The 8th California Oak Symposium

Sustaining Oak Woodlands Under Current and Future Conditions

October 31-November 3, 2022
Embassy Suites, San Luis Obispo
San Luis Obispo, California

Presented by

University of California Division of Agriculture and Natural Resources

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

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FOR MORE INFORMATION

PROGRAM CONTENT

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CONFERENCE REGISTRATION, LOGISTICS AND FACILITIES

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UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

PURPOSE AND OBJECTIVE

This will be the eighth symposium on oaks in California. The previous conferences, held in 1979, 1986, 1990, 1996, 2001, 2006, and 2014 serve as rich sources of information about a wide range of subjects on oak ecology, management, uses, planning and conservation. This 2022 symposium is intended for anyone involved in research, education, management, and conservation of California's oak woodlands. This includes foresters, range managers, tribes, arborists, community groups, land trusts, and policy makers.

STEERING COMMITTEE MEMBERS

Co-Chairs:
Bill Tietje, Dept. of ESPM, UC Berkeley, located in UC Cooperative Extension, San Luis Obispo County
Jessica Wright, USFS Pacific Southwest Research Station

Committee Members:
Royce Larsen, UC ANR Cooperative Extension
Devii Rao, UC ANR Cooperative Extension
Matthew Shapero, UC ANR Cooperative Extension
Claudia Tyler, UC Santa Barbara

PROGRAM OF EVENTS

Tour Day — **Monday October 31**

7:30 AM – **Tour Registration**
8:30 AM – **Field Tours Depart from Embassy Suites**
5:00 PM – **Field Tours Return to Embassy Suites**

Tuesday November 1

7:00 AM Registration and Continental Breakfast, *Ballroom Foyer*

San Luis Obispo Ballroom

7:45 **Welcome**—Bill Tietje, Symposium Co-Chair, Cooperative Extension, San Luis Obispo County, Dept. of Environmental, Science, Policy and Management, UC Berkeley

7:55 **Opening Remarks**—Senator John Laird, District 17
Introduced by Chris Greer, Extension Advisor and Acting Director of Cooperative Extension, San Luis Obispo

Plenary Session I – Climate Change: Challenges & Prospects for Sustaining California Oak Woodland
Moderator: Paul Starrs, University of Nevada, Reno

8:10	**Keynote Address** **Setting the Tone: An Overview of Climate Change and Oaks**—David Ackerly, Dean and Professor, Rausser College of Natural Resources, UC Berkeley
8:35	**The Past: What Blue Oak Tree Ring Analysis Tells Us About California Climate and Ancient Oak Woodlands**—David Stahle, Distinguished Professor, Dept. of Geosciences, University of Arkansas
9:00	**The Present**: **Multiple Stressors Create an Inflection Point for Oak Sustainability**—Ted Swiecki, Principal Plant Pathologist, Phytosphere Research; Elizabeth Bernhardt, Principal Plant Pathologist, Phytosphere Research
9:25	**The Future: The Uncertain Future of California's Oak Woodlands**—Frank Davis, Distinguished Professor, Bren School of Environmental Science and Management, UC Santa Barbara
9:50	**Q&A Session**
10:00	**Break,** *Foyer*
10:30-12:00 PM	**Concurrent Session 1** (4 presentations of 20 minutes each) Session 1A: Climate Change I, *SLO Ballroom* Session 1B: Status of Oaks, *Edna* Session 1C: Regeneration/Restoration, *Los Osos*
12:00 PM	**Lunch,** *Atrium*

Plenary Session II – Climate Change: Challenges & Prospects for Managing Privately-Owned Oak Woodland
Moderator: Chris Dicus, Cal Poly San Luis Obispo

1:30	**21st Century Management Strategies for Managing California Oak Populations**—Victoria Sork, Life Sciences Division Dean and Professor, Dept. of Ecology & Evolutionary Biology, University of California, Los Angeles
1:55	**Past, Present, and Future Fire Regimes in California Oak Communities**—Jon Keeley, Senior Research Scientist, Western Ecological Research Center, Sequoia-Kings Canyon Field Station, US Geological Survey and Dept. of Ecology and Evolutionary Biology, UC Los Angeles
2:20	**The Influence of Climate Change on Oak Pests and Pathogens**—Richard Cobb, Dept. of Natural Resources Management & Environmental Sciences, Cal Poly San Luis Obispo
2:45	**Climate Change and the Management of California Oaks in the Urban Environment**—Igor Lacan, Bay Area Environmental Horticulture and Urban Forestry Advisor, UC Cooperative Extension, San Mateo-San Francisco Counties

3:10	**Q&A Session**
3:30	**Break,** *Foyer*
	Concurrent Session 2 (4 presentations of 20 minutes each) Session 2A: Climate Change II, *SLO Ballroom* Session 2B: Rangelands: Assessment & Management, *Edna* Session 2C: Oak Pests and Diseases, *Los Osos*
5:30-8:00 PM	Poster Session and Strolling Dinner*, SLO Ballroom South* *Music by Justin Ralls – Tree Ride*

Wednesday November 2

7:00 AM	**Continental Breakfast**, *Foyer*
8:00	**Concurrent Session 3** (5 presentations of 20 minutes each) Session 3A (Special Topic Panel): Education, Outreach, & Engagement: Lessons from the Field, *SLO Ballroom* Session 3B: Oak Ecology & Conservation, *Edna* Session 3C: Wildlife Ecology & Conservation, *Los Osos*
10:00	**Break,** *Foyer*
10:30	**Concurrent Session 4** (4 presentations of 20 minutes each) Session 4A: Climate Change III, *SLO Ballroom* Session 4B: Fire I, *Edna* Session 4C: Sustaining Working Landscapes, *Los Osos*
12:00 PM	**Lunch,** *Atrium*
1:30	**Concurrent Session 5** (4 presentations of 20 minutes each) Session 5A (Special Topic Panel): New Technologies, *SLO Ballroom* Session 5B: Northern California Regeneration/Restoration Projects, *Edna*
3:00	**Break,** *Foyer*
3:30	**Concurrent Session 6** (4 presentations of 20 minutes each) Session 6A: Fire II, *SLO Ballroom* Session 6B: Oak Adaptation & Resilience, *Edna* Session 6C: Sustaining Oak Woodland Resources, *Los Osos*
5:30	*By RSVP Only* – GCCO/SDZWA Workshop and Networking Meeting

Thursday November 3

7:00 AM **Continental Breakfast**, *Foyer*

San Luis Obispo Ballroom

Plenary Session III – Maintaining & Managing California's Working Landscapes
Moderator: Leslie Roche, UC ANR Cooperative Extension Specialist, Dept. of Plant Sciences, UC Davis

8:00 **California's Working Oak Woodlands in a Changing Environment: Keeping Carbon in the Bank**—Lynn Huntsinger, Professor, Rangeland Ecology and Management; Russell L. Rustici Chair in Rangeland Management, UC Berkeley

8:30 **Adapting Ranch Management to Prolonged Drought and Changing Plant Species Composition**—Royce Larson, Area Natural Resource/Water Advisor, UC Cooperative Extension, San Luis Obispo, Monterey and Santa Barbara Counties

9:00 **Working Lands for Conservation: A Vital Step for 30x30**—Adina Merenlender, UC ANR Cooperative Extension Specialist and Adjunct Professor, Dept. of Environmental, Science, Policy and Management, UC Berkeley and UC ANR Hopland Research & Extension Center

9:30 **Why Keeping the Ranch in the Family Matters: The Rancher's Perspective**—Steve Sinton, California Livestock Producer, Attorney at Law and co-founder, The California Rangeland Trust; Daniel Sinton, Writer and Director, The California Rangeland Trust

10:05 **Q&A Session**

10:20 **Break,** *Foyer*

10:35 **Acknowledgments and Introduction to Capstone**—Bill Tietje, Symposium Co-Chair, Cooperative Extension, Dept. of Environmental, Science, Policy and Management, UC Berkeley

Capstone: Where Have We Been and Where Are We Going? —Paul Starrs, Writer and Regents & Foundation Distinguished Professor, Dept. of Geography, University of Nevada, Reno

11:15 **Wrap Up**—Jessica Wright, Symposium Co-Chair, Research Geneticist, Pacific Southwest Research Station, USDA Forest Service, Davis, California

11:35 Adjourn

CONCURRENT SESSION 1 – TUESDAY, NOVEMBER 1, 2022

Session 1A: Climate Change I		*SLO Ballroom*	Moderator: Leander Anderegg, UC Santa Barbara
10:30 AM	#1	**Champion Oaks of California and Where They Are** – Matt Ritter, Dept. of Biology, Cal Poly San Luis Obispo	
10:50	#2	**The Tree-Ring Record of Seasonal Precipitation Variability and Change from the Blue Oak Woodlands of California** – Ian Howard, Dept. of Geosciences, University of Arkansas	
11:10	#3	**Survival and Growth of Blue Oaks Under Power Transmission Lines 10 Years After Tree Topping** – Royce Larsen, Area Natural Resource/Water Advisor, UC Cooperative Extension, San Luis Obispo, Monterey and Santa Barbara Counties	
11:30	#4	**Oak Versus Conifer: Competition, Climate and Drought Effects on Tree Growth in Northern California** – Rosemary Sherriff (presenter) and Jill Beckmann, Dept. of Forestry & Wildland Resources, Cal Poly Humboldt	
11:50		Q&A	

Session 1B: Status of Oaks		*Edna*	Moderator: Amy Byrne, The Morton Arboretum
10:30 AM	#5	**Oaks in the 21st Century: A New Way to Map Oak Woodlands and Forests –** Tom Gaman, California Wildlife Foundation/California Oaks	
10:50	#6	**Structure of the Valley Oak Population at Hastings Reservation –** Walter D. Koenig, Hastings Reservation, UC Berkeley	
11:10	#7	**Coordinating Collaborations to Conserve California Oaks –** Amy Byrne, The Morton Arboretum and Christy Powell, San Diego Zoo Wildlife Alliance	
11:30	#8	**Investigating Blue Oak Phenology, Vigor, and Mortality on Central California Rangelands** – Rebecca Ozeran, UCCE Fresno County	
11:50		Q&A	

Session 1C: Regeneration/Restoration		*Los Osos*	Moderator: Claudia Tyler, UC Santa Barbara
10:30 AM	#9	**Part 1: Conifer Encroachment and Removal in a Northern California Oak Woodland: Influences on Ecosystem Physiology and Biodiversity** – Lucy Kerhoulas, Dept. of Forestry and Wildland Resources, Cal Poly Humboldt	
10:50	#10	**Reproduction and Recruitment of Blue Oak in the Sierra Nevada Foothills of California** – M.V. Eitzel, Center for Community Science, UC Davis	
11:10	#11	**Substrate Enhancements and Botanical Diversity for Successful Oak Habitat Creation** – Richard B. Lewis III, Psomas	
11:30	#12	**Re-Oaking North Bay: A Strategy for Restoring Native Oak Ecosystems, Focusing on Napa and Sonoma Valleys** – Sean Baumgarten, San Francisco Estuary Institute	
11:50		Q&A	

CONCURRENT SESSION 2 – TUESDAY, NOVEMBER 2022

Session 2A: Climate Change II		*SLO Ballroom*	Moderator: Claudia Tyler, UC Santa Barbara
4:00 PM	#13	**New Oaks For A Climate Changing California** – David Muffly, Oaktopia	
4:20	#14	**Developing a Climate Resilient Native Tree Planting Plan for the Santa Monica Mountains National Recreation Area** – Rosi Dagit, RCD of the Santa Monica Mountains	
4:40	#15	**Modeling Climate-Driven Migration and Urban Habitat Connectivity for Valley Oak (*Quercus lobata* Née)** – Brenna Castro Carlson, Atlas Lab Inc., work completed at UC Berkeley	
5:00	#16	**Climate Change and Masting After 40 Years of Acorn Surveys at Hastings Reservation** – Mario Pesendorfer, Institute of Forest Ecology, University of Natural Resources and Life Sciences, Vienna	
5:20		Q&A	

Session 2B: Rangelands: Assessment & Management		*Edna*	Moderator: Elizabeth Reikowski, Willow Creek Land and Cattle, LLC
4:00 PM	#17	**Ranchers and Land Managers Responses to an Oak Survey** – Devii Rao, UCCE San Benito County	
4:20	#18	**Do Land Ownership Motivations Determine Land Management? Ranchers, Water, and Shallow Wetlands in the Sierra Nevada Foothills** – José L. Oviedo, Institute of Marine Sciences of Andalusia (ICMAN), CSIC	
4:40	#19	**Background Total Suspended Solids and Turbidity Conditions in Oak Woodland Headwater Streams** – David Lewis, UCCE Marin County	
5:00	#20	**Screening Oak Taxa for Suitability for Producing Acorns as an Animal Feed Crop** – Shawn Overstreet, Dept. of Plant Sciences, UC Davis	
5:20		Q&A	

Session 2C: Oak Pests and Diseases		*Los Osos*	Moderator: Kim Corella, California Department of Forestry and Fire Protection
4:00 PM	#21	**The Mediterranean Oak Borer (MOB, *Xyleborus monographus* Coleoptera: Curculionidae: Scolytinae) a New Invasive Species Infesting Valley and Blue Oak in Northern California** – Curtis Ewing, California Department of Forestry and Fire Prevention	
4:20	#22	**Long-term Monitoring of Mixed Oak Woodlands for Goldspotted Oak Borer Host Preference and Spatiotemporal Patterns in Host Colonization** – Adrian Poloni, Inland Empire Resource Conservation District (IERCD)	
4:40	#23	**A 25-year Retrospective on the Goldspotted Oak Borer (*Agrilus auroguttatus*) in Southern California** – Thomas Scott, Dept. of Environmental Science Policy and Management, UC Berkeley	
5:00	#24	**Other Pests of Oaks in California** – Thomas Smith, California Department of Forestry and Fire Prevention	
5:20	#25	**Monitoring Drought and Beetle Mortality in the Santa Monica Mountains and Implementing an Early Detection-Rapid Response Plan** – Rosi Dagit, RCD of the Santa Monica Mountains	
		Q&A	

CONCURRENT SESSION 3 – WEDNESDAY, NOVEMBER 2, 2022

Session 3A (Special Topic Panel): Education, Outreach, & Engagement: Lessons from the Field		*SLO Ballroom*	Moderator: Greg Ira, Director, UC ANR California Naturalists Program
8:00 AM		**K-12 Education - A Case Study of the Learning Among the Oaks (LATO) Program** – Beverly Gingg, Learning Among the Oaks, The Land Conservancy of San Luis Obispo County	
8:20		**Adult Education: Forest Stewardship Education Initiative** – Kim Ingram, UC Cooperative Extension, Davis	
8:40		**Teacher Professional Development: Project Learning Tree** – Cyndi Chavez, CA Project Learning Tree, 4-H Program, UC ANR	
9:00		**Community Science: Sudden Oak Death (SOD) Blitz Survey Project** – Douglas Schmidt, Dept. of Environmental Science, Policy, and Management, UC Berkeley	
9:20		**Revitalizing Indigenous Stewardship and Sense of Place: Lessons from Amah Mutsun Land-based Educational Programming** – Alexii Sigona, PhD Candidate, Dept. of Environmental Science, Policy and Management, UC Berkeley	
9:40		Q&A	

Session 3B: Oak Ecology & Conservation		*Edna*	Moderator: David Lewis, Director, Advisor UC Cooperative Extension Marin and Napa Counties
8:00 AM	#26	**Do Soil Microbes Affect Drought Tolerance in *Quercus lobata*? A Greenhouse Study on Seedlings and Soil from Tejon Ranch, CA** – Laura Bogar, Dept. of Ecology, Evolution, and Marine Biology, UC Santa Barbara; Ronja Keeley, UC Santa Barbara	
8:20	#27	**Protecting *in situ* Engelmann Oak Within a Broad *ex situ* Collection of *Quercus* Species** – Nicole Cavender, The Huntington	
8:40	#28	**Carbon Sequestration in California Oak Woodlands** – Virginia Matzek, Dept. of Environmental Studies and Sciences, Santa Clara University	
9:00	#29	**Spheres of Influence: Host Tree Proximity and Soil Chemistry Shape rRNA, but Not DNA, Communities of Symbiotic and Free-Living Soil Fungi in a Mixed Hardwood-Conifer Forest** – Gabriel Runte, Dept. of Ecology, Evolution, and Marine Biology, UC Santa Barbara	
9:20		Q&A	

Session 3C: Wildlife Ecology & Conservation		*Los Osos*	Moderator: Melanie Gogol-Prokurat, CA Dept. of Fish and Wildlife
8:00 AM	#30	**Nest-site Relationships Among Cavity-nesting Birds of Oak Woodlands in California: Identifying the Source of Cavities for Non-excavators** – Katherine Purcell, USDA Forest Service, Pacific Southwest Research Station	
8:20	#31	**Vegetation Associations for Amphibians and Reptiles in Undisturbed California Oak Woodlands** – Christopher Evelyn, Dept. of Environmental Science, Policy, and Management, UC Berkeley	
8:40	#32	**Exploring the Value of California Black Oaks for Fishers in a Landscape Altered by Disturbance** – Rebecca Green, US National Park Service	
9:00	#33	**California's Oaks in the 21st Century: Oak Habitat for Endangered, Threatened and Candidate Species** – Angela Moskow, California Wildlife Foundation/California Oaks	

