Coast Redwood Forests in a Changing California

June 21-23, 2011

University of California

Santa Cruz, CA

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PROGRAM CONTENT: Symposium Co-Chairs

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SYMPOSIUM REGISTRATION, LOGISTICS AND FACILITIES

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CONTINUING EDUCATION CREDITS

*This program has been reviewed and is approved for professional **CFE credits by the Society of American Foresters**. Be sure to sign in EACH day and we'll have a certificate for you to pick up.*

6/21 Field Tours
- North County Tour 4.5 hours of Category 1-CF
- South County Tour 5.5 hours of Category 1-CF

6/22 - 6 hours of Category 1-CF
6/23 - 6.5 hours of Category 1-CF

PURPOSE AND OBJECTIVE

Policies and strategies guiding the use and management of California's coastal ecoregion are dependent on objective scientific information. Attention to this region has increased in recent years. At the same time, much new information has been collected. Each year the array of decisions affecting lands and natural resources in the redwood region carry more weight; evidence the recent interest in watershed assessment, fish and wildlife recovery efforts and silvicultural changes. This symposium is part of a continuing effort to promote the development and communication of scientific findings to inform management and policy decisions.

PLANNING COMMITTEE MEMBERS

Leonell Arguello, Redwood National Park
Pascal Berrill, Humboldt State University, Dept. of Forestry and Watershed Management
Sherry Cooper, UC Division of Agriculture and Natural Resources
Neal Ewald, Green Diamond Resource Company
Mike Furniss, USDA FS PSW Redwood Sciences Lab
Greg Giusti, UC Cooperative Extension
Ruskin Hartley, Save the Redwoods League
Russ Henly, California Dept. of Forestry and Fire Protection
Mike Jani, Humboldt Redwood Company, LLC
Janet McCrary Webb, Big Creek Lumber
Brendan O'Neill, California State Parks, Russian River District
Doug Piirto (co-chair), California Polytechnic State University
Dan Porter, The Nature Conservancy
Scott Sink, California Polytechnic State University
Richard B. Standiford (co-chair), University of California Center for Forestry
Steve Staub, Consulting Forester
John Stuart (co-chair), Humboldt State University, Dept. of Forestry and Watershed Management
Brad Valentine, California Dept. Fish & Game
Yana Valachovic, UC Cooperative Extension

COORDINATORS

University of California, Berkeley, Center for Forestry and College of Natural Resources

University of California, Division of Agriculture and Natural Resources

Cal Poly San Luis Obispo, Natural Resources Management. Dept. and College of Ag., Food and Environmental Sciences

Humboldt State University Dept. of Forestry and Wildland Resources and College of Natural Resources and Sciences

PROGRAM OF EVENTS

Tuesday June 21

June 21

Field Tour Participants

7:30 a.m.	Arrive and park in Lot 109 or 110
	Check in and register for the tours—*College Circle*
8:30	Depart for tours from *College Circle*
5 p.m.	Return to UC Santa Cruz

All Participants Arriving on Tuesday

5-6 p.m.	Pick up Parking/Lodging/Meal Tickets—*Stevenson Event Center*
5-8 p.m.	Symposium Registration—*Stevenson Event Center*
6-7 p.m.	Dinner—*Cowell/Stevenson Dining Commons (for non-commuters)*
7-9 p.m.	Ice Cream Reception—*Stevenson Event Center (for all)*

Wednesday June 22

7:00 – 8:00 a.m. Registration and check in—*College Circle*

Location: *Classroom Unit 2*

Refreshments

9:00 - 9:10	**Opening Remarks and Welcome** Rick Standiford, UC Berkeley Doug Piirto, Cal Poly San Luis Obispo John Stuart, Humboldt State University J. Keith Gilless, UC Berkeley, College of Natural Resources
9:10 – 9:15	Panel Moderator Remarks—Doug Piirto, Cal Poly San Luis Obispo
9:15 – 9:50	**Historical Perspective: Humans in the Redwood Region**—Sandy Lydon, Santa Cruz Local Historian
9:50 – 10:25	**Redwood Forest Canopies: Insights from 15 Years of Tree Climbing—** Steve Sillett, Humboldt State University
10:25	**Break—***Refreshments*
10:45 -11:20	**Redwood Conservation: Where Do We Go From Here?—**Ruskin Hartley, Save the Redwoods League
11:20 – 11:55	**Redwood Products - An Economic Perspective on Sustainable Management**— Ron Jarvis, Home Depot
11:55	Questions and Answers from morning panel

12:15 – 1:30 p.m.	**Lunch** (for all; meal ticket required)—*Cowell/Stevenson Dining Commons*
1:30 - 3:10	**Concurrent Session 1**
Classroom 175	Session 1A, Watershed Processes—Michael Furniss, PSW Redwood Sciences Lab
Classroom 150	Session 1B, Ecology—Dan Porter, The Nature Conservancy; Emily Linn, Save the Redwoods League
Stevenson Event Ctr.	Session 1C, Forest Health—Kim Camilli, Cal Fire/CalPoly
3:10 - 3:30	**Break**—Stevenson Event Center
3:30 - 5:30	**Concurrent Session 2**
Classroom 175	Session 2A, Watershed Processes—Michael Furniss, PSW Redwood Sciences Lab
Classroom 150	Session 2B, Ecology—Dan Porter, The Nature Conservancy; Emily Linn, Save the Redwoods League
3:30 - 5:50	
Stevenson Event Ctr.	Session 2C, Forest Health—Kim Camilli, Cal Fire/CalPoly
6:00 - 8:30 p.m.	Poster Session and Hosted Reception/No-host Bar

Thursday June 23

7 a.m.	**Breakfast** for those staying on campus *Cowell/Stevenson Dining Commons*
	Refreshments provide for all—*Stevenson Event Center*
7:50 - 10:10	**Concurrent Session 3**
Classroom 175	Session 3A, Watershed Processes—Michael Furniss, PSW Redwood Sciences Lab
Stevenson Event Ctr.	Session 3C, Wildlife, Fisheries Aquatic Ecology—Brad Valentine, Cal. Dept. of Fish & Game
7:50 – 9:30	Session 3B, Ecology—Dan Porter, The Nature Conservancy; Emily Linn, Save the
Classroom 150	Redwoods League
9:30 – 12:30	Session 3B, Silviculture, Restoration—Scott Sink Cal Poly Tech; Pascal Berrill,
Classroom 150	Humboldt State University
10:10 - 10:30	**Break**—*Stevenson Event Center*
10:30 – 11:50	**Concurrent Session 4**
Classroom 175	Session 4A, Watershed Processes—Michael Furniss, PSW Redwood Sciences Lab
Classroom 150	Session 4B, Silviculture, Restoration— Scott Sink Cal Poly Tech; Pascal Berrill, Humboldt State University
Stevenson Event Ctr.	Session 4C, Wildlife, Fisheries Aquatic Ecology—Brad Valentine, Cal. Dept. of Fish & Game
11:50 – 12:30	**Concurrent Session 4** *continued*
Classroom 175	Session 4A, Economics, Policy—Rich Thompson, Cal Poly
Classroom 150	Session 4B, Silviculture, Restoration— Scott Sink Cal Poly Tech; Pascal Berrill, Humboldt State University
Stevenson Event Ctr.	Session 4C, Monitoring—Helge Eng, CalFire
12:30 - 1:30	**Lunch** (for all; meal ticket required)—*Cowell/Stevenson Dining Commons*

1:30 – 2:50	**Concurrent Session**
Classroom 175	Session 5A, Economics, Policy—*Rich Thompson, CalPoly*
Classroom 150	Session 5B, Silviculture, Restoration— Scott Sink Cal Poly Tech; Pascal Berrill, Humboldt State University
Stevenson Event Ctr.	Session 4C, Monitoring—Helge Eng, CalFire

Location: *Stevenson Event Ctr.*

3:00	**Introduction to the Closing Session**—John Stuart, Humboldt State
3:10	**Future of research in the Redwood Region**—John Helms, UC Berkeley and Mike Liquori, Sound Watershed
3:40 - 4:15	**Panel response: Interface of Research, Management and Conservation**—moderated by John Stuart Dan Porter, The Nature Conservancy Lowell Diller, Green Diamond Kevin O'Hara, UC Berkeley
4:15	**Wrap-up and Next Steps**—Rick Standiford
4:30	**Adjourn**—*Lodging Check Out 1:30 – 5:30 p.m.*

NOTES:

CONCURRENT SESSION 1 – WEDNESDAY, JUNE 22, 2011			
Abstract # precedes presentation title	**WATERSHED PROCESSES** **1A: Classroom 175**	**ECOLOGY** **1B: Classroom 150**	**FOREST HEALTH** **1C: Stevenson Event Center**
Session Chairs	***Michael Furniss*** PSW Redwood Sciences Lab	***Dan Porter*** The Nature Conservancy ***Emily Limm*** Save The Redwoods League	***Kim Camilli*** Cal Fire/CalPoly
1:30 - 1:50	*#35* - Declining Sediment Loads from Redwood Creek and the Klamath River, North Coastal California—R.D. Klein, Redwood National and State Parks	*#72* -Spatial Structure of an Upland Old-Growth Redwood Forest—P. van Mantgem, USGS	*#54* - Regeneration and Tanoak Mortality in Coast Redwood Stands Affected by Sudden Oak Death—B.S. Ramage, UC Berkeley
1:50 - 2:10	*#65* - Sediment Yield Response to Sediment Reduction Strategies Implemented for 10 Years in Watersheds Managed for Industrial Forestry in Northern California—K. Sullivan, Humboldt Redwood Company, LLC	*#16* - Stand Structure in Old-Growth Redwood Alluvial Flat Forests of Northern California—C.M. Dagley, Humboldt State University	*#70* - Sudden Oak Death and Surface Fuels in Douglas-Fir-Tanoak Forests—Y. Valachovic, UC Coop. Ext.
2:10 - 2:30	*#56* - Comparing Hydrologic Responses to Tractor-Yarded Selection and Cable-Yarded Clearcut Logging in a Coast Redwood Forest—L.M. Reid, USDA Forest Service PSW Research Station	*#71* - Size Distribution of Old-Growth Redwood Forests in Mendocino County—B. Valentine, California Fish and Game	*#74* - Invasive Weed Management in Redwood Forest; Jackson Demonstration State Forest's Approach—L.A. Webb, California Dept. Forestry and Fire Protection
2:30 - 2:50	*#2* - Road Surface Erosion on the Jackson Demonstration State Forest: Results of a Pilot Study—B. Barrett, California Dept. of Forestry and Fire Protection	*#38* - Foliar Uptake of Fog in the Coast Redwood Ecosystem: A Novel Drought-Alleviation Strategy Shared by Most Redwood Forest Plants—E. Limm, Save the Redwoods League	*#20* - Post-fire Response of Coast Redwood One Year After the Mendocino Lightning Complex Fires—R.B. Douglas, Mendocino Redwood Company
2:50 - 3:10	*#34* - Sediment Production in a Coastal Watershed: Land use, Legacy, Recovery, and Rehabilitation—E. Keppeler, USDA Forest Service PSW Research Station	*#25* - Fog and Soil Weathering as Sources of Nutrients in a California Redwood Forest—H.A. Ewing, Bates College	*#45* - Basal Cavities as an Indicator of Mortality Risk and Past Fire Regimes in Coast Redwood Forests—S. Norman; USDA Forest Service

CONCURRENT SESSION 2 – WEDNESDAY, JUNE 22, 2011			
Abstract # precedes presentation title	**WATERSHED PROCESSES** **2A: Classroom 175**	**ECOLOGY** **2B: Classroom 150**	**FOREST HEALTH** **2C: Stevenson Event Center**
Session Chairs	***Michael Furniss*** PSW Redwood Sciences Lab	***Dan Porter*** The Nature Conservancy ***Emily Limm*** Save The Redwoods League	***Kim Camilli*** Cal Fire/CalPoly
3:30 – 3:50	*#57* - Landslides after Clearcut Logging in a Coast Redwood Forest— L.M. Reid, USDA Forest Service PSW Research Station	*#12* - Inexpensive Restoration Techniques for Rapidly Increasing Wood Cover in California Coho Streams—J. Carah, The Nature Conservancy	*#15* - Decomposition and N Cycling Changes in Redwood Forests Caused by Sudden Oak Death— R.C. Cobb, UC Davis
3:50 - 4:10	*#32* - Large Woody Debris Budgets in the Caspar Creek Experimental Watersheds— S. Hilton, USDA Forest Service PSW Research Station	*#52* - The Effects of Albinism on the Water Relations and Stem Hydraulics of *S. Sempervirens* Shoots— J. Pittermann, UC Santa Cruz	*#69* - Impacts of *Phytophtora Ramorum* on Redwood Forest Dynamics in Central California — A. Torres, San Jose State University
4:10 - 4:30	*#66* - An Approach to Study the Effect of Harvest and Wildfire on Watershed Hydrology and Sediment Yield in a Coast Redwood Forest—C.G. Surfleet, Oregon State University	*#43* – Accounting for Variation in Root Density and Percent Carbon Increases Accuracy of Belowground Carbon Estimates—B.H. Namm, Humboldt State University	*#1* - Damage and Mortality Assessment of Redwood and Mixed Conifer Forest Types Following Wildfire—S. Auten, Cal Poly San Luis Obispo
4:30 - 4:50	*#40* - Assessing Effects of Changing Land Use on Sediment Loads in Panther Creek, North Coastal California—M.A. Madej, USGS	*#8* - Responses of Redwood Soil Microbial Community Composition and N Transformations to Climate Change—D.C. Bradbury, UC Berkeley	*#42* - The Effects of Sudden Oak Death and Wildfire on Forest Composition and Dynamics in the Big Sur Ecore—M.R. Metz, UC Davis
4:50 - 5:10	*#26* - Erosion at Decommissioned Road-Stream Crossings: Case Studies from Two Northern California Watersheds— S.A. Flanagan, Bureau of Land Management	*#30* - A Chronosequence of Vegetation Change Following Timber Harvest in Naturally Regenerating Coast Redwoods —K. H. Michels, San Jose State University	
5:10 - 5:30	*#41* - Fine Sediment Sources of Coastal Watersheds with Marine Uplifted Terraces —S.S. Madrone, Madrone Enterprises	*#59* - "Pygmy" Old-growth Redwood Characteristics on an Edaphic Ecotone in Mendocino County, California— W. Russell, San Jose State University	

CONCURRENT SESSION 3 – THURSDAY, JUNE 23, 2011

Abstract # precedes presentation title	**WATERSHED PROCESSES** **3A: Classroom 175**	**ECOLOGY** **3B: Classroom 150**	**WILDLIFE, FISHERIES, AQUATIC ECOLOGY** **3C: Stevenson Event Center**
Session Chairs	***Michael Furniss*** PSW Redwood Sciences Lab	***Dan Porter*** The Nature Conservancy ***Emily Limm*** Save The Redwoods League	***Brad Valentine*** CA Department Fish & Game
7:50 - 8:10	*#61* - The Effect of Selection Logging in a Redwood Forest on Watershed Hydrology and Sediment Yield in a Coastal California Watershed—A. Skaugset, Oregon State University	*#58* - Response of *Montia Howellii* (Howell's Montia) to Road Management in California Coastal Timberlands—M.A. Renner, Humboldt Redwood Company, LLC	*#36* - A Permeability Study on Salmonid Spawning Areas in Northern Humboldt County, California—C. Knopf, Green Diamond Resource Company
8:10 - 8:30	*#78* - Delineation of Default Landslide Buffers Along Steep Streamside Slopes in Northern California— J.S. Woodward, Green Diamond Resource Company	*#21* - Clonal and Population Studies in Redwood Using a New Suite of Nuclear Microsatellite Markers—V. Douhovnikoff, Simmons College	*#27* - How Do We Know How Many Salmon Returned to Spawn? Implementing the California Coastal Salmonid Monitoring Plan in Mendocino County, California—S.P. Gallagher, California Fish and Game
8:30 - 8:50	*#39* - The VTAC Committee: Developing Guidance for an Alternative Regulatory Pathway to the Anadromous Salmonid Protection Rules—M. Liquori, Sound Watershed	*#19* - Genetic Divergence and Potential for Response to Climate Change of Coast Redwood—R.S. Dodd, UC Berkeley	*#79* - Measurements of Key Life History Metrics of Coho Salmon in Pudding Creek, California — D.W. Wright, Campbell Timberland Management
8:50 - 9:10	*#10* - Total Maximum Daily Loads, Sediment Budgets, and Tracking Restoration Progress of the North Coast Watersheds—M.S. Buffleben, California Regional Water Quality Control Board	*#9* - Rangewide Genetic Variation in Coast Redwood—C. Brinegar, University of Maine Farmington	*#76* - Frogs, Fish and Forestry: The Need for a Holistic View of Network Processes to Conserve Biodiversity—H.H. Welsh, Jr., USDA Forest Service PSW Research Station
	WATERSHED PROCESSES **3A: Classroom 175**	**SILVICULTURE, RESTORATION** **3B: Classroom 150**	**WILDLIFE, FISHERIES, AQUATIC ECOLOGY** **3C: Stevenson Event Center**
Session Chairs	***Michael Furniss*** PSW Redwood Sciences Lab	***Scott Sink*** CA Poly Technic State University ***Pascal Berrill*** Humboldt State University	***Brad Valentine*** CA Department Fish & Game
9:10 - 9:30	*#11* - Logging-Related Increases in Stream Density in a Northern California Watershed— M.S. Buffleben, California Regional Water Quality Control Board	*#29* - Management Practices Related to the Restoration of Old Forest Characteristics in Coast Redwood Forests—G.A. Giusti, UC Coop. Ext.	*#7* - Distribution and Persistence of Larval *Ascaphus Truei* and *Rhyacotriton Variegatus* in Headwater Streams on Redwood Timberlands in North Coastal California—R. Bourque, Green Diamond Resource
9:30 - 9:50	*#46* - Sediment Yield in the Gualala River-Comparison of Sediment Budget Techniques and Suspended Sediment—M. O'Connor, O'Connor Environmental, Inc.	*#49* - Variable-Density Thinning in Coast Redwood: A Comparison of Marking Strategies to Attain Stand Variability—K.L. O'Hara, UC Berkeley	*#18* - Two Decades of Research and Monitoring of the Northern Spotted Owl: What Do We Know and What Challenges Remain—L. Diller, Green Diamond Resource Company
9:50 - 10:10	*#13* - Physics-Based Simulations of the Impacts of Forest Management Practices on Hydrologic Response—A.E. Carr, Argonne National Laboratory		*#75* - Northern California Redwoods Provide Important Seasonal Habitat for Migrant Bats—T.J. Weller, USDA Forest Service PSW Research Station

CONCURRENT SESSION 4 – THURSDAY, JUNE 23, 2011

Abstract # precedes presentation title	**WATERSHED PROCESSES** **4A: Classroom 175**	**SILVICULTURE, RESTORATION** **4B: Classroom 150**	**WILDLIFE, FISHERIES, AQUATIC ECOLOGY** **4C: Stevenson Event Center**
Session Chairs	***Michael Furniss*** PSW Redwood Sciences Lab	***Scott Sink*** CA PolyTechnic State University ***Pascal Berrill*** Humboldt State University	***Brad Valentine*** CA Department Fish & Game
10:30 -10:50	*#64* - Summer Water Use by Mixed-Age and Young Forest Stands, Mattole River, Northern California, USA—A.P. Stubblefield, Humboldt State University	*#67* - Forest Restoration at Redwood National Park: A Case Study of an Emerging Program—J.R. Teraoka, Redwood National Park	*#14* - Sonoma Tree Vole Habitat on Managed Redwood and Douglas-Fir Forestlands in North Coastal California—S. Chinnici, Humboldt Redwood Company, LLC
10:50 -11:10	*#55* - Use of Basitemp© to Predict Summer Stream Temperatures in the South Fork Ten Mile River Basin, CA—R. Real de Asua, Stillwater Sciences	*#73* - Whiskey Springs Long Term Redwood Density Management; Final Growth, Redwood Sprout, and Yield Result—L.A. Webb, Calif. Dept. Forestry and Fire Protection	*#31* - Ecology and Management of *Martes* on Private Timberlands in North Coastal California— K. Hamm, Green Diamond Resource Company
11:10 -11:30	*#4* - Experimental Reintroduction of Complex Wood Jams in a Redwood Coastal Stream in Northern California—J.R. Benegar, California State Parks	*#48* - The Scotia Plantation: Implications for Multiaged and Even-aged Silviculture—K.L. O'Hara, UC Berkeley	*#62* - Mesocarnivores as Focal Species for the Restoration of Post-Logging Second Growth in the Northern Redwoods— K.M. Slauson, USDA Forest Service PSW Research Station
11:30 -11:50	*#50* - Fluorometry as a Bacterial Source Tracking Tool in Coastal Watersheds, Trinidad, CA—T.A. Parker, Streamline Planning Consultants	*#51* - Using FORSEE and Continuous Forest Inventory Information to Evaluate Implementation of Uneven-aged Management in Coastal Redwood Forests in Santa Cruz County—D.D. Piirto, Cal Poly San Luis Obispo	
	ECONOMICS, POLICY **4A: Classroom 175**	**SILVICULTURE, RESTORATION** **4B: Classroom 150**	**MONITORING** **4C: Stevenson Event Center**
Session Chairs	***Rich Thompson*** CalPoly	***Scott Sink*** CA PolyTechnic State University ***Pascal Berrill*** Humboldt State University	***Helge Eng*** CalFire
11:50 -12:10	*#5* - Observations About the Effectiveness of Utilizing Single Tree Selection Silviculture in Redwood Forests—R. Berlage, Big Creek Lumber Company	*#6* - Stand Density and Spatial Pattern in Coast Redwood: Implications for Management, Research, and Carbon Sequestration—J.P. Berrill, Humboldt State University	*#17* - Comparing LiDAR-Generated to Ground-Surveyed Channel Features in a Forested Mountain Stream—B.C. Dietterick, Cal Poly San Luis Obispo
12:10 -12:30	*#63* - Subdivide or Silviculture: Choices Facing Family Forest Owners in the Redwood Region—W. Stewart, UC Berkeley	*#3* - Coast Redwood Live Crown and Sapwood Dynamics—C.B. Beal, Humboldt State University	*#22* - Tree Height Estimation in Coastal Redwood/Douglas-Fir Stands in Mendocino County, California—H. Eng, California Dept. Forestry and Fire Protection

CONCURRENT SESSION 5 – THURSDAY, JUNE 23, 2011

Abstract # precedes presentation title	**ECONOMICS, POLICY** **5A: Classroom 175**	**SILVICULTURE, RESTORATION** **5B: Classroom 150**	**MONITORING** **5C: Stevenson Event Center**
Session Chairs	***Rich Thompson*** CalPoly	***Scott Sink*** CA PolyTechnic State University ***Pascal Berrill*** Humboldt State University	***Helge Eng*** CalFire
1:30 – 1:50	*#68* - Estimating Benefits and Costs of Carbon Storing Forestry-Offset Projects Using California's Climate—R. Thompson, Cal Poly San Luis Obispo	*#33* - Carbon Storage in Young Growth Coast Redwood Stands—D.A. Jones, UC Berkeley	*#44* - Land Surface Phenology as a Coarse-Filter Indicator of Disturbance and Climatic Effects Across the Coast Redwood Range— *S.* Norman, USDA Forest Service
1:50 - 2:10	*#24* - The Watershed NTMP: A Proposal to Manage the Redwood Ecosystem—F.D. Euphrat, Forest, Soil & Water, Inc.	*#53* - Using Wood Quality Measures to Evaluate Second-Growth Redwood—Y. Valachovic, UC Coop. Ext.	*#60* - Management of the Rare Plants of the Coast Redwood Forests: A Case Study of One Timber Company's Approach—C. Sanville, Green Diamond Resource Company
2:10 - 2:30	*#23* - Protecting Forests Across Landscapes and Through Generations: The Sonoma County Forest Working Group—F.D. Euphrat, Forest, Soil & Water, Inc.	*#47* - Coast Redwood Responses to Pruning—K.L. O'Hara, UC Berkeley	*#37* - Prioritizing Treatment of Second-Growth Forests Using LiDAR—L.P. Leonard, California State Parks
2:30 - 2:50	*#28* - California's Coast Redwood in New Zealand—T. Gaman, East-West Forestry Associates, Inc.		*#77* - Use of LiDAR and Multispectral Imagery to Determine Conifer Mortality and Burn Severity—R. White, Cal Poly San Luis Obispo

Abstracts of Invited Presentations

Redwood Forest Conservation: Where do we go from here?

Ruskin K. Hartley, *Save the Redwoods League, rhartley@savetheredwoods.org*

One hundred and nine years after the first redwoods were set aside in public ownership, the redwood movement has come a long way. For most of the public "saving redwoods" has meant placing threatened giants in parks and reserves -- Big Basin State Park (1902), Muir Woods National Monument (1908), Humboldt Redwoods State Park (1921), Redwood National Park (1968), and the Headwaters Forest Reserve (1999). But after a century when more than 95 per cent of the ancient redwoods were felled and where most of the large groves are now protected in public parks and reserves, what does it mean to save the redwoods today? If for the first 100 years saving meant buying and placing in public ownership, I argue that for the next 100 years, saving will mean working together to restore the forest, whether in public or private ownership. In a time of rapid climate change, it also means the arbitrary lines we've drawn on a map to denote public and private ownership become increasingly irrelevant and we'll need a new paradigm to think about building resilience and adaptability to climate change into the system to the benefit of both public and private owners. What science is needed to guide these efforts? Do practitioners have the tools they need? How can we do this in a way that makes economic sense for private companies and the public good? And most importantly, how can we engage and gain the support of a skeptical public more used to liquidation lumbering than restorative forestry? If we do it right, it can be a model for how forests around the world are managed; if we fail we risk losing the redwood forest we all love.

Redwood Forest Canopies: Insights from 15 Years of Tree Climbing

***Stephen Sillett**, Department of Forestry and Wildland Resources, prof.sillett@gmail.com*

The pace of research on *Sequoia sempervirens* forests increased dramatically in 1996 with initiation of scientific tree climbing at Humboldt State University. Direct measurements of tree structures and epiphytes have revealed an arboreal ecosystem that was previously under-appreciated, because upper canopies of tall forests are scarcely visible from the ground. As they age, and in response to damage from wind and falling neighbors, redwood trees develop highly individualized crowns consisting of reiterated trunks arising from the main trunk, other trunks, and limbs. Over many years, these woody components of a crown interact, sometimes abrading each other and fusing such that living cambium produces sapwood that bridges regions of the crown hydraulically. Fusions, old limbs, and crotches between reiterated trunks provide ideal platforms for accumulation of epiphytes and debris. In redwood rain forests of Humboldt and Del Norte Counties, the fern *Polypodium scouleri* forms sprawling mats overlying arboreal soils up to 1 meter deep on these substrates. The set of fern mats in an old crown can exceed 800 kilograms dry mass and over 8000 liters of water. Soils beneath ferns and decaying wood inside trunks and limbs store 25 to 53 thousand liters of water per hectare, sustaining desiccation-sensitive organisms high above the ground throughout the year. The lungless salamander, *Aneides vagrans* – the only amphibian denizen of redwood forest canopies – resides in cavities within fern mats and decaying wood and feeds on a rich invertebrate community that includes aquatic crustaceans known as harpacticoid copepods. In addition to *P. scouleri*, redwood forest canopies are home to at least 265 epiphyte species (186 lichens, 26 mosses, 19 liverworts, 15 angiosperms, 5 ferns, 4 conifers), including a species new to science, the lichen *Calicium sequoia* Williams & Tibell. Even in the most complex redwood forests, a few old trees per hectare sustain the bulk of arboreal biodiversity, because these trees provide the bulk of gnarly structures available in the forest (e.g. large diameter, reiterated trunks and limbs). Combining diameter measurements with increment coring of main trunks along the height gradient permits accurate quantification of both ages and growth rates of standing trees. These measurements reveal that the amount of wood produced by a tree increases with size through old age such that redwoods over 1500 years of age now produce on average, more wood annually than at any previous time during their lives. The quality of wood produced by a tree also improves substantially with increasing age. By 1000 years of age, 95 percent of wood produced annually by a redwood's main trunk is tight-grained, decay-resistant heartwood. Diameter and dendrochronology measurements of many standing trees allows quantification of growth histories over the past 1000 years throughout much of redwood's geographic range. From Jedediah Smith Redwoods State Park to Big Basin Redwoods State Park, wood production of old-growth redwood forests increased significantly during the 20th century. Causes and consequences of this apparent growth surge are now under intense investigation by scientists at Humboldt State University and UC Berkeley.

