Eighth Biennial Conference of Research on the Colorado Plateau

du Bois Center, Northern Arizona University

7 - 10 November 2005

Program and Abstracts of Presented Papers and Posters

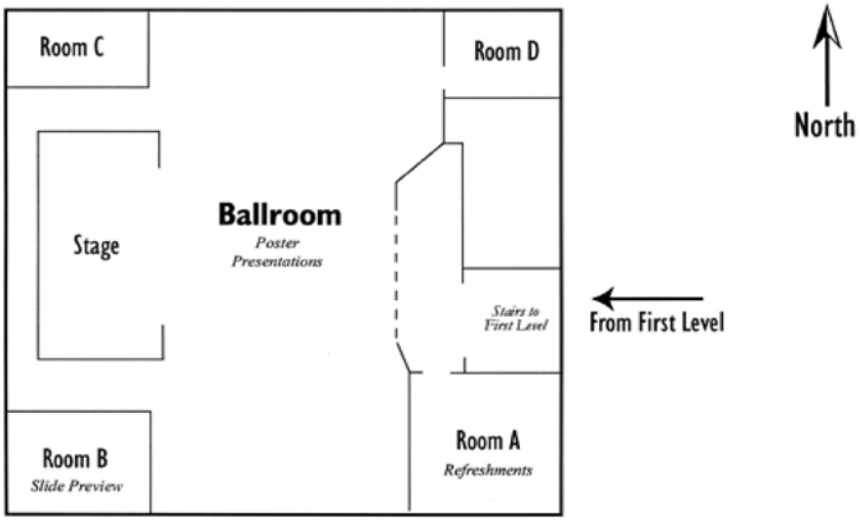
(Version 2.0)

Sponsored by:

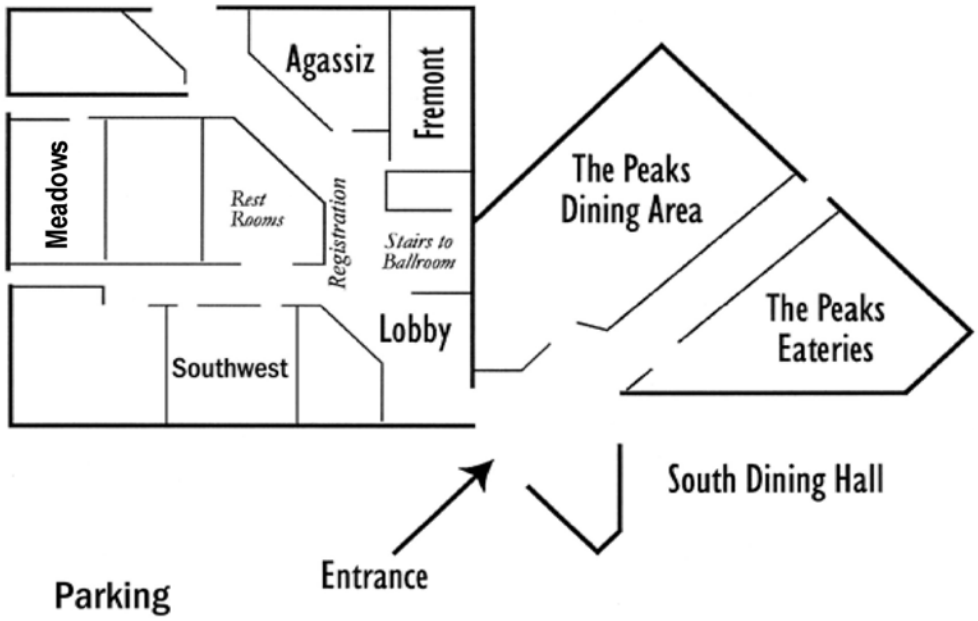
USGS Southwest Biological Science Center
NAU Center for Sustainable Environments
NAU Merriam-Powell Center for Environmental Research
Colorado Plateau Cooperative Ecosystems Studies Unit
Bureau of Land Management
National Park Service
Diablo Trust

duBois Conference Center Floor Plan

Second Level



First Level



Conference Coordinators

Conference Chair	Mark Sogge
Program Chair	Mark Sogge
Registration Manager	Julye Evans and Marie Saul
Food and Promotion	Julye Evans
Audio-Visual	Kristina Ecton
Information Technology	Ryan Stevens
Poster Session Chair	Terry Arundel

Session Developers

Cave Resource Management	J. Judson Wynne
Colorado Plateau Cooperative Ecosystems Studies Unit Social/Meeting Sponsor	Rod Parnell and Ron Hiebert
Conservation Science, Policy and Practice	Paul Beier
Creating Successful Partnerships for Rangealnd Conservation	Michele James and Karan English
Demystifying Mycorrhizae	Bala Chaudhary
Ecological Networks and Long-term Research on the Colorado Plateau	Neil Cobb
Ecology and Management of Biological Soil Crusts	Matt Bowker
Ecology, Management and Restoration of Riparian Habitats	Gery Allen
Ecosystem Responses to Fuel Management Treatments in Ponderosa Pine Forests	John Bailey
Fossil Creek: An opportunity to Restore Diverse Native Fishery and Study the Effects of Return of Full Flows	Michele James and Allen Haden
Integrating Science with Resource Management Through Collaborative Approaches and Adaptive Modeling Systems	Neil Cobb and Tom Sisk
Invasive Plant Ecology	Chris McGlone
Past, Present, and Future Climate Variation and Ecological Impacts	Neil Cobb
Southwest Regional GAP Analysis: the Colorado Plateau	Kathryn Thomas
Status of the Colorado River Ecosystem	Ted Melis

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. – 4:00 p.m.	Monday, November 7th
7:30 a.m. – 4:00 p.m.	Tuesday, November 8th
7:30 a.m. – 4:00 p.m.	Wednesday, November 9th
7:30 a.m. –12:00 p.m.	Thursday, November 10th

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).

Email service will be available in Room B of the du Bois Conference Center Ballroom.

Dining: Meals are available at several locations at the du Bois Conference Center or at nearby off-campus restaurants. Please see the Flagstaff Travel Guide available at the registration desk for a list of eating establishments (p. 42) and a city map (back inside cover).

Parking: Follow the posted signs to Biennial Conference parking. Conference participants can use Lots 40 and 66 (north and northest, respectively, of the duBois Center. Refer to the NAU Campus map in the registration folder. 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.

Submissions for the Proceedings of the 8th Biennial Conference of Research on the Colorado Plateau

We invite interested individuals to publish research presented at the 8th Biennial conference of Research on the Colorado Plateau in the 8th 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 seven 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://www.usgs.nau.edu/conf2005/authorsguide.htm

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: 06 January 2006

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

7th volume of the Biennial Conference Proceedings Series

A proceedings of the 7th Biennial Conference of Research on the Colorado Plateau has been published as a book, entitled "The Colorado Plateau II", by The University of Arizona Press. UA Press will be present and taking orders for the book at the 8th Biennial Conference.

CONFERENCE SCHEDULE

	Rooms			
Time	*BALLROOM*	*AGASSIZ*	*FREMONT*	*SOUTHWEST*
Tuesday Morning	**OFFICIAL INTRODUCTION** **Fire Treatments and Restoration**	**Integrating Science with Resources Management Through Collaborative Approaches and Adaptive Modeling Systems**	**Southwestern Regional GAP Analysis: The Colorado Plateau**	
Tuesday Afternoon	**Ecology, Management and Restoration of Riparian Habitats**	**Human Dimensions in Resource Management**	**Ecosystems Responses to Fuel Management Treatments in Ponderosa Pine Forests**	
Tuesday Evening	**Poster Session**			
Wednesday Morning	**Conservation Science, Policy and Practice I**	**Demystifying Mycorrhizae** **Ecology and Management of Biological Soil Crusts**	**Cave Resource Management**	**Modeling and Classification** **Resource History and Assessment**
Wednesday Afternoon	**Conservation Science, Policy and Practice II**	**Ecological Effects of Past, Present and Future Climate Change on Southwestern Forests and Woodlands**	**Cave Resource Management**	**Animal Ecology I** **Vegetation Ecology**
Thursday Morning	**Invasive Plant Ecology**	**Ecological Networks and Long-term Research on the Colorado Plateau**	**Fossil Creek: An Opportunity to Restore Diverse Native Fishery and Study the Effects of Return of Full Flows**	
Thursday Afternoon	**Status of the Colorado River Ecosystem**	**Animal Ecology II**	**Creating Successful Partnerships for Rangeland Conservation**	

PROGRAM SYNOPSIS

MONDAY, 7 November 2005

Side-Meetings

9:00 – 1:00 Ecological Networks
1:00 – 2:30 NBII (National Biological Information Infrastructure) Southwest Information Node
1:00 – 5:00 Restoration Research Opportunities at Grand Staircase-Escalante National Monument
2:00 – 5:00 Restoration of Ponderosa Pine Ecosystems in Wilderness Areas and National Park Service Backcountry
2:45 – 5:00 National Park Service All-taxa Biodiversity Inventory

7:00 – 9:00 Colorado Plateau Cooperative Ecosystem Studies Unit Mixer

TUESDAY, 8 November 2005

8:30 – 9:00 **Official Introduction**

9:00 – 11:20 Integrating Science with Resource Management through Collaborative Approaches and Adaptive Modeling Systems (*Special Session*)

9:00 – 12:00 Fire treatment and Restoration (*General Session*)

9:00 – 11:20 Southwest Regional GAP Analysis: the Colorado Plateau (*General Session*)

12:00 – 1:00 Lunch

1:00 – 3:00 Ecology, Management and Restoration of Riparian Habitats (*Special Session*)

1:30 – 3:00 Ecosystem Responses to Fuel Management Treatments in Ponderosa Pine Forests (*Special Session*)

1:00 – 4:20 Human Dimensions in Resource Management (*General Session*)

7:00 – 9:00 **Poster Session**

WEDNESDAY, 9 November 2005

8:00 – 9:30 Demystifying Miccorhizae (*Special Session*)

8:00 – 12:00 Conservation Science, Policy and Practice I (*Special Session*)

8:00 – 9:40 Modeling and Classification (*General Session*)

8:00 – 12:00 Cave Resource Management I (*Special Session*)

9:30 – 11:50 Ecology and Management of Biological Soil Crusts (*Special Session*)

10:20 – 12:00 Resource History and Assessment (*General Session*)

WEDNESDAY, 9 November 2005 - continued

12:00 – 1:00	Lunch
1:00 – 3:00	Animal Ecology I (*General Session*)
1:00 – 3:00	Cave Resource Management II (*Special Session*)
1:00 – 5:00	Conservation Science, Policy and Practice II (*Special Session*)
1:00 – 4:20	Ecological Effects of Past, Present and Future Climate Variation on Southwest Forests and Woodlands (*Special Session*)
3:00– 5:00	Colorado Plateau Cave Resources Managers Meeting
3:20 – 5:00	Vegetation Ecology (*General Session*)
7:00 – 9:00	Mixer/ Social at the Museum of Northern Arizona

THURSDAY, 10 November 2005

8:20– 12:00	Ecological Networks and Long-term Research on the Colorado Plateau (*Special Session*)
8:20 – 11:20	Fossil Creek: An Opportunity to Restore Diverse Native Fishery and Study the Effects of Return of Full Flows (*Special Session*)
8:20 – 11:20	Invasive Plant Ecology (*Special Session*)
8:00 – 10:00	Colorado Plateau Cave Resources Managers Meeting
12:00 – 1:00	Lunch
1:00– 4:20	Animal Ecology II (*General Session*)
1:00 – 3:00	Creating Successful Partnerships for Rangeland Conservation (*Special Session – Panel Discussion*)
1:00 – 4:20	Status of the Colorado River Ecosystem (*Special Session*)

SIDE MEETINGS – Monday November 7th

9:00 – 1:00 Ecological Networks
SOUTHWEST ROOM
Organizer: Neil Cobb

1:00 – 2:30 NBII (National Biological Information Infrastructure) Southwest Information Node
SOUTHWEST ROOM
Organizer: Neil Cobb

1:00 – 5:00 Restoration Research Opportunities at Grand Staircase-Escalante National Monument
HUMPHREYS ROOM
Organizer: Marietta Eaton

2:00 – 5:00 Restoration of Ponderosa Pine Ecosystems in Wilderness Areas and National Park Service Backcountry
AGASSIZ ROOM
Organizer: David Ostergren

2:45 – 5:00 National Park Service All-taxa Biodiversity Inventory
SOUTHWEST ROOM
Organizer: Neil Cobb

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: Rod Parnell and Ron Hiebert

DETAILED SCHEDULE

Official Welcome & Introduction

Tuesday Morning 8:30-9:00 a.m.
BALLROOM

8:30-8:35	MARK SOGGE, *Supervisory Ecologist, USGS Southwest Biological Science Center* – Conference Chair Welcome
8:35-8:45	LAURA HUENNEKE, *Dean, College of Engineering and Natural Sciences* – Northern Arizona University Welcome
8:45-8:55	Dennis Fenn, *Center Director, Southwest Biological Science Center* – USGS Welcome

Fire Treatment and Restoration

Tuesday Morning 9:00 a.m.-12:00 p.m.
BALLROOM
Moderator: Matt Johnson, *USGS Southwest Biological Science Center, Colorado Plateau Research Station, Northern Arizona University*

9:00-9:20	RESTORATION OF SOUTHWESTERN PONDEROSA PINE FORESTS: IMPLICATIONS AND OPPORTUNITIES FOR WILDLIFE. **WIGHTMAN**, CATHERINE S., Steven S. Rosenstock
9:20-9:40	LANDSCAPE-SCALE CHANGES IN CANOPY FUELS AND POTENTIAL FIRE BEHAVIOR FOLLOWING PONDEROSA PINE RESTORATION TREATMENTS. **ROCCAFORTE**, JOHN PAUL, Fulé, Peter Z. Covington, W. Wallace
9:40-10:00	PRE-FIRE TREATMENT EFFECTS AND POST-FIRE FOREST DYNAMICS ON WHITE MOUNTAIN APACHE TRIBE LANDS WITHIN THE RODEO-CHEDISKI BURN AREA, ARIZONA. **STROM**, BARBARA A., Peter Fule
10:00-10:20	BREAK
10:20-10:40	EVALUATE TREATMENTS TO REDUCE HAZARDOUS FINE FUELS CREATED BY NON-NATIVE PLANTS IN ZION CANYON. **DECKER**, CHERYL, Matthew Brooks, Curt Deuser, J.R. Matchett, Aviva O'Neil and Jennifer Vollmer
10:40-11:00	EFFECTS OF PRESCRIBED FIRE ON BARK BEETLE COLONIZATION IN SOUTHWEST PONDEROSA PINE FORESTS. **BREECE**, CAROLYN R., Thomas E. Kolb, Karen M. Clancy, Joel D. McMillin, Brett G. Dickson
11:00-11:20	EVALUATING POSTFIRE SEEDING TREATMENTS TO SUPPRESS CHEATGRASS (*BROMUS TECTORUM*) IN PONDERSOSAL PINE FORESTS ON THE SHIVWITS PLATEAU. **LAIR**, BRIDGET, Matt Brooks, Curt Deuser
11:20-11:40	RESPONSE OF FUELBED CHARACTERISTICS TO RESTORATION TREATMENTS IN PIÑON-JUNIPER-ENCROACHED SHRUBLANDS ON THE SHIVWITS PLATEAU, ARIZONA. **SMITH**, HELEN Y., Sharon Hood, Matt Brooks, JR Matchett, Curt Deuser
11:40-12:00	FIVE YEARS OF VEGETATION CHANGE FOLLOWING HIGH-SEVERITY FIRE AND FIRE-FIGHTING ACTIVITIES IN GRAND CANYON NATIONAL PARK. **CRAWFORD**, JULIE, Niki Juarez-Cummings

Integrating Science with Resource Management Through Collaborative Approaches and Adaptive Modeling Systems

Tuesday Morning 9:00-11:20 a.m.
AGASSIZ
Moderator: Neil Cobb and Tom Sisk, *Merriam Powell Center for Environmental Research and Center for Environmental Sciences, Northern Arizona University*

9:00-9:20	PROJECT FRAME (**F**RAMING **R**ESEARCH FOR **A**DAPTIVE **M**ANAGEMENT OF **E**COSYSTEMS): USING COLLABORATIVE MODELING APPROACHES TO LINK SCIENCE TO RESOURCE MANAGEMENT NEEDS. **TURNER,** CHRISTINE, Richard Zirbes, George Leavesley
9:20-9:40	SPATIALLY EXPLICIT MODELING OF COLORADO PLATEAU LANDSCAPES FROM CONCEPTUAL MODELS TO A COMPUTER SYSTEM. **CHEW**, JIMMIE D., Kirk Moeller, Chris Stalling
9:40-10:00	A MODULAR MODELING APPROACH TO INTEGRATING ADAPTIVE MODELING SYSTEMS WITH RESOURCE MANAGEMENT IN THE FRAME PROJECT. **LEAVESLEY**, GEORGE, Roland Viger, Jim Chew, Christine Turner, Richard Zirbes, William Romme, Mark Miller, George San Miguel, Neil Cobb, and Lisa Floyd-Hanna
10:00-10:20	BREAK
10:20-10:40	MANAGEMENT GOALS DRIVE THE DEVELOPMENT OF ADAPTIVE MODELS FOR FOREST CONSERVATION AND WILDLAND FIRE PLANNING AT MESA VERDE. **SAN MIGUEL**, GEORGE L.
10:40-11:00	MODELING EDGE EFFECTS INCREASES RELEVANCE OF FIELD RESEARCH IN HABITAT MANAGEMENT. **SISK**, TOM, Haydee Hampton, Leslie Ries, Arriana Brand
11:00-11:20	INTEGRATED SPATIAL MODELS INFORM LANDSCAPE-LEVEL PLANNING FOR FOREST RESTORATION AND TREATMENTS. **DICKSON**, BRETT G., Haydee M. Hampton, John W. Prather, Thomas D. Sisk, Yaguang Xu

Southwest Regional GAP Analysis: the Colorado Plateau

Tuesday Morning 9:00-11:20 a.m.
FREMONT
Moderator: Katherine Thomas, *USGS Southwest Biological Science Center, Sonoran Desert Reearch Station, University of Arizona*

9:00-9:20	KEEPING COMMON SPECIES COMMON. **PRIOR-MAGEE**, JULIE S., John Lowry, Ken Boykin, Andrea Ernst
9:20-9:40	ECOLOGICAL SYSTEMS OF THE COLORADO PLATEAU. **THOMAS**, KATHRYN, Keith Schulz, John H. Lowry
9:40-10:00	VERTEBRATE SPECIES OF THE COLORADO PLATEAU. **BOYKIN**, KENNETH G., Charles A. Drost, J. Judson Wynne
10:00-10:20	BREAK
10:20-10:40	LAND STEWARDSHIP AND THE GAP ANALYSIS. **ERNST**, ANDREA E., Julie S. Prior-Magee
10:40-11:00	CONSERVATION OPPORTUNITIES ON THE COLORADO PLATEAU: LAND COVER. **LANGS**, LISA A., Kathryn A. Thomas, John H. Lowry, Keith Schulz
11:00-11:20	VERTEBRATE GAP ANALYSIS ON THE COLORADO PLATEAU USING SOUTHWEST REGIONAL GAP (SWReGAP) DATA. **WYNNE**, J. JUDSON, Charles A. Drost, Kenneth G. Boykin

Ecology, Management and Restoration of Riparian Habitats

Tuesday Afternoon 1:00-3:00 p.m.
BALLROOM
Moderator: Gery Allan, *Department Of Biological Sciences And Environmental Genetics And Genomics Research Laboratory, Northern Arizona University*

1:00-1:20 RETURNING NATURAL FLOW INTO THE OXBOW: RESTORATION OF A 40 YEAR-OLD DIVERSION IN CAPITOL REEF NATIONAL PARK, UTAH. **WORTHINGTON**, DAVID

1:20-1:40 LINKAGES AMONG TERRESTRIAL RIPARIAN COMPONENTS IN THE COLORADO RIVER CORRIDOR OF GRAND CANYON NATIONAL PARK. **KEARSLEY**, M., D. Lightfoot, S. Brantley, J. Frey, G. Carpenter, H. Yard, N. Cobb

1:40-2:00 CONSEQUENCES OF THE INVASION OF EXOTIC SALTCEDAR: AN ARTHROPOD PERSPECTIVE. Durst, Scott L., Tad C. Theimer, EBEN H. **PAXTON**, Mark K. Sogge, Marlyse C. Waskiewicz

2:00-2:20 PATTERNS OF DROUGHT MORTALITY IN A DOMINANT RIPARIAN TREE. **GITLIN**, ALICYN R., Thomas G. Whitham

2:20-2:40 PLANT GENES LINK FORESTS AND STREAMS. **LEROY**, CARRI J., Thomas G. Whitham, Paul Keim, Jane C. Marks

2:40-3:00 ECOLOGICAL GENETICS OF COTTONWOOD HYBRID ZONES. **ALLAN**, GERY J., Randy Bangert, Thomas C. Whitham, Paul Keim

Human Dimensions in Resource Management

Tuesday Afternoon 1:00-4:20 p.m.
AGASSIZ
Moderator: Gary Deason, *Center for Sustainable Environments, Northern Arizona University*

1:00-1:20 HUMAN DIMENSIONS OF MOUNTAIN LION MANAGEMENT: VALUE ORIENTATIONS AND POLICY PREFERENCES OF NORTHERN ARIZONA RESIDENTS. **RUTHER**, ELIZABETH J., David M. Ostergren, David J. Mattson

1:20-1:40 STEALING OR "JUST LOOKING:" STUDIES OF VISITORS AND RESOURCE INCIDENCE AT PETRIFIED FOREST NATIONAL PARK, ARIZONA. **HOSPODARSKY**, DENVER, Martha E. Lee, Kathleen McBride

1:40-2:00 SAFETY AND PREPAREDNESS OF DAY HIKERS AT GRAND CANYON. **STEWART**, William, Erik Backlund, Cary McDonald

2:00-2:20 USER DISCRETIONARY TIME: A MODEL TO ESTIMATE OPPORTUNITIES FOR VISITOR EXPERIENCE. **BOWMAN**, CARL B.

2:20-2:40 HYBRID POPLAR PRODUCTION FOR MULTIPLE BENEFITS IN THE SEMI-ARID SOUTHWEST. **HEYDUCK**, ROB, Mick O'Neill, Kevin Lombard, Dan Smeal, Rick Arnold

2:40-3:00 CANYONS, CONSERVATION AND A COMMUNITY CORP: AN INTEGRATED APPROACH TO CULTURAL AND NATURAL RESOURCE PRESERVATION AT CANYON DE CHELLY NATIONAL MONUMENT. **LESLIE**, F. ELAINE, Travis Scott

Human Dimensions in Resource Management - continued

3:00-3:20 BREAK

3:20-3:40 PROTECTING NORTHERN ARIZONA'S NATIONAL MONUMENTS: THE CHALLENGE OF TRANSPORTATION MANAGEMENT. Hartley, Dawn, Janice L. Thomson, JILL **OZARSKI**, Karen Murray, Nada Wolff Culver

3:40-4:00 RECREATIONAL IMPACTS RELATED TO THE IMPLEMENTATION OF A TRANSPORTATION SYSTEM: A CASE STUDY OF ZION NATIONAL PARK. **FOTI**, PAM, Jeff Bradybaugh

4:00-4:20 MOTIVATION FOR OFF-HIGHWAY VEHICLE RECREATION AND PERCEPTIONS OF MANAGEMENT STRATEGIES AND PROPOSED POLICIES OF OFF-HIGHWAY VEHICLE RIDERS AND FOREST SERVICE MANAGERS. **TOMCZAK**, L.M., M. E. Lee

Ecosystem Responses to Fuel Management Treatment in Ponderosa Pine Forests

Tuesday Afternoon 1:00-4:50 p.m.
FREMONT
Moderator: John Bailey, *School of Forestry and Merriam Powell Center for Environmental Research, Northern Arizona University*

1:30-2:10 FIRE AND FIRE SURROGATE RESEARCH: PROGRAM OVERVIEW AND OVERSTORY VEGETATION DYNAMICS IN ARIZONA. **BAILEY**, JOHN D., Carl Edminster

2:10-2:35 FIRE-FIRE SURROGATE STUDIES ON THE SOUTHWEST PLATEAU: INITIAL IMPACTS ON SOILS. **SULLIVAN**, BENJAMIN W., Stephen C. Hart, Steven T. Overby, Dan Guido, Dana Erickson, Dan Neary, Carl Edminster

2:35-3:00 UNDERSTORY VEGETATION RESPONSES TO GROUP SELECTION THINNING AND PRESCRIBED FIRE AT THE ARIZONA FIRE AND FIRE SURROGATE SITES. **SPEER**, ROBERT K., Carolyn Hull Sieg

3:00-3:20 BREAK

3:20-3:45 SMALL MAMMAL POPULATION RESPONSES TO FOREST FUEL REDUCTION TREATMENTS AT THE SOUTHWEST PLATEAU FIRE AND FIRE SURROGATE PROJECT. **CONVERSE**, SARAH J., William M. Block, Gary C. White

3:45-4:10 AVIAN COMMUNITY RESPONSES TO FOREST THINNING AND PRESCRIBED SURFACE FIRE, ALONE AND IN COMBINATION. **REED**, SARAH, Thomas D. Sisk, William M. Block, Brett G. Dickson

4:10-4:50 PANEL DISCUSSION

Poster Session

Tuesday Evening 7:00-9:00 p.m.
BALLROOM
Posters are listed in order of their location.

1 GEOLOGIC MAPPING OF THE GREATER GRAND CANYON REGION, NORTHWESTERN ARIZONA. **PRIEST**, SUSAN S., Tracey J. Felger, George H. Billingsley

2 PUMA ECOLOGY AND MOVEMENTS IN THE GRAND CANYON REGION. **GARDING**, EMILY, Elaine F. Leslie, R.V. Ward, Eric C. York

3 CLIMATE CHANGE, ECOSYSTEM IMPACTS, FOREST MANAGEMENT AND EXTENSION EDUCATION. **JONES**, CHRISTOPHER, Gregg Garfin, Thomas DeGomez, Alix Rogstad, Melanie Lenart, Katharine Jacobs, Michael Crimmins

4 A TALE OF TWO DROUGHTS: CHANGING TEMPERATURES & SOUTHWESTERN DROUGHTS. **GARFIN**, GREGG, Jean Morrill, Andrew Comrie, Jeremy Weiss

5 REMOTELY SENSED ECOSYSTEM IMPACTS OF DROUGHT AT C. HART MERRIAM TRANSECT. K**IM**, YOUNGWOOK, Alfredo R. Huete

6 EXPLORATORY ANALYSES OF CONTEMPORARY HUMAN ACTIVITY AT PREHISTORIC SITES IN SOUTHWEST COLORADO. **HARTLEY**, RALPH J., Anne M. Wolley Vawser

7 YOUTH FARMING AND RESTORATION PROJECT AT WEPO SPRINGS. **KELLEY**, Shawn R., Louella Nahsonhoya, Brandon Nahsonhoya, Andrew Lewis

8 THE EFFECTS OF TRAVERTINE DAMS ON LEAF LITTER RETENTION IN FOSSIL CREEK, AZ. **MIER**, MEAD, Zaccheaus, Compson

9 HAIRY WOODPECKER WINTER ROOST CHARACTERISTICS IN BURNED PONDEROSA PINE FOREST. **COVERT-BRATLAND**, KRISTIN A., Tad C. Theimer, William M. Block

10 DOES PRESCRIBED FIRE AFFECT BARK-FORAGING BIRD DENSITY IN WINTER? **POPE**, THERESA L., William M. Block, and Paul Beier

11 PROSPECTS FOR TROUT TO SURVIVE WILDFIRES IN THE WHITE MOUNTAINS OF ARIZONA. **LONG**, JONATHAN, Codey Carter, John Rinne

12 GEOLOGY MEDIATES LONG-TERM RESPONSE TO THE DUDE FIRE. **LEONARD**, JACKSON M., Alvin L. Medina, and Jonathan W. Long

13 EFFECTS OF FUELS REDUCTION EFFORTS IN THE FLAGSTAFF URBAN-WILDLAND INTERFACE ON POTENTIAL FIRE BEHAVIOR: IS VARIETY THE SPICE OF FIRE? **SMITH**, EDWARD BENNETT, Pat Hall

14 ANALYSIS OF UNDERSTORY VEGETATION RECOVERY ON THE RODEO-CHEDISKI FIRE. **KUENZI**, AMANDA M., Pete Z. Fule, Carolyn H. Sieg

15 ANT COMMUNITIES OF THE COLORADO PLATEAU AND GREAT BASIN: COMPARISONS OF STRUCTURE IN SPACE AND TIME USING GENUS AND FUNCTIONAL GROUP CLASSIFICATIONS. **GRAHAM**, TIM B., Wyatt I. Williams

16 COMPARISON OF ORTHOPTERA COMMUNITIES IN SALT CREEK, CANYONLANDS NATIONAL PARK: FLUCTUATIONS OVER TIME IN OPEN-, CLOSED-, AND NO-ROAD PARTS OF THE CANYON. **GRAHAM**, TIM B., Kelly N. Wilson

17 COLEOPTERA AND HYMENOPTERA DIVERSITY IN SALT CREEK CANYON, CANYONLANDS NATIONAL PARK, UT. **PECH**, LOUIS L., Tim B. Graham

18 INVESTIGATING EFFECTS OF THE NOVEMBER 2004 HIGH-FLOW RELEASE FROM GLEN CANYON DAM ON AEOLIAN SAND-TRANSPORT RATES IN THE COLORADO RIVER CORRIDOR, GRAND CANYON, ARIZONA. **DRAUT**, AMY E., Rubin, David M.

19 UPPER STREAM VS LOWER STREAM WATER QUALITY OF EIGHT SOUTHERN UTAH STREAMS. **ORNES**, HAROLD

20 DECLINE OF NORTHERN LEOPARD FROGS (RANA PIPIENS) ON THE SOUTHERN COLORADO PLATEAU. **DROST**, CHARLES, Lisa Gelczis, Jay Baker, Karen Mock

Poster Session - continued

21 INDIRECT EFFECTS OF UNGULATE BROWSING ON INSECT COMMUNITY STRUCTURE. **PEARSON**, KRISTEN M., Sanjeev Pandey, David W. Huffman, Daniel C. Laughlin

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

23 ALLOCATION OF WOODY AND HERBACEOUS BIOMASS IN PONDEROSA PINE STANDS VARYING IN STAND STRUCTURE AND BURN HISTORY. **SABO**, KYLA, Carolyn, Hull Sieg, John Duff Bailey, Stephen C. Hart

24 EXOTIC PLANT SPECIES RICHNESS AT TWO PONDEROSA PINE SITES IN NORTHERN ARIZONA. **FOWLER**, JAMES F., Carolyn Hull Sieg, Brett G. Dickson

25 SWEMP: DOCUMENTING INVASIVE NON-NATIVE PLANT OCCURRENCES REGIONALLY. **THOMAS**, KATHRYN

26 VEGETATION COMMUNITIES OF SUNSET CRATER, WALNUT CANYON, AND WUPATKI NATIONAL MONUMENTS. **HANSEN**, MONICA, Kathryn Thomas

27 HANGING GARDEN VEGETATION ASSOCIATIONS. **FOWLER**, JAMES F, N. L. Stanton, Ronald L. Hartman

28 A MULTI-SCALE ASSESSMENT OF THE EXTENT AND CONDITION OF GRASSLANDS IN ARIZONA: CONSIDERATIONS FOR CONSERVATION, RESTORATION, AND FIRE. **SCHUSSMAN**, HEATHER, Dave Gori, Carolyn Enquist

29 WARM DRY MIXED CONIFER PLANT COMMUNITY DIVERSITY IN SOUTHWESTERN COLORADO. **KORB**, JULIE E., Mark L. Daniels, Daniel C. Laughlin, Peter Z. Fule

30 DISTURBANCE-FOCUSED CONCEPTUAL MODELS OF MONTANE TERRESTRIAL ECOSYSTEMS ON THE COLORADO PLATEAU. **VANKAT**, JOHN L., Lisa Thomas, Mark Miller

31 ECOLOGICAL RESTORATION DEMONSTRATION TREATMENTS: A STARTING POINT FOR LOCAL ECOLOGICAL MONITORING AND ADAPTIVE MANAGEMENT. **TUTEN**, MATT C., W. Walker Chancellor, H.B. Doc Smith, Dennis Lund

32 A HOLISTIC APPROACH TO MONITORING: THE POET MODEL. **MOTTEK-LUCAS**, ANNE L.

33 IDENTIFYING THE IRRIGATION REQUIREMENTS OF NATIVE-PLANT LANDSCAPES ON THE COLORADO PLATEAU. **WILLIAMS**, ZACHARY, Daniel Smeal, Michael K. O'Neill, Margaret West, Richard N. Arnold

34 MYCORRHIZAL FUNGI ABUNDANCE ACROSS FLOOD INUNDATION GRADIENTS, VIRGIN RIVER, UTAH. **SHORROCK,** DONNA, Stutz, Jean, Stromberg, Julie

35 RESTORING ROADS WITH FUNGI: EVALUATING THE USE OF FUNGAL INOCULUM AND WOOD MULCH APPLICATION IN AN ARIZONA PONDEROSA PINE FOREST. **TRUDEAU**, JOSEPH M.

36 THE IMPACTS OF SAGEBRUSH ECOTYPE TREATMENTS ON THE PYGMY RABBIT AND OTHER WILDLIFE. **ALSTON**, JACKEE, Jerran T. Flinders

37 RELATIONSHIP BETWEEN MEASURED HABITAT QUALITY AND FIRST YEAR SURVIVAL FOR TRANSPLANTED BIGHORN SHEEP IN ARIZONA. **WAKELING**, BRIAN F.

38 ARIZONA WILDLIFE LINKAGES. **NORDHAUGEN**, SIOBHAN E., Evelyn Erlandsen, Paul Beier, Bruce Eilerts, Ray Schweinsburg, Terry Brennan, Ted Cordery, Norris Dodd, Melissa G. E. Maiefski, Janice Przbyl, Steve Thomas, and Kim Vacariu

39 SAFE HAVENS, SAFE PASSAGES: THE GRAND CANYON ECOREGION WILDLANDS NETWORK DESIGN. **CRUMBO**, KIM

40 REMOVAL OF PINYON-JUNIPER WOODLANDS ON THE COLORADO PLATEAU. **MIER**, MEAD, Michael Peters, Neil Cobb

Conservation Science, Policy and Practice

Wednesday Morning 8:00-5:00 p.m.
BALLROOM
Moderator: Paul Beier, *School of Forestry, Northern Arizona University*

SESSION I

8:00-8:20 WILDLIFE WATER DEVELOPMENTS AND THE SOCIAL CONSTRUCTION OF CONSERVATION CONFLICT. **MATTSON**, DAVID, Nina Chambers

8:20-8:40 WILDERNESS RESTORATION: LEGAL AND POLITICAL CONSIDERATIONS FOR WILDERNESS AREAS AND NATIONAL PARK SERVICE LANDS IN NORTHERN ARIZONA. **OSTERGREN**, DAVID

8:40-9:00 RESTORING TRADITIONAL ECOLOGICAL KNOWLEDGE OF THE APACHE. **LONG**, JONATHAN, Judy DeHose

9:00-9:20 IMPENDING CONGRESSIONAL ACTION ON THE ENDANGERED SPECIES ACT. **JOHNSON**, SCOTTY

9:20-9:40 IS SALTCEDAR HABITAT ALWAYS BAD FOR BIRDS? LESSONS FROM STUDIES OF THE SOUTHWESTERN WILLOW FLYCATCHER. **SOGGE**, MARK K., Eben H. Paxton

9:40-10:00 THE FLYCATCHER AND THE PHOENIX: RIPARIAN HABITAT CREATION AND DESTRUCTION IN A FLUCTUATING RESERVOIR. **PAXTON**, EBEN H.

10:00-10:20 BREAK

10:20-10:40 ARIZONA'S STATE LAND REFORM INITIATIVE. **FOX**, EDWARD

10:40-11:00 SELECTING CONSERVATION LANDS FOR ARIZONA'S STATE TRUST LAND REFORM INITIATIVE. **GRAHAM**, PATRICK

11:00-11:20 REFORMING STATE TRUST LAND THROUGHOUT THE WEST. **LAURENZI**, ANDY

11:20-11:40 PANEL DISCUSSION ON CONSERVATION OF STATE LANDS

11:40-12:00 AN EVALUATION OF STATE-SPONSORED PROPERTY TAX INCENTIVE PROGRAMS FOR PRIVATE FOREST LANDOWNERS IN THE WESTERN UNITED STATES. **ECKHOFF**, MIKE, Kurt Mackes, Tim Reader

12:00-1:00 LUNCH

SESSION II

1:00-1:20 DECOMMISSIONING THE CHILDS-IRVING HYDROELECTRIC FACILITIES. **SMITHERS**, PHIL

1:20-1:40 THE RETURN OF FLOWS TO FOSSIL CREEK, AN IDEA WHOSE TIME HAD COME. **STEFFERUD**, JEROME A.

1:40-2:00 CHALLENGES AND REWARDS OF COLLABORATION TO RESTORE FOSSIL CREEK. **OVERBY**, CECELIA, Janie Agyagos

2:00-2:20 BUREAU OF RECLAMATION ROLE IN RESTORING NATIVE FISH TO FOSSIL CREEK. **CLARKSON**, ROBERT W.

Conservation Science, Policy and Practice - continued

2:20-2:40	PRACTICAL LESSONS LEARNED: STRATEGIC APPROACHES OF THE FOSSIL CREEK ENVIRONMENTAL PARTNERS. **SCHLIMGEN-WILSON**, MINDY
2:40-3:00	PANEL DISCUSSION ON RESTORATION OF FOSSIL CREEK
3:00-3:20	BREAK
3:20-3:40	A LONG TERM ASSESSMENT OF PRONGHORN MANAGEMENT ON ANDERSON MESA: MISCALCULATIONS AND REMIDIES. **BROWN**, DAVID E., HENRY PROVENCIO
3:40-4:00	~~TACTICAL PLANNING OF VEGETATION MANAGEMENT IN SUPPORT OF PRONGHORN HABITAT ENHANCEMENT ON ANDERSON MESA, AZ. **CLARK**, MATTHEW~~ (CANCELLED)
4:00-4:20	GRASSLAND HABITAT RESTORATION IN NORTHERN ARIZONA. **DEVOS**, JAMES C., Jr., David Belitsky, Richard Miller, Steven S. Rosenstock
4:20-4:40	PROACTIVE EFFORTS TO REDUCE CALIFORNIA CONDOR LEAD EXPOSURE IN ARIZONA. **SIEG**, RON, Kathy Sullivan
4:40-5:00	VEGETATION AND SEED BANKS OF THE ZION RIVER RIPARIAN CORRIDOR (UTAH): IMPLICATIONS FOR RESTORATION. **SHORROCK**, DONNA, Stromberg, Julie

Cave Resource Management

Wednesday Morning 8:00 a.m.-3:00 p.m.
FREMONT
Moderator: J. Judson Wynne, *USGS Southwest Biological Science Center, Colorado Plateau Research Station, Northern Arizona University*

8:00-8:10	INTRODUCTION – **WYNN, J. JUDSON**
8:10-8:40	CAVES – EXPANDING BEYOND THE HOLLOW PLACES. **KERBO**, RONAL C.
8:40-9:00	CAVE RESOURCE MANAGEMENT - NOW IS THE TIME TO STANDARDIZE. **TROUT**, JERRY
9:00-9:20	THE DRAFT CAVE, KARST AND MINE MANAGEMENT PLAN, AND THE RAPID CAVE ASSESSMENT AND CLASSIFICATION SYSTEM, GRAND CANYON NATIONAL PARK. **RIHS**, JOHN
9:20-9:40	RESTORATION OF BLOOMINGTON CAVE, SOUTHERN UTAH. **VOYLES**, KYLE, Jon Jasper
9:40-10:00	A HISTORY OF THE DISCOVERY AND EXPLORATION OF THE CAVES OF HORSESHOE MESA, GRAND CANYON NATIONAL PARK. **BUECHER**, ROBERT H.
10:00-10:20	BREAK

Cave Resource Management - continued

10:20-10:40 STATUS ON THE NEWLY PROTECTED CATHEDRAL CAVES PRIVATE PRESERVE, NORTHERN ARIZONA. **BILLINGS**, DOUG, Tom O. Gilleland, John Norman, Robert Winkler

10:40-11:00 BIOLOGY OF STREAM CAVES IN GRAND CANYON NATIONAL PARK. **DROST**, CHARLES A.

11:00-11:20 CAVES AS REFUGIA FOR NON-TROGLOBITIC ORGANISMS DURING PERIODS OF DROUGHT, IMPLICATIONS FOR THE SOUTHWEST. **PRATHER**, JOHN W., Jeffrey T. Briggler, J. Judson Wynne

11:20-11:40 ROOSTING SITES OF SPOTTED BATS (*EUDERMA MACULATUM*) IN NORTHERN ARIZONA. **HERDER**, MICHAEL J., Carol L. Chambers, R. Jason M. Corbett, John W. Prather

11:40-12:00 CAVE ECOLOGY ON THE ARIZONA STRIP. **WYNNE**, J. JUDSON, Kyle Voyles, Charles A. Drost, Benjamin G. Solvesky, Michael J. Herder

12:00-1:00 LUNCH

1:00-1:20 AN OVERVIEW OF THE ARIZONA CAVE SURVEY. **GILLELAND**, TOM O.

1:20-1:40 RESURRECTION OF CRUCIFIXION CAVE - A PHOTOMONITORING GIS ANALYSIS TO EVALUATE VISITOR IMPACTS IN THE LAST 15 YEARS. **SAINSBURY**, BENJAMIN N.

1:40-2:00 ~~DIGGING IN THE DARK: CULTURAL RESOURCE MANAGEMENT IN GRAND CANYON'S CAVES. **HORN**, AMY~~ (CANCELLED)

2:00-2:20 FOSSIL PLANT REMAINS IN COLORADO PLATEAU CAVES. **COLE**, KENNETH, Owen K. Davis

2:20-2:40 DRY PRESERVATION OF ICE AGE ORGANIC REMAINS AND THE UNIQUE RECORD OF VERTEBRATE FAUNA OF COLORADO PLATEAU CAVES. **MEAD**, JIM I.

2:40-3:00 LONG-TERM CAVE ROOSTING AND DIET OF SPOTTED BATS (*EUDERMA MACULATUM*) IN NORTHERN ARIZONA AS INDICATED BY STABLE ISOTOPES FROM MUMMIFIED REMAINS AND LIVE BATS. **CHAMBERS**, CAROL L., Richard Doucett, David G. Mikesic

Colorado Plateau Cave Resource Managers Meeting / Breakout I

Wednesday Afternoon 3:20 a.m.-5:00 p.m.
HUMPHREYS
Moderator: J. Judson Wynne, *USGS Southwest Biological Science Center, Colorado Plateau Research Station, Northern Arizona University*

This special session will mark the first opportunity for Colorado Plateau cave researchers and land managers to meet in a forum where they can share their research and ideas, discuss management issues, and identify research needs. In light of this great opportunity, we also will hold a breakout session either the day before or after the special session. The objective of the breakout session will be to identify key resource management issues facing Colorado Plateau caves, discuss site-specific management concerns, identify research needs, and begin to strategize how these issues and concerns may be addressed.