9:20	#34	**Response of a Keystone Species to the Removal of Downed Wood in a California Oak Woodland** – William Tietje, UC Cooperative Extension, Dept. of Environmental Science, Policy, and Management, UC Berkeley
9:40		Q&A

CONCURRENT SESSION 4 – WEDNESDAY, NOVEMBER 2, 2022

Session 4A: Climate Change III		*SLO Ballroom*	Moderator: Jessica Wright, USFS Pacific Southwest Research Station
10:30	#35	**Participatory Field Gene Banks: A Novel Climate Change Adaptation Strategy for California Oaks** – Blair McLaughlin, Hampshire College	
10:50	#36	**Will Oak Populations Migrate? The Role of Vicariance in California Oak Distributions** – Thomas Scott, Dept. of Environmental Science Policy and Management, UC Berkeley	
11:10	#37	**Detecting Introgression and Determining the Potential of Adaptive Gene Flow Between Two Hybridizing Californian White Oaks (*Quercus sect. Quercus*)** – Scott O'Donnell, Dept. of Ecology and Evolutionary Biology, UC Los Angeles	
11:30	#38	**Plasticity Drives Geographic Variation and Trait Coordination in Blue Oak Drought Physiology** – Leander Anderegg, Dept. of Ecology, Evolution, and Marine Biology, UC Santa Barbara	
11:50		Q&A	

Session 4B: Fire I		*Edna*	Moderator: Matthew Shapero, UCCE Ventura County
10:30	#39	**Post-fire Oak Survival and Regeneration in Oak Woodlands Impacted by the River Fire at Hopland Research and Extension Center** – Michael Jones, UCCE Mendocino, Lake, and Sonoma Counties	
10:50	#40	**Identifying Second Order Effects of Fire on California Oaks** – Shane Dewees, Dept. of Ecology, Evolution, and Marine Biology, UC Santa Barbara	
11:10	#41	**Determining the Long-Term Effects of Wildfire on Goldspotted Oak Borer in Southern California** – Kim Corella, California Department of Forestry and Fire Protection	
11:30	#42	**Response of Post-wildfire California Black Oak Sprout-clumps to Crown Modification; Early Results** – Martin Ritchie, USDA Forest Service, Pacific Southwest Research Station	
11:50		Q&A	

Session 4C: Sustaining Working Landscapes		*Los Osos*	Moderator: Sheila Barry, UCCE Santa Clara County
10:30	#43	**California's Ranch Water Quality Planning Program Revamped and Redeployed** – Morgan Doran, UCCE Capitol Corridor	
10:50	#44	**Ranching - The Next Generation: Reflections on Innovative Ways for Young Ranchers to Contribute to the Preservation of Oak Woodlands** – Elizabeth Reikowski, Willow Creek Land and Cattle, LLC	
11:10	#45	**Challenges Faced by California Ranchers: Environmental, Regulatory, and Encroachment Pressures** – Seth Scribner, P.E. Third Generation California Rancher and Grazing Management Strategist	
11:30	#46	**An Updated California Rangeland Decision Assistance Tool: the CRSA** – Rebecca Ozeran, UCCE Fresno	
11:50		Q&A	

CONCURRENT SESSION 5 – WEDNESDAY, NOVEMBER 2, 2022

Session 5A (Special Topic Panel): New Technologies	*SLO Ballroom*	Moderator: Maggi Kelly, UC ANR IGIS Statewide Program
1:30 PM		**Drones in Oaks: Mapping the River Fire Impact on Oaks at Hopland Research and Extension Center** – Sean Hogan and Maggi Kelly (presenter), UC ANR IGIS Statewide Program
1:50		**Conservation Dashboards - Recording, Monitoring, and Reporting Live from the Coast Live Oak Restoration Project at the Dangermond Preserve** – Kelly Easterday, The Nature Conservancy
2:10		**The Climate Adapted Seed Tool: Using Provenance Tests to Inform Oak Seed Transfer in a Changing Climate** – Joseph Stewart, UC Davis
2:30		**Gradient Nearest Neighbor (GNN) Mapping as Applied to California Oak Woodland** – Hans Andersen, USDA Forest Service, Pacific Southwest Research Station
2:50		Q&A

Session 5B: Northern California Regeneration/Restoration Projects	*Edna*	Moderator: Josh Davy, UCCE Tehama County
1:30 PM	#47	**Drill-seeding Blue Oak Acorns is a New Method for Restoration in California's Rangelands** – Alex Palmerlee, Far View Ranch
1:50	#48	**North Coast Oak Woodland Restoration: Assessment of Post-treatment Understory Conditions** – Jeffrey Stackhouse, UCCE Humboldt County
2:10	#49	**North Coast Oak Woodland Restoration: Oregon White Oak and Black Oak Tree Response to Release from Douglas-fir Encroachment** – Yana Valachovic, UCCE Humboldt and Del Norte Counties
2:30	#50	**Resistance to Armillaria in Encroached and Open True Oak Woodlands of the North Coast** – Chris Lee, California Department of Forestry and Fire Protection
2:50		Q&A

CONCURRENT SESSION 6 – WEDNESDAY, NOVEMBER 2, 2022

Session 6A: Fire II		*SLO Ballroom*	Moderator: Michael Jones, UCCE Mendocino, Lake, and Sonoma Counties
3:30	#51	**Can Grazing Reduce Wildfire Risk?** – Matthew Shapero, UCCE Ventura County	
3:50	#52	**Bark Properties and Expected Conferred Resistance to Fire-induced Mortality in Three California Oak Species** – Kaili Brande, Bren School of Environmental Science and Management, UC Santa Barbara	
4:10	#53	**Successional Dynamics in Maritime Vegetation on a Fire-Suppressed Landscape** – Jim Thorne, Dept. of Environmental Science and Policy, UC Davis	
4:30	#54	**Post-fire Recovery in the Understory: Woody Fuels Management and Restoration in Oak Forests at Pepperwood** – Michelle Halbur, Pepperwood Preserve	
4:50		Q&A	

Session 6B: Oak Adaptation & Resilience		*Edna*	Moderator: Devii Rao, UCCE San Benito County
3:30	#55	**Rescuing Acorns and Wild Seedlings Borne by Legacy Oaks in Urban Areas: Conserving the Genetic Heritage of California's Original Oak Forests** – Timothy Vendlinski, Independent Conservationist	
3:50	#56	**Theoretical Model of Oak Persistence Under Competition and Herbivory** – M.V. Eitzel, Center for Community Science, UC Davis	
4:10	#57	**Examining Abiotic and Biotic Factors Influencing Specimen Black Oaks (*Quercus kellogii*) in Northern California to Reimplement Traditional Ecological Knowledge and Promote Ecosystem Resilience Post-wildfire** – Cory O'Gorman, Dept. of Biology, Sonoma State University	
4:30	#58	**California Oaks: Evolved for Resilience in California's Changing Climate** – Chad Roberts, Retired Conservation Ecologist	
4:50		Q&A	

Session 6C: Sustaining Oak Woodland Resources		*Los Osos*	Moderator: Julie Finzel, UCCE Kern County
3:30	#59	**Drone-based Remote Sensing of Canopy Thinning to Inform Conservation Management for California Live Oak Communities Facing Insect Pest Invasions and Drought** – Marc Mayes, UC Santa Barbara, Earth Research Institute	
3:50	#60	**Assessing the Contribution of Oak Woodland Habitats to Biodiversity Conservation Using CWHR and ACE** – Melanie Gogol-Prokurat, California Department of Fish and Wildlife	
4:10	#61	**Coordinated Squirrels: Harvesting Acorns for Reforestation Using Community Volunteers, Smartphones and Persistent Chat Applications** – Zarah Wyly, Sacramento Tree Foundation	
4:30	#62	**Context-dependent Effects of Cattle and Wildlife on Floral Resources at Tejon Ranch in Southcentral California** – Devyn Orr, USDA Agricultural Research Service	
4:50		Q&A	

ABSTRACTS OF CONCURRENT PRESENTATIONS

#1 Champion Oaks of California and Where They Are

Matt Ritter, Cal Poly, Biology Department

Oaks are the most iconic and characteristic trees of California. Oak woodlands occur throughout much of the state, covering about ten percent of the land area. Most oak species native to the state occur primarily in the California Floristic Province and nowhere else. For millennia their acorns provided a primary food source for California's Native Americans. There are 21 species native to California, 10 of which grow into stately trees, whereas the remaining 11 mature as multi-stemmed shrubs found in chaparral and arid woodlands of the southeastern deserts. California's oaks range in size from small shrubs, barely knee high, to some of the most enormous oaks in the world: the canyon live oaks (*Quercus chrysolepis*) and valley oaks (*Q. lobata*). I will present the results of a recent California tree oak mapping project and define areas of unexpectedly high and low tree oak diversity in the state. I will also offer an update on the oak trees on the California Big Tree registry, some of which have been impacted by recent wildfires and climate change.

#2 The Tree-Ring Record of Seasonal Precipitation Variability and Change from the Blue Oak Woodlands of California

David Stahle, and **Ian Howard**, Department of Geosciences, University of Arkansas

Blue oak (*Quercus douglasii*) is a California endemic found in the foothills of the Coast Ranges and Sierra Nevada. Blue oak individuals over 500-years old have been documented with dendrochronology and tree-ring chronologies over 700-years long have been developed from old blue oak trees and long-dead remnant wood. Ring width chronologies of blue oak are very highly correlated with wet season precipitation totals, in some cases above r = 0.90, among the strongest precipitation signals yet detected in tree-ring data worldwide. Selected ring-width chronologies of blue oak in the drainage basin of the American River have been used to reconstruct winter precipitation, calibrating over 75% of the instrumental precipitation variance. Separate reconstructions of autumn precipitation have also been developed from earlywood-width chronologies of gray pine (*P. sabiniana*) and of spring precipitation from latewood-width chronologies of ponderosa pine (*P. ponderosae*). The co-occurrence of very wet spring conditions following an already wet winter increased after 1950 in both the instrumental and reconstructed data and coincided with many of the largest spring discharge events ever recorded on the American River at Folsom. The frequency of wet-on-wet winter and spring precipitation extremes in the last 70-years is unprecedented in the seasonal tree-ring reconstructions since 1750. The valuable precipitation records in the tree-ring chronologies of blue oak and associated conifers are relevant to flood risk and water supply in California and provide another argument for the conservation management of ancient blue oak woodlands.

#3 Survival and Growth of Blue Oaks Under Power Transmission Lines10 Years After Tree Topping

Royce Larsen, University of California Cooperative Extension

Bill Tietje, University of California Cooperative Extension; **Karl Striby**, United States Department of Agriculture, Natural Resource Conservation Service; **Steve Sinton**, San Luis Obispo County Rancher; **Kevin Jensen**, United States Department of Agriculture, Agriculture Research Service

Blue oaks (*Quercus douglasii*) have been an important part of California's ecosystems for millennia. It has been recognized for more than 100 years that California oaks in general are not adequately regenerating at a rate that will sustain populations. There are regeneration concerns for many areas within California oak woodlands and there are many reasons for alarm. Some important reasons for maintaining oak populations include the values that oaks provide for wildlife, carbon sequestration, erosion control, and maintaining view sheds. But at the same time, fire is a huge concern in California. Wildfires that start due to faulty power transmission lines have had much attention during the last decade. As a result, PG&E has been aggressively clearing trees under its lines. We started a study to evaluate tree survival and growth after PG&E first intended to cut down oaks under their power lines but was convinced to only top trees beneath their powerlines on a private ranch in 2012. There were 89 topped trees that we tagged, then measured the diameter at breast height (DBH) and the cut height in January of 2013. The average DBH was 10.1 inches (range 4.9 in. – 33.8 in.). The average cut height was 11.5 feet (range 6.0 ft. – 32.0 ft.). We found that 10% of the trees had died by 2022, while the remaining trees averaged 8.4 feet (range 0.0 ft. – 18.0 ft) of growth and looked healthy. We found no correlation with tree mortality or growth with DBH. Of the 10% of trees that died, 80% had an initial cut height of less than 8 feet. It is important to note two things: first that it may reasonably be assumed that none of the trees that would have been cut off at the base would have survived and second, that the mortality of 10% of the topped trees is low, especially given that there have been severe drought conditions since 2012.

#4 Oak verses Conifer: Competition, Climate, and Drought Effects on Tree Growth in Northern California

Jill J. Beckmann, School of Forestry, Northern Arizona University

Rosemary L. Sherriff; Department of Geography, Environment, & Spatial Analysis, Humboldt State University; **Lucy P. Kerhoulas**, Department of Forestry and Wildland Resources, Humboldt State University; **Jeff M. Kane**, Department of Forestry and Wildland Resources, Humboldt State University

Oregon white oak (*Quercus garryana* Douglas ex Hook.) is experiencing increasing competition from Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) across its range at the same time as climate models are predicting increasing climate variability, including drought. An improved understanding of the combined effects of competition, climate, and drought is therefore needed to inform management of oak woodlands in an altered climate. Across a broad range of crowding conditions, we used linear mixed effects models to evaluate the effects of tree diameter, Douglas-fir crowding, oak crowding, and climate on Oregon white oak and Douglas-fir tree growth (2002-2016) and drought response (2013-2015). Here, we focus on highlighting our findings from an important and representative site in a network of sites across the North Coast region of California. Oregon white oak growth had positive relationships with winter and summer precipitation, spring mean maximum temperature, and September maximum temperature; and negative relationships with oak crowding, Douglas-fir crowding, and summer maximum temperature. Douglas-fir growth had a positive relationship with late spring precipitation and negative relationships with Douglas-fir crowding and summer mean maximum temperature. Oregon white oak growth was more resistant to prolonged drought than Douglas-fir. However, oak resistance to drought was also negatively related to Douglas-fir crowding and positively related to oak crowding. These results suggest that Oregon white oak may be better suited to a future climate than Douglas-fir, but Douglas-fir encroachment may threaten the ability of Oregon white oak to resist future drought. Prevention and management of Douglas-fir encroachment and maintenance of variable oak density is expected to optimize the vigor and drought resistance of Oregon white oak and best preserve ecosystem function under climate change.

#5 Oaks in the 21st Century: Status Update of California Oak Woodlands and Forests

Tom Gaman, Registered Professional Forester and **Angela Moskow**, California Oaks Program of California Wildlife Foundation

Research will provide an estimate of the extent and status report on eight species of trees that comprise much of California's oak forests and woodlands. The authors primarily utilize LEMMA 2017 (Landscape Ecology, Modeling, Mapping, and Analysis; see: https://lemma.forestry.oregonstate.edu). LEMMA is a collaborative research group of the U.S. Forest Service Pacific Northwest Research Station and Oregon State University and is engaged in modeling forest structure using Landsat imagery in combination with U.S. Forest Service Forest Inventory and Analysis ground-based data. For this project LEMMA is used to create maps and tables that show attributes for seven *Quercus* species (*agrifolia*, *chrysolepis*, *douglasii*, *garryana*, *kelloggii*, *lobata*, and *wislizeni*) and tan oak (*Notholithocarpus densiflorus)*.

The report's analyses will include a summary of impacts of fires on California's oak landscapes and will also suggest protections to further conservation of vulnerable oak woodlands and forests.

#6 Structure of the Valley Oak Population at Hastings Reservation

Walter D. Koenig, Hastings Reservation, University of California Berkeley

Between 1997 and 2015, I exhaustively surveyed all valley oaks (*Quercus lobata*) on and in the vicinity of Hastings Reservation, upper Carmel Valley, that were saplings or larger. A total of 3420 trees within an area of approximately 800 ha were marked and measured, for an average of 4.27 trees/ha. Ages of trees were estimated based on 85 trees on which we placed dendrometers measuring radial growth over a period of 25 years. Based on these estimates, mean (± SD) age of trees was 159 ± 106 years. Only 3% of trees were estimated to be <50 years old, but 32% were <100 years old, and 9% were >300 years old. Although age estimates are rough, these data suggest that despite appearances, there has been a fair amount of regeneration of this species during recent times, including both the university (1937 – present; 20% of trees) and ranching (1850 – 1937; 49% of trees) eras, while 14% of trees date back to the early European era (1542 – 1769) and ~2% to the Native American era (pre-1542). Observations of saplings tall enough to evade grazing by deer remain scarce in the area; however, the few that have been found have achieved growth out of the seedling stage within only a few years. Given that seedlings can survive in the grassy undergrowth for decades, and that once trees are sufficiently tall to avoid being grazed down by deer they may survive for 500 years or more, it may not be as surprising as thought that trees in the intermediate stage between seedling and sapling are rare.