Abstracts of Oral Presentations

1 Damage and Mortality Assessment of Redwood and Mixed Conifer Forest Types Following Wildfire

***Steve Auten**, Cal Poly, Swanton Pacific Ranch, sauten@calpoly.edu; **Nadia Hamey**, Big Creek Lumber Company, nadiah@big-creek.com*

On August 12, 2009, the Lockheed Fire ignited the west slope of the Santa Cruz Mountains burning approximately 7,819 acres. A mixture of vegetation types were in the path of the fire, including approximately 2,420 acres of redwood forest and 1,951 acres of mixed conifer forest types representative of the Santa Cruz Mountains. Foresters and land managers were left with tough decisions on how to treat tree damage and mortality compounded by the Pine Mountain Fire which occurred in the same area in 1948. Big Creek Lumber Company (BCL), Cal Poly's Swanton Pacific Ranch (SPR) and other professionals familiar with this region of redwood teamed up to develop a method for evaluating damage and mortality. Qualitative criteria for evaluating stand damage focused on historic defect, cambial death, root damage, and associated fire intensity. Quantitative damage criteria was used to contrive three mortality assessment tables, broken up by diameter class (1-8, 9-16, 17+), for all tree species and tested against 83, 1/5th acre fixed plots from SPR's Continuous Forest Inventory (CFI). Since the initial mortality evaluation using the new tables in fall of 2009, each of the 2877 trees have been re-evaluated in spring 2010 and spring 2011. Percent accuracy against the initial evaluation is 89.3%.

2 Road Surface Erosion on the Jackson Demonstration State Forest: Results of a Pilot Study

***Brian Barrett**, Jackson Demonstration State Forest, brian.barrett@fire.ca.gov; **Rosemary Kosaka**, National Marine Fisheries Service, rosemary.kosaka@noaa.gov; **David Tomberlin**, National Marine Fisheries Service, david.tomberlin@noaa.gov*

This paper presents results of a 3-year pilot study of surface erosion on forest roads in the Jackson Demonstration State Forest in California's coastal redwood region. Ten road segments representing a range of surface, grade, and ditch conditions were selected for the study. These hydrologically isolated segments ranged in surface composition from native soil to rocked; grade from 0% to 9%; in length from 84m to 207m; and in percentage of ditch vegetated from 0% to 75%. At each segment, settling basins with tipping buckets were installed to measure coarse sediment and total runoff. Laboratory analysis of Total Suspended Solids (TSS) samples from the runoff provided estimates of fine sediment production from the study segments.

Total sediment production (coarse and fine) on the ten road segments studied ranged from negligible (0.04 kg/m2/yr) to more than 4.5 kg/m2/yr, and varied greatly from year to year on most sites, in some cases by an order of magnitude. TSS in runoff samples varied from 6 mg/L to 5400 mg/L, though for most sites the mean annual TSS exhibited less inter-annual variation than did total sediment production. The share of TSS in yearly total sediment production ranged from 2% to 92%, and for many sites also varied greatly from year to year. Small sample size precludes formal statistical analysis of the factors contributing to the variability in sediment production on the sites. While surface, grade, and ditch vegetation appear to offer partial explanations of results for each site, we also found large variations among sites with very similar characteristics.

In addition to the particular empirical results reported here, several lessons emerged from this study that may be useful to similar, larger-scale efforts in the future. Based on a small (n=12) number of runoff samples tested for organic solids, the share of organics in TSS was found to be as high as 18%, suggesting that on some sites distinguishing organic from inorganic would be important to estimating mineral sediment production. Tests of the estimates' sensitivity to intra-seasonal variation in instrument performance suggested that on 9 out of 10 instruments the effects of such variation were negligible relative to other sources of uncertainty such as catchment area. Lastly, the study required significant investment, both in terms of direct expenditures and staff time, and careful thought should be given to the value of the information generated relative to the costs incurred. With regard to that question, we have begun a formal decision-theoretic analysis of conditions under which long-term management performance is better served by expensive, high-quality information vs. cheaper, lower-quality information.

3 Coast Redwood Live Crown and Sapwood Dynamics

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Understanding tree crown rise and sapwood taper will help coast redwood forest managers design silvicultural regimes. Management objectives such as producing long branch-free boles for old growth restoration, or producing sawlogs with a high proportion of heartwood, can be met once crown rise and sapwood taper are understood.

We apply principles of stand density and self-thinning to predict crown rise, and the pipe model theory to predict taper of sapwood cross-sectional area from breast height to the base of the live crown. Crown rise was predictable, yet variable due to the clumpy spatial pattern in second growth redwood stands of stump sprout origin. Sapwood taper relations varied between wet northern and dry southern sites. Thus, redwood trees of a given size contained more heartwood in southern stands.

Models that predict crown rise and sapwood taper are presented. The models were linked to existing models and applied in combination to design example silvicultural regimes for restoration and production objectives in coast redwood stands. Results indicated that a lengthy delay in thinning was needed to induce crown rise and create long branch-free boles without artificial pruning in the old growth restoration regime. Heartwood as a proportion of total butt log volume increased with advancing stand age and tree size.

4 Experimental Reintroduction of Complex Wood Jams in a Redwood Coastal Stream in Northern California

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Whole tree materials that include trees with attached rootwads, logs, and branches are recognized as important components of streams flowing through coastal redwood forests of Northern California. As the understanding of the importance of large wood materials has emerged, they have been recognized as key physical elements missing from many streams due to the historic and systematic removal associated with timber harvest and stream cleaning practices. The recognition of the ecological importance of wood materials within stream and floodplain ecosystems has led scientists and managers to advocate for the re-introduction of large wood directly into these environments. However, common applications of instream wood restoration can fall short of producing features capable of inducing the physical changes necessary to achieve desired restoration objectives, such as the formation of deep pools and cover. Current research shows that natural wood jams, with increased wood piece counts and volumes, are more effective at producing the hydraulic and geomorphic conditions necessary for creating and sustaining complex habitat. This study hypothesized that wood jams constructed with whole tree materials, increased wood piece counts, and greater wood volumes would be more effective than simple structures at creating the hydraulic conditions necessary for increasing instream complexity, geomorphic function, and aquatic habitat quality. Results were based on an evaluation of changes to surface sediment textures and channel morphology at ten constructed wood features built with varying complexity and wood volumes. Eight of these features were complex wood jams constructed with whole tree materials including large diameter trees with attached rootwad, logs, and branches. Each complex jam was individually designed to interact with seasonal variations in stream flow, floodplain morphology, and the dominant sediment transport regime. Two of the studied features were "simple structures" constructed in 1995 and comprised of one or two logs anchored to imported boulders with cable. The simple structures were designed following a standard California restoration protocol. Results indicate that complex wood jams were more effective than simple fish habitat structures in achieving common restoration objectives that include: (1) increasing percentage pool cover; (2) increasing scour pool habitat; (3) metering and sorting salmon spawning gravels; and (4) improving habitat heterogeneity. In addition, the effectiveness of an individual constructed jam improved as the overall wood piece count and volume within the jam increased. While the results of this study are limited to a single 3rd order stream in Northern California, they begin to fill an important gap in the literature by illustrating the range of results that are possible from jams constructed with increasing quantities of wood. Results of this work will be presented using a multimedia format.

5 Observations About the Effectiveness of Utilizing Single Tree Selection Silviculture in Redwood Forests

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Harvesting in predominantly redwood forests has been ongoing in the Santa Cruz Mountain region for over 150 years. Under California Forest Practice rules specific to the southern subdistrict of the Coast District, clearcutting has been outlawed since 1970. Since that time, single tree selection has been the only silvicultural practice allowed in the southern subdistrict.

Big Creek Lumber Company has been practicing some form of selective harvesting throughout coastal redwood forestlands in the Santa Cruz Mountains since 1946. Sixty-five years of experience makes it is possible to form general observations about the effectiveness of this silvicultural practice within a redwood forest environment

Increasing population and urban sprawl have created pressures on redwood forestlands in California, and particularly on the Central Coast. Tensions resulting from population increases and ongoing urban encroachment into forestlands in the Santa Cruz Mountains have increased over time. This has created significant logistical and socio-political challenges for the local forest products industry. Not surprisingly, these challenges are now beginning to be seen elsewhere in the redwood region

Selection harvesting can provide positive benefits, particularly adjacent to densely populated areas. These benefits include providing local, sustainable products for local consumers, supporting working forestlands that provide a buffer against the pressures of land conversion and urban sprawl, as well as being a mechanism for maintaining complex redwood forest ecosystems.

6 Stand Density and Spatial Pattern in Coast Redwood: Implications for Management, Research, and Carbon Sequestration

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Stand density and spatial pattern of tree locations affect various aspects of mensuration and silviculture in coast redwood. Sampling with different plot types and sizes was simulated using tree location maps and data collected in three even-aged coast redwood stands selected to represent uniform, random, and clumped spatial patterns of tree locations. Fixed-radius circular plots, belt transects, and variable-radius plots were installed by simulation. Bootstrap sample means, coefficient of variation (CV), and 95% confidence intervals were calculated for sample estimates of eight important stand parameters. Percent CV models depicted sample precision and enable calculation of minimum sample size for forest inventories. Precision differed between stand parameters e.g., dominant height and mean top height estimates were most precise; in many cases four times as precise as density estimates. Precision was affected more by spatial pattern than plot type, and generally ranked: uniform, random , clumped. Density, average diameter, and average height estimate precision was especially sensitive to spatial pattern, and generally poorer in variable-radius plots. However, variable-radius plots generally produced the most precise estimates of basal area, volume, and leaf area index.

A series of uneven-aged silvicultural prescriptions were simulated to demonstrate the influence of key variables defined by managers: stand density, harvest return interval, and number of replacement trees in younger cohorts. These variables affected stand structure, growth, and yield. Total cubic stemwood volume production was affected by complexity of stand structure (number of cohorts), and was greater at higher stand densities. Sustained yield of recoverable volume (board feet) exhibited a saturating relationship with stand density, peaking at an intermediate level; higher stand densities arrested individual tree development which in turn impacted board foot volume production. Results provide insight into stand dynamics and relationships between influential variables defined by managers. Silvicultural regimes with lower and higher density management zones, and clumped versus dispersed spatial patterns, are presented and contrasted in terms of carbon sequestration and wood production objectives (i.e., cubic versus board foot volume production), regeneration vigor, and ease of implementation. Results inform design of forest inventories and silvicultural prescriptions, and selection of plot sizes and experimental treatments for field research.

7 Distribution and Persistence of Larval Ascaphus Truei and Rhyacotriton Variegatus in Headwater Streams on Redwood Timberlands in North Coastal California

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The Coastal Tailed Frog (*Ascaphus truei*) and Southern Torrent Salamander (*Rhyacotriton variegatus*) are listed in the state of California as species of special concern. Both species are adapted to live in clear cold-water habitats and populations may be reduced as a result of sedimentation and increased water temperatures caused by timber harvesting and road building and maintenance. Due to conservation concerns, Green Diamond Resource Company (GDRCo) included both amphibian species in its aquatic habitat conservation plan (AHCP), which was approved in June 2007 by the U.S. Fish and Wildlife Service and National Marine Fisheries Service. One monitoring objective for the two amphibians was to sustain known occupancy rates across the ownership and assess potential impacts of forest management activities.

To satisfy this objective, we studied the distribution and persistence of larval *A. truei* and *R. variegatus* in headwater streams across GDRCo's California ownership. Larval distributions and occupancy for both species were initially determined from surveys conducted in 1994 and 1995 at randomly selected headwater streams. These surveys found that *A. truei* and *R. variegatus* occurred in 75% and 80%, respectively, of the streams across the ownership and these occupancy rates were used as baselines for assessing future change in occupancy. In 2008 and 2009, we revisited streams currently within the ownership and some new randomly selected streams to account for recent land acquisitions. A random subset of streams was visited twice. We used patch occupancy models to calculate occupancy rates and detection probabilities and corrected Akaike's Information Criterion to assess potential affects of timberland management and potentially important geomorphic covariates (e.g., geology, sub-basin area, aspect, and etc.) on occupancy rates.

We detected larval *A. truei* at 81% of all streams surveyed, and 82% of sites initially visited in 1995. *R. variegatus* were detected at 85% of all streams surveyed and 88% of sites visited in 1995. The detection probabilities were high (> 88%) for the survey method used to detect both species, indicating high confidence in our results. Geologic formation was found to be an important covariate that predicted occupancy for both species. These findings demonstrated that occupancy rates of both species were constant or potentially higher in headwater streams in coastal redwood timberlands managed by Green Diamond over the past 14 years, which suggested that populations will persist under the current protective measures in the existing AHCP.

8 Responses of Redwood Soil Microbial Community Composition and N Transformations to Climate Change

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Soil microorganisms perform critical ecosystem functions, including decomposition, N mineralization and nitrification. Soil water availability can be a critical determinant of the rates of these processes. During the otherwise dry summer, the presence of fog reduces soil water loss via evapotranspiration, and fog drip can provide an important source of water.

This research examined how changes in climate and the resulting impacts on soil water availability affect redwood soil microbial community composition and rates of gross N mineralization and nitrification. Soils were reciprocally transplanted between three coast redwood sites located across a latitudinal climate gradient, from near the southern extent of redwood to near their northern extent (establishing North, Middle and South sites). Soils were transplanted at the end of the summer and collected one year later. Molecular analyses were used to examine the changes in fungal and bacterial community composition, and 15N isotope pool dilution was used to measure gross rates of N mineralization and nitrification.

After one year, climate had a measurable impact on fungal and bacterial and community composition, though transplanted soil microbial communities still differed in composition from those of their new destination. Both climatic and edaphic variables were correlated with microbial community composition. Thus, edaphic characteristics, including biological interactions, codetermine with climate the magnitude and trajectory of the change in soil microbial community composition.

The responses of gross N mineralization and nitrification to the transplant-induced changes in climate differed. Gross nitrification rates were highly influenced by the impacts of climate and soil characteristics on soil water availability. Rates of gross nitrification were highest in the North climate and in soils with a North origin. There appears to be a critical water availability below which rates of gross nitrification are severely inhibited and above which rates vary as a function of other controllers. In contrast, there were few significant differences in gross N mineralization rates between soil-climate

combinations, and the rates in soils from a given origin did not differ significantly between transplant sites. However, the mean rate of gross N mineralization did vary by a factor of three across soil origin-climate combinations.

In summary, changes in redwood climate, fog frequency and summer water availability may not significantly affect rates of gross N mineralization, but will likely alter soil microbial community composition and rates of gross nitrification.

9 Rangewide Genetic Variation in Coast Redwood

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The 450-mile range of coast redwood (*Sequoia sempervirens*) is often subdivided into northern, central and southern forests based on climate and forest composition. Although significant climatic variation exists within each region, southern redwoods are more adapted to the generally warmer and drier conditions found along the Central Coast of California while central and northern trees exist in the increasingly cooler and moister climates north of the San Francisco Bay. The purpose of this study was to determine if the observed differences between these three major forest subdivisions are actually reflected in the genetic composition of their populations.

Four hundred trees (40 from each of 10 old-growth redwood populations) were analyzed at a highly variable chloroplast tetranucleotide microsatellite locus. The sampled populations were located in Del Norte, Humboldt (2), Mendocino, Sonoma, Marin, Santa Cruz (2), and Monterey (2) counties.

Overall, 17 unique haplotypes were observed, ranging from 4-21 repeats of the CTTA microsatellite motif. Owing to the dominance of the 8-repeat haplotype in all populations, the average haplotype size ranged from 7.4-9.4 repeats per population. However, there was a statistically significant difference between the average haplotype size of the combined Monterey and Santa Cruz county populations (7.7 ± 0.2) versus the combined central and northern populations (8.6 ± 0.5).

Even more significant differences were found in measures of haplotype diversity. The four southern populations (Santa Cruz and Monterey counties) were the least genetically diverse as judged by haplotype richness (2-4 haplotypes per population) and standardized haplotype diversity index ($Hs = 0.18 \pm 0.12$). Genetic diversity of the combined central and northern populations was significantly higher (8-12 haplotypes per population; $Hs = 0.60 \pm 0.13$).

Although the low genetic diversity of the southern redwood forests in the study described above was due to a deficiency in rare haplotypes, a separate study on a second-growth population in Santa Cruz County did, in fact, show that there were at least 10 haplotypes in this southern population – equal to the average haplotype richness of central and northern populations in the first study – but a sample size of 425 (vs. 40) was required to detect them. Six of those haplotypes had frequencies < 0.005.

Data from this locus suggest that the present range of redwood forests was derived from a single diverse founding population but that post-glacial conditions and range recession in the southern redwood forests have led to a marked reduction in the frequency of rare alleles through genetic drift. The predicted northward recession of redwood forests caused by future climate change will likely be accompanied by the loss of these rare alleles at the southern edge of the range.

10 Total Maximum Daily Loads, Sediment Budgets, and Tracking Restoration Progress of the North Coast Watersheds

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The predominate water quality problem in northern coastal California watersheds is the impairment of salmonid habitat. Most of the North Coast watersheds are listed as "impaired" under section 303(d) of Clean Water Act. The Clean Water Act requires states to develop Total Maximum Daily Loads (TMDLs) for the listed waterbodies. TMDLs are an estimate of the load necessary to meet water quality standards. In a general sense, a TMDL is a water quality attainment strategy and provides a framework for assessing the watershed condition, evaluating the sources of pollution contributing to the water quality impairment, and developing a water quality restoration plan for the watershed.

Sediment budgets are useful tools to evaluate sediment impacts to water quality and channel morphology. To meet TMDL requirements, sediment budgets have been developed for twenty northern California watersheds. Anthropogenic activities such as logging and its associated road building, which commonly occur in this region, has dramatically increased sediment loads. These studies estimate that is will take several decades or more for streams to transport the excess sediment out of the watersheds.

Tracking recovery of the watersheds over time will be difficult. The Regional Water Board will use several tools to verify that progress is being made. These tools include updating sediment budgets, as well as monitoring hillslope and water quality conditions in the listed watersheds.

11 Logging-Related Increases in Stream Density in a Northern California Watershed

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Although many sediment budgets estimate the effects of logging, few have considered the potential impact of timber harvesting on stream density. Failure to consider changes in stream density could lead to large errors in the sediment budget, particularly between the allocation of natural and anthropogenic sources of sediment.

This study conducted field surveys in randomly selected catchments in two managed and one old-growth watershed to determine the location of the channel's origins in the catchments. The drainage areas for identified channel heads were then delineated using a 1-m digital elevation model derived from laser altimetry. The two managed watersheds were heavily impacted by previous logging activities, particularly by tractor operations used to yard the timber out of the watersheds. The channel heads in the managed watersheds had smaller drainage areas than channels in a nearby old-growth watershed. The management activities led to a tripling of the drainage density in the managed watersheds.

Timber harvesting and the construction of skid trails used to transport timber to the road system led to increases in peak flow, ground water interception, soil compaction and drainage diversion, which reduced the drainage area necessary to initiate stream channels. Furthermore, it appears that recent ground-based yarding operations have further extended stream channels upslope, potentially creating additional sources of sediment for downstream receptors. Although these results may be unique to these watersheds, the changes in drainage density due to management activities found here emphasize the need to compare managed watersheds with undisturbed watersheds before using the current drainage network as a base-line for watershed investigations.

12 Inexpensive Restoration Techniques for Rapidly Increasing Wood Cover in California Coho Streams

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Salmonid species on the North Coast, including coho and Chinook salmon, and steelhead trout, have declined rapidly over the last fifty years and are listed as species threatened or endangered by extinction at both the state and federal levels. Coho in particular are in deep trouble, with trends indicating that most or all populations in California coastal streams will disappear in next 25---50 years in the absence of serious intervention. One of the most urgent actions identified in federal and state coho recovery plans to improve coho spawning and rearing habitat is to add large woody material [LWM]) to creeks. It is imperative that this and other key coho recovery actions be implemented quickly in California. Yet the current pace and scale of LWM augmentation is not meeting the urgent need. For example, nearly 80% of priority focus watersheds have been identified as having poor LWM volume and cover in the National Marine Fisheries Service's draft 2010 Recovery Plan for Evolutionarily Significant Unit of Central California Coast Coho Salmon.

The Nature Conservancy (TNC), The Conservation Fund (TCF) and Campbell Timberland Management (CTM) have been implementing innovative, efficient LWM augmentation techniques in Mendocino County, California since 2008. We are using a process –based (rather than engineered) approach to large wood augmentation, including adding approximately –sized, unanchored LWM and letting natural stream processes move and place the wood, and 'build' structures organically. This approach seeds understocked creeks with wood as an interim measure until riparian forests attain adequate size and stocking to achieve sufficient natural LWM recruitment rates. This approach is highly cost-efficient and can be implemented rapidly, enabling treatment over large swaths of coho habitat quickly. In the last three years, TNC, TCF and CTM have treated over 20 miles of priority coho streams using these techniques, and will have over 12 more miles treated by the end of 2011. This presentation will cover specific techniques used and results, as well as an overview of costs to complete these projects.

13 Physics-Based Simulations of the Impacts of Forest Management Practices on Hydrologic Response

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The impacts of forest management practices on near-surface hydrologic response at the catchment and watershed scales were examined quantitatively using numerical simulation. The simulations were conducted with the Integrated Hydrology Model (InHM) for the North Fork of Caspar Creek Experimental Watershed, located near Fort Bragg, California. InHM is a comprehensive physics-based hydrologic-response model. The North Fork watershed (including 11 tributary catchments) is the site of an ongoing study monitoring the impacts of forest practices.

InHM was parameterized and calibrated using existing data and new field measurements of soil-hydraulic properties. Long-term simulations were conducted for three wet seasons: before logging, after logging, and after a period of regrowth. The simulated increases in discharge depths and peak discharges were considerably higher after partial and full clearcut harvesting.

Hypothetical-reality cumulative watershed effects (CWEs) simulations were carried out to examine potential impacts of alternative timber harvest levels and methods relative to those that occurred in the North Fork watershed. The results from these simulations show that the increases in the simulated discharge after clearcutting were significant for the catchment and watershed scales and that relatively small changes in soil-hydraulic properties produced substantial changes in hydrologic response. The simulations in this study clearly illustrate that timber harvesting can alter the streamflow generation mechanisms and patterns within a given catchment.

14 Sonoma Tree Vole Habitat on Managed Redwood and Douglas-Fir Forestlands in North Coastal California

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The Sonoma Tree Vole (*Arborimus pomo*) is a California Species of Special Concern and an important prey species of the northern spotted owl (*Strix occidentalis caurina*). This small arboreal mammal has been associated with mature forests, raising concerns regarding loss of habitat due to harvest, fire, and conversion. We examined A. pomo use of pole to mature forest seral stages from 2001-2005 using line transects at 64 study sites distributed across redwood, mixed conifer, Douglas-fir (*Pseudotsuga menziesii*), and hardwood dominated stands. A total of 441 nests were found including 215 active and 226 inactive nests. The highest percentage (33%) of A. pomo nests were in un harvested and partially harvested old growth Douglas-fir stands. All pole and young stands, and stands that were predominantly redwood, had 77% fewer nests. This study suggests that A. pomo could benefit from forest management strategies aimed at retaining a mature Douglas-fir stand component.

15 Decomposition and N Cycling Changes in Redwood Forests Caused by Sudden Oak Death

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Phytophthora ramorum and the resulting disease sudden oak death are selectively removing tanoak (*Notholithocarpus densiflorus*) from many coast redwood forests. Disease spread and intensification is highly influenced by stand densities of tanoak and bay laurel (*Umbellularia californica*) which support *P. ramorum* sporulation on twig and leaf infections (respectively). Tanoak removal is likely to shift redwood forest species composition to increasing dominance of bay laurel and redwood depending on initial composition and physiographic characteristics of disease impacted stands. We measured litterfall, N mineralization, and litter decomposition in thirty plots with varying levels of disease caused mortality and also quantified species level influences on soil N cycling. Disease reduces tanoak litterfall and tends to increase rates of nitrification. Litter decomposition rates were rapid in bay laurel and slow in redwood and tanoak. In our species level study, redwood and tanoak were associated with low rates of nitrification while N cycling beneath bay laurel was dominated by nitrate turnover. Short-term changes in ecosystem function were modest, but long-term changes associated with shifting species composition will be at a much greater magnitude. Disease driven shifts towards greater importance of bay laurel will increase rates of N and C cycling in coast redwood forests.

16 Stand Structure in Old-Growth Redwood Alluvial Flat Forests of Northern California

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Structural attributes in three alluvial flat old-growth redwood forests were quantified to support the design of restoration prescriptions. All stems ≥ 15 cm dbh were mapped and measured on three 1-ha plots. Dbh, total height, base of the live crown, crown radius, species, canopy class, crown shape, and crown fullness was recorded for each tree. To investigate individual tree complexity each redwood tree was assessed for the presence or absence of burls, reiterations, goose pens, and epicormic sprouting. All snags ≥ 15 cm dbh were mapped and measured for dbh. Down logs ≥ 30 cm in diameter and 2 m in length were mapped and measured at two study sites to determine the volume, mass, and percent cover of large down wood found in these forests. Three 100-m x 4-m North-South transects were established in each plot with the objective of quantifying regeneration and understory vegetation and groundcover.

Results indicated some structural features were common among all three sites and can serve as key targets for restoration. Redwood density ranged from 118-148 trees ha-1 and an upper canopy density of 45-74 trees ha-1. The diameter distributions were right-skewed and broad. Crown ratio was similar across the three study sites with the overall mean of 64.3%. The percentage of canopy gap area ranged from 17-25%. These and other results are discussed in the context of reference conditions for restoration efforts.

17 Comparing Lidar-Generated to Ground-Surveyed Channel Features in a Forested Mountain Stream

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Light Detection and Ranging (LiDAR) holds promise to provide an alternative to traditional ground-based survey methods for stream channel characterization and some change detection purposes, even under challenging landscape conditions. Within six study reach locations along Little Creek, a forested headwater stream on Cal Poly's Swanton Pacific Ranch, fifty three ground-surveyed cross-sectional profiles are compared to LiDAR-generated profiles at the same locations. Airborne LiDAR datasets were collected in 2002, 2008, and 2010, spanning a period of rapid technical improvement. Visual inspection and statistical comparisons between field-surveyed and LiDAR-derived channel features (bankfull depth, bankfull width, bankfull area, and thalweg elevation) show evidence of significant improvement as LiDAR capabilities improve. This improvement is demonstrated in part by the increased ground point density of the LiDAR cross-sectional profiles (1 point per 5.46 meters in 2002, 1.00 meters in the 2008, and 0.49 meters in 2010). The visual and statistical agreement has improved dramatically, but there are still limitations for some change detection purposes. The threshold of change detection possible is dependent on LiDAR sensor and flight specifications, and physical site conditions at the time of the flight. Yet, the level of agreement achieved here suggests there are acceptable applications for LiDAR-generated cross-sectional profiles in hydrologic and geomorphic evaluations, when accuracy limitations are defined.

18 Two Decades of Research and Monitoring of the Northern Spotted Owl: What Do We Know and What Challenges Remain

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Surveys for northern spotted owls were first initiated in 1989 on lands owned by Green Diamond Resource Company (formerly Simpson Timber Company) in coastal northern California. In the following year, a long-term demography and density study was initiated and has continued to the present time. A Habitat Conservation Plan (HCP) was developed for the species in 1992 and numerous habitat studies followed. During the course of these studies, 1068 nests have been located and 1792 owls have been captured and banded, which is the single largest dataset of spotted owls in existence. This extensive dataset was used to estimate the trend in owl numbers, develop resource selection functions for nighttime activity and nesting habitat, and analyses were done to determine the factors influencing spotted owl survival, fecundity and habitat fitness (i.e., ability of the habitat to support a stable population of owls).