Demystifying Mycorrhizae

Wednesday Morning 8:00 a.m.-930 a.m.
AGASSIZ
Moderator: Bala Chaudhary, *Northern Arizona University*

8:00-8:15	INTRODUCTION. **CHAUDHARY,** V. BALA
8:15-8:30	IS SOIL STABILITY LINKED TO MYCORRHIZAL FUNGI? UNTANGLING THE ARID ECOLOGY OF FUNGAL MUTUALISTS. **CHAUDHARY,** V. BALA, Thomas O'Dell, Andrea Redman, Matthias Rillig, Nancy Johnson
8:30-8:45	ORV DISTURBANCE IN A RIPARIAN HABITAT: NEGATIVE IMPACTS AND MANAGEMENT IMPLICATIONS FOR PLANT AND ARBUSCULAR MYCORRHIZAL COMMUNITIES. **ANTONINKA**, ANITA, Suzy Neal, Robin Rauch
8:45-9:00	MECHANICAL MASTICATION VS. SLASH BURNING TREATMENTS IN A PINYON-JUNIPER ECOSYSTEM: EFFECTS ON UNDERSTORY PLANT COMMUNITIES AND THEIR ARBUSCULAR MYCORRHIZAL ASSOCIATIONS. **NEAL**, SUZY, Carolyn Hull Sieg, Catherine Gehring, Nancy Collins Johnson
9:00-9:15	HYBRIDIZING AND DOMINANT RIPARIAN TREES SUPPORT UNIQUE ECTOMYCORRHIZAL COMMUNITIES. **KOVACS**, ZSUZSI I., Catherine A. Gehring, Tom G. Whitham
9:15-9:30	ECTOMYCORRHIZAL DIVERSITY OF STRESSED PINYON PINES. **HUBERT**, NATE, Kristin Haskins, Rebecca Mueller

Ecology and Management of Biological Soil Crusts

Wednesday Morning 9:30-11:50 a.m.
AGASSIZ
Moderator: Matt Bowker, *Department of Biological Sciences, Northern Arizona University*

9:30-9:45	INTRODUCTION. **BOWKER**, MATTHEW A.
9:45-10:00	HOW OLD ARE BIOLOGICAL SOIL CRUSTS? **BERALDI-CAMPESI**, HUGO, Ferran Garcia-Pichel
10:00-10:20	BREAK
10:20-10:35	BIOLOGICAL SOIL CRUSTS AND WHY THEY ARE DISAPPEARING. **ROSENTRETER**, ROGER
10:35-10:50	EFFECTS OF SUMMER PRECIPITATION ON BIOLOGICAL SOIL CRUSTS. **BELNAP**, JAYNE, Stan Smith, Dave Housman, Jeff Zimpfer
10:50-11:05	BIOLOGICAL SOIL CRUST RESTORATION IN THEORY AND PRACTICE: AN UNDEREXPLOITED OPPORTUNITY? **BOWKER**, MATTHEW A.
11:05-11:20	PHOSPHOROUS CONTROLS ON SOIL NITROGEN CONCENTRATIONS AND N-FIXATION RATES OF A RECOVERING SEMI-ARID PRAIRIE. **REED**, S. C., T. R. Seastedt, C. Mann, A. R. Townsend
11:20-11:35	BIOLOGICAL CRUSTS AND THE PUSUIT OF NOVEL FUNGAL DIVERSITY. **BATES**, SCOTT T.
11:35-11:50	SCALING ISSUES AND THE ECOLOGY OF DESERT SOIL CRUST BRYOPHYTES. **BRINDA**, JOHN C.

Modeling and Classification

Wednesday Morning 8:00a.m.-9:40 p.m.
SOUTHWEST
Moderator: Mark Miller, *USGS Southwest Biological Science Center, Colorado Plateau Research Station, Northern Arizona University*

8:00-8:20 MODELING POST WILDFIRE HYDROLOGIC EVENTS USING THE FULLY DISTRIBUTED MODEL MIKE SHE. **POFF**, BORIS, Daniel Neary

8:20-8:40 SELECTING SAMPLE LOCATIONS FOR NATURAL AMBIENT SOUND CHARACTERIZATION IN A DIFFICULT ENVIRONMENT. **FALZARANO**, SARAH, Ken McMullen

8:40-9:00 DISTURBANCE-FOCUSED CONCEPTUAL MODELS OF MONTANE TERRESTRIAL ECOSYSTEMS ON THE COLORADO PLATEAU. I. MODEL DEVELOPMENT AND PINYON-JUNIPER AND PONDEROSA PINE ECOSYSTEMS. **VANKAT**, JOHN L., Lisa Thomas, Mark Miller

9:00-9:20 DISTURBANCE-FOCUSED CONCEPTUAL MODELS OF MONTANE TERRESTRIAL ECOSYSTEMS ON THE COLORADO PLATEAU. II. MIXED CONIFER, SPRUCE-FIR, GRASSLAND, AND SHRUBLAND ECOSYSTEMS. **VANKAT**, JOHN L.˙ Lisa Thomas

9:20-9:40 COMPARING CONCEPTUAL AND EMPIRICAL RANGE VEGETATION CLASSIFICATION SYSTEMS FOR THE NORTHERN COLORADO PLATEAU. **ADAIR**, WILLIAM A., R. Douglas Ramsey, John Lowry

Resource History and Assessment

Wednesday Morning 10:20a.m.-12:00 p.m.
SOUTHWEST
Moderator: Charles van Riper, *Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona*

10:20-10:40 FIRE HISTORY IN PIÑON-JUNIPER WOODLANDS, KAIPAROWITS PLATEAU, GLEN CANYON NATIONAL RECREATION AREA. **FLOYD**, M. LISA, David Hanna, William H. Romme, Mark Winterowd, Dustin Hanna

10:40-11:00 THE ASSESSMENT OF SAND DUNE MOBILITY FROM 1980 THROUGH 2004 ON THE COALMINE MESA CHAPTER AREA OF THE NAVAJO NATION. **THORNBRUGH**, CASEY T., Margaret Hiza-Redsteer

11:00-11:20 DEVELOPMENT OF A RESTORATION RAPID ASSESSMENT TOOL. **HIEBERT,** Ron, Amy Richey, Talise Dow

11:20-11:40 CONDUCTING A RAPID LANDSCAPE-SCALE ECOLOGICAL ASSESSMENT OF THE KANE AND TWO MILE RANCHES IN NORTHERN ARIZONA. **AUMACK**, ETHAN N.

11:40-12:00 FROM TREES TO GRASSES: UNDERSTANDING COMMUNITY GENETICS WITH GEOGRAPHY AND CLIMATE. **ZHANG**, HUARONG, Laura E. DeWald, Steven E. Smith

Ecological Effects of Past, Present and Future Climate Variation on Southwestern Forests and Woodlands

Wednesday Afternoon 1:00-4:20 p.m.
AGASSIZ
Moderator: Neil Cobb, *Merriam Powell Center for Environmental Research, Northern Arizona University*

1:00-1:20 A BRIEF HISTORY OF SOUTHWEST CLIMATE CHANGES AND A GLIMPSE AT THE FUTURE. **GARFIN**, GREGG M., Michael A. Crimmins, Jeremy L. Weiss

1:20-1:40 GROWTH RESPONSES OF NORTHERN ARIZONA FORESTS TO CLIMATIC VARIATION. **KOLB**, T.E.

1:40-2:00 EVIDENCE FOR CLIMATE FORCING OF HISTORIC STAND-REPLACING FIRE OCCURRENCE IN UPPER MONTANE FORESTS OF THE SOUTHWESTERN UNITED STATES. **MARGOLIS**, E. Q., T.W. Swetnam, C.D. Allen

2:00-2:20 IMPACTS OF DROUGHT, BEETLES, AND MANAGEMENT TREATMENTS ON FIRE BEHAVIOR IN PINYON/JUNIPER WOODLANDS. **ROCCA**, MONIQUE, Neil Cobb, Kirsten Ironside, Bill Romme

2:20-2:40 GLOBAL WARMING AND INSECT OUTBREAKS IN SOUTHWESTERN FORESTS. **LYNCH**, Ann

2:40-3:00 EXPLORING PAST, PRESENT, AND FUTURE CLIMATE CHANGE IMPACTS ON THE DISTRIBUTION OF ONE-SEEDED JUNIPER, *JUNIPERUS MONOSPERMA*, AT WUPATKI NATIONAL MONUMENT. **IRONSIDE**, KIRSTEN E., Kenneth L. Cole, Cynthia Parker

3:00-3:20 BREAK

3:20-3:40 REGIONAL VEGETATION DIE-OFF IN RESPONSE TO GLOBAL-CHANGE TYPE DROUGHT. **BRESHEARS**, DAVID D. , Neil S. Cobb, Paul M. Rich, Kevin P. Price, Craig D. Allen, Randy G. Balice, William H. Romme, Jude H. Kastens, M. Lisa Floyd, Jayne Belnap, Jesse J. Anderson, Orrin B. Myers, Clifton W. Meyer

3:40-4:00 PLANT PRODUCTION AND DIVERSITY IN A PONDEROSA PINE FOREST: THE IMPORTANCE OF INTER-ANNUAL CLIMATIC VARIABILITY. **LAUGHLIN**, DANIEL C., Margaret M. Moore

4:00-4:20 ASSESSING CLIMATE CHANGE IMPACTS ON SOUTHWEST FORESTS AND WOODLANDS: IMPLICATIONS FOR POLICY AND MANAGEMENT. **SWETNAM**, TOM

Animal Ecology I

Wednesday Afternoon 1:00-3:00 p.m.
SOUTHWEST
Moderator: Erika Nowak, *USGS Southwest Biological Science Center, Colorado Plateau Research Station, Northern Arizona University*

1:00-1:20 COLORADO PLATEAU AQUATIC INSECT COMMUNITY CLASSIFICATION. **MOLINE**, ANGELA B., N. LeRoy Poff

1:20-1:40 GENETIC VARIATION AMONG AND WITHIN THREE IMPORTANT BARK BEETLE SPECIES FOUND IN PONDEROSA PINE FORESTS OF ARIZONA. **ALLENDER**, CHRISTOPHER J., Karen M. Clancy, Joel D. McMillin, Thomas E. DeGomez, Paul Keim, David M. Wagner

1:40-2:00 THE BEES OF GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT: DYNAMICS, DISTRIBUTIONS, AND DIVERSITY. **MESSINGER**, OLIVIA J., Terry Griswold

2:00-2:20 DISPERSAL OF NONNATIVE FISHES AND PARASITES IN THE LITTLE COLORADO RIVER, ARIZONA. **STONE**, DENNIS M., David R. Van Haverbeke, David L. Ward

2:20-2:40 FORAGING ECOLOGY OF PEREGRINE FALCONS ALONG THE DAM-REGULATED COLORADO RIVER, GRAND CANYON, ARIZONA. **STEVENS**, LAWRENCE E., Bryan T. Brown, Kirsten Rowell

2:40-3:00 SUMMARY OF THE 1996-2000 GCMRC BIRD MONITORING PROGRAM ALONG THE COLORADO RIVER. **SPENCE**, JOHN R.

Vegetation Ecology

Wednesday Afternoon 3:20-5:00 p.m.
SOUTHWEST
Moderator: Kathryn Thomas, *Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona*

3:20-3:40 DROUGHT INDUCED IMPACTS ON VEGETATION DYNAMICS OF THE COLORADO PLATEAU: DERIVED FROM SATELLITE-BASED MODIS VEGETATION INDEX OBSERVATIONS. **DIDAN**, KAMEL, Alfredo Huete

3:40-4:00 MORPHOLOGICAL VARIATION IN PINYON NEEDLES OF THE VERDE VALLEY AND THEIR RELATIONSHIP TO ANNUAL PRECIPITATION. **COLE**, KENNETH, Jessica Fisher, Sandra Swift

4:00-4:20 PATTERNS OF WOODY PLANT MORTALITY FOLLOWING DROUGHT AT THE PONDEROSA PINE/PINYON-JUNIPER ECOTONE. **KOEPKE**, Dan F., Thomas E. Kolb, Christopher P. Bickford

4:20-4:40 DYNAMICS OF JUNIPER INVADED GRASSLANDS AND OLD-GROWTH WOODLANDS IN AND NEAR WUPATKI NATIONAL MONUMENT, NORTHERN ARIZONA, USA. **HASSLER**, F.C., J. D. Bailey

4:40-5:00 COMPARISON OF THINNING TECHNIQUES FOR PINYON-JUNIPER ENCROACHED SHRUBLANDS ON THE SHIVWITS PLATEAU, ARIZONA. **MATCHETT**, J.R., Matt Brooks, Curt Deuser, Helen Smith, Henry Bastian

Social at the Museum of Northern Arizona

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

MUSEUM OF NORTHERN ARIZONA

Invasive Plant Ecology

Thursday Morning 8:20 a.m.-11:20 a.m.
BALLROOM
Moderator: Chris McGlone, *Northern Arizona University*

8:20-8:40	EXOTIC INVASIVE PLANTS OF SOUTHWESTERN PONDEROSA PINE FORESTS: MANAGEMENT AND RESEARCH PRIORITIES. **SIEG**, CAROLYN HULL, James F. Fowler, Barb Satink Wolfson
8:40-9:00	PREDICTING ALIEN PLANT DISTRIBUTIONS IN NATURAL LANDSCAPES FOLLOWING DISTURBANCE REMOVAL. **DOW**, S. TALISE , Ron Hiebert, Kathryn McEachern
9:00-9:20	INTEGRATING WEED CONTROL AND RESTORATION ON WESTERN RANGELANDS. **LANDMESSER**, JACOB, Kim Allcock, Robert S. Nowak
9:20-9:40	SFPWMA: PARTNERS IN INVASIVE WEED STRATEGIES. **ALBRECHT**, WADE
9:40-10:00	MANAGING LIVESTOCK GRAZING TO INHIBIT CHEATGRASS SPREAD. **LOESER**, MATTHEW R., AMY E. **RICHEY**, Vanessa L. Humphreys, Tischa A. Muñoz-Erickson, Thomas D. Sisk, Timothy E. Crews
10:00-10:20	BREAK
10:200-10:40	SOIL AND CLIMATE CONTROLS ON THE DISTRIBUTION OF EXOTIC ANNUAL GRASSES IN THE WESTERN UNITED STATES. **BELNAP**, JAYNE
10:40-11:00	THE DISTRIBUTION AND OCCURRENCE OF CHEATGRASS (BROMUS TECTORUM) POPULATIONS ON THE UNCOMPAHGRE PLATEAU. **MONSEN**, STEPHEN B., ALLAN R. **STEVENS**
11:00-11:20	DIFFUSE AND SPOTTED KNAPWEEDS: REAL THREATS. **WOLFSON**, BARB SATINK , Carolyn Hull Sieg, James F. Fowler

Colorado Plateau Cave Resource Managers Meeting / Breakout II

Thursday Morning 8:00-10:00 a.m.
HUMPHREYS
Moderator: J. Judson Wynne, *USGS Southwest Biological Science Center, Colorado Plateau Research Station, Northern Arizona University*

This is a continuation of the breakout session that began on Wednesday afternoon.

Cathedral Caverns Speological Preserve Field Trip

THURSDAY MORNING 10:00 A.M.- LATE AFTERNOON

Preserve owner Doug Billings and USGS wildlife ecologist J. Judson Wynne will lead a half-day field trip to Cathedral Caverns near Ash Fork, Arizona. Van limited to 12 people. Contact J. Judson Wynne to participate.

Ecological Networks and Long-term Monitoring on the Colorado Plateau

Thursday Morning 8:20-12:00 p.m.
AGASSIZ
Moderator: Neil Cobb, *Merriam Powell Center for Evironmental Research, Northern Arizona University*

8:20-8:40 OPPORTUNITIES FOR LONG-TERM ECOLOGICAL RESEARCH AND MONITORING IN GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT. **MILLER**, Mark E., Marietta Eaton

8:40-9:00 HISTORICAL STUDIES ON THE COLORADO PLATEAU: AN OVERVIEW. **BAKKER**, JONATHAN D., Margaret M. Moore, Andrew J. Sánchez Meador

9:00-9:20 HISTORICAL STUDIES ON THE COLORADO PLATEAU: RESULTS FROM TWO LONG-TERM DATA SETS. **SÁNCHEZ MEADOR**, ANDREW J., Margaret M. Moore, Jonathan D. Bakker

9:20-9:40 INVASIVE SPECIES NETWORKS: CHALLENGES FOR THE COLORADO PLATEAU. **THOMAS**, KATHRYN

9:40-10:00 ESTIMATING LAND SURFACE PHENOLOGY FROM SATELLITE IMAGERY. **REED**, BRADLEY C.

10:00-10:20 BREAK

10:20-10:40 INTERIOR WEST FOREST INVENTORY AND ANALYSIS: A DESCRIPTION OF THE PROGRAM AND OPPORTUNITIES FOR COLLABORATION. **SHAW**, JOHN D.

10:40-11:00 INTEGRATING DATA ON HISTORIC VEGETATION CHANGE BETWEEN THE SAN FRANCISCO PEAKS AND GRAND CANYON. **COLE**, KENNETH

11:00-11:20 A SYNTHESIS OF RIPARIAN RESEARCH AND MONITORING ON PUBLIC LANDS OF THE COLORADO PLATEAU. **SHANNON**, JOSEPH, Emma Benenati

11:20-11:40 THE NATIONAL BIOLOGICAL INFORMATION INFRASTRUCTURE – SOUTHWEST INFORMATION NODE: A PORTAL TO BIOLOGICAL INFORMATION FOR THE COLORADO PLATEAU. **PRIOR-MAGEE**, JULIE S., Leanne Hanson, Sean Finn

11:40-12:00 DEVELOPING A MONITORING PLAN FOR THE NATIONAL PARK UNITS ACROSS THE COLORADO PLATEAU. **THOMAS**, LISA, Thomas O'Dell, Chris Lauver, Steve Garman

Fossil Creek: An Opportunity to Restore Diverse Native Fishery and Study the Effects of Return of Full Flows

Thursday Morning 8:20-11:20 p.m.
FREMONT
Moderator: Allen Haden, *Environmental Monitoring and Asessment Program & Foundation, Northern Arizona University*

8:20-8:40	PHYSICAL AND BIOLOGICAL RESTORATION OF FOSSIL CREEK, ARIZONA: SUCCESSFUL COLLABORATION ACROSS ORGANIZATIONS AND INDIVIDUALS. **HEDWALL,** SHAULA, Pam Sponholtz, David Weedman, Amy Unthank, Ian Reid, Allen Haden
8:40-9:00	CHEMICAL RENOVATION OF FOSSIL CREEK, ARIZONA. **WEEDMAN**, DAVID A.
9:00-9:20	THE RELATIVE EFFECTS OF FLOW DIVERSION AND NONNATIVE INVASIVE FISH ON THE NATIVE FISH COMMUNITY OF FOSSIL CREEK. **HADEN**, ALLEN, Jane. C. Marks
9:20-9:40	CHANGING POPULATION STRUCTURE OF A NON-NATIVE CRAYFISH INVADER DURING STREAM RESTORATION. **ADAMS**, KENNETH J., Jane C. Marks
9:40-10:00	INFLUENCES OF TRAVERTINE DAM FORMATION ON LEAF LITTER DECOMPOSITION AND ALGAL ACCRUAL IN FOSSIL CREEK, ARIZONA. **CARTER**, CODY D.᾽ Jane Marks
10:00-10:20	BREAK
10:20-10:40	RECREATION MONITORING ON FOSSIL CREEK, **HANCOCK**, PAUL, Matt Jedra, Marty Lee
10:40-11:00	THE EFFECTS OF TRAVERTINE DAMS ON LEAF LITTER RETENTION IN FOSSIL CREEK, ARIZONA. **COMPSON**, ZACCHAEUS G., Mead Z. Mier, Jane. C. Marks
11:00-11:20	MICROBIAL COMMUNITY CHARACTERIZATION: WHO IS DECOMPOSING LEAF LITTER IN FOSSIL CREEK? **HARROP**, BRENDA L., Mary E. Watwood, Jane C. Marks, Rebekka M. Rieder

Status of the Colorado River Ecosystem

Thursday Afternoon 1:00-4:20 p.m.
BALLROOM
Moderator: Ted Melis, *USGS Southwest Biological Science Center, Grand Canyon Monitoring and Research Center, Flagstaff, AZ*

1:00-1:20 INFLUENCE OF GLEN CANYON DAM OPERATIONS ON DOWNSTREAM SAND RESOURCES OF THE COLORADO RIVER IN GRAND CANYON. **WRIGHT**, SCOTT, Ted Melis, David Topping, Rubin

1:20-1:40 FISHES OF THE GRAND CANYON. Coggins, Lewis, STEVEN **GLOSS**

1:40-2:00 WATER QUALITY IN LAKE POWELL AND THE COLORADO RIVER. **VERNIEU**, WILLIAM, Susan Hueftle, Steven Gloss

2:00-2:20 AQUATIC ECOLOGY: THE ROLE OF ORGANIC MATTER AND INVERTEBRATES. **KENNEDY**, THEODORE, Steven Gloss

2:20-2:40 RIPARIAN VEGETATION AND ASSOCIATED WILDLIFE. **RALSTON**, BARBARA

2:40-3:00 BIRDS OF THE COLORADO RIVER IN GRAND CANYON: A SYNTHESIS OF STATUS, TRENDS, AND DAM OPERATION EFFECTS. Holmes, Jennifer, John Spence, MARK **SOGGE**

3:00-3:20 BREAK

3:20-3:40 CULTURAL RESOURCES IN THE COLORADO RIVER CORRIDOR. **FAIRLEY**, HELEN

3:40-4:00 RECREATIONAL VALUES AND CAMPSITES IN THE COLORADO RIVER ECOSYSTEM. **KAPLINSKI**, MATTHEW, Jeff Behan, Joseph Hazel, Roderic Parnell, Helen Fairley

4:00-4:20 THE STATE OF THE CO RIVER ECOSYSTEM IN GRAND CANYON OR SCORE REPORT: LESSONS FROM 10 YEARS OF ADAPTIVE MANAGEMENT IN GRAND CANYON. **LOVICH**, JEFFREY E., Ted Melis, Steve Gloss

Animal Ecology II

Thursday Afternoon 1:00-4:20 p.m.
AGASSIZ
Moderator: Eben Paxton, *USGS Southwest Biological Science Center, Colorado Plateau Research Station, Northern Arizona University*

1:00-1:20 FIRE EFFECTS ON FISHES AND AQUATIC ECOSYTEMS IN THE SOUTHWEST: CASE STUDIES, LAB INQUIRES AND LANDSCAPE PERSPECTIVES. **CARTER**, CODY D., John Rinne, Jonathan Long

1:20-1:40 WOODPECKER RESPONSE TO PRESCRIBED FIRE IN SOUTHWESTERN PONDEROSA PINE FORESTS. **GWINN**, NATHAN, Brett G. Dickson, Stephanie Jentsch, William M. Block

1:40-2:00 PRELIMINARY HOME RANGE AND LIFE HISTORY FROM RADIO TELEMETRY OF *CROTALUS OREGANUS CERBERUS*, THE ARIZONA BLACK RATTLESNAKE. **SCHOFER**, JUSTIN

2:00-2:20 AN ACOUSTIC SURVEY FOR BATS ALONG THE COLORADO RIVER CORRIDOR. **BUECHER**, DEBBIE C.

2:20-2:40 FORAGING AREAS FOR FEMALE AND MALE SPOTTED BATS (*EUDERMA MACULATUM*), NORTHERN ARIZONA. **CHAMBERS**, CAROL L., Michael J. Herder, R. Jason M. Corbett

Animal Ecology II - continued

2:40-3:00 FORAGING PATTERNS AND ROOST SITES FOR FEMALE BIG FREE-TAILED BATS (*NYCTINOMOPS MACROTIS)* IN NORTHERN ARIZONA. **CORBETT**, R. JASON M., Carol L. Chambers, Michael J. Herder, Elaine F. Leslie

3:00-3:20 BREAK

3:20-3:40 RADIOISOTOPIC ANALYSES OF POTENTIAL SOURCES OF LEAD CONTAMINATION IN CALIFORNIA CONDORS. **CHESLEY**, JOHN, Peter Reinthal, Tim Corley, Chris Parrish, Joaquin Ruiz

3:40-4:00 THE ECOLOGICAL EFFECTS OF ARTIFICIAL WATER SOURCES IN A CHANGING HYDROLOGIC REGIME. **HOLTON,** P. BRANDON, David J. Mattson

4:00-4:20 PREDATION BY COUGARS IN THE FLAGSTAFF UPLANDS 2003-2005. **MATTSON**, DAVID, Jan Hart, Terry Arundel

Creating Successful Partnerships for Rangeland Conservation

Thursday Afternoon 1:00-3:00 p.m.
FREMONT
Moderator: Karan English, *Environmental Monitoring and Asessment Program & Foundation, Northern Arizona University*

Panel Discussion

The focus of this panel discussion will be on the components and challenges inherent in forming successful partnerships for rangeland conservation. The panel members will bring their experience and perspectives on the ingredients for successful community-based collaboratives. Specifically, panel members will discuss working with public land permittees, public lands grassbanking in northern New Mexico , preserving the tradition of grazing while improving rangelands, working within multi-party landscapes, and collaborating with community-based organizations such as the Malpais Borderlands Group and the Diablo Trust. The goal of the panel discussion is ultimately to apply the lessons and experiences of the panel members to the conservation of grasslands on the Colorado Plateau.

Panel Members:

Whitney Tilt, Project Manager for Resources for Community Collaboration (RCC). Sonoran Institute, Northwest Office, Bozeman , MT.

Craig Conley, Director, Rowe Mesa Grassbank. Quivira Coalition, Santa Fe , NM .

Peter Warren, Grassland Conservation Program Manager. The Nature Conservancy, Arizona Chapter, Tucson, AZ.

Tom Sisk or Tischa Munoz-Erickson. The Sisk Lab , Northern Arizona University, Flagstaff , AZ.

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

COMPARING CONCEPTUAL AND EMPIRICAL RANGE VEGETATION CLASSIFICATION SYSTEMS FOR THE NORTHERN COLORADO PLATEAU

ADAIR, WILLIAM A.[1], R. Douglas Ramsey[2], John Lowry[3]
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Vegetation classification systems provide a framework for defining resources and assessing their status and trends. Conversely, monitoring and mapping efforts can be used to evaluate a vegetation classification system's operational utility. The classification schemes most commonly used to describe Colorado Plateau rangelands, including SRM Range Cover Types, NRCS Ecological Site Descriptions, BLM Ecological Site Inventories, and NVC Ecological Systems, Alliances, and Associations, are all based on *a priori* concepts of how rangeland communities are organized. Although these systems differ in detail, they are all similar in that they force the user to impose a pre-defined pattern onto natural landscape variation. During the course of the Southwest Regional GAP Analysis Program (SWReGAP) vegetation mapping process, we encountered a number of problems associated with this pattern-forcing process, such as "missing" plant communities and "garbage-can" types. This experience encouraged us to investigate the opposite approach to vegetation classification, i.e., develop a strictly empirical classification system based on statistical patterns inherent to the data. To achieve this objective, we applied a variety of multivariate clustering techniques to the field training data collected for the SWReGAP and Landfire mapping projects. We created alternative datasets to address concerns typical of vegetation classification systems in general (e.g., dominant species vs. whole communities) and specific to the Colorado Plateau (e.g., include or exclude substrate measures). Not surprisingly, the classes that emerged from our analysis share much in common with existing schemes, and particularly with the NVC. However, these classes also suggest new ways for resolving problems associated with defining plant communities, particularly those associated with information content. While our application of sophisticated multivariate models to relatively unsophisticated monitoring data led to many problems, these problems highlight critical, but often overlooked, aspects of long-term, large-area monitoring projects. We anticipate that our efforts will also lead to better maps, and perhaps even change the way that we look at rangelands in the arid West.

CHANGING POPULATION STRUCTURE OF A NON-NATIVE CRAYFISH INVADER DURING STREAM RESTORATION

ADAMS, KENNETH J., Jane C. Marks[2]
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Orconectes virilis is invading Fossil Creek, Arizona, a stream that had undergone two restoration events by 2005: non-native fish removal and flow restoration from the decommissioning of a century old hydropower dam. We combined crayfish surveys with an enclosure-exclosure experiment in the summers before and after restoration events to predict how the crayfish population structure would respond to restoration and how changes in density mediated effects could impact the stream community. Preliminary trapping and mark-recapture surveys were conducted two summers prior to restoration at 10 sites along the length of the creek. These surveys indicated that the crayfish population was most abundant at downstream sites toward the confluence with the Verde River, with densities decreasing upstream. The greatest densities were found to be located downstream of the area in which a fish barrier was installed during restoration events to prevent upward migration of non-native fish from the Verde River. In the summer of 2005, after the restoration treatments, a mark-recapture survey at sites above the fish barrier revealed a two-fold increase in crayfish population densities. At two sites below the fish barrier, in areas of the creek that were still accessible to non-native fish, there was also an increase in density levels, but the magnitude of the increase was not doubled. Prior to restoration, a set of enclosure-exclosure experiments was conducted at two sites in the stream, one below and one above the future fish barrier. These experiments tested the effect of two different densities of crayfish on algal production, allochthonous matter processing, and invertebrate abundance and biomass. There were significant differences in the response variables between high and low density treatments, with high densities having large negative effects on the responses. While low density treatments showed similar trends in the responses, they were not significantly different than controls, showing that pre-restoration levels of the crayfish population were probably not having large negative effects on the stream community. The experiment is being re-tested at post-restoration population levels.

SFPWMA: PARTNERS IN INVASIVE WEED STRATEGIES

ALBRECHT, WADE
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Invasive and noxious weeds are spreading at an exponential rate in northern Arizona. Tight budgets and diminishing personnel have led land managers into creative solutions to combating weeds and restoring landscapes. Education efforts provide outreach to schools and homeowner associations to ensure prevention and early detection, but within our communities, there is largely uninformed audience on this issue. The San Francisco Peaks Weed Management Area (SFPWMA) brings together those concerned about responsible weed management within Northern Arizona to build local awareness of invasive weeds, develop common management objectives, facilitate effective treatment, and coordinate efforts along logical geographical boundaries with similar land types, patterns and problem species. This will allow partners to respond more effectively to community and ecological concerns.

ECOLOGICAL GENETICS OF COTTONWOOD HYBRID ZONES

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Cottonwoods are dominant riparian trees that form habitat for numerous arthropod species. Cottonwoods also form hybrid zones consisting of different cross types, which appear to attract different assemblages of arthropods. In this study we examine the utility of genetic markers for: (1) discriminating among different hybrid and parental cross types; (2) assessing whether genetic differences reflect arthropod community preference for particular cross types and; (3) understanding the role genetic variation in a dominant riparian tree plays in determining arthropod community diversity and structure. Our results suggest that genetic differences among cross types are detectable and that a subset of the arthropod community is responding to the genetic composition of the hybrid zones. These findings suggest that genetic variation in cottonwood hybrid zones can play a critical role in the formation, structure and long-term stability of riparian-based herbivore communities.

GENETIC VARIATION AMONG AND WITHIN THREE IMPORTANT BARK BEETLE SPECIES FOUND IN PONDEROSA PINE FORESTS OF ARIZONA.

ALLENDER, CHRISTOPHER J.[1], Karen M. Clancy[2], Joel D. McMillin[3], Thomas E. DeGomez[4], Paul Keim[5], David M. Wagner[6].
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In Arizona's ponderosa pine forests, bark beetles play an important role as native tree pests that help to stimulate snag recruitment. Since 2001, bark beetle activity has caused unprecedented levels of ponderosa pine mortality in central and northern Arizona. For example, it is estimated that during 2002 more than one million trees were killed by bark beetle activity. Because of this record high tree mortality, it is essential to develop a better understanding of the population structure of bark beetle species in order to address questions of their dispersal and movement across the landscape. Here, we describe the use of genetic techniques to investigate the population structure of three bark beetle species collected from multiple sites along an elevation gradient in Arizona ponderosa pine forests. We have developed novel genetic markers that distinguish among and within populations of *Dendroctonus brevicomis*, *D. frontalis*, and *Ips pini*. For designations among the species, we utilized a region of DNA considered as the "barcode of life" - the cytochrome oxidase I gene. This locus is commonly used to identify eukaryotic organisms at the species level. To resolve genetic variation within each species, we utilized fluorescently-labeled Amplified Fragment Length Polymorphisms, or fAFLPs. This technique uses polymorphisms present throughout the genome of an organism to generate high-resolution genetic fingerprints suitable for population level analyses. We generated genetic fingerprints for more than 150 individuals from each of the three species and calculated genetic distances within each species set. For all species, genetic distance was not correlated with geographic distance or elevation, which suggests there is great dispersal throughout the study area. This further suggests that future outbreaks may occur at regional rather than local scales because of the beetles' ability to disperse over large distances. We believe that the genetic markers developed in this study will assist future efforts to further understand bark beetle dispersal through time in the ponderosa pine forests of Arizona, as well as the rest of the Colorado Plateau region.

THE IMPACTS OF SAGEBRUSH ECOTYPE TREATMENTS ON THE PYGMY RABBIT AND OTHER WILDLIFE

ALSTON, JACKEE, Jerran T. Flinders
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Impaired sagebrush ecosystems are a dilemma facing managers across the Western US. These ecosystems are being treated to either (a) create functioning habitats for species such as Sage-grouse and mule deer or (b) increase livestock forage production. However, current data are incomplete on the impacts of treatments on state sensitive species and federally petitioned species. Such data require pre-treatment and post-treatment monitoring at multiple scales and with multiple species. In Utah, well-meaning treatments of sagebrush habitat include: federally funded wildfire fuel reduction operations; sagebrush canopy reductions; and combinations of objectives that remove most or all of the sagebrush canopy and replace this with grasses, forbs and even shrubs favored by mule deer, elk, domestic sheep and domestic cattle. In agreement with Utah=s AWildlife Habitat Initiative@, the primary focus of our study is the maintenance of critical pygmy rabbit (Brachylagus idahoensis) habitat, restoration of habitats to establish meta-population connectivity, and the identification of habitat perturbations that have a positive effect on pygmy rabbit populations. Additionally species composition and abundance of bird and jackrabbit populations are recorded using line transects. These data will assist in the development of creating guidelines for sagebrush manipulations with multiple species considerations.

ORV DISTURBANCE IN A RIPARIAN HABITAT: NEGATIVE IMPACTS AND MANAGEMENT IMPLICATIONS FOR PLANT AND ARBUSCULAR MYCORRHIZAL COMMUNITIES

ANTONINKA, ANITA[1], Suzy Neal[2], Robin Rauch[3]
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We investigated the effects of off-road vehicle (ORV) use on the abundance and diversity of plant and arbuscular mycorrhizal fungal (AM) communities in a riparian ecosystem. This is important because ORV use in riparian habitats is increasing rapidly, and riparian habitat is rare and ecologically valuable in the arid southwest. In addition, there is a need to determine management implications for ORV use to limit damage to plant and AM fungal communities. Our research design allowed us to compare direct disturbance (on ORV tracks) with intermediate disturbance (1m from the tracks) and no disturbance (12m away from the tracks). Six significant patterns emerged: 1. Soil compaction and density were 4.3x greater on the ORV track and 1.4x greater 1m away than compared with the 12m transects. 2. Plant cover was 10x lower on ORV tracks than 1m away and 14.8x lower on ORV tracks than 12m away. 3. Plant species richness was 5.4x lower on ORV tracks than one meter away and 7.8x lower on ORV tracks than 12m away, and plant cover was negatively correlated with soil compaction. 4. AM spore abundance was 1.4x lower on the track than 1m from the track and 1.9x lower than 12m from a track. 5. AM richness was 1.2x lower on a track compared to 1m from a track and 2.6x lower compared to 12m from a track. 6. AM abundance and richness were both positively correlated with plant abundance and diversity, while AM abundance was negatively correlated with soil compaction and bare ground. We conclude that unmanaged ORV disturbance increases selection pressures in which plant and mycorrhizal communities suffer reduced fitness and abundance. The magnitude of our findings illustrates that managing these anthropogenic disturbances is necessary to restore ecosystem processes.

CONDUCTING A RAPID LANDSCAPE-SCALE ECOLOGICAL ASSESSMENT OF THE KANE AND TWO MILE RANCHES IN NORTHERN ARIZONA

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The Grand Canyon Trust and The Conservation Fund are jointly purchasing the Kane and Two Mile ranches, whose livestock grazing permits extend across nearly 850,000 acres north of the Grand Canyon. In purchasing the ranches, we plan to work with land managers and a diverse array of stakeholders over the coming years to identify and implement restoration projects across a diverse array of ecosystems, and manage livestock in a manner consistent with restoration and maintenance of ecological and scenic integrity. Recognizing the need to better understand current conditions across the ranches, and to establish a baseline from which the effects of livestock management and restoration activities could be measured, we initiated a landscape-scale ecological assessment of the ranches in the spring of 2005. Thus far, we have focused field data collection efforts on assessing rangeland, forest, and water resource conditions across the ranches. For the rangeland portion of the assessment (encompassing the entire project area) we have used a stratified random sample design to conduct vegetation and soil surveys at approximately 650 plot locations. For the forested portion of the project area, we are coordinating a volunteer-centered forest overstory data collection effort at more than 200 sites. Collaborating with the Forest Ecosystem Restoration Analysis project at NAU, we will combine overstory data collected with Landsat ETM and digital orthophoto quads to develop continuous, high resolution maps describing forest composition and structure, wildlife habitat, and watersheds conditions across the Kaibab Plateau. We are collaborating with the Grand Canyon Wildlands Council to strategically assess water resources, including springs, streams, natural lakes across the project area. Synthesis of field data in combination with extensive review of studies and management plans already conducted will help the Trust to develop a scientifically rigorous and effective strategy for adaptively managing livestock and pursuing restoration goals. Assessment methodologies, preliminary results of data synthesis, and implications for livestock management and restoration strategies across the ranches will be presented.

FIRE AND FIRE SURROGATE RESEARCH: PROGRAM OVERVIEW AND OVERSTORY VEGETATION DYNAMICS IN ARIZONA

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Many contemporary forests of North America, and particularly in the West, have high fuel loads after a century or more of grazing and active fire suppression. Such forest conditions promote stand-replacing wildfires where frequent surface fires were the norm. Land managers are now struggling with precisely how to treat these forests to reduce future wildfire risk and restore appropriate structure, particularly in the wildland-urban interface. Proposed solutions include various forms of mechanical thinning and prescribed fire, alone and in combination. There is, however, uncertainty surrounding the separate and combined effects of these silvicultural treatments on long-term productivity and ecological function in these forests, and the degree of fire hazard reduction actually provided. In 2000, the national Joint Fire Sciences Program funded a 13-region study to address ecological effects, economical impacts, and fire hazard reduction of these different alternatives that included: 1) a common set of replicated treatments in each region; 2) large experimental plots of a size similar to typical stand management units; 3) a shared suite of measurements that are used to evaluate treatment effects; and 4) data archival in a national database for meta-analyses. In this presentation, we will provide some details on the national study and what we have learned, describe the treatment and establishment details of our local replicate here in the Flagstaff area, and report the short-term response of the overstory trees to the treatments. Our replicate includes three ponderosa pine stands where four treatments were applied: a cool-season prescribed fire alone, mechanical thinning alone in the form of a multi-aged group selection harvest, the same mechanical harvest followed by prescribed fire, and an untreated control. Harvest damage to overstory trees was surprising low throughout the study. Tree mortality from crown scorching was also surprising low in the prescribed fire only treatment, higher in the harvest and burn treatment given differences in fire behavior. Resulting diameter distributions show a major alteration in forest structure with mechanical harvest, but little change with the first prescribed fire entry.

HISTORICAL STUDIES ON THE COLORADO PLATEAU: AN OVERVIEW

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Long-term vegetation studies can provide valuable insights into ecosystem structure and function. Many such studies have been conducted in northern Arizona, though their full potential has not been utilized. Examples include the Woolsey plots, Hill plots, Chimney Spring interval burning study, Gus Pearson Natural Area restoration experiment, Taylor Woods thinning study, and Fort Valley ponderosa pine provenance trial. In our research on the Woolsey and Hill plots, we begin by locating historical data in archives, agency files, herbaria, and other locations. Data quality is assessed by examining its quantity, the intent for which it was collected, and the methodology employed for locating sites and sampling units. Field sites are then relocated and assessed for ecological integrity and vegetation change. Site histories can be strengthened by examining historical photos, reviewing agency files, and interviewing scientists that worked there historically. The research objectives of a new study, which may differ from those of the historical study, will determine how historical data are used and which contemporary measurements are made. If historical and contemporary data are to be compared, it is necessary to carefully duplicate the historical sampling methods. The scope of inference can be established by assessing the representativeness of study sites. Limitations of long-term studies include their rarity, the low number of replications generally established, and the costs of maintaining sites and preserving data in accessible formats. Long-term maintenance and protection of sites requires the active cooperation of land management agencies, who may be unaware of their existence or importance, by incorporating them into their GIS layers and planning. Education of the public can minimize vandalism and build support for projects. Historical and contemporary data should be properly archived and documented to ensure their availability to future scientists. While long-term studies require additional effort compared to temporary, short-term studies, they can generated surprising and unique results, as described in the following presentation.

BIOLOGICAL CRUSTS AND THE PUSUIT OF NOVEL FUNGAL DIVERSITY

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A range of estimates from 500,000 to 9.9 million for the total number of fungal species present in the earth's biosphere have been put forward. The sum of fungi that have been described at the species level thus far range between 74,000 and 120,000. The realization that as little as a tenth of a percent of the world's fungal species may have been described compels the mycologist to probe unexplored niches in the quest to uncover novel fungal diversity. The paucity of literature addressing fungi associated with biological soil crust (BSCs) suggests that this niche is ripe for investigation. While culture dependent methodologies have limited our ability to access fungal diversity in the past, recent advances in molecular biology hold promise as a mean to recover novel fungal diversity in BSCs. Understanding what fungal organisms are associated with BSCs is the first step toward understanding the ecological role that fungi play in the crust community.

EFFECTS OF SUMMER PRECIPITATION ON BIOLOGICAL SOIL CRUSTS

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Future climate changes will affect soil moisture regimes through increased temperature and the alteration of precipitation regimes. These effects will be especially pronounced in deserts, as soils are generally young, with low water-holding capacity. Biological soil crusts can be important components in these ecosystems. Because they are only metabolically active when wet, they are at high risk to any changes in soil moisture. We altered precipitation regimes for crusts from winter rainfall deserts. In SE Utah, altered precipitation frequency (but not amount) during summer months resulted in the reduction of fluoresence, pigment production, biomass, and N-fixation in both cyanobacteria and the lichen Collema. However, these negative effects were much more pronounced in the lichen than the cyanobacteria. In a second SE Utah experiment with Collema, altered precipitation frequency again depressed fluoresence, but this time favored N fixation. In a experiment in southern Nevada, increasing summer precipitation decreased lichen cover dominated by Collema and Placidium, while cyanobacterial biomass and fluoresence increased. In addition, it also reduced moss performance. These results indicate that increased frequency or amount of summer precipitation is likely to favor cyanobacteria over lichens, resulting in biological soil crusts that appear more like those found in deserts whose precipitation regimes are dominated by summer rain than those dominated by winter rain. Such a shift will result in species that contribute less to soil stability and fertility than those species currently present.

SOIL AND CLIMATE CONTROLS ON THE DISTRIBUTION OF EXOTIC ANNUAL GRASSES IN THE WESTERN UNITED STATES

BELNAP, JAYNE
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Finding factors that predict the invasion of exotic plants has long been a goal of many research efforts. Based on our observation that the invasion of annual grass into western US rangelands often occurs in a patchy manner, we investigated the effect of various site factors on the presence and absence of these plants. We surveyed 432 sites in the Chihuahuan, Mojave, Colorado Plateau, and Great Basin deserts, assessing site variables such as plant cover, ground cover, slope, aspect, elevation and soil characteristics including chemistry, texture, pH, and cation exchange capacity. Our results show that within a given climate region, soil characteristics are different between uninvaded and invaded patches. Invaded patches in regions with lower precipitation during times of lower air temperatures (winter, in this case) had higher available phosphorus than uninvaded patches. As winter precipitation increased, available phosphorus was no longer the sole predictor of annual grass cover, as potassium and maganese became important as well. Soil depth was important in areas with shallow soils, and texture played a role in some regions as well. Because soil texture and nutrients can be mapped, sites susceptible to annual plant invasions can also be mapped. Because the limiting nutrient is at least partially controlled by climate, the distribution of annual grasses is expected to change in the future as temperatures increase and precipitation patterns are altered.

HOW OLD ARE BIOLOGICAL SOIL CRUSTS?