#7 Coordinating a Global Network to Conserve Priority Oaks with a Focus on California Oaks

Amy Byrne, The Morton Arboretum

Silvia Alvarez-Clare, The Morton Arboretum; **Dan Crowley**, Botanic Gardens Conservation International; **Abby Meyer**, Botanic Gardens Conservation International-US

The Global Conservation Consortium for Oak (GCCO) is a coordinated network of institutions and oak experts working together to implement comprehensive conservation strategies to prevent extinction of

the world's oak species. The GCCO was launched by Botanic Gardens Conservation International (BGCI) and The Morton Arboretum, partly motivated by a 2019 study by Griffith, et al. which showed that gardens must collaborate to conserve genetic diversity, especially for exceptional species, like oaks, whose seeds cannot be conventionally seed banked. In the US specifically, participants are working to conserve the 29 US species of conservation concern, outlined in The Conservation Gap Analysis of Native US Oaks. Out of the 29 species of conservation concern, 10 of them are geographically distributed throughout California. In this presentation, we will highlight the GCCO network, how it came to be, and summarize the progress made in the US, specifically focusing on the work California partners have been conducting, as they are an important region for oak diversity. Finally, we will conclude with recommendations and next steps to participate in oak conservation efforts.

#8 Investigating Blue Oak Phenology, Vigor, and Mortality on Central California Rangelands

Rebecca Ozeran, University of California Cooperative Extension

Julie Finzel, University of California Cooperative Extension and **Devii Rao**, University of California Cooperative Extension

On rangelands in the southern San Joaquin Valley and Central Coast, mature oaks dominate blue oak populations. Past research in California identified a biological bottleneck in which seedlings rarely establish, particularly in areas with lower precipitation. Regional land managers are concerned by oak population decline, where older oaks die and young oaks fail to recruit. These managers value blue oaks for cultural resources, wildlife habitat, biodiversity, shade, and beauty (Rao et al. 2022*). However, we lack regional data on the extent and indicators of blue oak decline. In 2017, 23% of standing blue oaks were dead in Sequoia National Park, while only 5% of standing blue oaks were dead under pre-drought conditions (Das et al 2020). Site variation makes it difficult to extrapolate mortality rates across the landscape. Thus, we will establish long-term monitoring plots in Madera, San Benito, Tulare, and neighboring counties to quantify trends in regional blue oak populations.

Initial plot data describe current blue oak mortality, oak size, and stand density. Long-term, we will track individual and plot-scale mortality, as well as vigor based on leaf canopy. To track annual variation in growth we will measure shoot elongation on branches. When present, seedlings and acorn crops will be counted or estimated, respectively. Time-lapse cameras will document oak phenology, including leaf-out and leaf drop. Weather data collected near each site will be correlated to oak activity.

We will present preliminary data from three plots established in Fall 2021 and describe our ongoing monitoring methods. In a future stage of this project, we will collect and correlate land-use data to population information to identify practices that support resilient blue oak populations in the region. Over time, we will gain greater understanding of indicators of blue oak population decline, and will highlight best practices for land managers to sustain blue oak populations.

*Abstract also published in these proceedings, submitted by Rao, Finzel, and Ozeran. *Ranchers and Land Managers Want More Research and Extension to Better Manage Rangeland Oaks: Responses to a Survey.*

#9 Conifer Encroachment and Removal in a Northern California Oak Woodland: Influences on Ecosystem Physiology and Biodiversity

Gabriel Goff, Dept. of Forestry, Cal Poly Humboldt, Arcata; ***Lucy Kerhoulas**, Dept. of Forestry, Cal Poly Humboldt, Arcata

Nicholas Kerhoulas, Dept. of Forestry and Dept. of Wildlife, Cal Poly Humboldt; **Jill Beckmann**, School of Forestry, Northern Arizona University; **Jeffrey Kane**, Dept. of Forestry, Fire, & Rangeland Management, Cal Poly Humboldt; **Rosemary Sheriff**, Dept. of Geography, Environment, & Spatial Analysis, Cal Poly Humboldt

Fire suppression since the colonization of western America by Europeans has induced landscape-level changes, altering species composition and disrupting traditional successional processes. Oregon white oak (*Quercus garryana*) woodlands across their range are becoming increasingly threatened by encroaching Douglas-fir (*Pseudotsuga menziesii*) as a result of fire suppression, expanding landscape homogeneity, threatening biodiversity, and degrading important cultural spaces. Although previous research has investigated oak woodland responses to conifer encroachment and subsequent thinning treatments, few studies have evaluated these responses using physiology and biodiversity metrics in tandem to paint a larger, more complex picture. Using stem-level water potential (Ψ) and stomatal conductance (Gs), this study investigates the physiological effects of conifer encroachment and subsequent removal.

Pre-treatment physiology results suggest that Ψ was highest in open sites, indicating that water availability was the most limiting factor on these sites. Our findings also suggest that on open and moderately encroached sites Gs and Ψ displayed a negative relationship, indicating that these sites are water limited. On heavily encroached sites, Gs and Ψ exhibited a positive relationship where net photosynthesis increased as the trees became more water stressed. These results suggest that heavily encroached sites are light limited environments where increased water stress is likely due to high live crowns competing with conifers. Although conifer shade prolonged stand water availability, it significantly reduced oak productivity early in the growing season, a crucial time for rapid and vigorous growth. Heavy conifer encroachment also significantly reduced understory plant diversity, but increased bird diversity. As such, we conclude that conifer encroachment reduces oak woodland vigor via shading and loss of plant diversity and recommend further long-term monitoring of ecosystem responses to restoration.

#10 Reproduction and Recruitment of Blue Oak in the Sierra Nevada Foothills of California

M.V. Eitzel, Science & Justice Research Center, University of California, Santa Cruz

Susana Rodríguez-Buriticá, Instituto de Investigación de Recursos Biológicos Alexander von Humboldt**, W. Stanley Harpole**, German Centre for Integrative Biodiversity Research and Helmholtz Environmental Research Center UFZ, **Rebecca Aicher**, AAAS Center for Scientific Evidence in Public Issues, **Loralee Lairos**, Botany and Plant Sciences, University of California, Riverside, **Mitchel McClaran**, Arizona Experiment Station and University of Arizona, Tucson, and **Katharine Suding**, Ecology and Evolutionary Biology and Institute of Arctic and Alpine Research, University of Colorado, Boulder

California oaks suffer from recruitment problems due to a number of climate and management-related factors, including timing and presence of grazing. Our study examines these potential factors by

quantifying reproductive success (numbers of new seedlings and their sizes) and survival and growth of the younger life stages (seedlings and saplings), and by exploring how the timing of grazing, topographical variables, and rainfall limit reproduction, growth, and survival for these life stages, helping to identify potential management and restoration strategies to enhance the population viability of blue oak. We followed a population of blue oak (*Quercus douglasii*) seedlings and saplings in the Sierra Nevada foothills, measuring adult seed production and initial seedling recruitment (number and size of new seedlings), seedling growth and survival, seedling recruitment to saplings (growing greater than 10 cm in height), and sapling growth and survival. We tested the impacts on these demographic processes of timing and intensity of grazing, light availability, water availability, and individual size. Seedlings were more sensitive to moisture availability while saplings were more sensitive to light availability. Individual level variables such as the previous year's size impacted adult trees as well as seedlings and saplings, pointing to individual characteristics as an important component of demography. Grazing had a negative impact on seedling survival, sapling growth, and numbers of new seedlings, but the timing of the grazing mattered. High-quality, larger adult trees in good locations could be key in enabling early life stage transitions, though density-dependence and competition with the adult may mediate that beneficial effect. Future studies could examine the impact of competition with invasive exotic grasses and also how fire severity impacts these benefits of adult trees on early life stages. Ultimately a population model is needed to synthesize these data with information on other demographic transitions in order to establish population persistence.

#11 Substrate Enhancements and Botanical Diversity for Successful Oak Habitat Creation

Richard B. Lewis III, Psomas

Los Angeles County Public Works (Public Works) is creating 8 acres of oak woodland and sage scrub on a formerly unvegetated sediment placement site (SPS) in the San Gabriel Mountains foothills. The Santa Anita Oak Woodland Project (SAOWP) rapidly naturalized a newly graded landform as mitigation associated with reservoir sediment removal. Intensive resource inputs included 132 species of locally-harvested (subwatershed) plants/seeds, tons of salvaged coarse woody debris and placed natural snags (oak), and boulder assemblages—initiating decay/regeneration processes that would not otherwise occur for many years. The palette included hundreds of oaks of four species (two rare) via acorn planting with excellent growth/survival, and several fern species that were strategically situated in niches amongst placed debris. A total of 151 native plant species have been established including volunteer recruitment. A total of 114 native vertebrate species, 15 nesting bird species, and numerous invertebrates have been observed to date. Acorn woodpeckers have created cavities and nested in the placed snags for multiple years.

Technical studies (compaction, drainage, soils analyses) were performed to ensure site suitability for oak woodland creation. Public Works-designed spiraling drainages convey off-site inflows across the SPS to optimize storm water distribution/percolation. The soils were conditioned by incorporating a large volume of native mulch to a minimum depth of two feet via heavy machinery. Irrigation (discontinued 2018) was sparingly applied to foster drought hardiness. At the 7.5-year mark, the SAOWP has met several of the 10-year performance standards of the California Department of Fish and Wildlife.

Psomas prepared the habitat mitigation plan for Public Works; performs long-term vegetation/wildlife studies; and leads a team of landscape architects, restoration contractors, seed collectors, and plant nurseries. The SAOWP received awards from the American Council of Engineering Companies and the

American Society of Civil Engineers. Project documentation is on Public Works' website: https://dpw.lacounty.gov/wrd/Projects/SAHMP/index.cfm.

#12 Re-Oaking North Bay: A Strategy for Restoring Native Oak Ecosystems, Focusing on Napa and Sonoma Valleys

Sean Baumgarten, San Francisco Estuary Institute

Robin Grossinger, San Francisco Estuary Institute**; Matthew Benjamin**, San Francisco Estuary Institute; **Micaela Bazo**, San Francisco Estuary Institute; **Frances Knapczyk**, Napa County Resource Conservation District

Vast expanses of oak savanna historically occupied the rich alluvial soils of Napa and Sonoma valleys (Dawson 2008, Grossinger et al. 2012). The immense and long-lived valley oak (*Quercus lobata*) dominated these savannas, accounting for more than 65% of trees. Over the past two centuries, however, much of this oak savanna has been cleared to make way for orchards, vineyards, and towns.

The Re-Oaking North Bay initiative was established to provide an overarching strategy to help guide and prioritize oak restoration -- or re-oaking -- efforts in the region, with the ultimate goal of restoring our native oak communities in places where they could once again thrive and benefit our landscapes into the future. Priority areas for re-oaking Napa and Sonoma valley floors were identified by comparing present and past distributions of valley oaks, analyzing opportunities in the modern landscape, and demarcating potential areas to exclude based on valley oaks' physiological constraints.

The re-oaking spatial strategy map highlights various priority areas for restoring valley oaks on the Napa and Sonoma valley floors, including around existing oak nodes, along riparian corridors or other linear features, and in areas of recent and historical oak loss. Groups, or nodes, of multiple oak trees in relatively close proximity allow trees to cross-pollinate (Pluess et al. 2009) are generally more beneficial to wildlife than widely spaced trees. For instance, oak nodes 15-20 acres in size and with at least 20 trees are likely necessary to support acorn woodpecker colonies (Spotswood et al. 2017). Within oak nodes, individual oak trees should be spaced close enough together to facilitate wildlife movement and ensure that trees can cross-pollinate. In order for successful pollination to occur, oaks within nodes should be spaced no more than 500 feet apart (Sork et al. 2002, F. Davis pers. comm.).

Continuous corridors of oak trees facilitate connectivity between oak populations, and provide opportunities for wildlife to move both across the valleys (i.e., between oak nodes) and into adjacent upland habitats. Such connections are critical for supporting biodiversity in developed areas and maintaining plant, bird, and other wildlife populations that are resilient to disturbances like fires and floods, and to future climate changes (Tewksbury et al. 2002, Beninde et al. 2015). Tributaries of the Napa River and Sonoma Creek are particularly high priority areas for creating oak corridors, as these waterways provide natural pathways between upland oak populations on either side of the valley (Gray et al. 2018). In addition to tributaries, other linear features like highways, city streets, farm roads, margins of agricultural fields, or property boundaries can provide good opportunities for creation of oak corridors. Overly narrow corridors will exclude many wildlife species (Holmes et al. 1999, Hilty and Merenlender 2004, Collins et al. 2006), and thus widening existing corridors through re-oaking in surrounding areas can greatly increase the ecological value of these oak corridors.

Areas of recent or historical oak loss can also be prime locations for oak restoration. Though many aspects of the landscape have been altered in Napa and Sonoma valleys, the historical presence of oaks is often a strong indicator that the physical conditions of a particular area may still be suitable for

oaks, at least at a coarse scale. Alluvial fans, for example, historically supported high densities of valley oaks (Griffin & Critchfield 1972). Areas of oak loss that overlap with potential oak nodes and corridors meanwhile offer opportunities to maximize the benefits of oaks.

Areas with soil types, groundwater levels, or other physical conditions that limit oak growth may be unsuitable for oak restoration, and are indicated as potential areas to exclude on the spatial strategy map. Valley oaks require well drained soils and are unlikely to tolerate clay-rich soils. In addition, valley oak root systems are not adapted to withstand very shallow water tables (Cooper 1926), while water tables deeper than 60-80 feet may be inaccessible to oak taproots (Lewis and Burgy 1964, Brown and Davis 1991). These sites may be unsuitable for oak restoration in the absence of irrigation or other active management.

Restoring oak communities in priority areas indicated on the spatial strategy map would provide a range of benefits, from native biodiversity support to carbon sequestration to shade and temperature regulation. The re-oaking spatial strategy is intended to serve as a model for similar strategies for other valleys in the North Bay and elsewhere.

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#13 New Oaks For A Climate Changing California

Dave Muffly, Oaktopia

As the climate continues to warm and increase in volatility, California's forests face unprecedented threats. Climate models suggest increasing aridity, and also unpredictable and unprecedented changes in rainfall timing and intensity. As we seek arboreal stability in the face of climatic uncertainty, the testing of new tree types becomes critical.

But some of the most promising new trees are closely related to existing native trees, especially oaks, and could threaten native genetic integrity. Urban locations, with their already-disrupted ecology, offer a laboratory for tree testing without threatening existing native genomes.

With the likelihood of extreme climate change increasing, many are now realizing the climate threat to native trees. Existing native genomes may prove inadequate to meet the realities of vastly altered weather patterns. If these extreme scenarios play out, and if we in the meantime have tested a substantial range of potential candidate trees in our urban forests, we may then look to those forests to model exurban tree adaptation.

California has been a tree laboratory since Europeans first started planting their familiar Mediterranean trees here more than two centuries ago. Recalling this tradition, efforts have been made in recent years to discover, test, and publicize new trees. In most cases, these trees are native to places which already experience the range of temperature and precipitation which await California. Ideally, these new trees will support a range of existing, and migratory, biodiversity.

At this critical moment in California history, a broad expansion in nursery tree types is mercifully occurring. Tough and durable tree species that have been used in limited quantities in California are proving themselves, and are becoming available in quantity. Now is a time for bold experimentation, and here we present some of the leading tree candidates to serve California forests over the coming turbulent century.

#14 Developing a Climate Resilient Native Tree Planting Plan for the Santa Monica Mountains National Recreation Area

Rosi Dagit, RCD of the Santa Monica Mountains

The 150,000 acre Santa Monica Mountains National Recreation Area (SMMNRA) is a complex mosaic of private and public lands. However, our native oak and riparian woodlands provide ecosystem services and benefits that cross jurisdictional boundaries and function as an integrated whole. Threats from drought, wildfire, climate change, and invasive species are distributed across the entire landscape. Tree species that currently occupy the SMMNRA have a proven ability to survive cyclic climate changes, as well as the cycle of annual summer drought that defines Mediterranean climates. From this perspective, questions of tree species persistence in the SMMNRA can be framed by how much change these trees can tolerate, rather than modeling shifts in ideal conditions.

Local city, county, state and federal agencies individually regulate management of their woodlands. This project provided a coordinated effort to anticipate effects of climate change to develop strategies for restoring and expanding native oak and riparian woodlands into the future. With assistance from the NASA DEVELOP team, we developed interactive maps that identify sites of high, moderate and low vulnerability to climate change that provide the basis for designating management units for native tree species. These maps identify existing geographic locations where woodland assemblages are anticipated to persist under future climate change conditions to enhance carbon storage and ecosystem services benefits, as well as areas that are anticipated to be able to support trees in the future.

The Los Angeles County Native Tree Priority Planting Plan (2019) articulates strategies to maintain biodiversity and resiliency of local trees and woodlands that provide critical habitat and linkage connectivity as climate change creates significant stressors to their long-term survival. This blueprint will help guide a coordinated, inter-jurisdictional approach leveraging required mitigation planting with voluntary restoration.

#15 Modeling Climate-Driven Migration and Urban Habitat Connectivity for Valley Oak (*Quercus lobata* Née)

Brenna Castro Carlson, PLA, ASLA, Atlas Lab Inc. Work completed while at the University of California, Berkeley.

As climate change drives migration of California oaks, habitat connectivity will be a critical determinant of migration success. Urban land use can be a barrier to migration and gene flow due to habitat loss and fragmentation. This project proposes an approach for the design and planning of urban habitat networks to facilitate climate-driven oak migration – a function that is currently not a typical goal of urban open space planning – focusing on valley oak (*Quercus lobata Née*) in the Sacramento metropolitan area.

