUTS OF THE COLORADO RIVER IN GRAND CANYON. **KENNEDY**, THEODORE A., Emma Rosi-Marshall, Robert O. Hall Jr., Wyatt Cross, Barbara Ralston

10:00-10:20 BREAK

Using Native Plants in Ecological Restoration

Wednesday Morning 8:00 - 10:00 a.m.
AGASSIZ
Moderator: Janet Lynn, *Ecological Monitoring & Assessment Program & Foundation, Northern Arizona University*

8:00-8:20 A SYSTEMATIC REVIEW OF SPECIES SELECTION AND TREATMENT EFFECTIVENESS FOR REVEGETATION IN THE MOJAVE DESERT, USA. **ABELLA**, SCOTT R. and Alice C. Newton

8:20-8:40 SPECIES SELECTION AND THE OUTCOME OF A 28-SPECIES REVEGETATION SEEDING ON A SONORAN DESERT BURN. **GUNN**, JOHN, Scott R. Abella , Mark L. Daniels, Judith D. Springer and Susan E. Nyoka

8:40-9:00 A REGIONAL PERSPECTIVE ON REHABILITATING BURNED DESERT TORTOISE HABITAT IN THE MOJAVE DESERT. **SCOLES**, SARA, Lesley DeFalco, Kathleen Harcksen, Christina Lund, Karen Prentice, Aaron Wilkerson, Todd Esque

9:00-9:20 AN OVERVIEW OF GYPSIFEROUS SOILS RESEARCH AND RESTORATION AT LAKE MEAD NATIONAL RECREATION AREA. **NEWTON**, A.C. and E. Cayenne Engel

9:20-9:40 POST FIRE REFORESTATION EFFORTS ON LANDS OF WHITE MOUNTAIN APACHE TRIBE. **KESSAY**, DANIEL

9:40-10:00 TO SEED OR NOT TO SEED? DISCUSSION ON RECENT WHITE MOUNTAIN APACHE TRIBAL BAER REVEGATION PROJECTS. **STUEVER**, MARY

10:00-10:20 BREAK

Native Plant Production and Seed Increase I

Wednesday Morning 10:20 a.m.- 12:00 p.m.
AGASSIZ
Moderator: Janet Lynn, *Ecological Monitoring & Assessment Program & Foundation, Northern Arizona University*

10:20-11:20 FACTORS TO CONSIDER IN THE DEVELOPMENT AND MANAGEMENT OF REGIONAL NATIVE PLANT PROGRAMS AND NATIVE PLANT PRODUCTION FROM SEED COLLECTION TO COMMERCIAL PRODUCTION. **MONSEN**, STEPHEN B. and Kelly Memmot

11:20-11:40 NATIVE PLANT MATERIALS AND RESTORATION TECHNOLOGY FOR THE GREAT BASIN. **JENSEN**, SCOTT and Nancy Shaw

11:40-12:00 BUREAU OF LAND MANAGMENT NATIVE SEED AND PLANT PROGRAM AND THE COLORADO PLATEAU. **LAMBERT**, SCOTT M.

Drought and Climate

Wednesday Afternoon 1:00-4:40 p.m.
BALLROOM
Moderator: Ken Cole, *USGS, Southwest Biological Science Center, Colorado Plateau Research Station*

1:00-1:20 CLIMATIC CHANGE TREATMENTS ALTER SOIL CO2, CH4, & N2O FLUXES IN MULTIPLE ECOSYSTEMS. **BROWN**, JAMIE R., Paul Dijkstra and Bruce A. Hungate

1:20-1:40 RUINS PRESERVATION STRATEGIES AT FLAGSTAFF AREA NATIONAL MONUMENTS: CONTENDING WITH FUTURE CLIMATE CHANGE. **STARK**, J.T., Lisa Baldwin, Jessica Bland and Walter Gosart

1:40-2:00 LAND SURFACE ALBEDO CHANGES OVER A FIRE CHRONOSEQUENCE IN PONDEROSA PINE FORESTS: IMPLICATIONS FOR CLIMATIC FEEDBACKS. **JONES**, KYLE, Isaac Bickford, Bruce Hungate and George Koch

2:00-2:20 A PALEOCLIMATIC RECORD 2600 TO 950 CAL YRS B.P. FROM LITTLE GREEN VALLEY, CENTRAL ARIZONA. **SMITH**, SUSAN J., R. Scott Anderson and Sarah Herr

2:20-2:40 IMPACT OF THE NORTHERN ANNULAR MODE ON COOL SEASON CLIMATE PATTERNS IN THE SOUTHWEST. **MCAFEE**, STEPHANIE and Joellen Russell

2:40-3:00 BREAK

3:00-3:20 PATTERNS OF DROUGHT INDUCED TREE MORTALITY IN PINYON-JUNIPER WOODLANDS. **CLIFFORD**, MICHAEL J., Neil S. Cobb and Paulette L. Ford

3:20-3:40 VEGETATION CHARACTERISTICS UNDER THREE TREE TYPES WITHIN PINYON-JUNIPER WOODLANDS EFFECTED BY DROUGHT RELATED MORTALITY. **VESPI**, JESSICA A., Michael J. Clifford and Neil S. Cobb

3:40-4:00 THE IMPACT OF PINYON MORTALITY ON GROUND-DWELLING ARTHROPODS. **DELPH**, ROBERT J., Michael J. Clifford, Neil S. Cobb and Paulette Ford

4:00-4:20 CHANGES IN PRECIPITATION AND RUNOFF IN THE CHEVELON CREEK WATERSHED OF ARIZONA. **HOENIG**, MICHAEL and Aregai Tecle

Cave Research in the Western United States

Wednesday Afternoon 1:00-4:40 p.m.
FREMONT
Moderator: J. Judson Wynne, *USGS Southwest Biological Science Center, Colorado Plateau Research Station, Northern Arizona University*

1:00-1:20 DIFFERENTIATING KARSTS FROM PSEUDOKARSTS IN THE AMERICAN SOUTHWEST. **HALLIDAY**, WILLIAM R.

1:20-1:40 FOSSIL SALAMANDERS AND THE CAVE PALEONTOLOGY OF SEQUOIA NATIONAL PARK CAVES. **SCHAAF**, LISA N, Jim I Mead and Joel Despain

1:40-2:00 A COMPARISON OF CAVE-DWELLING INVERTEBRATE COMMUNITIES FROM THE NORTH RIM AND THE INTERIOR GRAND CANYON. **WYNNE**, J. JUDSON

2:00-2:20 VERTEBRATE SPECIES IN DESERT CAVES AND MINES – A COMPARISON BETWEEN THE CHIHUAHUAN AND SONORAN DESERTS. **STRONG**, THOMAS R.

2:20-2:40 PRELIMINARY RESULTS OF A CAVE BIOINVENTORY AT GREAT BASIN NATIONAL PARK. **TAYLOR**, STEVEN J., Jean K. Krejca and Michael E. Slay

2:40-3:00 BREAK

3:00-3:20 ASSESSING BIOLOGICAL RESOURCES OF CAVES IN LAVA BEDS NATIONAL MONUMENT, CALIFORNIA. **TAYLOR**, STEVEN J., Jean K. Krejca, and JoAnn Jacoby

3:20-3:40 UPDATE ON THE SYSTEMATIC INVENTORY AND SURVEY OF THE CAVES IN GRAND CANYON – PARASHANT NATIONAL MONUMENT, ARIZONA. **VOYLES**, KYLE D. and J. Judson Wynne

3:40-4:00 INEXPENSIVE LINEAMENT ANALYSIS FOR DISCOVERING INGRESS NEXUS (ILADIN). **MCDONOUGH**, FRANK

4:00-4:20 THERMAL BEHAVIOR OF SOUTHWESTERN U.S. CAVES AND PIT CRATERS ON ARSIA MONS, MARS. **WYNNE**, J. JUDSON, Glen E. Cushing, Timothy N. Titus, Charles A. Drost, Rickard S. Toomey III, Murzy Jhabvala, Penelope J. Boston, Knutt Peterson and Russell Harter

4:20-4:40 DIFFERENTIATING SKYLIGHTS OF INTERPLANETARY LAVA TUBE CAVES FROM NON-TARGET SITES FOR EXPLORATION. **WYNNE**, J. JUDSON and William R. Halliday

Restoration and Preservation

Wednesday Afternoon 1:00-5:00 p.m.
MEADOWS
Moderator: Gary Deason, *Center for Sustainable Environments, Northern Arizona University*

1:00-1:20 RESTORATION ECOLOGY IN THE AGE OF GENETIC INFORMATION: USING GENETIC TOOLS TO GUIDE RESTORATION SUCCESS. **ALLAN**, GERARD J., Randy K. Bangert, Sharon M. Ferrier and Thomas G. Whitham

1:20-1:40 TESTING REVEGETATION METHODS FOLLOWING EXOTIC GRASS REMOVAL TO IMPROVE RESTORATION PLANNING AT ZION NATIONAL PARK. **DELA CRUZ**, MICHELLE P., Cheryl Decker, Ron Hiebert and Tom Sisk

1:40-2:00 REVISITING TRENDS IN VEGETATION RECOVERY FOLLOWING PROTECTION FROM GRAZING, CHACO CULTURE NATIONAL HISTORIC PARK (CCNHP). **FLOYD**, M. LISA, David D. Hanna, Thomas L. Fleischner and Brad Shattuck

2:00-2:20 RIPARIAN VEGETATION RESPONSES TO UNGULATE GRAZING IN SEMI-PERMANET WETLANDS: THE SCIENCE BEHIND CURRENT GRAZING MANAGEMENT IN NORTHERN ARIZONA. **VESPI**, JESSICA A., Thomas Sisk, Richard Miller, Mike Hanneman and Jacquline Vaughn

2:20-2:40 USING A RAPID FUNCTIONAL CONDITION ASSESSMENT PROTOCOL (RSRA) TO HELP ENCOURAGE COMMUNITY INVOLVEMENT IN THE CONSERVATION AND RESTORATION OF STREAM-RIPARIAN ECOSYSTEMS IN THE AMERICAN SOUTHWEST. **STACEY**, PETER B., Allison Jones, James E. Catlin and Mary O'Brien

2:40-3:00 BREAK

3:00-3:20 USING ORAL HISTORIES TO DOCUMENT ENVIRONMENTAL CHANGE IN NORTHERN ARIZONA. **FRIEDERICI**, PETER G., Michele A. James and George W. Lubick

3:20-3:40 STATUS OF TWO G2 ENDEMIC PLANTS ON THE KAIBAB PLATEAU, ARIZONA. **SPENCE**, JOHN R.

3:40-4:00 GENETIC DIVERSITY OF HISTORIC APPLE TREES ON THE COLORADO PLATEAU AND IMPLICATIONS FOR THEIR PRESERVATION. **ROUTSON**, KANIN and Gary Paul Nabhan

4:00-4:20 IDENTIFICATION AND CHARACTERIZATION OF ARIZONA HERITAGE WATERS. Springer, Abe, Lawrence Stevens, Robert Glennon, Gary Paul Nabhan, Carl Olson, Laura Monti, Everett Shock, Janet C. Lynn, CATHERINE **WOODWELL**

4:20-4:40 WILDERNESS AREAS AND FIRE RESTORATION: PUBLIC PERCEPTIONS AND PREFERENCES FOR WILDERNESS MANAGEMENT. **OSTERGREN**, DAVID and Megan Triplett

4:40-5:00 STEALING OR "JUST LOOKING:" CONCLUSIONS ON VISITOR AND RESOURCE INCIDENCE AT PETRIFIED FOREST NATIONAL PARK, ARIZONA. **HOSPODARSKY**, DENVER, Martha E. Lee and Kathleen McBride

Native Plant Production and Seed Increase II

Wednesday Afternoon 1:00-5:00 p.m.
AGASSIZ
Moderator: Janet Lynn, *Ecological Monitoring & Assessment Program & Foundation, Northern Arizona University*

1:00-1:20	THE NORTHERN ARIZONA NATIVE SEED ALLIANCE: WORKING TOWARDS A SUSTAINABLE MARKET. **LYNN**, JANET A.
1:20-1:40	THE UNCOMPAHGRE PLATEAU PROJECT – RESTORATION AND COLLABORATION IN WESTERN COLORADO. **MOTLEY**, PAM
1:40-2:00	TREES FOR THE RIM. **BLAKE**, BRAD
2:00-2:40	ROUNDTABLE DISCUSSION
2:40-3:00	BREAK
3:00-5:00	COLORADO PLATEAU NATIVE PLANT INITIATIVE/NORTHERN ARIZONA NATIVE SEED ALLIANCE MEETING

Social at the Museum of Northern Arizona (handout available with map & directions)

Wednesday Evening 7:00-9:00 p.m.

Forests and Fire Ecology

Thursday Morning 8:00 a.m.-12:00 p.m.
BALLROOM
Moderator: Bill Block, *US Forest Service, Rocky Mountain Research Station, Northern Arizona University*

8:00-8:20	FEMALE ELK *(CERVUS ELAPHUS)* HABITAT USE AFTER THE CATSATROPHIC RODEO CHEDESKI FIRE IN NORTHEAST ARIZONA. **BRISTOW**, KIRBY D. and Stan C. Cunningham
8:20-8:40	BRINS FIRE: ONE YEAR POST WILDFIRE, AQUATIC COMMUNITY RESPONSE IN OAK CREEK, AZ. **BERN**, MITCHELL D., Emma L. Benenati and Joseph P. Shannon
8:40-9:00	SUSTAINED EFFECT OF A WILDFIRE ON STREAM BENTHOS; KANAB CREEK, GRAND CANYON NATIONAL PARK. **BENENATI**, EMMA L., Nichols Ballew, Talise Dow and Joseph Shannon
9:00-9:20	RESPONSE OF HERPETOFAUNA TO PONDEROSA PINE FOREST TREATMENTS PRESCRIBED BY THE NATIONAL FIRE AND FIRE SURROGATE STUDY. **BLOCK**, JEAN L. and Kiisa Nishikawa

Forests and Fire Ecology - continued

9:20-9:40 TASSEL-EARED SQUIRREL RESPONSES TO FOREST TREATMENTS: MOSAICS MATTER. **WIGHTMAN**, CATHERINE S. and Steven S. Rosenstock

9:40-10:00 FIRE AND FIRE SURROGATE TREATMENT IMPACTS ON SOIL MOISTURE CONDITION IN SOUTHWESTERN PONDEROSA PINE FORESTS. **POFF**, BORIS, Daniel G. Neary and Aregai Tecle

10:00-10:20 BREAK

10:20-10:40 ANALYSIS OF CURRENT AND HISTORICAL SURFACE FLOWS AND HYDROLOGIC RESPONSE TO RESTORATION TREATMENTS IN THE UPPER LAKE MARY WATERSHED, ARIZONA. **MILLER**, CORY A., David G. Brewer and W. Wallace Covington

10:40-11:00 THE EFFECTS OF A RESTORATION THINNING ON CARBON STOCKS IN A NORTHERN ARIZONA PONDEROSA PINE FOREST. **FINKRAL**, ALEX J. and Alexander M. Evans

11:00-11:20 THINNING REDUCES CARBON DIOXIDE, BUT NOT METHANE, FLUXES IN SOUTHWEST PONDEROSA PINE FOREST SOIL. **SULLIVAN**, B. W., Thomas E. Kolb and Stephen C. Hart

11:20-11:40 50 YEARS OF CHANGE IN FOREST UNDERSTORY VEGETATION AT BRYCE CANYON NATIONAL PARK. Ironside, Kirsten E., Dana H. Ikeda and JOHN R. **SPENCE**

11:40-12:00 A 50-YEAR FOREST SUCCESSION STUDY AT BRYCE CANYON NATIONAL PARK, UTAH. **IKEDA**, DANA H. and Kirsten E. Ironside

Animal Ecology II

Thursday Morning 9:00 a.m.-12:00 p.m.
FREMONT
Moderator: Charles Drost, *USGS, Southwest Biological Science Center, Colorado Plateau Research Station*

9:00-9:20 ASPECTS OF THE ECOLOGY OF SONORA MUD TURTLES AT MONTEZUMA WELL. **LOVICH**, JEFF, Charles Drost, Dennis Casper and A.J. Monatesti

9:20-9:40 MILKSNAKES AT PETRIFIED FOREST NATIONAL PARK: IMPLICATIONS FOR MONITORING RARE VERTEBRATES. **NOWAK**, ERIKA M.

9:40-10:00 ROOSTS OF ALLEN'S LAPPET-BROWED BAT IN NORTHERN ARIZONA. **SOLVESKY**, B.G. and Carol L. Chambers

10:00-10:20 BREAK

10:20-10:40 MULE DEER ANTLER GROWTH AND HUNTING MANAGEMENT ON THE NORTH KAIBAB, ARIZONA. **WAKELING**, BRIAN F.

Animal Ecology II - continued

10:40-11:00 SCENT-STATION SURVEYS: INDEXING RELATIVE ABUNDANCE OF MESOPREDATORS IN ARIZONA. **MCKINNEY**, TED and Thorry W. Smith

11:00-11:20 MOUNTAIN LION DEPREDATION HARVESTS IN ARIZONA. **MCKINNEY**, TED and Brian F. Wakeling

11:20-11:40 LIONS ON THE COLORADO PLATEAU: RESEARCH PROGRAM HIGHLIGHTS FROM 2003-2007. **HART**, JAN, Eric York, David J. Mattson, Terrence R. Arundel, RV Ward, Emily A. Garding, Elaine F. Leslie, Diane Miller, Mike Miller, Paul Whitefield, Claire Crow, Brent Hetzler and David Worthington

11:40-12:00 MANAGING FOR HUMAN SAFETY IN MOUNTAIN LION RANGE. **MATTSON**, DAVID, Kenneth Logan and Linda Sweanor

Invasives

Thursday Morning 9:00 a.m.-12:00 p.m.
MEADOWS
Moderator: Mark Miller, *USGS, Southwest Biological Science Center, Colorado Plateau Research Station*

9:00-9:20 GLEN CANYON NRA RESPONSE TO WESTERN QUAGGA MUSSELS. **ANDERSON**, MARK and Jesse Granet

9:20-9:40 HABITAT RELATIONS AND EFFECTS OF INVASIVE EXOTIC PLANTS ON THE FEDERALLY ENDANGERED SHIVWITS MILK-VETCH *(ASTRAGALUS AMPULLARIOIDES)*, WASHINGTON COUNTY, UTAH. Miller, Mark E., REBECCA K. **MANN**, Harland Goldstein and James D. Yount

9:40-10:00 PREDICTING ALIEN PLANT DISTRIBUTIONS IN NATURAL LANDSCAPES FOLLOWING DISTURBANCE REMOVAL. **DOW**, S.T., R. D. Hiebert and K. McEachern

10:00-10:20 BREAK

10:20-10:40 CONTROLLING BROME GRASSES IN ZION CANYON USING IMAZAPIC (PLATEAU®) HERBICIDE. **MATCHETT**, J. R., Aviva O'Neill, Matt Brooks, Cheryl Decker, and Jennifer Vollmer

10:40-11:00 EFFECTIVENESS OF NATIVE SEEDING AND LANDSCAPE SCALE HERBICIDE APPLICATIONS FOR CONTROLLING CHEATGRASS IN ZION NP. **THODE**, ANDREA and Karen L. Weber

11:00-11:20 WHY SALTCEDAR MATTERS AS BIRD HABITAT IN THE SOUTHWEST. **SOGGE**, MARK K., Susan J. Sferra and Eben H. Paxton

11:20-11:40 INVASION BY EXOTIC PLANT SPECIES OF NORTHERN ARIZONA RIPARIAN AREAS AND POSSIBLE SOLUTIONS. **ALDEN**, ELISABETH A and Aregai Tecle

11:40-12:00 TAMARIX: PASSENGER OR DRIVER OF ECOSYSTEM CHANGE IN RIPARIAN AREAS OF THE SOUTHWEST? **JOHNSON**, TYLER D.

Restoration and Conservation at the Landscape Scale: The Kane 2 Mile Ranch Project

Thursday Morning 9:00 a.m.-12:00 p.m.
AGASSIZ
Moderator: Tom Sisk, *Center for Environmental Sciences and Merriam-Powell Center for Environmental Research, Northern Arizona University*

8:55-9:00 INTRODUCTION, Tom Sisk

9:00-9:20 IMPLEMENTING AN ADAPTIVE, MULTI-SCALE RESTORATION PROGRAM FOR THE KANE AND TWO-MILE RANCHES IN NORTHERN ARIZONA. **AUMACK**, ETHAN

9:20-9:40 THE WARM FIRE'S EFFECTS ON UNDERSTORY VEGETATION, PONDEROSA PINE CROWN MORTALITY, AND FUELS: IMPLICATIONS FOR POST-FIRE MANAGEMENT. **MCMASTER**, MELISSA and Andrea Thode

9:40-10:00 MODELING CHEATGRASS OCCURRENCE TO TARGET RESTORATION PRIORITIES ON THE KANE AND TWO-MILE RANCHES, NORTHERN ARIZONA. **ALBANO**, CHRISTINE, Brett G. Dickson, Ethan Aumack, Thomas D. Sisk and Steve Fluck

10:00-10:20 BREAK

10:20-10:40 MULE DEER HABITAT IMPROVEMENT ON THE KAIBAB NATIONAL FOREST. **ROGERS**, ANDI S., Ron Sieg and Todd Buck

10:40-11:00 PUBLIC RANGELAND RESTORATION ON THE PLATEAU: MAKING INFORMED DECISIONS IN A CONFLICTED LANDSCAPE. **BERNSTEIN**, ELI J., Thomas Sisk, Tim Crews, Steve Rosenstock, David Schlosberg and Ethan Aumack

11:00-11:20 RESEARCH AND MONITORING TO GUIDE MANAGEMENT: K2M AS A CASE STUDY FOR PUBLIC LANDS STEWARDSHIP. **SISK**, THOMAS D.

ABSTRACTS OF PRESENTED PAPERS AND POSTERS (listed alphabetically by 1st author)

A SYSTEMATIC REVIEW OF SPECIES SELECTION AND TREATMENT EFFECTIVENESS FOR REVEGETATION IN THE MOJAVE DESERT, USA

ABELLA, SCOTT R.[1] and Alice C. Newton[2]
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Biologically and cost-effective strategies are needed for revegetating southwestern arid lands, such as the Mojave Desert. Many disturbances – failed agricultural attempts, grazing by exotic herbivores (e.g., burros, cattle), creation of roads, land clearing for military or mining activities, off-road vehicles, and wildfires fueled by exotic grasses – have modified or eradicated native vegetation. Natural revegetation often is slow, or consists of exotic species. As a result, active revegetation using native species may accomplish biological and utilitarian objectives, such as enhancing native plant communities, curtailing fugitive dust that poses a human health hazard, or establishing non-flammable vegetation for reducing wildfires. We evaluated the following questions by systematically reviewing published revegetation studies in the Mojave Desert: (1) Which species have been most commonly and effectively planted or seeded? Which treatments have increased plant establishment? What are the relative performances of planting and seeding, and are these species specific? A total of 40 species, 36 of them shrubs, were outplanted in 13 planting studies. None of the eight species planted in ≥ 3 studies were immune to a complete failure (0% survival) in one or more treatments in one or more studies, although some species (e.g., *Atriplex* spp.) often exhibited high survival relative to other species. Fencing, shelters, and irrigation have increased survival of some species, although these treatments require cost/benefit analyses. Though seeding frequently is discouraged relative to planting, seeding success appears species specific. For example, *Baileya multiradiata*, *Phacelia parishii*, *Atriplex polycarpa*, *Penstemon palmeri*, and *Penstemon bicolor* established at densities ranging from 3-9 plants/m^2 in individual seeding studies. Based on published data, we believe that seeding should not be discounted and that it warrants additional research as a revegetation option.

BIOSPHERE 2: TESTING THE INFLUENCE OF GLOBAL CHANGE DYNAMICS ON KEY INTERACTIONS BETWEEN PLANTS AND WATER.

ADAMS, HENRY D.[1], Juan C. Villegas[2], David D. Breshears[3], Maite Guardiola-Claramonte[4], Chris B. Zou[5], Greg A. Barron-Gafford[6], Travis E. Huxman[7]
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Answering the big questions about how global change will affect dynamic relationships between water, vegetation, and climate is difficult. Observational and correlative studies have broadened our understanding of these interactions, but ultimately experimental science is required to provide a causal connection between climate change and these ecosystem properties. The University of Arizona recently assumed management of Biosphere 2, a facility with unique environmental controls, offering unprecedented opportunities to untangle these key interactions between plants and water. One such challenge is the recent large-scale die-off of pinyon pine (*Pinus edulis*) in the Southwest. At Biosphere 2 we can isolate the influence of drought on mortality from the effects of pinyon pine bark beetle and associated pathogens. High recent mortality is hypothesized to be caused by increased temperatures relative to past less-widespread, cooler droughts. We will test the physiological basis of this hypothesis by examining drought mortality under historical and elevated temperatures (+4°C). We expect pinyon pines to experience severe stress and die sooner under warmer, global change-type drought conditions. Our results will improve predictions of pinyon pine die-off in response to future climate shifts. Additional projects at Biosphere 2 include using the facility's mass balance to study flow paths of water through landscapes. In drylands, evapotranspiration represents a significant portion of the water budget. However, partitioning evapotranspiration into evaporation and transpiration fluxes, as well as the effect of vegetation cover on this partitioning, are not fully understood. We will build a moveable matrix with containers of trees and soil that can be configured to test these effects along a continuum of bare ground to complete canopy cover. Also planned are large indoor hillslopes, constructed to study multiple paths of water-loss across vegetation gradients. Opportunities exist for future collaboration at Biosphere 2 to study issues important to the Colorado Plateau.

CRAYFISH POPULATION TRENDS AT FOSSIL CREEK

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This study followed the response of a population of exotic crayfish, *Orconectes virilis*, during a large restoration project in Fossil Creek, Arizona where stream flow was restored as part of a dam decommissioning, and non-native, predatory fishes were removed from part of the stream to recover native fishes. It was predicted that crayfish would increase with restored flow and that increases would be higher where exotic fish were removed, relative to where they remain, due to a release from competition and predation. Changes in relative abundance of the crayfish population were documented at ten sites, two years prior to restoration and two years post-restoration. Results indicated that crayfish abundance rapidly increased throughout the creek the first year after restoration, with at least a two-fold greater increase in areas where exotic fishes were removed relative to where they remain. However, during the second year after restoration, in upstream areas of the creek that contained active travertine deposition, the abundances showed a dramatic shift and decreased relative to downstream areas where there was less travertine deposition. Likewise, downstream of the fish barrier constructed during restoration, where exotic predatory fish remain, relative abundances also decreased, by half. These results indicate that despite the dramatic increase in the population during the first year after restoration, both active travertine deposition and the remaining predatory exotic fishes have negated the initial increase in the upstream and downstream sections of the creek, and may actually regulate population growth. Previous experimental evidence suggests that

this may prevent the crayfish population from negatively affecting the recovering native biological community of the creek. Unfortunately, there is a small section located in the middle of the creek, upstream of the fish barrier, where crayfish abundances remained stable and did not show signs of decreasing.

MODELING CHEATGRASS OCCURRENCE TO TARGET RESTORATION PRIORITIES ON THE KANE AND TWO-MILE RANCHES, NORTHERN ARIZONA.

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In the Southwest, invasive plant species pose a significant threat, especially in areas where the structure and composition of native vegetation has been affected by fire, fire suppression policies, or livestock grazing. Following the purchase of the 340,000-ha Kane and Two-Mile Ranch allotments in 2005, the Grand Canyon Trust initiated a baseline ecosystem assessment to characterize existing conditions and to identify restoration priorities across the Kaibab and Paria Plateaus and in House Rock Valley. Vegetation, ground cover, and soil characteristics were measured at 606 random plot locations. Of the 34 exotic and invasive plant species we detected, cheatgrass (*Bromus tectorum*) was the most widely distributed, occurring on 41% of the plots. Given recent disturbances, such as the 2006 Warm Fire, and degraded conditions associated with historical livestock grazing and fire suppression, there is high potential for further invasion on this landscape. Identification of the environmental conditions that influence the occurrence of this highly invasive weed is essential for targeting restoration efforts and deterring further spread. We used a model selection approach to identify and estimate important plot- and landscape- (eg. GIS-derived physiography and forest structure) scale variables and used this information to build a continuous probabilistic model of cheatgrass occurrence across the landscape. We present model results that are empirically based, spatially explicit, and essential to understanding patterns of rapid cheatgrass establishment on the Kane and Two-Mile Ranch landscape.

INVASION BY EXOTIC PLANT SPECIES OF NORTHERN ARIZONA RIPARIAN AREAS AND POSSIBLE SOLUTIONS

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Saltcedar, Tamarisk sp., and Russian olive, Eleagnus angustifolia, are invasive exotic plants established in riparian areas in Arizona. They were intentionally introduced to the area over 100 years ago. The spread of the plants has been associated with human induced modifications of riverine riparian areas through damming for flood control, energy generation and water supply as well as to provide water-based recreational opportunities. These kinds of activities have changed the natural flow behavior of streams resulting in the recruitment and rapid proliferation of many exotic species in place of native plants whose productivity has become reduced. The spread of exotic species, however, is not limited to wetlands disturbed by human activities. Many remote water ways and undisturbed seeps and springs in Arizona and the Southwest have also becoming invaded by exotic plants, which have out-competed native plants and established mono-trophic stands in places where native vegetation used to thrive. The situation, which is having a serious negative effect on the ecological and economic health of many areas have to be resolved. Studies have indicated that the most promising way of solving the problem is through complete removal of the invading species. However, removing saltcedar and Russian olive is time consuming, costly, and may lead to reinvasion by the same or other exotic species. To make the process cost-effective and successful, it needs to be well thought out, innovative and community based. One creative approach that is shaping up in Northern Arizona involves partnering with schools and students to restore disappearing springs and streams. The students and other community members remove the invasive species. Once removed, the plant biomass can be burned to heat greenhouses used for growing native plant seedlings for planting in treated areas. The entire process of removing invasive exotic plants and replacing them with native species and maintaining the latter where it is still in place requires comprehensive planning and good partnership between federal, state and local agencies and the community.

RESTORATION ECOLOGY IN THE AGE OF GENETIC INFORMATION: USING GENETIC TOOLS TO GUIDE RESTORATION SUCCESS

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Restoration ecology is a rapidly advancing field of research that is changing the way restoration projects are designed and implemented. One aspect of restoration ecology that has received little attention is the role that population genetic information can play in ensuring the restoration of damaged ecosystems. In this study we examine how genetic diversity in three riparian species (Populus fremontii, Salix exigua, S. goodingii) affects their ability to adapt and survive in a common garden restoration project along the Lower Colorado River (LCR) bordering California and Arizona. We used AFLP technology to determine genotypes for over 500 individuals from different populations of each species. Preliminary results reveal roughly similar within (Hs) and among (Gst) population genetic variation for each of the three species (Hs/Gst: P. fremontii = 0.082/0.43; S. exigua = 0.122/0.40 S. goodingii = 0.078/0.40). Based on these results we have propagated, designed and established mosaic plantings of the three species (N = 22196 individuals) with the following questions in mind: (1) Does genetic variability contribute to restoration success as measured by (a) planting survivorship and (b) monitoring of biodiversity of restored riparian communities; and (2) Do co-occurring genotypes provide an advantage when planted in a common garden setting? Our restoration strategy is designed to answer each of these questions to better inform land managers of the role genetic diversity may play in the restoration of riparian ecosystems, especially those along the LCR.

CLIMATE-RELATED TRENDS IN NORTHERN NEW MEXICO ECOSYSTEMS: LONG-TERM MONITORING, THRESHOLD EFFECTS, AND DISTURBANCE INTERACTIONS

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Retrospective studies and long-term monitoring of multiple ecosystem parameters from the Jemez Mountains region (New Mexico, USA) since ca. 1990 reveal a variety of ecological responses to climate variability. Retrospective studies, including tree-ring based fire and climate histories, *Pinus edulis* demographies, and repeat photography, document historical patterns of ecosystem responses to climate, such as fire:climate relationships and pulses of tree natality and mortality. Long-term monitoring of woodland surface cover conditions, surface-dwelling arthropod populations, and *Pinus* tree growth exhibit a number of trends in productivity and biodiversity related to climate variability spanning wet and severe drought periods from the early 1990s to 2007. For example, weekly *Pinus ponderosa* tree growth shows trends that predict landscape-scale patterns of tree mortality, while long-term vegetation data document extensive drought-induced mortality of trees and grasses. Measurements of runoff and erosion from a desertified hillslope show extreme variability in response to climate conditions at all time scales, and these multi-scale hydrological data also demonstrate the nonlinear threshold responses of runoff and erosion to the connectivity of bare soil patches. Threshold drivers of multiple disturbance processes, as well as interactions among such disturbances as fire, forest dieback, insect outbreaks, and accelerated soil erosion, are described. The utility of these site-specific long-term ecological data has been enhanced through linkages with larger research networks such as arthropod assemblages at several LTER sites, modeled responses of watershed hydrology and net primary productivity to climate change through the USGS Western Mountain Initiative, and global collaborations on forest dieback and desertification processes, allowing local contributions to global change-scaled research. For example, climate-induced forest stress and dieback are now becoming evident in many semiarid parts of the world, allowing comparison of local and regional dieback patterns from New Mexico with examples from around the world.

