Past, Present, & Future Challenges to Natural & Managed Ecosystems

Sagebrush, Salmon, & Syrah in a Non-stationary Environment

86th Annual Meeting Northwest Scientific Association
April 1-4, 2015
Columbia Basin College, Pasco, WA

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Program and Abstracts
Northwest Scientific Association
86th Annual Meeting

Columbia Basin College
Pasco, Washington

April 1-4, 2015

Held in Cooperation with

Columbia Basin College

Ice Age Floods Institute

MCBONES Research Center Foundation

Mount St. Helens Institute

Northwest Lichenologists

US Forest Service Pacific Northwest Research Station

Washington State University – *Tri-Cities*

THANK YOU to all who helped

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Pacific Northwest National Laboratory

Gary Kleinknecht
Ice Age Floods Institute

Jenny von Reis
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University of Washington

Symposium Organizers

35th Anniversary of the 1980 Eruption of Mount St. Helens Science Symposium
Ray Yurkewycz and Charlie Crisafulli
USFS Pacific Northwest
Research Station

Fish Passage and Fish Ecology in the Northwest
Allison Colotelo and Ryan Harnish
Pacific Northwest National
Laboratory

Thanks also to Ice Harbor Brewing Company, Kiona Vineyards, and Hedges Family Estate for providing the beer and wine for the Wednesday evening social.

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A WELCOME FROM THE PRESIDENT

Northwest Scientific Association

… promoting scientific research and disseminating scientific knowledge since 1923
http://www.northwestscience.org/

Welcome to the 86th Annual Meeting of the Northwest Scientific Association (NWSA). Thank you for supporting the Association and your community of scientists in northwestern North America. Our conference organizers, Janelle Downs, Gary Kleinknecht, George Last, and Bax Barton have put together an exciting program to consider past, present, and future forces shaping arid lands and their consequences for natural and managed ecosystems. We are especially honored to have keynote and banquet speakers Dr. Gregory Jones and Roy Gephardt. Dr. Jones studies the effects of climate on wine production at Southern Oregon University and will talk about the meaning and significance of terrior to viticulture and how it may be affected by a changing climate. Mr. Gephardt is recently retired from the Pacific Northwest National Laboratory and has 40 years of experience in the radioactive waste industry. He will describe the history of Hanford, and the status, uncertainties, and challenges of clean-up. Complementing the technical sessions, our field trips invite participants to see evidence of the geology and paleoecology of the Coyote Canyon Mammoth Site and Ice Age floods, explore the Hanford Reach, learn about viticulture in the Lower Yakima Valley, or discover the diversity of lichens and mosses living in the Saddle Mountains. Through offering a variety of technical and poster sessions, workshops, field trips, and conversations we hope that this conference provides inspiration and fosters collaboration.

If you are not a member of NWSA, I strongly encourage you to join. We welcome anyone in the northwestern United States and western Canada who is interested in science, and we strive to be inclusive. Through our diverse membership, annual conference, peer-reviewed journal, website, and Facebook page we seek to connect scientists in the natural and applied sciences and disseminate scientific knowledge. Our Association provides a means to connect with others, look for job opportunities, seek student grants, publish research, and identify mentors. Explore our website at http://www.northwestscience.org to keep current on NWSA events and to sign-up or renew your membership. Our journal, *Northwest Science,* can be viewed on-line at the BioOne website, http://www.bioone.org/loi/nwsc. Full content is available to NWSA members. Given our worldwide accessibility via BioOne, *Northwest Science* is a great place to publish your work!

Please take a moment to review NWSA Information on the next page to learn about NWSA, how to get involved, and who to thank for making NWSA activities happen, including this conference. NWSA is sustained by many dedicated and hard-working people.

This year's conference has benefited from the support of generous sponsors: Columbia Basin College, Washington State University – Tri-Cities, Ice Age Flood Institute, MCBONES Center Research Foundation, USDA Forest Service Pacific Northwest Research Station, Mount St. Helens Institute, Northwest Lichenologists, US Geological Survey, and the Pacific Northwest National Laboratory. On behalf of the NWSA Board of Directors, I am truly grateful for their backing.

I hope you enjoy the meeting and have a chance to see old friends and make new connections. And thank you for your support of the NWSA through your membership and meeting attendance.

Sincerely,

Andrea Woodward

President

Linking Scientists throughout Northwestern North America

Since 1923 the Northwest Scientific Association (NWSA) has existed for the purpose of promoting scientific knowledge in the northwestern USA and western Canada. Our membership includes students and instructors from high school through university, federal agency employees and professional and amateur scientists interested in applied, natural, environmental and conservation sciences in the Pacific Northwest. Each year the NWSA publishes four issues of our peer-reviewed journal, Northwest Science. Our annual meetings are held in cities throughout the Pacific Northwest and provide an opportunity for all members to share their current research results and establish collaborative interactions.

Would you like to get involved? Students are encouraged to join and participate in the NWSA. All members in good standing, including Student members, are eligible to serve on various committees, including the Nominations, Student Research Grant, Awards and Honors, and local Annual Meeting Program committees.

Would you like to get involved and begin networking with the oldest and largest association of scientists in the Pacific Northwest? To learn more, talk to one of the board of directors, or go to our website at http://www.northwestscience.org.

A Special *THANK YOU* is extended to our Board of Directors

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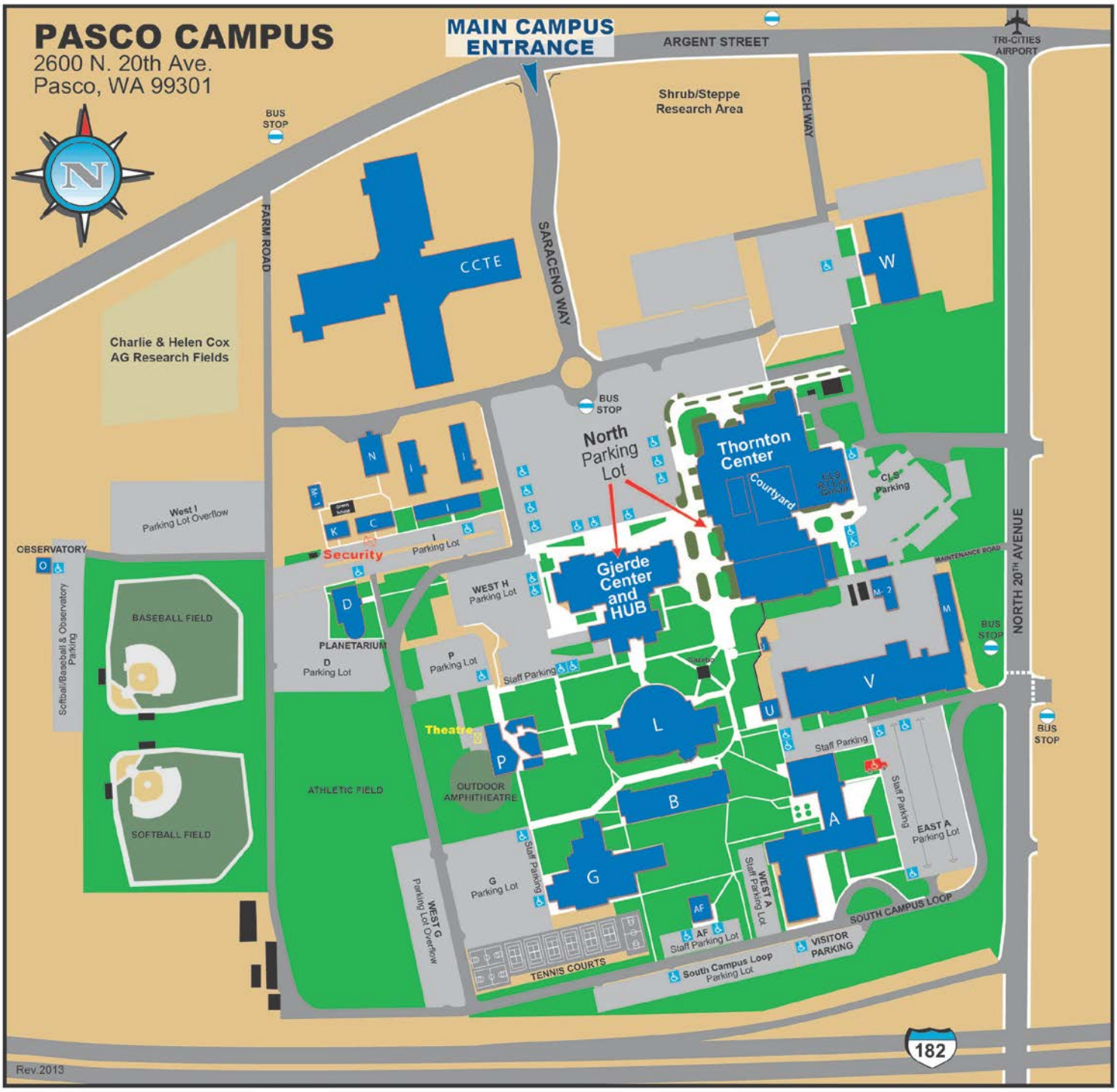
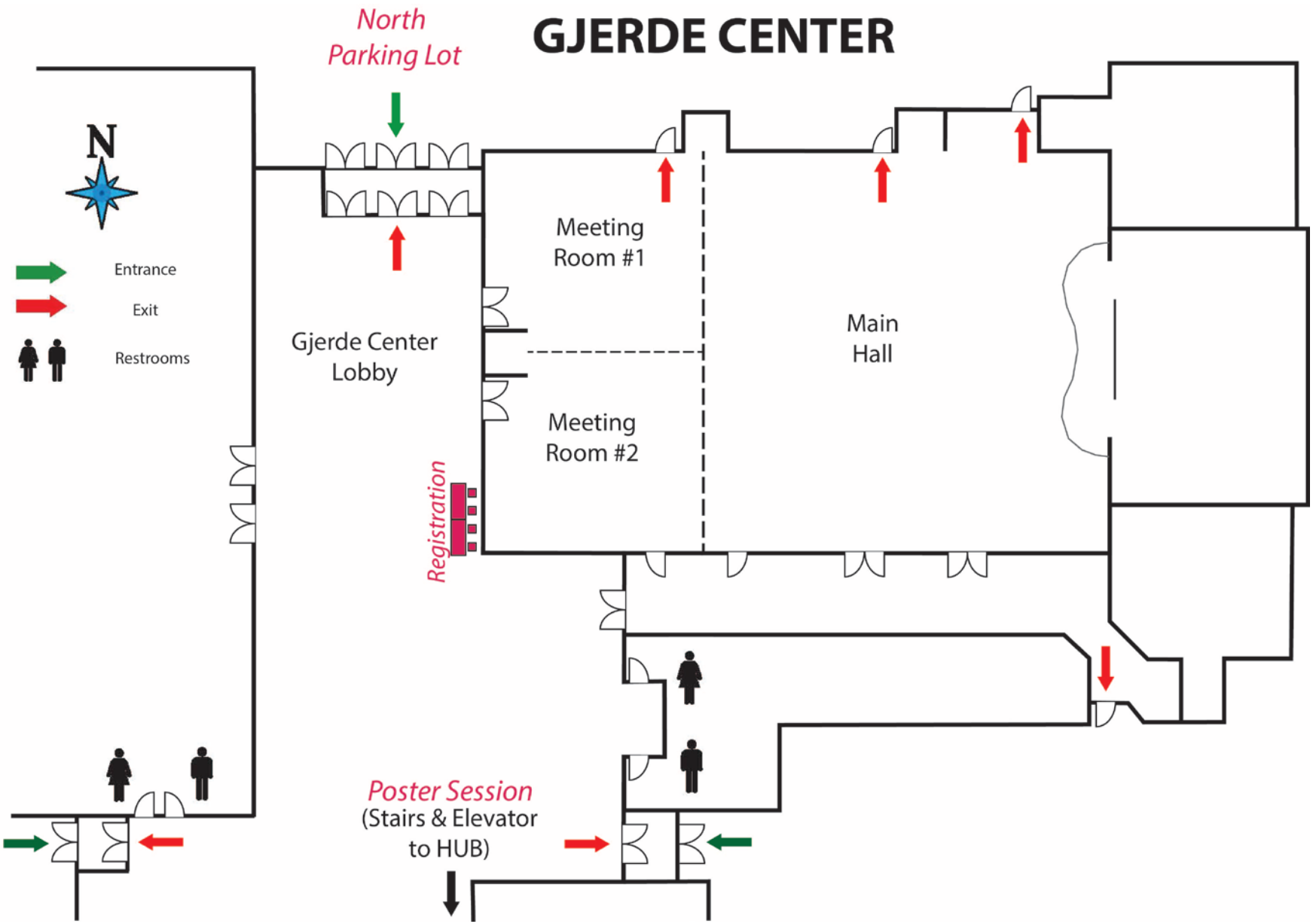
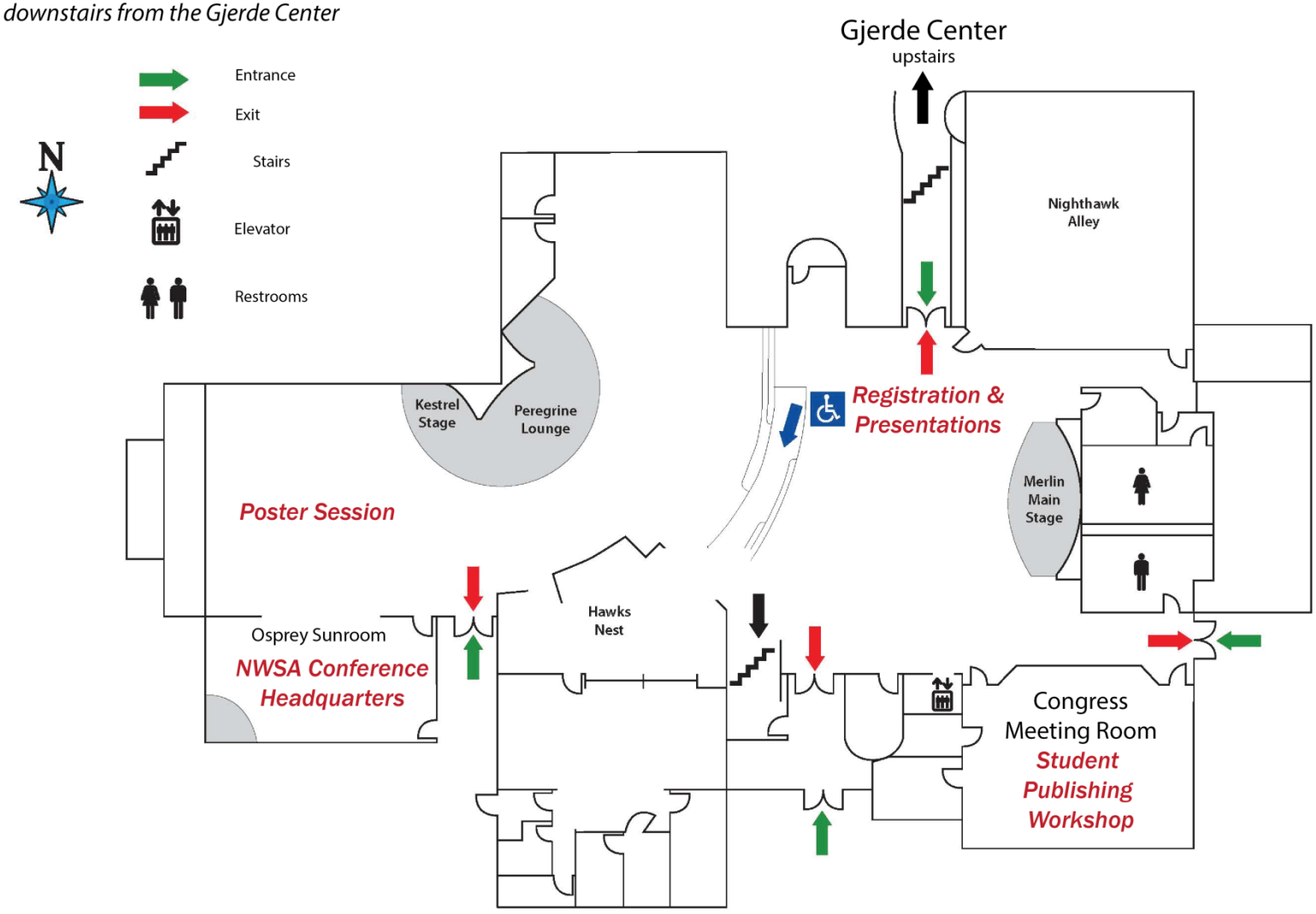
Northwest Scientific Association
Conference Site Map
Parking is in the North Parking Lot




GJERDE CENTER
North
Parking Lot
N
Entrance
Exit
Restrooms
Gjerde Center
Lobby
Meeting
Room #1
Meeting
Room #2
Main
Hall
Registration
Poster Session
(Stairs & Elevator
to HUB)

Hawk Union Building (HUB)

downstairs from the Gjerde Center




Thornton Center
S219
S218
S217
S216
S220
S221
S222
S223
S224
S203
S202
S210
S106
S104
S103
S102
S101
S100
S207
S206
S107
S108
S205
S109
S110
S121
S126
S125
S122
S127
S111
S112
S113
S114
S115
S134
S136
S138
S141
S143
S144
S145
S146
Stockroom
S147
S151
S152
S153
S154
S156
Gjerde
Center
S226
S229
S230
S233
S239
S238
S237
S235
S243
Lichen
Workshop
S246
S247
S248
S249
Greenhouses
Courtyard
Wednesday
Social
S338
S339
S337
S340
S336
NWSA Board
Meeting
Gjerde
Center
TD403
Student Support
Services
TD414
TD415
Student
Retention
Outreach
TD422
SSS
TD420
TD428
TD419
TD418
TD433
Training
Classroom
TD435
Math
Success
Center
TD439
Conference
Room
TD434
Tutor Center
T445
Storage
N
Restrooms
Entrance/Exit

Table of Contents

A sampling of science-based art illustrating Ice Age floods and Columbian mammoths will be on display in the lobby during Friday's (April 3) technical presentations. The original paintings, created by Corvallis artist Stev Ominski, support several presentations being offered Friday morning in the "Geology, Paleontology and Ice Age Floods" session.

Need a Wireless Connection?

A wireless connection is available for your convenience. Please follow these steps:

1. Look for available wireless networks
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Program Overview

Thursday April 2, 2015		
Location	Main Hall	
8:15 – 9:30	**Welcome and President's Message**	
	Keynote Address: Dr. Greg Jones *Climate, Grapes, & Wine: Structure, Suitability, & Sustainability in a Changing Climate*	
9:30 – 10:00	Break	
Location	Main Hall	Room 1
10:00 – 12:00	35th Anniversary of the 1980 Eruption of Mount St. Helens Science Symposium	Climate and Integrated Resource Management in Natural and Agricultural Systems
12:00 – 1:15	Lunch	
1:20 – 2:40	35th Anniversary of the 1980 Eruption of Mount St. Helens Science Symposium (Cont.)	Management and Restoration in Sagebrush Ecosystems
2:40 – 3:10	Break	
3:10 – 4:10	Impacts of Changing Climates in Natural and Managed Systems	Management and Restoration in Sagebrush Ecosystems (Cont.)
Location	HUB (Downstairs from the Gjerde Center)	
4:30 – 6:30	Attended Poster Session	

7:00 – 9:00 Banquet at the Red Lion Inn
Roy Gephart will speak about History & Status of the Hanford Site: Implication for the Future

Friday April 3, 2015			
Location	**Main Hall**	**Room 1**	**Room 2**
8:20 – 9:40	Fish Passage and Fish Ecology in the Northwest	Geology, Paleontology and Ice Age Floods in the Northwest	Ecology of Pacific NW Rangelands and Forests
10:00 – 10:20	Break		
10:20 – 12:00	Fish Passage and Fish Ecology in the Northwest (Cont.)	Geology, Paleontology and Ice Age Floods in the Northwest (Cont.)	Ecology of Pacific NW Rangelands and Forests (Cont.)
12:00 – 1:15	Lunch		
1:20 – 2:40	Fish Passage and Fish Ecology in the Northwest (Cont.)		Ecology of Pacific NW Grasslands and Forests
2:20 – 3:00	Break		
Workshops			
1:20 – 3:00	Photosynthetic Symbionts in the Landscape, Both Lichenized and Free-Living Workshop, Thornton Center Rooms 243 and 246		
3:20 – 4:20	Photosynthetic Symbionts in the Landscape, Both Lichenized and Free-Living Workshop (Cont.), Thornton Center Rooms 243 and 246 Student Workshop on *Best Practices for Submitting Manuscripts to Scientific Journals*, HUB Congress Room		

Program at a Glance

Wednesday April 1

3:00 – 5:30 pm	Registration Desk Open, Gjerde Center Lobby
3:00 – 6:00 pm	NWSA Board Meeting, Lee R Thornton Center, Conference Room TD 439
6:00 – 8:00 pm	Evening Social (complimentary hors d'oeuvres and no-host bar featuring wine from Hedges Family Estate and Kiona Vineyards wineries and beer from Ice Harbor Brewing Company) Lee R. Thornton Center Courtyard

Thursday April 2

7:30 am – 4:30 pm	Registration Desk Open, Gjerde Center Lobby
8:00 am – 9:30 am	Welcome and Introduction Plenary Session – Keynote Address by Dr. Greg Jones, Gjerde Center Main Hall
9:30 – 10:00 am	Morning Break, Gjerde lobby
10:00 am – 12:00 pm	35th Anniversary of the 1980 Eruption of Mount St. Helens Science Symposium, Gjerde Main Hall Climate and Integrated Resource Management in Natural and Agricultural Systems technical session, Gjerde meeting rm 1
12:00 – 1:15 pm	Lunch Break on your own
1:20 – 2:40 pm	35th Anniversary of the 1980 Eruption of Mount St. Helens Science Symposium, Gjerde Main Hall Management and Restoration in Sagebrush Ecosystems technical session, Gjerde meeting rm 1
2:40 – 3:10 pm	Afternoon Break, Gjerde lobby
3:30 – 4:30 pm	Management and Restoration in Sagebrush Ecosystems technical session, Gjerde meeting rm 1
4:30 – 6:30 pm	Attended Poster Session, HUB (downstairs from the Gjerde Center) *Light refreshments provided*
7:00 – 9:00 pm	Banquet at the Red Lion Inn featuring Roy Gephart - *History & Status of the Hanford Site: Implication for the Future*

Program at a Glance (continued)

Friday April 3

7:30 am – 4:30 pm	Registration Desk Open, Gjerde lobby
8:20 am – 4:30 pm	Steve Ominski display of science-based art illustrating Ice Age floods and Columbian mammoths, Gjerde lobby
8:20 – 10:00 am	Geology, Paleontology and Ice Age Floods in the Northwest technical session, Gjerde meeting rm 1
	Ecology of Pacific NW Rangelands and Forests technical session, Gjerde meeting rm 2
	Fish Passage and Fish Ecology in the Northwest Symposium, Gjerde Main Hall
10:00 – 10:30 am	Morning Break, Gjerde lobby
10:30 – 11:50 am	Geology, Paleontology and Ice Age Floods in the Northwest technical session, Gjerde meeting rm 1
	Ecology of Pacific NW Rangelands and Forests technical session, Gjerde meeting rm 2
	Fish Passage and Fish Ecology in the Northwest Symposium, Gjerde Main Hall
11:50 – 1:20 pm	NWSA Business Lunch in the HUB (downstairs from the Gjerde Center or lunch on your own
1:20 – 3:00 pm	Ecology of Pacific NW Grasslands and Forests technical session, Gjerde meeting rm 2
	Fish Passage and Fish Ecology in the Northwest Symposium, Gjerde Main Hall
	Photosynthetic Symbionts in the Landscape, Both Lichenized and Free-Living Workshop (Cont.), Thornton Center Rooms 243 and 246
3:00 – 3:20 pm	Afternoon Break, Gjerde lobby
3:00 – 4:20 pm	Photosynthetic Symbionts in the Landscape, Both Lichenized and Free-Living Workshop (Cont.), Thornton Center Rooms 243 and 246
	Student Workshop on *Best Practices for Submitting Manuscripts to Scientific Journals*, HUB Congress Room

Program at a Glance (continued)

Saturday April 4 Field Trips – All meet in the CBC North parking lot

Participants should wear sturdy shoes (in some cases, hiking boots are advisable) and appropriate clothing for changing weather conditions and cheatgrass. Participants should also bring their own water, snacks, lunches, etc. as appropriate.

Oh, and don't forget your camera.

8:00 am – 11:00 am	Geology, Paleontology, & Paleoecology of the Coyote Canyon Mammoth Site
8:30 am – 4:30 pm	Ice Age (Missoula) Floods Through the Mid-Columbia Region
8:30 am – 2:30 pm	The Hanford Reach – Influences of Energy and Agriculture on Resources in the Reach
8:30 am – 4:30 pm	Lichens of the Saddle Mountains
8:30 am – 4:30 pm	Exploring the Past, Present, and Future of Viticulture in the Lower Yakima Valley

Symposia Descriptions

35th Anniversary of the 1980 Eruption of Mount St. Helens Science Symposium

Thursday, April 2, 2015, 10:00 AM-2:40 PM

"Volcanism as a force shaping Pacific Northwest ecosystems: Lessons learned from 35-years of research at Mount St. Helens"
The spectacular explosive eruption of Mount St. Helens on May 18, 1980 captured the world's attention and created an exemplary opportunity for ecologists to study ecosystem responses to a large, intense disturbance. Thirty-five years following the eruption, the volcano continues to be a hotbed for learning, holding the interest of long-term researchers and attracting a young and vibrant new cohort of scientists. This symposium highlights several short- and long-term studies that illuminate our understanding about ecological responses for a variety of system types (i.e., uplands, riparian, riverine, ponds, and lakes) and taxa, across a range of spatial and temporal scales, and also highlights the global importance of Mount St. Helens to the field of volcano ecology. Presenters will provide a general overview of the Mount St. Helens ecology program as well as describe several unexpected impacts of tephra fall on forest understory plants, the invasion and assembly of aquatic macroinvertebrate communities in ~ 100 ponds created during the eruption, the surprising characteristics of a newly formed rainbow trout population in Spirit Lake, the interesting biogeochemical roles of a herbivorous fossorial rodent during early primary succession, and the prevalence of invasive exotic plants in areas under different post-eruption management conditions along a volcanic disturbance gradient.

Jointly Sponsored and Organized by the US Forest Service, Pacific Northwest Research Station and the Mount St. Helens Institute.

Moderators: Ray Yurkewycz and Charlie Crisafulli

Fish Passage and Conservation in the Pacific Northwest Technical Session

Friday, April 3, 2015, 8:00 AM-2:40 PM

The Pacific Northwest of the United States is home to a diverse group of both marine and freshwater fishes. Due to the diversity and abundance, fish are prevalent in the culture of the Pacific Northwest, being a staple in the cuisine, an icon for many Native American tribes, and an economic staple with the fishing industry. Despite the popularity, fish populations have declined in the last century, and the reasons are numerous and complex, but include overharvest, the construction of barriers throughout the river systems, and habitat alterations. As such, the Pacific Northwest is home to some of the most extensive research on fish populations in the world. Numerous federal, state, and private agencies are focused on understanding the reasons for the decline of fish populations and options for their recovery. This session includes a broad range of studies that examine some of the most pressing fish conservation issues in the Pacific Northwest, most notably fish passage. It also highlights some of the technology and approaches designed to address these issues.

Organized by Pacific Northwest National Laboratory

Moderators: Alison Colotelo and Ryan Harnish

Session Schedule
Thursday, April 2

35th Anniversary of the 1980 Eruption of Mount St. Helens Science Symposium

Room: Gjerde Center Main Hall
Moderators: Ray Yurkewycz and Charlie Crisafulli

10:00 **MOUNT ST. HELENS ECOLOGICAL RESEARCH: A 35 YEAR PERSPECTIVE.** *Charles M. Crisafulli*, USDA Forest Service, Pacific Northwest Research Station, Amboy, WA; Frederick J. Swanson, USDA Forest Service, Pacific Northwest Research Station, Corvallis, OR

10:20 **DIVERSITY OF MOBILE MACROINVERTEBRATES IN PONDS CREATED ON THE DEBRIS-AVALANCHE DEPOSIT FOLLOWING THE 1980 ERUPTION OF MOUNT ST. HELENS.** *Shannon M. Claeson*, USDA Forest Service, Pacific Northwest Research Station, Wenatchee, WA; Charles M. Crisafulli, USDA Forest Service, Pacific Northwest Research Station, Amboy, WA; Peter A. Bisson, USDA Forest Service, Pacific Northwest Research Station, Olympia, WA

10:40 **CHARACTERISTICS OF A NEW RAINBOW TROUT POPULATION IN SPIRIT LAKE, MOUNT ST. HELENS: 2000-2014.** *Tara Blackman*, Charlie Crisafulli, USDA. Forest Service, Pacific Northwest Research Station, Amboy, WA

11:00 **THE SPREAD OF EXOTIC PLANT SPECIES AT MOUNT ST. HELENS: THE ROLES OF A ROAD, DISTURBANCE TYPE AND POST-DISTURBANCE MANAGEMENT.** *Lindsey Karr*, Jeffrey Gerwing, Portland State University, Portland, OR 97207; Charlie Crisafulli, USDA Forest Service, Pacific Northwest Research Station, Amboy, WA

11:20 **AFTER THE ASH FALLS…–PLANT RESPONSES TO VOLCANIC TEPHRA.** *Don Zobel*, Oregon State University, Corvallis, OR; Joe Antos, University of Victoria, Victoria BC, Canada

11:40 **DO CLEAR-CUTS DELAY VEGETATION RECOVERY FOLLOWING VOLCANIC DISTURBANCE IN COMPARISON TO OLD-GROWTH FORESTS?** *Dylan G. Fischer*, The Evergreen State College, Olympia, WA; Joseph A. Antos, University of Victoria, Victoria, BC, Canada; Abir Biswas, The Evergreen State College, Olympia WA; Donald B. Zobel, Oregon State University, Corvallis, OR

Lunch

1:20 **GOPHER MOUNDS DECREASE NUTRIENT CYCLING RATES AND INCREASE ADJACENT VEGETATION IN VOLCANIC PRIMARY SUCCESSION AT MOUNT ST. HELENS.** *Raymond P. Yurkewycz*, Mount St. Helens Institute, Amboy, WA; John G. Bishop, Washington State University - Vancouver, Vancouver, WA; Charles M. Crisafulli, USDA Forest Service, Pacific Northwest Research Station, Amboy, WA; John A. Harrison, Washington State University - Vancouver, Vancouver, WA; Richard A. Gill, Brigham Young University, Provo, UT

1:40 **THE CENTRAL ROLE OF MOUNT ST. HELENS IN DEVELOPMENT OF VOLCANO ECOLOGY: A GLOBAL PERSPECTIVE.** *Frederick J. Swanson*, USDA Forest Service, Pacific Northwest Research Station, Corvallis, OR; Charles M. Crisafulli, USDA Forest Service, Pacific Northwest Research Station, Amboy, WA

2:00 **Panel Discussion**

Climate and Integrated Resource Management in Natural and Agricultural Systems

Room: Gjerde Center room 1
Moderator: George Last

10:00 **APPLICATION OF FUZZY LOGIC IN LAND-SUITABILITY ASSESSMENT FOR GRAPEVINES.** *Golnaz Badr* and Gerrit Hoogenboom, AgWeatherNet Program, Washington State University – Prosser, Prosser WA

10:20 **LIMITED IRRIGATION IN WINTER WHEAT FOR REDUCING AGRICULTURAL WATER USE IN THE NORTHWEST CHINA.** *Zhen Zheng*, Huanjie Cai, Lianyu Yu, Northwest A&F University, Yangling, Shaanxi, China; Gerrit Hoogenboom, Washington State University – Prosser, Prosser, WA

10:40 **IMPACTS OF FUTURE CHANGES ON LOW FLOW IN A HIGHLY CONNECTED RIVER-AQUIFER SYSTEM: A CASE STUDY OF THE SPOKANE RIVER AND THE SPOKANE VALLEY-RATHDRUM PRAIRIE AQUIFER.** *Heather Baxter*, Tung Nguyen, Jennifer Adam, Muhammad Barik, Washington State University, Pullman, WA; Michael Barber, University of Utah, Salt Lake City, UT; Akram Hossain, Washington State University – Tri-Cities, Richland, WA

11:00 **BENEFIT-COST ANALYSIS OF YAKIMA BASIN INTEGRATED PLAN PROJECTS: AN INTERDISCIPLINARY ANALYSIS OF AN INTEGRATED WATER RESOURCE MANAGEMENT PROPOSAL.** *Jonathan Yoder*, Jennifer Adam, Michael Brady, Stephen Katz, Keyvan Malek, Qingqing Yang, Washington State University, Pullman WA; Joseph Cook, Shane Johnston, University of Washington, Seattle, WA; Daniel Brent, Monash University, ABN Australia

Management and Restoration in Sagebrush Ecosystems

Room: Gjerde Center Meeting Room 1
Moderator: Janelle Downs

1:20 **RESURRECTION AFTER FIRE: TEMPORAL AND SPATIAL VARIATION IN SEEDING SUCCESS ON SANDY SOILS AND SILT LOAM SOILS.** *Janelle Downs*, Mike Sackchewsky, Pacific Northwest National Laboratory, Richland, WA