We mapped potential valley oak migration through species distribution modeling for current (2020) and near-future (2070) habitat suitability in California. Directional changes in suitability are summarized for the Sacramento region as a migration trajectory vector. Within the region, the suitable range for valley oak is projected to shift by 536m per year to the northeast – a rate which may exceed dispersal capabilities for the species.

We overlaid this trajectory with detailed mapping of the existing habitat network in Sacramento to identify potential migration routes through the metropolitan area. We applied two modes of connectivity

analysis: Circuitscape to visualize potential connections between habitat patches, followed by Graphab to identify functional connectivity based on dispersal thresholds. We analyzed connectivity of the existing habitat network, then designed and analyzed three scenarios for new habitat, and finally designed and analyzed a hybrid scenario to optimize connectivity. The optimized scenario projects a twofold increase in valley oak habitat connectivity compared to baseline conditions. This project demonstrates an approach to habitat connectivity modeling that may be used in urban land use planning, and the habitat master plan envisions an urban open space network that supports and protects regional biodiversity in the face of climate change.

#16 Climate Change and Masting After 40 Years of Acorn Surveys at Hastings Reservation

Walter D. Koenig, Hastings Reservation, University of California Berkeley

Johannes M. H. Knops, Department of Health and Environmental Sciences, Xi'an Jiaotong Liverpool University; **William J. Carmen**, Carmen Ecological Consulting

Whether climate change will or will not alter patterns of seed production by mast-fruiting species is a topic of considerable current debate. At Hastings Reservation in upper Carmel Valley, central coastal California, daily weather records go back to 1939 and annual acorn surveys have been conducted since 1980, providing 80 years of weather data and 40 years of acorn surveys of five species of oaks (*Q. lobata, Q. douglasii, Q. chrysolepis, Q. agrifolia,* and *Q. kelloggii*). Annual conditions are highly variable, particularly for rainfall, which is strongly non-normally distributed. Over the 80-year period, however, mean maximum temperature and rainfall has not changed appreciably; in contrast, mean minimum temperature has increased by ~1.1oC, increasing during all months of the year except for December. Annual variability in temperatures and rainfall as measured by the coefficient of variation using 10-year windows have not changed, however. Thus, although variability has not increased, conditions have warmed significantly as a result of warmer night-time conditions. This change has not had a detectable effect on either the mean or the variability of acorn production by any of the species based on our annual surveys. The relationship between climate change and masting behavior will not be easy to determine empirically, if for no other reason than that even 40 years of data is barely enough to address this critical issue.

#17 Rancher and Land Manager Responses to an Oak Survey

Devii R. Rao, University of California Cooperative Extension

Julie Finzel, University of California Cooperative Extension and **Rebecca Ozeran**, University of California Cooperative Extension

Livestock and Natural Resources Advisors from the University of California Cooperative Extension conducted a survey to identify the highest priority research needs for people managing California oak landscapes. The survey was conducted primarily on the Central Coast and Central Valley, though forty-nine people from twenty-three counties responded to the survey. Respondents identified as follows: rancher (22), agency staff (9), academic (2), consultant (2), other (11), and unidentified (9). Some people chose more than one category.

The survey asked seven questions, including a question about the importance of oaks. Four common responses were that oaks are important because they provide habitat, shade, beauty, and other ecosystem services. When asked which of three pre-defined topics were most important, 28 people

wanted to know how to prevent their oaks from dying; 27 wanted to understand how to increase the number of oaks on their properties; and 18 wanted to know why their oaks are dying.

Many questions still need to be answered to help ranchers and other land managers across the state care for our oak ecosystems. Information on invasive species in oak woodlands was the most requested topic, followed by ecological site descriptions, carbon dynamics and climate change in oak woodlands. One outcome from this survey is that we recently deployed a new research project to investigate blue oak phenology, vigor, and mortality. Based on results from this survey, additional high priority activities include 1) working with the Natural Resources Conservation Service (NRCS) to develop ecological site descriptions in oak woodland and oak savanna landscapes and 2) ensuring managers are aware of the extensive oak-related research that was conducted over the years through the Integrated Hardwood Range Management Program.

#18 Do Land Ownership Motivations Determine Land Management? Ranchers, Water and Shallow Wetlands in the Sierra Nevada Foothills

José L. Oviedo, Institute of Marine Sciences of Andalusia (ICMAN), Spanish National Research Council (CSIC)

Lynn Huntsinger, Department of Environmental Science, Policy and Management, University of California at Berkeley; **Nathan Van Schmidt**, Department of Environmental Science, Policy and Management, University of California at Berkeley; **Tracy V. Hruska**, Department of Environmental Science, Policy and Management, University of California at Berkeley; **Steve Beissinger**, Department of Environmental Science, Policy and Management, University of California at Berkeley

It is likely to find a variety of landownership motivations among ranchers and oak woodland owners, from pure profit maximization to absentee types. While this variety of motivations has been often identified in the literature, there are few empirical works that analyzes whether they condition land management and how landowners respond to external drivers that may determine their decision on how to manage land and operations. In this paper, we illustrate this type of analysis by presenting a specific land use problematic in oak woodland area in the Sierra foothills of California. We administered a mail survey in 2013-2014 to 466 landowners and ranchers in Nevada and Yuba counties within a study area defined by the distribution of habitat for a water dependent bird, the California black rail, to better understand land management motives and practices and how they might affect wildlife habitat in general, and particularly the habitat of the California black rail. Using factorial analysis, we found up to six different landownership typologies based on up to 24 possible motivations for ownership. Using binary (yes/no) questions included in the survey and logit models, we then analyze the probability of wetland/water area change based on landowner typologies, water sources, water availability, water price and other variables in the context of a severe drought such as that suffered in California, especially in the period 2011-2015. The analysis shows that ownership motivations determine decisions related to the management of shallow wetlands in the rangeland properties of the Sierra foothills. We found a gradient from pure profit maximizer landowner, more likely to take actions putting both wetlands and land operations at risk, to recreation or environmentally motived owners, less likely to do so. Tradition and lifestyle motivations are found halfway between these two ends of the gradient.

#19 Background Total Suspended Solids and Turbidity Conditions in Oak Woodland Headwater Streams

David J. Lewis, University of California Cooperative Extension Marin County

Anna Dirkse, University of California Cooperative Extension Marin County; **Anthony O'Geen**, University of California Davis; **Kenneth W. Tate**, University of California Davis; **Safeeq Kahn**, University of California, Merced

Oak woodlands are a primary source of surface water in California with more than 75% of the surface flows originating from or flowing across them. This water is critical for multiple uses, including agriculture, residential, and environmental, among others throughout the Central Valley and along California's coast. The provisioning of water for these beneficial uses is predicated on water of sufficient quality to meet these needs.

Background concentrations of water quality constituents, like Total Suspended Solids (TSS) or Turbidity, are influenced by multiple factors including precipitation timing and intensity, underlying geology and soils, and land use. Using eight years of water quality sampling and analysis from four experimental watersheds, we explore background concentrations for these two constituents and how these factors influence their variability. The four paired, instrumented watersheds are located near Hopland, California two hours north of San Francisco, California. These are first order catchments, representing headwater landscape positions across publicly and privately managed oak woodlands. Two of these watersheds – A and B - were lightly grazed throughout the period of water quality sampling and analysis while the other two – C and D - are in a preserve and have not had grazing livestock on them since the 1950s. Additionally, a low-intensity prescribed burn was conducted in watershed B and C during the study period.

Annual cumulative precipitation during the eight years of study, ranged from 603 mm in water year 2001 to 1437 mm in water year 2006. Mean TSS across the eight years of study was 1,198 mg/L (SD = 432 mg/L), 1,042 mg/L (SD = 235 mg/L), 1,039 mg/L (SD = 351 mg/L), and 945 mg/L (SD = 720 mg/L) for watershed A, B, C, and D respectively. Similarly, mean turbidity was 1,197 mg/L (SD = 121 mg/L), 1,052 (SD = 50 mg/L), 1,050 mg/L (SD = 117 mg/L), and 944 mg/L (SD = 91). Within these summary statistics is the relationship of these constituents to the flashy nature of streamflow generation resulting from individual storm intensity and duration. These dynamics and the resulting variability in water quality are discussed relative to water quality criteria.

#20 Screening Oak Taxa for Suitability for Producing Acorns as an Animal Feed Crop

Shawn Overstreet, Independent Scholar, UC Davis

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Substituting perennial carbon-sequestering oak trees for a portion of the annual cereal grains grown for animal feed is a way to help California meet its 2030 goals of curbing greenhouse gas emissions. Feeding studies indicate that oak acorns can be substituted for 25% of the grain in animal feed rations for most livestock species, with the ideal acorn being low in fat and tannins, and high in protein.

Acorns from sixty-three oak taxa were collected from across the United States in the fall of 2015 for a chemical analysis of their nutritional composition. Additionally, the oak taxa were screened for their

climatic adaptability based on the number of USDA hardiness zones in which they would grow successfully. Four taxa were identified as having a high potential to be an animal feed crop. Acorns of *Quercus macrocarpa*, *Q. lyrata*, and *Q. suber* all met the requirements for an ideal acorn animal feed, and the climatic adaptation and growth requirements of these three taxa compliment each other. If acorn oil extraction prior to use as animal feed is considered as an option, *Q. emoryi* (35.9% fat) would also have a high potential as an animal feed crop.

These encouraging results suggest that all 21+ taxa of native California oaks should also be screened. Understanding the suitability of our locally-adapted oak species for use as an animal feed crop could help inform management of both natural oak woodlands and marginal croplands suitable for acorn orchards.

#21 The Mediterranean Oak Borer (MOB, *Xyleborus monographus* Coleoptera: Curculionidae: Scolytinae) a New Invasive Species Infesting Valley and Blue Oak in Northern California

Curtis Ewing, California Department of Forestry and Fire Prevention

Sheri Smith, USDA-FS, Region 5 and **Michael Jones**, UC-ANR, Lake County

The Mediterranean oak borer (MOB), *Xyleborus monographus*, is an invasive ambrosia beetle native to the Mediterranean region, including Europe, the Middle East, and North Africa, where it primarily attacks oak species. The first North American infestations of MOB were confirmed in valley oaks in Napa County, California in late 2019, followed by Lake and Sonoma Counties in early 2020, and Sacramento County in September 2020. MOB attacks at least 12 species of oaks in its native range. In California, it has been found infesting two species of white oak: most commonly valley oak and, to a lesser extent, blue oak. A single, very limited attack was found in a severely distressed California black oak. All ambrosia beetles (like MOB) grow fungi inside their galleries and use it as food for larvae and adults. Some of these fungi can be pathogenic and cause tree diseases that may lead to tree decline and, sometimes, tree death. Several species of fungi have been found associated with MOB in Napa County, and research is underway to determine if these fungi cause tree diseases. Oak trees infested with MOB are most easily identified by damage caused by the beetle's tunneling activity (galleries) in the xylem. MOB galleries are often trellis-like, very crowded and intersecting, fan out in a single plane and 1.2-1.5 mm in diameter. Other signs and symptoms of MOB tunneling activity include boring dust in cracks of the tree bark, and sometimes oozing sap ("sap flux"). In addition to looking at the associated pathogens, cooperative work is also ongoing to 1) provide information regarding the origin, distribution, and age of the infestations, 2) determine estimated rate of spread, 3) identify the locations of un-infested susceptible oaks to develop a broader tree inventory in order to estimate potential economic losses as this invasive insect continues to spread, 4) evaluate the flight periodicity, flight height, lure efficacy and mode of attack, 5) evaluate the efficacy of verbenone splat as a deterrent, and 6) provide training to a variety of audiences regarding MOB identification and management. For more information and a MOB pest alert can be found here: https://www.ucanr.edu/sites/mobpc/.

#22 Long-term Monitoring of Mixed Oak Woodlands for Goldspotted Oak Borer Host Preference and Sspatiotemporal Patterns in Host Colonization

Adrian L. Poloni, Inland Empire Resource Conservation District (IERCD)

Stacy M. Hishinuma, Forest Health Protection, USDA Forest Service; **Alex Chacon**, Inland Empire Resource Conservation District (IERCD); **Kevin Harrington**, Inland Empire Resource Conservation

District (IERCD); **Sam Nielsen**, Inland Empire Resource Conservation District (IERCD); **Kim Corella**, California Department of Forestry and Fire Protection (CAL FIRE)

Oak woodlands throughout southern California continue to experience accelerated oak mortality due to the introduction of the goldspotted oak borer (GSOB), *Agrilus aurogutattus*. In its invasive range in California, this exotic wood boring beetle prefers to infest and kill large diameter California black oak, *Quercus kellogii*, and coast live oak, *Q. agrifolia*. Interior live oak, *Q. wislizeni*, is not considered to be a significant host in the beetle's current distribution. There are no data on the current and potential impact of GSOB on hybrid oaks. In fall of 2021, ground surveys were conducted in Edgar Canyon (Yucaipa, San Bernardino County, California) to document the health of the individual oak trees and the severity of GSOB infestation within a 165-acre area. Within this property are *Q. chrysolepsis Q. agrifolia*, *Q. kelloggii*, *Q. wislizeni*, and oracle oak (*Quercus x morehus*), a cross between a preferred host (*Q. kelloggii*) and a non-preferred host (*Q. wislizeni*). The goals of the study were to (1) establish long-term monitoring of individual trees to investigate individual tree characteristics associated with GSOB infestation in several species of oaks, (2) document spatiotemporal dynamics of GSOB infestation in mixed oak stands, and (3) to investigate characteristics of hybrid oaks infested by GSOB that may be correlated with infestation severity. For all oak trees within the study area, diameter at breast height (DBH), crown dieback, tree height, tree crown height, damage by other agents, bark thickness, and signs and symptoms of *A. auroguttatus* infestation and injury (number of exit holes, bark staining and woodpecker feeding) were recorded and all trees were tagged and georeferenced. This survey represents the first year of observations in the long-term monitoring of individual native oaks in the project area and the first documented investigation of the impact of *A. auroguttatus* on oracle oaks.

#23 A 25-year Retrospective on the Goldspotted Oak Borer (*Agrilus auroguttatus*) in Southern California

Thomas Scott, Department of Environmental Science Policy and Management Environmental Science, Policy and Management, University of California Berkeley and Department of Earth and Planetary Sciences, University of California, Riverside

Kim Camilli, Forest Pathology and Entomology Program, California Department of Forestry and Fire Protection; **Jan Gonzales**, University of California Cooperative Extension, San Diego County; **Beatriz Nobua-Behrmann**, University of California Cooperative Extension, South Coast Research and Extension Center; **Kevin Turner**, California Department of Forestry and Fire Protection (retired)

The Goldspotted oak borer (*Agrilus auroguttatus,* hereafter GSOB) was linked to oak declines in 2008, over 12 years after it arrived in southern California. By that time, it had occupied over 7,500 acres of oak woodlands in San Diego County, infesting primarily California Black oak (*Quercus kelloggii*) and coast live oak (*Quercus agrifolia*). Now 25 years past its earliest time of detection, this invasive exotic beetle occupies over 150,000 acres of oak woodlands in California, having spread by diaspora to 4 other counties (Riverside, Orange, Los Angeles, San Bernardino). The primary means of dispersal is transport of larvae/pupae in the bark of infested-oak firewood. The longest known diaspora by firewood was 120 miles, which places over 100,000 acres of hardwood range in the Coast Ranges and southern Sierra within a radius of infestation risk by GSOB.

New outbreaks are typically discovered 3 to 5 years after infestation, suggesting that education outreach in at-risk communities is a stronger strategy than early detection. Because of this lag time in outbreak discovery, management has evolved to slow oak morbidity and mortality with little hope for eradication. Management options currently focus on prophylactic/remedial treatment of individual oaks,

based on vulnerable points in the life history of GSOB and triage of oaks in infested woodlands. Pesticide bark-barrier sprays have been the most effective treatment, because they potentially to kill both emerging adults and larvae entering the surface of the bark. At a population level, management is focused on GSOB hot spots within outbreak areas, and the identification of the heavily infested oaks that amplify GSOB outbreaks. However, at the time of discovery, many managers opted to treat all large oaks within an infested woodland.

Initial years of the GSOB outbreak occurred during a period of record drought in San Diego County, with a devastating impact on mature oaks. Since that time the loss of oaks to GSOB has risen and fallen with annual precipitation. GSOB typically contributes to the mortality rate of all large red oaks (>20 inches), but with a small number of intriguing individuals (*Quercus agrifolia*) that appear to be resistant to GSOB infestation.

#24 Other Pests of Oaks in California

Thomas F. Smith, California Department of Forestry and Fire Protection

Although major invasive insects and diseases have been shown to have profound impacts on oaks in California there are many other pests that do act as stress agents too. Foliar diseases such as *Tubakia* and anthracnose, root pathogens such as *Phytophthora* species, leaf gall insects and cankering fungi can all impact oak growth and survival, particularly during periods of stress such as droughts and extreme heat events. These minor pests can impact the oak habitats and resources throughout the State.