LISTENING TO THE LAND: GEOARCHAEOLOGICAL RESEARCH ON THE NAVAJO NATION

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Archaeological excavations on the Navajo Nation are a necessary precursor to infrastructure projects, commonly related to transportation and communication improvement. Backhoe trenching along linear right of way corridors provide windows from which to study buried archaeological sites, and the associated soils and landforms. Reconstructing past landscapes, investigating soil properties, and obtaining radiocarbon ages on archaeological sites allows for a better understanding of human/landscape interactions. On the Kaibito Plateau, chronostratigraphic reconstructions of eolian, soil, and cultural features date to the early Holocene, where hearths are associated with stable surfaces. During the middle Holocene dune activity seems to have increased, and a lack of soils and cultural features indicates cultural activity in the area decreased, a finding supported by previous regional studies. Later Holocene dunes were stabilized, as evidenced by soil formation and increased cultural activity. These patterns in landscape and human interactions can perhaps best be explained by climatic trends, where a middle Holocene period of decreased climatic favorability marks overall regional population decreases. The response of the landscape to the less favorable climate was a destabilization of eolian sand deposits, erosion of soils, and probably a decrease in resources. The formation of Bw soils during more favorable climates provides a positive feedback on surface stability, water and nutrient holding capacities, and therefore plant and animal resources. A decrease in the soil cover has the opposite affect, creating a landscape that would make it difficult for subsistence cultures to thrive. The Bw soils are an indicator of a healthy landscape, and their absence marks a change to less favorable conditions. The middle Holocene reactivation of sand deposits, loss of soil cover, and consequent decrease in resources is a viable analogy to understanding the potential affects of global climate change on human populations in a semi-arid landscape.

GLEN CANYON NRA RESPONSE TO WESTERN QUAGGA MUSSELS

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Glen Canyon National Recreation Area (NRA) has operated ever more progressive zebra mussel (dreissenidae) prevention program at Lake Powell since 2000. With the discovery of quagga mussels (Dreissena bugensis) in the lower Colorado River in January of 2007, the program was expanded to address the heightened threat. New requirements, supported by park-specific regulations, for all boaters have been instituted. Through the 2007 season, hundreds of boats have been decontaminated at new facilities developed to meet the increased demand. In July of 2007, larval zebra mussels (veligers) were detected in plankton samples from the lake. Many questions exist around the discovery, but the path forward remains clear. A brief history of zebra mussel prevention at Lake Powell and details of the 2007 program expansion will be discussed. Results and uncertainties related to the veliger detection will be detailed. The future of management of this issue at Glen Canyon NRA will also be discussed.

IMPLEMENTING AN ADAPTIVE, MULTI-SCALE RESTORATION PROGRAM FOR THE KANE AND TWO-MILE RANCHES IN NORTHERN ARIZONA

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In 2005, the Grand Canyon Trust and The Conservation Fund jointly purchased the Kane and Two Mile ranches, whose livestock grazing permits extend across nearly 850,000 acres and a 2,000m elevation gradient north of the Grand Canyon. We used a field- and remote sensing-based rapid ecological assessment of the ranches in 2005 to identify and prioritize linked restoration and livestock management strategies across the project area. Analysis of landscape-scale vegetation and soil characteristics has allowed us to prioritize appropriate initial locations for site-specific restoration efforts. We have initiated seven site-specific grassland, woodland, forest, and stream restoration projects whose results are being used in combination with landscape-scale baseline assessment results to inform broader landscape-scale restoration efforts. Expanded efforts are being systematically focused along key ecological gradients to account for and learn from the significant heterogeneity existing across the project area. We have also used assessment results to characterize "baseline" conditions, and to inform the development of a long-term, multi-scaled monitoring and adaptive management plan for the project area. By working adaptively and systematically across scales we intend to develop and implement restoration approaches that are efficient, effective and relevant to emerging public lands management challenges across the southwestern United States.

THE ROLE OF CLIMATE AND LAND USE IN PINYON PINE RECRUITMENT AND GROWTH

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Over the last century there has been a marked expansion of pinyon-juniper woodlands into grassland and shrubland ecosystems in the arid and semi-arid regions of the West. Although pinyon-juniper populations have fluctuated along elevational and latitudinal gradients with changing climate throughout the Holocene; over the last century, local scale impacts such as livestock grazing, changes in fire regimes, and increasing atmospheric CO_2 concentrations are thought to be more recent drivers of pinyon-juniper woodland distribution. More recently the multi-year drought across this region has resulted in large-scale tree mortality, which is especially pronounced in pinyon populations. To better understand the role of past land use and climate in pinyon-juniper woodland dynamics we compared pinyon stand dynamics on a relict mesa site to a nearby historically grazed site in Grand Staircase-Escalante National Monument. No differences in pinyon density or basal area were observed across the sites. Stand age structure of pinyons showed peak recruitment occurred during the early 1900s across both sites; 16% and 17% of the pinyon trees on No Man's Mesa and Deer Springs Point dated to the period 1920-1930, which was a time period of above average precipitation across the Southwest. Our results also suggest that over the past several decades increasing summer temperature has negatively impacted pinyon growth. The negative effect of increasing summer temperatures on pinyon growth is most likely due to an indirect effect of increasing temperatures on soil water availability, resulting in more pronounced drought conditions during the growing season as opposed to a direct effect of temperature on tree growth. The overall effect on pinyon growth has been a 25% reduction in pinyon growth for a given amount of precipitation during the last 50 yrs (1954-2003) as compare to earlier in the century (1896-1945).

RESTORATION OF TAMARIX-DOMINATED XERIC RIPARIAN AREAS

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Thousands of hectares of riparian vegetation dominated by *Tamarix* have been treated in the southwestern United States, using a combination of strategies including herbicide application, burning and mechanical removal. There is substantial scientific knowledge and numerous case studies that can inform revegetation of relatively mesic riparian sites with native *Populus* spp. and *Salix* spp. However, revegetation of upper floodplain or ?xeric riparian? areas, where over bank flooding is impossible, soil salinity is high, groundwater is deep and mycorrhizal fungal symbionts are potentially absent, still presents a significant challenge to riparian land managers along the Rio Grande and other southwestern rivers. This project aims to address this knowledge gap by identifying suitable native plant species and revegetation techniques for these xeric riparian sites. Components of this study include: 1) identification of candidate native plant species and communities through characterization of reference sites, review of historical botanical accounts of the Rio Grande valley, and communication with restoration practitioners; 2) germination trials where seeds of candidate native species are germinated in solutions of differing salinity levels; 3) greenhouse trials to examine the effect of salinity and mycorrhizal fungi on seedling survival and growth; and 4) field experiments testing the efficacy of various revegetation methods in soils of varying texture and salinity. Results from these experiments will be used to develop cost-effective protocols aimed at restoring xeric riparian shrubland and grassland communities.

EVERYBODY TALKS ABOUT CLIMATE CHANGE, BUT WHAT CAN I DO ABOUT IT?

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Human contribution to climate change can be stabilized and even reversed if we "reduce, replace, and offset" – that is, "reduce" the use of energy and products that contribute to greenhouse gas emissions, "replace" gas-emitting sources of energy with less-emitting types, and "offset" remaining emissions by storing an equivalent amount of greenhouse gasses (mainly carbon dioxide). But who exactly is the reducer-replacer-offsetter, what is the priority among these 3 actions, what is the best way to store carbon, and how can I help? In 2006, the Society for Conservation Biology became the first professional organization related to resource management to take responsibility for its climate impacts. As the reluctant chair of SCB's fledgling carbon offset committee, at that time I considered climate change the ultimate doom-&-

gloom scenario, and atmospheric chemistry, carbon markets, and offsets were alien realms. Because offsets can be abused as a "license to pollute" and continue our addiction to fossil fuel, our committee agonized over our decision to "offset" rather than "reduce" or "replace." We let SCB members opt out of the carbon offset fee to force individuals to think about all three responsibilities. An astounding 97% of SCB registrants paid the fee. Because some offsets harm biodiversity (e.g., converting wildlands to biomass production) and some conservation projects harm local livelihoods, we also struggled to find an investment that was biologically and socially responsible. In South Africa's Baviaanskloof world heritage site, we found a "win-win-win" project that stores carbon, restores a globally endangered biome, and alleviates poverty. The experience also nudged me into lifestyle changes that would've been good for me even if climate change were not an issue – adding a fourth "win" to my involvement. Climate change may be the ultimate doom-&-gloom scenario. But we can do a lot about it. And it's fun.

REPRESENTATIVENESS OF THE OLDEST PERMANENT PLOTS IN NORTHERN ARIZONA PONDEROSA PINE FORESTS

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A set of permanent plots established between 1909 and 1913 (the Woolsey plots) contain the oldest data in northern Arizona ponderosa pine forests. These data may be used to reconstruct presettlement reference conditions and assess changes in forest structure and composition. However, selection of plot locations followed a subjective non-random approach, since it occurred before the importance of randomization was formally recognized in 1925. To evaluate the applicability of results obtained from these historical plots, we compared their environmental characteristics (terrestrial ecosystem unit [TEU, based on a US Forest Service ecological classification system], site index, elevation, insolation index, and soil parent material) as well as contemporary forest structure (trees per hectare, basal area per acre, and quadratic mean diameter) with two large inventory samples: US Forest Service Forest Inventory and Analysis (FSFIA) and Arizona State Land Department Continuous Forest Inventory (AZCFI). Analytical methods included multivariate permutation tests, ratios of variance, and Kolmogorov-Smirnov two-sample tests. Results indicated that: (a) the Woolsey plots were neither historically nor contemporarily representative of the entire study area because of environmental and current forest structural differences with respect to the FSFIA and AZCFI inventories, and (b) the Woolsey plots may be considered historically representative of their corresponding TEUs. Our study supports the use of TEUs for defining the applicability of information obtained from the Woolsey plots.

CLIMATE CHANGE AND DUST: WHAT DOES THE FUTURE HOLD?

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Dust emissions from dryland ecosystems have cascading consequences for social and environmental systems at local, regional, national, and global scales. Increasing temperatures and droughts will result in decreased soil moisture and thus plant cover throughout the desert Southwest, and thus dust emissions will increase as well. Diminished plant cover leaves soils vulnerable to erosion. Dust emissions increase during drought years, especially in plant communities where native perennial grasses have been replaced by annual grasses or when soils are disturbed. There is a further dramatic increase in dust emission when plant communities are both annualized and the soils are disturbed. Soil loss has reduced soil fertility in selected areas, indicating the potential for further reductions in soil fertility due to activities that destabilize soils, reduce vegetative cover, and lead to accelerated soil loss. Studies of alpine lake sediments demonstrate that post-European settlement dust loading to western U.S. alpine ecosystems has increased ~500% above average loadings for the previous 5000 years. The dust deposited on snowpack of mountains near low elevation sites can reduce the duration of snow cover. Therefore, activities in lower elevation lands can alter the timing of water delivery in many western rivers and streams, as well as contribute to regional warming and drying by changes to desert soil surface albedo. Regional-scale hydrologic effects from land use activities and potential dust-climate feedbacks strongly suggest that dryland soil stability is a major issue with implications for the capacity of social and environmental systems to adapt and respond to climate change.

50 YEARS OF SCIENTIFIC RESEARCH PERMITTING AT GRAND CANYON NATIONAL PARK: WHAT HAVE WE LEARNED?

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750 Research Permits were examined from the past 5 decades to determine trends of study topics, research products, and principal investigators of Grand Canyon National Park. Over the past 50 plus years, the Research Permitting system has evolved into a standardized, yet highly complicated process. Grand Canyon National Park has one of the largest Research Permitting programs in the National Park Service. We have an average of 100 active Research Permits and 250 investigators annually. Past and current developments in managing research in a high profile park will be defined. This will include the many aspects of research coordination: application, proposal development, qualifications, peer review, negotiation, compliance, mitigation, etc. Final report submission rate for the past 5 decades was 68%. Current annual report submission rate is less than 50%. 67% of academic principal investigators reported in peer reviewed journal articles while 27% of government agency investigators did the same. The relationship between research and management was also evaluated and areas of improvement will be defined to better link credible science and public lands management.

SUSTAINED EFFECT OF A WILDFIRE ON STREAM BENTHOS; KANAB CREEK, GRAND CANYON NATIONAL PARK

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In the spring of 1996 the Bridger-Complex fire occurred within the Kanab Creek drainage and covered 21km2. Near the confluence of Kanab Creek and Colorado River, 26 km down stream of the fire, we had a 10 year stream monitoring site. An adjacent stream, Tapeats Creek, was also monitored during the same period and used as a control. Kanab Creek macroinvertebrate density estimates were significantly lower ($P<0.01$; $n=122$) in 1997, 1999, and 2001 than they were compared to pre-fire conditions. This 60 - 90% reduction in density remained for at least six years after the fire. In 2003, 2004, and 2006 macroinvertebrate density returned to and occasionally exceeded pre-fire estimates. There was a significant negative relationship between macroinvertebrate density from 1996 through 2001 with precipitation and a significant positive relationship with precipitation 2003 and later. Tapeats Creek benthic response variables did not vary significantly ($p>0.05$) during the study. Prolonged benthic recovery in Kanab Creek can be attributed to the deposition of ash in pools and periodic re-suspension during spates which negatively impacted the benthos. Precipitation records within the Kanab Creek drainage had a high amount of seasonal variation during the study period (0 - 238% of average), with high flows both clearing ash from the channel and depositing ash in pools. This investigation demonstrates the value of long-term monitoring and the interaction between stream recovery from fire and highly variable precipitation patterns as predicted in Southwest U.S. climate change models.

BRINS FIRE: ONE YEAR POST WILDFIRE, AQUATIC COMMUNITY RESPONSE IN OAK CREEK, AZ

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Wild land fires can influence the heterogeneity and bio-diversity of aquatic ecosystems for extended periods of time. Between June 18-28 2006 the Brins Fire burned 4,317 acres within the Oak Creek watershed north of Sedona, AZ. Large amounts of ash, soil, and burned debris were deposited into Oak Creek by monsoon storms though autumn following the fire. We established three collection sites; Site 1 control – 4km above fire; Site 2-within fire area; Site 3-8 km below fire. Four collections were made: 29 June and 17 November 2006; 6 June and 18 July 2007. The Oak Creek macroinvertebrate density estimates varied significantly by site and season, with Site 1 having about 40% more for the collection period. Site 1 macroinvertebrate density varied the least, 38% between collections, while Site 2 and Site 3 varied by 93 and 96%, respectively. Trichoptera and Ephemeroptera were abundant at Site 1, but were rare at sites 2 and 3. In contrast Chironomids (Diptera) densities at Site 2 and 3 were 75% higher compared to Site 1 indicating a compositional response to the fire-impacted sites dominated by low tolerance taxa. We have determined that the run-off (sediment and ash) from the Brins Fire can be detected all the way to confluence of Oak Creek and the Verde River, 20 km down stream. Sustained monitoring is required to fully understand the ecosystem response between the Brin Fire and Oak Creek. We also suggest that more priority be given to the riparian-upland interface (RUI) in order to protect the few riparian and stream communities left in the Southwestern United States.

PUBLIC RANGELAND RESTORATION ON THE PLATEAU: MAKING INFORMED DECISIONS IN A CONFLICTED LANDSCAPE

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Significant degradation of public rangeland ecosystems has occurred throughout the Southwest as a result of historic overgrazing by livestock, setting off a heated debate over the appropriate role of grazing in these semi-arid environments. Still, current research suggests that regionally complicated and interdependent relationships between grazing, climate and a site's ecological characteristics may best explain the agroecosystem dynamics of these rangelands. Without having to resolve this debate we can still agree on the widespread need for landscape-level restoration. However, efforts to conduct ecosystem restoration within the West's public rangelands are constrained by a dual policy mandate to manage for both ecosystem health and food production. Our research took place on the Kane ranch, a large public allotment on the Arizona Strip recently purchased by the Grand Canyon Trust. We examined the effects of eight different restoration treatments on the germination success of seeded, cool-season native grasses. The effects of livestock grazing, seeding technique, wet vs. dry climate scenarios, as well as the interactive effects of these treatments, were analyzed. Results indicate that drill seeding in wet years may be the only way to successfully re-seed these species. However, wet years also appear to stimulate exotic species germination, setting up potentially competitive interactions between native and exotic species that contradict overall restoration goals. To make informed decisions within such a challenging landscape, managers must apply themselves to understanding ecological complexity while finding support for a deep time approach to restoration within the policy environment of public rangeland management in the arid West.

TREES FOR THE RIM

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The Rodeo-Chediski fire in June of 2002 burned over 478,000 acres in the White Mountain area of northeastern Arizona. An estimated 8000 acres of privately owned land held by homeowners, business owners, and municipalities were also impacted by this fire. To help these landowners with restoration efforts on their lands, a non-profit organization, "Trees for the Rim," was established through generous contributions from corporations including Safeway, Salt River Project, and Arizona Public Service. To date over 230,000 trees, shrubs and grass plugs have been distributed, free of charge, to private landowners and municipalities. I will discuss the production of the plant material and the general establishment and organization of Trees for the Rim.

RESPONSE OF HERPETOFAUNA TO PONDEROSA PINE FOREST TREATMENTS PRESCRIBED BY THE NATIONAL FIRE AND FIRE SURROGATE STUDY

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Ponderosa pine forests across the southwestern United States are being treated by thinning and burning to reduce fuel loads and the risk of catastrophic wildfire. However, very little is known about how these treatments influence herpetofauna. Compared to bird and mammal studies, herpetofauna are underrepresented in the literature. Studying their response to forest treatments is especially important given their general decline worldwide. I compared richness, diversity, abundance, and occupancy rates of herpetofauna between four different treatments prescribed by the National Fire and Fire Surrogate Study on the Colorado Plateau. Additionally, I correlated habitat variables with habitat use by Sceloporus undulatus tristichus. My study site included three replicates with four 10-hectare treatments including thinning, burning, thinning and burning, and no treatment. Two major patterns emerged. There was a significant interaction effect between replicate and treatment for abundance of Sceloporus u. tristichus. Additionally, habitat variables associated with late successional forest stages were negatively correlated with habitat use while those associated with early successional stages were positively correlated with habitat use. This study suggests that forest treatments on larger geographic scales with more replicates are needed to detect potential differences in herpetofauna response to forest treatments. Furthermore, microhabitat analysis of habitat variables before and after forest treatments is important to understand patterns of resource use and distribution of herpetofauna.

A CURRENT PERSPECTIVE ON OUR DEVELOPING UNDERSTANDING OF DROUGHT-INDUCED DIE-OFF AND ITS CONSEQUENCES

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The Colorado Plateau has witnessed major responses in vegetation to previous drought events. Despite the importance of these droughts, many uncertainties remain about the conditions that trigger ecosystem changes, how effects cascade through ecological systems, the consequences of such effects, and how land managers and decision makers can most effectively deal with these related issues. The Colorado Plateau and the southwestern US in general are projected to experience drier and hotter conditions as global warming progresses, making these topics particularly pressing regionally. The recent die-off and its effects that are being documented are being recognized as an important case study not only for the regional but across the country and globally. Here I provide some highlights and synthesis of recent developments within the research community that addresses these issues, including from presentations in the same session. I strive to stimulate discussion on current advances, knowledge gaps and challenges that need to be addressed in the near future.

FEMALE ELK *(CERVUS ELAPHUS)* HABITAT USE AFTER THE CATSATROPHIC RODEO CHEDESKI FIRE IN NORTHEAST ARIZONA

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Between 18 June and 7 July 2002, the catastrophic Rodeo Chediski Fire burned a total of 184,096 ha of United States Forest Service, state, private, and Fort Apache Reservation land along the Mogollon Rim of Arizona. Before 1880, Arizona's ponderosa pine (Pinus ponderosa) forest communities, and the elk (Cervus elaphus) that inhabit them, were subjected to large-scale (>5,000 ha) episodic fires approximately every 2-10 years. Aggressive suppression of wildfires, livestock grazing, and even-aged timber management have rendered Arizona ponderosa pine forests densely stocked. The over-accumulation of fuels coupled with recent drought conditions have resulted in several catastrophic fires, which could be considered ecologically "abnormal". Understanding the impacts of these stand replacing fires on elk habitat and how elk use areas recovering from fire could provide insights to improve forest and fire management to protect and enhance wildlife habitat. Beginning 3 years after containment, we investigated habitat selection and modeled habitat use by female elk (n=11) within the boundary of the Rodeo-Chediski fire. Female elk selected Ponderosa pine habitats with 40-60% canopy cover that were classified as having been subjected to heavy to extreme burn intensity. Favorable precipitation in the years following the fire, increased light transmission to the forest floor, and enhanced soil condition likely enhanced the vigorous growth of forbs and shrubs that improved forage conditions and attracted elk use. High elk use (≥150 locations/km2) was associated with higher proportion (≥ 0.50/1km2) of preferred habitat (Ponderosa pine, 40-60% canopy, heavy to extreme burn). Due to the speed of the Rodeo-Chediski fire, a mosaic of forest types that correspond well to the habitat preferences of elk were left. Forest treatments and prescribed fire designed to reduce tree densities while maintaining ≥40% canopy cover in a mosaic pattern would likely improve habitat conditions for elk in ponderosa pine communities.

CLIMATIC CHANGE TREATMENTS ALTER SOIL CO2, CH4, & N2O FLUXES IN MULTIPLE ECOSYSTEMS

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Carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) are powerful greenhouse gasses driving global change. As global atmospheric concentrations of CO2, CH4, and N2O increase, in-situ terrestrial flux measurements of these gasses are an important part of quantifying sources and sinks as well as determining positive or negative feedbacks. We assessed responses of soil fluxes of CO2 (soil respiration), CH4, and N2O to elevated temperature and altered precipitation treatments along the C. Hart Merriam Elevation Gradient Transect in Northern Arizona during a monsoon season. We found that soil respiration and N2O efflux increase with elevation, whereas CH4 oxidation (uptake) declined. We found that warming of ~3 °C in the mixed conifer ecosystem removed temperature limitations on production of N2O and CO2, and that warming significantly reduced CH4 oxidation in the desert grasslands. We also found that altering precipitation within ecosystems influenced fluxes of all three gasses. As soil moisture increased, soil respiration and N2O efflux increased, while CH4 oxidation appeared to become limited by diffusion of CH4 and/or oxygen. Overall, we found that a warmer and wetter monsoon season will increase soil respiration and N2O production and decrease CH4 oxidation by soils. These changes constitute a positive feedback for all three gasses in response to the climatic changes caused by increasing atmosphere concentrations of CO2, N2O, and CH4.

STOCKING THREATENED AND ENDANGERED NATIVE FISHES INTO FOSSIL CREEK

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Through habitat degradation and negative interaction with nonnative fishes, native fishes have declined throughout the state. Out of 20 native fish species that historically occupied the Gila River basin 12 are federally listed as endangered or threatened. To protect and enhance the native fish assemblage in Fossil Creek, the Bureau of Reclamation funded the construction of a fish barrier, approximately 4.5 miles above the confluence with the Verde River. This barrier protected approximately 9.5 miles of habitat and .2 miles of federally designated critical habitat for spikedace and loach minnow. Numerous cooperators including the Arizona Game and Fish Department (AGFD), US Fish and Wildlife Service (FWS), US Forest Service (USFS), Bureau of Reclamation (BOR), Salt River Project (SRP), Northern Arizona University (NAU), Arizona State University (ASU) salvaged native fish from and chemically renovated Fossil Creek to remove non-native fish threats. The stream was then re-stocked with native fishes that were removed prior to renovation. This presentation focuses on the stocking of federally listed native fishes into Fossil Creek. The project will introduce spikedace (*Meda fulgida*), loach minnow (*Tiaroga cobitis*), Gila topminnow (*Poeciliopsis occidentalis*) and desert pupfish (*Cyprinodon macularius*), into Fossil Creek. A proposed second phase of the stocking project would introduce an assemblage of native "big-river" fishes into Fossil Creek: razorback sucker (*Xyrauchen texanus*), Colorado pikeminnow (*Ptychocheilus lucius*), woundfin (*Plagopterus argentissimus*), and flannelmouth sucker (*Catostomus latipinnis*). A brief description of the fishes stocked, their preferred habitats, the methods and logistics of stocking, monitoring and augmenting will be discussed.

MODELING THE IMPACTS OF CLIMATE CHANGE – CHANGES MADE IN A SPECIES SPECIFIC MODELING SYSTEM

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SIMPPLLE is a spatially-explicit, dynamic landscape modeling system for projecting temporal changes in the spatial distribution of vegetation in response to insects, disease, wildland fire and other natural and management-caused disturbances. A variable for "regional climate" has allowed SIMPPLLE to be initially used to address climate impacts such as drought on the severity of bark beetles in Southern California, increasing temperature on spruce beetle activity in South Central Alaska, and warmer and drier conditions on cheatgrass invasion in Mesa Verde National Park. To be able to quantify how climate changes will alter the distribution and abundance of species resulting in species migration, adaptation to new climates, and local to regional extinctions the modeling system is being expanded. A linkage to other models is being developed to quantify the impact that these vegetation changes will have on hydrologic flows and aquatic habitat. We will demonstrate how we are incorporating four categories of changes to SIMPPLLE; the inclusion of downscaled climate model output, the inclusion of species specific climate space, the modification of SIMPPLLE's "system knowledge" to respond to a comparison of the climate model output to a species suitable space on a plant community basis, and the linkage to other models for hydrologic response, surface erosion and aquatic habitat through the USDA/ARS CoLab modeling project.

FIRE REHABILITATION EFFECTS ON BIRDS AND HABITAT IN A BURNED PINYON-JUNIPER WOODLAND

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Climate change carries with it predictions for increased fire frequency and burn severity in the arid Southwest, including the Colorado Plateau. Many large fires have burned over the past 10 years across large tracts of pinyon-juniper woodland on the Colorado Plateau, much of it under jurisdiction of the Bureau of Land Management (BLM). Fire rehabilitation is a common practice across the BLM, and some level of rehabilitation has taken place on most of these fires. Among the most common rehabilitation practices are those of applying seed, and mechanically treating dead trees with a chain, mulcher or rollerchopper to incorporate seed into the soil and provide some level of protective soil cover. These treatments potentially have additional, unforeseen impacts to other ecosystem components. This study examined the

response of the bird community and vegetation in their habitat to a variety of treatment combinations including burned, unburned, seeded, unseeded, and seeded and mulched/rollerchopped treatments on a 32,000 acre fire that burned in 2002 in western Colorado. Key findings documented that the highest bird use occurred in the fall in burned unseeded areas, while burned rollerchopped areas supported more ground foragers and nesters, and some cavity nesting species were higher in burned than in unburned areas. The study indicates that the bird community responds to habitat differences brought about not only by fire, but also by post-fire rehabilitation actions—a factor which should be considered during fire rehabilitation planning.

PATTERNS OF DROUGHT INDUCED TREE MORTALITY IN PINYON-JUNIPER WOODLANDS

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Drought in the southwestern US during the past decade have caused dominant tree die-off among many vegetation types, specifically, pinyon-juniper woodlands. As drought progressed from early stages (prior to 2002) to later stages (2002 and later), mean elevation of pinyon (Pinus edulis) and juniper (Juniperus monosperma) mortality increased 34 meters and 98 meters, respectively. These increases in elevation indicate the severity of the drought conditions, while showing vegetation changes throughout pinyon-juniper woodlands and not only in traditionally stressed areas (i.e., low elevations). Spatial patterns showed significant clustering of pinyon mortality during early stages of drought, but quickly became dispersed as the drought progressed and mortality levels increased. This clustering of mortality alludes to an epicenter of mortality, but during extreme drought, mortality factors rapidly expanded causing widespread pinyon mortality. These spatial patterns are not consistent in junipers, but during extreme drought, areas of high pinyon mortality showed high juniper mortality, indicating biotic factors relating to tree mortality magnifies tree die-off, but environmental and local variables influence mortality as well. High mortality among pinyons have shifted stand populations to a younger age class, as older, lager trees were preferentially killed, while there no pattern was observed in junipers. These changes in stand structure show how climatic events alter vegetation patterns at different scale, while showing that biotic mechanisms can magnify abiotic stressors and drastically alter vegetation patterns.

VEGETATION CHANGE ON THE COLORADO PLATEAU FOLLOWING PAST CLIMATE WARMING EVENTS: AN ANALOG FOR THE PRESENT AND FUTURE

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Abundant fossil records on the Colorado Plateau detail climatic and ecological changes of the last 20,000 years. During this period, two events of sudden climate warming stand out from the others in their rates and magnitudes. The first of these occurred between 16,000 to 14,000 calendar years ago as climates warmed from the full glacial Wisconsinan to the peak warmth of the Bölling and Alleröd periods. However, this warming took place over a long time span and was punctuated by cooler intervals such as the older Dryas period. Following this warm Alleröd period climates dramatically cooled during the younger Dryas only to warm sharply again at its conclusion. This post-younger Dryas warming between ca. 11,700 and 11,500 years ago increased temperatures more than 4 □C over this time span of less than 200 years. Such a rate and magnitude is similar to climate changes projected for the next 100 years by GCMs. Analysis of the ecological consequences of this sharp warming using plant assemblages from fossil packrat middens can yield projections for future ecological change. These analyses demonstrate that this rapid warming was followed by an abrupt increase in early successional species, and a decline in the number of late successional trees and shrubs. Most species migrated up elevational gradients rapidly, but late successional species were delayed from 2000 to more than 5000 years in their latitudinal responses. Because the rate and magnitude of this past warming is similar to that projected to occur over the next century, ecological responses to these future events should be similar. Current trends in arid to semi-arid ecosystems suggest that these changes may have already begun.

USING ECOSYSTEM PRODUCTION BUDGETS TO ASSESS RESOURCE LIMITATION OF NATIVE AND NON-NATIVE FISHES IN COLORADO RIVER, GRAND CANYON

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The Colorado River below Glen Canyon Dam has been drastically altered with regard to temperature and flow regimes, sediment supply, and community composition. As a consequence, abundance and distribution of native and non-native fishes have changed, including steady declines in abundance of some native fishes (e.g., humpback chub) and increased abundance of many non-natives (e.g., rainbow trout, carp). We hypothesize that these changes are, in part, due to altered food availability associated with dam operations. To test this hypothesis we constructed ecosystem production budgets for 2 contrasting reaches of the Colorado River (near Glen Canyon Dam and 362 kilometers downstream). Using these budgets, we compared food availability (i.e., invertebrate and algal production, detrital pools) to annual energetic demand of native and non-native fishes. Our initial results demonstrate that directly below Glen Canyon Dam, invertebrate production is sufficient to support the energetic demands of dominant invertivorous non-native fishes (i.e., rainbow trout). Further downstream, food limitation is likely for native invertivorous fishes (e.g., humpback chub), but not for native (e.g., suckers and dace) and non-native (e.g., carp, catfish) omnivores. Our estimates will help guide research priorities and management decisions aimed at conservation of native fishes and ecosystem services in the Colorado River.

THE CHALLENGE OF BUILDING NEW CITIES IN MOHAVE COUNTY WITHOUT A RENEWABLE WATER RESOURCE

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Encouraging population growth in the Southwest has been the cornerstone of the region's political economy for over a century. The Phoenix and Las Vegas metropolitan areas have been the focus of the majority of this growth in recent decades; however, more than half a dozen new development proposals for "new cities" are now appearing in rural areas, namely Mohave County. Unlike the rapidly urbanizing areas of Phoenix and Las Vegas, Mohave County has yet to develop the administrative, physical, or artificial natural resource enhancement infrastructure to fully deal with this expansion. On the other hand, Mohave County does view these new developments as a way to bring such advancements by encouraging migration from other parts of the nation, namely the relocation of the retiring baby-boom generation beginning in 2010. Water resources are a critical component to sustain this growth in groundwater basins wholly dependent on aquifers with minimal recharge. Without a renewable readily available water supply, a historically federally-subsidized resource which has allowed our desert cities to flourish, these new urban proposals must provide an innovative and alternative way to ensure water supply that will provide for the long-term health and welfare of future residents without being abandoned in a few generations.