1:40 **CLIMATE STRONGLY CONTROLS BROMUS TECTORUM DOMINANCE IN UNBURNED SAGEBRUSH STEPPE.** *Matt Lavin*, Kimberley Taylor, Tyler Brummer, Bruce D. Maxwell, Lisa J. Rew, Jay Rotella, Montana State University Bozeman, MT

2:00 **ANNUAL GRASS INVASION IN SAGEBRUSH-STEPPE: THE RELATIVE IMPORTANCE OF CLIMATE, SOIL PROPERTIES, BIOTIC INTERACTIONS AND DISTURBANCE.** *Sheel Bansal*, USDA Forest Service, Pacific Northwest Research Station, Olympia, WA; Roger L. Sheley, USDA-Agricultural Research Service, Eastern Oregon Agricultural Research Center, Burns, OR

2:20 **POST-TREATMENT INDICATORS OF CHEATGRASS INCREASES – COULD FUEL TREATMENTS CREATE FUEL PROBLEMS?** *Scott E. Shaff,* David A. Pyke, U.S. Geological Survey, Corvallis, OR; Jeanne C. Chambers, USDA Forest Service, Reno, NV; Eugene W. Schupp, Utah State University, Logan, UT; Paul S. Doescher, Oregon State University, Corvallis, OR

3:00 **THE REINTRODUCTION SUCCESS OF DESERT MOSSES IS DEPENDENT ON OVERWINTERING.** *Lea A. Condon*, Oregon State University, Corvallis, OR; David A. Pyke, US Geological Survey, Corvallis, OR

3:20 **BIOLOGICAL SOIL CRUST DIVERSITY AND CHEATGRASS COVER IN SIX VEGETATION TYPES OF SW IDAHO.** *Roger Rosentreter*, Boise State University, Boise, ID

3:40 **SIX YEARS AFTER THE FIRE: EFFECTIVENESS OF VEGETATION REHABILITATION TREATMENTS ON THE OVERLOOK FIRE, HANFORD REACH NATIONAL MONUMENT, WASHINGTON.** Debra Salstrom, *Richard Easterly*, SEE Botanical Consulting, Bellingham, WA

4:00 **HIGH RESOLUTION SAGEBRUSH CANOPY MAPPING: A CASE STUDY.** *Jerry Tagestad*, Pacific Northwest National Laboratory, Richland, WA

4:20 **THE EFFECT OF PLANT SIZE ON BLUEBUNCH WHEATGRASS SURVIVAL IN AN ARID ENVIRONMENT**. *Erin Campbell*, Tim Parker, Whitman College, Walla Walla, WA

Impacts of Changing Climates in Natural and Managed Systems

Room: Gjerde Center Main Hall
Moderator: Duane Horton

3:00 **THE INFLUENCE OF CLIMATE VARIABILITY ON NITROGEN DEPOSITION IN THE NORTHWEST UNITED STATES.** *Sarah M Anderson*, Benjamin A Harlow, Serena H Chung, Washington State University, Pullman, WA; Jeffrey M Welker, University of Alaska Anchorage, Anchorage, AK; R. Dave Evans, Washington State University, Pullman, WA

3:20 **COMBINING A DYNAMIC GLOBAL VEGETATION MODEL WITH A SOPHISTICATED CLIMATE ENVELOPE MODEL TO PROJECT IMPACTS OF CLIMATE CHANGE ON WESTERN WASHINGTON FORESTS AT REGIONAL AND LANDSCAPE SCALES.** *David Ross Conklin*, Common Futures, Corvallis, OR; Joshua S. Halofsky, Washington State Department of Natural Resources, Olympia, WA; Jan Henderson, US Forest Service (retired), Edmonds, WA

3:40 **A REGIONAL PERSPECTIVE ON HOLOCENE FIRE REGIMES IN THE PACIFIC NORTHWEST.** *Megan K. Walsh*, Central Washington University, Ellensburg, WA; Jennifer R. Marlon, Yale University, New Haven, CT; Simon J. Goring, University of Wisconsin-Madison, Madison, WI; Kendrick J. Brown, Natural Resources Canada, Canadian Forest Service, Victoria, BC and University of British Columbia, Kelowna, BC, Canada; Daniel G. Gavin, University of Oregon, Eugene, OR

4:00 **PREDICTED INTERACTIVE INFLUENCES OF CLIMATE CHANGE AND AGRICULTURAL INTENSIFICATION ON STREAM HABITAT IN A PACIFIC NORTHWESTERN WATERSHED.** *Sandra J. DeBano*, David E. Wooster, Oregon State University, Hermiston, OR; Jon Walker, Laura McMullen, ICF International, Portland, OR; Donald Horneck, Oregon State University, Hermiston, OR

4:20 **EXAMINING THE RESPONSE OF STEELHEAD (*ONCORHYNCUS MYKISS*) TO CLIMATE CHANGE AND AGRICULTURAL INTENSIFICATION IN THE UMATILLA BASIN USING A SPATIALLY EXPLICIT MODEL.** *David E. Wooster*, Sandra J. DeBano, Oregon State University, Hermiston, OR; Willis McConnaha, Jon Walker, Laura McMullen, ICF International, Portland, OR; Donald Horneck, Oregon State University, Hermiston, OR

Session Schedule
Friday, April 3

Fish Passage and Fish Ecology in the Northwest Symposium

Room: Gjerde Center Main Hall
Moderators: Alison Colotelo and Ryan Harnish

8:20 **JSATS TAG DEVELOPMENT FOR JUVENILE SALMON, STURGEON, EEL, AND LAMPREY.** *Daniel Deng*, Huidong Li, Jie Xiao, Mitchell Myjak, Jun Lu, Jayson Martinez, Tom Carlson, Mark Weiland, Rich Brown, Pacific Northwest National Laboratory, Richland, WA; Brad Eppard, U.S. Army Corps of Engineers, Portland District, Portland, OR

8:40 **DOWNSTREAM MIGRATION OF FISH THROUGH RIVERS CONTAINING HYDROELECTRIC FACILITIES. Alison Colotelo**, Ryan Harnish, Geoff McMichael, Daniel Deng, Kenneth Ham, Mark Weiland, Pacific Northwest National Laboratory, Richland, WA; John Skalski, University of Washington, Seattle, WA; Brad Eppard, U.S. Army Corps of Engineers, Portland District, Portland, OR; Tim Wik, Chris Pinney, U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, WA

9:00 **EVALUATION OF THE FACTORS AFFECTING ROUTE OF PASSAGE AND SURVIVAL OF ACOUSTIC-TAGGED SALMONIDS AT SNAKE RIVER HYDROELECTRIC DAMS.** *Ryan Harnish,* Kenneth Ham, Alison Colotelo, Daniel Deng, Pacific Northwest National Laboratory, Richland, WA

9:20 **HYDROACOUSTIC EVALUATION OF JUVENILE SALMONID PASSAGE AND DISTRIBUTION AT FOSTER DAM.** *James Hughes*, Pacific Northwest National Laboratory, Richland, WA; Fenton Khan, U.S. Army Corps of Engineers, Portland, OR 97208; Jina Kim, Jose Vazquez, Pacific Northwest National Laboratory, Richland, WA; Gary Johnson, Portland, OR

9:40 **FISH PASSAGE AND REINTRODUCTION INTO THE UPPER COLUMBIA RIVER.***Keith Kutchins,* Stephen Smith, Upper Columbia United Tribes, Spokane, WA

10:30 **WHOOSH FISH TRANSPORT SYSTEM: EVALUATION OF A NOVEL APPROACH TO MOVING LIVE FISH.** *Katie A. Wagner,* Alison H. Colotelo, Tim J. Linley, Ann L. Miracle, David R. Geist; Pacific Northwest National Laboratory, Richland, WA

10:50 **AUTOMATED CLASSIFICATION OF FISH EPITHELIAL DAMAGE FROM FLUORESCENT IMAGES.** *Sadie A. Mckee*, Pacific Northwest National Laboratory, Richland, WA

11:10 **INVESTIGATING FALLBACK AND SURFACE PASSAGE ROUTES FOR OVERWINTERING ADULT STEELHEAD AT LOWER COLUMBIA RIVER DAMS.** *Brad Trumbo*, US Army Corps of Engineers, Walla Walla District, Walla Walla, WA

11:30 **ACOUSTIC TRACKING OF REDBAND TROUT (*ONCORHYNCHUS MYKISS* VAR. *GARDNERII*) IN LAKE ROOSEVELT, WASHINGTON.** *Jessica A. Walston*, Krisztian Magori, Allan T. Scholz, Eastern Washington University, Cheney WA

Lunch

1:20 **STEELHEAD OUTMIGRATION IN THE WALLA WALLA RIVER BASIN, AN EXPLORATORY LOOK AT A COMPLEX SYSTEM.** *Eli Robinson*, Timothy H. Parker, Whitman College, Walla Walla, WA

1:40 **GENETICS AND MOVEMENT OF COLUMBIA RIVER REDBAND TROUT, *ONCORHYNCHUS MYKISS GAIRDNERI*, IN DRY CREEK, IDAHO.** *Christoph A. Walser*, Shelby Richins, Sarah Walsh, The College of Idaho, Caldwell, ID

2:00 **FISH PRESENCE/ABSENCE AND STREAM HABITAT IN AREAS AFFECTED BY SEDIMENT FROM MOUNT SAINT HELENS ERUPTION**. *James Hughes,* Pacific Northwest National Laboratories, Richland, WA; Fenton Khan, U.S. Army Corp of Engineers, Portland District, Portland, OR; Geoff McMichael, Evan Arntzen, Chris Vernon, Eric Fischer, Ryan Harnish, Sadie Mckee, Robert Mueller, Jose Vazquez, Pacific Northwest National Laboratories, Richland, WA

2:20 **2014 NWSA Student Grant Recipient Presentation**

EVALUATING HYPOXIA-INDUCIBLE FACTOR- 1α mRNA EXPRESSION IN A PELAGIC FISH, PACIFIC HERRING *CLUPEA PALLASII*, AS A BIOMARKER FOR HYPOXIA EXPOSURE. *Halley E. Froehlich*, Steven B. Roberts, Timothy E. Essington, University of Washington, Seattle, WA

Geology, Paleontology, and Ice Age Floods in the Northwest

Room: Gjerde Center Meeting Room 1
Moderators: Bruce Bjornstad and Karl Lillquist

8:20 **TERRACETTES: CONSTRUCTION AND DESTRUCTION BY BIOLOGIC AND GEOLOGIC PROCESSES?** *Robert J. Carson*, Whitman College, Walla Walla, WA

8:40 **SPATIAL PATTERNS OF ROCK GLACIERS IN THE EASTERN CASCADES, WASHINGTON: A PRELIMINARY ASSESSMENT.** *Karl Lillquist*, Mark Weidenaar, Central Washington University, Ellensburg, WA

9:00 **PRELIMINARY MORPHOMETRIC SPECIES AND AGE ANALYSIS OF A MOLAR FROM THE COYOTE CANYON MAMMOTH, BENTON COUNTY, WASHINGTON.** *Barton, Bax R*, University of Washington, Seattle, WA; Gary C. Kleinknecht, Ice Age Floods Institute, Kennewick, WA

9:20 **WORKING HYPOTHESES FROM FIVE YEARS OF STUDY AT THE COYOTE CANYON MAMMOTH SITE.** *George V. Last*, Pacific Northwest National Laboratory, Richland, WA; Bax R. Barton, Burke Museum of Natural History and Culture and Quaternary Research Center, University of Washington, Seattle, WA; Gary C. Kleinknecht, Kennewick, WA

9:40 **POSSIBLE INFLUENCES OF THE CHENEY FRACTURE ZONE AND PALEODRAINAGES ON BASALT AQUIFERS OF THE WEST PLAINS, EASTERN WASHINGTON.** *Chad J. Pritchard*, Cassandra Hennings, Brea Lund, Eastern Washington University, Cheney; Shawna Ernst, Spokane County GIS, Spokane, WA

10:30 **ICE-RAFTED ERRATICS AND BERGMOUNDS FROM PLEISTOCENE OUTBURST FLOODS, RATTLESNAKE MOUNTAIN, WASHINGTON.** *Bruce Bjornstad*, Richland, WA

10:50 **PRELIMINARY COSMOGENIC NUCLIDE CHRONOLOGY OF LATE PLEISTOCENE MISSOULA FLOODS.** *Andrea Balbas*, Jorie Clark, Peter U. Clark, Oregon State University, Corvallis, OR; Marc Caffee, Thomas Woodruff, Purdue University, West Lafayette, IN; Victor R. Baker, University of Arizona, Tucson, AZ

11:10 **EVIDENCE FOR THE FLOOD ORIGINS OF THE SPOKANE VALLEY – RATHDRUM PRAIRIE AQUIFER.** *Stan Miller*, Inland Northwest Water Resources, Spokane, WA

11:30 **ART AND SCIENCE BEHIND THE ICE AGE FLOODS.** *Bruce Bjornstad*, Richland, WA; Stev Ominski, Corvallis, OR

Lunch

Ecology of Pacific NW Rangelands and Forests

Room: Gjerde Center Meeting Room 2
Moderator: Janelle Downs

8:20 **RESPONSE OF THE NITROGEN-FIXING LICHEN *LOBARIA PULMONARIA* TO PHOSPHORUS AND MICRONUTRIENTS.** Jade A. Marks, Julie C. Pett-Ridge, Oregon State University, Corvallis, OR; Steven S. Perakis, US Geological Survey, Corvallis, OR; Jessica L. Allen, New York Botanical Garden, Bronx, NY; *Bruce McCune*, Oregon State University, Corvallis, OR

8:40 **TARDIGRADES OF SMITH ROCKS STATE PARK.** *Alex Young*, Lewis & Clark College, Portland OR

9:00 **THE EFFECT OF LAND USE AND LAND MANAGEMENT ON CARBON SEQUESTRATION AT CABIN CREEK RANCH IN SHEPHERD, MONTANA.** *Hailey Kisch*, Clayton Marlow, Montana State University, Bozeman, MT

9:20 **SUGGESTIONS FOR SUMMARIZING HERITAGE VEGETATION RECORDS.** *Clayton B. Marlow,* Neto Garcia, Montana State University, Bozeman, MT

9:40 **UNDERSTORY DEVELOPMENT 17 YEARS AFTER VARIABLE-DENSITY THINNING.** *Leslie C. Brodie*, Constance A. Harrington, USDA Forest Service, Pacific Northwest Research, Station, Olympia, WA

10:30 **USE OF LIDAR TO DETECT SHRUBS.** *Caileigh Shoot*, Sean Jeronimo, Van Kane, Monika Moskal, University of Washington, Seattle, WA; Jim Lutz, Utah State University, Logan, UT

10:50 **IMPACTS TO SOIL CHEMISTRY DUE TO THE INVASION OF ILEX AQUIFOLIUM (ENGLISH HOLLY) INTO SECOND-GROWTH FORESTS OF THE PACFIC NORTHWEST.** *Andy Berger*, Dr. Dylan Fischer, Evergreen State College, Olympia, WA

11:10 **VEGETATION TREND FOLLOWING ELK HERD SIZE TREND: AFTER 70 YEARS OF DATA WHAT WE EXPECTED AND WHAT WE OBSERVED IN THE GALLATIN CANYON.** *Neto Garcia*, Clayton Marlow, Montana State University, Bozeman MT

11:30 **VEGETATION STABILITY AND THE HABITAT ASSOCIATIONS OF THE ENDEMIC TAXA OF THE OLYMPIC PENINSULA, WASHINGTON, USA.** *Daniel G. Gavin*, University of Oregon, Eugene, OR

Lunch

Ecology of Pacific NW Grasslands and Forests

Room: Gjerde Center Meeting Room 2
Moderator: Clayton Marlow

1:20 **EFFECTS OF LIGHT AND STAND HISTORY ON BEARGRASS MORPHOLOGY AND POPULATION DEMOGRAPHY.** *David H. Peter,* Timothy B. Harrington, US Forest Service, Olympia, WA

1:40 **EFFECTS OF FALL PRESCRIBED BURNING ON THE INVASIVE SPECIES YELLOW STARTHISTLE (*CENTAUREA SOLSTITIALIS*) IN A PALOUSE PRAIRIE REMNANT IN SOUTHEASTERN WASHINGTON.** *Benjamin Zamora*, Steven Woodley, Washington State University, Pullman WA

2:00 **THE LASTING EFFECTS OF RESTORATION ON COMMUNITY COMPOSITION AND PERSISTENCE AND SPREAD OF NATIVE PRAIRIE SPECIES.** *Charlotte C. Trowbridge*, Jennifer L. Williams, University of British Columbia, Vancouver, BC

2:20 **ASSESSING EFFECTS OF GRASSLAND RESTORATION ON NATIVE BEE AND SPIDER COMMUNITIES IN A PACIFIC NORTHWEST AGROECOSYSTEM.** *Lauren Smith*, Sandy DeBano, Oregon State University, Hermiston Agricultural Research and Extension Center, Hermiston, OR

2:40 **LONG-TERM BEE MONITORING AT A PRIVATE CONSERVATION RANCH IN WEST-CENTRAL MONTANA.** *Marirose Kuhlman*, Skyler Burrows, MPG Operations, LLC, Missoula, MT

Poster Session

Arranged by last name of presenting author (italicized)

THE EFFECTS OF MARINE RESERVES ON REGIONAL GROUNDFISH DIVERSITY WITHIN THE SAN JUAN ARCHIPELAGO, WASHINGTON.
Kwasi Addae, The Evergreen State College, Olympia, WA

APPLICATIONS OF A NEW LICHEN CHEMICAL DATABASE.
Elisa Alphandary, Bruce McCune, Oregon State University, Corvallis, OR

POPULATION DYNAMICS OF COLUMBIAN SPOTTED FROGS (*RANA LUTEIVENTRIS*) IN NORTHEAST OREGON
Devin Bailey, Marcus James, Cathryn Polehn, Laura A. Mahrt, Eastern Oregon University, La Grande, OR

THE IMPACTS OF SPACING ON TREE GROWTH, MORTALITY AND TREE CROWN DEVELOPMENT.
Sheel Bansal, Robert O. Curtis, Constance A. Harrington, USDA Forest Service, Pacific Northwest Research Station, Olympia, WA

BEE DIVERSITY IN THE BITTERROOT VALLEY.
Skyler Burrows, Marirose Kuhlman, MPG Operations, LLC, Missoula, MT

SPATIAL INTERPOLATION APPROACH OF TEMPERATURE OBSERVATIONS FOR THE STATE OF WASHINGTON.
Oscar Castillo, Gerrit Hoogenboom, Melba Salazar, Bernardo Chaves, Nicholas Loyd, Sean Hill, Washington State University – Prosser, Prosser, WA

MYSTERIES OF THE CORE: AN INTERACTIVE GAME ABOUT SCIENTIFIC OCEAN DRILLING AND A GLACIAL LAKE MISSOULA OUTBURST FLOOD.
Patrice Ceisel, Ceisel & Associates Inc., Chicago, IL; Barbara A. Becker, Exhibit Planning & Research, Berwyn, IL

FIRE HISTORY RECONSTRUCTION OF LEMANASKY LAKE, EASTERN CASCADES, WA.
Grant J. Clifton, Megan K. Walsh, Central Washington University, Ellensburg, WA

MODERATE, LOCALIZED WATER DEFICIT POSSIBLE IN WILLAMETTE BASIN OVER 21ST CENTURY.
Roy Haggerty, John Bolte, Sam Chan, *Dave Conklin*, William Jaeger, Christian Langpap, Phil Mote, Anne Nolin, Andrew Plantinga, David Rupp, Mary Santelmann, Desirée Tullos, Dave Turner, Kellie Vaché, Dan Bigelow, Matt Cooper, Matt Cox, Kelly Gleason, Kathleen Moore, Travis Roth, Cynthia Schwartz, James Sulzman, Maria Wright, Oregon State University, Corvallis, OR; Dave Hulse, University of Oregon, Eugene, OR; Heejun Chang, Portland State University, Portland, OR; Andrew Plantinga, University of California at Santa Barbara, Santa Barbara, CA

COLIFORM BACTERIA IN THE END CREEK WETLANDS.
Joseph A. Corsini, Karen Antell, Chung Pak, Brian Tarpy, Eastern Oregon University, La Grande, OR; Larry R. Peters, Aquinas College, Grand Rapids, MI

***ASPICILIA* PHYLOGENETICS: RECONCILING MORPHOLOGICAL PLASTICITY WITH MOLECULAR DATA.**
Joseph Di Meglio, Bruce McCune, Oregon State University, Corvallis, OR

POST-GLACIAL FIRE AND VEGETATION HISTORY OF HORSETAIL LAKE IN THE TEANAWAY AREA OF THE CENTRAL EASTERN CASCADES, WASHINGTON.
Serafina Ferri, Megan Walsh, Central Washington University, Ellensburg, WA

COMBINING FIELD AND GREENHOUSE EXPERIMENTS TO UNDERSTAND THE RELATIONSHIP BETWEEN CLIMATE AND BUDBURST IN COAST DOUGLAS-FIR (*PSEUDOTSUGA MENZIESII* VAR. *MENZIESII*)
Kevin R. Ford, Constance A. Harrington, USDA Forest Service, Pacific Northwest Research Station, Olympia, WA

FIRE REGIME DYNAMICS OF FISH LAKE, BLUE MOUNTAINS, OREGON.
Christopher Goodner, Megan Walsh, Central Washington University, Ellensburg, WA

UNDERSTANDING TEMPERATURE INVERSIONS AND IMPROVING FROST FORECASTING FOR CENTRAL WASHINGTON GROWERS.
Jonathan Gramann, Gerrit Hoogenboom, Washington State University – Prosser, Prosser, WA

IMPACT OF CLIMATE CHANGE ON WHEAT PRODUCTIVITY AT FARMERS' FIELD IN PAKISTAN.
Muhammad Habib ur Rahman, Ashfaq Ahmad, Fahd Rasul, Aftab Wajid, Tasneem Khaliq, Muhammad Shaukat, University of Agriculture, Faisalabad, Punjab, Pakistan; Gerrit Hoogenboom, Washington State University – Prosser, Prosser, WA

MEASURING THE BIOTIC INTEGRITY OF MIDDLE FORK JOHN DAY RIVER, OR. WITH RESTORATION
Robin M. Henderson, James R. Pratt, Washington State University – Tri-Cities*,* Richland, WA

THE ORIGIN OF XENOLITHS WITH CUMULATE TEXTURES FOUND ABOVE THE SUBSURFACE EXTENSION OF THE STILLWATER COMPLEX, MT.
Cassandra Hennings, Jennifer A. Thomson, Eastern Washington University, Cheney, WA; Michael L. Zientek, US Geological Survey, Spokane, WA

A POPULATION GENETIC INVESTIGATION OF THE COLUMBIA SPOTTED FROG (*RANA LUTEIVENTRIS)* IN EASTERN OREGON.
Marcus James, Devin Bailey, Mackenzie Graham, Jacob Johnstun, Cathryn Polehn, John E. Rinehart, Laura A. Mahrt, Eastern Oregon University, La Grande, OR; Rosie Alberts, La Grande High School, La Grande, OR

ORIGIN OF ENIGMATIC ROCKS LOCATED NORTH OF THE STILLWATER COMPLEX, MONTANA.
M. Christopher Jenkins, Jennifer A. Thomson, Eastern Washington University, Cheney, WA; Michael L. Zientek, US Geological Survey, Spokane, WA

CALIFORNIA BEARING RATIO (CBR) OF PALOUSE SOIL NEAR THE EASTERN WASHINGTON UNIVERSITY CAMPUS, CHENEY, WA.
Alexander J. Fry, *M. Christopher Jenkins*, Duc Minh Nguyen, Richard L. Orndorff, Eastern Washington University, Cheney, WA

OPTIMAL MOISTURE CONTENT FOR COMPACTION OF PALOUSE SOIL NEAR THE EASTERN WASHINGTON UNIVERSITY CAMPUS, CHENEY, WA.
Jessica Reed, *Dallin Jensen,* Ashleigh Gertsch, Vanessa Jordan, Richard Orndorff, Eastern Washington University, Cheney, WA

ETHANOL IN DOUGLAS-FIR ROOTS STRESSED BY *PHELLINUS SULPHURASCENS* INFECTION: IMPLICATIONS FOR DETECTING DISEASED TREES AND BEETLE HOST SELECTION.
Rick G. Kelsey, Doug Westlind, Walter G. Thies, USDA Forest Service, Pacific Northwest Research Station, Corvallis, OR; Gladwin Joseph, Azim Premji University, Bangalore, India

ARSENIC CONTENT OF THE LATAH FORMATION AND ITS POTENTIAL FOR GROUNDWATER CONTAMINATION.
*Ian Leav*y, Pacific Northwest National Laboratory, Richland, WA; Carmen A. Nezat, Eastern Washington University, Cheney, WA

USCS CLASSIFICATION OF PALOUSE SOIL NEAR THE EASTERN WASHINGTON UNIVERSITY CAMPUS, CHENEY, WA.
Brea D. Lund, Shyla A. Hatch, Pedro Severino, Tatiany Santos, Richard L. Orndorff, Eastern Washington University, Cheney, WA

INVESTIGATION OF NITRATE HOTSPOTS IN SPOKANE COUNTY.
Justin Luppens, Chad Pritchard, Eastern Washington University, Cheney, WA

190 YEARS LATER: THE REDISCOVERY OF *POLYPYRENULA ALBISSIMA* AN ENIGMATIC FUNGUS PREVIOUSLY BELIEVED TO BE EXTINCT.
Ricardo Miranda-González, Oregon State University, Corvallis, OR.; André Aptroot, ABL Herbarium, Soest, The Netherlands; Robert Lücking, The Field Museum, Chicago, IL; María de los Angeles Herrera-Campos, Universidad Nacional Autónoma de México, D. F. México; Bruce McCune, Andy Jones, Oregon State University, Corvallis, OR.

SONGBIRD DIVERSITY OF SAGE-STEPPE HABITAT IN EASTERN WASHINGTON: PRELIMINARY RESULTS FROM A COMMUNITY-SCIENCE RESEARCH PROGRAM.
Lori Wollerman Nelson, Lower Columbia Basin Audubon Society, Richland, WA; Christi Norman, Audubon Washington, Seattle, WA; Matthew Vander Haegen, Washington Department of Fish and Wildlife, Olympia, WA

NATURALLY-OCCURRING ARSENIC CONTAMINATION IN RICE PRODUCTS IN NORTHERN VIETNAM.
Duc M. Nguyen, Carmen A. Nezat, Eastern Washington University, Cheney, WA

A METHODOLOGICAL APPROACH TO DETERMINE FLOWER BUD VULNERABILITY TO LOW TEMPERATURE DURING EARLY SPRING.
Andres J Peña Q, Melba R Salazar G, Gerrit Hoogenboom, Washington State University – Prosser, Prosser, WA

WATER QUALITY AND ALGAE DYNAMICS IN TEN MOUNTAIN LAKES ALONG THE MOUNTAIN LOOP HIGHWAY, WASHINGTON.
Katy Pfannenstein, Robin Matthews, Western Washington University, Bellingham, WA

HOLOCENE FIRE HISTORY OF GREEN LAKE, EASTERN CASCADES, WASHINGTON, DETERMINED USING HIGH-RESOLUTION MACROSCOPIC CHARCOAL ANALYSIS.
Dusty Pilkington, Megan Walsh, Central Washington University, Ellensburg, WA

SNOWPACK AS A RESERVOIR OF NITROGEN DEPOSITION IN SUBALPINE ECOSYSTEMS OF THE CASCADES.
Justin Poinsatte, Sarah M. Anderson, Ben A. Harlow, R. Dave Evans, Washington State University, Pullman, WA

A TWO COUNTY COMPARISON OF PARASITE LOAD IN THE COLUMBIAN SPOTTED FROG (*RANA LUTEIVENTRIS*)
Cathryn Polehn, Marcus James, Devin Bailey, Dr. Laura A. Mahrt, Eastern Oregon University, La Grande, OR

HOLOCENE FIRE RECONSTRUCTION OF THE LONG LAKE AREA NEAR RIMROCK RESERVOIR IN THE EASTERN CASCADES, WASHINGTON.
Zoe Rushton, Megan Walsh, Central Washington University, Ellensburg, WA

CLIMATIC TRENDS, BIOCLIMATIC INDICES AND THE RELATION TO WINE-GRAPE HARVEST QUALITIES.
Corydon Funk, *Melba Salazar*, Bernardo Chaves, Gerrit Hoogenboom, Washington State University – Prosser, Prosser, WA; Rick Hamman, Hogue Ranches, Prosser, WA; Bill Riley, Ste. Michelle Winery Estates, Woodinville, WA

CHARCOAL PRODUCTION IN MIXED-CONIFER FOREST UNDER HIGH SEVERITY INTIAL FIRE AND REPEAT BURNS.
Aspen Ward, University of Montana, Missoula, MT; C. Alina Cansler, University of Washington, Seattle, WA; Andrew J. Larson, University of Montana, Missoula, MT

THE SHORT-TERM EFFECT OF DIFFERENT ANESTHETICS ON RAINBOW TROUT (*ONCORHYNCHUS MYKISS*) SWIMMING ABILITY.
Shawna Warehime, Jessica Walston, Krisztian Magori, Allan Scholz, Mark Paluch, Eastern Washington University, Cheney, WA

MARINE NUTRIENT SUBSIDIES IN INLAND RIPARIAN FORESTS OF THE COLUMBIA RIVER BASIN.
Tadd A. Wheeler, University of Idaho, Moscow, ID; Kathleen L. Kavanagh, Texas A&M University, College Station, TX; Andrea Noble-Stuen, University of Idaho, Moscow, ID

UNCONFINED COMPRESSIVE STRENGTH OF PALOUSE SOIL NEAR THE EASTERN WASHINGTON UNIVERSITY CAMPUS, CHENEY, WA.
Wesley Silvey, Forest Trampush, *Michael Wilson,* Richard Orndorff, Eastern Washington University, Cheney, WA

DIET, AGE AND GROWTH OF THREE CYPRINID FISHES IN THE UPPER COLUMBIA RIVER DRAINAGE, WASHINGTON.
Bryan Witte, Eastern Washington University, Cheney, WA

ENVIRONMENTAL FACTORS TRIGGERING THE EMERGENCE OF *EUSTENOPUS VILLOSUS* AND *LARINUS CURTUS* WITHIN *CENTAUREA SOLSTITIALIS* POPULATIONS ON THE KRAMER PRAIRIE IN SOUTHEASTERN WASHINGTON.
Steven Woodley, Benjamin Zamora, Washington State University, Pullman, WA

Field Trips
Saturday April 4, 2015

LICHENS OF THE SADDLE MOUNTAINS

Leader: Jenny von Reis, Lichenologist
Time: 8:30 am to 4:30 pm
Pick-Up Location: Columbia Basin College (CBC), North Parking lot

The group may visit two different areas within the Saddle Mountains about 35 miles north of Pasco. Options may depend on availability of 4-wheel drive vehicles for carpooling. If 4WD vehicles are available, we will visit Wahatis Peak (elevation 2696 feet) and the northern end of the Saddle Mountains overlooking the Columbia River. Depending on vehicles, the trip may also visit the north side of the Saddle Mountains by traveling west on Crab Creek Road with multiple stops to look at undisturbed biological soil crusts, rocky outcroppings, or to higher elevations via a hike. Hiking boots are advisable. This trip may coincide with the emergence of rattlesnakes from their hibernacula – and we will teach safe techniques to avoid them. Travel time from CBC is approximately 1 hour and 35 minutes to the crest of the ridge, and a little over an hour to reach the north side of Saddle Mountain via Crab Creek.

GEOLOGY, PALEONTOLOGY, & PALEOECOLOGY OF THE COYOTE CANYON MAMMOTH SITE

Leaders: Bax Barton, Paleoecologist, George Last, Geologist, & Gary Kleinknecht, Education Director
Time: 8:00 am to 11:00 am
Pick-Up Location: Columbia Basin College (CBC), North Parking lot. We will carpool to the site, located about 20 miles away - about a 30 minute drive. Participants should wear sturdy shoes, appropriate clothing for the weather and cheatgrass, and bring water, snacks, lunches, etc. Oh, and don't forget your camera.

The Coyote Canyon mammoth was discovered in November 1999 while excavating fine-grained soil for use as topsoil. In spring 2008, test excavations confirmed the location of the mammoth site. A number of mammoth-size bones, including a humerus and scapula in near articulated position, were uncovered. Excitement grew that this site might offer a unique opportunity for students, teachers, and researchers to investigate well-preserved mammoth subfossils in the context of Ice Age flood deposits, and a non-profit organization, the Mid-Columbia Basin Old Natural Education Sciences (MCBONES) Research Center Foundation was established to oversee environmental, paleontological, and geological research and education at the site.

Formal excavation of the site began on September 25, 2010, and has continued two weekends a month from March through October. Soil/sediment is excavated in 10 cm layers using archeological techniques. All sediment is wet screened (washed) to remove the clay, silt and fine sand, making it easier to pick out micro-flora and -fauna specimens (such as rodent bones) to yield evidence on the site paleoecology over time.

Research director and paleoecologist, Bax R. Barton, geologist George Last, and education coordinator, Gary Kleinknecht, will be your guides to one of the best mammoth research and education sites in the northwest. Learn about our past findings, current hypotheses, and future research and education opportunities.

