PROGRAM AND ABSTRACTS

NORTHWEST SCIENTIFIC ASSOCIATION
81ST ANNUAL MEETING

University of Washington
Seattle, Washington
25-28 March 2009

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Program and Abstracts
Northwest Scientific Association
81st Annual Meeting

University of Washington
Seattle, Washington

March 25-28, 2009

Held in Cooperation with:

University of Washington
College of Forest Resources
Earth and Space Sciences
Burke Museum of Natural History and Culture
Elwha River Consortium
Northwest Lichenologists

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LOCAL PROGRAM COMMITTEE

Katherine Glew, Chair
Lichen Collections WTU Herbarium, UW-HHMI Biology
University of Washington
Northwest Scientific Association

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Mt. Baker-Snoqualmie National Forest
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Steve Rust
Northwest Institute on Plant Community Restoration
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Ellen Matheny
Olympic Natural Resources Center
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Additional Information available on the Northwest Science Association webpage
http://www.vetmed.wsu.edu.org_nws/NWsci_Home.htm

LETTER FROM THE PRESIDENT

Northwest Scientific Association

...promoting scientific research and disseminating scientific knowledge since 1923.
http://www.vetmed.wsu.edu/org_NWS/NWSci_Home.htm

March 25, 2009

Welcome to the 81st Annual Meeting of Northwest Scientific Association! Thank you for choosing to support Northwest Scientific Association by attending the 81st Annual Meeting.

Formed in 1923, the Association is dedicated to serving the scientific community of the northwestern United States and western Canada through three primary activities: (1) convening an annual meeting which offers scientists opportunity to share research findings, (2) supporting student research through a small grant competition, and (3) disseminating scientific knowledge through publication of our quarterly journal, *Northwest Science*. The work of the Association is entirely supported by its members - there is no paid staff.

Through honorary awards the Association also works to recognize excellence in science and service. Individuals that have contributed to the Association in the past are your teachers and mentors. We all owe them a great deal of thanks. You can contribute to this legacy and help build the future of Northwest Scientific Association by providing leadership through service on the Association's board of directors. If this (or other volunteer opportunities) interests you, please do not hesitate to contact any member of the current board to find out more. These positions are open to all members of the Association.

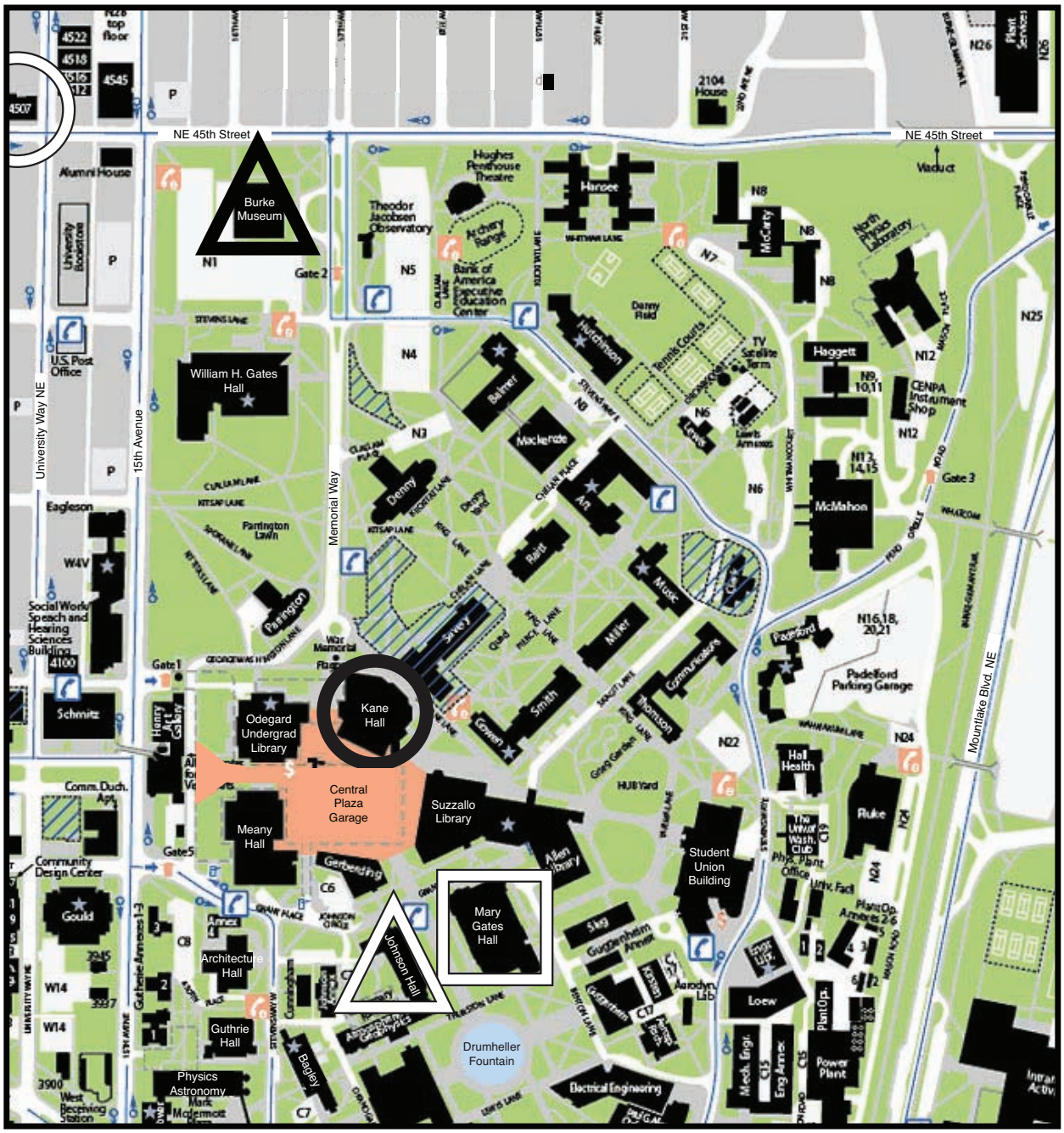
I would like to give special thanks to Dr. Katherine Glew, this year's annual meeting planning committee chair. After serving two consecutive three-year terms on the board of directors - many years as chair of the student grants committee - Katie is serving as honorary board member this year to lead the effort to host the 81st annual meeting here at University of Washington. As should be expected there are many others to thank as well: planning committee members, symposia organizers, session moderators, program sponsors, and the many presenters.

The annual meeting is a natural time of change - when members of the board of directors change positions, welcome new members, and form a new team. My whole hearted thanks to those that have served on this year's board of directors: Bax Barton, University of Washington; Doug Call, Washington State University; Jana Compton, US Environmental Protection Agency; Lori Daniels, University of British Columbia; Jeff Duda, US Geological Survey; Kevin Feris, Boise State University; Katie Glew, University of Washington; Nancy Grunewald, Washington State University Press; Mark Harmon, Oregon State University; Judy Harpel, University of Washington; Robin Lesher, USDA Forest Service; Elizabeth Nesbitt, University of Washington; Pat Pringle, Centralia College; Allen Sullivan, Yakima Training Center; and Kathy Goetz Troost, University of Washington.

Most of all, I invite you to enjoy yourself while attending the annual meeting. The University of Washington campus is beautiful in spring. Seattle is a great place - rain or shine. Have fun! Enjoy the company of old friends and new acquaintances.

Sincerely,
Steven K. Rust, President
Northwest Scientific Association

CONFERENCE SITE MAP



PROGRAM AT A GLANCE

WEDNESDAY, MARCH 25TH

4:00pm – 10:00 pm	**Registration:** Hotel Deca Lobby, 4507 Brooklyn Ave NE
4:30pm – 6:30 pm	**Northwest Scientific Association Board Meeting:** Executive Board Room, Hotel Deca
6:30pm – 10:00pm	**Evening Social**: Governor Room, Hotel Deca

THURSDAY, MARCH 26TH

7:30am – 12:00am	**Registration:** Kane Hall Lobby, University of Washington
8:30am – 8:45 am	**Welcome and Introduction:** Steve Rust, Katherine Glew, Kane Hall 120
8:45am – 9:45 am	**Plenary Session Key Note Address:** Brian Fagan, Kane Hall 120
9:45am – 10:15am	**Morning Break:** Kane Hall Lobby
10:15am – 12:00am	**Plenary Session:** Kane Hall 120
12:00pm – 4:00pm	**Registration:** Mary Gates Hall Commons
12:00pm – 1:20pm	**Lunch:** (on your own)
1:00pm – 2:40pm	**Poster Session Setup:** Mary Gates Hall Commons
1:20pm – 2:40pm	**Symposium:** Forest Science for the Future, Johnson Hall 102 **Concurrent Session:** Johnson Hall 075 **Workshop:** NW Lichenologists - Crusts on Rocks and Other Problematic Collections, Hitchcock Hall 226
2:40pm – 3:20pm	**Afternoon Break:** Mary Gates Hall Commons
3:20pm – 5:00pm	**Symposium:** Forest Science for the Future, Johnson Hall 102 **Concurrent Session:** Johnson Hall 075 **Workshop:** NW Lichenologists - Crusts on Rocks and other Problematic Collections, Hitchcock Hall 226 **Attended Poster Session:** Mary Gates Hall Commons Authors available for discussion/questions.
6:00 – 7:00 pm	**Social Hour:** Hosted Bar, Appetizers, and Exhibit Viewing Burke Museum of Natural History and Culture
7:00 – 10:00 pm	**Banquet:** Burke Museum of Natural History and Culture Speaker: Cliff Mass, Professor of Atmospheric Sciences and author of “The Weather of the Pacific Northwest”

FRIDAY, MARCH 27TH

7:30am – 12:00am **Registration:** Mary Gates Hall Commons

8:00am – 10:00am **Symposium:** Assembling the Geologic History of the Pacific Northwest, Johnson Hall 102
Concurrent Sessions: Johnson Hall 022, 075, 111, 175
Poster Session: Mary Gates Hall Commons

10:00am – 10:40am **Morning Break:** Mary Gates Hall Commons

10:40am – 12:00am **Symposium:** Assembling the Geologic History of the Pacific Northwest, Johnson Hall 102
Concurrent Sessions: Johnson Hall 022, 075, 175
Lichen Forum: Contracting for Lichen Survey Work, Johnson 111
Poster Session: Mary Gates Hall Commons

12:00pm – 1:20pm **Northwest Scientific Association Annual Membership Meeting and Luncheon:** Mary Gates Hall Commons

1:20pm – 2:40pm **Symposium:** Assembling the Geologic History of the Pacific Northwest, Johnson Hall 102
Symposium: Elwha River Restoration Project, Johnson Hall 075
Concurrent Sessions: Johnson Hall 022, 111, 175
Poster Session: Mary Gates Hall Commons

2:40pm – 3:20pm **Afternoon Break:** Mary Gates Hall Commons

3:20pm – 4:00pm **Poster Session Take Down:** Mary Gates Hall Commons

3:20pm – 5:00pm **Symposium:** Elwha River Restoration Project, Johnson Hall 075
Concurrent Sessions: Johnson Hall 102, 111, 175

SATURDAY, MARCH 28TH – Field Trips: Meeting Times and Locations

7:30am Northwest Lichenologists
Valley of the South Fork Stillaguamish River

9:00am Puget Lowland Botany and Bryophyte Walk
Shadow Lake Bog, King County

TBA Geology of the Seattle Area

8:00am Natural Areas in King County

10:00am Washington Park Arboretum / UW Botanic Gardens
Graham Visitor Center - Washington Park Arboretum

10:00am Burke Museum - Behind the Scenes
Burke Museum of Natural History and Culture

SESSION SCHEDULE
THURSDAY, MARCH 26

SESSION 1: PLENARY SESSION: HISTORICAL CHANGES IN CLIMATE AND ENVIRONMENT
ROOM: KANE HALL 120
MODERATOR: PATRICK PRINGLE

8:30 **WELCOME and INTRODUCTION.** Steve Rust and Katherine Glew

8:45 **KEYNOTE ADDRESS**:
THE GREAT WARMING, OR THE STORY OF THE SILENT ELEPHANT IN THE ROOM – Brian Fagan, University of California, Santa Barbara CA.

10:15 **ONE MILLION YEARS OF GLACIERS AND THE ORIGIN OF PUGET SOUND** – Derek B. Booth, University of Washington and Stillwater Sciences Inc., Seattle WA.

11:00 **VEGETATION HISTORY OF WESTERN WASHINGTON** – Jan A. Henderson, USDA Forest Service, Mt. Baker-Snoqualmie National Forest, Everett WA.

SESSION 2: FOREST SCIENCE FOR THE FUTURE SYMPOSIUM
ROOM: JOHNSON HALL 102
MODERATOR: ROBERT EDMONDS

1:20 **WHAT FOREST RESEARCH MIGHT BE RELEVANT IN AN ERA OF INSTABILITY AND SURPRISE?** – Jerry Franklin, College of Forest Resources, University of Washington, Seattle WA.

2:00 **ASSESSING POTENTIAL CLIMATE IMPACTS ON SPECIES AND POPULATIONS** Joshua Lawler, College of Forest Resources, University of Washington, Seattle WA.

3:20 **PLANT GROWTH-PROMOTING BACTERIA OF BIOENERGY CROP PLANTS** Sharon Doty, College of Forest Resources, University of Washington, Seattle WA.

4:00 **OPPORTUNITIES AND BARRIERS TO USING FOREST BASED BIOMASS FOR THE PRODUCTION OF RENEWABLE ENERGY AND RENEWABLE FUELS** – Rick Gustafson, Larry Mason, John Calhoun, Bruce Lippke, and Natalia Raffaeli, College of Forest Resources, University of Washington, Seattle WA.

SESSION 3: RESTORATION ECOLOGY
ROOM: JOHNSON HALL 075
MODERATOR: JONATHAN BAKKER

1:20 **RESTORATION OF NATIVE PLANT COMMUNITIES AFTER ROAD DECOMMISSIONING IN THE NORTHERN ROCKY MOUNTAINS** – Ashley S. Grant and Cara R. Nelson, College of Forestry and Conservation, University of Montana, Missoula MT.

1:40 **RECONSTRUCTION OF OLD-GROWTH FOREST STAND STRUCTURE AND COMPOSITION FOR TWO STANDS HARVESTED AROUND 1930 ON THE OLYMPIC PENINSULA, WASHINGTON** – David H. Peter and Constance A. Harrington, USDA Forest Service, Pacific Northwest Research Station, Olympia WA.

2:00 **GARRY OAK RESTORATION: SEEDLING RESPONSES TO POST-PLANTING TREATMENTS IN CENTRAL WASHINGTON** – Laura Blume and Jonathan D. Bakker, College of Forest Resources, University of Washington, Seattle WA.

2:20 **RESTORING FOREST HEALTH IN WASHINGTON STATE PARKS** – Robert Fimbel and Tom Ernsberger, Stewardship, Washington State Parks, Olympia WA.

3:20 **RESTORATION OF WESTERN OREGON MONTANE MEADOWS FOLLOWING CONIFER INVASION** – Charles B. Halpern and Ryan D. Haugo, College of Forest Resources, University of Washington, Seattle WA.

3:40 **THE EFFECTS OF TWO FORMS OF CARBON ON A NON-NATIVE GRASSLAND PLANT COMMUNITY** – Rachel Mitchell and Jonathan D. Bakker, College of Forest Resources, University of Washington, Seattle WA.

4:00 **TOWARDS RECOVERY OF GOLDEN PAINTBRUSH: MONITORING AND OUTPLANTING SITE SELECTION** – Peter W. Dunwiddie, The Nature Conservancy, Seattle WA; Joseph L. Arnett, Washington Department of Natural Resources, Natural Heritage Program, Olympia WA.

4:20 **THE IMPACT OF MULTIPLE SEVERE WILDFIRES ON SAGEBRUSH STEPPE VEGETATION** – Jonathan D. Bakker, Eva Dettweiler-Robinson, G. Matt Davies, College of Forest Resources, University of Washington, Seattle WA; Peter Dunwiddie, Jim Evans, The Nature Conservancy, Seattle WA; Sonia A. Hall, The Nature Conservancy, Wenatchee WA; Janelle Downs, Pacific Northwest National Laboratory, Richland WA; Michael Marsh, Washington Native Plant Society, Seattle WA.

SESSION 4: LICHEN WORKSHOP
ROOM: HITCHCOCK HALL 226
MODERATOR: Katherine Glew and Richard Droker

1:20 **CRUSTS ON ROCKS AND OTHER PROBLEMATIC COLLECTIONS**

PROGRAM OVERVIEW
THURSDAY, MARCH 26

Time	Kane Hall 120	Johnson Hall 102	Johnson Hall 075	Hitchcock Hall 226	Mary Gates Hall Commons
8:00-10:00	Registration (7:30-8:00) Welcome and Introductions (8:30) **SESSION 1**				
10:00-10:40	Plenary Session (8:45-12:00)				
10:40-12:00					
12:00-1:20	**LUNCH**				**Registration**
1:20-2:40		**SESSION 2** Forest Science for the Future Symposium	**SESSION 3** Restoration Ecology	**SESSION 4** Lichen Workshop	**SESSION 17** Poster Session setup
2:40-3:20	**BREAK**				
3:20-5:00		**SESSION 2** Forest Science for the Future Symposium	**SESSION 3** Restoration Ecology		
6:00-10:00	Social Hour and Banquet at Burke Museum of Natural History and Culture				

SESSION SCHEDULE
FRIDAY, MARCH 27

SESSION 5: ASSEMBLING THE GEOLOGIC HISTORY OF THE PACIFIC NORTHWEST SYMPOSIUM
ROOM: JOHNSON HALL 102
MODERATOR: KATHY TROOST

8:00 **THE CHIWAUKUM STRUCTURAL LOW: CENOZOIC SHORTENING OF THE CENTRAL CASCADE RANGE, WASHINGTON STATE, USA** – E.S. Cheney, Department of Earth and Space Sciences, University of Washington, Seattle, WA; Nicholas W. Hayman, University of Texas, Institute for Geophysics, Jackson School of Geosciences, Austin TX.

8:40 **DIVERSE EOCENE MAGMATISM AND EXTENSION ACROSS THE PACIFIC NORTHWEST: IS THERE A UNIFYING EXPLANATION?** – Jeffrey H. Tepper and Kenneth P. Clark, Geology Department, University of Puget Sound, Tacoma WA.

9:20 **LATEST UNDERSTANDING OF THE LATE PLEISTOCENE GLACIATION IN THE CENTRAL PUGET LOWLAND** – Kathy Goetz Troost, The Pacific Northwest Center for Geologic Mapping Studies, Dept. of Earth and Space Sciences, University of Washington, Seattle WA.

10:40 **THE PUGET-LOBE 2-STEP: A CLOSE TANGO BETWEEN RELATIVE SEA LEVEL AND GLACIER ADVANCE AND RETREAT AT THE END OF THE PLEISTOCENE IN NORTHWEST WASHINGTON** – Douglas H. Clark, Geology Dept., Western Washington University, Bellingham, WA; Eric J. Steig, Dept. Earth and Space Sciences, University of Washington, Seattle WA.

11:20 **DEGLACIATION OF THE SOUTHERN SALISH LOWLAND** – Ralph A. Haugerud, U.S. Geological Survey c/o Dept. Earth & Space Sciences, University of Washington, Seattle WA.

1:20 **HOLOCENE BURIED AND SUBMERGED FORESTS OF WASHINGTON AND OREGON—TIME CAPSULES OF GEOLOGIC, ENVIRONMENTAL, AND CLIMATE HISTORY** – Patrick Pringle, Science Dept., Centralia College, Centralia WA.

2:00 **HOLOCENE HISTORY OF ALPINE GLACIATION IN THE PACIFIC NORTHWEST** Jon L. Riedel, National Park Service, North Cascades National Park, Marblemount WA.

SESSION 6: LARGE WILDFIRES IN THE PACIFIC NORTHWEST
ROOM: JOHNSON 075
MODERATOR: JESSICA HALOFSKY

8:00 **LOST GROUND: SOIL C AND N DECREASES ASSOCIATED WITH THE BISCUIT WILDFIRE** – Peter Homann, Department of Environmental Sciences, Western Washington University, Bellingham WA; Bernard Bormann, Pacific Northwest Forest Research Station, Corvallis OR; Brett Morrissette, Oregon State University, Forestry Sciences Laboratory, Corvallis OR; Robyn Darbyshire, USFS Gold Beach Ranger District, Brookings OR.

8:20 **MANAGING SOIL EROSION AFTER LARGE WILDFIRES: SEEDING AND FERTILIZATION EFFECTS ON SOIL COVER AND VEGETATION RECOVERY** – David W. Peterson and Erich K. Dodson, Pacific Northwest Research Station, USDA Forest Service, Wenatchee WA.

8:40 **PLANT COMMUNITY DYNAMICS FOLLOWING WILDFIRE AND RESTORATION TREATMENTS IN THE TIMBERED ROCK FIRE** – Lori Kayes, Klaus Puettmann, Department of Forest Ecosystems and Society, Oregon State University, Corvallis OR; Paul Anderson, Pacific Northwest Research Station, USDA Forest Service, Corvallis OR.

9:00 **STAND DYNAMICS AND FIRE SEVERITY IN MANAGED DRY FORESTS OF THE EASTSIDE CASCADE RANGE, WASHINGTON** – Christina Lyons-Tinsley, College of Forest Resources, University of Washington, SeattleWA; David L. Peterson, USDA Forest Service, Pacific Northwest Research Station, Seattle WA.

9:20 **FIRE SEVERITY AND POST-FIRE VEGETATION RECOVERY IN RIPARIAN AREAS OF TWO OREGON FIRES** – Jessica Halofsky and David Hibbs, Department of Forest Ecosystems and Society, Oregon State University, Corvallis OR.

9:40 **EFFECTS OF A CENTURY OF FIRE SUPPRESSION ON RIPARIAN FORESTS OF SOUTHWESTERN OREGON** – Michael Messier and David Hibbs, Oregon State University, Corvallis OR.

10:40 **TWENTY YEARS OF RECOVERY AFTER FIRE IN THE KLAMATH-SISKIYOUS** – David Hibbs, Department of Forest Ecosystems and Society, Oregon State University, Corvallis OR; Jeff Shatford, Wood Buffalo National Park of Canada, Fort Smith, Northwest Territories; Maria Lopez, Veteranos del 70, Asuncion, Paraguay.

11:00 **HABITAT SELECTION OF NORTHERN SPOTTED OWLS FOLLOWING WILDFIRE IN SOUTHWESTERN OREGON** – Darren Clark, Robert Anthony, and Steve Andrews, Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis OR.

11:20 **WATERSHED-SCALE MAPPING OF FIRE SEVERITY IN A MIXED-SEVERITY REGIME** – Karen Kopper, North Cascades National Park, Marblemount, WA; Donald McKenzie, Pacific Wildland Fire Sciences Laboratory, Seattle WA.

11:40 **THE STRUCTURE OF NATIVE LANDSCAPE RESILIENCE AND ITS SPATIAL CONTROLS** – Paul F. Hessburg and Nicholas A. Povak, USDA Forest Service, Pacific Northwest Research Station, Wenatchee WA.

SESSION 7: LICHENOLOGY / BRYOLOGY
ROOM: JOHNSON 111
MODERATOR: Erin Martin

8:40 **OBSERVATIONS ON THE DISJUNCT POPULATION OF THE RARE AND ENDANGERED BOREAL FELT LICHEN *(ERIODERMA PEDICELLATUM)* IN SOUTHCENTRAL ALASKA** – Peter Nelson, Department of Botany and Plant Pathology, Oregon State University, Corvallis OR and Central Alaska Network, National Park Service, Denali Park AK; Christoph Scheidegger, Swiss Federal Institute for Forest, Snow and Landscape Research, Birmensdorf, Switzerland; James Walton, Central Alaska Network, National Park Service, Denali Park AK.

9:00 **MACROLICHEN DIVERSITY IN NOATAK NATIONAL PRESERVE, ALASKA** – Bruce McCune, Emily Holt, Dept. Botany and Plant Pathology, Oregon State University, Corvallis OR; Peter Neitlich, National Park Service, Winthrop WA; Teuvo Ahti, Botanical Museum, Helsinki University, Finland; and Roger Rosentreter, Bureau of Land Management, Boise ID.

9:20 **WHAT CAN SEATTLE'S CEDAR RIVER WATERSHED TELL US ABOUT LICHEN DIVERSITY?** – Katherine Glew**,** Lichen Collection, Herbarium, Seattle WA.

9:40 **THE STATUS OF LICHEN CONSERVATION IN CALIFORNIA** – Erin P. Martin, Pacific University, Department of Biology, Forest Grove OR, and California Lichen Society, San Francisco CA; Eric Peterson, Tom Carlberg, California Lichen Society, San Francisco CA.

SESSION 8: ECOLOGY AND RESOURCE MANAGEMENT
ROOM: JOHNSON HALL 175
MODERATOR: JOSEPH ARNETT

8:20 **USING THE CAMPUS AS A LIVING LABORATORY FOR SUSTAINABILITY STUDIES** Jill Whitman, Rose McKenney and Claire Todd, Department of Geosciences, Pacific Lutheran University, Tacoma WA.

8:40 **SPATIAL AND TEMPORAL PATTERNS OF SEDIMENT RESUSPENSION IN URBAN STORMWATER DETENTION PONDS** – Katherine K. Norton and J. Alan Yeakley, Environmental Science and Management, Portland State University, Portland OR.

9:00 **WHERE IS THE RAIN-ON-SNOW ZONE IN THE WEST-CENTRAL WASHINGTON CASCADES? MONTE CARLO SIMULATION OF LARGE STORMS IN THE PACIFIC NORTHWEST** – Matthew J. Brunengo, Geology Department, Portland State University, Portland OR.

9:20 **USING LIDAR FOR MULTI-SCALED ASSESSMENTS OF FOREST STRUCTURE** Van R. Kane, James A. Lutz, Jonathan D. Bakker, Jerry Franklin, College of Forest Resources, University of Washington, Seattle WA; Robert McGaughey, Pacific Northwest Research Station, USDA Forest Service, University of Washington, Seattle WA, and Rolf Gersonde, Watershed Services Division Seattle Public Utilities, North Bend WA.

9:40 **BACK TO THE FUTURE: BIOLOGICAL, DISTURBANCE, LANDSCAPE, GEOGRAPHIC, ARCHAEOLOGICAL, AND HISTORIC LEGACIES FROM RAILROAD LOGGING—50 TO 130 YEARS OF POST DISTURBANCE RECOVERY ACROSS NORTH AMERICA** – Erik Piikkila, Railroad Logging Legacies Project, Victoria BC.

10:40 **A COMPARISON OF LANDSCAPE-LEVEL PATTERNS IN THE DEMOGRAPHY AND DISTRIBUTION OF TREE SPECIES IN CENTRAL ALASKA – EVIDENCE FOR WIDESPREAD MORTALITY AND RECOVERY OF TAMARACK (*Larix laricina*) FROM A RECENT LARCH SAWFLY OUTBREAK** – Carl Roland, National Park Service, Fairbanks AK.

11:00 **A POTENTIAL HABITAT MODEL FOR SALAL *(GAULTHERIA SHALLON)* FOR THE OLYMPIC NATIONAL FOREST, WASHINGTON** – Robin Lesher, Jan Henderson and Chris Ringo, USDA Forest Service, Mt. Baker-Snoqualmie National Forest, Everett WA.

11:20 **STATUS AND DISTRIBUTION OF TREE VOLES IN THE COLUMBIA RIVER GORGE AND NORTHWEST OREGON –** James Swingle, Department of Fisheries and Wildlife, Oregon State University, Corvallis OR; Eric Forsman, USDA Forest Service, Pacific Northwest Research Station, Corvallis OR; Michael McDonald, Nicholas Hatch, and Scott Graham, Department of Fisheries and Wildlife, Oregon State University, Corvallis OR.

11:40 **IMPACTS OF MANAGING PUBLIC LANDS FOR LIVESTOCK PRODUCTION** Michael Marsh, Washington Native Plant Society, Seattle WA.

SESSION 9: VEGETATION CLASSIFICATION AND WORKSHOP
ROOM: JOHNSON HALL 022
MODERATOR: REX CRAWFORD

8:00 **BENTON COUNTY SHRUB-STEPPE COMMUNITIES—ECOSYTEMS SHAPED BY HUMAN AND NATURAL FORCES** – Michael Marsh, Washington Native Plant Society, Seattle WA.

8:20 **CLASSIFICATION OF CRATERS OF THE MOON PLANT COMMUNITIES: ASSESSING BOUNDARIES BETWEEN THE GOOD, BAD, AND UGLY** – Steven K. Rust, Northwest Institute on Plant Community Conservation, Boise ID.

8:40 **PLANT COMMUNITIES OF LAKE ROOSEVELT NATIONAL RECREATION AREA, WASHINGTON** – Steven K. Rust, Northwest Institute on Plant Community Conservation, Boise ID.

9:00 **STATUS OF THE INTERNATIONAL VEGETATION CLASSIFICATION AND ITS APPLICATION TO THE WASHINGTON NATURAL HERITAGE STATEWIDE CLASSIFCATION** – Rex C. Crawford and F. Joseph Rocchio, Natural Heritage Program, Washington Dept. Natural Resources, Olympia WA.

SESSION 10: LICHEN FORUM AND DISCUSSION
ROOM: JOHNSON HALL 111
MODERATOR: John Villella

10:40 Contracting for Lichen Survey Work

SESSION 11: BOTANY
ROOM: JOHNSON HALL 022
MODERATOR: TRACY FUENTES

10:40 **TAXONOMIC IMPLICATIONS OF DNA PLOIDY DISTRIBUTION PATTERNS IN THE NORTH AMERICAN *CREPIS AGAMIC* COMPLEX AS INFERRED FROM FLOW CYTOMETRY CONDUCTED ON DRIED LEAF MATERIAL** – Chris Sears and Jeannette Whitton, Department of Botany, University of British Columbia, Vancouver, BC.