Some of the most important conclusions generated to date are as follow: 1) Despite extensive past and current timber harvesting activities, portions of the study area continue to have high densities of spotted owls. 2) Survival of spotted owls

was associated with weather during the early nesting season, quality of the nesting habitat and proximity to spotted owl set-asides. 3) Fecundity was also associated with weather during the early nesting season and proximity to spotted owl set-asides, but it was also influenced by the age of the female, whether or not it had been "taken", proximity to good foraging habitat and the amount of mature stands in the vicinity of the nest site. 4) When the factors associated with survival and fecundity were integrated to estimate habitat fitness, the primary factors were proximity to set-asides, precipitation during the early nesting season, open edge density (i.e., juxtaposition of young and older stands) and "take." 5) A projection of habitat into the future indicated that the highest quality habitat (habitat that has the potential to support an increasing population) will increase dramatically over the next 50 years. 6) The owl population was stable from 1990-2000, but consistent with range-wide trends, spotted owl numbers have declined in recent years despite the projected increase in both the quantity and quality of habitat. 7) The decline in spotted owls coincided with an apparent increase in barred owls and the barred owl covariate was included as a negative coefficient in the top statistical models for both fecundity and survival.

Our current knowledge of the ecology of spotted owls is sufficient to provide a high level of confidence in being able to provide for the future habitat needs of the species on managed lands. However, the invasion of barred owls into northern California creates a very serious threat to the long term persistence of spotted owls. Preliminary results of recently initiated barred owl removal experiments suggest that it should be possible to control the barred owl threat through active management.

19 Genetic Divergence and Potential for Response to Climate Change of Coast Redwood

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The California Floristic Province is one of the world's hotspots of diversity, including a large number of endemic species. This diversity is threatened by the effects of climatic change that are predicted over the next century, effects that are likely to be exacerbated by fragmentation of populations due to urban encroachment and conversion of wild lands to industrial and agricultural production. Assisted movements of plants may be needed in the face of rapid climate change and poor dispersal capability. This will require knowledge of genetic divergence among populations of a species as divergent lineages may carry different allele combinations that will offer variations in future adaptive potential.

We developed a set of nuclear microsatellite markers for the study of genetic diversity in coast redwood (*Sequoia sempervirens [D.Don] Endl.)* and have applied them to a range-wide study of genetic variation among watersheds in this species. The microsatellite loci were highly variable, yielding a total of 142 alleles. Up to six alleles were detected in each individual consistent with the ploidy of coast redwood. Variation within the 17 watersheds sampled, explained most of the genetic diversity, with less than 4% of the variation attributable to watersheds. Our data showed divergence between more or less continuous populations north of 36.8°N (the Sonoma- Mendocino county border) and disjunct populations south of this latitude. We are analyzing chloroplast DNA markers to confirm this lineage divergence in redwood.

We discuss the potential for redwood to adapt to new climatic conditions, or of migrating into displaced habitats with anticipated climate change given the importance of vegetative reproduction over much of its range. Southern populations are likely to be at greatest risk and these appear to form a lineage, or group of lineages distinct from northern populations and should be a priority for conservation.

20 Post-Fire Response of Coast Redwood One Year After the Mendocino Lightning Complex Fires

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Over the past century, timber harvesting, fire suppression, and human encroachment have substantially altered the environmental context where coast redwood (*Sequoia sempervirens*) grows today. A major concern is that increased woody debris, dense forests, and a drier regional climate, will lead to higher fire frequency and/or more catastrophic wildfires. Understanding the relationship between fire-injury and tree mortality has been essential to developing guidelines for salvaging trees in wildfire prone ecosystems. To date, very little research has been conducted on redwood response to wildfire because significant fire events have been uncommon during the fire suppression era. As a result, forest managers and agencies often lack adequate empirical data to develop or evaluate salvage proposals for redwood.

In late June of 2008, a series of lighting storms caused 129 separate fires in what became known as the Mendocino Lightning Complex. These fires burned 22,193 hectares (54,817 acres) of forestland in Mendocino County over a four-week period,

42.3 % of which encompassed a single industrial timberland owner. This unprecedented event provided an opportunity to study the post-fire response of coast redwood on commercial timberlands. Here, we collected fire-injury data on 1024 redwood trees in four separate fire areas three months after the fire, and assessed growth responses one year later.

Logistic regression modeling indicated that percent crown scorch, diameter at breast height, and cambium kill were significant predictors of tree mortality. Although over half the sampled trees had at least 90% of their crowns scorched, only 18.2 % were completely top-killed after one year; and, 87.7% of this mortality was confined to trees less than 20.3 cm (8 in) in diameter. Over 80% of the trees regenerated leaves and shoots from axillary buds, and a similar percentage of both live and top-killed trees resprouted basally.

In this study, redwood exhibited considerable resilience to wildfire even on a landscape where most trees are relatively young. The high observed and predicted survival of most merchantable-sized trees challenges us to better define what characteristics constitute a damaged redwood tree, as using mortality alone may not be an appropriate standard for guiding salvage of this species. Annual monitoring of these fire areas will continue into the future and is necessary to answer long-term questions regarding latent mortality, reduced growth rates, increased pathogen susceptibility, wood quality, and generation time for structures important to wildlife.

21 Clonal and Population Studies in Redwood Using a New Suite of Nuclear Microsatellite Markers

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Coast redwood is unique among conifers in its heavy reliance on natural clonal reproduction. This type of reproduction may lead to the dominance of a relatively small number of clones over a large area and the long-term persistence of these clones in redwood forests. Clonal reproduction benefits plants by allowing them to share resources, reduce their reliance on seeds for reproduction, and produce more offspring quickly in difficult environments. However, heavy reliance on clonal reproduction may also decrease genetic diversity in clonal stands, making it more difficult for clonal communities to adapt to rapidly changing environments, and also making them susceptible to the negative effects of inbreeding depression and genetic drift. Here, we study the spatial patterns of coast redwood clones on three one-hectare plots using six highly variable microsatellite loci. Although previous work has examined clonal patterns at small scales, this study will use more advanced methodology over larger scales to interpret clonal patterns. Understanding spatial patterns of coast redwood clones can give us insight into this species' reproductive ecology and indicate potential for adaptation to climate change. Results will also guide restoration and reforestation treatments that look to natural clonal patterns as a basis for reestablishing redwood clones. Additionally, we hope that the findings of this study will serve as a basis for future work on nutrient sharing between coast redwood clones.

22 Tree Height Estimation in Coastal Redwood/Douglas-Fir Stands in Mendocino County, California

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Height-diameter equations are commonly used to estimate heights from measured diameters in forest inventories. These equations avoid the need for expensive and time-consuming height measurements in forest inventories. They are also used in growth-and-yield modeling applications.

Height-diameter equations are usually species-specific regression equations fitted to empirical data of tree heights and diameters. It is well known that the height-diameter relationship changes over time as stands develop. Although additional explanatory variables such as age and stand structure are potentially significant in explaining the height of trees, species-specific height-diameter equations are widely used. Such equations tend to provide reasonable predictions within the range of data used to generate the equations.

In this study, height equations were developed for coastal redwood/Douglas-fir stands in Mendocino County, California. Equations were developed by species to predict tree height as a function of diameter as well as other factors that are known to potentially explain tree height, including age and stand structure. Different equations were compared and evaluated for explanatory power and practical utility in forest inventory application. We used 50 years of continuous forest inventory data from Jackson Demonstration State Forest, and data from similar lands. This information will be useful in explaining height-diameter relationships in coastal redwood/Douglas-fir stands, and for planning and implementation of forest inventories.

23 Protecting Forests Across Landscapes and Through Generations: The Sonoma County Forest Working Group

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There are approximately 513,000 acres of coniferous forests and oak woodlands in Sonoma County. Most of the oak woodland, and over 68% (132,000 acres) of the coniferous forestland, is controlled in private ownerships of 50 acres or less. These unique forests are found in few other places in the world, and, together, provide a suite of economic benefits, social benefits and ecosystem services. A number of factors, including population growth, regulatory requirements, estate issues and changes in the economy create pressure to convert Sonoma's forests to other uses. In order to address these threats, an ad-hoc committee of forest landowners, local and regional land trusts, watershed councils, and state and local agencies created the Sonoma County Forest Conservation Working Group. The Group is a team with forestry and conservation expertise working to provide information and resources to forest landowners with the goal of protecting, sustaining and improving the health and long-term tenure of forests and woodlands. To date, it has used community workshops, seminars and household meetings to disseminate information, and connect experts, landowners and resource managers to access technical and financial support. Citizens' groups and neighborhood associations now seek the Group's assistance. This presentation will describe the process, the issues and the lessons learned from five years of constructive effort.

24 The Watershed NTMP: A Proposal to Manage the Redwood Ecosystem

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Under present California Forest Practice Rules, Non-industrial Timber Management plans give small landowners the flexibility to operate under a specific set of rules 'forever,' allowing short notice for pre-approved harvest operations. This permit is presently restricted to single forest ownerships less than 2500 acres, and gives forest managers the ability to react to market conditions, and to have certainty for planning over the long term. Reorienting this concept for larger ownerships, with explicitly directed outcomes in terms of wildlife, watershed benefits and carbon sequestration, would improve both environmental outcomes and cost-effectiveness of planning efforts under the California permit process. This is a proposal for watershed-based management plans, in which wildlife management would be explicitly defined for specific species, and carbon managed for maximum retention. Finding the 'sweet spot' that gives environmental advocates trust and landowners incentive will require both specificity and flexibility in inventory, wildlife assessment, carbon standards and modeling. With standards for baseline information and monitoring, a Legislative bill or Board of Forestry initiative could bring about this tool for watershed and timber management.

25 Fog and Soil Weathering as Sources of Nutrients in a California Redwood Forest

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Fog water deposition is thought to influence the ecological function of many coastal ecosystems, including coastal redwood forests. In California, as in many coastal ecosystems, fog presence is distinctly seasonal and its distribution within and among ecosystems is patchy. As a horizontally driven vector, fog interacts with the structure of the landscape and the ecosystem to create spatial patterns of deposition not seen in the more even distribution of vertically delivered rainwater. We examined spatial and temporal patterns of cation and anion inputs from fog and rain, as well as the fate of these inputs, within a Sonoma County, California, coastal redwood forest to elucidate the availability of these ions and some of the biotic and abiotic processes that may influence their relative abundance. At this site, the spatial patterns of water, chemical inputs and the their movement through the soil-plant ecosystem differed between the summer fog and winter rain seasons. Most (98%) of the annual water and approximately 82% of the total ionic load was delivered to the forest during the rain season. While water inputs were relatively uniform across the forest, the mean daily ionic load was nearly two-fold greater at the edge than in the interior of the forest. During the fog season, the spatial pattern of inputs was markedly asymmetrical across the site: the forest edge received approximately five times more water and more than three times the daily ionic load than the forest interior. Spatial variation was driven both by differences in water inputs (fog season) and in ionic concentration of throughfall (both seasons): the interior of the forest received the most concentrated throughfall in the fog season while the

edge throughfall was more concentrated in the rain season. Soil water patterns followed those of throughfall. Water for plant use was most available in the rain season, however, after large fog events (fog season) plant-available soil water was also collected at the forest edge. Differences between soil water and throughfall chemistry were likely to be a function of the mobility of each ion, whether or not an ion was a soil weathering product, and the likely biological demand for the ion. The impact of redwoods as fog catchers, transformers, and redistributors of both water and chemistry may extend all the way into the soil profile: in our plots, soil organic matter content was higher and organic-rich horizons thicker at the forest edge than in the forest interior. Thus, our data suggest that although total fog water inputs were small compared to inputs from rain, fog carried nearly one fifth of the total ionic inputs—inputs that, presumably, continued to be biologically available until their loss during the rain season. Cross-seasonal, functional coupling of above (canopy) and belowground (soil) processes are likely to be prevalent in this and other fog-inundated redwood forests.

26 Erosion at Decommissioned Road-Stream Crossings: Case Studies from Two Northern California Watersheds

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Post-treatment erosion was observed for 41 decommissioned road stream crossings in two northern California watersheds. Sites were purposefully selected in order to characterize the nature and range of post-treatment erosional responses. Sites with the highest visible erosion were selected in order to better understand the dominant process and incorporate any lessons learned into future projects. Sites were also intentionally selected where post-treatment erosion appeared to be negligible, or excavation techniques were judged be have been fully effective at removing erodible material. In these cases, our objectives and methods remained identical, but we wanted to examine the conditions that led to the apparent negligible erosion.

Results are consistent with other findings in the region. Erosion volumes ranged from 1.5 m^3 to 60m^3, or, 0.1% to 4.5% of the initial volume excavated during treatment. Erosion averaged 11m^3 per site or 0.4% of excavated volume in the Headwaters Forest Reserve and 21m^3 per site or 2.4% of excavated volume in Lacks Creek. Repeat monitoring of a sub-set of sites in the Headwaters Forest Reserve over subsequent years, indicates that 99% of post-treatment erosion occurs in the first year following treatment. Channel incision is the dominant process of sediment production from treated sites, accounting for 80% of observed erosion. In response, woody debris has been incorporated into recently excavated crossings with the intent of providing armor and roughness elements to reduce channel incision. At those sites where post-treatment erosion is apparently minimal, incision remains the dominant process of sediment generation and can exceed 20m^3. In some cases, excavation techniques were judged to be largely effective at removing erodible material, however, interstitial material stored between larger, more immobile clasts can produce surprisingly large erosion volumes as this material is winnowed away during higher flows.

27 How Do We Know How Many Salmon Returned to Spawn? Implementing the California Coastal Salmonid Monitoring Plan in Mendocino County, California

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California's coastal salmon and steelhead populations are listed under the California Endangered Species Act and Federal Endangered Species Act. Both listings require recovery plans and monitoring to provide measures of recovery. Since 2004 the California Department of Fish and Game and NOAA Fisheries have been working to develop a plan for monitoring California's coastal salmonid populations (the California Coastal Salmonid Monitoring Plan- CMP). This plan outlines a strategy to monitor salmonid populations status and trends at evolutionarily significant regional spatial scales, while still providing population level estimates. For the CMP, data to evaluate adult population status are collected in a rotating panel design using a spatially balanced probabilistic (e.g. Generalized Random Tesselation Stratified- GRTS) design. Under this scheme a two-stage approach is used to estimate regional population status. Regional redd surveys (stage 1) are conducted in stream reaches in a GRTS sampling design at a survey level of 15% or $\geq$ 41 reaches, which ever results in fewer reaches, of available habitat each year. Spawner: redd ratios, derived from smaller scale census watersheds (stage 2) where "true" escapement is estimated using capture-recapture methods, are used to estimate regional escapement from expanded redd counts. Beginning in 2008-09 we applied the results of our previous pilot studies to estimate salmonid escapement for the Mendocino coast region, the first implementation of the CMP in the state. Here we present the results of the first two years of this monitoring effort and discuss our findings in context of expanding the CMP to all of coastal California. We discuss sample frame development, sample size, and present escapement data for six independent and eight potentially independent populations and two Diversity Strata within the Central California Coho Salmon Evolutionarily Significant Unit.

28 California's Coast Redwood in New Zealand

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New Zealanders are making a significant effort to develop their forest industry to benefit from rapid growth exhibited by *Sequoia sempervirens* on both the North Island and South Island. US and New Zealand forest products companies have established redwood plantations in the past decade, and have found that microclimate, site preparation, soil chemistry, fertilization and precise silvicultural practices are all of utmost importance. Farm foresters have established experimental redwood tree crops alongside Pinus radiata and many other western US and NZ native species. The NZ Farm Forestry Association Redwood Working Group has 40+ experimental growth monitoring plots scattered around the country. Nursery producers are testing several California redwood clones that have shown exceptional promise. Researchers have been monitoring plantations of these and other clones here in California and in New Zealand. Genetic traits such as wood density, growth rates, and knot size are known to affect final product quality. Tree growers recognize the importance of investment in improved growing stock. While New Zealand plans to develop domestic and Australian markets for redwood products, consumer acceptance, currency exchange rates, shipping costs to distant and competitive international forest products markets are also of great concern to southern hemisphere producers.

29 Management Practices Related to the Restoration of Old Forest Characteristics in Coast Redwood Forests

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Historic and contemporary forestry practices have simplified the structural components of coast redwood forests. Recruiting the structural elements commonly found in older forests is recognized as an important management objective in younger forest stands to address issues of biological diversity and forest integrity. Obviously, old forest features are a function of time; as such they often include stand characteristics not associated with younger stands. Old forest characteristics are often the result of chaotic events e.g. storms, fire, and landslides whose legacies shape forest structure and composition and which may be difficult to mimic.

There exists a limited knowledge base regarding the structure and composition of older forests from which to make sound management decisions. This has lead to the reliance on data sources from other forests in the Pacific Northwest to help guide management decisions across the redwood region. Much of the scientific inquiry investigating the characteristics of redwood forests is relatively new and promises to provide useful and enlightening information in the years to come. Even so, it will be helpful to review our current knowledge base regarding the role and function of structure and composition of coastal redwood forests.

This project was designed to "identify and articulate the applied knowledge that exists from practitioners who have experience with silvicultural operations that might affect forest restoration efforts." Knowledgeable individuals who are widely recognized by their peers who have demonstrated an ability to successfully recruit old forest characteristics into their managed stands were surveyed with standardized questions throughout the range of coast redwoods. The results of those interviews are included.

30 A Chronosequence of Vegetation Change Following Timber Harvest in Naturally Recovering Coast Redwoods

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The management of second-growth coast redwood (*Sequoia sempervirens*) forests for the purpose of restoration and ecological conservation is a growing trend. However, little is known about the long-term regenerative potential of this forest type in the absence of post-harvest management techniques such as thinning and planting. Data were collected on a chronosequence of second-growth sites (18 to 127 years) and three old-growth reference sites in order to estimate changes in stand structure and composition over time. A total of 360 plots on 18 sites with minimal post-harvest treatment were sampled in the central range of the coast redwood forest in California in order to compare stand conditions between post-harvest age groups.

One-way ANOVA with Bonferroni post-hoc analyses indicated that stand density, canopy cover, and species richness approached old-growth conditions within 40-80 years. Total basal area and the mean maximum diameter of *S. sempervirens* stems continued to increase up to 127 years. Cover of non-native species declined with stand age to the extent that no non-native species were recorded in stands older than 60 years. The cover of old-growth associated understory species was highest on the oldest second-growth stands and in some cases reached levels statistically equivalent to the old-growth

references sites between 40-100 years. Results suggest that coast redwood forests are highly resilient to human disturbance and will recover naturally over time in the absence of post harvest management.

31 Ecology and Management of Martes on Private Timberlands in North Coastal California

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Green Diamond Resource Company (GDRCo) has conducted periodic studies of fisher (*Martes pennanti*) on its California timberlands since the mid-1990's. A graduate study in 1994-1995 used track plates to investigate the distribution and habitat associations of fishers. In 2002-2003, another graduate study used mark-resight techniques to estimate density of fishers on two 100 km2 study sites on the ownership. In addition, one in-house telemetry study was conducted to identify specific habitat elements important to the species for resting and denning behavior. One decade after the initial survey, a second repeated track plate survey was conducted to monitor potential changes in the distribution and abundance of fisher across the study area. Collectively, these studies facilitated refinement of green tree retention standards applied in timber harvest plans and development of an occupancy model for predicting future habitat for fisher in a managed forest landscape.

The repeated track plate surveys conducted a decade after the initial effort revealed the presence of marten (*Martes caurina*) west of a recently discovered population of the species. In 2004, Marten were detected at two stations within two track plate segments. An impromptu survey effort in 2006 to investigate a potential regional decline in fisher numbers again confirmed the presence of marten in the same area and a potential expansion of the occupied area. Martens were detected at nine stations within three track plate segments. The proportion of fisher detections at track plate stations was lowest in 2004, but the proportion of fisher detections increased in 2006.

The detection of marten in Prairie Creek State Park in 2009-2010, about six miles west of the 2004-2006 detections on GDRCo, prompted additional surveys on GDRCo lands in 2010-2011. Beginning in October 2010, we deployed an array of remote cameras in northern Humboldt and southern Del Norte counties to assess presence of fisher and marten within a select area of the ownership. To date, fishers were detected at 47% of camera stations with one complete survey and no martens were detected. The results of additional pending surveys will be presented.

Our studies indicate that fishers appear to be compatible with current forest management strategies in coastal redwood forests, and they are likely to occupy this landscape into the future. However, our current knowledge of the marten in this area is very limited, and basing forest management decisions on habitat associations from public lands may not be appropriate or even realistic given the abundance of fishers on the managed landscape.

32 Large Woody Debris Budgets in the Caspar Creek Experimental Watersheds

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An important aspect of sustainable forest management is maintaining adequate levels and types of Large Woody Debris (LWD) in stream channels. Because LWD inputs are often episodic and pieces can persist for decades in the channel, an LWD budgeting approach can be used to estimate long-term effects of management activities, but such budgets are limited by the reliability of the estimates used for inputs, survival, and outputs. Monitoring of LWD in the mainstem channels of the two Caspar Creek experimental watersheds since 1998, combined with older data from other work on the watersheds, gives estimates of these parameters in intermediate-sized channels in coastal redwood forests and factors affecting them.

Input rates from standing trees from 1995-2010 show the combined effects of episodic events and stand history. A series of windstorms in 1995 caused very high input rates in the North Fork, mostly from buffer strips adjacent to 1989-92 clearcut stands, while those same storms had no obvious effect in the smaller, younger stands in the South Fork, which had been selectively logged in the 1970s. Rates in the North Fork decreased rapidly though the 1990's, then gradually increased as new fir snags began contributing wood. Snag inputs also increased in the South Fork, both from fir snags and from recently-dead riparian alders. Riparian alders are not present in the North Fork.

Detailed LWD budgets for these channels from 1998-2008 show a strong contrast in total volumes in all categories between the two channels, partially due to the post-logging inputs in the North Fork. They also show significant volumes going into and coming out from "storage" – down pieces on hillslopes, floodplains, banks, or buried in the bed, that are not currently available to the channel. Some of the largest of these pieces are legacy wood--old-growth redwood stumps, chunks, and rootwads. Legacy wood is significant in both channels but particularly important in the South Fork, where it makes up more than 40% of the total volume in or adjacent to the channel.

Calculation of piece survival in these channels is not straightforward. In addition to "stored" pieces, which might or might not be considered still present, whether a piece moved was also not obvious. Due to the length of the study reaches (~1.8 km) very few pieces moved entirely out of the reaches. Pieces that moved within the reaches often moved very short distances, rotating out of the flow or gradually sliding down the bank so, for instance, a piece that was originally well above the active channel is now interacting with high flows. Pieces also frequently broke without moving, or broke partway through, or broke and only one part moved, none of which are unambiguously categorized into "moved" or "not moved." We redescribed any piece that had noticeably changed dimensions or position in the channel, and recorded distance moved for all moved pieces, so we are able to look at stability using a variety of definitions. Using a very strict definition, that is, pieces that never significantly changed position or size, approximately 40-50% of the pieces present in each fork in 1998 were unchanged in 2008.

33 Carbon Storage in Young Growth Coast Redwood Stands

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Carbon sequestration is an emerging forest management objective within California and around the world. With the passage of California's Global Warming Solutions Act (AB32) our need to understand the dynamics of carbon sequestration and to accurately measure carbon storage has become paramount to the successful implementation of carbon credit projects throughout the State. As the leader in forest carbon credit projects within the US, California's forest carbon protocols are being looked to as templates for successful carbon credit accounting. Coast redwood stands have the largest measured biomass per acre making the argument for use of the species in long-term carbon sequestration projects self evident. To date no direct measurement of both carbon fraction and specific gravity of coast redwood has been undertaken. With this study we tested the applicability of the current forest carbon project protocols set out by the Climate Action Reserve for forest carbon credit projects within California. Specifically we tested the applicability of a carbon fraction of 0.5 and a greenwood specific gravity of 0.34 for coast redwood tree boles. Our main findings were that: 1) a species-average of 0.34 significantly underestimated the specific gravity of the measured trees, 2) specific gravity varied predictably with tree height and wood type, 3) carbon fraction was significantly higher than the default 0.5 fraction, and 4) carbon fraction varied predictably in relation to wood type. Our results indicate that a simple approach to estimating carbon storage utilizing a carbon fraction of 0.5 and a species-average specific gravity fails to accurately predict carbon in young growth redwood stands across all stand structures. Given the regional nature of carbon credit projects our results indicate that forest project protocols should be adjusted to allow for calculations that incorporate directly measured specific gravity and carbon fraction values within the forest carbon project area.

34 Sediment Production in a Coastal Watershed: Land Use, Legacy, Recovery, and Rehabilitation

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Sediment production has been measured for nearly half a century at the Caspar Creek Experimental Watersheds. Over a 20-year period of rapidly evolving forest management practices, the second-growth redwood and Douglas-fir forest of this coastal basin was selectively tractor-logged (South Fork, 424 ha, 1971-73) and partially cable clear-cut (North Fork, 473 ha, 1989-92). New roads were constructed in both watersheds in conjunction with timber harvest. A main-haul riparian road was built in South Fork four years prior to harvest and decommissioned in 1998, 25 years post-harvest. These varied land use treatments influence hydrologic processes, recovery time-frames, and restoration responses. Examination of this long-term sediment record provides a useful insight to the relative magnitudes and durations of sediment production from these management practices.

In the South Fork, pre-Forest Practice Act road construction and logging roughly doubled sediment production, with a return to pre-treatment levels about 11 years after harvest ended. However, sediment production again increased in the 1990's as roads and skid trails deteriorated. Road crossings decommissioned in 1998 eroded a volume equivalent to 57% of the total annual yield in 1999 and 29% of the average annual yield for the three years following. A 2011 re-assessment of these stream crossings showed some subsequent incision at about half the sites while many have stabilized and fully revegetated. About 20% of the total erosion from these sites occurred in the last decade. Recent assessment of 1970's era roads and skid trails in the South Fork found 443 remaining stream and swale crossings. Most have experienced partial failure with at-risk volumes estimated to be minimal (6 m^3ha^{-1}). About 10% of stream crossings are active diversions while nearly one in three are potential diversions. Ongoing erosion inventories indicate that diversions along entrenched roads and skid trails contribute to fill-slope saturation and failure although these episodic inputs appear to have declined since the 1990's. South Fork tributary loads are elevated relative to North Fork controls, suggesting that untreated legacy sediment sources are still active. Mainstem loads on the South Fork are elevated relative to tributary gages located above the decommissioned main-haul riparian road indicating that sediment yields at the weir are enhanced along the mainstem itself—especially during larger

peakflows when stored sediments are remobilized. During the last 15 years, South Fork turbidities exceed ecosystem thresholds of concern 50% more frequently than North Fork.

Results indicate that erosion persists decades after tractor-logging. Forest managers need to consider this legacy effect and hydrologic change when planning future harvests and prescribing watershed rehabilitation treatments designed to restore natural drainage and hydrologic function.

35 Declining Sediment Loads from Redwood Creek and the Klamath River, North Coastal California

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River basin sediment loads are affected by several factors, with climate and watershed erosional stability playing dominant and dynamic roles. Long term average sediment loads for northern California river basins have been computed by several researchers by several methods. However, characterizing the dynamic nature of climate and watershed stability requires computation of annual loads. We assembled previously computed annual loads available for portions of the record and computed loads for other years for both Redwood Creek and the Klamath River. Results show high sediment loads coincident with a period of accelerated logging by destructive practices and large storms in the 1950s though 1970s followed by a decline in sediment loads through the present. Analyses of annual departures from normal and sediment distribution residuals indicate the decline in loads is not due solely to the lack of very large storms. We infer it can also be explained by the partial recovery of watershed erosional stability from the 1980s though the present due to reduced logging rate, use of lower impact logging practices, and implementation of treatment programs for reducing erosional threats from logging roads.

36 A Permeability Study on Salmonid Spawning Areas in Northern Humboldt County, California

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Increased fine sediment levels in rivers and streams are a concern for many land managers due to possible detrimental effects on salmonids. Investigations have been conducted using various methods such as bulk sampling, freeze core and permeability to assess the condition of spawning gravel. Permeability, the parameter used in this investigation, is defined as the rate of flow through the substrate. Increased permeability allows for a greater rate of delivery of oxygenated water to developing salmonid embryos and alevins which has been shown to produce higher rates of survival to emergence. When gravel is impacted with fine sediment, presumably decreasing permeability, the delivery of oxygen and the removal of waste are impeded.