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Biological Soil Crusts (BSC) are nowadays widely spread around the world, and the knowledge of their rol in arid ecosystems has improved significantly in the last decades; however, nothing is known about their origins and evolution throughout the history of the Earth. As cyanobacteria being a very ancient microbial group and the main biotic components of modern BSC, it is possible that they formed BSC-like communities in the early continents, way before of their colonization by plants. In that sense, the physical, chemical, and biological features exhibit by modern BSC could be characterized in order to recognize them in the rock record. From those characterizations and lab experiments, also the biotic and abiotic processes involved in the development of BSC can be known, leading to a better understanding of the extant BSC existence and their fate.

STATUS ON THE NEWLY PROTECTED CATHEDRAL CAVES PRIVATE PRESERVE, NORTHERN ARIZONA

BILLINGS, DOUG[1], Tom O. Gilleland[2], John Norman[3], Robert Winkler[4]
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In 2004, four western cavers purchased the property containing Cathedral Caves of Northern Arizona. Once purchased, this became one of the few, if only, private, and caver owned speleological preserves in the west. The caves on the property have suffered from decades of overuse, vandalism, and neglect. Cathedral and its sister, Indian Cave, were popular haunts along Route 66 for many years to the adventurers and tourists. Unfortunately, a heavy toll was paid for years of uncontrolled visitation. Graffiti, stripping of formations, and even the killing of bats has been documented. There has never been any successful management in place over that last 100 years of casual visitation until now. To our surprise, we found the cave resources were much greater than expected. We proposed a basic management plan and efforts to secure the caves were quickly put in place. Although vandalism was extensive, many beautiful formations and passages remained and the cave still contains significant biological, archeological and paleontological resources. I will discuss these resources within Cathedral Caves, what we have learned through privately managing these caves and their resources, and the caves, much brighter future.

BIOLOGICAL SOIL CRUST RESTORATION IN THEORY AND PRACTICE: AN UNDEREXPLOITED OPPORTUNITY?

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Biological soil crusts (BSCs) are a ubiquitous community type of cryptogams and microorganisms which are critical structural and functional components of many ecosystems. Most ecosystems of the world have these communities either as a successional sere (wetter, closed-canopied systems), or as a permanent feature (dryer, open-canopied systems). Despite their ubiquity and importance BSCs rarely are addressed in the restoration literature. In succession, most evidence supports that BSCs play a facilitative role for later seres, suggesting that assisted recovery of BSCs could speed succession. In arid – subhumid systems, loss of BSCs may be synonymous with crossing degradation thresholds because they are ecosystem engineers and strongly contribute to several vital ecosystem attributes. However, assisted recovery of BSCs may allow a transition from a degraded steady state to a more desired alternative steady state. In practice, BSC restoration has three major components: 1) establishment of reference conditions, 2) selection and integration of techniques, and 3) monitoring. Whenever possible, I advocate statistical modeling of reference conditions based upon surveys of numerous contemporary areas which have not undergone strong disturbance impacts. Restorationists may choose techniques that attempt to correct (in decreasing order of difficulty) active soil erosion, resource deficiencies, or BSC propagule scarcity. Success is likely to be contingent upon prior evaluation of site condition and identification of likely constraints to natural BSC reestablishment. Because BSC restoration may be long term, monitoring techniques must be chosen that can be implemented by non-experts and by multiple observers. I advocate a combined strategy including a measure of abundance and functional diversity (e.g. cover by functional group), a measure of biomass (e.g. chlorophyll a), and a measure of function (e.g. soil aggregation). The strong influence that BSCs exert upon ecosystems is an underexploited opportunity for restorationists to return disturbed ecosystems to a

desirable trajectory. Proper attainment of this goal entails an understanding of the theoretical role of BSCs in a given system, and a conceptual framework for identifying a course of action.

VERTEBRATE SPECIES OF THE COLORADO PLATEAU

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The Southwest Regional Gap Analysis Project modeled 820 terrestrial species within the 5-state project area. We modeled species using regional datasets including land cover, elevation, and hydrography. Models were constrained by hydrologic units with reproductive and seasonal use identified. We present the results of our habitat modeling effort in context of the Colorado Plateau. We will provide examples output for specific species habitats and taxa groups for the Colorado Plateau and place these habitat models in context with natural features and the life history of the species. We also present the results of an accuracy assessment based on National Park Service Inventory and Monitoring data.

USER DISCRETIONARY TIME: A MODEL TO ESTIMATE OPPORTUNITIES FOR VISITOR EXPERIENCE

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User Discretionary Time (UDT) was developed at Grand Canyon National Park to measure visitors' "free time" on Colorado River rafting trips. This measurement augmented more traditional use level measurements (such as user-days) for the Colorado River Management Plan Environmental Impact Statement's alternative analysis. The UDT model factors in the amount of daylight throughout the year that is available for visitor activities. Mandatory visitor activities (e.g., eating, traveling downriver) on a "typical" Colorado River trip were then identified, and subtracted from the total daylight available in half-month intervals. The remaining "free time" is considered discretionary time for visitors to spend as they personally wish. The UDT results were used to provide some insight into visitor experience, and visitor opportunities to engage in activities beyond the essential tasks of a camping/rafting trip through the Grand Canyon. Values and limitations of this type of measurement are discussed.

EFFECTS OF PRESCRIBED FIRE ON BARK BEETLE COLONIZATION IN SOUTHWEST PONDEROSA PINE FORESTS

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Prescribed fire is increasingly used as a tool to restore southwest ponderosa pine forests to pre-settlement conditions, improve forest health, and to reduce risk of large stand-replacing wildfire. Possible undesirable effects of prescribed fire include increased bark beetle activity and unacceptable levels of tree mortality. We present data from the first year of a 3-year study on effects of prescribed fire on ponderosa pine mortality and bark beetle colonization. Our research is part of the Birds and Burns Network, a large-scale cooperative study of effects of fire on bird populations (www.rmrs.nau.edu/lab/4251/birdsnburns/index.shtml). We sampled four sites in Arizona and New Mexico that were treated with prescribed fire during fall 2003 and winter/early spring 2004. Each site is 250-400 hectares in size and is paired with an unburned control site of similar size and stand characteristics. We measured fire damage and bark beetle presence on nearly 2500 ponderosa pine trees. While the numbers of bark beetle attacks were low on both burned and unburned sites, more attacks occurred on burned sites than unburned sites. By sampling for beetle activity at different heights along the bole, we found *Dendroctonus* species to attack mostly mid-bole (3-5 meters) and *Ips* species to attack mostly the upper bole (5-7 meters), indicating possible resource partitioning. The amount of tree crown damage by fire is a good indicator of probability of bark beetle attack: most bark beetle attacks occurred on trees with greater amounts of crown damage. This study will provide insight into how we can use prescribed fire effectively while keeping tree mortality levels reasonable for management goals and keeping bark beetle populations endemic by improving forest health.

REGIONAL VEGETATION DIE-OFF IN RESPONSE TO GLOBAL-CHANGE TYPE DROUGHT

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Future drought is projected to occur under warmer temperature conditions as climate change progresses—referred to here as global-change type drought—yet quantitative assessments of the triggers and potential extent of drought-induced vegetation die-off remain pivotal uncertainties in assessing climate change impacts. Of particular concern is regional-scale mortality of overstory trees, which rapidly alters ecosystem type, associated ecosystem properties, and land surface conditions for decades. Here we quantify regional-scale vegetation die-off across southwestern North American woodlands in 2002-2003 in response to drought and associated bark beetle infestations. At an intensively studied site within the region, we quantified that following fifteen months of depleted soil water content, more than 90% of the dominant, overstory tree species (Pinus edulis—a piñon) died. The die-off was reflected in changes in a remotely sensed index of vegetation greenness (Normalized Difference Vegetation Index), not only at the intensively studied site but also across the region, extending over 12,000 km^2 or more; aerial and field surveys confirmed the general extent of the die-off. Notably, the recent drought was warmer than the previous sub-continental drought of the 1950s. The limited, available observations suggest that die-off from the recent drought was more extensive than that from the previous drought, extending into wetter sites within the tree species' distribution. Our results quantify a trigger leading to rapid, drought-induced die-off of overstory woody plants at sub-continental-scale and highlight the potential for such die-off to be more severe and extensive for future global-change type drought under warmer conditions (From Breshears *et al.* 2005, Proceedings of the National Academy of Sciences USA: in press.)

SCALING ISSUES AND THE ECOLOGY OF DESERT SOIL CRUST BRYOPHYTES

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In studies of desert soil crust ecology, bryophytes as a group have largely been neglected. This neglect is unfortunate because these plants provide unique and important ecosystem services to the desert community. For example, the effect of moss cover on nutrient cycling processes has scarcely been investigated for desert ecosystems while its significance in other environments is well known. The soil binding and water holding capacity of a solid clump of desert moss is quite remarkable and a familiar phenomenon to many desert researchers. However, these properties have yet to be adequately studied and quantified. Their ability to persist in the desiccated state for months at a time and resume activity virtually immediately upon rewetting gives them a unique advantage among the land plants when it comes to utilizing the resources made available by sporadic rainfall. As such, they may play a key role in the responses of desert ecosystems to the pulse events that characterize these environments. Finally, many bryophytes have very specific habitat and substrate requirements that make them especially sensitive indicators of both natural ecological variables as well as environmental pollutants. Because of their small size, bryophytes are strongly affected by fine-scale variation in their environment. These effects can often override processes operating at the usual scale of ecological investigation, leading to complex patterns that can be difficult to interpret. Expanding our knowledge of the basic ecology of desert soil crust bryophytes at the appropriate scales is essential to understanding the behavior of these crusts. At UNLV we will be investigating how important variables such as light, temperature, moisture, etc. vary across the microscale habitats that these organisms occupy. By gaining an understanding of the tolerance limits of these species we hope to offer insight into the processes of dispersal and establishment and eventually the ability to predict both species composition along with potential cover and biomass. Bryophyte ecology lags far behind vascular plant ecology in this area, but it remains a crucial first step towards predicting how these species may be affected by the environmental impacts of fire, global change, or specific management practices.

A LONG TERM ASSESSMENT OF PRONGHORN MANAGEMENT ON ANDERSON MESA: MISCALCULATIONS AND REMIDIES

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Pronghorn (Antilocapra americana) populations on Anderson Mesa exploded during the wet years of the 1920s before fluctuating greatly in the 1930s. Although a hunting season was initiated in 1940 to spread the buck:doe ratio and decrease intraspecific competition, the population generally declined during most of the 1940s and the season was closed from 1944 to 1949. Fawn survival rates and populations continued to fluctuate until the early 1990s when a marked decline in fawn survival and population numbers occurred. Despite various management prescriptions including closed seasons, habitat closures, and coyote reduction, pronghorn populations on Anderson Mesa appear to have been influenced mostly be weather fluctuations, ungulate competition, and long term habitat changes. Mid-summer drought, exacerbated by

ungulate predation on perennial forage plants is hypothesized to now be the primary factor limiting pronghorn populations. Population fluctuations, always a characteristic of Anderson Mesa's pronghorn, appear to have accelerated since the 1970s. Drought and forage condition are believed to be the factors determining pronghorn population size, and management prescriptions should revolve around the condition of perennial browse plants.

AN ACOUSTIC SURVEY FOR BATS ALONG THE COLORADO RIVER CORRIDOR

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Appropriate conservation requires an understanding of how the resource is used by an animal. Because bats are nocturnal mammals, knowledge of how they use a resource has been difficult and time-consuming to obtain. Prior to the development of ultrasonic bat detectors, a resource inventory for bats was conducted using standard mist-netting techniques at water sources. However, netting is biased towards bats easily captured over pools of water or along low flyways. In addition, the vast remoteness of much of the Colorado River Plateau, combined with the ability of bats to fly long distances over rugged terrain, has constrained our knowledge of when and how bats might use the resource. However, since the development of affordable field-robust bat detectors, we now have another tool by which to evaluate the landscape for use by bats. I will present a brief overview of bat echolocation plus information regarding two field-popular bat detectors: Anabat II (frequency division) and Pettersson D240x (time-expansion). Both detectors are designed to record the ultrasonic calls of bats for later identification in the laboratory. However, since each system has known advantages and disadvantages, by combining the two methods we benefit from the advantages and reduce the disadvantages. I will discuss the techniques I used to monitor bat-use of the Colorado River corridor using both detectors, providing specific examples of acoustic sampling of ultrasonic bat calls conducted during a research river trip in September 2004.

A HISTORY OF THE DISCOVERY AND EXPLORATION OF THE CAVES OF HORSESHOE MESA, GRAND CANYON NATIONAL PARK

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Many of the caves on Horseshoe Mesa were discovered in the late 1890's by copper miners working at the Grandview Mine. The initial exploration of the largest cave, now known as Cave of the Domes, is documented by numerous inscriptions found on the cave walls and by a series of period newspaper articles. Because the early mining effort supported the construction of the scenic Grandview Trail, the caves soon became a tourist attraction and additional caves were discovered and developed. However, the notoriety was short lived. The closing of the mine and development of Grand Canyon Village as the center of Grand Canyon tourism abruptly ended most tourist trips to the caves. Soon the names and inventories of the individual caves became confused. In the 1970's a team of cave researchers inventoried the known caves and re-established the historic names with specific caves and cavern features. I will present results from this work and describe a reconstruction of historic events through an inventory of period signatures and photographs from Horseshoe Mesa caves by known Grand Canyon explorers.

FIRE EFFECTS ON FISHES AND AQUATIC ECOSYTEMS IN THE SOUTHWEST: CASE STUDIES, LAB INQUIRES AND LANDSCAPE PERSPECTIVES

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The increase in fuel loading and subsequent increase in large, high intensity wildfires has been well documented on the Colorado plateau, as well as throughout the western United States. These fires can have dramatic negative impacts on aquatic ecosystems. In recent years we have studied the effects of wildfire on fishes and aquatic ecosystems from 9 wildfires, impacting 15 streams and 14 species of fish in the SW. Results have varied from little or no impact to 70%-90% reduction in total fish numbers, to complete extirpation of entire fish assemblages. Re-colonization of fishes has been slow in some streams, and long-term alteration of habitat has been observed. As a group, native fishes are one of the most threatened assemblages in the southwest. Invasive nonnative fishes, damming, and dewatering of streams, have taken their toll on native fish populations. The result is that many remnant populations of native fishes persist in small isolated habitats with little or no connectivity to other populations, leaving them especially vulnerable to impacts from large, high-intensity wildfire. Possible causes for the loss of fish include post-fire ash and sediment loads, sustained exposure to poor water quality, violent flooding, short and long term alteration of habitat (channel scouring, filling in of pools, alteration of substrate composition) loss of food resources, or, most likely, a combination of these and other factors. Mortality due to brief exposures to high levels of suspended ash was assessed in the lab. Ash LC50 levels were assessed for 5 native fishes (10.61 g/l – 16.65 g/l) and 2 introduced species indicate that mortality can be at least partially explained by brief exposure to high levels of suspended ash concentrations. Water samples collected from fire-impacted streams have been measured at, and many times above, the LC50's calculated in the lab. Physical and geo-spatial data from fire impacted research sites are currently being compiled to begin linking the physical impact on the watershed with the biological impact found in the stream. Our results from lab and field studies underscore the need for fuels reductions to help reduce the severity of wildfire. Fuels reduction treatments/prescribed fires need to be monitored for effects to aquatic ecosystems so that this data, along with existing data from wildfires, can be used to model how much fire intensity a watershed can sustain without negatively impacting fisheries resources.

INFLUENCES OF TRAVERTINE DAM FORMATION ON LEAF LITTER DECOMPOSITION AND ALGAL ACCRUAL IN FOSSIL CREEK, ARIZONA

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This study addresses the differences in the aquatic food base of a travertine dam forming reach and a non-travertine dam forming reach in Fossil Creek, Arizona. Allochthonous sources of energy input were assessed through leaf pack processing experiments. Nutrient diffusing artificial substrates (clay flowerpots) were used to compare algal accrual rates and nutrient limitations between the reaches. Leaf litter processing rates were significantly faster ($p < .0001$) at the travertine dam forming reach than at the non-travertine reach for both Arizona alder, *Alnus oblongifolia*, and Arizona Sycamore, *Platanus wrightii*, leaf species. Associated macroinvertebrate communities were more diverse in the travertine reach. Alder decomposed more quickly than sycamore at both reaches ($p = .0001$). Algae accrued at a much faster rate at the travertine reach than the non-travertine reach. Algae responded positively to nutrient enrichment (nitrogen and phosphorous) in the summer at the travertine reach. In contrast, algae never responded to nutrient enrichment in the non-travertine reach, suggesting algae is limited by other factors at this reach. The diversion dam and hydroelectric facility built on Fossil Creek near the turn of the century has recently been decommissioned. Full flows have been returned to the stream, which is expected to increase travertine formation. The results of this study indicate faster leaf litter processing and greater algal accrual at the travertine reach, providing a richer food base for higher trophic levels. The expected increase in travertine formation should promote a richer food base in Fossil Creek. Most, if not all, species of the native fish assemblage in Fossil Creek should benefit by increased travertine formation. The substantial growth release for the nutrient enriched substrates at the travertine reach indicates a potential for nuisance level blooms of algae in the summer if anthropogenic inputs are not managed. This research will contribute to the foundation of basic knowledge about how stream ecosystems, especially travertine forming systems, function. The decommissioning of the dam and subsequent return of full flows gives us the opportunity to use this study as baseline data to assess changes associated with stream restoration and dam removal including changes in geomorphology. It will add to the now sparse body of knowledge about the ecosystem effects of dam removal.

FORAGING AREAS FOR FEMALE AND MALE SPOTTED BATS (*EUDERMA MACULATUM*), NORTHERN ARIZONA

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We attached radio transmitters to 4 female and 3 male spotted bats (*Euderma maculatum*) captured over ponds in Great Basin desertscrub vegetation type, Upper Colorado River area, 27-28 June 2005. We tracked bats for 7 to 16 days to identify foraging areas and travel corridors. Bats foraged primarily in Great Basin desertscrub and pinyon-juniper vegetation. Marble Canyon and adjacent tributaries were used as travel corridors to access foraging areas. On most nights, bats emerged at approximately 30 min after sunset, foraged until ~ 23:30, and returned to roosts between 0300 and 0400. Bats regularly used canyons and washes to travel to foraging sites. On 4 successive nights, 12 to 61 spotted bats passed through a canyon in a 1-hr period. One bat roosted in Soap Creek and used this canyon to travel to cliffs approximately 7 km away. We documented several bats using canyons along the east side of the Kaibab Plateau. Foraging routes appeared to be circular and counterclockwise, with some bats foraging in the same general area. It did not appear that spotted bats maintained exclusive foraging areas, although they may have partitioned habitat use temporally. Bats changed foraging locations during the project, possible evidence of bats tracking shifting resources. For example, 1 bat changed her foraging location from desertscrub to pinyon-juniper. Spotted bats appeared to night roost in pinyon-juniper woodlands between midnight and 01:00 to 0:300. They foraged within 20 to 30 km of roosts. Spotted bats appear to be patchily distributed but locally common in northern Arizona. Spotted bats used similar habitat compared with other populations; foraging distances that we documented remain much greater than reported from other locations in western North America.

LONG-TERM CAVE ROOSTING AND DIET OF SPOTTED BATS (*EUDERMA MACULATUM*) IN NORTHERN ARIZONA AS INDICATED BY STABLE ISOTOPES FROM MUMMIFIED REMAINS AND LIVE BATS

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In 1995, a mummified spotted bat (*Euderma maculatum*) was discovered in a limestone cave (1,530 m elevation; Great Basin desertscrub vegetation) in northern Arizona. Using radiocarbon analysis, the bat was dated as 9180 $\pm$50 radiocarbon years old (^{14}C years Before Present [B.P.]). In 2003 and 2005, we retrieved 8 additional spotted bat mummies. Remains dated from <50 yrs B.P. to 2110 $\pm$ 40 yrs B.P. (approximate ages: <50 (n = 2), 120, 180, 300, 1450, 1760, 2110 yrs B.P.), indicating long-term stable use of the cave roost. An exit count at the cave indicated high use in May 2005 (n = 24 spotted bats); at other times during spring, summer, and fall, <10 spotted bats were heard exiting. We captured live spotted bats roosting in this cave (n = 8) and on the Kaibab Plateau (2500 m elevation, ~35 km from the cave, n = 27). We collected hair and wing samples from mummified remains and live bats. Stable isotope signatures from live spotted bats and from the <50 yr B.P. mummified spotted bat were similar. However, mummified spotted bats >50 yrs B.P. were more enriched in ^{13}C suggesting their diet had shifted within the past 100 years from a higher proportion of C4 plant-feeding moths to C3 plant-feeding moths. We hypothesize that this shift in spotted bat diet could be related to one of several causes: (1) decrease in C4 plant density, (2) increase in C3 plant density, (3) diet shift in spotted bats, (4) isotope enrichment in C3 plants > 100 yrs B.P., or (5) early in the mummification process digenesis shifted the isotopic signature which then remained constant for thousands of years.

IS SOIL STABILITY LINKED TO MYCORRHIZAL FUNGI? UNTANGLING THE ARID ECOLOGY OF FUNGAL MUTUALISTS

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We examined the relationship between soil stability and the structure and functioning of mycorrhizal fungal communities of the Colorado Plateau. Mycorrhizal fungi form symbiotic, often mutualistic, belowground associations with most plants in arid and semi-arid ecosystems. Previous studies have shown mycorrhizal fungi to strongly influence soil stability. For instance, mycorrhizal fungi bind soil particles together through the production of hyphal networks and glomalin, a sticky glue-like protein. However, few studies have examined the reverse, how altered soil stability affects mycorrhizal fungi. To examine the relationship between degraded soil stability and mycorrhizal fungi, we compared mycorrhizal activity across low and high stability sites (as per the BLM Rangeland Health Assessment Protocol) within the Grand Staircase-Escalante National Monument. Several key patterns emerged. (1) Mycorrhizal fungal spores were 3 times more abundant and 1.5 times more species rich in high stability soils compared to low stability soils. (2) NMDS ordinations showed soil degradation to cause an overall shift in mycorrhizal fungal communities. (3) Soil glomalin content was up to 3 times higher in high stability soils compared to low stability soils. We were not able to directly test whether soil stability causes depauperate AM fungal communities or whether the lack of AM fungi caused unstable soils. However, the strength and causality of these relationships is explored using structural equation modeling. Our results indicate a community-level relationship between mycorrhizal fungi and soil degradation never before demonstrated in arid ecosystems. We also report interesting and novel results relating mycorrhizal fungal community diversity to the function of glomalin production. These findings reveal information on the basic ecology of mycorrhizal fungi in arid ecosystems as well as provide insight into how mycorrhizal fungi factor into soil erosional feedback loops.

RADIOISOTOPIC ANALYSES OF POTENTIAL SOURCES OF LEAD CONTAMINATION IN CALIFORNIA CONDORS

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One problem associated with attempts to reintroduce condors (Gymnogyps californianus) at Vermilion Cliffs, Arizona, is that many birds are getting lead poisoning. Fragments of bullets in carcasses and lead from mines or other environmental inputs have been hypothesized as potential sources of the lead contamination. Here we use radiogenic isotopes to lead (Pb 204, Pb 206, Pb 207 and Pb 208) to investigate the potential sources of environmental lead contamination and linkages between bullet fragments and blood contamination. Specifically we attempt to (1) compare isotopic signatures of specific bullet fragments with lead in the blood and (2) compare lead signals in condor populations with background environmental and bullet lead signatures. We present conclusive data to support the hypothesis that bullet fragments are the source of lead poisoning in condors.

SPATIALLY EXPLICIT MODELING OF COLORADO PLATEAU LANDSCAPES FROM CONCEPTUAL MODELS TO A COMPUTER SYSTEM

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Models are an essential means of incorporating science into adaptive ecosystem management. The development and use of models facilitates the explicit specification of assumptions on ecosystem functioning and the analysis of management alternatives with the uncertainties that come with limited scientific information. The process of building and using models provides transparency and enables the critical examination of assumptions. Spatially explicit simulation models can generate hypotheses concerning future trajectories of ecosystems and valued ecosystem attributes. The integration of simulation modeling into management planning can allow managers, resource specialists, and stakeholders to examine and compare potential outcomes of proposed management alternatives in relation to management objectives and desired conditions. SIMPPLLE is a spatially explicit landscape-scale modeling system for simulating vegetation changes caused by disturbance processes of wildfire, insects, and diseases. Stochastic simulations provide a range in vegetation conditions and levels of disturbance processes. A system variable of regional climate is used to capture the interaction between cyclic changes in temperature and moisture and disturbance processes. SIMPPLLE was originally developed for ecosystems in the Northern Rocky Mountains and its application to the Colorado Plateau is being done through the FRAMES (Framing Research to support Adaptive Management of Ecosystems) project which involves the U.S. Geological Survey, USDA Forest Service, Colorado State University, Mesa Verde National Park, Prescott College, and Northern Arizona University. The system uses conceptual models and research results specific to the Colorado Plateau and has the potential to integrate vegetation, soil, and aquatic components of landscapes. Simulation results from Mesa Verde National Park are used to quantify current trends, historic conditions, and management alternatives.

TACTICAL PLANNING OF VEGETATION MANAGEMENT IN SUPPORT OF PRONGHORN HABITAT ENHANCEMENT ON ANDERSON MESA, AZ.

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The Anderson Mesa pronghorn (*Antilocapra americana*) herd is of special conservation and management concern, due to significant population declines since the mid 1980s. A host of factors have been attributed to the decline of this population. Piñon-juniper woodland encroachment into the mesa's grassland ecosystems has emerged as one of these factors. Pronghorn are a keenly visual prey species that evolved in, and prefer open habitats. The Arizona Game and Fish Department (AZGF) is currently working to restore the structural component of grasslands on and surrounding Anderson Mesa by implementing a multi-million dollar collaborative project to remove woody vegetation in important pronghorn habitat to enhance, expand and connect the available grassland habitat. Our objective was to develop a model to maximize the efficiency and effectiveness of habitat enhancement activities, while simultaneously reconciling habitat enhancement objectives with financial and operational considerations for a 10-year planning horizon. To achieve this, we utilized a GIS-linked simulated annealing optimization model to integrate spatially-explicit expert knowledge and resource inventory information across a 260,000-acre analysis area, with a focus on pronghorn habitat requirements and use. Our model was able to integrate complex decision factors at a landscape level, and provides a decision-support tool for wildlife and land managers who desire to develop a sound tactical woodland treatment strategy in the greater Anderson Mesa area. In consultation with managers, we developed a zoning scheme to codify current and potential pronghorn habitat use, and established management goals. Based upon these management goals, we generated 3 different trade-off management scenarios. Results indicate habitat enhancement goals for this landscape are achievable given agency operational constraints.

BUREAU OF RECLAMATION ROLE IN RESTORING NATIVE FISH TO FOSSIL CREEK

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During a 2001 Endangered Species Act consultation with the U.S. Fish and Wildlife Service (FWS) over impacts of potential nonnative fish transfers to the Gila River basin via the Central Arizona Project aqueduct, Reclamation proposed constructing a series of fish barriers on high value native fish streams to assist with recovery of threatened and endangered fishes. The purpose of the fish barriers is to prevent upstream movements of nonnative fishes (which are incompatible with persistence of native fishes) into stream reaches dedicated for native fish management. Although the native fishery of Fossil Creek had been degraded over the past century by flow depletion from Arizona Public Service's (APS) Childs-Irving Hydropower Project and invasions of nonnative fishes, the stream could be restored for native fish dedication if nonnative fishes were removed and protected against their reinvasion by a fish barrier. Flow restoration via the proposed decommissioning of the hydropower project was an added bonus for the stream, which could then serve as a replication site for the rare Verde River population of the federally-threatened spikedace, *Meda fulgida*, a species that is found only in relatively pristine medium to large rivers. The near-magical alignment of Reclamation funding for construction of a fish barrier and financial support for stream renovation activities, flow restoration of the stream by APS, and support for the project by the public, government agencies, and environmental groups brought the massive Fossil Creek native fish restoration project to realization. A fish barrier was constructed in October 2004, and the salvage, renovation, and repatriation of salvaged fish tasks were completed soon thereafter. Historical flows were returned to the stream in June 2005. All that remains for complete project success is to repatriate spikedace and other appropriate native fishes.

FISHES OF THE GRAND CANYON

Coggins, Lewis, STEVEN **GLOSS**

This talk examines the status, trends, and recent condition of Grand Canyon fishes, focusing particular attention on the endangered humpback chub (*Gila cypha*) because of its prominence within the Glen Canyon Dam Adaptive Management Program. The session begins with a discussion of the conditions that led to the development of the Grand Canyon's unique native fish populations and then moves on to the reasons for their decline. The effects of the modified low fluctuating flow (MLFF) alternative on fish populations are also examined. The presentation concludes with a discussion of possible management options to slow or reverse the decline of humpback chub numbers.

FOSSIL PLANT REMAINS IN COLORADO PLATEAU CAVES

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The general horizontal stratigraphy of the plateau, and the prevalence of karst-forming limestone substrates, combine with the scarcity of water to produce a great abundance of dry caves on the Colorado Plateau. These dry caves form excellent archives for the preservation of mummified plant remains. In such a dry region with low erosion rates, many of these caves persist water-free for longer than the last 50,000 years from which plants can be aged by radiocarbon dating. As a result, caves not only protect abundant data on past vegetation change, but these deposits are unprecedented in a world where plant fossil records are typically rare in desert environments. These plant fossil records take many forms. Packrat middens, debris piles of plant parts collected by packrats and hardened by continuous coatings of urine, often are mistaken for rocks by the uninitiated. Cave sediments can contain continuous deposits of pollen blown in over many thousands of years. Both packrat middens and pollen deposits can even be found under small ledges. Middens have also been discovered that were left by other animals such as ringtails (*Bassariscus astutus*), porcupines (*Erethizon dorsatum*) and domestic sheep (*Ovis aries*). Caves adjacent to rivers can contain Pleistocene driftwood. The most unique and invaluable cave deposits consist of dung of extinct animals such as mammoth, sloth, camels, and horses. Although the study of digested plant parts in fossil dung could easily win an award for the most absurd sounding scientific study, there is really no better source of information on the ecological niche for an extinct species.

INTEGRATING DATA ON HISTORIC VEGETATION CHANGE BETWEEN THE SAN FRANCISCO PEAKS AND GRAND CANYON

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Abundant data exist on past vegetation change on the Colorado Plateau. Unfortunately, these data are often dispersed among many different highly specialized fields of study. And, because these data encompass a wide variety of spatial, temporal, and taxonomic scales, it can be difficult to draw them together into a synthetic picture of historic vegetation change. But, without this vision of historic vegetation change, it is difficult to distinguish between noise and trends in shorter-term data sets. Between the top of the San Francisco Peaks and the bottom of the Grand Canyon, data sets demonstrate vegetation changes that have occurred from the late Pleistocene up until the Twentieth Century. Leaves, seeds, and twigs of past plants have been accumulated by packrats and saved as mummified debris in packrat middens. Although these studies may be focused into different time periods ranging from 250 to 50,000 years ago, these data reflect vegetation changes on local sites of upland, often rocky, desert slopes. Fossil pollen from plants is preserved in lake or pond sediments, packrat middens, or even in dry caves or desert rock fissures. But these records mostly represent wind-pollinated species of higher elevation habitats where lakes are most common. Data on long-term plant succession is available through the study of soil development, plant succession, and colonization on geomorphic substrates of differing ages, especially the abundant volcanic flows. Archives of data on past tree populations exist in and near every forest and woodland in the form of tree-rings. Not only can the rings of living and dead trees be used to study past fluctuations in populations, but some can be used to reconstruct specific climatic variables over the past 100's to 1000's of years. Finally, these longer-tern records can be integrated with shorter-term records such as GLO tree survey data, written historical observations, and early photography. Upon further study, disparities between the interpretation of two different sources of data often can be seen to result from reflecting two different aspects of the same change, further increasing our understanding of the change through integration of multiple data sets.

MORPHOLOGICAL VARIATION IN PINYON NEEDLES OF THE VERDE VALLEY AND THEIR RELATIONSHIP TO ANNUAL PRECIPITATION

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Pinyon pines often have variable frequencies of needles per needle-fascicle, especially in northern Arizona. Because some taxonomic classifications are based nearly entirely upon this character, this causes uncertainty in species identifications. In the Verde Valley, these numbers range from almost 100% two-needle fascicles above 2000 m elevation to almost 100% one needle-fascicles below 1200 m. The majority of the pinyon trees grow between these elevations and support intermediate frequencies of both needle types. This situation is analogous to pinyon populations along the central Nevada/Utah border where the two-needled Colorado Pinyon (*Pinus edulis*) grow near the Singleleaf Pinyon (*Pinus monophylla*). A previous study demonstrated that the frequency of needle types on one Nevada population varied from year-to-year, corresponding to precipitation over the previous 9 months. We analyzed pinyon branches from Verde Valley populations from near three climate stations that have recorded greatly differing amounts of precipitation between each other and from year-to-year. Our results show that, like the Great Basin pinyon, the frequency of one and two-needle fascicles is variable from year-to-year and correlated to precipitation. However, unlike the Great Basin pinyon, these Verde Valley mixtures are thought to represent the two-needled Colorado Pinyon (*Pinus edulis*), and the lower-elevation Arizona Singleleaf Pinyon, which was originally described by Elbert Little as: *Pinus edulis* var. *fallax*. Subsequently, others have re-classified these pines as: *Pinus monophylla* var. *fallax*; or, *Pinus californiarum* var. *fallax*. In view of the fact that it is inappropriate for individual trees to change species from year-to-year, it would seem that the Arizona Singleleaf Pinyon should remain a variety of that species to which they can morph following a wet year: *Pinus edulis* var. *fallax*. This classification is the most consistent in describing the central Arizona populations, but also better describes the broader array of morphological and genetic variation across their ranges. Additional measurements on these branches demonstrate that while needle-fascicle number and needle length are correlated with precipitation over the proceeding 9 months, shoot length seems to better reflect precipitation over the year prior to the growth.

THE EFFECTS OF TRAVERTINE DAMS ON LEAF LITTER RETENTION IN FOSSIL CREEK, ARIZONA

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Leaf retention is an important process for ecosystem maintenance because it allows leaves to become colonized by microbes and, subsequently, invertebrate shredders that further break down leaves, thereby providing an important nutrient input to the stream food web. Some of the main factors influencing leaf retention are (1) stream discharge; (2) substrate coarseness; (3) stream sinuosity; and (4) debris dams. Though many studies have attempted to determine the relative importance of these factors, few have examined travertine in the context of leaf retention, which is important because travertine forms specialized types of debris dams that have the potential to greatly influence leaf retention. This study compared leaf retention at three travertine dam and three free-flowing sites within Fossil Creek, Arizona in order to determine the role of travertine as a coarse substrate in leaf retention. Three *a priori* hypotheses were tested: greater leaf retention will be found at (1) the travertine dam sites versus the free-flowing sites, (2) sites with lower average velocities, and (3) sites with overall coarser substrates. Results indicated that travertine sites were much better at retaining leaves, and that velocity, not discharge, was a primary contributor to retention. The hypothesis that greater leaf retention would occur at sites with overall coarser substrates, however, was rejected, as coarser substrates were found at the free-flowing sites. Travertine was the primary coarse substrate type found at the travertine sites, while cobble and boulder made up a majority of the coarse substrates at the free-flowing sites. These results suggest that travertine may be a more important contributor to leaf retention than other substrate types. The decommissioning of the Irving Power Plant in the summer of 2005 has increased flows dramatically in parts of Fossil Creek, and subsequent travertine deposition is expected to increase nearly ten-fold. Our

findings suggest that the increased travertine deposition will lead to greater leaf retention and, ultimately, a more rapid restoration of Fossil Creek.

SMALL MAMMAL POPULATION RESPONSES TO FOREST FUEL REDUCTION TREATMENTS AT THE SOUTHWEST PLATEAU FIRE AND FIRE SURROGATE PROJECT

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We examined responses of small mammals to initial thinning treatments for fuel reduction at the Southwest Plateau Fire and Fire Surrogate Project study area. We conducted mark-recapture data collection on small mammal populations and estimated capture probabilities, movements, and population densities. We then used a weighted least-squares regression analysis to evaluate density responses to thinning treatments. We evaluated strength of evidence for our *a priori* hypotheses based on Akaike's Information Criterion (AIC). We marked 7 species of small mammals over the course of 4 years, and present analyses for the 2 most common species at the study area. We found that both deer mice (*Peromyscus maniculatus*) and chipmunks (*Tamias cinereicollis*) generally increased, as predicted, in the first year after thinning, though the response was not consistent across replicated study sites. Important lessons from this research are: (1) indices of population size based on an assumption of equal capture probabilities over space and time are unreliable for detecting population responses to treatments, (2) variability in pre-treatment conditions may substantially impact responses to treatments, and (3) longer-term studies of responses to forest fuel reduction treatments are needed. Small mammal responses to wildfire have also been monitored, and analyses of those data are ongoing.

FORAGING PATTERNS AND ROOST SITES FOR FEMALE BIG FREE-TAILED BATS (*NYCTINOMOPS MACROTIS)* IN NORTHERN ARIZONA

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We attached radio transmitters to 8 female big free-tailed bats (*Nyctinomops macrotis*) captured at 6 different sites throughout northern Arizona, June-August 2005. We tracked bats for a cumulative total of 13 days to identify foraging patterns, roost locations, and travel corridors. Tagged bats kept their transmitters for only 2 (±2) days. One bat was tracked for 7 nights and spent almost all of its time foraging over Great Basin desert scrub vegetation and on one occasion made a 1-hr round trip flight into ponderosa pine forest; an elevation gain of 1077 m. Great Basin desert scrub and various tributaries to the Colorado River were used extensively as foraging areas and travel corridors. Total distance traveled nightly was estimated as ~32 km each for 2 bats. Roost sites were in cracks and crevices in sandstone in the upper portions of vertical cliffs along the upper Colorado River (Marble Canyon), Kanab Creek (Grama Canyon), and Canyon de Chelly. Of the 7 bats tracked back to roost sites, 3 were found to be roosting in the same location in Marble Canyon and 2 other bats were found to be roosting in the same location at Canyon de Chelly. An exit count conducted at the Canyon de Chelly roost confirmed at least 4 bats exiting thus suggesting big free-tailed bats form small maternity colonies which is consistent with the literature. We were unable to document night roosting for big free-tailed bats. Bats emerged from day roosts ~2030 each night, foraged for approximately 6 hours and returned to their day roost. Previous work in the southwestern United States with big free-tailed bats indicated similar roost sites; however, information regarding foraging patterns is absent from the literature. Big free-tailed bats appear to be patchily distributed in northern Arizona and use similar habitat compared with other populations in Utah, New Mexico, Texas, and Mexico.

HAIRY WOODPECKER WINTER ROOST CHARACTERISTICS IN BURNED PONDEROSA PINE FOREST

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For North American woodpeckers, winter roosts afford escape from extreme climatic conditions such as wind and snow, reduce heat and energy loss, and provide protection from predators. However, little information on the characteristics and use of winter roosts in burned areas exists. We monitored the use and characteristics of 12 winter roosts used by 9 radio-tagged Hairy Woodpeckers (Picoides villosus) in ponderosa pine forests of Northern Arizona that had experienced wildfire in 1996 and 2000. Compared to random trees in the surrounding forest that had experienced similar burn severities, roost trees were larger than 95% of random trees. Using point-center quarter method, trees immediately surrounding roost trees were less dense than 95% of those surrounding random non-roost trees. Two-thirds of roost trees were created by fire and these roost trees were smaller then those created by other means. Two-thirds of the roosts were outside or on the edge of estimated home ranges based on diurnal locations. This study suggests that fire-killed trees are a likely source of winter roost trees for hairy woodpeckers. Therefore, restoration of natural fire regimes in ponderosa pine forests of the Colorado plateau that create roost trees could benefit hairy woodpeckers.

FIVE YEARS OF VEGETATION CHANGE FOLLOWING HIGH-SEVERITY FIRE AND FIRE-FIGHTING ACTIVITIES IN GRAND CANYON NATIONAL PARK.

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The Outlet Fire burned over 13,000 acres of mostly mixed conifer forest on the North Rim of Grand Canyon National Park and Kaibab National Forest in 2000. Post-fire monitoring began that summer and continued through 2004. The objective of the study was to examine post-fire vegetation change in relation to three types of disturbed sites: burned areas, fire-fighting staging areas, and fire-fighting handlines. Indicator Species Analysis, Nonmetric Multidimensional Scaling, and ANOSIM were employed to determine indicator species and trends across years and among disturbance types. There were statistically significant differences in floristic composition, cover, and diversity over time and among disturbance types. Burned sites had the highest vegetation cover in the first year and cover remained high through 2004. Diversity in the burned areas decreased following dieback of the initial ruderal invasion. By 2004 the areas were largely floristically homogeneous, which may have ramifications for other trophic levels. Few exotic species were present, although by 2004, Bromus tectorum (cheat grass) had become an indicator species of high-severity burned areas. Staging areas used in fire fighting contained the greatest number of exotic species in all years of study, but this may be related to continued use of these roadside areas by Park visitors. Areas of handlines showed no statistically significant differences between 2000 and 2004, indicating no vegetation recovery has occurred. Current methods of site rehabilitation following handline construction may need to be modified to improve vegetation recovery. Continued monitoring is essential for enhancing our understanding of long-term changes in these high elevation forests.

SAFE HAVENS, SAFE PASSAGES: THE GRAND CANYON ECOREGION WILDLANDS NETWORK DESIGN

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Grand Canyon Wildlands Council and collaborators are in the final stages of developing a draft Wildlands Network Vision document that integrates science and passion to protect and heal wild nature in the Grand Canyon region–from the High Plateaus of Utah, across Grand Canyon to the Mogollon Rim in Arizona, and up to the headwaters of the Little Colorado River in New Mexico. While we expect to have the preliminary draft ready for peer review by January 2006, we would like to take this opportunity to present in a poster format, an outline and summary of the vision document at the 8th Biannual Conference in Flagstaff. The Wildlands Network envisions an inspirational landscape of safe havens and safe passages for all the region's native wild creatures. Equally important in this landscape view is that it assures all species the fullest potential to adapt to the changing world. We trust not in naïve optimism, but in an unrelenting commitment to the ethical treatment of that grand creation called wild nature. Toward a Wilder Grand Canyon. Our goal is not to capture some static vignette of a bygone era, but to "re-wild," that is, restore the promise and natural complexity of self-willed, naturally evolving wildlands. Land conservation in the past has generally taken the form of designating relatively small safe havens. These are in fact islands of protected habitat in an expanding sea of degraded lands. They are managed for static sets of characteristics, isolating the natural components and processes, both spatially and in time. Just as real islands lose their native diversity of life, even national parks like Grand Canyon have lost native animals, including at least seven vertebrate species. One part of the solution is to create more and larger safe havens such as wilderness, national parks and national monuments, but other, supplemental efforts are needed. While safe havens, or protected core areas, provide critical components for preserving wild nature, many native species inhabiting core areas require additional natural connections and dynamics that can be provided only through connectivity. Safe passages are needed for wildlife migration and for plant and animal dispersal and evolution. Ultimately, to deliver the Grand Canyon region's remarkable array of wild nature to future generations, with all their intimacy and magnificence, with their full compliment of species and ecological functions, is the challenge we collectively share.

EVALUATE TREATMENTS TO REDUCE HAZARDOUS FINE FUELS CREATED BY NON-NATIVE PLANTS IN ZION CANYON

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Annual plant invasions have altered plant communities, fuel-bed characteristics, and fire regimes throughout western North America. This shift results in a serious hazardous fuel condition and is a foremost management concern at Zion National Park, where the entire Zion Canyon is currently dominated by a dense growth of exotic grasses. Effective management tools have not yet been identified that can simultaneously control exotic plants, re-establish native plants, and help restore historical fuel conditions and fire regimes. This proposed project will experimentally evaluate a series of treatments to achieve these management objectives, and establish a demonstration site at Zion National Park where the results can continue to be evaluated and observed into the future. Information gained from this project will be integrated back into the process of land management planning. Initiated in July 2005, the project study design, preparatory planning and objectives will be presented.