HUMAN-ENVIRONMENT INTERACTION ON THE SOUTHERN COLORADO PLATEAU DURING THE LAST TWO MILLENNIA

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Human cultural change is not inevitably driven directly by responses to environmental stimuli. Rather, through the filter of their cultures, societies interact with their environments to adjust adaptive behavior and preserve prevailing systems or, under extreme conditions, create qualitatively new adaptations to altered circumstances. Due to a combination of circumstances, the American Southwest has been a laboratory for studies of long-term human behavioral adaptation to environment stability, variation, and change. Among these circumstances are environments marginal for agriculture, high quality paleoenvironmental reconstructions of numerous environmental variables, plentiful ethnohistorical data on the modern inhabitants of the region, and a rich archaeological record of long-term adaptive behavior. A diverse array of paleoenvironmental techniques reconstruct low and high frequency variability in a broad spectrum of environmental factors including the deposition and erosion of floodplain sediments, the rise and fall of alluvial water tables, changes in the composition and distributions of plant communities, precipitation, temperature, streamflow, droughts, freezes, wildfires, and others. These environmental data are incorporated into conceptual and operational models of sociocultural adaptation that integrate three classes of variable (environment, behavior, and demography) to help understand human-environment interaction in the region during the last 2000 years. These models identify periods when environmental, cultural, and demographic conditions were especially favorable or especially detrimental to the subsistence activities of the inhabitants of the region and therefore especially likely to maintain existing systems or trigger adaptive changes. Especially favorable conditions occurred during the A.D. 925-1130 interval, while especially severe conditions prevailed during the middle 12th century, the late 13th century, the late 16th century, the 1950s, and the late 1990s-early 2000s. Expected behavioral responses to these conditions predicted by the models are evident in cultural and population stability or growth during favorable periods and major disruptions during unfavorable periods.

TESTING REVEGETATION METHODS FOLLOWING EXOTIC GRASS REMOVAL TO IMPROVE RESTORATION PLANNING AT ZION NATIONAL PARK

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Annual grasses have invaded many areas in the western United States, drastically altering vegetation communities and natural fire regimes. In Zion Canyon, the accumulation of dense exotic brome grasses have replaced native plants and have created a potential fire hazard, prompting park managers to devise a restoration strategy. Recent studies have found the most effective treatments to control exotic grasses in Zion Canyon; the next phase is to re-establish native plants. This project experimentally tests a suite of revegetation methods along upland terraces of the Virgin River in Zion Canyon. Treatments include application of Plateau herbicide to remove annual bromes and combinations of seeding methods with native seed (grasses, forbs, shrubs and trees), mulching, and watering. We found that the herbicide treatment reduced annual grass cover, opening up areas for native plants to germinate. Furthermore, seeded native grasses had the highest germination counts and existing native individuals were resilient to the herbicide. Since some of the seeded species often germinate in the second year, we expect a broader range of species to emerge in 2008, and will collect additional recruitment and cover data. Final results will evaluate the cost, labor investment and germination success of each treatment and will be used to make recommendations for future restoration planning and monitoring.

THE IMPACT OF PINYON MORTALITY ON GROUND-DWELLING ARTHROPODS

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Drought has severe negative affects on plants and their associated arthropod communities, specifically in arid and semi arid ecosystems. Arial surveys and ground studies have shown regional death of pinyons, thus demonstrating large-scale landscape changes in canopy volume and understory vegetation. In this study we documented the impacts of drought-induced mortality of pinyon pine (Pinus edulis) on ground-dwelling arthropod dynamics of the Middle Rio Grande Basin, New Mexico. Our major objectives were to determine if there were differences in species composition, richness and abundance of ground dwelling-arthropods associated with environments experiencing high or low pinyon mortality. Pitfall traps were used to quantify ground-dwelling arthropod dynamics in response to pinyon die-off. We predicted significant impacts on arthropod community dynamics due to the increased complexity of micro-habitats from both standing and fallen trees. Analysis of arthropod community composition between high and low pinyon mortality environments showed significant differences, including 25% of the individual taxa being indicators of high or low pinyon mortality. Experimental plots with and without woody debris quantified the effect of fallen woody debris on ground-dwelling arthropod dynamics. Analysis showed that arthropod abundance was higher in areas with woody debris. Thus both observational and experimental plots showed that arthropods can be highly responsive to disturbance events that lead to even moderate changes in the environment.

FINE-SCALE PROCESSES REGULATE THE RESPONSE OF EXTREME EVENTS TO GLOBAL CLIMATE CHANGE

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We find that extreme temperature and precipitation events are likely to respond substantially to anthropogenically enhanced greenhouse forcing and that fine-scale climate system modifiers are likely to play a critical role in the net response. At present, such events impact a wide variety of natural and human systems, and future changes in their frequency and/or magnitude could have dramatic ecological, economic, and sociological consequences. Our results indicate that fine-scale snow albedo effects influence the response of both hot and cold events and that peak increases in extreme hot events are amplified by surface moisture feedbacks. Likewise, we find that extreme precipitation is enhanced on the lee side of rain shadows and over coastal areas dominated by convective precipitation. We project substantial, spatially heterogeneous increases in both hot and wet events over the contiguous United States by the end of the next century, suggesting that consideration of fine-scale processes is critical for accurate assessment of local- and regional-scale vulnerability to climate change.

PREDICTING ALIEN PLANT DISTRIBUTIONS IN NATURAL LANDSCAPES FOLLOWING DISTURBANCE REMOVAL

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Santa Rosa Island of Channel Islands National Park has experienced severe biological invasions from introduced plant species since the 1800s, when non-native ungulates were first brought to the island for grazing. Once governed by coastal sage scrub and native perennial grasses, the landscape of Santa Rosa Island is now defined by the exotic annual grasses that critically reduced habitat for many endemic species now considered threatened or endangered. After 150 years of grazing the island, cattle were removed in 1998, eliminating the frequent disturbance regime necessary for many alien plants' persistence. The exotic species of Santa Rosa Island were surveyed in 1998-1999 at the time of removal to provide a baseline distribution and abundance map for future study. Through the use of these 1998-1999 alien plant distribution and abundance mappings paired with life history traits for high priority alien plants, 17 target weed species were placed into prediction persistence guilds of (1) decreasers; (2) persisters; (3) increasers. These predictions were tested in summer 2005 by revisiting some of the same sites mapped in 1998-1999 to determine if distributions of these target species have changed since cattle removal. These results were compared to annual vegetation monitoring results of species abundance for increased accuracy of species abundance measurements. Results from the 2005 surveys and annual monitoring indicate that species abundances and distributions of the 17 target weed species have changed since the removal of cattle in 1998. Disturbance dependent annual exotic plants species such as Xanthium spinosum decreased as anticipated by the persistence predictor guilds while many perennials and hardy annuals increased. Native perennial grasses and native shrubs demonstrated increasing trends while exotic annual grasses appear to be decreasing. The results of this study provide site- and species specific ecological knowledge that will inform an island-wise management plan for Channel Islands National Park and serve as a guide to other natural areas seeking cost-efficient restoration strategies for biologically invaded areas where disturbance has been removed.

DECLINE OF NORTHERN LEOPARD FROGS IN NORTHERN ARIZONA

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Along with many other amphibian species in western North America and other parts of the world, northern leopard frogs (*Rana pipiens*) have experienced marked declines over the last 40 years, and are now considered a species of conservation concern by State and Federal agencies in Arizona and the Southwest. Historical survey data shows that northern leopard frogs were formerly widespread and common in the area. Beginning in the 1970's, however, the species began to decline and disappear from many sites. In recent surveys of Grand Canyon and Glen Canyon, northern leopard frogs were found at only 12 of 30 sites where they formerly occurred. Populations persist in scattered areas of northern Arizona, but only one or two sizeable metapopulations remain. Most remaining sites are largely or completely isolated from one another. Loss of local populations has prompted Arizona Game and Fish Department and U.S. Fish and Wildlife Service staff to begin work to establish refuge populations. We are initiating a survey of known sites (sites where frogs were found in the past) and other areas of potential habitat throughout northern Arizona. In addition to documenting current distribution and population status of the frogs, we will collect and analyze genetic material from populations to assess genetic isolation and recent population bottlenecks. This analysis may be crucial in understanding current and likely future population trends and long-term viability of remaining populations. Assessment of habitat data from areas supporting northern leopard frogs will provide the basis for habitat improvement efforts, and possible restoration of the species to sites where it has been lost. As field survey work begins, we are seeking information on possible leopard frog sightings, and other information that will help us complete a comprehensive survey, from land managers, wildlife professionals, and the interested public.

REDEFINING THE WILDLAND-URBAN INTERFACE AS AN ECOLOGICAL CONCEPT

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"Wildland-Urban Interface" (WUI) areas have become the focus and priority of current fire policies in the United States. Hundreds of Community Wildfire Protection Plans (CWPPs), as mandated by the Healthy Forest Restoration Act of 2003, have begun to delineate WUI boundaries on the ground, prioritizing WUI areas for hazardous fuels reduction treatments—essentially turning a social-political construct into a physical reality, with potentially major ecological consequences. Despite the broader ecological significance of the WUI, it has remained almost exclusively a fire-centric concept. This study includes a comparative analysis of WUI delineations, based on existing legislation, as they have been applied through CWPPs in the Southwest. Preliminary estimates for Arizona's 2-million acre western Mogollon Plateau region indicate a high degree of variability, with WUI areas encompassing 8% to over 25% of the landscape, depending on the decision criteria applied. Using a GIS-based approach, we demonstrate the potential ecological significance of the WUI delineation process and consider the impacts on Mexican Spotted Owl and Northern Goshawk habitat. Ultimately, WUI areas offer a unique opportunity to integrate biodiversity conservation, restoration and urban ecology, and fire hazard reduction; they can be merely an extension of our urban footprint, or alternatively a redefinition of our relationship with the surrounding landscape.

CLIMATE MODELING AND PROJECTION IN SUPPORT OF SOCIETAL IMPACTS ASSESSMENTS

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The need to provide climate projections that support societal impacts assessments is increasingly recognized in the climate modeling community. This recognition has led to efforts to produce climate projections with finer resolution in both space and time. In addition, climate modelers recognize the need to quantify uncertainties in climate projections, and are developing methodologies to do this. This talk will discuss these issues, and show examples of new climate projections that are designed to be used as the basis of societal impacts assessments. I will also list specific sources of climate projections that are suitable for societal-impacts studies.

INSTITUTING THE HYDROCLIMATIC INDEX IN MONITORING DROUGHT ACROSS THE COLORADO RIVER BASIN

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In the western United States drought unfolds slowly over months, and thus it affords time for monitoring, reaction, and mitigation of the potential impacts. Efforts to monitor and portray drought status are hampered, however, by reliance on indices that contain regional biases and limited relationship to the multiple dimensions of drought. The index preferred by most climatologists today only accounts for precipitation, ignoring one-half of the hydrologic equation – the temperature-driven climatic demand for water. This is a critical problem in the Southwest, where evaporative loss dominates the hydrologic budget during summer; thus, despite comparable seasonal totals, summer precipitation is rendered much less effective than winter precipitation. Presented here is the Hydroclimatic Index – a recently derived drought monitoring tool that represents the contrast in natural hydroclimatic supply and demand, can be used to monitor the different dimensions of drought, allows for direct comparison of conditions within different climate types, and is transparent to stakeholders. The Colorado River Basin has been the focus for development of the Hydroclimatic Index, but the method is universally applicable. The Index is ultimately slated to be handed off to the Arizona Drought Monitoring Committee, made available through the United States Drought Portal as part of the National Integrated Drought Information System, and used in research focusing on drought variability, drought forecasting, and climate change-drought scenario building.

FACTORS INFLUENCING EXOTIC SPECIES RICHNESS AND ABUNDANCE WITHIN PONDEROSA PINE FORESTS NEAR FLAGSTAFF, ARIZONA

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We analyzed an extensive multivariate dataset collected in 2003 to elucidate and explain patterns of exotic species richness and abundance using geomorphology, soils, and vegetation data collected from 66 500-m^2 plots within *Pinus ponderosa* forests in a 110,000-ha landscape in northern Arizona. We utilized an existing ecosystem classification that delineated 10 ecosystem types for the 66 plots from multivariate analyses of geomorphology, soils, and vegetation data. Exotic species richness differed among ecosystem types. Exotic species richness per square meter was over 5 times greater in treeless basins than the average exotic richness within more forested habitats. Aspen-dominated sites with high organic N and C had the second greatest exotic species richness with a mean of 1.0 exotic species/ m^2 subplot, whereas the mean across all plots was 0.5 species/ m^2. In contrast, sites with black cinder soils containing little understory cover were least invaded, with an average of only 0.2 species per 500 m^2 plot. Among soil characteristics, gravel and rock content, soil type, and pH were the greatest predictors of exotic richness. Exotic species richness was not directly related to soil nutrient content (total C and N), which differs from previously published analyses of the entire plant community. Exotic species richness was predicted by and often had a positive relationship with native species richness. We found that exotic species presence varied with soil and plant community variables, which were synthesized by the ecosystem classification.

A CLIMATE CHANGE VULNERABILITY ASSESSMENT FOR BIODIVERSITY IN NEW MEXICO: RECENT CLIMATE DEPARTURES & CONSERVATION IMPLICATIONS

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While there is consensus that climate change will affect species and ecological systems, there is a lack of practical information for conservation practitioners and managers. The Nature Conservancy in New Mexico recently initiated an assessment in three parts: (1) analysis of recent changes in climate (2) development of future conservation planning and management scenarios, and (3) identification of adaptation strategies to ultimately facilitate conservation of biodiversity and ecosystem services. To analyze recent changes in regional climate we used spatially explicit meteorological data (PRISM) to map climate anomalies from the 1961-1990 baseline climatology. Comparative time periods included a 30-year long-term mean (1976-2005), a non-overlapping 15-year mean (1991-2005), and the recent drought period (2000-2005). Consistent, directional departure patterns of warming were apparent, while precipitation patterns were variable. Taken together, 70% of the region experienced hotter-drier conditions during the 2000-2005 timeframe, a period of severe drought resembling predictions of future regional climate. The remainder experienced predominantly hotter-wetter conditions. Areas of the region that experienced particularly consistent hotter-drier patterns included the Colorado Plateau and the Bootheel-Borderlands. To evaluate vulnerability of major habitat types (MHTs) and drought-sensitive species of conservation concern to current and future climate change, geographic occurrence data were analyzed for exposure to the 2000-2005 climate anomalies. Grasslands comprise 60% of the region yet showed differential exposure to climate departures, with a majority of semi-arid grasslands experiencing hotter-drier conditions and a majority of Great Plains grasslands experiencing hotter-wetter conditions. The remaining MHTs (forest, desert, and shrubland) experienced predominantly hotter-drier conditions. Nearly 70% of drought sensitive species occurrences, analyzed by taxonomic group (plants, mammals, and amphibians), were associated with MHTs experiencing hotter-drier conditions. This historical retrospective and rapid assessment approach enables managers to take action now instead of focusing on the uncertainty that is implicit to projections of future climate change. These results also provide a baseline for generating future management and adaptation scenarios in the next phases of our project.

NEST SITE SELECTION OF THE COMMON BLACK-HAWK (Buteogallus anthracinus): CONSERVATION IMPLICATIONS

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An estimated 85–98 % of Arizona's native riparian habitat has been destroyed or severely degraded since Euro-American settlement, putting native riparian habitat obligates at risk. The Common Black-Hawk (Buteogallus anthracinus) is a riparian obligate that breeds in the southwestern United States and is currently considered at risk throughout much of its range. Breeding Common Black-Hawks require large, structurally complex riparian habitats consisting of cottonwoods (Populus spp.), Arizona sycamore (Plantanus wrightii) and willows (Salix spp.). This species is known to construct their nests mainly in large cottonwoods and sycamores, yet few studies have attempted to quantify the decisive factors involved in nest site selection. We discuss what those nest site characteristics are in Arizona and also show that this species not only requires riparian gallery forests for nesting, but it also chooses the largest trees available to nest in. In addition, we discuss the implications of restoring and monitoring native riparian habitat in relation to Black-Hawk conservation in the southwestern United States, including the southern Colorado Plateau.

SHIFTING LANDSCAPES IN MOUNTAIN ENVIRONMENTS: HOW CLIMATE CHANGE HAS INFLUENCED GLACIER NATIONAL PARK

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Evidence that the mountain landscapes of Glacier National Park are responding to climate change abounds. Alpine glaciers, as iconic landscape features, are disappearing rapidly with some glaciers losing one half of their area in five years. A model developed in the 1990s to predict future rates of melt has proved too conservative when compared to recent measurements. The largest glaciers in Glacier National Park are almost 10 years ahead of schedule in their retreat. The cascading ecological effects of losing glaciers in high-elevation watersheds includes creating new habitat for arctic poppies (Papaver radicatum) and shifts in distribution and dominance of temperature-sensitive stream macroinvertebrates as stream volume dwindles (or disappears) in later summer months and water temperatures increase. Critical spawning areas for threatened bull trout (Salvelinus confluentus) will be lost without the consistent supply of cold water that melting snow and ice provide and raise management questions regarding the efficacy of recovery efforts. Snowpacks are documented as becoming smaller and melting earlier in the spring, facilitating the invasion of subalpine meadows by trees and reducing habitat for current alpine wildlife. Trees have been able to invade alpine tundra during the last 20 years and are now found in places that have been tree-free for at least a millennium. Even rates of vital ecosystem disturbances, such as periodic snow avalanches that clear mountain slope forests, have been shown by tree-ring studies to be responsive to climatic trends and are likely to become less prevalent. Because avalanche paths are preferred feeding areas for grizzly bears (Ursus arctos) there will be less habitat for these and other animal populations. Ecosystem models suggest larger, more frequent wildfires at mid-elevations but faster forest growth at higher elevations. All these shifting landscapes will have profound implications for ecosystem services to people in the western U.S.

INCORPORATING GENETIC DIVERSITY INTO RIPARIAN RESTORATION: THE IMPORTANCE OF MERGING RESTORATION WITH LANDSCAPE LEVEL EXPERIMENTS

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Our studies of cottonwoods show that diverse species from microbes to vertebrates are sensitive to individual plant genotypes and that the application of genetics to restoration can have major impacts on biodiversity and the success of any restoration effort. Our studies have resulted in three major findings. 1. Genetic analyses of restoration sites and wild populations show that we are currently failing to mimic the genetic structure of natural stands in our restoration plantings. This may have negative community consequences. 2. Biodiversity is positively correlated with genetic diversity in cottonwoods. For example the genetic diversity in stands of cottonwoods explains about 60% of the variation in the diversity of an arthropod community composed of 207 arthropod species. Thus by altering genetic diversity of the trees used in restoration we may influence the diversity of insects and the organisms dependent upon them for survival (e.g. birds and mammals). 3. Incorporating collaborations with both basic and applied goals among diverse funding agencies and institutions allows for a majoe leveraging of funds and a rare opportunity to merge the latest scientific developments with current management practices.

FINDING GAPS IN THE PROTECTED AREA NETWORK IN THE COLORADO PLATEAU: A CASE STUDY USING VASCULAR PLANT TAXA IN UTAH

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About 18% of the Colorado Plateau region of Utah is currently under some form of permanent protective status. Most of these protected areas, however, were established for their scenic, cultural, or recreation value rather than conservation of biological diversity. I used Gap Analysis methods to determine how well vascular plant species are represented in the existing protective network and to identify types of species, habitats, and geographic areas that are unprotected. At present 1030 plant taxa (36.9%) of the 2790 known from the Utah section of the Colorado Plateau are not found within formally protected areas. Of these, 558 (54.2%) are either plateau endemics or otherwise rare in Utah and 472 (45.8%) are widespread or non-native. By comparison, 584 (33.2%) of the protected taxa are plateau endemics or rare species and 1176 (66.8%) are widespread or non-native. About 52% of the 728 species of concern tracked by the Utah natural heritage program occur outside protected areas in the Colorado Plateau. Species from high elevation habitats (especially alpine, spruce-fir forest, and aspen woodlands) and wetlands are the most likely to be unprotected. Important areas of high species richness or local endemism are also not adequately represented, including the San Rafael Swell, Arapien Shale badlands, Aquarius Plateau, Uinta Basin, and the La Sal, Abajo, Henry, and Tushar ranges. The protective network needs to be expanded in these and other areas with high concentrations of rare species to ensure that the full complement of the native biological diversity of the Colorado Plateau in Utah is conserved.

THE EFFECTS OF A RESTORATION THINNING ON CARBON STOCKS IN A NORTHERN ARIZONA PONDEROSA PINE FOREST

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Vast areas of ponderosa pine (Pinus ponderosa Dougl. ex Laws.) forest in the western United States have become unnaturally dense because of relatively recent land management practices that include fire suppression and livestock grazing. Global climate change has focused attention on the carbon storage in forests. An unintended consequence of fire suppression has been the increased storage of carbon in ponderosa stands. Forest restoration treatments reduce standing carbon stocks while releasing carbon through the combustion of fuel in logging machinery, burning slash, and the decay of logging slash and wood products. These reductions and releases of stored carbon must be

compared to the risk of catastrophic fire burning through the stand and releasing large quantities of carbon to the atmosphere to more fully understand the costs and benefits – in carbon terms - of forest restoration strategies. This study measures the change in carbon stocks in a ponderosa pine stand due to a restoration thinning treatment. The total pre-treatment above-ground carbon stock was 48,880 kg C ha-1 and the post-treatment stand had 36,420 kg C ha-1. 8,240 kg C ha-1 was removed from the site and sold to the wholesale firewood market, 71 kg C ha-1 was released from the combustion of fuel in harvesting operations and trucking, and the burning of slash released 4,140 kg C ha-1. We estimated that in a stand-replacing fire, the restored stand would release 2,410 kg C ha-1 less to the atmosphere than the untreated stand. However, the restoration treatment resulted in stand structural changes that make the stand less likely to support a crown fire and therefore more likely to avoid the carbon releases associated with crown fires, even under extreme fire conditions.

REVISITING TRENDS IN VEGETATION RECOVERY FOLLOWING PROTECTION FROM GRAZING, CHACO CULTURE NATIONAL HISTORIC PARK (CCNHP)

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Livestock grazing has serious ecological consequences in the arid Southwest, leading to management dilemmas that become more problematic with global climate change projections. Management can be illuminated by long-term monitoring studies, especially under different climatic conditions. We revisted sites in CCNHP where we had previously analyzed historic livestock grazing impacts (1999-2000) under drought conditions. Two ages of grazing exclosures were created by fencing projects in the 1930s and 1990s such that long-term protection (>60 years of exclosure), recent protection (≤12 years), and current grazing were immediately adjacent at six sites of varying substrates and elevation. We compared plant species richness, cover of biological soil crusts, shrub density, vegetative cover, and plant community composition at these six sites. Our recent resurvey (2006) was during higher precipitation and temperatures; results were similar to those from the earlier drought except for higher forb density and cover in all grazing treatments. Plant species richness was significantly greater under long-term protection at all six sites. The cover of black biological soil crusts was significantly higher under long-term protection at three of the four sites monitored; in the fourth, cover was highest under short-term protection. Crust cover was six times higher than in the currently grazed treatment on Menefee Shales at Kin Klizhin. These results affirm our earlier assertion that recovery of soil crusts can proceed rapidly with protection from grazing. Post-grazing trends were variable at the six sites. For example, at Fajada Gap (a grassland) there was a significantly greater shrub density and cover in the currently grazed treatment than under protection. In contrast, at Mockingbird Headwater (a low shrubland) there was a significantly greater shrub density and cover in protected treatments. Thus, as previously documented, plant community structure re-established itself differentially with protection from grazing depending on the inherent biotic potential of each site.

BUNCHGRASS TRANSPLANTS FOR SOUTHWESTERN PONDEROSA PINE UNDERSTORY COMMUNITIES

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Land managers face several challenges in the restoration of southwestern ponderosa pine understory communities following severe wildfire or anthropogenic changes in the soil profile and/or plant cover. While reseeding with native species is a commonly accepted practice, it has two possible negative consequences: seed contamination with invasive exotics and contamination of the local population gene pool with immigrant genes. In an effort to avoid the latter problems, we tested the possibility of vegetative, greenhouse propagation of three native bunchgrasses, *Elymus elymoides,, Muhlenbergia montana,* and *Festuca arizonica* and one native rhizotamous grass, *Bouteloua gracilis*. One hundred small clumps (2-3 cm) of each species were cut from existing plants growing in the ponderosa pine understory and transplanted into individual pots filled with commercial sterile topsoil. At the end of four months, survival ranged from 85-98% for the three bunchgrass species and was 99% for the rhizotamous *B. gracilis*. The two species with the highest survival, *B. gracilis* and *F. arizonica*, also had the greatest number of high vigor pots and the lowest total number of inflorescences produced. These results point to the feasability of field trials, the next step for this research.

EFFECTIVENESS OF LITTER REMOVAL IN PREVENTING MORTALITY OF YELLOW BARKED PONDEROSA PINE IN NORTHERN ARIZONA

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Removal of deep litter and duff from the base of mature southwestern ponderosa pine trees is commonly recommended to reduce mortality following prescribed burns, but experimental studies that quantify the effectiveness of such practices in reducing mortality are lacking. Following a pilot study, on each of four sites in northern Arizona we monitored 15-16 sets of 8 matched trees (N=488) on areas designated to be burned and adjacent unburned sites and randomly assigned one of four litter removal treatments: 1) to 9" with raking, 2) to 9" with a leaf blower, 3) to 40" with raking, and 4) no litter removal. By 2-3 years post burn, no trees had died due to the fall prescribed burns, but litter removal prevented most cambial kill and bole char. Litter removal to 9" was as effective in preventing cambial kill and bole char as removal to 40" and there was no difference between removal by raking versus leaf blowing. These results suggest that litter and duff removal is not needed to prevent ponderosa pine mortality following fall prescribed burns, but removal to 9" is adequate to prevent spots of cambial kill or bark char.

IMPORTANCE OF JUNIPER *(JUNIPERUS OSTEOSPERMA)* TO BIRDS NESTING IN PIÑON-JUNIPER WOODLANDS IN NORTHWEST NEW MEXICO

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Piñon (Pinus spp.)-juniper (Juniperus spp.) woodlands are common throughout the interior west of United States, yet relatively little is known about the breeding biology and habitat selection of many members of its avian community. Here we report on a previously unknown importance of juniper to the nesting birds within this woodland. The study was conducted during the summers of 2005-2007 in piñon (Pinus edulis)-juniper (Juniperus osteosperma) forests within the Bureau of Land Management's (BLM) Rattlesnake Canyon Habitat Management Area, San Juan County, in northwest New Mexico. We found a total of 400 nests of 35 species. Of 335 nests in trees, 280 were in junipers, and the selection of juniper as a nest tree was significantly higher than expected from the piñon-juniper ratio (1:1.49). Among 56 cavity nests in trees, 45 were in juniper, which is also higher than the expected piñon-juniper ratio. Results from 2005-2006 suggest that the juniper density and piñon-juniper ratio may also be important to the avian community – sites with low nest densities (mean nest density per year ≤ 5 nests per site) had a significantly lower proportion of junipers in the piñon-juniper ratio (1.03:1) than the higher nest density sites (1:1.67, mean nest density per year > 5 nests per site). High nest density sites also had a significantly lower proportion of dead piñons than the low nest density sites, suggesting that the avian community may avoid openings caused from piñon mortality where predation and parasitism risk may be higher. These findings differ from previous studies, which have suggested that a presence of piñon is among the most important habitat features to the piñon-juniper avian community. The unequivocal importance of junipers to birds nesting in piñon-juniper woodlands should be considered when managing this habitat, particularly with regards to thinning.

USING ORAL HISTORIES TO DOCUMENT ENVIRONMENTAL CHANGE IN NORTHERN ARIZONA

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Oral histories represent an important but often overlooked source of information about change over time, including environmental change. Since 2005, the Ecological Oral Histories project at NAU has obtained digital video narratives from over 20 long-time residents of northern Arizona in order to document first-person experiences of environmental change that would otherwise likely not be included in the scientific or historical record. Narrators have discussed changes (or, in some cases, stasis) in such quantities as wildlife populations, vegetation patterns, the spread of nonnative species, water availability, weather patterns, land uses, and human perspectives on the land. Collectively, the narratives present an overview of broad-scale trends that generally coincide with other lines of evidence about environmental change. Individually, they may present opportunities to analyze ecological change at a finer scale than is often possible with other methods; for example, they allow ecologists to understand when the replacement of native riparian species took place along specific drainages, or whether hydrological changes have occurred in particular watersheds. The narratives also constitute a publicly available archive whose value will continue to increase over time. This presentation will provide an overview of lessons learned to date from the project, and assess the lasting value of the data obtained.

TRACKING THE VERTICAL GROWTH OF TRAVERTINE DAMS FOLLOWING THE RESTORATION OF FLOW TO FOSSIL CREEK, ARIZONA.

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Decommissioning of a diversion dam on Fossil Creek, Arizona, has restored a steady baseflow of $CaCO_3$-rich spring water, triggering rapid growth of channel-spanning travertine dams. These natural travertine structures create a step-pool morphology that provides important aquatic habitat. Biotic processes in turn, can catalyze travertine deposition and vertical growth in travertine dams, potentially accelerating the recovery of a once threatened ecosystem. Here we report preliminary results from an ongoing study that takes advantage of this opportunity to study the complicated set of feedbacks between the biotic and abiotic processes that control the deposition of travertine. We hypothesize that biotic factors, such as solar insolation and algal growth, microbial activity, and trapping of leaf litter and large woody debris, are the dominant influences on the rate of travertine dam growth. To measure change in travertine dam height, we imbedded ~250 magnets into nascent travertine structures, beginning in the summer of 2006, over a 12km stretch of river immediately downstream from the diversion dam. We use a magnetometer to measure the change in intensity of the magnetic field at the surface, from which we can calculate the thickness of travertine that has accumulated above the magnet. This method allows very precise measurements without disturbing the travertine surface or affecting growth rates. We installed magnets in sites that display a wide variety of both abiotic and biotic attributes. In addition, we chose sites spaced to resolve spatial trends along the entire 12km stretch, at a smaller 500m reach scale and within individual riffle sections less than 100m long. Preliminary results suggest that the travertine is growing vertically ~3cm/yr on average with individual measurement ranging between -20 and 30cm/yr. Furthermore, the high variability at the <100m riffle scale obscures any downstream gradient in travertine growth rates.

DESIGN, LOCATION AND TRAFFIC VOLUME: A CONCEPTUAL MODEL OF HIGHWAY EFFECTS ON WILDLIFE

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We develop a conceptual model that describes how individual wildlife species potentially vary in their response to roadways depending upon species-specific responses to three attributes of the roadway itself: 1) overall design (number of lanes, fencing, etc), 2) the roadway location on the landscape relative to the habitat needs of that species and 3) the volume and temporal pattern of traffic. Species response to overall highway design likely depends on their innate level of neophobia (fear of unfamiliar objects) and their physical ability to transit through the design. Within and across highway designs, species will differ depending upon the location of the roadway relative to important species-specific habitat features, with motivation to cross highways related to the importance of habitat features highways subdivide. Finally, within any highway design, species will vary in both their response to traffic volume on the roadway and in how effectively they can respond to the temporal pattern of that traffic. For example, given that many roadways experience higher traffic volumes during the day, diurnal species are likely to be more severely impacted by the same road that has a negligible impact on nocturnal species simply because of this temporal variation in traffic volume. Incorporating all three aspects of wildlife responses to roadways will be necessary to effectively predict and mitigate for the effects of highway construction and expansion on wildlife species.

PROJECTED CLIMATE CHANGES AND THEIR POTENTIAL IMPACTS ON NATIVE AMERICAN LANDS OF THE SOUTHERN COLORADO PLATEAU

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Projected climate changes for the Southern Colorado Plateau are likely to increase environmental stresses on the already vulnerable landscapes and surface water resources of Native American lands. Paleoclimate records for the region document high year-to-year precipitation variability, as well as persistent droughts lasting two decades or longer. Such records also hint at a connection between increased aridity and higher temperatures. Projections from coupled global climate models used in the IPCC Fourth Assessment Report (AR4) suggest increased aridity in the Four Corners area and Upper Colorado River Basin, as well as large increases in temperature in all seasons, if we do not substantially reduce greenhouse gas emissions. Among the suspected mechanisms for the aforementioned changes are a northward movement of winter storms as they enter North America and increasing atmospheric subsidence (high pressure, dry conditions) during the winter half of the year in the Southern Colorado Plateau. This presentation will highlight results from statistical downscaling of IPCC climate model output for the Southern Colorado Plateau, developed as part of a National Institute for Climate Change Research project housed at Northern Arizona University. Environmental implications include potential shifts in species distribution, increased likelihood of fire, longer growing seasons coupled with increased summer temperature stress, and decreased runoff in surface streams.