This research was conducted to determine if local salmonid, specifically coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*O. tshawytscha*, and the steelhead trout (*O. mykiss*), redd location is dependent upon the permeability of the streambed. The study took place in four coastal drainages in northern Humboldt County, California. Sampling occurred over a sixteen month period from June 2004 – October 2005. This period covered pre and post spawning conditions, as well as changes in seasonal flow conditions. Surveys were conducted to determine if permeability affected redd placement, or if redd placement affected permeability. Sampling grids, with points spaced generally every 1.2 meters, were established at each site to allow for repeatable permeability measurements. The number of measurements taken ranged from 37 to 105, depending on site and wetted width of the channel. Permeability measurements were taken using a battery operated pump to draw water through a perforated standpipe driven into the streambed at a depth of approximately 25 cm.

Study results showed that permeability was not significant in predicting redd location. In addition, results showed that permeability measurements varied in orders of magnitude within as little as 30 cm. Graphic representations of the spawning areas were created using GIS and clearly display the heterogeneity of the streambed. The results of this study support the need for further investigation of sampling methods that will be able to accurately assess the condition of spawning gravel with consideration of extreme spatial variation while providing minimal disturbance to the streambed. Although the monitoring of permeability rates can be an indicator of general bed conditions in a specific location, results do not indicate that individual rates or even average permeability values from specific sites can be used to characterize spawning gravel conditions for entire watersheds or even smaller stream reaches.

37 Prioritizing Treatment of Second-Growth Forests Using Lidar

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We used multi-return light detecting and ranging (LiDAR) to develop a cost-effective method for describing forest conditions and prioritizing stand treatment in over 14,000 hectares of second-growth forests (7-80 years old) in Del Norte Coast Redwoods State Park (DNCRSP). DNCRSP consists primarily of redwood and Douglas-fir dominated forests with scattered tanoak dominated stands. Analysis of old growth forests within the data acquisition area is ongoing.

We implemented a stratified sampling design to establish plots throughout the range of age classes and vegetation types within the property in 2009. A key step to building a model to predict forest metrics with LiDAR was to ensure that each fixed-radius ground plot was accurately represented by an extracted plot LiDAR point cloud cylinder. To accomplish this, we attempted to obtain sub-meter accuracy for all ground plot centers. We also established plots in locations that appeared to be relatively uniform so that any LiDAR point cloud cylinder extracted within two meters of the actual plot center would be similar.

We used Forest Vegetation Simulator (FVS) software to calculate current plot conditions and account for 2-3 years of growth, corresponding to the number of growing seasons between the LiDAR flight in 2007 and the plot installation in 2009. Relative change in basal area could then be used to back-calculate metrics for each plot at the time of the flight.

We developed descriptive statistics of the cylinders of normalized LiDAR data for each extracted plot using the USFS Fusion/LTK tools. We paired observed stand conditions and the statistical descriptions of the LiDAR data within each plot to create 3-4 parameter multivariate regression relationships for each metric. To date, we have developed models for four metrics: basal area ($R2 = 0.89$), quadratic mean diameter ($R2 = 0.90$), stand density index (SDI) ($R2 = 0.80$), and tree density ($R2 < 0.50$). We obtained an R2 for tree density of 0.79 when we focused on younger stands (where P95>16.11m). A similar result for tree density of all stands is expected soon.

We calculated stand-level forest metrics using our regression models, then ranked stands independently based on both their SDI and the coefficient of variation of the canopy height model (CV of CHM). We chose CV of CHM as a ranking factor because it is an indication of the variation in tree heights within a stand and therefore useful in ranking a stand's ability to differentiate. The use of CV of CHM was also useful for identifying stands that were not even aged and therefore SDI is an inappropriate tool for prioritization. We then combined rankings to identify stands in greatest need of thinning to improve growth rates of dominant trees and to prevent stagnation. Stands will similarly be ranked by tree density once an adequate tree model is developed. California State Parks adopted this method to prioritize stands for forest restoration treatments but the methodology could be adopted for other objectives, such as thinning and harvesting schedules, habitat delineation or general inventories.

38 Foliar Uptake of Fog in the Coast Redwood Ecosystem: A Novel Drought-Alleviation Strategy Shared by Most Redwood Forest Plants

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Marine fog is a defining feature of the summertime climate of coastal California where the coast redwood forest ecosystem occurs. While fog provides critical water to this ecosystem when rainfall is largely absent, it is poorly understood how plants acquire fog water as a resource and if fog alleviates plant water deficit during the driest time of year.

We investigated (1) how many species in the redwood forest acquire fog directly by foliar water uptake, (2) how foliar fog uptake influences the water balance of the dominant understory fern *Polystichum munitum*, (3) how geographical variation in *P. munitum* canopy cover and foliar uptake capacity affects fog drip interception along the redwood forest range, and (4) how fog influences the seasonal timing and intensity of drought stress for understory plants. For these studies we evaluated aspects of plant water relations among redwood forest species in the field and after artificial fog exposure in the glasshouse with particular emphasis on *P. munitum*.

First, we found that 80% of dominant species investigated exhibit foliar fog uptake and become more hydrated following fog exposure. Second, we found that foliar fog uptake by *P. munitum* increases plant water status (water potential and content) above the soil water status. Third, we found that *P. munitum* canopy cover increases towards the northern end of the redwood forest ecosystem, but foliar uptake capacity is highest in the center of the range. This indicates that little fog drip interception and absorption can occur in southern forests where *P. munitum* leaf area and water absorption capacity is lower. Fourth, we found that fog eliminates drought stress in both tree saplings and ferns during the summer growing season when leaf wetting frequently occurs.

Together, these findings demonstrate that redwood forest species readily acquire fog water directly through their leaves and thereby become hydrated even when soil water availability is low. With less fog exposure during the summer dry season, water limitation could reduce the growth potential and even survival of redwood forest plants in the future.

39 The VTAC Committee: Developing Guidance for an Alterative Regulatory Pathway to the Anadromous Salmonid Protection Rules

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In recent decades, riparian protection standards have been guided by generalized prescriptive rules. With the passage of the Anadromous Salmonid Protection rules in 2009, the Board of Forestry and Fire Protection (Board) established a regulatory pathway that provides an alternative approach for riparian protection based on site-specific criteria (14 CCR § 916.9 [936.9, 956.9](v)). This new pathway seeks to promote more immediate (short-term) responses to active riparian management practices that might not otherwise occur under the more prescriptive rule protocols. This approach requires consideration of both watershed-scale limiting factors (i.e., context assessment) and site-based factors to lead to a modified riparian management design that provides benefits to the aquatic environment. It is the Board's intent that allowing site-specific plans will create an economic incentive for landowners to engage in active management and restoration activities in riparian areas.

The implementation of this new approach is being overseen by the Anadromous Salmonid Protection Rule Section V Technical Advisory Committee (VTAC), composed of members from academia, the timber industry, professional consulting firms, and the public. The California Department of Forestry and Fire Protection (CAL FIRE) appointed this committee in October 2010. The VTAC is seeking to establish principles, guidelines, and procedures to guide landowners in the use of this new rule section. The VTAC is focusing on: (a) broadening incentives, and (b) developing permitting efficiencies that properly balance the risks of negative impacts with the potential benefits to listed salmonid species. In short, one goal of the VTAC is to reduce the regulatory barriers that might otherwise prevent landowners from engaging in active management and restorative actions in riparian areas.

The VTAC will use multiple pilot projects identified by landowners in both the Coast Ranges of California and the interior part of the state to demonstrate active riparian management, with potential implementation in 2011. These pilot projects include a range of desired objectives, including increasing large wood loading, promoting increased biotic diversity, reducing catastrophic wildfire risk, and accelerating conifer tree growth. A report on the progress of the pilot projects and an implementation guidance document that will allow for broad application of the site-specific approach for riparian management will be presented to the Board in the second half of 2011. The final VTAC report is expected to be completed by July 2012.

40 Assessing Effects of Changing Land Use on Sediment Loads in Panther Creek, North Coastal California

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Revisions to the California Forest Practice Rules since 1983 were intended to increase protection of water quality in streams draining timber harvest areas. Protective measures included more extensive use of riparian buffers, where timber harvest operations are limited, and improved road standards for newly constructed and upgraded roads.

Panther Creek drains a 15.4 km2 watershed in Humboldt County, north coastal California, and is a tributary of Redwood Creek. Timber harvest and associated road building have been the primary land uses since early in the 20th century. We evaluated the effects of timber harvest and road use intensity and improved road designs and maintenance on sediment loading in Panther Creek by computing land use statistics, analyzing suspended sediment discharge rating curves through time, and comparing sediment yields in Panther Creek to two control (unlogged) streams, Little Lost Man and Prairie creeks. A gaging station at the mouth of Panther Creek has operated from 1980 to the present. From 1978 to 2008, 8.2 km2 (over half the watershed) was clearcut and other timber management activities (thinning, selection cuts, etc.) affected an additional 5.9 km2. Road density is 4.2 km/km2. Since 1984, 33.5 km of streams in harvest units received riparian buffer strip protection. Since 2000, 22 km of roads were upgraded and 9.7 km were decommissioned, reducing potential sediment production by 37,500 m3.

Although we could not detect a clear signal among improved road conditions, timber harvest rates, and annual sediment yields, some general trends over the period of record are evident. A large storm in 1997 initiated several landslides throughout the Redwood Creek basin, including a road-associated debris torrent that delivered about 7,700 m3 to Panther Creek. Sediment yields at the gaging station were elevated for several years after this event. Sediment rating curves from 2001 to the present indicate a decrease in suspended sediment concentrations when compared to the pre-1996 period. Panther

Creek still has a higher sediment yield on a per unit area basis than the control streams, but the ratio of sediment yields to control streams is much lower in recent years than in 1997.

Assessing the influence of land use changes and hillslope improvement work on sediment loads is complicated by factors such as the lag time between implementing erosion control work and sediment transport events, the effect of legacy features from past timber harvest, the exact timing of ground disturbance related to recent timber harvest activities, and the occurrence of extreme events. Continued stream monitoring coupled with hillslope monitoring would help elucidate such linkages.

41 Fine Sediment Sources of Coastal Watersheds with Marine Uplifted Terraces

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Erosion and sedimentation related to roads in mountainous areas have long been a concern for land managers and those charged with protecting the soil, the water and the streams. Erosion in the Mill and Luffenholtz Creek watersheds, near Trinidad California, with their extensive clay soils, can lead to high turbidity levels in receiving bodies of water. These eroded clays once suspended in flowing water can increase the costs of treating water for these domestic water supplies. Furthermore a health hazard can result from the creation of dangerous bi-products, such as chloro-tri-halmethanes, during the treatment process.

There were several reasons for studying turbidity in these creeks including the use of these creeks for domestic water supplies and the existence of endangered species of fish. There is also the fact that the receiving waters of Trinidad Bay have been designated an Area of Special Biological Significance (ASBS), as well as a Critical Coastal Area (CCA), and lastly because the local residents were interested in identifying sediment sources and implementing practices to remedy these problem areas.

Detailed road and erosion surveys and monitoring of suspended sediment, discharge, and turbidity levels in Mill Creek (3.11 kilometers2) and Luffenholtz Creek (12.95 kilometers2) were completed to determine the sources of turbidity. Turbidity was related to land use, forest road density, road surfacing and use, timber harvest practices and intensities, geology, fire history, and gradients.

Two continuous turbidity and stage monitoring stations in lower Mill and Luffenholtz Creek were maintained along with 8 grab sample locations. Watershed physiographic and land use characteristics were compared for those basin areas upstream from the eight monitoring.

The Luffenholtz Creek watershed, particularly the North Fork and the main stem of Luffenholtz, just below the 21 Rock Quarry, were the watershed and sub-watershed areas with the highest turbidities. They were also the watershed and sub-watershed areas with the highest density of roads, the most miles of roads adjacent to streams, and the highest concentration of identified erosion prone sites. A Wilcoxon"s Rank-Sum analysis showed that Luffenholtz Creek and its North Fork were significantly more turbid than Mill Creek, and the collection site below the "21 Rock Quarry was significantly more turbid than the site above the 21 quarry. Total loads for a three-storm period of 23 days in early May of 2009, representing 3 of 8 major storms for the year, were approximately 21 metric tons for Luffenholtz Creek and 0.02 metric tons for Mill Creek.

Mill Creek was the watershed with the highest rate of timber harvesting over the past ten years, the steepest profile, and a history of more extensive fires, and yet its turbidities were consistently lower than Luffenholtz Creek. The sediment was coming from roads. Cooperative efforts are now underway with the local watershed council, local contractors, and Green Diamond Resource Company, and other local landowners to resolve these erosion problems in both watersheds. This cooperative effort will help reduce turbidity in these sensitive watersheds.

42 The Effects of Sudden Oak Death and Wildfire on Forest Composition and Dynamics in the Big Sur Ecore

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Sudden oak death (SOD), caused by *Phytophthora ramorum*, is an emerging forest disease associated with extensive tree mortality in coastal California forests. *P. ramorum* is a generalist pathogen that infects many hosts, but hosts differ in their ability to transmit the disease and in the impacts caused by the disease. In coast redwood forests, tanoak (*Notholithocarpus densiflorus*) is the main host dying from SOD and the main source of pathogen innoculum. SOD leads to compositional changes in these habitats through selective mortality of tanoak. Elevated mortality may lead to increased fuel loads in these forests, leading to the potential for SOD to interact with wildfire severity. We hypothesize that long-term forest composition will depend on the joint and interacting effects of these disturbances.

We established a network of 280 monitoring plots throughout the Big Sur ecoregion in coastal California in 2006-07 to examine the impacts of SOD on forest dynamics. Two wildfires in 2008 burned over a third of this network, providing the opportunity to compare forest dynamics in uninfested and infested areas, both within and outside the burned areas, using pre-fire data on fuel availability and disease impacts and post-fire data burn severity and tree mortality. During plot establishment, we measured all live and dead standing woody biomass and estimated large, downed woody debris. We conducted a survey of burn severity in 2008, and surveyed for tree mortality in 2009. We began long-term monitoring of forest recovery and regeneration in 2010.

Burn severity did not vary according to pathogen presence along, but rather with the abundance and type of fuels that occur at different stages of the disease progression. Mortality was significantly higher in burned areas than unburned areas, regardless of the presence/absence of SOD. Fire-caused mortality also varied greatly between canker host species (which die from the disease) and non-host or foliar host species (which do not have lethal infections). Species composition varied according to the time since establishment of the disease and whether the plot burned in 2008. These changes in composition and in forest regeneration may lead to long-lasting impacts to forest diversity, dynamics, and structure in areas impacted by SOD in these fire-prone systems.

43 Accounting for Variation in Root Density and Percent Carbon Increases Accuracy of Belowground Carbon Estimates

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Little is known about belowground biomass and carbon in tanoak. The acquisition of accurate estimates of belowground biomass usually requires destructive root system sampling, a laborious process unfavorable for landowners.

Tanoaks (*Lithocarpus densiflorus*) provide a valuable resource to wildlife, yet their ability to sprout and dominate a stand after disturbance renders them problematic to foresters. Although tanoaks rarely provide merchantable wood, an assessment of belowground carbon loss due to tanoak removal and Sudden Oak Death will yield valuable information to future tanoak and redwood ecosystem conservation.

We present efficient methods for root sample extraction, processing, and measurements. This information will help other researchers new to belowground research with planning, budgeting, and implementing research programs in the region.

Traditional carbon analysis generally assumes a standard calculation of 50% of the dry biomass, and data collection fails to consider the proportion of carbon at different locations in the root system. Understanding whether wood density and carbon content changes along the length of a root will provide more accurate estimates of belowground carbon provided easily measurable aboveground variables such as dbh.

To understand the relationship between root density and carbon content, tanoak trees were first removed using an excavator. Root wood samples were taken from four locations within the root system. We used a corer to collect samples of known volume within the lignotuber and aboveground stump and measured the wood density and carbon content of the cores. We also accounted for carbon content at the start of the root (adjacent to the lignotuber), halfway along the length of the root, and at the end of the root (near tip). These last three measurements were collected by analyzing carbon content within a subsample of the roots with known volume and dry weight.

The carbon content of each sample provided information about carbon density at increasing distance from the lignotuber. We found that root wood density does not change with size or distance from the stem. Percent carbon was highest at the sample farthest from the lignotuber, while samples from the other locations were not statistically different. Root carbon also varied among root systems sampled. Because this data is contrary to many aboveground studies, it is not safe to assume that above- and belowground components allocate C in the same way.

44 Land Surface Phenology as a Coarse-Filter Indicator of Disturbance and Climatic Effects Across the Coast Redwood Range

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Satellite-based measurements provide a systematic measure of the seasonal fluctuations and general condition of forest vegetation, including that of the coast redwood region. Year-to-year variation in greenness may be caused by gradual disturbances, successional recovery or climatic variation, while within-year variation reflects disturbance events and the response of vegetation types to seasonal change. Here we show how the inter- and intra-year condition of coast redwood vegetation is captured by the Normalized Difference Vegetation Index (NDVI) using a MODIS-based vegetation change

model developed as part of the US Forest Service's Threat Assessment Centers' Early Warning System. Results show how the land surface phenology of old growth and second growth forests of Humboldt, Mendocino, Santa Cruz and Monterey Counties in California changed before and after wildfire. Following the September-October 2003 Canoe Fire in Humboldt Redwoods State Park, the productivity of second growth forests, as measured by NDVI, inverted from being higher to being lower than old growth. The early summer 2008 wildfires in Mendocino County did not cause this reversal, presumably because fire effects in second growth were less severe. The August 2009 Lockheed Fire in Santa Cruz County experienced a sharp drop in second growth productivity, as did the early season 2008 wildfires in Monterey County. As a coarse-filter monitoring tool, this NDVI time series product from the Early Warning System reflects this variation across vegetation types caused by climate and disturbances for the entire conterminous United States.

45 Basal Cavities as an Indicator of Mortality Risk and Past Fire Regimes in Coast Redwood Forests

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Fire was an important component of old growth development in most coast redwood forests, yet the frequency, severity and origin of wildfires varied greatly in space and time. Fire use is hampered by uncertainties about the variable historical importance of fire, but more often by uncertainties about how restoring fire might lead to undesired consequences. In particular, managers want to know how fire will affect large, centuries-old trees and the long-term consequences for structural and compositional diversity.

A century ago, observers noted how even low severity fires led to the collapse of numerous large old redwood. This is consistent with observations made during some recent fire events after a long period of fire exclusion. While such fire-induced mortality of a small percentage of mature trees might not alter the long-term age structure of an old growth stand's population, the sudden death of these high-value trees may be inconsistent with wildlife, aesthetic and other management objectives. Knowing the specific mechanisms that put old trees at risk can inform manager's decisions of where, when and how to burn, and could lead to mitigation strategies.

Analysis of redwood cross sections collected for historical fire regime analysis reveals how cavities form according to an intricate process of scarring, decay and healing. Scar healing rates and decay depend on scar attributes, and these are regulated by local fire severity. If repeated fires burn prior to healover, a cavity can be formed. Surveys of fire-generated cavities in old growth trees and stumps from across the northern coast redwood range suggest how environmental factors and tree age further regulate cavity formation. Mortality from the burnout of basal cavities, varies in response to these cross-scale factors. This research presents an integrated probabilistic model of tree mortality that includes the effects of variable fire history over the lifespan of trees, site factors and the different effects of fire severity related to differences in seasonal fire weather.

46 Sediment Yield in the Gualala River-Comparison of Sediment Budget Techniques and Suspended Sediment

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Many watersheds in the Northern California Coast Range have been designated as "impaired" with respect to water quality because of excessive sediment loads that negatively affect beneficial uses of water, including instream habitat for anadromous fish. Sediment budget techniques have been used to estimate current sediment delivery rates to streams and to develop quantitative goals for acceptable levels of management-induced erosion. This study examines erosion rates estimated by various methods for portions of the Gualala River watershed, designated as having water quality impaired by sediment under provisions of the Clean Water Act Section 303(d), located in northwest Sonoma County. The watershed is underlain by Jurassic age sedimentary and meta-sedimentary rocks of the Franciscan formation. The San Andreas Fault passes through the western edge of watershed, and other active faults are present. A substantial portion of the watershed is mantled by rock slides and earth flows, many of which are considered dormant.

This study compares quantitative estimates of sediment delivery rates to streams developed at different spatial and temporal scales. It is motivated by a proposed vineyard development project in the watershed, and the need to document conditions in the project area, assess project environmental impacts and meet regulatory requirements pertaining to water quality. Sediment delivery rate estimates were previously developed using sediment budget techniques for relatively large drainage areas (~100 to 1,000 km2) by the North Coast Regional Water Quality Control Board and US EPA and by the California Geological Survey. In this study, similar sediment budget techniques were used for smaller watersheds (~3 to 8 km2), and were supplemented by a suspended sediment monitoring program conducted during the winter runoff season for Water Year 2006

and 2007. Stream flow monitoring and turbidity monitoring have continued to the present and data have been compiled through Water Year 2010.

Suspended sediment yield was measured for both wet (2006) and dry (2007) years, providing perspective on the range of measured sediment yield in relation to sediment budget estimates. The measured suspended sediment yields were substantially lower than predicted by sediment budget methods, strongly suggesting that current sediment yields are comparable to the desired future conditions identified in the sediment TMDL for the Gualala River. The implications for water quality regulatory policy include the need to reconsider the validity of sediment budget methodology and the need for monitoring to validate characterization of water quality conditions as impaired.

47 Coast Redwood Responses to Pruning

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A large-scale pruning study was established in the winter of 1999-2000 at seven different sites on Green Diamond Resource Company forestlands in Humboldt County. The objective of this study was to determine the effects of pruning on increment, epicormic sprouting, stem taper, heartwood formation, and bear damage on these young trees. Pruning treatments varied pruning severity and were usually applied in conjunction with thinning treatments. Trees were assessed six years after pruning.

Tree increment was assessed in terms of basal area increment, height increment, and cubic volume increment. Basal area increment decreased with increasing pruning severity but results were inconsistent from one study site to another. Height increment was unaffected by pruning. Six-year volume increment results resembled those for basal area increment: heavier pruning sometimes resulted in lower increment. Additionally, the negative effects of pruning on tree increment were probably short-lived in redwood because of the fast growth rates of this species.

Results indicate the number of epicormic sprouts was generally unaffected by pruning severity with the notable exception of the most severe pruning treatments. By year six, the number of sprouts was no different in the unpruned treatments than in most pruned treatments. The exception was the severe crown removal that left only approximately 15 percent residual live crown length. Epicormic sprouting does not appear to be a deterrent to pruning in redwood.

Tree stem taper was also unaffected by pruning severity. Pruning is generally assumed to decrease stem taper, but the taper in the lower bole exhibited few significant effects of pruning and these varied from indicating pruning increased to pruning decreased taper. Heartwood formation was expected to increase with pruning severity. However, no effects were evident in these data. Apparently, the greater heartwood expected in more severely pruned treatments was obscured by the same factors that minimized treatment effects on increment: in the six years following treatment, the pruned trees had rebuilt crown foliage and required similar sapwood for water transport as unpruned trees.

Bear damage was observed at four of the seven study sites and was severe in several plots. However, not trends were evident relative to pruning treatment.

In summary, pruning that leaves residual crown lengths of 40 to 60 percent should result in minimal levels of epicormic sprouting and no effects on tree increment.

48 The Scotia Plantation: Implications for Multiaged and Even-Aged Silviculture

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The Scotia Plantation was established in 1982 on the large alluvial flat south of Scotia, adjacent to the Eel River. Seedlings, from local "woods run" seed sources, were established on a 10x10 ft grid. In 1997, the area was divided into blocks and a series of thinning treatments were randomly assigned to these blocks. Thinning treatments included alternate row, diagonal row, every-third row, a double-alternate row, and a low density treatment. Plots were established and measured in the winter of 2002/03 and remeasured in 2007 after five growing seasons.

Stump sprout development following thinning treatments was very sensitive to available light resources. In the most heavily thinned treatment, the largest understory sprouts were up to 42 ft in height and 5 inches in dbh in only 10 years. However, at low light intensities many sprout clumps were completely dead. Implications for multiaged silvicultural strategies suggest that treatments that create stump sprouts may not be sufficient by themselves for regenerating a new age class: additionally, light levels must also be sufficient to allow these sprouts to grow and survive. Our results suggest a light level of 40% of full sunlight is needed to sustain sprout growth of about 3 ft/yr and light levels of 10% of full sunlight is needed for sprout survival.

Volume increment for the Scotia Plantation was comparable to the fastest growing conifer plantations in the world. Periodic annual increment (PAI) ranged from 613 to 1082 ft3/ac/yr depending on treatment. Mean annual increment (MAI) ranged

from 220 to 570 ft3/ac/yr; MAI was considerably lower than PAI suggesting MAI was far from culmination and that these values underestimate potential productivity for the Scotia Plantation. Results are compared to other conifer and broadleaf plantations around the world to demonstrate the enormous production potential of coast redwood.

49 Variable-Density Thinning in Coast Redwood: A Comparison of Marking Strategies to Attain Stand Variability

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Variable-density thinning (VDT) is an emerging thinning method that attempts to enhance stand structural heterogeneity by deliberately thinning at different intensities throughout a stand. Subsequent stand development forms a more varied structure than is common in many even-aged forest stands. VDT is becoming a treatment of choice in many restoration efforts where even-aged stands are being directed on trajectories towards old forest stand structure conditions because 1) VDT enhances structural heterogeneity, and 2) a reduction in tree density provides for an accelerated development towards old forest conditions. A primary difficulty in marking VDT treatments is systematically attaining the variability necessary in a VDT prescription. Instead, markers are seemingly trained to implement a prescription by applying a uniform treatment across a stand that enhances structural homogeneity.

In coast redwood, VDT has become the primary restoration treatment for young stands within the state parks of Humboldt and Del Norte Counties. These stands are young and even-aged developing following clearcutting by previous industrial landowners. VDT is being used to increase structural heterogeneity, increase the proportion of redwood or other conifers, or accelerate development towards old forest structures. Six marking prescriptions have been used to date to achieve the VDT objectives. We compare these six marking prescriptions with regard to: 1) ease of use; 2) effectiveness of achieving spatial heterogeneity; 3) capability to approach density/species composition targets; and 4) qualitative assessments of potential for bear damage, potential costs, and long-term stand development trends.

50 Fluorometry as a Bacterial Source Tracking Tool in Coastal Watersheds, Trinidad, CA

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Bacteria counts have long been used as indicators of water pollution that may affect public health. There are currently four bacterial groups that are used to monitor public beaches and to post health warnings if a certain number is exceeded. By themselves, the bacteria are indicators only and do not tell the entire story of the source type or location of the pollutant. Various methods of microbial source tracking to answer these questions have been investigated. Unfortunately, these methods are generally time consuming, labor intensive and too expensive to be feasible in most instances. A variety of other types of methods are under investigation, but there is no generally accepted standard method that has proven itself as accurate and cost efficient.

In this study, a fluorometer was used to measure fluorescence in natural creeks as an indicator of concentrations of optical brighteners (OBs) found in laundry detergent for use as a source tracking tool for failing or malfunctioning Onsite Wastewater Treatment Systems (OWTS). This tool was used in Trinidad area watersheds in conjunction with bacterial sampling and measurement of other water quality and land use data for correlation / comparison. In this case, a good relationship between indicator bacteria and fluorescence was not found over a variety of watershed and flow conditions. There was some evidence that optical brighteners, coupled with other information such as rainfall may be able to accurately predict whether bacterial standards will be exceeded. Though the fluorometer may still prove to be a useful tool in source tracking pollution, particularly from OWTS, there are many variables that need to be accounted for, in particular, rainfall and turbidity.

51 Using FORSEE and Continuous Forest Inventory Information to Evaluate Implementation of Uneven-Aged Management in Santa Cruz County Coast Redwood Forests

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The area known as Swanton Pacific Ranch and Forest in northern Santa Cruz County has been owned and managed by California Polytechnic State University (Cal Poly) Foundation since 1987. The California Forest Practice Rules specific to

the Southern Sub-District of the Coast District limit harvest rate and opening size. Cal Poly forest managers are implementing uneven-aged forest management on 1182 acres of 80 to 110 year old, second-growth coast redwood forests using a modified Guldin BDq. The Lockheed Fire spread into most of the managed forest area during the summer of 2009.