GRASSLAND HABITAT RESTORATION IN NORTHERN ARIZONA

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Historical management practices and recurring drought have left many northern Arizona grasslands in poor ecological condition, typified by the loss of native grasses, forbs, and shrubs, encroachment of juniper and other woody species, and the spread of invasive weeds. Many of these areas also contain large amounts of woody debris from tree removal efforts undertaken decades ago. Collectively, these changes have adversely impacted the ecological function of grasslands, which has resulted in declines in wildlife such as pronghorn, burrowing owls, and other grassland obligate species. In 2003, the Arizona Game and Fish Department initiated trials of restoration treatments on the Raymond Wildlife Area and adjacent lands managed by the Diablo Trust, Arizona State Land Department, and U.S. Forest Service. Treatments included removal of live and dead trees by chainsaw crews, anchor chaining, hydraulic shears, a tree chipper, or front end loader, followed by lopping and scattering or burning of slash piles. Treatments ranged in cost from $30-$100/acre, successfully met objectives for removal of encroaching trees and woody debris, and appear to have facilitated pronghorn movement into previously unused areas. The next phase of restoration will focus on reestablishing native grasses, forbs, and shrubs that provide forage and cover for wildlife, but have been depleted or lost from many areas. Restoring these habitat components and associated ecosystem function is a significant challenge that will require: 1) obtaining large quantities of seed from locally adapted native plants, 2) developing successful seeding techniques in an environment subject to recurrent drought and dominance by invasive species, 3) applying treatments within activity constraints imposed by cultural and other resources on federal lands, and 4) managing utilization by domestic and wild ungulates to ensure establishment and persistence of highly palatable forage plants. Developing new partnerships with land managers and researchers on the Colorado Plateau is an important part of this effort.

INTEGRATED SPATIAL MODELS INFORM LANDSCAPE-LEVEL PLANNING FOR FOREST RESTORATION AND TREATMENTS

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Increasingly, models of forested ecosystem attributes are being used to identify important areas for management and conservation. However, these models can be difficult to integrate with a formal decision-making process and are not typically constructed at the broad scales over which management actions should occur. Efforts to manage and conserve southwestern landscapes will be most effective when sound science guides the decision-making process in a spatially-explicit framework. To facilitate such efforts, the Forest Ecosystem Restoration Analysis (ForestERA) project has developed empirically-based models and tools framed within a spatial decision support system for predicting and comparing the impacts of alternative forest management strategies on forest structure, fire hazard, wildlife, invasive plants, and watersheds. For example, when implemented within our prioritization tool, our fire risk layer, which quantifies regional factors influencing patterns of large fire ignition, can improve our ability to target areas for resource protection and manage fire risk at the landscape scale. We present results that demonstrate the utility of our approach in a collaborative planning process

DROUGHT INDUCED IMPACTS ON VEGETATION DYNAMICS OF THE COLORADO PLATEAU: DERIVED FROM SATELLITE-BASED MODIS VEGETATION INDEX OBSERVATIONS

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The Colorado Plateau is a region that is particularly vulnerable to drought episodes with lasting impacts on vegetation communities and wildlife. The most recent drought has plagued this region with widespread impacts on the landscape, most notably through wildfires, an acute shortage of water, and plant mortality. Droughts are usually associated with a series of ecological events, ranging from increased fire hazard, amplified tree sensitivity to disease, alteration of the vegetation cover dynamics, loss of species diversity, reduced green biomass, and profound vegetation temporal behavior disturbances and eventually extensive landscape restructure. Although much work has focused on the hydrological implications of these droughts, the large-scale impact on vegetation distribution and phenology is less well studied. Whereas much of the drought induced events are beyond our preventative capabilities, some are actually manageable, and with early intervention and planning can be mitigated. By offering a dependable and fast method to collect spatial information the land surface characteristics, and vegetation in particular, remote sensing can augment our abilities to foresee the progress of these droughts on the regional scale, and in doing so enables regional planner prepare (fire prevention, vulnerable region identification, grazing management) for these reoccurring events and assess the extent of their impacts. In this study we used the 5+ years of continuous satellite-based vegetation index and land cover time series records to assess spatial and temporal patterns in vegetation cover dynamics. Data from the highly calibrated and precisely geolocated Moderate Resolution Imaging Spectroradiometer (MODIS) from the Terra platform was used in conjunction with a phenology parameter extraction algorithm to analyze vegetation temporal patterns and inter-annual anomalies. Our results indicate significant changes to the phenological behavior of vegetation are taking place over much of the area and that these changes are elevation and land cover dependent. Drought impact was also dependent on vegetation physiognomy with deeper-rooted vegetation less affected through the five years. These anomalies also show strong correlation with the Palmer drought index for the same period.

PREDICTING ALIEN PLANT DISTRIBUTIONS IN NATURAL LANDSCAPES FOLLOWING DISTURBANCE REMOVAL

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Grazing in natural areas has played a large role in the anthropogenic disturbance on the Colorado Plateau. Livestock presence has also come at great ecological costs to biodiversity and ecosystem functions, facilitating the spread of many introduced plant species. The severe impact of cattle grazing on one of the most biologically opulent areas of North America has led federal agencies to confront the issue by mandating stricter management and in some cases, by phasing-out grazing altogether. Many western parks including Capitol Reef National Park and Glen Canyon Recreation Area have taken such measures. Yet, the results of these measures in terms of recovery have yet to be determined. This study looks at Santa Rosa Island of Channel Islands National Park, where cattle were removed in 1998 following 150 years of grazing and biological invasions, to identify plant community responses and to determine if elimination of the disturbance regime would affect alien plant 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. The distribution results were then transferred to an MS Access database and Arc View file for spatial mapping and query-running. Through the use of these 1998-1999 alien plant distribution and abundance mappings paired with life history traits for high priority alien plants, target weed species were placed into prediction guilds of (1) decreasers; (2) persisters; and (3) increasers. These predictions were tested in summer 2005 by revisiting the same sites mapped in 1998-1999 and using the same methodology to determine if abundances of these target species have changed since cattle removal. The results of this study will provide site- and species specific ecological knowledge for an island-wise resource management plan and will help elucidate relationships between disturbance removal and invasive plant responses for natural areas within the Colorado Plateau.

INVESTIGATING EFFECTS OF THE NOVEMBER 2004 HIGH-FLOW RELEASE FROM GLEN CANYON DAM ON AEOLIAN SAND-TRANSPORT RATES IN THE COLORADO RIVER CORRIDOR, GRAND CANYON, ARIZONA

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In November, 2004, a 60-hour experimental flood release from Glen Canyon Dam held the Colorado River flow through Grand Canyon, Arizona, above 1160 m3 s-1 (41,000 ft3 s-1). This high-flow experiment was designed to rebuild fluvial sand deposits, restoring a component of the ecosystem that had declined since closure of the dam in 1963. Transport and deposition of aeolian sand has important implications for archaeological resources in the river corridor, many of which are located in and covered by aeolian deposits. This study presents aeolian sediment-transport data collected in the river corridor during the year before and in the months after the flood experiment. At each of the six study locations, substantial new deposition of fluvial sand occurred as a result of the 2004 flood, which temporarily increased the amount of sand available for aeolian entrainment. However, high daily fluctuations (142-566 m3/s; 5,000-20,000 ft3/s) of the river flow from January to March 2005 removed much of the new sand before the start of the 2005 windy season. The greatest potential for aeolian re-distribution of flood-deposited sand occurred during the April-May windy season, during which the highest measured winds can locally exceed 25 m s-1, with sand-transport rates ~5 kg cm-1 day-1. These data may be used to guide decisions regarding future experimental floods and subsequent flow schedules, if maximizing sand redistribution by wind is a management objective.

BIOLOGY OF STREAM CAVES IN GRAND CANYON NATIONAL PARK

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Most of the large cave systems in the Grand Canyon are in the Redwall and Muav formations. Although the caves were formed within these thick limestone layers by dissolution by water, the majority of them are now dry. Some of the Grand Canyon cave systems that still have active streams include Vasey's Paradise, Roaring Springs, Thunder River, and Tapeats Caves. The biology of caves in the Grand Canyon is relatively poorly-studied, and the stream caves are perhaps even less well-known. In this presentation, I review what is known of stream caves and their biology and ecology in the Grand Canyon region. I focus on the Roaring Springs cave system, with notes on other stream caves, as available. Although the fauna of these caves is relatively depauperate, they support a variety of endemic species. Peculiar aspects of their ecology are just beginning to be explored.

DECLINE OF NORTHERN LEOPARD FROGS (*RANA PIPIENS*) ON THE SOUTHERN COLORADO PLATEAU

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The Colorado River and its major tributaries once provided more or less continuous habitat for northern leopard frogs (*Rana pipiens*) and other amphibian species. Historic surveys found leopard frogs to be widespread both along the main course of the river and in perennial side canyon areas. Subsequent fragmentation of populations in the Glen Canyon region has resulted from the construction of Glen Canyon Dam. With the filling of the Lake Powell reservoir, leopard frog populations along the mainstem river have nearly all disappeared. While populations persist in some side canyon areas, these populations now appear to be largely or completely isolated from one another. In the Grand Canyon region, the last records of northern leopard frogs date from the 1990's, and recent extensive surveys have found no remaining populations.

Genetic analyses of leopard frog populations in the region reveal that regional diversity is high, but individual populations show pronounced population structure. This indicates that there is little gene flow, and populations are sharply isolated. These patterns suggest that direct management efforts may be required to prevent further loss of subpopulations. Such management efforts might include a) a translocation program to enhance population diversity, or prevent loss of local genetic diversity, and b) habitat restoration measures to sustain larger populations in particular areas.

CONSEQUENCES OF THE INVASION OF EXOTIC SALTCEDAR: AN ARTHROPOD PERSPECTIVE

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A common perception associated with the invasion of exotic plant species is a depauperate or negatively altered arthropod community. Arthropods serve many vital ecosystem functions, and are important in their role as a vertebrate food resource. However, the impact of exotic species on arthropod communities is too infrequently examined. We studied the effects invasive saltcedar has had on altered riparian systems historically dominated by cottonwoods and willows in the American Southwest at Roosevelt Lake in central Arizona. In 2002 and 2003, we quantified the arthropod communities in three different habitats dominated by native willow, exotic saltcedar, and those habitats with a mosaic of native and exotic vegetation. We discovered three major patterns: (1) a large difference between years in terms of total arthropod biomass and arthropod species richness presumably due to the impact of a millennial level drought in 2002. (2) In 2003, the year with more normal precipitation, there was no difference in total arthropod biomass by habitat, but significantly higher species richness in mixed habitats, during the 2002 drought there was no difference in species richness, while native habitat had the greatest total arthropod biomass. (3) Each riparian habitat supported a different arthropod community at different sampling periods, but there were no arthropod groups that were consistently associated with any habitat. The overall pattern that emerged among the three habitats was that each supported a diverse, though different, arthropod community that changed between and within years, and no habitat was clearly superior in terms of arthropod diversity and biomass. To understand whether the arthropod community differences by habitat may affect an obligate riparian insectivore, the Southwestern Willow Flycatcher, we examined the flycatcher's diet. We found that the flycatcher's diet also varied by habitat, but that it consumed a wide variety of prey items in all habitats, and showed no differences in adult survival or breeding productivity among habitats, metrics that in part rely on the adequacy of food resources. We concluded that the invasion of exotic saltcedar at Roosevelt Lake has had little impact of either riparian arthropod diversity or biomass. We hypothesize that the relatively close proximity of the different riparian habitats at Roosevelt Lake and the surrounding Sonoran Desert Upland may have contributed to the over biomass and diversity of the arthropod community, yet this hypothesis remains to be tested.

AN EVALUATION OF STATE-SPONSORED PROPERTY TAX INCENTIVE PROGRAMS FOR PRIVATE FOREST LANDOWNERS IN THE WESTERN UNITED STATES

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State and local governments have seen dramatic increases in demand for services while at the same time experiencing dramatic decreases in budgets to provide and deliver the services a growing public demands. As it relates to private forest landowners and private forest management, several states offer property tax incentives (forest-agricultural tax designations) to encourage a variety of forest conservation practices and also to limit the conversion of the forested property to other uses that increased tax burden can bring about. In addition, many small logging and wood products businesses may rely substantially on the access to raw material and the opportunity to conduct forest management treatments that the tax incentive programs provide. However, under increasing budgetary pressure, local governments have begun to criticize such agricultural property tax designations of forested property and the reduction in tax revenues that result. Increased criticisms can be expected on eligibility requirements, compliance, and monitoring, as local governments try to maintain tax revenues. However, it is likely that reduced tax revenues may be partially or fully offset by the conduction of forest management activities required as a condition of eligibility in forest tax incentive programs. Activities that contribute revenues and receipts to local governments include the purchase, sale, transportation, and manufacture of wood products. In order for states to fully communicate the benefits of such tax incentive programs to local governments faced with reduced tax revenues, information on economic activity and revenues being generated must be compiled and collected to make informed decisions as to the true value of such state-sponsored tax incentive programs. This investigation will survey and review the existence, eligibility requirements, and compliance measures currently in place for state sponsored property tax incentives in the western United States as a basis for a more thorough review of an individual state's forest tax incentive program.

LAND STEWARDSHIP AND THE GAP ANALYSIS

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A primary goal of the U.S. Geological Survey's Gap Analysis Program is to provide an assessment of the conservation status for key elements of the landscape. The map of land stewardship provides a representation of the existing network of conservation lands and is a fundamental data layer in the final SWReGAP product. The stewardship data layer consists of the categorization of the individual land parcels into conservation status codes driven by existing agency management plans. The status codes are contingent on the permanency of conservation efforts, types of anthropogenic activities, and overall guiding principles of natural resource management. GAP combines the conservation status codes with geographic boundaries that represent land ownership and management. This layer distinguishes individual parcels with differing levels of management protection. This information is the foundation for other SWReGAP analysis and products, and provides a tool for land stewards to make informed conservation decisions about management practices regarding biodiversity.

CULTURAL RESOURCES IN THE COLORADO RIVER CORRIDOR

FAIRLEY, HELEN

This talk describes research, monitoring, and mitigation activities during the past 15 yr that have evaluated and addressed ongoing impacts to cultural resources in the Colorado River corridor because of dam operations and other agents of deterioration, such as visitation and rainfall-induced erosion. The presentation begins with a summary of research and inventory activities prior to the early 1990s, which is followed by a summary of the monitoring and research activities initiated in response to the Operation of Glen Canyon Dam Final Environmental Impact Statement (EIS) and the Secretary of the Interior's Record of Decision (ROD). The session ends with some potential strategies for the future.

SELECTING SAMPLE LOCATIONS FOR NATURAL AMBIENT SOUND CHARACTERIZATION IN A DIFFICULT ENVIRONMENT

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The 1987 Overflights Act mandated that Grand Canyon National Park (GCNP) substantially restore natural quiet to the Park. In 1994, the NPS defined "substantial restoration of natural quiet" to mean that 50% or more of the Park has no aircraft audible for 75 to 100% of the day, each and every day. To determine aircraft audibility, the natural ambient sound levels must be measured and quantified as a baseline. Natural ambient sounds vary by vegetation type, elevation, and terrain features. Different habitats are utilized by different species of birds, insects, and other wildlife, which in turn have different sounds associated with them. Natural sounds are also produced by physical processes of the environment, such as flowing water, wind, snow, and rain. Characterizing the GCNP natural ambient sound levels began by selecting an appropriate vegetation map and classification scheme. Striking a balance between over and under representing the key vegetation types is important. Too many classes results in an enormous field data collection effort and prohibitive cost of data collection. Too few classes will not allow the separation of significantly different natural ambient sound levels between vegetative communities. The objective of this paper is to provide information on the methods and materials used to select representative vegetation classes and sample sites in GCNP that characterize the natural ambient sound levels of the Park.

FIRE HISTORY IN PIÑON-JUNIPER WOODLANDS, KAIPAROWITS PLATEAU, GLEN CANYON NATIONAL RECREATION AREA

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Navajo Point, the southeastern tip of the Kaiparowits Plateau, is ringed by Navajo Sandstone and cut by numerous small canyons. We investigated the fire history of *Pinus edulis-Juniperus osteosperma* (piñon-juniper) woodlands. Dendrochonological and surface fuel analyses of 24 stands identified three woodland types, (1) old-growth, characterized by large (dbh up to 90 cm) piñon trees which were >500 years old and presumably older junipers, (2) stands with maximum ages between 200 and 500 years, and (3) stands with maximum ages < 200 years. Supervised classifications of DOQ and Landsat TM imagery were performed using textural and spectral characteristics to delineate canopy differences between historic burns and unburned landscapes within these three categories. Helicopter surveys and eight 1-km line intercept samples further refined the relative areas of each type, which was in turn used to determine the fire cycle. A fire cycle of approximately 350 year rotation was calculated for the entire study area; however, in the northern potions, fires are stand-replacing and cover many hectares, and in the southern portion ample evidence of charcoal, juniper stags, and sagebrush occur in an anastomosing pattern such that a network of old-growth is interspersed with small stand-replacing fires. The fire pattern in the southern portion is unlike other old-growth stands on the Colorado Plateau and may result from (1) a gradient of soil depth, becoming shallow and sandy in south, supporting relatively light surface and canopy fuels, (2) topographic factors that prevent fire spread in southern portions of the plateau, and (3) the influence of climatic patterns.

RECREATIONAL IMPACTS RELATED TO THE IMPLEMENTATION OF A TRANSPORTATION SYSTEM: A CASE STUDY OF ZION NATIONAL PARK

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In May, 2000, Zion National Park implemented a component of their transportation plan which closed Zion Canyon Road to private vehicles and allowed access to Zion Canyon only by shuttle buses. A question arose within the Park as to the impact of closing Zion Canyon Road on the pull-outs and their adjacent lands on another park road, which would remain open to private vehicles, the Zion-Mt. Carmel Road. Just prior to the official closing of Zion Canyon road, a recreation impact inventory of pull-outs and their adjacent lands was completed along the Zion-Mt. Carmel Road. The initial inventory of 2000 set the baseline data for recreational impacts along the road and was then followed by replications in 2002 and 2004. All three inventories used the same site variables and included GPS coordinates and digital images. Site variables were developed which related to recreation impacts of the pull-outs and related to recreation impacts of lands adjacent to the pull-outs. Beyond basic parameters of surface, length, width, and creep, the inventory collected data on litter, vegetative damage, bank impacts, and cryptobiotic impacts. Adjacent land variables included evidence of recreational activities (trails, campsites, etc.), presence of barren cores related to use, fires, litter, human waste, pet waste, vegetative damage, and others. Over the course of three inventories (2000, 2002, 2004), it was found that impacts had increased on the pull-outs. For example, formal (paved) pull-outs increased by 12.5%; pull-out length increased by 5.1 feet; and pull-out width increased by 11-20 feet in 10% of the cases. In addition, there were increases in litter, human sanitary waste, and vegetative damage directly associated with the pull-out. Beyond the pull-outs, the adjacent lands associated with the pull-outs also felt the increase in recreational impacts. The number of trails, day use sites, streambed access points, and barren cores areas increased over the 5 years of the project. In addition, there were increased recreational impacts on the lands adjacent to the pull-outs, such as litter, human sanitary waste, vegetative damage, rock impacts, pet impacts, and graffiti. The results of this study indicate that as parks implement closures on park roads and divert private vehicle access to other roads within the park, the incident of recreational impacts along the diversion road may, indeed, increase. While the benefits of the closure of Zion Canyon Road to private vehicles have been significant, the potential for impacting another area based on the closure should not be discounted or forgotten. As with all managerial decisions, there are trade-offs inherent to each available option. The results of this study encourage site managers to consider the recreational impacts of shifting use patterns from one resource area to another and the impacts associated with that shifting.

ARIZONA'S STATE LAND REFORM INITIATIVE

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The Arizona constitution limits the state's ability to plan and dispose of state lands in a way that directs development to the most suitable areas and conserves ecologically important lands. The Arizona State Land Reform Initiative would provide tools and processes to balance growth and conservation. It would permanently conserve 260,000 acres of some of the most important natural areas in Arizona, create an educational reserve of 73,000 acres and allow an additional 360,000 acres to be purchased for conservation by cities, towns, or nonprofits. The initiative also requires the state land department to cooperate with local communities for planning and conservation, and ensure essential classroom funding. As one of the key players in the process, I will describe the history of the initiative, how the current initiative differs from the 2004 version, how ranchers, real estate developers, conservation groups, and school advocates shaped various versions of the initiative, and which groups are on-board now.

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

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Current management practices on many National Forests in the southwest call for raking the deep litter and duff accumulation away from the base of mature ponderosa pine (Pinus ponderosa) trees before prescribed burns to reduce their mortality. These mitigation efforts are intended to compensate for 100 years of fire suppression that allowed deep litter and duff to accumulate on the forest floor. In spite of the common perception that these efforts will enhance survival of old growth trees, there are few published findings that address whether this practice does, in fact, lead to higher survival of mature ponderosa pine trees following fire. In previous work on the Coconino National Forest, Sally Haase has found that leaf blowers cause less damage to root collar bark, cambium, and lateral roots and that removal to 9" lowers cambial heating to less than lethal temperatures. Yet, these mitigation efforts may actually cause mortality by exposing lateral roots, are very labor intensive, and there is not an agreed upon technique or distance for removing the litter and duff. We have identified five areas across northern Arizona that will be burned in the fall of 2005. On each area, we permanently marked 60 trees within the burn area and 60 similar trees in an adjacent unburned area. All trees measure at least 18" in diameter at breast height and have at least 4" of accumulated litter at the base. One of four treatments was randomly assigned to each tree: raking litter to a distance of 9", raking to a distance of 36", leaf blowing to a distance of 9", and no litter removal. The effectiveness of these treatments will be measured by testing for live cambium within the first year post burn, by measuring a subsample of cambial temperatures during the fire, and by tree mortality 3 years post burn. Studies such as this that control, to the extent possible, other confounding factors that might also contribute to mortality of old trees, are needed to examine whether removing litter and duff actually decreases mortality, and if so, what technique and what distance is the most effective.

EXOTIC PLANT SPECIES RICHNESS AT TWO PONDEROSA PINE SITES IN NORTHERN ARIZONA.

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A floristic survey of two 2200 acre ponderosa pine (Pinus ponderosa) sites was conducted from 2002-2005. The Kendrick site was 25 miles northwest of Flagstaff in the Kaibab National Forest, and the IMAX site was 50 miles southeast of Flagstaff in the Coconino National Forest. A total of 249 vascular plant species were found; 10% of those species (n=26) were exotic to Northern Arizona. Thirteen percent of the vascular plants at the Kendrick site were exotic (22 exotic, 169 total) and the IMAX site was 12% exotic species (19 exotic, 163 total). Eleven of the 26 exotic species are cool season grasses and forbs that were intentionally introduced to increase forage quality for livestock and to revegetate disturbed sites such as roadsides, log landings, and after wildfires. This list includes species such as Bromus inermis, Poa pratensis, Elymus hispidus, Agropyron pectiniforme, and Melilotus officinale. The remaining 15 species were probably accidental introductions, and included Cirsium vulgare, Polygonum aviculare, Bromus tectorum, B. japonicus, and Convolvulus arvensis.

HANGING GARDEN VEGETATION ASSOCIATIONS

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Hanging gardens are island-like habitats dominated by mesophytic-hydrophytic plant communities, growing on seeps on the xeric canyon walls of the Colorado Plateau in the American West. We measured the abundance of vascular plant species on 73 individual hanging gardens during the growing seasons of 1991-1993. Cluster analysis of a simplified Morisita community similarity index matrix produced four distinct clusters of associated herbaceous vegetation: Adiantum capillus-veneris, Aquilegia micrantha, Calamagrostis scopulorum, and Cirsium rydbergii Herbaceous Vegetation Associations. These associations are based on species abundance and are floristically described via stand tables showing dominance, constancy, and presence of hanging-garden endemic species. Two associations were dominated by species endemic to hanging gardens: Aquilegia micrantha and Cirsium rydbergii. These four hanging garden associations contrast with previous local vegetation surveys which place all hanging garden communities into one vegetation type despite the lack of a common dominant or constant species.

PUMA ECOLOGY AND MOVEMENTS IN THE GRAND CANYON REGION

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Although pumas are present throughout Grand Canyon National Park, little is known about their movements and ecology in the Park and adjacent areas. We present initial data from a puma capture and monitoring study in Grand Canyon National Park in northern Arizona. We document movement patterns of pumas using portions of the National Park and adjacent public lands. The objectives of this study are: to examine puma movements and habitat use in a highly variable topographic landscape, to document puma use of areas of high human activity, and to document puma prey selection. To date four male and three female pumas have been collared and monitored in and around the South Rim of the Grand Canyon. Pumas are tracked daily via GPS and VHF transmitters and their movements are mapped using GIS. Results will be applied toward Park planning, land protection, and management in the Grand Canyon eco-region. Information from this study will be incorporated into Park education and outreach programs to increase public understanding of puma ecology and movements.

A BRIEF HISTORY OF SOUTHWEST CLIMATE CHANGES AND A GLIMPSE AT THE FUTURE

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It is well documented that the climate of the Southwest exhibits high interannual variability, in addition to pronounced multi-decadal variability. Interannual precipitation variability is chiefly related to the El Niño-Southern Oscillation, whereas multidecadal precipitation variability is related to decade-scale ocean variability in the Pacific and Atlantic basins. Millennial-length tree-ring reconstructions of drought and precipitation show extensive Southwest drought in virtually every century, with exceptional severe sustained droughts in the mid-1100s, 1200s, late 1500s, 1700s and mid-20th century. These reconstructions also show periods of rapid shifts from dry to wet regimes; investigators have related these variations to ecological disturbance in Southwest forests. Moreover, reconstructions of drought, precipitation and temperature show a tendency for higher aridity to be associated with elevated temperatures. The last point is now of special concern, given the evidence of temperature increase-driven climate change in the Arctic and at high altitudes; these changes are well associated with climate model predictions. Evidence from the instrumental record of temperature, precipitation, snow, and streamflow shows trends, as well as interannual and multi-decadal changes, in western North America, including the Colorado Plateau. Manifestations of trend-related changes in the Southwest, which may be related to anthropogenic climate change, are tendencies toward increasing minimum temperatures, earlier snowmelt

and less substantial snowpack. This presentation examines the evidence for past and present climate changes in the Southwest, and discusses projected climate changes and their implications for water supply and ecosystem change.

A TALE OF TWO DROUGHTS: CHANGING TEMPERATURES & SOUTHWESTERN DROUGHTS

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In 2004, CLIMAS initiated a multidisciplinary investigation of regional vulnerability to climate variability and change in northeastern Arizona and northwestern New Mexico. The region has been affected by fire and drought and area stakeholders expressed interest in information about the climate history of the region. This study compares the underlying climate of the 1947-1956 drought with that of the 1999-2004 drought. During winter, the 1999-2004 drought exhibited warmer minimum and maximum temperatures. Although both droughts had below average winter precipitation, 1999-2004 snowpack was consistently lower. During summer, minimum temperatures were warmer in 1999-2004, whereas maximum temperatures were similar in both periods. Below average summer precipitation was more persistent in 1947-1956. Sea surface temperature and ocean/air circulation patterns probably are not sufficient to explain differences in temperature. If temperatures continue to increase, enhanced drought effects could have profound regional economic and social impacts as a significant portion of the economy is dependent on the ski industry, tourism, and forestry.

AN OVERVIEW OF THE ARIZONA CAVE SURVEY

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Historically, most Arizona caves have been successfully managed with a hands-off approach of secrecy and limited access. With the advent of GPS technology, increasing human populations, easy to use computer databases, and Internet information distribution, this secrecy based resource management philosophy has become ineffective. As cave location information becomes more widespread, there will be increasing pressures on this unique and limited resource. New and proactive management plans will be needed to manage the caves and their important biological, archaeological, paleontological, historical and geological resources. The first step to manage a resource is to determine what the resource consists of. The primary goal of the Arizona Cave Survey (ACS) is to gather all information about caves in the state of Arizona. A great deal of information already exists, but due to the historical secrecy ethic, much of the data is not available to qualified researchers and land managers. Through extensive literature searches, caver and land manager communications, and on-site fieldwork, the ACS has compiled a great deal of cave data. Due to the sensitive nature of this information, the ACS will only release information to qualified researchers and the actual land managers of specific caves. The compiled cave data consists of a master database of nearly 1,000 Arizona Caves, a computer based GIS location plot, a collection of cave maps, digital and hard-copy files on each cave, and a library of Arizona cave literature. The Arizona Cave Survey is an on-going project, and as the cave data grows so will the capability to care for this unique resource.

PATTERNS OF DROUGHT MORTALITY IN A DOMINANT RIPARIAN TREE

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This study quantifies patterns of drought mortality for two species of cottonwood trees (narrowleaf cottonwood, *Populus angustifolia,* and Fremont cottonwood, *P. fremontii*) and their first-generation (F_1) hybrid offspring. Stand dieback was sampled at 46 sites on the Colorado Plateau and 20 sites in four parallel drainages of the Mogollon Rim in 2003. In 2004, three rivers with intact zones of each crosstype were sampled to assess within-river patterns. Hybrid trees performed best both years, demonstrating consistently low mortality and the ability to produce new saplings during drought. Narrowleaf and Fremont cottonwood mortality showed high variability between river systems, suggesting greater sensitivity to localized factors. Narrowleaf cottonwood mortality increased in saline soils and Fremont cottonwood mortality increased in areas of high tamarisk (*Tamarix sp.*) cover. Fremont cottonwood stands on the Colorado Plateau are far more likely to harbor invasive species than narrowleaf cottonwood or hybrid stands, and changes in the abundance and distributions of different cottonwood crosstypes can be expected if environmental stress continues. The effects of invasive plant removal on tree growth is being investigated, to determine whether current restoration practices are benefitting native riparian trees.

SELECTING CONSERVATION LANDS FOR ARIZONA'S STATE TRUST LAND REFORM INITIATIVE

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The initiative to reform the near century old state trust land laws includes provisions to conserve nearly 700,000 of the 9.3 million acres of state trust land. Three classes of conservation reserve land would be created – permanent, education, and provisional. The lands were selected based on their ecologic, recreation, and open space values through a negotiation process that involved conservation, education, development, and cattle grower interests. Many of these lands contribute to conservation of important aquifers and rivers, wildlife corridors, and native grasslands. This initiative directs development away from these lands to more suitable areas.

ANT COMMUNITIES OF THE COLORADO PLATEAU AND GREAT BASIN: COMPARISONS OF STRUCTURE IN SPACE AND TIME USING GENUS AND FUNCTIONAL GROUP CLASSIFICATIONS

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Ants can be important ecosystem drivers, and community dynamics of ants can influence and be influenced by disturbances and environmental stress. Ants were collected with pitfall traps from two sites in the Grand Staircase-Escalante National Monument (GSENM) Utah, three sites in Canyonlands National Park (CANY), Utah, and four upland shrub-steppe sites, two in southern Utah and two in southeastern Oregon. The GSENM sites were sampled in spring and late summer from 2000 through 2003, both sites had been grazed prior to November 1998, one site was closed to grazing in November 1998. The CANY sites, sampled from 2000 to 2003 in June and September, were in Salt Creek Canyon, one was along a 4WD road, one along a section of the road that was closed in July 1998; the third site had not had vehicles near it for at least 40 years. The upland sites were trapped once each year, in 2000 and 2001, in spring, and were centered around livestock watering sources; ants were sampled at 5 (in 2000) or 6 (2001) distances from the water sources. Traps were open for four days each session, sites varied in number of times traps were opened each year. Specimens were identified to genus and assigned to functional groups. The alluvial bench sites in Grand Staircase-Escalante National Monument and riparian sites in Canyonlands each had 13 genera represented, upland Utah sites had a total of 11 genera, while only nine genera were trapped in Oregon upland sites. Proportional representation of genera and functional groups varied among sites and over time within sites. Differences in community structure resulted from latitude, landscape position, year, season and disturbance regime. Implications for using ants to monitor ecosystem condition will be discussed.

COMPARISON OF ORTHOPTERA COMMUNITIES IN SALT CREEK, CANYONLANDS NATIONAL PARK: FLUCTUATIONS OVER TIME IN OPEN-, CLOSED-, AND NO-ROAD PARTS OF THE CANYON

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Salt Creek, Canyonlands National Park, is an interrupted stream with more aquatic and mesic riparian habitat than any canyon in the park except the Green and Colorado Rivers. Salt Creek was used by vehicles for at least 50 years; in 1998, 14 km of the road was closed by a Federal judge, providing an opportunity to track recovery of the riparian ecosystems after decades of vehicle disturbance. We began to describe and compare invertebrate communities in the open-, closed-, and no-road segments of the caZon in 2000. Here we report on the Orthoptera from one site in each segment, sampled in June and September 2000-2003, to determine whether there were consistent patterns among the Orthoptera related to either disturbance history or the intensifying drought that occurred during the study. It was hypothesized that over the years the closed road site would more closely resemble the no road site. Results show that the closed road site more closely resembles the open road site. Abundance of Gryllus species showed the greatest differences between caZon segments; other taxa show trends as well, but total numbers are small. Differences between the no-road samples and open- and closed-road samples are due at least in part to inherent differences in the character of the caZon upstream (no-road) and downstream (open- and closed-road). Lack of difference between open- and closed-road sites may be due to slow recovery because of drought conditions experienced during the years of sample collection.

WOODPECKER RESPONSE TO PRESCRIBED FIRE IN SOUTHWESTERN PONDEROSA PINE FORESTS

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Prescribed fire as a method of forest restoration and fuels reduction is an increasingly utilized technique in southwestern ponderosa pine forests. However, little is known about the effects of these treatments on wildlife communities. In a landscape-scale experiment, we examined the numerical response of two woodpecker species to prescribed fire treatments on four National Forest sites in Arizona and New Mexico. We used four years of pre- and post-treatment data to detect changes in woodpecker abundance and occupancy. We found that after the implementation of prescribed fire there was an increase in the number and spatial use of individuals detected on treatment units, and

that these responses could be tied to burn severity. Our results suggest that the short-term response of woodpeckers to prescribed fire could serve as an indicator of forest health, and as such could influence management decisions regarding prescribed fire.

THE RELATIVE EFFECTS OF FLOW DIVERSION AND NONNATIVE INVASIVE FISH ON THE NATIVE FISH COMMUNITY OF FOSSIL CREEK.

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Fossil Creek provides an excellent site to study the relative effects of physical and biotic habitat modification on native fish communities. Water releases through the streambed have been regulated by a hydropower project for >90 years and create a unique gradient of water quality and stream morphology characteristics along the stream. Additionally, nonnative, green sunfish and smallmouth bass have actively invaded the stream until management actions in late 2004. We studied the native and nonnative fish community composition at 14 sites in Fossil Creek to look at patterns of distribution. At seven of these sites we correlated physical habitat parameters (discharge, depth, travertine deposition, water chemistry and temperature) with community composition to see which physical habitat variables were responsible for structuring fish communities. Additionally, we studied the trophic structure of the fish community using stable isotopes (^{13}C and ^{15}N) at three sites to look at the relative effects of hydrology and nonnative fish on food web structure. The distribution of both communities was primarily a function of distinct waterfall barriers in the stream and not water quality or other habitat variables. Nonnative fish increased in relative abundance and species richness in a gradient downstream from Fossil Springs to the Verde River. Biotic interactions with nonnative species affected native communities. Abundance of native fish (especially small-bodied fish declined with increasing relative abundance of nonnatives. Stable isotopes analysis indicated that native fishes were top predators in portions of the stream without nonnative fish, feeding mainly on invertebrates. However, in the presence of nonnatives, trophic position of natives was lower, and diet was restricted to a smaller portion of available invertebrate taxa. Our findings indicate that nonnative taxa were having a larger effect on native fish communities in Fossil Creek than stream water diversion. While, restoration of flows will help restore ecosystem processes within the stream, management and removal of nonnative taxa are a necessary part of the restoration process in this stream.

RECREATION MONITORING ON FOSSIL CREEK

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Recreation use and users of Fossil Creek in northern Arizona were studied to gather baseline data as part of a long-term monitoring effort to document changes in recreation use and users following removal of the Fossil Creek Dam and reintroduction of full flows. The monitoring program included two projects: 1) a visitor survey to gather information on visitor demographics, activities, experiences realized, reasons for visiting, responses to proposed recreation management strategies, and their interest in environmental stewardship and 2) a campsite impact and monitoring effort begun by the Forest Service wherein campsites and other use concentration areas were mapped and permanent resource condition monitoring plots established. A combination on-site and mail-back survey was used to gather information from Fossil Creek visitors between August and December 2004. A total of 170 completed questionnaires were obtained. Results showed that Fossil Creek visitors were primarily from Arizona, the Phoenix area in particular. The most important reasons identified for visiting included viewing the scenery, enjoying nature, seeing Fossil Creek, and getting away from life's demands. Popular activities included sightseeing, walking, swimming, hiking, and wading. Visitors were generally supportive of removal of non-native fish and removal of the dam to restore full flows. Support for proposed changes in recreation management of Fossil Creek varied, with visitors showing less support for allowing only day use on the upper section of Fossil Creek but supported allowing camping only in designated dispersed sites in the middle section of Fossil Creek. The campsite impact and monitoring program was originally conducted on 41 riparian area campsites. As a result of spring flooding a number of sites were destroyed and the final number of sites inventoried was 17. Permanent sampling plots were established where vegetation cover, amount of bare ground, and species present were among the data gathered. The campsite inventory is being expanded to include sites in the pinyon-juniper benches above the creek. Both the visitor survey and the campsite inventory will continue as part of the recreation monitoring effort on Fossil Creek and will continue to be done in collaboration with the U.S. Forest Service.

VEGETATION COMMUNITIES OF SUNSET CRATER, WALNUT CANYON, AND WUPATKI NATIONAL MONUMENTS

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The vegetation of the three National Monuments east of Flagstaff - Sunset Crater, Walnut Canyon, and Wupatki - is diverse and reflects the broad geomorphic, geologic, and topographic diversity of the area. Recently the US Geologic Survey Southwest Biological Science Center, the Bureau of Reclamation Remote Sensing and GIS Group, and Nature Serve jointly completed vegetation mapping at all three park units as part of the USGS-NPS Vegetation Mapping Program. Plant communities were described using the evolving National Vegetation Classification System (NVC) and included barren, sparse, grassland, shrubland, dwarf-shrubland, steppe, woodland, and forest lifeforms. A total of 41 NVC alliances, 55 associations, eight local communities, and seven unique stands were described and mapped using 59 map labels. These projects are the first of the 19 parks in the National Park Service Southern Colorado Plateau Network to be mapped using the NVC standards for describing vegetation. Mapping and vegetation descriptions were initiated in 1999 and completed in 2004; the resulting data are currently being used for landscape management activities at the monuments. Products include a final project report and a suite of digital products including: vegetation classification descriptions, land-use classification system, vegetation classification key, digital and hard copy vegetation

map, digital project boundaries, digital field points, photos of field sites, database of field data, accuracy assessment results, and FGDC-compliant metadata.

MICROBIAL COMMUNITY CHARACTERIZATION: WHO IS DECOMPOSING LEAF LITTER IN FOSSIL CREEK?

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Previous studies of Fossil Creek suggest greater primary production rates and greater decomposition rates in the travertine dam reach than in free-flowing reaches below the diversion dam, providing more energy to support the food web in the travertine dam reach. Leaf litter is an important allochthonous energy input, both during the growing season when riparian vegetation shades the creek and after autumn leaf-fall. Using litter bags, we determined decomposition rates for two leaf species at distinct study sites along the travertine gradient. Decomposition rates varied significantly between leaf species and between travertine dam and free-flowing study sites. Differing decomposition rates may correspond with different microbial communities along the gradient. We are now characterizing the microbial communities present on leaf litter samples, targeting the bacterial, archaeal, and fungal components. We are using the Terminal Restriction Fragment Length Polymorphism (TRFLP) molecular approach to generate community profiles for each treatment. Initial results suggest that fungal community composition varies primarily with study site location, while bacterial community composition varies with leaf species. TRFLP analysis of individual clones from prepared libraries will enable us to assign tentative identities within the community profiles. Future research is planned to determine if dam decommissioning and stream recovery corresponds with alterations in microbial community structure; the current work will provide baseline data for those studies.

PROTECTING NORTHERN ARIZONA'S NATIONAL MONUMENTS: THE CHALLENGE OF TRANSPORTATION MANAGEMENT

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Transportation planning is one of the most significant challenges facing the Bureau of Land Management (BLM) and the National Park Service (NPS) as the agencies develop a management plan for the Arizona Strip Resource Area. The plan determines the direction of management, including transportation management, for the next twenty years at two monuments – Grand Canyon-Parashant and Vermilion Cliffs. The role of roads and other transportation routes for recreation and public safety access must be balanced against the responsibility to protect the area's resources – including the wildlife. A large body of scientific studies indicates that roads can have significant negative effects on wildlife species in the Arizona Strip monuments. A spatial analysis of the area was conducted to assess the potential effects that two different transportation systems are likely to have on habitat for five wildlife species – the desert tortoise, mountain lion, bighorn sheep, pronghorn, and mule deer. The transportation systems are the BLM's Route Inventory and the Conservation Route Proposal, a network supported by the Arizona conservation community. Landscape fragmentation metrics were measured for the entire landscape and within wildlife habitat boundaries for each of the route networks. A comparison of results with biological field literature describing road impacts on wildlife suggests that impacts to all five species are significant for the BLM Route Inventory. The Conservation Route Proposal presented less overall impact to wildlife, while failing to provide sufficient habitat for some of the selected species, desert tortoise in particular. Specific transportation management recommendations were crafted based on the findings. A few examples include: provide large blocks of core habitat more than a mile from a road within desert tortoise habitat, reduce road mileage in mountain lion habitat to densities less than 1 mi/mi^2, and use landscape fragmentation metrics to guide management decisions regarding transportation routes for wildlife species within the monuments.

EXPLORATORY ANALYSES OF CONTEMPORARY HUMAN ACTIVITY AT PREHISTORIC SITES IN SOUTHWEST COLORADO

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Contemporary human use of a place of prehistoric activity can alter if not destroy remains that have been assigned public value. Sites with prehistoric architectural remains are those most commonly disturbed in the area surrounding McPhee Reservoir in southwest Colorado. This study used exploratory procedures to (1) assess whether associations exist between a set of characteristics of a prehistoric site and evidence of modern activities at that place; (2) ascertain how evidence of subsurface "looting" varies with site characteristics; and (3) assess the vulnerability of sites to contemporary human activities during exposure after periods of inundation. Four categorical variables reflecting modern activities were used with five prehistoric site descriptors to describe the relationships between the remains of human activities in the past and present at 29 sites. Over half of these sites have been subjected to subsurface digging and eleven of the 32 sites examined have been subjected to inundation at some time since 1986. This study resulted in the construction of testable predictions oriented toward gaining insight into how and where contemporary visitors to the area use places of prehistoric activity. Using a small sample of sites an analytical framework was pursued that can be used with expanded data and with refined categorical variables to enhance management protection as well as further interest in contemporary recreational behavior at places on the landscape used by humans in prehistory.

DYNAMICS OF JUNIPER INVADED GRASSLANDS AND OLD-GROWTH WOODLANDS IN AND NEAR WUPATKI NATIONAL MONUMENT, NORTHERN ARIZONA, USA

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Land managers at Wupatki National Monument in northern Arizona, USA have become increasingly concerned about expansion of one-seed juniper (*Juniperus monosperma* (Engelm.) Sarg.) into the semi-arid grassland ecosystem. We quantified these trends by means of dendrochronological analysis across multiple geologic formations within and south of the Monument on the Coconino National Forest. Juniper size attributes (height, drip line, diameter at root collar) of all trees in experimental plots were measured. A root collar cross section of one tree from each of four size classes were removed from each plot for dendrochronological analysis. Tree size was then correlated to tree age, thus allowing the estimation of the age of all measured trees with minimal tree destruction. Juniper trees became established in the young juniper "savanna" stands (past grasslands) within the Monument within the last 150 years on most geologic formations, but growth and survival rates were highly variable depending on microclimate. In these past grassland areas, trees of all ages were found to be equally susceptible to wildfire-induced mortality, with an average of 58% mortality. Thus we conclude that regular, high-severity fires are necessary to repel juniper, which acts as an invasive species in the absence of fire, altering the ecological trajectory towards savanna and woodland conditions. Prescribed fire can therefore be an effective management tool for maintaining grassland and open savanna conditions. Conversely, denser, juniper and juniper-pinyon woodland stands on the adjacent National Forest appear to have been established for 700 years or more, first becoming established after the eruption of the nearby Sunset Crater and subsequent intensive Anasazi occupation of the area. Little evidence of low severity surface fires was found in these areas, though many instances of a single or small number of trees killed by a highly-localized, presumably lightning-ignited fire were observed. Therefore, it seems that the fire regime of these older juniper woodlands has not been significantly altered by fire suppression and grazing in the last 150 years. Subsequently, there is no ecologically-based motivation for thinning, prescribed fire or other high-intensity “restoration” activities and management of these stands.