DOWNSCALED CLIMATE CHANGE PROJECTIONS FOR THE SOUTHERN COLORADO PLATEAU

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This presentation examines Southern Colorado Plateau climate change projections developed specifically for a National Institute for Climate Change Research project on potential regional vegetation changes for individual species. The projections were developed from the average of a subset of IPCC Fourth Assessment Report (AR4) coupled global climate models. The models were selected based on their ability to portray 20th-century pre-monsoons seasonal dryness and summer monsoon precipitation for the Southern Colorado Plateau region. Data were statistically downscaled to a spatial grid specified by the Parameter-Elevation Regression on Independent Slopes Model (PRISM) database of the Spatial Climate Analysis Service of Oregon State University. We compare these results with coarse spatial scale projections from (a) a 14-model average from the IPCC AR4, (b) an 18-model average from the Program for Climate Model Diagnosis and Intercomparison **(**PCMDI**)** database at the Lawrence Livermore National Laboratory, (c) projections from individual models, and (d) results from recent peer-reviewed literature. In general, average and individual projections show a high likelihood of almost monotonically increasing regional temperatures; precipitation projections show a likely decrease in winter precipitation. Interpretations of summer precipitation projections are less clear, due to a wide range of skill in simulating the North American monsoon and related intraseasonal variability.

MAPPING ECOLOGICAL SITES FOR LONG-TERM MONITORING IN NATIONAL PARKS

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The Northern Colorado Plateau Inventory and Monitoring (NCPN) program of the National Park Service is tasked with long-term (>50 yrs) monitoring of upland systems in 16 park units throughout the Colorado Plateau. The use of a relatively immutable, spatially explicit sampling frame is key to the success of this monitoring effort. Ecological sites were chosen as the sampling frame because they are based on relatively static physical factors (soil depth and texture, landform, geology), as well as climate and potential vegetation. Existing NRCS (Natural Resources Conservation Service) soil surveys map soil-component complexes and link components to ecological site type. However, spatially explicit mapping of ecological sites is not provided. We evaluated two methods for explicit mapping of ecological sites in Canyonlands and Capitol Reef National Parks. For both methods, soil map units containing targeted ecological sites were identified, several hundred 1-ha plots were randomly selected, and each plot was assigned to an ecological site in the field following NRCS ecological site descriptions. Ecological

site type and biophysical attributes of each plot extracted from color DOQQs, DEMs, and maps of soil, vegetation, and geology were used to train a spatial-pattern recognition model, and to generate a Classification and Regression Tree (CART) model. In both approaches, the resulting model was applied to soil map units to produce explicit maps of ecological site types. Independent data were collected for accuracy assessment. Classification efficiency was similar for the pattern recognition and CART models, and ranged from 60 to 71%, depending on ecological site. Further evaluation involved simulating the probability of selecting locations of an ecological site using NRCS soil-component proportions. Compared to simulated efficiencies, predictive mapping methods were up to twice as efficient. Both predictive methods provide reliable mapping of ecological sites, and can be easily applied throughout the Colorado Plateau.

EFFECTS OF SPACING AND IRRIGATION ON SEED PRODUCTION OF NATIVE PERENNIALS

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Human activity and fire suppression on the Uncompahgre Plateau (Plateau) in western Colorado have led to encroachment by Juniper into winter feeding areas of large mammals, leading to population declines. In order to begin restoration of these areas the Uncompahgre Plateau Project initiated its Native Seed Program and identified 50 critical species necessary for restoration work on the Plateau. Native plant seed of six species was collected in 2004, (Junegrass, *Koeleria macrantha;* Muttongrass, *Poa fendleriana;* Sulfur Buckwheat, *Eriogonum umbellatum;* Milkvetch, *Astragalus eastwoodiae;* Blue Flax, *Linum lewisii;* and Bluestem Penstemon, *Penstemon cyanocaulis*) germinated in a greenhouse and transplanted into field plots in spring of 2005 in a spacing x irrigation study to determine optimal conditions to maximize seed production. The spacing treatments included 45, 60 and 75 cm between plants and irrigation treatments were bi-monthly irrigations until: a) seed set; or b) fall dormancy (except for approximately 10 – 14 days near seed maturation); with three replications. Plots were 9.0 m x 3.8 m and included four rows on 0.76 m centers. Irrigation timing used soil moisture monitoring devices attached to a data logger and placed at 15, 30 and 45 cm. When soil moisture reached approximately -122 kg m^{-2}, at the 30 cm depth, irrigations were for 4 – 6 hours, depending on climate conditions, using buried drip tape with an irrigation rate of 75 l hr^{-1} 30 m^{-1}. Results and observations show that the longer irrigation treatment encouraged more robust fall plant growth, possibly leading to the higher seed yields realized in 2007. Generally, the 60 cm spacing yielded higher on a per plant basis than the other spacings. These results indicate that full season irrigation and 60 cm spacing appear to be the better conditions for maximizing seed production in these native perennials.

WHAT'S DYING IN SOUTHERN CALIFORNIA'S MOUNTAINS: REPEAT SURVEYS AND MICROMETEOROLOGICAL MEASUREMENTS ALONG AN ELEVATION GRADIENT

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Southern California supports many ecosystem types, including grassland, coastal sage shrubland, chaparral shrubland, broadleaf evergreen forest, mixed conifer forest, subalpine forest, pinyon juniper woodland, cactus scrub, and Sonoran desert. Southern California's plant communities experienced dramatic mortality during 2002-04, a period that followed a series of unusually dry years. We revisited a transect of vegetation plots along an elevation gradient that was first surveyed in the 1970s to better quantify the effect of mortality on vegetation distribution in the San Jacinto and Santa Rosa Mountains. The cover-weighted mean elevation of 9 of the 10 most widespread species increased, with an average rise of 65 m. For example, the cover-weighted elevation of white fir increased from 2421 m in 1977 to 2518 m in 2007. The increases in elevation were independent of altitude and the shifts do not appear to have resulted from changes in fire frequency or air pollution. The climate in the area warmed by ~0.8°C, the proportion of precipitation falling as snow at mid elevation decreased by ~40%, and the interannual precipitation variability doubled from 1949-78 to 1979-06. The changes in plant distribution appear to reflect rapid responses to shifts in climate. We have been using the eddy covariance technique since early 2006 to measure the exchanges of CO_2, water vapor and energy by six different types of vegetation along the elevation gradient. 2006-07 was almost as dry as 2001-02, raising the possibility of further plant mortality in the coming year. All of the eddy covariance sites were exhibiting stress as of August 2007, with markedly reduced rates of gas exchange. It is still too early to tell whether the eddy covariance measurements are picking up the early stages of another round of drought-induced mortality and a further upslope shift in species distribution.

VEHICLES IN STREAMS: EFFECTS OF DRIVING THROUGH POOLS ON *BUFO WOODHOUSII* (WOODHOUSE TOAD) EGG SURVIVAL

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Effects of roads on species are varied, ranging from fragmentation and destruction of habitat, to providing corridors for invasive species. Roads in desert streams and riparian zones may have greater impacts since most desert organisms use riparian ecosystems for at least some part of their lives. Off-road vehicle use is increasing on the Colorado Plateau; land managers face difficult decisions in balancing recreation demands with protection of sensitive habitats. Salt Creek in Canyonlands National Park (CANY) contains the most extensive riparian ecosystem in the park besides the Colorado and Green River corridors. It was used extensively by livestock prior to 1964, with a four-wheel drive (4WD) road from at least the late 1940's; the upper end was gradually closed, only 20 km were still open in 1998. In July 1998, the upper 14 km (8.5 mi) of road was closed; approximately 6 km (3.5 mi) of the cañon remain open to vehicle use. The road crosses Salt Creek over 60 times, and frequently the stream channel *is* the road. Since 2000, studies of amphibian population trends and arthropod community structure have been conducted in Salt Creek, with sites in the open-, closed-, and no-road segments of Salt Creek. Known numbers of *Bufo woodhousii* eggs were placed in pools in road crossings of the open road. A vehicle was driven through the pool once at low speed and the

number of eggs remaining in the pool were counted. A single pass through a pool significantly reduced the number of eggs recovered from the pool immediately after the pass.

COMMUNITY STRUCTURE OF FLIES IN THE GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT: DIFFERENCES IN OCCURRENCE AND ABUNDANCE AT TWO SITES, SPRING 2000 AND SPRING 2005

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Insects perform many important ecosystem functions such as herbivory, decomposition, and pollination. Sustainability of natural systems depends upon the continued performance of these functions. Insect diversity may provide redundancy of functions and thus resilience to perturbations, yet disturbance can affect insect communities and thus ecosystem condition. Few ecological relationships involving insects have been described on the Colorado Plateau. More can be learned about the role of insects in ecosystem functioning by monitoring changes in insect community structure in response to changes in disturbance regimes. Retirement of grazing permits in parts of the Grand Staircase-Escalante National Monument provided an opportunity to track changes in arthropods following the removal of livestock, and to compare arthropod communities in grazed and retired systems. The Diptera were consistently one of the numerically dominant groups at sampling sites in the Gulch and Steep Creek over the course of this study (fall 1999-spring 2006). Here we examine differences in composition and abundance of flies at the family levels on alluvial bench environments in Steep Creek (ostensibly retired from grazing in 1999) and The Gulch (still open to grazing), comparing community structure of spring fly faunas a the two sites from 2000 and 2005 and seasonal differences from spring to fall 2005. Thirty nine families are represented in samples, with 22-27 families at a given site in a given sampling period. Some flies showed similar changes at both sites, such as the Sciaridae which increased from a few individuals to well over 100 at each site from spring 2000 to spring 2005. Increases at C2 were coupled with decreases at G1 for some families, such as the Anthomyiidae, while the opposite pattern also occurred, e.g., the Sarcophagidae. Ecological implications of these changes over time and differences in space will be discussed.

SPECIES SELECTION AND THE OUTCOME OF A 28-SPECIES REVEGETATION SEEDING ON A SONORAN DESERT BURN

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Wildfire in the Sonoran Desert is a fairly recent phenomenon. Desert wildfires are typically associated with changes in fuel characteristics induced by past and present land management practices, such as livestock grazing. Invasions by exotic grasses and expansions in non-palatable, oily shrub species have increased fuel loads, boosting fire frequency and intensity when combined with multiple ignition sources. We have much to learn about how to most effectively manage and restore these desert burns. Active restoration of burned sites requires a team approach with adequate funding. Species selection, rainfall patterns, drainage, crust texture, seed predation, and herbivory appear to be the primary ecological determinants of which species become established during revegetation efforts. We discuss a case study of revegetation efforts at Cave Creek Regional Park in the upper Sonoran Desert. On June 1, 2005, a 1.5-ha fire entered the park from adjacent private land. Fire managers indicated that the fire burned "hot," killing most of the perennial plants within the burn perimeter. The bare soil was exposed to erosive forces and to potential invasion by exotic plants. We hydro-seeded this burn with 28 native species, including a diverse array of shrubs, forbs, and grasses. Twenty-one months after seeding, desert senna (*Senna covesii*) was the most successful species, with a frequency of 82% (based on 22, 10-m^2 plots) and a relative cover of 19%. Three other species also established in ≥ 50% of plots after 21 months. Several seeded species, including desert senna (which flowered only seven weeks after seeding) and purple threeawn (*Aristida purpurea*), were observed with seed heads during the study. Although precipitation was only 67% of normal for 21 months following seeding and 71% of species established in < 10% of plots, we consider the seeding a short-term partial success because of the subset of highly successful species.

DEVELOPMENT OF NATIVE PLANT MATERIALS FOR NATIONAL PARKS: AN INTERAGENCY PLANT MATERIALS PROGRAM

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Since 1989, an interagency agreement between the National Park Service and the Natural Resources Conservation Service has led to an exchange of technical information and the development of park indigenous plant materials, seed /plant propagation technologies and revegetation methodologies. The highly successful program provides assistance to National Parks through NRCS Plant Materials Centers (PMC) to: 1) identify plant species needed 2) collect and process native seed 3) provide high quality custom grown container plants and field production of native forb and grass seed from site specific collections 4) ensure genetic integrity 5) provide technical assistance on site preparation, plant propagation and establishment, weed control, seed collection and processing and invasive species control 6) conduct workshops for park service personnel in subjects of native revegetation, riparian restoration and bioengineering. In the past 18 years the program has: assisted over 45 National Parks in cooperation with fourteen Plant Materials Centers; tested over 1400 native species and developed successful propagation techniques for more than 700 species; produced approximately 35,000 pounds of grass/forb seed and 800,000 tree/shrub seedlings; developed computer tools and a guide to assist in cost estimation, seeding rate/mixture and specification development; an NPS revegetation intranet/internet website. Propagation protocols developed from research by the Park Service and PMCs have been placed on an interagency website (http//nativeplantnetwork.org) for access by agencies, nurseries, seed producers and the general public.

DIFFERENT AGED STANDS INCREASE LANDSCAPE HETEROGENEITY AND SUPPORT GREATER BIODIVERSITY

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We addressed the hypothesis that landscape heterogeneity, in the form of a chronosequence, affects biodiversity. It is widely accepted that landscape heterogeneity leads to increased biodiversity. Heterogeneous landscapes offer a wider variety of microhabitats, microclimates, refugia, resources and thus niches to support more diverse communities than do homogenous landscapes. We examined the specific hypothesis that the arthropod communities differ significantly between stands in a chronosequence of trees. The variation in tree age in a chronosequence inherently increases landscape heterogeneity for arthropods, supporting a more diverse overall arthropod community. We tested this by nondestructively sampling the arboreal arthropod communities in several different aged stands (seven, five and two years old) of Fremont cottonwood (Populus fremontii) planted for habitat restoration. We found that the arthropod communities were significantly different in 1) community composition, 2) species richness, 3) species diversity, 4) evenness, and 5) indicator species. These clear differences indicate that increased landscape heterogeneity leads to increased biodiversity, both directly through supporting increased arthropod diversity, and indirectly by supporting this prey resource important for other vertebrate animals. While the concept of increased heterogeneity supporting increased biodiversity is not novel, finding this link between an arthropod community and a chronosequence of a long-lived foundation riparian tree species is. Because a landscape of mixed stands supports greater biodiversity than monocultures of equal-aged stands, by incorporating varied stand age into restoration designs managers can effectively increase the biodiversity of the dependent community. This may be especially important in threatened ecosystems like the riparian Southwest.

DIFFERENTIATING KARSTS FROM PSEUDOKARSTS IN THE AMERICAN SOUTHWEST

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In the American Southwest, differentiation of karst, pseudokarst, and non-karst often is difficult because of (1) effects of superposition of cavernous karstic and pseudokarstic features, and (2) occurrence of cavities within and beneath alluvium. In April 2007 a selected team investigated features in southern Nevada, southwest Utah, northeast Arizona, and southeast California. Identified were sandstone pockets with inverse spheroidal exfoliation, intra- and sub-alluvial cavities (two of which are clearly karstic while another requires additional study), a large, complex cave formed tectonically along the strike of a monocline in limestone, small dissolution caves and sinks in limestone along the flanks of basalt flows, one linear subsidence presumably along the course of a crevice cave in gypsum, lava tube caves, basalt talus caves within a large crevice and others overlying dissolution cavities in limestone, and a large open vertical volcanic conduit (OVVC) in still unidentified volcanic rock at the summit of Lunar Crater Hill, NV. A small, newly-discovered cave in lithified salt was found to be a complex of tectonic and solutional features. Piping was found to form sizeable caves up to 50 meters long in a variety of poorly consolidated formations. Especially notable were "slot caves" in Cathedral Gorge State Park (NV) which were perceived as analogues of headward- migrating dome pits in limestone. Morphology and extent of piping caves were found to be influenced strongly by distribution and quantity of intercalated gravelly and angular debris and by bedding. Additional field studies are planned for October 2007.

BUILDING AGREEMENT ON AND ESTIMATING THE SUPPLY OF RESTORATION-BASED SOURCES OF SMALL DIAMETER WOOD IN NORTHERN ARIZONA

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Stakeholders across northern Arizona have identified the importance of developing community-based industries capable of utilizing wood fiber harvested to improve forest health and reduce the threat of wildfire to communities. To estimate the availability of wood fiber, primarily from small diameter trees, we combine a landscape-scale analysis of wood byproducts with collaboratively derived restoration treatment scenarios. Our 900,000 ha analysis area includes ponderosa pine-dominated lands within the proclamation boundaries of four National Forests. Consensus-based working sessions using map-based information, ecological modeling, and other technical information are aimed at building ecologically appropriate treatment scenarios across the region. A 20-member working group includes representatives from the US Forest Service, US Fish and Wildlife Service, Arizona Game and Fish Department, Arizona State Forestry, Ecological Restoration Institute, conservation non-governmental organizations, tribes, forest product industries, and city and county management. A public outreach component encourages interested stakeholders to attend working group meetings and provide comments on products. The scenarios developed will clarify the volume of wood fiber by diameter size class deemed by the group to be available for utilization within the study area. Additionally, we will provide recommendations on forest growth models for forecasting increases in wood volume. To support economic development scenarios, we are identifying local wood harvesters within the analysis area and the volume of wood they provide to mills and manufacturers. We have developed volume imputation procedures and a spatial database of landscape features and ecosystem characteristics to support decision-making. The group has removed several categories of lands from consideration as significant sources of wood, including critical wildlife habitat and steep slopes, and has developed management objectives to guide the selection of various levels and types of treatments. Our presentation will summarize progress to date on this project designed to build agreement on wood harvested for restoring fire adapted ecosystems.

FOSSIL CREEK: FOSTERING STEWARDSHIP AND ENGAGING LOCAL RESIDENTS AS PARTNERS

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The long-term health of a restored Fossil Creek ecosystem depends, in part, on the support of local residents and visitors. The goal of this research effort was to document local resident knowledge, attitudes, and perceptions of the Fossil Creek restoration project as potential predictors of their willingness to take on a stewardship role at Fossil Creek. A total of 309 surveys were completed by community residents from Camp Verde, Pine, Payson, and Strawberry, Arizona and 197 surveys were completed by high school students from those same communities. Most of the community residents and high school students were not informed and not involved in the decision process regarding the removal of non-native fish and the removal of the diversion dam to restore full flows to Fossil Creek. Although there was a small percentage who were interested, many of the respondents were not interested in being a member of a volunteer stewardship group (Friends of Fossil Creek for example) that would work with the Forest Service to manage and protect Fossil Creek. By engaging the local communities, the restoration of Fossil Creek will have the best chance of being successful and broadly accepted.

COVARIANCE BETWEEN ECOSYSTEM PROCESSES AND SOIL MICROBIAL COMMUNITY STRUCTURE ALONG THREE MILLION YEARS OF ECOSYSTEM DEVELOPMENT IN NORTHERN ARIZONA

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One of the fundamental questions in soil microbial ecology is whether or not the diversity and structure of microbial communities influence the functioning of terrestrial ecosystems. We used a semi-arid, soil chronosequence within the San Francisco Volcanic Field in northern Arizona to evaluate if soil nutrient cycling processes covaried with the diversity and structure of resident soil microbial communities. As has been found previously in soil chronosequences in more mesic ecosystems, soil phosphorus availability was greatest in younger soils and decreased over the three million year substrate-age gradient. Also similar to more mesic ecosystems, nitrogen availability increased with soil development, but declined at the oldest site. Additionally, within each site, the relative availabilities of these nutrients varied strongly with canopy type (under Juniperus monosperma or Pinus edulis canopies or within intercanopy spaces). We characterized major soil microbial groups among these contrasting sites and canopy types using phospholipid fatty acids, while community diversity and structure of ectomycorrhizal fungi and chemolithotrophic nitrifiers were assessed using molecular techniques. Our results suggest that microbial communities associated with different degrees of soil development and contrasting canopy types may substantially alter rates and patterns of nutrient cycling during ecosystem development. Although these and previous correlative approaches toward evaluating the importance of soil microbial structure to ecosystem function are suggestive, more studies that experimentally manipulate nutrient cycling rates across broad ecosystem gradients are needed to unequivocally link the importance of identity and arrangement of soil microorganisms to the function of terrestrial ecosystems.

LIONS ON THE COLORADO PLATEAU: RESEARCH PROGRAM HIGHLIGHTS FROM 2003-2007

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Mountain lions (Puma concolor) are the most widespread large predator in the western United States, creating both opportunities and challenges for wildlife and public lands managers. Mountain lions are sufficiently abundant to not only directly and indirectly affect ecosystems, but also to pose a threat to humans. In 2003 we began two independent programs to study mountain lions on the southern Colorado Plateau. At Grand Canyon National Park the National Park Service initiated a study to examine mountain lion use of the South Rim area in the vicinity of human facilities. The U.S. Geological Survey began a similar study in the Flagstaff, Arizona uplands, which was conceived to address concerns about mountain lion-human interactions at nearby Walnut Canyon National Monument and in the adjacent urban-wildland interface. Both studies have consistently applied Global Positioning System (GPS) technology to acquire high-accuracy location data from telemetry-collared mountain lions. Our combined goals are to provide research-based information that will allow managers to assess impacts of mountain lion predation on prey species, impacts of humans on mountain lions, and the temporal and spatial dimensions of risk to humans. Over the past five years these programs have grown collaboratively, expanding both in focus and geographic scope. Today, at three National Parks and three National Monuments on the Colorado Plateau, as well as across the greater Flagstaff uplands, GPS-collared lions are contributing to our understanding of how mountain lions share the landscape with humans. Our research data is yielding useful information about mountain lion movements, dispersal, habitat selection, predatory behaviors, survival and reproduction. We are further utilizing research findings to inform and educate the public about local mountain lion habits and demographics, and how to more safely share the landscape with these important predators.

CONSERVATION AND RESTORATION RESEARCH AT THE ARBORETUM AT FLAGSTAFF

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There are many factors that contribute to the "rare" or "declining" status of a plant species and several of these factors, including climate change, population growth and increasing development, are on the rise. Because the Colorado Plateau is one of the areas experiencing increased climate change effects and population expansion, many local, native plant species that currently survive in small populations are at risk for being listed as rare or threatened. Another challenge that is often faced by land managers is a lack of local, native plant seed to use in restoration efforts. This issue really came into focus after the severe 2002 wildfire season when hundreds of thousands of acres burned. Here we highlight two examples of our conservation efforts, *Astragalus cremnophylax* var. *cremnophylax* in the Grand Canyon and *Purshia subintegra* in the Verde Valley, and discuss our involvement in a local native plant propagation movement that is being conducted with the USFS and the Museum of Northern Arizona. The examples we present demonstrate the importance of collaborative associations and how they can be successful in achieving conservation and restoration goals. The Arboretum at Flagstaff has been working in support of rare plant conservation and restoration efforts for over 25 years and as funding becomes more and more difficult to acquire, we look forward to expanding our collaborative relationships to achieve our conservation and restoration goals.

IMPLEMENTATION OF AN ADAPTIVE MANAGEMENT STRATEGY FOR SPECIAL STATUS SPECIES: LOWLAND LEOPARD FROGS IN FOSSIL CREEK

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Following chemical renovation of Fossil Creek, the "Adaptive Management Strategy for Special Status Species and Habitat Associated with the Childs-Irving Project Decommissioning" was implemented to address potential issues associated with sensitive species, such as the lowland leopard frog (*Rana yavapaiensis*). This strategy identified monitoring objectives and potential adaptive management strategies that may be taken by Arizona Public Service (APS) if lowland leopard frogs did not persist above the Fossil Springs dam or disperse downstream. If the frog was not responding positively, APS agreed that dam removal would be delayed. Following chemical renovation of Fossil Creek, the Forest Service, U.S. Fish and Wildlife Service, and the Arizona Game and Fish Department have monitored the presence/absence and distribution of lowland leopard frogs along the creek and the development of riparian habitat downstream of the Fossil Springs dam. Monitoring completed to date indicates that leopard frogs are persisting above the dam, and dispersing and reproducing downstream of the dam into the newly renovated habitat.

WATERSHED RESTORATION ON THE COLORADO PLATEAU: A META-ANALYSIS OF PROJECTS AND EVALUATION PROCEEDURES

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The Colorado Plateau ecoregion consists of multiple federal, state, tribal and private jurisdictions. Throughout history, relatively scarce water resources have defined private and public management strategies. This meta-analysis will set the stage for a long term assessment of the cumulative effects from watershed restoration projects. Our initial goal is to record and catalog watershed restoration projects on federal, state and tribal lands on the Colorado Plateau. Subsequent analysis will determine evaluation strategies in each project. In the academic literature, restoration is generally defined as the recreation of structure, function and species composition as they existed prior to degradation and Euro-American settlement. However, ecological conditions were never static prior to degradation presenting a wide range of initial conditions. In addition, federal, state and tribal agencies may have varying definitions for watershed restoration based on their mandates and missions that translate to a project's goals and implementation. With the different aspects of watershed integrity ranging from wildlife habitat to water quality values, and the different methods for achieving these values, our initial challenge is in defining watershed restoration. In this presentation we define watershed restoration for the purpose of recording and cataloging such projects and offer preliminary results.

ORAIBI WASH ARROYO CUTTING — THE ROLE OF CLIMATE VARIABILITY AND EFFECTS ON CULTURE

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The alluvial valley of Oraibi Wash on the Hopi Reservation contains a rich sedimentary history of alternating episodes of erosion and deposition that relate to watershed erosion over the past 10,000 years. Presently, Oraibi Wash occupies an arroyo that is more than 100 m (330 ft) wide, up to 24 m (59 ft) deep, and extends the length of the wash. Based on field studies and review of historical information, the date of arroyo incision has been identified as 1906 with most of the arroyo cutting ending about 1934. Arroyo cutting corresponded with the 1905 to 1943 wet period, the wettest of the past 710 years, according to precipitation estimates reconstructed from the tree-ring chronology of the Black Mesa region. This wet climate was related to an episode of frequent, intense El Niño events during the early 20th century. Arroyo

cutting effectively ended the Hopi practice of Ak-Chin irrigation on the Oraibi-valley floor, since it was no longer possible to spread water during high flows. Impacts to traditional land use were also felt at Tolani Lake where much of the eroded sediment was deposited.

PEREGRINE FALCON (*FALCO PEREGRINUS*) A METHOD OF USING DIGITAL RECORDING EQUIPMENT AND VIDEO CAMERAS FOR EARLY CONFIRMATION OF EYRIE LOCATIONS AND TO RELIEVE LONG OBSERVATIONS BY OBSERVERS.

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I had found that by using digital video recording equipment we can confirm eyrie locations sooner by viewing sped up recorded images. A days observations of one possible eyrie location can then be viewed in about one hour without missing any exchanges by the adults. I found that if we were doing observations at the same time as the recorder was running and if the birds were indeed using the eyrie the camera was recording, many times we would not see the exchanges which the camera was catching. Additionally we would put the camera on a possible site and leave for the day. This allowed us to perform other work in another location. After viewing the sped up recorded video we could confirm weather or not the birds were using that ledge. This saved us about a days worth of observation time with the added bonus of being able to go back and view any activity. All images are time and date stamped. This has help us in speeding up the confirmation of eyrie locations in regards to climbing closers in which are in affect the first of March. This has meant that climb's which do not have nesting falcons can be opened sooner and used by the public.

PEREGRINE FALCON (FALCO PEREGRINUS) A SUMMERY OF NESTING / OCCUPANCY SURVEYS ON THE COLORADO PLATEAU 1991-2007 FOR THE NATIONAL PARK SERVICE AFTER THE PEREGRINES RECOVERY

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I monitored nesting success of peregrine falcons for the National Park Service 1991-2007 in three Parks on the Colorado Plateau. Glen Canyon National Recreational Area, Dinosaur National Monument and Zion National Park. Data was collected on Phenology, Occupancy, Productivity and behavior and entered into a Computer dataset. This report summarizes the findings of over two hundred nesting territory records of peregrines on the Colorado Plateau for ruffly17 years of data collection after the peregrines recovery.

RESTORATION IN THE NATIONAL PARK SERVICE; PROGRAMS, FUNDING, AND ASSESSMENT

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National Park Service policy calls for the protection, management, and restoration of natural systems found within the boundaries of land under its management. There is targeted funding for disturbed site restoration and invasive plant control. Other funds can be applied towards restoration. NPS has a Restoration Technical Advisory Group which has directed the development of a rapid disturbed site assessment tool to help prioritize/categorize sites for restoration. I and a team from the NPS, USGS, Northern Arizona University, and the University of Minnesota are near to completing an automated Restoration Rapid Assessment Tool. The tool will be described and an application described. Possible application of the tool within the context of the CPCESU watershed restoration project will be discussed.

IMPACTS OF CLIMATE CHANGE AND LAND USE ON THE NAVAJO NATION IN THE SOUTHWESTERN UNITED STATES

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Native Americans of the southwest, including the people of the Navajo Nation, live in an ecologically sensitive arid to semi-arid region with limited resources. In this region, as on other Native lands, traditional people live a subsistence lifestyle that is closely tied to, and dependent upon landscape conditions. An ongoing drought has impacted the southwest, including the Navajo Nation, since 1996. Long term average temperature and precipitation patterns are changing. In the past couple of decades, average temperatures have risen (compared to historic averages) in many parts of the world, including the southwestern United States. Moreover, average annual snowfall has decreased significantly since the early part of the 20th century. Snowfall and snow pack are important for their contribution to recharge of aquifers and water storage in reservoirs. The dual effects of increased temperatures and changing patterns of precipitation have profound effects (both geologic and biologic) on this semi-arid landscape. For the region of the Navajo Nation and those lands at similar latitude, the amount of effective precipitation, i.e. the moisture not lost to evaporation, decreases by approximately 2 inches for every 1o C increase in temperature. These calculations highlight the clear connection between climate change and drought severity. Annual rainfall in many parts of the western Navajo Nation averages between 5 and 7 inches in "normal" years, but has been as low as 1 to 2 inches in many areas during recent drought years. These "drought stresses" to the ecosystem have been compounded by the biologic effects of above normal spring temperatures. Our work has found that some land use practices, such as importing weedy hay during periods of drought, and off-highway vehicle use, are compounding the effects of drought and climate change by further mobilizing surface sediment and degrading rangeland. Sand dunes that cover approximately two-thirds of rangeland on the Navajo Nation have become active to partly active in many areas in recent years. A combination of changing climatic variables and land use practices have dramatically affected the landscape conditions on the Navajo Nation.

CHANGES IN PRECIPITATION AND RUNOFF IN THE CHEVELON CREEK WATERSHED OF ARIZONA

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Chevelon Creek is located in northeastern Arizona along the southern edge of the Colorado Plateau. Its headwaters are along the Mogollon Rim in the Apache-Sitgreaves National Forest. From there it flows in a northerly direction passing an arid area before its confluence with the Little Colorado River near Winslow, AZ. Overall, Chevelon Creek drains an area of approximately 270 square miles of upland forests, pinyon-juniper woodlands and grassland/savannah vegetation types. This study examines the stream and its watershed for any changes with time in their hydrologic regime as they are important sources of water for groundwater recharge and surface water supply for communities and wildlife species in the area. For example, the existence of the Little Colorado spinedace (Lepidomeda vittata), an endangered species of fish, in the area would depend on the presence of minimum stream flow regime in Chevelon Creek. Our main goal in this study is to determine the influence of recent drought and relatively rapid human development in the area on base flow since any reduction in stream flow along the Creek may drastically impact the sensitive ecosystem in the area. The main approach to the study consists of examining current and historical base flow as well as precipitation patterns in the Chevelon Creek watershed. It is expected that any finding in the Chevelon Creek will be an indicator of a much more widespread possible problem of ecosystem impacts of dewatering of flowing streams on the Colorado Plateau.