11:00 **USE OF CONSERVATION DETECTION DOGS FOR SURVEYS OF A THREATENED PRAIRIE PLANT, KINCAID'S LUPINE *(LUPINUS SULPHUREUS SSP. KINCAIDII)*** David G. Vesely, Oregon Wildlife Institute, Corvallis OR; Deborah A. Smith and Alice Whitelaw, Working Dogs for Conservation Foundation, Three Forks MT; Greg Fitzpatrick, The Nature Conservancy, Corvallis OR.

11:20 **RARE *CAREX CONSTANCEANA* REDISCOVERED AND REASSESSED** – Barbara L. Wilson, Richard E. Brainerd, Nick Otting, *Carex* Working Group, Eugene OR; Andrew Hipp, Morton Arboretum, Lisle, IL; Peter Zika, WTU Herbarium, University of Washington, Seattle WA.

11:40 **HIMALAYAN BLACKBERRY INVASION UNDER SEASONALLY FLUCTUATING WATER AVAILABILITY CONDITIONS** – Josh Caplan and Alan Yeakley, Environmental Sciences, Portland State University, Portland OR.

SESSION 12: ELWHA RIVER RESTORATION PROJECT SYMPOSIUM
ROOM: JOHNSON HALL 075
MODERATOR: JEFFREY DUDA

1:20 **FROM THE HEADWATERS TO THE SEA: A RIVERSCAPE PERSPECTIVE ON DISTRIBUTION AND ABUNDANCE PATTERNS OF FISH COMMUNITIES IN THE ELWHA RIVER PRIOR TO DAM REMOVAL** – Jeffrey Duda, U.S. Geological Survey, Western Fisheries Research Center, Seattle WA; Sam Brenkman, National Park Service, Olympic National Park, Port Angeles WA; Roger Peters, U.S. Fish and Wildlife Service, Western Washington Fisheries Division, Lacey WA; Christian Torgersen and Ethan Welty, U.S. Geological Survey, Cascadia Field Station, Seattle WA; George Pess, NOAA Northwest Fisheries Science Center, Seattle WA; and Mike McHenry, Lower Elwha Klallam Tribe, Port Angeles WA.

1:40 **EFFECTS OF SALMON CARCASSES ON RIVERINE FOOD WEBS: AN EXPERIMENTAL FIELD STUDY ON THE ELWHA RIVER** – Sarah Morley, Holly Coe, Northwest Fisheries Science Center, NOAA, Seattle WA; Jeffrey Duda, U.S. Geological Survey, Western Fisheries Research Center, Seattle WA; Michael McHenry, Lower Elwha Klallam Tribe, Port Angeles WA.

2:00 **RESPONSE OF RIPARIAN WILDLIFE COMMUNITIES TO RESTORATION OF ANADROMOUS FISH IN THE ELWHA RIVER ECOSYSTEM** – Kurt Jenkins, USGS Forest and Rangeland Ecosystem Science Center, Olympic Field Station, Port Angeles WA; Nathan Chelgren, Michael Adams, Steve Perakis, USGS Forest and Rangeland Ecosystem Science Center, Corvallis OR; Kim Sager-Fradkin, Lower Elwha Klallam Tribe, Port Angeles WA; Patricia Happe, Olympic National Park, Port Angeles WA.

2:20 **SEDIMENT TRANSPORT AND FLUVIAL GEOMORPHOLOGY ON THE ELWHA RIVER** – Christopher A. Curran, U.S. Geological Survey, Tacoma WA; Amy E. Draut, U.S. Geological Survey, Santa Cruz CA; Christopher S. Magirl, U.S. Geological Survey, Tacoma WA.

3:20 **PREDICTING THE RIPARIAN VEGETATION RESPONSE TO DAM REMOVAL ON THE ELWHA RIVER** – James Michel and James Helfield, Huxley College of the Environment, Western Washington University, Bellingham WA.

3:40 **USING MODERN PROCESSES TO UNDERSTAND POSTGLACIAL DELTA EVOLUTION: ELWHA RIVER DELTA** – Kristen M. Lee, Andrea S. Ogston, Charles A. Nittrouer, Department of Oceanography, University of Washington, Seattle WA.

4:00 **ALONGSHORE MOVEMENT OF COARSE BEACH MATERIAL ADJACENT TO THE ELWHA RIVER MOUTH, STRAIT OF JUAN DE FUCA, WASHINGTON** – Ian Miller, Department of Ocean Sciences, UC Santa Cruz, Santa Cruz CA; Jon Warrick, U.S. Geological Survey, Coastal and Marine Geology, Santa Cruz CA; Guy Gelfenbaum, U.S. Geological Survey, Coastal and Marine Geology, Menlo Park CA; Gary Griggs, Department of Earth and Planetary Science, UC Santa Cruz, Santa Cruz CA; Chris Morgan, Olympic Park Institute, Port Angeles WA.

4:20 **RESTORATION OF SEDIMENT PROCESSES RESULTING FROM REMOVAL OF ELWHA RIVER DAMS: DEVELOPING BASELINE DATA AND REFERENCE AREAS TO MONITOR FISH RESPONSES IN NEAR COASTAL HABITATS** – Kurt Fresh, Josh Chamberlin, Anna Kagley, NOAA Fisheries, NWFSC, Seattle WA; Larry Ward, Lower Elwha Fisheries Office, Port Angeles WA; Nichole Sather, PNNL, Department of Energy, Sequim WA; Anne Shaffer, WDFW, Habitat Program, Port Angeles WA.

4:40 **SCUBA SURVEYS TO CHARACTERIZE NEARSHORE BIOLOGICAL COMMUNITIES PRIOR TO REMOVAL OF THE ELWHA RIVER DAMS** – Steve Rubin, U.S. Geological Survey, Western Fisheries Research Center, Seattle WA; Ian Miller, Ocean Sciences Department, University of California Santa Cruz, Santa Cruz CA; Nancy Elder, U.S. Geological Survey, Western Fisheries Research Center, Nordland WA; Reg Reisenbichler, Jeff Duda, U.S. Geological Survey, Western Fisheries Research Center, Seattle WA.

SESSION 13: PACIFIC NORTHWEST FUNGI IN A CHANGING ENVIRONMENT
ROOM: JOHNSON HALL 111
MODERATOR: DEAN GLAWE

1:20 **RATES OF DISCOVERY OF NEW HOST-FUNGUS RECORDS IN THE PACIFIC NORTHWEST: EXAMPLES FROM THE PALOUSE REGION OF NORTHERN IDAHO AND EASTERN WASHINGTON** – Frank M. Dugan, USDA-ARS Western Regional Plant Introduction Station, Washington State University, Pullman WA.

1:40 **DIVERSITY OF POWDERY MILDEWS IN THE PACIFIC NORTHWEST AND IMPLICATIONS FOR ESTIMATING SPECIES DIVERSITY OF OTHER FUNGAL GROUPS** – D.A. Glawe, Department of Plant Pathology, Washington State University and College of Forest Resources, University of Washington, Seattle WA.

2:00 **PALE SPORED MEMBERS OF THE FAMILY AGARICACEAE (=LEPIOTACEAE) IN WESTERN WASHINGTON** – Joshua M. Birkebak, University of Washington, Department of Biology, Seattle WA.

2:20 **THE RELATIONSHIP BETWEEN MACRO-FUNGUS SPECIES RICHNESS AND WEATHER DATA IN A SECOND-GROWTH URBAN FOREST IN THE PACIFIC NORTHWEST** – Luke Bayler, Department of Biology, Seattle WA.

3:20 **WINTER CLIMATE CHANGE AND INTERACTION WITH DISEASES OF WHEAT IN THE PACIFIC NORTHWEST U.S.** – Timothy D. Murray, Department of Plant Pathology, Washington State University, Pullman WA.

3:40 **SOME OBSERVATIONS ON PACIFIC NORTHWEST MUSHROOM GEOGRAPHY** Joe Ammirati, Department of Biology, University of Washington, Seattle WA.

SESSION 14: ADAPTATION OF FORESTS TO CLIMATE CHANGE
ROOM: JOHNSON HALL 175
MODERATOR: DANIEL CHMURA

1:20 **USING THE FOREST SYSTEM TO MITIGATE GREENHOUSE GAS EMISSIONS** Mark E. Harmon, Department of Forest Ecosystems and Society, Oregon State University, Corvallis OR.

2:00 **FORESTS OF THE INLAND WEST: LIFE CYCLE ANALYSIS AND FULL CARBON ACCOUNTING** – Bruce Lippke, Director of CORRIM and College of Forest Resources, University of Washington, Seattle WA; Elaine Oneil, College of Forest Resources, University of Washington, Seattle WA; Leonard Johnson, College of Forest Resources, University of Idaho, Moscow ID.

2:20 **CONTRIBUTIONS OF ECTOMYCORRHIZAL FUNGAL MATS TO FOREST SOIL RESPIRATION** – Claire L. Phillips, Department of Forest Ecosystems and Society, Oregon State University, Corvallis OR; Laurel Kluber, Department of Crops and Soil Science, Oregon State University, Corvallis OR; Julia Pedersen, Barbara J. Bond, Department of Forest Ecosystems and Society, Oregon State University, Corvallis OR.

3:20 **GENETIC MALADAPTATION OF COASTAL DOUGLAS-FIR SEEDLINGS TO FUTURE CLIMATES** – Glenn T. Howe, Department of Forest Ecosystems and Society, Oregon State University, Corvallis OR; Brad St.Clair, Pacific Northwest Research Station, USDA Forest Service, Corvallis OR.

4:00 **EFFECT OF WINTER ENVIRONMENT ON SPRING BUDBURST IN DOUGLAS-FIR** Constance A. Harrington, Peter J. Gould, J. Bradley St. Clair, USDA Forest Service, Pacific Northwest Research Station, Olympia WA.

4:20 **CLIMATE CHANGE AS A DRIVER OF MOUNTAIN PINE BEETLE OUTBREAKS IN EASTERN WASHINGTON** – Elaine Oneil, College of Forest Resources, University of Washington, Seattle WA; Don McKenzie, Pacific Wildland Fire Science Lab, Pacific Northwest Research Station, USDA Forest Service, Seattle WA.

4:40 **EFFECT OF DISTURBANCE TYPE ON LIVE AND DEAD BIOMASS STORES IN COASTAL FOREST ECOSYSTEMS OF ALASKA** – Mikhail A. Yatskov; Olga N. Krankina; Mark E. Harmon, Oregon State University, Corvallis OR; Tara M. Barrett, Kevin R. Dobelbower, USDA Forest Service, Pacific Northwest Research Station, Anchorage AK; Andrew N. Gray, USDA Forest Service, Pacific Northwest Research Station, Corvallis Forestry Sciences Lab, Corvallis OR.

SESSION 15: FIRE ECOLOGY
ROOM: JOHNSON HALL 022
MODERATOR: STEVEN RUST

1:20 **THE EFFECT OF MOISTURE CONTENT ON FIRE INITIATION FROM SMOLDERING IGNITION SOURCES** – G. Matt Davies, College of Forest Resources, University of Washington, Seattle WA; Colin Legg, Centre for the Study of Environmental Change and Sustainability, The University of Edinburgh, Scotland; Rory Hadden and Guillermo Rein, BRE Centre for Fire Safety Engineering, The University of Edinburgh, Scotland

1:40 **SNAG RETENTION, WILDLIFE USAGE, AND SURFACE FUEL DEPOSITION FOLLOWING LARGE, STAND-REPLACING WILDFIRES IN DRY CONIFEROUS FORESTS** – Erich K. Dodson and David W. Peterson, Pacific Northwest Research Station, USDA Forest Service, Wenatchee WA.

2:00 **PYRODIVERSITY ACROSS THE METOLIUS FIRESHED: A CARBON PERSPECTIVE** Garrett W. Meigs and Beverly E. Law, Department of Forest Ecosystems and Society, Oregon State University, Corvallis OR.

2:20 **STAND STRUCTURE AND DISTURBANCE EFFECTS IN SOUTHWESTERN OREGON *QUERCUS GARRYANA*-DOMINATED WOODLANDS** – Laurie Gilligan and Patricia S. Muir, Department of Botany and Plant Pathology, Oregon State University, Corvallis OR.

SESSION 16: SEISMICITY AND TECTONICS
ROOM: JOHNSON HALL 102
MODERATOR: THOMAS PRATT

3:20 **MONITORING THE ACTIVE CASCADE VOLCANOES** – Stephen D. Malone, Department of Earth and Space Sciences, University of Washington, Seattle WA.

3:40 **EPISODIC TREMOR AND SLIP ON THE CASCADIA MEGATHRUST—TRYING TO UNVEIL THE INNER WORKINGS** – John E. Vidale, Pacific Northwest Seismic Network, University of Washington, Seattle WA.

4:00 **COMPARISON OF GEODETIC AND PALEOSEISMIC RATES OF DEFORMATION IN THE PUGET SOUND-GEORGIA BASIN, PACIFIC NORTHWEST** – Brian L. Sherrod, U.S. Geological Survey at Dept. of Earth and Space Sciences, University of Washington, Seattle WA; Stephane Mazzotti, Geological Survey of Canada, Natural Resources Canada, Sidney, BC, Canada; Ralph Haugerud, U.S. Geological Survey at Dept. of Earth and Space Sciences, University of Washington, Seattle WA.

4:20 **IS THE SEATTLE FAULT BENEATH DOWNTOWN SEATTLE?** – Thomas Pratt, U.S. Geological Survey, School of Oceanography, University of Washington, Seattle WA; Kathy Troost, GeomapNW, Department of Earth and Space Sciences, University of Washington, Seattle WA.

4:40 **ATLAS OF ACTIVE TECTONIC DEFORMATION IN THE PUGET SOUND REGION** Elizabeth Barnett, U.S. Geological Survey, Dept of Earth and Space Sciences, University of Washington, Seattle WA.

PROGRAM OVERVIEW
FRIDAY, MARCH 27

Time	Johnson Hall 102	Johnson Hall 075	Johnson Hall 111	Johnson Hall 175	Johnson Hall 022	Mary Gates Hall Commons
	SESSION 5	**SESSION 6**	**SESSION 7**	**SESSION 8**	**SESSION 9**	**SESSION 17**
8:00-10:00	Assembling the Geologic History of the Pacific NW Symposium	Large Wildfires in the Pacific NW	Lichenology Bryology	Ecology and Resource Management	Vegetation Classification and Workshop	Registration (7:30-8:00) Poster Session
10:00-10:40	**BREAK**					
	SESSION 5	**SESSION 6**	**SESSION 10**	**SESSION 8**	**SESSION 11**	**SESSION 17**
10:40-12:00	Assembling the Geologic History of the Pacific NW Symposium (cont.)	Large Wildfires in the Pacific NW	Lichenology Bryology Forum	Ecology and Resource Management	Botany	Poster Session
12:00-1:20	**LUNCH**					
	SESSION 5	**SESSION 12**	**SESSION 13**	**SESSION 14**	**SESSION 15**	**SESSION 17**
1:20-2:40	Assembling the Geologic History of the Pacific NW Symposium	Elwha River Restoration Project Symposium	Pacific NW Fungi in a Changing Environment	Adaptation of Forests to Climate Change	Fire Ecology	Poster Session
2:40-3:20	**BREAK**					
	SESSION 16	**SESSION 11**	**SESSION 13**	**SESSION 14**		
3:20-5:00	Seismicity and Tectonics	Elwha River Restoration Project Symposium	Pacific NW Fungi in a Changing Environment	Adaptation of Forests to Climate Change		Poster Session Take Down

SESSION 17: POSTER SESSION
ROOM: MARY GATES HALL COMMONS
THURSDAY, MARCH 26

12:00 – 3:20 Poster Session Setup

3:20 – 5:00 Attended Poster Session
(Authors will attend their posters to be available for questions and discussion.)

FRIDAY, MARCH 27

8:00 – 3:20 Poster Session Display

VARIABILITY IN OVERSTORY DENSITY REDUCTIONS IS REFLECTED IN UNDERSTORY VEGETATION RESPONSE IN CONIFEROUS FORESTS OF WESTERN OREGON – Adrian Ares, Andrew R. Neill, and Klaus J. Puettmann, Oregon State University, Department of Forest Ecosystems and Society, 321 Richardson Hall, Corvallis, OR USA 97331; *adrian.ares 'at' oregonstate.edu*

GEOLOGIC AND HYDROGEOLOGIC CONDITIONS OF THE CITY OF BLAINE GROUND WATER MANAGEMENT AREA, NORTHWEST WHATCOM COUNTY, WASHINGTON Bridget August, Charles Lindsay, Associated Earth Sciences, Inc., 2911 ½ Hewitt Ave. Suite 2, Everett, WA, 98201; *baugust@aesgeo.com*

OVERSTORY DENSITY EFFECTS ON GROWTH OF THREE CONIFEROUS SPECIES OF REGENERATION – Leslie C. Brodie, USFS Pacific Northwest Research Station, 3625 93rd Ave SW, Olympia, WA 98506**;** *lbrodie 'at' fs.fed.us*

SEISMIC SITE CLASS AND THREE-DIMENSIONAL GEOLOGIC MAPPING FOR SPOKANE VALLEY AREA IN WASHINGTON – Recep Cakir, Robert E. Derkey and Timothy J. Walsh, Division of Geology and Earth Resources, Washington State Department of Natural Resources, Olympia, WA; *recep.cakir 'at' dnr.wa.gov*

USE OF EARTHQUAKE CATALOG AND WAVEFORM DATA FOR TECTONIC MAPPING IN WA – Recep Cakir, Joe Dragovich, Timothy J. Walsh, Division of Geology and Earth Resources, Washington State Department of Natural Resources, Olympia, WA 98501; Renate Hartog, The Pacific Northwest Seismic Network, University of Washington, Seattle, WA; Shelton S. Alexander, Department of Geosciences, The Pennsylvania State University, University Park, PA 16802; Megan L. Anderson, Department of Geology, Colorado College, Colorado Springs, CO 80903; *recep.cakir 'at' dnr.wa.gov*

REMOTELY OPERATED VEHICLE (ROV) VIDEO INVESTIGATION OF TWO LARGE SEAFLOOR MOUNDS IN SOUTHERN HOOD CANAL, WASHINGTON – Recep Cakir, Robert L. Logan, Chris Johnson, Timothy J. Walsh, Division of Geology and Earth Resources, Washington State Department of Natural Resources, Olympia, WA 98501; Robert Pacunski, Lisa Hillier, and James Beam, Washington State Department of Fish and Wildlife, Olympia, Washington; Todd Palzer, Division of Aquatic Resources, Washington State Department of Natural Resources, Olympia, WA 98501; *recep.cakir 'at' dnr.wa.gov*

TWO-DIMENSIONAL MULTI-CHANNEL ANALYSIS OF SURFACE WAVES (MASW) IMAGING AT TWO PALEOSEISMIC TRENCH SITES IN WASHINGTON – Recep Cakir, Timothy J. Walsh, Trevor A. Contreras, Kelsay Stanton, Isabelle Sarikhan, Division of Geology and Earth Resources, Washington State Department of Natural Resources, Olympia, WA; *recep.cakir 'at' dnr.wa.gov*

CHEMICAL AND PHYSICAL CHARACTERIZATION OF ELWHA RIVER SEDIMENTS RELATING TO PHOSPHORUS RELEASE – Emily Cavaliere, Peter Homann, Western Washington University, Department of Environmental Sciences, Bellingham, WA 98225-9181. *cavalie 'at' cc.wwu.edu*

PREDICTION OF SEDIMENT YIELD FROM SWIFT CREEK LANDSLIDE USING THE DISTRIBUTED-HYDROLOGY-VEGETATION-MODEL – Curtis Clement and Robert Mitchell, Western Washington University, Geology Department, 516 High St., Bellingham, WA 98225; *clemenc2 'at' cc.wwu.edu*

STATUS AND POPULATION STRUCTURE OF FRESHWATER MUSSELS IN THE ELWHA RIVER 100 YEARS AFTER THE DAMS – David L. Cowles, Layla Cole, Department of Biology, Walla Walla University, College Place, WA 99324; Patrick Crain, Olympic National Park, 600 E. Park Avenue, Port Angeles, WA 98362-6798; *david.cowles 'at' wallawalla.edu*

ACTIVE FAULTING ALONG A SEGMENT OF THE SADDLE MOUNTAIN FAULT ZONE, SOUTHEASTERN OLYMPIC MOUNTAINS, WA: A PALEOSEISMIC TRENCHING STUDY

Jessica L Czajkowski[1], Elizabeth A Barnett[2], Timothy J Walsh[1], Trevor A Contreras[1], Kelsay Davis-Stanton[1], Brian Sherrod[2], Harvey M Kelsey[3], Elizabeth R Schermer[4], Robert J Carson[5], (1) Division of Geology and Earth Resources, Washington State Department of Natural Resources, Olympia, WA 98504; (2) U.S. Geological Survey, Department of Earth and Space Sciences, University of WA, Seattle, WA 98195; (3) Department of Geology, Humboldt State University, Arcata, CA 95521; (4) Geology Department , Western Washington University, Bellingham, WA 98225; (5) Department of Geology, Whitman College, Walla Walla, WA 99362 *trevor.contreras 'at' dnr.wa.gov*

CHARACTERIZATION OF BIOLOGICAL DIVERSITY WITHIN OLD-GROWTH REFUGIA AND MANAGED FORESTS IN THE WILLAPA HILLS, WASHINGTON – Liane Davis, David Rolph, Yoav Bar-Ness, and Heidi Huber, The Nature Conservancy, Washington Field Office, 1917 First Avenue, Seattle, WA 98101; David Shaw, Department of Forest Engineering, Resources and Management, Oregon State University, 204 Peavy Hall, Corvallis, OR 97331; *ldavis 'at' tnc.org*.

SEASONAL PATTERNS IN OREGON WHITE OAK GROWTH – Warren D. Devine, Constance A. Harrington, USDA Forest Service PNW Research Station, 3625 93rd Ave SW, Olympia, WA 98512; *wdevine 'at' fs.fed.us*

GEOLOGIC MAP OF THE NORTH BEND 7.5-MINUTE QUADRANGLE, KING COUNTY, WASHINGTON—IMPLICATIONS FOR MAJOR CENEZOIC FAULTS, FOLDS AND BASINS IN THE AREA – Joe D. Dragovich[1], Timothy J. Walsh[1], Megan L. Anderson[2], Renate Hartog[3], S. Andrew DuFrane [4], Jeff Vervoot[4], Stephanie A. Williams[1], Recep Cakir[1], Kelsay M. Davis[1,] Fritz E. Wolff[1], David K. Norman[1], and Jessica L. Czajkowski[1].[1] Washington Division of Geology and Earth Resources, PO Box 47007, Olympia, WA 98504-7007; [2] Colorado College Department of Geology 14 E Cache La Poudre St, Colorado Springs, CO 80903; [3] Pacific Northwest Seismic Network University of Washington P.O. Box 351310; Seattle, WA 98195-1310; [4] Washington State University School of Earth and Environmental Sciences P.O. Box 642812; Pullman, WA 99164-2812; *joe.dragovich 'at' dnr.wa.gov*

HABITAT UTILIZATION AND DISPERSAL PATTERNS OF JUVENILE CHINOOK SALMON INFERRED FROM OTOLITH ANALYSIS – Jeffrey J. Duda, Karl Stenberg, Kim Larsen, U.S. Geological Survey, Western Fisheries Research Center, 6505 NE 65th St., Seattle, WA; Matt Beirne, Mike McHenry, Lower Elwha Klallam Tribe, Port Angeles, WA 98363; Kurt Fresh, Anna Kagley, and Josh Chamberlin, NOAA Fisheries, Northwest Fisheries Science Center, Seattle, WA; and Anne Shaffer, Washington Department of Fisheries and Wildlife, Port Angeles, WA 98362' *jduda 'at' usgs.gov*

GEOCHEMICALLY ANOMALOUS IGNEOUS ROCKS OF THE OLYMPIC PENINSULA: IMPLICATIONS FOR EOCENE TECTONICS – Sarah E. Glancy, Jeffrey H. Tepper, University of Puget Sound, Department of Geology, 1500 N. Warner St., CMB 1048, Tacoma, WA; *sglancy 'at' ups.edu*

SIMULATING EFFECTS OF CLIMATE CHANGE ON FORESTS, FIRE, AND HYDROLOGY IN AN EASTERN CASCADES WATERSHED – Richard Gwozdz, College of Forest Resources, Box 352100, University of Washington, Seattle, WA 98195; Don McKenzie, USDA Forest Service, Pacific Wildland Fire Sciences Lab, 400 N 34th Street, Suite 201, Seattle, WA 98103; *rgwozdz 'at' u.washington.edu*

MARDON SKIPPER *(POLITES MARDON)* OVIPOSITION SITE SELECTION IN PUGET SOUND PRAIRIES – Erica Henry, Cheryl Schultz, School of Earth and Environmental Sciences, Washington State University Vancouver, 14204 NE Salmon Creek Ave, Vancouver, WA 98686; *erica_henry 'at' wsu.edu*

SOIL CRUST LICHEN HUNTING AND IDENTIFICATION ON THE WILD HORSE WIND FARM AND WHISKEY DICK WILDLIFE AREA OF KITTITAS COUNTY, WASHINGTON
Dawn-Marie Jensen, Central Washington University, Resource Management Program, PO Box 1658, Ellensburg, WA 98926; *clampittd 'at' cwu.edu*

PARKING LOT TO PRAIRIE: A VEGETATION ASSESSMENT OF ECOLOGICAL RESTORATION ON THE UNION BAY NATURAL AREA, SEATTLE – Lacey Jeroue, Lexine Long, College of Forest Resources, University of Washington, Seattle, WA 98195; *arinl 'at' u.washington.edu*

TREE GROWTH RESPONSES TO SNOWPACK ACROSS AN ELEVATIONAL GRADIENT AT MOUNT RAINIER NATIONAL PARK, WASHINGTON, USA – Ailene Kane, Janneke Hille Ris Lambers, Jonathan Deschamps, Gerald Lisi, Department of Biology, Box 351800, University of Washington, Seattle, WA 98195-1800; *ailene 'at' u.washington.edu*.