#25 Monitoring Drought and Beetle Mortality in the Santa Monica Mountains and Implementing an Early Detection-Rapid Response Plan

Rosi Dagit, RCD of the Santa Monica Mountains

Since 2012 hundreds of native trees (alders, oaks, sycamores, willows) in the Santa Monica Mountains have died, mostly due to the drought, but many are also victims of the invasive shot hole borer/fusarium complex (ISHB) and a pathogen newly carried by the western oak bark beetle (WOBB). The Santa Monica Mountains National Recreation Area is a mosaic of over 150,000 acres of public open space interwoven into the urban-wildland interface of Los Angeles County.

Concerned about the ecological implications of massive native tree loss, the RCDSMM initiated a community science-based study in 2015 tagging over 350 trees in 41 randomly selected 25 meter plots located near the urban wildland interface throughout the western Santa Monica Mountains. This was augmented in 2017 by deployment of 46 homemade beetle traps in sensitive riparian areas to monitor direction and rates of spread of invasive beetles. Over 850 individual trap samples were collected, and ambrosia beetles found in 225 samples sent for DNA confirmation. Of these, 52 samples were confirmed as ISHB or western oak bark beetle. Additional volunteer training has expanded the number of contributors to over 50 people, with several hundred observations posted. This resulted in identifying two new areas of infestation in 2020 which are now being closely monitored.

Concurrently, this data provided on-the-ground information used in a NASA DEVELOP Project using remote sensing tools and satellite data to help understand the landscape level impacts over time. Results show that extensive drought impacts occurred in 2015, followed by increased loss associated with invasive pathogens in 2016-17. Additional remote sensing work in 2019 following the Woolsey Fire which burned over half of the study area assisted in identifying priority areas of concern.

A partnership of local, state, and national park landowners, the Los Angeles and Ventura County Agricultural Commissioners then developed the Los Angeles County Early Detection-Rapid Response Plan. This plan was formally adopted by Los Angeles County in 2020 and implementation is leading to a more appropriate and realistic management strategy for urban/wildland interface trees to meet the forecast challenges of a changing climate.

#26 Do Soil Microbes Affect Drought Tolerance in *Quercus lobata*? A Field and Greenhouse Study of Oak Drought Responses in the Tehachapi Mountains, CA

Laura Bogar, Department of Plant Biology, University of California, Davis and **Ronja Keeley**, Department of Ecology, Evolution, and Marine Biology, University of California-Santa Barbara

Gabe Runte, **An Bui**, **Oceana Tavasieff**, **Carina Motta**, and **Holly Moeller**; Department of Ecology, Evolution, and Marine Biology, University of California-Santa Barbara

Oaks, like nearly all plants, rely on soil microorganisms to improve access to water, unlock recalcitrant nutrients, and reduce their susceptibility to pathogenic infections. As the climate of California becomes warmer and drier, these partnerships with soil microbes like ectomycorrhizal fungi will become even more essential for oaks, especially at the seedling stage, when drought stress and pathogen pressure can be especially severe. This talk will present findings from two studies undertaken in the Moeller Lab at UCSB. In the first study, we used a natural climatic gradient in the Tehachapi Mountains to study how the ectomycorrhizal associates of valley oak (*Quercus lobata*) varied with aridity. We collected soil samples from below the canopies of fifty-three trees, sequenced DNA to identify members of the fungal community, and used trait databases to map fungal species identity to functional roles. We found that fungal traits mapped to environmental conditions. As rainfall decreased and trees experienced more arid (and stressful) conditions, they associated with fungal partners capable of gathering and transporting resources over longer distances. In the second study, we inoculated oak seedlings with soils from the same sites and subjected them to drought stress. We measured seedling physiology and growth, and are extracting DNA to determine if fungal traits affected seedling growth outcomes. Soil microbes are a key mediator of oak physiology across life stages, and understanding how climate may shift the functioning of these soil communities is essential to forecasting the future of oak woodlands in California and beyond.

#27 Protecting *in situ* Engelmann oak within a broad *ex situ* collection of *Quercus* species

Nicole Cavender and **Tim Thibault**, The Huntington

Though still nascent, The Huntington has a uniquely integrated oak conservation program involving *in situ* conservation of *Quercus engelmannii*, *ex situ* conservation collections of US and Mexican oak species, as well as an herbarium, field program, tissue culture lab and cryopreservation research. This breadth of activity is particularly important for exceptional species like oaks.

Working within the broader botanic garden plant conservation community, The Huntington is a partner in multiple subregions of the newly formed Global Conservation Consortium for Oak (GCCO), including the Western US Subregion that includes California. The primary purpose of the GCCO is to coordinate conservation activities on threatened oak species, based on data from both the International Union for Conservation of Nature (IUCN) Red List and the Conservation Gap Analysis of US Native Oaks (CGA). As no one institution can house the diversity of oaks, GCCO uses a metacollection approach that

shares germplasm across multiple sites. The Huntington currently holds significant *ex situ* collections of several oak species for the GCCO, including the California native *Quercus dumosa*.

Balancing these conservation activities becomes particularly tricky with *Quercus engelmannii*. IUCN lists numerous threats to *Quercus engelmannii*, including urbanization, agriculture, change in fire regimes, habitat shift and hybridization. *Quercus engelmannii* is considered a particularly promiscuous oak species and steps need to be taken to limit chances of pollination by other species, especially those in the same section of the genus, including *Quercus dumosa* for example. Arrangement of the collections becomes an issue, but ameliorated by creating an *in situ* preserve for the site native species and limiting other species in the same section of the genus to downwind sites. Additionally, the CGA identifies critical needs for population reinforcement, as well as for education, outreach and training for *Quercus engelmannii* that The Huntington is well positioned to fulfill as one of only 19 collections to hold the species. An overview of current oak conservation activities is provided with an eye to finding additional partners.

#28 Carbon Sequestration in California Oak Woodlands

Virginia Matzek; Santa Clara University, Department of Environmental Studies and Sciences

Restoring degraded oak woodlands, and preserving those that are now threatened by suburban development, could be a part of California's greenhouse gas (GHG) emissions reductions strategy, if the habitat's carbon storage potential was sufficiently well understood. To aid in this effort, I compiled a database of 3,352 forest inventory plots and used it to parameterize growth models and understand drivers of biomass for eight types of California oak woodland. Plot data came from both published and unpublished sources and were originally recorded for various purposes, but all plots had in common a complete census of woody stems dentified to species and measured for their diameter at breast height. Diameters were converted to biomass and then to carbon measurements using allometric equations. The Von Bertalanffy growth equation was fitted to biomass estimates for woodland types using the subset of 1132 plots for which stand age was known or estimated. Look-up tables were produced from live and standing dead biomass curves, as well as estimates of forest floor, understory, and soil carbon modeled according to methodologies approved by the California Air Resources Board. Latitude, longitude, slope, aspect, and elevation were used to predict the average carbon stock in representative habitats of each oak woodland type.

#29 Spheres of Influence: Host Tree Proximity and Soil Chemistry Shape rRNA, but Not DNA, Communities of Symbiotic and Free-Living Soil Fungi in a Mixed Hardwood-Conifer Forest

Gabriel C. Runte, Ecology, Evolution and Marine Biology, University of California, Santa Barbara

Alex H. Smith, Holly V. Moeller and **Laura M. Bogar**, Ecology, Evolution and Marine Biology, University of California, Santa Barbara

Host and symbiont diversity are inextricably linked across partnerships and ecosystems, with degree of partner reliance governing the strength of this correlation. In many forest soils, symbiotic ectomycorrhizal fungi coexist and compete with free-living saprotrophic fungi, with the outcomes of these interactions shaping resource availability and competitive outcomes for the trees aboveground. Traditional approaches to characterizing these communities rely on DNA sequencing of a ribosomal precursor RNA gene (the internal transcribed spacer region), but directly sequencing the precursor

rRNA may provide a more functionally relevant perspective on the potentially active fungal communities. Here, we map ectomycorrhizal and saprotrophic soil fungal communities through a mixed hardwood-conifer forest to assess how above- and belowground diversity linkages compare across these differently adapted guilds. Using highly spatially resolved transects (sampled every 2 m) and well-mapped stands of varying host tree diversity, we sought to understand the relative influence of symbiosis versus environment in predicting fungal diversity measures. Canopy species in this forest included two oaks (*Quercus agrifolia* and *Quercus douglasii*) and one pine (*Pinus sabiniana*). At the scale of our study, spatial turnover in rRNA-based communities was much more predictable from measurable environmental attributes than DNA-based communities. And while turnover of ectomycorrhizal fungi and saprotrophs were predictable by the presence and abundance of different canopy species, they both responded strongly to soil nutrient characteristics, namely pH and nitrogen availability, highlighting the niche overlap of these coexisting guilds and the strong influence of aboveground plants on belowground fungal communities.

#30 Nest-site Relationships Among Cavity-nesting Birds of Oak Woodlands in California: Identifying the Source of Cavities for Nonexcavators

Kathryn Purcell, USDA Forest Service, Pacific Southwest Research Station

We explored differences and similarities in nest sites among and within cavity-nesting bird species that excavate their own cavities and those that use pre-existing cavities, predicted the source of excavated cavities used by nonexcavators, and explored the potential for nest-site competition between European Starlings (*Sturnus vulgaris*) and native cavity nesters. We modeled differences in cavities excavated by Acorn Woodpeckers (*Melanerpes formicivorus)* and Nuttall's Woodpeckers (*Picoides nuttallii*) and predicted use by seven nonexcavator species. Acorn Woodpecker cavities were deeper, had longer entrances and larger entrance holes, and were more often in blue oaks (*Quercus douglasii*). Nuttall's Woodpecker cavities tended to face more downward. European Starlings used mainly Acorn Woodpecker-excavated cavities, while nests of Ash-throated Flycatchers (*Myiarchus cinerascens*), Oak Titmice (*Baeolophus inornatus*), House Wrens (*Troglodytes aedon*), and Western Bluebirds (*Sialia mexicana*) were classified more often as Nuttall's Woodpecker cavities. Cavities used by European Starlings were similar to those of Western Bluebirds, Violet-green Swallows (*Tachycineta thalassina*), and, to a lesser extent, White-breasted Nuthatches (*Sitta carolinensis*). Data on phenology showed that nest initiation dates of European Starlings overlapped extensively with those of Acorn Woodpeckers, White-breasted Nuthatches, and Oak Titmice. Results also suggested avoidance of peak nesting dates of starlings by Acorn Woodpeckers and Western Bluebirds. Nests of Acorn Woodpeckers, Western Bluebirds, and Violet-green Swallows had northern orientations, which is likely an adaptation for avoiding heat stress. Nest sites used by Ash-throated Flycatchers were not optimal for reproductive success, but those used by European Starlings appeared to be. The impact of European Starlings on native cavity-nesting species is potentially significant for Acorn Woodpeckers, Western Bluebirds, Violet-green Swallows, and possibly White-breasted Nuthatches when nest sites are limiting. Acorn and Nuttall's woodpeckers are keystone species in this bird community, calling for long-term monitoring of population trends and management strategies that aid in enhancing the populations of these two species.

#31 Vegetation Associations for Amphibians and Reptiles in Undisturbed California Oak Woodlands

Christopher Evelyn, University of California Santa Barbara, Earth Research Institute

William Tietje and **Anne Polyakov**, University of California Berkeley, Department of Environmental Science, Policy, and Management

Declining populations of many amphibian and reptile species are of increasing concern worldwide. Understanding how the distribution and abundance of these species is associated with habitat variables across multiple spatial scales can inform resource agencies and conservation organizations when setting management priorities. In 1995, we measured 23 vegetation attributes on nine 5.8-ha study plots in blue oak (*Quercus douglasii*)-coast live oak (*Q. agrifolia*) woodland located in coastal-central California. From 1995 to 2002, we conducted amphibian and reptile surveys between January and May by use of 136 plywood coverboards systematically placed within each of the nine study plots. During 9 to 14 annual visits to each plot, we recorded >8,900 observations of 11 reptile and 4 amphibian species. We combined data from our vegetation and herpetofauna surveys with GIS environmental variables and analyzed the combined dataset using multivariate techniques to determine habitat associations for slender salamander (*Batrachoseps* sp.), California Legless Lizard (*Anniella pulchra***)**, Western Skink (*Plestiodon skiltonianus*), Western Fence Lizard (*Sceloporus occidentalis*), Ringneck Snake (*Diadophis punctatus*), and night snake (*Hypsiglena torquata nuchalata*). Several of these species are of conservation concern in California oak woodland. Our study results will assist in a better understanding of the key oak woodland vegetation attributes necessary for the conservation of our focal species.

#32 Exploring the Value of California Black Oaks for Fishers in a Landscape Altered by Disturbance

Rebecca E. Green, US National Park Service

Eric McGregor, Oregon State University and **Kathryn Purcell**, Pacific Southwest Research Station, USDA Forest Service

Over the last decade, drought, increased temperatures, conifer mortality, and exceptionally large fires have occurred within the distribution of a rare forest carnivore in the southern Sierra Nevada. Persistence of the fisher (*Pekania pennanti*), a member of the weasel family that relies on components of older forests (e.g., large tree cavities) and extensive cover, is of increasing conservation concern as the forested landscape in this region continues to change.

In a suite of recent analyses focused on fisher habitat use pre- and post-disturbances (2007 – 2020), the presence of oaks - particularly California black oak (*Quercus kelloggii*) - consistently comes up as an important habitat component in areas where fishers continue to persist. California black oaks naturally provide cavities of suitable size to support fisher resting and reproduction and they were less impacted by recent drought and beetle outbreaks compared to local conifers. Thus, the presence of oaks in the current landscape appears especially important in maintaining habitat suitable for fishers in this region.

We summarize findings from several analyses associated with a long-term fisher project in the southern Sierra Nevada to highlight the ways in which oaks (especially California black oaks) may help mitigate some of the impacts of a changing climate and habitat disturbances in this region. From fine-scale tree

cavity microsites which can buffer extreme temperatures to broad-scale distribution of oaks that can provide some live tree cover in places with extensive tree mortality, we explore the role that oaks can play in fisher conservation efforts into the future.

#33 California's Oaks in the 21st Century: Oak Habitat for Endangered, Threatened, and Candidate Species

Angela Moskow, California Wildlife Foundation/California Oaks

California Wildlife Foundation's California Oaks (CWF/CO) program recently completed a report that demonstrates the importance of oaks for California's biodiversity, with a focus on species and subspecies that are federally and/or state designated as endangered, threatened and candidate (listed).

California Department of Fish and Wildlife (CDFW) provided lists of sensitive species associated with oaks. Vertebrate data were derived from the California Wildlife Habitat Relationship (CWHR) information system (https://wildlife.ca.gov/Data/CWHR). The CWHR query focused on vertebrate species that utilize oak (*Quercus* and *Notholithocarpus*) habitat for reproduction, cover, or feeding.

CWF/CO derived scientific names for listed vertebrate species and subspecies by consulting *State and federally listed endangered and threatened animals of California* and *Special Animals List*. Next, we reviewed scientific and state and federal listing documentation to ensure that the subspecies in the report are oak-dependent.

The plant and invertebrate tables were created first with a cross-reference of California Natural Diversity Database (CNDDB, https://wildlife.ca.gov/Data/CNDDB) occurrence records with the oak woodland dataset in CDFW's Areas of Conservation Emphasis (ACE) system. The CNDDB listing includes 134 plant species and subspecies that are designated as state or federally threated or endangered, or are candidates for federal or state designations, out of 839 sensitive native plant species associated with oak habitat. It includes 26 candidate and listed invertebrate species and subspecies out of 201 sensitive invertebrate species and subspecies that are associated with oak habitat. The CNDDB queries were exclusively for oak *(Quercus)*, as CNDDB does not track tanoak *(Notholithocarpus)*.

The report also contains recommendations of how current protections can be better enforced to conserve California's oaks.

#34 Response of a Keystone Species to the Removal of Downed Wood in a California Oak Woodland

William D. Tietje, Department of Environmental Science, Policy and Management, University of California, Berkeley

Timothy J. Smyser, National Wildlife Research Center, Fort Collins, Colorado; **Michael A. Hardy**, Department of Environmental Science, Policy and Management, University of California, Berkeley

Downed wood (DW) and snags can fulfill a variety of important ecological needs for small terrestrial vertebrats. Due to increasing frequency of wildfires, fuel-reduction practices, and higher mortality of large trees this century, the study of DW and snags has taken on increased importance in the Western United States. From 2004 to 2009, we used a before-after-control-impact (BACI) study design to assess the effects of an experimental removal of DW on a population of big-eared woodrats (*Neotoma*

macrotis) in an oak (*Quercus* spp.) woodland in coastal-central California. We used mark-recapture analyses to investigate the influence of DW removal on survival and emigration (movement off treated areas), and further explored relationships between snags and woodrat reproduction. Woodrat survival was lower and movement off study plots was higher in response to the removal of DW. Apparently due to high-quality nesting sites provided by snags, successful reproduction was more likely on plots with greater snag densities. Collectively our findings suggest that DW and snags are key components of high-quality habitat for big-eared woodrats. In areas with more DW and snags, woodrats survive better, make fewer risky movements, and are more likely to reproduce successfully. Given that DW and snags can increase wildfire risk, strategic planning is needed to balance fire prevention strategies with preserving the ecological benefits of DW and snags for species such as the big-eared woodrat.