STEALING OR "JUST LOOKING:" CONCLUSIONS ON VISITOR AND RESOURCE INCIDENCE AT PETRIFIED FOREST NATIONAL PARK, ARIZONA

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Illegal removal of wood from visitor sites within Petrified Forest National Park (PEFO) remains a long-standing concern of park managers. A series of research studies over the past decade has attempted to document non-compliant visitor behavior in the form of the unauthorized collection of petrified wood. Some of these studies also have sought to explain the motives of visitors' variable compliance with park rules and communications regarding visitor behavior appropriate to minimize impacts on park resources. One study resulted in population estimates of 10–12 tons of petrified wood being illegally removed from visitor sites during a one-year period. The study, however, did not distinguish between petrified wood taken out of the park, and that remaining within the park as the result of displacement by visitors to other park locations. In order to quantify the amount of wood internally displaced, its location before and after displacement, and the amount removed from the park, a three-year study was begun in 2004. The study used two quite different research approaches, each designed to provide complimentary results in answering the research questions. A self-administered questionnaire was administered to gather information on the travel patterns of 1,000 visitors within the park over a one-year period, under the assumption that petrified wood may be displaced in similar patterns. During 2005-2007, removal and deposit of petrified wood on 240 fixed-plots were monitored at park sites where visitors have unsupervised access to wood. Additional monitoring was done of road ditches known to be regular depositories of discarded wood. All wood of souvenir size within plots was invisibly marked with material having a unique spectral signature, thus establishing the origin of marked deposits found in the fixed plots and road ditches. Results suggest visitor travel patterns within the park are fairly regularized, with visits to certain sites and the sequence of visits being rather predictable. Results from the fixed-plot monitoring are less definitive owing to small sample size and natural erosional processes within the Park. Wood displacement trends are evaluated in comparison with visitor travel patterns and management implications discussed.

TREE-RING SAMPLING OF HISTORIC NATIVE AMERICAN WOODEN STRUCTURES, GRAND CANYON NATIONAL PARK, AZ

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On the South Rim of Grand Canyon National Park, one of the least understood yet highly threatened cultural resources are historic Navajo and Havasupai wooden structures. The Navajo and Havasupai people used this area of the Coconino Plateau in historic times and built 6- and 8-sided horizontal log shelters and vertical pole shelters and sweatlodges. Sporadic artifact assemblages date some of the structures to the period between 1850-1950, but have not been helpful in determining construction dates. Tree-ring dating was proposed as a method to better define construction dates and site occupation history. However, the Navajo Nation and Havasupai Tribe requested that direct tree-ring sampling of wooden structures not be used. Archaeologists therefore used a strategy to indirectly date the structures by taking tree-ring samples from culturally modified trees within 50 meters of the structures. Developing this type of non-direct strategy could provide a valuable means for dating sites with poor preservation or no remaining wooden elements. Through consultation with representatives from both Tribes, Park managers gained a better understanding of each Tribe's perspectives on the Park's management of historic archaeological sites. Park resource managers also gained a better understanding of traditional building techniques and preferential selection, processing and use of wooden materials in this type of architecture. Further clarification from the Navajo and Havasupai and more precise dating may result in changes in the Park's management of these structures, notably a decision to not protect some structures from forest fires or actively stabilize deteriorated wooden structures.

IMPLICATIONS OF EPISODIC DEFOLIATION OF TAMARISK BY THE SALTCEDAR LEAF BEETLE ON THE COLORADO PLATEAU

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Tamarisk (*Tamarix*) species are among the most successful and economically costly plant invaders in the western United States. Accordingly, local, state and federal agencies have undertaken considerable efforts to eradicate tamarisk and restore riparian habitats to pre-invasion status. Traditional eradication methods, including herbicide treatments are now considered undesirable because they are costly and have unintended negative impacts on native species. A new biological control - the saltcedar leaf beetle (*Diorhabda elongata*) – was released in the summer of 2004 at several locations in eastern Utah to control the spread and impact of tamarisk within the Colorado River watershed. One release point was centered 15 km down stream from the recently established University of Utah Field Station and Education Center along the Dolores River. There are currently no public or private programs in place to monitor either the movement of the beetle from its release points or whether its presence ultimately leads to tamarisk mortality, changes in watershed hydrology and plant community structure. The release of the beetle near the Field Station provides an ideal opportunity to fill the monitoring gap between management activity and scientific research on the consequences of tamarisk defoliation on the Colorado Plateau. We have recently begun research to investigating the following questions: (1) does defoliation of tamarisk by the salt cedar leaf beetle result in widespread mortality? (2) To what extent will tamarisk defoliation result in water salvage? (3) Will tamarisk defoliation and mortality enhance establishment and growth of secondary invasive species through enhanced resource availability (i.e. water and nitrogen)? Results from this research will establish a quantitative framework for scientists, natural resources managers and the private sector to better manage riparian areas in order to maintain ecosystem services in the face of climate change and invasions of non-native plants on the Colorado Plateau.

A 50-YEAR FOREST SUCCESSION STUDY AT BRYCE CANYON NATIONAL PARK, UTAH

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Permanent plots were established in Bryce Canyon National Park in the late 1950s to monitor forest successional changes. The plot design used the point center quarter method and established nine transect running almost the entire length on the park. Currently four surveys have been completed recording the overstory and five surveys of understory, providing a 50 year forest succession dataset. Over this time period all forest types showed an increase in forest density. In particular, Abies concolor showed the most significant increase. Populus tremuloides, showed the most significant decrease in numbers since the first survey in 1957. The Pinus ponderosa- Juniperus scopulorum and Abies concolor forests, while increasing in density, showed almost no change in relation to species composition. Other forest types, such as the Pinus ponderosa-Pseudotsuga menziesii, Pinus flexilis and Pinus ponderosa-Abies concolor are drifting toward Abies concolor dominated forests. Non-fire related tree mortality in the past 6 years has been predominately Abies concolor and Pseudotsuga menziesii but has not been high enough to reduce the density of trees to that of the late 1950s. In some areas of the park where fire has been reintroduced into the system, there has been success in reducing tree densities, primarily sapling and seedling densities.

EXPLORING MODELING APPROACHES FOR PREDICTING CLIMATE CHANGE IMPACTS ON DOMINANT PLANTS; EXTREMES VS. MEANS AND COMMUNITIES VS. SPECIES

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The implications of present and future climatic changes for natural systems are becoming more and more important for scientists and natural resource managers to understand. For more than two decades a great deal of research has been done to predict what could happen to ecosystems as a result of changing climates. Many approaches have been taken, from using plant assemblages as the unit of analysis to looking at potential individual plant species responses. In addition to the differing units of analysis the way climate may influence these units has also widely varied, from using average climate to extreme climatic events. This talk will explore how different predictions can be depending on the approach taken. The most common plant community on the Colorado Plateau, pinyon- juniper woodlands, will be used as a unit of analysis as well as the species that compose them. Using our modeling approach, the predictions made using a community versus the species that compose them result in very different predictions. Also whether or not climatic change impacts are modeled as changes in extreme events versus the climate on average can yield very different predictions. The issues that these models represent are rooted in classical plant ecology theory; the concept of the plant association, individual biological potentialities, ecological thresholds, and the time scale on which these operate on.

50 YEARS OF CHANGE IN FOREST UNDERSTORY VEGETATION AT BRYCE CANYON NATIONAL PARK

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Data has been collected on >200 permanent plots in the understory of the forests in Bryce Canyon National Park five times since 1957. Each plot consists of a one m2 quadrat, with each species mapped and given canopy cover estimates. Since the 1950's conditions at Bryce Canyon have become warmer and drier. The forests, particularly at higher elevations, have become denser. Understory vegetation has changed significantly in the plots. The changes vary depending on elevation, aspect and forest cover type. Low elevation Pinus ponderosa forests are the richest in understory, but have shown significant changes due primarily to fire, both natural and prescribed. In higher elevation mixed conifer and subalpine spruce-fir forests understory cover has dropped for some important species, especially shrubs that require light, such as Ceanothus martini and Purshia tridentata. These changes may be related to the forest cover becoming denser, although climate changes may also be a factor. Overall species richness has declined in these forests since the earliest surveys.

NATIVE PLANT MATERIALS AND RESTORATION TECHNOLOGY FOR THE GREAT BASIN

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Objectives of this effort, the Great Basin Native Plant Selection and Increase Project, are to improve the availability of native forbs and to provide the knowledge and technology required for their use in restoring diverse native plant communities damaged by extensive wildfires and human impacts across the Great Basin. Specific goals are to develop genetically appropriate materials, seed production practices, and wildland seeding techniques for individual species and for mixtures of native grasses, forbs and shrubs. Approximately 25 species were chosen for research through consultation with land managers, botanists, and agriculturists. Scientists from a variety of disciplines, as well as seed regulatory agencies and private seed growers are collaborating on this project. Research includes studies of species' distribution and variation, breeding systems, pollination biology, cultural requirements for seed production, seed biology and technology, and equipment development for harvesting, conditioning, and planting seeds. To date this work has yielded data on the basic biology of many forbs not previously used for restoration and guidelines for their use. This project is continuing to improve land managers' ability to obtain and use native plants on rehabilitation and restoration projects.

TAMARIX: PASSENGER OR DRIVER OF ECOSYSTEM CHANGE IN RIPARIAN AREAS OF THE SOUTHWEST?

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In areas that have substantial ecosystem alteration associated with establishment and spread of an invasive species, the question arises whether the invading species caused the system to change or whether the invasion was facilitated by ecosystem change. The former scenario indicates that the invasive species is a "driver" of ecosystem change. The latter is explained by the invasive species being a "passenger" of ecosystem change. A species that drives ecosystem change is thought to displace native species while a passenger replaces native species. With this framework I have applied the question of passenger or driver to tamarisk invasion in riparian areas of the Southwestern United States. Review of the literature suggests that tamarisk is a passenger of ecosystem change, but possesses a suite of characteristics that accelerates ecosystem change once it is established. Tamarisk also has strong associations with human altered riparian areas that will ensure that it will maintain its dominance in some riparian systems. Thus, tamarisk is a passenger to ecosystem change "with its foot on the gas petal and its safety belt on".

DOES RIPARIAN VEGETATION INFLUENCE TAMARISK ESTABLISHMENT?

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Tamarisk establishment and spread has been purported to be one of the gravest threats to riparian areas in southwestern ecosystems. Many rivers in the Southwest are dominated by tamarisk, while others have very little tamarisk. Tamarisk is a minor ecosystem component on the Upper Verde River, where it accounts for 6% of all individual woody species that occur within 5m of the active channel. We demonstrate based on a decade of repeated measurements on 19 permanent monitoring stations that herbaceous and woody vegetative characteristics of the riparian zone are not significant predictors of tamarisk presence or absence. Contrary to many reports of tamarisk association with depauperate plant communities and loss of native plant diversity, we found that sites where tamarisk was present exhibit higher average overall plant cover, higher average native plant cover, and higher perennial plant cover. The implications of these findings, along with a growing body of evidence, suggest that vegetative characteristics in riparian areas may have minimal influence on tamarisk establishment and spread.

LAND SURFACE ALBEDO CHANGES OVER A FIRE CHRONOSEQUENCE IN PONDEROSA PINE FORESTS: IMPLICATIONS FOR CLIMATIC FEEDBACKS.

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Albedo, the ratio of reflected to incident radiation, is an important component of surface energy balance and is strongly affected by vegetation, soil type, and presence or absence of snow. In boreal forests, stand-replacing fires increase albedo by removing vegetation and increasing snow cover. In terms of radiative forcing, this increase in albedo exerts a greater cooling effect than the warming due to the carbon dioxide release from combustion and altered vegetation carbon sequestration in the decades after the fire. In southwestern forests the influence of fire on albedo has not been examined comprehensively. We are using the MODIS albedo product to examine albedo (annual and seasonal) at sites in ponderosa pine forests that experienced stand-replacing wildfire. We will discuss the effects of wildfire on albedo, and how these effects play out in the years and decades following fire. Understanding the net effect of stand-replacing wildfires in southwestern forests on radiative forcing will require integrating albedo changes with estimates of fire effects on carbon storage and release.

ALLOCHTHONOUS ORGANIC MATTER FROM TRIBUTARY FLOODS DOMINATES ORGANIC MATTER INPUTS OF THE COLORADO RIVER IN GRAND CANYON

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Prior to Glen Canyon Dam, the Colorado River in Grand Canyon was sediment laden and the organic matter budget was dominated by allochthonous carbon from upstream reaches. Glen Canyon Dam reduced sediment transport by 93% and probably reduced organic matter inputs by a similar amount, thereby disconnecting the Grand Canyon reach from the upstream watershed. To understand the sources and quantity of basal resources we constructed a budget of organic matter inputs (AFDM) for the 385-km reach of the Colorado River in Grand Canyon. Annual allochthonous inputs from Lake Powell are 5x1010 gDOM and 5x109 gPOM. The 25-km tailwater reach has high algal production (≤800 g/m2/yr), but this drops dramatically downstream of the Paria River (≤320 g/m2/yr), due to inputs of suspended sediment that reduce water clarity. Annual allochthonous inputs from the riparian zone are 4.9x108 g, or 14 g/m2 of river surface. In contrast, particulate allochthonous inputs from a two-day Paria River flood contributed at least 3.3x1010g, representing 900g/m2 of river surface, and annual inputs from all tributaries in the Grand Canyon reach likely exceed 5x1011g, or 13,000g/m2. Although allochthonous material from tributary floods dominates the input budget for the Colorado River, it is unclear how much of this material is retained or contributes to secondary production.

POST FIRE REFORESTATION EFFORTS ON LANDS OF WHITE MOUNTAIN APACHE TRIBE

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The White Mountain Apache Tribe, through an Indian Self-Determination Contract (PL 93-638), has planted over 1.5 million ponderosa pine seedlings on the Rodeo-Chediski (2002) and Kinishba (2003) burns. Cones have been collected from live trees in and adjacent to the burns, seed extracted from cones, seed sowed, seedlings grown and hardened off, and seedlings planted, all through the efforts of White Mountain Apache Tribal members. Tribal Forestry staff have developed programs and procedures to maximize tribal member involvement while striving for optimum tree survival rates in the face of continuing drought conditions.

TREE MORTALITY FOLLOWING THE EXTREME 2002 DROUGHT AT THE PONDEROSA PINE/PINYON-JUNIPER ECOTONE IN NORTHERN ARIZONA: BIOTIC AND ABIOTIC INFLUENCES

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Tree-ring and meteorological data show that the 2001-2002 drought, which resulted in extensive tree and shrub mortality, was the most severe drought year in over 400 years in the Southwest U.S. We conducted a study in 2004 within the ponderosa pine/pinyon-juniper ecotone of northern Arizona at sites with soils derived from three parent materials (SPM; sedimentary, flow basalt, cinder) to assess the extent of tree dieback and mortality that occurred during this drought. Our objectives were to determine if tree condition varied among sites of different SPMs that differed in water-holding capacity, and among woody plant species. We categorized trees into three groups: alive with low-dieback (<25% of canopy volume), alive with high-dieback (>25%), and recently dead. SPM influenced the percentage of trees with high-dieback only for one-seed juniper (cinder 51%, sedimentary 3.3%, flow basalt 7.0%). Across all SPMs, high-dieback was greater for juniper and pinyon (19.8% and 10.9%) than for ponderosa (3.4%). Mortality did not differ significantly among SPMs for any species. Mortality over all SPMs was greater for ponderosa and pinyon pines (17%, n=948 and 15%, n=1120) compared to juniper (0.5%; n=407). Pre-dawn water potential, taken during the peak drought season of 2007, did not differ among SPMs for either ponderosa or pinyon pine, but juniper at the cinder SPM was significantly higher (less water stressed) than at either the sedimentary or flow basalt SPMs. Logistic regression of mortality on a suite of physical (elevation, slope, aspect) and biotic (dbh, basal area of the target species, BA of other woody species) factors explained 9.8-60.0% of variation in tree mortality for ponderosa and 14.7-26.8% for pinyon, depending on SPM. In general, abiotic factors were a more important source of variation in mortality at the drier cinder SPM than other SPMs.

CARBON DIOXIDE AND ENERGY EXCHANGE IN DISTURBED SOUTHWESTERN PONDEROSA PINE FORESTS

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Our research addresses the effect of disturbances by forest management and stand-replacing fire on exchange of carbon dioxide and energy in ponderosa pine forests of northern Arizona. Eddy covariance measurements are being made in three ponderosa pine stands located near Flagstaff, Arizona: a) a control stand with no treatments or major disturbances in the last century, b) a restored stand where thinning in 2006 reduced tree density by 67% and basal area by 39%, and c) a stand burned by a stand-replacing fire in 1996. The control, untreated stand was a carbon dioxide sink of -164 g C m-2 yr-1 in year 2006. In contrast, the burned site was a carbon dioxide source of 109 g C m-2 yr-1 in 2006. The shift from a sink to a source of carbon dioxide caused by burning resulted more from a reduction in gross primary production than a change in ecosystem respiration. Burning also altered site energy balance by increasing albedo, reducing net radiation, reducing latent heat, and increasing heat flux into the soil. Preliminary results for the first year of post-treatment comparison between the control and restoration stands suggest that thinning reduced carbon dioxide sink strength in proportion to the reduction of tree leaf area by thinning. Our results show that carbon losses following stand-replacing fire in southwestern ponderosa pine forests can persist for decades.

BUREAU OF LAND MANAGMENT NATIVE SEED AND PLANT PROGRAM AND THE COLORADO PLATEAU

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The Bureau of Land Management (BLM) began reseeding arid sites on public land in the late 1940's. Prior to the 1990's, BLM seedings included only a few non-native species such as crested wheatgrass, intermediate wheatgrass, and alfalfa. Since the mid-1990's BLM has used more native seed and plants in fire rehabilitation and restoration projects. We will continue to utilize native plants, cultivars and source-identified seed wherever possible, and where seed or stock is available and meets with land management goals. Natural plant colonization is allowed to take place on sites that have a native seed source and low possibility of weed invasion, which includes over 50% of our project areas. BLM has several national consolidated seed buys for the western states each year. The ten year average of these seed buys is about 2.6 million pounds of seed per year. In 2005, 3.6 million pounds of seed were procured for BLM projects. In 2006, over 4.6 million pounds of seed were applied on public land, over 62% of seed types are considered to be native to western USA ecoregions. The agency operates a seed warehouse located in Boise, Idaho for seed distribution to BLM projects. BLM has three main regions for seeding/planting projects: 1) Great Basin, 2) Mojave Desert, and 3) Colorado Plateau. BLM native seeds from Colorado Plateau sources that are needed for site restoration in the region include sideoats grama grass, blue grama, bottlebrush squirreltail, Indian ricegrass, native penstemons, native milkvetches, tapertip hawksbeard, globemallows, Wyoming big sagebrush, and fourwing saltbush. For the Mohave Desert, seed sources for warm desert forbs and shrubs are needed. Monitoring of current and future BLM seedings by US Geological Survey and others is necessary for the agency to accurately determine and improve plant establishment on the arid lands of the Western states.

DIFFERENT COTTONWOOD GENOTYPES SUPPORT DIFFERENT ABOVEGROUND FUNGAL COMMUNITIES

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Understanding factors influencing the distributions of species and composition of communities is a major focus in ecology. There is an emerging body of evidence indicating that intraspecific genetic variation in foundation plant species can affect the distribution of associated species, communities and ecosystem processes. Many of these communities and ecosystem processes correlate with tree traits such phytochemistry, suggesting potential mechanisms connecting tree genes to their community phenotypes. Here we utilize a common garden containing replicated genotypes of narrowleaf cottonwood (Populus angustifolia) to measure the influence of genetics on the associated fungal community, including lichen, a leaf pathogen (Marssonina) and twig endophytes. We also measured twig condensed tannin, leaf condensed tannin, and leaf phenolic glycoside concentrations, as well as twig growth, aboveground tree productivity and bark texture, to explore potential links between cottonwood genes and associated fungi. Our results demonstrate: 1) lichen cover, Marssonina abundance, and endophyte abundance differ significantly among tree genotypes, 2) the overall fugal community composition varies significantly among tree genotypes, and 3) aboveground tree productivity is a strong predictor of endophyte abundance but twig volume is not, bark roughness is highly correlated with lichen abundance, and phytochemistry does not predict fungal abundance or community composition. These findings demonstrate a significant genetic component to fungal community structure. Tree genetics could prove to be a major overlooked factor structuring a wide range of fungal communities. Although covariance between plant genetics and fungal pathogens is well documented, no studies have incorporated the taxonomic and functional diversity of fungi reported here.

PRACTICAL ASPECTS AND IMPLICATIONS OF SELECTING SITES FOR LONG-TERM MONITORING OF SOILS AND VEGETATION AT NATIONAL PARKS

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The Southern Colorado Plateau Network (SCPN) is charged with developing a statistically-valid program to monitor the condition of natural resources at 19 units of the National Park Service on the Plateau. We present a case study overview of our current effort to select sites for long-term monitoring of upland soils and vegetation at Bandelier National Monument. In consulting with park resource experts, pinyon-juniper and mixed conifer were selected as the target ecosystems for monitoring by SCPN. Instead of using maps that delineate these ecosystems from which to select sampling sites, we used ecological sites (landscape divisions developed by USDA-NRCS) to define the initial sampling frame. Ecological site descriptions and associated data from soil maps were used to identify soil map units that match the target ecosystems; these map units represent the initial sampling frame. A series of GIS steps are then performed sequentially to buffer or eliminate areas that are considered to be non-targets from the frame, including areas adjacent to roads, steep slopes, and areas that require significant time to access. These steps are needed to create a viable area-based frame from which to select sampling sites, but also significantly reduce the coverage of the original frame. Because this reduction in coverage could contain a bias in the distribution of physical features, we compared the distributions of features such as elevation and slope between the original and final sampling frames. We present some of the challenges and implications of both the work in the lab and the field to select sampling sites for monitoring the pinyon-juniper ecosystem at Bandelier NM. Benefits include consensus with park resource experts on details of the monitoring objectives, and a sampling design that allows inferences to be made on soil and vegetation trends across a spatially-explicit sampling frame.

N MINERALIZATION INCREASES MICROBIAL 15N ENRICHMENT IN INCUBATED GRASSLAND SOILS

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Microbial transformation of organic nitrogen (N) into plant available forms is a fundamental process in natural and agricultural systems, which drives the productivity of above ground biomass. Stable isotope signatures of soil N pools can provide insight into these crucial ecosystem processes. Previous research (Dijkstra et al. 2006) showed consistent 15N enrichment of the soil microbial biomass compared to the soil soluble N pool. We tested whether 15N natural abundance of the soil microbial biomass changes during soil incubation and correlates to net N mineralization. Soils from three sites (Great Basin desert, piñon-juniper woodland, mixed conifer forest) along an elevation gradient in northern Arizona were incubated for a one month period. N isotope composition of the microbial and soil soluble N pools was analyzed before and after incubation, and rates of net N mineralization were determined. Microbial 15N enrichment changed during incubation. The change was positively correlated to the amount of N that was mineralized during this period. N isotope signatures of the soil soluble and microbial N showed inverse changes during incubation. These findings suggest that the N signatures of soil N pools are dynamic and correspond to rates of N mineralization.

TASSEL-EARED SQUIRREL USE OF RESTORATION TREATED FOREST MOSAICS

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Previous research in northern Arizona indicates that tassel-eared squirrels (*Sciurus aberti*) generally will not use restoration-treated ponderosa pine (*Pinus ponderosa)* forests if treatments are applied across a relatively large landscape. However, we hypothesize that squirrels may utilize restoration-treated ponderosa pine patches if they are embedded in a forest mosaic that includes dense-canopied patches for nesting sites and winter movements. During winter 2005/2006, we radio-tracked 9 squirrels in a forest mosaic of treated and untreated or minimally thinned from below patches (~10-15ha each) near Flagstaff, Arizona. We collected 29 - 41 GPS locations per squirrel and found that the 95% fixed kernel estimates of home range varied from 4.2-26.7 ha. All home ranges covered some treated and untreated areas. Proportion analysis of home range distribution showed that winter home ranges consisted of 56% treated and 44% untreated. In addition, 46% of winter nest locations were in untreated areas. Thus, our results indicate that squirrels will use restoration-treated forest patches for both nesting and non-nesting activities, if dense-canopied forests are nearby. Because winter 2005 received very little snowfall, squirrels were able to move through the forest by ground or canopy. In winters with heavy snowfall when squirrel movements may be restricted to areas with interlocking canopies, use of treated patches might be more limited.

ASPECTS OF THE ECOLOGY OF SONORA MUD TURTLES AT MONTEZUMA WELL

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The Sonora mud turtle (Kinosternon sonoriense) ranges from Durango and Sonora, Mexico, north into Arizona and New Mexico, reaching their northwestern distributional limit near Montezuma Well, Yavapai County, Arizona. Montezuma Well, a natural wetland, is chemically-challenging to most aquatic organisms, devoid of fish, and rich in invertebrate endemism. Sonora mud turtles appear to thrive in the 0.8 ha wetland along with non-native red-eared slider turtles (Trachemys scripta elegans), the latter introduced from the Mississippi River Valley as unwanted pets. Although the primary purpose of our ongoing study is to examine possible competitive interactions between the two turtle species, we report preliminary results of the ecology of the Sonora mud turtle in the unique wetland and nearby Wet Beaver Creek. From May-September, 2007, 89 turtles were recaptured 128 times. We recaptured some individuals up to three times but males were much more likely to

be recaptured than females. Trappability of males declined during the same period while female trappability remained relatively constant. The sex ratio was 59 males:30 females (1.97:1) not including four juveniles of unknown sex. Maximum male carapace length was 146 mm while that for females was 149 mm, markedly smaller than turtles in the Chiracahua Mountains. Activity decreased from April through August, ranging from 0 to over 12.4 observations per hour, despite relatively constant water temperatures. Lizard and snake species were noted in the diet in sharp contrast to most other turtles in the United States. The egg laying season ranges from May to at least September. Clutch size ranges from 1-8 eggs with a mean of 4.73 eggs and is not correlated with body size. The smallest gravid female had a carapace length of 125 mm and some females produce at least two clutches per year. The proportion of gravid female mud turtles gradually increased from about 60%-90% from May through July, decreasing thereafter. Hatchlings appear to overwinter in the nest, emerging with the onset of summer rain in the year following oviposition, after a long diapause in the egg.

THE NORTHERN ARIZONA NATIVE SEED ALLIANCE: WORKING TOWARDS A SUSTAINABLE MARKET

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Millions of federal, state, tribal, and private dollars are spent annually to restore and rehabilitate Arizona's diverse ecosystems as a result of a wide variety of disturbance events such as fire, invasion by aggressive non-native plant species, agriculture, livestock grazing, and recreational usages. As the effects of disturbance events increase in the Southwest, human intervention through revegetation has become a necessity in many instances. Sound management demands the use of native plants and seed adapted to northern Arizona's local ecotypes to accelerate the recovery of these disturbed areas. However, there currently are no reliable locally-adapted native plant and seed sources to sufficiently supply the large-scale revegetation projects within Arizona. In March 2007, a diverse group of stakeholders from northern Arizona came together to discuss the need for native plant materials. Although not a new concept or need, the timing seemed ripe for a more organized effort to bring people together around this topic. From this concept the Northern Arizona Native Seed Alliance (NANSA) began to take shape. NANSA is a task force currently comprised of individuals, commercial businesses, and personnel from federal and state agencies as well as numerous members from non-profit organizations and research programs at Northern Arizona University who are interested in developing a source of native plant materials for revegetation following wildfires, restoration, and other revegetation projects throughout northern Arizona. This collaborative approach is designed to assist in identifying common values and strengthen communication among stakeholder groups and work towards developing a sustainable market for native plant materials.

TRAVERTINE DAMS INCREASE PRODUCTIVITY AND NUTRIENT RETENTION: IMPLICATIONS FOR RIVER RECOVERY

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Travertine dams and terraces are increasing rapidly in Fossil Creek, offering a unique opportunity to study, in real time, how geomorphology affects ecosystem processes. Our results show that travertine dams and pools are hotspots of biogeochemical activity, associated with high rates of productivity, decomposition and nutrient uptake. Specifically, nitrogen retention and reach scale gross primary productivity correlate positively with travertine deposition. In addition, fish densities and macroinvertebrate diversity are higher in areas with travertine dams. We use our experimental results to predict how food web structure and ecosystem processes will likely change over the next decade.

CONTROLLING BROME GRASSES IN ZION CANYON USING IMAZAPIC (PLATEAU®) HERBICIDE

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Alien brome grasses currently dominate the understory vegetation throughout Zion Canyon, Zion National Park, UT. These grasses have displaced native vegetation and created a hazardous fuel bed that greatly increases the risk of wildfire. Beginning in 2005, Zion National Park, USGS, and BASF Corporation initiated a research study to test the effectiveness of the herbicide imazapic (Plateau®) to control brome grasses and promote re-establishment of native vegetation. The experimental design consisted of first modifying existing vegetation biomass by either burning or mowing, followed by herbicide application in either the fall or the spring, followed by seeding or not seeding with native plant species. Each treatment combination was replicated 3 times at each of 4 study blocks throughout the canyon. Vegetation cover, density, biomass, and multiscale species richness were quantified for 2 years following treatments. Relative to an untreated control, the fall application of imazapic reduced brome biomass by 96 and 91% in the burn and mow treatments, respectively, after the first year. The spring herbicide application was less effective, reducing brome biomass by 64 and 56% in the burn and mow treatments, respectively, in year one. Two years after application, only the burn/fall herbicide combination still controlled brome grasses, reducing biomass by 72% relative to the untreated control. The re-establishment of native plants was generally insignificant during the first post-treatment year, although seedlings of the grass species Sporobolus were higher in the seeding treatments. The burn/fall application combination increased species richness by about 2 species per 100 square meters relative to the other treatment combinations. In 2 of the 4 study blocks, herbicide treatments caused a substantial increase in Salsola sp. (Russian thistle), which park crews quickly removed by hand-pulling.

EVALUATION OF THINNING TECHNIQUES IN A PINYON-JUNIPER ENCROACHED SHRUBLAND

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The encroachment and densification of pinyon-juniper stands within historically shrub-dominated ecosystems is a major concern for many land management agencies on the Colorado Plateau. It is hypothesized that decades of fire suppression and the removal of fine fuels by over-grazing have lead to drastic changes in vegetation composition and fire regimes, although long-term climate patterns may also play an important role. At the Grand Canyon-Parashant National Monument in northwestern Arizona, recent management plans call for creating a diverse mosaic of sagebrush and pinyon-juniper communities, with a variety of seral stages in between. Ecologically and economically effective techniques for reducing tree density, promoting understory vegetation growth, and creating a fuel bed to allow reintroduction of fire should be assessed before application at landscape scales. In this study we evaluated 3 thinning techniques: 1) cut and leave, 2) cut, buck, and scatter, and 3) basal herbicide application (picloram, Tordon 22k®). Each treatment targeted 80% of "post-settlement" trees. The 3 thinning treatments plus an untreated control were applied to 20-ac. plots, with 8 replicates of each treatment. Changes in vegetation cover, density, and richness were monitored for 2 seasons following treatments. Relative to untreated controls, total understory cover increased by 90, 38, and 84% for cut-leave, cut-buck-scatter, and herbicide treatments, respectively. Much of this increase was caused by an increase in forb cover. The herbicide and cut-buck-scatter treatments doubled the recruitment of desirable shrubs species, while the density and cover of perennial grasses and annual alien brome grasses were unaffected by the treatments. The 3 thinning treatments increased species richness, with about 8 more species relative to the control at a 1000 square meter scale.

MANAGING FOR HUMAN SAFETY IN MOUNTAIN LION RANGE

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Attacks by mountain lions on people in Canada and the USA have increased substantially since the 1970s and promise to remain comparatively more common as increasing numbers of people choose to live and recreate in mountain lion range. Mountain lion managers are faced with developing more discerning and varied strategies for increasing human safety in the face of increasingly conflicted demands expressed by increasingly diverse stakeholders. We describe a conceptual partitioning of risk of human injury and death and review existing evidence regarding factors affecting the risk-related transitions: (1) probability of a human encountering a mountain lion (exposure); (2) probability of a mountain lion responding aggressively given an encounter; (3) probability of a mountain lion attacking given an aggressive response; and (4) probability of human death given a mountain lion attack. Young mountain lions in poor condition seem more likely to aggress and attack people, although death rates of people attacked by adult lions are higher (37-44%) compared to people attacked by juvenile lions (9-13%). Odds of aggression and attack are higher for solitary adult humans moving like prey (e.g., jogging or skiing) at dusk, and for children regardless of whether alone or in company of adults. The death rate of attacked children is 75-80% unless an adult intervenes, in which case the rate drops to below 10%. We recommend use of loud sustained noise to deter aggressive mountain lions, maximum resistance if attacked, and rapid forceful intervention by adults if a child is attacked.