MICRO-PLASTICS MONITORING IN PUGET SOUND AND NORTHWEST STRAITS – Jen Kingfisher, Chrissy McLean, Anne Murphy, Jean Walat, Port Townsend Marine Science Center, 532 Battery Way, Port Townsend, WA 98368; Cinamon Moffett, University of Maine, School of Marine Science, Orono, ME 04469; *jkingfisher 'at' ptmsc.org*

POPULATION GENOMICS IN SPECIES CONSERVATION: TOOLS FOR THE STUDY OF LOCAL ADAPTATION AND FISHERIES MANAGEMENT IN KOKANEE *(ONCORHYNCHUS NERKA)* – Stephanie L. Kirk, Michael A. Russello, Unit of Biology & Physical Geography and Centre for Species at Risk and Habitat Studies, University of British Columbia Okanagan, 3333 University Way, Kelowna, BC, V1V 1V7; *skirk 'at' interchange.ubc.ca*

DOES PLOT DESIGN MATTER WHEN MODELING TREE SPECIES DISTRIBUTIONS? Heather Lintz, Department of Botany and Plant Pathology, Cordley 2082, Oregon State University, Corvallis, OR 97331-2902; Andrew N. Gray, USDA Forest Service, Pacific Northwest Research Station, 3200 SW Jefferson Way, Corvallis, OR 97331; corresponding author: *lintzh 'at' onid.oregonstate.edu*

MIMA MOUNDS FORMATION AND THEIR IMPLICATIONS FOR CLIMATE CHANGE – Robert L. Logan and Timothy J. Walsh, Washington Division of Geology and Earth Resources, Washington State Department of Natural Resources, 1111 Washington St SE, P.O. Box 47007, Olympia, WA 98504-7007; *josh.logan 'at' dnr.wa.gov*

NO, WE SHOULD USE THE *OTHER* HAMMER: A TOOLBOX-BASED APPROACH TO NEGOTIATING PHILOSOPHICAL DIFFERENCES WITHIN CROSS-DISCIPLINARY RESEARCH GROUPS – Chris Looney, Sanford D. Eigenbrode, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83844; Brian Crist, Michael O'Rourke, Ian O'Loughlin, Department of Philosophy, University of Idaho, Moscow, ID 83844; Stephen Crowley, Department of Philosophy, Boise State University, Boise, ID 83725; Shannon Donovan, J.D. Wulfhorst, Department of Agricultural Economics and Rural Sociology, University of Idaho, Moscow, ID 83844. *clooney 'at' vandals.uidaho.edu*

FEEDER BLUFF MAPPING IN GREATER PUGET SOUND—A TOOL FOR PROCESSED-BASED NEARSHORE RESTORATION AND CONSERVATION – Andrea MacLennan, Jim Johannessen, and Stephanie Williams, Coastal Geologic Services, Inc. 410 Harris Avenue, Suite 320, Bellingham, WA 98225; *Stephanie 'at' coastalgeo.com*

POLLEN EFFECTS ON PLANT REPRODUCTION IN THE RARE PLANT, *ASTRAGALUS PECKII* – Elizabeth Martin, Oregon State University, Department of Botany and Plant Pathology, Cordley Hall 2082, Corvallis, OR, 97331-2902; *martieli 'at' science.oregonstate.edu*

SEDIMENT AND WOODY DEBRIS DYNAMICS OF HEADWATER STREAMS IN MANAGED FORESTS OF WESTERN WASHINGTON – Melissa Maxa; Robert Edmonds; Dan Vogt, College of Forest Resources, University of Washington, Seattle, WA 98195; Richard Bigley, Washington State Department of Natural Resources, 1111 Washington St. SE, Olympia, WA 98504; Douglas Martin, 2103 N 62nd Street, Seattle, WA 98103; *maxa0006 'at' u.washington.edu*

THE WEST COAST GEOGRAPHY OF RAILROAD LOGGING: HISTORIC SITES AND POSSIBLE RESEARCH SITES – Erik Piikkila, Railroad Logging Legacies Project, 592 Atkins Rd. Victoria BC V9B 3A3; *espcwd 'at' shaw.ca*

RECONNAISSANCE LANDSLIDE INVENTORY AND MAPPING OF RELATIVE LANDSLIDE HAZARD ALONG THE MARINE SHORE OF THURSTON COUNTY, WASHINGTON – Michael Polenz; Gabriel Legorreta-Paulin; Isabelle Sarikhan; Timothy Walsh, Washington Department of Natural Resources, 1111 Washington Street SE, Olympia, WA 98501; Aaron Young, Robinson, Noble & Saltbush, Inc., 3011 South Huson Street, Suite A, Tacoma WA 98409; *michael.polenz 'at' dnr.wa.gov*

A MULTI-SCALE APPROACH FOR QUANTIFYING CARBON DYNAMICS IN WASHINGTON FORESTS – Crystal Raymond, College of Forest Resources, Box 351200, University of Washington, Seattle, WA 98195; Donald McKenzie, USDA Forest Service Pacific Northwest Research Station, Seattle, WA, 98103; *clrfire 'at' u.washington.edu*

WASHINGTON GEOLOGIC SURVEY'S LANDSLIDE RESPONSE TO THE JANUARY 7-8TH, 2009 STORM – Isabelle Y. Sarikhan; Trevor A. Contreras; Kelsay M. Davis Stanton; Michael Polenz; Timothy J. Walsh; Recep Cakir; Washington State Department of Natural Resources, Division of Geology and Earth Resources, PO Box 47007, 1111 Washington Street SE, Olympia, WA 98504-7000; *isabelle.sarikhan 'at' dnr.wa.gov*

FISH USE OF THE ELWHA ESTUARY – J. Anne Shaffer, Washington Department of Fish and Wildlife, 332 E. 5th Street, Port Angeles WA 98362; Matt Beirne, Lower Elwha Klallam Tribe, Fish Hatchery Road, Port Angeles WA 98362; Rebecca Paradis, Daniel Brooks, and Dwight Berry, Western Washington University Huxley Program for the Peninsula, Port Angeles WA 90362; Patrick Crain, Olympic National Park, 600 E. Park Avenue, Port Angeles WA 98362, and Cathy Lear, Clallam County, 224 E. 4th Street, Port Angeles WA 98362; *shaffjas 'at' dfw.wa.gov*

THE ELWHA NEARSHORE: LINKING MANAGEMENT, EDUCATION, AND RESEARCH TO ACHIEVE ECOSYSTEM RESTORATION. PRIORITY RECOMMENDATIONS OF THE ELWHA NEARSHORE CONSORTIUM 2009 – Anne Shaffer, ENC coordinator, WDFW 332. E. 5th Street, Port Angeles WA 98362; Cathy Lear, Clallam County, 224 E. 4th Street, Port Angeles WA 98362; Matt Beirne, Lower Elwha Klallam Tribe, Fish Hatchery Road, Port Angeles WA 98362; Patrick Crain, Olympic National Park, 600 E. Park Avenue, Port Angeles WA 98362; Shea McDonald and Willie Spring, Western Washington University Huxley Program for the Peninsula, Port Angeles, WA 90362. *shaffjas 'at' dfw.wa.gov*

THE CRESCENT FORMATION ALONG LAKE CUSHMAN'S NORTHERN SHORE, OLYMPIC PENINSULA, WASHINGTON: A STRATIGRAPHIC, CHEMICAL AND STRUCTURAL STUDY
Elizabeth A Smith, Kenneth P Clark, 1500 N Warner, Tacoma, WA 98416-4044; *smielizabeth 'at' gmail.com*

EARTHQUAKE-INDUCED LANDSLIDE AND LIQUEFACTION SUSCEPTIBILITY IN TSUNAMI EVACUATION ROUTES, COASTAL WASHINGTON – Kelsay Davis Stanton, Timothy J. Walsh, Recep Cakir, Trevor A. Contreras, Division of Geology and Earth Resources, Department of Natural Resources, PO Box 47007, Olympia, WA 98504-47007; *kelsay.davis 'at' dnr.wa.gov*

CONSERVING A WESTERN POND TURTLE *(ACTINEMYS MARMORATA)* POPULATION IN WEST EUGENE WETLANDS, LANE COUNTY, OREGON – David G. Vesely, Oregon Wildlife Institute, P.O. Box 1061, Corvallis, OR 97339-1061; Sally Villegas-Moore, USDI Bureau of Land Management, Eugene District, 751 S. Danebo Ave., Eugene, OR 97402; *dave 'at' oregonwildlife.org*

GEOCHEMICAL, PETROGRAPHIC, AND STRATIGRAPHIC ANALYSIS OF THE CRESCENT FORMATION, MOUNT TEBO, SOUTHERN OLYMPIC MOUNTAINS, WASHINGTON – E.M. Waldron and K. Clark, Geology, University of Puget Sound, 1500 N Warner, Tacoma, WA 98416; *ewaldron 'at' ups.edu*

TSUNAMI HAZARD MAP OF TACOMA, WASHINGTON: MODEL RESULTS FOR SEATTLE FAULT AND TACOMA FAULT EARTHQUAKES – Timothy J. Walsh, Division of Geology and Earth Resources, Department of Natural Resources, PO Box 47007, Olympia, WA 98504-47007; Diego Arcas, Angie J. Venturato, Vasily V. Titov, Harold O. Mofjeld, Chris C. Chamberlin, and Frank I. Gonzalez, NOAA Center for Tsunami Research, NOAA/PMEL - UW/JISAO, 7600 Sand Point Way, NE, Seattle, WA 98115; *tim.walsh 'at' dnr.wa.gov*

FIELD GUIDE TO THE SEDGES OF THE PACIFIC NORTHWEST – Barbara L. Wilson, Richard E. Brainerd, Nick Otting, *Carex* Working Group, 2710 Emerald Street, Eugene, OR 97403; Bruce Newhouse, Salix Associates, 2525 Potter, Eugene, OR 97405; *bwilson 'at' peak.org*

PHYTOREMEDIATION OF CHLORPYRIFOS – Keum Young Lee, Sharon L. Doty, Box 352100, College of Forest Resources, University of Washington, Seattle, WA 98195; Stuart E. Strand, Box 352700, College of Forest Resources, Department of Civil and Environmental Engineering, University of Washington, Seattle, WA 98195; *sldoty 'at' u.washington.edu*

FIELD TRIPS
SATURDAY, MARCH 28

NORTHWEST LICHENOLOGISTS - VALLEY OF THE SOUTH FORK STILLAGUAMISH RIVER.
Leader: Richard Droker
Contact: drokoo 'at' mac.com
Time: 7:30 am
Meet Location: Gravel lot on Boat Street across street north of Aqua Verde afe

Probably the most pristine area within one hour's driving time from the University of Washington. The hike will explore the lower elevations of the valley. Abundant *Usnea longissima* is expected and indicative of a healthy habitat. Several lichen stops will be made along the river and on side roads. The lower elevation forest is dominated by old-growth forest, consisting of western hemlock, western redcedar, and occasional Douglas-fir. Red alder, big leaf maple and black cottonwood are abundant along the river. Upper elevation forests along Perry Creek will include grand fir. Access to higher elevations will be limited by persistent winter snow pack. If the group is so inclined we should be able to walk for some distance on trails.

BURKE MUSEUM – BEHIND THE SCENES
Leader: Burke Museum Curators and Collections Managers
Contact: basqrc 'at' u.washington.edu
Time: 10:00 am
Meet Location: Burke Museum of Natural History and Culture

The Burke Museum of Natural History is located on the University of Washington campus. Take a tour of the paleontology and biology collections with curators and collections managers. We will open up the cabinet doors and show you our collection of fossils, birds and mammals and describe how the collections are made and conserved, and how they are used. The Paleontology & Geology Division holds some of the oldest museum acquisitions and now includes ~4 million specimens, from petrified wood slabs and dinosaur bones to microfossils. Tour at 10 am - 12.30 pm, and then you are free to see the museum's exhibits that include a new one on *Coffee.*

WASHINGTON PARK ARBORETUM/ UW BOTANIC GARDENS
Leader: UW Botanic Garden Docent
Contact: kglew 'at' u.washington.edu
Time: 10:00 am
Meet Location: Graham Visitor's Center – Washington Park Arboretum

Stroll through the University of Washington Botanic Gardens in early spring. You will be escorted by an expert of the gardens past seasonal gardens and wetlands, towards the newest garden – Pacific Connections. Early cherries may be blooming and the winter garden will be at its peak. After the tour, you are welcome to wander through the rest of the arboretum. Tour lasts approximately 90 minutes.

PUGET LOWLAND BOTANY AND BRYOPHYTE WALK – SHADOW LAKE BOG, KING COUNTY

Leader: Tracy Fuentes and Guest Bryologist
Contact: tracyfuentes 'at' yahoo.com
Time: 9:00 am
Meet Location: TBA

Search a mixed conifer, alder, and big leaf maple forest for early spring wildflowers, mosses, and liverworts. Hike will be on and off-trail, pushing aside branches, staring at newly emerged shoots, and peering at twigs. We expect to examine mossy logs, rocks, and trees up close and personal. Bring a hand lens.

GEOLOGY OF THE SEATTLE AREA

Leader: Kathy Goetz Troost, Director of the Pacific Northwest Center for Geologic Mapping
Contact: ktroost 'at' u.washington.edu
Time: TBA
Location: TBA

This one-day field trip will visit tidal, bluff, intertidal, and steep slopes to view the geology of Seattle. Seattle lies in a unique geologic setting: near a subducting plate and having been glaciated more than 6 times in the last 2 million years. The area is geologically very young and very complex. Seattle is subject to abundant geologic hazards, such as volcanic activity, earthquakes, faulting, landslides, liquefaction, and other ground failures. Even though an urban center may seem an improbable place to find *any* geologic exposures, much less a rich geologic story, such examples abound here. We will visit Tertiary marine rocks, dipping Quaternary interglacial layers, uplifted subtidal sediment, deposits from the last glaciation, and spectacular landslides. The outcrops provide representative views of the deposits and landscape present throughout the Puget Lowland. We will also discuss the evidence for the Seattle fault and the tectonic setting of the Lowland. Be prepared for rain and wear sturdy (waterproof) boots or shoes. Lunch and guidebook will be provided.

NATURAL AREAS IN KING COUNTY

Leader: Rex Crawford, Natural Heritage Program, Washington Dept. Natural Resources
Contact: rex.crawford 'at' dnr.wa.gov
Time: 8:00 am
Location: Carpool - Johnson Circle on UW campus, entrance off of 15th Avenue just south of Central Plaza Parking Garage. Self-drivers – Meet at 9:00 am at U.S. Forest Service North Bend Ranger Station in North Bend (4204 SE North Bend Way)

Management of natural areas focuses on the protection of natural features and the processes supporting them. The rapidly changing environments in urbanizing King County and the range of possible impacts related to climate change create great challenges for Natural Area persistence. This field trip will visit small wetland Natural Area Preserves (NAP) and a large Natural Area Conservation Area (NRCA) managed by the Washington Department of Natural Resources that are 20 miles from UW in Seattle. Sphagnum bog ecosystems, rare in very good condition, that support populations of rare plants and beetles will be visited at the NAPs. The Mount Si NRCA at 9,522 acres includes steep, rugged and mountainous terrain with habitat and a variety of wildlife

native mountain goats, cougar, and black bear. The NRCA safeguards unique geologic features, examples of old growth forests, and sensitive plant species and is the most heavily used NRCA in the state. Viewing natural areas of differing sizes provide a face-to-face encounter with conservation biology in a changing world. Rain gear and rubber boots are advised.

ABSTRACTS

(Arranged by last name of presenting author)

SOME OBSERVATIONS ON PACIFIC NORTHWEST MUSHROOM GEOGRAPHY

Joe Ammirati, Department of Biology, 351330, University of Washington, Seattle, WA 98195; *cort 'at' u.washington.edu*

The science of mushroom taxonomy, the names and their applications, progressed from Europe to eastern North American and other parts of the world over a period of several decades, finally developing on the Pacific Coast in the late 1800s. Alexander H. Smith and several earlier workers, while applying European names to many mushroom species from the Pacific Northwest, soon recognized that many mushrooms in this region were unique or showed subtle to more substantial differences, when compared to European and certain eastern North American species. This resulted in the description of numerous western species over the last century and continues today, as we unravel the mycota of this region. The use of molecular phylogenies provides an opportunity to evaluate mushroom geography on a broad scale, making it possible to look at changes in traits, including ecological ones, and in the case of symbiotic species, gain some insight into their co-evolution with host plants. Intercontinental geographical patterns of species in two genera will be discussed: the saprobic genus *Tubaria*, and the ectomycorrhizal genus *Cortinarius*.

VARIABILITY IN OVERSTORY DENSITY REDUCTIONS IS REFLECTED IN UNDERSTORY VEGETATION RESPONSE IN CONIFEROUS FORESTS OF WESTERN OREGON

Adrian Ares, Andrew R. Neill, and Klaus J. Puettmann, Oregon State University, Department of Forest Ecosystems and Society, 321 Richardson Hall, Corvallis, OR USA 97331; *adrian.ares 'at' oregonstate.edu*

Within the context of multi-objective silviculture, stand density management is aimed at accelerating development of late-successional features with reduced impacts on tree regeneration and long-term forest productivity. We examined effects of thinning on overstory and understory vegetation 11 years after harvest in three 40- to 60-year old forests dominated by Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) in western Oregon. Each site contained a non-thinning treatment (238-1446 tpha) and three thinning treatments (high density = 120 tpha; moderate density = 80 tpha; variable density = 120, 80 and 40 tpha with gaps and leave islands). Stand basal area and overstory cover was greater in the non-thinning treatment than in thinning treatments. Seedling regeneration varied greatly among sites, but was generally more abundant in the variable-density thinning with 80 tpha than in high-density and non-thinning treatments. Among the most abundant vascular plant groups, cover of low shrubs and ferns tended to be greater in the variable-density treatments than in the non-thinning treatment. Tall shrub cover was greater in the high-density treatments. Within stands, cover of low and tall shrubs was similar in forest interior and gaps and lower in leave islands, whereas variability in cover was greater in gaps. Fern cover was greater in gaps than in forest interior and leave islands, and more variable in leave islands and gaps than in forest interior. Variability in overstory density reductions is likely reflected in understory vegetation response, and combinations of thinning intensities may develop high diversity of understory conditions.

GEOLOGIC AND HYDROGEOLOGIC CONDITIONS OF THE CITY OF BLAINE GROUND WATER MANAGEMENT AREA, NORTHWEST WHATCOM COUNTY, WASHINGTON.

Bridget August, Charles Lindsay, Associated Earth Sciences, Inc., 2911 ½ Hewitt Ave. Suite 2, Everett, WA, 98201; *baugust 'at' aesgeo.com*

The City of Blaine currently provides municipal water to a population base of over 13,000 located in northwest Whatcom County. Twelve production wells, located within the City's Ground Water Management Area (GWMA), currently are the City's sole source of potable water. The GWMA appears to be underlain by a thick sequence of nonglacial sediments (Olympia and Whidbey) and glacial deposits (Fraser, Possession and Double Bluff) overlying bedrock. The City of Blaine recently installed two deep production wells (PW-5.1 and PW-8.1) in the GWMA. The information developed during the installation and testing of these two deep wells, combined with pre-existing information indicates that the GWMA is underlain by at least two regionally extensive confined aquifers (intermediate and deep aquifers) and one shallow, localized perched aquifer. The intermediate aquifer is located within permeable portions of Fraser glacial deposits and the upper, coarse-grained portion of Olympia nonglacial sediments. The deep confined aquifer is generally encountered below elevations of approximately -200 to -300 feet. A recent soil sample obtained from a depth of approximately 460 feet (elevation -300 feet) in City production well PW-5.1 had a C^{14} age of 43,510 ybp, which is mid to early Olympia. The radiocarbon age dating information for PW-5.1 indicates that the Olympia sediments are at least 200 feet thick beneath portions of the City's GWMA.

THE IMPACT OF MULTIPLE SEVERE WILDFIRES ON SAGEBRUSH STEPPE VEGETATION

Jonathan D. Bakker, Eva Dettweiler-Robinson, G. Matt Davies, College of Forest Resources, University of Washington, Box 354115, Seattle, WA 98195-4115; Peter Dunwiddie, Jim Evans, The Nature Conservancy, 1917 1st Ave., Seattle, WA 98101; Sonia A. Hall, The Nature Conservancy, 6 Yakima St., Ste. 1A, Wenatchee, WA 98801; Janelle Downs, Pacific Northwest National Laboratory, P.O. Box 999, Richland, WA 99352; Michael Marsh, Washington Native Plant Society, 6310 NE 74th St., Suite 215E, Seattle, WA 98115; *jbakker 'at' u.washington.edu*

Fire is a natural part of sagebrush steppe ecosystems but changing fire regimes pose a significant threat to their character, their long-term viability, and the environmental services they provide. Existing research documents how these ecosystems recover following single fires but we have little quantitative knowledge of the impact of multiple, severe disturbances. Large wildfires burnt the Arid Lands Ecology Reserve (ALE) of the Hanford Reach National Monument in 2000 and 2007. These fires, combined with colonization by invasive species, particularly *Bromus tectorum*, have caused profound changes in vegetation composition and structure. Restoration has been challenging; extensive restoration efforts undertaken after the 2000 fire were compromised by the 2007 fires. Three long-term vegetation monitoring studies were established on ALE and surrounding private and public lands in the 1990s. These studies were remeasured after the 2000 fire and provide a unique opportunity to understand how multiple, severe fires affect plant communities, to describe the successional pathways sagebrush steppe ecosystems follow, and to quantify the potential for, and timescales of, vegetation recovery. We used multivariate, non-parametric techniques to quantify vegetation changes caused by the 2000 fire, including extensive losses of *Artemisia tridentata* and expansion of *Bromus tectorum*.

We will return to ALE in Spring 2009 and 2010 to study the impacts of the 2007 fires and prior and on-going restoration work on sagebrush steppe dynamics and recovery.

ATLAS OF ACTIVE TECTONIC DEFORMATION IN THE PUGET SOUND REGION

Elizabeth Barnett, U.S. Geological Survey, Dept of Earth & Space Sciences, Box 351310, University of Washington, Seattle, WA 98195; *eli 'at' ess.washington.edu*

Research during the last quarter century accounts for nearly all of what is known today about the locations, earthquake histories, and damage potential of active, shallow crustal faults in the Puget Sound region. There may be as many as a dozen faults with evidence for earthquake activity in the past 10,000 years that contribute to the seismic hazard of the region. Ongoing research continues to clarify the characteristics of these fault zones and their potential for generating large, damaging earthquakes. This atlas compiles and summarizes the evidence for recent crustal faulting in the region. It is comprised of 14 maps that are organized thematically based on the type of investigation and deformation evidence. In the atlas, the first maps begin with locations of deformation observed on the ground surface, including fault scarp and deformed shoreline field studies. The next maps display locations of fault-generated subsurface deformation inferred from potential-field and seismic studies. Together, these geological and geophysical studies form the basis for inferred and observed fault locations. In the final summary maps, fault traces are draped over the data sets compiled from the preceding maps. Overall, this suite of maps provides map-users with a visual overview of crustal deformation observations that underpin current interpretations of earthquake hazards in the densely populated Puget Sound area.

THE RELATIONSHIP BETWEEN MACRO-FUNGUS SPECIES RICHNESS AND WEATHER DATA IN A SECOND-GROWTH URBAN FOREST IN THE PACIFIC NORTHWEST

Luke Bayler, Department of Biology, Box 351800, Seattle, WA 98195-1800; *lukeb 'at' u.washington.edu*

Bridle Trails State Park (BTSP), located in the Puget Sound region of Washington State, between Lake Washington and Lake Sammamish, has been the subject of a preliminary inventory of macro-fungi. Around the 1920s, most of the park's 481 acres were clear-cut, and the rest was selectively logged. Currently, this temperate conifer forest of *Pseudotsuga menziesii*, *Tsuga heterophylla*, and *Thuja plicata*, with a mixture of broadleaf trees (*Acer macrophyllum, Alnus rubra, Arbutus menziesii, Populus trichocarpa*), shows signs of a strong recovery with older trees, mixed-age stands of trees, forest canopy gaps due to fallen trees, standing snags and decaying coarse woody debris, all supporting a diversity of fungi. The study has focused on determining the species richness and general diversity of the macro-fungi residing in the park. To do this, in calendar year 2007, weekly collection trips were made, or more frequently when macro-fungi were abundant. The park has three marked routes of varying distances. One route leads you around the northwest corner, another around the center, and a third leads you around the eastern area. Throughout these three areas, the habitat is highly homogeneous, and the species richness from each of these areas is comparable. Another goal of the study was to correlate the phenology of macro-fungi with weather data such as temperature, relative humidity, barometric pressure, solar radiation, and precipitation. Continuation of this study should consider developing a more rigorous sampling protocol, recording of data with environmental data loggers, and determination of fungus indicator species.

PALE SPORED MEMBERS OF THE FAMILY AGARICACEAE (=LEPIOTACEAE) IN WESTERN WASHINGTON

Joshua M. Birkebak, University of Washington, Department of Biology, 7937 10th Ave SW Seattle, WA 98106; *birkebak 'at' gmail.com*

The pale-spored members of the Family Agaricaceae (Lepiotaceous fungi) have never been inventoried in the Pacific Northwest. A study of western Washington species was conducted from collections deposited in the Burke Museum fungus herbarium and supplemented by recent collections made from 2005-2009. Fifty-eight species in seven genera were documented for the study area. Thirteen of these are thought to be new species and await publication after further study. Two species, *Chlorophyllum olivieri* and *Leucocoprinus brebissonii*, are considered to be invasive. They were first collected in the region about ten years ago, and now are among the most common members of the Puget Sound mycota. Alternatively some species were found to be endemic to Western Washington, these included *Lepiota concentrica* and several new species. There are many Lepiotaceous species that occur in Western Washington but also are found in Europe. Western Washington provides significant insights into the distribution and ecology of Lepiotaceous fungi.

GARRY OAK RESTORATION: SEEDLING RESPONSES TO POST-PLANTING TREATMENTS IN CENTRAL WASHINGTON

Laura Blume, Jonathan D. Bakker, College of Forest Resources, University of Washington, Box 354115, Seattle, WA 98195-4115; *lblume 'at' u.washington.edu*

In the Pacific Northwest, Garry oak (*Quercus garryana*) has been in decline over the past century due to urban and agricultural development as well as changes in historical fire regimes associated with European settlement. The only oak native to this region, it is a priority restoration species. Post-planting treatments for Garry oak have been studied in western Washington but not east of the Cascades, where the climate is hotter and drier. We planted 720 bare root Garry oak seedlings in an old agricultural field in the eastern foothills of the Cascade Mountains. We used a split plot design to test the effects of tree shelters, plastic mulch, irrigation, and seedling age at planting on seedling survivorship and growth over one growing season. Plastic mulch significantly improved survivorship (63% survival with plastic mulch vs. 22% survival without plastic mulch), as did irrigation (57% vs. 28% survival). One-year-old seedlings had higher survival than three-year-old seedlings (51% vs. 34%), as well as greater diameter growth. We found no significant benefits of solid tree shelters. Based on our findings to date, we recommend using one-year-old seedlings for bare root Garry oak plantings east of the Cascades. We recommend the use of plastic mulch and regular irrigation throughout the summer to ensure ample moisture availability. Tree shelters did not affect seedling growth in this study and are not necessary if browse is not a concern.

ONE MILLION YEARS OF GLACIERS AND THE ORIGIN OF PUGET SOUND

Derek B. Booth, University of Washington and Stillwater Sciences Inc., 1314 NE 43rd Street #210, Seattle, WA 98195, *dbooth 'at' stillwatersci.com*

Recent geological studies of Puget Sound have greatly illuminated our understanding of this great resource, the second-largest estuary in the United States. The record of global warming and cooling recorded in deep-sea cores shows that there were many glacial eras during the last one to two million years, and that many such advances of ice into western Washington can be recognized in the deposits and landforms of the region. The Puget lobe, the southwesternmost extension of the Cordilleran ice sheet, last advanced into the Puget Lowland about 18,000 years ago. Much of the record of this last ice advance is still well-preserved in the landforms and deposits of the region, allowing us to analyze and reconstruct this long-vanished glacier. As the ice sheet advanced, it deposited voluminous sediment on a prograding outwash plain, ahead of an ice front that extended from the Olympic Mountains to the Cascade Range and which today can be recognized as the "Great Lowland Fill." Subsequent overrunning of this deposit by the ice sheet excavated a striking network of deep linear troughs, which today we appreciate as the large lakes and marine arms of Puget Sound. Excavating these troughs and valleys of the Puget Lowland required the net transport of about 1000 km^3 of sediment, almost entirely during ice occupation and primarily by subglacial water. These landforms of glaciofluvial deposition and erosion define the modern landscape here, emphasizing the importance of these processes in the region's geomorphology and to our collective natural history.

OVERSTORY DENSITY EFFECTS ON GROWTH OF THREE CONIFEROUS SPECIES OF REGENERATION

Leslie C. Brodie, USFS Pacific Northwest Research Station, 3625 93rd Ave SW, Olympia, WA 98506**;** *lbrodie 'at' fs.fed.us*

We conducted a study of response of overstory trees and planted conifer seedlings —Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), and western redcedar (*Thuja plicata* Donn ex D. Don) --to a range of overstory densities. The study was established in cooperation with the Washington State Department of Natural Resources on Capitol State Forest in western Washington. Three replicates of 40- to 70-year-old stands of primarily Douglas-fir were harvested leaving retention levels of 0, 8, 16, 24, 32 and 40 percent of full basal area stocking. Five-year response of the understory seedlings was species dependent with hemlock growing the most (mean height 279 cm and diameter of 2.9 cm), followed by Douglas-fir (mean height 166 cm and diameter of 2.3 cm), and then redcedar (mean height 91 cm and diameter of 1.3 cm). All species responded significantly to overstory retention level with Douglas-fir and redcedar showing the greatest growth in the lowest retention levels (0 and 8%) and hemlock responding best at the 8 and 16% retention levels. Soil temperatures in the lower retention levels were initially warmer in the summer and cooler in the winter than those in higher retention levels. By year 5, the magnitude of temperature differences among the treatments had diminished, but were still statistically significant. Soil moisture levels initially were significantly greater in the lower retention levels, but differences between treatments diminished over time.

WHERE IS THE RAIN-ON-SNOW ZONE IN THE WEST-CENTRAL WASHINGTON CASCADES? MONTE CARLO SIMULATION OF LARGE STORMS IN THE PACIFIC NORTHWEST

Matthew J. Brunengo, Geology Department, Portland State University, P.O. Box 751, Portland, OR 97207-0751; *mbruneng 'at' pdx.edu*

Western North America experiences warm winter storms, and many episodes of flooding and landsliding occur during heavy rain plus melting snow. Historic research, theory, instrumental records, and fieldwork have illuminated many aspects of *rain-on-snow* (ROS) phenomena: ROS seems more likely in middle elevations; changes in land use and climate alter processes, geography and magnitude. How much does ROS affect long-term frequency of water input? Can we delineate peak ROS zones? Temporal/spatial variability complicate ROS studies, but modellng can be informative. A computer program combining probabilistic and deterministic components performs Monte Carlo simulation of large hypothetical "storms" over 1000 "years". In each event precipitation falls, snow accumulates and/or melts, and percolation is tracked to the ground. Input distributions are based on data from the western Washington Cascades, some combined into functions of elevation and date, so the model can act for specific sites or generalized elevations. One version calculates outputs for actual events, to test algorithms and calibrate parameters. Validation focuses on Stampede Pass weather and snow stations on the Cascade crest. The model is used to estimate the significance of ROS with elevation. Over a "millennium", the presence of snowpacks in some events reduces the water reaching the ground during model storms: often where winter snow is common and deeper, but sometimes also at moderate elevations. Considering several metrics, results suggest that ROS significantly affects hydrologic inputs from ~500–1200 m, with the greatest effect at ~800 m, where snowmelt enhances water to the ground during ~20% of major storms.

SEISMIC SITE CLASS AND THREE-DIMENSIONAL GEOLOGIC MAPPING FOR SPOKANE VALLEY AREA IN WASHINGTON

Recep Cakir, Robert E. Derkey and Timothy J. Walsh, Division of Geology and Earth Resources, Washington State Department of Natural Resources, Olympia, WA; *recep.cakir 'at' dnr.wa.gov*

Spokane in eastern Washington experienced a swarm of shallow earthquakes in 2001. Shaking caused by these earthquakes, which originated at shallow depths (<1km), was experienced in downtown Spokane. Severity of shaking from any future earthquakes is strongly related to the nature and extent of subsurface Quaternary sedimentary and/or flood deposits in Spokane. Therefore, understanding and seismically classifying the local near-surface geology is an important factor for measuring the shaking (and ultimately destructive) capacity of the deposits in response to future earthquakes in and near Spokane. Well log data used for aquifer system mapping of the Spokane Valley area were compiled and updated by the USGS and its partners for the Spokane Valley—Rathdrum Prairie Aquifer (SVRPA) project. We use this recently available well log data along with other subsurface geophysical information to construct a 3D geologic map of the Spokane area. This 3D geologic mapping subsequently allows us to generate thickness grid map of shallow Quaternary units that can be used for calculations of average shear-wave velocities for upper 30 meter (Vs30m), thus for production of seismic site-class map in the area. We used ArcGIS tools to construct the all 2D and 3D mapping elements

throughout this ongoing project. Preliminary examples of the 3D geologic, thickness and seismic site class mapping products of this ongoing project will be presented.

USE OF EARTHQUAKE CATALOG AND WAVEFORM DATA FOR TECTONIC MAPPING IN WA

Recep Cakir, Joe Dragovich, Timothy J. Walsh, Division of Geology and Earth Resources, Washington State Department of Natural Resources, Olympia, WA 98501; Renate Hartog, The Pacific Northwest Seismic Network, University of Washington, Seattle, WA; Shelton S. Alexander, Department of Geosciences, The Pennsylvania State University, University Park, PA 16802; Megan L. Anderson, Department of Geology, Colorado College, Colorado Springs, CO 80903; *recep.cakir 'at' dnr.wa.gov*

Washington is one of the most hazardous earthquake regions in the U.S. Generally, more than 1,000 earthquakes occur in the state annually. Washington has a record of at least 20 damaging earthquakes during the past 125 years. Active fault (tectonic) mapping is the major step required to prepare a seismic hazard map, which is the major source for building code and insurance policies and mitigation programs at state and county levels. The Pacific Northwest Seismic Network (PNSN) has been providing very useful earthquake catalog, waveform and focal mechanism data that can be directly used in quadrangle active fault (tectonic) mapping. We recently used crustal (upper 30 km) earthquake catalog and waveform data to verify focal depths of several M>3 earthquakes and to determine the fault mechanisms for active fault mapping of North Bend and Snoqualmie 7.5 minute quadrangles. Although controversial, a regional d**é**collement may be indirectly deduced by the relatively high density of ~17-28 km-deep hypocenters and focal mechanisms that cannot easily be correlated with surface faults in these quadrangle areas. Cross-sections and the hypocenter distribution of the earthquakes have been incorporated with available fault mechanism solutions to better understand the geometry and behavior of active faults in the quadrangle area. The 2D and 3D mapping elements of the ArcGIS and GMT software tools were used in construction of these cross-sections, focal mechanisms and seismicity maps. Examples from quadrangle mapping (North Bend and Snoqualmie) and individual fault generated mainshock-aftershock events (e.g. Duvall Earthquake) will be presented.