ICE AGE (MISSOULA) FLOODS THROUGH THE MID-COLUMBIA REGION

Leader: Bruce Bjornstad, Author of two "On the Trail of the Ice Age Floods" geologic guidebooks
Time: 8:30 am to 4:30 pm
Pick-Up Location: Columbia Basin College (CBC), North Parking lot

Geologist-Author Bruce Bjornstad will lead a day-long, 150-mile field trip to observe many of the Ice Age floods' features unique to the Pasco Basin. These include the Lake Lewis Isles, slackwater-flood rhythmites, ice-rafted erratics and bergmounds, giant flood bars and coulees, as well as, the diversion of the Yakima River, which was created by multiple outburst floods as recently as 13,000 years ago. A number of stops and short walks, like that at the White Bluffs Overlook within the Hanford Reach National Monument, will provide exceptional overviews of Ice-Age flood features as well as the Columbia River and Hanford operations.

EXPLORING THE PAST, PRESENT, AND FUTURE OF VITICULTURE IN THE LOWER YAKIMA VALLEY

Leader: Dr. Alan Bussaca, Owner & Manager, Vinitas Consultants, LLC.
Time: 8:30 am to 4:30 pm
Pick-Up Location: Columbia Basin College, North Parking lot

Washington is the second largest premium wine producer in the United States! There are over 350 wine grape growers in 13 American Viticultural Areas (AVAs). Several of these AVAs are located in or adjacent to the Lower Yakima Valley. We will visit four of them: Red Mountain, Yakima Valley, Snipe Mountain and Rattlesnake Hills AVAs. We'll explore the geology, hydrogeology, climate, and viticultural practices that produce some of the world's best wine grapes. We will also look into the future - the potential changes - as this region responds to water, climate, and ecological demands.

The field trip is limited to 20 participants. The $40 cost includes transportation (using two 12-passenger vans), a sack lunch, and wine tasting.

THE HANFORD REACH—INFLUENCES OF ENERGY AND AGRICULTURE ON RESOURCES IN THE REACH

Leaders: Dr. Duane Horton, Geologist & Dr. Janelle Downs, Ecologist
Time: 8:30 am to 2:30 pm
Pick-Up Location: Columbia Basin College (CBC), North Parking lot

The Hanford Reach field trip travels upstream alongside some of the last free flowing waters of the Columbia River, adjacent to the Department of Energy's Hanford Site and along the White Bluffs. This field trip will involve some hiking (and maybe even a little bushwhacking!).

The Hanford Reach is part of the Hanford National Monument, which has provided protection to the adjacent lands and resources. Formation of the Hanford Atomic reserve in 1943 protected 560 square miles of shrub steppe habitats and wildlife. This is in contrast to shoreline and agricultural development seen throughout most of the Columbia Basin. Still, the development of nuclear power and materials, cleanup of legacy wastes and facilities, hydropower operations, and irrigated agriculture outside the Hanford boundary all continue to influence the river and adjacent habitats. As we travel north of Pasco and east of the river, we will observe thousands of acres of irrigated agriculture that use Columbia River to water a variety of crops. Along the way, we will discuss the past Hanford Site operations that lead to subsurface contamination and the current efforts to cleanup that contamination. After reaching the river at Ringold, the trip includes stops at a number of points and overlooks to view and discuss:

- Missoula floods and their influence at Hanford
- Cause and effects of mass wasting occurring along the White Bluffs
- Ringold Formation sediments that document the history of the Columbia River in the Pasco Basin
- Columbia River Basalt and recent studies to use the basalt as a subsurface storage facility for natural gas and as a repository for sequestered carbon dioxide.
- Hydropower operations and influences on riparian vegetation and rare plants
- Rare plant habitats on the uplands
- Shrub steppe restoration after fire
- Sage Steppe research on fuels and cheatgrass

UPDATE: We are adding two components to the Hanford Reach Field Trip that focus on sagebrush steppe ecology and recovery. Richard Easterly and Debora Salstrom will lead a review and discussion at selected stops highlighting the success and failures of post-fire restoration. Scott Shaff will lead a short tour and discussion of research at the Sage-Steppe research site as we travel back to Pasco

Abstracts

Arranged by last name of presenting author (italicized)

THE EFFECTS OF MARINE RESERVES ON REGIONAL GROUNDFISH DIVERSITY WITHIN THE SAN JUAN ARCHIPELAGO, WASHINGTON. Kwasi Addae, The Evergreen State College, Graduate Program on the Environment, 2700 Evergreen Parkway NW Olympia, Washington 98505; *kwasi131@gmail.com*

Groundfish populations in the greater Puget Sound region have experienced intense declines as a result of past commercial and recreational fisheries. In recent decades, mitigation efforts have included harvest limitations, fishery closures, and the utilization of Marine Protected Areas such as marine reserves. By prohibiting the harvest of target species, marine reserves have been successful in bolstering diversity, size, and abundance for depressed groundfish species within reserve boundaries. To explore how these positive attributes to groundfish populations may affect a large-scale ecosystem outside reserve areas, this study investigates the regional effects of established marine reserves on the biodiversity of groundfish within the San Juan Archipelago. Fishery-independent data from the Washington Department of Fish and Wildlife's trawl and R.O.V groundfish surveys were used to analyze temporal and spatial variations in mean diversity levels for three species groups: family *Gadidae* (Cod), family *Hexagrammidae* (Lingcod and Greenlings) and the genus *Sebastes* (Rockfish). Two diversity indices calculated diversity values for the189 trawl samples sites (8 sampled years between 2001 and 2012), while the 139 R.O.V sample transects, collected in 2010 along with catch composition of the trawl samples, provided species occurrence and abundance per habitat type and depth strata. Efforts to determine which species group benefit from the existing marine reserves showed that *Sebastes* and *Hexagrammidae*, normally associated with complex rocky substrate, significantly prefer habitat of that type. This suggests that established marine reserves are appropriately located for these targeted species, and the implementation of new reserves should be considered. Using GIS "Hot-spot" and "Cluster" analyses significant groupings of high and low diversity sampled sites were observed throughout the region. However, no spatial correlation could be made between areas of high diversity and distance to nearest marine reserve. Significant temporal variations in mean diversity values (± SE) for each sampled year were observed, however the cause of these fluctuation in diversity values could not be determined by this study. Results from this study highlight the need to monitor ecosystems where marine reserves have been established, to gain a better understanding of their regional influence on groundfish species.

APPLICATIONS OF A NEW LICHEN CHEMICAL DATABASE. Elisa Alphandary, Bruce McCune, Department of Botany and Plant Pathology, 2082 Cordley Hall, Oregon State University, Corvallis, OR 97331; *alphande@onid.orst.edu*

Lichens are composed of a symbiotic relationship between a fungus, green algae and sometimes cyanobacteria. The ascomycete fungi involved produce hundreds of secondary metabolites providing a tool used for identification, for example with Thin Layer Chromatography (TLC). In addition to aiding in identification, these substances have many functions ranging from UV light protection, anti-herbivory and antibiotic activity. Although we assume that species tolerances to specific environments are conditioned by secondary substances, their relationships to lichen succession and other ecological processes are not well understood. To facilitate future research on chemical diversity we compiled a database of known lichen substances in Pacific Northwest and Alaskan lichens. We anticipate two primary uses for the database: to facilitate: (1) identification of lichen species and metabolites, and (2) studies on the relationship of production of secondary metabolites and environmental factors. The resulting database includes 746 species, 142 secondary metabolites, 20 chemical classes and 3 biosynthetic pathways. Using this database, we illustrate an ecological application by relating lichen chemical succession to community succession and environmental changes over time on developing Oregon ash branches. This was achieved by multiplying two matrices; sample unit x species and species x secondary substance, followed by a weighted averaging step. This yielded a single matrix containing abundances of substances in those sample units. We then related substance abundance to branch age, demonstrating chemical succession over time. For example, anthraquinones showed a high abundance in the younger branch segments and diminished over time. Evernic acid was the next substance to come in, followed by atranorin and finally physodic acid. Presumably these patterns of chemical succession depend on the functions of the compounds present. For example anthraquinones absorb UV light, evernic acid has antifungal activity and atranorin and physodic acid have antimicrobial activity. These chemical functions likely aid in protection against microbial decomposition, suggesting that chemical turnover plays a significant role in the dynamics of lichen communities.

THE INFLUENCE OF CLIMATE VARIABILITY ON NITROGEN DEPOSITION IN THE NORTHWEST UNITED STATES. **Sarah M Anderson**, School of Biological Sciences, Washington State University; Benjamin A Harlow, School of Biological Sciences, Washington State University, Pullman, WA 99163; Serena H Chung, Lab for Atmospheric Research, Washington State University, Pullman, WA 99163; Jeffrey M Welker, Department of Biological Sciences, University of Alaska Anchorage, Anchorage, AK 99501; R. Dave Evans, School of Biological Sciences, Washington State University, Pullman, WA 99163; *sarah.anderson2@email.wsu.edu*

The Northwest United States is affected by four major climate patterns: the El Niño Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO), the Pacific-North American pattern (PNA), and the Arctic Oscillation (AO). Climate patterns affect the atmospheric processes that can alter the transport and chemistry of reactive nitrogen (N) with corresponding effects on deposition. We analyzed how wet N deposition changes during different phases of these patterns. Samples came from the US Network for Isotopes in Precipitation (USNIP) archive of National Atmospheric Deposition Program (NADP) samples. For this study, precipitation samples were originally collected between 1997 and 2004 at three sites across the Northwest: WA19 North Cascades National Park, ID11 Reynolds Creek, and WY00 Snowy Range. This time period captures extreme phases in the major climate patterns. Nitrate (NO_3^-) concentration and precipitation data are from NADP. Samples were analyzed for the isotope composition of NO_3^- and water. The $\delta^{15}N$-NO_3^- and the $\delta^{18}O$-H_2O inform us about sources of nitrogen and source areas of precipitation, respectively. Linear regression analyses identified N deposition at WA19 as influenced most by AO, while N deposition at ID11 and WY00 is more influenced by PNA. The AO explained 14% of the variation in $\delta^{15}N$ (p=0.06) and 15% of the amount of precipitation (p=0.06) at WA19. However, the PNA explained 19% of the variation in $\delta^{15}N$ (p=0.05) and 18% in NO_3^- concentration (p=0.05) at ID11 and 13% of the variation in $\delta^{15}N$ (p=0.08) and 18% in $\delta^{18}O$-H_20 (p=0.05) at WY00. The AO explained 25% of the variation in the amount of precipitation (p=0.02) at ID11 despite the PNA providing more explanatory power for N deposition. PDO and ENSO only helped to explain deposition at the WY00 site with PDO explaining 15% of the $\delta^{18}O$-NO_3^- (p=0.07) and ENSO explaining 28% of the $\delta^{18}O$-NO_3^- (p=0.01) and 13% of the NO_3^- concentration (p=0.09). The influence of climate phases on N deposition is both phase and site specific. Climate patterns are potentially changing atmospheric circulation patterns which would alter the composition of source areas contributing to N deposition and therefore altering the composition of N deposition itself.

APPLICATION OF FUZZY LOGIC IN LAND-SUITABILITY ASSESSMENT FOR GRAPEVINE.
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In the Pacific North West, especially in the State of Washington there is great potential for growing grapes(*Vitis vinifera* L.). However, there are few studies that have focused on the development of a comprehensive spatial suitability system. The objective of this study was to apply fuzzy logic to help determine the suitable sites for grape production in the state of Washington. Growth and development of grapes require a distinct fusion of several environmental variables that include weather, soil, and topography. Several soil properties such as pH, depth, drainage, and organic carbon were obtained from the Gridded Soil Survey Geographic (gSSURGO) dataset. The individual soil data layers were reclassified based on fuzzy logic and were combined to obtain the soil suitability layer.

The Digital Elevation Model (DEM) was obtained from the National Elevation Data layer (NED). The main three components of the topographic suitability data layer were slope, aspect, and elevation. The topographic components also were reclassified and combined using fuzzy logic. The daily weather data were obtained from the University of Idaho Gridded Surface Meteorological data set for a period of 30 years (1983-2012). Several bioclimatic indices were computed based on the weather data and reclassified using fuzzy logic. The final suitability layer was obtained by combining the soil, weather, and topographic suitability layers. The fuzzy score for the vineyards that have been established in the state of Washington was extracted from the final suitability data layer.

The results revealed that the mean fuzzy score for the vineyards was 0.82. The lowest fuzzy score for the vineyards was 0.6 and the highest score was 0.9. Based on the fuzzy scores 33% of land in Washington is within the suitable range for growing grapes. Among the suitable areas 48% were located within the optimum fuzzy scores (fuzzy score >0.8). The results of this study provide a spatial suitability system based on fuzzy logic that can be used for research, extension, and education to assist stakeholders and others interested in understanding the impact of environmental factors on grapevine performance.

POPULATION DYNAMICS OF COLUMBIAN SPOTTED FROGS (*RANA LUTEIVENTRIS*) IN NORTHEAST OREGON.
Devin Bailey, Marcus James, Cathryn Polehn, Laura A. Mahrt, Eastern Oregon University, Biology Program, One University Blvd, La Grande, OR 97850; *baileyds@eou.edu*

Columbian Spotted Frogs (*Rana luteiventris*) are distributed throughout the Pacific Northwest with some areas experiencing declines in numbers producing small disjunctive populations. Major factors contributing to their loss include: modification to their habitat, chytrid fungus, climate change and introduction of non-native aquatic species. The declining populations have led the Columbian Spotted Frog to be considered as a threatened species in Oregon. These frogs prefer cold quiet waters in which to lay their eggs and to forage. Females of this species only lay one egg mass per year with large fluctuations in size of egg masses. McCoy Creek, an upper tributary of the Grande Ronde River (located in northeast Oregon) was canalized approximately 45 years ago. Farm crops were planted and cattle were grazed there until 1995. Since the summer of 1997, McCoy Creek has been under active restoration. Between 1997-2000 work was performed to restore the creek to its original path. The old channel was dammed and a series of swimming pool shaped ponds were established. During the summer of 2002, these ponds were reshaped based on the USDA NRCS Oregon Biology Technical Note No. 46. Frogs began exploiting these ponds during the 2003 spring breeding season. Of the 12 ponds created, frogs deposited eggs in five with a total of 57 egg masses. Currently the frogs are utilizing 9 of the ponds. Throughout the 2014 breeding season, the frogs laid a record 187 egg masses. The carrying capacity of the McCoy Meadows population has been calculated at 166 females with an intrinsic value of increase of 0.92.

PRELIMINARY COSMOGENIC NUCLIDE CHRONOLOGY OF LATE PLEISTOCENE MISSOULA FLOODS. Andrea Balbas, Jorie Clark, Peter U. Clark, College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, 104 CEOAS Administration Building, Corvallis, OR 97331-5503; Marc Caffee, Thomas Woodruff, Purdue University, Department of Physics and Astronomy, 525 Northwestern Avenue, West Lafayette, IN 47907-2036; Victor R. Baker, Department of Hydrology and Water Resources, College of Science, School of Earth and Environmental Sciences, University of Arizona, 1133 E James E Rogers Way, J W Harshbarger Bldg Rm 122, PO Box 210011, Tucson, AZ 85721-0011; *Balbasa@geo.oregonstate.edu*

The Missoula floods had the largest known peak flood discharges of fresh water known from the geologic record. Multiple floods are believed to have originated from the failure of the Purcell trench ice lobe, which dammed glacial Lake Missoula. The flood waters traveled westward creating the Channeled Scabland region, a spectacular complex of anastomosing channels, coulees, cataracts, loess islands, rock basins, broad gravel deposits, and immense gravel bars in east-central Washington State. Several important questions about the Missoula floods and the formation of the Channeled Scabland remain, primarily due to the few geochronological constraints on their timing. Attempts to date the duration of the multiple floods have produced a wide range of ages (13-19 ka from land deposits and 13-31 ka from marine cores), but few of these directly constrain the age of the major flood landscape elements. Here we present 14 new *in situ* cosmogenic ^{10}Be ages from quartz-bearing boulders deposited at four sites in eastern Washington. Wallula Gap is a narrow constriction along the Columbia River between Oregon and Washington. Hydraulic damming of floodwater at Wallula Gap created glacial Lake Lewis. Surface exposure ages on large boulders found at over 300 m elevation above the river at this site will date the largest flood events. The Wenatchee region represents the most northwestern area influenced by flooding. Dates from this area will determine when flooding occurred after the retreat of the Okanogan lobe. We sampled boulders from the lower Pangborn Bar, ice-rafted boulders north of Wenatchee, and boulders from a flood bar on the Columbia River north of Wenatchee**.** A boulder from the Mattawa Fan was sampled to assess the last time a megaflood came through the Sentinel Gap. Finally, in order to constrain the last debris dam failure at the southern end of the Upper Grand Coulee, we sampled flood boulders deposited on the Ephrata Fan.

THE IMPACTS OF SPACING ON TREE GROWTH, MORTALITY AND TREE CROWN DEVELOPMENT. Sheel Bansal, Robert O. Curtis, Constance A. Harrington, Olympia Forestry Sciences Laboratory, USDA Forest Service, Pacific Northwest Research Station, USDA Forest Service, 3625 93rd Avenue Southwest, Olympia, WA 98512*; sheelbansal9@gmail.com*

Initial tree spacing has important implications for both silvicultural objectives and ecological functioning. From a silvicultural perspective, spacing impacts the timing that crowns of individual trees converge, thus intensifying competition and reducing tree vigor. From an ecological perspective, the closure of canopies affects light and thermal regimes of the forest floor, which impacts the resident plant, animal and microbial communities. Riparian zones are particularly sensitive to changes in shade and temperature that occur when canopies close. In addition, as trees begin to compete with each other, branch and whole tree mortality will occur, which will have implications for both forest management and forest ecology. Therefore, understanding the long-term effects of spacing distance on canopy cover is key information necessary to achieve multifunctionality of forests. One of the largest, well-replicated, spacing trials was established in 1979 with coast Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*) growing across a wide-range of spacing distances (1-6 meters) at Wind River Experimental Forest, Washington. Growth, crown characteristics and mortality were measured intermittently over 33 years, with the most recent measurement in 2013. Basal area and mortality were greatest at the smallest spacing distance (1 m). Measures of relative density were reasonably good predictors of canopy closure and live crown ratio. 33 years after planting, only the largest spacing distance (6 m) still had open canopy cover, while the other spacings had full closure and considerable overlap of crowns among trees. Spacing distance to optimize timber production may be closer that distances ideal to maintain open canopies.

ANNUAL GRASS INVASION IN SAGEBRUSH-STEPPE: THE RELATIVE IMPORTANCE OF CLIMATE, SOIL PROPERTIES, BIOTIC INTERACTIONS AND DISTURBANCE. Sheel Bansal, Olympia Forestry Sciences Laboratory, USDA Forest Service, Pacific Northwest Research Station, 3625 93rd Avenue Southwest, Olympia, WA 98512; Roger L. Sheley, Eastern Oregon Agricultural Research Center, USDA-Agricultural Research Service, 67826-A Hwy 205, Burns, Oregon 97720, USA; *sheelbansal9@gmail.com*

Currently, there is uncertainty as to the most important ecological drivers of annual grass invasion in sagebrush-steppe ecosystems of the western US. Vast amounts of research have focused on climate, soils, biotic interactions or disturbances, but very few have holistically examined all factors together. Knowing the relative importance of these abiotic and biotic factors that constrain the distribution and abundance of annual grasses is essential information for modeling and managing their spread into sagebrush-steppe. To address this research gap, we conducted a comprehensive analysis of the 100 most cited climate, soil, plant community (functional group abundances and diversity) and disturbance factors (grazing, fire history) at each of 90 field sites that spanned an invasion gradient ranging from 0 to 100% annual grass cover in eastern Oregon. Using correlation and regression analyses, we determined which factors had the strongest positive and negative relationships with cover of annual grasses and each of the resident functional groups (i.e. perennial grass and forb, annual forb, shrub, tree, microbial biomass). Annual grass cover was negatively related with perennial grass cover and biodiversity, which were among the strongest relationship of annual grasses with any of the measured abiotic or biotic factors. Annual grass cover was also negatively related with perennial forb, shrub and biological soil crust cover, while annual forb and tree cover and microbial biomass were minimally related with annual grasses. Annual grass cover was also strongly related with climate, particularly winter season variables (positively with minimum soil temperature and negatively with precipitation as snow), but was less related with soil or disturbance factors (negatively with mineral N and with grazing). Our findings indicate strong support for the importance of biotic interactions and climate on the abundance and distribution of annual grasses, while soil factors and disturbances had lower explanatory value, and indicated that climate change may favor the spread of annual grasses into sagebrush-steppe ecosystems.

PRELIMINARY MORPHOMETRIC SPECIES AND AGE ANALYSIS OF A MOLAR FROM THE COYOTE CANYON MAMMOTH, BENTON COUNTY, WASHINGTON. **Barton, Bax R**., Burke Museum of Natural History and Culture, and Quaternary Research Center, University of Washington, Box 351360, Seattle, WA 98195-1360; Gary C. Kleinknecht, Ice Age Floods Institute, 8220 Gage Blvd. # 186, Kennewick, WA 99336. *baxqrc@uw.edu*

Coyote Canyon Mammoth Site is located in the Horse Heaven Hills 5 km southwest of Kennewick, WA, and was discovered in 1999 during sand and gravel quarrying. The mammoth has been radiocarbon dated to roughly 17,449 cal yr BP. During the initial period of discovery several bones where photographed in situ and recovered. The site was then backfilled and otherwise left untouched for scientific exploration and excavation that commenced in 2008. Several bones, including a complete molar currently in possession of the original discoverer (J. Potter collection), have since been made available to the authors for scientific study. Many previous mammoth finds from the Columbia Plateau have been reported but of these only three (Moxee City, Wenas Creek, and Ledgerwood) have yielded reliable radiocarbon dates. Of these none have been diagnosed using modern taxonomic methods to establish the species, and they remain at best ascribed to the genus and species '*Mammuthus* species indeterminate.' Here we apply current morphometric analysis to the Coyote Canyon mammoth molar to establish both the species and age of this mammoth. We analyzed the Coyote Canyon mammoth molar for the following attributes: skull position (hemisphere and side), plate count (Pl), length (Lg), width (W), height (Ht), enamel thickness (En), lamellar frequency (Lf), length/lamellae ratio(R), and hypsodonty ratio (H) (Saunders 1970, 1999; Barton 1996). By comparing the Coyote Canyon molar attribute scores with comparable data from four species of North American mammoths our analysis indicates that this molar is the lower right sixth molar (RM/6) of a Columbian mammoth (*Mammuthus columbi*). The percentage of plates in wear on the molar occlusal surface, when compared to comparable data from modern African elephants, suggests that the Coyote Canyon mammoth was roughly 42+/-3 years of age at death (Laws 1966; Haynes 1991). In terms of modern African elephant social group structure this age indicates that the Coyote Canyon mammoth was a member of the 'senior adult' social age cohort at the time of death (Sikes 1971). This marks an advance on previous analyses of mammoth remains in the region.

IMPACTS OF FUTURE CHANGES ON LOW FLOW IN A HIGHLY CONNECTED RIVER-AQUIFER SYSTEM: A CASE STUDY OF THE SPOKANE RIVER AND THE SPOKANE VALLEY-RATHDRUM PRAIRIE AQUIFER. **Heather Baxter,** Tung Nguyen, Jennifer Adam, Muhammad Barik, Department of Civil and Environmental Engineering, Sloan 101, PO Box 642910, Washington State University, Pullman, WA 99164-2910; Michael Barber, University of Utah, Civil and Environmental Engineering, 110 S. Central Campus Drive Suite 2000, Salt Lake City, UT 84112; Akram Hossain, Washington State University – Tri-Cities, Civil Engineering, 2710 Crimson Way, Richland, WA 99354-1671; *heather.baxter@email.wsu.edu*.

The Spokane, Washington-Coeur d'Alene, Idaho Corridor contains the Spokane Valley-Rathdrum Prairie (SVRP) Aquifer, which is a sole source of drinking water for more than 500,000 people. This aquifer is highly connected to the Spokane River, making the river relatively vulnerable to climate and anthropogenic changes such as pumping. Recent studies have found a decline in minimum daily flow in the Spokane River in the last 100 years, raising concern for the sustainability of human and ecosystem water usage in the next decades. In this research, we investigated the potential impacts of future changes in both climate and human activities on low flows in the Spokane River – SVRP system. A distributed, physically-based hydrological model, the Precipitation Runoff Modeling System (PRMS), and a Modular three-dimensional finite-difference ground-water model (MODFLOW) were used to estimate recharge into the SVRP and the interaction of surface water and groundwater. The model was calibrated and validated at a daily time-step using 16 years of both observed streamflow and observed well data from 1990 to 2005. To assess future climate change impacts, statistically downscaled climate projections of temperature and precipitation between 2010 and 2050 from four general circulation models were used. The results from the coupled model provide insight on the interplay between climate and human activities on groundwater recharge and low flow discharge in the highly connected Spokane River – SVRP Aquifer system. Results can be used to help direct long term water resources management and planning in the region.

IMPACTS TO SOIL CHEMISTRY DUE TO THE INVASION OF ILEX AQUIFOLIUM (ENGLISH HOLLY) INTO SECOND-GROWTH FORESTS OF THE PACFIC NORTHWEST. Andy Berger, Dr. Dylan Fischer, The Evergreen State College, 2700 Evergreen Pkwy NW, Olympia, WA, 98505; *Berand@evergreen.edu*

There is growing concern about the potential of *Ilex aquifolium*, also known as English Holly, becoming an invasive tree in the Pacific Northwest. Cultivated as an ornamental since the 1870's in Washington state (Boersma et. al 2006), little attention has been paid to the rapidly naturalizing tree until it began reproducing at an exponential rate. One of the characteristics that makes this plant so unique is its ability to readily establish itself in undisturbed forests. In the Seattle area, it now constitutes 60% of all tree regeneration (Forterra et. al 2012). With this, *I. aquifolium* has significant potential to transform native ecosystems on a wide scale. However, outside of investigating the physical characteristics of growth, reproduction and distribution (Stokes et. al 2014), little is known about the interaction between *I. aquifolium* and the soil. As a pilot study in 2013-14, we began examining the effects of *I. aquifolium* on the native soil in a second growth forest located in western Washington. In the continuation of that study, we have developed a network of *I. aquifolium* specimens to be used for long term observations. In this most recent study, we examined changes in bulk density, organic matter, pH, soil respiration and nutrient availability due to the presence of *I. aquifolium.*

ICE-RAFTED ERRATICS AND BERGMOUNDS FROM PLEISTOCENE OUTBURST FLOODS, RATTLESNAKE MOUNTAIN, WASHINGTON. Bruce Bjornstad, 1918 Harris Ave. Richland, WA 99354; *bjorn99352@yahoo.com*

Exotic ice-rafted debris from the breakup of ice-dammed glacial lakes Missoula and Columbia is common in slackwater areas along the 700-mile route for outburst floods in the northwestern US. A detailed analysis was performed at Rattlesnake Mountain, which lay beyond the limit of the former ice sheet, where an exceptionally high concentration of ice-rafted debris exists midway along the floods' path. Here flood-waters temporarily rose up to 1,250 ft elevation (forming short-lived Lake Lewis) behind the first substantial hydraulic constriction for the outburst floods near Wallula Gap. Within the 25 km^2 study area more than 2,100 erratic isolates and clusters, as well as bergmounds were recorded. Three quarters of erratic boulders are of an exotic granitic composition, which stand in stark contrast to dark Columbia River basalt, the sole bedrock in the region. Other exotics include Proterozoic quartzite and argillite of the Belt Supergroup as well as gneiss, diorite, schist and gabbro, all once in direct contact with the Cordilleran Ice Sheet far to the north. Most ice-rafted debris is concentrated between 600 and 1,000 ft elevation. Far fewer erratics and bergmounds lie above 1,000 ft elevation because of the preponderance of less-than-maximum floods. Plus, larger deep-rooted icebergs were forced to ground farther away from the ancient shorelines of transient Lake Lewis. As floodwaters moved across the uneven surface of Rattlesnake Mountain, many erratic-bearing icebergs congregated into pre-existing gullies that trend crosswise to flood flow.

ART AND SCIENCE BEHIND THE ICE AGE FLOODS. Bruce Bjornstad, 1918 Harris Ave. Richland, WA 99354; Stev Ominski, 29540 SE Becker Dr., Corvallis, OR 97333; *bjorn99352@yahoo.com*

Science-based fine art plays a role in visualizing geologic processes that are no longer active, especially those without a modern analog - like Ice Age megafloods. Starting in the year 2000, with "The Tip of the Iceberg", artist Ominski has produced a steady series of paintings and drawings depicting monstrous Ice Age floods that last swept through the Pacific Northwest ~13,000 years ago. Ominski's work utilizes the most recent research and opinion from the scientific community to arrive at the most accurate representations with the information available. These include geomorphic analysis of erosional and depositional landforms as well as evidence for past glaciation and maximum flood heights via the distribution of ice-rafted erratics. This information, plotted onto shaded-relief DEM maps, supplied to the artist, render the most accurate reconstructions possible. Also considered are differences in the Pleistocene flora and fauna that existed during colder and drier Ice Age climates. The final story of the Ice Age floods, including the exact timing and frequency of the floods, is still unfolding and as new scientific evidence is revealed a clearer "picture" of ancient environments and landscapes comes into focus. New scientific advancements, as they develop, will be incorporated by the illustrator to most accurately portray future additions to the artistic collection.

CHARACTERISTICS OF A NEW RAINBOW TROUT POPULATION IN SPIRIT LAKE, MOUNT ST. HELENS: 2000-2014. Tara Blackman, Charlie Crisafulli, USDA. Forest Service, Pacific Northwest Research Station, 42218 NE Yale Bridge Road, Amboy, WA 98601;
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Volcanism generates infrequent, but intense disturbances that can alter aquatic habitats and the biota they support over extended periods of time. Because eruptions are episodic fish responses to these events are rarely observed. The impact of the May 18, 1980 eruption of Mount St. Helens on Spirit Lake, a basin located immediately north of the volcano, provided an excellent opportunity to investigate fish responses to disturbance. The lake was subjected to extreme disturbance that resulted in mortality of all multicellular life, including several species of anadromous and resident fish. Within six years, Spirit Lake had regained water quality and prey base conditions that could support fish, however natural and human engineered barriers precluded colonization. Rainbow Trout (*Oncorhynchus mykiss*) were first observed in Spirit Lake in 1993, likely the result of clandestine stocking, and have since maintained a self-sustaining population. From 2000-2014 we annually sampled fish using hook and line and intermittently using gillnets to obtain population characteristics. During this 15-year period mean fish mass declined 78.8 g per year (95% CI: 73.8-83.1 g), and mean snout-fork length declined 9.4 mm per year (95% CI: 8.6-10.3 mm). Catch per unit effort of gillnet samples indicate the population increased substantially after 1993. Inlet steams were initially unsuitable for fish presumably due to high sediment loads and poor habitat condition, but by 2011 juvenile fish were observed rearing in streams. Back calculations using emergence dates and stream temperatures indicate spawning dates in 2013 from early May through early June. Variation in stream biophysical habitat conditions has likely influenced the development of alternate life histories and facilitated changes in the demographic structure of the population probably by increasing the duration of stream residence and increasing recruitment into the population. Natural disturbances such as volcanic eruptions provide perspective on the recovery of freshwater ecosystems and the range of conditions under which salmonids can persist. Examining individual and population responses to novel and early successional environments may improve our understanding of how this species may succeed or fail to colonize disturbed habitat.

UNDERSTORY DEVELOPMENT 17 YEARS AFTER VARIABLE-DENSITY THINNING. Leslie C. Brodie, Constance A. Harrington, U.S. Forest Service, Pacific Northwest Research, Station, 3625 93rd Ave SW, Olympia, WA 98512 *lbrodie@fs.fed.us*

Variable-density thinning has been suggested as a means to increase biodiversity and accelerate the development of characteristics associated with late-successional forests such as multiple stand layers and variation in the distribution of species. To test this silvicultural tool, the Olympic Habitat Development Study was started in 1994 in 8 stands (ages 35 – 70) on the Olympic Peninsula using a plot layout that included reserve areas (10% of the stand), small gaps (15% of the stand) and a thinned matrix. Year 17 vegetation surveys have now been completed at two of the sites on the west side of the peninsula. Understory development was increased in the matrix but gains in % cover were greatest in the gaps. Cover of herbaceous plants and shrubs in the matrix and gaps was greatest at year 7 and declined for most species in subsequent measurements (years10 and 17). Percent cover of non-native species was also greatest at year 7, but never exceeded 1% for any species and by year 17, had a maximum mean percent cover of only 0.1% within the treatment plots. A decrease in percent cover of herbaceous species in the gaps at years 10 and 17 was likely attributable to the development of shrubs, seedlings, and saplings -- primarily *Tsuga heterophylla*. Edge effects were significant with increases in percent cover of herbaceous species and percent cover of tree regeneration extending more than 15 meters beyond gap edges. In year 3, cover of moss and liverwort species was generally lowest in the more disturbed areas (gaps and thin), but increased to levels similar to the reserve and control treatments by year 17. For the 2 sites measured at year 17, species richness of herbaceous and shrub species were 53 and 66 percent higher in the variable density plots than in the corresponding control plots.