Whereas scientific information does exist on uneven-aged management in coast redwood stands, relatively little information is available on implementation of uneven-aged forest management for coast redwood stands in the Southern Sub-District of the Coast District in Santa Cruz County especially within the context of how fire can influence implementation over the longer term. This McIntire Stennis funded, observational research study used the FORSEE program and a 20+ year Continuous Forest Inventory (CFI) record to evaluate changes in past and current stand structure using trees per acre, basal area per acre, and volume per acre.

52 The Effects of Albinism on the Water Relations and Stem Hydraulics of S. Sempervirens Shoots

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Redwood trees are famous first and foremost due to their size. It is interesting however that the genetic capacity that allows the redwoods to grow indeterminately may also be responsible for mutations that result in an unusual phenotype known as the albino redwood. Although some albino individuals may have a small amount of chlorophyll in their leaves, the vast majority of these clumpy shoots exhibit a complete lack of photosynthetic pigment, rendering the stems and leaves white in appearance and completely dependent on the parent plant for carbon, not unlike a parasite. Albino plants are extremely rare, but a single study on albino citrus shoots showed that pigment-less mutants presented higher rates of transpiration and nearly double the amount of stomata on the leaf surface, as compared to the green foliage. Because nutrients, CO2 and even some sugars may move through the plant water transport tissue (xylem), these higher transport rates are thought to supply the albino shoot's demand for carbon and thus facilitate growth in absence of photosynthesis. We predicted that similar transport patterns would be operative in albino redwoods with the prediction that these mutants would exhibit greater transpiration rates, increased stomatal density and increased xylem water transport capacity relative to green foliage. Preliminary data indicate that contrary to our predictions, albino redwood xylem exhibits reduced water transport rates on account of smaller growth rings and conduit cell size, and that compared to xylem in green shoots, the albino xylem may be more vulnerable to transport failure due to drought stress. We speculate that the lack of pigment, combined with the albino redwood's understory, light-limited locations severely compromises these plants' hydraulic performance and the structural quality of their xylem. *S. sempervirens* is the only species of conifer known to exhibit albinism, so this unusual trait will not only inform the field of plant physiology, but also our understanding of redwood natural history.

53 Using Wood Quality Measures to Evaluate Second-Growth Redwood

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Redwood is a valued species for use in appearance grade applications, such as decking, exterior siding and interior paneling, because of its dimensional stability. It is also valued for certain exterior-use applications because of its natural durability. Some have suggested that young-growth redwood is less durable [categorized as “moderately resistant” rather than “resistant or very resistant”], and also exhibits greater shrinkage and swelling than old-growth redwood (Wood Handbook, USDA Forest Service, Forest Products Laboratory, 2010). Differences in natural durability and dimensional stability between old-growth and young-growth could be accounted for by changes in the extractives found in the heartwood and changes in the microfibril angle in the S2 layer of the cell wall, respectively. Differences in extractive content in the heartwood would be related to the age of the tree.

Can silvicultural techniques be used to enhance the durability and dimensionally stability of second-growth redwood? The objective of this paper will be to: 1) review anatomical and chemical characteristics of redwood that influence in-service performance and durability, 2) review the results of research that evaluate the influence of silvicultural practices on wood quality characteristics of redwood and other wood species, and 3) present results of preliminary tests conducted on samples obtained from second-growth redwood.

54 Regeneration and Tanoak Mortality in Coast Redwood Stands Affected by Sudden Oak Death

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Sudden oak death, an emerging disease caused by the exotic pathogen Phytophthora ramorum, is impacting coast redwood (*Sequoia sempervirens*) forests throughout coastal California. The most severely affected species, tanoak (*Notholithocarpus densifolorus*), is currently widespread and abundant in the redwood ecosystem, but diseased areas have begun to experience considerable mortality. Tanoak, which is extremely valuable as food source to numerous wildlife species, is unlikely to successfully regenerate in these areas, and thus affected redwood forests are transitioning to a novel state.

In this study, to predict which species might replace tanoak, we investigated regeneration patterns in heavily impacted stands in Marin County, California. Our main findings were: (1) despite reductions in canopy cover, there is no evidence that any species other than tanoak has exhibited a regenerative response to tanoak mortality, (2) the regeneration stratum was dominated by redwood and tanoak (other tree species were patchy and/or scarce), and (3) some severely affected areas lacked sufficient regeneration to fully re-occupy available growing space. Our results indicate that redwood is likely to initially re-occupy the majority of the ground relinquished by tanoak, but also provide evidence that longer-term trajectories have yet to be determined and may be highly responsive to management interventions.

55 Use Of Basintemp© to Predict Summer Stream Temperatures in the South Fork Ten Mile River Basin, CA

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We used the water temperature model BasinTemp© to predict water temperatures in the South Fork Ten Mile River Basin (Mendocino County). BasinTemp© is a model developed by Douglas Allen (Stillwater Sciences and University of California Berkeley) that attempts to quantify the basin-wide effects of summer stream temperatures in basins where the data inputs are scarce. It is a model that assumes that direct solar radiation is the chief mechanism behind stream summer heating in mid latitudes. We applied the model in the South Fork Ten Mile River Basin to understand the dynamics of stream summer stream temperatures, the influence of timber management and climate change on water temperatures, and the implications for coho salmon habitat.

Three vegetation scenarios (current vegetation conditions, reference vegetation conditions and topography only conditions) and their effects on the Maximum Weekly Average Temperatures (MWATs) throughout the basin were analyzed. We predicted a significant increase in water temperature related to the decrease in shade as vegetation conditions shift from the reference condition to current conditions under timber management. However, we also found that current vegetation accounts for significant amounts of shade that effectively reduce solar radiation and stream temperatures. In an average water year, the predicted MWATs under reference conditions are generally similar as those under current conditions. By contrast, under a dry water year, MWATs predicted under current conditions are warmer than under reference conditions. All results were heavily influenced by location within the watershed, with some stream reaches apparently sensitive to land management, and others more influenced by natural factors such as orientation, topography, groundwater input, or fog influence.

To predict water temperatures based on climate change models, we modeled shade under current and reference conditions based on data collected during the 2006 heat wave. We predict a trend of increasing MWATs in the South Fork Ten Mile River, regardless of land management actions. Under these conditions, more of the mainstem South Fork Ten Mile River will become too warm for coho salmon, and cold-water tributaries located downstream within the coastal fog zone will likely play a heightened role in overall salmon productivity.

56 Comparing Hydrologic Responses to Tractor-Yarded Selection and Cable-Yarded Clearcut Logging in a Coast Redwood Forest

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Clearcutting has been a preferred practice in northern coast redwood forests for about three decades, but there is increasing pressure to adopt uneven-age management strategies in the area. An understanding of how the hydrologic responses to clearcutting compare with those to selective logging would thus be useful in these forests. This study examines mid- and long-term hydrologic results from two watershed-scale experiments at the Caspar Creek Experimental Watersheds near Fort

Bragg, California, to quantify differences in response and recovery trajectories for peakflows and low flows after logging of second-growth coast redwoods.

After 10 years of monitoring at the North Fork (473 ha) and South Fork (424 ha) Caspar Creek stream gauging weirs, about 67% of the wood volume in the South Fork watershed was selectively logged and tractor-yarded in 1971-1973 while the North Fork was left as a control. About 37% of the North Fork watershed was then clearcut and cable-yarded in 1989-1992, with three forested sub-watersheds left as controls. In each case, treatment effects initially were estimated by comparing measured hydrologic responses in treated watersheds to those predicted from correlations established between control and pre-treatment watersheds.

Magnitudes of initial peakflow responses were similar during the two experiments, showing increased discharge-weighted peakflows of 0.4% (South Fork) and 0.6% (North Fork) for each percent of equivalent clearcut area above the weirs. Peakflows remained slightly elevated in the selectively logged South Fork for about two decades after logging ended. Tributary watersheds of the North Fork showed measurable but diminishing effects for at least a decade, after which responses again increased due to precommercial thinning. In the North Fork, peakflows of the early wet season—those influenced strongly by transpiration effects—showed more rapid recovery than those occurring at the height of the wet season, when changes in rainfall interception provide a dominant influence.

Comparison of low-flow responses at the weirs has been difficult because 1) the South Fork had not fully recovered by 1989 and so could not provide an equivalent control for North Fork responses, and 2) the North Fork was no longer useful as a control after minor preliminary logging in 1985. These problems were circumvented by developing a model to allow calculation of expected low-flow values from antecedent precipitation indices rather than from control measurements. Results suggest that initial increases in low flow after selective logging in the South Fork had disappeared by 5 to 7 years after logging ended, and that low flows then dropped to below expected values for the subsequent 25 years. Pre-treatment levels appear to have been reattained by about 2000, nearly 30 years after logging began. During the 10 years following completion of clearcut logging, low-flow values in the North Fork increased to nearly twice those expected, then diminished to near pre-treatment levels by 2008, and the recovery trajectory suggests that flows will continue to decrease.

Differences in hydrologic response patterns for the two treatments are consistent with a rapid recovery of dry-season transpiration rates in selectively logged forests of this summer-dry climatic regime.

57 Landslides After Clearcut Logging in a Coast Redwood Forest

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The 473-ha North Fork Caspar Creek watershed, located 10 km south of Fort Bragg, California, was partially clearcut in 1989-1992 during an experiment designed to evaluate the cumulative effects of clearcut logging. Since 1985, new landslides larger than 7.6 m^3 have been mapped and measured along gaged tributary channels after each major storm, and other slides visible from roads or on aerial photographs are mapped throughout the watershed.

Between 1991 and 2006, 65 slides of 7.6 to 380 m^3 were mapped within 15 m of gaged channels, and comparison of sliding rates in logged and forested portions of the watershed shows no significant difference for these slides. Over the same period, 13 slides larger than 98 m^3 occurred in the watershed, not necessarily near gaged channels. Slides larger than 98 m^3 in forested areas displaced about 12 $m^3/km^2/yr$, while rates in logged or roaded areas were one and two orders of magnitude higher, respectively, per unit areas logged or roaded. Moreover, volume rates of sliding from roads in logged areas were at least 3 times greater than those from roads in forested areas.

A major storm in 2006 triggered the largest slide complex (5500 m^3) observed in the North Fork since Caspar Creek studies began in 1962. The slide initiated in a logged (1991) and thinned (2001) swale below a road-drainage outfall and triggered a debris flow that scoured sediment from the downstream channel. Much of the debris remains stored along the channel and may become a long-term sediment source. This slide, in combination with a similar 1995 slide that occurred in an ungaged portion of the watershed that was logged in 1985, accounts for about 3/4 of the sediment displaced by slides in the North Fork watershed between 1985 and 2009.

Landslide volumes in the gaged watersheds were not correlated with sediment yields between 1986 and 1995, showing that small to moderate slides were not a major influence on sediment yield. In contrast, the 2006 slide transported more than 1000 times the mean annual sediment yield measured for the affected tributary before logging.

Logging appears to have influenced landsliding in North Fork Caspar Watershed primarily through an increase in the incidence of large landslides and by destabilization of slopes adjacent to roads. Logging can affect landslide incidence by reducing root strength, though this effect is less important in coast redwood forests because much of the root biomass

survives. Logging also reduces transpiration and rainfall interception, increasing average soil moisture and contributing to heightened pore pressures during storms. Interception by Caspar Creek forests removes 21% of the rainfall during large storms, so canopy removal increases rainfall at the ground surface by 27%, effectively increasing the magnitude and frequency of landslide-generating storms.

58 Response of Montia Howellii (Howell's Montia) to Road Management in California Coastal Timberlands

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Howell's montia (*Montia howellii S. Wats.)* is a diminutive, winter-germinating annual herb which ranges from western British Columbia along the western slopes of the Coast Ranges to Northern California. It was thought to be extirpated in California prior to its re-discovery in 1999 on Humboldt Redwood Company (formerly Pacific Lumber Company) land, where we have now documented 43 populations totaling over 300,000 plants. It is specific to lightly disturbed sites with compacted mesic soils, typically occurring on native surface or lightly rocked roads and turnouts, or in meadows grazed by cattle on Humboldt Redwood Company lands. It has also been found on other ownerships in Humboldt County in similar habitats.

Initially, complete protection of plant groups by avoidance was the mitigation method of choice, but these plants occur on roads used for timberland management. Several mitigation methods were developed through consultation with California Department of Fish and Game. The only mitigation that appeared to preserve the populations was moderate road use during the summer, including grading. Monitoring results at numerous locations showed that individual populations fluctuated widely from year to year; we observed that road use during the summer was likely spreading the population spatially, while lack of use resulted in an overall decline in plant numbers. Left undisturbed, competing vegetation apparently crowded out the Howell's montia populations. Scarification of the shiny black seed coats may also occur through road use.

We began a 6-year project in 2005 to examine the spatial and temporal movement of Howell's montia on ten contiguous road systems that contained known populations of the plants. These roads accounted for approximately 40% of the known locations and 80% of the plants on the property. We counted the plants in each 10-meter segment of road, starting from a random location outside the known occupied areas. We monumented the original start location so that the 10-meter segments were consistent from year to year. We displayed the data in GIS and linked the fixed road segments to an event table. This allowed us to visually document the changes in plant numbers in each segment, as well as the movement of plants into new segments and their decline and disappearance from segments over the six years.

We found that, while the overall plant numbers on the property remain fairly constant, as management activities started up in specific areas after a several-year lull, the plants increased in numbers and often spread in space for a few years, followed by decline in both numbers and spatial extent when road use ceased. Conversely, on rocked roads getting heavy use and maintenance annually, populations are not well sustained. We conclude that where Howell's montia occurs on roads, periodic seasonal use appears to be beneficial to the population, provided surface changes do not remove the seed bank and the road use is light to moderate.

59 'Pygmy' Old-Growth Redwood Characteristics on an Edaphic Ecotone in Mendocino County, California

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The 'pygmy' forest is a specialized community that is adapted to highly acidic, hydrophobic, nutrient deprived soils, and exists in pockets within the coast redwood forest in Mendocino County. While coast redwood is known for producing the tallest trees in the world, stunted trees exhibit unusual growth-forms on pygmy soils. The objective of this study was to characterize forest composition, structure, and the growth-form of redwood trees, across the pygmy/redwood ecotone.

We used a stratified random sampling procedure to gather data on the density, height, and diameter of trees; the percent cover of herbaceous species; the height and percent cover of shrub species; the growth-form and canopy characteristics (large lateral branches, reiterated trunks, fire hollows, and ephiphytic plants) of individual redwood trees; and soil conditions including pH, soil color, and presence of hardpan layer. Results indicate that canopy cover, tree height, tree diameter, herbaceous cover, shrub height and cover, and the presence of pygmy forest endemics were negatively correlated to soil pH, presence of hardpan, and distance from the center of the pygmy formation. In addition, the structure of individual redwoods varied significantly along the transect exhibiting three main growth forms: 1) Stunted multi-stemmed (>100 stems/individual) shrub-like specimens less than 2-meters in height near the center of the pygmy forest; 2) Small diameter muti-stemmed (2-10 stems/ individual) trees with an average height of 12-meters growing as subcanopy under pygmy cypress and bolander pine;

3) ‘Pygmy’ old-growth redwoods with an average height of 25-meters (compared to 60-meters for full stature redwoods in the same area) growing as a co-dominant and exhibiting complex canopy structure, large fire hollows, and abundant epiphytic plants.

The results of this study demonstrate that while the growth-from of individual redwoods is dramatically affected by ‘pygmy’ soil conditions, stunted trees can exhibit structural characteristics and canopy complexity similar to full stature redwoods. Further research is needed to determine if the structural characteristics exhibited in the ‘pygmy’ redwoods provide the same wildlife habitat potential as full-stature stands.

60 Management of the Rare Plants of the Coast Redwood Forests : A Case Study of One Timber Company's Approach

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Green Diamond Resource Company (GDRCo) has been conducting pre-disturbance floristic surveys in Timber Harvest Plans (THPs) for ten years, covering over 66,000 acres and nearly 16% of the ownership. Surveys are floristic in nature and focused on detecting rare plants,thirty-six of which have been found on the ownership. Each observation of a rare plant isdocumented, mapped and reported to the California Natural Diversity Database (CNDDB).

When the rare plant rank warrants it, populations are protected by an array of plant protectionmeasures (PPMs) developed in partnership with the California Department of Fish and Game(DFG). This reactive approach to rare plant management focuses all available botanicalexpertise to detecting and avoiding impacts to rare plants when they occur in THPs with littlecontribution to the long-term management of rare plants at the landscape level. The rate of newspecies detections on GDRCo property peaked in 2004, the fourth year of surveys. The only twospecies newly encountered since 2006 were found during focused surveys of unique botanicalhabitat. This trend lends support for a proactive landscape level management plan thateffectively protects the species known to occur and minimizes risks to species that may bepresent, but are truly rare on the landscape.

The evolution of an ownership-wide Sensitive PlantConservation Plan (SPCP) has been ongoing since 2005. Integral to the SPCP is the division ofthe ownership into Botanical Management Areas (BMAs) and the development of area-specificmanagement plans such as the one implemented in 2008 for the Coastal Lagoons and Little RiverBMA. This BMA contains most of the running pine (Lycopodium clavatum) known to occur inCalifornia and PPMs are in place to maintain the current distribution. Surveys within this BMAare now restricted to those areas that contain unique botanical habitat. The development ofadditional BMAs and associated management plans will be informed by a spatial analysis thatutilizes inventory data as well as other available ecological data. Acquisition of ecological dataspecific to rare species has not kept pace with inventory data and filling this gap will contributegreatly to the efficient and effective management of rare plants.

61 The Effect of Selection Logging in a Redwood Forest on Watershed Hydrology and Sediment Yield in a Coastal California Watershed

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Little Creek in the Swanton Pacific Ranch, the school forest for the California Polytechnic State University, near Davenport, California is the location of a nested, paired watershed study. The original objective of the Little Creek Study was to investigate the impact of selection logging in the mixed coast redwood forest on the hydrology and sediment yield of the watershed. The Little Creek watershed supports a harvest regenerated forest that consists primarily of redwood and Douglas-fir. From the 2002 WY through the 2008 WY, discharge and sediment yield data were collected at three stream gauging locations in the Little Creek watershed; the North Fork, South Fork, and Upper North Fork. During the summer of 2008 timber was logged from a harvest unit in the North Fork Little Creek between the North Fork and Upper North Fork gauging stations. The silvicultural system used was an individual tree selection system and the timber was logged, for the most part, with a slackline skyline yarding system. Streamflow and sediment yield were collected through the 2009 WY, which was the first winter after timber harvest occurred. During the summer 2009, the Little Creek watershed was burned in a wildfire. This essentially truncated the traditional nested, paired watershed study because the control watersheds were no longer undisturbed.

The impact of selection logging on watershed hydrology and sediment yield of Little Creek will be analyzed with only the one winter of post-harvest data. Five parameters will be analyzed; total annual water yield, total annual sediment yield, storm peak flows, storm runoff volumes, and storm sediment yield. Statistical models will be developed with the calibration data that will predict the value of these parameters in the treatment watershed based on corresponding values from the control

watershed. Treatment effect will be detected by comparing observed values of the parameters during the winter after timber harvest with predicted values based on the calibration relationships. A similar analysis will be carried out with the data from the Upper North Fork gauging station to determine the effect, if any, of activities upstream of the harvest unit on watershed hydrology and sediment yield.

62 Mesocarnivores as Focal Species for the Restoration of Post-Logging Second Growth in the Northern Redwoods

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Intermediate-sized mammalian carnivores (*mesocarnivores*) are an ideal group of species to evaluate the effects of forest change. Collectively, they respond at large spatial scales and include species adapted to complex forest conditions for hunting (e.g., Humboldt marten [*Martes americana humboldtensis*]) as well as opportunistic generalists that respond positively to human-altered ecosystems (e.g., gray fox [*Urocyon cinereoargenteus*]). From 2002-2010 we studied how several species of *mesocarnivores* have responded to old growth and second growth forest characteristics, forest roads, and restoration efforts. *Mesocarnivore* species diversity is higher in second growth, but is dominated by larger-bodied habitat generalists such as gray fox. Old growth landscapes typically have fewer *mesocarnivore* species, but are the only locations where the rare Humboldt marten is detected. Regional occupancy modeling revealed that dense shrub cover, measured at a spatial scale close to each species' home range size, significantly increased (i.e., marten) or decreased (i.e., fisher [*Martes pennanti*] and gray fox) the probability of their occurrences. Camera survey results revealed that 80% of the detections of the habitat generalists occurred on roads but 80% of the detections of the habitat specialists occurred in interior habitats, along creeks. Stands restoratively thinned 15-30 years ago have regenerated moderately dense shrub layers that are composed of native, shade tolerate shrub species which approach the conditions in old growth redwood stands, and the condition of stands used by the Humboldt marten. Suitable resting structures for martens, including large diameter trees, snags, and downed logs with cavities or platforms, have been significantly reduced in second growth stands compared to old growth stands and stands used by martens.

Restorative thinning and road removal will affect *mesocarnivores* over the short term (1-3 decades) by restoring dense shrub cover and reducing its fragmentation, factors that will likely benefit habitat specialists like the Humboldt marten. These changes may also discriminate against the larger-bodied generalist mesocarnivores that can kill martens, but which cannot maneuver as well as martens through the complex structures formed by stands of dense shrubs. However, because individual carnivores have large home ranges, restoration actions will need to be strategically located to have the greatest impact. There is also a paucity of large-diameter standing and downed woody structures in second-growth stands, which are critical resting and denning locations for the Humboldt marten. Because the natural recruitment of these structures will likely take >200 years, alternatives for creating suitable structures will be necessary to improve habitat conditions in the interim.

63 Subdivide or Silviculture: Choices Facing Family Forest Owners in the Redwood Region

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Families or family businesses own nearly all of the private redwood forestland. Using subsample of survey results of California forest and rangeland owners, we explore the resource management implications of family forest ownership. Strong environmental stewardship values and a focus on a high quality of family life were the dominant values expressed by a large majority of forest landowners. The smaller contingent of owners that owns a majority of family forestland shared most of those environmental values and also had a greater interest in the financial value of the forestland. Parcel size was more important than expressed values as a predictor of resource management actions. All landowners with more than 50 acres undertook high levels of resource stewardship regarding controlling invasive species, protecting water quality, improving fish and wildlife habitats, and removing individual trees to promote forest health. Around half of the owners of the larger properties also engaged in timber harvesting. Unlike most other resource management activities that are typically discretionary, timber harvesting in California requires permission from up to five state agencies and three federal agencies. The high transaction costs limit involvement to forest owners with both large land holdings and strong skills in business management. Sustainable timber production is the most significant legal alternative to real estate sales as a means for generating revenue from forest properties too large to be used as a single residential property. It is not inconceivable that California's forest ownership pattern could become more like Washington State over time where small rather than large holdings represent the majority of family forestland.

64 Summer Water Use by Mixed-Age and Young Forest Stands, Mattole River, Northern California, USA

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Resource managers have noted a decline in summer flow levels in the last decade in the Mattole River watershed, Humboldt County, California. Reduced river flows pose a threat to endangered coho and chinook salmon in the watershed, as stream heating is inversely proportional to discharge. While the cause of the reduced flow is unclear, several factors have been cited: increased groundwater pumping from residential development in the area, regional climate shifts tied to global warming, and the recovery of forest cover after widespread deforestation in the 1950s and 1960s. The goal of this project was to gain insight into the effect of stand age and composition on forest water consumption. Quantitative information on tree and stand level transpiration was collected in order to inform comprehensive hydrologic budgets being developed for the Mattole River watershed under existing conditions and resulting from prospective forest management activities. Granier thermal dissipation probes were inserted into 18 Douglas-fir (*Pseudotsuga menziesii*) trees in mixed and even-aged stands in order to record water use over the course of the 2008 summer dry season. Trees ranged in size from 10 – 91 cm diameter at breast height (dbh). A tight relationship was found between sapwood area (cm2) and water use (liters/season, $y = 7.68x – 638.6$, $r2=.86$). Strong positive relationships were also found between dbh (cm) and water use ($y = 92.40x – 1068.4$, $r2=.90$), and for basal area (cm2) and water use ($y = 1.261x + 241.57$, $r2=.94$). The relationship between basal area and water use was much steeper for the youngest trees ($y = 3.42x – 233.15$. $r2=.76$), indicating a steep increase in water use with increasing tree size at the lower end of the size range. This information will be used to model stand level water use with the current composition and under future scenarios.

65 Sediment Yield Response to Sediment Reduction Strategies Implemented for 10 Years in Watersheds Managed for Industrial Forestry in Northern California

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For the past decade, the productive forestlands now owned and operated by the Humboldt Redwood Company have been managed with low impact practices designed to reduce sediment delivery according to voluntary agreements and regulatory requirements of state and federal agencies. These timberlands located in the erosive sedimentary terrain of the northern coast of California have been extensively roaded and several generations of redwood dominated forests have been clearcut since the 1860's. Intensive watershed and property-wide studies of sediment processes within the past 50 years when information is most reliable have created watershed sediment budgets and documented significant sediment impacts from past management activities. Forest operations now include geologic hazard avoidance and an extensive road upgrading and removal program that collectively have minimized landslide and road erosion that were found to be the dominant sediment sources. Over the past decade, sediment and streamflow have been continuously monitored at a number of locations in the mainstems and major tributaries of Freshwater Creek and Elk River. In this paper we explore the extent of sediment reduction in the watersheds and effects on water quality that may be evident in the relatively short monitoring record.

66 An Approach to Study the Effect of Harvest and Wildfire on Watershed Hydrology and Sediment Yield in a Coast Redwood Forest

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The Little Creek watershed, within California State Polytechnic University's Swanton Pacific ranch, is the location of a paired and nested watershed study that investigates the watershed effects of coast redwood forest management. Streamflow, suspended sediment, and stream turbidity have been collected during storms at two locations on the North Fork Little Creek and at the outlet of South Fork Little Creek from 2002 until present. In 2008, the watershed area between the two monitoring stations on the North Fork Little Creek watershed was harvested with an individual tree selection silvicultural system after the Santa Cruz County Rules of the California Forest Practice Rules. The South Fork Little Creek was left unharvested to serve as a control. In 2009, the Little Creek watershed was burned by a wildfire. The wildfire eliminated our control watersheds for the proposed Before After Control Intervention (BACI) study design.

We propose an alternative approach at detecting harvest and fire effects that uses rainfall/runoff models, soil erosion models, and sediment runoff relations to simulate runoff and sediment yield from the watersheds. The models and sediment runoff relationships will be developed within the framework of an uncertainty assessment to simulate pre-harvest and pre-fire

conditions for the North and South Forks of Little Creek. The modeled results will be used as the control for the study which had been eliminated from the wildfire in 2009. The use of models to detect change in watershed hydrology and sediment yield presents many challenges. The variability of the climate and physical factors that influence watershed response are poorly represented by model calculations and sediment runoff relations. The quality of input data to models and the ability of the data to replicate the physical environment create uncertainty. Thus, a thorough uncertainty assessment will be carried out as a part of the modeling effort.

We use the HBV hydrologic model and sediment runoff relations to demonstrate our approach. An uncertainty assessment will be carried out using the dynamic evolution adaptive metropolis (DREAM) approach examining parameter and climate input uncertainty. The sediment rating curves will be used with HBV simulated runoff in the post harvest and post fire time periods to estimate sediment yield if harvest or fire had not occurred. An evaluation of post-harvest and post-fire runoff and sediment changes within the uncertainty of the approach will be presented.

67 Forest Restoration at Redwood National Park: A Case Study of an Emerging Program

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Over 50,000 acres of Redwood National Park is comprised of second-growth forests. After being acquired by the National Park Service in 1968 and 1978, these second-growth forests were left unmanaged and developed into dense stands with deficient redwood composition and overrepresentation of Douglas-fir. These forest conditions promote low floral diversity, poor habitat for wildlife and a low potential for stand differentiation.