IMPACT OF THE NORTHERN ANNULAR MODE ON COOL SEASON CLIMATE PATTERNS IN THE SOUTHWEST

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Variability in the Northern Annular Mode (NAM) index is associated with north-south shifts in the position of the storm track, with positive index values indicating a northward displacement of the storm track. Many climate models project increases in the NAM index over the 21st century and hence a northward shift in the storm track. Since most cool season precipitation is delivered to the southwestern United States by the mid-latitude storm track and since cool season temperatures are also influenced by the position of the storm track, it is reasonable to expect that variations in its position will alter both the temperature and the amount of precipitation that the Southwest receives. By correlating the NAM index with high-resolution gridded precipitation data over three-month seasons from October – December to April – June, we demonstrate that high index NAM years are associated with warmer, drier springs, though not necessarily with anomalies earlier in the season. This implies that a more positive average NAM will be associated with earlier onset of spring weather conditions. In addition, variations in storm track position may interact with other cool season climate teleconnections. For example, if the average storm track position is further north, the precipitation anomalies currently associated with El Niño conditions may not be as significant, leading to a loss of particularly wet winters for the Southwest.

INEXPENSIVE LINEAMENT ANALYSIS FOR DISCOVERING INGRESS NEXUS (ILADIN)

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An inexpensive technique has been developed that increases the probability of finding cave entrances in undeveloped karst and pseudokarst terrain. The first trial of this technique was done in Sequoia National Park in late 2002. A small solution cave previously unrecorded by the National Park Cave Survey was found in the area (~465 m²) ILADIN predicted would have a high probability of containing cave entrances. The theory behind this technique will be discussed as well as additional discoveries that have been made since 2002 using the method. Included in the talk will be a demonstration of the technique.

SCENT-STATION SURVEYS: INDEXING RELATIVE ABUNDANCE OF MESOPREDATORS IN ARIZONA

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During 2004 and 2005, we evaluated habitat-specific scent station surveys to index relative abundance of bobcats, coyotes, and foxes in Arizona. We developed scent-station transects statewide to survey chaparral, pinyon-juniper woodland, ponderosa pine forest, semi-desert grassland, and Upper Sonoran Desert scrub habitats. Scent-station visitations were highly variable, and failed to index presence of bobcats and coyotes in some habitat types they are known to occupy. Scent-station surveys indexed presence and relative abundance of bobcats only in chaparral and ponderosa pine forest habitats, where station visitation rates were low. Coyotes did not visit scent stations in ponderosa pine forest habitat. In contrast, foxes visited scent-stations in all habitat types, but visitation rates were lowest in semi-desert grassland. Results suggest that habitat-specific scent-station surveys in Arizona provide a reliable method for indexing relative abundance of coyote and fox populations in most habitat types, but the technique is generally unreliable for indexing relative abundance of bobcats.

MOUNTAIN LION DEPREDATION HARVESTS IN ARIZONA

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We compiled and analyzed confirmed legal depredation harvests of mountain lions (Puma concolor) between 1976 and 2005 throughout Arizona to describe patterns, trends, and demographics of harvest, determine relationship between depredation and sport harvests of the predator, and evaluate depredation harvests associated with predation of cattle and other domestic prey. Depredation harvest of mountain lions increased between 1976 and 2005, contributed substantially to total statewide harvest of mountain lions particularly since 1985, and was negatively correlated with abundance of mule deer (Ococoileus hemionus). Depredation harvest of mountain lions involved primarily adult males, but harvests of all age and sex classes increased between 1976 and 2005. Harvest of mountain lions for cattle depredations comprised 90% of all depredation harvests, and 98% of harvests for cattle depredations resulted from predation of calves. Harvest of mountain lions for depredations of cattle occurred in 12 of 15 counties, and 5 counties accounted for 92% of depredation harvests. We hypothesize that relative abundance of mule deer is a factor contributing to depredation of cattle by mountain lions in Arizona.

THE WARM FIRE'S EFFECTS ON UNDERSTORY VEGETATION, PONDEROSA PINE CROWN MORTALITY, AND FUELS: IMPLICATIONS FOR POST-FIRE MANAGEMENT

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On June 8th, 2006, a lightning strike ignited the Warm Fire on the northeastern edge of the Kaibab Plateau. The fire was managed first as a Wildland Fire Use (WFU) fire and then as a wildland fire, burning a total of 24,000 ha, and was one of the most substantial fires to burn in the Southwest in recent history. The fire has caused a tremendous amount of controversy about the WFU program and management decisions made by the Kaibab National Forest, illustrating the pressing need to resolve a growing interest in WFU with the need to safely manage fires for community protection and ecological health. Through the partnership with Grand Canyon Trust, Northern Arizona University and the Forest Service, we began an initial assessment across the three fire severity types in the wildland and WFU portions of the fire. This research characterized understory vegetation response, Ponderosa Pine tree crown mortality, and changes in fuel characteristics across the burned area in an effort to resolve fire management controversies through an assessment of the fire's ecological effects. Interpretation of these effects will be instrumental in guiding post-fire management decisions. This talk will introduce our study sites, the methods used for assessment, and preliminary findings.

ANALYSIS OF CURRENT AND HISTORICAL SURFACE FLOWS AND HYDROLOGIC RESPONSE TO RESTORATION TREATMENTS IN THE UPPER LAKE MARY WATERSHED, ARIZONA

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Upper Lake Mary is the sole surface water reservoir for Flagstaff, Arizona, and has historically provided 40% of the city's drinking water. The forested watershed has grown dense with trees since large-scale logging, livestock grazing, and fire suppression activities began approximately 135 years ago. Surface flows into the reservoir have declined over time, even in years with similar precipitation. These factors suggest that a likely cause is the increased transpiration and interception of precipitation that accompanies increased overstory vegetation. In its current condition, the watershed is at risk for severe wildfire that could impede its ability to meet water quality standards for domestic purposes. This study was undertaken to assess forest management solutions to these problems. We calculated current and historic surface flows based on forest inventory results. Four management alternatives were analyzed: no action, thinning to 75% of current basal area, thinning to 50% of current basal area, and restoration treatments based on historic reference conditions. We modeled water yields, sedimentation, and erosion resulting from these treatments. We also determined the possible effects of severe wildfire on sedimentation, erosion, and water quality. Water yield increases ranged from 3%-6.6% for thinning to 75% of current basal area, 10.5%-19% for 50% reduction, and 17%-28.9% for ecological restoration treatments. Restoration treatment values are also the approximate amounts by which streamflows have declined since about 1870. Erosion soil loss tolerances were exceeded in the wildfire scenario, and for ecological restoration treatments in some areas greater than 15% slope, but only in the first few years following disturbance. Of the three thinning alternatives modeled, only restoration treatments were self-sustaining in terms of maintenance and renewal of streamflow response, because of re-introduction of a frequent, low-intensity fire regime.

RESPONSES OF COLORADO PLATEAU DRYLANDS TO CLIMATE CHANGE: VARIABILITY DUE TO LAND USE AND SOIL-GEOMORPHIC HETEROGENEITY

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Dryland ecosystems comprise well over 50 percent of the Colorado Plateau province and are subjected to land uses such as livestock grazing, recreation, and energy development. Low and variable amounts of precipitation constrain dryland resilience to land-use activities, making drylands particularly susceptible to persistent changes in structure, function, and capacity for providing key ecosystem services such as soil stabilization. Through effects on soil and vegetation attributes, land use likewise mediates ecosystem responses to climate. Ecosystem responses to interactive effects of land use and climate also vary spatially in relation to soil-geomorphic properties such as texture, depth, horizonation, and topographic setting due to effects of these properties on water and nutrient availability, soil erodibility, and site susceptibility to hydrologic alteration by soil-surface disturbances. We illustrate these concepts with data from Colorado Plateau drylands, and we pose a set of testable hypotheses about climate-land-use interactions (i.e., how climate and land use each affect ecosystem resilience to the other) in relation to soil-geomorphic properties. In general, we predict that climate-land-use interactions in Colorado Plateau drylands will be greater on deep soils than on shallow, rocky soils because the former support grasslands and shrubsteppe ecosystems that have been most extensively used and modified by livestock grazing. We also predict that climate-land-use interactions will be greater on relatively fine-textured soils than on coarse-textured soils because the former tend to be more susceptible to exotic plant invasions and hydrologic alteration following disturbance, and because they exhibit greater fluctuations in resource availability in relation to precipitation variability. Variable ecosystem responses to climate due to land use and soil have implications for scientists' efforts to predict ecological consequences of climate change with sufficient detail to inform management decisions, and for decision makers' efforts to prioritize and evaluate risks of different management strategies.

HABITAT RELATIONS AND EFFECTS OF INVASIVE EXOTIC PLANTS ON THE FEDERALLY ENDANGERED SHIVWITS MILK-VETCH *(ASTRAGALUS AMPULLARIOIDES)*, WASHINGTON COUNTY, UTAH

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The herbaceous perennial legume Astragalus ampullarioides (Shivwits milk-vetch) is one of four federally protected plant species restricted to particular geologic substrates at the edge of the Colorado Plateau and Mojave Desert in Washington County, Utah. All of these plants are threatened by soil-surface disturbances, the proliferation of invasive exotic plants, and by habitat loss and fragmentation associated with rapid urbanization. To support conservation management of the Shivwits milk-vetch by federal agencies and other cooperators, the U.S. Geological Survey is conducting research to examine the distribution of this species in relation to geologic and geomorphic setting, soil properties, and plant community composition, as well as effects of invasive exotic plants on soil properties and milk-vetch performance. Surveys conducted in spring of 2006 increased the documented number of individuals from 1000 to 4205, and found the species on a new geologic substrate – thereby expanding potential habitat for the milk-vetch. Soil and plant community sampling demonstrated that variations in milk-vetch frequency among known population locations were not correlated with total live plant cover, relative cover of invasive exotic plants, or soil properties. However, spatial patterns of milk-vetch frequency and exotic plant cover within several population locations were associated with fine-scale variations in soil texture and gravel content controlled primarily by geomorphic processes. With improved knowledge of habitat characteristics, a spatial predictive model of potential habitat was created using climatic and geologic data in a GIS (Geographic Information System). After field verification and subsequent refinements, this model will be used to guide future survey and recovery efforts. On-going field experiments in Zion National Park will examine effects of the invasive exotic grass Bromus rubens on milk-vetch seedling recruitment, shoot growth, and reproductive output, and on communities of arbuscular mycorrhizal fungi in soil that supports growth of the Shivwits milk-vetch.

FACTORS TO CONSIDER IN THE DEVELOPMENT AND MANAGEMENT OF REGIONAL NATIVE PLANT PROGRAMS AND NATIVE PLANT PRODUCTION FROM SEED COLLECTION TO COMMERCIAL PRODUCTION

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Development of site adapted native seeds in sufficient amounts to ensure restoration of extensive disturbances amid quite diverse plant communities is a formidable task and involves numerous players. Contrary to the development of many commercial products, the identification and development of native species is primarily the responsibility of federal and state agencies. In addition, the agencies not only bear the responsibility of identifying the species required, but currently assume the role to research and develop the products, coordinate and promote commercial vendors, and ultimately become the principal buyers. Considerable expense is required over a long-term period. Support and funding must be in place to initiate and sustain such an effort. Species identified for development must be suitable for a large regional area to sustain research, support seed increase and development, and ultimately support a commercial seed market. Formulation of the Great Basin Native Plant program and the Colorado or Uncompahgre Native Plant program have a number of similarities, yet differ significantly in the conception of each program. Native species required by both regions differ due to the plant communities where disturbances occur. In addition, the current availability of species between regions, and the infrastructure to utilize native plants differ significantly. Of considerable importance in any program is the recognition of areas or plant communities where disturbances have and continue to occur and will require active seeding. In addition, the decision to promote the development and availability of a sufficient number of species necessary to restore entire plant communities in contrast to advancing only a select number of plants significantly influences any program. Efforts to advance each individual species are highly variable. Information is needed concerning the ecology of the plant, seed rearing and cultivation requirements,

seed germination, seedbed ecology, seeding and establishment amid wildland conditions. on, seedbed ecology, seeding and establishment amid wildland conditions.

STREAM RESTORATION ON THE COLORADO PLATEAU: CHALLENGES AND OPPORTUNITIES

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Natural Channel Design, Inc. is a river engineering and stream restoration firm in Flagstaff, AZ that has specialized in the restoration of alluvial stream systems across the Southwest over the past ten years. NCD has designed and implemented restoration projects across the region from the Mogollon Rim to the Virgin River in Utah and many lessons have been learned. Unexpected challenges have presented themselves because of the high range of variability found in riparian systems within the Plateau. Land uses are just as variable, introducing unique political situations within to implement projects. The hydrologic flow regime in the region, which includes high-intensity short duration floods and a very low base flow, present specific challenges for designing natural channels and re-establishing plant communities. From a cultural perspective, clearly defining objectives between multiple landowners, land users, and stakeholders, while working within funding constraints and aiming to restore ecological function is often daunting. Restoring streams within the context of real world situations is difficult, but necessary and should not be avoided. Using the insight gained from practitioners and others working on the ground will help increase success for all restoration projects in the future. An overview of restoration projects that have been implemented on the Plateau will be presented with special focus on the lessons learned during implementation and working within political realities. In addition, priorities for stream restoration on the Plateau from an on-the-ground perspective will be shared.

THE UNCOMPAHGRE PLATEAU PROJECT – RESTORATION AND COLLABORATION IN WESTERN COLORADO

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The Uncompahgre Plateau (UP) Project is a landscape collaborative that is working to restore and maintain the ecosystem health of the Uncompahgre Plateau in western Colorado, using best science and public input. Since 2001, the UP Partnership has been working to bring together federal and state agencies, interest groups and community members to coordinate, fund and facilitate activities across jurisdictional boundaries. Our main activities include: interagency/community collaboration; public outreach and education; compatible inter-agency GIS data sharing; scientific research; land health assessments; community-based educational field trips and work sessions; leveraging and pooling funding; a native plant propagation program; landscape-scale assessments and implementation plans; and invasive species management. In 2004, our native plant program expanded into eastern Utah and we are currently involved in the formation of the Colorado Plateau Native Plant Initiative (CPNPI).

POTENTIAL IMPACTS OF CLIMATE CHANGE ON THE COLORADO PLATEAU

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The Colorado Plateau has a mixed Climate, being strongly influenced by winter cyclonic storms from the Northwest and the Arizona Monsoon from the South and Southeast. Under future climate change the Former could shift further north and the latter may strengthen. And, overall the region will warm up. Implications of these possible climate shifts will be explored using the Dynamic General Vegetation Model, MC1 (MAPSS-Century Hybrid, version 1). Under all future scenarios over the 21st century, the upper elevational ecotones move up, limiting high altitude vegetation. However, lower elevational ecotones could shift up or down depending on the moisture regime, accounting for changes in both winter and summer precipitation, as well as CO_2-induced elevated water use efficiency. Fires will tend to increase in regions that experience drought stress and convert a lower vegetation density. But, fires may also increase under improved moisture conditions, which build larger fuel beds. Several scenarios will be explored in search of common patterns of response across scenarios in some regions, as well as to define regions of greater uncertainty. Uncertainty among future scenarios and vegetation responses will remain a reality for the foreseeable future and must be recognized as an ever-present issue in natural resource planning, rather than delaying management responses under the false impression that uncertainty will be reduced to some 'acceptable' level.

AN OVERVIEW OF GYPSIFEROUS SOILS RESEARCH AND RESTORATION AT LAKE MEAD NATIONAL RECREATION AREA

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Effective restoration methods for gypsiferous soils are greatly needed, but little published research has been conducted on these soils in the Mojave Desert. They are extremely vulnerable to wind and water erosion from disturbance created by exotic ungulate grazers and off-road vehicles. Many of the region's rare and endemic vascular plants occur on these soils. Gypsic soils also support sensitive and well-developed biological crust communities which are extremely important to arid systems for nutrient cycling, soil stability, and vascular plant establishment and success. New classifications and morphologies are still being described, some of them unique to Lake Mead NRA. Many gypsic soil characteristics are not well understood and create challenges to restoration success. We describe several past, present, and future projects within Lake Mead NRA which explore methods of soil structure rehabilitation; vascular plant establishment; crust salvage, storage, and establishment; the relationship of biological crust presence to plant establishment; plant/insect interactions; and other ecological questions relevant to gypsic soils management and restoration.

CLIMATE CHANGE AND VARIABILITY ON THE DEFIANCE PLATEAU: IMPACTS AND THE INTERSECTIONS OF WESTERN SCIENCE AND TRADITIONAL KNOWLEDGE

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Rural areas like most of the Colorado Plateau often do not have long and continuous instrumental records of the local climate. This research focuses on climate change impacts on the environment, as well as the role of traditional knowledge in documenting and characterizing changes on the Navajo Nation. To date, little work has been done regarding how traditional knowledge may combine with information from western science in understanding climate impacts on rural land-dependent populations. This research deals with some of the specific projected changes for the Southwest and examines to what degree they may or may not be presently occurring on a local level. To identify changes and their impacts on the vulnerable farming and livestock-raising sector, the investigator used a combination of climate data and experiences of Navajo Nation members in the Chuska Mountain area. Whereas society may not find an abstract change in atmospheric temperature meaningful, people do recognize consequences of environmental indicators of such change. Such climate change would ultimately affect their social, economic, and cultural wellbeing. This research demonstrates 1) that experience of climate-sensitive communities can identify environmental changes (seasonal temperature and precipitation) and impacts already underway and complement the quantitative climate data, and 2) that this comparison can serve as complements to one another in meaningfully communicating current and projected change, and its impacts on land-dependent sectors.

MILKSNAKES AT PETRIFIED FOREST NATIONAL PARK: IMPLICATIONS FOR MONITORING RARE VERTEBRATES

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Milksnakes (*Lampropeltis triangulum*) are widely distributed across the eastern and central United States, but the subspecies occurring in northern Arizona (*L. t. taylori*) is a uniquely patterned and diminutive form. Due to its apparent rarity and unique characteristics, the subspecies is popular with snake breeding and collecting enthusiasts. Surveys conducted at Petrified Forest National Park since 1997 have confirmed the park's importance as a protected stronghold for milksnakes in Arizona. In 2006, we initiated targeted surveys for milksnakes at Petrified Forest NP, using artificial cover, drift fence and box trap transects, and nighttime road driving and walking surveys. Our goal was to determine which methods would be most effective in monitoring a potential commercially valuable snake population. Unexpected results also included one mammal and one snake species that had not been previously detected during previous inventories. I will discuss overall research results in relation to herpetological inventories we have completed in other Colorado Plateau National Parks. I will conclude by discussing the problems and opportunities associated with monitoring rare (or secretive) vertebrate species of concern in national parks.

NATIVE FISH POPULATION INCREASE FOLLOWING FLOW RESTORATION AND EXOTIC FISH REMOVAL IN FOSSIL CREEK, ARIZONA

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The decommissioning of the Fossil Creek dam in Arizona presents a unique opportunity to study the effects of flow restoration and exotic fishes removal (bass and sunfish) on five species of native fishes. Here we compare the responses of native fish across four treatments: 1) control sites above the dam which have always experienced full flow and only native species, 2) sites where only flow was restored which never had exotic fish, 3) sites where flow was restored and exotic fish remain, 4) sites where flow was restored and exotic fish were removed. Native fish increased at all sites without exotic fish, including control sites. However, increases were significantly higher in the treatment where exotics were removed and flow was restored relative to all other treatments. Native fish increased 10-fold at these sites, with the smallest sized fishes responding greatest. The only sites where natives did not increase were where exotics are still present regardless of flow restoration. We conclude that restoring flow alone does not increase native fish populations. However, restoring flow and removing exotic fish does help native fish populations and may be an important management tool for reviving native fish populations in the Southwest.

EFFECTS OF GAS WELL COMPRESSOR NOISE ON NESTING BIRDS IN PIÑON-JUNIPER *(PINUS EDULIS-JUNIPERUS OSTEOSPERMA)* WOODLANDS OF RATTLESNAKE CANYON MANAGEMENT AREA (BLM) IN NORTHWEST NEW MEXICO.

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From 2005 through 2007, we investigated the effects of gas well compressor noise on birds breeding within piñon-juniper (Pinus edulis-Juniperus osteosperma) woodlands in the Rattlesnake Canyon Habitat Management Area (managed by the Bureau of Land Management) in northwest New Mexico. Nest predation was higher among nests with sound levels less than 48.6 dB-A than among nests with sound levels greater than 48.6 dB-A. We observed similar results during two experiments conducted in 2006 and 2007 using artificial nests made from wicker baskets covered with wood excelsior and baited with real quail eggs. Twenty motion-triggered cameras focused on artificial nests revealed that predators included scrub jays (Aphelocoma coerulescens), Stellar's jays (Cyanocitta stelleri), and chipmunks (Tamias spp.). After making an equal nest searching effort, we found no difference in nest density between treatment sites (origin at gas wells with compressors) and control sites (origin at gas wells without compressors); however, we did observe differences in species composition. House

finch (Carpodacus mexicanus) and black-chinned hummingbird (Archilochus alexandri) nests were more common on treatment sites, and mourning dove (Zenaida macroura) nests were more common on control sites. Bird surveys conducted during 2007, using DISTANCE sampling (582 point counts with 5,492 individual detections) also revealed that species composition differed between treatment and control sites; however, there were no differences between treatment and control sites in species richness, species diversity, or number of individuals. Results from the bird surveys also suggested that house finches and black-chinned hummingbirds were more common on treatment sites, whereas mourning doves were more common on control sites; for none of these three species were there differences between treatment and control sites in mean distance from birds to site origins on the well pads. Scrub jays (one of the predators revealed in the camera study) were more common on control sites than treatment sites.

WILDERNESS AREAS AND FIRE RESTORATION: PUBLIC PERCEPTIONS AND PREFERENCES FOR WILDERNESS MANAGEMENT

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What role should humans play in the restoration of fire to Wilderness areas? The US Forest Service, Bureau of Land Management and National Park Service manage wilderness areas in northern Arizona that are dominated by Ponderosa pine ecosystems. Agencies, researchers and NGOs acknowledge that these ecosystems are out of their natural range of variability and need some restoration of composition, structure and function. Across the southwest, the most significant process that has been excluded is fire. Wilderness may be one of the most important places to reintroduce fire. We investigate how the general public perceives Wilderness and fire restoration and what management strategies may be acceptable. Intercept surveys and semi-structured interviews were conducted in the USFS Kachina Peaks Wilderness Area just north of Flagstaff, AZ. Her we present our tentative results and compare the general public to managers, academicians and NGO specialists in fire and Wilderness.

A COMPARATIVE STUDY OF PLANT NICHES AT ZION NATIONAL PARK

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Zion National Park in southwestern Utah is an area of highly variable topography and geology that houses a correspondingly high botanical diversity. Numerous field surveys conducted in the park have yielded insights into plant species distributions and habitat requirements. A project was undertaken to consolidate these survey data into a GIS and build statistical niche models relating plant species distributions to environmental variables. Niche models were then compared by way of exploratory analyses aimed at detecting the imprint of niche evolution on the Zion National Park flora. By examining niche specialization and niche overlap of related taxa in multiple lineages and at multiple levels of a phylogenetic hierarchy, patterns of niche evolution were characterized. Results reveal a variety of niche patterns suggesting niche conservatism in certain lineages and niche divergence in others. Although this study does not capture broader evolutionary trends of entire lineages across their full range, it does indicate that phylogenetic relatedness is a factor worth considering when modeling plant species niches at a landscape scale. A benefit of a phylogenetic approach to niche modeling is that niches of poorly-known species can be inferred from better-known related species in lineages where niche conservatism is detected.

SURVIVORSHIP ACROSS THE ANNUAL CYCLE OF A MIGRATORY PASSERINE: CONSERVATION IMPLICATIONS FOR THE WILLOW FLYCATCHER

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Annual survivorship in migratory birds is a product of survivorship across the different periods of the annual cycle (i.e., breeding, wintering, and migration), and rates of survivorship may vary substantially among these periods. Determining which periods have the highest mortality, and thus are potentially limiting a population, is important especially for species of conservation concern. To estimate survivorship of the Willow Flycatcher (Empidonax traillii) in each of the annual periods, we combined demographic data from a 10-year breeding season study conducted in Arizona, United States, with that from a 5-year wintering season study conducted in Costa Rica. This is only the second study partitioning survivorship across the annual cycle for a long-distance migratory passerine. Overall, annual survivorship estimates derived separately from both the breeding and wintering studies were similar (66% and 65%, respectively). Additionally, estimates of monthly within-season survivorship for both the breeding (99%) and wintering seasons (98%) were nearly identical; however, because flycatchers are on the wintering grounds at least twice as long as on the breeding grounds, seasonal survivorship was lower on the wintering grounds (88%) than on the breeding grounds (97%). The migratory period had the lowest survivorship probability (77%), accounting for 62% of the annual mortality even though it comprises only one quarter or less of the annual cycle. The migratory period of the Willow Flycatcher and many other Neotropical migrants is poorly understood, and further research is needed to identify mortality threats during this crucial period.

COMPARING TRAPPING METHODS FOR SAMPLING BEETLE DIVERSITY AND MONITORING EFFECTS OF OFF-ROAD VEHICLES IN SALT CREEK CANYON, CANYONLANDS NATIONAL PARK, UT

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Salt Creek Canyon in Canyonlands National Park (CANY) is one of few perennial or semi-perennial riparian environments in CANY. Historically, Salt Creek has been used as a road by off-road vehicles. Portions of the canyon have been closed recently, thus dividing Salt Creek Canyon into three sections: an upper No Road (NR) section, where vehicle use ended in 1964, a middle Closed Road (CL) section, where vehicle use ended in 1998, and a lower Road Open (RO) section, where vehicle use continues. To evaluate methods for examining the effects of vehicle disturbance and response to road closure, we compared three trapping methods for monitoring beetle diversity: flight-interception traps, colored bowl traps, and pitfall traps. During June 2005 and June 2006, 78% of specimens were collected in flight-interception traps, 6% in pitfalls and 16% in colored bowls. Flight-interception traps sampled 83%, pitfalls 55%, and colored bowls 51% of the morphospecies collected. While most taxa were collected by multiple methods, a few, such as members of the families Carabidae, Melyridae, Dermestidae and Scarabaeidae, were caught almost exclusively by one trap. Results from all three methods suggest that certain taxa respond to different ecological conditions in the canyon and to changes in conditions from year to year. Therefore, these taxa may be useful as indicators of ecological conditions in the canyon.

FIRE AND FIRE SURROGATE TREATMENT IMPACTS ON SOIL MOISTURE CONDITION IN SOUTHWESTERN PONDEROSA PINE FORESTS

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The experimental study on Fire and Fire Surrogates (FFS) demonstrates use of group selection silvicultural practices to replace and/or augment fuel reduction strategies in the semi-arid Southwest. The FFS study incorporates soil moisture measurements into the existing experimental design. The data gathered in this study provides information on the amount of soil moisture available to plants at different rooting depths. Permanent plots have been established consisting of four treatments (control, burn only, cut only & cut and burn). Each treatment consists of 36 permanent plots. The soil moisture availability study was conducted near A1 Mountain in northern Arizona. There 10 permanent plots from each treatment were selected for installing semi-permanent soil moisture probes. Of the ten plots, four of them were equipped with 15 cm probes, another four plots with 30 cm probes, while the remaining two plots have both 15 and 30 cm probes. The probes were installed around a “marker” tree in each plot in all four cardinal directions of the tree. Data was collected on a monthly basis from April 2006 to March 2007. An extensive statistical analysis of the soil moisture data was conducted and the findings are presented.

MULE DEER HABITAT IMPROVEMENT ON THE KAIBAB NATIONAL FOREST

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The Kaibab mule deer herd (*Odocoileus hemionus*) is considered one of the premier herds in Arizona. For the last decade, there has been controversy over the relationship between mule deer population size and the subsequent impact on winter range shrub species. The westside of the North Kaibab Ranger District is an important area in that it provides the herd with primary, critical, and transitional winter ranges used during seasonal migration. Several disturbances, such as wildland fire, historic livestock grazing, and exotic species invasion (specifically cheatgrass *(Bromus tectorum)*), have reduced winter browse species. The Arizona Game and Fish Department, along with the Forest Service have initiated a landscape scale native seeding project of winter shrub species and follow up cheatgrass treatments. These treatments use mechanical and chemical means to eliminate plant competition in order to promote shrub species growth, in addition to creating adequate seed beds for germination. The goal of these treatments is to increase forage species available to the wintering deer herd. The approach to meet this goal is to proceed with landscape scale treatments while simultaneously gathering data, (through the assistance of Universities and non-governmental organizations) from research and monitoring plots embedded within the treatment areas.

GENETIC DIVERSITY OF HISTORIC APPLE TREES ON THE COLORADO PLATEAU AND IMPLICATIONS FOR THEIR PRESERVATION

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Historic apple trees growing in abandon orchards and around old homestead and town-sites surviving through green revolution, may hold valuable genetic material in both ‘lost’ heirloom fruits, and in drought adapted varieties. The 19th century is referred to as the golden years of apple growing in the United States by horticultural texts; following the era of fruit diversification from the mid 1700s into the early 1800s when seedling cider orchards where widely planted, thousands of named varieties emerged to become the orchards of the 19th century. Upwards of 80-90% of these varieties disappeared from cultivation during the 20th century. In this study, I am mapping the genetic diversity of historic apple trees growing in abandoned homestead orchards throughout the Colorado Plateau using seven microsatellite markers. Samples taken from 250 historic apple trees from over 40 historic sites in Arizona, Utah, and New Mexico will be compared with 140 heirloom varieties introduced into the southwest in the late 19th century by USDA agriculture experiment stations and Stark Brother’s Nursery. Historic trees that cannot be matched to any of the control varieties will be considered of interest for further study, and unique, desert-adapted varieties will be identified for preservation.

VARIATION IN NEAR-GROUND SOLAR RADIATION AS A FUNCTION OF TREE COVER: A PRELIMINARY ASSESSMENT ALONG A WOODLAND GRADIENT

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Piñon-juniper woodlands are extensive and dynamic throughout North America and characterized spatially as heterogeneous; ranging in canopy cover from less than 5 percent to greater than 60 percent, and ranging widely in patterns of aggregation. The near-ground light environment associated with woodland ecosystems drives patterns of energy and water and varies with increasing gradients of canopy cover, and also varies between canopy and intercanopy areas. The systematic variation of solar radiation as a function of woody cover has been simulated in piñon-juniper computer models but empirical field data are lacking. Furthermore, natural and/or human induced factors that modify piñon- juniper stand architecture, such as fire, thinning treatments, restoration and elevational gradient stand dynamics, may add to finer resolution changes in near-ground solar radiation compared to "natural" stands, and these possible differences have not yet been explored. We developed a control model in piñon-juniper ecosystem on a mesa north of Flagstaff, Arizona ranging in canopy cover from 5 to 65 percent and calculated mean solar radiation 1 meter above ground level. Preliminary results have shown a near-linear decrease in mean solar radiation with increasing coverage and a curvilinear variance with increasing cover, with the peak variance at 45 percent cover. We plan to compare our calculations from the control to areas within piñon-juniper of equal cover classes that exist within disturbed or intensively managed areas (thinned, burned, restored, and impacted by drought-induced mortality). We also plan to further substantiate the proposed correlation between solar radiation and energy and water patterns by using a suite of measurements 5cm below the soil surface within our control area throughout a 2 year period: these will include soil moisture, soil temperature and evapotranspiration rates. We anticipate that our results will be applicable to piñon-juniper woodlands throughout their geographic range as well as other woodland ecosystems.

HISTORICAL STEM-MAPPED PERMANENT PLOTS INCREASE PRECISION OF RECONSTRUCTED REFERENCE CONDITIONS IN PONDEROSA PINE FORESTS OF NORTHERN ARIZONA

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Forest structural reference conditions are widely used to both understand how ecosystems have been altered and guide restoration and management objectives. We utilized six historically stem-mapped permanent plots established in the early 20th century to provide precise reference conditions for ponderosa pine forests of northern Arizona prior to Euro-American settlement. Reconstructed tree densities and sizes for these plots in 1873-1874 included: tree densities of 45-127 trees ha^{-1}, mean tree dbh of 43.8 cm with a corresponding QMD range of 41.5-51.3 cm, and stand basal area ranging from 9.2 to 18.0 m^2 ha^{-1}. The reconstructed diameter distributions (for live ponderosa pine trees with dbh ≥ 9.14 cm) prior to fire exclusion varied in shape but generally displayed an irregular, uneven-aged size distribution with one or two dominant size cohorts. We outline management objectives for structural restoration treatments of ponderosa pine forests of northern Arizona emphasizing: (1) conservation and retention of all presettlement (> 130 years) trees; (2) reduction of tree densities with the restoration objective of 50-150 trees ha^{-1} where the corresponding large tree component is 25-50% of the total trees ha^{-1}, respectively; (3) manipulation of the diameter distribution to achieve an irregular, uneven-aged shape (possibly targeting a balanced, uneven-aged shape on cinder soils types) through the use of harvest and thinning practices which mimic gap disturbances (i.e., individual tree selection system); and (4) availability of 3 to 11 snags and logs ha^{-1} resulting from natural mortality.