#35 Participatory Field Gene Banks: A Novel Climate Change Adaptation Strategy for California Oaks

Blair McLaughlin, Hampshire College

Alissa Fogg, Point Blue Conservation Science

Climate change already is causing range contraction and loss of genetic diversity at some oak species' trailing edges. Edge populations, most exposed to climatic extremes, may contain adaptive traits important for a species' survival in a changing climate. Thus, the loss of trailing edge genetics may reduce possibilities for human-assisted gene flow and increase the likelihood of extinction. Oaks genetic conservation is challenging – acorns cannot be preserved in traditional seed vaults, and living conservation within botanic gardens is prohibitively costly. In a novel approach, we propose climate-adaptive, dispersed, land manager-participatory field gene banks to conserve threatened, trailing edge oak genetic diversity. Such field gene banks also present an opportunity to evaluate assisted gene flow as a climate change adaptation strategy.

To test the viability of this approach, we used blue oak (*Quercus douglasii*), which experienced extensive recent drought-related trailing edge dieback. In a cooperative effort between researchers and land managers dedicated to stewarding these oaks into the future, we translocated seedlings from nine threatened trailing edge sites to 12 common garden sites across the central/northern parts of the range. We also established a manipulative experiment with rainout and irrigation treatments at Hopland REC. Performance of both local and trailing edge seedlings was sufficient to establish a viable population in a restoration context. Additionally, in very dry conditions trailing edge seedlings showed lower levels of herbivory and disease, indicative of drought-adaptive traits that could benefit local populations as climate change progresses.

While assisted gene flow is a new, relatively high-risk strategy, the risk of losing narrow-ranged, endemic oaks in a changing climate is also high. The dispersed field gene bank maintains options as transplants can be removed before reproductive maturity if needed, and trailing edge genetic resources will be preserved in multiple locations even as they are lost *in situ*.

#36 Will Oak Populations Migrate? The role of Vicariance in California Oak Distributions

Thomas Scott, UC Cooperative Extension, Department of Environmental Science Policy and Management, UC Berkeley, and Department of Earth Sciences, UC Riverside

Andrew Sanders, Curator, UC Riverside Herbarium, University of California Riverside; **Scott Mensing**, Department of Geography, University of Nevada, Reno

A number of studies have estimated the impacts of climate change on oak distributions, framed by questions of how far or fast oaks populations will need to migrate to survive. While the fossil record and phylogenies suggest that lineages of oaks (*Quercus kelloggii, Q. lobata, Q. chrysolepis*) moved south into California as climate changed in the Paleocene, there are equally compelling arguments for role of vicariance and barriers in the history of modern oak species distributions in the United States and Mexico. One of the strongest barriers to current oak distributions in California occurs in the Sonoran Desert and Baja California Norte, where oak lineages from the California Floristic Province (CFP) meet lineages from the southwestern US and Mexico. This barrier forms a Wallace's line for *Q.* section *Quercus* and *Q*. section Lobatae, crossed by only 3 (of 44) species from Mexican oak lineages (*Q. turbinella, Q. englemannii, Q. peninsularis*), and no species from the CFP (16 species). The most intriguing part of this separation occurs across the Gulf of California, where the movements of the Pacific and North American plates have created one of best studied vicariant events in North American biogeography (including the evolution of *Q. brandegeei*). The landmass captured and moved north by the Pacific plate extends from the tip of Baja California to Mendocino County (CA), and coincides with (or encompasses) the distributions of 11 species and varieties of oaks (32% of oak taxa in the CFP). Fossils of these species also tend to occur on the Pacific plate, and their records on the North American plate are qualified by limited number, ambiguities, or exceptionally early (Eocene) dating. In the case of *Quercus agrifolia*, 95% of herbarium records are located on the Pacific Plate, and most of the records on the North American Plate are located within 30 miles of the plate boundary. In the case of *Q. engelmannii*, *Q. agrifolia* var. *oxyadenia*, and *Q. parvula* var. *sherevi*, all the herbarium records are on the Pacific Plate. Plate boundaries may not be as critical as the mountain and rift basins that form along plate margins, creating dispersal barriers like the inland seas and rain shadows that formed in the California Central Valley and southern California deserts. Nevertheless, the hypothesis that *Q. agrifolia* rafted north with the movement of the Pacific plate could help to explain why a 15-million-year-old species with a remarkably broad tolerance of habitats failed to establish populations or remain in the Sierra Nevada, Tehachapi or San Gorgonio Mountains. Questions of how far or fast oaks populations will migrate in the future should be qualified by an assessment of how their current distributions could be tethered to tectonic plates or have been affected by 150 to 350 km of northward movement.

#37 Detecting Introgression and Determining the Potential of Adaptive Gene Flow Between Two Hybridizing Californian White Oaks (*Quercus sect. Quercus*)

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The ability of closely related oaks (*Quercus* spp.) to hybridize is well known. This ability may also increase the potential for exchanging genetic variation across species boundaries through backcrossing events; a process otherwise known as introgression. This phenomenon should not only result in the exchange of neutral genetic variation between species, but it also could transfer of beneficial alleles. To test this hypothesis, we focused on two white oak (*Quercus* sect. *Quercus*) species found in the California Floristic Province that freely hybridize when in close proximity: the more mesic Engelmann oak (*Quercus engelmannii*) and the drought tolerant California scrub oak (*Q. berberidifolia*). Whole-genome sequence data was generated for 75 individuals of both *Q. berberidifolia* and *Q. engelmannii* (150 total samples) collected throughout southern California where their contemporary ranges overlap. By comparing genomic sequence data between these two species, regions of the genome that contain heightened levels of introgression relative to background levels of shared genetic variation between species were identified. These regions of the genome were then mapped to the well-annotated valley oak (*Q. lobata*) reference genome to identify any potential functional genes in these portions of the genome. Additionally, we analyzed the patterns of introgression at a landscape scale to determine if some populations were experiencing differential levels of introgression of functional genes depending on the location. We found several genes that are potentially important to traits associated with climate adaptation that have patterns of introgression suggestive of differential selection between populations. These results indicate that introgression may have the potential to directly influence the fitness of the species involved. Further work should be focused on specific introgressed alleles associated with increased levels of fitness.

#38 Plasticity Drives Geographic Variation and Trait Coordination in Blue Oak Drought Physiology

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Two decades of widespread drought-induced forest mortality events on every forested continent have raised the specter of future unpredictable, rapid ecosystem changes in 21st century forests. Yet our ability to predict drought stress, much less drought-induced mortality across the landscape remains limited. This uncertainty stems at least in part from an incomplete understanding of within-species variation in hydraulic physiology, which is the complex result of genetic differentiation among populations (ecotypic variation) and phenotypic plasticity in response to growth environment. We examined among-population genetic differentiation in a number of morphological and hydraulic traits in California blue oak (*Quercus douglasii*) using a 30-year-old common garden. We then compared this genetic trait differentiation and trait-trait integration to wild phenotypes in the field from the original source populations.

We found remarkably limited among-population genetic differentiation in all traits in the common garden, but considerable site-to-site variation in the field. However, it was difficult to explain trait variation in the field using site climate variables, suggesting that gridded climate data does not capture the drivers of plasticity in drought physiology in this species. Moreover, population mean trait values were uncorrelated in the garden versus the field. Trait-trait relationships were also considerably stronger in the field than in the garden, particularly links between leaf morphology, leaf hydraulic

efficiency and stem hydraulic efficiency. Indeed, while twelve of 45 potential trait-trait relationships showed significant wild phenotypic correlations, only four relationships showed both genetic and phenotypic correlations, and five relationships showed significantly different genetic and phenotypic correlations. Collectively, our results highlight limited ecotypic variation in drought-related physiology but considerable geographic variation in physiology and phenotypic integration in the wild, both driven largely by plasticity.

#39 Post-fire Oak Survival and Regeneration in Oak Woodlands Impacted by the River Fire at Hopland Research and Extension Center

Michael I. Jones, UC Cooperative Extension, Mendocino, Lake and Sonoma Counties

In July 2018, the River Fire burned ~3,000 acres of oak (*Quercus* spp.) woodlands, chaparral, and grasslands at the Hopland Research and Extension Center. Fire behavior was highly variable across the site, resulting in a mosaic pattern of low to high burn severity. To assess how the fire impacted oak survival and regeneration, long-term monitoring plots were established in burned and unburned oak stands.

Data were collected on 468 trees representing seven oak species. At the time of plot establishment several months after the fire, 41.3% of oak trees in burned plots appeared dead (compared to 5.4% in unburned plots) with extensive bark charring, cambium damage, and > 90% canopy torching. However, new (post-fire) epicormic and/or basal sprouts were observed on 29.2% of trees that had high severity burn damage, suggesting observed mortality may have been limited to aboveground biomass.

Plots were reassessed November 2019 and apparent mortality (no evidence of regeneration) had decreased to 12.7%, while 81.0% of trees with high severity burn damage had basal or epicormic sprouting. Oak seedlings were often detected in plots with moderate to high burn severity. Deer browse and powdery mildew on basal sprouts was commonly observed. Evidence of insect feeding (galleries and exit holes) were observed on dead trees, but few signs of pests were detected on living trees or living tissue of fire stressed trees.

These results indicate even though many of the oak woodlands in this study appeared to have been significantly impacted by the River Fire, most trees with aboveground mortality were already regenerating through basal sprouting and there was abundant seedling recruitment. Continued monitoring will elucidate the success of regeneration and if continued injury from pests will have a lasting impact on new growth.

#40 Identifying Second Order Effects of Fire on California Oaks

Shane Dewees, Dept. of Ecology, Evolution, and Marine Biology, UC Santa Barbara

Leander Anderegg, Max Moritz, Nicole Molinari

Fire can cause tree mortality both imediately, through large-scale tissue necrosis, and post-fire, through second order effects on the phloem and xylem. The extent of the occurrence of these second order effects is largely believed to be driven by fire intensity. As climate change continues to worsen and is causing more frequent and intense fires, understanding the extent to which these second order effects occur in a tree and how they affect tree health is of growing importance. Our preliminary work on *Quercus kelloggii* (Black oak), a culturally and ecologically important oak species, reveals that a relatively low intensity surface fire can cause full depth cambium necrosis in the bark. Additionally, we identified heat-plume induced leaf embolism, which caused a significant reduction in leaf specific

conductivity. Considerable variation in the degree of damage was observed, however. Therefore, future work will be focused on better understanding the determining factors of the extent of post-fire damage and investigating the affects that damage has on whole tree health.

#41 Determining the Long-Term Effects of Wildfire on Goldspotted Oak Borer in Southern California

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The goldspotted oak borer (GSOB), *Agrilus auroguttatus* Schaeffer, is an invasive flatheaded wood borer that infests and kills California black oak (*Quercus kelloggii* Newberry) and coast live oak (*Quercus agrifolia* Née) trees in Southern California. Since its introduction from southeastern Arizona into San Diego County in the late 1990s, GSOB has spread into four additional counties: Riverside, Orange, Los Angeles, and San Bernardino. GSOB's impact on forest stands is significant because of the beetle's preference for large, mature oaks. In areas of San Diego where GSOB has been present for over 10 years, tree mortality has reached 90%. Tree mortality can be reduced in localized areas where active GSOB management occurs, but in wildland areas there are no direct management options. Studies are underway to examine how current forest vegetation management practices may reduce the progression of GSOB infestation however no data exists on the impacts of wildfire on GSOB. Recent studies of future fire regimes have shown that climate change will have a substantial impact and suggests that there will be an increase in burned area and fire occurrence. In order to characterize the long-term effects of wildfire on GSOB-infested stands and GSOB populations within those stands, forest inventory plots were established in or surrounding two recent wildfires. The Valley Fire in San Diego County (16,390 acres) and El Dorado fire in San Bernardino County (22,744 acres) burned through GSOB-infested areas. Within or near the footprint of those two fires, 19 x 1/5-acre plots were established in GSOB-infested burned areas and 9 x 1/5-acre plots were established in GSOB-infested stands that were not burned. Forest stand conditions, tree mortality, degree of tree injury associated with wildfire severity, and severity of GSOB-infestation were recorded in each plot. Preliminary findings of this research will be discussed.

#42 Response of Post-wildfire California Black Oak Sprout-clumps to Crown Modification; Early Results

Martin Ritchie, Pacific Southwest Research Station

Ethan Hammett, Pacific Southwest Research Station; **Pascal Berrill**, Humboldt State University; **Jonathan W. Long**, Pacific Southwest Research Station

California black oak is commonly found in many forested areas in California and southern Oregon. The species is susceptible to top-kill by moderate and high-severity fire but typically sprouts vigorously from latent buds in the root collar. The tree then typically assumes a shrub form for some time while, gradually, self-thinning within the sprout-clump takes place. While black oak is highly valued for wildlife foraging and nesting, during the time while the individual exhibits a shrub form this value is diminished.

For example, acorn production and opportunities for nesting habitat are more associated with mature trees than with young sprouting individuals.

We studied the prospect for accelerating the transition to tree form by selecting individual sprout-clumps to receive one of three treatments: remove all but a single stem, remove all but three stems, and a control where the sprout remains unaltered. After losses to wildfire and woodcutters, eleven sites were retained in northern California with latitudes ranging from 38.43° to 41.23°, ranging from 3-16 years since disturbance. We observed pre-treatment, immediate post-treatment, and three-year post-treatment sprout-clump characteristics, including crown dimensions, 3 dominant stem diameters, count of stems at breast height, degree of resprouting post-treatment, and mast production. In addition, we observed overstory and understory competing woody vegetation.

After three years sprout-clumps reduced to one stem had a vigorous sprout response resulting in an average recruitment of 4.3 stems at breast height. In contrast the second treatment retaining 3 stems only saw an average recruitment of 0.2 stems at breast height. While controls on average self-thinned by 1.5 stems at breast height. Thus, it appears that reducing to a single stem promotes further sprouting within black oak, while with three stems this undesirable outcome is reduced.

Using a mixed-effects model with adjustments for sprout size, three-year basal area increment of the largest stem was accelerated for both treatments, with much greater response from the thinning to a single stem. Expressed as a percentage, the increase in increment over the control varied by site. For thinning to three remaining stems, assuming an initial basal stem diameter of 5 cm, the percentage increase varies from 15 to 240%. Thus, in the short term, treatment benefit to tree increment can be substantial. While we did not estimate effects of treatment on leaf area, we did observe a loss of crown volume of 16.9 m^3 in trees treated to retain only three stems. As the tree rebuilds crown loss to thinning, the response over a longer time horizon will likely change. Longer-term effects will require future remeasurement of the plots.

After three years from study initiation, thinning California black oak sprouts to three remaining stems appears to increase growth rate of the largest retained stem, without promoting subsequent resprouting.

#43 California's Ranch Water Quality Planning Program Revamped and Redeployed

Morgan Doran, UCCE Capitol Corridor

The University of California recently unveiled the next evolution of the Ranch Water Quality Planning (RWQP) outreach program. Since its inception in 1995, the RWQP program has delivered more than 80 short courses in 35 counties to over 1,000 ranching and community members, resulting in more than two million acres of rangeland, including oak woodlands, placed under water quality plans throughout California. RWQP short courses have been highly dependent on University of California Cooperative Extension academics to organize and deliver workshops using a flexible curriculum framework to adapt educational content to local issues and regulatory programs. The updated RWQP program centers on a multi-media package that enables UC Cooperative Extension (UCCE), and non-UCCE people and organizations alike, to organize and convene a series of locally-relevant RWQP workshops with the purpose of coaching ranchers and land managers to build their own ranch water quality plan. The core of the package is a RWQP Instructor's Guide and Lesson Plan that consists of nineteen lesson plans organized into six learning modules. A key resource for workshop planners are the twenty-nine educational and instructional videos curated on YouTube and available to augment the content of planned workshops. The RWQP Instructor's Guide is available as a downloadable PDF document and

on the UC Rangelands website. The Guide provides the resources and tools to plan and implement Ranch Water Quality Planning workshops and field days for grazing livestock producers, agency staff, and other stakeholders interested in grazing management and water quality. These new resources provide a wealth of contemporary information about water quality management on rangelands based upon more than thirty years of research and education conducted by UC Cooperative Extension and partners. This presentation reviews the evolution of the RWQP program and the intended use of the Instructor's Guide, and demonstrates how to access and use the Instructor's Guide and its major components.

#44 Ranching – The Next Generation: Reflections on Innovative Ways for Young Ranchers to Contribute to the Preservation of Oak Woodlands

Elizabeth Reikowski, Owner, Willow Creek Land and Cattle, LLC

Maintaining the economic and cultural viability of working ranches is critical to preserving oak woodlands. Over 80% of California's oak woodlands are privately owned, and the majority of these are used for livestock grazing. Thus, oak woodlands form an important land base for ranching operations and, reciprocally, profitable working ranches protect oak woodlands from land-type conversions. Unfortunately, cattle ranching faces a variety of economic, social, and environmental threats, including (1) climate driven changes in forage and water availability, (2) the high price of land ownership, leading to a gradual trend away from family-owned ranches and toward tenant ranchers operating under wealthy landowners, and (3) a generally older ranching demographic and lack of young ranch operators. In order to be successful, young ranchers will have to find new niches for revenue and strategically blend tried and true ranching traditions with new, innovative methods.