Using novel applications of traditional and non-traditional silvicultural methods as a restoration tool for enhancing forest structure and composition in degraded forests is increasingly being employed by conservation agencies in the Pacific Northwest. There have been several studies conducted at Redwood National Park over the past 30 years in an effort to aid resource managers in prescribing future silvicultural treatments for restoring forests at the Park and in similar forest reserves that are managed for ecological values. The knowledge gained through these studies has culminated in The South Fork of Lost Man Creek Forest Restoration Plan, which was approved in 2009. This forest restoration plan calls for implementing five silvicultural prescriptions throughout 1,700-acres of the Lost Man Creek watershed. The two prominent prescriptions are (1) a crown thinning on steep slopes, reducing the stand basal area by 25-percent, lopping-and-scattering woody biomass and (2) a low thinning on gentle slopes, reducing the stand basal area by 40-percent, removing woody biomass from the site to be utilized as different forest products.

The South Fork of Lost Man Creek Forest Restoration Plan is Redwood National Park's first successful attempt at programmatic forest restoration. This is also the first forest restoration project in a redwood reserve that has successfully attempted to off-set costs by selling the woody biomass, a byproduct of the restoration, to the contractor that is conducting the restoration work. There will be many more plans, many more acres to treat, and new silvicultural techniques to implement as the park engages in a full-scale effort to restore its oft-neglected second-growth forests.

68 Estimating Benefits and Costs of Carbon Storing Forestry-Offset Projects Using California's Climate

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As nations grapple with various approaches to reducing greenhouse gas emissions, using forests as an offset to CO2 emissions has been somewhat controversial. Unlike simply reducing emissions, offsets are complex, and difficult to assure permanence. Nevertheless, offset projects like afforestation, improved forest management, and avoiding forest conversion have recently been sanctioned through many new policies such as California's Climate Action Registry (CAR). Endorsed by the state Air Resources Board, the CAR offers a detailed protocol to quantify the volume of CO2 sequestered in forests and in turn sell on climate exchanges.

To quantify the benefits and costs of modifying forest management for carbon storage, Cal Poly's Swanton Pacific demonstration forest will be used to test the CAR protocol and identify optimal management strategies for both wood and carbon markets. Residing in the Southern Subdistrict with its clearcutting restrictions, Swanton offers an ideal test site as an increasing number of landowners transition from even-aged to uneven-aged management.

69 Impacts of Phytophtora Ramorum on Redwood Forest Dynamics in Central California

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California oak populations have been declining throughout the central coast at an astonishing rate due to the invasive pathogen *Phytophthora ramorum*, the causal agent of sudden oak death. The pathogen is known to infect various species in coast redwood/mixed evergreen forests with tanoaks and coast live oaks having the highest mortality rates. Such severe impacts could potentially alter the entire coast redwood/mixed evergreen forest structure and composition.

This study examined how forest community composition (stand age, species diversity, and arrangement) and elevation effected the spatial distribution of *Phytophthora ramorum* in California's central coast redwood forests. Symptomatic *P. ramorum* was analyzed at a community level scale in three counties around the San Francisco Bay Area. Using multiple point pattern GIS analyses the effects of host density and spatial arrangement on the distribution and frequency of symptomatic *P. ramorum* was mapped on a community scale. A stepwise multiple linear regression was applied to determine which forest components played an important role in the distribution of *P. ramorum* on a landscape scale. Preliminary results have shown that regions with high species diversity and thicker canopies have a greater incidence of symptomatic *P. ramorum*. Landscape topography was a key factor in the distribution of the pathogen. In regions where infections were found on the tops of ridges no matter how great the infection larger patches of symptomatic *P. ramorum* were almost always found below. Younger forest stands were found to more susceptible to symptomatic *P. ramorum* infections when in close proximity to older forest stands with higher canopies. The results of this study can be used to model the potential susceptibility of forest stands to *P. ramorum* infections based on the vegetation composition, terrain, and the spatial arrangement of vegetation within the community.

70 Sudden Oak Death and Surface Fuels in Douglas-Fir-Tanoak Forests

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We compared stand structure and fuel loading in north coast forests invaded by *Phytophthora ramorum*, the cause of sudden oak death, to assess whether the continued presence of this pathogen alters surface fuel loading and potential fire behavior in ways that may encumber future firefighting response. To attempt to account for these kinds of changes over a longer term than *P. ramorum* has been present in California, we supplemented sampling of pathogen-killed stands with those killed by herbicides. Although fuel loadings were greater in diseased than in undiseased stands, great variability was observed and the differences did not rise to the level of significance. Fuel loading observed in herbicide-treated stands was significantly greater than that in control stands ($P < 0.001$); total weight of downed woody debris (1-, 10-, 100-, and 1000-hour fuel loadings) approximately doubled with the herbicide treatment ($\bar{x} = 106.3$ Mg ha-1) over the control condition ($\bar{x} = 58.1$ Mg ha-1). The increasing trends in herbicided and diseased plots resembled each other, suggesting that fuel loadings in diseased plots will continue to increase relative to the controls over a longer time horizon than observed. Fuel models based on the observed surface fuel accumulations in herbicide-treated and diseased plots predict that for some early-to-mid-phase (2-8 years) herbicide-treated forests, and for late-phase (8 years plus) diseased forests, rates of spread, flame lengths, and fireline intensities could increase significantly over the baseline, challenging effective firefighter response. These results, together with the "background" surface fuels observed in the control stands, highlight the need for fuels treatments and effective disease management strategies in infested stands and as sudden oak death expands throughout a broader region.

71 Size Distribution of Old-Growth Redwood Forests in Mendocino County

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Late-seral conditions in redwood forests are becoming a management goal on some timberlands. However, there is little published information regarding the structure of late-seral forests upon which silvicultural prescriptions can be guided, or upon which to measure success. Old-growth forests -- those perceived to be near or at the successional climax -- are the ultimate model. However, old-growth forests are a rare commodity in Mendocino County, limited mostly to state parks and small stands on private lands. Their rarity yields a poor sampling of the variation among stands, making historic sources of information valuable. Despite incomplete information relative to the complexity of their trees' canopy and boles (e.g., no explicit information regarding basal hollow frequency or dimensions), as well as often not collecting information on ecologically important but non-commercial vegetation such as hardwoods, historic inventory information can add to the information set on old-growth forest conditions. Analysis of a 1929 data set derived from timber stands stratified into 20 board feet per acre classes on Caspar Lumber Company lands reveals an inverse J shaped size frequency distribution. Across the stand conditions, redwood comprised 67 – 96 % of the tree density (31-51 trees per acre) and 73 – 97 % of the basal area (116-537 ft2/acre); the diameter50 (diameter at which half of the trees were smaller) ranged from 17 to 30 inches dbh; while

the d90 ranged from 42 to 70 inches dbh. The largest size classes measured were 126+ inches, 78-82 inches, and 42-46 inches for redwood, Douglas-fir, and white fir, respectively.

72 Spatial Structure of an Upland Old-Growth Redwood Forest

***Philip van Mantgem**, USGS, pvanmantgem@usgs.gov*

There is concern that restoration treatments in redwood forests that promote uniform forest structure may not reflect old-growth conditions. Indeed, it has been shown that the spatial arrangement of trees of redwood forests in alluvial habitats is often clumped or random. However, alluvial and upland redwood forests differ in many respects, and it is uncertain if the spatial structure of upland forests will follow similar patterns.

I describe live tree spatial distributions in an upland old-growth redwood forest from six 1-hectare plots by considering individual trees as points, and examining patterns at multiple scales using the inhomogeneous K-function, a second-moment measure that accounts for variability in the average density of trees across each plot. Results indicate a random arrangement of stems, though analysis of redwood alone suggests significant clumping at small scales at three of the six plots. Marked point process models of redwood versus other co-occurring species indicate these groups are strongly segregated at larger spatial scales.

My findings support the idea that restoration prescriptions that encourage uniform spatial arrangements of stems do not mimic current conditions in old-growth upland redwood forests. However, due to on-going changes, particularly the disruption of historic disturbance regimes, it is unclear how well current conditions represent stand structure prior to European settlement.

73 Whiskey Springs Long Term Redwood Density Management; Final Growth, Redwood Sprout, and Yield Result

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Multi-decadal studies of commercial and pre-commercial thinning in redwood stands are rare and consequently of value. The Whiskey Springs study at Jackson Demonstration State Forest has a data set spanning 34 years. It has provided information on the growth of; individual trees, stands, seedlings and stump sprouts. Though originally designed to explore thinning growth and yield response, the results can provide important information for evaluating regeneration and alternative silviculture treatments.

In 1970, the original treatment thinned unmanaged approximately 40 year old redwood forest from below to densities representing 25, 50, and 75 percent of initial the basal area (approx. 400 ft2). Twelve 0.4-acre blocks (132 x 132 feet) were established. The measurement area was a 0.2-acre plot located centrally in the treatment blocks. Three plot replicates of the four treatments were assigned in randomized design. Sprouts and seedlings were abundant in the 50% and 25% retention areas so unplanned regeneration subplots were established in 1986 which thinned the regeneration to the equivalent of 200, 300, and 400 sprotus per acre.

The results will include growth and mortality of the original stand and redwood regeneration over the entire study period. Over the 34 year period the basal area of the 25%, 50%, 75% and 100% retention areas increased by 168, 232, 226 and 210 square feet of basal area per acre respectively. Data analysis of the individual tree and plot growth and yield will be presented with statistical tests. The effects of individual blocks site variation and the experimental design will be described. The initial questions regarding thinning regimes will be explored. The results can be explored for insights regarding; aesthetics, economic aspects, density, and comparison to growth expectations.

Regeneration and the sprouting understory have provided useful information to explore growth of a second or understory cohort of relevance to uneven age or continuous cover management. This information will be evaluated and presented in context.

This presentation is intended to provide the conclusion of the formal research at this Whiskey Springs Study site. Because the study has reached or possibly exceeded its planned duration, the research area will transition to a demonstration and education site. It will continue to provide visitors tangible examples of the long term density management in redwood forests.

74 Invasive Weed Management in Redwood Forest; Jackson Demonstration State Forest's Approach

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The moist temperate climate of the Mendocino redwood region provides ideal conditions for many invasive plant species. Invasive plants can out-compete native plants for space, water, light, and nutrients, as well as alter soil chemistry and stream flows. Increasing fire intensity and frequency can be the result of invasive plants infestations. Additionally the infestations impair transportation, recreation, aesthetics, and wildlife habitat. In the Mendocino redwood region, invasive plants negatively affect management including; forestry, rare species, fisheries, recreation, tourism, and infrastructure maintenance. The California Invasive Plant Council lists 256 species of invasive plants in the North West Floristic Province where Mendocino County lies. At least 12 species of invasive plants are found on Jackson Demonstration State Forest (JDSF).

This presentation will provide a brief overview of the role of invasive weeds Mendocino redwood forests. Complementary management focuses will be described. One is the cooperative context of the Mendocino Coast Weed Management Area. Partners in this weed management area include private land managers, public agencies, educational institutions, and conservation organizations. Other management focuses include; developing integrated pest management, working within the regulatory and social context, as well as evaluating and prioritizing treatments.

Two specific Invasive Weed Management case studies of will be presented as illustrations of JDSF's demonstration function. The first is habitat management to reduce the impact of invasive weeds on a state listed rare plant, Humboldt milk-vetch (Astragalus agnicidus). The second is successful integrated weed management in timber harvest areas.

75 Northern California Redwoods Provide Important Seasonal Habitat for Migrant Bats

***Theodore J. Weller**, Forest Service, Pacific Southwest Research Station, tweller@fs.fed.us*

That redwood forests provide important habitat for a multitude of resident wildlife species, including a dozen species of bats, is well known. Less appreciated, and more difficult to ascertain, is the value of redwood habitat to migrant species. Between February 2008 and October 2010, I captured 491 bats during 74 mist net surveys in redwood forests in northwestern California. During November-March, silver-haired bats, *Lasionycteris noctivagans*, accounted for 79% of 34 captures and male:female sex ratio was (15:12). By contrast, during June-August, silver-haired bats accounted for 13.8% of 269 captures and sex ratios were highly male skewed (34:3). In combination with other regional information, this indicates that female silver-haired bats migrate to redwood forests. At a minimum female silver-haired bats are drawn from beyond the Coast Range of northern California, and potentially from much greater distances. To infer summer locations of silver-haired bats captured in redwood forests throughout the year, I analyzed stable isotopes of hydrogen (δD) and sulfur (δ34S) in their fur. Structure observed between δD and δ34S ratios provides optimism that these two isotopes can be used to elucidate distances traveled to reach the redwoods. Such information is important for understanding the influence redwoods may have on the ecology of this wide-ranging species.

76 Frogs, Fish and Forestry: The Need for a Holistic View of Network Processes to Conserve Biodiversity

***Hartwell H. Welsh, Jr.**, USDA Forest Service, Pacific Southwest Research Station, hwelsh@fs.fed.us*

I review research conducted on entire stream catchments in Northwest California, from headwater swales to river mouths, indicating how headwater processes, both natural and anthropogenic, influence downstream fish-baring reaches. The implications of these relationships for salmonids and other elements of native biological diversity are explored. Comparing riparian protections from the U. S. federal Northwest Forest Plan with those of the three Pacific Northwest states, I discuss fluvial and geomorphologic process domains of stream networks and how they relate to these guidelines. Focusing in particular on headwater (1st to 3rd order) channels, evidence for the effectiveness of current riparian management to maintain viable populations of native amphibians is reviewed. Using evidence from multiple studies of amphibian environmental relationships, including several from the redwood region, I document the ineffectiveness of current riparian protections to prevent increasing water temperatures, the introduction of fine sediments, and the loss of large woody debris by detailing the responses of headwater amphibians to these adversely altered attribute states. Combining the concepts of the stream continuum and the dendritic network, I examine linkages between the status of biota in headwater reaches and elements like salmonids that depend on downstream conditions. This research indicates that to recover and maintain sensitive species at

upper and lower extremes and throughout stream networks will require recognizing and applying the concept of hydrologic connectivity. Embracing this concept is essential to promote adequate management of stream networks to protect all the parts and the interconnecting processes needed to maintain catchment-wide ecological integrity. These results have implications for stream networks worldwide.

77 Use of Lidar and Multispectral Imagery to Determine Conifer Mortality and Burn Severity

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The effects of wildfire on tree mortality, stand structure, and regeneration are majors concern in many California ecosystems. These effects are often highly variable across the landscape and can be difficult to assess at broad scales. There are few datasets that provide a detailed description of stand conditions, both before and after wildland fire, particularly in the Coast Redwood forest type. This study provides a unique collection of pre- and post-fire remote sensing data to evaluate the effects of the 2009 Lockheed Fire, a 7819 acre wildland fire that occurred near Santa Cruz, CA.

High resolution, discrete-return airborne LiDAR collected in 2008 and 2010, provide detailed metrics of horizontal and vertical structure of second-growth Coast Redwood forest impacted by fire. In addition, 1 m color infrared imagery collected in 2009 and 2010, enable "fusion" of the three-dimensional LiDAR attributes with multispectral imagery. Remotely-derived estimates of burn severity will be compared to field-based assessments of burn severity and tree mortality conducted at 85 GPS-located forest inventory plots. Many parameters are available to characterize changes in vegetation condition following the fire. Such parameters include overhead canopy cover, vegetation height, vertical distribution of LiDAR returns, and indices of surface reflectance, such as NDVI. LiDAR and multispectral imagery are becoming more widely available for forest management applications, and this presents a valuable opportunity to investigate the benefits of high-resolution data, and to explore LiDAR-based metrics of vertical canopy structure as a means of assessing burn severity.

78 Delineation of Default Landslide Buffers Along Steep Streamside Slopes in Northern California

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Green Diamond Resource Co (GDRCo) applies tree retention buffers to steep slopes along fish bearing (Class I) and non-fish bearing (Class II) streams that are in addition to the standard riparian management zone associated with timber harvest plans. These Steep Streamside Slope (SSS) buffers were designed to reduce the amount of sediment delivering to watercourses as a result of landslides generated by forest management related operations. The initial default buffers were developed through a landslide study during the planning stages of GDRCo's Aquatic Habitat Conservation Plan (AHCP). The continued evaluation of streamside landslides across the property is one of the AHCP's Long Term Research projects, which is aimed at re-defining the SSS "default" prescriptions using a spatially distributed probability based sampling design. For logistical reasons and rapid assessment, the initial study was intentionally focused in areas that showed high concentrations of recent landslides. Through continued research, our goal is to refine the minimum slope gradients and maximum slope distances associated with the Steep Streamside Slope criteria for each of the 11 Hydrographic Planning Areas (HPA) identified in GDRCo's AHCP.

Our first HPA to be re-evaluated was the Coastal Klamath HPA, which is a grouping of several watersheds near the mouth of the Klamath River in Humboldt and Del Norte counties. Our sampling consists of 93 half-mile long stream segments that represent roughly ten percent of the lineal distances of Class I streams and five percent of the lineal distances of Class II streams within this HPA. The sampling method used insured both random selection and spatial distribution of the half mile segments within the study area. We then surveyed the hillsides adjacent to these segments for shallow streamside landslides. Our study focused on those landslides that were non road-related, active to historically active, and had observably delivered sediment to a watercourse. The landslide data collected included causal factors, slope characteristics, cross sections, and dimensions of the source and debris, of more than 600 landslides in this region.

The initial prescriptions were applied uniformly across the HPA regardless of morphology or bedrock type, both of which can vary dramatically across this one-hundred and eight thousand-acre region. Using a terrain roughness model on a 50-meter LiDAR-based DEM and field-based geologic mapping of the area, we divided the area into distinct morphologic units. The results from the analysis of the landslide data provide new slope gradient and distance thresholds for the SSS default prescriptions. These new SSS prescriptions are unique to each of these morphologic units and provide site specific

protections to areas prone to streamside landsliding within the Coastal Klamath HPA. More to come from the remaining 10 HPAs.

79 Measurements of Key Life History Metrics of Coho Salmon in Pudding Creek, California

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Campbell Timberland Management and the California Department of Fish and Game, with oversight from NOAA Fisheries, have been monitoring coho salmon in Pudding Creek, California, since 2005. Research has focused on using an adult trap, spawning surveys, PIT tags, direct observation dives, and a smolt trap to estimate adult escapement, juvenile abundance, juvenile growth, winter survival, and marine survival.

Since 2005 adult abundance has declined dramatically, from 1,200 spawners in 2005 to 50 in 2009. Smolt abundance during the same time period peaked at 24,000 in 2006, and has remained consistently around 15,000 individuals despite continued declines in escapement. Over-wintering habitat in the watershed is available, although not abundant, and winter survival was measured at around 20%. Despite suitable summer water temperatures, juvenile growth rates within the upper watershed were low during summer and significantly higher in spring and fall. Smolt sizes appear to be relatively small (with the exception of documented two-year old smolts). Over two complete coho life cycles, ocean survival appeared to strongly affect adult returns. In all years since 2008, ocean survival for Pudding Creek spawners was less than 1%, possibly due in part to small smolt size.

Ongoing research is focused on assessing growth opportunities and survival in a large pond downstream of the outmigrant trap. We are also continuing to use PIT tag returns to determine the factors affecting marine survival and instream growth and distribution.

Abstracts of Posters

Post-fire Responses in a Coastal Redwood/Douglas-Fir Forest, Santa Cruz Mountains, CA — Poster #1

Garren Andrews *and* ***Christopher Dicus****, California Polytechnic State University, San Luis Obispo, hunnington@email.com*

We investigate how fire severity impacts the survival and response (sprouting/seeding) of multiple species in the Santa Cruz Mountains of coastal California, including coast redwood (*Sequoia sempervirens*), Douglas-fir (*Pseudotsuga menziesii*), tanoak (*Lithocarpus densiflorus*), and Pacific madrone (*Arbutus menziesii*). During August 2009 the Lockheed fire burned nearly 3,160ha of mixed-conifer stands with variable severity. Data from 37 Continuous Forest Inventory (CFI) plots were collected immediately before and for 2 successive years following the 2009 Lockheed Fire. This research entails three objectives. First, we will quantify post-fire mortality of trees that vary in species, size, and fire severity. Second, data will be quantified for post-fire response (sprouting, seeding) of those four tree species in areas of varying fire severity. Third, we will develop logistic regression models that predict post-fire mortality and response for each of the four species. Understanding the relationship between burn severity, mortality and regeneration can allow for better post-fire predictive services. This research will support forest managers in determining the best management practices to facilitate long-term sustainability and protection of environmental infrastructure within coast redwood/Douglas-fir forests.

Jackson Demonstration State Forest – Fulfilling a Vision of Research and Demonstrations — Poster #2

Brian Barrett *and* ***Lynn Webb****, California Department of Forestry and Fire Protection, Jackson Demonstration State Forest, brian.barrett@fire.ca.gov*

Jackson Demonstration State Forest (JDSF) has contributed research and demonstrations to the coast redwood region for over sixty years, since its establishment in 1947. The state forest was established with a bold vision of proving that cutover timber land was worth managing for the long term and second growth redwood could be grown as a viable product. The coast redwood region and California have changed through the years and research has grown more complex. It is now focused on forest and watershed ecosystem processes including best management practices, cumulative effects, and sustainability. A selection of research projects are presented to give an overview of the current JDSF research program and promote opportunities for future research.

The California Board of Forestry and Fire Protection highlighted their commitment to research in the coast redwood region by approving the Jackson Demonstration State Forest Management Plan (FMP) in 2008. JDSF's mission of research and demonstration has entered a new phase with FMP approval and the resumption of timber harvest operations. JDSF has many unique features that create tremendous opportunity for research in the coast redwood region:

- It is located near the center of the redwood region and is the largest publicly owned forest in the redwood region with a research and demonstration mandate.
- The number of acres (48,562), breadth of age classes, and range of sites allow for landscape level research to complement stand and individual project level work.
- It is ideal for long term research that is needed for the study of complex natural systems. Long-term data sets, such as tree growth and hydrology are available to supplement and compare data.
- It is a working forest that conducts sustainable forestry practices including active management and periodic timber harvests that can be tested and explored.
- Best management practices and regulations can be studied and tested, including the range of variables and conditions, to make scientifically supportable conclusions.
- A diverse group of adjoining landowners, including state parks and industrial timberland, provides opportunities for cooperative research in contrasting management settings.

JDSF is developing and strengthening cooperative relationships with university, governmental, and non-governmental research institutions. The Forest Learning Center housing facility was constructed in 2003 to encourage research at JDSF. The original vision of proving the importance of managing coast redwood for the long term has evolved and changed with the addition of new research questions. Change will continue in the coast redwood region and JDSF. Research needs will increase with the addition of complex issues such as climate change and carbon sequestration. With ever increasing pressures on wildland resources, forest and watershed research at JDSF is critical to improving our understanding and making informed management decisions for Coast Redwood Forests in a Changing California.

Applications of Long-Term Watershed Research to Forest Management in California: 50 Years of Learning from the Caspar Creek Watershed Study

Poster #3

***Peter H. Cafferata**, California Department of Forestry and Fire Protection, pete.cafferata@fire.ca.gov; **Leslie M. Reid**, U.S. Forest Service Pacific Southwest Research Station*

Initial stream discharge, suspended sediment, and rainfall measurement began in the Caspar Creek watershed located in western Mendocino County on October 1, 1961. During the following 50 years, this basin has been the site of a long-term cooperative study between the U.S. Forest Service Pacific Southwest Research Station (PSW) and the California Department of Forestry and Fire Protection (CAL FIRE). The Caspar Creek watershed is one of only a small number of watersheds in the United States with a continuous record of streamflow and sediment for this length of time. Two major watershed experiments have been carried out at Caspar Creek to study the hydrologic effects of second-growth harvesting of coast redwood and Douglas-fir. Lessons learned from these studies have been applied to address numerous forestry-related issues in California.

Registered Professional Foresters prepare Timber Harvesting Plans (THPs) and other types of plans that require approval by state agencies prior to approval for commercial timber harvesting operations. These documents require that the anticipated impacts of the project, both individually and cumulatively, be analyzed and disclosed for public review. Larger scale documents such as aquatic Habitat Conservation Plans (HCPs) and Program Timberland Environmental Impact Reports (PTEIRs) assess potential impacts at a landscape level. Results from the Caspar Creek studies are used in these types of documents to make reasoned assessments of potential watershed-related impacts. Examples of applications include: (1) prediction of changes in peak flows associated with timber harvesting, (2) evaluation of expected changes in annual water yield and summer low flows, (3) estimation of rates of landsliding and hillslope erosion in tractor and cable-logged areas, (4) assessment of the relative contributions of sediment from different source areas on the landscape, (5) prediction of large wood recruitment to stream channels, (6) prediction of changes in water temperatures following riparian zone harvesting, (7) assessment of the relative importance of fog drip in annual water yield, (8) consideration of nutrient export rates following clearcut harvesting, and (9) evaluation of biological impacts to salmonids and macroinvertebrate communities.

Results from Caspar Creek watershed studies have also been instrumental in the development and refinement of numerous California Forest Practice Rules addressing watershed-related topics. Results from peakflow studies have been used by state agencies to design strategies to control hydrologic changes from logging in privately owned coast redwood forests. Results from Caspar Creek are often cited by state and federal agencies charged with regulating the effects of forestry practices on flooding, water supply, water quality, riparian condition, and aquatic habitat (e.g., Official Responses for THPs), as well as by citizens commenting on THPs. Finally, Caspar Creek studies have led to development of new monitoring methods that provide more detailed information while reducing monitoring costs and effort.

Estimating Tree Vigor Following Wildland Fire in Coast Redwood — Poster #4

***Benjamin T. Caldwell**, **Benjamin Ramage**, **Kevin O'Hara**, UC Berkeley, btcaldwell@berkeley.edu*

Fire is an important natural disturbance agent in coast redwood (*Sequoia sempervirens)* forests. Coast redwood is well-adapted to fire, tolerating it better than many competitors. In 2008, wildland fires ignited by lightning burned throughout much of the range of coast redwood, providing a rare opportunity to study the impact of and response to fire in these systems. This study evaluated the utility and accuracy of different metrics of tree vigor in burned and unburned stands, with the object of identifying the most efficient and accurate metrics for evaluating stem health.

Sites were selected throughout the range of burned stands in old-growth and second-growth coast redwood forests. Variable-radius plots were selected in transects moving from the bottom of a drainage to the top of a ridge. Tree-level metrics were taken on individual stems within each plot, as well as measurements of site such as location and exposure. Mixed-effect models were fit to determine what measured variables best predicted 5- year increment in the unburned sites, using AIC values to compare models. The best predictor of vigor in unburned sites useful in burned areas was then used as the best proxy for vigor in burned sites, and models re-fit for burned sites. Hierarchical linear mixed models were fitted to the data to account for the nested sampling design (site/transect/plot).

Unburned -In these stands leaf area alone was the best predictor of vigor (5-year increment). DBH, crown length and cambial electrical resistance together provided the next best model for vigor. *Burned*-The best predictor for vigor (crown length one year after fire) in burned sites was a model that used cambial electrical resistance as measured by a Shigometer. There were few other reasonable predictor variables for crown length in burned stands, however. Bark thickness and slope position were not good predictors of vigor in burned or unburned sites. Possible useful metrics not measured are stand site quality or average soil and air moisture content.

Coast redwood stems can survive fire disturbances that may kill or severely damage co-occurring species. While DBH, crown length, leaf area, and cambial electrical resistance all provide useful metrics for evaluating tree health and vigor, this study confirms that traditional metrics such as crown length are good predictors of tree vigor, while highlighting other possible approaches such as cambial electrical resistance for managers interested in multiple dimensions for evaluating tree health in burned stands.

Future useful research in this area might explore abiotic factors that most impact redwood vigor after fire, measurements of growth after fire per unit leaf area, as well as interactions of fire, competition, and vigor in coast redwood dominated systems.