BEE DIVERSITY IN THE BITTERROOT VALLEY. Skyler Burrows, Marirose Kuhlman, MPG Operations, LLC, 1001 S Higgins Ave Ste A3, Missoula, MT 59801; *Skyer.Burrows@aggiemail.usu.edu*

Native bees are essential to maintaining diverse plant communities. We conducted a series of bee collections in order to measure the effect of plant restoration efforts along an elevation gradient on bee communities at MPG Ranch in the Bitterroot Valley south of Missoula, MT. Bees were sampled by using a combination of net collections and bowl trapping at 24 different sites from June to September in 2013 and May to September in 2014. Over this period, we collected 32,294 bees representing 5 families, 37 genera, and 217 species. Few large scale bee surveys have been conducted in Montana and as a result 93 of these species are new records for the state. Our collections showed that elevation had a significant effect on bee diversity, with higher bee species richness at higher elevations. The impact the plant restoration on bee communities at our sites is less clear. Many bees use collected plant pollen to provision the nests so it will likely take more years of sampling to see an impact of MPG Ranch's restoration efforts on bee diversity in the area.

THE EFFECT OF PLANT SIZE ON BLUEBUNCH WHEATGRASS SURVIVAL IN AN ARID ENVIRONMENT. Erin Campbell, Tim Parker, Whitman College, Biology Department, 280 Boyer Avenue, Walla Walla, WA 99362; *campbeeg@whitman.edu*

Native ecosystems throughout the Inland Northwest are under threat. Bluebunch wheatgrass (*Pseudoroegneria spicata*), a native perennial bunchgrass, has declined in correlation with overgrazing and competition from invasive species such as cheatgrass (*Bromus tectorum*). In the arid environments of the Northwest, soil moisture competition from cheatgrass may be especially detrimental to bluebunch wheatgrass survival, particularly in young plants whose shorter roots have difficulty accessing deep moisture. Over three summers we monitored bluebunch wheatgrass plants on sites of high and low soil moisture and experimentally manipulated soil moisture evaporation at another site. We found that survival rates increased as plant size (stem number) increased at each site and under experimental conditions. We then identified the size threshold that bluebunch wheatgrass plants must reach at each site such that we could no longer detect any mortality on either drier or wetter sites. Among plants established under experimentally reduced evaporation conditions for two years, returning evaporation to ambient levels reduced survival relative to plants remaining under reduced evaporation conditions. The plants in these experimental plots had not reached the size threshold for high survival rates that we observed in the unmanipulated plants. These results indicate that although there is a threshold size at which bluebunch wheatgrass mortality is no longer detected despite soil moisture levels, two years of establishment in buffered conditions does not seem to be enough to reach this size. Further research on the amount of time bluebunch wheatgrass plants must grow under high soil moisture conditions until they are buffered from mortality risk will have important implications for the recovery of native bluebunch communities.

TERRACETTES: CONSTRUCTION AND DESTRUCTION BY BIOLOGIC AND GEOLOGIC PROCESSES? Robert J. Carson, Whitman College, Department of Geology, 345 Boyer Avenue, Walla Walla, WA 99362, *carsonrj@whitman.edu*

In a classic book, Landslides and Related Phenomena, Sharpe (1938) summarized research on the origin of terracettes, defined in the Glossary of Geology (Jackson, 1997) as "a small ledge, bench, or steplike form, or a series of such forms, produced on the surface of a slumped soil mass… and developed as a result of small landslides and subsequent backward tilting…" Synonyms include "catstep" and "cattle terraces". Darwin (1890) noted some terracettes used by grazing animals and others as a result of sliding. Ódum (1922) favored slumping as the cause of some "sheep-tracks". A key phrase by Sharpe (1938) is "terracettes of combined organic and tectonic origin." Almost all of the terracettes in eastern Oregon and Washington have been made entirely by animals: wild herbivores, Native American horses, and large numbers of sheep and cattle. Arguments that most terracettes are made by geologic processes, especially slumping and soil creep, ignore observations that mass wasting obliterates terracettes. Indeed, terracettes where cattle were excluded three decades ago have almost completely disappeared. Soil creep rounds upper edges of the risers and fills the inward side of the treads.

SPATIAL INTERPOLATION APPROACH OF TEMPERATURE OBSERVATIONS FOR THE STATE OF WASHINGTON. Oscar Castillo, Gerrit Hoogenboom, Melba Salazar, Bernardo Chaves, Nicholas Loyd, and Sean Hill, AgWeatherNet Program, Washington State University – Prosser, 24106 N Bunn Rd, Prosser, WA 99350; *o.castilloromero@wsu.edu*

An important challenge for meteorology is to provide weather information for locations where there are no weather and monitoring stations. For agriculture, temperature has a major impact on growth, development, yield, and quality of crops. Although the general problem of spatializing atmospheric variables and especially temperature has been studied, it is important to understand how regional and local conditions create different challenges for each specific methodology. These include topography, seasonal effects, land use and fixed location of sample points or weather stations. Even expert knowledge is valuable in preprocessing the weather data. A more complex factor is the time series of the data in order to adjust statistical parameters of the models. It is, therefore, necessary to assume intrinsic stationary or second-order stationary conditions, for instance. For accomplishing a first approach of interpolation map a combination of deterministic and stochastic models as Kriging were utilized, because its range of spatial functions can provide spatial uncertainty through parameters estimation. A standard error map based on threshold values can then define the spatial limit of the error and then allow for a representation of the influence area for an observation such as temperature. A user will then be able to know the temperature with its respective interval of error for locations where there is no weather station coverage. Moreover, with an approximation of a local interpolation map, further research can focus on evaluating the spatial coverage of the weather station network and propose potential locations for installing new weather stations.

MYSTERIES OF THE CORE: AN INTERACTIVE GAME ABOUT SCIENTIFIC OCEAN DRILLING AND A GLACIAL LAKE MISSOULA OUTBURST FLOOD. Patrice Ceisel, Ceisel & Associates Inc., 1715 W. Gregory, Chicago, IL 60640; Barbara A. Becker, Exhibit Planning & Research, 1416 Gunderson Ave, Berwyn, IL 60402; *pceisel@ceisel.com*

Deep-ocean cores drilled 160 miles off California's coast included traces of material from a glacial outburst flood that roared across the Pacific Northwest between 10,000 and 15,000 years ago. Organic materials and minerals in some core layers suggested a land-source, which was traced by scientists to the Columbia River and subsequently the flooding events of that era. Working with NSF-funds granted to the Consortium for Ocean Leadership and the International Ocean Discovery Program (IODP), the authors developed an inquiry-based game that encourages users to take a close look at one of the cores, and then, through a process of exploration and inquiry, hypothesize which river the materials might have come from. The correct answer is rewarded with an animated sequence of the Glacial Lake Missoula flooding event that occurred around 15,000 years ago. This poster will include an opportunity to play the 3.5-minute game, as well as descriptions of the processes the developers used to create the game and test it with informal learning audiences. For example, early sampling of visitors at Chicago's John G. Shedd Aquarium indicated that many could not find relevance in deep-ocean core science, unless they could connect it with some event (usually land-based) that they were more familiar with; this led us to select a story with a vivid "hook" (big flood) and a strong land-based connection (in this case the flood-impacted landscapes in the Pacific Northwest). Interviewees also said they wanted to look more closely at materials in the cores; we provided a "zoom" on the shells and other organic materials that clearly distinguish the core layers. Likewise, many interviewees found it hard to imagine how fossils and other materials came to be on the ocean floor; we provided an inquiry sequence in which users speculate about the source of the land plant debris in the ocean core. Final prototype testing showed that users found the game and flood-story engaging and relevant, and they used science vocabulary to talk about it. Through this process we found that users of this "serious game" could have a significant STEM learning experience.

DIVERSITY OF MOBILE MACROINVERTEBRATES IN PONDS CREATED ON THE DEBRIS-AVALANCHE DEPOSIT FOLLOWING THE 1980 ERUPTION OF MOUNT ST. HELENS. Shannon M. Claeson, USDA Forest Service, Pacific Northwest Research Station, Wenatchee Forestry Sciences Laboratory, 1133 N. Western Avenue, Wenatchee, WA 98801; Charles M. Crisafulli, USDA Forest Service, Pacific Northwest Research Station, Olympia Forestry Sciences Laboratory, Mount St. Helens NVM, Amboy, WA 98601; Peter A. Bisson, USDA Forest Service, Pacific Northwest Research Station, Olympia Forestry Sciences Laboratory, 3625 93rd Avenue SW, Olympia, WA 98512; *sclaeson@fs.fed.us*

One of the most notable aspects of the 1980 eruption of Mount St. Helens was the enormous rockslide debris-avalanche that deposited unconsolidated sand to boulder-sized sediment in a 60 km^2 area of the North Fork Toutle Valley. The average and maximum deposit thickness in this area was 45 m, and 195 m, respectively. The presence of hummocks, elevated mounds of debris (up to 100 m tall), and intervening depressions formed ~130 basins, that filled with ground water and precipitation, creating a wide variety of pond types. These ponds provide a unique opportunity to examine community development in fishless lentic environments. We sampled mobile aquatic macroinvertebrates each summer of 2003-2005 from 97 ponds ranging in size and water permanence. We compared species richness, community composition, and trophic organization to pond and riparian habitat variables. Mobile macroinvertebrates inhabiting 23-25-year old ponds were diverse in spite of their close geographical proximity and similar disturbance history. Community composition varied among the study ponds, both spatially and temporally, and was heavily influenced by relatively rare taxa. Of the 111 taxa observed, 20% were collected from one location and 28% were collected only once. This variability in taxa presence was high but consistent between the three study years. In general, species richness was positively related to hydroperiod length, although only spring-dry ponds (shortest hydroperiod) were significantly lower in taxa richness compared to perennial ponds. Macroinvertebrate communities shifted from predator-dominated by abundant Odonata and *Notonecta* species in perennial ponds to predacious diving beetles *Acilius* and *Dytiscus* species in spring-dry ponds. Perennial ponds were generally larger in surface area and more open to sunlight (less canopy cover) than spring-dry ponds. Although the ponds in the debris-avalanche deposit zone share the same climate/weather and disturbance history, and pool of potential colonists, ponds supported distinct communities suggesting both stochastic colonization and environmental filtering as important factors in driving community assembly dynamics.

FIRE HISTORY RECONSTRUCTION OF LEMANASKY LAKE, EASTERN CASCADES, WA. Grant J. Clifton, Megan K. Walsh, Department of Geography, Central Washington University, 400 E. University Way, Ellensburg, WA 98926; *cliftong@cwu.edu*

Macroscopic charcoal analysis of lake sediments has been successfully used to reconstruct past fire patterns throughout the Pacific Northwest. However, there has been little research done on the forests of the eastern Cascades of Washington. This research reconstructs the fire history of Lemanasky Lake, WA (48.7°N, -119.6°W; elevation: 1088 m), located in the Cascade foothills near the Sinlahekin Wildlife Area, roughly five miles northwest of Tonasket, WA. The analysis of macroscopic charcoal from a five meter long sediment core provides an approximately 9,000 year long record of fire activity in the forest surrounding the lake. The primary research question addressed in this study is: "How has fire activity changed at the study site during the past ~9,000 years, and what has been the cause of those changes?" In order to reconstruct the local fire history of the site, we are currently counting all macroscopic charcoal particles >125 microns from contiguous 2 cm^3 samples taken at 1 cm intervals. We identify each particle as either herbaceous or woody; the total proportion of each indicates the type of fuel burned and the overall severity of the fires. CharAnalysis is being used to identify past fire events and to calculate fire frequency. Preliminary results show frequent low-severity ground fires during the late Holocene, with less frequent fire activity prior to that. This reconstruction will not only facilitate our understanding of changes in fire frequency and severity at the site as a result a past climatic variability, but more importantly shows how 20^{th} century fire suppression has affected the forest. Additionally, the results may assist landowners within the wildlife-urban interface of Washington in implementing safe fire management practices.

DOWNSTREAM MIGRATION OF FISH THROUGH RIVERS CONTAINING HYDROELECTRIC FACILITIES. Alison Colotelo, Ryan Harnish, Geoff McMichael, Daniel Deng, Kenneth Ham, Mark Weiland, Pacific Northwest National Laboratory, 902 Battelle Boulevard, MSIN K7-70, Richland, WA 99352; John Skalski, Columbia Basin Research, University of Washington, 1325 4th Avenue, Suite 1515, Seattle, WA 98101; Brad Eppard, U.S. Army Corps of Engineers, Portland District, P.O. Box 2946, Portland, OR 97208-2946; Tim Wik, Chris Pinney, U.S. Army Corps of Engineers, Walla Walla District, 201 N Third Avenue, Walla Walla, WA 99362; *Alison.Colotelo@pnnl.gov*

The Columbia River Basin provides more than 40% of total hydroelectric generation in the U.S. and it is home to a number of anadromous fishes including, salmon, steelhead, and lamprey. The presence of hydroelectric dams can affect fish in a variety of ways, including influencing their downstream migrations. To examine these influences, many studies have used the Juvenile Salmon Acoustic Telemetry System (JSATS) to collect information on both juvenile and adult salmonids as they approach and pass downstream of hydroelectric facilities and move into the estuary. JSATS includes cabled receivers that are mounted on the upstream face of the dam and allow researchers to track the 3-D behavior of fish prior to dam passage, including determination of the ultimate route of passage through the dam. In addition, autonomous receivers are deployed in key locations in the river to estimate survival and travel rates. The results of these studies have demonstrated that the majority of juvenile and adult salmonids pass the dams via surface routes when available and a low proportion pass through the powerhouse (turbines and juvenile bypass systems). This information has been useful for configuring and operating hydroelectric facilities to provide safe downstream fish passage.

THE REINTRODUCTION SUCCESS OF DESERT MOSSES IS DEPENDENT ON OVERWINTERING. Lea A. Condon, Department of Botany and Plant Pathology, 2082 Cordley Hall, Oregon State University, Corvallis, OR 97331; David A. Pyke, U.S. Geological Survey, Forest & Rangeland Ecosystem Science Center, 3200 SW Jefferson Way, Corvallis, OR 97331. *Lea.Condon@science.oregonstate.edu*

Desert mosses reduce soil erosion and contribute to the water and nutrient cycling of a site. Fire or the introduction of non-native annual grasses such as cheatgrass, *Bromus tectorum*, may kill or reduce desert mosses thereby impacting ecosystem function. Land managers in the sagebrush steppe of the Great Basin frequently seed burned areas following fire in an attempt to rehabilitate native vegetation and hinder invasion by cheatgrass. Despite this current practice, protocols do not exist for reintroducing desert mosses. We examine effects and interactions between some common site amelioration treatments and the establishment of two moss species frequently found in the Great Basin: *Bryum argenteum* and *Syntricia ruralis*. Treatments included irrigation, addition of organic matter, and seasonal timing of moss inoculation. Each moss species was collected from two environmentally distinct locations (populations): the Birds of Prey National Conservation Area near Boise ID, that has a warm and dry climate, and the Steens Mountain Cooperative Management and Protection Area near Burns, OR, that has a wet and cool climate. Treatments were tested on four combinations of moss species by population to determine if effects of treatments differed between species-population combinations. Mosses were grown in a common garden, outdoors, in central Oregon (warm and dry climate) between the spring seasons of 2013 and 2014. Preliminary results indicated that the interaction between organic matter and spring irrigation had the greatest positive effect on *Bryum* cover from both populations early in the first spring. However, moss cover declined with subsequent irrigation and did not recover to initial spring cover values by the end of study. By the end of the study, *Bryum* from the drier population that was inoculated in the spring and only received the addition of the organic matter, had the highest average cover of any combination tested, in excess of 25%. Site amelioration treatments and season of inoculation had less effect on *Syntrichia* sp. For both species, mosses collected from the warm/dry location reached greater cover throughout the study. Results from this work can be used to develop protocols for reintroductions.

COMBINING A DYNAMIC GLOBAL VEGETATION MODEL WITH A SOPHISTICATED CLIMATE ENVELOPE MODEL TO PROJECT IMPACTS OF CLIMATE CHANGE ON WESTERN WASHINGTON FORESTS AT REGIONAL AND LANDSCAPE SCALES. **David Ross Conklin**, Common Futures, 444 NW 35th St., Corvallis, OR 97330; Joshua S. Halofsky, Washington State Department of Natural Resources, 1111 Washington St. SE, Olympia, WA 98504; Jan Henderson, US Forest Service (retired), 21817 77th Place W, Edmonds, WA 98026; *david.conklin@mac.com*

We examined potential climate change impacts on forests in western Washington State USA by implementing the algorithms of a sophisticated climate envelope model inside a dynamic global vegetation model (DGVM). We used equations and coefficients from an updated version of the U.S. Forest Service Potential Natural Vegetation (PNV) model to refine the forest biogeography classification rules in the MC2 dynamic global vegetation model. Where the DGVM previously identified only broad vegetation classes such as "maritime needleleaf forest", now it distinguishes regional forest types such as the Sitka spruce zone, the western hemlock zone, and the Pacific silver fir zone. The PNV model considers not only aspects of the temperature and precipitation regimes, but also elevation, fog effect, cold air drainage, aspect, slope position, and shortwave radiation. The MC2 DGVM has always used temperature, precipitation, and elevation, but was modified to make use of the additional inputs from the PNV model. In addition to the vegetation maps usually produced by envelope models, the DGVM also provides projections of wildfire and biomass over time as climate changes. Simulations were performed on a 30 arc-second (~800 meter) grid with three different future climate scenarios drawn from the collection used in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. All three climate scenarios project warming, with mean annual temperatures increasing from 4 to 7 C by 2100. Some results were common to all the scenarios. In our simulations, net primary productivity increased somewhat over the 21st century, fire increased markedly, and wood volume declined somewhat despite increased NPP, as a result of the large increase in wildfire. Optimal conditions for the Sitka spruce zone and the subalpine parkland zones largely disappeared by 2100. The western hemlock zone remained dominant in terms of area, while the Douglas-fir zone grew to occupy a major fraction of the total area. Mapping familiar forest zones rather than simply showing broad vegetation classes made the output more intuitive and relevant to natural resource managers. The DGVM's output time series of leaf area, biomass, and wildfire augmented the picture provided by the forest zone maps.

MODERATE, LOCALIZED WATER DEFICIT POSSIBLE IN WILLAMETTE BASIN OVER 21ST CENTURY. Roy Haggerty, John Bolte, Sam Chan, **Dave Conklin**, William Jaeger, Christian Langpap, Phil Mote, Anne Nolin, Andrew Plantinga, David Rupp, Mary Santelmann, Desirée Tullos, Dave Turner, Kellie Vaché, Dan Bigelow, Matt Cooper, Matt Cox, Kelly Gleason, Kathleen Moore, Travis Roth, Cynthia Schwartz, James Sulzman, Maria Wright, Oregon State University, Corvallis, OR 97331-5503; Dave Hulse, Dept. of Landscape Architecture, University of Oregon, Eugene, OR 97403-5234; Heejun Chang, Dept. of Geography, PO Box 751; Portland State University, Portland, OR 97207-0751; Andrew Plantinga, Bren School of Environmental Science & Mgmt, 2400 Bren Hall, University of California at Santa Barbara, Santa Barbara, CA 93106-5131; *roy.haggerty@oregonstate.edu*

We modeled water resources and land use change driven by climate change, population growth, and economic growth over the 21st century in the 30,000-sq-km Willamette Basin of Oregon. Results suggest that, at the basin scale and over an annual time scale, water quantity is relatively resilient to climate change. Downscaled general circulation model outputs indicate warming temperatures through the century, but similar precipitation totals and timing. Although climate change is likely to significantly reduce snow pack, which will reduce summer stream flow, snowmelt currently makes up less than 20% of the basin's water budget in any month. In the lowlands, although total urban water demand will increase due to population and income growth, the accompanying expansion of urban areas into previously irrigated farmland mean that consumptive water use in parts of the basin may, in fact, decrease in the 21st century. However, deeper summer drought may become common, particularly at higher elevations. Cascade-sourced stream flows may become less reliable in late summer, and higher elevation soils may become drier. As a fraction of total water available, consumptive use may be higher in the summer in part because of reduced stream flow. The Willamette Basin population will likely more than double, causing urban water consumptive use to exceed summer surface irrigation diversions by the end of the century.

COLIFORM BACTERIA IN THE END CREEK WETLANDS. **Joseph A Corsini**, Karen Antell, Chung Pak, Brian Tarpy, Eastern Oregon University, One University Blvd, La Grande, OR 97850; Larry R. Peters, Aquinas College, Biology Dept., 1607 Robinson Rd SE, Grand Rapids, MI 49506-1799; *jcorsini@eo.edu*

In 2005 a 555 acre tract of agricultural land containing two small waterways near La Grande, OR, was registered in the Federal Wetlands Reserve Program. This designation was part of a plan to reclaim and restore the wetland to its natural state. Initial efforts at the End Creek Restoration Project restored End Creek to a natural course through rechanneling, and several plantings have restored some of the native flora. Since its establishment, the End Creek waterways have become a reserve for many migratory birds and the threatened Columbia Spotted Frog (*Rana luteiventris*). As part of an effort to establish a baseline for water quality, we monitored total springtime coliform and fecal coliform bacteria in three of the End Creek Ponds for three years. The results of this study indicate that, throughout any given spring, the numbers of both coliform and fecal coliform bacteria can fluctuate markedly between ponds on any given day, and in any particular pond the numbers fluctuate from week to week. In addition, our analysis suggests that for an early spring collection date, the numbers of these organisms fluctuate from year to year. The causes of the fluctuations are not well understood, but are expected to reflect both springtime flooding and the migrations of source animals such as waterfowl and cervids. Information gathered from this study will inform future management activities on the wetland.

MOUNT ST. HELENS ECOLOGICAL RESEARCH: A 35 YEAR PERSPECTIVE. Charles M. Crisafulli, USDA Forest Service, Pacific Northwest Research Station, 42218 Northeast Yale Bridge Road, Amboy, WA 98601; Frederick J. Swanson, USDA Forest Service, Pacific Northwest Research Station, 3200 Jefferson Way, Corvallis, OR 97333; *ccrisafulli@fs.fed.us*

The 1980 eruption of Mount St. Helens involved a complex ensemble of volcanic disturbance types and intensities that dramatically altered 600 km^2 of Cascadian terrain. These events created a mosaic of large-scale disturbance zones distinguished by characteristics of the new deposits and the amounts of plants, animals and other organisms surviving (legacies) from the pre-eruption ecosystems. The post-eruption environments created an outstanding opportunity for ecological research, and scientists flocked to the volcano where they established dozens of studies and installed a network of plots to investigate both short- and long-term ecological responses to the suite of volcanic disturbance processes. The ecological research portfolio at Mount St. Helens is unique among volcano ecology research programs in that it covers all levels of biological organization, spans numerous taxonomic groups, is conducted in diverse system types (lakes, streams, uplands), and includes studies lasting more than three decades. Research focal areas include: (1) patterns and processes of biophysical legacies, including their types, amount, spatial distribution, and ecological roles; (2) biotic reassembly (3) succession, and (4) soil genesis. Accordingly, investigators have paid detailed attention to processes such as dispersal, establishment and community development, and the underlying stochastic and deterministic factors that strongly influence these processes. Overall, research findings have demonstrated that biological legacies accelerate the pace and influence the direction of ecological response; that the rate of ecological change varies greatly among system types; that stochastic factors play important roles in biotic assembly; that amelioration of substrates and habitat development for animals is often required for establishment; that secondary disturbances serve as powerful resetting events, leading to increased heterogeneity of habitats; that ample growing season moisture coupled with stable substrates lead to the development of biological hotspots; that biotic interactions appear to be loosely coupled, resulting in boom-and-bust populations; that keystone species and bioengineers have strongly influenced the first 34 years of ecological change; and that no single model of succession explains ecological process at the volcano. Several factors are likely to cause strong and abrupt, future ecological shifts, including transition to shrub/sapling seral stage and the potential arrival of the Gray wolf (*Canis lupus*).

PREDICTED INTERACTIVE INFLUENCES OF CLIMATE CHANGE AND AGRICULTURAL INTENSIFICATION ON STREAM HABITAT IN A PACIFIC NORTHWESTERN WATERSHED.

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Climate change and agricultural intensification are two potential stressors that may pose significant threats to aquatic habitats in the inland Pacific Northwest streams and rivers over the next century. Climate change may impact running water through numerous pathways, including effects on water temperature and flow. In certain regions of the Pacific Northwest, agricultural activities, such as crop production, may become more profitable if water projects result in more irrigation water. If so, riparian buffers in non-forested areas may be converted into cropland, which may in turn affect aquatic habitats through increases in sediment and agrochemical runoff into streams. We used currently available downscaled temperature and hydrology data, in combination with a habitat quality framework developed for steelhead (*Oncorhynchus mykiss*), to predict how different levels of each stressor alone and in combination, may impact aquatic habitats in a watershed dominated by high value agriculture in the inland Pacific Northwest, the Umatilla Subbasin. We developed spatially explicit predictions for how changes in flow and water temperature associated with three climate change scenarios and loss of riparian buffers in two agricultural intensification scenarios may impact aquatic habitats. We also examined the cumulative effects of the interaction of extreme climate change and agricultural intensification scenarios. Our results show that all three climate change scenarios are expected to primarily impact aquatic habitats in the upper reaches of the Subbasin. In contrast, agricultural intensification scenarios did not have large impacts on temperature, but are predicted to affect other water quality variables in the lower reaches of the Subbasin. A moderate scenario of agricultural intensification had relatively little effect on aquatic habitat, while the removal of all riparian buffers in agriculturally viable reaches had a substantially negative effect on sediment, embeddedness, and large woody debris in the lower Subbasin. Interactions between the most extreme climate change and agricultural intensification scenarios reflected a complementarity of effects, with climate change primarily affecting the upper Subbasin and agricultural intensification primarily impacting the lower Subbasin. This work suggests that the Umatilla Subbasin and similar watersheds will present a challenging habitat for warm water- and pollution-intolerant species in the coming century.

JSATS TAG DEVELOPMENT FOR JUVENILE SALMON, STURGEON, EEL, AND LAMPREY. Daniel Deng, Huidong Li, Jie Xiao, Mitchell Myjak, Jun Lu, Jayson Martinez, Tom Carlson, Mark Weiland, Rich Brown, Pacific Northwest National Laboratory, Richland, WA; Brad Eppard, U.S. Army Corps of Engineers, Portland District, Portland, OR; *Zhiqun.deng@pnnl.gov*

In recent years acoustic telemetry has been a primary method for studying salmon passage. However, the size of the existing transmitters limits the minimum size of fish that can be studied, introducing a bias to the study results. We developed the first acoustic transmitter that can be implanted by injection instead of surgery. It is 15.00 mm in length and 3.35 mm in diameter, and weighs 216 mg in air. The tag can last > 100 days at a pulse rate interval of 3 s. A field experiment demonstrated that the new transmitter would function as designed both during implantation and following release of implanted fish. In addition, the single reach survival rates of fish tagged with the injectable tag are better than those of the fish tagged with regular transmitters at every downstream array. Because the new transmitter costs significantly less to use and may substantially reduce adverse effects of implantation and tag burden, it will allow for study of behavior and survival of species and sizes of fish that have never been studied before.

Little is known about the behavior and habitat use of small juvenile (< 1 year old) sturgeon. Their small size has precluded intensive research using telemetry techniques because the transmitters commercially available are too large, have too short of a lifetime, or have an inadequate ping rate. We developed a new acoustic transmitter for juvenile sturgeon. The sturgeon tag weighs approximately 700 mg in air, is 5.0 mm in diameter and 24.2 mm in length. Its source level can be up to 163 dB re 1 µPa compared to the 156 dB for the injectable tag. It has a tag life of 365 days at a source level of 161 dB and a PRI of 15 s.

Knowledge of juvenile eel and lamprey behavior and survival are critical for developing mitigation strategies for dam passage, including design of bypass systems at hydroelectric facilities. We just started a new project to design, prototype, and evaluate an acoustic microtransmitter that can be used to study the behavior and survival of juvenile eel and lamprey.

***ASPICILIA* PHYLOGENETICS: RECONCILING MORPHOLOGICAL PLASTICITY WITH MOLECULAR DATA. Joseph Di Meglio**, Bruce McCune, Oregon State University, Department of Botany and Plant Pathology, 2082 Cordley Hall, Corvallis, Oregon 97331; *dimeglij@onid.orst.edu*

Aspicilia filiformis and *Aspicilia reptans* are two species complexes of lichenized fungi that each includes many possible species. These two groups each exhibit great plasticity in growth forms and have few distinguishable secondary metabolites; these make correct identification challenging. These two species complexes are widely distributed throughout western North America. The *A. filiformis* complex has a fruticose, sprawling filamentous growth habit that is loosely attached to the substrate. This complex includes *A. filiformis*, *A. californica* and potentially undescribed species. This complex also has distinct forking lobe tips or compound lobe tips that lack a photobiont; *Aspicilia filiformis* is K- while both *A. californica* and *A. sp.* are K+ red and contain norstictic acid. The *A. reptans* complex includes three species in question, *A. reptans, A. aspera* and *A. mansourii*. This group has a fruticose to crustose habit, closely adheres to its substrate, has a filamentous to beaded or warty thallus and simple lobe tips. To elucidate species concepts and resolve phylogenetic relationships, we used nuclear DNA sequence data of the ITS and LSU loci. DNA extraction and sequencing was performed using fresh specimens from seven western U.S. states. We used Staden package for assembling sequence data and PhyML in Geneious for phylogenetic tree assembly by maximum likelihood analysis. We present preliminary ITS and LSU phylogenetic trees resolving these taxa, as well as morphological characters useful to distinguish them. Our data suggests that *A. reptans* group is polyphyletic and breaks up into several clades within the two genera *Aspicilia* and *Circinaria*, with seven possible distinct species groups. The *A. filiformis* group exhibits support for a monophyletic clade including *A. californica* and *Aspicilia sp.* as closely related species.

RESURRECTION AFTER FIRE: TEMPORAL AND SPATIAL VARIATION IN SEEDING SUCCESS ON SANDY AND SILT LOAM SOILS. *Janelle Downs*, Mike Sackchewsky, Pacific Northwest National Laboratory, Richland, WA 99352; *jl.downs@pnnl.gov*

More than half of the original sagebrush steppe ecosystems in Washington have been converted to agriculture and many of the remaining stands of sagebrush are degraded by invasion of exotic annuals such as cheatgrass (*Bromus tectorum* L.). The increasing frequency of wildfire in sagebrush-dominated landscapes is one of the greatest threats to these habitats and also presents one of the most difficult to control. Post-fire seeding of native plant species is often employed to accelerate recovery of native habitat, reduce potential erosion, and potentially reduce non-native invasion by reducing open niches. Following the 2007 Wautoma Fire on the Hanford Site, the U.S. Department of Energy seeded approximately 7000 acres on central Hanford with a mix of native grasses and a forb. To evaluate the recovery and success of seeding, we measured species canopy cover and density on 20 burned, unseeded and 49 burned, seeded plots in different soils for 3 years post-fire. Without consideration of soil type, differences between recovery measured as canopy cover and density of native forbs and grasses were not detected between seeded and unseeded areas. Comparisons of seeding success by soil type indicated that seeding in Burbank loamy sand was more successful in recovering canopy cover and density of native perennial forbs and grasses than seeding in silt loam or sands.

SIX YEARS AFTER THE FIRE: EFFECTIVENESS OF VEGETATION REHABILITATION TREATMENTS ON THE OVERLOOK FIRE, HANFORD REACH NATIONAL MONUMENT, WASHINGTON. Debra Salstrom, **Richard Easterly**, SEE Botanical Consulting, 578 Whitecap Rd, Bellingham, WA 98229; *seebotanical@gmail.com*

The lightning-caused 2007 Overlook Fire burned over 20,000 acres on the Wahluke Slope, Hanford Reach National Monument, Washington. Subsequent vegetation rehabilitation treatments included herbicides (Journey®, Plateau® and Roundup®), seeding native species (drill and aerial) and planting bare-root shrubs. We monitored treatment effects on random plots that were read one, two, three and six years after the fire. Cheatgrass was initially suppressed on Journey® and Plateau® sites, while cover and frequency of Russian thistle was highly elevated relative to untreated sites and sites treated with Roundup®. By year six, levels of cheatgrass and Russian thistle were similar to untreated sites. Journey® and Plateau® sites also had distinct swaths of killed Sandberg bluegrass and spring annuals were greatly suppressed for several years after herbicide application. During the first three years after the fire, cover and density of cheatgrass on plots in sites treated with Roundup® were indistinguishable from untreated sites; during year six, cheatgrass measurements were nearly double those recorded on plots in untreated sites. None of the herbicide treatments had detectable effects on the establishment of tall bunchgrass, and seeding treatment results were not different from untreated sites. Few tall perennial bunchgrass seedlings were detected on the plots after treatments and a small percentage of those became established, presumably due at least in part to dry weather conditions during the early years after treatment. Most tall perennial grass present in year six was needle-and-thread grass, which increased primarily in places it had been known to occur prior to the fire, including on untreated sites. Post-fire seedlings of that species were commonly observed in those areas prior to seeding treatments. Drill seeding also had no discernable effect on bunchgrass establishment, presumably due to dry weather before and after treatment. After year one, survival of planted sagebrush and antelope bitterbrush starts was 61% (CI 16%, alpha 0.1) and 23% (CI 9%, alpha 0.1), respectively. In addition, volunteer sagebrush seedlings were observed throughout much of the site after the fire and before planting efforts, some of which survived and set seed within two years.