PHYSICAL AND BIOLOGICAL RESTORATION OF FOSSIL CREEK, ARIZONA: SUCCESSFUL COLLABORATION ACROSS ORGANIZATIONS AND INDIVIDUALS

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Fossil Creek is a tributary to the Verde River in central Arizona. In 1999, after nearly a century of diverting Fossil Creek's flow for hydropower, Arizona Public Service (APS) committed to decommissioning two power plants and restoring full flows to the stream channel. Prior to flow restoration, biologists recognized the opportunity to restore the stream’s native fish community. Fossil Creek remains a last stronghold for native fish in the entire Gila River drainage, yet invasion of exotic species has prevented recruitment in native aquatic vertebrates, including ranid frogs. In a collaborative effort between state and federal agencies, including two national forests, universities; and many volunteers, a native fish fauna was salvaged from over 10 stream miles which included designated wilderness. Piscicide was applied to the stream and native fishes were repatriated after exotic fishes appeared to be eliminated. A barrier was constructed to prevent future invasions while simultaneously preserving wilderness values. The philosophical outcome of this project was a renewed sense of what can be accomplished when agency mandates to protect native species are supported and conflicting politics are set aside. It also instilled hope and generated excitement for other fish restoration projects in the desert Southwest that were once considered unachievable due to logistical or political constraints.

ROOSTING SITES OF SPOTTED BATS (*EUDERMA MACULATUM*) IN NORTHERN ARIZONA

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We used radiotelemetry to locate roosts of spotted bats (*Euderma maculatum*) in the Colorado River drainage, Canyon de Chelly, and other locations in northwestern Arizona from June - August, 1999 and 2005. In 1999, we attached transmitters to two male spotted bats. In 2005, we attached transmitters to six female and five male spotted bats, including five temperature sensitive transmitters. Tagged bats retained their transmitters for 7 to 16 days (life of transmitter). We used fixed and mobile ground stations, as well as aerial telemetry to determine approximate locations for 13 day roosts. Due to the extremely rugged nature of the terrain, including 400 m vertical cliffs, most roost locations were approximated to within a 0.5 km area. Roost sites were in cracks and crevices in Coconino sandstone in the upper third of vertical cliff faces at Vermillion Cliffs, Marble Canyon (Upper Colorado River), Trail Canyon (Lower Colorado River), Ft Pierce Wash, and Canyon de Chelly. None of the telemetered bats appeared to use caves, though cave and karst features are abundant in these areas. Nor did any of the telemetered bats appear to roost with other telemetered bats. At least 2 of the radio-telemetered female bats used two roosts. Three to four days after radiotagging, a nonreproductive female moved 31 km to a new roost. A pregnant female moved 13 km. No bats used more than two roosts during any of the tracking periods. Length of stay at a roost ranged from 4 to 15 days (duration of study). Data from temperature sensitive transmitters indicated variation in body temperature among individuals. Most bats with temperature sensitive transmitters exhibited reduced body/environmental temperature within one hour after entering the day roost.

HYBRID POPLAR PRODUCTION FOR MULTIPLE BENEFITS IN THE SEMI-ARID SOUTHWEST

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Hybrid poplar (*Populus* spp.) is recognized as one of the fastest growing temperate tree species in North America, capable of producing marketable material in short rotations of 3-15 years. Hybrid poplar grown in the Four Corners region could provide a wide range of benefits such as solid wood and fiber products, fuel wood, biofuel feedstock, and sequestered carbon. Additionally, poplar uses water at a rate comparable to alfalfa and provides numerous environmental benefits including wildlife habitat, erosion control, and augmented soil carbon. During May 2002, ten poplar clones were planted at the NMSU Agricultural Science Center in Farmington, NM and were irrigated via a low-pressure drip system at rates sufficient to replace daily evapotranspiration (ET). Total irrigation as precipitation equivalent was 635, 686, and 762 mm for 2002, 2003, and 2004, respectively. These values are all lower than the recommended seasonal application for alfalfa in the region (1,270 mm). The trees were evaluated over three years for growth potential, chlorosis, and survival. Clone OP-367 had 100% survival and showed the greatest growth potential, producing 26 m^3 ha^{-1} of wood during the initial three years. Five other clones had 95% or better survival, of which two clones, 58-280 and 311-93, produced more than 10 m^3 ha^{-1} of wood. Initial results led to the May 2004 installation of a 40-ha plantation at the Navajo Agricultural Products Industry (NAPI) utilizing the top-producing clones. NAPI is now growing wood for regional fiber markets, while also providing wildlife and conservation benefits. During a ten-year rotation, the NAPI plantation could potentially sequester approximately 140 metric tons of carbon per hectare, based on the projected growth of OP-367. The expansion of similar projects can mitigate CO_2 emissions from fossil fuel production and use on the Colorado Plateau

DEVELOPMENT OF A RESTORATION RAPID ASSESSMENT TOOL

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Although National Park Service areas contain some of the best examples of native ecosystems, they also contain disturbed areas in need of restoration. Some of the areas may not be restorable due to the inability to remove the stressors (e.g. dammed rivers). Other sites may be restorable but require differing levels of effort to approach a reference or desired condition. Sites also vary as to ecological and social value. The National Park Service desires to direct resources towards restoring the sites of highest value and those with the highest feasibility of success. Thus, we are developing a decision support tool to help prioritize sites within a large park, a cluster of parks, or a region based upon site value, past and present land use, and feasibility of restoration. A "strawman" tool has been tested in disturbed riparian areas in the Eastern Deciduous Forest, California Coast, Northern Great Plains and the Colorado Plateau. The tool includes 60 indicators of departure from desired condition. Variables are soil condition, hydrology, erosion, ecosystem processes, native vegetation, and invasive plants. Separate shells address stressors (past, present, and future) and site value. Validation of indicator accuracy was part of the tool testing. A team and adaptive approach is being employed to refine the tool. Most importantly, the project team includes the end users. We will report on test results to date, next steps, and desired final product.

BIRDS OF THE COLORADO RIVER IN GRAND CANYON: A SYNTHESIS OF STATUS, TRENDS, AND DAM OPERATION EFFECTS

Holmes, Jennifer, John Spence, MARK **SOGGE**

This presentation summarizes the considerable information available from recent studies on the ecology of Grand Canyon bird species and communities. Because changes in riparian habitat undoubtedly influence the abundance and distribution of Grand Canyon birds, the presentation starts by briefly examining dam-induced habitat alterations that may affect birds. The direct and indirect effects of Glen Canyon Dam operations, including the modified low fluctuating flow (MLFF) alternative that was implemented starting in 1996, are considered for how they influence specific bird species and communities. Particular attention is given to species of special concern, including the southwestern willow flycatcher (*Empidonax traillii extimus*), California condor (*Gymnogyps californianus*), bald eagle (*Haliaeetus leucocephalus*), and American peregrine falcon (*Falco peregrinus anatum*). The session concludes with a summary and a discussion of research priorities within the context of the Glen Canyon Dam Adaptive Management Program.

THE ECOLOGICAL EFFECTS OF ARTIFICIAL WATER SOURCES IN A CHANGING HYDROLOGIC REGIME

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The water regime of the Colorado Plateau has changed dramatically within the last century. Drought and human land use have reduced availability of naturally-occurring water. Ambient temperatures have increased, resulting in shorter seasonal durations of accessible water accompanied by reductions of snowpack and earlier spring run-off. In response, artificially created waters, including stock tanks and wildlife water developments, have been built throughout the Southwest to mitigate reductions in natural waters and provide perennial water to livestock and game species. Resource managers remain in need of information about the ecological effects of artificial waters, to assess potential effects on wildlife. In August of 2004, we began deploying remote camera units at natural and artificial waters around Wupatki and Walnut Canyon National Monuments in north-central Arizona to monitor water availability and patterns of use by mid- to large-sized mammals along boundaries of these Monuments. To date, we have 16 cameras monitoring 7 natural and 9 artificial water sources. We also recorded snow cover, when present, and measured moisture content in vegetation, bimonthly, to assess the availability of pre-formed water. To date, we have photo-documented thousands of wildlife events, including several hundred instances of target species using artificial and natural water sources. Preliminary results suggest that when both natural and artificial water sources are available, mid- to large-sized mammals use artificial water sources more frequently than nearby natural water sources. Patterns of interspecific use at artificial water sources vary among different subsets of ecologically similar species, including both considerable overlap among mesopredators and exclusion between some herbivores, such as domestic cattle and pronghorn (*Antilocapra americana*). With increasing moisture content of vegetation, animal detections at water sources decrease, suggesting a reliance on pre-formed water. We plan to continue monitoring water availability and wildlife activity at water sources for an additional year, with a final report on the project completed in late 2006.

DIGGING IN THE DARK: CULTURAL RESOURCE MANAGEMENT IN GRAND CANYON'S CAVES

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Grand Canyon National Park contains an estimated 1,000 caves. The NPS has documented 335 caves. Of these, approximately 50 contain recorded archeological remains. Known cultural resources include 4,000 year old split-twig figurines, protohistoric arrow shafts, baskets, and even artifacts that document the historic use and exploration of caves. However, hundreds of caves lack inventories. The limited inventory and monitoring of caves and their resources, combined with the remote location of most caves, presents a challenge to the effective management of these cave resources. Recent impacts to cultural resources include theft, campfires, camping, and general visitation. This paper discusses the challenges and opportunities in managing the cultural resources of Grand Canyon's caves.

STEALING OR "JUST LOOKING:" STUDIES OF VISITORS 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, by the authors and other investigators, has been undertaken 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 a sum of 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 uses two quite different research approaches, each designed to provide complimentary results in answering the research questions. A self-administered questionnaire was designed to gather information on the travel patterns of 750 visitors within the park over a one-year period, under the assumption that petrified wood may be displaced in similar patterns. Over the same period, removal and deposit of petrified wood on 240 fixed-plots is being monitored at park sites where visitors have unsupervised access to wood. Additional monitoring is done of road ditches known to be regular depositories of discarded wood. All wood of souvenir size within plots has been invisibly marked with material having a unique spectral signature, thus establishing the origin of marked deposits found in the fixed plots and road ditches. Preliminary results from the on-going study 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 the lack of a full monitoring cycle and resulting small sample size. Wood displacement trends from the latest plot data are described and evaluated as intermediate results of the study.

ECTOMYCORRHIZAL DIVERSITY OF STRESSED PINYON PINES

HUBERT, NATE, Kristin Haskins, Rebecca Mueller

Northern Arizona has recently experienced the adverse effects of severe drought. Mortality of native conifers, including pinyon pine, has been observed at the landscape scale. Ectomycorrhizal (EM) fungi may buffer trees from drought stress by increasing the uptake of water and nutrients. Theoretical models have been proposed that predict the dynamics of EM species richness, but the real contribution of EM diversity to ecosystem stability and resilience remains largely unknown. The pinyon-juniper woodlands of northern Arizona offer an excellent opportunity to study the effect of fungal symbiont diversity on host plant performance, because pinyon pine is the only EM host plant at these sites. The diversity and relative abundance of EM fungal species belonging to the divisions Ascomycota and Basidiomycota have been shown to indicate host-related biotic stress, such as plant competition and parasitism; and abiotic stress such as drought, slope, cardinal aspect and soil quality. Thus, there is great potential for land management via manipulation of the EM fungal community. Future research should focus on 1) the ecological function of common symbionts, 2) changes in plant-mycorrhizal diversity as a measure of forest condition, and 3) managing mycorrhizal communities towards conservation and restoration efforts.

EXPLORING PAST, PRESENT, AND FUTURE CLIMATE CHANGE IMPACTS ON THE DISTRIBUTION OF ONE-SEEDED JUNIPER, *JUNIPERUS MONOSPERMA*, AT WUPATKI NATIONAL MONUMENT

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One-seeded juniper encroachment into southern Colorado Plateau Grasslands has been an ecological concern for natural resource management at Wupatki National Monument for the past few decades. Woody species encroachment into grasslands has been documented throughout the world and attributed to a variety of casual factors such as overgrazing, fire suppression, carbon dioxide fertilization, and natural cyclic variability. Using modeling techniques, incorporating hierarchy theory and conceptual modeling, we explore the potential changes in suitable climate distribution for one-seeded juniper using a global climate model scenario for the 21st Century. The modeling approach uses CLIMLIM, a program which ranks climatic factors for their influence on species distributions. Then, the most important climatic factors are used as independent variables to create a maximum likelihood probability surface using ArcGIS software. We measured the relative change between simulated present and simulated 2XCO2 climates from the CCM3 AOGCM model on a ~75 km grid and then projected these changes to a ~1 km grid of present day climates. The resulting 2XCO2 climate values on the ~ 1 km grid created a data surface with sufficient resolution to assess local landscape-level impacts of potential climate change. Ecological characteristics along with paleoecological information from packrat midden fossil research were used to create a hierarchical conceptual model that was incorporated into a least cost path analysis in Arc GIS. The results of this modeling exercise were then compared to recent trends in the changes of one seeded juniper distribution observed in aerial photography from 1936 to the present. The modeling resulted in a general trend of one-seeded juniper shifting up in latitude and down in elevation towards many areas currently inhabited by grasslands, using a future GCM scenario. This general trend also is present in the aerial imagery from 1936 to the present. The modeling exercise demonstrates that observed ongoing changes in one-seeded juniper distribution can be simulated from entirely independent GCM climate modeling. Although the one-seeded juniper is just beginning to invade its 2XCO2 climate range, it seems that it is already changing along its future predicted trajectory.

IMPENDING CONGRESSIONAL ACTION ON THE ENDANGERED SPECIES ACT

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Since its passage in 1973, the Endangered Species Act has become a symbol of our nation's commitment to conserving America's imperiled biodiversity. Because of the Act, future generations will be able to enjoy that plants and animals such as wolves, grizzly bears, manatees and our nation's symbol, the bald eagle. The Act has an impressive success rate: just nine of the more than 1,800 species protected by the Act since its passage have been declared extinct. Despite this, there have been many calls to change the Act. In August 2005, a new draft ESA reform began circulating in the House Resources Committee that contained seven proposals to drastically change the federal effort to help endangered species. One change would allow many major development projects to avoid the need to consult with Fish & Wildlife Service or write a Habitat Conservation Plan to accommodate needs of listed species. Another "sunset clause" would cause the ESA to expire in 2015. After this draft was leaked to the press, an outcry erupted and the draft was withdrawn. However, Richard Pombo, Chair of the Resources Committee, is likely to promote other major changes to the ESA in the current Congress. This presentation will describe the latest legislative proposals related to our core environmental laws, and strategies to keep this seminal conservation law strong and functional.

CLIMATE CHANGE, ECOSYSTEM IMPACTS, FOREST MANAGEMENT AND EXTENSION EDUCATION

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Forest managers around the world are being challenged by large-scale landscape changes triggered by multi-year to multi-decade climatic fluctuations. These disturbances alter the environmental balance and reset the ecological clock over hundreds of thousands of acres. Ecological responses to these large-scale disturbances will dictate the face of the land for the next century or more. Despite efforts by climatologists and ecologists to provide new perspectives and knowledge to address these resource management challenges, natural resources managers find it difficult to incorporate long-term climate information into their management plans. As a first step to address the need for understandable, practical, and applicable scientific information on the potential impacts of climate variability and change, University of Arizona Cooperative Extension (UACE) held a workshop in February, 2005, that brought together climate change scientists, ecologists, educators and natural resource managers. Using an innovative approach developed by UACE, the workshop explored the concerns of natural resources managers, and fostered dialogue and collaboration between managers (end-users of scientific knowledge), cooperative extension agents and specialists (interpreters and disseminators of scientific knowledge), and leading scientists (producers of scientific knowledge). The workshop covered the state of knowledge about the following climate-induced ecosystem changes through plenary talks and breakout discussions: insect-related disturbance, woody vegetative response to increasing atmospheric carbon dioxide fertilization, forest vegetation recruitment, dispersal, and survivorship, wildfire intensity and frequency, shifts in invasive species' populations and dispersal, implications for grazing on forest lands, and spatial scales of climate-induced change. Workshop participants engaged in lively discussion and contributed ideas that will be synthesized into topical UACE fact sheets for land managers. Key results of the workshop with ramifications for climate-induced ecosystem impacts include: the science talks can be more effective by better connecting research conclusions with specific management situations and potential management actions; managers need "hard numbers" on documented climate-induced ecosystem responses; region-specific climate change scenarios are needed for managers to develop practical management options; and the complexity of climate change and ecosystems' response requires increased interaction and partnership between scientists and managers, facilitated by extension educators, for effective communication. For more information, see http://cals.arizona.edu/climate/ws/climchg/sedona05.htm.

RECREATIONAL VALUES AND CAMPSITES IN THE COLORADO RIVER ECOSYSTEM

KAPLINSKI, MATTHEW, Jeff Behan, Joseph Hazel, Roderic Parnell, Helen Fairley

This talk presents an assessment of the current state of knowledge concerning the impacts of Glen Canyon Dam operations on the changing condition of campsite areas and sandbars and the implications of physical changes of the Grand Canyon ecosystem for visitor capacity and quality of experience. After defining the study area and some key concepts, the presentation briefly reviews the relationships between the condition and extent of Colorado River sandbars and the quality of the visitor recreation experience. An overview of historical status and trends of the number and size of campsites along the Colorado River is followed by a summary of recent findings. Discussion focuses on the effects of the modified low fluctuating flow (MLFF) alternative and high-volume experimental flows on campsite area. The session concludes with an evaluation of these results relative to the stated recreation goals and management objectives of the Glen Canyon Dam Adaptive Management Program (GCDAMP).

LINKAGES AMONG TERRESTRIAL RIPARIAN COMPONENTS IN THE COLORADO RIVER CORRIDOR OF GRAND CANYON NATIONAL PARK

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After three years of integrated sampling of vegetation, arthropods, herpetofauna, breeding birds and small mammals in riparian habitats of the Colorado River corridor of Grand Canyon National Park, several patterns emerged. First, trend analysis showed a decline in both vegetation and avifaunal abundances. Vegetation trends were in addition to effects of regulated flow and precipitation. Declines in breeding bird densities may be due to declines in vegetation abundance, but are likely also affected by factors outside of the breeding area. Second, arthropod abundances are not tied to overall vegetation abundance, but individual taxonomic and feeding groups are tied to different individual plant species. Third, vegetation is a poor surrogate for habitat quality for herpetofauna and small mammals. And fourth, sampling of habitat patches, delineated by investigators, does not always capture important habitat features.

YOUTH FARMING AND RESTORATION PROJECT AT WEPO SPRINGS

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Revitalizing essential cultural practices and traditional food systems is a major priority on the Colorado Plateau. Many Native American communities are now experiencing epidemic rates of nutrition related diseases, like diabetes, with the erosion of traditional farming practices. At Hopi, the last fifty years has brought a decline in the once strong and vibrant food system. This food system consists of many culturally critical and healthy foods that have sustained people for centuries. In 2004 interests to restore the once productive farming area located at Wepo springs, materialized when community members formed a work party to dig out the spring in order to get water flowing into the fields. The Wepo site is an example of current efforts to rebuild the local food system from the ground up by restoring the springs, garden terraces, orchards and wet lands to rekindle community interest in farming and visiting the area. During the summer of 2005 restoration work continues with the addition of summer Wepo youth farming program. Youth learn about traditional farming practices, native plant uses, and the cultural history of the area. One of the main focuses of the summer program is to bring awareness of the Hopi food system and culture to the youth. Bringing students to the outdoor classroom is an important place to interact and learn from elders, while being involved with a culturally relevant style of education that is essential to learning about their culture. The summer farming project has inspired youth to become involved with agriculture and learn more about how their culture connects them to their surroundings. The accomplishments at Wepo have spurred interest in the community to restore other agricultural sites and create additional ways to involve youth with their food and heritage.

AQUATIC ECOLOGY: THE ROLE OF ORGANIC MATTER AND INVERTEBRATES

KENNEDY, THEODORE, Steven Gloss

This talk describes the results of the research and monitoring activities that have investigated the kinds of organic matter and invertebrate communities in the Colorado River below Glen Canyon Dam. Collectively, organic matter and the aquatic invertebrates that consume it largely constitute the food base for fish in the Colorado River ecosystem. This discussion focuses on patterns, trends, and important controls on the amount and sources of organic matter and invertebrates that are primary food resources for humpback chub (*Gila cypha*) and rainbow trout (*Oncorhynchus mykiss*) in an effort to understand the role that food plays in determining the distribution, population density, and growth of these fish in this ecosystem. This session also addresses how organic matter and invertebrates are affected by the timing and magnitude of water releases from Glen Canyon Dam, including the modified low fluctuating flow (MLFF) alternative, which was implemented in 1996 and continues as the operating regime for Glen Canyon Dam today. Finally, this session concludes with a brief discussion of possible research directions and management actions.

CAVES – EXPANDING BEYOND THE HOLLOW PLACES

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Promoting ethics and clarifying the reasons for conservation and the imperative need for research and understanding caves as systems is not within the scope of our existing laws, which makes it imperative that agencies and scientists working in or managing caves need to go beyond the hollow portion of a cave and assure that the caves are understood as systems. More and more attention is being focused on outdoor activities, especially those which are deemed to fall within the so-called “extreme sports” area. Caves are viewed in recent magazine articles, television programs and movies as places where one can practice “extreme” activities with seemingly no regard for the resource. The people involved in the “extreme” sports arena seem to lack an understanding of conservation ethic and, if any at all, an extreme misunderstanding of caves and karst systems. Without an understanding that caves are the result of natural processes that are not magical, mysterious, or supernatural, but that conform to a series of measurable geological and biological actions, a conservation ethic can never be expected from these particular users of caves. While we have laws that help protect caves and their contents including the Federal Cave Resources Act of 1988 and various state laws, none of the current laws place priority on the need to understand caves and the processes by which they are created. No current legislation insures that caves will be considered in terms of environmental ethics. The important work of establishing an acceptable conservation and research protocol ethic must be accomplished one step at a time by patient speleologists who have devoted their energies to speleological research, education, and public outreach. There have been many positive changes over the last 35 years-changes accomplished by the persistent spirits of individual and collective speleologists who think beyond the hollow spaces.

REMOTELY SENSED ECOSYSTEM IMPACTS OF DROUGHT AT C. HART MERRIAM TRANSECT

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The Colorado Plateau is in the midst of a severe drought with significant impacts on ecosystems (desert shrub to conifer forest). There have been extensive mortality and bark beetle insect populations in conjunction with the multi-year drought. We analyzed and then mapped various remotely-sensed drought indicators across a series of ecosystems from desert shrub, grassland, pinyon-juniper, and Ponderosa pine with Airborne Visible Infra-Red Imaging Spectrometer (AVIRIS) data flown across the C. Hart Merriam Transect in northern Arizona in July and October of 2003. The AVIRIS instrument is a hyperspectral optical sensor that delivers calibrated images in 224 contiguous spectral bands with wavelengths from 400 to 2500 nanometer and nearly 5m spatial resolution. This hyperspectral sensors affords opportunities to assess canopy chemistry within the drought stricken ecosystems. The various indicators used to assess drought impacts included ‘greenness’, soil,

shadow, and non-photosynthetic vegetation (NPV) obtained using a linear mixture model. We also utilized combined chlorophyll- and water-based index relationships as surrogates for canopy water status per unit of leaf area index. We found tree mortality sites exhibited high NPV and soil signals accompanied with low 'greenness'. The water indices in conjunction with chlorophyll indices provided measures of fuel moisture status, fire vulnerability, and drought status. Significant differences in slope-based relationships describing the quantity of canopy moisture per unit level of chlorophyll (or greenness) were found between dates (dry and wet seasons), across ecosystems, and with drought impact. Our preliminary results show that ecosystem health and drought impact response to climate change and human land cover modifications can be characterized using remote sensing.

PATTERNS OF WOODY PLANT MORTALITY FOLLOWING DROUGHT AT THE PONDEROSA PINE/PINYON-JUNIPER ECOTONE

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Tree-ring and meteorological data have indicated that 2000 and especially 2002 were the most severe drought years in over 400 years in the Southwest U.S., and resulted in extensive tree and shrub mortality. We conducted a study within the ponderosa pine/pinyon-juniper ecotone of northern Arizona to assess the extent of woody plant dieback and mortality that occurred during this drought. Our objectives were to determine if tree and shrub condition varied among sites of different soil parent materials (SPMs), and if condition varied among species at a common SPM. Our study sites were located within the Coconino National Forest at elevations ranging from 1790 to 2105 m and occurred at SPMs that differed in soil texture and water availability: sedimentary, flow basalt, and basalt cinders (driest). Within each SPM were three sites that included twenty 0.05 ha circular plots 100 m apart. All woody plants were classified into one of three condition classes: live with low amount of dieback (LLD) where < 25% of the canopy was recently dead, live with high amount of dieback (LHD) where > 25% of the canopy was recently dead, and dead (D). The percent D pooled over species was 14.2% for trees and 8.8% for shrubs at the cinder sites, 14.1% for trees and 10.6% for shrubs at the flow basalt sites, and 12.3% for trees and 19.0% for shrubs at the sedimentary sites. For the major trees, percent D was lower for Juniperus monosperma compared to Pinus ponderosa and P. edulis. Pooled over all trees and shrubs, the percent of plants in the LHD category was higher on cinder vs. flow basalt and sedimentary SPMs. The same result occurred for P. edulis and J. monosperma, but not for P. ponderosa, in which percent LHD was similar among SPMs. In general, shrubs showed greater percent LHD than trees. Overall, our results show moderate amounts of mortality for woody plants at the ponderosa pine/pinyon-juniper ecotone and greater canopy dieback for living trees and shrubs at the cinder compared to the flow basalt and sedimentary SPMs.

GROWTH RESPONSES OF NORTHERN ARIZONA FORESTS TO CLIMATIC VARIATION

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Tree rings contain information on historical responses of tree growth and physiology to climatic variation that can inform understanding of future responses to climate change. Recent studies in northern Arizona showed that severe regional drought reduced growth of all dominant tree species over a gradient of precipitation and temperature represented by a 1,500 m change in elevation on the San Francisco Peaks, but response to drought varied among species and sites. Leaf ^{13}C data suggests pronounced stomatal closure in response to drought for both low- and high-elevation forests, and differences in water-use efficiency among species. A long-term thinning experiment for ponderosa pine showed that resilience and sensitivity of growth to drought depended on stand density. Guidelines derived from these results for understanding effects of climate variation on tree growth for Southwestern mountain landscapes and in the context of forest management will be discussed.

WARM DRY MIXED CONIFER PLANT COMMUNITY DIVERSITY IN SOUTHWESTERN COLORADO

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The mixed conifer forest type of southwestern Colorado is poorly understood in comparison to other common forest types in this area, in part due to its compositional complexity. We identified 4 dominant tree canopy types within the warm, dry mixed conifer based on an IV value (relative frequency plus relative abundance): white fir, ponderosa pine, aspen, and Douglas-fir. We then examined how understory composition and abundance varied across these 4 types, and assessed the correlation between biotic and abiotic variables and the understory vegetation. Understory community composition was significantly different between tree canopy types, with aspen plots having the most distinct understory plant community of the 4 canopy types. Total plant cover was significantly higher in the aspen plots, and shrub richness was significantly higher in the Douglas-fir plots. On average for all tree canopy types combined, shrubs dominated the understory cover (11.35 %), followed by forbs (7.89 %), and graminoids (4.34 %). Multivariate multiple regression showed that several site factors (distance to drainage, slope, and aspect), and stand characteristics (white fir trees per hectare [TPH], ponderosa pine TPH and basal area [BA], and aspen BA) helped account for some of the variability of the understory community. Univariate regression showed that variation in annual species richness and Simpson's Index of diversity were partially explained by tree canopy and site data. Our findings illustrate the necessity to not simplify forest dynamics for all western forest types or even within one forest type (warm, dry mixed conifer) for a general region. Forest management implementation needs to be based on site specific knowledge within localized geographic regions in order to restore or preserve natural communities within a range of historic variability.

HYBRIDIZING AND DOMINANT RIPARIAN TREES SUPPORT UNIQUE ECTOMYCORRHIZAL COMMUNITIES

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We examined the hypothesis that two dominant riparian tree species, narrowleaf and Fremont cottonwoods (Populus angustifolia and P. fremontii, respectively), which are known to hybridize, support different ectomycorrhizal (EM) communities. Over 5000 species of fungi form ectomycorrhizal associations with host plants, yet little is known about the effect of host plant species composition on rates of ectomycorrhizal colonization, diversity and community composition. In particular, few studies have looked for differences in ectomycorrhizal communities between two closely related host plant species. In a common garden where environment was held constant, 1 soil core was collected under 10 trees, of known and unique genotypes, 5 representing each species, and morphotyped 100 root tips from each sample. The following 4 results emerged: (1) Although this difference was not statistically significant, narrowleaf cottonwoods had 14% lower levels of mycorrhizal colonization than Fremont cottonwoods. (2) EM morphotype richness and diversity were higher in narrowleaf cottonwoods, but again this difference was not significant. (3) Only seven EM of forty-five morphotypes were shared between narrowleaf and Fremont cottonwoods, accounting for only 10% of the root tips counted. (4) The EM morphotype community supported by narrowleaf and Fremont were significantly different from each other. This study indicates that unique EM communities are supported by closely related tree species growing in a common environment. Based on previous research, such closely related species would be expected to support similar communities. These results suggest that host plant identity has an under-appreciated role in determining EM species composition and that conserving EM fungal diversity will require conserving closely related plant taxa. Implications for conservation of ectomycorrhizal diversity fall in line with the need to conserve populations of these dominant, yet declining, riparian host species.

ANALYSIS OF UNDERSTORY VEGETATION RECOVERY ON THE RODEO-CHEDISKI FIRE

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The Rodeo-Chediski fire burned 468,000 acres in central-eastern Arizona in 2002. This fire left a mosaic of burn severities across the landscape on both White Mountain Apache Tribal lands (WMAT) and the Apache-Sitgreaves National Forest (A-S). This study intends to investigate richness and abundance of native and exotic species in the burn area in order to describe if treatments prior to the fire provided for a more healthy and resilient understory following the burn. We sampled 192 plots 2 years after the fire, and remeasured 3 years post-burn. The 108 plots on WMAT sampled areas determined to be high or low burn severity by satellite imagery over a gradient of treatments including prescribed fire combined with thinning, prescribed burning alone, and no treatment. We sampled 84 paired plots on A-S in stands that had been thinned or not thinned. We will compare the plant communities in the various combinations of fire severity and treatments, specifically looking at richness and abundance of natives and exotics.

EVALUATING POSTFIRE SEEDING TREATMENTS TO SUPPRESS CHEATGRASS (*BROMUS TECTORUM*) IN PONDERSOSAL PINE FORESTS ON THE SHIVWITS PLATEAU

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The interaction between fire and invasive plants is of great concern to land management agencies on the Colorado Plateau. Both prescribed fire and naturally occurring wildfire are increasingly resulting in a dominant understory of the invasive annual grass cheatgrass (*Bromus tectorum*), which has the potential to create excessively short fire return intervals, and impede the establishment of later successional plant species. There is some evidence that where native perennial grasses such as the cool season grass bottlebrush squirreltail (*Elymus elymoides*) and the warm season grass blue grama (*Bouteloua gracilis*) occur naturally after fire, cheatgrass dominance is low and diversity and cover of native perennial grasses, shrubs, and forbs is high. This suggests that native perennial grasses may be competing with and reducing the dominance of cheatgrass. We designed a project to evaluate effects of postfire seeding of bottlebrush squirreltail (3lbs /ac pls) and blue grama (2lbs/ac pls) on dominance by cheatgrass. The study area is located on the Shivwits Plateau on the western edge of the Colorado Plateau. NPS and BLM Fire Management personnel conducted a prescribed fire in a sagebrush meadow in October 2003 in an ongoing program to reintroduce fire into the ponderosa pine ecosystem. In November 2003, seeding, seeding plus raking, and unseeded controls were each randomly applied to 6 replicate treatment plots (n=18 total plots), each 25m x 50m (1,250m2). Immediate postfire vegetation and soil seed bank data were collected in fall 2003 to establish burn severity and baseline plant community data. Two years of postfire and post treatment data have been collected in spring of 2004 and 2005. Sampling will continue for an additional 2 years. The study site will also be maintained by the Lake Mead National Recreation Area as a demonstration site where the long-term effects of the seeding treatments can be observed and the information integrated back into the process of land management planning.

INTEGRATING WEED CONTROL AND RESTORATION ON WESTERN RANGELANDS

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Native plant restoration and weed control in western rangelands involve economic concerns that force us to choose management techniques based on application over large areas with limited input of time and labor. Historically, this has often involved herbicide application and seeding using non-native species. Our goal is to identify ecological mechanisms by which to control the spread of cheatgrass (*Bromus tectorum*) on western rangelands. Efforts to control cheatgrass need to focus on its competitive ability and reproductive capacity while simultaneously restoring native plants. We have implemented a series of experiments across four states to test techniques for controlling cheatgrass, establishing native plant communities, and restoring ecosystem structure and function. One of these experiments tested the applicability of seeding with a modified Truax© range drill in native plant restoration, the impact of herbicide on both cheatgrass and native plant species, and how the establishment of certain native plant species is related to density of cheatgrass and other non-native plant species. We used a randomized split plot design at each site to test and establishment success of 29 accessions comprising 18 native plants. Cheatgrass responded negatively to herbicide treatment, whereas native and non-native species responded differently. Neither cheatgrass density nor biomass were reduced by planted accession and accessions differed in establishment success depending on site, which have immense implications for management. Our other experiment tested the role of soil nitrogen in mediating competition between native species and cheatgrass, and the effectiveness of native species in reducing soil nitrogen and cheatgrass production. Sucrose decreased soil nitrogen, as well as other soil nutrients, and resulted in reduced cheatgrass biomass and seed production. Effects of native species on cheatgrass density, and of cheatgrass on native species density, were not consistent across sites. Species responded differently to both sucrose and competition with cheatgrass. Subsequent years of data will be vital in determining the competitive effects of native species on cheatgrass performance and for assessing the effectiveness of herbicide and sucrose application.

CONSERVATION OPPORTUNITIES ON THE COLORADO PLATEAU: LAND COVER

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In its geographic approach to biodiversity assessment and planning, the Gap Analysis Program (GAP) has as its mission to “keep common species common.” “Gap analyses” are performed to identify areas of high biological value relative to current land management practices and to assess the degree to which protection is afforded. Information resulting from these analyses can be used to prioritize areas in need of conservation, to re-evaluate current management practices in light of regional conservation needs, and to facilitate cooperative management and planning among land stewards. The Southwest Regional GAP Analysis Project (SWReGAP) recently completed a seamless regional land cover map for Arizona, Colorado, Nevada, New Mexico, and Utah. Results of the gap analysis for land cover of the Colorado Plateau Ecoregion will be the focus of this presentation. Conservation opportunities associated with using the land cover data set as a separate resource will also be discussed. With an intended scale of 1:100,000, the land cover map is best suited for landscape to regional level assessments. The land cover map provides a useful context for a range of biological and regional planning efforts including large area resource management objectives, human-wildland interface issues, and environmental impact assessments and socio-economic studies in the event of loss of a particular biological resource.

PLANT PRODUCTION AND DIVERSITY IN A PONDEROSA PINE FOREST: THE IMPORTANCE OF INTER-ANNUAL CLIMATIC VARIABILITY

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Plant production is known to vary considerably from year to year in semi-arid environments. We analyzed a 14-year (1992-2005) dataset from the Gus Pearson Natural Area located near Flagstaff, AZ to determine the effects of inter-annual variation in precipitation on aboveground herbaceous standing crop and species richness. In multiple regression models, precipitation and treatment explained 82% of the variation in total herbaceous standing crop. A precipitation x treatment interaction term was also significant in this model suggesting that the intercepts and the slopes of the regression lines differed between treatments. These factors also explained graminoid standing crop (R^2adj = 0.94), forb standing crop (R^2adj = 0.61), C_3 graminoid standing crop (R^2adj = 0.96), legume standing crop (R^2adj = 0.74), perennial forb standing crop (R^2adj = 0.39), and annual forb standing crop (R^2adj = 0.67). Interestingly, 84% of the variation in C_4 graminoid standing crop could be explained by the treatments, but precipitation did not improve the model, suggesting that C_4 graminoids are resilient to temporal variation in precipitation, and therefore, less affected by the drought experienced in 1996, 2002 and 2004. We also used structural equation modeling to test a general multivariate model of herbaceous plant species richness. Overall, we found that ponderosa pine (basal area) consistently had a strong negative effect on herbaceous standing crop, and that standing crop exhibited a unimodal (“hump-shaped”) relationship to species richness, suggesting that competitive exclusion occurs within the herbaceous community. However, this relationship is dampened in drought years, suggesting that competitive exclusion in the understory occurs only in years when enough moisture is available to drive abundant plant growth.

REFORMING STATE TRUST LAND THROUGHOUT THE WEST

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In 1785, the U.S. Congress established a policy of granting land to states when they entered the Union as an asset to generate funding to support the public education system, a fundamental state responsibility. Starting with Ohio in 1785 and ending with Arizona and New Mexico in 1910, each new state received a set of federal lands to be held in trust for the benefit of the public schools. To date, lease and sale of natural products are the principal sources of revenue. But as the West urbanizes and its economy matures, trust land managers recognize a need to broaden the land use activities of their portfolios to include commercial, industrial and residential development, as well as recreation and conservation. To bring diverse interests together and providing information to stakeholders and decision makers, the Lincoln Institute and Sonoran Institute have created a Joint Venture project to (a) facilitate efforts to modernize state trust land laws and regulations in western states, (b) foster education and research on key issues, (c) increase public awareness of the diverse values of state trust lands and the impacts of management decisions on local communities, (d) develop and implement on-the-ground innovative approaches to collaborative land use planning and conservation management of state trust lands, and (e) provide technical information and tools to key decision makers and agency staff.

A MODULAR MODELING APPROACH TO INTEGRATING ADAPTIVE MODELING SYSTEMS WITH RESOURCE MANAGEMENT IN THE FRAME PROJECT

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The FRAME (Framing Research to support Adaptive Management of Ecosystems) project is a collaborative, multi-disciplinary effort currently focusing on pinyon-juniper woodland management on the Colorado Plateau. The USGS Modular Modeling System (MMS) (http://wwwbrr.cr.usgs.gov/mms) provides a modular framework to address a variety of pinyon-juniper management issues using a set of adaptive modeling tools. MMS is being coupled with the U.S. Forest Service model SIMulating Patterns and Processes at Landscape Scales (SIMPPLLE) (http://www.fs.fed.us/rm/missoula/4151/SIMPPLLE) to enable the assessment of the effects of alternative resource-management options on a variety of hydrologic and ecosystem processes. A variety of watershed, erosion, hydraulic, and ecosystem models in MMS will be used to evaluate the spatially explicit output of SIMPPLLE. Output from SIMPPLLE is an ensemble of potential vegetation conditions years to decades into the future. Key components of the linked MMS and SIMPPLLE models are 1) tools to estimate parameters in MMS process-based models using vegetation and ecosystem attribute data from SIMPPLLE output, and 2) a climate generator to provide time series of meteorological variables, such as precipitation and temperature, for use as input to the process-based models. The magnitude and timing of these meteorological variables must be spatially and temporally representative of possible future climate conditions. Initial application of the coupled MMS-SIMPPLLE modeling tools is to support fire-management planning at Mesa Verde National Park. A major objective of the development and application of these tools is to allow resource managers to develop more flexible management scenarios that can adjust to changing conditions, and to develop spatially explicit landscape-management scenarios that incorporate the social, economic, legal, and environmental constraints that managers face. A review of the modular framework and selected framework tools will be presented.

GEOLOGY MEDIATES LONG-TERM RESPONSE TO THE DUDE FIRE

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Recent studies of forest vegetation in the Mogollon Rim area have found that severe crown fires have induced shifts in vegetation from ponderosa pine forests to manzanita-oak shrublands. Geologic differences could potentially alter the responses of different areas subjected to severe wildfire. To test this hypothesis, we compared vegetation and ground cover in burned and unburned areas across sandstone and limestone geologic formations. We located the study sites in pine/juniper/oak forest below the Mogollon Rim on the Tonto National Forest in central Arizona. The burned sites had been burned by the Dude wildfire in 1990. We sampled half the sites in 2001 and 2002, and the other half in 2005. We measured cover of soil, gravel, litter and canopy cover of vegetation in 40 plots at each site, using a modified Daubenmire sampling method. We distributed the 60 sites evenly across sandstone/limestone geologies and burned/unburned areas. Vegetative cover was not significantly different between limestone and sandstone geologies within the unburned areas ($x = 3.82 \pm 2.37\%$, mean ± standard deviation, $n = 15$, and $x = 4.03 \pm 2.14\%$, respectively). Average soil cover on unburned limestone sites was less ($5.23 \pm 6.63\%$) than on unburned sandstone sites ($7.98 \pm 7.17\%$). In the burned areas, bare soil was less on limestone sites ($12.67 \pm 7.15\%$) than on sandstone sites ($28.15 \pm 8.38\%$), supporting our hypothesis that limestone sites would be more resilient to wildfire. However, vegetation cover was higher on burned sandstone sites ($8.98 \pm 4.06\%$) than on burned limestone sites ($6.68 \pm 5.48\%$). This result reflects the fact that the seeded, non-native weeping lovegrass (Eragrostis curvula) was more abundant on burned sandstone sites ($5.12 \pm 3.74\%$) than on burned limestone sites ($3.89 \pm 5.94\%$). Our results demonstrate that geology influences vegetative response to severe wildfire and should be a consideration of post-fire management strategies.

PLANT GENES LINK FORESTS AND STREAMS

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Recent terrestrial research demonstrates the importance of genetic variation within tree species such as oaks, aspen and cottonwoods in affecting the function of forest ecosystems. We show similarly that genetic variation within cottonwoods can affect stream ecosystem function through litterfall. The genetic makeup of cottonwood leaf litter directly affects in-stream leaf decomposition rates, aquatic fungal accumulation and macroinvertebrate assemblages. This genetic variation is especially important in the western United States because cottonwoods are a dominant riparian tree and are currently in dramatic decline. In western rivers, cottonwood genetic diversity may be elevated due to naturally-occurring hybridization zones. We collected litter from five genotypes of each of four cottonwood cross types from common garden trees and measured decomposition rates using litterbag techniques in the Weber River (UT). Among the cottonwood genotypes decomposition rates ranged on average from 0.0077 ± 0.0003 day^{-1} for backcross to *P. angustifolia* hybrids to 0.0105 ± 0.0003 day^{-1} for *P. fremontii*. Similar and substantial differences among F_1 and backcross hybrids provide evidence for genetic control over in-stream decomposition rates. Prior studies have shown that species diversity influences litter quality and stream function. This study extends this by linking genetic diversity to stream ecosystem function.

CANYONS, CONSERVATION AND A COMMUNITY CORP: AN INTEGRATED APPROACH TO CULTURAL AND NATURAL RESOURCE PRESERVATION AT CANYON DE CHELLY NATIONAL MONUMENT

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Aggressive infestation by tamarisk (*Tamarix ramosissima, T. chinensis*) and Russian olive (*Elaeaganus angustifolia*), in combination with intensive historic grazing and tour operations within the riparian corridors of the canyon floor, have created the need for an integrated and collaborative approach to managing cultural and natural resources within the canyons and their associated watersheds. Invasive plant infestations have seriously altered stream processes creating unnatural rates and severity of channel incision and land erosion, and have consequently reduced land areas available for traditional farming. In addition, natural biological diversity has been significantly reduced along the riparian corridor. Restoration and preservation of this diversity is important for maintaining the natural ecology of the canyons and for sustaining traditional and ethnological uses by the Navajo peoples residing within the canyon bottoms. These changes have dramatically altered and seriously threaten valuable and irreplaceable archeological resources, cultural landscapes, at-risk species and traditional lifeways. The park is addressing these issues by developing a local and sustainable canyon conservation corp.