FOSSIL SALAMANDERS AND THE CAVE PALEONTOLOGY OF SEQUOIA NATIONAL PARK CAVES

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With more than 250 known caves, Sequoia National Park (SEKI) provides ample opportunities for well-preserved paleontologic records of the Sierra Nevada Range, but few caves have been sampled and investigated. Recently, the discovery of several new species of modern cave invertebrates and the discovery of a 5000-year fossil record in Bear Den Cave has led park officials to expand investigations into other caves. This paper describes the results of sampling in five different caves - Bear Den, Crystal, Pet Sematary, Kaweah, and Ursa Minor. Preliminary results suggest that in addition to the previous discoveries of *Aneides ferrus/vagrans* and *Plethodon sp.* from Bear Den Cave, Pet Sematary contains records of *Ensatina sp.* This paper also reports the discovery of the tip of an obsidian projectile in Bear Den Cave, and the discovery of a unifacially-flaked obsidian tool in close association with the remains of a black bear in Ursa Minor Cave, one of the most recently-discovered and scientifically interesting caves in the park. The archaeological discoveries in Bear Den and Ursa Minor are especially significant because of the paucity of obsidian-ontaining archaeological sites in the park.

DEVELOPMENT OF A COLLABORATIVE RESEARCH MODEL TO FACILITATE INTERDISCIPLINARY RESEARCH ON DAM DECOMMISSIONING PROJECTS

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To fully understand ecosystem response to dam decommissioning and removal activities, the scientific community has called for long-term, detailed monitoring programs to accompany dam removal projects. Many in the scientific community have advocated that an interdisciplinary approach to research and monitoring can provide a better understanding of ecosystem response than more traditional, reductionist approaches. Because many barriers to interdisciplinary research exist, identifying these barriers and providing recommendations for overcoming them can help to ensure that interdisciplinary approaches are successful. This presentation evaluates one interdisciplinary research team's approach to investigate ecosystem response to dam decommissioning activities on a travertine-depositing stream at Fossil Creek, Arizona. From this evaluation many important lessons have been learned about conducting interdisciplinary research in this particular context. This presentation will synthesize the lessons learned by interdisciplinary researchers. These lessons learned were used to develop a collaborative research model to improve the effectiveness of collaborative, interdisciplinary approaches to research and monitoring on present and future dam decommissioning projects.

A REGIONAL PERSPECTIVE ON REHABILITATING BURNED DESERT TORTOISE HABITAT IN THE MOJAVE DESERT

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Multiple lightning strikes ignited wildfires that burned more than 78,000 acres of designated Critical Habitat for Mojave Desert Tortoise in southern Nevada and northwest Arizona during the summer of 2005 and an additional 12,000 acres in northwest Arizona during the summer of 2006. The impacts of fire, including loss of perennial plants for cover from predators and extreme temperatures and the shift from native shrubland to invasive grassland with increased fire frequency may have profound and lasting effects on desert tortoise populations in the Mojave Desert. Recent studies in Mojave Desert restoration have guided efforts on rehabilitating burned desert tortoise habitat and emphasize the importance of 1) replenishing seed sources lost as a result of fire injury, 2) creating a microenvironment that is amenable to seed germination and seedling growth and 3) reducing non-native annual grasses (namely red brome) that may out-compete establishing plants. As a complement to these recent studies, USGS is monitoring seeding efforts by BLM to accelerate the recovery of plants important as food and cover for tortoises in desert tortoise Critical Habitat following the 2005/2006 wildfires. In northwestern Arizona and southern Nevada BLM implemented three different replicated seeding treatments: aerial seeding, aerial seeding followed by seed incorporation, and hand seeding. This monitoring effort spans a range of sites that vary in the timing and amount of precipitation, which has implications for current and future predictions for rehabilitation success. We report the progress to date on the monitoring of the effectiveness of seeding burned habitat for the desert tortoise and discuss the importance of a regional perspective to understand the drivers of plant establishment when rehabilitating burned desert tortoise Critical Habitat.

SPATIAL DISTRIBUTION OF PRECIPITATION ON THE NAVAJO NATION AND GAUGE DENSITY

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The Navajo Nation has approximately 100 gauges that currently monitor monthly precipitation and most have at least a five-year record of digitized data. The overall density is less than 4.6 gauges per 100 km2, but the distribution is neither stratified nor uniform. Due to limited resources, the Navajo Nation is interested in maximizing the hydrological information their network can provide. The questions for the rain gauge network were: 1) how well do the current stations reflect the precipitation distribution across the nation, and 2) how can the rain gauge network be modified to provide optimal hydroclimate information? Three Navajo-NWS Cooperative Observer (COOP) pairs of stations were compared. Winter, summer and annual data for all stations were analyzed spatially using variograms and compared with COOP data, and the data were also divided into the western, eastern, and Chuska Mountain regions. Of the five years analyzed, two had more spatial autocorrelation for summer rainfall than winter, and for all five years, the mountains had greater spatial autocorrelation than either of the two flatter regions. This is not entirely due to the higher station density in the mountain region, as the eastern region had almost the same density. The station pairs did not have similar precipitation, even at an annual timescale, indicating the local topography and site conditions are very important. Overall results indicate that improved hydroclimate information should result from better siting of stations, in terms of locations near flash flood headwaters, and proximity to highly populated areas, and low ground where roads can be washed out. The trade-off between adding real-time telemetry and reducing the total number of gauges, with priority given to vulnerable areas with high population density, should result in improved efficiency, both in manpower information access.

SIMULATED VEGETATION RESPONSE TO FUTURE CLIMATE CHANGE IN THE WESTERN UNITED STATES

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Future changes in climate and atmospheric CO_2 concentrations may significantly alter the vegetation of the western United States. Understanding the potential character and magnitude of those changes is important to help conservation and natural resource managers develop management responses to climate change. Our research investigates the simulated response of vegetation to future climate change using process-based vegetation models (e.g., BIOME4) run at 5-minute and finer spatial resolutions. The vegetation simulations use future climate data for 2001-2100 downscaled from the UKMO-HadCM3, CGCM3.1(T47) and CCSM3 OAGCM climate simulations produced for the World Climate Research Programme's Coupled Model Intercomparison Project, phase 3. The results indicate that projected future changes in atmospheric CO_2 concentrations, coupled with future changes in temperature and precipitation, may promote increases in woody vegetation (e.g., shrubs, trees) across the region while reducing grassland areas. These vegetation changes are strongly influenced by the simulated vegetation response to increased atmospheric CO_2 concentrations. The overall simulated future vegetation changes are discussed in terms of their implications for land management activities in the region.

SIGNATURES OF VEGETATION CHANGE IN A STRATEGIC INVENTORY AND MONITORING SYSTEM

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The Forest Service Forest Inventory and Analysis (FIA) program is a strategic-level inventory and monitoring system that samples all forested lands of the United States. The system can detect and quantify population-wide trends, such as the widespread, drought-related increase in mortality that recently occurred in pinyon and ponderosa pine forests of the Southwest. Widespread mortality and range alteration are recognized as potential vegetation responses to climate change. However, other responses such as changes in growth form, growth rates, or stand composition may occur. These responses are likely to vary by species, so a sampling system must be sufficiently robust that both anticipated and unexpected changes are captured. FIA data collected in recent years suggest that non-lethal responses have been detected; examples of different responses captured by the FIA program are illustrated.

RESEARCH AND MONITORING TO GUIDE MANAGEMENT: K2M AS A CASE STUDY FOR PUBLIC LANDS STEWARDSHIP

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The way we manage America's public lands is changing. As public involvement increases via collaborative groups, public interest and political organizations, and coordinated local constituencies, federal budgets that support land and resource conservation continue to decline. There is an emerging "capacity vacuum" that is only now becoming apparent, and it is unclear how it will be filled. The Kane and Two-Mile Ranch Project (K2M) is a response to this situation on the southern Colorado Plateau, where the changing economics of livestock ranching, combined with the increasing responsibilities of strained federal agencies, have created a need for new public/private partnerships to pursue collaborative management across 850,000 acres of stunningly beautiful public lands ringed by national parks and monuments. At the core of this novel experiment is a science program that integrates ecological assessment, targeted experimentation, and an adaptive management approach powered by efficient monitoring of environmental change and management effectiveness. By examining the relationships among these ongoing efforts, and their links to complex management questions, I will identify opportunities for integrating science and management through new partnerships that could redefine the roles of livestock permitees, federal land managers, and the public, and realign efforts to restore and conserve our public lands.

A PALEOCLIMATIC RECORD 2600 TO 950 CAL YRS B.P. FROM LITTLE GREEN VALLEY, CENTRAL ARIZONA

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Little Green Valley is located east of Payson, Arizona, in the rugged landscape of the Transition Zone physiographic province. The complex climatic and vegetation ecotone location of the valley at the base of the Mogollon Rim, multiple proxy data (pollen, macro plant and charcoal remains, and stratigraphy), a chronology corrected for rapid depositional units, and fine interval sampling has contributed a high resolution record of paleoenvironments in central Arizona from ca. 2600 to 950 cal yrs B.P. Regional paleoecological records point to a low frequency climatic shift between ca. 2000 and 1000 cal yrs B.P. (low resolution records) or approximately 1700-1600 cal yrs B.P. (high resolution records). The Little Green Valley record registers a climatic change at 1660 cal yrs B.P. that ended a ca. 950 year-long cool and arid period in a particularly severe drought (ca. 1750-1660 cal yrs B.P.; A.D. 200-290). Warming temperatures by ca. 1400 cal yrs B.P. coincide with evidence of agriculture and the beginning of the main period of prehistoric residential construction in the sub-Mogollon region (ca. 1400-900 cal yrs B.P.; A.D. 550-1050).

NATIVE PLANT RESTORATION ACTIVITIES ON THE COLORADO PLATEAU

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BLM in Utah is an active participant in native plant restoration activities on the Colorado Plateau. A formal native plant management program is being developed and implemented. Initial activities include contributing funding for the construction of a native seed storage facility in Ephraim, Utah, and developing and funding a full time Colorado Plateau Coordinator position which will be stationed in the BLM Utah State Office. Partnerships are being developed with several different federal and state agencies, universities, etc. Efforts are being made to coordinate these activities with established programs to increase funding and efficiency.

WHY SALTCEDAR MATTERS AS BIRD HABITAT IN THE SOUTHWEST

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In the southwestern United States, there are extensive efforts underway to control exotic saltcedar (*Tamarix ramosissima*, *T. chinensis*, or hybrid). Although saltcedar habitat tends to support fewer species and individual birds than does native habitat, many riparian-dependent species use saltcedar in the southwest. The Arizona Breeding Bird Atlas and Birds of North America document 49 species breeding in saltcedar habitat. Eleven of these, including some Partners in Flight priority species, have the potential to be negatively affected by widespread saltcedar control in at least part of their range. For example, the Yellow-billed Cuckoo (*Coccyzus americanus*) has greatly declined following a large-scale saltcedar removal project in the lower Pecos Valley, New Mexico. Furthermore, there is surprisingly little data showing that birds breeding in saltcedar are actually suffering negative effects. Therefore, saltcedar control could have unintended consequences. For example, the federally endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*) is as reproductively successful in saltcedar-dominated habitat as in native habitat. Given that almost 30 percent of all Southwestern Willow Flycatchers breed in habitat dominated by saltcedar, the recovery plan cautions that extensive saltcedar defoliation via biocontrol insects could render flycatcher breeding sites unsuitable or inferior to their pre-control state. Overall, we contend that a) saltcedar dominated woodlands are important to southwestern riparian bird species, especially where native habitat can no longer exist, and b) saltcedar control and restoration projects that do not replace saltcedar with higher quality native riparian habitat can actually result in a net habitat loss for riparian obligate birds.

ROOSTS OF ALLEN'S LAPPET-BROWED BAT IN NORTHERN ARIZONA

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We examined roosting habits of Allen's lappet-browed bat (Idionycteris phyllotis) in ponderosa pine (Pinus ponderosa) forests in northern Arizona since little is known about roost selection. We used radio telemetry to locate 22 new roosts (17 maternity, 3 post lactating, 2 bachelor roosts) to add to unpublished maternity roost data (n = 11) of Allen's lappet-browed bat collected in 1993-95. All but one female maternity roost (n = 28) were located in larger than average diameter at breast height (dbh) ponderosa pine snags, under exfoliating bark and in close proximity to a linear edge, in particular forest roads and drainages with minimal forest canopy closure. The forest immediately surrounding maternity snag roosts had higher densities of snags and downed woody debris than did forest surrounding randomly-selected snags. Exit counts of maternity snag roosts averaged 11 bats per roost (SE = 2, n = 15) and were located an average distance of 1.6 km from capture sites (SE = 0.3, n = 17). Male roosts were located in vertical sandstone canyon cliff faces in lower elevation pinyon-juniper (Pinus edulis-Juniperus spp.) woodlands ~12 km from capture sites, indicating sexual segregation may occur during the maternity season. We resurveyed maternity snag roosts located in 1993-95, 1 continued to function as a roost; however, all other snags had fallen or no longer had exfoliating bark capable of supporting a maternity colony. Managers should maintain patches of large diameter ponderosa pine snags in low-moderate decay classes to provide maternity roosting habitat for Allen's lappet-browed bat.

STATUS OF TWO G2 ENDEMIC PLANTS ON THE KAIBAB PLATEAU, ARIZONA

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Section 6 funding was obtained from the U.S. Fish & Wildlife Service to examine the status of the Kaibab endemics Castilleja kaibabensis and Physaria kaibabensis. Surveys for these species had not been done since prior to the onset of regional drought in 1998-1999. Both species occur in upper montane to subalpine meadows, and have extremely restricted world distributions. In 2006, surveys were conducted at historical locations. Physaria kaibabensis was re-located at seven of nine historical sites, while one site proved to be the related P. kingii. One historical site was partially destroyed by road widening. Castilleja kaibabensis appears to be largely restricted to De Motte Park, where it remains common. All other historical locations were occupied by the related C. miniata, which is abundant in upper elevation forests on the Plateau. Permanent monitoring transects were established in three populations for each species. Density ranged from 10-60 individuals per m2 in Physaria kaibabensis. It remains abundant at the type locality in Pleasant Valley, but is relatively rare elsewhere. Estimates of abundance range from 300,000 to over one million individuals. Demographic data revealed a wide range of life stages, with over-winter mortality of 14-46% depending on location. Castilleja densities were about 1-2 plants per m2, but total estimates could not be made due to its scattered and patchy distribution. This species may be hybridizing with C. miniata, as they share pollinators, and bract color is extremely variable. Not all plants apparently emerge every year, as many mapped individuals from 2006 could not be re-located in 2007, yet densities actually increased along transects. Potential impacts of climate change on the two species are discussed.

IDENTIFICATION AND CHARACTERIZATION OF ARIZONA HERITAGE WATERS

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Since the beginning of human settlement in Arizona, access to a dependable source of water has meant the difference between flourishing and struggling for survival in a harsh, unforgiving environment. Our state's springs and other water sources have played a pivotal role in the establishment of human cultures by providing a focal point for hunting, sanctuary during times of drought, stopping-points on cross-country expeditions and settlement routes, and supplying irrigation water for crops. They are also among the most biologically diverse, productive, and threatened terrestrial ecosystems. Through grant funding from the Arizona Water Institute, cultural and scientific experts have designated 23 waters that have played a pivotal role in the geohydrology, biology, and cultural history of the state as "Arizona Heritage Waters." A multi-disciplinary collaboration among the state's universities, and numerous non-profit organizations, the Arizona Heritage Waters Project provides information to the public, and the scientific, resource management, and conservation communities about the identified sites and brings attention to the threats that these sites are confronting.

USING A RAPID FUNCTIONAL CONDITION ASSESSMENT PROTOCOL (RSRA) TO HELP ENCOURAGE COMMUNITY INVOLVEMENT IN THE CONSERVATION AND RESTORATION OF STREAM-RIPARIAN ECOSYSTEMS IN THE AMERICAN SOUTHWEST.

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The successful conservation and restoration of human impacted ecosystems usually requires the cooperation of diverse groups of concerned individuals, from those that depend upon the ecosystem for their economic livelihood, to others that may wish to maintain a viable ecosystem for recreational, aesthetic, or philosophical purposes. Cooperation among these groups is often limited by a lack of common understanding of both how the particular ecosystem might be expected to function under natural conditions, as well as how different human activities may have altered the health of that system. In arid and semi-arid regions like the American southwest, the restoration of stream-riparian ecosystems is particularly challenging, because of the importance of these areas to both humans and native plants and animals. We have developed an integrated, multi-dimensional method for the rapid assessment of the functional condition of riparian and associated aquatic habitats, called the Rapid Stream-Riparian Assessment (RSRA). The protocol evaluates the extent to which natural processes predominant in the ecosystem, and the extent to which there is sufficient terrestrial and aquatic habitat complexity to allow for the development of diverse plant and animal communities. It was developed specifically in reference to small and medium sized streams in the Colorado Plateau region, but it is also applicable to similar ecosystems throughout the West. The field methods are relatively simple and unbiased, and can be conducted without using expensive equipment. As a result, the RSRA protocol also can be a useful tool in educating non-specialists in the basics of stream-riparian function, as well as illustrating where problems in a particular stream reach may currently exist. We illustrate the potential of the RSRA protocol as both a scientific and educational tool with a discussion of several recent community workshops and stream health surveys on the Colorado Plateau during 2006 and 2007.

A NEW COLORADO PLATEAU RIPARIAN HEALTH ASSESSMENT METHOD: THE *RAPID STREAM-RIPARIAN ASSESSMENT* (RSRA) PROTOCOL

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The science of riparian area health (ecological and hydro-geomorphologic processes) is generally well understood. However, the implementation of restoration efforts is often difficult because one must deal with either limited or very technical methods for evaluation and monitoring, and at the same time work with a variety of stakeholders who have actual and perceived differences in goals and limited understanding of ecosystem functioning. The goals of the new *Rapid Stream/Riparian Assessment* (RSRA) protocol are to: provide a rapid and understandable measure of the current functional condition of stream-riparian ecosystems on the Colorado Plateau, address the ability of the ecosystem to provide various desired functions, provide guidance for future restoration - if necessary, be an objective method that can be easily repeated by different people at different times in different places, and to be repeatable so it can be used to monitor future changes in the ecosystem. In considering the different key components of the overall ecosystem (including water quality, hydrology/geomorphology, fish/aquatic habitat, riparian vegetation, and wildlife habitat), RSRA uses field indicators that can be measured rapidly in the field and that do not require specialized equipment or knowledge. For scoring those field indicators the protocol also uses a 5-point scale ranging from non-functional to excellent condition, and each indicator uses specific scoring criteria for each level of score. Using reference sites enables the user to determine score scaling, i.e. "what would an unimpacted site look like on the same river or in a similar riparian environment?" The average of the scores for the individual indicators provide a complete picture of the riparian area, showing which characteristics of the stream are healthy and which are not (and thus may require restoration).

RUINS PRESERVATION STRATEGIES AT FLAGSTAFF AREA NATIONAL MONUMENTS: CONTENDING WITH FUTURE CLIMATE CHANGE

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Federal legislation mandates the National Park Service to conserve, unimpaired, natural and cultural resources within its jurisdiction. The Cultural Resources Management Division at Flagstaff Area National Monuments is, thus, charged with the preservation of archeological sites at three locally situated, yet very distinct national monuments in the vicinity of Flagstaff, Arizona. One-hundred-percent surveys for cultural resources at Wupatki and Walnut Canyon National Monuments have located numerous archeological sites with standing architecture. Due to above-ground exposure, standing architecture is highly susceptible to a rapid rate of deterioration from the combined effects of natural and human agents (i.e., precipitation, vandalism, fire, and visitation). Both natural and human agents of deterioration experience significant changes in intensity from altered weather patterns, thereby altering the intensity of impacts to standing architecture. Climatic change will require ruins preservationists to modify existing strategies as well as develop new ones. This paper reviews various models put forth on future climate change on the Colorado Plateau and relate these conclusions to the effects facing ruins preservation at Flagstaff Area National Monuments.

EFFECTS OF ECOLOGICAL RESTORATION TREATMENTS ON THE HOME RANGE SIZES OF TASSEL-EARED SQUIRRELS (*Sciurus* aberti) WITHIN THE WILDLAND URBAN INTERFACE SURROUNDING FLAGSTAFF, ARIZONA

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Many southwestern forests are unhealthy, therefore restoration using fuels reduction and thinning are becoming more necessary for land managers to alleviate extreme fire danger; however, effects of these treatments on wildlife are a concern. The tassel-eared squirrel, a US Forest Service Management Indicator Species (MIS) for ponderosa pine (*Pinus ponderosa*) forests is a species of concern in treatment projects due to their reliance on pines and habitat preferences for interlocking canopies. Land managers implementing restoration surrounding Flagstaff, Arizona are willing to leave patches with high proportions of interlocking crowns; however, they lack necessary information about the appropriate size and orientation. In November 2005 18 tassel-eared squirrels were trapped and radio-collared in two different areas, one treated and one untreated, of the Wildland Urban Interface surrounding Flagstaff. Global Positioning System locations were recorded between winter 12/05 to 3/06, and non-winter 4/06 to 11/06. Using ArcView GIS 3.3 and the Animal Movements and Home Range extensions, home range sizes were determined for squirrels at both areas, in both seasons. Results suggest that squirrels in treated areas have smaller home ranges and overall do not travel as far for resource allocation compared to squirrels in untreated areas. On average, home ranges were larger during non-winter (N = 7, x = 12.84 ha, SE = 0.66) in Mountainaire compared to winter (N = 7, x = 10.18 ha, SE = 0.76). Compared to the home range averages in Mountainaire, the Fort Valley squirrels exhibited much smaller home range sizes: non-winter (N = 6, x = 7.46 ha, SE = 0.87); winter (N = 6, x = 7.2 ha, SE = 0.59). Treated areas may have greater resource availability due to improved forest health, allowing squirrels to travel less for resource allocation and possibly store enough food to allow them shorter travel distances to sustain themselves during winter. This data adds to the understanding of forest treatment effects on tassel-eared squirrels which is valuable to land managers in alleviating potential risks of restoration to squirrel populations.

NATIVE FISH REBOUND IN FOSSIL CREEK

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Native roundtail and headwater chub, Sonora and desert sucker, longfin and speckled dace, collected from Fossil Creek prior to a piscicide treatment, were repatriated into the stream at several locations along a ca. 4-mile reach in autumn 2004. Total number of fish repatriated was 1746, comprised of 52% speckled dace, 20% desert sucker, 14% roundtail and headwater chubs, 13% Sonora sucker, and 0.7% longfin dace. Populations of all except longfin dace have rebounded, as indicated by strong year-classes and expansion into reaches outside the repatriation sites. Entrapment gear (baited hoop nets and minnow traps) captured 2262 individuals in autumn 2005, 1737 in spring 2006, 1341 in autumn 2006, and 1478 in spring 2007. Roundtail and headwater chubs predominated numerically, comprising between 60 and 77% of the total catches. Sonora sucker comprised 15 to 18%, and desert sucker between 2 and 4%. Speckled dace were numerous in autumn 2005, comprising 24% of the sample; but declined in subsequent sampling to between 2 and 8%. We have not encountered any longfin dace. Autumn sampling has been characterized by predominance of young-of-year individuals. Qualitative observations (visual inspection by snorkeling) generally support the relative abundance and age-structure results gathered by quantitative gear. Smallmouth bass and green sunfish are present immediately below a fish barrier constructed to prevent immigration of nonnative fishes, but to date none have been captured nor observed above it.

YELLOW-BILLED CUCKOO DISTRIBUTION, BREEDING STATUS AND HABATAT USE ALONG THE LOWER COLORADO RIVER

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We documented western yellow-billed cuckoo (*Coccyzus americanus occidentalis*) distribution, abundance, and habitat use along the Lower Colorado River within the Multi-Species Conservation Plan boundary area. We conducted cuckoo surveys using playback recordings. Cuckoos were detected at 32% of the areas surveyed in 2006 and 35% of the areas in 2007. In 2006, the majority of the cuckoo detections occurred at the Bill Williams River National Wildlife Refuge AZ sites (n = 117) and the Grand Canyon National Park–Lake Mead National Recreation Area AZ delta sites (n = 29 detections). In 2007, most of the detections again occurred at Bill Williams River NWR (n = 140 detection), while at the Grand Canyon-Lake Mead sites we did not detect cuckoos. The sudden absence of cuckoos at the Lake Mead Delta sites may be due to the ongoing drought, which affects water levels in Lake Mead Reservoir and the amount of water available to the riparian vegetation the cuckoo depends on. We compared the distribution and abundance of woody species between occupied and unoccupied sites. Occupied sites tended to have higher average canopy cover, attributable to higher average cover of the mid and low canopy. In addition, occupied sites in most areas had lower than average total tree density whereas unoccupied sites were denser than average. When densities of trees in different size classes were compared between occupied and unoccupied sites within areas, it appeared that cuckoos did not use sites with the highest density of small trees (< 8 cm dbh), mostly tamarisk. We also measured microclimate variables (temperature, relative humidity, soil moisture) at occupied and unoccupied sites at Grand Canyon NP–Lake Mead NRA and Bill Williams River NWR. We found that locations occupied by yellow-billed cuckoos were generally slightly cooler and more humid than unoccupied sites. On average, soil moisture was slightly higher at occupied cuckoo locations.

VERTEBRATE SPECIES IN DESERT CAVES AND MINES – A COMPARISON BETWEEN THE CHIHUAHUAN AND SONORAN DESERTS

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Underground features, including caves and abandoned mines, provide important resources for a wide variety of vertebrate species in arid regions. Resources used by these species include shelter, nest sites, water, foraging sites, and relief from extreme environmental conditions. Because of different availability of caves and mines in the Sonoran and Chihuahuan Deserts, there could be differences in the patterns of species use of these resources. Agency files, literature sources, internet sources, and site visits were used to compile records of species using caves in the Chihuahuan Desert near Carlsbad, New Mexico. Literature sources and site visits were the primary data sources for caves and mines in the Sonoran Desert of Arizona. Underground features in the Chihuahuan Desert were limited to natural caves in limestone and gypsum. Ponded or flowing water is relatively common in these caves. Features in the Sonoran Desert were mainly abandoned mines, but there were also several limestone caves and a few basalt and gypsum caves. Water is relatively scarce in these features. Despite these differences, the general patterns of species distribution and diversity are similar between these two regions. A few species are found in many caves, and numerous species are found in a few caves. Similarly, a many caves or mines support a few vertebrate species, and a few sites have larger numbers of species. Differences in the species composition between Sonoran and Chihuahuan caves may be due to differences in the pools of species present in each desert and to the differences in the sources of data in each region. The availability and structural characteristics of the caves and mines in each region may also contribute to differences in species use of these features. These underground features provide important resources that may allow species to survive in harsh climatic conditions.

TO SEED OR NOT TO SEED? DISCUSSION ON RECENT WHITE MOUNTAIN APACHE TRIBAL BAER REVEGATION PROJECTS

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The high costs associated with post-fire aerial seeding of grasses and forbs are often weighed against project effectiveness. On the tribal lands of the White Mountain Apache, various strategies of aerial seeding were implemented on the 2002 Rodeo-Chediski and the 2003 Kinishba burns. Monitoring results from 2003-2005 offer insight to some national BAER issues. Cereal grains were included on both sites, but seeded separately and earlier on the Kinishba burn. In both sites, cereal grains quickly decreased in abundance in the first few years. Goals for revegetation may need to be site specific, rather than using the same plant density goal across ecosystems. Seeded grass species were more prevalent than non-seeded species, but forb seeding did not show significant results. Additionally, no evidence of noxious weed introduction was observed for either burn. Managers need to have a post-fire revegetation strategy prepared before the fire season, and the strategy should include a public information component to explain the decision to seed or not to seed.

IMPLICATIONS OF MICROCLIMATE ON NEST PREDATION OF THE SOUTHWESTERN WILLOW FLYCATCHER

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Nest predation is the leading cause of nest failure for passerines, therefore determining factors that contribute to high predation rates may be crucial to establishing viable populations of endangered birds. Several factors may affect nest predation rates, including habitat characteristics at or near the nest, such as vegetation structure, microclimate, activity level of the adults, and predator community structure. We monitored nest success of the endangered Southwestern Willow Flycatcher at two sites varying in elevation and vegetation structure from 2003-2006. We looked at whether five habitat structure variables (nest height, canopy height, canopy cover, ground cover, and concealment) and/or microclimate (maximum and minimum temperature and humidity) at the nest site could explain nest predation by testing 10 a priori models at each site using multiple logistic regression followed by model selection using Akaike's Information Criterion. Our results indicated that nests that experienced low minimum temperatures and low minimum and maximum humidity were more likely to be preyed upon. I hypothesize that

physiological constraints imposed on both the embryo and/or nestling and the incubating adult by differences in temperature and humidity may alter incubation behavior in ways that attract predators. These results may potentially be applied to the assessment and management of current breeding sites as well as restoration sites in terms of predation risk based on microclimatic factors.

THINNING REDUCES CARBON DIOXIDE, BUT NOT METHANE, FLUXES IN SOUTHWEST PONDEROSA PINE FOREST SOIL

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Forest soils of the southwest United States respire carbon dioxide (CO2) and biologically oxidize methane (CH4), the two most significant greenhouse gases contributing to climate change. Land managers are thinning forests to reduce the hazard of high-severity wildfire as climate change contributes to increasing the frequency and intensity of fire. We evaluated how forest thinning alters fluxes of CO2 and CH4 from soil for one year after thinning by measuring pre- and post-thinning soil gas fluxes at a restored site and a nearby unmanaged control site. Fluxes of CO2 and CH4 were obtained simultaneously using static chambers and gas chromatography. We hypothesized that forest thinning would increase both CO2 efflux and CH4 oxidation. However, our results suggest that thinning reduced CO2 efflux but had little effect on CH4 oxidation. These findings are in contrast to the effects of thinning on greenhouse gas fluxes reported in similar forests, which have either not measured pre-thinning stand conditions or are conducted more than one year after thinning. Changes in soil water content and soil temperature did not explain the changes in gas fluxes due to thinning. The reduction in CO2 efflux may be due to the loss of respiring belowground plant biomass and changes in the microbial community. We suggest that forest thinning, at least for one year after treatment, inhibits soil CO2 efflux, and has no effect on CH4 oxidation.

PRELIMINARY RESULTS OF A CAVE BIOINVENTORY AT GREAT BASIN NATIONAL PARK

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Great Basin National Park, Nevada, is located in one of the numerous mountain ranges in the Great Basin. A variety of rock types are present in the Park, and caves can be found at various elevations wherever large units of limestone are exposed at the surface. Notable among these caves is Lehman Caves, which is accessible to the public via guided tours. Here we report preliminary findings from an ongoing bioinventory of these caves, begun in January 2003, and concluding in March 2008. Undescribed, cave-limited species in the Park include a previously known dipluran (Campodiidae), along with three taxa we have discovered: two millipedes and a globular springtail (*Arrhopalites* n. sp.). One of the millipedes, *Idagona lehmanensis* Shear (Conotylidae) was described this year. The geographic distribution of two known troglobites, *Microcragris grandis*, a pseudoscorpion (Neobisiidae), and *Cryptobunus ungulatus ungulatus*, a harvestman (Triaenonychidae), have been expanded, and *C. u. ungulatus* was recorded from caves near the base of the mountain range as well as caves near timberline. We have found several troglophilic taxa which may be new species, including a third millipede found primarily in high elevation caves. An ongoing evaluation of the biological impacts of visitation on Lehman Caves includes timed bioinventories throughout the year at bait stations near to, and far from, the tour trail in different parts of the cave which vary in levels of human impacts. In the course of the ongoing study we have also trained Park personnel, produced photographs for interpretive use, identified potential threats to the caves, recommended monitoring techniques, and identified areas for future research.