REMOTELY OPERATED VEHICLE (ROV) VIDEO INVESTIGATION OF TWO LARGE SEAFLOOR MOUNDS IN SOUTHERN HOOD CANAL, WASHINGTON

Recep Cakir, Robert L. Logan, Chris Johnson, Timothy J. Walsh, Division of Geology and Earth Resources, Washington State Department of Natural Resources, Olympia, WA 98501; Robert Pacunski, Lisa Hillier, and James Beam, Washington State Department of Fish and Wildlife, Olympia, Washington; Todd Palzer, Division of Aquatic Resources, Washington State Department of Natural Resources, Olympia, WA 98501; *recep.cakir 'at' dnr.wa.gov*

Division of Geology and Earth Resources (DGER) and Division of Aquatic Resources (DAR) of WA-Department of Natural Resources and WA-Department of Fish and Wildlife (WDFW) conducted a joint survey near DeWatto Bay in southern Hood Canal, Puget Sound, Washington, to investigate two seafloor dome-shaped features (mounds) reported earlier. We made direct visual observations on these two mounds by using a remotely operated vehicle (ROV) operated from a small boat navigated by the WDFW crew. The traversed mounds are mostly composed

of well-rounded, cobble-sized clasts that appear much like compact Olympic provenance outwash gravels and tills found just above sea level in the bluffs of DeWatto Bay and in the submarine scarp at the mouth of the bay. While most other streams that empty into Hood Canal have deltas, both DeWatto River and Little DeWatto lack deltas, further evidence for submarine collapse and suggesting relatively recent events. Previous investigation suggested that the mounds are drumlins. However, their shapes are inconsistent with Puget Lowland drumlins, which are larger and more streamlined than the DeWatto mounds. Suggestions that the mounds may be natural gas seeps are dispelled by the coarseness of the observed mound material. The inferred headwalls of both mounds are very steep, leaving little lateral support of the shoreline, that may be subject to future sub-aerial or submarine failures. One such failure has been mapped on the south shore of DeWatto Bay. This joint venture, besides geological investigation, also proved to be quite informative to the WDFW biologists who participated.

TWO-DIMENSIONAL MULTI-CHANNEL ANALYSIS OF SURFACE WAVES (MASW) IMAGING AT TWO PALEOSEISMIC TRENCH SITES IN WASHINGTON

Recep Cakir, Timothy J Walsh, Trevor A Contreras, Kelsay Stanton, Isabelle Sarikhan, Division of Geology and Earth Resources, Washington State Department of Natural Resources, Olympia, WA; *recep.cakir 'at' dnr.wa.gov*

By using the multichannel analysis of surface waves (MASW) method we conducted two surveys at the USGS trench sites in Darrington Devil Mountain and Price Lake areas, Washington. The purpose of these surveys was to construct 2-D shear-wave velocity (Vs) images as an aid to identification of the possible paleo-rupture locations near and at the trench sites. Results from each survey are presented as 2-D shear-wave velocity images showing a smoothed vertical offsets that may be roughly interpreted as locations for the surface rupture traces. This 2-D MASW imaging technique, additional to other seismic imaging methods such as refraction and reflection, may be used for future trench-site studies of the paleo-seismological interpretations of the active faults in Washington.

HIMALAYAN BLACKBERRY INVASION UNDER SEASONALLY FLUCTUATING WATER AVAILABILITY CONDITIONS

Josh Caplan, Alan Yeakley, Environmental Sciences, Portland State University, Portland, OR 97207; *jcaplan 'at' pdx.edu*

Invasive plants in communities with high resource availability frequently have adaptations enabling them to capture large amounts of limiting resources, while invasive plants in low resource communities tend to use resources efficiently or gain access to sources of the resource that the native community did not. We hypothesized that *Rubus armeniacus* (Himalayan blackberry) combines resource use strategies of both high- and low- resource invaders. We compared water relations of *R. armeniacus* and those of the Pacific Northwest native shrub species *R. spectabilis* (salmonberry) and *R. parviflorus* (thimbleberry). In eight stands of each species that co-occurred in natural areas in Portland, Oregon, we measured daily time series of stomatal conductance, leaf water potential, hydraulic resistance, and environmental conditions at four time periods spanning the 2007 growing season. Our results demonstrated that the invasive *R. armeniacus* released water more liberally throughout an increasingly dry growing season relative to the native species. At the same time, *R. armeniacus*

had smaller changes in water potential, a factor potentially attributable to advantages in both its root and shoot systems. Water relations may therefore enable *R. armeniacus* to maintain its characteristic rapid carbon fixation rates into the late summer, contributing to its rapid growth, copious seed production, and super-abundance the landscape scale. Our results show that *R. armeniacus* is capable of both rapid water use when water is widely available, and more extensive water acquisition when it is in short supply, characteristics predicted in plant invaders in high- and low- resource plant communities, respectively.

CHEMICAL AND PHYSICAL CHARACTERIZATION OF ELWHA RIVER SEDIMENTS RELATING TO PHOSPHORUS RELEASE

Emily Cavaliere, Peter Homann, Western Washington University, Department of Environmental Sciences, Bellingham, WA 98225-9181. *cavalie 'at' cc.wwu.edu*

Two large dams on the Elwha River, Olympic Peninsula of Washington State, are scheduled for removal in 2011. Removing the Glines Canyon Dam will release over 13.8 million cubic yards of sediment from Lake Mills. The sediments will be exposed to new physical and chemical conditions and become redistributed throughout the ecosystem. In the summer of 2008, samples were taken from the exposed delta and submerged lake bottom of Lake Mills to identify initial physical and chemical characteristics relating to the variable status of phosphorus in the sediments. The mean particle diameter was 278 micrometers for the delta sediments and 12 micrometers for the lake sediments. Delta sediments had only one-third as much carbon as lake sediments. The carbon:nitrogen ratio was 4.5 for the delta sediments and 8.4 for the lake sediments. The lake-sediments value fell within the range of a similar study conducted by Olympic National Park. However, the delta-sediment ratio is startling low, which could indicate that the concentrations were near the detection limits of the analytical technique. Preliminary analysis of composite sediments has found 5.4 mg/kg of amorphous iron in the delta sediments and 17.0 mg/kg in the lake sediments, and substantial amounts of iron- and calcium-bound phosphorus in both types of sediments. Changes in the sediment oxygen environment associated with dam removal, water release and sediment redistribution will likely influence phosphorus partitioning between the sediments and the water column, potentially influencing stream productivity.

THE CHIWAUKUM STRUCTURAL LOW: CENOZOIC SHORTENING OF THE CENTRAL CASCADE RANGE, WASHINGTON STATE, USA

Cheney, E.S. Department of Earth and Space Sciences, University of Washington, Seattle, WA 98195-1310; Nicholas W. Hayman, University of Texas, Institute for Geophysics, Jackson School of Geosciences, J.J. Pickle Research Campus 10100 Burnet Road, (R2200), Austin, TX 78758, USA; *cheney 'at' ess.washington.edu*

Folding is well documented in pre-Tertiary and Neogene rocks on the eastern flank of the central Cascade Range. Nonetheless, the ruling hypothesis is that the region underwent crustal extension or transtension during the Eocene because, reputedly, the mid-Eocene, arkosic Chumstick Formation was deposited syn-tectonically in the Chiwaukum graben. However, compositionally, texturally, and stratigraphically the Chumstick Formation is equivalent to the Roslyn Formation about 25 km southwest of the graben. The southwestern boundary of the

graben is the northwest striking Leavenworth fault zone. Units in the fault zone previously mapped as syntectonic Chumstick conglomerates are outliers of the regionally extensive, Early Eocene, arkosic Swauk Formation. One reverse fault in this zone places folded Swauk Formation over younger and folded Chumstick Formation. Elsewhere, the 39 to 42 Ma Naches Formation unconformably overlies such folds. The northeastern bounding fault of the "graben", the Entiat fault, fractures the Chumstick Formation. We rename the "graben" the Chiwaukum Structural Low (CSL). The northwesterly striking reverse faults and folds are cut by northerly striking strike-slip faults, which likely are satellites of the late Eocene to Oligocene, regional Straight Creek fault. These younger faults partially bound the CSL. All rocks participated in broader and gentler folding of the Miocene Columbia River Basalt Group (CRBG). This later folding largely defines the regional map pattern, including part of the CSL. Our reinterpretations of the "graben" have ramifications for tectonic reconstructions of the northwestern Cordillera, the distribution of neotectonic strain, and the exploration for natural gas beneath the nearby CRBG.

HABITAT SELECTION OF NORTHERN SPOTTED OWLS FOLLOWING WILDFIRE IN SOUTHWESTERN OREGON

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We investigated habitat selection of northern spotted owls (*Strix occidentalis caurina*) following wildfire in southwestern Oregon. Habitat selection was assessed at a landscape and home range scale through the comparison of odds ratios to determine selection or avoidance of cover types over early seral stands. At a landscape scale we observed that owls avoided non-forested areas. Roosting and foraging habitat with a low or high severity burn and salvage logged areas were used in a similar fashion to early seral stands. Owls selected roosting and foraging habitat with a moderate severity burn and nesting, roosting, and foraging habitat with a low, moderate, or high severity burn. Furthermore, owls were found more frequently near perennial streams and lower in elevation than at random. Within individual home ranges we observed several patterns in habitat selection. Owls with home ranges inside the burn demonstrated strong selection for nesting, roosting and foraging habitat with a low severity burn and roosting and foraging habitat with a moderate severity burn and a weak selection for nesting, roosting and foraging habitat with moderate severity burn and roosting and foraging habitat with low severity burn. These owls also used areas lower in elevation and closer to perennial streams than at random. Owls with home ranges outside the burn selected nesting, roosting and foraging habitat with low/unburned severity and used areas lower in elevation and closer to perennial streams than at random. Based on our results we provide guidelines for the management of spotted owl habitat in post-fire landscapes.

THE PUGET-LOBE 2-STEP: A CLOSE TANGO BETWEEN RELATIVE SEA LEVEL AND GLACIER ADVANCE AND RETREAT AT THE END OF THE PLEISTOCENE IN NORTHWEST WASHINGTON

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New constraints from LiDAR and sediment outcrops reveal a complex interplay between eustatic sea level rise, isostatic rebound, and glacier fluctuations at the end of the late-Pleistocene Fraser Glaciation. The late-glacial Everson deposits near Bellingham, Washington, have long been interpreted as recording a unique sequence of deglaciation, marine transgression to ~115 m above modern sea level (asl), regression to ~0 m asl, a second transgression to ~200 m asl, and final regression, all followed by a final readvance of the Puget Lobe during the Sumas stade. The short duration (~1000 ^{14}C yr) and the lack of a plausible mechanism for such rapid, large-magnitude changes in local sea level make this sequence difficult to explain. Geomorphic relationships expressed in bare-earth LiDAR offer an attractive alternative. Cross-cutting moraines and marine strandlines indicate that 1) there was only a single transgression in the region to ~100 m asl following initial retreat of the Puget Lobe to Canada, 2) this transgression was driven by rapid eustatic sea level rise (Meltwater Pulse 1a) that temporarily outpaced the local isostatic rebound, 3) the transgression was closely followed by (and possibly caused) a late-glacial readvance of the Puget Lobe that culminated in Bellingham Bay, and 4) isostatic rebound then surpassed eustatic rise, coincident with final glacier retreat. Deposits previously mapped as Sumas terminal moraines instead appear to be recessional moraines from this more-extensive pre-"Sumas" advance. The close timing between transgression and advance, regression and retreat, suggests a dynamic link (i.e., reduced basal shear stress) with this advance.

PREDICTION OF SEDIMENT YIELD FROM SWIFT CREEK LANDSLIDE USING THE DISTRIBUTED-HYDROLOGY-VEGETATION-MODEL

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Swift Creek is an active landslide in Northwest Washington. The slide is composed of naturally occurring asbestos. Although the slide has not exhibited catastrophic movement, it does produce large quantities of sediment to agricultural land and residential areas which poses a human health risk. This sediment fills channels that frequently have to be dredged to prevent flooding and road damage. In previous years, the material was used in a variety of ways including fill dirt in newly constructed residential areas. Studies performed by the Environmental Protection Agency show that the asbestos fibers found amongst the dredged deposits do pose health risks to those who live, work, and play on or near the material. Because of potential health risks, Whatcom County faces a challenge about the disposal of the material. Knowledge of what parameters impact the sediment yield being eroded from the slide and an accurate quantification of the sediment discharge is very important to form remediation plans. To assist mitigation, I will predict annual sediment yield by modeling the sediment load of Swift Creek over time resulting from surface erosion and mass wasting from the landslide. I will use a numerical model known as the distributed-hydrology-soil-vegetation model (DHSVM) to model the watershed calibrated to stream discharge. I will also employ a sediment module developed for

DHSVM by researchers at the UW to model sediment flux in the stream. During the calibration process I hope to learn what hydrologic forcings are having the greatest impact on landslide-derived sediment discharge.

STATUS AND POPULATION STRUCTURE OF FRESHWATER MUSSELS IN THE ELWHA RIVER 100 YEARS AFTER THE DAMS

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We surveyed the middle and lower reaches of the Elwha River (from Lake Mills to the river mouth) for freshwater mussels in the summer of 2008. The river was surveyed by snorkelers, at least two on each side of the river. Lakes Mills and Aldwell were surveyed by boat and wading, and spot checks were made of Lake Sutherland. No mussels were found in the entire middle reach of the Elwha from Glines Canyon Dam to Lake Aldwell. Several small populations of *Margaritifera falcata*, the western pearlshell mussel, were found in the lower reach of the river below Elwha Dam, in regions still frequented by Chinook salmon. Age estimates based on size and ligament length suggest that some of these mussels may predate the dams. Some younger individuals were present but not abundant in the river populations. Abundant mussels were found in the water system surrounding the Elwha salmon rearing ponds and the associated industrial channel. Approximately 9000 mussels were found in this area. Mussels were abundant both in the stream draining the rearing ponds and in the North Outfall, an overflow from the industrial channel. These populations had many juveniles but few large individuals. This is likely due to robust recruitment combined with mass mortalities as the water levels in the manmade facilities have been manipulated over the years. No mussels were found in Lakes Mills or Aldwell, but *Anodonta* sp, probably *A. oregonensis*, the Oregon floater, was found in Lake Sutherland.

STATUS OF THE INTERNATIONAL VEGETATION CLASSIFICATION AND ITS APPLICATION TO THE WASHINGTON NATURAL HERITAGE STATEWIDE CLASSIFCATION

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This workshop presents the recent framework of the International Vegetation Classification (IVC) in its national application, the USNVC, adopted by the Federal Geographic Data Committee in 2008, NatureServe in 2009, and the Ecological Society of America in 2009. This classification applies to both wetland and upland vegetation based on existing composition and structure and associated ecological factors within an eight-level, ecologically based framework. The workshop will present an application of the IVC hierarchy to a recent classification project on National Parks in Washington and its implication for ongoing efforts to provide a statewide classification that guides conservation of Washington's vegetation. A discussion session will follow during which interested scientists are invited to evaluate the IVC and discuss possible applications in Washington State.

SEDIMENT TRANSPORT AND FLUVIAL GEOMORPHOLOGY ON THE ELWHA RIVER

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Uplift of the Olympic Mountains, coupled with active denudation from high precipitation, has created an Elwha River with high sediment transport and an active geomorphic channel. Moreover, the nature of the river created a historically productive salmonid fishery that was deleteriously impacted by construction of two dams in the early 20th century. Based on recent measurements, the total annual sediment load entering Lake Mills (the reservoir behind the upper dam) is estimated to be about 500,000 Mg/yr, with 80% of this as suspended load and 20% as bedload. Analysis shows that about 90% of this sediment is retained in Lake Mills. Despite the retention of most sediment in the Elwha River behind the reservoirs, the river channel remains remarkably active below the dams. Analysis of the historic position of the river between 1939 and 2006 within 4 km of the mouth shows lateral migration rates of up to 10 m/yr. The quantification of the overall sediment transport rate and the analysis of the geomorphic response of the river under flow regulation give us insight into the fluvial processes active in the river today. The data also enable us to offer predictions of the response of the river channel after removal of both dams.

ACTIVE FAULTING ALONG A SEGMENT OF THE SADDLE MOUNTAIN FAULT ZONE, SOUTHEASTERN OLYMPIC MOUNTAINS, WA: A PALEOSEISMIC TRENCHING STUDY

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A 20 meter long paleoseismic trench was excavated during the fall of 2008. The trench was dug across a LiDAR-detected, Holocene-age fault scarp near Price Lake. The scarp is located approximately 0.5 miles southeast of and roughly parallel to the Saddle Mountain East and West fault scarps. The trench exposed a southwest-striking, steeply-dipping fault which offsets bedrock (Eocene Crescent basalt), glacial deposits, soil horizons and colluvium deposits. The vertical separation of bedrock is 3.2 m. From slickenlines measured on both the active fault surface and within the fractured bedrock surfaces in the hanging wall, the direction of fault movement is uncertain, although data is highly suggestive that older movement on the fault (measured on fracture surfaces in bedrock adjacent to the active fault surface) was oblique reverse. Holocene-age movement (measured on the clay-lined active fault surface) was sub-horizontal to slope-parallel, which implies left-lateral strike-slip offset when coupled with the vertical sense of bedrock offset. However, the scarp facing direction implies right-lateral offset, making the determination of slip direction problematic. Further investigation is necessary to resolve this. The relationships between faults, colluvium and soil development within the trench give strong evidence for multiple (possibly four) Holocene-age faulting events on this newly-found segment of the Saddle Mountain fault system.

THE EFFECT OF MOISTURE CONTENT ON FIRE INITIATION FROM SMOLDERING IGNITION SOURCES

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Understanding smoldering fire behavior is critical for predicting when fires will develop from two key ignition sources: embers and cigarettes. Embers transported by the fire plume can dramatically increase fire spread rates, whilst discarded cigarette ends are blamed as important causes of accidental wildfires. There has been comparatively little research into fire initiation from burning embers and none that examines cigarette ends as a major contributor to wildfire outbreaks. The principal problem in studying the ignition process is the ability to define the power and heat output of the ignition source. In laboratory tests, we used a heated coil to simulate smoldering ignition on a constructed fuel bed. The methodology is replicable and allows the investigator control over the power, shape and size of the ignition source. We investigated the flammability of pleurocarpous mosses from *Calluna vulgaris*-dominated heathlands in Scotland. Similar fuels are also a common component of the ground-layer in northwestern forests. A critical fuel moisture threshold of 15% was defined; below this point the moss smouldered rapidly and frequently switched to flaming combustion. Transitions to flaming frequently occurred at the edge of the fuel bed, possibly due to increased air flow. Ignitions also seemed to be highly dependent on the size of the igniter, its position within the fuel-bed and the bulk density of the fuel surrounding it. Further tests are required with a simulated wind field but they suggest that very particular conditions need to be met in order for cigarettes to ignite forest fuels.

CHARACTERIZATION OF BIOLOGICAL DIVERSITY WITHIN OLD-GROWTH REFUGIA AND MANAGED FORESTS IN THE WILLAPA HILLS, WASHINGTON

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Over the last century, coniferous forests within the Willapa Hills of Washington have been extensively managed for timber production; today, less than 1% of the original old-growth forests remain. A diverse range of compositional and structural diversity amongst these remnants is recognized, but it has never been documented. The Nature Conservancy's recent conservation efforts in the Willapa Hills have focused on landscape-scale forest restoration of young, managed ("regrowth") lowland coniferous forests. A pivotal question for restoration, however, concerns the role old-growth forest remnants play in supporting biological diversity across the existing young-managed forest landscape. In order to better define restoration goals, managers need a better understanding of the range of conditions found in unmanaged forests throughout the Willapa Hills. To fill this information gap, The Nature Conservancy initiated a study to document and compare vegetation, canopy lichen, and arthropod communities of old-growth forest patches and 35-70 year-old regrowth stands located within the Willapa Bay watershed. Each old-growth patch was paired with a regrowth stand located in close geographic

proximity and of similar topographic position, aspect, and historical species composition. For the canopy arthropods, three old-growth and three regrowth stands were sampled. For the vegetation and lichens, eleven old-growth stands and eleven regrowth stands were sampled. Lichens were collected using a litter pick-up technique (McCune1994). Preliminary results indicate old-growth forests in the Willapa Hills harbor a higher diversity of canopy mites, a more diverse range of tree sizes and species, and a greater biomass of canopy lichens than regrowth forests.

SEASONAL PATTERNS IN OREGON WHITE OAK GROWTH

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Diameter growth of Oregon white oak trees (*n*=41) under various levels of competition was measured biweekly throughout the 2008 growing season using band dendrometers in a stand near Olympia, Washington. Soil water content at 10-30 cm depth was measured near each tree on the same dates. Open-grown trees and trees that were released from overtopping conifers four years earlier had the greatest diameter growth (2.5 mm). Trees growing under partial crown competition from other oak trees or from conifers grew poorly (0.5 mm); trees that were completely overtopped by Douglas-fir exhibited no measureable stem growth. Growth rates were greatest in early July, and most of the trees' annual diameter growth was completed by late July. Fluctuations in stem size later in the year were attributed primarily to changes in tree water status. The correlation between soil water content and current growth rate was stronger during early June than during other parts of the growing season, but overall, soil water content was a poorer growth predictor than the degree of crown competition. Trees exhibiting the greatest growth were those that had little crown competition, confirming the importance of light availability for Oregon white oak trees growing in association with conifers. Growth patterns of these trees in the Puget Sound Region were compared to those of other regions. Oregon white oak trees in central Washington completed most of their annual growth by early to mid-July. In contrast, oak trees in the Willamette Valley maintained rapid growth rates through August.

SNAG RETENTION, WILDLIFE USAGE, AND SURFACE FUEL DEPOSITION FOLLOWING LARGE, STAND-REPLACING WILDFIRES IN DRY CONIFEROUS FORESTS

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Fire-killed trees provide critical habitat for many species, but may also add to surface fuel loads as they decay and fall. Recent debates over post-fire logging practices and their impacts have highlighted the need for a greater understanding of trade-offs between snag utilization by cavity-nesting birds and fuel succession patterns after high severity wildfires. We sampled fire-killed trees and surface fuels on 126 plots within a chronosequence of 49 wildfires that burned dry coniferous forests of eastern Washington and Oregon during 1970-2007. Small fuels (1-hour to 100-hour) and 1000-hour sound fuels tended to increase to a peak 10-20 years following fire with larger size classes taking longer to peak. Rotten 1000-hour fuels increased with time since fire. 1000-hour fuels were also positively correlated with stand basal area. Snags with broken tops were more likely to have cavities than whole snags, and ponderosa pine snags were somewhat more likely to have cavities than Douglas-fir snags. The probability of a snag being

used by a cavity-nester increased over time, but rates varied among snag diameter size classes. Moderate size snags (30 to 60 cm diameter) had the greatest increase in probability of a cavity with time since fire up to 30 years. These results suggest that removing smaller trees after fire, especially in dense stands, may help reduce fuels with little impact on cavity nesters, but retaining moderate-sized trees may be necessary to maintain habitat in the immediate decades following wildfire.

PLANT GROWTH-PROMOTING BACTERIA OF BIOENERGY CROP PLANTS

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In studying the microbes living within the stems of poplar and willow, now seen as key bioenergy crops, we have identified a variety of endophytes with the potential for nitrogen fixation. The strong prevalence of diazotrophic microorganisms suggests that they play an important role in the biology of these colonizing tree species. Through genetic analysis and several assays research into the plant growth promoting endophytic bacteria and fungi has been rapidly accelerating as the need for more environmentally sustainable methods in agriculture has increased. For nitrogen fixation, we demonstrated that one of the isolates is able to fix nitrogen and positively impact the growth of commercially important, fertilizer-demanding plants, including turf grass and corn. We have also identified plant growth-promoting endophytes of another bioenergy crop, sweet potato, in a collaborative study with a team in East Africa.

GEOLOGIC MAP OF THE NORTH BEND 7.5-MINUTE QUADRANGLE, KING COUNTY, WASHINGTON—IMPLICATIONS FOR MAJOR CENEZOIC FAULTS, FOLDS AND BASINS IN THE AREA

Joe D. Dragovich[1], Timothy J. Walsh[1], Megan L. Anderson[2], Renate Hartog[3], S. Andrew DuFrane [4], Jeff Vervoot[4], Stephanie A. Williams[1], Recep Cakir[1], Kelsay M. Davis[1,] Fritz E. Wolff[1], David K. Norman[1], and Jessica L. Czajkowski[1].[1] Washington Division of Geology and Earth Resources, PO Box 47007, Olympia, WA 98504-7007; [2] Colorado College Department of Geology 14 E Cache La Poudre St, Colorado Springs, CO 80903; [3] Pacific Northwest Seismic Network University of Washington P.O. Box 351310; Seattle, WA 98195-1310; [4] Washington State University School of Earth and Environmental Sciences P.O. Box 642812; Pullman, WA 99164-2812; *joe.dragovich 'at' dnr.wa.gov*

Vashon recessional kames, kame deltas were deposited near the edge of the receding Puget lobe. A still-stand of glacial Lake Snoqualmie at ~800 ft apsl is evidenced by lake strandlines and sediment distribution. Snoqualmie River sediments compositionally match the older fluvial sediments we map as Olympia beds. The volcanic rocks of Rattlesnake Mountain occur as a complexly faulted imbricate body within the broad Rattlesnake Mountain fault zone (RMFZ) and are fault-imbricated with the Puget Group in both the eastern and western parts of RMFZ. Local seismicity, tectonically deformed glacial deposits, and uplifted Olympia beds suggest the eastern RMFZ is active. Strike-slip offset is indicated for the RMFZ by the fault strand linearity, along-strike variation in structural features, steep bedding near faults, dominance of sub-horizontal fault slickenlines, and shallow focal mechanisms. Much of the Snoqualmie River valley may be structurally controlled by RMFZ fault strands, strike-slip basins and en-echelon fold axes. The RMFZ is projected north of the area and correlated with the active southern

Whidbey Island fault zone. The Seattle fault zone terminates at the RMFZ northwest of the area where the RMFZ forms the eastern tectonic boundary of the Seattle uplift. In this model, dextral strike-slip offset along the RMFZ accommodates northerly vergence on the Seattle fault zone. The newly mapped Steele Creek fault aligns with the Olympic-Wallowa lineament and may be seismically active in the mid-crust. A regional décollement *may* be indirectly deduced by the clustering of ~17-28 km-deep hypocenters that cannot easily be correlated with surface faults.

FROM THE HEADWATERS TO THE SEA: A RIVERSCAPE PERSPECTIVE ON DISTRIBUTION AND ABUNDANCE PATTERNS OF FISH COMMUNITIES IN THE ELWHA RIVER PRIOR TO DAM REMOVAL

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Historically, the Elwha River watershed was home to resident and anadromous fish communities dominated by 10 different runs of all 5 species of Pacific salmon, as well as resident trout and lamprey. Construction of two dams in the early 1900s has dramatically altered fish communities, as some salmon runs were extirpated and the remaining populations are in serious decline. Currently, anadromous salmonids are limited to the lower 7.9 rkm below the lower dam and most populations are supplemented by fish hatcheries. A large scale ecosystem restoration project, led by removal of both dams, is expected to return some anadromous fish to spawning and rearing grounds protected within Olympic National Park. As part of a program to document baseline conditions of key ecosystem components prior to dam removal, we conducted a snorkel survey, using 21 divers, over 72 river km during base flows to document fish communities above, between, and below the Elwha River dams. Our goal was to provide a large-scale snap-shot of fish assemblages and habitat conditions so that we could: a) determine the spatial extent of existing salmonids in the mainstem river; and b) assess how species composition, abundance, and habitat features change across a 1,372 m longitudinal gradient. Sampling occurred during 5-7 days in 2007 and 2008 and patterns of fish assemblages and their habitats are presented. In 2009 a similar survey is planned for the Quinault River, an adjacent watershed many researchers are using as a reference site for studies of fish response to dam removal.

HABITAT UTILIZATION AND DISPERSAL PATTERNS OF JUVENILE CHINOOK SALMON INFERRED FROM OTOLITH ANALYSIS

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As juvenile Chinook salmon migrate from freshwater rearing areas, they undergo the physiological, behavioral, and life history changes necessary for transition to life in the ocean.

The Elwha River, its estuary, and the nearshore areas of the Strait of Juan de Fuca are expected to undergo many changes following a large dam removal and ecosystem restoration project. We identified patterns in the microstructure of otoliths (ear stones) from juvenile Chinook salmon to better understand the relative importance – to fish growth – of the lower Elwha River, the estuary complex at the mouth of the river, and the sub-tidal and near tidal areas near the river's mouth. We also identified the relative proportions of hatchery and naturally spawned juveniles, and the migratory pathways following entry into the estuary and into the central Strait of Juan de Fuca. Recognizable microstructure patterns of otolith cross-sections were apparent in individuals derived from three different sources: naturally spawned Elwha River, thermally marked Elwha River hatchery, and Dungeness River hatchery. We also were able to determine unique patterns of growth between freshwater and estuary/nearshore habitats and to quantify average daily growth rates in each habitat type. The use of otolith microstructure is a useful tool for obtaining life history information on Chinook salmon. Additional research and larger sample sizes are required to further develop the use of otolith technologies as a method to examine habitat specific growth patterns and migratory pathways in Elwha River Chinook salmon.