MANAGING LIVESTOCK GRAZING TO INHIBIT CHEATGRASS SPREAD

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The role of anthropogenic and natural disturbances on invasive species is great, but their interactive effects are poorly documented. In a northern Arizona grassland, where the extent of exotic invasion was heretofore poorly documented, we reflect upon responses of invasive annual plants to a gradient of grazing intensity (cattle removal, moderate grazing, and high-impact grazing) during an eight year experiment. We found strong evidence that 1) grazing effects on invasives were contingent upon climate; and 2) resource-availability mediated the invasion. In the seventh year of the study, and shortly after a millennium-scale drought, we document an eight-fold increase in cheatgrass (*Bromus tectorum*) due to high-impact grazing. Cheatgrass responded positively to increased soil nitrogen that was a result of high-impact grazing. In a controlled greenhouse experiment, cheatgrass produced 20% more biomass in soils from the high-impact treatment than other treatments. Although increased cattle density consistently benefited cheatgrass, the converse strategy of cattle removal did not decrease susceptibility to cheatgrass spread in comparison with moderate grazing practices. We conclude that grazing effects on invasive annuals are strongly dependent on environmental conditions, and drought creates conditions that favor post-drought outbreaks of invasive annuals. Finally, we outline a monitoring approach for tracking cheatgrass spread at a landscape scale and document its spatial distribution on Anderson Mesa.

RESTORING TRADITIONAL ECOLOGICAL KNOWLEDGE OF THE APACHE

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Many Native Americans are tremendously concerned with conserving ecologically and culturally important sites, and they see a need to reinforce traditional cultural values among young people. The high school in the Western Apache village of Cibecue implemented a special summer course in historical ecology for 16 high school and college students. In the late 1970s, elders from the community had asked a well-known anthropologist to help map, photograph, and record stories about over 250 places in a 20-mile radius in Cibecue. This community-generated database presented a unique opportunity for today's students to examine ecological change, since many of the sites have withstood severe wildfires, record floods, extended droughts, and various management activities in the intervening decades. After a few weeks of instruction, students revisited the sites, retook their photographs, conducted ecological inventories, and interviewed elders about changes that had occurred. A main objective was to determine whether modern techniques for ecological assessment could complement and reinvigorate interest in traditional Apache systems for describing places. The students demonstrated great enthusiasm for this research, and they developed the basic skills needed to classify and examine wetland conditions at 16 sites. We were concerned that relying on non-Apache methodologies might displace or undermine traditional ways of knowing the land. Therefore, instructors emphasized the use of Apache names and taught students about the cultural significance of the sites prior to visiting them. Many students expressed greater appreciation for water and greater use of their native language at the end of the course. We created a video to communicate the outcomes of the project to the community and to outside groups. This video shows how the participants had relived actions of their ancestors through their visits to these places. The effort to cultivate awareness among young tribal members is serving as a foundation for the community to plan culturally appropriate and historically based efforts to conserve and restore the waters on which they depend. Consequently, this project demonstrated how past efforts to record traditional knowledge can feed modern efforts to put that knowledge back into practice.

PROSPECTS FOR TROUT TO SURVIVE WILDFIRES IN THE WHITE MOUNTAINS OF ARIZONA

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Ecologists debate whether wildfires present a widespread threat to native fish populations, or instead constitute merely an isolated problem facing small populations in degraded watersheds. The threat of wildfire to Apache trout is difficult to evaluate since large wildfires have not struck its ancestral home on Mount Baldy in recent decades, but recent wildfires in the White Mountains may serve as proxies. The Steeple fire (2003), KP fire (2004), and Three Forks fire (2004) burned parts of the watersheds of Grant
Creek, KP Creek, and the East Fork of the Black River, respectively. We sampled fish populations and habitat conditions in these streams after the 2004 fires had been contained and before major flood events had occurred. We resampled fish populations at the sites one year later. We located sites to approximate those that the Arizona Game and Fish Department had established a decade earlier to help compare conditions before and after the fires. Despite fire-induced flooding and erosion in KP and Grant Creeks, trout survived in those streams in numbers comparable to historical levels. At the Three Forks sites, fish also survived despite short-term declines in water quality due to ash flows. These results contrast with much more destructive effects of earlier wildfires on streams west of the White Mountains along the Mogollon Rim. A coarse comparison of fire impacts indicates that the percent of the watershed burned at moderate or high severity is a reliable predictor of fish survival. Landscape attributes such as basin slope, geology, aspect, and stream power index are useful predictors of vulnerability to wildfire because they influence both the severity of the fire and channel responses. Field observations suggest that localized factors such as the presence of roads and spring-fed refugia in drainage bottoms mediate fire impacts. Streams occupied by Apache trout are similar in topography, geology, and vegetation to the burned streams in the White Mountains, and therefore they appear less vulnerable to wildfire than streams along the Mogollon Rim. Nevertheless, the risk to multiple populations of a threatened species warrants proactive treatments to rehabilitate roads in drainage bottoms and safeguard critical springs.

THE STATE OF THE CO RIVER ECOSYSTEM IN GRAND CANYON OR SCORE REPORT: LESSONS FROM 10 YEARS OF ADAPTIVE MANAGEMENT IN GRAND CANYON

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The year 2005 marks the 10th anniversary of the completion of the Final Environmental Impact Statement (EIS) on the Operation of Glen Canyon Dam. A decade of research and monitoring provides an important milestone to evaluate the effects of dam operations on resources of concern and determine if the desired outcomes are being achieved and whether they are compatible with one another or not. A comprehensive effort was undertaken by the USGS, Grand Canyon Monitoring and Research Center to assess the scientific state of knowledge of resources of concern, as identified in the EIS. The result was the production of a peer-reviewed publication, "State of the Colorado River Ecosystem in Grand Canyon" or SCORE Report. This report is the first systematic attempt to conduct an assessment of the changing state of Colorado River ecosystem resources in Grand Canyon over a decadal timeframe. Table II-7 of the EIS contains 30 predictions or expected outcomes for how various resources would respond under the preferred alternative of Modified Low-Fluctuating Flows (MLFF). Because of a lack of data or subsequent analyses to confirm whether the prediction stated in the EIS was correct, or not, 14 or 47 percent of the outcomes, are essentially unknown, despite ten years since completion of the EIS. These unresolved outcomes constitute an important list for further study in the program. Excluding outcomes that are unclear, then the remaining predictions in the EIS were correct in 5 out of 16 outcomes, or 31 percent of the categories listed. Mixed outcomes occur in 6 out of 16, or 38 percent of the categories, and failed

predictions, occur in 5 out of 16, or 31 percent of the categories. These disparities underscore the uncertainties associated with working in a large complex system with limited data. The acceptability of this kind of uncertainty is influenced by interpretation, societal values, agency missions and mandates, and other factors. However, failure to correctly predict the future, in and of itself, is not deleterious under the paradigm of adaptive management where large uncertainties provide opportunities for learning and adjustment through an iterative process of "learning-by-doing." The report makes clear that dam operations during the last 10 years have benefited some resources under MLFF, they have not restored fine sediment resources or native fish populations in Grand Canyon, two resources of significant importance to the program.

GLOBAL WARMING AND INSECT OUTBREAKS IN SOUTHWESTERN FORESTS

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Insects are historically the greatest cause of disturbance in forested ecosystems, and may dramatically exceed historic levels during times of climate change. Populations are particularly sensitive to changes in temperature, precipitation, and the seasonality of climate. The response time to changing climate is very short, as insect population dynamics change dramatically once threshold conditions are reached. Forest insects in western North America have already been influenced by recent climate trends: Outbreaks have been more extensive and severe, further north or at higher elevations, or of species that were previously unknown or innocuous. Warming climate also affects the likelihood that exotic pests will establish and become pests, with potentially serious consequences for sensitive ecosystems. A seemingly small increase in temperature (about 1°C since 1940 at 2100 m) has dramatically altered the seasonality of temperature limits associated with insect populations. Winter is shorter and minimum temperatures are warmer. Spring is earlier, warmer and less frosty. In some areas, warmer temperatures have been accompanied by drought. Many of the contemporary insect and disease outbreaks are clearly associated with these warm temperatures, while others are associated with prolonged drought. As climate change progresses, insects and pathogens will serve as agents of change, catastrophically disrupting forest ecosystems in relatively short periods of time.

EVIDENCE FOR CLIMATE FORCING OF HISTORIC STAND-REPLACING FIRE OCCURRENCE IN UPPER MONTANE FORESTS OF THE SOUTHWESTERN UNITED STATES

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We sampled sixteen sites in the upper montane vegetation zone of eight mountain ranges in Arizona, southern Colorado and New Mexico to date historical stand-replacing fires. Stand-replacing fire dates were determined from seral, post-fire quaking aspen stands using multiple lines of tree-ring evidence. The four lines of evidence included: 1) aspen inner-ring dates, 2) fire-killed conifer bark dates, 3) tree-ring width changes or other morphological indications of injury and 4) fire scars. Eighteen stand-replacing fires were reconstructed between 1842 and 1904. Multiple sites, separated by hundreds of kilometers, recorded fires during three years (1851, 1861, and 1879), thus ten unique fire dates were used for the climate analysis. All stand-replacing fires occurred during drought years, as indicated by negative reconstructed summer PDSI. The average PDSI value for all fire years (-2.53) indicates moderate to severe drought conditions associated with stand-replacing fire occurrence. It is possible that an anomalous, multi-year pluvial followed by a multi-year drought in the mid 19th century was the cause of the documented stand-replacing fires. Similar oscillations from multi-year wet to multi-year dry conditions in the early 21st centuries may be partially responsible for recent stand-replacing fires in the upper elevation forests of the region.

COMPARISON OF THINNING TECHNIQUES FOR PINYON-JUNIPER ENCROACHED SHRUBLANDS ON THE SHIVWITS PLATEAU, ARIZONA

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The encroachment of pinyon and juniper trees into historically shrub-dominated landscapes has caused major changes in ecosystem structure and function, including dramatic changes in fuel structure and fire regimes. Restoration techniques are often labor intensive and expensive to implement, so it is prudent to determine their effectiveness before they are applied over large areas. Land managers on the Shivwits Plateau in northwestern Arizona are currently faced with thousands of acres of tree-invaded shrublands, some within wildland/urban interface areas, and are seeking effective techniques to restore these areas to pre-invasion conditions and reduce wildfire hazards in the process. We established a study to test the effectiveness of 3 techniques for reducing the density of post-invasion pinyon and juniper trees: (1) cut and leave, where 80% of the trees were cut down and left where they fell; (2) cut and scatter, where 80% of the trees were cut down, then bucked and scattered; and (3) herbicide, in which 80% of the trees were sprayed with Tordon 22k around the base of their trunks. Treatment plots were 20 acres, with 8 replicates each of the 3 treatments plus an untreated control. We are currently evaluating changes in vegetation composition and fuel structure in response to the treatments. First year results suggest a strong effect of the herbicide treatment on density and cover of herbaceous plants, generally 200% higher compared to the untreated control, and of species richness at a 1000-sq-m scale, increasing by about 10 species versus the control. Changes in vegetation composition and fuel structure will be monitored in the future, with the goal of identifying the treatment method that will create a high diversity plant community dominated by shrubs, perennial grasses, and forbs, plus a fuel bed structure that will promote periodic burning to prevent re-invasion of pinyon and juniper trees.

WILDLIFE WATER DEVELOPMENTS AND THE SOCIAL CONSTRUCTION OF CONSERVATION CONFLICT

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Public land and wildlife managers built numerous developments throughout the arid and semi-arid West to artificially provision wildlife with water at a time when these developments were assumed to be a universal good. Within the last 15 yrs some public-land stakeholders have questioned both the efficacy and legality of these wildlife water developments, recently in often highly publicized ways. The resulting conflict has challenged all participants in this policy issue, with a resulting turn to science and the courts as final arbiters. We used methods of narrative and discourse analysis to examine the oral and written material in this case, drawing on scientific and media articles, promotional literature, and statements of participants in conversations and at a public workshop held during November 2004 in Phoenix, AZ. Our goal was to better understand underlying value demands and the framing context to facilitate identification of methods for finding common ground. We differentiated 9 narrative elements – 5 characterizing the dominant discourse and 4 characterizing the counter-discourse. The dominant discourse was articulated primarily by those self-identified as hunters and wildlife managers, and promoted the virtues of hunting culture and pragmatism, the primacy of bureaucratic control, the special status of science, and the governance model of total quality management (TQM). The counter-discourse was articulated primarily by self-identified environmentalists, as well as by those interested in process reform, and promoted the virtues of pristine nature, the need for compliance with federal policies, redistribution of access to power and respect, and the imperative of common ground. These conflicting discourses were rooted in fundamentally different worldviews regarding governance and human relations with nature. We see little prospect for finding common ground as long as participants remain focused on worldview differences, using authority and science to strategically advance their interests. We suggest an alternative approach that authoritatively engages conflicted stakeholders in collaboratively solving concrete problems with a common interest focus.

PREDATION BY COUGARS IN THE FLAGSTAFF UPLANDS 2003-2005

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Predation rates and prey composition are relevant to judging effects of cougars (*Puma concolor*) on ecosystems. Radiocollars that frequently obtain and satellite-transmit GPS locations provide researchers with unprecedented opportunities to collect sustained reliable information on cougar predation. We fitted 10 cougars (5 males and 5 females) in the Flagstaff uplands of Arizona with Telonics GPS/Argos radiocollars and collected information from nearly 200 kills made by these animals between July 2003 and October 2005. We also obtained a comprehensive record of movements based on 4-hour-interval GPS locations from collars deployed on and dropped by 3 males and 4 females. As of August 2005, 38% of kills were elk (*Cervus elaphus*), 34% were deer (*Odocoileus* spp.), and 21% were smaller mammals. Elk <1-year-old comprised the largest single category of kills (26%). Compared to adult females, adult male cougars killed more elk and fewer small mammals. Four female cougars killed a total of 27 mesocarnivores, of which 21 (13% of total kills) were coyotes (*Canis latrans*). We also documented 7 instances of scavenging, all on adult elk. Almost all kills occurred between 1700 and 1100 hours and were most frequent between 2100 and 0500 hours. Median intervals between kills ranged from150 to 288 hrs, depending on the animal. Median time spent consuming large prey (>30 kg wet weight) ranged from 47 to 96 hrs, whereas median time spent consuming small prey ranged from 25 to 49 hrs. Our future objectives for this study include collecting more of the types of information summarized here as well as an analysis of features associated with successful predation and different types of behaviors observed at kills (e.g., burial and dragging of carcasses).

DRY PRESERVATION OF ICE AGE ORGANIC REMAINS AND THE UNIQUE RECORD OF VERTEBRATE FAUNA OF COLORADO PLATEAU CAVES

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Caves as unique resources for Pleistocene (Ice Age) vertebrate faunas is not a new idea, yet now it is timely to revisit their value. The Pleistocene contains two North American Land Mammal Ages: Irvingtonian (~1.8 – 0.15 Ma; million of years ago) and Rancholabrean (~0.15 – 0.011 Ma). Of the greater-than 150 Rancholabrean-age mammal localities in Arizona and the Colorado Plateau, the most valuable data sets (vertebrate fossils in association with macrobotanical data) come from localities with dried-preserved remains. The Colorado Plateau contains predominantly sedimentary formations of Paleozoic and Mesozoic age. Many of the rock units have the capability to produce alcoves, rock shelters, and caves. Coupled with these long-lasting natural structures is the semi-arid climate of the region. These criteria have permitted an inordinate amount of biological data to be preserved for tens of thousands of years – data that is typically lost to decay. Grand Canyon contains a particularly rich repository of caves and alcoves due predominantly to the exposure of the Redwall and Muav limestone. Considering that the exposure of these rock units continues almost the entire 277 river miles of the Colorado River (plus miles of side canyon exposures), literally thousands of caves are known from the park. Dry-preservation of fossils in these caves is the rule, not the exception, yet only about 300 to 400 caves are recorded and extremely few are adequately assessed of their paleontological resources. Types of preserved fossils include: dung, muscle tissue, hair, bone, bone chemistry, plant macrofossils, pollen, and microhistology. Caves preserve important data sets, such as: 1) precise dating the extinction of Harrington's mountain goat and ground sloth, 2) arrival of the bighorn sheep, 3) extinction of the mammoth and shrub-ox, 4) plant community mosaic through time, 5) diet of the extinct mountain goat, mammoth, ground sloth, shrub-ox, and 6) extirpation of the condor and bison. The resource is available for basic research questions but can and should be used for wildlife land management issues such as: 1) when did the wapiti arrive, and 2) is the river otter a recent introduction as is the javelina?

THE BEES OF GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT: DYNAMICS, DISTRIBUTIONS, AND DIVERSITY

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Solitary bees, a key component in many ecological systems, are thought to be most diverse in southwest North America, a region dominated by the Colorado Plateau (CP). Despite the CP's large size and distinctiveness, few studies of its bee fauna exist. A fifteen-year study of the San Rafael Swell (south-central Utah) represents the most intensive survey prior to 2000. Results hint at the potential of the CP for rich and abundant faunas, and also suggest that bee patterns of richness and abundance in the southwest follow a bimodal distribution across the season. However, there are several gaps in the study. Both spatially, and across the fifteen years, collections were variable and sporadic making any statistical analysis virtually impossible. A four-year study in Grand Staircase-Escalante National Monument (GSENM) provided an opportunity to better understand the bee fauna of the CP. At the edge of the CP where cold and hot desert regimes meet and encompassing nearly 2 million acres and numerous habitats, GSENM provided an ideal setting in which to study one CP bee assemblage. Specifically, we aimed to: 1) establish baseline data for monument managers, 2) address biologic boundaries produced by the juncture of two disparate climates 3) establish one-hectare plots for long term monitoring (plots that would also allow for statistical comparison of alpha and beta diversity across the monument), and 4) assess the degree to which landscape characteristics influence community structure. We have recorded 643 bee species in GSENM. Our results have expanded known distributions of several bees. Species previously thought restricted to hot deserts have been found in GSENM; the same is not true for known cold desert bees. GSENM's bees have proven highly spatiotemporally variable, both in terms of richness and abundance. Bimodal patterns are marked. We used ordination techniques to illustrate the minimal role that habitat plays in defining bee communities, especially compared to elevation and geographic region. Floral resources dictate bee abundance more than richness. These results provide a foundation for further bee studies on the CP, illustrate the intrinsic variability of desert bees, and indicate the CP's potential for rich, unique faunas.

THE EFFECTS OF TRAVERTINE DAMS ON LEAF LITTER RETENTION IN FOSSIL CREEK, AZ

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Leaf litter, a form of coarse particulate organic matter, has been shown to provide an important source of carbon in smaller and shaded streams. We conducted an experiment to determine if travertine dams are important factors in leaf litter retention in Fossil Creek, Arizona. Fossil Creek is a first order stream which has had a >90% stream flow diversion for hydropower use for nearly 100 years, until decommissioning occurred this June 2005. We released 2000 leaves along each of six reaches before decommissioning, three free flowing and three with travertine dams. This experiment is being repeated at all sites currently, now that dam decommissioning has occurred and full stream flow has been returned to the creek. Methods of data collection include collecting released leaves in seine nets at the end of each site, capturing average velocity and stream discharge at each site, measuring mass of travertine dams and coarse woody debris, capturing average substrate coarseness at each site, recording distance traveled, and recording leaf retaining substrate for all visible leaves. Our preliminary data has found greater leaf retention in the travertine sites. Lower velocities and greater abundance of coarse woody debris were also found to be factors that increased leaf retention in the travertine reaches. Substrate coarseness was not significantly different among the sites. The decommissioning of Fossil Creek Dam provides a unique opportunity for researchers to observe ecosystem restoration, as research on dam removals is still limited. There are expectations that restored flow to Fossil Creek will increase travertine deposition, which will result in an increase in the number of travertine dams over time. According to this experiment, new travertine formations will result in an increase of leaf retention in these areas, which will benefit the food base.

REMOVAL OF PINYON-JUNIPER WOODLANDS ON THE COLORADO PLATEAU

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Pinyon-Juniper (PJ) woodland cover 35% of the Colorado Plateau, and is the largest vegetation type administered by the Bureau of Land Management (BLM) on the Colorado Plateau. These woodlands have been increasing dramatically in density and extent over the last 100 years. In response to this increase and a concomitant loss of grasslands, the BLM has been actively treating the landscape by clearing pinyon and juniper and reseeding since the 1950's. Our project addresses a key need by mapping past treatments and acquiring all associated data, the first step needed to assess the effectiveness of past PJ removal and re-vegetation treatments. We have synthesized the archives in both an ArcMap geodatabase and an Oracle database (PJWOOD,) and made it available for online access of more than 100 variables, GIS datasets, and over 2000 photos and figures associated with treatments. The PJWOOD database allows for simple queries of individual treatments or synthesizing information across the Colorado Plateau. To date we have mapped the distribution of over 700 treatments encompassing ~700,000 acres of PJ woodland on BLM lands have been treated in the last fifty-seven years. This constitutes 7% of all pinyon-juniper on BLM lands. The number of treatments applied within a field office varied from 2 to 124 and treatment sizes varied from 1 to 14,417 acres. There were two well-defined periods we refer to as the "Chaining Era" from 1950 to 1979, characterized by chaining and/or bull dozing, and a "Diversified Methods Era" from 1980 to the present where prescribed burning was the most common but the hydroaxe, rollerchop, select hand thinning, and chemical treatments were also applied. These findings indicate widely distributed impacts on pinyon-juniper ecology and the opportunity for landscape level analysis and regional land management planning.

OPPORTUNITIES FOR LONG-TERM ECOLOGICAL RESEARCH AND MONITORING IN GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT

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Occupying 1.9 million acres of the Colorado Plateau physiographic province, the Bureau of Land Management's Grand Staircase-Escalante National Monument is characterized by gradients in elevation, climate, soils, land-use legacies, and contemporary management regimes that provide a rich matrix for ecological research and monitoring. In the 9 years since its establishment in 1996 as the largest unit in the Bureau's National Landscape Conservation System, the Monument has served as a unique field laboratory for studies investigating a wide range of ecological topics including broad-scale patterns in plant community composition; the importance of climate and substrate characteristics as factors driving the distribution, structure, and functioning of biological soil crusts; responses of amphibians and terrestrial invertebrates to the cessation of livestock grazing; effects of livestock grazing on vegetation structure and soil biogeochemistry; and the status of arbuscular mycorrhizal fungi communities in relation to field measures of soil quality. In 2005, a promising new phase in the development of the Monument's science program was initiated with the opening of a science-support facility in Escalante, Utah, and with the housing of a U.S. Geological Survey scientist at Monument headquarters in Kanab, Utah. The latter event marks the establishment of a multi-agency science partnership with the Survey's Southwest Biological Science Center and the National Park Service's Zion National Park to increase opportunities for cooperation, collaboration, and scientific and technical support. Coincident with this new phase of science support and cooperation, new opportunities for ecological investigations are arising in a number of key areas that will benefit from a regional perspective. Particular needs and opportunities include monitoring of long-term environmental change, restoration of damaged dryland ecosystems, application of research and monitoring to adaptive management of Monument resources, and development of approaches to address human dimensions of current and future resource-management challenges.

COLORADO PLATEAU AQUATIC INSECT COMMUNITY CLASSIFICATION

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Small, free-flowing streams and rivers on the Colorado Plateau may provide important refuge habitats for fish, invertebrate, and algal species that have been extirpated from the larger rivers due to water regulation. Unfortunately, the biology of these smaller systems is not well understood. Our research focuses on describing and classifying the aquatic communities in the free-flowing streams and mid-sized rivers on the Colorado Plateau. We are developing a hierarchical stream classification system to relate aquatic insect diversity and abundance to stream habitat parameters, such as streamflow permanence, channel morphology, substrate type, and algal abundance at the multiple scales. At the regional scale, we expect that the range of different flow regimes (from snowmelt-fed perennial systems to monsoon-driven ephemeral streams) limits aquatic insect distribution. We expect that relatively benign perennial streams have a rich biota, whereas biodiversity in ephemeral streams will be more limited. At a finer scale, physical habitat parameters are expected to describe aquatic insect diversity and abundance. Preliminary data from the Plateau indicates that the insect community assemblages of high-gradient, bedrock dominated streams are markedly different from the community in low-gradient, sandy streams. Research in other ecoregions has shown that aquatic insect diversity and richness are correlated with stream habitat type and our work will allow a “typology” of habitat associations for aquatic insects to be created for the Colorado Plateau. This classification system will have practical application for land management on the Colorado Plateau as most of the land is managed by the federal government. A hierarchical stream classification would allow managers to use physical parameters to manage small streams at multiple scales. These data will allow managers to make more informed decisions about stream and river restoration in this ecologically unique region.

THE DISTRIBUTION AND OCCURRENCE OF CHEATGRASS (BROMUS TECTORUM) POPULATIONS ON THE UNCOMPAHGRE PLATEAU

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In recent years Cheatgrass (Bromus tectorum) has become a more serious and prevalent weed throughout the Colorado Plateau. It continues to expand and occupies more diverse habitats. Studies were initiated in 2004 to locate and map sites within the Uncompahgre Plateau that were occupied with this annual grass. Areas of occurrence were classified by site conditions including soil type, vegetative communities, elevation, climatic conditions, and site disturbances. In addition, plants were collected from all principal locations and used to complete DNA tests to determine the presence and distribution of separate ecotypes. Studies demonstrated that cheatgrass primarily occupies disturbances including sites lacking native understory, roads and other related construction projects, and areas disturbed by livestock and wildlife activities. This annual weed is now so widely distributed that any disturbance results in immediate occupation by this grass. Between 15 and 20 separate ecotypes have been identified to occur within the Plateau. In contracts to studies within the Great Basin, the distribution of separate ecotypes is not so uniquely oriented. In general, most ecotypes were found throughout all community types, elevations, and site conditions. Apparently invasion of the weed has been a recent event, and individual ecotypes are adapted to most conditions that exist. Separation of specific ecotypes to particular sites has not occurred.

A HOLISTIC APPROACH TO MONITORING: THE POET MODEL

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The majority of the forests in the Southwest are ecologically degraded, baring a threat of catastrophic wildfire that would not only negatively impact ecosystems, but also could consume whole communities. For land practitioners that are faced with these pressing priorities, a new ecological/social paradigm has emerged. Within the new paradigm, community protection, ecological restoration, and a variety of social considerations and adaptations come into play. In order to assimilate the new paradigm within the context of land management priorities, a holistic approach can be conceived through the POET model. The POET model contains four interconnected variables that include: 1) population, 2) organization (social), 3) environment and, 4) technology. This model can aid in conceptualizing the shifting paradigm as well as organizing the response to its components. In response to the shifting priorities, new ecological techniques such as fuels reduction and ecological restoration prescriptions are tested. In order to assess their success, a holistic approach to monitoring the various alternatives is essential. Therefore, monitoring becomes an interdisciplinary link in determining whether "modern forestry" is succeeding in conjoining forces with the new ecological/social paradigm. In order to construct an effective monitoring protocol, all factors that will be affected by the outcome should be incorporated that include fuels reduction, ecosystem restoration, social issues and economic health. In addition, monitoring should avoid hidden sociopolitical or socioeconomic agendas, while its protocol should incorporate a research design utilizing program evaluation, a systematic fact-finding procedure that is objective and neutral. In utilizing this approach, monitoring results will be perceived as non-threatening and guiding. Although a multitude of experimental land management activities are currently being implemented, monitoring, set aside, has become a missing link within an adaptive management framework. In order to illustrate this approach, The Greater Flagstaff Forest Partnership (GFFP) Monitoring and Research Team has collaboratively developed an Adaptive Management Monitoring Framework. Within this presentation, both theoretical and practical applications of the monitoring and adaptive management process will be discussed.

MECHANICAL MASTICATION VS. SLASH BURNING TREATMENTS IN A PINYON-JUNIPER ECOSYSTEM: EFFECTS ON UNDERSTORY PLANT COMMUNITIES AND THEIR ARBUSCULAR MYCORRHIZAL ASSOCIATIONS

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There is considerable debate about the need for tree thinning and fuel reduction programs in pinyon-juniper woodlands of the Colorado Plateau. Despite the lack of agreement on if and how fuels should be reduced in this woodland type, increased pinyon mortality and high tree densities near housing developments have been the incentive for fuel management efforts in some areas. Existing management practices such as thinning and burning slash piles have been shown to benefit exotic plant species to a greater extent than native plants and to decrease soil arbuscular mycorrhizal (AM) propagules. Mechanical mastication is a new and alternative thinning treatment in which 'hydro-mow' equipment is used to shred live trees into wood chips with rotating blades and distributes the resulting large chips across the topsoil. Little is known about the effects of this thinning treatment on soil properties, plant communities, or mycorrhizae. Our study compares both one- and two-year old mastication and slash pile burns in a pinyon-juniper ecosystem near Dolores, Colorado. The following research questions will be addressed: Will mechanical mastication or slash pile burns: 1. Affect soil properties and available soil nutrients over time? 2. Change plant communities by increasing or decreasing native plant richness or exotic plant establishment? 3. Alter AM fungal abundance, community type, root colonization and/or inoculum potential? Preliminary data collected in August 2005 will help determine if mechanical mastication changes soil properties and nutrient availability, AM community, abundance and colonization potential, or plant community structure when compared to impacts from burnt slash piles and non-treated areas. Data on these same response variables will be collected in 2006 to provide an assessment of the temporal variation in the effect of these treatments. Results of this study will help determine if there is a preferred method to promote understory native plant richness and AM abundance and diversity, and thus decrease the opportunity for exotic plant establishment.

ARIZONA WILDLIFE LINKAGES

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Wildlife movement today is increasingly restricted as the majority of the remaining natural habitat is being isolated, impacted, or lost through human development and the building of structures such as fences, roads, canals, border security infrastructure, and reservoirs. The Arizona Department of Economic Security projects that the state's population will increase by 54% from 4.7 million in 1998 to 7.4 million in 2020. Arizona may soon lose its status as a state of wide-open spaces and low human impact. In order to protect the safe movement of people and wildlife, as well as maintain natural areas across Arizona for wildlife movement, a comprehensive approach is needed to protect the state's

ecological resources. Loss of connectivity is by no means inevitable, and growth of the human population does not always have to result in proliferation of barriers. Although road-widening projects generally increase vehicle traffic, such undertakings present the greatest opportunity to provide crossing structures that accommodate wildlife movement. Because most of Arizona's roads were not originally designed to accommodate wildlife movement, future highway construction and maintenance projects can dramatically improve permeability. Slower progress is anticipated when making canals and railroads more wildlife-friendly because these structures are not as regularly upgraded, as are roads. Fortunately, most important human structures are eventually upgraded, creating opportunities to improve connectivity. However, it is important to note that such improvements cannot happen unless policy makers and planners are aware of the necessity for wildlife connectivity in such project areas. The Arizona Wildlife Linkages Workgroup (AWLW) is an important collaborative effort between public and private sector organizations addressing habitat fragmentation in a cohesive, systematic approach intended to maintain and improve Arizona's wildlife biodiversity. The AWLW has developed a statewide map and report identifying 109 potential wildlife movement corridors as a tool to guide future planning, engineering and mitigation efforts. This map is a fluid product and will undergo revisions as additional information becomes available. Each linkage has been prioritized based on biological importance, existing and perceived threats, and potential opportunities in order to better direct the immediate efforts of the development of linkage designs.

UPPER STREAM VS LOWER STREAM WATER QUALITY OF EIGHT SOUTHERN UTAH STREAMS

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Most stream models predict the best water quality at or near the source (upper elevations) and deterioration downstream (lower elevations) as dissolved inorganic and organic matter accumulate. In a 15 month field study of 29 sampling sites on eight Southern Utah streams, preliminary monthly data indicates approximately half of the streams sampled had poorest water quality near the source of some streams and improved water quality downstream. The suspected deleterious factor is cattle grazing in and around the riparian zones. Parameters measured include temperature, conductivity, total dissolved solids, % dissolved oxygen, mg dissolved oxygen, pH, oxygen reduction potential, phosphates, nitrates, and salinity. Another year of monthly sampling should identify the best water quality parameters for detecting problematic riparian management practices and suggest acceptable ranges for each parameter.

WILDERNESS RESTORATION: LEGAL AND POLITICAL CONSIDERATIONS FOR WILDERNESS AREAS AND NATIONAL PARK SERVICE LANDS IN NORTHERN ARIZONA

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Restoration in wilderness areas and national parks presents a unique set of legal and political considerations that surpass those on most public lands. In Wilderness Areas (WAs) that contain fire dependent ecosystems, the debate whether or not to utilize prescribed fire has been ongoing since the 1970s. The debate hinges on the balance between whether we should have WAs that are natural, or untrammeled (i.e wild or self-willed). The National Park Service is using prescribed fires to restore fire dependent ecosystems in many areas. However either management preference or public resistance often limits/precludes any mechanical thinning. This analysis addresses legal and political issues surrounding the restoration debate in four northern Arizona wilderness areas (Mt. Trumbull, Mt. Logan, Kendrick and Kachina) and the north rim of Grand Canyon National Park.

CHALLENGES AND REWARDS OF COLLABORATION TO RESTORE FOSSIL CREEK

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Over the last 15 years, the Forest Service has been a key agency involved in several major efforts involving Fossil Creek, including the Childs-Irving Hydroelectric Powerplant Relicensing/Decommissioning project, the Fossil Creek Watershed Assessment, and the Fossil Creek Native Fish Restoration Project. The complexity, timing and overlap of these projects required a high level of communication, coordination, and collaboration to get to where we are today: decommissioning of the two power plants and restoration of full flows, restoration of Fossil Creek for native fish, and development of a management plan (in progress) to deal with the future management of the Fossil Creek area. While we were involved through the 1990's as biological resource advisors to the various projects, our involvement intensified as simple relicensing evolved into a project to restore native fish. Communication and coordination among 2 National Forests and a host of other players was challenging because of their differing missions, goals, perspectives, and values. Key issues included the disposition of Fossil Springs dam, wilderness and wild and scenic rivers impacts, and long-term control of non-native fish. We will discuss the challenges and rewards as we worked through these complex issues to the successful implementation of the native fish project. Experiences and lessons learned should help in future endeavors as scientists and managers grapple with similar issues and limited agency budgets.

THE FLYCATCHER AND THE PHOENIX: RIPARIAN HABITAT CREATION AND DESTRUCTION IN A FLUCTUATING RESERVOIR.

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The Southwestern Willow Flycatcher (*Empidonax traillii extimus*) is an endangered neotropical migrant and riparian obligate nester. As much as 95% of riparian habitat has been destroyed or degraded in the southwest, resulting in a sever reduction of habitat for the flycatcher and resulting in its subsequent decline. One important "source" of riparian habitat for the flycatcher is the exposed lake bed of fluctuating reservoirs across the southwest. When reservoirs are drawn down for multiple years, which can occur during drought periods, lush riparian forests can quickly emerge from the exposed lake bed. These high quality riparian forests are quickly colonized by riparian bird species, including Willow Flycatchers. One such breeding site, Roosevelt Lake in central Arizona, has been intensively studies for the last 10 years. In 1995 the reservoir was at full capacity, but gradually over the following nine years the reservoir level has fallen to historically low levels due to a sustained drought, creating abundant riparian vegetation in the exposed lake bed. Flycatchers, which prefer young, dense habitat, rapidly colonized the new habitat, tracking the bands of new habitat created by the gradually falling lake levels. The flycatcher population responded to the huge influx of habitat by increasing in size from around 40 individuals to almost 400 by 2004, becoming the largest known flycatcher breeding site. In 2004, almost all flycatchers were breeding in this young habitat; however, unusually heavy precipitation in the 2004/2005 winter caused the lake level to rise 70+ feet, completely inundating virtually all the new habitat. Ironically, that which destroyed this breeding habitat, the reservoir, is also what created it, and if the lake level was held down for a long period of time the habitat would become unsuitable to flycatchers and begin to die. This trait of reservoirs, their continuing cycle of habitat creation and destruction, in many ways mimics the dynamic nature of large, free-flowing river systems which no longer exist in the southwest; this understanding should lead to strategic management of these high quality, albeit temporary, riparian woodlands for all bird species.

INDIRECT EFFECTS OF UNGULATE BROWSING ON INSECT COMMUNITY STRUCTURE

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The growth and reproduction of woody plants are potentially constrained by ungulate browsing, consequently altering the resources available to insect communities. Specific changes in vegetative and floral attributes may be responsible for alterations in the insect community structure. We examined the relationships between vegetative and floral characteristics of grazed and ungrazed Ceonothus fenderli shrubs and their insect communities in ponderosa pine forests of Northern Arizona. Ceonothus fenderli shrubs were caged to protect them from browsing elk and deer and paired with a non caged shrub in the same area. Three years of data show that protected shrubs had longer stem lengths, greater number of stems and more flowering stems. We found a significant difference between the insect communities, with higher abundance and greater diversity of insect families on protected shrubs. Seven different insect families were indicators of protected shrubs, while there were no evident indicator families for unprotected shrubs. Insect abundance and diversity were strongly correlated with the number of flowering stems and stem height. Our results indicate that ungulate browsing of Ceonothus fenderli shrubs indirectly affects insect communities, suggesting that protection from browsing or alteration of grazing patterns could be a useful application for supporting a diverse insect community in ponderosa pine forests.

COLEOPTERA AND HYMENOPTERA DIVERSITY IN SALT CREEK CANYON, CANYONLANDS NATIONAL PARK, UT

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Recent evaluations of the status of biotic inventories indicate a very limited understanding of terrestrial arthropod biodiversity in U.S. national parks (Stohlgren and Quinn 1992, St. Clair et al. 1994, Stohlgren et al. 1995). Such descriptive work is a necessary prelude to the successful monitoring of the ecological effects of human activities in national parks. As part of a study on the possible effects of off-road vehicle use, Salt Creek Canyon in Canyonlands National Park, UT has since April 2000 been subject to an intensive effort to sample terrestrial arthropods in the canyon. Work in Salt Creek Canyon provides an opportunity to increase our knowledge of the biotic resources in a western national park. Here, we present a description of Coleopteran and Hymenopteran biodiversity in Salt Creek Canyon, and compare the Salt Creek Canyon beetle fauna to that of North America as evaluated by Marske and Ivie (2003). Ninety-nine morphospecies from 35 families have been collected in Salt Creek Canyon, representing 27% of the families and only 0.39% of the species found in North America. For North America, 10% of the families contain 75% of the species. In contrast, 75% of the Salt Creek Species are found in 31% of the families. Like the North American fauna, 50% of the Salt Creek Canyon species are found in the five most speciose families found in the canyon. When individual families are considered, in Salt Creek Canyon, 34% (12/35) of families contain more than 1% of the species in the canyon, whereas for North America only 14% (18/129) contain more than 1%. A list of families and genera is provided along with a discussion of possible range extensions for three genera of Scarabaeoidea. The Salt Creek Canyon Hymenoptera fauna consists of 26 families out of the 77 described by Borror et al. (1989), with 30% (8/26) of the families from the Chalcidoidea. Fifty-eight morphospecies have been tentatively established. A list of families and approximate number of morphospecies is provided.

MODELING POST WILDFIRE HYDROLOGIC EVENTS USING THE FULLY DISTRIBUTED MODEL MIKE SHE

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The western United States has experienced unprecedented catastrophic wildfires in the past three years. Next to the combustion of forest vegetation during a wildfire, the most destructive impact of a wildfire comes from post-fire flood peak flows. These flows can severely affect stream physical conditions, aquatic habitat, aquatic biota, cultural resources and human health and safety. Being able to accurately model such flood events is important for post-wildfire watershed restoration efforts, protecting human health and safety, and identifying key areas that need to thinned in order to protect important municipal and wildland watersheds. Industry specific data models, such as the Danish Hydraulic Institute's MIKE models, can be used within a single GIS platform to model such flood events. We are in the process of taking data from four previous wildfires in Arizona, namely the Coon Creek fire of 2000, the Rodeo-Chediski of 2002, the Aspen fire of 2003, and the Willow fire of 2004 to calibrate our model for the southwestern ponderosa pine forests and pinyon juniper woodlands. MIKE SHE (European Hydrological System Système Hydrologique Européen) is a fully distributed model that allows for spatially distributed rainfall data within a watershed. This is one of the essential key factors in modeling post-fire hydrologic events in steep mountain watersheds in the Southwestern US. Other spatially distributed values, such as soil conditions, burn severities can also easily incorporated into the MIKE SHE model. Yet another advantage of the SHE software is that is allows for lateral subsurface flow, which usually not found in other hydrologic modeling software. Once we have calibrated the model to the ponderosa pine forest and pinyon juniper woodland ecosystems, we hope to be able to accurately model post wildfire floods in these ecosystems. Through this effort we intend to be able to identify areas at high risk of flooding in the event of a wildfire. This in turn will allow us to guide restoration efforts post wildfire as well as prior to potential wildfires.

DOES PRESCRIBED FIRE AFFECT BARK-FORAGING BIRD DENSITY IN WINTER?

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Historically, ponderosa pine (Pinus ponderosa) forests of the southwest have had fire as a component of the system. These fires were of low intensity and generally stayed in the understory, maintaining an open, park-like stand. Forest practices of the past century, including fire suppression, livestock grazing, and logging have led to denser forests carrying higher fuel loads. This has led to unnatural and large crown fires that are destructive to the habitat. To combat these large fires, forest managers are attempting to simulate past fire regimes by using prescribed fire to reduce fuel loads. While the effects of large fires on avian species have been well documented, there have been few studies on the effects of prescribed fire on birds and none have been conducted during winter. Winter may be a critical time for resident species, since food is generally limited. This study was designed to examine the effects of prescribed fire on resident bark-foraging birds, including hairy woodpecker (Picoides villosus), pygmy nuthatch (Sitta pygmaea) and white-breasted nuthatch (Sitta carolinensis) during winter. The study sites were located in northern Arizona, as part of the larger Birds and Burns Network of the Rocky Mountain Research Station. Prescribed fires were conducted during the fall of 2003 and spring of 2004. Distance sampling to evaluate individual species density occurred on the burned plots and the corresponding control plots during the 2004-2005 winter season. Bark beetle surveys were also conducted during this time to assess the presence of food for the focal species on the plots. Preliminary results suggest that hairy woodpeckers occur in higher densities on the burned plots than the controls. This may be attributed to the increased presence of bark beetles on the burn plots after prescribed fire. White-breasted nuthatches, however, have similar densities in burned and control plots, while pygmy nuthatches show a higher density in the burned plots at only one of the study sites. Data collection will continue during the upcoming 2005-2006 winter season. Information provided by this study will assist forest managers in their ecological assessments included in their fire prescriptions.

CAVES AS REFUGIA FOR NON-TROGLOBITIC ORGANISMS DURING PERIODS OF DROUGHT, IMPLICATIONS FOR THE SOUTHWEST

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The importance of caves as habitat for troglobites, and serving as important breeding spots or hibernacula for taxa such as bats is well understood. However, the potential importance of caves as temporary habitat for a much larger set of species is often overlooked. During periods of drought, either seasonal and predictable, or related to more unpredictable long-term weather patterns, caves may serve as important refugia for small mammals, amphibians, and reptiles. During these periods caves may provide shelter, water (humidity), and/or food for normally non-troglobitic species. Over the course of three years in Arkansas, we surveyed the fauna of over 80 small caves in a single watershed. Cave use by salamanders during this time was strongly seasonal, with peaks during the hot and dry summer and autumn. In contrast, we found snakes and frogs in caves primarily during a single unusually hot and dry summer. We believe these taxa moved into the caves to maintain temperature and water balance, and perhaps to forage. All of these taxa were more likely to be found in cooler and more humid caves. In the southwest, there is a predictable annual dry period during the late spring and early summer, as well as a cycle of longer-term drought periods. During these periods, we believe caves may serve as important refugia for Tiger Salamanders (Ambystoma tigrinum), lizards, snakes, and small mammals. As few surveys have been done to date, we do not know the extent to which these taxa use caves. However, we propose that cave faunal surveys should include notes on the presence of non-troglobitic taxa, especially during periods when the outside climate may be stressful to them.