POST-GLACIAL FIRE AND VEGETATION HISTORY OF HORSETAIL LAKE IN THE TEANAWAY AREA OF THE CENTRAL EASTERN CASCADES, WASHINGTON. Serafina Ferri, Megan Walsh, Resource Management Program/Department of Geography, Central Washington University, 400 E. University Way, Ellensburg, WA 98926; *ferris@cwu.edu*

Landscapes of the Pacific Northwest have been shaped by dramatic shifts in climate since the last glacial maximum, and more recently, by human activity. However, it is unclear how past relationships between people, fire, and climate played out on the landscape. The purpose of this research is to reconstruct the post-glacial paleoenvironmental history of a wetland known as Horsetail Lake, located in the Teanaway area of the eastern Cascades. The goal is to evaluate how fire activity and vegetation patterns have varied under different climatic scenarios during the last ~13,000 years and in relation to human land-use actions. This lake was selected because it is one of only a few natural wetlands that exist in the Teanaway area below an elevation of 4000 feet, and because the archaeological record supports the idea that people utilized mountain environments in the eastern Cascades similar to that around the site. In 2011, a 10 meter-long sediment core was extracted from Horsetail Lake using a modified Livingstone corer. High-resolution macroscopic charcoal and pollen analysis is being used to reconstruct the fire and vegetation history of the Horsetail Lake watershed. The chronology of the sediment will be determined using radiocarbon (^{14}C) dating and tephra layer identification. Preliminary results of this study show that fire frequency and severity has varied widely at Horsetail Lake during the post-glacial period. The early Holocene shows high fire activity with a drop in fire activity during the middle Holocene. Fire activity then becomes more frequent during the late Holocene. Completion of the pollen analysis will show how the forest around Horsetail Lake has changed both in terms of composition and structure in relation to the fire history. My results will hopefully be incorporated in future management plans of forest environments in the eastern Cascades as climate continues to change.

DO CLEAR-CUTS DELAY VEGETATION RECOVERY FOLLOWING VOLCANIC DISTURBANCE IN COMPARISON TO OLD-GROWTH FORESTS? Dylan G. Fischer, Environmental Studies Program, Lab II, The Evergreen State College, 2700 Evergreen Parkway NW, Olympia WA, 98505; Joseph A. Antos, Department of Biology, University of Victoria, Cunningham Building 202, 3800 Finnerty Road (Ring Road), Victoria, BC, Canada V8P 5C2; Abir Biswas, Biogeochemistry and Ecology Laboratory, Lab II, The Evergreen State College, 2700 Evergreen Parkway NW, Olympia WA, 98505; Donald B. Zobel, Department of Botany and Plant Pathology Oregon State University, Cordley Hall, Corvallis, OR 97331-2902; *fischerd@evergreen.edu*

Initial vegetation conditions can have legacy effects on ecosystem response to large disturbances, such as the eruption of Mount St. Helens. We compared understory vegetation and soils between clear-cut and old-growth forest affected by tephra deposits from the eruption of Mount St. Helens in 1980. Previous research has evaluated old-growth forest understory plant communities following the eruption; here we compare communities in paired old-growth and clear-cut forests. At two separate sites in the tephra deposition zone, we paired a clear-cut that predated the eruption with an adjacent old-growth forest. Sites were classified as either high or low diversity, and received between 4 and 14 cm of tephra in the 1980 eruption. Mosses, herbs, and shrubs on clear-cut sites were sparse 33 years after the eruption, and percent vegetative cover was generally higher in the old-growth. Soil surfaces with a high percent cover of barren tephra and relatively open canopy structure were common in the clear cuts. In contrast, old-growth sites had thickly developed soil O-horizons overlaying 1980 tephra deposits. Ruderal, shade-intolerant species were more common in the clear-cut, but *Vaccinium* shrub species common in the old-growth sites were also present in high abundances. Non-metric multidimensional scaling ordination and associated multiple response permutation procedure tests demonstrated clear separation between high diversity sites and low diversity sites, and between clear-cut and old-growth sites. In old-growth forest, communities were much more divergent among old-growth sites than among clear-cuts, which could be because of enhanced microsite heterogeneity in old growth compared to clear-cuts. Even so, clear-cuts generally exhibited greater diversity in evenness and Shannon's Diversity Index (H') and Simpson's (D) diversity. Overall, these data suggest that intact old-growth forests seem to have had a different recovery trajectory in response to tephra deposition. Old-growth sites may at once have recovered greater percent cover of native vegetation and have higher inter-site diversity. In comparison, the clear-cuts demonstrated higher intra-site diversity, yet still had high percent bare ground cover, and generally lower vegetative cover. Greater canopy cover and soil O-layer development in old-growth may be the drivers of these differences.

COMBINING FIELD AND GREENHOUSE EXPERIMENTS TO UNDERSTAND THE RELATIONSHIP BETWEEN CLIMATE AND BUDBURST IN COAST DOUGLAS-FIR (*PSEUDOTSUGA MENZIESII* VAR. *MENZIESII*). **Kevin R. Ford**, Constance A. Harrington, USDA Forest Service, Pacific Northwest Research Station, 3625 93rd Ave SW, Olympia, WA 98512; *kevinrford@fs.fed.us*

The timing of annual growth initiation in plants has large impacts on species distributions and ecosystem function, and is sensitive to climate. Warmer spring temperatures have generally led to earlier budburst (initiation of primary growth) in temperate plants. However, many species require exposure to cool temperatures (chilling) as well as warm temperatures (forcing) during the winter and spring to burst bud. Warmer winters could disrupt this process. Specifically, trees experiencing reduced chilling may require more forcing to burst bud, which could delay or even prevent budburst. We studied the timing of budburst in coast Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*) by combining data from field studies at nines sites in Washington and Oregon (where plants experienced medium to large amounts of chilling) and greenhouse studies (where we manipulated the amount of chilling plants experienced from low to medium). In the field studies, we found little difference in the forcing required for budburst across the range of chilling values, with required forcing being slightly higher at the lowest chilling values. But in the greenhouse studies, as chilling values declined past those experienced in the tree's native range, the forcing required for budburst increased rapidly. Moreover, low chilling resulted in increasingly high proportions of trees failing to burst bud. As climate change leads to reduced chilling, coast Douglas-fir near the tree's southern range limit may approach a threshold at which the forcing required for budburst increases substantially and the budburst process is altered, leading to potential growth reductions and range contractions.

2014 NWSA Student Grant Recipient Presentation

EVALUATING HYPOXIA-INDUCIBLE FACTOR- 1α mRNA EXPRESSION IN A PELAGIC FISH, PACIFIC HERRING *CLUPEA PALLASII*, AS A BIOMARKER FOR HYPOXIA EXPOSURE. **Halley E. Froehlich,** Steven B. Roberts, Timothy E. Essington, University of Washington, School of Aquatic and Fishery Sciences, Box 355020, Seattle, WA 98105; *hefroehl@uw.edu*

Low dissolved oxygen (DO), also known as hypoxia (DO < 2mg L-1), is a major environmental perturbation for many aquatic ecosystems, particularly highly productive estuaries. Most research attention and understanding about the impacts of hypoxia on estuarine species has focused on the benthos, where hypoxia is most common. Although, the pelagic zone is also susceptible to the effects of hypoxia, the interactions and consequences are not as well understood in marine environments because documenting exposure or avoidance of hypoxia is often difficult. Physiological biomarkers might provide a way to gain more detailed spatiotemporal information regarding species' exposure to hypoxia. Here, we identified and tested a hypoxia-specific responsive gene, hypoxia-inducible factor-1α (HIF-1α), to evaluate its potential as a biomarker for hypoxia exposure in Pacific Herring (*Clupea pallasii*), an abundant and widely distributed pelagic fish species. We conducted controlled laboratory experiments to establish the level of elevated gene expression (>1sd normoxic mean), exposure amplification (2-8hrs), and reduction rate (ca. 24hrs) for HIF-1α. These experiments also indicated approximate lethal hypoxic limits of Pacific herring (ca. 2 mg L-1, ≥4hrs). We then used these findings to evaluate the spatiotemporal patterns of HIF-1α expression of Pacific herring in a seasonally hypoxia estuary, Hood Canal, Washington, USA. Counter to our expectations, gene expression was more frequently elevated in regions with moderate to low hypoxia. However, consistent with our hypothesis, herring from the more severe hypoxic year (2013) had a higher probability of having elevated mRNA levels. These patterns indicate that HIF-1α mRNA levels may not be directly indicative of local water quality conditions, but can potentially provide insight into hypoxia exposure over broader scales. Moreover, this study demonstrates key differences and limitations of hepatic HIF-1α as a biomarker for a pelagic, highly mobile species versus more benthic organisms.

VEGETATION TREND FOLLOWING ELK HERD SIZE TREND: AFTER 70 YEARS OF DATA WHAT WE EXPECTED AND WHAT WE OBSERVED IN THE GALLATIN CANYON. Neto Garcia; Clayton Marlow, Montana State University College of Agriculture, 309 Animal Bioscience Building, Bozeman MT 59717; *ngarcianeto@gmail.com*

Land managers and wildlife biologists from many agencies use grazing exclosures to draw inferences about wildlife habitat relative to herbivore population densities and the effectiveness of soil and vegetation manipulation on plant community recovery. In times of high herbivore density, vegetative suppression is expected with possible erosion and soil loss. As herbivore populations decrease, cascading trophic effects on trees, shrubs, and grasses have been hypothesized. The construction of exclosures should release the vegetation from intense grazing and browsing making it possible to reach its climax. In a case study using nearly 100 years of elk data and 70 years of vegetation data from wildlife exclosures in the Gallatin Canyon, Southwest, Montana, we present qualitative and quantitative assessments of a series of hypotheses about elk population interaction with vegetation. During times of high elk numbers (1958-1962), biologists from the U.S. Forest Service and Montana Fish, Wildlife and Parks performed a series of experimental vegetative treatments to improve low range conditions thought to be caused by heavy elk use: seeding with non-native grasses, planting shrubs, contour plowing to limit soil loss, sagebrush removal, and testing snow fences to trap snow for additional moisture. After the 1990's, multiple landscape-level changes, including the reintroduction of wolves, resulted in substantial declines in elk numbers. Wintering elk numbers decreased from a long-term average of 1,600 to fewer than 500. Given a 2/3 reduction in elk numbers, biologists hypothesized a trophic cascade would occur resulting in a shift from early seral to later vegetation seral or climax communities. We revisit the exclosures in 2013 and 2014 to locate and re-measure permanent transects. We summarized vegetation species to the successional stage and plotted trend curves. The overall result shows a slow succession where early seral and mid seral species increased, but after 70 years the climax species did not increased, not even inside the exclosures. The expected trophic cascade effect could not be noticeable maybe because of declining precipitation; the sites crossed a threshold, or it will take much more time to observe the recovery than we expect.

VEGETATION STABILITY AND THE HABITAT ASSOCIATIONS OF THE ENDEMIC TAXA OF THE OLYMPIC PENINSULA, WASHINGTON, USA. **Daniel G. Gavin**, University of Oregon, Department of Geography, Eugene, OR 97403; *dgavin@uoregon.edu*

Explanations for areas of endemism often involve relative climatic stability, or low climate velocity, over time scales ranging from the Pleistocene to the late Cenozoic. Given that many narrowly endemic taxa in forested landscapes display discrete habitat associations, habitat stability should be similarly important for endemic persistence. Furthermore, while past climate variability is exceedingly difficult to quantify on millennial time scales, past distributions of habitats may be robustly inferred from paleoecological records. The Olympic Peninsula, Washington, supports a biota with several insular features including 29 endemic plant and animal taxa. Here I present the geographic distribution and habitat of the endemic taxa, and then examine the vegetation stability of the past 14,300 years from five pollen records associated with discrete vegetation zones on the peninsula. I show that 11 endemics have distributions centered on dry alpine scree and rock in the northeast, and nine occur in shaded riparian forests in the southwest. Vegetation turnover during the post-glacial period was smallest in these areas. However, another long pollen record from the western peninsula reveals existence of shrub tundra and greatly reduced forest cover, indicating southward displacement of shaded riparian habitats by perhaps as much as 100 km. Although this study supports an association of post-glacial vegetation stability with endemism, records spanning the glacial maximum indicate widespread tundra during long periods of the late Pleistocene and therefore suggest southern displacement of forest-associated endemics. While some of the alpine scree-associated endemics may have persisted in situ, many other endemics are likely recently assembled from a variety of dispersal histories. These histories include dispersal from southern refugia towards ocean barriers preventing further northward dispersal, contraction from more widespread distributions, and recent divergence from sister taxa. This study shows that paleoecological records can cast strong doubt on the inference that areas of endemism necessarily imply *in situ* glacial survival.

FIRE REGIME DYNAMICS OF FISH LAKE, BLUE MOUNTAINS, OREGON. **Christopher Goodner**, Central Washington University, Resource Management, 400 University Way, Ellensburg, WA 98926; Megan Walsh, Central Washington University, Department of Geography, 400 University Way, Ellensburg, WA 98926; *goodnerch@cwu.edu*

Fire has been a key process in shaping the forests of the Pacific Northwest (PNW) throughout the Holocene (the past ~12,000 years). However, in recent centuries, anthropogenic climate change and land-use actions (e.g., fire suppression) have severely disrupted pre-Euro-American settlement fire regimes, leading to the risk of catastrophic wildfires in many forests. Federal agencies are interested in using prescribed fire to restore historic forest mosaics and to reduce the risk of these conflagrations; however, there is a lack of fire history data from many areas in the PNW that spans more than a couple hundred years, including the Blue Mountains of Oregon. This study is reconstructing the fire history of the Fish Lake watershed in the Wallowa-Whitman National Forest of the Blue Mountains using macroscopic charcoal analysis of a lake sediment core. The purpose of this research is to determine how fire regimes have changed at the site during the past ~12,000 years with respect to past climate variability. Fish Lake is located at an elevation 2,030 m and exists among trees with low fire return intervals, lodgepole pine (*Pinus contorta*) and subalpine fir (*Abies lasiocarpa*). Preliminary results indicate that infrequent high-severity fires have historically dominated the region. Our findings also suggest these fires have become more common in the last few hundred years. This will be compared using fire-scar analyses from the region to show how fire regimes have changed over the past. It is our hope that the information from this study can be used by forest managers to determine how fire activity may change in the future due to climate change.

UNDERSTANDING TEMPERATURE INVERSIONS AND IMPROVING FROST FORECASTING FOR CENTRAL WASHINGTON GROWERS. Jonathan Gramann, Gerrit Hoogenboom, AgWeatherNet, 24106 N. Bunn Rd., Washington State University – Prosser, Prosser, WA 99350; *jonathan.gramann@wsu.edu*

Temperature inversions are a reversal of the normal atmospheric lapse rate such that temperature decreases with increasing height. They most often form by radiation cooling during clear and calm nights. The goal of this project is to improve surface low temperature predictions and predict vertical temperature gradients up to 20 meters above the surface. This project involves the installation of sensors at 10 to 20 meter tall towers throughout the Tri-Cities area and Yakima Valley. This data will be used to calibrate a statistical forecast model. Currently, this project is in its beginning stages. Two sites have been operational for 3 months, and 3 more sites will be added in March. Preliminary data show one site achieving an inversion of 6.4°C over 10 meters. Ultimately this information will be used by agriculture to inform decisions of when to utilize frost protection methods.

IMPACT OF CLIMATE CHANGE ON WHEAT PRODUCTIVITY AT FARMERS' FIELD IN PAKISTAN. **Muhammad Habib ur Rahman**, Ashfaq Ahmad, Fahd Rasul, Aftab Wajid, Tasneem Khaliq, Muhammad Shaukat, Agro-Climatology Lab., Department of Agronomy, University of Agriculture, Faisalabad, P.O Box 127, Punjab, Pakistan; Gerrit Hoogenboom, Washington State University – Prosser, Prosser, WA, 99350; *m.habiburrahman@wsu.edu*

Wheat productivity, a prerequisite for food security, is extremely vulnerable to climate change globally in general, and arid to semi-arid regions of Pakistan in particular. Climate change hazards would be more devastating in future because there would be a 2.8 °C rise in maximum and 2.2 °C rise in minimum temperature for mid-century (2040-2069) in Rice-Wheat (RW) cropping systems. The main thrust of this study is to develop adaptation strategies through crop growth models (DSSAT and APSIM) to combat the effects of climate change at farmers' field and improve the livelihood of the farmers in the hotspot areas along with dissemination of relevant information to stakeholders. Crop growth models were calibrated and validated at experimental field data to develop the robust genetic coefficients. Calibrated models were validated at farmers' field (155) data of five districts in RW cropping system, regarding all agronomic aspects of wheat management from planting to harvesting. A close agreement was recorded for farmer field wheat yield with simulated one. When models were validated at farmers' field, goodness of model (R^2) with values of 0.64 was recorded in DSSAT and 0.37 for APSIM between observed and simulated yield of 155 farms. Comparison of individual farmer yield showed that DSSAT simulated wheat yield with percent difference (PD) ranging from -25 to 17% and -26 to 40% having Root Mean Square Error (RMSE) 436 and 592 kg ha^{-1} with d-statistic (0.87 and 0.88) and bias was observed 0.98 and 0.96 for DSSAT and APSIM, respectively. Climate change impact was quantified working with crop models for baseline climate (1981-2010) and future climate of five GCMs (CCSM4, GFDL, HadGEM, MIROC5, and MPI-ESM) for mid-century (2040-2069). Mean yield reduction for DSSAT ranged between 6.2 to 19% while for APSIM yield reduction was 10.6 to 12.3% with five GCMs. Adaptation technology was developed for wheat crops to cope with the ill effects of changing climate at farmer's field. To achieve high productivity and meet the need of growing population, it would be required to increase the planting density and fertilizer use up to 30 and 25% respectively which was considered as one of the adaptation strategy for promising varieties with 50% greater potential. Due to high temperature the cropping seasons will be affected and 15 days earlier planting over current is recommended. These strategies have a significant impact in reducing the vulnerabilities of the changing climate with 22% improvement in wheat yield to sustain food security. If current production technology prevails in future, there would be about 62 to 73% losers and poverty rate would be between 36 to 42% due to disconcerted climate. Quantification of climate change impact on future agricultural production systems depicted that there would be 49 to 67% losers and poverty rate would range between 18 to 23%. Potential adopters of the adaptation strategies ranged from 90 to 91% and poverty could reduce from 15 to 16% after the implementation of the adaptation strategies.

EVALUATION OF THE FACTORS AFFECTING ROUTE OF PASSAGE AND SURVIVAL OF ACOUSTIC-TAGGED SALMONIDS AT SNAKE RIVER HYDROELECTRIC DAMS. Ryan Harnish; Kenneth Ham; Alison Colotelo; and Daniel Deng, Pacific Northwest National Laboratory, 902 Battelle Boulevard, Richland, WA 99352. *Ryan.Harnish@PNNL.gov*

Dam passage survival studies were conducted at Little Goose (LGS) and Lower Monumental (LMN) dams in 2012 and 2013 to determine if the dams met the requirements of the Federal Columbia River Power System Biological Opinion (BiOp). A concurrent study was conducted to identify dam passage routes and survival of acoustic-tagged steelhead kelts at Lower Granite Dam (LGR), LGS, and LMN.

Dam passage survival estimates exceeded the BiOp standard for all species/stocks tested at LGS and LMN in both years except for subyearling Chinook salmon (CH0) at LGS in 2013. The Army Corps of Engineers funded a data diagnostic study to evaluate the reasons behind the low survival of CH0 at LGS in 2013 and to identify potential alternative dam operations that may improve survival.

Detections of acoustic-tagged fish on cabled and autonomous hydrophones were used to track the 3-dimensional movements of fish in the forebay, calculate forebay residence and tailrace egress times, identify routes of dam passage (spillway weir, conventional spill, juvenile bypass system, turbine), and estimate survival to a detection array located downstream of the dam. Bivariate and multivariable logistic regression modeling was used to evaluate the individual, behavioral, environmental, and dam operational variables that affected route of passage, residence and egress times, and survival of acoustic-tagged fish.

Model results indicated fish size, diel period, migration depth, approach location, searching behavior, discharge, and percent spill were among the variables that affected CH0 route of passage at LGS. High water temperature and low discharge were identified as the factors that were primarily responsible for the low survival of CH0 at LGS in 2013. However, we were able to identify specific operations used under these suboptimal conditions that resulted in survival estimates that exceeded the BiOp standard. For kelts, modeling results indicated forebay behavior (e.g., depth, approach location, searching behavior) was primarily responsible for their ultimate route of dam passage. The physical condition of steelhead kelts was the most influential variable affecting their survival.

The results of this study may be used better understand the factors that affect route of passage and dam passage survival of salmonids at hydroelectric dams.

MEASURING THE BIOTIC INTEGRITY OF MIDDLE FORK JOHN DAY RIVER, OR. WITH RESTORATION. Robin M. Henderson, James R. Pratt, Washington State University – Tri-Cities, 2710 Crimson Way, Richland, WA 99354; *robin.henderson@email.wsu.edu*

Aquatic ecosystems can be monitored using biotic indices, and one of the most commonly used indices is the Observed/Expected (O/E) ratio. To determine if the Middle Fork John Day River (MFJDR) sites (n=10) have improved biotic integrity scores following restoration, we developed random forest (RF) models using macroinvertebrate assemblage data from the Oregon Department of Environmental Quality (ODEQ) representing 105 reference sites and 442 test sites with the River Invertebrate Prediction and Classification System (RIVPACS) framework. The best performing model, based on model performance metrics, was chosen to test that the MFJDR sites have improved biotic integrity scores. The selected RF model predicted that 73% were in most disturbed and 27% in moderately disturbed condition in 2009 compared to 67% in most disturbed, 18% in moderately disturbed, and 18% in least disturbed biological condition in 2013. However, results indicate that there is not yet evidence of significant improvement in biotic integrity scores for restored MFJDR sites. Ongoing analysis is needed to characterize the variability of the macroinvertebrate community and to determine how management actions have affected O/E scores.

THE ORIGIN OF XENOLITHS WITH CUMULATE TEXTURES FOUND ABOVE THE SUBSURFACE EXTENSION OF THE STILLWATER COMPLEX, MT. Cassandra Hennings, Jennifer A. Thomson, Department of Geology, SCI 130, Eastern Washington University, Cheney, WA 99004; Michael L. Zientek, USGS Spokane Office, 920 West Riverside Ave., Spokane, WA 99201. *jthomson@ewu.edu*

The Archean Stillwater Complex is a large layered mafic-ultramafic intrusion (LMI) exposed in the Beartooth Mountains of south-central Montana. Gravity measurements suggest that the north-dipping complex extends under cover at depth. Some of the exposures located above the subsurface Stillwater Complex are younger Cretaceous stocks (Susie Peak and Sliderock Mountain stocks), diorite sills and andesite dikes, exposed north of the complex, passed through area of the gravity anomaly that may be the Stillwater Complex. In the summer of 2013, samples of the stocks and their included xenoliths (foreign rock fragments; commonly metamorphosed to greenschist facies conditions) were collected for study. Xenoliths with textures reminiscent of Stillwater Complex cumulates were chosen for further investigation. The host andesitic rocks containing the xenoliths exhibit porphyritic textures—phenocrysts of plagioclase, amphibole ± biotite occur in a finer-grained groundmass of the same minerals. Electron microprobe analyses of amphibole grains from both the host and xenolith are comparable in composition. Electron microprobe analyses for two samples of coexisting xenolith amphibole (Tschermakitic hornblende, magnesio-hastingsite) and plagioclase (rim $An_{83-91}Ab_{17-9}$) constrain temperature conditions at various pressures (P at 3, 5, and 6 kb; T = 500-656°C, respectively using Holland and Blundy (1994). These conditions are consistent with amphibolite facies metamorphism. Few xenoliths retain the original igneous mineralogy (with the exception of plagioclase) but one sample contains relict "Stillwater-like" mineralogy (e.g., clinopyroxene) and another contains chromite. Plagioclase and relict clinopyroxene compositions are somewhat comparable to Stillwater mineral compositions. The fact that the xenoliths are now metamorphosed and highly altered suggests that either they were metamorphosed prior to their inclusion in the melt or were metamorphosed or hydrothermally altered as a result of incorporation into the melt.

HYDROACOUSTIC EVALUATION OF JUVENILE SALMONID PASSAGE AND DISTRIBUTION AT FOSTER DAM. James Hughes, Pacific Northwest National Laboratory, P.O. Box 999, Richland, WA 99354; Fenton Khan, U.S. Army Corps of Engineers, P.O. box 2946, Portland, OR 97208; Jina Kim, Jose Vazquez, Pacific Northwest National Laboratory, P.O. Box 999, Richland, WA 99354; Gary Johnson, 620 SW Fifth Ave, Portland, OR 97204; *james.hughes@pnnl.gov*

Due to population declines of Upper Willamette River Spring Chinook salmon (*Oncorhynchus tshawytscha*) and Upper Willamette River steelhead (*O. mykiss*), these fish species were listed as threatened under the Endangered Species Act in 1999. To support decisions for long-term measures and operations to improve fish passage conditions at hydroelectric dams in the Willamette Valley for these populations, we conducted a 14 month study from April 2013 through May 2014. The study utilized fixed-location hydroacoustics to provide baseline data on juvenile salmonid passage at Foster Dam on the South Santiam River in Oregon. Hydroacoustic transducers were deployed at the two turbine intakes and the spillway. A screw trap in the tailrace was used to collect species composition data. The passage impacts of a fish weir that may be operated during summer months, when the reservoir is full but spill is minimal, were also examined using a block design where flow through the weir was turned on and off during turbine operation. Hydroacoustic results indicated a majority of juvenile sized fish passed Foster Dam through the turbines (78.2%), and passage rates were highest when the reservoir was at low pool during spring, fall, and winter months. While most juvenile fish passed via the turbines, seasonal passage proportions through the spill bays were as high as 38%, and proportionally more fish passed the spill bays per unit of water. The fish weir also passed proportionally high numbers of juvenile fish, particularly during the summer weir test, where 84% of the juvenile sized fish passed via the weir when both the turbines and weir were operational. Hydroacoustic data also indicated a majority of steelhead kelts (78.1%) passed via the fish weir during spring 2013 and 2014. These study results provide new data on fish passage estimates, run timing, and distributions at Foster Dam that could inform management decisions for long term operations for fish passage at the dam.

FISH PRESENCE/ABSENCE AND STREAM HABITAT IN AREAS AFFECTED BY SEDIMENT FROM MOUNT SAINT HELENS ERUPTION. **James Hughes,** Pacific Northwest National Laboratories PO Box 999, Richland, WA 99352; Fenton Khan, U.S. Army Corp of Engineers, Portland District, PO Box 2946, Portland, OR 97208; Geoff McMichael, Evan Arntzen, Chris Vernon, Eric Fischer, Ryan Harnish, Sadie Mckee, Robert Mueller, Jose Vazquez, Pacific Northwest National Laboratories PO Box 999, Richland, WA 99352; *james.hughes@pnnl.gov*

Researchers at Pacific Northwest National Laboratory (PNNL) evaluated the quality of habitat and life stage use and abundance of Endangered Species Act-listed salmonid species in two North Fork Toutle River (NFTR) tributaries for the U.S. Army Corps of Engineers-Portland District. The goal was to provide baseline data about anadromous fish habitat quality and use in NFTR tributaries and the presence of other sensitive fish species in areas influenced by sediment management related to the 1980 eruption of Mount Saint Helens—all to support decision-making for long-term sediment retention alternatives related to the Sediment Retention Structure (SRS) located on the NFTR. Currently, adult coho salmon and winter steelhead are captured at a Fish Collection Facility (FCF) below the SRS and transported upstream to and outplanted in Alder and Bear (Hoffstadt Creek drainage) creeks. To determine whether the current "trap and haul" approach has resulted in production of juvenile salmonids in the receiving streams and whether sufficient habitat quality and connectivity with the NFTR existed, PNNL collected data on spawning, rearing, and habitat availability and quality in Alder, Hoffstadt, and Bear creeks between April 2013 and July 2014. While the current practice of capturing and transporting adult salmonids appears to be successful in terms of production of juvenile offspring in the Alder and Hoffstadt drainages, uncertainty remains regarding the overwinter rearing and outmigration success of the juvenile salmonids in these systems. Additional work was conducted to determine the presence of eulachon and Pacific lamprey in the lower Cowlitz River downstream of the confluence with the Toutle River. During spring 2013, eulachon eggs and larvae were abundant in the lower Cowlitz River in early spring. In June 2013, larval lamprey were observed in the lower 9 km of the Cowlitz River.

A POPULATION GENETIC INVESTIGATION OF THE COLUMBIA SPOTTED FROG (*RANA LUTEIVENTRIS)* IN EASTERN OREGON. Marcus James, Devin Bailey, Mackenzie Graham, Jacob Johnstun, Cathryn Polehn, Dr. John E. Rinehart, Dr. Laura A. Mahrt, Eastern Oregon University, Biology Program, One University Blvd, La Grande, OR 97850; Rosie Alberts, La Grande High School, 708 K Ave La Grande, OR 97850; *mjames@eou.edu*

The Columbia Spotted Frog, *Rana luteiventris,* is a threatened species that is being considered for listing as endangered. Monitoring of molecular markers in populations can indicate gene flow and genetic health of populations. We obtained blood samples from 27 individuals in Union County, OR (End Creek and McCoy Creek) and 30 samples from Wallowa County, OR (Wallowa River). Populations were assessed for genetic diversity via PCR amplification of 4 microsatellite markers previously identified as useful in this species. Significant differences in allele number, allele sizes, and allele frequency were seen among the populations. This suggests that gene flow is reduced among these populations. AMOVA shows that 82.87 % of the variation seen is within individuals rather than within and among the populations. Nevertheless, there is a small (16.80 %) amount of variation among the groups. Novel alleles and null alleles were also discovered in the Wallowa County samples; as a result, the F_{ST} values comparing the Union County populations to the Wallowa County population revealed significant differences below the $p = 0.001$ level. Heterozygosity and mean diversity in the populations did not differ from expectation, suggesting that the populations are very diverse genetically.

ORIGIN OF ENIGMATIC ROCKS LOCATED NORTH OF THE STILLWATER COMPLEX, MONTANA. Michael Christopher Jenkins, Jennifer A. Thomson, Department of Geology, SCI 130, Eastern Washington University, Cheney, WA, 99004; Michael L. Zientek, USGS Spokane Office, 920 West Riverside Ave., Spokane, WA 99201. *jthomson@ewu.edu*

The Stillwater Complex is an Archean layered mafic-ultramafic intrusion located in southwestern Montana. The complex hosts a platinum-group element ore deposit—the J-M Reef. Recent geophysical data collected by the USGS from an area to the north of the Stillwater complex suggests that the complex continues at depth under cover. The northern exposure of Precambrian rock is not the complex but some enigmatic amphibolites. During the 2013 and 2014 field seasons, eight samples were collected from this Precambrian (?) lower-amphibolite to greenschist-facies metamorphic rock unit located approximately 2 kilometers north of the complex. Vail (1955) described the unit as an amphibolite schist composed primarily of amphibole and clinozoisite with minor amounts of quartz, calcite, chlorite, and epidote. He proposed three possible origins for the amphibolite schist: (1) metamorphosed floor rocks from below the Complex, (2) metamorphosed roof rocks from above the Complex, or (3) metamorphosed Complex rocks. Geraghty (2013) described the rock unit as a fine-grained, laminated, schistose mylonite, which may be the northern extension of the Madison mylonite zone (Erslev and Sutter, 1990). Electron microprobe analyses of coexisting amphibole (actinolite to actinolitic hornblende) and plagioclase (albite, An_{98}) were used to constrain the temperature conditions at various pressures for three samples (P at 3, 5, and 6 kb; T = 417-441°C, respectively using Holland and Blundy, 1994). These conditions are consistent with greenschist facies metamorphism. Bulk rock major, trace and rare earth element (REE) geochemistry of the samples were used to test the origin hypotheses proposed by Vail (1955). Our data were compared to existing geochemical data from floor rocks below the complex (hornfels, mafic dikes) and from rocks within the complex (cumulates). No known roof rocks that might be comparable in age to the samples and located above the complex have been identified. Rare earth element spider diagrams suggest that the samples do not appear to be cumulates, suggesting that Vail's (1955) hypothesis (3) is not valid. However, the REE patterns do resemble those of Precambrian dike rocks cutting the complex and adjacent Archean rocks. Our results provide a possible link to the origin of these enigmatic metamorphic rocks.