Willow Creek Land and Cattle is an example of a young cattle ranching business working to find innovative ways to successfully steward land and generate income. My brother and I started this business in 2018 (at the ages of 21 and 22, respectively), both because we were interested in leveraging livestock grazing as a land management tool and because we were drawn by the opportunities for innovation and independence that come from running your own ranching business. We built our business almost exclusively on leased rangeland, which we acquired by offering grazing practices designed to meet specific land management objectives in exchange for reduced-cost grazing leases. We supplement income generated by our cattle with a blend of targeted grazing contracts and grant-funded rangeland research and restoration projects. In addition to providing supplemental income, our involvement in research and restoration enhances our effectiveness as land stewards by helping us evaluate the efficacy of our management practices. Our business relies heavily on the advice and resources of numerous friends and family, as well as the expertise and mentorship of a wide variety of rangeland professionals. Novel and innovative business models, as well as close collaboration across generations and disciplines will be essential for young ranching businesses to thrive, and to maintain ranching's vital role in preserving California's oak woodlands.

#45 Challenges Faced by California Ranchers: Environmental, Regulatory, and Encroachment Pressures

Seth Scribner, P. E.

Complexities in modern ranching range from advancing regulations to environmental constraints to a dwindling labor pool. As a professional rancher, I hope to give some insight to the challenges faced by today's modern grazers, including:

California ranchers continually navigate a steady stream of ever-increasing regulations targeting governance of their water and land usages. In many instances operations who've been in existence for generations feel it's easier to sell their land to developers rather than fight tooth n' nail for their right to farm and ranch.

What does it take to ranch under a conservation easement? From BMP's to seasonal grazing to RDM, it takes a comprehensive grazing plan to keep the operator both profitable and in compliance. Each constraint not only adds to the complexity of the grazing regime, it comes at an economic cost as well. How about the current drought or next wildfire, what bearing will those have on ones operation?

In an industry where your office is outside, things sound glamorous, but in reality animals need care 24hrs a day whether it's 100 degrees outside or snowing or even on holidays. So when California forced agriculture to adhere to a 40hr work week, we've lost the lifestyle appeal and the labor pool.

#46 An Updated California Rangeland Decision Assistance Tool: the CRSA

Rebecca Ozeran, University of California Cooperative Extension

Sheila Barry, University of California Cooperative Extension; **Mark Brunson**, Utah State University; **Julie Finzel**, University of California Cooperative Extension; **John Harper**, University of California Cooperative Extension; **Royce Larsen**, University of California Cooperative Extension; **Brooke Latack**, University of California Cooperative Extension; **Fadzayi Mashiri**, University of California Cooperative Extension; **Devii Rao**, University of California Cooperative Extension; **Matthew Shapero**, University of California Cooperative Extension; **Jeffery Stackhouse**, University of California Cooperative Extension; and **William Tietje**, University of California Cooperative Extension.

California ranchers balance multiple ecosystem services, economic values, and social benefits when they manage rangelands, often while facing intense public scrutiny and development pressure. Regular evaluation and adaptation to maintain this balance on working lands can be challenging. To support ranchers in decision making, our project team has updated and digitized the California Rancher Sustainability Assessment (CRSA) to provide a rapid and simple method of self-evaluation, paired with science-based resources describing best practices. The CRSA currently offers five distinct modules covering forage management, soil health, wildlife management, drought management, and generational succession. These topics include ecological, social, and economic components of modern ranching and provide insights into how each module fits into the bigger picture of ranch sustainability. We will describe the iterative process of creating the online assessment, showcase how the modules work through a live demonstration, and discuss anticipated impacts to the future of ranching in California.

#47 Drill-seeding Blue Oak Acorns is a New Method for Restoration in California's Rangelands

Alex Palmerlee, Far View Ranch

Carrie Wendt, Point Blue Conservation Science and Truman Young, University of California at Davis

In both cleared and existing blue oak woodlands, there is a lack of new oak recruitment. Problems of this scale require restoration solutions that are cost-effective and scalable. Existing restoration techniques use a litany of interventions (irrigation, caging, tree tubes, weed control) to ensure high survival per individual at a high price per survivor.

We tested the application of drill-seeding to “farm” oaks in rangelands with a low-tech slip-plow attachment. In two consecutive years we planted blue oak acorns under varying conditions, combining drill-seeding with cattle grazing, shade, and herbicide in a paired nested block study.

Our data suggest that drill-seeding large-seeded species may be a viable restoration technique under multiple conditions. After a year and a half, seedlings are at 6% survival with no post-planting interventions. The lack of costly interventions means that even at low percentages, survival is still very cost-effective. Calculated as a factor of equipment and labor time required to collect, treat, store, and plant acorns, the cost per surviving seedling was under $3.

Current restoration challenges, including those posed by climate change, demand that we develop more cost-effective planting techniques that can be applied on thousands of acres per year. Drill-seeding acorns, surpassing recruitment limitations by mass-seeding, may be a valuable addition to the restoration tool box.

#48 North Coast Oak Woodland Restoration: Assessment of Post-treatment Understory Conditions

Jeffery Stackhouse, University of California Cooperative Extension

Yana Valachovic; **Lenya Quinn-Davidson; Brendan Twieg,** University of California Cooperative Extension and **Chris Lee**, CAL Fire

The loss of deciduous oak woodlands to native conifer encroachment is a major conservation concern in California, resulting in associated losses of wildlife habitat, traditional land uses, biodiversity, and other ecosystem services. These concerns have drawn increasing attention in the last decade, and oak woodland conservation and restoration efforts have gained momentum.

Throughout northwestern California, NRCS has played a critical role in initiating and funding oak woodland restoration. The agency has been on the cutting edge of the conifer encroachment issue, spurring great interest among private landowners and working to reduce negative trends for *Quercus kelloggii* and *Q. garryana* throughout the North Coast region. However, understanding of treatment effectiveness is largely anecdotal, and though the agency and its federal and private partners recognize the pressing need for oak woodland restoration, they lack data-driven guidance on treatment effectiveness and cost.

The purpose of the project was to assess effectiveness of conifer removal treatments and provide guidance to agencies and operators interested in doing this work. Among other aspects of woodland restoration, we analyzed lop and scatter, hand pile and burn, mechanical removal, and mastication treatment effects on tree regeneration, reestablishment of understory vegetation, and wildlife habitat conditions.

#49 North Coast Oak Woodland Restoration: Oregon White Oak and Black Oak Tree Response to Release from Douglas-fir Encroachment

Yana Valachovic, University of California Cooperative Extension

Jeff Stackhouse; Lenya Quinn-Davidson; Brendan Twieg; Wallis Robinson, University of California Cooperative Extension, and **Chris Lee**, CAL Fire

North Coast oak woodlands, dominated by deciduous Oregon white oak and California black oak, have long been central to the ecology and culture of the region. Oak woodlands support high levels of biodiversity and provide unique habitat for wildlife, and are deeply rooted in the human history of the region, as oaks have both sustained and been sustained by Native Americans, ranchers, and other local groups throughout recent history. However, management, lack of management, and landscape changes over the last century have altered these ecosystems, and both black and white oak woodlands are in decline throughout their ranges.

One of the primary concerns in North Coast oak woodlands is the absence of the disturbance regimes that historically shaped and maintained these ecosystems. Both black and white oak woodlands are fire-adapted, depending on frequent, low- to moderate-intensity fires to prevent the establishment of invading fire-sensitive vegetation and supply conditions suitable for regeneration. Fire exclusion over the last century has resulted in both direct and indirect impacts to oak woodlands, affecting their recruitment and persistence, stand structures and fire regimes, and overall ability to persist on the landscape.

The purpose of the research project was to assess the effectiveness of conifer removal treatments in Humboldt and Trinity Counties and provide guidance to agencies and operators interested in doing this work. We evaluated three key aspects of woodland restoration: 1) tree and stand-level responses to different oak release treatments; 2) mechanisms of oak decline in encroached stands and trajectory of oak health post-treatment; and 3) a survey of treatment costs and the ease of implementation and longer-term maintenance.

This work demonstrated the effectiveness of managing Douglas-fir (*Pseudotsuga menziesii*) encroachment into Oregon white and California black oak woodlands and provided critical data regarding the response of stand health variables, wildlife habitat values, fuels, along with other variables.

#50 Resistance to *Armillaria* in Encroached and Open True Oak Woodlands of the North Coast

Chris Lee, California Department of Forestry and Fire Protection, Fortuna, CA

Yana Valachovic; Lenya Quinn-Davidson; Jeff Stackhouse, University of California Cooperative Extension, Eureka, CA

Armillaria species are sometimes collectively known in California as the “oak root fungus” for their aggressiveness to oaks. Although this aggressiveness is most obvious in urbanized and agricultural landscapes, it also informs the dynamics of true oak decline under the canopies of encroaching conifers, particularly Douglas-fir in California’s north coastal counties. While studying the effects of encroaching Douglas-fir in Oregon white and California black oak woodlands in Mendocino, Humboldt, and Trinity Counties, we hypothesized that rapid Douglas-fir densification and ensuing stem exclusion (in which *Armillaria* sp. provides one mechanism of small tree death) would present ideal conditions for *Armillaria* sp. to spread to oak root systems and infect oaks compromised by the diminishing light resource. Moreover, we wondered whether oaks released from conifer competition by removal treatments, presumably after the establishment of *Armillaria* infections under shaded conditions, would continue to host significant infections. Upon excavation of white and black oak and Douglas-fir roots in plots treated by Douglas-fir removal and in control (untreated) plots, we observed significantly more signs and symptoms of *Armillaria* infection in control than treated plots, even though treated plots had numerous Douglas-fir stumps that were being decayed by *Armillaria* species, representing an enhanced inoculum potential on the plots. This suggests that upon release from light competition with

Douglas-firs, true oaks can rapidly mobilize resources to compartmentalize *Armillaria* and prevent further infection. Finally, we observed this to differ between Oregon white oaks and California black oaks, with the former generally more resistant to *Armillaria* infection. This distinction is potentially informative for the timing of conifer removal treatments during the encroachment process.

#51 Can Grazing Reduce Wildfire Risk?

Katherine Siegel, Theresa Becchetti, Stephanie Larson, Matthew Shapero, Fadzayi Mashiri, Lulu Waks, Luke Macauley, Van Butsic, UC Cooperative Extension

Livestock grazing has been removed from many rangelands due to concerns grazing negatively impacts ecosystems. Historically grazing pressure was one of the greatest tools for reducing fine fuels that carry wildfires. There is a growing concern about the negative impacts of wildfires on rangelands, forest and communities across California, which has seen increasingly larger and more severe wildfires. Livestock can play a role in reducing wildfire risk by removing fine fuels and preventing potential conversion to shrub species. While data suggest that grazing may reduce fire severity and size, there is little research into the effects of grazing on fire at the landscape scale. Mega-fires and unprecedented expenditures on fire suppression over the past decade have resulted in a renewed focus on pre-suppression management. Livestock are an appropriate tool to reduce fire fuels and grazing post fire increases the resistance of plant communities to post fire invasion and dominance by invasive species. **We ask if livestock grazing on California rangelands can reduce the potential for and severity of wildfires in California at the landscape scale.** Using past data of wildfires, climate, vegetation type, land ownership and biophysical variables we determined if grazed areas burned less frequently and/or with less severity than non-grazed areas. In addition, we seek to identify trade-offs and synergies between grazing and wildfire management. Grazing by livestock is likely the most cost effective and practical treatment to apply across large landscapes scales to manage herbaceous fuels.

#52 Bark Traits and Expected Conferred Resistance to Fire-induced Mortality in Three California Oak Species

Kaili Brande, Bren School of Environmental Science and Management, University of California, Santa Barbara

Frank W. Davis and **Bruce Kendall**, Bren School of Environmental Science and Management, University of California, Santa Barbara

Problem: As fire is returning to California ecosystems at a rapid pace, understanding the natural defense mechanisms that oaks have is increasingly important. Bark is considered to be critical in protection against fire-induced embolism of the cambium. However, bark traits of California oak species have been rarely studied. To address this gap, we evaluate bark thickness and rugosity to better understand the role they play in fire resistance for three dominant oak species in Southern California foothills: coast live oak (*Quercus agrifolia*), valley oak (*Quercus lobata*), and blue oak (*Quercus douglasii*). By identifying differences across size and species, and assessing allometric growth patterns of each trait, we can better estimate conferred fire resistance, and create predictions of vulnerability at the stand level to inform management decisions.

Methods: We collected data for all three species at Sedgwick Reserve, a unit of the UC Natural Reserve System. Samples were collected across a range of sizes and at two measurement heights

along the trunk. Patterns of variation in the two bark traits will be analyzed by species. The allometric growth patterns of each trait will be evaluated using OLS regression, and differences between measurement heights will be evaluated using a mixed effects model.

Results: Preliminary analyses suggest that mean rugosity values are more similar for valley and blue oak, than for coast live oak. We expect that bark thickness will also be most different for coast live oak, given prior visual assessments. We hypothesize that, based on allometric growth patterns and differences between measurement heights, the bark of all three species will suggest high conferred fire resistance.

Recommendations: With climate change and a changing fire regime in Southern California foothills, oaks are expected to experience fire at a greater frequency and intensity. Understanding the bark traits of resident species and how they may aid survival will be critical for oak woodland managers in the coming decades.

#53 Successional Dynamics in Maritime Vegetation on a Fire-suppressed Landscape

Jim Thorne, Department of Environmental Science and Policy, University of California

Brad Anderson, Lucy Genua, Genelle Ives, Meghan Bowen, Bren School of Environmental Science & Management, UC Santa Barbara

California's central coast is of significant importance for conservation for the state of California due to high levels of plant endemism and native oak woodlands that are threatened by climate change and development pressure. Past disturbances such as fire and grazing have had a large impact on Californian coastal ecosystems. Historical ecology is an interdisciplinary field that uses historical data to understand how ecosystems and landscapes have changed over time and it can be used to inform conservation and restoration planning. The Nature Conservancy's Jack and Laura Dangermond Preserve presents a unique opportunity to use historical ecological techniques to inform land management by better understanding the degree of anthropogenic impacts on a coastal Californian ecosystem. We use historical aerial imagery and historic vegetation maps (VTM) to show that over an 80-year period, the relative frequencies of different habitat types at the Dangermond Preserve have changed substantially. Since the 1930s, the overall area occupied by grassland has decreased, while shrubland and oak woodland area have increased on the property, likely due to conversion of grassland to shrubland and shrubland to oak woodland. Our results — particularly the decline in small trees — suggest that there has been limited coast live oak recruitment on the property since the 1930s. These trends are consistent with other studies along the central and north coast of California and are likely driven by declines in grazing and by fire suppression.

#54 Post-fire Recovery in the Understory: Woody Fuels Management and Restoration in Oak Forests at Pepperwood

Michelle Halbur, Pepperwood Preserve

Tosha Comendant, Pepperwood Preserve; **Michael Gillogly**, Pepperwood Preserve; **Devyn Friedfel**, Pepperwood Preserve; **Ryan Ferrell**, Pepperwood Preserve; **Makayla Freed**, Pepperwood Preserve; **Morgan Gray**, Pepperwood Preserve; **Sonja Barringer**, Pepperwood Preserve; **Steven Hammerich**, Pepperwood Preserve; **Lisa Micheli**, Pepperwood Preserve

Following severe wildfire, land managers are often faced with forest conditions that require intensive management in the understory, such as controlling plant invasions or addressing the perpetuation of

woody fuel loads in the forest understory from falling trees and limbs. Here we present our monitoring data and observations at Pepperwood Preserve, a 3,200-acre nature preserve in Sonoma County, that was burned in October 2017 and 2019 by the Tubbs and Kincade Fires. In areas managed for Douglas-fir incursion, we documented significant reductions in surface fuel loads (i.e., slash) after the Tubbs Fire, except for 1000-hour fuels that were maintained, and in some cases increased, from continuously dying and falling trees. Fine fuel loads rebounded within two years following fire, mostly due to increased herbaceous and invasive weed biomass. To deal with tree mortality in the canopy and the accumulation of understory slash, Pepperwood thinned oak forest areas and conducted pile burns in winter and spring 2020, resulting in localized areas of high burn intensity. We are restoring these pile burn areas to prevent additional invasive weed establishment and to encourage the forest understory to recover to a perennial grass-dominated system.

#55 Rescuing Acorns and Wild Seedlings Borne by Legacy Oaks in Urban Areas: Conserving the Genetic Heritage of California's Original Oak Forests

Tim Vendlinski, Independent Scientist Conserving Urban Creeks, Forests, and Prairies; Oakland, CA

We are quickly losing the last of our original, legacy remaining in California's urban areas. The trees have been exposed to multiple anthropogenic stressors, including reckless development patterns, paving and turfing; and more recently, the spread of pests and pathogens, unrelenting drought, excessive heat, and the dramatic loss of soil moisture. Even when municipal codes confer protections to legacy oak trees, the codes are not rigorously enforced, making otherwise healthy trees vulnerable to avoidable damage during construction activities, and the routine maintenance of parks, roadsides, and other built environments. Further, municipal tree programs do not protect the wild progeny of legacy trees, nor do urban foresters prioritize the planting of locally-sourced oaks in their approved street tree programs. For decades, urban foresters have placed the emphasis on planting non-native trees and cultivars - trees that provide only negligible benefit to wildlife, and no substantial contribution to biological diversity.