RATES OF DISCOVERY OF NEW HOST-FUNGUS RECORDS IN THE PACIFIC NORTHWEST: EXAMPLES FROM THE PALOUSE REGION OF NORTHERN IDAHO AND EASTERN WASHINGTON

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Over 50 new host-fungus records were documented from 2002 to the present by the plant pathology program at Western Regional Plant Introduction Station (WRPIS). WRPIS is part of the USDA-ARS National Plant Germplasm System. Monitoring the station's plant germplasm (including alternate hosts) for plant-associated microbes (especially pathogens) is a significant WRPIS activity because the germplasm is collected and distributed world-wide. Such monitoring is one of several ancillary activities of the station pathologist. The rate of accumulation of such records in incidental reporting by WRPIS implies considerable undocumented fungal diversity on agronomic plants in the Palouse.

TOWARDS RECOVERY OF GOLDEN PAINTBRUSH: MONITORING AND OUTPLANTING SITE SELECTION

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To meet goals in the federal recovery plan for federally threatened golden paintbrush (*Castilleja levisecta*), a minimum of 20 stable populations of 1000 individuals for 5 years must be sustained across the range of the species. Our work addresses several aspects necessary to accomplish these objectives: 1) Accurately documenting the status and trends of existing populations as their numbers change over time due to natural processes and on-site management, 2) Identifying new sites that are managed for conservation objectives and have the appropriate combinations of substrate, climate, and associated vegetation necessary to sustain viable populations of this species, and 3) Developing techniques for efficiently establishing large

numbers of plants in microsites where they are most likely to survive and reproduce. We have accomplished the first objective by developing a standardized monitoring protocol for tracking, usually on an annual basis, the number of flowering plants at all sites. The second objective is being addressed by systematically gathering detailed information on physical and biological parameters characterizing grasslands and other potential sites in Oregon, Washington, and British Columbia. We are also evaluating the suitability of some of these sites for supporting golden paintbrush as part of our focus on the third objective. Arrays of paintbrush plugs have been outplanted across 11 previously unoccupied sites in the Puget Sound region. Detailed data are gathered on the vigor and survival of all outplantings, and their performance is then related to microsite characteristics associated with each individual.

THE GREAT WARMING, OR THE STORY OF THE SILENT ELEPHANT IN THE ROOM

Brian Fagan, University of California, Santa Barbara.

Brian Fagan takes us back 1,000 years to the heart of the Medieval Warm Period and shows how the slight warming during these centuries had a dramatic global effect on history. We visit medieval farms in Europe, voyage with the Norse, learn about Maya water conservation, and of epochal droughts in California. Fagan shows us how the warming of a millennium ago has important lessons for the world of today and the future.

RESTORING FOREST HEALTH IN WASHINGTON STATE PARKS

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The Washington State Parks and Recreation Commission operates 120 parks and manages twice as many undeveloped parcels spanning more than 130,000 acres. The majority of these lands are forested. Many of these woodlands exhibit densely stocked stands, of natural or plantation origin, that create limited habitat for wildlife; an elevated risk of wildfire; and reduced recreational opportunities for the public. To address these issues the agency has launched a forest health effort designed to enhance vegetation composition, structure, and health in a number of state parks. The process begins with a vegetation association and rare plant survey in each target parks that helps to identify significant resources warranting either protection or enhancement actions, along with areas suited to forest rehabilitation efforts. Working in partnership with sister agencies and interested stakeholders, detailed inventories of the forest resources are conducted and treatments identified to enhance the natural functions and habitats characteristic of mature forest ecosystems. This talk will provide examples from this project, accomplishments to date, and discuss future activities.

WHAT FOREST RESEARCH MIGHT BE RELEVANT IN AN ERA OF INSTABILITY AND SURPRISE?

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Changes in environmental conditions are generating significant changes in forest conditions, including degradation as well as loss of forests to wildfire, pests and pathogens, and storms. Dramatic social changes brought about by globalization and increasing human populations are affecting societal perceptions and desires with regards to services and goods provided by forests. Future research is needed on: 1) anticipation/prediction of change, 2) management approaches that reduce risk and increase resilience and future societal options, and 3) maintaining forest ecosystem functionality. Research on ecosystem function relative to composition and structure is critical. Ecosystem science, such as that carried out over the last 30 years by LTER and at facilities, such as the Wind River Canopy Crane, has shown how relevant this science is to a broad range of practical issues, including concerns emerging *de novo*. The major NSF new investment in continental environmental research – NEON – also provides validation. In this century society will likely find itself frequently concerned with simply trying to maintain essential forest services, such as watershed protection or carbon sequestration, rather than provision of commodities, such as timber, or specific animal or plant species, including endangered organisms. Hence, science focused on understanding controls on forest function and the relationship of function to composition and structure is critical. Assessments of species' ecological amplitudes and research on approaches for assessing appropriate species substitutions, including introduction of non-native species, will also be important. A new sub-discipline of ecological engineering may emerge in order to deal with collapsing natural and cultivated ecosystems.

RESTORATION OF SEDIMENT PROCESSES RESULTING FROM REMOVAL OF ELWHA RIVER DAMS: DEVELOPING BASELINE DATA AND REFERENCE AREAS TO MONITOR FISH RESPONSES IN NEAR COASTAL HABITATS

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Removal of the Elwha River dams will restore sediment processes in the river's estuary and near coastal environments. The goal of our work is ultimately to assess responses of fish occurring in shallow sub-tidal and inter-tidal habitats in this region to this restoration action. Initial objectives have been to establish baseline conditions and select appropriate reference areas. We initially selected three reference areas and have been evaluating their usefulness as reference areas since 2006 using different assemblages of species. We have found high inter-annual variability in the fish community structure at treatment (likely modified by the dam removal) and reference sites as well as distinct differences in assemblages in the different regions. Major differences in abundance of some species occurred between regions as well as between years within a region. Differences were primarily due to fluctuations in abundance of small, mobile pelagic species such as juvenile northern anchovy. This suggests that a number of years are needed to assess adequacy of reference sites and restoration responses. Multivariate analysis was used to compare reference areas with treatment areas that were

selected to be geomorphically and environmentally similar. We found that some species groups (e.g., benthic flatfish) will likely be better indicators of restoration responses than other species groups as they were more consistent members of fish assemblages. Thus, comparability of reference and treatment areas depends in part upon the species groups that are used. Our results also indicate that multiple reference areas should be used when practical.

STAND STRUCTURE AND DISTURBANCE EFFECTS IN SOUTHWESTERN OREGON *QUERCUS GARRYANA*-DOMINATED WOODLANDS

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We lack information about historical fire regimes in southwest Oregon's interior valleys, but it is generally assumed that fuel loads are higher today than they were pre-European settlement. Many ecosystems in this area are being treated for fuels reduction to reduce potential fire severity and accomplish restoration, however restoration goals are based on an untested assumption that wildfire historically burned frequently and with low severity. We inventoried tree characteristics in 40 untreated *Quercus garryana* (Oregon white oak) dominated stands to describe their current condition and assess whether age or structural attributes varied systematically with site conditions or disturbance history. Multiple-stemmed oaks, which indicate past disturbance such as fire, tended to be associated with even-aged stands, and occurred more often in relatively high elevation and steeply-sloped stands, but were present across a range of environmental conditions. Multi-aged stands were common and occurred across a range of tree densities. In general, stand tree size-structure formed a reverse J-shaped curve which indicates continuous recruitment. However, 13% of stands did not support a sapling layer, which would indicate successful regeneration. Considering the various structural responses to disturbance and fire-suppression that we observed across stands, site-by-site management prescriptions may more effectively accomplish restoration goals than do one-prescription treatments.

GEOCHEMICALLY ANOMALOUS IGNEOUS ROCKS OF THE OLYMPIC PENINSULA: IMPLICATIONS FOR EOCENE TECTONICS

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Geochemically anomalous igneous rocks from four little studied localities on the Olympic Peninsula were studied through petrographic, ICP-ES and ICP-MS analysis to characterize samples and establish possible origin(s) and tectonic implications. Localities are considered anomalous because they differ from Crescent basalts, having higher SiO_2 and/or more alkaline compositions. The four localities are: (1) Makah Bay (MB), lahar deposits which contain clasts of hornblende-bearing basaltic trachyandesites and trachyandesites (50.6 - 56.1 wt.% SiO_2; 3.0 – 4.7 wt.% K_2O) with moderate LREE enrichment (La/Yb_N = 8.7-13.3), negligible Eu anomalies, OIB-like spidergrams, and extreme Ba enrichment (>5000 ppm). (2) Point of the Arches (PA), hornblende-bearing andesitic-to-dacitic dikes/sills (57.0 – 67.2 wt.% SiO_2; 0.9 – 2.0 wt.% K_2O), previously K-Ar dated at 59±3 Ma (Snavely et al., 1993), show modest LREE enrichment (La/Yb_N = 5.8-12.7), negligible Eu anomalies, and arc-like spidergrams (Nb depletions). (3) Yahoo Lake (YL), a rhyolitic tuff (74.7 – 77.0 wt.% SiO_2), and (4) Happy Valley (HV), a rhyolite

flow. Pronounced chemical differences indicate these localities do not share a common origin. MB sample compositions are consistent with a rift setting. The PA samples are unlikely to be differentiates of a more mafic parent; their compositions are more consistent with shallow melting (above the garnet field) of a basaltic source. Both rifting and the high temperatures necessary for melting in the forearc may be related to subduction of the Kula-Farallon Ridge at this time. Ongoing work will better establish the age of YL and the character and origin of the YL and HV.

DIVERSITY OF POWDERY MILDEWS IN THE PACIFIC NORTHWEST AND IMPLICATIONS FOR ESTIMATING SPECIES DIVERSITY OF OTHER FUNGAL GROUPS

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Powdery mildew fungi (Erysiphales) are conspicuous parasites of leaves, stems and fruits of many angiosperms. Because of their economic importance, and the long history of research on plant pathogens in the Pacific Northwest (PNW), one might assume that local Erysiphales have been well documented. Shaw's (1973) *Host Fungus Index for the Pacific Northwest* included about 30 named species. In 2002 a project was initiated to study the powdery mildews in the PNW. Results indicate that 125-150 species likely occur in the region. Several factors may explain the previous underestimation of Erysiphales diversity. Some species, such as *Erysiphe flexuosa* and *Leveillula taurica,* likely became established after Shaw completed his inventory. More significantly, powdery mildews have received surprisingly little study in North America; most 20th century taxonomic advances were made in Europe or Asia. North American scientists frequently use 19th century species and genus concepts, and resulting taxonomic and nomenclatural confusion has masked the presence of many species. The problems uncovered in the Erysiphales likely are typical of those limiting our understanding of total fungal diversity. About 15,000 species of fungi likely occur in the PNW but Shaw's compilation, the only one available, includes only 5,000 species. The challenge of completing the inventory of PNW fungi is formidable, particularly given the levels of funding available for biodiversity surveys. Such work may be aided by online resources designed to facilitate regional and international collaborations, including the *Pacific Northwest Fungi Database*, the *Erysiphales Database*, and the online mycology journal *North American Fungi*.

WHAT CAN SEATTLE'S CEDAR RIVER WATERSHED TELL US ABOUT LICHEN DIVERSITY?

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The Cedar River Watershed lies east of Seattle, Washington. Management of these forest lands recently included a lichen survey for maintaining safe water and preservation of the forests found in this natural area. Lichen collecting took place in the fall of 2006 and spring of 2007. Because of the close proximity to pollution sources from cities, lichen diversity was not expected to be high, especially for cyanolichens. Thinning practices were anticipated to have a negative effect on lichen diversity. Age class of forest was also considered in the analyses. Lichen species recorded were limited to macrolichens, but included a few microlichen species. The main factor affecting lichen diversity appeared to be variation in habitat and substrate within

a plot. Older sections of the watershed displayed higher biodiversity including plots where old fallen trees were allowed to remain in the forest. Forests resulting from plantation timber management had uniform substrate, resulting in lower lichen diversity. Several plots provided unexpected results. To date, the total number of lichen species identified is 185.

RESTORATION OF NATIVE PLANT COMMUNITIES AFTER ROAD DECOMMISSIONING IN THE NORTHERN ROCKY MOUNTAINS

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Road decommissioning is increasingly being recognized as a critical first step in the restoration of terrestrial and aquatic habitats. The US Congress recently appropriated $40 million for road removal and restoration in the western United States. Despite this relatively large public investment, little is known about the efficacy or ecological effects of road-removal practices. One particularly important issue that has not received enough attention is the impact of post-road-removal revegetation strategies. This study evaluated the short-term effects of road decommissioning on plant community composition and the effects of seed origin, seed-mix diversity, seeding density, and road-removal method on vegetation establishment on recently decommissioned roads. Although managers often justify seeding with nonnative species by the need for rapid establishment of plants on disturbed sites, one year after treatment we found no significant difference in total percent cover of vegetation regardless of seed mix used (native vs. nonnative). Although cover results did not vary by treatment, there was significantly less biomass of non-native plants in treatments seeded with native species than in the other treatments (0.44 vs. 5.70, respectively). Cover of seeded species was significantly higher for native seed treatments than for treatments seeded with nonnatives (5.95 vs. 1.61, respectively). Increasing seed-mix diversity resulted in significantly higher cover of seeded species. Plots that had been recontoured had significantly lower soil bulk density than those that had been scarified (0.786 vs. 0.951, respectively). These findings suggest that seeding with natives may increase the percent cover of vegetative establishment and reduce nonnative invasion.

OPPORTUNITIES AND BARRIERS TO USING FOREST BASED BIOMASS FOR THE PRODUCTION OF RENEWABLE ENERGY AND RENEWABLE FUELS

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Forest based biomass accounts for about two-thirds of the biomass potentially available for renewable energy and fuels production in Washington State. Consequently, use of this forest biomass is essential if Washington wants to meet its renewable energy and carbon emission goals. Further, there is need – especially on eastside forests – to clean out overstocked landscapes and mortality to reduce the threat of catastrophic forest fires. The renewable fuel demand pull and forest health issues should create a situation where forest biomass is readily available for renewable energy and fuel production – but that isn't the case. We will present an overview of the issues surrounding using forest biomass to produce renewable energy. Topics to be covered include: 1) technology for producing renewable energy and renewable fuels from forest based biomass, 2) factors motivating use of forest based biomass to produce renewable energy and fuels, 3) the economic and environmental opportunities associated with a robust

renewable energy and fuels industry using forest based biomass, and 4) the current barriers for using forest based biomass for production of renewable energy and fuels.

SIMULATING EFFECTS OF CLIMATE CHANGE ON FORESTS, FIRE, AND HYDROLOGY IN AN EASTERN CASCADES WATERSHED

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The composition, structure, and function of forests are largely determined by climate. Climate directly affects tree growth and recruitment while indirectly affecting the mortality by its control on fire regimes. A changing climate may therefore cause changes in tree distributions and or stand structure, which could have cascading effects on other forest resources. Effects on watershed hydrology are of particular interest to water managers in the western US because mountain forests store and transfer much of the water supply for downstream communities. We are using a landscape fire succession model to explore the effect of climate change on forest distributions and fire regimes for a watershed on the east slope of the Washington Cascades (USA). We simulate 20th century forest dynamics with historic climate data and future conditions with twenty different climate projections for the 21st century. Through analysis of simulation data, we explore changes in forest composition, structure, patch size distribution, fire size distribution, and fire frequency. We also use model output to parameterize hydrologic simulations that quantify how changing forest cover may affect watershed hydrology. Comparison of current and future stream flow illustrates the effect of forest cover and climate change on watershed hydrology. Our results could provide resource managers in the eastern Cascades with an indication of how climate change may affect the ability of forests to provide wildlife habitat, timber, carbon sequestration, and water resources.

FIRE SEVERITY AND POST-FIRE VEGETATION RECOVERY IN RIPARIAN AREAS OF TWO OREGON FIRES

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Although upland fire is relatively wellstudied, little is known about fire severity and post-fire vegetation recovery in riparian areas. The present study compared fire severity in riparian areas to that in adjacent uplands, and investigated the factors influencing riparian fire severity and post-fire vegetation recovery in two fires, the Biscuit Fire of southwestern Oregon and the B&B Complex fire in west-central Oregon. A stratified random sampling design was used to select points in a range of fire severity classes, stand ages, and stream sizes in each fire. At each selected point, plots were sampled in riparian areas and adjacent uplands. Fire severity was assessed in each plot, and we measured abundance of post-fire regeneration and characteristics of pre-fire vegetation and local topography in each riparian plot. We found that percent exposed mineral soil and scorch height in riparian areas were significantly lower than that of the adjacent uplands in both fires. However, there were no significant differences between percent crown scorch and dead basal area mortality in riparian areas and adjacent uplands in either fire. Fire severity in riparian areas was most strongly predicted by upland fire severity. In addition, aspects of riparian fuels were strong predictors of basal area mortality,

while aspects of local topography were strong predictors of exposed mineral soil. Post-fire vegetation recovery was controlled primarily by elevation and pre-fire community composition (hardwoods versus conifers). Abundant post-fire regeneration in riparian areas and self-replacement of hardwood- and conifer-dominated communities indicate high resilience of these disturbance-adapted plant communities.

RESTORATION OF WESTERN OREGON MONTANE MEADOWS FOLLOWING CONIFER INVASION

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Mountain meadows across western North America have experienced recent and rapid invasion by conifers. These invasions likely result from a combination of many factors including changes in climate, cessation of sheep grazing and wildfire suppression. Faced with the potential loss of these diverse habitats, land managers are beginning to use tree removal and prescribed burning as restoration tools. To guide these efforts we have established a series of retrospective and experimental studies at Bunchgrass Ridge, a complex of dry, montane meadows in the western Oregon Cascades. Our retrospective studies have identified several possible barriers to restoration including rapid replacement of meadow species by vigorous forest herbs and very limited potential for recovery of meadow species from the soil seedbank. Within this context, we examine the ability to restore invaded meadow habitat through tree removal, with or without prescribed fire, across a range of tree ages and densities. Along with untreated controls, these treatments are replicated using 9, 1-ha plots. First year responses indicate striking differences between the treatments. Broadcast burning lead to significant soil disturbance and elevated N availability compared to unburned and control plots. Yet the response of ruderal species was minimal in all treatments, despite dominance of the soil seedbank. In the short term, tree removal, with or without fire, appears to benefit meadow species at the expense of forest herbs. Longer term observations will be needed, however, to fully answer whether tree removal and prescribed fire can restore invaded meadows and under which conditions restoration is possible.

USING THE FOREST SYSTEM TO MITIGATE GREENHOUSE GAS EMISSIONS

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It is imperative that the rate greenhouse gases are added to the atmosphere is slowed. While carbon-free fuels are the ultimate solution, forest systems can be part of a bridging strategy that temporarily slows the rate greenhouse gases accumulate in the atmosphere. As a biological system, forests have the potential to remove carbon from the atmosphere and store it. Currently forests remove approximately 10% of the US's carbon dioxide emissions, creating a carbon sink that could be increased and maintained for many future decades. A wide variety of methods have been proposed to increase the carbon sink and stores within forest ecosystems including: lengthening harvest intervals, reducing the amount removed by harvest, fertilization, using genetically improved planting stock, and removing fuels. Increasing the stores of wood products is another proposed strategy, although doing this by shortening harvest intervals or increasing harvest intensity will lead to decreased stores within forests. Forest systems may also directly

offset fossil fuel emissions by serving as a source of bioenergy or substituting wood for more energy intensive materials during construction. With each proposed approach there is often a tradeoff with another, making policy decisions difficult. The degree each strategy contributes will be strongly influenced by economic as well as policy conditions. Regardless of the strategy selected, if climate change continues as projected, then many gains may be reversed by increased future disturbance. It is therefore essential that progress be made in other sectors so that forests can actually serve in a bridging strategy.

EFFECT OF WINTER ENVIRONMENT ON SPRING BUDBURST IN DOUGLAS-FIR

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Many temperate and boreal zone trees have a chilling requirement to prevent budburst during warm periods mid-winter. Past work has focused on determining the optimum temperatures to satisfy the chilling requirement and the range of temperatures that are effective for forcing. We present data on spring bud-burst from 13 treatments which imposed different winter temperature regimes on five families of Douglas-fir from western Washington and Oregon. Based on the results from these treatments and a survey of published literature, we suggest that although effectiveness varies with temperature, a wider range in temperature is effective in satisfying chilling than previously suggested and that both chilling and forcing occur simultaneously for much of the winter. For example, previous workers have used 0-5^{o}C as the effective range of chilling temperatures for Douglas-fir. We suggest, however, that both freezing temperatures and temperatures above 10^{o}C are effective. A minimum chilling requirement for bud-burst exists for Douglas-fir, but that level of chilling requires substantial hours of forcing to achieve bud-burst. Increasing amounts of chilling reduces the amount of forcing required. Our new model predicts that mean date of bud-burst will be earlier if mean winter temperatures increase slightly, but a wide range of date of bud-burst is possible depending on hourly conditions throughout the winter. Moderate or substantial increases in winter temperature will result in less chilling, however, and thus we predict under those circumstances, date of bud-burst would shift to later in the spring.

DEGLACIATION OF THE SOUTHERN SALISH LOWLAND

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Systematic interpretation of topography—including a rich trove of high-resolution lidar data—details the waning of the last, Vashon-age, ice sheet in northwest Washington and hints at the processes that controlled ice sheet and landscape behavior. (1) At the onset of glaciation, ice flowed east up the Skagit valley; at the end, ice flowed west from a North Cascade source. Either regional climate changed or the growing ice sheet created a new depocenter on the west slope of the North Cascades. (2) Melting at the margins of the ice sheet was facilitated by meltwater flow. Where there was less flow, there was less melting. (3) Restoration of 1 m/km up-to-the-north isostatic rebound, as suggested by Thorson, organizes ice-marginal alluvial flats into 5 elevation (age) groups that reflect changing base level as the ice sheet retreated. (4) Coherence of outwash delta elevations during a time of rapid isostatic rebound indicates that periglacial lakes were short-lived. (5) Absence of moraines between Olympia and northern

Whidbey Island and widespread dead-ice features suggest the Puget Lobe stopped moving and down-wasted in place, probably because it was decapitated by collapse of the Juan de Fuca lobe. (6) Extensive recessional outwash landforms, well-developed late-glacial marine shoreline features, and little subsequent landscape change suggest that the landscape was labile while unvegetated, then entered stasis as the forest grew. Once landscape patterns are recognized, anomalies become evident. An apparently-deformed outwash flat west of Bremerton suggests at least 3 large post-glacial earthquakes on the Seattle fault.

VEGETATION HISTORY OF WESTERN WASHINGTON

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The pattern of modern vegetation of western Washington is briefly described. Aspects of the recent historic patterns of vegetation are reconstructed and described, including effects of huge stand-replacing fires. Possible relationships with climate are considered, first through the life-span of existing trees (about 1000 years); then for the period of modern vegetation (about 5000 years); then back through the Holocene (about 12,000 years). Lastly, possible vegetation patterns comparable to current conditions are considered, back through the period of ice-core chronologies (about 800,000 years).

MARDON SKIPPER *(POLITES MARDON)* OVIPOSITION SITE SELECTION IN PUGET SOUND PRAIRIES

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Lack of basic biological information about at-risk butterfly species is a key limiting factor in butterfly conservation. The Washington State endangered Mardon skipper (*Polites mardon*) is no exception. Currently there is little more than anecdotal information on the habitat requirements and life cycle of the prairie dwelling South Puget Sound population of Mardon skippers. The prairies of the Pacific Northwest have been severely degraded by the invasion of non-native species such as tall oatgrass (*Arrhenatherum elatius*) and Scot's broom (*Cytisus scoparius*). These species are much taller than native vegetation and have vastly altered the structure of the prairies. In Spring 2008 I marked 18 oviposition locations at Scatter Creek Wildlife Area, 30 kilometers south of Olympia, Washington. I sampled vegetation at each oviposition location and random locations at the local and landscape scales. Fifteen variables were measured with respect to vegetation cover and structure. Oviposition was observed on native *Festuca roemeri* and *Danthonia californica*. Oviposition locations had relatively high native fescue and moss cover and low invasive tall oatgrass cover. The vegetation structure at oviposition locations was more open than at random locations with the greatest vegetation density occurring at landscape locations. This is the first step in describing the habitat of a butterfly about which very little is known. Since oviposition sites are the site of egg, larval, and likely pupal development, understanding the factors influencing oviposition site selection is key in developing effective habitat restoration strategies.

THE STRUCTURE OF NATIVE LANDSCAPE RESILIENCE AND ITS SPATIAL CONTROLS

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Mechanisms for resilience must exist in landscapes in order for large and complex ecosystems to persist across space and time, often in the face of substantial fire, insect, disease and weather disturbance, and environmental fluctuation. Furthermore, resilience mechanisms must occur at spatiotemporal scales that can reinforce the patterns, processes, and interactions that operate in ecosystems and across landscapes. Here, we examine the patchiness of multi-scale vegetative features on the landscape, and the spatiotemporal variability of that patchiness as it applies to the concept of resilience. We examine theoretical frameworks that can explain how organization and structure emerge on the landscape via disturbance processes and their variability. To date, fire ecology studies of forest and shrubland landscapes have focused on fire-size distributions and how power law statistics might explain them. We review datasets from different fire environments and discuss the applicability of the power law assumptions. Because fire size distributions may not be the most informative indicator of inherent landscape resilience, we examine the relationship between patch size distributions of other fire regime parameters (e.g., fire severity), their scale invariance, and why they may be useful measures for restoring landscape resilience. We conclude with an examination of "top-down" versus "bottom-up" controls on fire regimes in the Inland Northwest, how these forcings may have influenced vegetation structure and composition associated with a given fire regime, and what we might learn from past ecosystem structure and resilience to create more adaptable landscapes in an uncertain climatic future.

TWENTY YEARS OF RECOVERY AFTER FIRE IN THE KLAMATH-SISKIYOUS

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The Klamath-Siskiyou (K-S) region of northern California and southern Oregon is botanically and environmentally diverse as well as amazingly rugged. Overlain on this is a mixed-severity fire regime that adds to structural and age-class diversity. Across the middle portion of the moisture gradient of the K-S region, we examined areas that experienced high severity fire 15 to 20 years ago. Some sites had been managed after fire (salvage-logged, fuels treated, planted, brushed). We found that shrub cover was high and that conifer tree seedling density was high at all sites except at the driest sites. Tree seedlings had been establishing continuously for the first 10 to 15 years after fire and, while most are still within the shrub canopy, height growth rates suggest that most will emerge above the shrubs. Conifer growth rate was positively associated with shrub cover at low elevations and negatively at high elevations (white fir forest type). There was no decrease in seedling density up to 350 m from seed sources. Management reduced the number of snags, increased *Ceanothus* abundance on southerly or low elevation sites, had little effect on conifer seedling density, and slightly increased conifer regeneration size. The overall effect of post-fire management on young forest structure and diversity was fairly limited as environmental factors are the dominating driver in this system. Planting could be used to modify regeneration composition

LOST GROUND: SOIL C AND N DECREASES ASSOCIATED WITH THE BISCUIT WILDFIRE

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The 2002 Biscuit wildfire burned 200,000 ha of conifer forest in southwest Oregon, including previously established experimental plots of the Long-term Ecosystem Productivity Study. Pre-fire manipulations resulted in substantial heterogeneity among plots with respect to vegetation composition, structure, and woody surface fuel loads. The rare occurrence of ten of these previously sampled plots being burned by wildfire allowed direct evaluation of wildfire-induced changes in soils and fuels. The soil C loss due to wildfire varied among plots from 3 to 21 Mg C per ha, and the N loss from 0.03 to 0.60 Mg N per ha. On the most severely burned plots, soil C and N losses occurred not only from the O horizon, but also from the underlying mineral soil. Prescribed fire followed by wildfire resulted in 30% less soil C and N loss than wildfire alone. Soil C and N losses were positively and curvilinearly related to woody fuel consumption, which varied among the plots from 14 to 80 Mg per ha. This suggests manipulation of woody fuel loads and their subsequent combustion influenced soil C and N reduction via volatilization, particulate loss, or post-fire erosion. This study resulted in an unprecedented quantification of the relation between soil changes and the magnitude of wildfire fuel consumption; such a relation will be useful in forecasting potential impacts of wildfire on forest soils and their long-term productivity

GENETIC MALADAPTATION OF COASTAL DOUGLAS-FIR SEEDLINGS TO FUTURE CLIMATES

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Climates are expected to warm considerably over the next century, resulting in expectations that plant populations will not be adapted to future climates. We estimated the risk of maladaptation of current populations of coastal Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*) to future climates as the proportion of nonoverlap between two normal distributions where the means and genetic variances of current and future populations are determined from genecological models derived from seedling common garden studies. The risk of maladaptation was large for most traits when compared with the risk associated with current transfers within seed zones, particularly for the more drastic climate change scenario. For example, the proportion of nonoverlap for a composite trait representing bud set, emergence, growth, and root:shoot ratio was as high as 0.90. We recommend augmenting within-population variation by mixing local populations with some proportion of populations from lower elevations and further south. Populations expected to be adapted to climates a century from now come from locations as far down in elevation as 450-1130 m and as far south in latitude as 1.8-4.9°.

RESPONSE OF RIPARIAN WILDLIFE COMMUNITIES TO RESTORATION OF ANADROMOUS FISH IN THE ELWHA RIVER ECOSYSTEM

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The removal of two hydroelectric dams from the Elwha River on Washington's Olympic Peninsula provides a unique opportunity to improve understanding of habitat change and trophic effects associated with dam removal and anadromous fish restoration on riparian faunal communities of the Pacific Northwest. We conducted baseline studies of in-stream and streamside wildlife community composition, patterns of species distributions and occupancy, and ratios of marine-derived isotopes of nitrogen and carbon in selected wildlife species before dams are removed in 2011-12. We will present preliminary results on distribution and occupancy patterns of black bears, mesocarnivores, amphibians, and small mammals in riparian zones of the Elwha River, 2006-2008, and hypothesize changes that may occur following the dam removals.