CALIFORNIA BEARING RATIO (CBR) OF PALOUSE SOIL NEAR THE EASTERN WASHINGTON UNIVERSITY CAMPUS, CHENEY, WA. Alexander J. Fry, **M. Christopher Jenkins**, Duc Minh Nguyen, Richard L. Orndorff, Department of Geology, Eastern Washington University, Cheney, WA 99004; *mcjenkins@eagles.ewu.edu*

Eastern Washington University, located in Cheney, Washington, had a student enrollment of 13,453 in Fall 2014. Student enrollment grew by 17% over the last five years. Continued growth will require campus expansion. Residential neighborhoods surround the campus on three sides, limiting expansion projects to the north onto Palouse soil. Infrastructure necessary to campus expansion will require the construction of additional roads and parking lots. Results indicate potential suitability of soil as a base, subbase, or subgrade beneath both flexible and rigid roadways. We present results for the California Bearing Ratio (CBR) of Palouse soil according to ASTM standard D-1883. The CBR test determines penetration resistance of compacted soil for the purposes of road building. We tested the CBR of Palouse soil at optimal compaction versus suboptimal compaction and optimal moisture content versus excessive moisture content. At optimum moisture content (~15%), the CBR for Palouse soil north of the EWU campus was 17.6% of standard indicating this Palouse soil is a good subgrade or fair subbase for road building.

OPTIMAL MOISTURE CONTENT FOR COMPACTION OF PALOUSE SOIL NEAR THE EASTERN WASHINGTON UNIVERSITY CAMPUS, CHENEY, WA. Jessica Reed, **Dallin Jensen**, Ashleigh Gertsch, **Vanessa Jordan**, Richard Orndorff, Department of Geology, Eastern Washington University, Cheney, WA 99004; *dallinpj1@gmail.com*

Eastern Washington University prides itself on providing a high quality education at a tuition cost lower than most other comparable universities. These two attributes have led to rapidly growing enrollment (from 12,130 students in 2011 to 13,453 in 2014) that necessitates infrastructure growth. EWU is bordered on three sides by residential zoning, leaving the only cost effective solution for expansion north onto agricultural land. We present results for moisture content and compaction of Palouse soil according to ASTM standard D698. Compaction prior to construction increases unit weight and shear strength for soil, hence increasing resistance to settling. For the standard proctor method, we found the maximum unit dry weight to be 108.6 lbs/ft^3 at an optimal water content of 16.6%. The acceptable moisture content range for compaction to 95% of maximum unit dry weight is 11% to 21%. For the modified proctor test, optimal dry unit weight was 115 lbs/ft^3 and optimal moisture content was 14%, with an acceptable range of moisture contents for compaction from 9% to18%.

ETHANOL IN DOUGLAS-FIR ROOTS STRESSED BY *PHELLINUS SULPHURASCENS* INFECTION: IMPLICATIONS FOR DETECTING DISEASED TREES AND BEETLE HOST SELECTION. **Rick G. Kelsey,** USDA Forest Service, Pacific Northwest Research Station, 3200 Jefferson Way, Corvallis, OR 97331; Gladwin Joseph, Azim Premji University, Bangalore, India; Doug Westlind, Walter G. Thies, USDA Forest Service, Pacific Northwest Research Station, 3200 Jefferson Way, Corvallis, OR 97331; *rkelsey@fs.fed.us*

Phellinus sulphurascens (syn. *P. weirii*) is an important native pathogen causing laminated root rot in forests of western North America. Visual crown symptoms, or attacks by bark or ambrosia beetles appear only during advanced stages of the disease. Ethanol synthesis is one of many physiological responses tree tissues may express when stressed by pathogens. Headspace gas chromatography was used to analyze ethanol and other volatiles from root tissues of healthy and *P. sulphurascens* infected *Pseudotsuga menziesii*, Douglas-fir. Xylem and phloem from 20 diseased trees at two western Oregon sites contained higher ethanol concentrations than 20 healthy trees when sampled in September, November, and May. Tissues sampled along perpendicular transects in root cross-sections from eight diseased trees contained extremely variable ethanol concentrations, with highest quantities in a 0-2 cm zone outside the xylem infection boundary and lowest amounts inside the infection. A logistic regression model was built by backward stepwise elimination resulting in xylem ethanol concentration as the only significant parameter. It was validated using root ethanol concentrations from 80 trees growing adjacent to *P. sulphurascens* infection centers at two sites geographically separated from those used to build the model. This model successfully predicted trees with laminated root rot, but worked best for those with infections observed in roots and the root collar (100% correct). It was least effective at identifying trees with infection observed only at the root collar. Ethanol analysis for identifying individual hazard trees infected with *P. sulphurascens* would provide limited benefits beyond visual observations of decay or stain in increment cores from roots and the root collar. Its use in a general ground survey is not currently feasible, but it might be if future advances in sensor technology allow tree side detection with minimal tissue sampling. We propose that beetles do not attack until after *P. sulphurascens* infections in the lower bole or exposed roots advance to a point where ethanol is released from stressed tissue to the atmosphere in sufficient quantities to function as a primary attractant and initiate attacks.

THE SPREAD OF EXOTIC PLANT SPECIES AT MOUNT ST. HELENS: THE ROLES OF A ROAD, DISTURBANCE TYPE AND POST-DISTURBANCE MANAGEMENT. Lindsey Karr, Jeffrey Gerwing, Portland State University, Environmental Science and Management, P.O. Box 751, Portland, OR 97207; Charlie Crisafulli, USDA Forest Service, Pacific Northwest Research Station, 42218 Northeast Yale Bridge Road, Amboy, WA 98601; *lindsey@spu.edu*

Mount St. Helens and the surrounding landscape was dramatically transformed during the May 18, 1980 eruption, creating large expanses of denuded land that could be susceptible to invasion by exotic plants. Varied landscape management objectives could strongly influence successional patterns, including the role of invasive exotic species. We studied U.S. Forest Service lands designated as National Volcanic Monument to allow natural succession to proceed substantially unimpeded (passively managed) and areas outside the Monument, where salvage logging and tree planting occurred (actively managed). Our study focused on spatial patterns of exotic plant species richness and abundance along a road that traverses different management prescriptions and a volcanic disturbance gradient consisting of tephra fall and lateral blast (forest blow-down), and along a pedestrian trail in the roadless Pyroclastic flow zone. Plant communities were sampled along 20 replicate transects (70m) in each of five disturbance/management/succession areas. Linear regression was used to determine whether the road influenced exotic plant richness and abundance. In the late-seral forest, disturbed only by tephra fall (~20cm), seven exotic plant species were mostly restricted to within five meters of the road with mean covers of 2.6%, 1.5%, and 0.3% at 0m, 2m, and 5m, respectively. Within the blowdown zone, we documented 15 exotic species in the passively managed shrub-dominated area, and 13 in the actively managed salvaged logged and replanted area. Exotic plants in the actively managed and passively managed shrub-dominated areas significantly decreased moving away from the road (linear regression slopes of -0.056 and -0.045). In contrast, 15 exotic species were uniformly distributed along the 70m transects in the passively managed forb-dominated areas. In the Pyroclastic flow zone, where primary succession is occurring, total plant cover was low (10.9%), of which 2.7% was exotic plant cover, from only two species, *Hypochaeris radicata* and *Rumex acetosella*. Our research demonstrates an overall low abundance of exotic plants along the primary road traversing the Monument, that exotic plant species are more prevalent in close proximity to roadsides, and that natural forest and shrubs appear to slow their spread to the interior landscape.

THE EFFECT OF LAND USE AND LAND MANAGEMENT ON CARBON SEQUESTRATION AT CABIN CREEK RANCH IN SHEPHERD, MONTANA. Hailey Kisch, Clayton Marlow, Animal and Range Sciences, Montana State University, Bozeman, MT 59717;
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Carbon capture and storage is a method of mitigating carbon dioxide (CO_2) in the atmosphere to protect economic, human health and natural resource needs. The two main ways of capturing and storing carbon are using terrestrial or geological units. Using terrestrial carbon capture and storage processes, land managers can implement approaches to help mitigate rising CO_2 levels by enhancing naturally occurring ecosystem processes that would sequester CO_2. Soils can hold twice as much carbon as the atmosphere and 2.5 times as much as plants. Therefore, management practices that increase biomass production and limit the amount of soil disturbance could increase carbon capture and storage on target landscapes. To quantify the storage potential of carbon in soils and vegetation in semi-arid rangelands of central Montana, we investigated the distribution of carbon to a common depth of 45cm in native and introduced plant communities on seasonally grazed livestock ranges. Soil organic carbon (OC) consistently fell within the reported literature for different general vegetation classes (i.e. forest, grasslands, cropping systems). Cropland, forest and grassland sites averaged 3.6kg OC/m^2, 22.1kg OC/m^2, and 3.6kg OC/m^2, respectively. Even though vegetation communities appeared to cluster by perennial riparian, ephemeral riparian, degraded grasslands, forest and shrub classes there was no significant difference in terms of soil organic carbon ($P = 0.113$). However, the effect of depth on soil organic carbon was statistically significant ($p=0.00063$). At this point in time, vegetative cover management is needed to keep the soil intact.

LONG-TERM BEE MONITORING AT A PRIVATE CONSERVATION RANCH IN WEST-CENTRAL MONTANA. Marirose Kuhlman, Skyler Burrows, MPG Operations, LLC, 1001 S Higgins Ave Ste. A3, Missoula, MT 59801; *mkuhlman@mpgranch.com*

Restoration projects aim to return diverse plant communities and ecosystem function to disturbed landscapes. Bees play a critical role in this effort to increase biodiversity because they are the main pollinating taxon. In 2013, we initiated a long-term bee monitoring program at MPG Ranch in the Bitterroot Valley of Montana, south of Missoula. An objective of this project is to monitor how bee communities respond to habitat restoration treatments, which are large-scale, intensive, and ongoing at MPG Ranch. In 2013 and 2014, we bowl-trapped and netted bees at 24 sites on MPG Ranch, in several habitat types and along an elevation gradient. To date, we have sampled over 32,000 bees comprising 5 families, 37 genera, and 217 species. 93 species identified from our collections are new Montana records, most likely a reflection of the paucity of bee collecting in the state. Our sampling efforts have also revealed the widespread presence of a non-native, invasive leaf-cutter bee species, a declining bumble bee species, a rare gynandromorph bee, and a native bee genus that appears to track disturbance.

FISH PASSAGE AND REINTRODUCTION INTO THE UPPER COLUMBIA RIVER. Keith Kutchins, Stephen Smith, Upper Columbia United Tribes, 25 West Main Avenue, Suite 434, Spokane, WA, 99201; *keith@ucut-nsn.org*

On behalf of the region, Upper Columbia United Tribes (UCUT) is initiating Phase 1 of the "Upper Columbia River Basin Fish Passage and Reintroduction Project" to investigate reintroduction of anadromous fish above Chief Joseph and Grand Coulee dams pursuant to the 2014 Northwest Power and Conservation Council Columbia River Basin Fish and Wildlife Program. Given the magnitude and complexity of the project, UCUT has proposed a multi-tiered, regional coordination and communication framework along with a scientifically-based phased work plan that will be described. Native peoples' culture, nutrition, and spiritual existence have lacked salmon in areas upriver from Chief Joseph and Grand Coulee dams for over 70 years. Reintroduction of salmon is an important component of ecosystem-based function and adaptation to climate change. Technical, legal, social, economic, and political mechanisms now exist to achieve reintroduction into previously blocked habitats in these areas of the upper Columbia River. Additionally, U.S. Tribes and Canadian First Nations have issued a joint paper that describes a more comprehensive fish reintroduction plan involving the two U.S. dams and four dams in Canada that if implemented, could provide salmon access to thousands of miles of historical habitat.

WORKING HYPOTHESES FROM FIVE YEARS OF STUDY AT THE COYOTE CANYON MAMMOTH SITE. **George V. Last**, Pacific Northwest National Laboratory, P. O. Box 999 MSN P7-54, Richland, WA 99354; Bax R. Barton, Burke Museum of Natural History and Culture and Quaternary Research Center**,** University of Washington, P.O. Box 351360, Seattle, WA 98195-1360; Gary C. Kleinknecht, 3024 Brian Lane, Kennewick, WA 99338; *george.last@pnnl.gov*

The Coyote Canyon Mammoth Site is located on private land approximately 4 km south of Kennewick, Washington. A non-profit 501(c)(3) organization, Mid-Columbia Basin Old Natural Education Sciences (MCBONES), was created to engage students and teachers in detailed paleoecologic research at the site. Formal excavation and scientific study have been ongoing since the Fall of 2010. Seventy-three mammoth size bones and bone fragments have been recovered from the site, with several others (including a scapula, two humeri, and several ribs) still in place. These skeletal elements are located in fine-grained Late Pleistocene Ice Age flood deposits at an elevation of about 320 m in a distal canyon of former Lake Lewis. Numerous individual studies have yielded working hypotheses of the paleontological, geologic, and paleoecologic history of the site. Results suggest that the site was impacted by several Ice Age floods, and that the mammoth was killed by one of these floods dated at 17.5 ka with its carcass coming to rest alongside erratic (rock) debris on the shoreline of Lake Lewis, some 215 m above the present day Columbia River. Taphonomic studies indicate that the mammoth's carcass was temporarily exposed on the ground surface, where it decomposed, its bones scavenged by rodents and rabbits, and partially weathered. Subsequent Ice Age flood deposits repeatedly buried the skeletal remains, with at least four graded-bed sequences interpreted to interfinger and overlie the bone bed. The site was then exposed to a period of subaerial exposure and soil development, leaving behind an overprint of pedogenic calcite. Eolian activity later blanketed the site with about a meter of loess (L1 loess), and finally localized flash flooding cut into the loess deposits and left behind deposits of colluvial slopewash. Preliminary stable isotope analyses (i.e. $\delta^{18}O$) of sediment samples appear to correlate with the Marine Isotope Stages 1 and 2 interpreted at Carp Lake, Washington, suggesting that the climate during loess deposition was warmer and dryer than present, but was similar to today during slopewash deposition.

CLIMATE STRONGLY CONTROLS BROMUS TECTORUM DOMINANCE IN UNBURNED SAGEBRUSH STEPPE. **Matt Lavin**, Montana State University, Plant Sciences and Plant Pathology Department, Bozeman, MT 59717; Kimberley Taylor, Tyler Brummer, Bruce D. Maxwell, Lisa J. Rew, Montana State University, Land Resources and Environmental Sciences Department, Bozeman, MT 59717; Jay Rotella, Montana State University, Ecology Department, Bozeman, MT 59717; *mlavin@montana.edu*

Recent evidence implicates climate as important in mediating *Bromus tectorum* dominance and impact. We tested this hypothesis with a large-scale biogeographic survey of the western North American sagebrush steppe. We observed the presence of dense and extensive stands of *B. tectorum* among unburned sagebrush at 325 sites arranged along 21 megatransects. These megatransects encompassed the climatic spectrum of the sagebrush steppe from Montana and southern Idaho south to northern Arizona and New Mexico. Our results suggest that hot dry summers (i.e., July precipitation < 11 mm and August maximum temperatures > 30 C) and relatively warm, wet winters were most explanatory of the presence of dense and extensive stands of *B. tectorum* in unburned sagebrush steppe. These conditions that minimize plant productivity during midsummer and promote it during winter prevail in the sagebrush steppe mainly in the Lahontan Basin, the Columbia Plateau, the lower Snake River plains, and west central Utah. In other climatic regions, including mountain big sagebrush steppe and Wyoming big sagebrush steppe along the eastern tier of the sagebrush biome, *B. tectorum* does not form dense and extensive stands and is limited to roadsides, south-facing slopes, stream banks, and locally disturbed patches. Although predicted climate change may double the spatial extent of where *B. tectorum* can ultimately cause regime shifts in sagebrush steppe, management of *B. tectorum* where climate naturally limits its dominance should be avoided because the disturbance involved may reduce the pre-fire integrity or impede post-fire recovery of sagebrush steppe vegetation.

ARSENIC CONTENT OF THE LATAH FORMATION AND ITS POTENTIAL FOR GROUNDWATER CONTAMINATION. Ian Leavy, Pacific Northwest National Laboratory, PO Box 999, Richland, WA 99352; Carmen A. Nezat, Eastern Washington University, Department of Geology, 130 Science Building, Cheney, WA 99004 ; *Ian.Leavy@pnnl.gov*

Isolated cases of arsenic contamination in private wells have been reported in and around the Spokane area. Arsenic is highly toxic to humans and animals, and elevated levels in drinking water can lead to a wide array of health problems including internal cancers, cardiovascular disease, and respiratory problems. One possible source of this contamination is the Latah Formation, which consists of Miocene sedimentary interbeds within the Columbia River Basalt Group. The purpose of this study was to investigate local rocks as a potential source of arsenic to drinking water. Samples of granite, basalt and Latah Formation were collected from several outcrops over the greater Spokane area; basalt and Latah Formation interbeds were also collected from a Cheney Municipal Water Well drill core. Powered samples were leached in 10 mL of 1M nitric acid on a shaker table for 24 hours. The supernatant was filtered through a 0.45 µm polypropylene filter and analyzed using an Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES). We found that Latah Formation samples had an average arsenic concentration of 1.2 ug/g (n = 28) while the average arsenic concentrations of local granite and basalt formations were much lower (0.09, n = 8; and 0.31 ug/g, n = 8, respectively). The arsenic concentrations in Latah Formation samples varied widely among different localities (0.07 – 4.9 ug/g) and demonstrate great lateral variation of arsenic within and among different interbeds. These data suggest that particular beds in the Latah Formation have the potential to contaminate local private well as compared with that of typical basalt and granitoid rocks.

SPATIAL PATTERNS OF ROCK GLACIERS IN THE EASTERN CASCADES, WASHINGTON: A PRELIMINARY ASSESSMENT. **Karl Lillquist**, Mark Weidenaar, Central Washington University, Geography Department, 400 East University Way, Ellensburg, WA 98926; *lillquis@cwu.edu*

Rock glaciers are elongate to broad deposits of rock and ice that show evidence of movement away from steep slopes in mountainous terrain. They were traditionally considered key geomorphic and climate indicators of more continental mountain ranges, where snowfall and winter temperatures are lower than their marine counterparts. Little attention was previously given to rock glaciers in the marine-influenced Cascade Range of Washington state. We: 1) identified the spatial distribution of Eastern Cascades rock glaciers; 2) classified their morphologies, origins, and activity levels; and 3) used these data and other sources to better understand the causes of their spatial distributions. Using Google Earth Pro, we identified 348 rock glaciers, most (89%) of which were in the higher and wider, northern portion of the range. This pattern, combined with the median distance of 22 km east of the Cascade Crest, suggests that continental conditions favor Eastern Cascade rock glacier development. The median rock glacier aspect of 93 degrees limits insolation resulting in cold microclimates conducive to permafrost development and preservation. Reflecting the geology of the Cascades, rock glaciers form in a variety of rock types with most composed of blocky intrusive igneous and crystalline metamorphic rocks. Nearly 93% of rock glaciers occur within cirques. Lobate rock glaciers are most common on cirque sidewalls while tongue-shaped features are more frequent on headwalls. The remainder occur as tongue-shaped features on rotational slide scarps south of Stevens Pass in non-glaciated terrain. Despite the frequent cirque origins, most (93%) originate in talus rather than glacial till at the bases of cirque headwalls. Most (86%) are either active or inactive indicating that they still contain permafrost. Only 14% are relict (i.e., permafrost-free) features. These relationships suggest that the majority of Eastern Cascades rock glaciers formed after late Pleistocene glacial recession but that late Holocene climate change has rendered them inactive. This research is an important step toward better understanding post-Pleistocene climates and permafrost distribution in Washington=s Cascade Range. It also demonstrates that rock glaciers are a much more significant component of Cascade geomorphology than previously thought.

USCS CLASSIFICATION OF PALOUSE SOIL NEAR THE EASTERN WASHINGTON UNIVERSITY CAMPUS, CHENEY, WA. Brea D. Lund, Shyla A. Hatch, Pedro Severino, Tatiany Santos, Richard L. Orndorff, Department of Geology, Eastern Washington University, Cheney, WA 99004; *brea.lund@eagles.ewu.edu*

Eastern Washington University (EWU) is located in Cheney Washington, a park-like campus that is 300 acres in size. Currently there are more than 13,000 students that attend EWU and enrollment is increasing rapidly. Increased enrollment has led to tight quarters and a need for expansion. EWU borders residential areas on three sides of campus, so expanding northward onto Palouse soil is the only option. Geotechnical analysis of this soil is necessary prior to construction. We present results for the Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI) of Palouse soil according to ASTM standard D1883. Liquid and Plastic Limits define the moisture contents over which a particular fine-grained soil potentially shrinks, swells, and flows. High PI soils can result in damage or even complete failure of overlying structures. We additionally present results for particle size distribution according to ASTM D422 and use those results to classify Palouse soil using the Uniform Soil Classification System (USCS). The LL for Palouse soil is 32, the PL is 23, and the PI is 9. The particle size distribution for Palouse soil is 0% gravel, 78% sand, and 22% fines and the USCS classification is Sandy Silt (SM). The coefficient of uniformity (C_u) is 13.3 and coefficient of curvature (C_c) is 3.3.

INVESTIGATION OF NITRATE HOTSPOTS IN SPOKANE COUNTY. Justin Luppens, Department of Geology, Eastern Washington University, Cheney, WA 99004; Chad Pritchard, Eastern Washington University, Department of Geology 130 Science Building Cheney, WA 99004; *jluppens@ewu.edu*

Using water well reports and the Spokane Regional Health District water quality data, possible hotspots of increased nitrates have been identified in the West Plains of Spokane County. Studying possible hotspots of increased nitrates is important for public health as increased levels of nitrates (over 10 mg/L per EPA drinking water standards) have been linked with severe health problems for children such as methemoglobinemia (blue baby syndrome) and is generally associated with contamination by fecal material or inorganic fertilizer. As part of this project and as an internship with the Spokane County, a revised and expanded database of water well logs is used to interpret the geology and hydrology of the area. Use of the constructed database and cross sections are used to determine the location of high nitrates and conduct cluster analysis to very statistical and hydrogeologic relevance. Aerial photography, previous land use records, and local stratigraphy are then used to determine possible sources for nitrate contamination.

SUGGESTIONS FOR SUMMARIZING HERITAGE VEGETATION RECORDS. Clayton B. Marlow, Neto Garcia, Animal and Range Sciences Department, Montana State University, Bozeman, MT 59717-2900; *cmarlow@montana.edu*

Evaluation of ecosystem sustainability is commonly based on the comparison of certain system measures over extended time periods. This trend analysis coupled with land use and climatological records provides a gauge of ecological sustainability and can be a platform for predicting future ecosystem trajectories. However, this outcome can only be realized if information about plant community composition, stream discharge, sea level changes, etc. is recorded at the same point and in the same season. Further challenges arise when vegetation species are not correctly identified during each collection period. Inaccurate plant identification can create the appearance of change when, in fact, permanent change has not occurred. Basically, plant identification errors amplify natural variation making it virtually impossible to draw any inferences about the degree and direction of change over time because individual species values have become "too noisy" to draw any statistical inferences. We found that we could dampen some of the variation among technicians by grouping species according to their successional status, e.g. early, mid, late seral, climax. This grouping facilitated statistical comparison of 60 year old records of grassland community composition in Gallatin NF (GNF) wildlife exclosures and range monitoring sites on the US Fish and Wildlife Service National Bison Range (NBR). Analysis of long term records for individual climax species, *Festuca campestris, Festuca idahoensis, Pseudoroegneria spicata,* revealed no statistical differences ($P > 0.10$) over the 60 year period at either location. When frequency measures from the NBR were pooled for all three species significant differences ($P < 0.10$) over time were noted. However, pooling climax frequency measures for the GNF wildlife exclosures failed to produce a similar outcome. This probably occurred because of a difference in the number of monitoring sites, 10 at NBR vs 4 on the GNF. While pooling species may compensate for identification errors it is obvious that a low number of monitoring sites confounds advantages gained from assigning individual species to their respective success-ional class. Care must be exercised when sorting historic vegetation records because misidentification of some species within the same genera will mute advantages gained from pooling by successional stage.

RESPONSE OF THE NITROGEN-FIXING LICHEN *LOBARIA PULMONARIA* TO PHOSPHORUS AND MICRONUTRIENTS. Jade A. Marks, Julie C. Pett-Ridge, Dept. Crop & Soil Science, Oregon State University, Corvallis, OR 97331; Steven S. Perakis, US Geological Survey, Forest and Range Ecosystem Science Center, 3200 SW Jefferson Way, Corvallis, OR; Jessica L. Allen, Institute of Systematic Botany, New York Botanical Garden, Bronx, NY 10458; **Bruce McCune**, Department of Botany and Plant Pathology, 2082 Cordley Hall, Oregon State University, Corvallis, OR 97331;
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Nitrogen-fixing lichens (cyanolichens) are an important source of nitrogen (N) in Pacific Northwest forests, but we do not understand how elements essential for nitrogen fixation limit lichen growth. To investigate how nutrient limitation may affect cyanolichen growth rates, we fertilized a tripartite cyanobacterial lichen (*Lobaria pulmonaria*) and a green algal lichen (*Usnea longissima*) with the micronutrients molybdenum (Mo) and vanadium (V), both cofactors for enzymes involved in N fixation, with and without the macronutrient phosphorus (P). We then grew treated lichens on wooden racks in the field for one year in the Oregon Coast Range. At this site, both species grew rapidly and without differences among treatments, despite a previous demonstration of P-limitation in *L. pulmonaria* at a nearby location. The fast growth and lack of treatment effect observed in the current study cannot be explained by differences in N deposition or thallus N concentrations. Instead, we infer that local differences in P availability may have caused site-specific responses of *Lobaria* to P fertilization. We conclude that P, Mo, and V did not limit the growth of either cyanolichens or chlorolichens at the site of the current experiment. Analyses of P concentrations in lichens from both experiments provided a basis for reconciling the results from the two experiments. In the previous experiment, naturally occurring *Lobaria* and controls had low levels of P, and treatment with P more than doubled growth. In contrast, controls and naturally occurring *Lobaria* from the current experiment had P concentrations similar to the strongest treatment from the previous experiment. Our findings suggest a need to understand landscape-scale variation in P availability, and its effect on spatial patterns of cyanolichen nutrient limitation and nitrogen fixation.

AUTOMATED CLASSIFICATION OF FISH EPITHELIAL DAMAGE FROM FLUORESCENT IMAGES. Sadie A. Mckee, Pacific Northwest National Laboratory, 902 Battelle Blvd., Richland, WA 99354;
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Fluorescent dyes are widely used to reveal damaged epithelial regions on fishes. Manual measurement of these fluorescent regions is often the method of choice but this approach can be tedious and can yield inconsistent results. We developed an automatic image processing and measuring technique to rapidly quantify the proportion of damaged area in adult salmon. Ten fish from four different experimental exposure groups were dyed in fluorescein and placed under ultraviolet lights to photographically capture damage regions to the outer mucus membrane that binds to fluorescein dye. With both sides of the fish analyzed, a total of 80 images were processed and quantified using a Python script running on a standard desktop computer. Images of fish with more pronounced damage regions were classified using Otsu's method of thresholding due to the bimodal pixel distribution. Images of fish having little to no damage were not bimodal and therefore were classified using the median Otsu threshold calculated from the entire image set. Once damaged regions were classified, proportion of damage was calculated and compared across the different treatments. This technique of automatic image processing and quantification was more time efficient and produced more consistent results than manual analysis.

EVIDENCE FOR THE FLOOD ORIGINS OF THE SPOKANE VALLEY – RATHDRUM PRAIRIE AQUIFER. **Stan Miller**, Inland Northwest Water Resources, 1329 S. Ferris Court, Spokane, WA, 99202; *samillerh2o@comcast.net*

Though all of the maps of the major flood paths show the Spokane River Valley to be ground zero for the floods pouring out of Glacial Lake Missoula, we rarely think of the Spokane Valley – Rathdrum Prairie (SVRP) Aquifer as a feature of the Spokane/Lake Missoula Floods.

In this presentation we will examine several features in the Spokane River Valley that demonstrate the flood origins of the SVRP Aquifer. Recent studies of the sub-surface deposits of the valley give us a subtle look at the tremendous power of the early, valley forming events. There are a host of surface features that, though often modified by human activity stand in testimony to the floods: Several varieties of gravel bars are evident; flood sculpted outcrops scatter the landscape; exposure of the subsurface in gravel mining operations provide a look at the nature of flood deposition; and the very nature of the material deposited on the landscape is a clear reminder of the valley's flood origin. There is even a mini-plunge pool.

This quick tour of the region will point out many of the features described above. Once the viewer has developed an eye for flood features the valley will take on a new look as these features seem to pop up everywhere.

190 YEARS LATER: THE REDISCOVERY OF *POLYPYRENULA ALBISSIMA* AN ENIGMATIC FUNGUS PREVIOUSLY BELIEVED TO BE EXTINCT. **Ricardo Miranda-González**, Department of Botany and Plant Pathology, Oregon State University, 2082 Cordley Hall, Corvallis, OR. 97331-2902; André Aptroot, ABL Herbarium, G.v.d.Veenstraat 107, NL-3762 XK Soest, The Netherlands; Robert Lücking, Science and Education, The Field Museum, 1400 South Lake Shore Drive, Chicago, IL 60605-2496; María de los Angeles Herrera-Campos, Departamento de Botánica, Instituto de Biología, Universidad Nacional Autónoma de México. Apdo. Postal 70-327, C. P. 04510, D. F. México; Bruce McCune, Andy Jones, Department of Botany and Plant Pathology, Oregon State University, 2082 Cordley Hall, Corvallis, OR. 97331-290.; *mirandar_g@yahoo.com.mx*

The fungus *Polypyrenula albissima* (Fée) Aptroot was discovered in the West Indies in 1825, consisting of only two small samples in a poor state of conservation. Even though the species was never found again it still intrigues mycologists around the world and has no less than 6 synonyms. The main peculiarity of *P. albissima* is that its spores present two types of septa (eusepta and distosepta), a characteristic that is commonly diagnostic to family or genus level. The species is currently included in the order Pyrenulales of the class Eurotiomycetes and it is doubtfully lichenized. In the course of our studies of lichens of tropical dry forests we found seven new collections of *P. albissima* at three different localities in the Pacific coast of Mexico. This fascinating rediscovery showed that the species was not extinct and provided enough material to study its morphology and its phylogenetic position. DNA was successfully extracted from three samples collected five years ago using the Sigma-Aldrich REDExtract-N-Amp Plant PCR Kit (St. Louis, Missouri, U.S.A.), the whole ITS region was amplified with the primers ITS1F and ITS4 and the product was cleaned with ExoSAP-IT® for PCR product cleanup (Affymetrix, Santa Clara, CA, USA). Anatomical studies were made with the common techniques used in lichenology. Our study provided evidence for the first time that this species is lichenized with trentepohlioid algae. We also found that its hamathecium structure is anastomosed; this character, together with our preliminary analysis of the ITS region, suggest that the phylogenetic position of *P. albissima* is in the class Dothideomycetes and not in Eurotiomycetes as previously believed. We are currently extending our study to include two other genes in an effort to clarify in more detail its phylogenetic position.

SONGBIRD DIVERSITY OF SAGE-STEPPE HABITAT IN EASTERN WASHINGTON: PRELIMINARY RESULTS FROM A COMMUNITY-SCIENCE RESEARCH PROGRAM. Lori Wollerman Nelson, Lower Columbia Basin Audubon Society, PO Box 1900, Richland, WA 99352; Christi Norman, Audubon Washington, 5902 S Lake Washington Blvd S, Seattle, WA 98818; Matthew Vander Haegen, Washington Department of Fish and Wildlife, Wildlife Program, Science Division, 600 Capitol Way North, Olympia, WA 98501; *wollerman.nelson@gmail.com*

In 2014, we launched a pilot program in which non-scientist volunteers surveyed sage-steppe habitat for songbird diversity. Using 14 sites in Benton and Franklin Counties in Washington State, we focused especially on the abundance of five species: three sagebrush-obligate species (Brewer's sparrow, Sagebrush sparrow, and Sage thrasher) and two grassland species (Vesper's and Grasshopper sparrows). Volunteers were trained in classroom and field environments before the surveys began. Volunteers conducted surveys in three time periods (mid-April, early May, and early June) to coincide with the breeding periods of the target species. Each site was visited several times during each time period. Working in groups of 2-5, volunteers counted all birds seen or heard over a 3 min period at a pre-determined sampling location (stationary counts). Environmental variables, including sagebrush cover and windspeed, were also recorded. Groups counted all birds seen or heard during the walk to and from the sampling location (traveling to/from counts). Each group entered their data into pre-established ebird hotspots (ebird.org) after completing their survey. Volunteers reported a total of 74 species across all sites; the most commonly encountered species was the Western meadowlark (119 observations). The most diverse site had 24 species, the least diverse had 4 species. We observed at least one of the target species at 11/14 sites. This program is expanding to seven Audubon chapters in Eastern Washington in 2015. Goals of the program include establishing current distribution of key sagebrush and grassland passerines in Eastern Washington and raising awareness of sagebrush songbird conservation.

NATURALLY-OCCURRING ARSENIC CONTAMINATION IN RICE PRODUCTS IN NORTHERN VIETNAM. Duc M. Nguyen, Carmen A. Nezat, Department of Geology,130 Science Building, Eastern Washington University, Cheney, WA 99004; *duc_nguyen2192@eagles.ewu.edu*

Vietnam is one of many countries that suffer from naturally-occurring arsenic contamination in groundwater (Ellingson, 2014). The abnormally high concentration of arsenic in ground-water has been well documented in the recent years (Ellingson, 2014; Pehlivan, 2013). However, most of the previous studies have not addressed the detrimental impacts of arsenic in rice grain on the public health. This is not only a domestic problem for the Vietnamese people, but it is also becoming an international concern: aside from being one of the highest rice intake countries in the world (170 kg/capita/year compared to the world average of 58 kg/capita/year), Vietnam is also the second largest exporter of rice worldwide. The aim of this research is therefore to determine the arsenic concentration in Vietnamese rice, and to evaluate its potential effects on human health. About ten rice samples were collected on the Red River delta in northern Vietnam; some of the samples were obtained directly from the paddy fields along the river. Our results show that Vietnamese rice products contain an average of 32 µg of arsenic per serving, approximately seven times more than that of rice commonly purchased in USA. Based on this, the average Vietnamese person would consume 330 µg of arsenic per day which is double the tolerable intake level according to the World Health Organization.