GEOLOGIC MAPPING OF THE GREATER GRAND CANYON REGION, NORTHWESTERN ARIZONA

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Previous geologic mapping of much of the area surrounding the Grand Canyon is not detailed enough to provide adequate support for current resource management decisions. To fulfill this need, the U.S. Geological Survey/National Park Service (USGS/NPS) cooperative geologic mapping project is producing 1:100,000-scale digital geologic maps of this region in ArcGIS geodatabase format. The geodatabase for some of these maps also includes compilation data at 1:24,000-scale. These maps, which include bedrock and surficial geologic units, faults, folds, joints, sinkholes, breccia pipes, volcanic vents, mines, diversion dams, and stock tanks provide a detailed geological framework for environmental resource studies of the southwestern Colorado Plateau and eastern Great Basin provinces. Maps completed thus far are being used to address two resource management questions: (1) Is there a connection between geology and threatened or endangered plant and animal species habitat? and (2) How might increased ground-water development adjacent to the Grand Canyon affect the water table and spring flows within Grand Canyon? Tentative correlations have been identified between geology and the habitat of some plant and animal species, including the Mexican Spotted Owl, Sentry Milkvetch, bats, and the rare Paradine Plains cactus. Hydrologic studies such as regional surface-water and groundwater flow system modeling are benefiting from an improved geologic framework that includes faults, folds, joints and karst features. The digital geologic map databases with their improved level of detail enable resource managers and researchers from other disciplines to evaluate and identify possible relations between geology and resources of interest. The maps also provide baseline data for land use and resource management decisions for National Parks and Monuments of northwestern Arizona as well as the Bureau of Land Management, Bureau of Indian Affairs, National Forest Service, State of Arizona, local communities, and private landowners.

KEEPING COMMON SPECIES COMMON

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The goal of the U.S. Geological Survey's Gap Analysis Program is to keep common species common by identifying those species and plant communities that are not adequately represented in existing conservation lands. Common species are those not currently threatened with extinction. By identifying their habitats, Gap Analysis gives land managers and policy makers the information they need to make better-informed decisions when identifying priority areas for conservation. The Southwest Regional Gap Analysis Project (SWReGAP) is a mapping and assessment of biodiversity for the five-state region encompassing Arizona, Colorado, Nevada, New Mexico, and Utah. The primary objective of this project is to use a coordinated mapping approach to create detailed, seamless maps of land cover, habitat for terrestrial vertebrate species, land stewardship, and management status. This information is analyzed to identify animal species habitats and natural land cover types that are underrepresented on lands managed for their long term conservation. Regional labs at Utah State University and New Mexico State University coordinated the development of regional products for land cover mapping, animal habitat modeling, and stewardship for the entire five-state region. Information will be presented on the goals, objectives, and methods for the land cover mapping, animal habitat modeling, stewardship mapping, and gap analysis components of SWReGAP. Presentations that follow will describe the SWReGAP products available for the Colorado Plateau region.

THE NATIONAL BIOLOGICAL INFORMATION INFRASTRUCTURE – SOUTHWEST INFORMATION NODE: A PORTAL TO BIOLOGICAL INFORMATION FOR THE COLORADO PLATEAU

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The National Biological Information Infrastructure (NBII) is an electronic information network that provides access to biological data and information on our nation's plants, animals, and ecosystems. The Southwest Information Node (SWIN), one of the regional nodes of the NBII network, encompasses the Southwestern states of Arizona, Colorado, Nevada, New Mexico, and Utah. In the Southwest, federal resource agencies, environmental organizations, corporations, and the public need access to critical biological information to more effectively address the conflicting demands on natural resources. SWIN is currently creating a Web-access gateway to biological information for the Southwest region. One of the geographic areas of focus for SWIN is the Colorado Plateau. SWIN, in collaboration with the Merriam-Powell Center for Environmental Research and other Colorado Plateau natural resource professionals, will develop a plan to establish a Colorado Plateau Information Project that could serve as the biological information portal for this area. The Great Basin Information Project (GBIP), a component of SWIN, could serve as the model for the Colorado Plateau Information Project. GBIP's goal is to provide consolidated and efficient access to information about the Great Basin and Columbia Plateau regions of the Intermountain West. A variety of GBIP information tools such as the Great Basin Bibliography, Great Basin Metadata Server, Internet Mapper, and Science Locator serve as examples of the mechanisms that can be used to provide centralized retrieval of valuable biological information for a region.

RIPARIAN VEGETATION AND ASSOCIATED WILDLIFE

RALSTON, BARBARA

This presentation describes changes in the riparian and fluvial marsh communities along the Colorado River in Grand Canyon from the closure of the Glen Canyon Dam and the beginning of the regulation of the river in 1963 to the present. To provide a better understanding of how dam operations have affected riparian vegetation, changes in Grand Canyon riparian vegetation during three periods of time (1963–80; 1980–91; 1991–present) that correspond to major operational changes at Glen Canyon Dam are discussed. The effects on riparian vegetation of both the modified low fluctuating flow (MLFF) alternative, which was implemented beginning in 1996, and the recent drought are explored. The session concludes with a summary of the findings with respect to riparian vegetation as habitat and its relationship to other resources and with a discussion of monitoring priorities within the context of the Glen Canyon Dam Adaptive Management Program.

ESTIMATING LAND SURFACE PHENOLOGY FROM SATELLITE IMAGERY

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Phenology, the study of the timing of biological events, is considered to be an important cause and/or consequence of global change. Surface/atmosphere boundary layer conditions (e.g., albedo, moisture content, surface roughness, etc.) vary considerably with changing stages of vegetation development. Satellite remote sensing provides a means of continuously monitoring vegetation phenology changes throughout a growing season and of monitoring medium- to long-term trends of annual phenological events. The satellite data record that is suitable for phenology studies dates back to 1989 at 1km spatial resolution for the conterminous US and to 1982 at 8km resolution for the globe. Trend analysis of four phenology metrics (time of start of growing season, end of season, duration of growing season, and seasonally integrated greenness) was conducted for the conterminous US. Results show that most of the changing trends in phenology of the US are caused by changes in land use or changes in agricultural practices (crop shifts, crop varieties, etc.). This illustrates that human impacts on the land surface have potential far-reaching impacts on our global climate system.

PHOSPHOROUS CONTROLS ON SOIL NITROGEN CONCENTRATIONS AND N-FIXATION RATES OF A RECOVERING SEMI-ARID PRAIRIE

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The UN Environment Programme estimates that 25% of earth's land is threatened by desertification: defined as "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities". These vulnerable systems sustain the livelihoods of over 1 billion people in more than 100 countries. While the causes of arid and semi-arid land degradation have become progressively clearer, understanding how land managers can better protect or reclaim these ecosystems is an increasingly important aspect of ecology. Nutrient controls on a variety of ecosystem processes were tested on a restored grassland on the front range of Colorado's Rocky Mountains. The grassland site resides on a reclaimed gravel pit that was planted to native grasses in 1997. The site has been used since 2001 to study plant invasions and, as a part of this goal, phosphorus addition plots (+P) and phosphorus reduction plots (-P) were created. Three years after fertilization was begun, it was noticed that the +P plots had significantly higher inorganic nitrogen (N) concentrations than the control plots ($p = <0.001$). We hypothesized that the added P was enhancing the biological soil crust community's ability to fix N from the atmosphere and add it to this ecosystem. We employed the acetylene reduction assay technique to test this hypothesis and found that the +P plots had over 2x the N-fixation rates of the control plots ($p=0.036$), fixing just over 5 Kg/ha/yr of N. The increase in soil N as a result of fertilization with P was an unwanted result in the original experiment but offers interesting opportunities for land management. It is possible that, by relieving a P limitation, recovering lands could receive a "natural" source of N in non-saturating quantities through enhancing the soil crust community's ability to fix N. This adds support to the large body of knowledge showing the importance of biological soil crusts to arid and semi-arid ecosystem function and highlights possibilities for their employment in effective land regeneration and management.

AVIAN COMMUNITY RESPONSES TO FOREST THINNING AND PRESCRIBED SURFACE FIRE, ALONE AND IN COMBINATION

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In the past century, forest management practices have significantly altered the function and structure of southwestern ecosystems dominated by ponderosa pine (*Pinus ponderosa*). Fire suppression, grazing, and logging of old, fire-resistant trees have resulted in a dense, closed canopy forest with an increased susceptibility to stand-replacing wildfire. Mechanical thinning and prescribed fire are important tools for mitigating the threat of stand-replacing wildfire. However, the effects of these practices on wildlife communities are not well understood. For three Fire and Fire Surrogates experimental sites in northern Arizona, we examined the response of avian communities to thinning and prescribed fire, alone and in combination. For a suite of focal species, we evaluated changes in density due to these different treatments. We also used multivariate techniques to compare species composition among treatments. This research provides new insight regarding avian community responses to fuels reduction treatments, allowing for empirically-based decisions about forest management and conservation.

THE DRAFT CAVE, KARST AND MINE MANAGEMENT PLAN, AND THE RAPID CAVE ASSESSMENT AND CLASSIFICATION SYSTEM, GRAND CANYON NATIONAL PARK

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Grand Canyon National Park's (GCNP) vast cave and karst systems, their cultural and natural resources, and the natural processes dependent on these environments, are poorly understood. Concomitantly, these resources are experiencing increasing pressure from visitors. The National Park Service is mandated to proactively manage and protect these resources. GCNP has developed a draft Cave, Karst and Mine Management Plan that provides guidelines and direction for the protection and management of cave and karst resources. The plan contains specific rules, regulations, and protocols designed to protect resources while attempting to safeguard visitor enjoyment. The plan outlines procedures for the systematic inventory, mapping, classification, and assessment of cave resources as well as and permit issuance. This plan recognizes visitor use demands and strives to addresses recreational use, resource protection, research, education, and public safety. This plan will enable managers to make decisions on each cave use by: 1) identifying resources at risk, 2) setting appropriate recreational use levels and/or restrictions, and 3) identifying monitoring, research and restoration needs. A Rapid Cave Assessment protocol was developed to provide consistent and detailed information needed to begin the classification process, make determinations and build a database. Cavers are asked to provide information on the cave in general as well as information specific to biologic, physical, paleontological, cultural resources and human impact. The Park also requests that cavers rank each cave according to specific values and provide recommendations for management. This information will provide the basis of a caves classification and hence define its management. Effective implementation of the plan is largely dependent on establishing strong partnerships with stakeholders and the general public. Volunteer recruitment will greatly accelerate this process and help in solidifying partnerships and support.

IMPACTS OF DROUGHT, BEETLES, AND MANAGEMENT TREATMENTS ON FIRE BEHAVIOR IN PINYON/JUNIPER WOODLANDS

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Climate change-induced alterations of fuel loads and fire weather will potentially affect wildfire behavior and fire regimes on the Colorado Plateau. Predicting the direction and magnitude of climate effects on wildland fire is particularly challenging for pinyon/juniper woodlands, due to a scarcity of data on fire history and past climate-fire relationships in those ecosystems. We approach our investigation of climate effects on wildland fire by using fire behavior models to ask how recent drought years and the widespread, drought-induced ips beetle (*Ips confusus*) mortality should be expected to alter fire behavior in P/J woodlands. We then test our results using records of fire activity from the region over the last several years. We attempt to distinguish the immediate effects of pinyon mortality (increased available fuel loads) from longer-term changes in forest structure (stand-thinning) and climate-induced changes in ignition and spread probabilities. While our results provide some guidelines for managing fire and fuels on the Colorado Plateau, better data on fuel loads and stand-structure are needed to more fully understand the effects of climate change on fire regimes.

LANDSCAPE-SCALE CHANGES IN CANOPY FUELS AND POTENTIAL FIRE BEHAVIOR FOLLOWING PONDEROSA PINE RESTORATION TREATMENTS

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We evaluated canopy fuel and potential fire behavior changes following landscape-scale restoration treatments in a ponderosa pine forest at Mt. Trumbull, Arizona. The goal of the project was to restore historical forest structure by thinning and burning, thereby reducing canopy fuels and minimizing the potential for active crown fire. We measured 117 permanent plots before (1996/1997) and after (2003) thinning and burning treatments. The plots were evenly distributed across the landscape and represented an area of approximately 1200 ha, about half of which was an untreated control. We compared canopy fuel estimates using three different methods to assess whether fire behavior modeling outputs were sensitive to the choice of canopy fuel equation. Basal area and tree density were decreased significantly from 32.6 m^2 to 18.9 m^2 and from 784.6 trees/ha to 399.2 trees/ha, respectively, in the treated area between 1996 and 2003 while the control did not change significantly over the same time period. Restoration treatments decreased canopy fuel load (CFL) from 7.7-18.3 Mg/ha to 4.4-9.1 Mg/ha (the range of values reflects three different canopy fuel equations) and decreased canopy bulk density (CBD) from 0.038-0.172 kg/m^3 to 0.022-0.67 kg/m^3 in the treated area, while slight increases occurred in the control. We applied two simulation models to estimate potential fire behavior: FlamMap and Nexus. These models differ in several important features but predicted outcomes were consistent; under extreme drought and wind conditions, the proportion of the landscape susceptible to active crown fire and the mean patch size of these areas were both reduced in the treated area. In contrast, the models show little change in active crown fire susceptibility in the control over the same time period. We conclude that the restoration treatments have successfully addressed the project goals of reducing canopy fuels and the potential for active crown fire.

BIOLOGICAL SOIL CRUSTS AND WHY THEY ARE DISAPPEARING

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Biological soil crusts are composed of bryophytes, lichens, algae, and cyanobacteria. These crusts were a common component in the arid and semiarid ecosystems of North America. However, domestic livestock and other trampling enhanced the invasion of exotic annual grasses and has drastically changed the vegetation dynamics of the many arid regions. Clumped vegetation patterns have been replaced by more continuous annual grasslands. Livestock and human vehicle disturbance has broken the crusts and created a favorable seed bed for exotic annual grasses. Scientists in Idaho have found that biological soil crusts inhibit exotic annuals such as cheatgrass, which minimizes the cover and biomass of this invasive species. This change in cheatgrass distribution patterns greatly influences the risk of fire. Inhibition of annual grasses such as, cheatgrass by biological soil crusts was investigated in the lab after such spatial patterns were observed in the field. The ecological significance of this crust and weedy annual grass interaction is critical to the future of the arid ecosystems.

HUMAN DIMENSIONS OF MOUNTAIN LION MANAGEMENT: VALUE ORIENTATIONS AND POLICY PREFERENCES OF NORTHERN ARIZONA RESIDENTS

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Mountain lion management is at a critical juncture. Rarely do researchers and managers have the opportunity to make management strategies for a species that is relatively abundant. More often, they find themselves fighting against rapidly declining species populations. In the case of Puma concolor, species abundance is not necessarily the most important gauge for conservation. From a socio-ecological perspective, human-cougar encounters, human injuries and fatalities, and cat fatalities due to encounters with the public are also important indicators of lion health. Currently, managers have the unique opportunity to maintain and conserve mountain lion abundance by addressing human dimensions issues before they pose a threat to lion populations. We conducted a self-administered mail survey (n=693) of Northern Arizona residents during the summer of 2003 to analyze public concerns, support, and perceptions of mountain lions. The survey also explored underlying values that help explain demands and expectations of mountain lion management over the long term. We used regression analyses to test how well various suites of potential explanatory variables (Demographics; BEP: behaviors, experiences, and predispositions; and Value Orientations) could predict responses of survey participants to management options. Our results indicate that value orientations are not easily predicted by demographic characteristics or forest recreation activities. However, regression analyses revealed comparatively high R2 values (>0.23) when value orientations were used to predict mountain lion policy preferences. These results are consistent with the hypothesis that policy preferences are strongly tied to value orientations. Conversely, these findings indicate that value orientations could be reliable indicators of public policy preferences. Our results shed light on trends in public perceptions of carnivores and their management, as well as the extent to which value orientations influence public policy preferences in Northern Arizona. Understanding public value orientations is a useful tool for wildlife managers and is also an important step toward alleviating the agency/citizen tension that surrounds mountain lion management issues.

ALLOCATION OF WOODY AND HERBACEOUS BIOMASS IN PONDEROSA PINE STANDS VARYING IN STAND STRUCTURE AND BURN HISTORY

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The Stand Treatment Impact on Forest Health (STIFH) study was designed to assess and monitor over time the condition of forest ecosystems varying in stand structure and burn history within northern Arizona by identifying and using ecological indicators. We selected a subsample of STIFH plots to eliminate plots with basal area > 53 m2/ha. In 2004, we selected between three and four replicates of each of the four stand structures (unmanaged, commercial thin, thin and burn, and wildfire) for a total of 28 grazed plots. In 2005, we added an additional 12 plots to capture a mid-range (2 to 13 m2/ha ± 8) in basal area between the high basal area (5 to 53 m2/ha ± 22) of forested STIFH plots and the severe wildfire that was devoid of trees. At each 20 X 50m plot we quantified herbaceous and overstory biomass. Understory vegetation biomass was sampled by clipping plants to ground level in ten 0.25 m2 circular frames in each plot. Plant material was separated by species, dried at 70 degrees C for a minimum of 48 hours and weighed. Overstory tree measurements included diameter at breast height, which was used in regression equations to estimate total aboveground tree biomass from diameter at breast height measurements. Preliminary results suggest that aboveground biomass in unmanaged, thinned, and thinned and burned stands consisted of almost entirely woody material. In contrast, biomass in areas burned severely in a 1996 wildfire consisted only of herbaceous plants. Consequently woody biomass is directly related to herbaceous biomass in that herbaceous biomass declines as woody biomass increases. In addition, herbaceous biomass increased significantly between 2004 and 2005 due to above average rainfall during the spring months of 2005. This study is one of the few to attempt to quantify both herbaceous and woody biomass in southwestern ponderosa pine forests, and provides insights into plant production nine years after a severe wildfire.

RESURRECTION OF CRUCIFIXION CAVE - A PHOTOMONITORING GIS ANALYSIS TO EVALUATE VISITOR IMPACTS IN THE LAST 15 YEARS

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Crucifixion Cave, located southeast of Flagstaff in the Coconino National Forest was discovered in 1984 when a group of recreational cavers enlarged a blowing lead in a large basalt collapse. The group discovered over two miles of passages in the subsurface Kaibab Limestone and named the cave 'Crucifixion' in reference to historic graffiti near the entrance. From 1985 to 1988, recreational cavers explored and surveyed the cave noting the rare resources within. In June of 1990, recreational cavers completed a photo monitoring evaluation of the most sensitive areas and plotted their locations on the cave survey map. Since this time, the cave has been closed to recreational visitation. This project seeks to evaluate visitation to the cave in the last 15 years by comparing photomonitoring results of 1990 to those of today. A GIS has been created to plot the monitoring points and hyperlink the comparative photos for analysis.

MANAGEMENT GOALS DRIVE THE DEVELOPMENT OF ADAPTIVE MODELS FOR FOREST CONSERVATION AND WILDLAND FIRE PLANNING AT MESA VERDE.

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Resource managers at Mesa Verde National Park were very receptive to the idea of modeling pinyon-juniper woodlands to guide critical decision making in the coming years. With a new Wildland Fire Management Plan in progress, the park quickly needed a better way of evaluating the long-term consequences of different management alternatives under different environmental pathways. The unique natural and scientific values of the park's old-growth pinyon-juniper woodlands are at risk due to recent ecological changes driven by drought including high intensity wildfires, bark beetle infestations, rapid invasion of burned landscapes by non-native plants, and plans by some in the fire community for highly aggressive "fuels treatment" inside and outside the park. The concern was that these irreplaceable woodlands would not be sustainable at current loss rates in a relatively small management area that does not meet the minimum dynamic area required to sustain the full range of natural variability of the woodlands by natural processes alone. The information obtained from these studies would be crucial in developing long-term land management plans for the park with old-growth pinyon-juniper woodland conservation as a stated goal. The model would then be available for neighboring agencies and tribes as well.

HISTORICAL STUDIES ON THE COLORADO PLATEAU: RESULTS FROM TWO LONG-TERM DATA SETS

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Long-term data can be used to assess reference conditions and set restoration goals, quantify local levels of natural variability (both structurally and compositionally), quantify tree size, age, and spatial distributions at numerous points in time, and precisely describe trends in plant community dynamics. We present preliminary results from two sets of historical permanent plots, the Woolsey and Hill plots, to illustrate the types of questions that can be asked and surprising results that require a long-term perspective. We focus on tree demographics, spatial and temporal patterns, and mechanisms contributing to increased tree densities. Specific results from these data sets include: 1) Ninety-one percent of the historically (1909-1913 or older) mapped tree structures (live trees, snags, logs, stumps, etc.) were successfully relocated, suggesting the forest reconstruction field techniques are reliable within 10%. 2) Between plot establishment (1909) and present (2002), stand density increased more than 11 fold from 51 TPH to 574 TPH on COCS1A. Eighty-six percent of this increase occurred by 1949, when density reached 494 TPH. 3) Both before and after the initial harvest on COCS1A (1894), point pattern analysis shows a distinct peak in aggregation of trees from 7.0 to 8.5 m, indicating clumps of trees were approximately 0.02 ha in size. Additional patterns suggest that new tree establishment first occurred in the grassy interspaces, then followed in the newly available growing space (harvested areas), and finally occurred under the canopy of live (unharvested) trees. 4) Tree densities were lower in areas subject to long-term livestock grazing than in areas protected from grazing since 1912. While livestock grazing was a factor contributing to the pulse of ponderosa pine regeneration in the early 1900s, contemporary forests would be even denser than they are at present if grazing had not continued to occur in these forests. We are exploring many other types of analyses, including the development of stand/community-level state/transition models and herbaceous plant demography/turnover models. These data are also being used to test currently accepted models (growth, biomass, etc.) and to assess model utility giving special consideration to the spatial and temporal nature of the data.

PRACTICAL LESSONS LEARNED: STRATEGIC APPROACHES OF THE FOSSIL CREEK ENVIRONMENTAL PARTNERS

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During the Federal Energy Regulatory Commission (FERC) relicensing proceedings for the Childs-Irving Hydropower Plants, operated by Arizona Public Service (APS), leaders in Arizona's environmental community recognized a rare 'window of opportunity' to make a difference in the future of Fossil Creek's unique ecosystem. In 1998, at the request of local interests, American Rivers hired me to initiate a collaboration of environmental interests that later became known as the *Fossil Creek Environmental Partners* and eventually grew to include seven organizations. Over 2 years, our strategic actions resulted in these outcomes: (1) APS signed an *Agreement in Principle* publicly pledging to decommission the hydropower facilities within the designated time frame; (2) APS led a series of facilitated discussions with interested parties to develop detailed plans for the decommissioning process; (3) a legal *Settlement Agreement* was finalized among critical stakeholders and APS, and then submitted to FERC. In my opinion, there were several key principles that led to our success: (1) Identify and articulate a clear common goal. (2) Actively build and use a strong foundation of credible scientific research. (3) Build support (at a maximum) and understanding (at a minimum) across the full spectrum of interested parties. (4) Secure adequate funding, staff and volunteer resources for the entire time frame needed to make the desired change happen. (4) Respectfully nurture relationships among strategic individuals, to open and maintain dialog that could discover common ground among divergent viewpoints. (5) Be inclusive of all interested parties, giving credit and appreciation freely. Strengthening collaboration among environmental organizations, agency staff and decision-makers, and a corporation has proven to be an effective tool for *ecosystem restoration* at Fossil Creek. Although it wasn't strategy, the other critical element was the corporate leadership at APS that recognized their demonstration of environmental ethics on the ground could create a corporate asset of its own kind.

PRELIMINARY HOME RANGE AND LIFE HISTORY FROM RADIO TELEMETRY OF *CROTALUS OREGANUS CERBERUS*, THE ARIZONA BLACK RATTLESNAKE

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The Arizona Black rattlesnake, *Crotalus oreganus cerberus*, is a morphologically distinct rattlesnake snake species found only at higher elevations in Arizona. It does not have state or federal listing status. This species was recently determined to be a sister taxon to the western clade of the *Crotalus viridis* complex using mitochondrial DNA analyses (Pook et al. 2000, Douglas et al. 2001). Morphological differences are observable from other clades within the complex through color, elevation distribution, and possibly size. While range has been established (Stebbins 1985, Klauber 1972), general ecology and life history are poorly understood. Two communal hibernation den sites of *C.o cerberus* at sites near Flagstaff, Arizona provides an opportunity for study of the species. Colorado Plateau Research Station biologists have seasonally visited the dens in the spring and fall since 1999. During this time, 124 captures of 87 individual rattlesnakes were marked and recorded using Passive Integrated Microchip Transponders (PIT tags). In April of 2005 I initiated a radio telemetry study as part of a Masters of Biological Science on this northernmost distribution of the species. It is the first ever life history study specifically conducted on the species expanding upon our research begun at CPRS (Nowak and Schofer 2005). The telemetry study focuses on male home range movement patterns and ecology. The den sites in northern Arizona were used to obtain a sample size of 11 males. Preliminary results using Geographic Information Systems indicate male home range sizes are between one to two square kilometers. Life history observed from the first season of data revealed hunting strategies, insight into diverse prey items they are choosing, timing and frequency of ecdysis, dispersal and return dates to the dens, and mating strategies. Preliminary findings of the research indicate that woody debris plays a significant ecological role for *C. o. cerberus* in northern Arizona. As understanding the requirements of a species is the key to managing for it, the telemetry effort has a high degree of biological significance. This study will aid government agencies in understanding ecological requirements of an elusive and unstudied reptile predator of the Colorado Plateau.

A MULTI-SCALE ASSESSMENT OF THE EXTENT AND CONDITION OF GRASSLANDS IN ARIZONA: CONSIDERATIONS FOR CONSERVATION, RESTORATION, AND FIRE

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Semi-arid grasslands of the Southwest U.S. have undergone dramatic vegetation changes over the last 130 years, including encroachment by shrubs, loss of perennial grass cover, and spread of non-native species. The lack of wildfires has played an important role in these changes as fires reduce or kill shrubs and increase cover of perennial grasses and forbs; without fire, shrubs increase and compete with perennial grasses for water and nutrients. Changes in semi-arid grassland composition and structure have not occurred uniformly across the region and their extent and distribution are poorly understood at regional and broader scales. The purpose of this study was to rapidly assess and characterize the extent of the vegetation changes to grasslands in Arizona, and to identify the best remaining native grasslands and restorable grasslands for ecological management purposes. To complete the study, an expert-based approach was used to develop a broad-scale, rapid assessment of grasslands, interviewing 39 range management specialist from the Arizona State Land Department, Bureau of Land Management, Forest Service, Natural Resources Conservation Service, New Mexico Natural Heritage Program, The Nature Conservancy, and the University of Arizona. Expert input was verified and corrected where necessary through extensive field reconnaissance and quantitative vegetation sampling at random sampling points. Experts identified over 24.5 million acres of extant or former (historic) grasslands in AZ, or 34% of AZ's land surface; 14.2 million acres (58%) is of a known condition type. Of this, more than half is native grassland --a majority of which may be restorable with the use of prescribed fire. Conversely, Arizona has already lost over a quarter (27%) of its semi-arid grasslands during the last century due to shrub encroachment. Future protection and restoration of native grasslands will continue to involve the AZ State Land Department, federal land management agencies, (e.g. the Bureau of Land Management and the USDA Forest Service) and, in particular, private landowners.

A SYNTHESIS OF RIPARIAN RESEARCH AND MONITORING ON PUBLIC LANDS OF THE COLORADO PLATEAU

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We conducted a survey of research and monitoring activities on public land across the Colorado Plateau. Agency staff and cooperators were asked to define their project objects, collecting protocols, manipulative experiments, data archiving plans, publications, and overall patterns detected in their riparian habitats. Findings indicate similar research and monitoring objectives for riparian habitats across the Colorado Plateau, with alien taxa spread a prime concern. We will delineate the common trends across projects and suggest areas for improvement to help us better understand these ecologically diverse and sensitive habitats on the Colorado Plateau.

INTERIOR WEST FOREST INVENTORY AND ANALYSIS: A DESCRIPTION OF THE PROGRAM AND OPPORTUNITIES FOR COLLABORATION

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Forest Inventory and Analysis (FIA), previously known as Forest Survey, is one of the oldest research and development programs in the U.S. Forest Service. While forming the research branch of the Forest Service, the U.S. Congress charged it to find “facts as may be necessary in the determination of ways and means to balance the timber budget of the United States”. As a result, Forest Survey maintained a timber focus for much its history. As society’s interest in forests changed over time, so did information needs. In response, the Forest Inventory and Analysis program has evolved from Forest Survey to address diverse topics such as forest health, carbon storage, wildlife habitat, air pollution, and invasive plants, while remaining true to its mandate to monitor the Nation’s timber supply. The Forest Inventory and Analysis program now collects data on all land ownerships on an annual basis and makes the data available to the public at no cost. Exact locations of field plots are kept confidential to maintain plot integrity and to meet privacy requirements for data collected on private lands, as mandated by Congress in the 1998 Farm Bill. Although readily available, FIA data are underutilized by the scientific community. Some reasons for this situation include lack of awareness about the data, perception of the program as a “timber inventory”, the complex nature of the database, and perceived limitations to use imposed by privacy requirements. In fact, practical limitations to use of the data are few. The Interior West Forest Inventory and Analysis Program, the FIA database, and potential avenues for collaboration and data use are discussed.

MYCORRHIZAL FUNGI ABUNDANCE ACROSS FLOOD INUNDATION GRADIENTS, VIRGIN RIVER, UTAH

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Mycorrhizas are symbiotic associations between fungi and the roots of higher plants. 80-95% of terrestrial plants form obligate or facultative mycorrhizal associations. Plants provide sugars to the fungi, and in return, the fungi promote nutrient and water absorption that can lead to faster plant growth and protection against drought and pathogens. Mycorrhizas can improve soil structure and facilitate plant species diversity. Because of these benefits, mycorrhizal inocula can play a vital role in ecosystem restoration. In dynamic and heterogeneous riparian (riverine) ecosystems, knowledge of the spatial distribution of mycorrhizal propagules can aid restorationists. This study was conducted at a river site slated for future restoration to examine whether mycorrhizal fungi levels varied between surfaces with different flood frequencies. Soil samples were collected along the Virgin River in Zion National Park from areas of varying distances and relative elevations from the river, and thus with different flood return intervals. To examine mycorrhizal infection levels, a fast growing grass was grown in collected soil at a greenhouse as a host for mycorrhizal inocula. Roots were harvested, prepared, and inspected under a microscope from which the mycorrhizal infection percent was computed. Arcsine transformed data were analyzed using a 2-way ANOVA. Although there was a trend of decreasing mycorrhizal infection levels as flood return intervals increased, the differences were not statistically significant. Further analysis will explore correlations between mychorrhizal propagule levels and proximal vegetation species and density.

VEGETATION AND SEED BANKS OF THE ZION RIVER RIPARIAN CORRIDOR (UTAH): IMPLICATIONS FOR RESTORATION

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Traditional efforts to restore denuded riparian habitats have met with limited success. Consequently, rather than treating symptoms of degradation, restorationists are beginning to focus on restoring systems’ underlying ecological processes. This study takes place along the Virgin River in Zion National Park. Flood control measures have reduced overbank flooding, disconnecting many floodplain surfaces from the river. Characterized by cottonwood forests, this riparian corridor is reliant upon fluvial processes to facilitate seedling recruitment. On the disconnected surfaces, few new cohorts are establishing and the herbaceous vegetation is becoming more xeric. Concerned about the future of this habitat, Park resource managers are considering several restoration methods. By mandate, they must preserve the genetic integrity of Park species. One method to accommodate this goal is to utilize local soil seed banks. To examine riparian seed banks, soil cores were collected along the river from areas of varying distances and relative elevations from the river. The seedling emergence method was used to identify plant species grown in controlled ambient conditions resembling those in situ. Seed abundance, species diversity and richness were ascertained and seed bank species composition was compared with corresponding extant vegetation. Results indicated that seed bank species richness and abundance was greater in actively flooded areas than in those rarely inundated. Nevertheless, many riparian seedlings emerged from drier soils implying that the seed bank may facilitate revegetation, should restorative efforts to connect the river and its floodplain be undertaken.

EXOTIC INVASIVE PLANTS OF SOUTHWESTERN PONDEROSA PINE FORESTS: MANAGEMENT AND RESEARCH PRIORITIES

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Dozens of non-native plant species have been introduced to southwestern ponderosa pine forests. The introductions have been so numerous and widespread that the goal of eradicating all exotic plants is no longer feasible. Instead land managers and researchers must prioritize limited funding to focus on those species that have the greatest potential to cause undesirable and irreversible changes in plant communities. Unfortunately, there is not an agreed upon method for prioritizing which species to target. State noxious weed lists can provide insights into potential problem species, but noxious weed definitions vary from state to state and often focus on those species that occur in agricultural fields. A number of strategies for prioritizing invader species of wildlands have been proposed in recent years. In addition to the stage of the invasion, factors such as ecological impact, invasive potential, ecological amplitude, current distribution and abundance, and trend in distribution and abundance have been used to categorize the invasive potential of non-native species in wildlands. Unfortunately, for many of these recently introduced species, we have a poor understanding of their distribution, abundance, impacts on native plant communities in this region, and reliance on disturbances for their spread. A number of research and monitoring steps are needed to begin to fill knowledge gaps. The development of electronic databases of herbarium collections will enhance our understanding of what non-native species are present in the region, when they were first collected, and how widespread they have become. Long-term data collection on permanent plots provides additional insights into the persistence and spread of specific non-native species. Opportunistic sampling on wildfires and experimental studies that explore how various types and severities of disturbances influence populations of non-native species are needed to understand mechanisms involved in the spread of specific species. Research is also needed to quantify the role of roads and specific management practices in the spread of non-native species and how native plant communities can be restored in areas severely infested with invasive exotic plants.

PROACTIVE EFFORTS TO REDUCE CALIFORNIA CONDOR LEAD EXPOSURE IN ARIZONA

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California condors (Gymnogyps californianus) were reintroduced in Arizona in 1996. As of July 1, 2005 there are 53 free-flying condors in the state. Additionally, 5 chicks have been hatched in the wild. Condor exposure to lead is one factor affecting the success of the reintroduction program. There have been 164 documented cases of lead exposure since 1999. As of April 2005, 6 condor deaths have been attributed by necropsy to lead poisoning. While there may be other ways lead is acquired, we are working on reducing exposure from spent ammunition. There are two parallel processes ongoing. The first is a national effort to form sportsmen's coalitions to raise awareness and engage hunters in voluntarily reducing lead exposure potential in condor range. The second is an Arizona program to provide free non-lead ammunition to hunters in condor range as well as the use of GPS satellite transmitters to carefully track condor movements so that feeding behavior and potential lead exposure can be monitored. The outreach programs are based on background research including scientific telephone surveys of hunters, development of test messages, testing of these messages through focus groups and development of a communication plan. Based on surveys only 23% of Arizona hunters were aware that lead poisoning is an issue in condor recovery, and 77-98% were willing to take some action if credible lead exposure data were made available. Additionally, lead isotope research is underway to investigate any link between lead ammunition and condor lead exposure. Preliminary results have confirmed a direct match between lead ammunition fragments and lead found in a condor blood sample. Information on condors and lead has been published for 3 years in the Arizona Hunting Regulations and individual mailings have been sent to hunters in condor range asking them to assist in limiting the amount of lead condors are exposed to from spent ammunition. We hope that these voluntary programs result in lower lead exposure over coming years.

MODELING EDGE EFFECTS INCREASES RELEVANCE OF FIELD RESEARCH IN HABITAT MANAGEMENT.

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The study of "edge effects" – the influence of surrounding habitats on a focal patch or study area – has a long history in ecology. Since the 1930's researchers have conducted hundreds of field studies documenting diverse influences on many taxa and highlighting the pervasive influence of edges on habitat quality. However, consideration of edge effects in habitat planning and management has been slow to develop, with vague generalizations and overly simplistic rules of thumb dominating the treatment of edge effects in textbooks and management plans. Recent theoretical treatments and literature reviews have pointed out some coherency in scientific understanding, while management models that apply this knowledge to real landscapes have given managers a tractable approach for integrating edge effects into their planning and field activities. We describe the Effective Area Model and its uses in bridging from our improved scientific understanding to practical applications of edge effects in managing real landscapes.

EFFECTS OF FUELS REDUCTION EFFORTS IN THE FLAGSTAFF URBAN-WILDLAND INTERFACE ON POTENTIAL FIRE BEHAVIOR: IS VARIETY THE SPICE OF FIRE?

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The Greater Flagstaff Forests Partnership, in conjunction with the US Forest Service and several other entities, has endeavored since 1997 to restore ponderosa pine forests, and reduce the risk of uncharacteristic fire and its potential impact on residents of Flagstaff and surrounding communities. Through collaborative project design and management, several approaches to forest restoration have been attempted, but not all of these approaches and their effects on fuels reduction and potential fire behavior have been quantified or reported. We collected data from areas that either have been mechanically thinned through various silvicultural prescriptions, or burned with managed fire prescriptions, or both. Plot data collected according to standard US Forest Service specifications were analyzed for summary statistics, and were run through the potential fire behavior program NEXUS to compare the different treatments, and to compare with controls. Fuels reduction efforts have varying effects on the probability of a surface fire moving into the crowns of trees, and on the potential intensity and duration of fire events (data currently are being analyzed). We also discuss the importance of collecting fuels data prior to treatment to isolate the effects of preexisting stand characteristics from treatment effects.

RESPONSE OF FUELBED CHARACTERISTICS TO RESTORATION TREATMENTS IN PIÑON-JUNIPER-ENCROACHED SHRUBLANDS ON THE SHIVWITS PLATEAU, ARIZONA

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The encroachment of piñon and juniper trees into historically shrub-dominated landscapes has caused major changes in ecosystem structure and function, including dramatic changes in fuel structure and fire regimes. Restoration techniques are often labor intensive and expensive to implement, so it is prudent to determine their effectiveness before they are applied over large areas. Land managers on the Shivwits Plateau in northwestern Arizona are currently faced with thousands of acres of tree-invaded shrublands, some within wildland/urban interface areas, and are seeking effective techniques to restore these areas to pre-invasion conditions and reduce wildfire hazards in the process. We established a study on the Shivwits Plateau to test the effectiveness of 3 techniques for reducing the density of post-invasion pinyon and juniper trees: (1) cut and leave, where 80% of the trees were cut down and left where they fell; (2) cut and scatter, where 80% of the trees were cut down, then bucked and scattered; and (3) herbicide, in which 80% of the trees were sprayed with Tordon 22k around the base of their trunks. Treatment plots were 20 acres, with 8 replicates each of the 3 treatments plus an untreated control. Different methods were utilized in an attempt to characterize changes in the fuelbed structure and will be compared. Generally speaking, there was more shrub and herbaceous development in the treatment units versus the control units as well as an addition of woody fuels to the initially sparse sites that would help to carry surface fire through the treated areas. This information will be used to determine anticipated differences fire behavior and fire effects using software such as BehavePlus3.

DECOMMISSIONING THE CHILDS-IRVING HYDROELECTRIC FACILITIES

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The Childs and Irving Power Plants on Fossil Creek were Arizona's first commercial hydroelectric power plants. They are located near Fossil Creek surrounded by the rugged beauty of the Mogollon Rim country. In 1908, when construction began on the facilities, the design and remote location made Childs-Irving a logistical and engineering marvel. To spin the turbines, nearly all of Fossil Creek's flows were diverted to Childs and Irving for nearly a century. In the late 1990's Arizona Public Service Company – the developer, owner and operator of these facilities – decided to decommission these facilities and work to restore of Fossil Creek. APS formally filed a surrender application with the Federal Energy Regulating Commission in early 2001. For the past seven years, APS has worked closely with environmental organizations, historical groups, and agencies of the federal, state, county and local governments to support the surrender and removal of these facilities. The Childs-Irving facilities, situated on U.S. Forest Service lands, are listed on the National Historic Register and are American Society of Mechanical Engineering Historic Landmarks. APS has navigated through processes mandated by the National Environmental Policy Act and the National Historic Preservation Act, and addressed other federal, state, county and local issues to move forward with the decommissioning of these facilities. APS is currently proceeding with approved decommissioning of the historic facilities. Following restoration of full flow to Fossil Creek in June 2005, the state's largest electric utility began the deconstruction of plant facilities, which will be completed by the end of 2010.

IS SALTCEDAR HABITAT ALWAYS BAD FOR BIRDS? LESSONS FROM STUDIES OF THE SOUTHWESTERN WILLOW FLYCATCHER

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The Southwestern Willow Flycatcher (Empidonax traillii extimus: SWWF) is a riparian-obligate bird that breeds only in dense, typically wet riparian vegetation. In the mid-1990s, biologists discovered a substantial number of flycatchers breeding in habitat dominated by exotic saltcedar (Tamarix ramosissima). SWWFs nest in saltcedar-dominated riparian habitats at sites in Arizona, New Mexico, Nevada, and Utah. Approximately 25% of SWWF breeding sites, supporting one-third of the roughly 1,300 known flycatcher territories, are in saltcedar-dominated sites. Just as SWWFs do not breed in all native-dominated riparian habitat patches, they breed in only a small fraction (<1%) of the saltcedar habitats that are present in the w. U.S. Although diet of flycatchers in native and saltcedar habitats differs, dietary differences are not proof that food resources are limiting or insufficient in one habitat compared to the other. Therefore, studies were conducted to determine if there are negative effects to SWWFs breeding in saltcedar. Long-term (1996 to present) studies of flycatcher physiology, immunology, site fidelity, productivity, and survivorship found no evidence that nesting in saltcedar dominated habitat is detrimental to Willow Flycatchers at breeding sites in central Arizona. It is likely that saltcedar habitats vary with respect to suitability for breeding flycatchers, just as do native habitats. Therefore, results from a single study or site may not be applicable across the ranges of the SWWF or saltcedar. Ultimately, multiple long-term studies over a large geographic area must be compared to determine the relative suitability of native and saltcedar habitats at the landscape scale.

UNDERSTORY VEGETATION RESPONSES TO GROUP SELECTION THINNING AND PRESCRIBED FIRE AT THE ARIZONA FIRE AND FIRE SURROGATE SITES

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Over the past century, Southwest ponderosa pine forests have become increasingly denser due to factors such as the reduction of a frequent, low intensity natural fire regime. One of the results of this denser forest is the depletion of an understory consisting of grasses and forbs that once drove ground fires, which in turn naturally managed overstory densities. In an effort to better understand the roll of these understory species and their importance in ecosystem restoration, we studied understory vegetation responses to group selection thinning of ponderosa pine and surface prescribed fire at the Southwest Plateau Fire and Fire Surrogate sites. Understory vegetation data was collected on Modified-Whittaker plots based after Stohlgren on ten 20x50m plots per treatment type at each of the three sites (120 total plots), both pre-treatment and two years after treatments. On each 20x50m plot, species richness and basal cover was collected on ten 1m² sub-plots, and species presence or absence was collected on two 10m² and one 100m² sub-plots. The richness on these plots was used to produce species-area curves for predicting richness on a large scale in response to the overstory treatments and prescribed fire. We found that with increasing levels of management intensities (unmanaged, prescribed burn, group selection thinning, and thinning combined with burning), species richness and percent area covered by understory vegetation increased, accounting for pre-treatment difference between stands and sites. Management implications of these results suggest that more intensive management regimes contribute to a higher density of both native and exotic vegetation, which may influence fire behavior, ungulate grazing and browsing, and other forest health issues.