SOIL CRUST LICHEN HUNTING AND IDENTIFICATION ON THE WILD HORSE WIND FARM AND WHISKEY DICK WILDLIFE AREA OF KITTITAS COUNTY, WASHINGTON

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With an interest in comparing effects of differing management regimes on lichen and moss species diversity of biological soil crust (BSC), over 500 samples were collected from 105 sample points. Two thirds of the collection was processed yielding, 37 species identified, 7 to genera and 13 species unknown with a total of 57 species recognized. As a major component of the methodology was the spatially derived selection of sample points, sampling methods, the process of identification and finally preserving, mounting and storage of the individual specimens. ArcMap was used to geographically stratify the study area into forty unique sets of variables. The variables include four aspects, two management regimes, and five plant communities (derived from soil composition). Then ArcMap selected five random points for each of the unique variable sets. Three of the five plant communities were sampled, due to time and resource constraints. Sampling methods included point-line intercepts in five quadrats along a ten meter transect (a total of 180 intercepts per sample point). Samples were collected for each pin-point, where the content of the sample was unknown and placed in a numbered paper bag. Samples were stored in large plastic bags labeled with the sample point number. The data sheets include UTM coordinates and elevation for each sample point. So far, there does not appear to be a species diversity difference between the management regimes. More statistical analysis and completion of the sample processing are necessary.

PARKING LOT TO PRAIRIE: A VEGETATION ASSESSMENT OF ECOLOGICAL RESTORATION ON THE UNION BAY NATURAL AREA, SEATTLE

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Past efforts in ecological restoration set forth on a trajectory toward prairie systems have employed mounding as a site modification technique. Mounding used to modify a restoration site mimics natural prairie landscapes in which these geomorphic elements may play a critical role on the natural selection and establishment of many prairie vegetative species. In this study we examine vegetation that exists on a ten year prairie restoration site in which earthen mounding was employed. We look at mound and inter-mound plots within three different moisture classes. Because there is little canopy and similar topography within a particular grass prairie and this study site, moisture is often the greatest environmental variable such systems. A total of 240, ¼ meter quadrats were randomly established and sampled. Percent cover data was collected for each vegetative species present. Mounds located in each of the three moisture classes show little variability in species diversity while the inter-mound microhabitats progressively increase in species diversity with decreasing moisture availability. We look further in to diversity by comparing native and non-native weedy species. The site is dominated by non-native plants but we find in this study that native plants increase in diversity and in cover as elevation increases and soil moisture decreases. Mounds located in wetlands have a greater cover of invasive plants than the surrounding saturated inter-mounds.

TREE GROWTH RESPONSES TO SNOWPACK ACROSS AN ELEVATIONAL GRADIENT AT MOUNT RAINIER NATIONAL PARK, WASHINGTON, USA

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Future climate change scenarios predict warmer winter temperatures and reduced snowpack accumulations in the Pacific Northwest. We utilized tree increment cores and data from permanent forest plots at Mount Rainier National Park to examine how growth and distribution of five tree species correlates with different climate variables, including temperature, precipitation, snow depth, and snow water equivalent. Increment cores and permanent plot data were collected across an elevational gradient, which provided corresponding gradients in temperature, snowfall, and other climatic variables. We used climate data from long-term monitoring stations within the Park, as well as estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM) system for areas where no measurements are available. The five study species were *Pseudotsuga menziesii* (Douglas-fir), *Thuja plicata* (western redcedar), *Tsuga heterophylla* (western hemlock), *Abies amabilis* (Pacific silver fir), and *Tsuga mertensiana* (mountain hemlock). Snow water equivalent (SWE) was correlated with the relative abundance of all five species, and the sign and strength of this relationship varied by species. SWE was also correlated with annual growth of *Abies, Pseudotsuga*, and *T. heterophylla.* Results from this project suggest that snow is an important climate variable for trees at Mount Rainier, and that tree responses to snow differ by species. These analyses warrant further investigation in order to fully understand how changes in climate may affect tree distributions in the Pacific Northwest.

USING LIDAR FOR MULTI-SCALED ASSESSMENTS OF FOREST STRUCTURE

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Forest structure reflects patterns of establishment, mortality, and disturbance. LiDAR data can extend conventional plot-level structural assessments to the stand and landscape scales. We applied these techniques to sites in the *Tsuga heterophylla* and *Abies amabilis* forest zones of the Cedar River watershed, Washington. Three LiDAR metrics (95^{th} percentile height, rumple, and canopy density) were correlated with traditional field measurements of live tree structure. We used these LiDAR metrics to classify 94 0.09 ha study sites (age range = 25-360 years) on the basis of their structural characteristics without making a priori assumptions about patterns of stand development. When class memberships were compared to site ages, general trends of stand development predicted from theory were supported, but considerable variation within age classes was observed. Possible causes of variation include differences in establishment history and the presence or absence of chronic partial disturbance. Forest structure at the multiple patch scale (9 ha) was studied using wavelet analysis for 91 study sites in the Cedar River Watershed. Three patterns of variance were observed: peak variance at the scale of traditional field plot (0.09 ha) with rapid decline in variance at larger scales, high levels of variance at all scales measured, and low variance at the scale of the study site but increasing variance at larger scales. In on-going analyses, weak associations have been observed between these patterns and stand age, suggesting that differences in establishment or partial disturbance may help explain forest structure at multiple scales.

PLANT COMMUNITY DYNAMICS FOLLOWING WILDFIRE AND RESTORATION TREATMENTS IN THE TIMBERED ROCK FIRE

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The Timbered Rock Fire burned 12,000 ha of mixed conifer forest in southwestern Oregon. Prior to the fire, approximately 40% of the federal timberland was occupied by plantation forests less than 35 years old. Lack of seed sources, competition from other vegetation, and abiotic conditions can limit conifer reestablishment in burnt plantations leading to restoration using mixed species planting coupled with vegetation control. The presence of early-seral vegetation, particularly cryptogams (i.e. spore producing plants), coincides with the most active period of management intervention and is a good indicator of change during post-fire restoration activities. The objective of this study was to compare plant communities and structural layers in areas with and without vegetation removal on moderate and harsh aspects in severely burnt plantations of the Timbered Rock Fire. Vegetation established rapidly in burnt plantations following wildfire. Plant community composition and successional trajectories differed in areas with and without vegetation removal. Cryptogam communities showed stronger differences between areas with and without vegetation removal on moderate aspects than harsh aspects.

Initially bryophyte and shrub cover were lower where vegetation was removed compared to areas without vegetation removal. Reestablishment of bryophyte cover in areas with vegetation removal was evident by the fourth year after fire, but shrub cover remained decreased due to direct manipulation by vegetation removal. Low shrub cover was lower where vegetation was removed on moderate aspects but not on harsh aspects. Repeated manual vegetation removal was effective at suppressing tall shrubs with minimal effects on other vegetation components.

MICRO-PLASTICS MONITORING IN PUGET SOUND AND NORTHWEST STRAITS

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The Port Townsend Marine Science Center (PTMSC) is conducting a citizen science research program looking for the presence of micro-plastic debris in Puget Sound and Northwest Straits waterways and beach sediments. Ingestion of micro-plastic (defined here as 1-5 mm) has repeatedly been shown to adversely impact wildlife. The research program currently has two components - beach sediment sampling and gull bolus dissection. PTMSC staff and volunteers, along with volunteers from partnering community groups, are biannually sampling beach sediments from fifteen beaches around Puget Sound and the Northwest Straits. At each beach, three 7.5 liter samples of sediment are collected, sieved to create two size classes, and then sorted for marine debris. The debris is further sorted by type, counted and weighed. During the fall 2008 sampling program, plastic was present on all fifteen beaches. PTMSC staff and volunteers have collected and dissected over 200 Glaucous-Winged Gull boli (boluses) from Protection Island National Wildlife Refuge to determine if gulls are ingesting plastic. Boli were collected during the breeding season, after the eggs were laid but not hatched. All boli within the sample plots were collected if intact. Trained volunteers have dissected, sorted and quantified the contents of each bolus. Fourteen percent of boli collected in 2007 contained plastic debris. A second set of boli are currently being prepared for examination.

POPULATION GENOMICS IN SPECIES CONSERVATION: TOOLS FOR THE STUDY OF LOCAL ADAPTATION AND FISHERIES MANAGEMENT IN KOKANEE *(ONCORHYNCHUS NERKA)*

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A longstanding goal in conservation biology is the preservation of an organism's ability to adapt to changing environments. Our knowledge of genes that influence local adaptation within non-model organisms is limited. With the emergence of population genomics, genome-wide associations between fitness-related traits and segregating variation can be detected within natural populations. The Okanagan Lake kokanee present an ideal system for studying adaptive population divergence and exploring the utility of this information in conservation and management initiatives. Despite a dramatic decline in numbers, two sympatric reproductive ecotypes continue to exist. In previous studies, significant levels of population differentiation were detected between the two ecotypes. The genetic basis of these differences will be explored to identify gene regions that underlie adaptive divergence through genomic scans

utilizing >40 EST-linked microsatellite markers. The adaptive significance of detected outlier loci will be determined by performing comparative analyses with the wealth of web-based genomic resources available for salmonids. The utility of detected outlier loci in genetics-based stock assessments of kokanee will be further explored. Previous attempts have relied on mixed population analyses based on allelic variation at a limited number of microsatellite loci, which resulted in substantial error rates. The use of discrete characters in genetic classifications has the potential to more accurately assess the abundance of each ecotype and ultimately enhance kokanee stock assessments in Okanagan Lake. This study will be one of the first applications of population genomics within a species of conservation concern and will have direct implications for fisheries management and conservation.

WATERSHED-SCALE MAPPING OF FIRE SEVERITY IN A MIXED-SEVERITY REGIME

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Quantifying the variability in fire severity is critical to predicting landscape fire effects from the rising number of wildfires within Stehekin, North Cascades National Park, and the prescribed fires that are used to mitigate them. The Flick Creek wildfire (2006) burned 7900 acres of the Stehekin watershed, producing a gradient of very low to stand-replacing fire effects in the Douglas-fir / Ponderosa pine forests within the burned area. In 2007 we collected post-burn severity data (tree mortality by species, scorch percentage and height, and char height) and estimated fuel and vegetation consumption on 45 forest plots stratified by canopy cover within the fire perimeter. We have grouped these plots by five levels of canopy mortality and identified the common features (environmental and structural characteristics) within these 'severity groups'. We will compare a map of fire severity, produced by overlaying these groups on a vegetation map of the park, to the dNBR (delta Normalized Burn Ratio) fire severity map produced by analysis of satellite imagery. The severity groups are a preliminary product, which will be expanded to include the ranges of fire frequency for each group based on fire scars and stand age reconstructions that are currently in progress. The completed fire statistics will be mapped across the Stehekin landscape, thereby quantifying fire frequency and severity at the watershed scale; a finer resolution than most maps of mixed-severity fire regimes.

ASSESSING POTENTIAL CLIMATE IMPACTS ON SPECIES AND POPULATIONS

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Over the last century, global average temperatures have risen 0.7 ˚C. This increase has been accompanied by shifts in species distributions, changes in phenologies, altered fire and hydrologic regimes, and changes in disease dynamics. Global average temperatures are projected to rise an additional 1.1 to 6.4 ˚C by the end of this century. This additional increase will result in even greater changes to ecological systems. To date, most forecasts of the potential ecological impacts of climate change have involved projecting shifts in species distributions. Fewer studies have attempted to project population-level impacts of climate-related stressors. I will discuss two projects that forecast climate impacts on birds at two distinct spatial scales. First, I will discuss correlative modeling efforts that have resulted in projected

climate-induced range shifts for 1,818 species of birds in the western hemisphere. These projections are based on relationships between current ranges and current climate that are then used in conjunction with future climate projections to produce projected shifts in potential ranges. I will go on to describe much finer scale modeling of the potential impacts of climate change on a population of Red-cockaded Woodpeckers at Fort Benning, Georgia. These mechanistic simulations provide forecasts of population responses to climate-driven changes in habitat and food resources. These two studies demonstrate the importance of considering the effects of climate change at multiple spatial scales and reveal some of the challenges and limitations of both correlative and mechanistic modeling approaches.

PHYTOREMEDIATION OF CHLORPYRIFOS

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Chlorpyrifos is one of the commonly used organophosphorus insecticides and causes serious environmental and human health problems. Our hypothesis was that these problems may be partially or thoroughly solved by the emerging phytoremediation technology. To evaluate plant potential for degradation of chlorpyrifos, several selected plant species such as aspen, cottonwood, and willow were investigated. The species tested in this study were: willow clone SV1 (*Salix dasyclados*), SX61 (*S. sachalinensis*), SX64 (*S. miyabeana*), SX67 (*S. miyabeana*), 94006 (*S. purpurea*), black cottonwood (*Populus trichocarpa*), and poplar hybrid clone INRA 717-1B4 (*Populus tremula* x *P. alba*). Analysis of the percent removal of chlorpyrifos from solution showed that chlorpyrifos can be taken up by plant roots and degraded into TCP which is nontoxic. The best performing line, SX 64, removed chlorpyrifos in the highest uptake rate (micrograms of chlorpyrifos·day^{-1}·g^{-1} plant wet weight ± SEM), 21.27 ± 2.09, showing the highest statistical difference in uptake rate between SX64 and the unplanted vials. In addition there was a significant difference between three species (hybrid poplar, cottonwood, and SX61) and SX 64 at the 5% significant level ($p = 0.011$). To our knowledge, this work represents the first report for phytoremediation of chlorpyrifos using plants and it is expected that these types of trees will feature largely in phytoremediation research in the future.

USING MODERN PROCESSES TO UNDERSTAND POSTGLACIAL DELTA EVOLUTION: ELWHA RIVER DELTA

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The postglacial shoreline of the Elwha River delta is thought to have been 4 km seaward and ~50 m below the modern shoreline. Previous research suggests storm-driven waves and relative sea level are the primary forcings of the Elwha River delta over the past 10,000 years. Net eastward sediment transport formed three drowned paleospits at -29-m, -22-m, and -16-m depths. Sea-level rise slowed at ~4,500 years BP and created the well-developed modern spit, Ediz Hook. In recent times, the Elwha River was dammed and coastal bluffs armored eliminating sediment supply to the nearshore and causing a period of net shoreline erosion. We

created a base map of the subaqueous delta morphology using multibeam swath mapping and seismic reflection profiles to test Galster's (1978) model of shoreline evolution. The ancient morphology and stratigraphy can be interpreted using sediment-transport processes. We quantified the modern sediment transport pathways with current measurements and suspended-sediment concentrations collected in the bottom boundary layer using an instrumented tripod. Data indicates that sediment can be resuspended by a combination of waves and tidal currents. The strong tidal currents (over ~1 m/s) helped winnow the seafloor creating a substrate ranging from sand to cobble size. Anthropogenic changes to the nearshore sediment supply have led to a new phase of delta evolution - specifically one of net erosion. By assessing the Galster shoreline evolution model with direct geophysical and modern water-column observations, Elwha delta evolution over the past 10,000 years can be better understood.

A POTENTIAL HABITAT MODEL FOR SALAL *(GAULTHERIA SHALLON)* FOR THE OLYMPIC NATIONAL FOREST, WASHINGTON

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Understanding the ecology of a species and its distribution across the landscape is the basis for addressing questions of habitat requirements, amount and distribution of suitable habitat, and management needs. A potential habitat model and map that displayed the distribution and likelihood of occurrence of salal was developed and validated for the Olympic National Forest. The species habitat model is an application of the U.S. Forest Service Potential Natural Vegetation (PNV) model. This environmental gradient model uses known locations of a species and mathematical associations with environmental variables to predict areas on the landscape where suitable environmental conditions occur for the species. Ecology plot data were randomly split into two data sets, the model building set (1020 plots) and the model validation set (427 plots). Frequency distributions for salal abundance and absence were compared to frequency distributions for the study area for each environmental variable to identify predictive variables. The habitat model used nine PNV model variables to predict potential habitat for salal, Elevation plus Cold Air Drainage Effect and Soil Moisture were most predictive. The model output was a map of four habitat classes: high, moderate, low, not likely. The High Likelihood Habitat occupied 30% of the Olympic NF and averaged 35% salal cover. This map provides resource managers information on the abundance and distribution of potential habitat for salal. Data on salal harvest levels and growth response could be used in conjunction with this map to inform management decisions regarding sustainable levels of harvest for this forest product.

DOES PLOT DESIGN MATTER WHEN MODELING TREE SPECIES DISTRIBUTIONS?

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The accuracy of species' range mapping is important for providing reliable baselines to monitor change. Range maps are often based on habitat models built from large datasets containing species presence/absence data. The largest forest monitoring data set in the United States is

from the Forest Inventory and Analysis Program (FIA) of the U.S. Forest Service. FIA recently switched from a mix of plot designs optimized for specific areas and owners to a nationally standardized design; we need to understand how different tree selection probabilities affect model development. Some published works rely jointly on the different FIA sampling methods without exploring the consequences. Here, we determine if the change in sample design affects model and range map development from FIA data for geographic distributions of conifer species within the Pacific coastal United States. We build models using Non-Parametric Multiplicative Regression (NPMR) for probability of occurrence of common tree species including *Tsuga heterophylla*, *Pinus ponderosa*, *Psuedotsuga menziesii*, and *Tsuga mertensiana*, with respect to climate. We find that segregating data by sample design for most species yields models with the same climate predictors. However, the models show slight differences in fits and climate domains expressing statistical interactions. We discuss the implications for range mapping applications.

FORESTS OF THE INLAND WEST: LIFE CYCLE ANALYSIS AND FULL CARBON ACCOUNTING

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Life Cycle inventories were developed for the forest resources of the Inland West region of the Western US. These LCI's capture the breadth of management strategies landowners use to meet their goals across differing site capabilities, forest types and species. We examine four carbon pools and assess opportunities and trade-offs associated with managing standing forest carbon stocks to simultaneously reduce fire risk and provide co-products for bio-energy streams in the Inland West. We found that differences in forest management objective are likely to produce the largest differential in the potential for carbon sequestration and storage in the forest, while the economics of forest residual recovery drives the potential for providing biomass for renewable energy initiatives. Uncontrolled wildfires produces the largest overall climate change impact, but controlled burning of unused slash to reduce the risk of wildfire, either post harvest or as the primary treatment, is the largest contributor to the climate change impact category when managing forest lands for commodity production or fire risk reduction. Finding ways to use the slash for renewable energy initiatives would provide dual benefits by reducing the carbon footprint required to manage forests and reducing the risk of significant carbon emissions from wildfire.

MIMA MOUNDS FORMATION AND THEIR IMPLICATIONS FOR CLIMATE CHANGE

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Geomorphic evidence indicates that Mima Mounds in the southern Puget Lowland are spatially and probably temporally related to ice retreat at the end of the Wisconsinan. The mounds occupy pro-glacial recessional outwash channels that apparently formed as drainage from the east side of the Puget Lowland glacier surged around the glacier's snout periodically during the

ice front's retreat. There are at least four or five mound bearing channels between Tenino and Tacoma. The channels are all sharply cut and the mounds are of similar size, suggesting that the time interval between the episodic formation of both the channels and the mounds are short, possibly seasonal or shorter. If the channels formed seasonally, then the ice front may have retreated about 25 miles in four to five years. The fine-grained mounds are restricted to the braided coarse-grained outwash channels and are in sharp contact with the channel deposits, suggesting that the mounds were lowered onto the channel surface perhaps by melting ice. This could have occurred if hydraulically dammed, late stage shallow floodwater or possibly saturated flood gravels froze and subsequent lower energy drainage introduced the fine grained mound material on top of the ice. As atmospheric warming occurred the fine material migrated on the ice surface to sun cups, which, when melting was complete, formed mounds atop the outwash channels.

NO, WE SHOULD USE THE *OTHER* HAMMER: A TOOLBOX-BASED APPROACH TO NEGOTIATING PHILOSOPHICAL DIFFERENCES WITHIN CROSS-DISCIPLINARY RESEARCH GROUPS

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Many research questions require cross-disciplinary collaboration. However, distinctive approaches and traditions of individual disciplines can impede such collaboration. Among these impediments are the philosophical perspectives of science that differ across disciplines, e.g., the validity of qualitative versus quantitative data. We hypothesize that enhanced communication is the key to resolving these differences, and offer a philosophically based approach to enhancing communication within cross-disciplinary teams. Our approach uses a set of guiding prompts—the "toolbox"—in workshops to encourage structured dialogue. The toolbox is organized into "core questions" within two main philosophical dimensions of scientific thought (epistemology and metaphysics), and "probing statements" that focus on more detailed ways of articulating these issues. The toolbox application includes three methodological stages. First, participants review the philosophical structure and core questions of the toolbox and respond to a short survey based on the probing statements. Second, the team members meet to discuss their responses. This discussion is recorded and transcribed. Third, participants complete a post-session survey, re-visiting the probing statements. We use conversation analysis and descriptive interpretation of the surveys to understand (a) philosophical disparities within the group that could influence their collaboration, (b) social structure and cooperation or conflict within the group as revealed by conversation dynamics, and (c) the effect of the workshop on the philosophical positions of group members. Analysis of workshop results indicates values and objectivity are the most discussed concepts. Our analysis also indicates that toolbox sessions enhance communication within teams, primarily by promoting discussion of basic science philosophy.

STAND DYNAMICS AND FIRE SEVERITY IN MANAGED DRY FORESTS OF THE EASTSIDE CASCADE RANGE, WASHINGTON

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Studies have debated the flammability of young regenerating stands and no consensus has emerged. Fire effects in young stands are highly dependent on surface and live fuels, therefore treating fuels in young stands should have pronounced effects on fire severity. This question has not been adequately resolved using spatial imagery due to the fine scale of the mechanisms driving fire severity in young stands. For that reason, we collected empirical stand and fire severity data from 339 plots in the Okanogan-Wenatchee National Forest (OWNF) on the east side of the Cascade Range in Washington. The OWNF has implemented regeneration cuts (small clearcuts) to promote regeneration of tree species, including Douglas-fir, subalpine fir, Engelmann spruce, and western larch in mid-elevation dry forests. The units varied in size, age, species composition, and planting density, and had different types of post-logging surface fuel treatments. In 2006, the 70,925-ha Tripod Complex Fire burned through many of these regeneration units, providing an opportunity to analyze the relationship between fuel treatments, stand dynamics and fire severity in young stands. We compared fire severity in regeneration units with or without fuel treatments using a Permutational Multivariate Analysis of Variance (PERMANOVA). Units without fuel treatments had more severe fire effects. Other explanatory variables also contributed to differences in fire effects, including species composition and spatial distribution of units on the landscape. Results suggest that young stands can be fire resilient if surface fuels are treated and stands are planted in spatially strategic locations.

FEEDER BLUFF MAPPING IN GREATER PUGET SOUND—A TOOL FOR PROCESSED-BASED NEARSHORE RESTORATION AND CONSERVATION

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The term feeder bluff, as first coined by Wolf Bauer in the mid-1970s, refers to sediment source bluffs that are known to contribute the vast majority of sediment to Puget Sound beaches and net shore-drift systems. Processed-based restoration aims to restore and protect self-sustaining processes such as coastal bluff processes, which create and sustain valued nearshore habitats. Feeder bluff mapping, conducted by CGS, entails identification of bluff process areas for protection and restoration, in terms of both short term planning and permitting, and longer term nearshore restoration and conservation planning and implementation. Current and historic geomorphic mapping methods entail assessment of individual shore reaches or parcels using a landscape-scale systems approach. Results prioritize areas to target restoration and conservation efforts at the reach, drift cell and regional scale(s). Current conditions mapping has been completed along over 650 miles of Puget Sound regional shore and historic conditions along close to 250 miles. Synthesis of all data highlights the magnitude of sediment impoundment in the Puget Sound region and the necessity of restoring and conserving bluff sediment sources. Results of the mapping, which have been available in sections starting in 1999, have been applied by a wide variety of groups working in the nearshore, including counties, tribes, WRIAs, MRCs, and non-profits. Completion of the dataset Sound-wide would allow for true process-based analysis and restoration planning.

MONITORING THE ACTIVE CASCADE VOLCANOES

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While the ultimate mission of volcanology is to make living with volcanoes safer the sometimes conflicting specific goals of basic research compared to hazard mitigation requires a delicate dance between innovative, experimental techniques and robust, tried-and-true real-time monitoring. Unlike earthquakes, volcanoes almost always give ample warning before they become hazardous. Our monitoring efforts can have significant impact on hazard mitigation efforts. However, the complexity of volcanic systems and their proximity to the earth's surface means we need a plethora of monitoring techniques to try and anticipate their actions accurately. In the Cascades these include but are not limited to seismic, geodetic, gas chemistry, petrologic, photogrammetric, acoustic and electro-magnetic. Some techniques are more suited to the immediate warning of imminent danger while others are critical for an understanding of the whole volcanological process. From Lassen Peak in the south to Mount Baker in the north, seismic monitoring is expected to give the first indication of volcanic unrest. A form of seismic monitoring is used for realtime lahar detection and warning at Mount Rainier. Geodetic monitoring at some of the volcanoes can both see aseismic intrusions as well as assist in the interpretation of seismic sequences. Mount St. Helens has provided a living laboratory for the development of a variety of new or modified monitoring techniques. Since no Cascade volcano is currently erupting, these more experimental monitoring techniques are kept at the ready for initiating at the first signs of unrest at any volcano.

BENTON COUNTY SHRUB-STEPPE COMMUNITIES—ECOSYTEMS SHAPED BY HUMAN AND NATURAL FORCES

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I will describe the analysis of data collected in the first year of Steppe in Time, a long-term study of shrub-steppe at over 30 randomly located sites in Benton County, which was conducted from 1992 to 2001 with volunteer field crews. Each site was measured with two 200 meter transects. Cover and frequency observations were made in 1/10th meter microplots, and shrub cover was measured by line intercept. The thirty-two sites were grouped by various site factors, including elevation, slope, slope aspect (as heat load) and according to whether they were located on private grazed land. Sites were located on the Fitzner-Eberhardt Arid Lands Ecology range (ALE) on the Hanford site (ungrazed except for a herd of about 110 Roosevelt elk), or on ungrazed public and private lands not on ALE (land use factor). Cluster analysis suggests that the elevation site factor has the strongest influence on species composition and abundance, with the human-influenced site factor accounting for the next highest proportion of variance. Indicator species analysis identified downy brome (*Bromus tectorum*) and bluebunch wheat grass (*Pseudoroegneria spicata*) as the strongest indicator species for the elevation grouping and bluebunch wheatgrass as the most important indicator species for the land use grouping.

IMPACTS OF MANAGING PUBLIC LANDS FOR LIVESTOCK PRODUCTION

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The Washington Department of Fish and Wildlife (WDFW) has no legislative mandate to permit livestock grazing on wildlife areas, but when funds become available to purchase land that would be valuable for wildlife, the agency sometimes finds it advantageous to permit a property owner to continue grazing that land for a fixed interval as a condition of the sale. In the past decade, WDFW has announced a policy for domestic livestock grazing on its lands, has signed a memorandum of understanding with the Washington Cattleman's Association "to facilitate the establishment of several pilot livestock grazing projects to demonstrate the benefits to fish and wildlife and/or WDFW Land Management that can be derived from controlled livestock grazing". Also WDFW has taken part in development of two Coordinated Resource Management plans with other state agencies and local land-owners for the same purposes, permitting grazing on over 85,000 acres. Simultaneously the agency successfully purchased a large area of land in Kittitas County that broadly links Whiskey Dick Wildlife Area, which had not been grazed since 1989, with the Quilomene and LT Murray Wildlife Areas to the north. Those lands, together with the Yakima Firing Range and other public and tribally held lands to the south encompass more than 500,000 acres of contiguous shrub-steppe landscape of enormous conservation value. I will discuss the science related to use of livestock grazing as a management tool in arid landscapes and present our preliminary findings comparing the grazed Quilomene and recently ungrazed Whiskey Dick lands.

POLLEN EFFECTS ON PLANT REPRODUCTION IN THE RARE PLANT, *ASTRAGALUS PECKII*

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Astragalus peckii, a rare species endemic to Deschutes and Klamath Counties in central Oregon, has been found to have relatively low seed set. This study, therefore, evaluates the effect of pollen quantity and quality on reproductive success in the field. Pollen supplementation experiments were carried out over 2 years at 6 field sites to test for the effect of pollen quantity on reproductive success, and controlled crosses using self- and cross-pollen were done one year at three field sites to test for the effect of pollen quality. Additionally, seeds from self-pollinated and open-pollinated plants in the field were collected and used to test for inbreeding effects on seed germination and seedling growth. In general, plants were not limited by the quantity of pollen received, with only one site during the two years of study showing an increase in reproductive output with the addition of pollen. Conversely, pollen quality did have an effect on reproductive output, with cross-pollinated plants producing 0.32 more seeds per pollinated flower, which more than doubled reproductive output at 2 of the 3 sites. Seeds from self- and open-pollinated plants had similar germination rates, but after 10 weeks of growth, seedlings from open-pollinated plants were 82% taller than those from self-pollinated plants. Overall, results from this study indicate that pollen quality is of greater concern than pollen quantity for reproductive success and seedling growth in this species. From a conservation standpoint, this would be of greatest concern in small, shrinking, or increasingly isolated populations.

THE STATUS OF LICHEN CONSERVATION IN CALIFORNIA

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In 2001, the California Lichen Society established a conservation committee to develop an assessment of rare lichens. This committee established a sponsorship program, by which individuals summarized existing scientific data and assigned both global and local conservation ranks to the lichen they sponsored. Rarity and threat ranks for California lichens were based upon the California Natural Diversity Database and Natural Heritage methodologies. Taxa are also placed on lists equivalent to those of the California Native Plant Society. This combination provides basic status information to agencies, consultants and the public in a fashion they are familiar with. The California Native Plant Society subsequently adopted this sponsorship system. Currently, 11 lichens have been sponsored and four species have completed the yearlong review process. The California Lichen Society maintains a priority list of lichens in need of sponsorship. This presentation will include guidelines for lichen sponsorship and describe how to apply these guidelines to lichens and bryophytes in Oregon and Washington.