A METHODOLOGICAL APPROACH TO DETERMINE FLOWER BUD VULNERABILITY TO LOW TEMPERATURE DURING EARLY SPRING. Andres J Peña, Melba R Salazar G, Gerrit Hoogenboom, AgWeatherNet Program, Washington State University – Prosser, 24106 N. Bunn Rd., Prosser, WA 99350; *andres.penaquinones@wsu.edu*

The uncertainty and lack of knowledge about low air temperature that has the potential to cause injury (lethal temperature) is a common issue for growers during late winter and early spring. However, accurate information is needed with respect to the decision to turn on frost control systems and when to turn them on. Growers use exposure criteria as part of the decision-making process that considers lethal temperature as the vulnerability index and actual and future air temperature as the threat. The effect of air temperature on the loss of cold hardiness (increases in lethal temperature values) and floral bud development was studied in controlled environment chambers to determine flower bud vulnerability for three cultivars of sweet cherries and two cultivars of apples. Branches containing dormant floral buds were placed in three growth chambers that represented low-, medium-, and high-temperature spring days. Then, samples were submitted to different low temperatures by using a temperature test chamber where frost events were simulated. After cold exposure, dissections of flower buds were done in order to determine the lethal temperature (temperatures causing 10 percent of injury). We found flower bud development differences among different temperature exposures in the chambers and differences in the loss of cold hardiness. Thermal time expressed in degree-days could explain changes in floral bud development and vulnerability to frost injury. According to the results, warm spring days not only increase flower bud development (as several authors have reported in the last 30 years) but also increase the flower bud's cold vulnerability. It is a good reason to be concerned about warm winters and springs under climate change and climate variability scenarios. The next step in the research is to determine base temperatures for thermal time calculation and refine the methodology to find a starting date for thermal accumulation in field conditions.

EFFECTS OF LIGHT AND STAND HISTORY ON BEARGRASS MORPHOLOGY AND POPULATION DEMOGRAPHY. David H. Peter, Timothy B. Harrington, US Forest Service, Olympia Forestry Sciences Laboratory, 3625 93rd Ave., Olympia, WA, 98512; *dpeter@fs.fed.us*

Beargrass (*Xerophyllum tenax* (Pursh) Nutt.) is a common herbaceous evergreen perennial of certain forested and non-forested plant communities in higher elevations of the northern Rocky, Sierra Nevada, Klammath, Siskiou, Cascade and Olympic Mountains as well as lower elevations in coastal Washington, Oregon and northern California. It provides limited browse for mammals including deer, elk and bear, as well as pollen for insects. It has long been used for Native American basketry and has recently become an important floral green. However, its ecology and the specific conditions needed for successful reproduction and commercially valuable characteristics are not well known. This lack of knowledge makes informed management difficult. We modelled the role of photosynthetically active radiation (PAR) in determining beargrass reproductive success, flower stalk production, plant size, biomass, leaf size and leaf color using linear regression and graphical techniques for a lowland population of the southwestern Olympic Peninsula. We examined the crown size distribution of the population in relation to current and past overstory structure. Beargrass reproduced primarily in areas receiving greater than 30% of full PAR, yet most of the population was heavily shaded. Our data suggest that beargrass abundance matched the locations of former anthropogenically maintained, woodland openings. These openings have since forested over preventing further beargrass reproduction although the beargrass plants persisted. This implies that beargrass is vegetatively but not reproductively shade tolerant and that many plants have survived in the shade for more than 60 years. Shaded plants (those with $\leq$30% PAR or $\geq$50% tree cover) did not reproduce, but all measures of flowering and regeneration increased with light, and overstory removal stimulated reproduction. Larger plants and plants with denser foliage produced more vegetative shoots and flowers than smaller plants. We found a slight tendency towards longer, narrower leaves in shaded plants. Leaves were greener in the shade and yellower in the sun. Leaf blade density and overall crown density decreased with shade. We conclude that although beargrass is vegetatively shade tolerant, over the long term a sustainable population requires open stand conditions. However, commercially valuable characteristics require partial shade.

WATER QUALITY AND ALGAE DYNAMICS IN TEN MOUNTAIN LAKES ALONG THE MOUNTAIN LOOP HIGHWAY, WASHINGTON. **Katy Pfannenstein**, Robin Matthews, Institute for Watershed Studies, Huxley College of the Environment, Western Washington University, 516 High Street, Bellingham, WA 98225; *pfannek@students.wwu.edu*

Algae are well adapted to the environments in which they live, but are very sensitive to environmental changes, such as increased nutrient loading and chemical stressors. As global temperatures increase and seasonal precipitation fluctuates, algae should be good indicators of climate change, especially in mountain environments. For this study, ten mountain lakes were sampled along the Mountain Loop Highway in Washington for algae diversity and abundance, water quality parameters and watershed characteristics. The lakes chosen for this study were based on historical sampling data, geographical proximity and accessibility. Three sample locations were chosen at each lake and each lake was sampled in July and August 2014. Temperature and dissolved oxygen were measured in the field and conductivity, turbidity, pH, and silica were measured in the lab within 24 hours. Chlorophyll, alkalinity, total nitrogen, nitrate+nitrite, total phosphorous, and soluble reactive phosphorous were analyzed in the lab within 28 days. Total and dissolved organic carbon, sodium, magnesium, aluminum, potassium, calcium, manganese, iron, nickel, copper, zinc, arsenic, antimony and barium, as well as chloride and sulfate were analyzed in the lab within five months of collection. Initial water quality assessment grouped lakes based on high/low organic carbon content, Carson's Trophic State Index category and a possible bedrock influence. Hierarchical, kmeans, and nonmetric clustering of the water quality data revealed that the spatial and temporal variation had little effect on within lake similarity, to the extent that each lake formed a unique cluster separated from the other lakes. In addition, clustering revealed groups containing multiple lakes appeared to be related to the underlying bedrock. The ten lakes contained an incredible diversity of algal species, with over 400 species and varieties of algae, many of which are cold water specialists that are not tolerant of increasing global temperatures. Over 100 species of diatoms were found throughout all ten lakes. A rare collection of nearly 100 species of desmids were found in the boggy lakes and in total accounted for almost twice the biovolume as diatoms. Both diatoms and desmids are good indicators of water quality and could be used as bioindicators for the changing climate.

HOLOCENE FIRE HISTORY OF GREEN LAKE, EASTERN CASCADES, WASHINGTON, DETERMINED USING HIGH-RESOLUTION MACROSCOPIC CHARCOAL ANALYSIS. **Dusty Pilkington**, Megan Walsh, Central Washington University, Resource Management, 400 University Way Rm. 308, Ellensburg, WA, 98926; *pilkingtod@cwu.edu*

Wildfires are common in the dry ponderosa pine forests of the eastern Cascades, and play a vital role in maintaining ecosystem health. However, fire activity in the region has generally been suppressed during the past approximately 100 years. As a result, forests in this region have recently begun to experience larger, more damaging fire events. One such event, the Carlton Complex Fire, burned during the summer of 2014. As the largest wildfire ever recorded in Washington state history, it burned more than 130,000 hectares, consumed 300 homes, and caused considerable infrastructure damage before it was contained.

In order to put recent fire activity in the eastern Cascades into perspective, long-term fire histories that span the past ~15,000 years are needed. Here we present results from a study at Green Lake, Washington, which sits approximately 42 km from the Carlton Complex Fire. The lake was cored during summer 2012 and a 4.43 m long sediment core was recovered, providing an approximately 7600 year-long record. High-resolution macroscopic charcoal analysis was used to reconstruct the fire history of the site, along with loss-on-ignition and magnetic susceptibility analyses. Ratios of herbaceous to woody charcoal were used to determine fuel types and fire severity. Preliminary results indicate that low-severity ground fires were frequent throughout the record, but increased substantially after ca. 1400 AD and remained high until ca. 1850 AD. Future research will involve reconstructing the fire history of a lake within the Carlton Complex burn zone to compare with the Green Lake record.

SNOWPACK AS A RESERVOIR OF NITROGEN DEPOSITION IN SUBALPINE ECOSYSTEMS OF THE CASCADES. **Justin Poinsatte**, Sarah M. Anderson, Ben A. Harlow, R. Dave Evans, School of Biological Sciences, Washington State University, Pullman, WA 99163; *jpoinsatte@wsu.edu*.

Elevated anthropogenic nitrogen (N) emissions result in higher rates of atmospheric N deposition that can saturate sensitive ecosystems. Consequences of increased N deposition include higher emissions of greenhouse gases, eutrophication of watersheds, and deterioration of vegetation communities. Model projections of N deposition indicate that the Cascades are receiving elevated N deposition, which may be deleterious to sensitive subalpine ecosystems. In these ecosystems, most of the N deposition is stored in snowpack until it is released in a pulse event during spring snowmelt. Few studies have measured N deposition rates within the Cascades and whether any processing of the N occurs within the snowpack. We quantified snowpack ammonium (NH_4^+) and nitrate (NO_3^-) content and analyzed the stable isotope composition ($\delta^{15}N$, $\Delta^{17}O$, and $\delta^{18}O$) of the snow NO_3^- to evaluate the rate, relative N forms, and sources of this N deposition. Deposition rates were higher than anticipated based on nearby National Atmospheric Deposition Program (NADP) measurements. Ammonium (NH_4^+) was the dominant form of N deposition in winter snowpack, contrary to predictions by the Community Multiscale Air Quality (CMAQ) model. The NO_3^- $\Delta^{17}O$ values varied between 10 to 21‰, indicating that microbial NO_3^- processing may be occurring in the snowpack. Thus, our study will provide insight to land managers on the fate of anthropogenic N emissions and how N deposition may impact subalpine ecosystems.

A TWO COUNTY COMPARISON OF PARASITE LOAD IN THE COLUMBIAN SPOTTED FROG (*RANA LUTEIVENTRIS)*. **Cathryn Polehn**, Marcus James, Devin Bailey, Laura Mahrt, Eastern Oregon University, Biology Program, One University Blvd. La Grande, OR 97850; *cpolehn@eou.edu*

Columbian spotted frogs (*Rana luteiventris)* were once abundant in Eastern Oregon. They are now considered a "sensitive and critical" species, with many of the populations being small and isolated. Major factors contributing to their loss include modification of their habitat and introduction of non-native aquatic species. Parasite load is now thought to be a possible contributing factor to the diminishing population as well. A significantly high level of parasitization can weaken the infected organism and contribute to overall reduction in reproductive output if many individuals in the population are parasitized. Threatened, as well as, small in-bred populations may display reduced parasite species richness and disease resistance, resulting in weaker immune systems and higher parasite loads. In 2012, blood smear samples were collected from 27 adult and juvenile specimens along McCoy Creek (Union County, OR) to assess the population's parasite (*Lankasterella)* load. An infection frequency of 37% was observed. During the spring of 2014 this procedure was replicated along the Wallowa River (Wallowa County, OR). Low numbers of parasites were observed, as only 4 of the 30 samples displayed the hemoparasite *Lankasterella.* Fisher's Exact Test found there was no significant difference between the numbers of infected individuals between the two counties ($P = 0.063$). However, there was a significant difference in the two counties parasite load ($P = 0.019$). The Union County individuals carry a heavier parasite load than those individuals found in Wallowa County. High white blood cell counts were also observed in several of the samples from both populations. This may indicate the populations have intestinal parasites, or other secondary infections which may be contributing to the sensitivity of this species.

POSSIBLE INFLUENCES OF THE CHENEY FRACTURE ZONE AND PALEODRAINAGES ON BASALT AQUIFERS OF THE WEST PLAINS, EASTERN WASHINGTON. Chad J. Pritchard, Cassandra Hennings, Brea Lund, Eastern Washington University, Department of Geology, 130 Science Building, Cheney, WA 99004-2439; Shawna Ernst, Spokane County GIS, 1026 West Broadway Ave, Spokane, WA 99260, *cpritchard@ewu.edu*

The Columbia River Basalt Group in the West Plains of eastern Washington hosts declining aquifers and impedes storm water infiltration, which are both concerns to residence and governmental entities. Groundwater in the West Plains has isotopic ratios that generally correlate with the Pleistocene epoch, but two potentially active conduits for meteoric recharge/ mixing in the basalt aquifers are the Cheney Fracture Zone and Paleodrainages. Both of these features are heavily influenced by deposition and erosion from the Missoula Floods, especially the paleo-drainages which were filled by sand and gravel deposits of the outburst floods. This project 1) establishes the basalt stratigraphy of the West Plains using well cuttings and outcrop samples; 2) quantifies the magnitude and orientation of fractures using aerial-photo analysis of the three limbs of the Cheney fracture zone; and 3) generates contours of gravel fill in channels to identify the complexity and extent of paleodrainages. The aquifers include a shallow and less extensive aquifer in the Priest Rapids member of the Wanapum basalts and a deeper aquifer system near the contact of the Sentinel Bluffs and Wapshilla Ridge members of the Grande Ronde basalts. Deformation of the Cheney Fracture Zone is interpreted as lateral faulting in the bedrock that has propagated to the surface and potentially formed conduits for groundwater and allowed for preferential erosion by the Missoula Floods. Paleodrainages allow for interaction between basalt aquifers and meteoric water and are being developed for aquifer storage recovery wells and disposal of storm water.

STEELHEAD OUTMIGRATION IN THE WALLA WALLA RIVER BASIN, AN EXPLORATORY LOOK AT A COMPLEX SYSTEM. Eli Robinson, Timothy H. Parker, Whitman College, Walla Walla, WA 99362; *robinsew@whitman.edu*

Oncorhynchus mykiss is colloquially known as Steelhead (anadromous) and Rainbow Trout (resident), depending on life history. In the Walla Walla River basin sea-run *mykiss* return in numbers approaching 1000 adults annually. These fish then mate in the upper-reaches of the watershed, and after a period of 1-3 years some of their offspring out-migrate. This study analyzed survival and outmigration of these “smolt”. In each sub-basin smolt traps capture fish moving downstream, where Passive Integrated Transponder (PIT) tags are inserted into their abdominal cavities. Tagged, hatchery reared, *mykiss* smolt are also released into the system. PIT tag detection arrays are located around the Walla Walla Basin and at hydroelectric dams in the Columbia River. I used Microsoft Excel and program MARK to develop survival and detection probability matrices for hatchery and wild fish for the Touchet River, Mill Creek and the Walla Walla River. I found that both detection and survival rates at sites vary significantly from site to site. In the Touchet and Walla Walla rivers hatchery fish vastly outnumber wild fish, and competition for limited resources along with generally poor habitat conditions could explain the low 3% survival rate from release to the John Day Dam in the Touchet River. Mill Creek and the Walla Walla River, on the other hand, had estimated survival rates in the mid 40% range. A greater understanding of what contributes to variance in mortality amongst out-migrating salmonids could help maximize efficiency in our stocking efforts and target recovery efforts. In spite of my fairly large data set (from 356 tagged fish released in Mill Creek to 12580 fish in the Touchet River) many of my results are statistically insignificant, with smaller confidence intervals for survival and detection rated found amongst hatchery fish, likely due to their greater numbers. Furthermore the identification of detection arrays with low efficiency rates, such as Bolles Bridge and McNary Dam, has the potential to guide future improvement work on the array system.

BIOLOGICAL SOIL CRUST DIVERSITY AND CHEATGRASS COVER IN SIX VEGETATION TYPES OF SW IDAHO. Roger Rosentreter, Biology Department, Boise State University, 1910 University Dr., Boise, ID. 83709. *Roger.rosentreter0@gmail.com*

Biological soil crust species (59) were recorded during surveys on the Orchard Combat Training Center in SW Idaho. Large macroplots were examined in each of 6 different vegetation type plots within a 34.7 m radius, approximately equal to one acre or 0.38 hectares. This is a modification of the national forest health monitoring protocols. Biocrusts were composed of 43 lichens, 14 bryophytes, and 1 cyanobacteria. Plot species and diversity differed significantly, ranging from only 2 to as many as 53 species of biocrusts in the individual 1 acre plot. The most striking result of this study was that areas with a high % cover of biocrusts had little or no cheatgrass, even in a year with a wet spring (2014), which favored the abundant growth of cheatgrass throughout southwest Idaho. Additionally, a significant amount of the biodiversity, in arid west plant communities is found in the biocrusts, rather than in the vascular plant community. In spite of this, there is only minimal biological soil crust monitoring conducted on rangelands by most public land managing agencies.

The use of large macroplots, such as those used in this study, captures more biodiversity in a rapid and efficient amount of time and can be correlated to a specific vegetation type (Root and McCune 2013), as compared to the use of many small plots or sampling an entire area without defining a plot. However, sampling does need to be done by individuals knowledgeable about biocrust identification and diversity.

HOLOCENE FIRE RECONSTRUCTION OF THE LONG LAKE AREA NEAR RIMROCK RESERVOIR IN THE EASTERN CASCADES, WASHINGTON. Zoe Rushton, Megan Walsh, Resource Management Program/Geography Department, Central Washington University, 400 E. University Way, Ellensburg, WA 98926; *rushtonz@cwu.edu*

Recreational use of the forests in the Rimrock Reservoir area of Washington State by hikers, campers, whitewater rafters and others is increasing. Many of these forests have been subjected to 20th century fire suppression and various other timber practices that have resulted in dense forest stands, leading to disease and pest outbreaks, and are at risk of large fire events. A more thorough understanding of past fire frequency in the Rimrock Reservoir area will aid land owners and forest managers in planning for future fire events. In the summer of 2014 a nine meter-long sediment core was extracted from Long Lake, which is located approximately 5 km southeast of Rimrock Reservoir and 45 km west of Yakima. Fire event frequency was determined using macroscopic charcoal analysis, which quantifies the changing abundance of charcoal particles >125 μm taken at contiguous 1-cm intervals throughout the core. Past fire severity is indicated by the ratio of woody to herbaceous charcoal, which was visually determined for each charcoal particle. Preliminary charcoal results show frequent fire episodes for approximately the last 8,000 years, with a noticeable decrease in fire occurrence in recent centuries. Numerous macrofossils were removed from the sediment and will be used for radiocarbon (^{14}C) dating and to establish a chronology of the core. Preliminary loss-on-ignition results show that the organic content of the sediment remained fairly consistent throughout (~26%), but was notably lower where sand and volcanic ash layers were present. Continuing work includes pollen analysis of the Long Lake core, which will make it possible to compare the vegetation and fire histories of the study site, illustrating interactions between fuel type and fire activity. This research is part of a larger effort to reconstruct the Holocene fire history of the eastern Cascades.

CLIMATIC TRENDS, BIOCLIMATIC INDICES AND THE RELATION TO WINE-GRAPE HARVEST QUALITIES. Corydon Funk, **Melba Salazar-Gutierrez**, Bernardo Chaves, Gerrit Hoogenboom, AgWeatherNet Program, Washington State University – Prosser, Prosser, WA 99350; Rick Hamman, Hogue Ranches, Prosser, WA 99350; Bill Riley, Ste. Michelle Winery Estates, Woodinville, WA; *m.salazar-gutierrez@wsu.edu*

The post-harvest qualities of a wine-grape depend heavily on the baseline climate and the climatic variability for the specific location and the year when it is harvested. Four of the major grape varieties were used in this study: Cabernet Sauvignon, Merlot, Chardonnay, and White Riesling. Harvest and weather data were collected for four locations from 2009 to 2013. The climatic tendencies of each location were analyzed through multiple bioclimatic indices: The Branas Bernon and Levadoux Hydrothermic Index, The Cool Night Index, The Winkler Index, The Huglin Index, and two precipitation indices. The values of these indices were then correlated to brix Degrees, pH levels, and titratable acidity in order to analyze the effect of climate on wine-grapes. The cultivar's tendencies were also analyzed using a multidimensional preference analysis biplot. As a result, The Winkler Index, Huglin Index, and the Cool Night Index had significant correlations to the three wine qualities. In contrast, precipitation indices as well as the Branas Bernon and Levadoux index showed much fewer significant correlations than those based on temperature. The biplot showed evidence of the relationship between the yearly data and grape quality. Some qualities were affected by different year's climates more than others, as shown by the red varieties approaching brix degrees and pH while the white varieties more closely followed the TA trend line. Locations could also be broadly grouped by their influences from temperature or precipitation for a specific year utilizing the MPA. The multidimensional preference analysis showed that there was a relationship between the qualities, the location and the cultivar. For future studies, a larger set of data would provide for an improved analysis of the correlations of local climate and wine grape qualities. This study confirmed that temperature has a large impact on the wine grape qualities.

POST-TREATMENT INDICATORS OF CHEATGRASS INCREASES – COULD FUEL TREATMENTS CREATE FUEL PROBLEMS? Scott E. Shaff, David A. Pyke, U.S. Geological Survey, Forest & Rangeland Ecosystem Science Center, 3200 SW Jefferson Way, Corvallis, OR 97331; Jeanne C. Chambers, USDA Forest Service, Rocky Mountain Research Station, 920 Valley Rd. Reno, NV 89512; Eugene W. Schupp, Department of Wildland Resources & The Ecology Center, Utah State University, 5230 Old Main Hill, Logan, UT 84322; Paul S. Doescher, Department of Forest Ecosystems & Society, Oregon State University, 321 Richardson Hall, Corvallis, OR 97331; *sshaff@usgs.gov*

If arid sagebrush ecosystems lack resilience to disturbances or resistance to annual invasives, then alternative successional states dominated by annual invasives, especially cheatgrass (*Bromus tectorum* L.), are likely after fuel treatments. We identified six Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis* Beetle & Young) locations (152-381 mm precipitation) that we believed had sufficient resilience and resistance for recovery. As part of a larger study, we examined impacts of woody fuel reduction (fire, mowing, the herbicide tebuthiuron and untreated controls, all with and without the herbicide imazapic) on cheatgrass dominance using ANOVA. We also examined potential indicators of cheatgrass cover including distances among perennial plants (gaps), density of perennial grasses, cover of mosses and lichens, and bare ground cover. Initial results (years 1-3 post-treatment) indicated that cheatgrass was increasing with increases in perennial gap distances and bare ground, and with decreases in lichen and moss cover in fire and mowing treatments, but imazapic held cheatgrass in check while increasing bare ground. Imazapic did not appear to result in increased perennial plant cover and may delay the increase in cheatgrass until it degrades in the soil. Preliminary results indicate that by year 4, cheatgrass was increasing in cover above control levels in these treatments. Fire, mowing, and imazapic may be effective in reducing fuels for three years, but each has potentially undesirable consequences on plant communities, some of which may contribute to fuel levels.

USE OF LIDAR TO DETECT SHRUBS. Caileigh Shoot, Sean Jeronimo, Van Kane, Monika Moskal, University of Washington, School of Environmental and Forest Sciences, Seattle, WA 98195; Jim Lutz, Utah State University, S. J. & Jessie E. Quinney College of Natural Resources, 5230 Old Main Hill, Logan, UT 84322-5230; *shootc@uw.edu*

Shrubs are an important habitat component for wildlife and they play a significant role in the spread of wildfires. Despite their importance, land managers often do not have an adequate idea as to where shrubs are located or in what quantities they can be found across landscapes. In addition, mapping shrub cover in the past has been arduous and inaccurate on larger scales. LiDAR has been shown to measure upper canopy features fairly accurately when compared with field measurements, but has not been proven to be a viable method of measuring below-canopy features such as shrubs. The purpose of this study is to determine if LiDAR can be used to detect and map where shrubs are on a landscape. This study was performed on the 24.5 ha Yosemite Forest Dynamics Plot in Yosemite National Park. High-resolution (>40 points per m^2) discrete-return LiDAR data was acquired in 2010 at the same time that field crews mapped and identified the species of all shrub patches >2m^2. The LiDAR point cloud was processed to generate a 1 m digital terrain model (DTM) and a variety of grid-based metrics measuring vertical structure. From the DTM, slope, aspect, and topographic position were extracted. The grid-based metrics, topography metrics, and the shrub map were input into Random Forest, a modeling package for R. Preliminary results show that shrub presence or absence can be predicted with >70% accuracy.

HIGH RESOLUTION SAGEBRUSH CANOPY MAPPING: A CASE STUDY. **Jerry Tagestad**, Pacific Northwest National laboratory, Richland, WA 99352. *Jerry.Tagestad@pnnl.gov*

Shrub cover, particularly sagebrush cover is a critical habitat component for the Greater sage grouse as well as other sagebrush obligate species. We present a case study describing a new method for estimating and mapping shrub canopy cover mapping using high-resolution digital ortho-photographic images and demonstrate how emerging techniques in remote sensing and spatial modeling have applications for sage-grouse habitat assessment. We use a combination of quantitative and qualitative field sampling to build and validate a shrub canopy model using free, readily available imagery from the National Agricultural Imagery Program (NAIP). Qualitative assessment of mapped canopy for sites in Oregon and Idaho show that this approach results in a seamless map that is nearly identical to the ground-based measurements. Quantitative assessment of the Oregon site show that the measured shrub cover agreed well with modeled estimates (23.6% and 26.5%, respectively). The Idaho site assessment also showed very close correspondence between measured and modeled canopy (1.7% and 5.1% respectively). The image-based approach for mapping shrub habitats replicated the pattern of shrub cover in the field-based maps, required an order of magnitude fewer hours to create and is extensible to larger land areas resulting in a more comprehensive map of this important landscape habitat component.

ASSESSING EFFECTS OF GRASSLAND RESTORATION ON NATIVE BEE AND SPIDER COMMUNITIES IN A PACIFIC NORTHWEST AGROECOSYSTEM. Lauren Smith, Sandy DeBano, Department of Fisheries and Wildlife, Hermiston Agricultural Research and Extension Center, Oregon State University, 2121 S. 1st Street, Hermiston, OR 97838; *lauren.smith@oregonstate.edu*

Since pre-settlement times over 90% of native North American grasslands have declined, primarily due to agricultural conversion. Thus, much of grassland restoration efforts occur in the context of agroecosystems and may vary from small scale restoration projects to large scale projects, such as restoring field margins or roadsides to grassland habitat. Today, grasslands provide essential habitat for many rare and endangered plant and animal species; however, most research is disproportionately aimed at vertebrates, even though invertebrates are by far more specious and abundant. Invertebrates in North American grasslands provide diverse ecosystem services such as pollination, nutrient cycling, food web provisioning, and predation of crop pests. Yet it is unclear whether much of the grassland restoration occurring in the United States has resulted in restoration of invertebrate diversity and function. This is particularly true of bunchgrass grasslands in the Pacific Northwest. In the last decade, a growing realization of the importance of grassland habitats in agroecosystems has led to an increased number of restoration projects in eastern Oregon such as The Nature Conservancy Boardman Preserve, a 9,163 ha restoration site that was previously grazed and heavily invaded by cheat grass. The goal of this study is to use an observational study to understand how grassland restoration impacts native bee and spider diversity and if restoration returns diversity and richness to native levels by comparing restored, native, and degraded sites. In addition, one goal aims to determine if age of restoration plays a role in invertebrate responses. Ultimately, this research will result in management recommendations that can increase the number and diversity of beneficial invertebrates and the ecosystem services they provide in restored grasslands of the Pacific Northwest.

THE CENTRAL ROLE OF MOUNT ST. HELENS IN DEVELOPMENT OF VOLCANO ECOLOGY: A GLOBAL PERSPECTIVE. Frederick J. Swanson, USDA Forest Service, Pacific Northwest Research Station, 3200 Jefferson Way, Corvallis, OR 97333; Charles M. Crisafulli, USDA Forest Service, Pacific Northwest Research Station, 42218 Northeast Yale Bridge Road, Amboy, WA 98601; *fred.swanson@oregonstate.edu*

The dramatic 1980 eruption of Mount St. Helens attracted global attention, facilitated in part by several months of volcanic forewarning and ready access for a large, attentive science community and media. Mount St. Helens has strongly influenced the fields of volcanology and ecology by virtue of the diversity of geophysical processes involved and types of ecosystems affected, and because of the commitment to long-term research and monitoring at the site. Studies of this eruption have been instrumental in the development of volcano ecology as a subfield of disturbance ecology, which itself emerged as a major field of study in the 1980s. Based on a preliminary database search of 440 publications concerning plant and animal responses to disturbance by volcanic processes, only 11% of the 404 volcanoes that have erupted since 1883 have been the subject of published ecological studies. Only three of these volcanoes have been the subject of sustained, multi-taxa ecological study; and Mount St. Helens is by far the most intensively studied. Both studied and unstudied eruptions are well distributed around the globe, and they occur in all major terrestrial biomes of the Earth. The intensity and duration of study reflects factors such as sustained commitment of science agencies and individuals and the tension between ready access and remoteness that limits land use that could disturb natural succession. The Mount St. Helens experience has stimulated studies at other sites of recent eruptions. Our studies of the 2008 Chaiten and 2011 Cordon-Caulle eruptions in Chile, for example, have displayed important variation of ecological effects of a single process type (tephra fall) with limited range of deposit thickness (5-50 cm), resulting from interactions of properties of the tephra (e.g., bulk density of rock clasts) with properties of the vegetation (e.g., deciduous vs. evergreen, ability to sprout). These experiences make clear the important components of volcano ecology research: get in early, even while the eruption continues; take an interdisciplinary view, especially at the geology-ecology interface; sustain the field studies for many years; and compare findings with observations of other eruptions in other volcano-socio-ecological settings.

THE LASTING EFFECTS OF RESTORATION ON COMMUNITY COMPOSITION AND PERSISTENCE AND SPREAD OF NATIVE PRAIRIE SPECIES. Charlotte C. Trowbridge and Jennifer L. Williams, Department of Geography, University of British Columbia, 1984 West Mall, Vancouver, BC V6T 1Z2; *charlotte.trowbridge@geog.ubc.ca*

The major goals of grassland restoration are to reduce the abundance of exotic species while maintaining or boosting native species abundance and diversity, but it is often difficult to extend monitoring efforts far beyond project timelines. Understanding how initial trends play out over the long-term is essential for evaluating treatment efficacy. Observing how native species establish and spread following restoration treatments can further inform decisions regarding seeding practices and management timelines. To assess the degree to which initial treatment effects persist after project completion, we revisited prairie restoration sites 6 years after experimental treatments and supplemental seeding had ceased and evaluated plant community composition. We tracked the persistence of seeded species across treatments and measured population spread as a metric to evaluate longer-term success, suitability of restoration species, and the ability of the habitat to support native plant populations. We found that plots that received supplemental seeding of native species continued to exhibit higher native richness than those left unseeded, regardless of treatment, but that this did not necessarily translate to higher total cover of native species. Treatment was found to be a significant indicator in the persistence of 4 out of 8 of the seeded species, but treatment type did not have a significant lasting effect on the cover of exotic grasses. A case study of the seeded native species, *Plectritis congesta*, indicated that where persistence occurred, the population could achieve a level of spatial advance in agreement with theoretical predictions. Our results confirm that seeding native species plays a critical role in grassland restoration given that, once established, native species seem to have the ability to persist and perform in line with expectations even in exotic-dominated communities.

INVESTIGATING FALLBACK AND SURFACE PASSAGE ROUTES FOR OVERWINTERING ADULT STEELHEAD AT LOWER COLUMBIA RIVER DAMS. Brad Trumbo, US Army Corps of Engineers, Walla Walla District, 201 N. Third Ave., Walla Walla, WA 99362; *bradly.a.trumbo@usace.army.mil*

A portion of adult summer steelhead returning to the Columbia River Basin overwinter within Federal Columbia River Power System before entering their natal tributary to spawn. These fish may experience "fallback", which is downstream passage over or through a dam following successful fishway ascension. While not unique to overwintering steelhead, fallback is a concern of fishery managers. The powerhouse is typically the only available downstream winter passage route and steelhead that fallback generally experience lower fishery and hydropower system escapement. Early radio-telemetry studies estimated up to 50% of steelhead fallback at lower Columbia River dams, but more recent estimates are generally $\leq$ 10%. With a large number of adult steelhead observed overwintering in the McNary Dam forebay, fallback estimates at McNary are among the highest of the four lower Columbia River dams. Winter hydroacoustic studies at McNary Dam (2010-2012) estimated up to 2,300 fallback events, December through April. Fallback at McNary is of particular importance as lower Columbia River populations may migrate past ("overshoot") their natal tributaries and continue upstream beyond McNary. Therefore, to reach their spawning grounds, lower Columbia steelhead overshoots that migrate past McNary must pass back downstream. Passage survival studies have been conducted comparing turbine passage to surface passage routes (e.g. spillway weirs [SW]). Results suggested that survival was significantly higher for adult steelhead passing a surface route compared to turbines at Bonneville and The Dalles Dams which led to extended annual surface passage operations for steelhead in March at these facilities. Similarly, an adult steelhead survival study was conducted at McNary Dam in 2014 comparing turbine and SW survival. Adult steelhead (mean total length 591mm) turbine survival was significantly lower (90.7% [± 5.0%; 95% confidence]) than SW survival (97.7% [± 3.2%; 95% confidence]). The US Army Corps of Engineers continues to investigate winter SW passage for adult steelhead at McNary and other Federal Columbia River Power System facilities.