Magnificent Chinese and American Redwoods — Poster #5

***Momei Chen**, UC Berkeley Department of ESPM, momeichen@berkeley.edu*

Redwoods have always been esteemed, all three monotypic genera (Taxodiaceae or, more recently, Cupressaceae): the voluminous *Sequoiadendron giganteum* (giant sequoia, big tree, or Sierra redwood) endemic to the western Sierra of California, the stately *Sequoia sempervirens* (coast redwood) native to coastal central and northern California and southern Oregon, and the living fossil *Metasequoia glyptostroboides* (dawn redwood) endemic to China and first described from fossils in 1941, with live plants discovered in 1944 and the species described as new in 1948. Dr. Diane M. Erwin evaluated the natural history event "this book is a wonderful tribute to the Redwood's discovery, their natural history, and the spirit of international scientific cooperation that transcended cultural and political boundaries - a spirit of international collaboration that today continues to enrich our understanding of this majestic group of conifers. Among the book's highlights, Momei Chen and her colleagues have successfully compiled one of the most accurate comprehensive historical accounts of the 'living fossil' dawn redwood (Metasequoia), from its initial description by the Japanese researcher Miki in 1941 as a fossil species, to Wang's remarkable discovery in 1943 of Metasequoia trees growing in China, to the formal description of the Chinese Metasequoia by Hu and Cheng in 1948. China represents the last native home of the dawn redwood and so this country's effort to help conserve these trees is loudly applauded and widely appreciated by botanists around the world. This book is printed in both Chinese and English and so is of especial value to

readers of these languages". Philologist Rudolf Schmid reviewed "I commend Momei Chen for updating these classic and rather obscure works and for making them readily available in both English and Chinese."

Watershed and Forest Restoration in the Headwaters Forest Reserve — Poster #6

David Fuller *and* ***David LaFever****, U.S. Bureau of Land Management Arcata Field Office, dfuller@ca.blm.gov*

Headwaters Forest Reserve is part of the National Landscape Conservation System managed by the Bureau of Land Management. It was acquired in 1999 and encompasses 7,472 acres. Roughly 3,000 acres are comprised of dense old-growth coastal redwood (*Sequoia sempervirens*) forest. Approximately 4,400 acres have been previously logged and roaded. Management goals of the Reserve include protection of this rare stand of old-growth redwoods, restoration of natural watershed processes, and re-growth of previously logged redwood forests to provide habitat for late-seral species.

Elevated sediment delivery rates to streams caused by past intensive forestry activities and naturally erosive geology have led to degraded habitat conditions for salmon and steelhead. The management plan proposes reducing erosion rates by removing the nearly 50 miles of road that existed in 1999. Since 2000, heavy equipment has been used to remove roads leaving the hillslopes in pre-road conditions and allowing for natural hydrologic expression of the landscape; stream crossings are fully excavated and road reaches are outsloped. As of 2010 over 18 miles of road were removed. Post-treatment monitoring has found minimal erosion.

The desired outcome of forest management involves restoration of old-growth characteristics in order to recreate high quality habitats in the Reserve for threatened and endangered species, and other biotic members of the ecosystem. Management prescriptions aim to accelerate rate of succession among forest seral stages, create continuity between old-growth and other seral stages as they advance successionally, and restore structural diversity of second-growth stands. Forest restoration activities in the Reserve include stem-density management (tree thinning) and replanting road removal sites. As of 2010, approximately 1,600 acres of second-growth forest stands have been thinned and 10 miles of decommissioned roads have been replanted with redwood seedlings.

The Fritz Wonder Plot – 80 Years of UC Forest Research — Poster #7

Gregory A. Giusti*, University of California Cooperative Extension, gagiusti@ucdavis.edu;* ***Daniel Porter****, The Nature Conservancy; and* ***Mathew Gerhardt****, The California Coastal Commission.*

Started in 1923 by Emmanuel Fritz, the "Wonder Plot" has been continually evaluated for growth and redwood stand ecological process on a decadal basis. It provides one of the longest datasets available for assessing the long-term progression of stand development in coast redwoods. This poster provides the latest decadal (2005) measurements and stand evaluation data. The data captures individual tree growth, or loss, and recruitment within a one-acre plot in which every tree is marked, measured and cataloged. The information demonstrates the ability of coast redwoods to grow and a continued, sustained rate for an extended period of time

A LIDAR and CIR Based Stratification To Reduce Inventory Costs and Improve Inventory Accuracy: A Case Study Application Using a Young Working Forest in Mendocino County — Poster #8

Jordon Golinkoff*, The Conservation Fund, jgolinkoff@conservationfund.org; Mark Hanus; Jennifer Carah, The Nature Conservancy*

The voluntary carbon market is a new and growing market that is increasingly important to consider in managing forestland. Monitoring, reporting, and verifying carbon stocks and fluxes at a project level is the single largest direct cost of a forest carbon offset project. There are now many methods for estimating forest stocks with high accuracy that use both Airborne Laser Scanning (ALS) and high-resolution optical remote sensing data. However, many of these methods are not appropriate for use under existing carbon offset standards and most have not been field tested. To bridge this implementation gap, a new method that meets the requirements of the Climate Action Reserve (CAR) Forest Project Protocol has been designed and applied to a verified and registered carbon project in California.

This approach meets the requirements of the CAR standard while reducing the costs of inventory and increasing the accuracy of estimates of carbon stocks and basal area. This method also applies a unique parametric and non-parametric application of ALS data to forest carbon estimation. The 3 goals of this paper are to

1. Present a novel method that has been successfully verified and registered at the project level and can be easily understood by land managers and verifiers.
2. Present a method that can determine the optimum grid cell size to aggregate remote sensing data and that can be used to find the minimum sample size need to meet given accuracy targets.
3. Explain how to leverage the inventory data collected in this way for future management, monitoring, and carbon verifications.

Coast Redwood Cone Collection 2009 - Vintage Year in Mendocino County — Poster #9

***Teri Griffis**, California Department of Forestry and Fire Protection, L.A. Moran Reforestation Center, teri.griffis@fire.ca.gov; **Brian Barrett**, California Department of Forestry and Fire Protection, Jackson Demonstration State Forest and Andy Armstrong, Mendocino Redwood Company*

The most significant coast redwood (*Sequoia sempervirens*) cone crop in nearly 25 years was produced in Mendocino County in 2009. Cone survey and collection efforts were coordinated by the CAL FIRE L.A. Moran Reforestation Center (LAMRC) in order to replenish the State Seed Bank and reserves. A partnership of five landowners and interested stakeholders contributed to these redwood collection efforts. The cone collection and processing efforts are presented as a case study including discussion of cone surveys and collection results at both Jackson Demonstration State Forest and Mendocino Redwood Company.

Coast Redwood is a sprouting species and significant cone crops are rare. It is not completely known what combination of factors aligned to produce the 2009 cone crop. Factors may have included weather patterns both short and long term, tree health and stress, and timing of pollination. Curiously many but not all of the trees with significant cone crops were located in or near burned areas from the 2008 Mendocino County lightning fires. In fact, the most productive cone collection area in 2009 was located within a burned area. However, it is beyond the scope of the case study to research whether cone productivity is correlated to proximity of burned areas.

The poster includes discussion of: the CAL FIRE cone survey and seed bank program, seed zones and elevation, criteria for tree selection, assessment of cones for seed ripeness and viability, cone collection and transport, seed extraction and testing, seed storage in the CAL FIRE Seed Bank, and the history of previous coast redwood cone collection efforts. Logistical problems will be described including the necessary removal of all plant parts, other than cones and seed, prior to transport from a quarantine county to the LAMRC site to comply with Sudden Oak Death (SOD) regulations. The clipping could not have been accomplished without the considerable contributions of CAL FIRE Conservation Camp crews and the cooperation of the California Department of Corrections and Rehabilitation.

Significant and viable cone crops are necessary to conduct an efficient cone collection operation. Approximately 320 bushels (8 gallons/bu) of cones were collected in 2009, resulting in over 800 pounds of coast redwood seed. The combined yield from three separate collections was approximately 2.5 pounds of seed per bushel of cones which is significantly higher than the historic average of 0.5 pounds of seed per bushel. The seed collected in 2009 are somewhat smaller than average for seed zones 094 and 095 with a weighted average of approximately 126,400 seed per pound. The average germination rate is 60% - a very good result. High quality seeds produce vigorous seedlings and have higher storage capability. The redwood seed produced from the 2009 collections will be stored at the CAL FIRE Seed Bank and used to grow an estimated 23 million seedlings that will be used in reforestation efforts for many years.

Coastal Redwood Forests: Plant Functional Responses to Fog, Drought, & Pathogens — Poster #10

***Sharifa M. Gulamhussein**, University of California, Santa Cruz, Environmental Studies, sgulamhu@ucsc.edu; **Dean F. Meason**, New Zealand Forest Research Institute Limited, Scion; **Gregory S. Gilbert**, University of California, Santa Cruz, Environmental Studies*

Recent climate studies suggest summer maritime fog frequency may decrease along California's coast. This will increase drought-stress and evaporative demand in redwood forest plants under hotter summer temperatures. Although fog is considered a vital factor for coast redwood forest growth and persistence, it is unclear how different plant species will respond to fog, drought-stress, and disease pressure. Notably, the impacts of seedling diseases could decrease with reduced fog, potentially increasing seedling survival. However, a combination of disease and drought-stress could reduce seedling physiological performance and contribute to higher mortality rates overtime. Few studies examine the interaction between drought-stress and pathogens on seedling growth and survival. In the case of redwood (*Sequoia sempervirens*), seedling establishment is usually very low due to high seedling mortality from pests and pathogens. This experiment examines the effect of bottom-up and top-down interactions on redwood seedling growth and survival in a controlled greenhouse setting. Future research will investigate multiple species interactions in the field.

Community Forestry - The RFFI Model — Poster #11

***Art Harwood**, Redwood Forest Foundation Inc., artharwood@hughes.net*

The Redwood Forest Foundation (RFFI), a not for profit organization, located in northern California's redwood region has a vision of the creation of self sustaining communities managing community-held assets with a focus on benefits to future generations--communities that give local residents both the opportunity and the responsibility to manage their natural resources effectively and to enjoy the benefits of that responsibility. Further, while RFFI is engaging residents in the control and sustainable management of their region's natural resources their work is also directed at having national and global impact. This unique partnership has launched an innovative approach to sustainable forestry that holds enormous promise for both the local and global community in terms of benefits to the environment, the economy and creating a replicable ownership model of social equity in forest management.

What sets RFFI apart from all of the other "community" efforts is the ability of RFFI to directly influence the direction of the forest and its impacts to the surrounding area. Most community efforts have always been constrained by trying to influence bureaucratic policy. Community input has been limited to having people trying to influence someone else's work, ideas or policies.

RFFI is not a project….it's a vision….an attempt to think about participatory forest management from the "inside out"…not the traditional way of "from the outside in".

Old Growth Restoration Plan for 107 Acre Redwood Headwaters in the Santa Cruz Mountains — Poster #12

***Aaron Hebert**, Sempervirens Fund, ahebert@sempervirens.org; Tom Roberts, Environmental Science Associates (ESA); **Dan Sicular**, Environmental Science Associates (ESA)*

Sempervirens Fund, a land trust dedicated to the preservation of redwoods in the Santa Cruz Mountains, purchased a 107-acre property in January 2010 from Redtree Properties, a local timber company. This property is located in the upper portions of the San Lorenzo River watershed at "Waterman Gap" and is within the boundary of Castle Rock State Park. After the restoration treatments are in place, Sempervirens plans to transfer ownership of the property to the California Department of Parks and Recreation.

The primary goal of this restoration plan is to identify, based on a thorough analysis of existing conditions, constraints, and opportunities, the specific actions Sempervirens can take to improve habitat and biodiversity and accelerate the transition of this property from a working forest to a forest preserve that will better encourage the development of old-growth processes and characteristics.

Our approach will begin by establishing and marking 48 1/5 acre plots that represent the stratification of tree vegetation types. Within these plots, we will collect information on slope and aspect, number of trees >12"dbh, diameter and height of trees, species composition, trees/ basal area per acre, size class distribution, snag density, size and decay class, large woody debris, size and decay class, presence of true old growth specimen trees, presence and size of large branching structures, existing property infrastructure, such as landings and skid trails. This information will be used to establish habitat polygons for the property.

The next part of the analysis focuses on the watershed and hydrologic function of the property. The watershed analysis will examine erosions sources, stream sedimentation, and stream channel conditions and stability, based on two separate surveys: an assessment of erosion features and stream sediment sources (sediment source analysis), and a geomorphic assessment of stream channel conditions (channel geomorphology analysis).

Both the forest inventory and the watershed analysis will inform the opportunities/constraints analysis. Using the plot-by-plot approach, Sempervirens will consider various treatments, including variable-density thinning, a silvicultural prescription that has been shown to promote some old-growth conditions in other selected second-growth coniferous forests of the Pacific Coast. Thinning in this sense differs from its silvicultural meaning, because it has little to do with commercial value, and might deliberately preserve trees with complex, 'unproductive' growth forms. This treatment will retain structure and species complexity while 'releasing' stands for accelerated growth. This acceleration of tree growth and re-establishment of ecosystem function (with, for example, large woody debris and repaired hydrology) should restore the forest over time to have old-growth processes and characteristics.

Forest Carnivore Surveys and Monitoring in Managed Industrial Timberlands — Poster #13

***Michael R. Holley**, Mendocino Redwood Company, mholley@mendoco.com; **Robert B. Douglas** and **Hayley H. Ross**, Mendocino Redwood Company*

More than a century of intense harvest in the redwood region has resulted in forests with few intact late seral or old growth stands. This is especially true in Mendocino County, where much of the old growth redwood occurs as scattered residual trees within younger stands. Loss of late seral forests, in addition to trapping for fur, may have led to the local extirpation of two species of forest carnivore, Pacific fisher (Martes pennanti) and Humboldt marten (Martes americana humboldtensis), from much of their historic ranges within the redwood region of Mendocino County. Few surveys, with the power to predict local densities for these species, have been conducted.

We completed systematic track plate and camera station surveys across the ownership of Mendocino Redwood Company in 2008, covering nearly 25% of the redwood forests of Mendocino County. We subsequently monitored select patches of late seral forest with cameras activated by infrared and motion sensors. We detected no fisher or marten in systematic surveys or at monitoring sites. At track plate stations, we detected one species of marsupial and 17 species of mammals, including 10 species of carnivores. At camera stations, we detected one marsupial species and six mammal species, including four carnivore species.

Track plate surveys produced baseline information on presence and distribution of common forest carnivores. Sentinel camera sites provided the flexibility to continue the search for rare species in suspected potential habitat, and to monitor use of remnant patches of later seral forest over longer periods of time. Continued monitoring and repeated systematic surveys can document when or if rare species re-colonize, while building larger data banks of occurrences of common species. Documenting and monitoring rare and common species can help inform regulators and land managers of current distributions and the possible effects of management on these species, and may provide additional tools for assessing forest and ecosystem health. We encourage other landowners and researchers within the redwood region to contribute to this effort by surveying fisher and marten using methods that collect physical vouchers.

Geomorphic Mapping of a Redwood-Forested Watershed — Poster #14

Kerri N Johnson, *University of California, Santa Cruz, KJohnson@es.ucsc.edu;* ***Noah Finnegan****, University of California, Santa Cruz;* ***Brian Dietterick****, California Polytechnic State University, San Luis Obispo*

Geology is the basis on which landforms, soils and ecosystems develop. But the way bedrock lithology influences geomorphic processes is not thoroughly understood. By mapping landforms which record surface processes such as landslides, debris flows and other mass wasting events and comparing these features with a geologic map, we hope to correlate and better understand how the underlying geology influences these surface processes.

Scotts Creek Watershed, north of Davenport, CA in the Santa Cruz Mountains, is an ideal place to study the relationships between the spatial distribution of lithology and surface processes for many reasons. Tributary subwatersheds with diverse lithology are found side by side providing the opportunity to focus on the influence of contrasting rock types while comparing areas with similar climate, tectonic, and management histories. Local historical knowledge of this area, other research associated with Cal Poly San Luis Obispo's Swanton Pacific Ranch and National Marine Fisheries salmonid habitat research provide valuable context for this geomorphic study.

A landslide inventory map was produced using high-quality LiDAR data from flights of the watershed in 2008 and 2010. The 2010 data were taken following the Lockheed incident wildfire which burned approximately 30 percent of the watershed and provided excellent bare earth data and a glimpse of the periodic nature of mass wasting in these types of systems. The map was verified with extensive field work and post-fire mass movement observations.

Future work with these data will continue to address questions of geomorphology's relationship with lithology in these complex redwood-forested watersheds. We hope this better understanding of the geomorphic processes at work in these types of landscapes will be useful to others when making management decisions or studying other aspects of watershed response to changing conditions.

Testing Approaches for Accelerating the Development of Late-Seral Forest Conditions in Redwood — Poster #15

Shannon D. Johnson*, Jackson Demonstration State Forest, California Department of Forestry and Fire Protection, Shannon.Johnson@fire.ca.gov;* ***Lynn A. Webb****, Jackson Demonstration State Forest, California Department of Forestry and Fire Protection.*

The setting for this study of acceleration of late-seral forest conditions is a 100 year-old, second-growth, mixed redwood (*Sequoia sempervirens*) stand at Jackson Demonstration State Forest, Fort Bragg, CA. This study was developed as a result of a legal settlement that occurred during the process of developing the Forest's management plan. The members of the Jackson Advisory Group (JAG) collaborated with CAL FIRE staff and others to frame additional guidance and desired outputs for this project. The JAG Camp Three report noted that late seral conditions are

"… part of the forest successional continuum that culminates in "old growth" or "climax forest", but is better described in terms of the elements of stand composition and crown structures of dominant trees. "Late seral" is best considered a condition of a stand, and not an individual tree."

This approach focused on developing structural characteristics that could help achieve acceleration of late seal conditions. The specific attributes recognized include; living trees, canopy conditions, snags, down logs and coarse woody debris.

The protocol in the JAG report anticipates testing to compare two silvicultural prescriptions and the no treatment area to determine the effectiveness of the results treatments for accelerating late seral forest conditions. Specific parameters the JAG identified include; stand cubic foot volume growth, the extent of accelerated growth of trees in the upper 50th to 80th percentile of tree diameter, stand diameter growth and stand diameter distribution.

Working within the framework set forth in the settlement agreement and the complex topography of the Camp Three area, three experimental blocks were designated. Treatments consisted of;

- no treatment block (158 acres),
- 30% basal area removal (block B - 51 acres)
- 45% basal area removal (block C - 51 acres).

Forty-five plots (15 permanent and 30 temporary) were established and surveyed pre-harvest for species, stand volume, stand structure, understory structure, abiotic factors as well as litter and duff. Harvest operations were completed in 2010. The first set of post-treatment data is scheduled to be collected in 2011.

The permanent plots are based on JDSF's existing Continuous Forest Inventory Protocol. Added to this protocol are measures to document understory vegetation and abiotic data. Infrastructure for future research opportunities are provided by the permanent plots. The study area will become the setting for a forest visitor trail that can provide demonstration and educational opportunities.

Redwood Decking - Carbon and Energy Performance — Poster #16

***Charlie Jourdain**, California Redwood Association, Charlie@calredwood.org; **Bob Mion**, California Redwood Association, **Mike Jani**, California Redwood Association,*

Choosing redwood decking over plastic composites or concrete alternatives makes use of a renewable resource and can significantly reduce carbon emissions. The energy to produce redwood comes mostly from the sun whereas the energy to produce composites and other alternatives comes from burning emission-spewing fossil fuels. Furthermore, redwood trees remove carbon dioxide from the air through photosynthesis as they grow and redwood decking stores much of that carbon safely out of the atmosphere for decades – a typical redwood deck can store more than a half-ton of carbon for years. This poster session will address the carbon cycle and how using wood products can reduce greenhouse gas emissions. The session will rely on Life Cycle Assessment data to compare the environmental impacts of redwood decking to alternative materials.

Resistance and Resilience to Fire in the Coast Redwood Forests of the Santa Cruz Mountains, California — Poster #17

***Rachel Lazzeri-Aerts**, Department of Environmental Studies, San Jose State University, rachel.lazzeri@gmail.com; **Will Russell, PhD**, Department of Environmental Studies, San Jose State University*

Fire plays a central role in determining structure, composition, and recruitment in many forest types. In coast redwood forests, the role of fire is not well understood, particularly in the southern part of the range. We collected data on survivorship and post fire regeneration in order to determine how *Sequoia sempervirens* responds to fire. Additionally, we were interested in how the coast redwood forests fare compared to adjacent forest types in terms of mortality and regeneration. We collected data using randomly selected ten meter diameter sample plots located on three sites in the Santa Cruz Mountains that experienced fire in 2008 or 2009. Data collected included mortality, tree height, DBH, scorch height, percent residual and regenerated canopy cover by species, and the number of basal spouts and seedlings by species, as well as environmental factors such as slope and aspect. Coast redwood trees had the lowest mortality levels, highest crown survival, and greatest regeneration. Overall, redwood basal sprouts and redwood seedlings far outnumbered those of associate tree species. However, there was high variability between sites. This variation may be attributed to differing soils, distance from the ocean, different land uses, or a combination of factors.

Estimating Site Index for Conifer and Mixed Conifer and Hardwood Stands Using LiDAR — Poster #18

***Lathrop P. Leonard**, California State Parks, lleonard@parks.ca.gov; **Daryl Van Dyke**, US Fish and Wildlife Service; **Quentin Stewart**, **Ryan Graves**, and **Andrew Goldman**, California State Parks*

We used multi-return light detecting and ranging (LiDAR) to develop a cost-effective method for describing forest conditions and prioritizing restoration treatments in over 20,000 hectares of second-growth forests (7-80 years old) in Del Norte Coast Redwoods State Park (DNCRSP) and Humboldt Redwoods State Park (HRSP). DNCRSP consists primarily of redwood and Douglas-fir dominated forests with scattered tanoak dominated stands. Species composition in DNCRSP has generally shifted towards Douglas-fir due to previous logging practices. The second-growth stands of HRSP are generally dominated by both Douglas-fir and tanoak with

varying amounts of redwood. Much of HRSP was unmanaged immediately after logging which has resulted in tanoaks dominating many sites where conifers were once abundant.

In 2009, we implemented a stratified sampling design to establish plots throughout the range of age classes and vegetation types within the property. A key step to building a model to predict forest metrics with LiDAR was to ensure that each fixed-radius ground plot was accurately represented by an extracted plot LiDAR point cloud cylinder. To accomplish this, we attempted to obtain sub-meter accuracy for all ground plot centers. We also established plots in locations that appeared to be relatively uniform so that any LiDAR point cloud cylinder extracted within two meters of the actual plot center would be similar.

Using Douglas-fir tree heights and stand age, we determined site index for each plot. We compared site index to descriptive statistics developed for the corresponding LiDAR point cloud cylinders to create regression relationships for predicting site index. The ability to develop regression equations for single species stands as compared to mixed species stands is explored.

Site index can be a used to determine the productivity of a stand. The most productive lands within the flight tended to be dominated by redwoods, moderate sites by Douglas-fir and the poorest sites with tanoak. By comparing site index to current species composition, we may be able to identify areas deficient in species present under pre-logging conditions. Knowledge of shifts in species composition can be a tool to identify restoration needs and prioritize treatments.

Predicting Soil C in Redwood Forest Soils with Quantitative Color Measurements

Poster #19

***Garrett C. Liles**, University of California Davis – Land Air and Water Resources, gcliles@ucdavis.edu; **Dylan E. Beaudette**, University of California Davis LAWR; **Joe Seney,** Redwood National and State Parks, **Mary Ann Madej**, USGS - Arcata and **William R. Horwath**, University of California Davis, LAWR.*

Redwood ecosystems are spatially limited but socially revered, economically productive and ecologically significant. These factors have driven recent efforts to quantify site C resources and the accumulation of C in forest stands, for C credits, to support conservation and land stewardship efforts. This process requires intensive plot level measurement by the landowner and external third party validation over time to achieve certification. Soil C is largely neglected across these intensive measurements even though soils are known to hold the largest stock of terrestrial C on Earth. Three factors generally limit efforts to accurately estimate site soil C resources: intrinsic variability within an expected range of values (large sample numbers are needed to generate estimates or models with suitably narrow confidence intervals), time (sample collection, processing and analysis) and cost (labor and analysis). Of these three factors, time and cost can be addressed with new approaches that generate predictive model relationships by relating surrogate or proxy measures to actual measured data.

Color has been employed as a diagnostic proxy to identify a variety of useful and important soil characteristics since humans began to cultivate soil. Early agriculture relied heavily on identifying dark C rich soils as places that were fertile for crop production. This principal of 'color as predictor' is the foundation of our research that employs quantitative measurements of soil color with reflectance spectroscopy to predict the C content of soil samples. Employing ~ 350 surface soil samples collected in Redwood National Park (RNP), we will create a predictive model relationship for soil on sandstone parent material that cross the range of mineral soil C contents found in Redwood forests (~ 10 - 100g/kg). We have existing models for soils under mixed conifer forests on granitic and volcanic parent materials in the Southern Cascade and Sierra Nevada mountains. These models have shown good linear model fit ($R^2 = 0.7 – 0.81$) for individual data sets of similar size (350-400 samples) and error estimates ranging between 10-20%. In spring (2011), additional samples collected from Redwood forests around Humboldt County, based on the range of climatic conditions and extensive soil series, will enhance our sample size and validate this model relationship as a robust predictive tool. This approach reduces hours of processing and analysis to a simple point and click measurement and will support spatially explicit sample collection and soil C estimation across a plot or stand at a fraction of the cost . The ability to map and monitor soil C could provide landowners additional revenue over the long term and expand our understanding of the C cycle in these unique forest ecosystems.

Post-fire Observations of Little Creek Watershed: Evaluation of Change in Sediment Production and Suspended Sediment Export — Poster #20

***Drew Loganbill**, Natural Resources Management Department, Cal Poly State University, San Luis Obispo/Swanton Pacific Ranch, dloganbill@gmail.com; **Brian Dietterick, Ph.D, P.H**., Swanton Pacific Ranch, Cal Poly State University*

The Little Creek study was initiated to document the watershed's response to selective timber harvest in the Santa Cruz Mountains by evaluating event-based suspended sediment export, sediment sources, and channel change. A 7-year calibration period was conducted using 3 monitoring stations providing for a paired and nested watershed study. The North Fork of Little Creek was harvested in 2008 and the post-timber harvest evaluation included one year with below average rainfall amounts. The Lockheed Fire occurred in August 2009, consuming 92% of the 500 hectare watershed, and subsequently changing the focus of the Little Creek study to determining the watershed's response to wildfire.

In order to assess response to wildfire in the Little Creek Watershed efforts were made to identify changes in event-based suspended sediment export, identify change in sediment production locations, and determine the influencing factors contributing to sediment production. Eight years of pre-fire event-based suspended sediment data from 3 monitoring stations were compared to the first year of post-fire data to identify changes in suspended sediment export. Sediment source surveys were performed to document near-stream sediment contributions dating back to 1998 and these observations along with data from sediment fences and field observations were used to identify change in sediment source areas. Multivariate analysis was used to determine the most influencing factors for sediment production using rainfall data from 6 gauges and streamflow data. Hydrophobicity tests, rainfall simulations, surface erosion plots, and site characteristics were used to further support the objectives of this study.

Watershed response to wildfire is not well documented in coastal redwood forests. Identifying changes in sediment sources and sediment transport provides essential information to landowners and regulatory agencies in understanding the risks of wildfire and for planning management activities in the Santa Cruz Mountains.

Economic Value of Soquel Demonstration State Forest — Poster #21

***Maria E. Milanes-Murcia**, California Department of Forestry and Fire Protection, Maria.Milanes-Murcia@fire.ca.gov; **Helge Eng**, California Department of Forestry and Fire Protection.*

Soquel Demonstration State Forest is located in the Santa Cruz Mountains along California's central coast. It includes the east branch of Soquel Creek, portions of Amaya Creek and Fern Gulch Creek. Among the different species, the Forest contains redwood, mixed hardwoods, and riparian ecosystems. The beauty of the coastal redwoods and the wildlife provide the public with an important value.

Soquel is unique because it is the only State Forest located near large urban areas. San Francisco and Monterey Bay Area provide large number of visitors to Soquel Demonstration State Forest. The Department of Forestry and Fire Protection manages the Forest. Visitors can enjoy hiking, bicycling, picnicking and horseback riding.

Aesthetic and recreation are economic value which provides large amount of income each year. An economic analysis shows how coastal redwoods are an important economic source for California.