SEDIMENT AND WOODY DEBRIS DYNAMICS OF HEADWATER STREAMS IN MANAGED FORESTS OF WESTERN WASHINGTON

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This study was designed to quantify and describe woody debris and sediment in headwater streams under varied forest management treatments. Objectives of the study were to: 1) assess whether timber harvest and riparian buffers impact woody debris and stored sediment and 2) examine the ecological and morphologic controls over in-stream woody debris and sediment. Twenty-one first-order streams in the Black Hills and Willapa Hills region of southwestern Washington were selected and placed into three pre-determined treatment groups, with seven streams per group. Treatment groups included headwater drainage basins which had experienced clearcut timber harvest: 3-5 years ago (Clearcut), 3-5 years ago with riparian buffers retained (Buffer), and 50-70 years ago (Reference). A segment of each stream <3 m wide was surveyed to quantify and describe woody debris and sediment. Woody debris was quantified by volume and large-diameter wood piece counts and characterized by species, source, spatial position in the channel, and sediment storage function. Sediment storage was quantified by volume, bulk density, and particle size distribution. Results indicate elevated levels of woody debris loading in Clearcut channels, compared to Reference and Buffer channels. No treatment group differences were detected for in-stream sediment storage volume, but the proportion of fine sediment (<2 mm in diameter) was found to be higher in Clearcut channels. Controlling for stream power, an index of drainage basin size and channel slope, enhanced the treatment effects. A relationship between in-stream wood volume and in-stream sediment volume was only found for streams with channel gradients <20%.

MACROLICHEN DIVERSITY IN NOATAK NATIONAL PRESERVE, ALASKA

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We sampled Noatak National Preserve with a stratified random sample to allow unbiased park-wide diversity estimates, along with an intensive sample in a limited area. The purpose of the intensive sample was to allow us to calculate a correction from diversity estimates based on a single person in a time-constrained method to a value that more closely approximates the "true" diversity of a plot. Our 88, 0.38-ha plots averaged 26 species of macrolichens in the sample, while our best estimate of the true average was 42 species per plot. Our raw estimate of gamma diversity (park-wide macrolichen species richness) was 209 species, with jackknife estimates adjusting this to 255 or 290 species, depending on the estimator. Overall beta diversity was rather high at 7.1, reflecting the considerable variation in lichen communities among topographic positions, rock chemistry, substrate pH, climate, and vegetation. The richest lichen communities were in conifer forests, low birch/ericaceous vegetation, dwarf shrub, and talus lichen cover. Sparse vegetation was the cover type with lowest lichen species richness, reflecting the frequency of bare rock in that cover type. The herbaceous cover type was the most heterogeneous in lichen communities, having high gamma diversity, high beta diversity, but averaging rather low alpha diversity. Several notable species are among the 364 taxa found in this study.

PYRODIVERSITY ACROSS THE METOLIUS FIRESHED: A CARBON PERSPECTIVE

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Since 2002, mixed-severity wildfires have burned more than 65,000 hectares in the Eastern Cascades of Oregon. This study quantifies diverse ecosystem responses and carbon cycle implications across four large fires that burned ~35% of the Metolius Watershed (~115,000 ha) in 2002 and 2003. We stratified the postfire landscape by three gradients: forest type (ponderosa pine (PP) and mixed-conifer (MC)), burn severity (unburned, low, moderate, and high overstory mortality), and prefire biomass. Basal area (BA) mortality ranged from 14% in low severity PP stands to 100% in high severity PP stands, with parallel patterns in MC stands. Additionally, fire-sensitive *Abies grandis* accounted for the majority of mortality in low and moderate-severity MC stands (74% and 54% of BA mortality, respectively), whereas fire-adapted *Pinus ponderosa* and *Pseudotsuga menziesii* tended to survive, representing a potential shift toward historic conditions. Postfire conifer seedling density was negatively correlated with burn severity (median range: 10,223 seedlings ha^{-1} in low severity MC to zero seedlings ha^{-1} in high severity PP), while shrub cover and biomass showed the opposite trend. Despite widespread tree mortality and associated declines in net primary productivity (NPP), non-tree NPP more than doubled in moderate and high severity stands, resulting in a substantial offset of decreased carbon uptake. In PNW forest ecosystems, the mixed-severity mosaic drives a wide range of short- and long-term trajectories of carbon loss and recovery.

EFFECTS OF A CENTURY OF FIRE SUPPRESSION ON RIPARIAN FORESTS OF SOUTHWESTERN OREGON

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Fire suppression has been associated with structural and compositional changes in many upland forests of the western United States, but little is known about the impacts on riparian forests. Because frequent, low- to moderate-severity fire shaped upland forests throughout southwestern Oregon, it has likely been important in shaping and maintaining riparian forests as well. For this study, our objective is to identify the ways in which riparian forest structure and composition in the xeric 'interior valley zone' (*Pinus-Quercus-Pseudotsuga*) and the more mesic 'mixed conifer' (*Pinus-Pseudotsuga-Calocedrus-Abies*) forest types of southwestern Oregon have changed over the past 100 to 150 years, with a particular focus on the effects of fire suppression. We used dendro-ecological methods to analyze tree ring data collected in riparian forest stands in the Rogue River basin of southwestern Oregon. Preliminary results suggest: 1) riparian forests in the *Pinus-Quercus-Pseudotsuga* and *Pinus-Pseudotsuga-Calocedrus-Abies* forest types of southwestern Oregon developed with frequent disturbance by low- to moderate-severity fire; 2) since fire suppression became effective, riparian forests have entered a new successional trajectory with uncharacteristically high tree densities and increased recruitment of fire-sensitive species. Future management actions might increase the patchiness of conifer canopy cover in riparian forests to prevent the elimination of *Quercus garryana*, *Quercus kellogii*, and *Arbutus menziesii* from 'interior valley' sites and to prevent the replacement of *Pseudotsuga menziesii* by the more shade-tolerant *Abies concolor* on 'mixed conifer' sites.

PREDICTING THE RIPARIAN VEGETATION RESPONSE TO DAM REMOVAL ON THE ELWHA RIVER

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The removal of Glines Canyon and Elwha dams on the Elwha River in Olympic National Park Washington State, scheduled for 2012, will be among the largest planned dam removals in the world. One of the challenges associated with this undertaking will be to understand processes controlling revegetation and invasive species colonization upon sediments exposed by dam removal. It is not clear how the approximately 14 million cubic yards of sediment trapped behind these dams will be deposited in the floodplain, or how this sediment deposition will affect downstream riparian plant communities. To determine the trajectory of post- dam vegetation succession within the Elwha River floodplain and the extent to which reservoir sediments will facilitate the colonization of invasive species, we undertook a two-part greenhouse experiment. During summer 2008, funnel traps were deployed along 3 reaches of the Elwha River to capture wind-dispersed seeds capable of colonizing new floodplain surfaces. Captured seeds were sown into greenhouse pots containing either fine sediments dredged from the bottom of the Lake Mills reservoir or a commercially-available peat/vermiculite mixture. In a second greenhouse experiment, coarser sediments were mixed with fine sediments to create a gradient of textures and were seeded with species likely to be used for restoration following dam removal, or with potentially problematic invasive species. Our hope is that these studies will help predict which species are most likely to colonize exposed sediments in the floodplain and

former reservoirs, and will be of benefit to invasive control and management during and following dam removal.

ALONGSHORE MOVEMENT OF COARSE BEACH MATERIAL ADJACENT TO THE ELWHA RIVER MOUTH, STRAIT OF JUAN DE FUCA, WASHINGTON

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A planned 2012 removal of two dams on the Elwha River is expected to release approximately 0.2 to 1.5 Mcy of coarse sediment (sand, gravel and cobble) to the lower river and coastal zone. Predicting the transport of this material is of importance to understanding how the removal of the impoundments may influence beach morphology. This investigation seeks to quantify alongshore movement of coarse material on a mixed grain-size beach with the goal of enhancing predictions of post dam-removal beach morphology. Measurements of clast movement at three different locations on the beach adjacent to the Elwha River mouth were collected during July, August and September 2008 and February 2009. We use Radio Frequency Identifier (RFID) tags drilled into the rocks, which can be detected even when buried up to 75 cm, to aid in recovery and identification of clasts and map their distributions over timescales from one day to multiple months. Movements varied from 0 to 150 m per day and were dependent upon wave energy and wave angle. Clast movements are paired with sediment characteristics and converted to a mass flux value and compared across sites to evaluate the role of breaking wave angle in beach sediment transport.

THE EFFECTS OF TWO FORMS OF CARBON ON A NON-NATIVE GRASSLAND PLANT COMMUNITY

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In 2008, we began to investigate whether soil carbon amendments could alter plant abundance and composition. We tested the effects of two types of carbon, sugar and activated carbon (C), that have been suggested as prairie restoration techniques. Sugar stimulates the microbial community and can temporarily reduce plant available nitrogen (N). Activated C, on the other hand, is stable over long time scales and can adsorb plant available N and organic compounds. Our study site is a grassland dominated by non-native species in central Whidbey Island. Six experimental plots that had undergone one of three pretreatments (mowed, tilled, or planted with *Festuca roemeri*) were utilized. Sugar (1000 g/m^2; equivalent to 420 g/m^2 of C) and C (420 g/m^2) were applied in early spring. Carbon treatments did not have a significant effect on community composition in the spring (several weeks after application), but affected summer composition ($P = 0.02$). The total biomass and the composition of biomass by functional group were significantly affected by sugar ($P= 0.02$, $P = 0.01$). Sugar had a significant effect on forb biomass ($P < 0.01$) but not on grass ($P = 0.58$) or legume ($P = 0.76$) biomass. These results suggest that sugar has significant effects on the plant community; carbon did not affect the community within one year of application. Future work will focus on how these treatments affect

soil chemistry, how long effects are evident, and how well they can be integrated with seeding of native species to restore prairie vegetation.

EFFECTS OF SALMON CARCASSES ON RIVERINE FOOD WEBS: AN EXPERIMENTAL FIELD STUDY ON THE ELWHA RIVER

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The impending removal of two dams on the Elwha River will restore access by anadromous salmonids to over 90% of this river basin. In order to better understand how future re-colonization by salmon will affect river productivity, we conducted nutrient limitation and salmon carcass addition experiments to ask: (1) is the Elwha River nutrient limited, (2) does the addition of carcasses increase productivity, and (3) how long do these effects persist in time? Our study sites consisted of paired reference and treatment reaches in multiple side channels above and below the Elwha Dam. At each site we collected data on nutrient limitation status, primary and secondary production, juvenile fish use, and applied stable isotope analysis to evaluate the transfer of marine resources to the riverine environment. We observed a higher proportion of the heavier ^{15}N isotope in treatment reaches following carcass placement, with the timing and persistence of this signal varying by species. Based on nutrient limitation experiments, we concluded that Nitrogen and Phosphorus typically co-limit primary productivity during non-winter months. Following carcass placement, periphyton growth rates were elevated in treatment reaches relative to reference reaches for up to three months. Benthic invertebrate and fish sample analysis is not yet complete. This study will help to develop a more mechanistic understanding of how marine nutrients affect freshwater productivity, and do so in the context of monitoring a major watershed restoration effort.

WINTER CLIMATE CHANGE AND INTERACTION WITH DISEASES OF WHEAT IN THE PACIFIC NORTHWEST U.S.

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Wheat is the second-most valuable plant agricultural commodity produced in Washington State with a 2008 value of $975M. Speckled snow mold disease, caused by the soilborne fungus *Typhula ishikariensis*, is prevalent in the wheat-producing area of north-central WA where snow falls on unfrozen or lightly frozen soil and persists for 100 days or more. Snow mold can be limiting to wheat production if not controlled; control relies on disease-resistant varieties. Adequate cold-hardening of wheat is critical both for expression of resistance to snow molds and surviving low temperatures. Research under controlled environment conditions demonstrated that cold-hardening temperature (2-4°C), duration of cold hardening (2-6 wk), and duration of pre-hardening have significant effects on survival of wheat following snow mold. Inadequately hardened resistant varieties do not survive snow mold any better than susceptible varieties. In WA, snow molds occur in a transition area where persistent snow cover does not occur regularly; therefore, increasing winter temperatures and decreasing snow cover likely will result in less frequent occurrence of snow molds. Other diseases caused by soilborne fungi

including Cephalosporium stripe and Eyespot, and foliar rust diseases caused by *Puccinia* sp., likely will become more prevalent in areas where snow molds now occur as winter temperatures increase. Interactions between plant diseases and environmental conditions are complex; shifts in geographic distribution, frequency of occurrence and severity of diseases are expected in response to winter climate change. Anticipating change and developing varieties with effective disease resistance are important to prevent significant losses.

OBSERVATIONS ON THE DISJUNCT POPULATION OF THE RARE AND ENDANGERED BOREAL FELT LICHEN *(ERIODERMA PEDICELLATUM)* IN SOUTHCENTRAL ALASKA

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Erioderma pedicellatum (Hue) P. M. Jørg. is a globally rare, epiphytic cyanolichen listed as critically endangered by the IUCN and previously thought to be restricted to southeastern Canada, having been extirpated from Norway and Sweden. In 2007, *E. pedicellatum* was found in Denali National Park by NPS staff during a non-vascular plant inventory. The next year, subsequent private search efforts and additional NPS survey work yielded more locations and information about this rare lichen. This work presents a summary of the knowledge about the Alaskan population of *E. pedicellatum* gained from both private and NPS surveys over the past 2 years. *E. pedicellatum* is now known form a total of 11 locations sprinkled within a swath of discontinuous humid boreal forest in the upper Susitna River of south-central Alaska. Its apparent normal population density is very low with sporadic individual trees with relatively high concentrations of thalli. *E. pedicellatum* seems to be quite substrate specific and occurs in a very narrow microclimate, as indicated by its co-occurrence with a distinct suite of associated lichen species, many of which are regionally rare.

SPATIAL AND TEMPORAL PATTERNS OF SEDIMENT RESUSPENSION IN URBAN STORMWATER DETENTION PONDS

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The purpose of this study was to quantify the resuspension of sediment from two detention ponds receiving runoff from suburban residential developments. To measure resuspension, we deployed paired sediment traps at 8 or 10 trapping stations within each pond. Cylindrical sediment traps measured the gross deposition of sediment; plate traps measured net accumulation of sediment. Resuspension was the difference between the sedimentation on the cylinders and the plates. Results based on measurements at 2-3 week intervals between July 2007 and January 2008 showed that resuspension accounted for 33% and 46% of deposited sediment in the two ponds, resulting in overall rates of resuspension of 11.11 $kgm^{-2}y^{-1}$ and 31.25 $kgm^{-2}y^{-1}$. The within-pond spatial pattern of resuspension showed that at each sampling period resuspension occurred at stations along the axis between the inlet and the outlet regardless of the vegetation condition at the station. Temporal patterns of resuspension among sampling

intervals were well explained by one hour rainfall intensity in the pond that received primarily surface water (r^2=0.46, p=0.04). A multiple regression model with an interaction between one hour rainfall intensity and pond depth best explained resuspension in the pond that received significant ground water (r^2=0.69, p=0.056). These findings suggest that flow path position, not vegetation condition, determines which areas of a pond are subject to resuspension. Design modifications that reduce the flow along the central axis of the pond should reduce resuspension. These findings further suggest that resuspension is driven by brief intense flows in these surface-water-dominated systems.

CLIMATE CHANGE AS A DRIVER OF MOUNTAIN PINE BEETLE OUTBREAKS IN EASTERN WASHINGTON

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Climate change influences mountain pine beetle (MPB) outbreaks in our native pine species by altering tree vulnerability. Research has found that the dominant climatic predictor of increasing host vulnerability to these outbreaks in Washington State is summer vapor pressure deficit (VPD). Using analysis of the climatic drivers behind current MPB outbreaks coupled with future climate projections for areas east of the Cascade crest we have identified likely future climate impacts on native pine forests of our region. Linking expected climate impacts to site, stand, and tree characteristics is necessary in order to develop a blueprint for management action that can reduce the incidence of widespread MPB attacks. While increasing insect activity under warmer climate conditions is certainly implicated in the increase in MPB attack levels in the recent past, actions that address increasing host susceptibility are necessary to control the magnitude of this disturbance vector under a changing climatic regime.

ENVIRONMENTAL BASELINES AND RESTORATION OF SECOND-GROWTH FORESTS ON LYELL ISLAND, HAIDA GWAII (THE QUEEN CHARLOTTE ISLANDS)

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One of the central challenges for restoration is baselines, both for determining best actions and monitoring their success relative to original ecosystem conditions. Historical baseline data of original forests are rare worldwide. In coastal British Columbia, however, we have 1937 air photos that predate most logging as well as 1960s era forest cover maps. Using basic timber inventory techniques, it is possible to reconstruct the original forest cover from these sources, supplemented by historical cruise data and groundtruthing stumps and logs. We do not have a good understanding of the habitat potential of second-growth forests or reference data for determining restoration targets. Logging methods have changed drastically since the 1900s. We cannot assume the biological legacy from logging has stayed the same. In Haida Gwaii, forests are strongly influenced by introduced deer which browse western redcedar seedlings and understory species and have increased drastically since their introduction a century ago. For Lyell Island, the legacy from logging has varied widely. Large residual trees and snags of all species, cedar and understory species are present in second-growth forests, but their abundance varies with logging era. However, it is not simply a matter of the oldest logging

containing the most diverse stands. All the information generated in this study; original forest cover and current second-growth structure and composition; will be used as the basis for restoration of second-growth riparian and cedar forests on Lyell Island. A variety of potential strategies and techniques for restoration will be presented.

RECONSTRUCTION OF OLD-GROWTH FOREST STAND STRUCTURE AND COMPOSITION FOR TWO STANDS HARVESTED AROUND 1930 ON THE OLYMPIC PENINSULA, WASHINGTON

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Some managers of young-growth forests are tasked with accelerating the development of old-growth stand characteristics, but may not have site-specific information for developing targets to guide management actions. Using General Land Office Surveys and surveys of legacy stumps we reconstructed the species composition and stand structure that existed prior to a 1930 harvest for two ~250 year-old stands straddling the Western Hemlock/Sitka Spruce Zone boundary on the Olympic Peninsula in western Washington. Each data source provided unique information but also had limitations or biases. Both reconstructed old-growth stands were dominated by large, widely-spaced Douglas-fir trees. Diameter class reconstructions from legacy stumps in each stand suggested that western hemlock co-dominated with Douglas-fir in one stand and was a mid- and understory component in the other. In the latter case, we believe that wind-formed gaps or red alder senescence allowed western hemlock to enter an established Douglas-fir stand. The ~70-year-old modern stands are currently much denser, with smaller trees than the historical stands, and in one stand only a small component of Douglas-fir is present. While restoring Douglas-fir to a ~70 year-old western hemlock dominated stand is impractical, repeated thinning and gap creation might promote more rapid development of structural diversity. Thus, accelerated restoration of old-growth structural diversity may be possible at both sites through repeated artificial gap creation, but species composition will remain different at one site. We suggest that multiple successional pathways determined largely at stand initiation are possible with stand development implications lasting for centuries.

MANAGING SOIL EROSION AFTER LARGE WILDFIRES: SEEDING AND FERTILIZATION EFFECTS ON SOIL COVER AND VEGETATION RECOVERY

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Severe wildfires kill vegetation and consume surface litter, exposing bare soil and increasing soil erosion hazards. Erosion hazards decline as vegetation recovers and litter covers bare soil, but vegetation recovery rates may be limited by various factors, including residual plant density, soil nutrients, and soil moisture. We studied seeding and fertilization effects on the development of soil cover during the first 2-3 years following high severity wildfires in dry mixed-conifer forests of Washington State using a field experiment with a generalized randomized complete block design. Fertilization effects varied considerably among sites, increasing live plant cover significantly at some sites, but not others. Seeding treatment effects were mostly small, with a native perennial forb, yarrow (*Achillea millefolium*), producing most of any added cover. Combined, seeding and fertilization reduced bare soil by up to 13% and 21% in the first and

second years following wildfire. Our results suggest that soil nutrients and plant density both limit plant cover and litter production somewhat following high severity wildfires in dry forests, with the dominant limiting factors varying among sites, and perhaps among years. Seeding treatments increase plant cover by augmenting natural post-fire colonization, which is particularly important on sites with sparse understory vegetation prior to the fire. Fertilization increases plant cover by stimulating growth of both surviving and colonizing species. Responses to seeding and fertilization may be dependent on soil water availability, however, making treatment effectiveness also dependent on climatic variability.

CONTRIBUTIONS OF ECTOMYCORRHIZAL FUNGAL MATS TO FOREST SOIL RESPIRATION

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Ectomycorrhizal (EM) fungi are a prominent and ubiquitous feature of forest soils, forming symbioses with most tree species, yet little is known about the magnitude of their impact on forest carbon cycles. A subset of EM fungi form dense, perennial aggregations of hyphae, which have elevated respiration rates compared with neighboring non-mat soils. These mats are a foci of EM activity and thereby a natural laboratory for examining how EM fungi impact forest soils. In order to constrain the contributions of EM fungi to forest soil respiration, we quantified the proportion of respiration derived from EM mat soils in an old-growth Douglas-fir stand in western Oregon. One dominant genus of mat-forming fungi, *Piloderma*, covered 46% of the soil surface area. *Piloderma* mats were monitored for respiration rates over 15 months and found to have on average 17% higher respiration than non-mat soil. At the stand level, this amounts to roughly 8% of soil respiration due to the presence of *Piloderma* mats. We calculate that these mats may constitute as much as a third of autotrophic respiration, based on respiration rates from trenched plots in a neighboring forest stand. *Piloderma* mats are most abundant in old-growth forest, and the high carbon demand they can impose on trees may potentially contribute to age-related declines in tree growth.

BACK TO THE FUTURE: BIOLOGICAL, DISTURBANCE, LANDSCAPE, GEOGRAPHIC, ARCHAEOLOGICAL, AND HISTORIC LEGACIES FROM RAILROAD LOGGING—50 TO 130 YEARS OF POST DISTURBANCE RECOVERY ACROSS NORTH AMERICA

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An extensive literature review covering 110 years revealed important aspects of railroad logging. Railroad logging impacted millions of acres on the West Coast of North America (BC, WA, OR, and CA), and other US States. Resulting second growth forests (the current matrix) contain remnant old growth forest structures and ecological processes crucial for old growth dependent species. Biological legacies included large diameter springboard stumps, logs, snags; individual or patches of conifers, all currently defined as aboveground biomass. Reports and studies from 1899 to 1950, described huge volumes of logging slash left as waste or slash. Waste averaged

21,407 bft/ac (125 m^3/ha) while slash (coarse debris) averaged 59,520 bft/ac (346 m^3/ha), and snag retention was 3.8/ac (9.4/ha). Slash created huge fire risks and on an area basis, 3.9% reburned annually. Fires, during and/or after harvesting acted as secondary, tertiary, and perhaps quaternary disturbances. Disturbance legacies resulted from interactions between railroad logging and fires (human and/or natural). Landscape legacies such as large disturbance patches, fewer edge effects and habitat fragmentation, and more interior habitat were created by the unique spatial patterns of yarding systems (single/multiple) that reached out 2000–6000 feet. Recently, railroad logging was investigated using archaeological methods; historic land use and archival information have appeared in ecological works. The potential application of ecological, historic and retrospective methods for the analysis of 50 to 130 years of post-disturbance recovery will be discussed. These discoveries will enhance ongoing efforts in carbon sequestration, structural retention, adaptive management, and forest and wildlife ecology.

THE WEST COAST GEOGRAPHY OF RAILROAD LOGGING: HISTORIC SITES AND POSSIBLE RESEARCH SITES

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An extensive literature review covering 110 years revealed important aspects of railroad logging. Railroad logging impacted millions of acres on the west coast of North America from the Alaska Panhandle to the redwoods and Sierra Nevada forests of California. Railroad logging occurred at many operations, in many locations, and spanned almost 80 years (1880's – 1959). Many railroad logging sites are available. but few have fairly complete historic records. Historic records include forest inventories, railroad grade construction and locations, harvesting reports, fires reports (accidental, prescribed, and wildfire), logged volumes (scaling), aerial photos, maps, and one time or long term studies (waste, regeneration and fire). Locating good railroad logging areas requires sites where ecological studies, permanent sample plots, re-established historic plots, and long-term plot projects have occurred in the last 40 years. Fluxnet sites (US and Canada) present valuable synergies between historic and modern era studies. The Fluxnet Canada site near Campbell River, Vancouver Island is an excellent site. Well documented historic studies from the early 20th Century need to be rediscovered. One such post-harvest and fire study (1926) is located on the Santiam River near Mill City, Oregon. These sites represent millions of acres of known and undiscovered research sites. Discovering the locations and legacies of railroad logging will complement modern ecological studies of the West Coast forests.

RECONNAISSANCE LANDSLIDE INVENTORY AND MAPPING OF RELATIVE LANDSLIDE HAZARD ALONG THE MARINE SHORE OF THURSTON COUNTY, WASHINGTON

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We inventoried landslides and mapped relative landslide hazards for a 1:12,000 reference scale along the marine shore of Thurston County. We aimed to map landslides and landslide hazards in all areas where slope stability could reasonably be expected to meaningfully interact with shoreline processes. To that end, the map area extends upslope from the shore by a variable distance that was subjectively defined based on review of LiDAR-based images. Information was compiled on 898 landslide polygons (some overlapping), based on prior reports (203 slides), field work (mostly by viewing shore from boat), LiDAR-based digital elevation model data, aerial photos (years 2003, 2001/2002, and limited review of historic photos). Each landslide polygon is assigned a unique number that lets users identify slide-specific observations and comments in separate tables. Some postulated landslide polygons were excluded from the inventory; to preempt future confusion, a record of excluded polygons, their source, and the reasons for their exclusion was kept. The inventory omits many landslides and covers some areas more exhaustively than others; it provides support for assigning relative levels of landslide hazard to landforms that we present as proxies for landslide hazard. While a high relative landslide hazard along steep slopes and high bluffs was no surprise, we also noted that the stability of glacio-lacustrine units in the map area appears to be strikingly sensitive to removal of lateral support. The mapping is intended for distribution as GIS-compatible, digital product.

IS THE SEATTLE FAULT BENEATH DOWNTOWN SEATTLE?

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The Seattle fault is an ~80-km-long reverse fault that trends east-west beneath the Puget Lowland of western Washington State, and is interpreted to extend beneath the Seattle urban area just south of the downtown area. The fault ruptured about A.D. 930 in a large earthquake that uplifted parts of the Puget Sound shoreline as much as 7 m, caused a tsunami in Puget Sound and extensive landslides throughout the area. Compilation and re-interpretation of all the existing seismic profiles in the area indicate that the northern strand of the Seattle fault, specifically a fold associated with the northernmost, blind fault strand, lies beneath downtown Seattle, about 1.5 to 2 km farther north than has previously been interpreted. Seismic profiles in central Puget Sound and Lake Washington show that the shallow part of the northern fault strand dips to the south at about 35 degrees, consistent with the 35 to 40 degree dip previously interpreted from tomography data. A second fault strand about 2 km south of the northern strand causes gentle folding of the Holocene strata. Two prominent backthrusts are on strike with prominent scarps on the eastern and western shorelines. Hints of fault-related features on the profiles in Elliot Bay, clear images in Lake Washington, and subsurface geologic data are consistent with the fault strand extending beneath the downtown area. If indeed the Seattle fault

extends beneath downtown Seattle, the downtown area may experience ground deformation during a major Seattle fault earthquake.

HOLOCENE BURIED AND SUBMERGED FORESTS OF WASHINGTON AND OREGON—TIME CAPSULES OF GEOLOGIC, ENVIRONMENTAL, AND CLIMATE HISTORY

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Use of radiocarbon dating and dendrochronology to study Holocene subfossil forests has provided valuable clues to the history and impacts of postglacial volcanism, fault movements, landslides, and flooding. Subfossil trees occur in submerged coasts sites; landslide-, lava flow-, and fault-dammed lakes; within landslide deposits; or in aggraded riparian environments, many downstream of volcanoes. Submerged sites along coastal Washington, Oregon, or Puget Sound contain subfossil snags that record the timing of subsidence or submergence events including paleo-earthquakes. Ages for more than 28 landslides have been estimated by radiocarbon dating of associated subfossil wood or by tephrochronology. Yet fewer than 25 percent of these allow precise constraint of the calendric age of tree mortality to within a few decades, and more sampling will be required to obtain outer wood. Additional tree-bearing lakes have been discovered but not sampled, and more than twenty candidate sites lack reconnaissance. Volcanic disturbances, mainly lahars and laharic flooding, buried extensively-forested riparian landscapes downstream of volcanoes. Laharic aggradation caused delta progradation that dramatically altered the coastline of the Puget Lowland, impacted the Columbia or other rivers, or, in extreme cases triggered stream piracy (Stillaguamish/Skagit River, Fraser/Nooksack, and White/Puyallup Rivers)—These events undoubtedly buried extensive forests. While combined use of radiocarbon 'wiggle matching' and dendrochronology on subfossil trees can precisely date past geologic events, Pacific Northwest subfossil trees remain largely poorly studied—Systematic dendrochronology investigations of these forests could allow better correlations among sites and yield more extensive paleoclimate records and valuable paleoenvironmental information for the Pacific Northwest.

A MULTI-SCALE APPROACH FOR QUANTIFYING CARBON DYNAMICS IN WASHINGTON FORESTS

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This research demonstrates a method for quantifying successional patterns of forest carbon pools and fluxes at multiple scales. The approach combines plot-level inventory data from the Forest Inventory and Analysis program with spatial data layers of stand age and potential vegetation for forested ecosystems in Washington, USA. Plot-level carbon attributes, including live tree biomass, dead wood biomass, net primary productivity, and mortality, are estimated from inventory data using species-specific allometric equations, and non-linear functions are fit to the data for chronosequences of carbon attributes. Stand age for the chronosequence is defined using tree age distributions from the inventory data. For coarse-scale analysis, inventory plots are grouped by "ecosections", an abiotic ecosystem classification based on topography and climate; therefore we assume that climate is the primary factor that drives productivity and

biomass accumulation at this scale. For fine-scale analysis, the domain comprises the national forests of Washington and inventory plots are grouped by environmental site potential (ESP). Stand age for the chronosequence is based on spatial data layers indicating year of origin for stands within the forests. ESP is an abiotic and biotic ecosystem classification; therefore we assume climate and vegetation type drive productivity and biomass accumulation at this scale. This method uses publicly available data in a simple procedure to quantify successional patterns of biomass accumulation and productivity in different regions and forest types. These successional patterns can be combined with data on disturbance regimes and age-class structures to quantify disturbance-based limits on potential carbon storage.