WHOOSH FISH TRANSPORT SYSTEM: EVALUATION OF A NOVEL APPROACH TO MOVING LIVE FISH. Katie A. Wagner; Alison H. Colotelo; Tim J. Linley; Ann L. Miracle; David R. Geist; Pacific Northwest National Laboratory, P.O. Box 999, Richland, WA 99352; *katie.wagner@pnnl.gov*

Standard methods for moving live fish around in-river barriers often involve extensive handling, which can be stressful and result in injury and/or mortality for the fish. Whooshh Innovations LLC has adapted a flexible transport conduit, used in the agriculture and food processing industry, for moving live fish in hatcheries and around in-river barriers, such as hydroelectric dams. We evaluated the efficacy of this technology with adult fall Chinook Salmon *Oncorhynchus tshawytscha* by comparing the physical, physiological, and reproductive effects of passage through two different lengths (40 feet and 250 feet) of the Whooshh Fish Transport System (WFTS) to trap and haul, a standard method used to move fish around in-river barriers. No mortalities or obvious signs of injury to the fish due to the WFTS were observed. Immune responses and egg survival were similar among the WFTS-40 foot, WFTS-250 foot, and trap and haul treatments. Our results indicate that for adult fall Chinook Salmon the effects of the WFTS, regardless of transport distance, were comparable to that of a trap and haul method.

GENETICS AND MOVEMENT OF COLUMBIA RIVER REDBAND TROUT, *ONCORHYNCHUS MYKISS GAIRDNERI*, IN DRY CREEK, IDAHO. Christoph A. Walser, Shelby Richins, Sarah Walsh, The College of Idaho, Department of Biology, 2112 Cleveland Blvd, Caldwell, ID 83605; *cwalser@collegeofidaho.edu*

The Columbia River redband trout (*Oncorhynchus mykiss gairdneri*) is native to the Columbia River Basin east of the Cascades. Throughout the region, the genetic structure of many redband trout populations has been influenced by introgression with hatchery stocks (coastal rainbow trout) and by isolation due to migration barriers. Dry Creek is a small tributary of the Boise River which flows across the boundary of the central Idaho mountains and the Snake River plain. The creek is located approximately 6-km north of Boise, Idaho, and is characterized by large seasonal fluctuations in temperature and flow. The objective of our research was to describe the genetics of the Dry Creek redband trout population and evaluate the effects of a road culvert on trout movement. During 2012 and 2013 fin clips were taken from 259 redband trout collected throughout the Dry Creek watershed. Fish collected in 2013 were also implanted with Biomark© PIT tags and individual fish movement across the road culvert was monitored via two 10' Biomark© Lite PIT Tag Antenna Systems; each powered by a 120W portable solar system. Genetic analyses of fin clips were carried out at the Idaho Department of Fish and Game (IDFG), Fish Genetics Laboratory in Eagle, Idaho. Each fish was genotyped at 186 single nucleotide polymorphisms (SNPs), used by IDFG for genetic stock identification and determining range-wide relationships among rainbow trout/steelhead populations. Genetic data were used to describe population sex ratios, genetic purity, and genetic differentiation between fish collected above and below the road culvert. Sex ratios were 1:1 and genetic analyses confirmed a single population (F_{ST}=0.011) of non-introgressed Columbia River redband trout. The majority (91%) of fish movements were upstream (median distance 92-m) while 9% of movements were downstream (median distance 53-m). No tagged fish crossed both arrays. Fish movement peaked in June, prior to drying of low to mid-elevation reaches. Redband trout were observed in pools with dissolved oxygen levels of 1.8 mg/L, suggesting adaptations to hypoxia. Given the recent establishment of a conservation easement for upper Dry Creek, the results of this study will assist efforts to design an effective watershed management plan.

A REGIONAL PERSPECTIVE ON HOLOCENE FIRE REGIMES IN THE PACIFIC NORTHWEST.
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Wildfire plays an important role in ecosystems of the Pacific Northwest, but past relationships between fire, climate and human actions remain unclear. A multi-scale analysis of 34 macroscopic charcoal records from a variety of biophysical settings (i.e., high/low elevation, coastal/inland, forest/woodland, wet forest/dry forest) was conducted to reconstruct fire activity for the Pacific Northwest during the past 12,000 years. The analysis includes 23 records archived in the Global Charcoal Database ver. 3, five from additional published sources, and six unpublished records contributed by the authors. Trends in biomass burning and fire frequency are compared to paleoenvironmental and population data at a variety of temporal and spatial scales to better understand fire regime variability on centennial- to millennial-length time scales. Pacific Northwest fire activity in the early Holocene is linked to climatic and vegetation changes; however, increased fire activity in the middle to late Holocene is inconsistent with long-term trends in temperature and precipitation. Two hypotheses are explored to explain the rise in fire activity after ca. 5500 calendar years before present, including greater climate variability and increased human use of fire. Climatic changes such as increased El Niño/ Southern Oscillation event frequency during the past approximately 6000 years could have led to hydrologic shifts conducive to more frequent fire events, despite overall trends towards cooler and moister conditions. Alternatively, increasing human populations and their associated uses of fire may have increased biomass burning. Centennial-scale changes in fire activity, such as during the Medieval Climate Anomaly and the Little Ice Age, closely match widespread shifts in both climate and population, suggesting that one or both influenced the late-Holocene fire history of the Pacific Northwest.

ACOUSTIC TRACKING OF REDBAND TROUT (*ONCORHYNCHUS MYKISS* VAR. *GARDNERII*) IN LAKE ROOSEVELT, WASHINGTON. Jessica A. Walston, Krisztian Magori, Allan T. Scholz, Eastern Washington University Cheney WA 99004*; jflowers@ewu.edu*

Little is known about the movements of native Columbia River Redband trout (*Oncorhynchus mykiss* var. *gardnerii*) in Lake Roosevelt, a reservoir formed by Grand Coulee Dam on the Columbia River. Since April of 2013, acoustic telemetry was used to identify long-term horizontal movements of redband trout within this reservoir. This study tagged fifty fish (17 females, 10 males, and 23 unknown sex; average total length: 408 ±148 mm) from April to May in 2013 and sixty fish (21 females, 26 males, and 13 unknown sex; average total length: 457 ±56 mm) from March to May in 2014. The goal of this study was to determine if redband trout occupy unique distributions based on their capture stream and if entrainment rate of redband trout is affect by age/size class, proximity to dam, or reservoir operations. The movements were modeled using state-space modeling (dynamic Brownian Bridge Movement Model and utilization distribution modeling) in R. Fish were grouped by capture stream (tributary group) and their movements were compared among each other. Preliminary data analysis indicates that the fish may have unique utilization distributions. An average of 77.2 ±2.15 % of the fish exhibited a unique utilization distribution based on capture stream groups. Four fish entrained from three different capture streams (two tagged in 2013 and two tagged in 2014). None of these fish appear to have entrained as a result of reservoir operations and there is no evidence that proximity to the dam will increase the likelihood a fish entrains. The methods used to model movements of fish to determine their unique distribution could aid in the management of native fish.

CHARCOAL PRODUCTION IN MIXED-CONIFER FOREST UNDER HIGH SEVERITY INTIAL FIRE AND REPEAT BURNS Aspen Ward, College of Forestry and Conservation, The University of Montana, Missoula, MT 59812; C. Alina Cansler, School of Environmental and Forest Sciences, University of Washington, Seattle, Washington 98195-2100; Andrew J. Larson, College of Forestry and Conservation, The University of Montana, Missoula, MT 59812; *aspen.ward@umontana.edu*

Factors controlling the net amount of black carbon in the form of charcoal has yet to be well understood in mixed-conifer forest ecosystems. Charcoal is a fundamental component for the available carbon in a forest system and is most commonly produced through fire events. Charcoal production on coarse woody debris has been understudied and is becoming more important to understand as research continues looking at fire and carbon dynamics with a climate lens. To understand the influence of fire on a landscape's potential charcoal production, samples were taken at ten sites where an initial fire burned at high severity in 2003 with ten corresponding sites of the same initial fire that experienced a repeat burn in 2011 and 2013. Samples were cross-sections of coarse woody debris present on the ground where charcoal depth was measured along transects. The total volume of charcoal produced was greater in sites that experienced a repeat burn with the mean of the repeat burn sites accumulated charcoal equaling 11.8 m^3/ha compared to the once-burned mean of 6.4 m^3/ha in a standard T-test. Charcoal volume varied in sites that experienced only the initial high severity fire. The charcoal production appeared significantly different between the two types of sites, indicating that repeat burns of various severity types may produce differences in charcoal availability. Management techniques able to reflect an allowance of repeat burns in areas may allow an increase availability of carbon in mixed-conifer forest systems.

THE SHORT-TERM EFFECT OF DIFFERENT ANESTHETICS ON RAINBOW TROUT (*ONCORHYNCHUS MYKISS*) SWIMMING ABILITY. Shawna Warehime, Jessica Walston, Krisztian Magori, Allan Scholz, and Mark Paluch, Eastern Washington University, Fisheries Research Center, Science 194, Cheney, WA 99004; *sbwarehime@eagles.ewu.edu*

This study investigated the effect of four anesthetics, tricaine methanosulfate (MS-222), eugenol (AQUI-S 20E), carbon dioxide (CO_2), and low volt electroanesthesia (LVEA), on the short-term swimming ability of rainbow trout (*Oncorhynchus mykiss*). These anesthetics have been widely used in fisheries management; however, there is little knowledge about the short-term effect on the fish. If a fish is still being influenced by an anesthetic after release, the fish may be susceptible to increased predation, an interruption in spawning behavior, or a change in migration. This study was conducted by swimming individual fish in increasing step-wise speed increments based on fish body length after immediately recovering from anesthesia. There were five treatment groups (n = 30). Swimming behavior was measured in number of tires and critical swimming speed (body lengths/sec; bl/sec; U_{crit}). Seven percent of control, 28% of MS-222, 31% AQUI-S 20E, 22% CO_2, and 12% LVEA anesthetized fish reached critical swimming speed during the test. Control fish had an average U_{crit} of 4.8 ± 0.3 bl/sec. MS-222 and AQUI-S 20E had an average U_{crit} of 3.2 ± 0.89 and 4.3 ± 0.7 bl/sec respectively. CO_2 had an average U_{crit} of 3.4 ± 0.4 bl/sec. LVEA had an average U_{crit} of 4.8 ± 0.4 bl/sec. LVEA and the control fish were observed to have fewer tires ($p < 0.05$) and were less likely to reach the critical swimming speed ($p < 0.001$). Based on this study, LVEA was observed to have the least impact on swimming behavior of rainbow trout. Both MS-222 and AQUI-S 20E were observed to impact swimming behavior most.

MARINE NUTRIENT SUBSIDIES IN INLAND RIPARIAN FORESTS OF THE COLUMBIA RIVER BASIN. Tadd A. Wheeler, University of Idaho, Department of Forest, Rangeland, and Fire Sciences, Box 441133, Moscow, ID 83844; Kathleen L. Kavanagh, Texas A&M University, Department of Ecosystem Science and Management, 305 HFSB, 2138 TAMU, College Station, TX 77843; Andrea Noble-Stuen, University of Idaho, Department of Forest, Rangeland, and Fire Sciences, Box 441133, Moscow, ID 83844; *taddw@uidaho.edu*

Prior to blockage of fish passage in the Columbia River Basin migration of anadromous fish from the Pacific Ocean would have brought with it large stores of marine derived nitrogen (N) and carbon (C) to central Idaho, USA. In a region dominated by nutrient poor soils and complex topography, anadromous fish may have been a major nutrient input to riparian forests. To examine the importance of this subsidy, anadromous fish carcasses were placed within riparian forests where salmon runs have been extirpated since the early 1900's. Soil samples 0-10cm collected beneath these amendments revealed the rapid development of nutrient "hot-spots" with a 480 fold increase in soil inorganic N to 918 (218SE) mg N kg^{-1} dry soil by 30 days following carcass deposition. The deposition of fish carcasses also stimulated a seven fold increase in dissolved organic C and an increase in soil microbial productivity as indicated by a three-fold increase in soil microbial N and soil respired CO_2 within 30 days of the amendment. However, estimates of soil N and C loading only accounted for 30% and 10% of the total fish carcass N and C content, respectively. This suggests a need for additional insight into soil mineralization and consumption rates as well as potential volatile loss rates for nutrient amendments of this magnitude in semi-arid ecosystems. In addition to soil biogeochemical responses, this investigation quantified the annual acquisition and inter-annual utilization of marine derived N in both herbaceous and woody understory vegetation using foliar $\delta^{15}N$ concentrations. The foliar $\delta^{15}N$ of *Equisetum arvense* suggest that the soil nutrient subsidy was depleted within two to three years. However, conifer seedlings appeared to have a much higher nutrient acquisition and storage capacity which resulted in the production of needles three years following the nutrient amendment which contained a large proportion of marine derived N, as indicated by a significant enrichment in foliar $\delta^{15}N$ (5.2‰ (0.9SE)) relative to untreated conifer seedlings (0.0‰ (0.6SE)).

UNCONFINED COMPRESSIVE STRENGTH OF PALOUSE SOIL NEAR THE EASTERN WASHINGTON UNIVERSITY CAMPUS, CHENEY, WA. Wesley Silvey, Forest Trampush, **Michael Wilson**, Richard Orndorff, Department of Geology, Eastern Washington University, Cheney, WA, 99004; *michaeljwilson1@eagles.ewu.edu*

The EWU campus is approximately 300 acres in size, and enrollment has increased 17 percent over the last five years, with 5.2 percent growth in 2014 alone. This makes Eastern Washington University the fastest growing public university in Washington State. Future campus expansion is restricted to the northwest into Palouse soils, due to bordering residential areas. We present results for unconfined compressive strength of Palouse soil according to ASTM standard D2166. This test reveals strain behavior of soil resulting from applied compressive stress and allows identification of the yield strength (elastic/ductile boundary) and ultimate strength (point of rupture) for soil, characteristics that play an important role in the ability of soil to support a structural load. We determined that the yield strength of optimally compacted (moisture content of 18%) Palouse soil was 4140 psf with an ultimate strength of 4713 psf. Increasing moisture contents saw a sharp reduction in ultimate strength. Compacted Palouse soil displays a brittle-ductile transition at a water content of 20%.

DIET, AGE AND GROWTH OF THREE CYPRINID FISHES IN THE UPPER COLUMBIA RIVER DRAINAGE, WASHINGTON. Bryan Witte, Eastern Washington University, 526 5th Street, Cheney, WA 99004*; bwitte2012@eagles.ewu.edu*

In summer 2014 a study was conducted by Eastern Washington University to compare the diet and growth of native cyprinids (minnows) in tributary streams of the Upper Columbia River near Kettle Falls and Northport, Washington. These minnows were Longnose Dace (*Rhinichthys cataractae*), Umatilla Dace (*R. Umatilla*), and Redside Shiner (*Richardsonius balteatus*). Diets of these three minnows were similar with the majority of prey items observed being benthic insects such as Trichopterans (caddisflies), Ephemeropterans (mayflies), and Dipteran larvae (true flies). Diet overlap was determined with Horn's formula (1966). Only two showed high diet overlap coefficients (>0.70), 0.90 between Longnose Dace and Redside Shiner, and 0.71 between Umatilla Dace and Reside Shiner. These high overlaps could be attributed to Redside Shiners being found in areas adjacent to where dace were collected, i.e. they partitioned habitat rather than food. Longnose Dace and Umatilla Dace had an overlap of 0.41. Since both dace were found in riffles an explanation for this smaller overlap is these species partitioned food rather than habitat. Average length at age from scales using the direct proportion method was found to be 38 mm (age 1), 61mm (age 2), 78 mm (age 3), and 104 mm (age 4) for Longnose Dace, 37 mm (age 1), 66 mm (age 2), 85 mm (age 3), 98 mm (age 4), and 118 mm (age 5) for Umatilla Dace, and 40 mm (age1), 67 mm (age 2), 93mm age (3), and 107 mm (age 4) for Reside Shiner. Though limited to one area of Washington State, this data adds to the limited life history information about these minnows in an area where fisheries research is geared almost exclusively to salmonids.

ENVIRONMENTAL FACTORS TRIGGERING THE EMERGENCE OF *EUSTENOPUS VILLOSUS* AND *LARINUS CURTUS* WITHIN *CENTAUREA SOLSTITIALIS* POPULATIONS ON THE KRAMER PRAIRIE IN SOUTHEASTERN WASHINGTON. Steven Woodley, Benjamin Zamora, School of the Environment, Washington State University, PO Box 646410, Pullman, WA 99164-6410; *steven.woodley 'at' email.wsu.edu*

In the Northwest, the life cycle of the yellow starthistle hairy weevil (*Eustenopus villosus*) and flower weevil (*Larinus curtus*) have been well described in relation to the phenology of their host plant yellow starthistle (*Centaurea solstitialis* L.). Studies have noted that hairy weevil adults emerged from the soil litter in late May and early June during the first budding stage to feed on leaves and young buds. Subsequently, adult flower weevils emerge in the latter budding and early flowering stage to feed on pollen and mate. It is necessary to expand on our knowledge of the emergence of these weevil species for Washington in relation to other studies because of the differences in site conditions and vegetation phenology across regions. Hence, the objective of this study was to determine if there is a relationship between their emergence with ambient temperature, soil temperature, and soil moisture. This study was conducted in the Kramer Prairie Natural Area a property owned by Washington State University and a designated natural area by the United States Fish and Wildlife Service. To test this relationship, 40 yellow starthistle patches were marked over 4 sample units and data were collected weekly from May through August. At each marker a Daubenmire plot was placed and site conditions were measured along with a 45 second observation period to assess the number of weevils present. In addition, the growth stage of the yellow starthistle was recorded and a photo was taken to document the development inside the Daubenmire plot at each marker. Data indicate a correlation between both weevil species with soil and ambient temperature. The hairy weevil began to emerge in late June peaking in early July with activity declining by late July. The flower weevil began emergence approximately two weeks later however, the peak emergence occurred in mid-July with a dramatic decline coinciding with the hairy weevil. Soil moisture is weakly correlated with the character of emergence for both weevils. The emergence phenology of both weevil species was approximately one month later than dates reported by studies in central Idaho.

EXAMINING THE RESPONSE OF STEELHEAD (*ONCORHYNCUS MYKISS*) TO CLIMATE CHANGE AND AGRICULTURAL INTENSIFICATION IN THE UMATILLA BASIN USING A SPATIALLY EXPLICIT MODEL. **David E. Wooster**, Sandra J. DeBano**,** Department of Fisheries and Wildlife, Hermiston Agricultural Research and Extension Center, Oregon State University, 2121 S. First Street, Hermiston, OR 97838; Willis McConnaha, Jon Walker, Laura McMullen, ICF International, 615 SW Alder St., Portland, OR 97205; Donald Horneck, Department of Crop and Soil Science, Hermiston Agricultural Research and Extension Center, Oregon State University, 2121 S. First Street, Hermiston, OR 97838; *david.wooster@oregonstate.edu*

Steelhead are important to river environments and the economy and culture of the Pacific Northwest. Predicting changes in their future productivity within watersheds is an important step towards developing management strategies for these species given potential changes in environmental conditions resulting from climate change and agricultural intensification. For river environments, climate change is predicted to have impacts on both water temperatures and flow. In addition, a burgeoning human population and potential changes in water management strategies might lead to increased land surface used for crop production, including riparian areas that buffer rivers from sediment and agrochemical inputs. We used a spatially explicit river habitat model, Ecosystem Diagnosis and Treatment (EDT), developed for steelhead, and downscaled temperature data to examine the impact of 12 scenarios involving climate change, agricultural intensification (i.e, the removal of riparian buffers), and combinations of these two factors to examine their impact on steelhead abundance, productivity and habitat capacity for life history diversity ("diversity") in the Umatilla Basin, Oregon. At a basin-wide level, results indicated that by 2080 over 36% of steelhead abundance would be lost under the most severe climate change scenario. Agricultural intensification resulted in over 25% of the abundance of steelhead lost under the highest intensity scenario. The two factors interacted such that under the worst-case scenario 55% of basin-wide steelhead abundance would be lost. At a reach scale, climate change effects were particularly strong in the upper basin where the most productive reaches occurred. Productivity and diversity were greatly lowered or reduced to 0 in ~42% of stream kilometers that are currently highly productive. In addition, large, continuous high quality reaches were fragmented into small, isolated reaches in the uppermost areas of the basin. Agricultural intensification influenced reaches lower in the basin where steelhead productivity and diversity tends to currently be relatively low. EDT output allowed an identification of which reaches are currently productive and which are most likely to be impacted by climate change and agricultural intensification. These results provide a means for guiding management and identifying reaches in need of protection for steelhead in the Umatilla basin.

BENEFIT-COST ANALYSIS OF YAKIMA BASIN INTEGRATED PLAN PROJECTS: AN INTERDISCIPLINARY ANALYSIS OF AN INTEGRATED WATER RESOURCE MANAGEMENT PROPOSAL. Jonathan Yoder, Jennifer Adam, Michael Brady, Stephen Katz, Keyvan Malek, Qingqing Yang, Washington State University, Pullman WA 99164; Joseph Cook, Shane Johnston, University of Washington, Seattle, WA 98195; Daniel Brent, Monash University, ABN Australia 12 377 614 012. *yoder@wsu.edu.*

The Yakima River Basin Integrated Water Resource Management Plan ("IP") has been proposed for the management of drought risk and salmonid recovery, and includes several surface and groundwater storage projects, fish passage projects, fish habitat enhancements, water conservation, and reservoir management changes including instream flow augmentation, and water market development. The plan as a whole is estimated to cost between $2.7 and $4.4 billion. This presentation reports the methods and results of a benefit-cost (B-C) analysis of the IP, focusing on benefits accruing though potential irrigated agriculture, municipal water security and demand growth, and salmonid population restoration in the basin. Methodologically, the study integrates economics, hydrology and climate forecasts, agricultural production impacts, and fish abundance estimates from instream flow, habitat restoration, and fish passage with a set of partially integrated simulation models. The analysis also account for the interdependence of benefits among the various IP projects. Our results show, for example, that the economic benefits of any given water storage project is highest when no other storage project is implemented, and lowest when the full integrated plan is implemented. We also show that water markets and storage infrastructure can be viewed as economic substitutes in that development of each reduces the value of the other. Overall, we find that because of their high cost, none of the water storage projects satisfy a B-C criterion (such that benefits are larger than costs) except in two cases under the most extreme climate and most restrictive market assumptions. Fish passage projects are found to be most likely to pass a B-C test, and uncertainty surrounding habitat and instream flow benefits precludes useful inference about the economic efficacy of these activities. In contrast to 2012 study commissioned by the U.S. Bureau of Reclamation and the Washington State Department of Ecology Office of Columbia River, we find that the IP as a whole is unlikely to satisfy a B-C criterion.

TARDIGRADES OF SMITH ROCKS STATE PARK. Alex Young, Lewis & Clark College, 8114 SE 11th Avenue, Portland, OR, 97202; *alexyoung.116@gmail.com*

One moss and twelve lichen samples collected from exposed rock cliffs at Smith Rocks State Park were assessed for tardigrade presence. A total of 125 tardigrades representing five genera provided the first documentation of the phylum Tardigrada within Smith Rocks State Park. While tardigrades are widely known for their capacity to survive in extreme environments, each species' realized niche is poorly understood. Previous research suggests that microclimatic variation may influence species distribution and habitation. To test if tardigrade community composition was impacted by changes in humidity, samples were collected at two distinct elevations separated vertically by 290 meters. Orientation, aspect, and quantity of sample debris were kept constant at both collection sites. Samples of lichen and moss were identified to species level after collection and confirmed by Dr. Bruce McCune. Tardigrade identification was confirmed with Dr. William Miller. Wide variation in tardigrade abundance and distribution was observed between seemingly identical habitats. *Echiniscus trisetosus, Hypsibius marcellinoi, Ramazzotius sp., Milnesium sp.* and a single *Macrobiotus sp.* were found to inhabit Smith Rocks State Park. While there was no clear trend governing community composition, results are still informative. *Echiniscus trisetosus* was dominant making up 60% of the collection, and occurred in three of eight samples containing tardigrades. The average abundance per sample was 12 tardigrades, with a maximum of 64 tardigrades found in one sample. Additionally, five samples were void of tardigrades.

GOPHER MOUNDS DECREASE NUTRIENT CYCLING RATES AND INCREASE ADJACENT VEGETATION IN VOLCANIC PRIMARY SUCCESSION AT MOUNT ST. HELENS. **Raymond P. Yurkewycz**, Mount St. Helens Institute, 42218 NE Yale Bridge Rd, Amboy, WA 98601; John G. Bishop, School of Biological Sciences, Washington State University - Vancouver, 14204 NE Salmon Creek Avenue, Vancouver, WA 98686; Charles M. Crisafulli, USDA Forest Service, Pacific Northwest Research Station, Mount St. Helens National Volcanic Monument, 42218 NE Yale Bridge Rd, Amboy, WA 98601; John A. Harrison, School of the Environment, Washington State University - Vancouver, 14204 NE Salmon Creek Avenue, Vancouver, WA 98686; Richard A. Gill, Department of Biology, Brigham Young University, 151 WIDB, Provo, UT 84602; *ryurkewycz@mshinstitute.org*.

The northern pocket gopher (*Thomomys talpoides*) influences plant community and biogeochemical processes in western North America through burrowing, mound building and herbivory, but its effects are unstudied in primary succession. Gophers colonized the primary successional Pumice Plain of Mount St. Helens volcano in 1992, 12 years post-eruption. We investigated their effects on soil nutrient dynamics, physical properties, and plant communities. For comparison, we also reviewed and summarized published studies on the effects of *Thomomys* spp. on soils and plant communities. Gophers were active in about 2.5% of the study area and formed ~328 mounds/ha. On gopher mounds, burial of plant shoots increased total soil carbon (TC) and nitrogen (TN) by 13% and 11% respectively, compared to adjacent undisturbed areas. Gopher mounds exhibited decreased plant species density and richness compared to mound margins and undisturbed areas, though these differences disappeared with age. Near-mound areas exhibited increased plant abundance and diversity compared to undisturbed areas. Soil crusts that formed on mounds resulted in decreased water infiltration, thereby protecting soil nutrient pools from subsurface leaching and encouraging the growth and diversity of plants in near-mound areas. Possibly because of this physical shielding, there were no detectable differences in rates of NO3-N, NH4-N or PO4-P leaching out of the rooting zone and CO2 flux rates from mounds were lower than undisturbed areas. While the negative effect of gophers on species density was similar in other studies, observed increases in TC and TN contrasted with the trends in other systems. On the Pumice Plain, gophers act as ecosystem engineers, increasing surface heterogeneity in primary successional by influencing a number of physical, chemical and biological characteristics through mound building.

EFFECTS OF FALL PRESCRIBED BURNING ON THE INVASIVE SPECIES YELLOW STARTHISTLE (*CENTAUREA SOLSTITIALIS*) IN A PALOUSE PRAIRIE REMNANT IN SOUTHEASTERN WASHINGTON. **Benjamin Zamora,** Steven Woodley, School of the Environment, Washington State University, PO Box 646410, Pullman WA 99164-6410; *bzamora@wsu.edu*

Yellow starthistle (*Centaurea solstitialis*) is a dominant invasive species on the Kramer Palouse Natural Area, a remnant of the Palouse Prairie in southeastern Washington under the ownership of Washington State University. Restoration efforts are underway to suppress yellow starthistle to restore the vegetation to its natural native character. In other North American western regions, prescribed burning is considered a viable suppression treatment when applied in consecutive years before seed dispersal (mid-summer). This treatment significantly and progressively depletes soil seed banks of yellow starthistle. In the Palouse Region of southeastern Washington, however, prescribed burning in mid-summer is unfeasible because of strict state and county burn restrictions and the proximity of small native prairie remnants to grain crops. Experimental burns utilizing a randomized complete block – split plot design were initiated in 2013 to examine the efficacy of fall burning to suppress yellow starthistle on the natural area. The objectives were to maximize litter reduction and soil heating to eliminate yellow starthistle seed banks in the litter and surface soil layers. The results of the experimental burns demonstrated the following. The density of yellow starthistle plants on burned sites were substantially reduced in comparison to unburned sites, however, residual plants regenerated from soil seed banks on all burned sites. Although yellow starthistle plant density was reduced, the individual plants that did regenerate on the burned area were taller with broader crowns with more branching and more floral heads per plant. Fire stimulated earlier germination of residual yellow starthistle seed in the fall in comparison to unburned areas. Fall burning created a significant amount of bare ground with the potential of greater incidence of soil surface disturbance by over-winter frost heaving. Annual grass abundance was reduced on all burn sites by 90+% which substantially reduced fuel loads in the following year for an effective re-burn of the infested sites. The growth response of native plants to fire on burned sites was significantly more vigorous in comparison to unburned sites.

LIMITED IRRIGATION IN WINTER WHEAT FOR REDUCING AGRICULTURAL WATER USE IN THE NORTHWEST CHINA. Zhen Zheng, College of Water Resources and Architectural Engineering, Northwest A&F University, Yangling, Shaanxi, 712100, China; Huanjie Cai, Key Laboratory for Agricultural Soil and Water Engineering in Arid Area of Ministry of Education, Northwest A&F University, Yangling, Shaanxi, 712100, China; Lianyu Yu, Institute of Water Saving Agriculture in Arid Areas of China, Northwest A&F University, Yangling, Shaanxi, 712100, China; Gerrit Hoogenboom, AgWeatherNet, Washington State University – Prosser, Prosser, WA 99350-8694; *xuechun.wang@wsu.edu*

Limited precipitation and water shortage is the main limitation that restricts yield of winter wheat (*Triticum aestivum L.*) grown in arid and semi-arid areas in Northwest China. Enhancing wheat productivity in water-limited environments with inadequate precipitation is challenging, hence it is important to develop water management practices to use less water and maintain a high crop yield. Regulated deficit irrigation method has been applied to improve the crop water use efficiency (WUE) without significant yield reduction. The objectives of this study were to (1) investigate the effect of spatial deficit irrigation on winter wheat of different stages on crop biomass, yield and WUE in Guanzhong Plain, (2) to determine the optimum deficit irrigation levels at different growth periods. Data were obtained from four irrigation experiments under a rain-out shelter and in the field in 2011-2012 and 2012-2013; all weret conducted on a clay loam soil during different growing stages of winter wheat at Guanzhong Plain in Northwest China. Three irrigation levels were set as 100%, 80% and 60% of evaportranspiration (ET_o) respectively and the irrigation times were applied at four different growing stages of winter wheat. Soil water content, crop growth, above-ground biomass, yield and yield components were measured. Results showed that the end of the booting stage or beginning of heading stage were more sensitive stage to water deficit, with reductions in biomass, yield and WUE. Yield reduction was mainly due to a lower number of spike densities per square meter. Deficit irrigation or higher intervals between irrigation at the trefoil stage did not significantly affect crop growth and yield. Combining the results obtained from the shelter and field regarding grain yield and WUE, it can be concluded that the treatment with severe water stress at trefoil and jointing phases and mild drying soil water content at heading stages results in high grain yield and WUE under the rain-out shelter, while the treatment in the field with high planting density and middle level water amount lead to a significantly high yield and WUE, which could offer a guideline for developing deficit irrigation regimes in Northwest China.

AFTER THE ASH FALLS…--PLANT RESPONSES TO VOLCANIC TEPHRA. Don Zobel, Oregon State University, Department of Botany and Plant Pathology, 2082 Cordley Hall, Corvallis, OR 97330; Joe Antos, University of Victoria, Biology Department, Victoria BC, Canada V8W 2Y2; *zobeld@science.oregonstate.edu.*

Deposition of tephra (aerially transported volcanic material) is the most frequent and widespread volcanic disturbance. Because effects of tephra were less dramatic than those of other disturbances from the 1980 eruption of Mount St. Helens, its effects might be considered insignificant. Our 30-year study of effects of tephra on forest understory plants demonstrates, however, that (1) tephra can damage vegetation severely, with long-term consequences; (2) many factors influence the effects of tephra; and (3) there are clear interactions between these factors and tephra disturbance. Several major lessons come from our studies in four subalpine old-growth conifer forests that received 4-15 cm of tephra. Many plants were killed, especially those shorter than the tephra depth. Four cm of tephra killed bryophytes and some herbs; 15 cm killed most herbs. Tephra deposited on snowpack also killed many shrubs and tree seedlings. Sensitivity of plants to tephra varied with seasonal stages of growth. Decades later, plant importance was still correlated with the degree of damage and sometimes was well below pre-disturbance levels. Early erosion of tephra increased survival. Within a growth form, response to tephra varied among species, in part related to a species' habitat breadth. Recovery of plant importance was enhanced by a species' long-term survival and growth-form plasticity during burial and by its ability to penetrate tephra. Success after burial involved vegetative expansion of survivors without seedling establishment, seedling establishment of species without survivors, and combinations of seedling and vegetative establishment. Differences in seed dispersal and in effectiveness of the pathway from flowers to seedlings were sometimes important. The net effect was that, in some aspects, the trajectory of vegetation change was toward a community different than that before the eruption.

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