Land Use Management: Soquel Creek Watershed in Soquel Demonstration State Forest — Poster #22

***Maria E. Milanes-Murcia**, California Department of Forestry and Fire Protection, Maria.Milanes-Murcia@fire.ca.gov; **Helge Eng**, California Department of Forestry and Fire Protection.*

Land use management provides information about the type of activities in the area, such as agriculture, recreation, grazing, or forestry. Knowledge regarding land use is crucial to develop future effective regional plans and to manage wildlife resources. Federal, State and Local agencies need information about land use and land cover to estimate water resource for the future and to analyze the possible action to restore forest and improve a specific area. Land use affects biological diversity in different ways, such as abundance, variety, and genetic structure of native animals and plants. A change in the land cover can provide a different habitat, which can increase or

decrease the variety of species. In addition, native species can lose available areas due to an incorrect change in land cover.

The loss of wildlife habitat has been a consequence of inappropriate changes in land use. Alteration in the number of forests across a landscape may show additions as croplands or rangelands. Also, inappropriate management of forests can cause fires and the destruction of wetlands. The Soquel Creek watershed is a good example of best forest land management practices. This watershed is managed in collaboration with government agencies and private landowners.

The analysis of land use and land cover owned by each agency and by private landowners provides information to efficiently manage Soquel State Demonstration Forest. The management of Soquel State Demonstration Forest in collaboration with other ownership shows the best land use practices management for the forest.

Spatial Clonal Patterns in Coast Redwood — Poster #23

***Lakshmi Narayan**, University of California Berkeley, lakshmi.narayan@berkeley.edu; **Kevin L. O'Hara**, University of California Berkeley*

Coast redwood is unique among conifers in its heavy reliance on natural clonal reproduction. This type of reproduction may lead to the dominance of a relatively small number of clones over a large area and the long-term persistence of these clones in redwood forests. Clonal reproduction benefits plants by allowing them to share resources, reduce their reliance on seeds for reproduction, and produce more offspring quickly in difficult environments. However, heavy reliance on clonal reproduction may also decrease genetic diversity in clonal stands, making it more difficult for clonal communities to adapt to rapidly changing environments, and also making them susceptible to the negative effects of inbreeding depression and genetic drift. Here, we study the spatial patterns of coast redwood clones on three one-hectare plots using six highly variable microsatellite loci. Although previous work has examined clonal patterns at small scales, this study will use more advanced methodology over larger scales to interpret clonal patterns. Understanding spatial patterns of coast redwood clones can give us insight into this species' reproductive ecology and indicate potential for adaptation to climate change. Results will also guide restoration and reforestation treatments that look to natural clonal patterns as a basis for reestablishing redwood clones. Additionally, we hope that the findings of this study will serve as a basis for future work on nutrient sharing between coast redwood clones.

Promoting Old Forest Features in Coast Redwood Forests Using Variable-Density Thinning — Poster #24

***Jonathan C. B. Nesmith**, Department of Environmental Science, Policy and Management, jnesmith@berkeley.edu; **Kevin L. O'Hara**, Department of Environmental Science, Policy and Management, University of California, Berkeley**; Lathrop P. Leonard**, California State Parks; **Daniel J. Porter**, The Nature Conservancy*

Restoring old forest features to second growth redwood stands has become a management objective in many areas throughout the redwood region of California. Variable-density thinning is management approach that can be used to accelerate the formation of old forest features through the development of heterogeneous spatial patterns and altered species abundance. In this study we tested the effectiveness of two variable density thinning treatments to promote old forest features in coast redwood forests in northern California. This study was conducted on Mill Creek property in Del Norte County, California. The experimental design consisted of three replicated blocks each containing a control, a low-density thin (125 trees/ha), and high-density thin (250 trees/ha). These thinning treatments represented a one-step vs. multi-step approach to achieve desired stand density.

Four years after thinning, target densities in both treatments surpassed target densities due to rapid ingrowth. Tree density in the control had declined due to self thinning. In all treatments, residual tree size had increased. Stem volume increased by 124% in the low-density thin, by 107 % in the high density thin, and by 72 % in the control plots. Species composition in the thinning treatments also shifted towards a higher proportion of redwood. Black bears have been noted as a possible obstacle to forest restoration and management in north coastal California. We found significant differences in the occurrence of bear damage among treatments and species preference with bears favoring the low-density thins and redwoods, respectively. While bear damage was rarely severe enough to

kill trees outright, it could alter future growth and structure of the stand. Both variable density thinning prescriptions achieved the management objectives of increasing tree size and structural heterogeneity and, if free from bear damage will acquire old forest features at an accelerated rate compared to unthinned stands. Bear damage appears to be a significant factor in stand development that is still poorly understood and may be an important consideration when comparing treatment options where bear activity is high.

Assessment of Post-Fire Rill Erosion Using Soil Physical Properties to Determine Factors Controlling Surface Runoff — Poster #25

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The Lockheed Fire occurred in late August 2009, burning 7,819 acres of the coastal mountains north of Santa Cruz, California. The fire burned a large portion of the Scotts Creek watershed, including over 90% of the Little Creek watershed, much of which is on Cal Poly's Swanton Pacific Ranch (SPR). After intense rains in late January and February of 2010 there was a significant amount of sediment deposited on the roads and in the creek. A large portion of this material was derived from hillslopes, where rill erosion had occurred. The purpose of this study is to determine what factors control the volume of surface runoff produced from soils on two burned hillslopes. Saturated hydraulic conductivity, surface infiltration, and particle size class were assessed to determine how the impacts of the fire affect the soil physical properties.

In order to address this goal, the soil physical properties were characterized on two hillslopes influenced by three different types of parent material: Santa Cruz mudstone, Santa Cruzmudstone colluvium, and a Santa Margarita sandstone and Santa Cruz mudstone colluvium. Thestudy, consists of eleven transects and three sampling points at 30, 60 and 90 ft, on 45-80%southeastern facing slopes. The vegetation consists of a knobcone pine chaparral mix then transitions down slope to a chaparral mix. The results of the assessment will be used to determine what factors and characteristics contribute to rill erosion on these two hillslopes.

Insights into the Vegetational Development of Headwaters Reserve — Poster #26

***Steve Norman**, USDA Forest Service Eastern Forest Environmental Threat Assessment Center, stevenorman@fs.fed.us; **Greg Jennings**, Bureau of Land Management, Arcata Field Office*

Fire and wind have long contributed to the development of forest composition and structure on the north coast, yet integrated studies of historical age structure and disturbance are rare. By itself, information on historical fire intervals is of little use if it is not linked to an expectation of the effects of prescribed fire and wildfire after fire exclusion. Similarly, vegetational data are of limited value if the unique processes that gave rise to forests are not appreciated. This research describes the vegetation patterns, disturbance history and partial establishment history of old growth forests within the Headwaters Reserve, Humboldt County, California.

Vegetation patterns were established based on an analysis of hundreds of gridded old growth plots that were established as part of the purchase of this property in the 1990s. Fire history was documented with stump cross sections cut along a coast-interior gradient. Fire history, wind effects and Douglas fir regeneration history were assessed by tree coring.

Results show a complex pattern of moderately frequent disturbance that helps explain the pattern and frequency of Douglas fir in this forest. Douglas fir readily establish after fire, and long-term fire exclusion may eventually reduce the importance of this species, both as a sub-dominant within redwood-dominated stands and as a colonizer of small patches caused by localized high severity fire. Tree ring data suggest that wind disturbance is associated with more coastal positions, while vegetational composition and tree ring data suggest that human or lightning fires had a dominant impact toward the interior. These past disturbances and disturbance effects provide insight into possible desired future conditions, restoration strategies, and risks associated with fire exclusion. Managers have and will continue to have a lasting influence on the forest structure and composition of this reserve.

Increased Tree Survival with August Plantings — Poster #27

***Joseph Paternoster**, DriWater, Inc., driwater@driwater.com*

Native vegetation evolves to survive and flourish with local climates, soil types, and ecosystems. Traditionally planting projects have been done in early winter to take advantage of the rainy season.

While late fall/early winter planting can provide the plants the water needed to survive the winter, it does not enable substantial root growth needed for long term survival and environmental improvement. Planting trees that are dormant or near dormant late in the season does not create optimum rooting conditions.

Planting trees in August can provide an adequate timeline to allow roots to push growth for a few months before the plants become dormant. The challenge is providing cost effective irrigation from August until the rainy season around November. In our study, root mass had the greatest overall increase in August.

Our testing shows that the rooting from August to November can provide increased ability to uptake water as nutrients over traditional methods. Our testing data indicates a 69% average increase in root mass. Increased survival rates along with the improved root mass, reduces the need for long term irrigation.

Geomorphic Change in a Small Coastal Tributary with Repeated Channel Surveys — Poster #28

***Drew Perkins**, Natural Resources Management Department Cal Poly San Luis Obispo/Swanton Pacific Ranch, drew.a.perkins@gmail.com **Brian Dietterick, Ph.D, P.H.**, Swanton Pacific Ranch, Cal Poly State University*

Six geomorphic study reaches were established in 2002 along a forested mountain stream on Cal Poly's Swanton Pacific Ranch in Santa Cruz County. These study reaches are a component of paired and nested watershed studies in the approximately 500 hectare Little Creek watershed.

The overall goal of this study was to monitor water quality and channel conditions before, during, and after a selective harvest of redwood in the Southern-Subdistrict of the Coast District. A selective harvest occurred in the North Fork of Little Creek in Summer 2008. In August 2009, approximately 90% of the Little Creek Watershed was burned in the Lockheed Incident wildfire.

Channel change was evaluated by measuring ground profiles using traditional survey methods. Cross section and longitudinal profiles are surveyed annually every summer in the six study reaches. Change is assessed through visual evaluation of cross sections and profiles, and analysis of bed elevation and area change data. Changes in the channel during this time have been relatively small and are typically associated with movement or introduction of coarse woody debris to the stream channel. However, during the study period no large stormflows occurred (return interval at the closest USGS gaging station does not exceed 5 years). Historically, large debris flow events have occurred in this watershed, with well documented events in 1955 and 1998. The survey data is an important tool for understanding change detection in channel characteristics before and after harvesting, and following fire disturbance.

Ferns Exhibit High Resistance to Drought-Induced Cavitation in the Coast Redwood Forest — Poster #29

***Christopher Rico**, Department of Ecology and Evolutionary Biology, University of California, Santa Cruz, CA, crico@ucsc.edu; **Emily Limm**, Save the Redwoods League; **Jarmila Pittermann**, Department of Ecology and Evolutionary Biology, University of California, Santa Cruz, CA*

Ferns in the southern range of the coast redwood forest ecosystem experience greater climatic drought conditions every year due to less rainfall and higher evapotranspiration. We hypothesized that ferns from drier forests would therefore exhibit reduced vulnerability to drought-induced cavitation and maintain higher hydraulic conductivity when seasonal leaf water potential declines relative to ferns from wetter forests.

During midsummer 2010, we measured the midday leaf water potential in the field, frond allometry, and stipe (frond base) vulnerability to cavitation curves in the laboratory of four dominant fern species in three forests

locations along the north-south gradient of the redwood forest ecosystem. We sample two evergreen ferns, *Polystichum munitum* (Western sword fern) and *Woodwardia fimbriata* (giant chain fern), and two deciduous ferns, *Pteridium aquilinum* (bracken fern) and *Adiantum aleuticum* (five-finger fern). We found that all four ferns species maintained high leaf water potential between -0.18 and -1.0MPa during midsummer, the time of year when evapotranspiration is highest and rainfall is lowest. Frond length and surface area increased slightly in ferns sampled from more northern sites for all species expect *W. fimbriata* which exhibited greater frond length and area in the south. There were no significant intraspecific differences in vulnerability to cavitation evident in any of the species. However, the evergreen ferns exhibited higher resistance to cavitation (*P. munitum* P50= -6.5 ± 2.3 SD; *W. fimbriata* P50= -6.1 ± 1.1 SD) than the deciduous ferns (*A. aleuticum* P50= -6.5 ± 2.3 SD; *P. aquilinum* P50= -6.5 ± 2.3 SD).

Our results suggest that redwood forest ferns maintain high water status despite their large leaf surface area that promotes high transpiration during midsummer drought conditions. In many southern ferns, reduced leaf area may help reduce water loss. Evergreen ferns exhibit greater resistance to cavitation (more negative P50 values) likely because their xylem must supply water to the fronds year-round even if drought is intense, while the deciduous frond can shed their fronds when water availability drops and hydraulic conductivity decreases. Both drought tolerance strategies will promote fern survival in the redwood forest as drought conditions intensify with climate change.

Stream Bug Diversity Suggests Sustainable Timber Management Can Protect Aquatic Life — Poster #30

***Larry Serpa**, The Nature Conservancy, lserpa@tnc.org*

The Garcia River watershed in coastal California was intensively logged between 1950 and 1980, severely impacting aquatic communities. Over the last two decades, a major effort has been underway by conservation partners in the Garcia watershed including landowners, community activists, non-profits and regulators to restore the health of the Garcia watershed through sustainable timber management and responsible land stewardship. A third of the watershed (23,780 acres) was purchased in 2004 by the Conservation Fund, in partnership with State Coastal Conservancy, the Wildlife Conservation Board, and The Nature Conservancy. The Conservation Fund manages the property for sustainable timber harvest and biodiversity protection and enhancement. The site is further protected by a conservation easement held by The Nature Conservancy. Aquatic insects are excellent indicators of water quality, and their habitats on the property were sampled intensively for over three years. The 59,103 animals identified showed that at least 490 species of aquatic macroinvertebrates were present, a larger number of species than is known for any other site in California. This clearly shows that sustainable timber harvest really can protect aquatic life.

Forest Regeneration on Decommissioned Roads in Redwood (*Sequoia sempervirens*) Forest Ecosystems in the Headwaters Forest Reserve — Poster #31

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One of the primary management objectives in the Headwaters Forest Reserve has been to accelerate the recovery of disturbed forest environments (logging roads and timber harvests) in order to improve forest and aquatic habitat conditions. In order to achieve this goal, the Bureau of Land Management (BLM) has been decommissioning logging roads since 2000 and replanting redwood (*Sequoia sempervirens*) seedlings since 2003 in an effort to enhance the successional recovery of these disturbed sites. However, no evaluation on the efficacy of these replanting efforts has been conducted. Our objective was to quantify the relative abundance of tree species regenerating on decommissioned roads in old-growth and second-growth redwood forest ecosystems within the Reserve. Our sampling design followed a stratified-random approach in which we sampled 43 belt transects along decommissioned road sections stratified by forest type and replanting year. We quantified our results by forest type, replanted/non-replanted, biophysical setting, and time since replanting to evaluate the relative abundance of each species in relation to environmental variables. Three tree species, Douglas-fir

(*Pseudotsuga menziesii*), redwood and alder (*Alnus rubra*) were common across all environments, in order of decreasing abundance. Along decommissioned roads, there were significantly higher numbers of redwood and Douglas-fir seedlings and saplings in replanted old-growth stands compared to non-replanted (old-growth or second-growth) stands. Across replanted roads, we also found significantly higher numbers of Douglas-fir seedlings and saplings in old-growth stands compared to second-growth stands. In contrast, comparing these same stands there were slightly fewer redwood and alder seedlings and saplings in old-growth stands. In non-replanted second-growth stands, alder abundance was substantially higher in comparison to other locations, whereas the abundance of Douglas-fir was lower and redwood was similar. Our preliminary findings indicate that replanting of redwood seedlings promotes higher abundance along decommissioned roads compared to non-replanted roads as would be expected, particularly in old-growth stands. Douglas-fir regeneration was high across forest types and replanting years, which suggests that Douglas-fir will be a dominant component of future stands. Results of this project will support long-term adaptive management and on-going planning in the Reserve by providing important information on the success of management actions.

A New Technique for Planting Redwoods on Severely Degraded Sites — Poster #32

***Steven Singer**, Steven Singer Environmental and Ecological Services, SWSingerMS@aol.com; **Suzanne Schettler**, Greening Associates and Aaron Hebert, the Sempervirens Fund*

We planted Coast Redwood (*Sequoia sempervirens*) and Douglas-fir (*Pseudotsuga menziesii*) on a one-half acre building demolition site in the Santa Cruz Mountains that had previously been subjected to cut-and-fill grading. Most areas of the site lacked any of the original soil and had a planting substrate that consisted of pulverized sandstone and construction rubble. This "urban soil" was compacted and was deficient in organic matter and nutrients.

We planted 30 redwood seedlings and 20 Douglas-fir seedlings, grown from seed collected locally, in pairs six feet (1.82 m) apart in loosened soil. Fertilizer and forest soil mycorrhizal inoculum were added to each planting hole. Since the urban soil was unsuitable for tree growth, we augmented normal planting techniques by creating pockets of nutrients and organic amendments within reach of the expanding root systems of planted trees. Except for controls, each pair shared a 2.0 cubic foot (0.056 cubic meter) resource pocket that we placed midway between the two trees. The resource pocket consisted primarily of organic compost but with a layer of cottonseed meal (0.97 kg) below, and below that a layer of biochar (0.82 kg).

To encourage development of a normal forest litter layer, which is crucial for building fertile forest soil, we relocated a one-inch (2.54 cm) layer of redwood forest litter collected from the adjacent undisturbed forest around each redwood seedling in an 18-inch (45.7 cm) radius circle. To restore organic matter to the soil and provide a food source for fungi, we also used wood straw as surface mulch. The wood straw was placed in an 18-inch (45.7 cm) wide doughnut ring around the litter layer mulch. Douglas-fir seedlings were also centered within a 36-inch (91.4 cm) radius mulch circle, but it was composed entirely of wood straw (0.1 bale).

The main innovation of our treatment was to create nutrient resource pockets in the soil. An additional innovative measure that we used was to add biochar to the planting hole and surrounding soil. Biochar is a type of charcoal made by pyrolysis. This process does not release carbon dioxide, but instead locks up almost all the carbon in the biochar. Biochar has been shown to dramatically increase some types of plant growth while sequestering carbon in the soil. About 0.8 lbs (360 g) of biochar was mixed into the loosened soil around the planting hole, and lbs (45.4 g) were added as a layer in the bottom of the planting hole. To test the effectiveness of the innovative treatment (nutrient resource pockets plus biochar) we created a control group of 10 trees. Each year we will record survival, height, and vigor of all planted trees and hope to be able to determine the effectiveness of our treatments in 4 – 5 years.

This project was funded by the Sempervirens Fund, a non-profit 501(c)(3) organization whose mission is to protect and permanently preserve redwood (*Sequoia sempervirens*) forests, wildlife habitat, watersheds, and other important natural and scenic features of California's Santa Cruz Mountains, and to encourage public appreciation and enjoyment of this environment.

Exploring Water Conservation through *There's No New Water!* Youth Curriculum

Poster #33

***Martin Smith**, University of California, Davis Veterinary Medicine Extension, UC Davis, mhsmith@ucdavis.edu; **Steven Worker**, University of California 4-H Youth Development Program*

Managing water resources is a critical 21st century global environmental issue (Brown & Flavin, 1999). Clean, available water is critical for life on the planet and needs to be managed carefully to ensure adequate supplies for the ecosystem and human consumption. Supported by the University of California's Division of Agriculture and Natural Resources (UC-ANR) strategic Initiative to Improve Water Quality, Quantity, and Security, UC is committed to extending scientific knowledge to California communities for water management education (Regents of the University of California, 2009).

Youth science literacy also represents a critical national issue. Assessments over the past two decades have indicated low levels of science literacy among school-age youth (Baldi, et al. 2007; Gonzales, et al. 2008; Grigg, Lauko, & Brockway 2006). These assessments have implications for individual's success in the 21st century along with concerns about American's long term economic prosperity and national security.

UC-ANR has made a commitment to target improved science literacy among California's youth. In connection with the Initiative to Increase Youth Science Literacy in Natural Resources, Agriculture, and Nutrition outlined in the UC-ANR's Strategic Vision 2025 (Regents of the University of California, 2009), the California 4-H Youth Development Program developed and tested a curriculum focused on water conservation and quality that targets science and environmental literacy for high-school-aged youth.

The There's No New Water! curriculum is based on the idea that water is a finite natural resource whose quantity and quality must be responsibly preserved, protected, used, and reused. Pedagogically, the curriculum is framed around effective educational methods – experiential learning and inquiry. With respect to content, the curriculum begins with an exploration of the natural water cycle; explores human impacts on water quality and quantity; examines the effects of the urban/rural interface; and includes service-learning projects that address local water issues.

An outcome evaluation was conducted in spring 2010 at two high schools. Students (n=65; ages 14-17; 57% female) participated through an Earth Science class or afterschool science club. UC Davis undergraduate students facilitated curriculum activities once per week for eight weeks. Data on content knowledge and life skills acquisition were collected using a retrospective survey that employed Likert scale questions. Paired t-test comparisons revealed improved content knowledge understanding relative to all questions ($p \leq 0.0002$). Most youth reported "some" or "a lot" of improvement on a majority of the life skill questions.

The outcome evaluation results are positive and suggest that the There's No New Water! curriculum could be useful for Extension outreach and education programming with youth.

Monitoring the Recovery of Stream Habitat and Salmonid Populations Within the Little North Fork Navarro River.

Poster #34

***David Ulrich**, Mendocino Redwood Company LLC, dulrich@mendoco.com; **Christopher Morris**, Mendocino Redwood Company LLC*

The Little North Fork Navarro River watershed is approximately 7082 acres, of which, Mendocino Redwood Company (MRC) currently owns and manages 6456 acres (91%). Over the last century this watershed has been heavily logged and managed as industrial timberland. Previous management practices included the construction of stream side roads, Humboldt crossings, and in-stream landings; all have contributed to the degradation of stream health. A top priority in MRC's management philosophy is to restore watersheds similar to the Little North Fork Navarro River back to a functional and healthy condition. Initial efforts to restore the watershed have included 3.5 miles of decommissioned streamside road, the removal of 10 stream crossings, and the control of over 30,000 yards of stored sediment. An additional 4.1 miles of streamside road and 37 crossings are planned to be decommissioned in late 2012. In addition to the road work, future restoration efforts will also focus on in-stream work such as adding large woody debris (LWD) and other structures where needed throughout the watershed.

In order to evaluate the recovery of this watershed, MRC will continue to monitor salmonid populations and the physical habitat conditions within the streams.

Over a decade of salmonid distribution data collection demonstrates that both steelhead and coho salmon are commonly present throughout the watershed. For the past five years, MRC has operated an out-migrant trap in the Little North Navarro River. Annual population estimates for coho salmon (*Onchorhynchus kisutch*) range from 64 to 1278 and steelhead (*O. mykiss*) population estimates range from 641 to 2462. Salmonid adult escapement surveys conducted the last three years show highly variable yearly returns ranging from 0 to 13 coho redds and 6 to 24 steelhead redds. Stream temperature has been monitored at 8 sites within the watershed for as long as 16 years, resulting MWATs (maximum weekly average temperature) have ranged from 20.6° C to 12.7° C. Stream habitat surveys conducted establishing baseline conditions include cross-sections, thalweg profiles, large woody debris counts, stream bed permeability, bulk gravel samples, and forest canopy measurements.

This data will be used to evaluate present stream conditions; however continual data collection is required to determine trends and recovery of stream habitat and salmonid populations. MRC has proposed a Habitat Conservation Plan (HCP) / California Natural Community Conservation Plan (NCCP) that includes heightened restoration goals and 80 years of monitoring. Under the HCP/NCCP our monitoring efforts would also expand to include continuous turbidity and suspended sediment monitoring. With more restoration and monitoring planned for the future, we hope that the knowledge gained from this project will assist in the recovery of similar watersheds.

Explicit Feature Modeling of Habitat Structures in Coast Redwood Forest — Poster #35

***Daryl Van Dyke**, USFWS - Klamath Strategic Habitat Conservation, daryl_van_dyke@fws.gov*

LiDAR provides a three-dimensional point cloud from which features can be identified. A separate body of work presented at this conference demonstrates the power of a statistical approach to landscape characterization. A complementary body of work allows for the identification, characterization, classification, and networking of explicit features of the forest. This work is designed to inform our understanding of forest structure in old-growth conditions, help guide second growth restoration to accelerate late-seral characteristic, and identify habitat features for species.

Suspended sediment loads in the South Fork of the Albion River, Mendocino County, California — Poster #36

***Kirk P. Vodopals**, Mendocino Redwood Company, kvodopals@mendoco.com*

Mendocino Redwood Company (MRC) collected continuous turbidity and suspended sediment data on the South Fork of the Albion River for the 2008, 2009 and 2010 hydrologic years. The goals of this data collection effort are a) to estimate suspended sediment annual loads and determine concentration-duration thresholds of suspended sediment and turbidity, b) discuss the potential impacts to aquatic species and c) make comparisons with similar data collection stations such as the Caspar Creek Experimental Watershed.

The South Fork of the Albion River is located in coastal Mendocino County and drains approximately 2360 hectares (23.6 km2), of which MRC owns roughly 80%. The primary land use within this watershed is timber production, predominately redwood and Douglas fir. Average annual precipitation in this area is approximately 1016 mm per year and maximum elevations are around 183 meters above sea level. Headwaters of the watershed are approximately 19 kilometers from the coast. Geologically, the Albion River lies within the Coastal Belt of the Franciscan Complex with rocks primarily composed of a sequence of slightly metamorphosed, interbedded, arkosic sandstone and interbedded siltstone and shale with minor pebble conglomerate and greenstone.

Preliminary results of the HY2008 data sets of turbidity, suspended sediment and hydrology in South Fork Albion indicate annual sediment loads on the order of 542,000 kg and a load per area of 230 kg/ha. The Caspar Creek Experimental Watershed, located 16 km northwest of the Albion River, has annual load estimates of suspended sediment for both North Fork Caspar Creek (473 hectares) and South Fork Caspar Creek (424 hectares). Preliminary results of similar HY2008 data sets in North Fork Caspar Creek indicated sediment loads of 139,724

kg (295 kg/ha) and 234,830 kg (554 kg/ha) in South Fork Caspar Creek. Total rainfall in HY2008 was 732 mm in the Albion watershed and 1006 mm in the Caspar Creek watershed.

Typically, watershed size is positively associated to unit area sediment loads. Potential explanations for these contrary observations could be a) geological and topographical characteristics, b) differences in land management activities and/or c) sediment sinks upstream of the gauging station in South Fork Albion.

Preliminary results of the HY2009 data sets in South Fork Albion indicate an annual load of approximately 35,000 kg (15 kg/ha). Rainfall in HY2009 was 752 mm, but precipitation intensity for each storm was much lower than in HY2008.

Results were currently unavailable neither for concentration-duration thresholds nor for annual loads of HY2010 in South Fork Albion or HY2009 and HY2010 for Caspar Creek.

Observations and Effects of a 2008 Lightning Fire in Coast Redwood at Jackson Demonstration State Forest

Poster #37

Lynn A. Webb and Brian G. Barrett, *Jackson Demonstration State Forest, Department of Forestry and Fire Protection lynn.webb@fire.ca.gov*

The June 2008 lightning event resulted in 129 fires in the Mendocino County State Response Area. All available fire fighting resources were utilized. Fire suppression was prioritized based on fire location and risk. The 2,096 acre Indian Fire on Jackson Demonstration State Forest was monitored for seven days prior to starting active suppression. Typically, wildfires in managed redwood forests are aggressively suppressed. JDSF Staff documented fire behavior and progression.

Monitoring of fire effects was carried out in 2008 and 2010, utilizing the limited number of existing Continuous Forest Inventory (CFI) growth plots within the fire area. In addition to the CFI stand structure data, understory vegetation, individual tree damage and sprouting as well as downed woody material were measured. The extent of canopy loss has been mapped as well.

The fire behavior in June, 2008 was relatively moderate. The fire was primarily limited to the understory with occasional upslope runs and crown scorching. A small percentage of the fire area experienced fire behavior that has resulted in canopy openings. Valuable observations of daily fire behavior by Forest Manager Marc Jameson (CAL FIRE, retired) are utilized.

The CFI plot data provided an interesting initial observation that individual redwood diameters at breast height were measurably smaller post fire as a result of bark consumption.

Wildfires in redwood forests are not as well documented as other California forest types. Although the Indian Fire is a case study, the information will be useful for individuals planning management and restoration activities as well as evaluating wildfire risks in the coast redwood forest type.

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