ASSESSING BIOLOGICAL RESOURCES OF CAVES IN LAVA BEDS NATIONAL MONUMENT, CALIFORNIA

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Lava Beds National Monument contains more than 500 lava tube caves and features, with more than 28 miles of passages that are home to a variety of cave-adapted organisms. We studied cavernicolous invertebrates in twenty-nine (29) caves between 2 June and 4 August 2005. Most of these caves had a dark zone varying from just above freezing to about 12 ºC, where relative humidity varied from about 85 to 100%. In 193 biological samples, 1,511 specimens were recorded. Of the animals recorded, 22.6% were flies (Diptera), 19.3% were springtails (Collembola), 16% were spiders (Araneae), 12.2% were millipedes (Diplopoda), 11.7% were mites (Acari), and 5.3% were diplurans (Diplura). A variety of other animal taxa make up the remaining 12.9%. Two common, large troglobitic invertebrates are the millipede *Plumatyla humerosa* and the dipluran *Haplocampa* sp. Common and nearly ubiquitous springtails of the family Tomoceridae (probably *Tomocerus* spp.) are important members of the Lava Beds cave community, and account for more than half of all springtails. Woodrats (*Neotoma* spp.) and bats (Vespertilionidae) are especially important in bringing nutrients into these caves, and bacteria and fungi growing on their feces provide energy to other cave animals. Notable undescribed taxa include an terrestrial troglobitic isopod (Trichoniscidae: *Amerigoniscus* n. sp.) which was rarely encountered, a psocopteran (Psyllipsocidae: *Psyllipsocus* n. sp.), a blind linyphiid spider, and a troglobitic pseudoscorpion (Arachnida). Richness of the taxa showed no discernable patterns with respect to their association with different lava flows, vegetation zones, or elevation.

THE STATE OF STREAM FLOW MEASUREMENT, DATA QUALITY AND ADEQUACY IN THE NAVAJO NATION

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Availability of reliable and adequate number of stream flow measuring facilities is important for any nation of any size and location. The Navajo Nation which was established in 1868 encompasses an area of more than 27,000 square miles straddling across Arizona, New Mexico and Utah. Except for the higher elevations of the Chuska Mountains and the Fort Defiance Plateau, most of the Navajo Nation is characterized by a semi-arid to arid climate. Management of water in such a water-deficit area requires availability of adequate data of the right kind. Getting such data require reliable and well-maintained instrumentation, timely data collection and processing following the right protocol and quality control standards, and making the data available to the user in the right form and at the right time. At present these requirements exceed the current Navajo Nation's manpower capacity, expertise, budget availability and data need. The entire nation has only 11 functioning stream gauges, two of which are operated by the U.S. Geological Survey. The nine gauges operated by the Navajo Department of Water Resources (NDWR) are concentrated on and near the Chuska Mountains. Even though this area produces about two-third of the surface water in the Navajo Nation, it does not represent its enormous size. Also because of debris accumulation and changes in stream cross-section, the gauges need constant maintenance and calibration to produce reliable data. At present this is lacking because the available hard working NDWR personnel are too few to perform all the tasks properly. Because quality stream flow is important for enhancing public safety by providing data for flood and drought forecasting and management, for designing and operating hydraulic structures such as reservoirs, bridges, culverts and conduits, for allocating water for municipal, industrial and agricultural uses, for setting minimum flow requirements for aquatic life, for developing and operating recreational facilities and for evaluating surface-groundwater interactions as well as for undertaking scientific studies in the Navajo Nation, we recommend ample investment for acquiring appropriate hydrologic information to help in developing a healthy economy and social well-being in the Navajo Nation.

EFFECTIVENESS OF NATIVE SEEDING AND LANDSCAPE SCALE HERBICIDE APPLICATIONS FOR CONTROLLING CHEATGRASS IN ZION NP

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After the Kolob Fire burned 10,516 acres of Zion National Park in late June of 2006, a Burned Area Emergency Rehabilitation (BAER) team was sent to evaluate the fire and formulate a rehabilitation plan. Due to the known prefire presence of cheatgrass (Bromus tectorum) and red brome (Bromus rubens) throughout the park and the ability of these species to dominate post-fire landscapes, controlling these invasive grasses was the primary concern of the BAER team. Native seeding and herbicide spraying were chosen as the prescribed treatments within the burned area. Over 8000 acres within the fire perimeter were aerially treated with imazapic (trade name Plateau®) herbicide and 473 acres were seeded with four native species. Three study sites are being used to evaluate the effectiveness of these treatments on the bromes and the residual plant community by measuring plant density, cover, and richness by species. This talk will introduce the three different study sites and preliminary results from one season of data will be discussed.

RESULTS AND MANAGEMENT IMPLICATIONS FROM WATER QUALITY MONITORING IN NORTHERN COLORADO PLATEAU PARKS

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Surface water in national parks is protected by the Clean Water Act and other policies that prevent unacceptable levels of pollution and establish acceptable values for other water-quality measures. Park managers need information on status and trends in surface-water quality and quantity to comply with the Clean Water Act and to mitigate historic and future impacts to park water resources that may have ecological and social significance. Recent monitoring by NCPN combined with historic monitoring data are used to demonstrate the utility of a practical water quality program that can be used by park managers to maintain or improve water quality where needed.

A CASE STUDY WITH BIRDS AT PETRIFIED FOREST NATIONAL PARK: IMPLEMENTING RESOURCE MANAGEMENT DECISIONS FROM SCIENTIFIC FINDINGS.

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I will provide information on the distribution, relative abundance, and habitat associations of breeding and wintering birds at Petrified Forest National Park, Arizona. This information is a summary of historical avian records, in concert with results of standardized surveys conducted during 1998 and 1999. In 1998 we established 10 sampling transects in order to document birds within the park. The numbers of count locations within each habitat type were established in proportion to the abundance of that habitat type within the park. Two survey methodologies (strip-transects and variable circular plots) were compared with data from 130 bird surveys during the breeding and winter seasons of 1998 and 1999. We counted a total of 2,812 birds representing 51 species. In addition, birds were captured with mist-nets in riparian habitat along the Puerco River during the 1998 breeding season. Evidence of breeding was observed for 24 species, of which 13 are newly recorded as breeding in the park. This research also provided a monitoring protocol that would enable Petrified Forest National Park to

track potential changes in bird populations. I will discuss how we structured our monitoring protocol and recommendations, so as to better enable park managers to assess potential impacts of future management activities on avian resources within Petrified Forest National Park.

CONCEPTUAL MODELING OF CLIMATIC INFLUENCES ON UPPER-ELEVATION PLANT COMMUNITIES ON THE COLORADO PLATEAU

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Climatic influences on upper-elevation plant communities are likely to be complex, involving a variety of proximate factors, including disturbances such as fire. Conceptual modeling is well-suited for dealing with such complexity, facilitating both understanding and communication. The challenge of conceptual modeling is achieving a balance between generality and detail that is appropriate for the task at hand. I present nested sets of conceptual models, originally developed to summarize and communicate what is known about upper-elevation ecosystems on the Colorado Plateau, especially vegetation-disturbance interactions. Each nested set consists of three types of models, with each model focusing on a different balance-point between generality and detail. Therefore, each nested set encompasses a broad range of scale and process specificity. The most generalized models, *ecosystem characterization models*, identify core components (including drivers) of ecosystems and illustrate how the components are functionally related. The *ecosystem dynamics models* show intermediate detail and portray the characteristic dynamics of ecosystems, indicating how ecosystems change and why. The most detailed models, *mechanistic models*, address specific mechanisms that underlie pathways of change (processes and transitions). Climatic effects are traced through models for ecosystems selected from Pinyon-Juniper, Ponderosa Pine, Mixed Conifer, Spruce-Fir, Montane-Subalpine Grassland, and Gambel Oak ecosystems.

RIPARIAN VEGETATION RESPONSES TO UNGULATE GRAZING IN SEMI-PERMANET WETLANDS: THE SCIENCE BEHIND CURRENT GRAZING MANAGEMENT IN NORTHERN ARIZONA

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Large scale grazing operations have been practiced on northern Arizona rangelands since the mid-1800's and still continue to shape the landscape today. Although these grazing impacts have been studied in many different systems and at many different levels, the dynamic systems of ephemeral and semi-permanent wetlands have had few previous studies. These unique wetlands constitute important habitats for many birds and wildlife species of Anderson Mesa of northern Arizona. In 2002 the US Forest Service installed exclosures designed to keep out large ungulates such as elk (Clervus canadensis) and cattle as part of the monitoring project mandated in the Pickett Padre Allotment EIS grazing re-lease first drafted in 2001. These exlcoures were placed within the vegetational transitions zones of six semi-permanent/emphermal wetlands of Anderson Mesa. Fifty frequency frames of species presence/absence and ground cover percent were taken inside and outside of each exclosure. During each year from 2002-2004 the Forest Service collected data where the wetland was the independent statistical unit. From 2002-2004 there were no significant effects of grazing detected. In 2005 and 2006, using the same collecting method, there was not a significant different, but when the independent reference point was changed from a wetland to a frequency frame, creating a nested design, a significant treatment effect was detected. Species richness and cover for grasses and forbs were higher in the ungrazed plots for both years; while bare ground was higher in the grazed plots. Not only was there effects from grazing found, but this study also indicated that with some very minor changes to the data collection and analysis of the project, it can be sensitive enough to detect these changes.

VEGETATION CHARACTERISTICS UNDER THREE TREE TYPES WITHIN PINYON-JUNIPER WOODLANDS EFFECTED BY DROUGHT RELATED MORTALITY

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During the past decade, drought in southwestern North America has triggered mortality of the co-dominate species of pinyon (Pinus edulis) in pinyon-juniper woodlands. During the severe drought of 2002 was when most of the tree mortality occurred, but drought is still presently persisting throughout much of the southwest. These mortality events can be seen as a "resetting" of the ecological clock, bringing the woodlands to an earlier successional stage. We hypothesized, that five years after the major pinyon die-off event, the understory vegetation response of pinyon-juniper woodlands in northern Arizona, would show signs of earlier successional stages more related to a pinyon-juniper grassland habitat, in which dead pinyons will serve as a different micro-habitat type than live pinyons and live junipers. A Daubenmire square was randomly placed under live juniper, live pinyon, dead pinyon trees, and in intercanopy spaces in 100 m2 plots. Species richness, cover by functional group, and cover by selected species were recorded to determine effects by tree type. Also, elevation and tree characteristics were recorded to determine their effects on the understory response. Results indicate that understory vegetation of dead pinyons exhibited significantly greater species richness. A pattern has emerged for all three vegetation variables with "dead pinyon" tree types being the most similar to "intercanopy spaces" then "live juniper" and "live pinyon". This indicates that dead pinyons create unique micro-habitat for understory species and over time the vegetation will trend towards a more pinyon-juniper grassland habitat.

UPDATE ON THE SYSTEMATIC INVENTORY AND SURVEY OF THE CAVES IN GRAND CANYON – PARASHANT NATIONAL MONUMENT, ARIZONA

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Cave resources of Grand Canyon Parashant National Monument are virtually unknown. During summer 2005 and early-spring 2006, we surveyed all 26 known caves on the Monument. Systematic procedures for mapping and inventorying geological, hydrological, paleontological, archeological and biological resources were developed and refined. Our study was the first regional systematic survey of caves in Arizona. Geologically, caves were found within Permian Kaibab limestone, Mississippian Redwall limestone, sandstone and basalt. We also documented airflow in 10 caves. Several caves may offer great opportunities for paleoenvironmental reconstruction. Two potentially significant archaeological sites were identified, and most caves were used during prehistoric and historic times. Several of the caves act as swallets and may be significant aquifer recharge points. We also inventoried vertebrates and invertebrates. Data collected during this study should be considered baseline data, which will be useful in identifying additional research needs on the monument. These data will also be used in developing cave resource management plans for these caves. The protocols developed have proven themselves in the field and are currently being used throughout the state. In the last year we have incorporated the use of volunteers and have discovered over 20 new caves and numerous new species of invertebrates.

MULE DEER ANTLER GROWTH AND HUNTING MANAGEMENT ON THE NORTH KAIBAB, ARIZONA

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Mule deer (Odocoileus virginianus) management must be biologically sustainable. Social expectations for hunter harvest and hunt quality often place greater restrictions on deer management than do biological limitations. The mule deer herd that inhabits the North Kaibab, Arizona (Game Management Unit 12A) is managed under Arizona Game and Fish Department alternative management guidelines that were designed to provide hunters with a greater opportunity to harvest a large-antlered deer, lower hunter densities, and higher hunt success during late season hunts. To determine appropriate age classes of deer for which to manage, I compared antler spread, antler points, and cementum age of mule deer bucks harvested on the North Kaibab from measurements taken at a mandatory hunter check station at Jacob Lake, Arizona. Mule deer antler points and antler spread increased with age until 5 years, at which point neither antler points or spread measurably increased. Through a public process, the Arizona Game and Fish Commission established alternative deer management guidelines that included permit adjustments for late season hunts to ensure 55-75% of animals harvested were ≥3 years of age and 20-30% of the animals harvested were ≥5 years of age.

POTENTIAL SPREAD OF A NON-NATIVE BARK BEETLE: ECOLOGICAL AND ECONOMIC CONSEQUENCES

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The spread of invasive non-native species can be facilitated by climate change, disturbance, and management. We are examining the potential spread of Dendroctonus mexicanus, a tree-killing bark beetle recently reported for the first time in the U.S. on the southern Arizona border. Our goal is to forecast the potential impacts on the forests, watersheds, recreational activities, and communities of Arizona and New Mexico, including both the potential economic loss and the possible interactions with wildfire, erosion, and other non-native species. The analysis is based on geographic data and models of climate change and vegetation dynamics. This work is being carried out through a Distributed Graduate Seminar on invasive forest pests and pathogens conducted nationwide with sponsorship from the National Center for Ecological Analysis and Synthesis and The Nature Conservancy. We are seeking feedback from managers and ecologists on the Colorado Plateau to uncover critical questions and concerns about the spread of invasive species.

THE EFFECTS OF GRAZING REGIME ON THE ABUNDANCE OF NATIVE WILLOW SPECIES

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In the Rocky Mountain West and Colorado Plateau region, cattle grazing is a common practice. These grazing regimes and livestock management practices play a key role in ecosystems where grazing occurs, as does the availability of water, which makes riparian areas quite vulnerable to adverse effects of overgrazing. Such a scenario occurred in Lone Mesa State Park – a relatively new state park in southwest Colorado. Long-term monitoring has been established in the park to determine the impacts of grazing on the riparian community of Plateau Creek. Cattle graze heavily on young willows, stunting their growth in areas where the plants are readily available. Study plots have been set up both inside and outside of exclosures built to limit the area where cattle can graze. Willow density was measured in each of the nine plots by counting the number of willows and height of each willow in a $10m^2$ plot. The relative density and frequency of willows was also measured along a 50m line-intercept transect. The abundance and size of willows inside and outside the exclosures can be compared to determine the effects of the current grazing regime on willow abundance and help to decide how best to control grazing in the future. Our data show that willows are much more abundant and much taller in areas that are not available to cattle, while grazed areas contain willows that are much smaller and less dense. This indicates that cattle do play a key role in the riparian ecosystem by stunting the growth of the native willows. This information may be used to help adapt future grazing regimes in the Park to minimize the impact that cattle grazing has on riparian vegetation.

CLIMATE AND PHENOLOGY DURING THE 1950S AND 2000S DROUGHTS IN THE SOUTHWESTERN U.S.A.

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The 1950s and 2000s droughts in the southwestern U.S.A. receive considerable examination of both the inherent climatic anomalies and subsequent effects. Here, we further investigate climatic differences between the two droughts and also present the concurrent phenologic differences by integrating spatial climate data and bioclimatic indices. Higher temperatures and lower atmospheric moisture during the 2000s drought primarily occur in spring and summer, whereas similar conditions occur during the 1950s drought in fall. Phenologically these conditions indicate in general that the 2000s drought is less limiting in minimum temperatures and more limiting in water stress. In the variable topography of the southwest, however, differential responses of phenology appear along elevation gradients and between seasons. Results also are interpreted to *Pinus edulis* die-off during the 2000s drought.

DISSECTING THE CAUSES AND EFFECTS OF A CLIMATE-INDUCED REGIONAL-SCALE TREE MORTALITY EVENT

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Droughts in the southwestern U.S. are projected to increase in frequency and intensity as global warming progresses (IPCC 2007). The recent protracted drought in the Southwest (1999-2003), in conjunction with warmer temperatures and bark beetle infestations, contributed to the subcontinental-scale mortality of overstory trees (primarily *Pinus edulis* and *Pinus ponderosa*). This rapid, widespread mortality will alter ecosystem structure and function for decades. Our goals are twofold: 1) to determine the driving forces behind the mortality by assessing the respective roles of abiotic climatic factors versus biotic host/pathogen population dynamics; and 2) to investigate possible changes in hydrological processes due to the mortality, in terms of precipitation and streamflow. Results of spatio-temporal pattern analysis demonstrate that mortality was primarily related to sustained low precipitation combined with increased temperatures and, secondarily, to stand properties associated with bark beetle infestation. In conjunction with drought, the high temperatures were key to the epidemic proportion of the mortality. To explore changes in the hydrological processes, we compare the temporal variability in the Rio Ojo Caliente streamflow (a subbasin of the Rio Grande where a significant portion of the overstory was impacted) to a remotely-sensed vegetation index (1-km AVHRR NDVI for 1989-2006), including the mean, anomalies from the mean, and seasonally-based duration curves. Significant correlations (correlation coefficient ρ = -0.61) exist between the streamflow and NDVI at approximately a three-month lag (NDVI lagging streamflow) during 1989-2006. In analyzing the three phases of the drought, the correlation is slightly stronger during the pre-drought (ρ = -0.64) and drought (ρ = -0.65) periods, yet markedly stronger during the post-drought period (ρ = -0.74), all with a three-month lag. This suggests that the coupling between vegetation water use and streamflow is tighter after the drought, which may be attributable to the reduction in the less-responsive overstory (tree mortality) and increase in the more-responsive understory (grasses and shrubs exploiting newly available resources). The aim of our research is to examine the causes and effects of a climate-induced regional-scale tree mortality event in order to improve our knowledge of ecosystem and hydrologic response to the changing climate.

CULTURAL RESOURCES PRESERVATION USING HYDROLOGIC MONITORING AND GIS AT AZTEC RUINS NATIONAL MONUMENT, NEW MEXICO

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Field studies were undertaken at Aztec Ruins National Monument in the town of Aztec, New Mexico starting in 2005 to assess the extent of shallow groundwater-related deterioration of several historic ruins. Aztec Ruins National Monument preserves the ruins of 900-year-old ancestral Pueblo great houses and kivas. These ruins have been exposed to many different types of precipitation events, including winter snowfalls, extended droughts, and monsoon rains in the summer months. Several piezometers were installed near the base of the walls of the main Aztec West great house ruin. Groundwater readings from these piezometers have been collected weekly since 2005. Preliminary analyses indicate that there is distinct seasonality to the groundwater level, and that the rise in late spring groundwater levels can be directly attributed to the onset of water flow in a large nearby irrigation ditch. GIS is being used in the construction of a comprehensive database of spatial data related to the Monument, including field results from the hydrology study, piezometer locations, great house and kiva locations, and visitor facilities (sidewalks, buildings, parking lots, and other visitor-related structures). When completed, this project will allow for the identification of water sources impacting the major ruins sites at the Monument leading to the recommendation of appropriate mitigation measures for protection of the ruins from continued deterioration. The GIS database will be used by National Park Service personnel as part of their ongoing effort to preserve the natural and cultural resources of Aztec Ruins National Monument.

WESTERN BLUEBIRDS COMPENSATE FOR INFLATED ECTOPARASITE INFESTATIONS IN A RESTORATION-TREATED FOREST

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Ponderosa pine (*Pinus ponderosa*) forest restoration treatments generally are considered high quality habitat for nesting western bluebirds (*Sialia mexicana*). However, levels of parasitism by the blowfly *Protocalliphora sialia* in treated forests are higher than reported elsewhere and may be outside the range of natural variability. Thus, treated areas could be functioning as an ecological trap for bluebirds, where fitness benefits are actually lower than perceived. We evaluated developmental and behavioral responses of bluebirds to *Protocalliphora* infestations in a restoration-treated ponderosa pine forest in 2003-2006 in northern Arizona to determine if and how bluebird nestlings are compensating for the higher parasite loads associated with treated forests. Nestlings with high *Protocalliphora* infestations (>15 pupae/nestling) were lighter and had less feather development at day six after hatch than nestlings with lower infestations (<15 puape/nestling). Heavily parasitized nestlings also reached 90% of their maximum weight up to 2.6 days later than nestlings with low infestations. However, nestlings with a lower rate of wing chord growth and later inflections point for weight gain fledged later, presumably using the additional time in the nest to achieve optimal development prior to fledge. In addition, we found no evidence to suggest that pre-fledging weight or parasite loads affected post-fledging survival. Therefore, we conclude that while high parasite loads can affect nestling development, nestlings may compensate for the effects of parasites before fledging using a delayed maturation strategy. Because bluebird nestlings appear to successfully employ developmental and behavioral plasticity to compensate for relatively high nest parasitism rates, parasite loads associated with treated forests appear to be within the natural range of variability for bluebirds.

TASSEL-EARED SQUIRREL RESPONSES TO FOREST TREATMENTS: MOSAICS MATTER

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The tassel-eared squirrel (Sciurus aberti), a resident of southwestern forests, is typically associated with dense, closed-canopy stands of ponderosa pine (Pinus ponderosa) with interlocking canopies. Because of their habitat associations, squirrels may respond negatively to forest treatments that greatly reduce tree density and canopy cover. To determine whether large-scale restoration treatments negatively influence squirrel abundance, we compared abundance at Mt. Trumbull, Arizona before (1997-1999) and after (2004-2006) application of reference condition-based restoration treatments. We found squirrel abundance declined during this time period, likely in response to drought conditions, but declined more steeply in a ~600-ha largely contiguous treatment area. To assess squirrel responses to treatment mosaics, we estimated abundance in wildland-urban interface treatment areas near Flagstaff, Arizona 2005-2007. Average squirrel abundance was highest in an untreated ponderosa pine forest and lowest in an untreated pine – Gambel oak (Quercus gambelii) forest. In 2005, after a winter with record snowfall (132”), we found the highest abundance of squirrels in two forest types: an untreated forest (~600-ha) and a treated forest (~700-ha) containing a mosaic of reference condition, natural process, and uneven-aged treatment prescriptions and unthinned patches (12-57 ha in size). Squirrel abundance was lowest in stands characterized as unthinned pine – oak and in a large (~400 ha) stand thinned using an uneven-aged but relatively even-spaced prescription. In 2006, after a mild winter with little snow (2”), squirrel abundance in this latter stand increased by 65%. In 2007, another mild winter, abundance increased at all plots except the unthinned pine – oak site. Our results indicate that a landscape management approach that incorporates a mosaic of treatments designed to improve tree production (e.g. restoration treatments), retain clumps of trees (e.g. some uneven-aged treatments), and maintain patches of unthinned forest can provide suitable squirrel habitat, even in relatively severe winters.

THE SECRET LIFE OF A VELVET ANT (HYMENOPTERA: MUTILLIDAE): CRYPTIC PATTERNS OF DIVERSITY ON THE COLORADO PLATEAU

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The Colorado Plateau is often characterized as part of the Great Basin Desert because of shared flora and fauna between these regions. Phylogeographic analyses of widespread species can uncover patterns of cryptic diversity that are important for conservation efforts. Many studies have explored genetic diversity patterns in the hot deserts of North America, while little work has been done on the Colorado Plateau and the Great Basin Desert. We used multiple genes to explore the phylogeographic patterns of a wide-spread velvet ant species, *Dilophotopsis concolor*. DNA sequences obtained from specimens across western North America suggest that populations in the Colorado Plateau are isolated, with little gene flow from populations in neighboring areas. These results suggest that, while *D. concolor* lives in both the Great Basin Desert and the Colorado Plateau, the populations on the Colorado Plateau are genetically distinct, supporting the distinctiveness of the Colorado Plateau.

IS INVASIVE SPECIES ABUNDANCE AFFECTED BY GRAZING INTENSITY?

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Invasive species in the West are becoming an ever-increasing problem, causing great losses in biodiversity. Lone Mesa State Park, along the northern reaches of the Colorado Plateau, was once overgrazed ranchland. A long-term monitoring project was begun in 2003 to help develop a stewardship plan for the Park, involving a change in grazing regimes. Several grazing exclosures were built as ‘test’ plots to study the effects of grazing compared to not grazing on vegetation composition. In nine sites both in and out of these exclosures, we collected data on percent-cover of native and non-native species using 0.5m^2 quadrats along the riparian corridor. We hypothesized that invasive species would be more prolific in areas that had been grazed, and less prolific in plots protected from grazing. Our final results could affect range management decisions by indicating how grazing impacts efforts to control invasive species in Lone Mesa State Park.

RIPARIAN RESTORATION WITHIN A CULTURAL LANDSCAPE AT HUBBELL TRADING POST NHS

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After years of over-grazing, unsuccessful erosion control efforts and invasion by non-native species, the Pueblo Colorado Wash was anything but healthy. With funding from various sources, Hubbell Trading Post began stream restoration efforts in 1998 with removal of invasive exotic plants. This work was followed by planting of native species and construction of in-stream structures to force the straight-running channel to meander. Almost ten years later this project is deemed a success based on the number of "technical experts" that have come to examine the project area. Situated in the middle of a cultural landscape this project isn't really a restoration, because the result is greener and lusher than anything recorded historically. This restoration project is only one component of general "restoration" projects at Hubbell. The park is also restoring agriculture to the park's landscape, with cultivation of fields and planned replacement of fruit trees and other non-native species that are part of the cultural landscape. This paper explores past and proposed restoration efforts in the park.

A COMPARISON OF CAVE-DWELLING INVERTEBRATE COMMUNITIES FROM THE NORTH RIM AND THE INTERIOR GRAND CANYON

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Cave invertebrate communities in Arizona are largely uncharacterized. While knowledge of invertebrate communities of caves in Grand Canyon and the Canyon's north rim is vastly incomplete, I will analyze invertebrates from these two regions using available data. Results from a review paper (Wynne et al. 2007) were used for Grand Canyon National Park and data from baseline invertebrate inventories were used for Grand Canyon-Parashant National Monument. In Grand Canyon National Park, approximately 37 invertebrates were identified from investigations at 15 caves. Researchers at Grand Canyon-Parashant National Monument identified at least 33 invertebrates from six caves. Differences in gamma diversity are likely due to the difference in sampling intensities between management units. While inconclusive, the similarity in total species per park does provide some interesting insights into differences in community composition between these two management units.

DIFFERENTIATING SKYLIGHTS OF INTERPLANETARY LAVA TUBE CAVES FROM NON-TARGET SITES FOR EXPLORATION

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Seven large cave-like structures were recently discovered on the northern flank of Arsia Mons, Mars. These features were tentatively described as cave skylights. By definition, the term "skylight" suggests these features may be connected to lava tube or piping cave structures. We have analyzed these features and compared them to both cave skylights and pit craters on Earth. The characteristics of the Arsia Mons features appear consistent with terrestrial pit craters. From our experience with terrestrial pit craters, these features do not provide subterranean access beyond being a deep pit or crevice. We suggest the Arsia Mons features are pit craters and probably do not provide access to the Martian subterranean realm. Thus, these features are unlikely to afford the level of protection necessary to support human habitation or access to possible evidence of life. While we expect speleogenesis to have occurred on Mars and we do expect to find caves on the Red Planet, our ability to detect caves is currently limited by the resolution and wavelengths of sensor platforms orbiting Mars. We suggest the best approach for characterizing skylights and other potential cave features will be through a combined high resolution visible-thermal imagery interpretation. HiRISE is currently capturing high resolution visible imagery (at 0.23 cm pixel size) and these imagery have been instructive in gaining further inference into the genesis of the Arsia Mons cave-like features. The only thermal imaging platform, THEMIS, provides only coarse resolution data (100m pixel size). Furthermore, we suggest we will likely find the most caves using an oblique angled sensor. Caves with a low angle trajectory are likely to be the highest priority targets for exploration because these features will be most suitable for potential human habitation and investigation to search for evidence of life.

THERMAL BEHAVIOR OF SOUTHWESTERN U.S. CAVES AND PIT CRATERS ON ARSIA MONS, MARS

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We have demonstrated caves on Earth may be detected using thermal imaging. From study of several caves in the southwestern U.S., we collected and analyzed ground-based hourly temperature data, ground-based thermography, and thermography via fixed wing aircraft and hot air balloons. Through this work, we have gained insights into detection of terrestrial caves in the thermal infrared. There are diurnal and seasonal temperature variations, and caves are most detectable when the temperature contrast between the entrance and ground surface is greatest. However, geological and structural aspects of caves and surrounding surface may affect thermal behavior and thus detectability. We

are applying insights and lessons learned from Earth caves to explore the feasibility of using orbiter-based thermal imagery to detect caves on the Martian surface. Preliminary analyses of visual and thermal imagery have revealed possible cave-like structures in several regions on Mars. Many of these features have thermal characteristics similar to some of our terrestrial sample sites. While it is inconclusive whether these features lead to subterranean passage into the Red Planet, these results are compelling and warrant further research.

FIELD-TO-DESKTOP: BUILDING WIRELESS CYBERINFRASTRUCTURE FOR ENVIRONMENTAL MONITORING

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The technology of wireless sensor networks has enabled new levels of spatial coverage and density in the monitoring of variables important in numerous applications, including ecological research and environmental management. These networks are composed of small, energy-efficient devices that wirelessly self-organize and collaborate to gather data on temperature, light, soil moisture, sap flux and other variables over space and time. However, a complete monitoring solution requires the conversion of this data to useful information for a user who may be anywhere in the world. To address this challenge, we have designed a complete field-to-desktop system for the acquisition, storage, and visualization of environmental data from a wireless sensor network using industry-standard networking, database, and web development tools. This paper describes the architecture and capabilities of the system and lessons learned from a test implementation at the Arboretum at Flagstaff designed for public outreach.

TEMPORAL RESPONSES OF MULE DEER TO PONDEROSA PINE FOREST RESTORATION TREATMENTS

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Forest restoration and fuels reduction treatments are currently being applied in forests throughout Arizona. These treatments open the forest canopy and stimulate shrub and herbaceous production. Treatments may improve foraging habitat for mule deer (*Odocoileus hemionus*) but may also reduce availability of day bed sites and fawn hiding cover. We evaluated mule deer habitat selection patterns across a restoration-treated ponderosa pine (*Pinus ponderosa*) landscape at Mount Trumbull, located on the Grand Canyon-Parashant National Monument in northern Arizona. Our objectives were to evaluate habitat selection within home range areas and to compare habitat selection patterns among day, night, and crepuscular hours. In 2003 we outfitted 15 female mule deer with GPS store-on-board collars, obtaining >16,500 locations from 13 individuals between June 2003 - September 2005. Overall, female mule deer spent more time in the treated areas when on or near the study area. Using resource selection functions estimated for deer separately for each time period, we used an information theoretic approach to select the best set of predictor variables for describing deer habitat use in different time periods. Deer exhibited strong selection for treated plots at night, whereas they appeared to split their time equally between treated and untreated plots during daytime hours. We suggest that female mule deer selected treated patches, especially at night, to take advantage of the higher abundance of forage in the treated areas. We also infer from our results that daytime cover was not limiting on treated plots. Gambel oak (*Quercus gambelii*) and juniper (*Juniperus* sp.) were not removed during treatment and may have provided some of this cover. Thus, in restoration-treated forests without an oak or juniper component, cover might be more limiting and availability of untreated patches or other features that provide cover could be more important for deer.

EFFECTS OF TOPOGRAPHY AND WOODY PLANT CANOPY COVER ON NEAR-GROUND SOLAR RADIATION: IMPLICATIONS FOR VEGETATION GRADIENTS AND DYNAMICS ON THE COLORADO PLATEAU

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The Colorado Plateau features various gradients of vegetation cover embedded in complex terrains. Vegetation cover and topography interact to mitigate the below-canopy solar radiation environment and create heterogeneity in microclimates. Heterogeneity in microclimates produces feedbacks through which ecohydrological processes drive ecological processes like seedling recruitment and tree mortality. The individual effects of canopy cover and topography on below canopy solar radiation is well understood, but a synthesis of the interactive effects of these two modification types is generally lacking. We systematically estimated near-ground surface solar radiation inputs as modified by key attributes of topography (aspect and slope) and tree cover (degree of openness) using solar radiation modeling based on hemispherical photographs. For south aspects, reductions in annual transmission were dominated by canopy cover rather than topography, even when canopy cover was low. Conversely, for north aspects, canopy effects dominated the reduction in annual transmission for slopes of up to 10^{o} within low canopy cover communities and up to 30^{o} under high canopy cover. Our results provide a synthetic perspective of the nonlinear, interactive, and temporally dependent effects of slope, aspect, and amount of canopy cover on near-ground solar radiation. Further, our results are directly applicable and accessible for studies of vegetation gradients on the Colorado Plateau and of related dynamics that change tree cover, such as tree thinning, fire and drought-induced tree mortality.