SUMMARY OF THE 1996-2000 GCMRC BIRD MONITORING PROGRAM ALONG THE COLORADO RIVER

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A summary of a 5-year effort to develop a monitoring program and collect baseline data on the aquatic and riparian avifauna of the Colorado River from Glen Canyon Dam to upper Lake Mead is presented. Data were collected for terrestrial breeding and wintering birds in the riparian zone, and for aquatic wintering birds. Breeding bird data was collected from 1700 fixed radius point counts in 62 patches of riparian vegetation. Winter terrestrial birds were sampled with 332 area searches in 85 patches, while aquatic birds were counted while floating the river corridor during six winter trips. Riparian vegetation patches were characterized by principal plant species, and volume determined using the total vegetation volume (TVV) method. The winter terrestrial bird community was more diverse than the breeding community (75 vs. 32 species), while 42 aquatic species were detected. Aquatic bird abundance was strongly correlated with river location, a proxy variable for primary productivity. Turbidity gradients vary exponentially downstream from the dam and bird abundance was highly correlated with turbidity. Strong and in many cases significant correlations were found between many riparian breeding and wintering terrestrial species and selected plant variables. Patch location along the river corridor was found to be a good predictor of many bird species, and significant differences were found in different reaches along the river corridor for many plant and bird variables. Based on MRPP and Mantel's test, significant positive relationships were found between distance matrices of winter terrestrial bird, breeding riparian birds, and vegetation datasets. This suggests that vegetation composition and structure affect both bird communities in similar ways. Retrospective power analyses were conducted on breeding riparian bird and winter terrestrial birds. Sufficient power to detect larger trend rates (>10% change/year) existed for only a few bird species over a time frame of 10 years, including eight breeding and four wintering species. Hence most species within the study area were not abundant enough to be monitored by the logistically intensive 1996-2000 program. Recommendations are made for future avifaunal monitoring by Grand Canyon Monitoring and Research Center and the Adaptive Monitoring Program.

THE RETURN OF FLOWS TO FOSSIL CREEK, AN IDEA WHOSE TIME HAD COME

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In late 1989, an innocuous memo from Arizona Public Service Company (APS) came to the Forest Service – where I worked as a fisheries biologist – announcing that they were beginning the process for relicensing of their Childs-Irving Hydroelectric facility on Fossil Creek. The memo explained that APS expected no change in operation as a result of relicensing, and that involvement of the Forest Service in the relicensing was expected to be minimal. Thus began my involvement with the long process of negotiation between APS, Forest Service, Federal Energy Regulatory Commission, Arizona Game and Fish Department, multiple other federal, state, and county agencies, Native American tribes, and a coalition of conservation groups that finally culminated in decommissioning of the project, and restoration of the native fishery in Fossil Creek in 2004. Although nobody in 1989 expected increased flows into Fossil Creek, there was consensus that APS should conduct studies that would address how the flora and fauna of Fossil Creek would react to different flow releases. The agencies insisted that a range of mean flows between operational conditions (near 0 cfs) and historical flows (43 cfs) needed to be analyzed. APS conducted many ecological studies using Instream Flow Incremental Methodology, to predict the likely responses of endangered species, riparian vegetation, and the entire biota to different potential flow regimes. As these studies progressed, agency personnel and conservationists began to hope for increased flows into Fossil Creek. By 1994, the idea of full restoration of flows had coalesced among the conservation groups, and in 1999, the Forest Service bought into the idea. During 1990-1999, the Forest Service provided input via innumerable meetings with and memos to APS in their development of an application for license renewal, and then FERC for their drafting of NEPA documentation. As a public servant and citizen-conservationist involved throughout this process, I offer my perspectives on how to effectively participate in this sort of effort.

FORAGING ECOLOGY OF PEREGRINE FALCONS ALONG THE DAM-REGULATED COLORADO RIVER, GRAND CANYON, ARIZONA

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Peregrine Falcon (*Falco peregrinus anatum*) foraging is difficult to observe and quantify in topographically complex terrain, and therefore is relatively poorly understood in southwestern canyons, where the species is recovering rapidly. We compiled observations of 355 Peregrine foraging events from our field notes and those of competent river runners downstream from Glen Canyon Dam on the Colorado River between 1973 and 1995. We documented prey species abundance, and Peregrine foraging behavior and foraging success. Peregrines attempted to forage on ≥45 prey species, including at least 39 bird species: swifts and swallows (29%), waterfowl (27%), other birds (22%), bats (10%) and large wasps (8%). Foraging frequency was positively related to prey abundance, and we observed greater relative predation intensity (RPI; the ratio of prey attack frequency to prey abundance), in the more turbid lower Grand Canyon where prey were less abundant. Air-to-air foraging attempts were most common (94% of 271 cases for which data were available), followed by air-to-water attempts (4%), and air-to-ground attempts (2%). Tandem foraging occurred in ≥43% of 168 cases, particularly in the breeding and post-breeding seasons. Overall foraging success was ≥52%, and was highest on large wasps (100%) and bats (87%); intermediate on large waterbirds (63%), swifts and swallows (42%), small terrestrial birds (42%), and waterfowl (40%); and low on belted kingfishers (18%) and small shorebirds. Foraging success was positively related to relative prey abundance and the number of falcons foraging together, and was negatively related to relative prey body mass. Most dietary biomass was derived from waterfowl (64%) and large waterbirds (25%); swallows and swifts contributed only 3% of the dietary biomass. Foraging success may be influenced by prey flight behavior. Our data indicate that dam-related turbidity characteristics affect Peregrine prey abundance and RPI, but not falcon distribution or foraging success.

SAFETY AND PREPAREDNESS OF DAY HIKERS AT GRAND CANYON

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Day hikers in the backcountry at Grand Canyon comprise a substantial segment of the 4.5 million annual visitors to the park. During the unusually hot summers of the mid-1990s, day hiker safety and preparedness became an issue due to an increase in search and rescue operations (SAR). The "Heat Kills, Hike Smart" campaign emerged as a response to the increase in SARs, and has been evaluated and slightly revised since its inception. This paper reports on a recent visitor study conducted in 2004 that interviewed close to 2,000 day hikers across seven different trails in the park's backcountry. Although the multiple objective study covered a comprehensive array of issues, this paper examines hiker preparedness and knowledge of low impact practices. Part of the concern for safety of day hikers involves their preparedness regarding items taken on their hike. When compared to day hikers of the South Rim corridor trails (Bright Angel, South Kaibab), day hikers of the threshold trails (Grandview, Hermit) were least likely to bring water, electrolyte replacement, map, sunscreen, and food. There were 13% of respondents of the threshold trails who indicated they did not bring sufficient water on their day hike, compared to 5% of respondents on both corridor and North Rim trails who reported the same. However day hikers on the threshold trails generally went on much shorter hikes compared to either corridor or North Rim hikers. For example, 42% of threshold respondents traveled less than 1.5 miles compared to about 16% of corridor and North Rim respondents who traveled this distance or less. Day hikers knowledge of minimum impact practices was fairly consistent across trails. Hikers with more previous hiking experiences were more knowledgeable compared to novice hikers. The least understood low impact behavior was related to human wastes and appropriate sanitary behavior. For example, 58% of respondents did not recognize the need to pack out toilet paper, and instead thought that burying it was appropriate behavior. The results suggest that hiking safety and low impact interpretive messages are being received by a majority of day hikers and that such information influences their hiking behavior.

DISPERSAL OF NONNATIVE FISHES AND PARASITES IN THE LITTLE COLORADO RIVER, ARIZONA

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We surveyed for nonnative fishes stranded in isolated pools near Grand Falls in the Little Colorado River (LCR), Arizona after the river ceased flowing (21 June and 12 July 2005) to evaluate whether nonnative fishes can invade the perennial, lower 21 km of the LCR from upriver sources. The encroachment of nonnative fishes could jeopardize resident populations of endangered humpback chub, Gila cypha, and other native fishes in the lower LCR. We captured black bullhead, Ameiurus melas, common carp, Cyprinus carpio, fathead minnow, Pimephales promelas, red shiner, Cyprinella lutrensis, and plains killifish, Fundulus zebrinus, all of which have been captured >132 km downriver in the lower LCR and 127 km upriver in the closest reservoir. Moreover, we detected Asian tapeworm, Bothriocephalus acheilognathi, in 9 of 30 common carp examined. Our findings suggest that nonnative fishes, including ones hosting parasites, can invade the lower LCR from upriver sources >250 km away during freshets and provide a mechanism for the dispersal of invasive aquatic species in intermittent river systems.

PRE-FIRE TREATMENT EFFECTS AND POST-FIRE FOREST DYNAMICS ON WHITE MOUNTAIN APACHE TRIBE LANDS WITHIN THE RODEO-CHEDISKI BURN AREA, ARIZONA

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The 2002 Rodeo-Chediski fire was the largest wildfire in Arizona history, and exhibited some of the most extreme fire behavior ever seen in the Southwestern United States. On the White Mountain Apache Tribal lands within the burn area, pre-fire fuel reduction treatments of thinning, timber harvesting, and prescribed burning set the stage for a test of the upper boundary of effectiveness of fuel reduction treatments at decreasing burn severity. We sampled 90 six-hectare study sites two years after the fire, representing 30% (34,000 ha) of the entire burn area on White Mountain Apache Tribe lands, and comprising a matrix of three burn severities (low, moderate, or high) and three treatments (cutting and prescribed burning, prescribed burning only, or no treatment). Our findings indicate that thinning, timber harvesting, and prescribed burning were associated with reduced burn severity even in an extraordinarily intense fire, provided that the treatments occurred within the decade before the fire. Prescribed burning without cutting reduced burn severity considerably, but the combination of cutting and prescribed burning had the greatest ameliorative effect. While burn severity explained more of the variation in forest structure than did treatments, increasing degree of treatment was associated with an increase in the number of live trees and a decrease in the extremity of fire behavior as indicated by crown base height and bole char height. Ponderosa pine regeneration was very low in untreated areas, with no ponderosa regeneration whatsoever in high severity untreated areas. Over half the study area had no ponderosa regeneration, and 16% of the study area had no ponderosa regeneration and no surviving ponderosa trees. Future forest development will most likely take one of two trajectories: recovery to a ponderosa pine/Gambel oak forest or a shift to an oak-dominated shrubfield state, with untreated and high-severity areas more apt to undergo a type conversion.

FIRE-FIRE SURROGATE STUDIES ON THE SOUTHWEST PLATEAU: INITIAL IMPACTS ON SOILS

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Many forests in the western U.S. currently have unnaturally high fuel loads. These loads have changed the fire dynamic from one of historically frequent surface fires to catastrophic crown fires. In an effort to restore forests, managers have prescribed fire, thinned mechanically, and combined the techniques. Uncertainty surrounds the effects of these alternative treatments. The US Joint Fires Sciences program funded a national study to address the ecological effects, economic impacts, and fire hazard reduction of these alternatives. Here, we report the impacts of the three treatments, mechanical thinning, burning, and thinning and burning, on the forest soils of three non-contiguous *Pinus ponderosa* stands on the Southwest Plateau near Flagstaff, AZ. We examined 1) functional diversity by looking at carbon substrate utilization patterns, 2) extracellular enzyme activity assays, 3) nitrogen mineralization, 4) cation exchange capacity, as well as 5) pH and 6) bulk density. In the short term, we have discovered large and divergent impacts on the soil from the three different silviculture treatments. Long term (decadal) impacts are not yet clear; we hope that this original five-year study can extend long enough to address these more long-term effects.

ASSESSING CLIMATE CHANGE IMPACTS ON SOUTHWEST FORESTS AND WOODLANDS: IMPLICATIONS FOR POLICY AND MANAGEMENT

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Like many states in the western U.S., Arizona has experienced extreme drought, enormous wildfires and forest insect outbreaks in recent years. Invasive species are beginning to generate wholesale changes in desert ecosystems via increased wildfire occurrence. Climate changes due to greenhouse gas emissions are expected to result in warmer seasonal temperatures in the Southwest in coming decades, with a likely continuation of conditions that promote these massive ecological disturbances. The Governor of Arizona, Janet Napolitano, has taken a leading role in initiating policy assessments and changes within the state and in the west to address drought and wildfire issues. She has also initiated a process to assess greenhouse gas emissions from Arizona (from both anthropogenic and anthropogenic sources) and to move toward strategies and policies to reduce these emissions. I will discuss projects and goals of two citizen advisory boards that the Governor has established that are beginning to address climate variability and change and effects on forest and woodlands in Arizona and the Southwest: The Forest Health Advisory and Oversight Councils (http://www.governor.state.az.us/FHC/), and the Climate Change Advisory Group (http://www.azclimatechange.us/index.cfm). Both of these advisory groups have a significant need for scientific and technical advice from experts within the state and elsewhere. The Governor's initiative to create these advisory boards is laudable, but there is a need for the scientific community to be more directly and broadly engaged in these efforts. Policy initiatives should move forward rapidly, but they should be founded upon the best available climate change science.

INVASIVE SPECIES NETWORKS: CHALLENGES FOR THE COLORADO PLATEAU

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Invasive non-native species - plants, animals, and microbes - can pose economic, ecological, and social threats to the ecosystems they infest. No cultural and natural setting of the Colorado Plateau is exempt of the risk of infestation and resulting impacts. In this presentation, we examine the existing structures for sharing technical and scientific information on invasive, non-native plants (weeds) within the four corner states that encompass the Colorado Plateau. Invasive species do not respect administrative boundaries. Recognition of this has spurred federal, state, county, and local agencies to seek ways to cooperate in developing management strategies and providing education through geographically based cooperative weed management areas or county-based districts. Other mechanisms of communication and data sharing have formally and informally developed including weed based workshops and conferences, list-serve distribution of information, web-based informational pages, advisory councils, and a regional occurrence database. Often the scientific research community has focused on the impacts and management of a weed as may be expressed in one environmental context - urban, agricultural, rangeland or wildland - rather than the entire environmental amplitude of the weed. As a result, weed impacts may be understood for some cultural and natural settings but not regionally. The academic and federal research community has a challenge to focus their investigations toward understanding the impacts, ecology, and behavior of invasive plants across the Colorado Plateau and to communicate their findings in a regionally effective manner.

ECOLOGICAL SYSTEMS OF THE COLORADO PLATEAU

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The Southwest Regional Gap Analysis Program (SWReGAP) has mapped land cover types in the 5-state southwest region using ecological systems to describe natural and semi-natural vegetation. The SWReGAP ecological system labels are derived from the Terrestrial Ecological Systems Classification framework developed by NatureServe and are linked to the National Vegetation Classification through associations and alliances. In the entire land cover map over 125 land cover types, including 109 ecological systems, 11 "disturbed/altered" sites, and 5 land cover classes, are mapped at a 1-acre resolution. In this talk, we present a tour of representative ecological systems in the context of the Colorado Plateau and discuss some of the challenges that arose in describing and mapping particular ecological systems.

SWEMP: DOCUMENTING INVASIVE NON-NATIVE PLANT OCCURRENCES REGIONALLY

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The U.S. Geographic Survey's Southwest Exotic Plant Mapping Project (SWEMP) facilitates the development of a regional database of invasive non-native plant (weed) occurrences in the Southwest. The regional database provides a view of what is known about the occurrences of weed infestations across administrative boundaries. It can be used to guide the development of local, such as agency or Cooperative Weed Management Area (CWMA), weed management strategies and regional, such as state or ecoregional, policies. The database is available at the affiliated web site, Southwest Exotic Plant Information Clearinghouse (SWEPIC), along with computer tools that support data entry into the SWEMP database, visualization of the data, and query of the database by several criteria. The computer tools provide CWMAs in the Southwest the means to share invasive plant data with all member partners. Individual members of CWMAs can use the data query tool to download invasive plant information across the entirety of the CWMA. 'Maplets' of weed infestations in areas of interest can be designed and printed from the interactive map. Example distribution maps are provided showing the documented occurrences of invasive non-native forbs and grasses in Arizona.

DEVELOPING A MONITORING PLAN FOR THE NATIONAL PARK UNITS ACROSS THE COLORADO PLATEAU

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Knowing the condition of natural resources in national parks is fundamental to the National Park Service's ability to manage park resources and a central goal of the NPS Inventory and Monitoring Program. The 35 national parks and monuments on the Colorado Plateau are organized into two inventory and monitoring programs, the Northern and Southern Colorado Plateau Network, respectively. Each network has its own staff and funding to design and implement a long-term monitoring program. The unique ecological context of the Colorado Plateau and a long history of shared natural resource efforts among the NPS units in this area prompted the two networks to collaborate in developing monitoring programs. We worked with several investigators to develop conceptual models of predominant Colorado Plateau ecosystems. Using independent selection approaches, the two networks reached similar conclusions in determining the most important ecosystem attributes to monitor across Colorado Plateau parks. Shared monitoring themes include climate, streams and springs, upland soils and vegetation, bird communities, invasive plants, and landscape patterns relating to land use, disturbance patterns, and vegetation cover and condition. We are currently collaborating with several teams of investigators in conducting pilot studies to support the development of detailed monitoring protocols. These research and development efforts span both networks and include: testing of methods to monitor upland soils, vegetation, and hydrologic function in selected ecological sites; determining sample allocation and sample selection methods for monitoring riparian and aquatic habitats and associated testing of methods to monitor riparian vegetation; collecting a time series of ground-based data on vegetation greenness and comparing it with satellite (MODIS) data; and determining remotely sensed data sets, image classification techniques, and change detection methods that can be effectively applied across the region to describe and monitor landscape patterns.

THE ASSESSMENT OF SAND DUNE MOBILITY FROM 1980 THROUGH 2004 ON THE COALMINE MESA CHAPTER AREA OF THE NAVAJO NATION

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This research is motivated by concerns about how climate change is affecting Indigenous communities across the globe. Many residents of the Navajo Nation on the southern Colorado Plateau are concerned that the future climate of the region will be warmer and drier than observed in the 20th Century. Droughts during the late 1980s through 2004 over this region have resulted in the decrease of many native plant species and an increase in sand dune mobility causing social harm, including damage to infrastructure and the loss of agricultural productivity. Effectively mitigating sand dune mobility requires understanding the annual and seasonal climate variability, which can affect sand dune development. A climatic sand dune mobility index using wind energy and effective precipitation was calculated to assess seasonal, annual, and decadal trends of potential sand dune mobility over the Coalmine Mesa chapter area on the Navajo Nation from 1980 to 2004. The results demonstrated a large variation in seasonal and annual potential sand dune mobility. For the period from 1980 to 2004, an increasing trend in potential sand dune mobility was observed and appears correlated with a trend of decreasing effective precipitation. These results have provided a better understanding of the climatic conditions over the last 25 years over the Coalmine Mesa chapter area, and show how these conditions relate to increased sand dune mobility. This work shows that the index can be used for other areas on the Navajo Nation, to identify locations at risk and help in planning efforts to mitigate effects from climate change.

MOTIVATION FOR OFF-HIGHWAY VEHICLE RECREATION AND PERCEPTIONS OF MANAGEMENT STRATEGIES AND PROPOSED POLICIES OF OFF-HIGHWAY VEHICLE RIDERS AND FOREST SERVICE MANAGERS

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This study explored the motivations to recreate with off-highway vehicles and the perceptions that off-highway riders and Forest Service managers have regarding management strategies and policies for off-highway vehicle recreation. Data was gathered using a mail survey. Two populations were sampled: off-highway vehicle riders who recreate in northern Arizona and Forest Service managers working on national forests in northern Arizona. Results show that motivations for off-highway vehicle recreation include escaping personal/social pressure, enjoying nature, achievement/stimulation, and to be with family and friends. Managers and riders showed some agreement on off-highway vehicle management strategies such as interaction among riders and managers, developing volunteer programs, and holding workshops to inform the public of off-highway vehicle issues. Data on perceptions of proposed off-highway vehicle management policies indicate that riders and managers differ on the possible implications of the proposed policies, including increased arbitrary trail closure, increased creation of social trails, increased trail removal, and increased cross-country travel by off-highway vehicles. Results of the manager survey indicate some managers feel the proposed policy changes may minimize resource damage, decrease cross-country travel, and increase access to off-highway vehicle trails. These results suggest both off-highway vehicle riders and off-highway vehicle managers agree interaction and cooperation between the two groups are effective management strategies. Results also suggest that differences in perceptions regarding proposed policy changes might require increased education and interaction between the two groups.

CAVE RESOURCE MANAGEMENT - NOW IS THE TIME TO STANDARDIZE

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Government agencies and caving groups alike have spent countless hours on cave(ing) and karst related documents, from permits, permit issuing regulations, mapping and survey standards, research standards, exploration techniques, conservation issues, and cave gating standards, to inventory standards. We are closer now than ever to handling cave and karst resources in similar fashion. It is timely to set some firm dates and assign the completion process and outcome to individuals, groups, or lead agencies. We will explore some of the history of these documents, what is out there now, and how we might best orchestrate the completion of several of what we decide are the most pressing documents. If we can accomplish this in the near future, we can most certainly improve the communication network regarding cave and karst resources, and the ability to interchange information needed to better manage and protect this precious resource.

RESTORING ROADS WITH FUNGI: EVALUATING THE USE OF FUNGAL INOCULUM AND WOOD MULCH APPLICATION IN AN ARIZONA PONDEROSA PINE FOREST

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Road closure is an important component of ecological restoration projects across many landscapes. Ecological restoration projects in southwestern ponderosa pine forests require the construction of temporary roads and log landings which cause soil compaction, hydrologic regime change and other damage. Residual logging debris is left on site to be burned in slash piles that have been shown to have harmful effects on forest soils. Holistic restoration projects should seek to eliminate the damage caused by roads and slash pile burning, and to close and restore established roads. The purposes of this study are to investigate the effects of using ground waste-wood (mulch) and fungal inoculum on plant establishment, and to evaluate the use of saprophytic fungi to accelerate decomposition of organic material. I selected three roads at Northern Arizona University's Centennial Forest near Flagstaff, Arizona. Each road was divided into five experimental blocks containing identical treatments. Treatments are 1)control, 2)mycorrhizal inoculum, 3)mulch, saprophytic fungi (Hypholoma capnoides), and mycorrhizal inoculum, and 4)mulch only. All plots were seeded with a mix of native grass and forb seeds. Data were collected in September 2004, two months after treatment. Initial results indicate that mycorrhizal inoculation had an insignificant effect (ANOVA $P = 0.481$) on establishment of seedlings, mulched plots have significantly less (ANOVA $P<0.001$) plant establishment, mulch has been successfully colonized by the saprophyte, and competition exists between the saprophyte and existing soil fungi. The short time between application of the treatments and data collection may explain the insignificant increase in establishment, and future benefits are anticipated as the mycorrhizae become established. One-year measurements will be collected in September 2005 and will shed more light onto the effectiveness of mulch and fungal inoculum for restoring forest roads.

PROJECT FRAME (**F**RAMING **R**ESEARCH FOR **A**DAPTIVE **M**ANAGEMENT OF **E**COSYSTEMS): USING COLLABORATIVE MODELING APPROACHES TO LINK SCIENCE TO RESOURCE MANAGEMENT NEEDS

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Today's federal land managers are challenged to use science to manage multiple resources under intense public scrutiny. The goal for resource managers is to optimize the management of multiple resources while minimizing negatives impacts of any given decision. Each decision is also made with the recognition that conditions change, which requires adaptive management approaches. Through Project **FRAME** (**F**raming **R**esearch for **A**daptive **M**anagement of **E**cosystems), the USGS and its partners are addressing these challenges. Our strategy is to couple collaborative problem-solving approaches with physical modeling tools. The modeling framework is the USGS Modular Modeling System (MMS), which is an ideal framework to support the collaborative integration of a broad range of models and tools from a wide range of scientific disciplines. The MMS approach is adaptive and can accommodate many types of science information by linking them in an integrated system. Developing this collaborative modeling approach for natural resource management requires a multi-year effort; however, through an initial focus on pinyon-juniper (PJ) management at Mesa Verde National Park and surrounding lands, we are making significant strides. PJ management involves a number of cross-cutting management issues, such as grazing, OHV use, soil erosion, ecosystem restoration, fire management, urban/wildland interface, woodcutting, invasive species, coal-bed methane development, and recreational tourism. Our approach to linking science information to resource management needs is to adhere to established principles of collaboration by continuously engaging the appropriate people (resource managers, modelers, PJ scientists) in a series of workshops. We have collaboratively framed the science questions embedded in PJ resource management and are collaboratively modeling the appropriate science for PJ ecosystem management. Collaboration goes beyond consultation or “input”—all parties learn from each other in the process. Collaborative identification of issues and science requirements for modeling helps overcome the common pitfalls of many efforts to link science to resource management needs, primarily by maintaining a focus on the decision context to ensure that the scientific information is useful for resource managers. In essence, we use modeling as a mechanism for collaboration. We are on our way to establishing a transportable collaborative modeling approach for adaptive management of ecosystems.

ECOLOGICAL RESTORATION DEMONSTRATION TREATMENTS: A STARTING POINT FOR LOCAL ECOLOGICAL MONITORING AND ADAPTIVE MANAGEMENT

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Ecological restoration treatments are planned throughout southwestern fire-adapted forest ecosystems. This has created a growing need for site-specific prescriptions adapted to local ecological and social conditions. The Ecological Restoration Institute in collaboration with the Wahoo Watershed Workgroup, a community based forestry organization, has initiated a series of small ecological restoration treatments within forested ecosystems in the Black Range District of the Gila National Forest, NM. The goals of these projects are to: 1) assess ecological conditions within restoration treatment areas; 2) develop site-specific treatment prescriptions using assessment data, expert opinion and existing research; and 3) monitor important ecological changes induced by ecological restoration treatments. Workgroup members initially identified the ponderosa pine/Gambel oak ecosystem type for restoration treatment due to its prevalence and degree of degradation within the approved project area. Ecological assessment and monitoring methods included fire scar sampling, measurement of a 10-acre forest structure macroplot, and the installation and measurement of six 0.1-acre monitoring plots per treatment unit. Monitoring plots were installed to assess changes in understory, shrub, and overstory vegetation and forest floor fuels before and after treatment. Four treatment options (two levels of restoration-based thinning with prescribed burn, prescribed burn only and control) were developed by the Workgroup after the initial assessment. Thinning within treatment areas was completed during summer 2005 and a prescribed burn is scheduled for spring 2006. This monitoring design, although limited statistically by pseudo-replication, is logistically simple to establish and will be relatively simple to manage and maintain. Treatment units situated in highly visible areas provide site-specific data demonstrating restoration treatments to the public. Most importantly this project has served as a pilot study, informing ongoing and future efforts in the local area.

DISTURBANCE-FOCUSED CONCEPTUAL MODELS OF MONTANE TERRESTRIAL ECOSYSTEMS ON THE COLORADO PLATEAU. I. MODEL DEVELOPMENT AND PINYON-JUNIPER AND PONDEROSA PINE ECOSYSTEMS

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The Inventory and Monitoring Program of the National Park Service (NPS) has undertaken the development of conceptual models of key ecosystems as a foundational step toward developing long-term monitoring of park natural resources. Models depicting primary structural components, system drivers, and their interactions help us understand the processes that affect the ecological integrity of these resources and thereby help focus monitoring efforts. Conceptual models also are useful for summarizing knowledge, identifying areas in need of additional research, and providing insight into ecosystem management. Our models focus on disturbance and were developed to support long-term monitoring of montane terrestrial ecosystems within NPS units on the Colorado Plateau. The models also apply to non-NPS wilderness areas and provide useful background for public and private lands where logging, grazing, etc. are permitted. Our conceptual models link important biological components such as vegetation-fuels with interactive controls such as disturbance, state factors such as climate-weather, and anthropogenic stressors such as exotic species. We developed a nested suite of three models for each ecosystem. “Ecosystem characterization models” provide a broad framework for information on the ecosystem, including major subsystems, components, and interactions. “Ecosystem dynamic models” focus on the dynamics of those disturbance-related ecosystem components and interactions that historically controlled the ecosystem. These models use a state-and-transition format and include communities within different states and identify processes that form the communities. “Ecosystem mechanistic models” summarize details on processes responsible for patterns depicted in ecosystem dynamics models. We illustrate our approach by presenting models for Pinyon-Juniper and Ponderosa Pine Ecosystems. We identify research needs and discuss applications to management and long-term monitoring. In general, the role of disturbance is poorly known for the Pinyon-Juniper Ecosystem of the Colorado Plateau; therefore, additional research is needed and this research will aid in the development of ecologically appropriate management practices. The role of disturbance is much better known for the Ponderosa Pine Forest Ecosystem; nevertheless, additional research is needed and this research will help refine management practices.

DISTURBANCE-FOCUSED CONCEPTUAL MODELS OF MONTANE TERRESTRIAL ECOSYSTEMS ON THE COLORADO PLATEAU. II. MIXED CONIFER, SPRUCE-FIR, GRASSLAND, AND SHRUBLAND ECOSYSTEMS

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Our conceptual models of montane terrestrial ecosystems on the Colorado Plateau focus on disturbance and were developed to support long-term monitoring within National Park Service (NPS) units. Our models also apply to non-NPS wilderness areas and provide useful background for public and private lands where logging, grazing, etc. are permitted. We developed a nested suite of three conceptual models for each ecosystem. The “ecosystem characterization models” provide a framework for information on the ecosystem, including major subsystems, components, and interactions. The “ecosystem dynamic models” provide a state-and-transition framework for information on the dynamics of those disturbance-related ecosystem components and interactions that historically controlled the ecosystem. The “ecosystem mechanistic models” summarize information on processes responsible for patterns depicted in ecosystem dynamics models. We present models for Mixed Conifer Forest, Spruce-Fir Forest, Montane Grassland, and Gambel Oak Montane Shrubland Ecosystems. We identify research needs and describe applications to management and long-term monitoring. Knowledge of the role of disturbance in Mixed Conifer Forest is emerging, but additional research and the development of ecologically appropriate management practices are needed. Disturbance

regimes of the Spruce-Fir Forest, Montane Grassland, and Gambel Oak Shrubland Ecosystems are either poorly known or known from only a few geographic areas of the Colorado Plateau. Additional research and the development of appropriate management practices are needed.

DISTURBANCE-FOCUSED CONCEPTUAL MODELS OF MONTANE TERRESTRIAL ECOSYSTEMS ON THE COLORADO PLATEAU

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The Inventory and Monitoring Program of the National Park Service (NPS) has undertaken the development of conceptual models of key ecosystems as a foundational step toward developing long-term monitoring of park natural resources. Conceptual models also are useful for summarizing knowledge, identifying areas in need of additional research, and providing insight into ecosystem management. Our models focus on disturbance and were developed to support long-term monitoring of montane terrestrial ecosystems within NPS units on the Colorado Plateau. We developed a nested suite of three models for each ecosystem. The “ecosystem characterization models” provide a framework for information on the ecosystem, including major subsystems, components, and interactions. The “ecosystem dynamic models” provide a state-and-transition framework for information on the dynamics of those disturbance-related ecosystem components and interactions that historically controlled the ecosystem. The “ecosystem mechanistic models” provide details on processes responsible for patterns depicted in the ecosystem dynamics model. We present models for Pinyon-Juniper, Ponderosa Pine Forest, Mixed Conifer Forest, Spruce-Fir Forest, Montane Grassland, and Gambel Oak Shrubland Ecosystems. We also seek feedback on our models.

WATER QUALITY IN LAKE POWELL AND THE COLORADO RIVER

VERNIEU, WILLIAM, Susan Hueftle, Steven Gloss

This presentation provides an overview of water-quality trends and conditions in Lake Powell and the Grand Canyon ecosystem. Because Lake Powell and Glen Canyon Dam operations have a strong influence on downstream water quality, the water quality of the reservoir is discussed in some detail. The session also addresses recent drought-induced changes and the effects of the modified low fluctuating flow (MLFF) alternative.

RESTORATION OF BLOOMINGTON CAVE, SOUTHERN UTAH

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Bloomington Cave has been receiving continual use since the late 1890’s. During the last century, many people have left their mark with carbide from headlamps and more recently, spray paint. The purpose of project was to remove modern spray paint graffiti via sandblasting equipment and to preserve all historic writings. During this project, we cleaned approximately 1100 feet of passage and preserved five known historic writing panels dating back to 1893 and discovered three new panels. This project was an effort involving over 50 volunteers and over 1000 person hours with individuals donating over 86,000 dollars in time and materials.

RELATIONSHIP BETWEEN MEASURED HABITAT QUALITY AND FIRST YEAR SURVIVAL FOR TRANSPLANTED BIGHORN SHEEP IN ARIZONA.

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Bighorn sheep (Ovis canadensis) have been transplanted throughout Arizona, primarily following evaluation of potential habitat using systematic evaluation criteria that allows managers to rank and prioritize habitats according to perceived suitability. Many appraisals have been conducted to determine how well a variety of systematic habitat evaluations function in predicting bighorn sheep habitat use and many provide functional expectations. Recently, mountain lion (Puma concolor) predation on transplanted bighorn sheep has been suggested to be indicative of increasing mountain lion populations. An alternate hypothesis that was not explored was that more recent bighorn sheep transplants occurred in lower quality habitat, which may incidentally affect predation rate by mountain lions. I use annual survival and cause-specific mortality estimates for the first year following release in several Arizona bighorn sheep transplants to examine correlations with a priori habitat evaluation scores.

CHEMICAL RENOVATION OF FOSSIL CREEK, ARIZONA

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Chemical renovation of Fossil Creek, central Arizona, was conducted in autumn 2004 to remove exotic smallmouth bass and green sunfish, and restore a native fish community consisting of roundtail and headwater chub, speckled and longfin dace and Sonora and desert sucker. Complex habitat conditions related to travertine dams, deep pools, and multiple channels complicated renovation. Breakdown of antimycin A by high pH and dissolved CO_2, $CaCO_3$, and iron required multiple pre-treatment bioassays. Native fishes were salvaged, transported nearby, held in captivity prior to treatment and repatriated after detoxification. Depending on local water quality, antimycin A (Fintrol®) was applied at concentrations of 50-100 ppb over 4-6 hours using drip buckets spaced approximately 150 m apart. Backpack sprayers applied Fintrol® in peripheral habitats, while antimycin-coated sand grains (Fintrol-15®) were added to deep pools. Antimycin A was applied twice in rapid succession to ensure complete mortality. Over 380 L of Fintrol® toxicant and 187 kg of Fintrol-15® sand was applied to about 16 km of stream. Liquid sodium permanganate was applied at 3 ppm near a constructed barrier to detoxify the antimycin A. Extensive aquatic habitat mapping, logistical planning and innovative application techniques contributed to this successful native fish restoration project.

RESTORATION OF SOUTHWESTERN PONDEROSA PINE FORESTS: IMPLICATIONS AND OPPORTUNITIES FOR WILDLIFE

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After a century of fire suppression, livestock grazing, and even-aged timber harvesting, forest managers in the Southwest face an enormous challenge. Millions of acres of ponderosa pine forest are extremely susceptible to uncharacteristic, high intensity wildfires, the consequences of which were amply demonstrated by recent mega-fires in Arizona and New Mexico. Current condition ponderosa pine forests are also atypically homogeneous in structure and composition, which results in reduced habitat biodiversity for wildlife. In response, land managers have begun planning and implementing extensive forest treatment projects along urban interfaces and in wildland areas. Although many of these projects are designed primarily to reduce the risk of high intensity wildfire, these treatments have considerable potential to improve wildlife habitat by creating diversity at the stand and landscape level and increasing productivity in shrub and understory layers. There is widespread agreement that restoration of Southwestern forests is needed, however, the location, scale, and approach of treatment prescriptions remain controversial, especially when addressing wildlife needs. We present a conceptual overview of wildlife responses to treatment-induced changes in ponderosa pine forest structure and summarize results from ongoing studies on the Mt. Trumbull restoration area in northern Arizona and the wildland-urban interface near Flagstaff.

IDENTIFYING THE IRRIGATION REQUIREMENTS OF NATIVE-PLANT LANDSCAPES ON THE COLORADO PLATEAU

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Population growth on the Colorado Plateau has more than doubled since the mid-1960s but allocated water supplies to support this growth have remained relatively constant. Consequently, many municipalities in the region have implemented water conservation plans to insure adequate water supplies for future development. Included in these plans have been restrictions on either the volume of water that can be used for irrigating existing landscapes or on the type or quantity of plant species that can be included in new landscapes. Incentives to replace existing high water-use landscapes (ie. turfgrass) with drought-tolerant landscapes consisting of native species have also been offered. Changing landscape type, however, does not necessarily result in water savings if irrigation strategies are not adjusted to accommodate the change. To accomplish this, the homeowner or landscape manager must be familiar with the specific water requirements of each replacement species. To exhibit and evaluate the water requirements of drought-tolerant native plant species that may be appropriate for Colorado Plateau landscapes, a xeric plant demonstration/research garden was established at New Mexico State University's Agricultural Science Center (ASC) at Farmington, NM during 2002. The ASC is located in the center of the Plateau at an elevation of 1700 meters and receives an average annual precipitation of 208 mm. Approximately 100 plant species, most of which are native to the Plateau, are exhibited in the garden at four different irrigation levels (0, 20, 40, and 60% of climate-based reference evapotranspiration [ET]). While many species have survived and exhibited acceptable quality with little to no supplemental irrigation, nearly all species have thrived at irrigation levels ranging from 20 to 40% of reference ET (10 to 20 L/ plant/week during summer). This presentation explains techniques for scheduling micro-irrigations on native-plants using climate data and plant canopy area. Additionally, it provides irrigation and species recommendations for water-conserving landscapes on the Plateau. Through implementation of these techniques and recommendations, more water will be available for other beneficial uses, including maintenance of in-stream flows and aquifer recharge, on the Colorado Plateau.

DIFFUSE AND SPOTTED KNAPWEEDS: REAL THREATS

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Spotted and diffuse knapweeds (*Centaurea biebersteinii* and *C. diffusa*) are considered by many to be invasive and are listed by 14 states and 4 Canadian provinces as noxious weeds. First documented in the Flagstaff area in 1979, diffuse knapweed now lines many county roads and state highways. Although less common in the region, spotted knapweed was documented in northern Arizona as early as 1983. Both species have a number of attributes that make them successful invaders. Diffuse knapweed can germinate under varying environmental conditions and its seedlings can survive extremes of temperature and soil moisture. We documented germination of diffuse knapweed as early as April in contained seed packets at an elevation of 2,560 m, and seedlings in our pot study survived extreme drought conditions that killed most native plants. Spotted knapweed seeds remain viable in the seedbank for at least eight years. Knapweeds are highly competitive under varying resource conditions and are allelopathic. Studies indicate only minimal, if any, grazing by wildlife and livestock once plants reach maturity. Although both spotted and diffuse knapweeds are currently limited mostly to high disturbance areas in this region, the concern is that they will expand into forest edges and eventually interior forests. We are also presently investigating dispersal rates into upland ponderosa pine forest and via storm water runoff. Severe fire could advance knapweed spread to these areas. Our research indicates that conditions created by either high severity wildfires or slash pile burns enhance germination of diffuse knapweed seeds compared to unburned sites. What steps can be taken to curtail the spread of these two invaders? Currently, governmental agencies and local organizations use various control treatments on both species. Unfortunately, diffuse knapweed populations are so extensive and well established that curtailment within Flagstaff will require large expenditures. Forest managers, home owners, and business owners both here and in other parts of the Colorado Plateau can do their part by treating populations of these species when they are small and relatively easy to contain.

RETURNING NATURAL FLOW INTO THE OXBOW: RESTORATION OF A 40 YEAR-OLD DIVERSION IN CAPITOL REEF NATIONAL PARK, UTAH

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During the 1961-62 construction of Utah State Highway 24 in south-central Utah, a portion of the Fremont River was rerouted. Rather than constructing the highway along a mile-long meander in the river or building bridges over the river to allow water to flow along its natural course, a 0.16-mile cut was excavated through an area of sandstone cliff and the road was routed through it. As part of road construction, a new river channel was constructed parallel to the road, which diverted the river from its natural course and cut off the meander of the river (the oxbow). This river diversion also created a man-made waterfall as the mile-long drop in stream elevation is now accomplished in less than 300 yards. At the time of river diversion, this area was outside the boundaries of Capitol Reef, but was subsequently encompassed by a 1969 expansion. Removal of flow from the oxbow extirpated a federally listed orchid, and the waterfall has created a hazard resulting in over 15 documented visitor injuries. In cooperation with the Utah Department of Transportation, the park proposes to return the river into its natural channel through the construction of two bridges on Highway 24. The proposed project would fill the man-made diversion channel that was constructed in 1962, which would eliminate the public safety hazard created by the waterfall at the end of the diversion channel. In addition, this proposal would re-establish the natural hydrology and stream corridor of the Fremont River through a 0.9 mile section and re-establish 16 acres of wetland habitat.

INFLUENCE OF GLEN CANYON DAM OPERATIONS ON DOWNSTREAM SAND RESOURCES OF THE COLORADO RIVER IN GRAND CANYON

WRIGHT, SCOTT, Ted Melis, David Topping, Rubin

The U.S. Geological Survey's (USGS) Grand Canyon Monitoring and Research Center and its cooperators have conducted extensive monitoring and research on fine-sediment transport and sandbar evolution in Grand Canyon. This talk presents a summary of the results of studies since the 1970s, as well as conclusions derived from recent syntheses of streamflow, sediment transport, and geomorphic data from 1921 to 2004, including recent sediment budgets. The effects of the MLFF operating alternative at Glen Canyon Dam (1996–2004) on fine-sediment transport and sandbars are examined in the context of these historical data. Finally, options identified by sediment scientists for testing alternative operations aimed at more effective conservation of fine-sediment resources are discussed.

CAVE ECOLOGY ON THE ARIZONA STRIP

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There is little ecological information on caves of the Arizona Strip. The few cave-related studies in the region represent opportunistic collecting of invertebrates and some limited bat inventories. This region presents great opportunities for increasing the body of knowledge concerning the discovery of new species, as well as increasing the body of knowledge concerning Arizona cave ecology. Additionally, information concerning cave use by bats will be an important contribution to better understanding bats of northwestern Arizona. We will present information on previous cave research, and provide results of 2005 surveys where we either inventoried or conducted site visits to 30 caves on BLM lands and Grand Canyon-Parashant National Monument. During our inventories, we trapped invertebrates in all light zones, captured

and released bats and noted all wildlife activity. To date, we have tentatively identified at least five caves as either ecologically sensitive or as containing significant ecological resources.

VERTEBRATE GAP ANALYSIS ON THE COLORADO PLATEAU USING SOUTHWEST REGIONAL GAP (SWReGAP) DATA

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Spatially explicit predictive models are an important tool for understanding wildlife-habitat relationships and guiding natural resource management decisions. For predictive models to be a useful tool in the decision making process, they must be accurate, general, and easy to apply. Gap analysis involves developing and relating wildlife habitat relationship models to regional land stewardship; through this process, the results of a gap analysis may be used to delineate areas identified as containing high species richness. Using the recently completely SWReGAP analysis data, we will examine the relationship between species richness indices and land stewardship on the Colorado Plateau. In so doing, we will delimit areas considered ecological "hotspots," relate these areas to conservation-oriented land stewardship and discuss how well the two intersect.

FROM TREES TO GRASSES: UNDERSTANDING COMMUNITY GENETICS WITH GEOGRAPHY AND CLIMATE

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Genetic diversity is the raw material for evolutionary processes and its understanding provides important information for forest conservation and restoration. The association between environmental heterogeneity and genetic diversity has been widely studied. However, little is known regarding genetic variation in forest canopy and understory species within the same community and how they may be related. We hypothesized there would be a correlation between genetic variation in ponderosa pine (*Pinus ponderosa*) and bottlebrush squirreltail (*Elymus elymoides*), an understory species found in ponderosa pine forests in northern Arizona. We examined the genetic relationships using measures of genetic and geographic distance, and climatic conditions. Allozyme data show these two species exhibit different genetic structures, which is likely due to the fact they have different life histories and mating systems. Ponderosa pine exhibits relatively high genetic variation within populations and low variation among populations, while bottlebrush squirreltail shows low genetic variation within populations and high variation among populations. This difference may be due to relatively low gene flow between populations of bottlebrush squirreltail compared to ponderosa pine. These two species also show different relationships between geographic distance and climatic conditions. There is a positive correlation between genetic variation of ponderosa pine and geographic distance, but no correlation between genetic variation and climatic conditions. In contrast, genetic variation of bottlebrush squirreltail is significantly correlated with climatic conditions, but has no correlation with geographic distance. Based on these findings, we will make recommendations for seed transfer and conservation of ponderosa pine and bottlebrush squirreltail.