HOLOCENE HISTORY OF ALPINE GLACIATION IN THE PACIFIC NORTHWEST.

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Alpine glaciers represent a significant water resource for the region and provide an important index of climate change. Since the end of the last ice age about 11,500 calendar years ago, alpine glaciers have undergone significant changes due to both longer and shorter term climate oscillations. Holocene glacial recession reached its maximum about 9,000 calendar years ago, when glacier termini retreated to positions near or slightly above present. Evidence collected on Mount Baker and elsewhere in the region indicates that glaciers began a significant re-advance sometime after about 6,000 years ago, and fluctuated in response to millennial-scale climate variability. Holocene glacier advances culminated in the Little Ice Age between about 700 and 100 years ago, when most glaciers in the region reached their maximum post-Pleistocene extents. Since 1900 glacier area in the region has decreased by about 50%, reflecting a pattern observed for mountain glaciers throughout the world. Observations of glacial mass balance in the last 50 years have quantified the recent loss, linked glacier change to decadal climate oscillations, and provided a measure of impact to regional water resources. For example, in the Skagit watershed, glaciers currently cover only about 2% of the basin, yet provide between 8–12% of total summer runoff, or about 120–180 B gallons. Glacial retreat in the last 16 years has resulted in a net loss of about 400 B gallons of water storage in the Skagit system.

A COMPARISON OF LANDSCAPE-LEVEL PATTERNS IN THE DEMOGRAPHY AND DISTRIBUTION OF TREE SPECIES IN CENTRAL ALASKA – EVIDENCE FOR WIDESPREAD MORTALITY AND RECOVERY OF TAMARACK *(LARIX LARICINA)* FROM A RECENT LARCH SAWFLY OUTBREAK

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As part of a long term ecological monitoring program, density, diameter, condition, and related attributes were measured for seven tree species that occur in Denali National Park, Alaska. These data were recorded in 767 plots distributed over a study area that spans more than 1.1 million hectares. Results from this study show marked differences in demographic parameters among species sharing very similar habitat preferences such as tamarack (*Larix laricina*) and black spruce (*Picea mariana*). Specifically, mortality patterns showed that a widespread and severe mortality event for tamarack trees occurred that was not observed for any other species in this area. The dramatic increase in tamarack mortality relative to other species was likely the result of an outbreak of the larch sawfly that defoliated and killed tamaracks across the state in

the 1990's. These data indicate that tamarack mortality during the outbreak was conspicuously concentrated in the largest size-classes for this species, indicating potential age-specific responses to attack by members of this species. The relatively large numbers of small-diameter tamarack saplings and seedlings observed in this plot network show an apparent recovery of tamarack populations following the outbreak. I discuss the distribution and habitat preferences of tamarack in relation to the observed recent mortality event.

SCUBA SURVEYS TO CHARACTERIZE NEARSHORE BIOLOGICAL COMMUNITIES PRIOR TO REMOVAL OF THE ELWHA RIVER DAMS

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The impending removal of the Elwha River dams will impact marine habitat when sediments that have accumulated for over 95 years are transported to the Strait of Juan de Fuca. In summer 2008 we initiated a scuba survey to characterize nearshore biological communities prior to dam removal. Sampling occurred directly off the river mouth and at varying distances beyond but still within the potential impact zone, as well as at more distant reference sites where minimal impact is expected. We also stratified by depth and substrate type, factors known to structure benthic communities. A recent sonar survey used acoustic back-scatter to classify substrate near the Elwha River mouth. We formed substrate strata from this classification where available, and from presence or absence of kelp overstory during the past 15 years in other areas. Within each stratum we enumerated fish, macroinvertebrates, and macroalgae along randomly selected 30 m transects to estimate benthic community structure. We also classified sediment grain size, relief, and sessile organisms every 0.5 m along each transect. We observed 29 fish, 84 macroinvertebrate, and 12 brown macroalgae taxa; we didn't attempt to identify red or green algae. Sediment grain size composition along transects agreed with our three substrate strata (hard, mixed hard and soft, soft). Percent boulder-bedrock, cobble, and sand, respectively, were 26, 55, and 19 in the hard, 11, 53, and 36 in the mixed, and 5, 20, and 75 in the soft stratum. The survey will be repeated in 2009, prior to dam removal.

CLASSIFICATION OF CRATERS OF THE MOON PLANT COMMUNITIES: ASSESSING BOUNDARIES BETWEEN THE GOOD, BAD, AND UGLY

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Craters of the Moon National Monument and Preserve lies on the Upper Snake River Plain of south central Idaho. The area encompasses sparse, vegetated lava and cinder cones, sagebrush steppe, wetlands, and montane shrublands, woodlands, and forest. Pristine stands protected within lava-bound exclosures contrast with stands of severely degraded shrub-steppe. Species composition data (1,240 samples) were analyzed using hierarchical cluster analysis, indicator species analysis and multi-response permutation procedures. Decisions regarding the identification of plant associations within the data were informed by cross-walking candidate

community groupings to the National Vegetation Classification (NVC). Classification tree analysis was employed to evaluate cluster analysis results. Ninety-three plant communities are identified as occurring within the study area. Nearly 50% of the associations identified within the Monument and Preserve are currently listed in the NVC. Minor name changes are proposed. Where overlap occurs, the classification largely corresponds to vegetation types identified in early studies. Associations described but not recognized by the NVC include: (1) semi-natural vegetation (18 associations) and (2) plant communities (21 associations) that have not been described previously at the association level. The prevalence and relative abundance of exotic annual grass species within degraded stands increased compositional homogeneity. The analysis results provide objective criteria for differentiating between natural (largely dominated by native species) versus semi-natural vegetation dominated by exotic species. These findings corroborate the work of others within the area in prioritizing stands for conservation and restoration.

PLANT COMMUNITIES OF LAKE ROOSEVELT NATIONAL RECREATION AREA, WASHINGTON

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Work on the vegetation map for Lake Roosevelt National Recreation Area was initiated in May 2007. The National Recreation Area occurs in central and northeast Washington, within the Columbia Basin and Okanogan Highlands ecoregional sections. Given its geographic breadth, the study area encompasses considerable geologic and climatic diversity. Vegetation within the area ranges from xeric shrub-steppe to coniferous forest. Initial plant community groups were identified using hierarchical cluster analysis. Plant community groups were successively partitioned to optimize within-group homogeneity, between-group difference, and the number of groups using indicator species analysis and multi-response permutation procedures. Decisions regarding the identification of plant associations within the data were informed by cross-walking candidate community groupings to the National Vegetation Classification (NVC). Classification tree analysis was employed in the evaluation of cluster analysis results. Eighty-one plant communities are identified as occurring within Lake Roosevelt National Recreation Area. Tests of null hypotheses of no difference between groups were rejected overall and in analyses by physiognomic group. Fifty-nine percent of associations identified within the National Recreation Area are currently listed in the NVC. Associations described but not recognized by the NVC include: (1) semi-natural vegetation (12 associations) and (2) plant communities (21 associations) that have not been described previously at the association level. Confidence in the classification is assessed using local and regional estimates. Ninety percent of samples from the area are classified within associations that possess high confidence by either the local or regional estimates. Utility of the classification will vary by application and vegetation type.

WASHINGTON GEOLOGIC SURVEY'S LANDSLIDE RESPONSE TO THE JANUARY 7-8TH, 2009 STORM

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On January 7th, 2009, the Department of Natural Resources (DNR) Division of Geology and Earth Resources (DGER) mobilized 5 teams of geologists to investigate and document landslides across 18 counties, with safety concerns of citizens as a main objective. Three flights were flown over western Washington to survey the landslides from the storm. In addition to investigations, the DGER was the clearinghouse for the event and managed incoming data from private citizens, cities, counties, and state agencies. DGER worked closely with the Emergency Operations Center (EOC) during and after the storm event to supply real time landslide location and impacts to help manage the disaster. More than 1,500 landslides are estimated to have occurred during the storm event, with the majority of those landslides in Lewis, Whatcom, and Skagit Counties. Damage from the storm exceeded 150 roads impacted or blocked by landslides and over 50 homes damaged or destroyed. During the storm event, a "Report a Landslide" webpage was available for the public to access and submit a simplified landslide form. A more detailed form was available for geoscientists and engineers. This allowed the DGER geologists to respond quickly to immediate or ongoing danger from landslides and collect critical data, such as the timing of when landslides occurred. Landslides identified in the storm are digitized, attributed and entered into a storm landslide database, allowing a spatial record of landslides from the storm.

TAXONOMIC IMPLICATIONS OF DNA PLOIDY DISTRIBUTION PATTERNS IN THE NORTH AMERICAN *CREPIS AGAMIC* COMPLEX AS INFERRED FROM FLOW CYTOMETRY CONDUCTED ON DRIED LEAF MATERIAL

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The North American *Crepis agamic* complex consists of nine taxonomic species distributed throughout dry regions of western North America. This superficial taxonomic simplicity masks the effects of polyploidy, apomixis, and interspecific hybridization, which result in innumerable lineages whose morphological boundaries seem to defy circumscription. Field identification is further confounded because many populations consist of two or more polymorphic lineages. All polyploid lineages are thought to have ultimately arisen from diploid populations through auto- or allopolyploidy. If one is to untie the Gordian knot of polyploid lineages, the diploid populations must first be identified. We have conducted flow cytometry on field-collected dried leaf material to characterize DNA ploidy variation within and among populations and species. A total of 438 samples from 85 populations have been analyzed from the regions in which diploids are known. When information on DNA ploidy, distribution, and detailed analysis of morphological variation are synthesized taxonomic species boundaries are more satisfactorily clarified. Our results illustrate the power of detailed analysis of DNA ploidy variation for clarifying the taxonomy of agamic complexes.

FISH USE OF THE ELWHA ESTUARY

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Physical processes that define the Elwha nearshore ecosystem have been severely disrupted by a variety of anthropogenic impacts, including more than 100 years of sediment starvation due to two large in-river dams, and diking of the estuary. This disruption is hypothesized to have an effect on habitat function for fish, but the relationships between nearshore habitat functions and disrupted sediment processes have not been documented. In this paper we define estuarine functional response to anthropogenic events in the watershed by testing the hypotheses that species diversity, species richness, total fish and salmon abundance, and fish length are not significantly different between three portions of the Elwha estuary. We assessed fish use of three main areas of the Elwha River estuary using standard beach seining techniques from March-September 2007. All four null hypotheses were rejected. Species composition, ecological indices, and relative proportion of all salmonids, particularly Chinook salmon (*Oncorhynchus tshawytscha*), were consistently significantly different across the estuary. We therefore conclude: 1. Fish use of the Elwha River estuary is complex and even fragments of connected estuary are critically important for migrating salmon; 2. Nearshore sediment transport processes affecting the Elwha River estuary are dynamic, and play an important role in habitat function; 3. Juvenile salmon appear to be able to respond to dynamic sediment environments if there are habitat options available, and; 4. Sediment delivery can be an important ecological driver in habitat function that should be appropriately considered in estuary habitat management and restoration.

THE ELWHA NEARSHORE: LINKING MANAGEMENT, EDUCATION, AND RESEARCH TO ACHIEVE ECOSYSTEM RESTORATION. PRIORITY RECOMMENDATIONS OF THE ELWHA NEARSHORE CONSORTIUM 2009

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The Elwha Nearshore Consortium (ENC) includes approximately 40 scientists, managers, and stakeholders dedicated to understanding and promoting the nearshore restoration associated with the upcoming Elwha dam removals. The ENC closely mirrors the goals and priorities of a number of regional research and restoration entities, including Washington Sea Grant and the newly formed Puget Sound Partnership. Regional Marine Research and Information Needs identified collaboratively by the West Coast Sea Grant programs, and Puget Sound Partnership Action agenda priorities are embodied in the work and priorities of the ENC. Cross cutting issues common among the three entities include: identifying and addressing priority scientific data gaps, ecosystem based restoration that provides the highest level of recovery certainty,

and informed and engaged education and citizen science. The ENC held its annual meeting at Peninsula College in Port Angeles on 8 January 2009 during which the group identified a number of additional priorities for 2009. Priorities include:

- Defining linkages in riverine and nearshore sediment processes;
- Lidar mapping of high bluff beaches in the Elwha and comparative drift cells;
- Continued long term monitoring and detailed study of fish use, including cross regional salmon use, of the nearshore Elwha and comparative drift cells; and;
- Modeling of physical habitat processes and biological function of the Elwha nearshore, including beaches and estuaries.

ENC priorities provide clear guidance to regional entities' action planners on priorities for restoration, research, and education for achieving local and cross regional scale restoration in the inland marine waters of Washington State.

COMPARISON OF GEODETIC AND PALEOSEISMIC RATES OF DEFORMATION IN THE PUGET SOUND-GEORGIA BASIN, PACIFIC NORTHWEST

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We compare geodetic rates of horizontal shortening in the Puget Sound-Georgia Basin region with long-term rates of horizontal shortening calculated from paleoseismic studies across the same region. Our region of comparison encompasses a zone of concentrated seismicity, lying within a rectangle centered at W122.5° and N48°, with edges defined by ±1.5°. Within this region, geodetic rates are well constrained by a network of permanent Global Positioning System (GPS) sites. The long-term N-S shortening rate is 3.2±0.8 mm/yr (after subtracting interseismic subduction loading). Extending this rate back though the Holocene, yields between 24 and 40 meters of horizontal shortening to account for data from paleoseismic investigations. Paleoseismic studies on 11 fault zones within our region of interest provided slip estimates of past earthquakes. Paleoseismic shortening rates are calculated using observed stratigraphic offsets and measurements of fault dip. Using these techniques, we can account for a minimum of about 36 meters of horizontal shortening during the Holocene. Within the Puget Sound-Georgia Basin region, long-term rates of horizontal shortening estimated using GPS compare favorably with long-term estimates of Holocene shortening. Shortening estimated from the paleoseismic record accounts for ~100% of the total Holocene rate suggested by GPS, within the uncertainties of each technique. About 50% of the total Holocene shortening occurred during large earthquakes on several faults around 1100 years ago, at or about the same time as the penultimate Cascadia subduction zone earthquake.

THE CRESCENT FORMATION ALONG LAKE CUSHMAN'S NORTHERN SHORE, OLYMPIC PENINSULA, WASHINGTON: A STRATIGRAPHIC, CHEMICAL AND STRUCTURAL STUDY

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The Crescent formation (Cf) is an unusually thick sequence of subaqueous and subaerial basalts interbedded with sedimentary layers which formed 53-45 Ma. The lower Cf is characterized by subaqueous, pillow basalts which are interbedded with, and underlain by, sedimentary rocks of the Blue Mountain unit while the upper Cf tends to be massive with jointed basalts. The Blue Mountain unit is a continentally-derived fan primarily composed of shales and slates. I examined and mapped the rocks of the lower Cf along Lake Cushman's northern shore to add to the chemical and structural database on the lower Cf. I collected twenty three samples for ICP-ES, SEM, petrographic, stratigraphic and structural analysis. ICP-ES analysis indicates that the lower Cf is enriched in calcium and strontium but contains lower silica values than neighboring basalts. Petrographic analysis displayed amygdaloidal weathering with secondary minerals beginning to replace primary minerals, such as plagioclase and pyroxene. Structural data shows a distinct boundary between the Skokomish River shore which was highly faulted with shallower strikes than the Lake Cushman shoreline sections of the study area. Preliminary analysis indicates that rocks of the Lake Cushman area are similar to those studied in other parts of the Cf, as their chemical data points to a rift setting. This area has undergone a substantial amount of weathering, faulting, and low-grade metamorphism. The orientation of mapped faults indicates that there has been strike slip motion which may have caused a bend in Lake Cushman itself.

EARTHQUAKE-INDUCED LANDSLIDE AND LIQUEFACTION SUSCEPTIBILITY IN TSUNAMI EVACUATION ROUTES, COASTAL WASHINGTON

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City managers and planners for communities in coastal Washington have used tsunami inundation maps to plan evacuation routes in the event of a tsunami. A Cascadia earthquake (M9+) may result in large ground accelerations causing massive ground failures as well as generate large tsunami that can reach the coastal communities quickly. There has been no evaluation of liquefaction and slope failure susceptibility available to help officials effectively plan tsunami evacuation routes to avoid potential failure areas. Soil liquefaction doesn't usually result in human death, but destroys roads, bridges, and building foundations. Even very small landslides or debris flows can render a road impassable for automobiles, thus complicating or prohibiting vehicular evacuation from a tsunami or hampering response and recovery efforts during and after an earthquake. We evaluate the susceptibility to liquefaction and slope failure from a M9 earthquake for the tsunami inundation zones in various coastal communities using GIS-based modeling.

STATUS AND DISTRIBUTION OF TREE VOLES IN THE COLUMBIA RIVER GORGE AND NORTHWEST OREGON

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Red tree voles (*Arborimus longicaudus*) are small arboreal microtine rodents that feed on conifer needles and construct nests from resin ducts they remove from these needles, their fecal pellets, cuttings of branch tips, small twigs, and lichen. We conducted surveys to document the current range of the tree vole in the Columbia River Gorge and northwest Oregon at historical locations where tree vole specimens were collected. In the Columbia Gorge we located small clusters of tree vole nests at multiple locations between Troutdale and Hood River. We also captured a tree vole in the headwaters of the Lake Branch Hood River where contract climbers had reported finding tree vole nests in 2003. The latter records are the only documented case of tree voles east of the Cascade Crest. In the Coast Range north of Tillamook we found several clusters of tree vole populations in the remnant patches of old forest in State Parks, but few or no tree voles in the young forests on state and private lands surrounding the parks. We found no evidence of tree voles in the Willamette Valley margin sites of Chehalem Mountains and the foothills around Molalla, where tree voles were locally common only 60 years ago, suggesting that populations in those areas have been largely decimated by logging, urban sprawl, and conversion to agriculture.

DIVERSE EOCENE MAGMATISM AND EXTENSION ACROSS THE PACIFIC NORTHWEST: IS THERE A UNIFYING EXPLANATION?

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During the Eocene the Pacific Northwest experienced unusually diverse and widespread magmatic and tectonic activity. To better understand the cause(s) of this activity we are studying five ~contemporaneous igneous units that define a W-to-E transect across WA: (1) Crescent basalts, (2) Gray's River Volcanics, (3) Olympic Peninsula adakites, (4) Teanaway dikes, and (5) Eocene granitoids from eastern WA. Mapping and chemical data indicate Crescent rocks in the southern Olympics represent at least three distinct volcanic sequences. The lower two are marine and separated by an angular unconformity and turbidites; the upper one erupted at or above sea level. The rocks show mixed MORB-OIB affinities and are inferred to have formed in a marginal rift setting. Gray's River lavas, dominantly subaerial basalt flows and hyaloclastites, are younger (40 – 37 Ma) and more enriched but also appear rift-related. In the NE Olympics small scattered outcrops of adakitic volcanics (47 – 43 Ma) imply melting of anomalously hot subducted lithosphere, probably at the edge of a slab window. In central WA the Teanaway dikes (~47 Ma) are basaltic andesites with arc traits; trace element data suggest they differentiated at depth and ascended rapidly. Eocene granitoids (63 – 47 Ma) also display arc signatures; isotopic and trace element data indicate lower crustal melting and rapid ascent. We will present evidence that these five diverse rock units all formed in response to subduction of the Kula-Farallon ridge and the resulting development of a slab window that promoted melting and extension as it migrated beneath the region.

LATEST UNDERSTANDING OF THE LATE PLEISTOCENE STRATIGRAPHY IN THE CENTRAL PUGET LOWLAND

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Geologic mapping and stratigraphic work in the last 15 years provides new insights into late Pleistocene glaciations of the central Puget Lowland. Time-stratigraphic units are best used to define glacial and interglacial deposits here. For all but the most recent deposits, chronologic control is needed to positively identify those units. Highlights of the last 15 years include the recognition of "Whidbey Island" strata in the Seattle, Tacoma, and Olympia areas. Possession-age deposits of till and outwash are recognized in Seattle, Tacoma, and Olympia. Thick deposits correlative with the Whidbey Formation are present in Seattle and Tacoma. Till, correlative with the Double Bluff glaciation is recognized in Tacoma. Another highlight is the older part of the late Pleistocene geological record, MIS 7 and 8, where previously no deposits had been recognized. The Hamm Creek interglaciation was informally named and is recognized in the Woodinville, Seattle, and Federal Way areas. This deposit, first noted for thick ash and pumice in south Seattle, dates to 200,000 (MIS 7). Newly recognized, the Defiance glaciation dates to around 250,000. It was first noted at Pt. Defiance in Tacoma but is also encountered throughout the area of the Tacoma uplift. One of the most important findings is that there is no single, mapable stratigraphic unit termed the "Kitsap Formation". At its type section, the Kitsap Formation includes two interglacial deposits separated by a glacial deposit. The name historically has been used for Olympia-age as well as Whidbey-age deposits and to label fine-grained material between glacial deposits.

CONSERVING A WESTERN POND TURTLE *(ACTINEMYS MARMORATA)* POPULATION IN WEST EUGENE WETLANDS, LANE COUNTY, OREGON

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We collected more than 200 observation records of western pond turtles from the West Eugene Wetlands (WEW) since 1995. Spatial coordinates of each record were used to map concentrations of turtle activity across the WEW, an area undergoing rapid urbanization. Fieldwork during 2008 was performed to classify habitats, locate blocked stream passages, and identify road segments likely to be hazardous to overland movements by turtles. This information was compiled into a geographic information system (GIS) to facilitate an analysis of factors limiting the WEW western pond turtle population. Our work is also intended to help restoration managers locate habitat improvement projects in areas most likely to be used by turtles and away from areas where vehicle traffic and other human activities cause turtles to be at risk.

USE OF CONSERVATION DETECTION DOGS FOR SURVEYS OF A THREATENED PRAIRIE PLANT, KINCAID'S LUPINE *(LUPINUS SULPHUREUS SSP. KINCAIDII)*

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In the Willamette Valley of Oregon, it is estimated that more than 99% of pre-European settlement grasslands have been lost through land conversion and other human-caused impacts. This loss of prairies and savannas has had a substantial effect on species closely-associated with these communities, including Kincaid's lupine, an ESA-list plant. During 2007-2008, we investigated the capabilities of conservation detection dogs to assist botanists conducting reconnaissance surveys for Kincaid's lupine. Three dogs were trained to discriminate the scent of Kincaid's lupine from all other odors, and to alert a handler to the location of individual plants. We measured detection error frequencies, detection distances, and search speed of the dogs on 378 plots representing different densities of Kincaid's lupine plants and a variety of environmental conditions. The dogs committed a total of 5 errors during the course of the trials (mean error frequency = 1.3%) and could detect the scent of lupine plants at a distance of at least 15 m. Based on our study with Kincaid's lupine, we believe that conservation detection dogs could be used to improve the effectiveness of reconnaissance surveys for rare plants.

EPISODIC TREMOR AND SLIP ON THE CASCADIA MEGATHRUST—TRYING TO UNVEIL THE INNER WORKINGS

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In the last 10 years, a strange way for faults to slip has been observed. Rather than regular earthquake fault slip in a matter of seconds or steady deformation, both of which have been known to occur for decades, large parts of deep faults move unsteadily over the course of days or weeks, then stop moving for months to years before lurching in slow motion again. This new mode of sporadic coupled deformation and weak seismic radiation is termed Episodic Tremor and Slip (ETS) has been discovered in several subduction zones. It recurs episodically down-dip from the locked portion of the Cascadia megathrust about every 14 months. The close relationship and likely interaction of the ETS zone with the locked and hazardous portions of subduction zones mandate better understanding of the ETS phenomena. We still have little idea of the physics driving ETS, but I'll review the diverse evidence from Cascadia and the numerous other subduction zones in which ETS has now been espied that gives us hope we will crack this nut soon.

GEOCHEMICAL, PETROGRAPHIC, AND STRATIGRAPHIC ANALYSIS OF THE CRESCENT FORMATION, MOUNT TEBO, SOUTHERN OLYMPIC MOUNTAINS, WASHINGTON

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The Crescent Formation (CF) is an unusually thick sequence of subaqueous basalts and sedimentary rocks that formed 45-53 Ma. The CF and the Olympic Core terrane are the two units that comprise the majority of the Olympic Mountains located on the Olympic Peninsula in northwestern Washington. The basalt flows vary from pillow basalts and breccias to massive and columnar flows. Foraminifera can be found in many of the inter-bedded sedimentary layers. An area of the CF at Mount Tebo was mapped using logging roads to gain clear access to outcrops. 13 different units were identified and 18 samples were collected from the field. 14 samples were selected for analysis using the Inducted Coupled Plasma-Emission Spectrometer (ICP-ES), Scanning Electron Microscope (SEM) and petrography. From ICP-ES data it was determined that the CF samples from Mount Tebo are enriched in calcium with one unit containing unusually high amounts of iron and titanium. Petrographic analysis showed amygdaloidal weathering with secondary minerals beginning to replace primary minerals such as plagioclase and pyroxene. Stratigraphic columns indicate unusually thick lava flows consistent with the rest of the CF. In this study I am comparing data collected from the Gray's River (GR) volcanics in southwestern Washington with my CF data to examine evidence of a rift zone formation for both the CF and GR and adding to the existing body of work on the CF.

TSUNAMI HAZARD MAP OF TACOMA, WASHINGTON: MODEL RESULTS FOR SEATTLE FAULT AND TACOMA FAULT EARTHQUAKES

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Numerical modeling of tsunamis generated by earthquakes on the Seattle fault and the Tacoma fault show that Tacoma would be subjected to larger and more damaging waves from a Seattle fault earthquake, even though the Seattle fault is considerably more distant. This is because the Seattle fault traverses Puget Sound in much deeper water and can therefore displace more water. The results show that a repeat of the Seattle fault earthquake of about A. D. 935 would generate inundation depths of more than 5 meters in much of the Puyallup delta. Although the Port of Tacoma has experienced substantial dredging and filling, there is still natural ground along the main stem of the Puyallup River in Fife and in Hylebos Waterway. Both of these channels have significant areas with modeled inundation depths of more than 5 meters for a Seattle fault event and more than 4 meters from a Tacoma fault event. These models will provide useful guidance for paleoseismology investigations of ~A. D. 935 tsunami deposits and perhaps also the last Tacoma fault earthquake and tsunami, which was also about 1,000 years ago but is less well constrained.

USING THE CAMPUS AS A LIVING LABORATORY FOR SUSTAINABILITY STUDIES

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In the Conservation of Natural Resources class (ENVT/GEOS 104), Pacific Lutheran University uses the campus as a living laboratory. This course, which provides an introduction to Environmental Science, serves a dual audience: students needing general education credit for a lab science and Environmental Studies majors and minors. Working with faculty and staff, the students collect and analyze data about PLU practices and systems. They conduct an audit of the garbage, under the guidance of the Environmental Services coordinator, to determine what could have been recycled and what materials comprise the majority of PLU's waste. The plumber helps students to measure flow from faucets around campus and a grounds keeper leads an activity in which irrigation patterns and soils are examined. In these labs, students also use data on water use to evaluate PLU's impact locally and within the region. Through these activities, students learn about the efforts of facilities management to reduce resource use on campus and they determine how practices by the university and by individuals could reduce our impact.

FIELD GUIDE TO THE SEDGES OF THE PACIFIC NORTHWEST

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The *Carex* Working Group announces a new resource for botanists: the Field Guide to the Sedges of the Pacific Northwest. The product of fifteen years of research, the guide includes identification keys to 160+ *Carex* and *Kobresia* taxa, species descriptions, comparisons of similar species, range maps, and more than 650 color photographs. The book also includes information about sedge ecology, habitat, and management. The field guide is published by Oregon State University Press. Ordering information may be found at the carexworkinggroup.com website.

RARE *CAREX CONSTANCEANA* REDISCOVERED AND REASSESSED

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Carex constanceana has been considered endemic to Mt. Adams, Washington, where it was collected between 1898 and 1909. It has sometimes been synonymized with *C. petasata.* Single collections made in the 1990s in the northern Sierra Nevada, California, and from the Warner Mountains, southern Oregon, were subsequently identified as *C. constanceana.* During 2008, a second southern Oregon population of *C. constanceana* was found. The recently collected plants and the *C. constanceana* type specimens are distinct from *C. petasata.* We have begun morphological and DNA-based comparisons to evaluate the relationship of *C. constanceana* to *C. davyi,* which is endemic to the Sierra Nevada of California.

EFFECT OF DISTURBANCE TYPE ON LIVE AND DEAD BIOMASS STORES IN COASTAL FOREST ECOSYSTEMS OF ALASKA

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Coastal forests of Alaska are vast with a large potential to store carbon. In recent decades these forests have been affected by timber harvest, spruce bark beetle (SBB) outbreaks, fires and other disturbances. We determined the effect of disturbance type on live and dead aboveground biomass stores in coastal forest of Alaska using Forest Inventory and Analysis (FIA) data. Preliminary analysis indicates live biomass stores in 120+ year old undisturbed stands were 117 $\pm$ 13 Mg/ha (mean $\pm$ SE), and dead biomass stores were 13 $\pm$ 2 Mg/ha. Live and dead biomass in high severity (>60% of spruce trees attacked) mature stands with SBB damage was 88 $\pm$ 47 Mg/ha and 48 $\pm$ 8 Mg/ha, respectively. Live and dead biomass in mature stands with low severity (<60% of spruce trees attacked) SBB damage was 81 $\pm$ 33 Mg/ha and 14 $\pm$ 5 Mg/ha, respectively. The predicted dead biomass stores in undisturbed forests older than 120 years assuming tree mortality of 0.005 yr^{-1} and decomposition rate of 0.02 yr^{-1} was 29 Mg/ha. This is higher than measured in forest inventories and indicates a possible underestimation of dead biomass in FIA data. Dead mass in clear-cut stands was 10 $\pm$ 2 Mg/ha; in wind disturbed stands it would likely range from 10 to 130 Mg/ha.