This paper makes the case for prioritizing the planting of native oaks as part of our municipal tree programs, and urges that we conserve the genetic wealth of legacy oaks that is so perfectly encapsulated by their acorns, and so remarkably expressed as wild seedlings growing across untended swaths of our urban landscapes. We can leverage the available cost-effective tools and methods to make native oaks the centerpiece of almost every municipal tree program in California. Oaks can be added to already canopied districts as replacement trees, and bring much needed shade, temperature relief, and equity to barren neighborhoods and marginalized communities. Wild oaks germinated from our legacy trees possess the genetic wealth to connect us materially to the past while providing an ecological bridge to the robust, urban forests of the future.

#56 A Theoretical Model of Oak Persistence Under Competition and Herbivory

M.V. Eitzel, Science & Justice Research Center, University of California, Santa Cruz

Oak tree populations in California face a number of challenges for population persistence. Adult mortality due to diseases like Sudden Oak Death and cutting for development, seedling competition with annual grasses for scarce water resources during dry summers, and herbivory by cattle, deer, and rodents all threaten different oak life stages. I use a differential equation-based theoretical model to represent three life stages of oaks: seedlings, juveniles, and adults. I include the population dynamics of seedlings transitioning to juveniles, juveniles to adults, and adults producing new seedlings, as well

as survival rates for each of the stages. I also include a model of competition for light and water within seedlings and between seedlings and annual grasses. Finally, I include a predation term to represent herbivores eating seedlings and grasses, using a Holling Type II (satiating) response with interference for predators and a death rate which depends on the resource extraction rate. After seeking an equilibrium with non-zero amounts of seedlings, juveniles, adults, grasses, and browsers, I then conduct a sensitivity analysis to parameters representing life stage transitions and survival, parameters representing the competition with grasses, and parameters representing herbivory. The analysis reveals that even low amounts of juveniles still result in overall persistence, and the most important parameters in determining this persistence are first the reproductive rate of adults, and second the survival rate of adults. Oaks in this model are not strongly impacted by competition and very little by browsing. This result implies that protecting adults is a key part of conservation strategy and therefore continuing to defend and strengthen policies preventing cutting of adults could be as important as improving seedling survival and transitions to juvenile stages.

#57 Examining Abiotic and Biotic Factors Influencing Specimen Black Oaks (*Quercus kellogii*) in Northern California to Reimplement Traditional Ecological Knowledge and Promote Ecosystem Resilience Post-wildfire

Cory O'Gorman, Dept. of Biology, Sonoma State University

California black oak, *Quercus kelloggii,* plays an important role in the lifeways of many indigenous tribes throughout California. Native peoples tend black oaks using Traditional Ecological Knowledge (TEK) to encourage the development and proliferation of specimen oaks. These mature, large, full crowned trees provide a disproportionate amount of ecosystem services, including acorns and habitat, when compared to smaller black oaks. Altered approaches to land management and the cessation of frequent low intensity cultural burns places these specimen oaks at risk from encroachment, forest densification, and severe wildfire. This project is a collaboration between academic researchers and a Native Advisory Council to examine abiotic and biotic factors influencing *Quercus kellogii* to reimplement traditional ecological knowledge and promote ecosystem resilience post-wildfire. Data were collected from 55 specimen black oaks at Pepperwood Preserve in northeast Sonoma County. Specifically, we classified specimen oak growth habitat by measuring specimen oak crown area and live crown ratio, the size and number of surrounding trees and amount of surface and ladder fuel loads. The preserve burned in both the Tubbs Fire in 2017 and the Kincade Fire in 2019, the latter of which occurred three months after the completion of the initial data collection. Immediately following the Kincade Fire we measured scorch height and related our abiotic and biotic variables to fire severity. Forest densification was found to have a significant negative effect on both canopy area ($p=0.003$) and live crown ratio ($p=0.038$) of the specimen oaks. Densification did not affect surface and ladder fuel load accumulation since the Tubbs Fire in October 2017 ($p>0.05$).

#58 California Oaks: Evolved for Resilience in California's Changing Climate

Chad Roberts, retired conservation ecologist

Recent oak-genome studies indicate that California's native oak clades originated in North America at least 40 million years ago, and (with minor exceptions) have evolved separately from other oak clades in North America and Eurasia. Species within each major clade form a syngameon, in which multiple species share genes and all species are genetically enriched, although individual species consistently demonstrate ecological separations from related species, shaped by local environmental conditions.

Oak species diversity in California arose in part because species in each clade evolved to overlap ecologically with species in other clades, resulting in coexistence of multiple clades in occupied habitats.

California oak clades diversified coincident with development of California's Mediterranean-type climate. California's landscape itself evolved significantly during that timeframe, increasing the range of available habitat conditions. California's native oaks are evolutionarily suited to conditions expected to be widespread with hotter, drier climate. Pollen data from the last 120,000 years indicate that oak dominance typically increased during warmer, drier climate intervals. Most California oak species exhibit enhanced drought tolerance, with greater resistance to xylem cavitation than in most conifer species and hardwood species. Most oak species readily sprout if top-killed by fire. Species in each major clade participate in a fire-mediated ecological dance with competing conifers, which have similar evolutionary histories.

Climate change is projected to increase ambient temperatures and seasonal droughts in California, shifting species distributions, altering plant community compositions in favor of deciduous species, and altering ecosystem services. Increased wildfire occurrence and severity are observed effects of climate change now, and further departure from historical conditions is anticipated. The intrinsic genetic richness within native oak clades provides an expansive potential for oaks to respond to altered climate and fire with expanded ranges and increased abundances, providing a rich palette for restoration planning and climate-change adaptation.

#59 Drone-based Remote Sensing of Canopy Thinning to Inform Conservation Management for California Live Oak Communities Facing Insect Pest Invasions and Drought

Marc Mayes, Earth Research Institute, University of California-Santa Barbara

Andrea Hefty, Stacy Hishinuma, Sheri Smith, US Forest Service, Pacific Southwest Region; **Juan Troncoso**, **Hannah Walchak**, The Escondido Creek Conservancy, Escondido, CA; **Erin Andreatta**, **Isaac Ostmann**, **Nathan Gregory,** Irvine Ranch Conservancy, Irvine, CA

Since the early 2000s, drought and insect invasions have threatened increasingly large areas of coast live oak (*Quercus agrifolia*) woodlands in southern California (CA). One challenge to addressing these threats has been reliable detection and differentiation of these stressors across rugged terrain to prioritize mitigation in the right places. Canopy thinning has been used as a general measure for oak woodland health in field and satellite remote sensing data over large areas. Drone imagery is a promising new resource for monitoring insect pest and drought stress, given it resolves individual tree crown and stand canopy changes at scales directly applicable to mitigation actions such as tree removal or contact insecticide spraying. However, improved understanding of (1) canopy thinning responses to stressors of concern (i.e., insects, drought), and (2) the accuracy of canopy thinning detection in drone and satellite imagery are needed to advance operational remote sensing use for conservation management.

Here, we report findings from the first year of a three-year project to advance drone-based remote sensing methods for surveillance of goldspotted oak borer (GSOB) (*Agrilis auroguttatus)* invasions, and evaluation of mitigation efficacy in CA coast live oak ecosystems. Our goals are to refine calibrations of drone and satellite imagery to canopy thinning, collect drone imagery over multiple years at GSOB-infested sites to monitor canopy conditions, and assess the efficacy of GSOB-mitigation actions for limiting further infestation, promoting crown health and tree recovery. We also conduct analyses of drone imagery-based metrics alongside satellite image time-series to explore differentiation of drought

stress from insect invasion in coast live oak woodlands. A final aim of the project is developing partnerships among academic, public agencies and private conservancies around use of new technologies, such as drones, to expand the spatial scale and efficiency of conservation management in coast live oak woodlands.

#60 Assessing the Contribution of Oak Woodland Habitats to Biodiversity Conservation Using CWHR and ACE

Melanie Gogol-Prokurat, Biogeographic Data Branch, California Department of Fish and Wildlife

Ryan Hill, Biogeographic Data Branch, California Department of Fish and Wildlife

The California Wildlife Habitat Relationships (CWHR) program contains data on more than 350 vertebrate species and subspecies in California that use oak woodland habitats for reproduction, cover, or feeding. The CWHR database is freely available and can be queried to produce species lists that can be filtered by location, oak woodland type, tree structure and density, seasonality, special status, and other habitat elements. In addition to data on habitat use, the CWHR program maintains a spatial library of species ranges which are available for download from the California Department of Fish and Wildlife website. The species ranges have been brought together with the best available vegetation maps to develop habitat distribution models for each species, so users can understand which species may be found in particular oak woodlands, and what adjacent habitat types might also be used.

CDFW has developed a statewide conservation planning tool called Areas of Conservation Emphasis (ACE), which uses a standardized framework of landscape units to facilitate the integration of these multiple facets of conservation planning. ACE uses the best vegetation maps available for California, and includes a dedicated oak woodlands layer as part of the significant habitats module. Certain oak communities are also represented in the ACE rare vegetation layer. ACE brings together data on the distribution of habitats in the landscape and the expected occupancy of species within those habitats based on CWHR to map biodiversity across the state. Together, ACE and CWHR provide the most comprehensive set of locational data for oak woodlands across California, the species associated with these habitats, and information on the ecological relationships between them. Using the information on oak woodland biodiversity alongside complementary analyses of habitat connectivity and climate resilience, we conducted a spatially-explicit analysis to identify where oak woodland habitats can contribute to multiple conservation planning goals.

#61 Coordinated Squirrels: Harvesting Acorns for Reforestation Using Community Volunteers, Smartphones, and Persistent Chat Applications

Zarah Wyly, Sacramento Tree Foundation

The Sacramento Tree Foundation operates an annual acorn harvesting program that gathers seven to fifteen-thousand acorns to support reforestation efforts, seedling propagation, and educational programming for students within the greater Sacramento region. This effort is focused on locally native species and covers an area of more than 2,000 square miles.

Acorns ripen from late September into December each year and it is challenging to gather the quantity we need in a sustainable and ethical way. Spatial fluctuations in the acorn crop, a six-county service area, and the desire to harvest genetically diverse and non-hybridized acorns from fully permitted harvesting locations are challenges we overcome in part by recruiting a large number of citizen scientists working within their own communities. Acorn Harvesters are specially trained community

volunteers whose efforts are coordinated using the smartphone application Slack. With dedicated communication channels for tree identification, real-time updates on acorn ripeness, and reporting of harvesting activities, the Head Squirrel is able to manage the whole effort easily and from anywhere.

The acorn harvest has been optimized over the last six years and is a highly effective and low-cost program to manage. The use of technology allowed easy adaptation and safe community involvement during the COVID-19 pandemic. This program could be easily replicated in other bioregions of California with similar oak conservation challenges.

The acorns harvested each year have an estimated value of $5,000 to $12,000. Reforestation efforts supported by the acorn harvesting program include direct-seeding and seedling planting projects that have established over 16,000 new native oak trees in the Sacramento region over the last 11 years. Successful tree planting and establishment practices include the use of locally derived, high-quality propagules and seedlings, tree protection materials targeted to site-specific hazards, soil and weather dependent supplemental irrigation, and strategic vegetation management. Educational experiences embedded within program operations support our organizational goal of an active and informed citizenry and are an additional benefit of the annual acorn harvest and reforestation efforts.

#62 Context-dependent Effects of Cattle and Wildlife on Floral Resources at Tejon Ranch in Southcentral California

Devyn A. Orr, USDA Agricultural Research Service

Michelle Lee; **Maggie Klope**; **An Bui**; **Hillary Young**, Dept. of Ecology, Evolution, and Marine Biology, University of California Santa Barbara

Oak woodlands are one of California's most iconic landscapes, providing both diverse and critical habitat to native plants and wildlife, as well as important ecosystem functions. However, oak woodlands are highly threatened by human activities, such as increasing grazing pressure and climate change. Large herbivores, including cattle, are well-known ecosystem engineers, and can have myriad impacts on plants and other wildlife, with cascading effects on key ecosystem services. One such service is the provisioning of floral resources. Although moderate herbivory can sometimes promote plant diversity, potentially benefiting pollinators, large herbivores might alternatively reduce resource availability for pollinators by consuming flowers or other plant reproductive tissue, promoting somatic regrowth over reproduction, or reducing plant density. The direction and magnitude of such effects may hinge on 1) abiotic context—such as weather or climatic conditions—which can modulate the effects of ungulates on vegetation, and 2) herbivory identity, density, and selectivity. Using a large-scale experiment replicated across a topoclimatic gradient at Tejon Ranch in southcentral California, we show that both wild (deer, elk) and domestic (cattle) large herbivores can either enhance or limit flower abundance, diversity, and landscape-scale nectar availability, but impacts are complex and vary tremendously across abiotic contexts. Cattle presence generally had a positive effect on floral resources under more arid conditions and a negative effect under wetter, cooler conditions, and varied from isolated effects of wildlife. Effects appear driven largely through indirect pathways, notably altered dominance and competition among plant species. Our results show that 1) moderate grazing may benefit plants and their pollinators under drier conditions; 2) conservation of wild herbivore populations may have the dual benefit of helping to protect floral resources; and 3) large herbivore management in oak woodlands must be considered simultaneously with other perturbations, notably climate change. These findings have important implications for the management and protection of plant and pollinator biodiversity given that nearly 80% of California's oak woodlands are managed for livestock and climate regimes are changing globally.

ABSTRACTS OF SPECIAL TOPIC PANELS

3A Education, Outreach, & Engagement: Lessons from the Field

Panel Abstract:

Education related to forest and oak woodland ecosystems and resources covers a wide range of approaches and audience groups. In recent years, engagement and inclusion elements of educational programs have become increasingly important and valued. Engagement addresses the degree to which the learner is actively and meaningfully involved, interested, and motivated by the educational program. Inclusion in this context refers to the policies and practices that promote equitable and inclusive access to programs; recognize, value and respect differences (physical, cognitive, social, cultural); create positive learning environments for everyone, and build a shared sense of belonging. Examples from five forest education programs in California (Learning Among the Oaks, CA Project Learning Tree, Forest Stewardship Education Initiative, Sudden Oak Death Blitz Survey Project, and Amah Mutsun Land-based Educational Programming) provide a mix of practices for addressing engagement and inclusion for different audience groups. While there is no single set of approaches that work for all educational programs and all audiences, we believe there are some common strategies that educators can adopt to increase student engagement and make programs more inclusive and relevant. By exploring these five distinct forest and woodland education programs, we highlight strategies for inclusion and engagement across a range of program types and audiences.

Panel Presentations:

K-12 Education - A Case Study of the Learning Among the Oaks (LATO) Program
Beverly Gingg, Learning Among the Oaks, The Land Conservancy of San Luis Obispo County

Adult Education: Forest Stewardship Education Initiative
Kim Ingram, UC Cooperative Extension, Davis

Teacher Professional Development: Project Learning Tree
Cyndi Chavez, CA Project Learning Tree, 4-H Program, UC ANR

Community Science: Sudden Oak Death (SOD) Blitz Survey Project
Douglas Schmidt, Dept. of Environmental Science, Policy, and Management, UC Berkeley

Revitalizing Indigenous Stewardship and Sense of Place: Lessons from Amah Mutsun Land-based Educational Programming
Alexii Sigona, PhD Candidate, Dept. of Environmental Science, Policy and Management, UC Berkeley

5A New Technologies

Panel Abstracts:

Drones in Oaks: Mapping the River Fire Impact on Oaks at Hopland Research and Extension Center

Sean Hogan and **Maggi Kelly**, UC ANR IGIS Statewide Program

This project explores the utility of multispectral cameras aboard UAVs to map extent and pattern of vegetation change after the River Fire (2018) at the Hopland Research and Extension Center (HREC). Using imagery gathered with a multispectral camera on an uncrewed aerial vehicle (UAV), we mapped 1) the amount and pattern of residual green vegetation post-fire, 2) the degradation of canopy condition, and 3) individual tree scorching. Overall, 82% of the canopy burned during the fire (at all severities), and response to fire was highly variable. There was evidence of some topographic refugia, with more non-burned canopy present in topographic depressions. Within the fire perimeter, the largest declines in NDVI were in closed canopy stands not in topographic depressions, and isolated trees showed less damage than continuous cover.

Conservation Dashboards – Recording, Monitoring, and Reporting Live from the Coast Live Oak Restoration Project at the Dangermond Preserve

Kelly Easterday, The Nature Conservancy

No abstract submitted.

The Climate Adapted Seed Tool: Using Provenance Tests to Inform Oak Seed Transfer in a Changing Climate

Joseph Stewart, Department of Environmental Science and Policy, UC Davis

Jessica Wright, Pacific Southwest Research Station, USDA Forest Service; **James Thone**, Department of Environmental Science and Policy, UC Davis; **Victoria Sork**, Department of Ecology and Evolutionary Biology, UC Los Angeles

Legacy guidelines for seed transfer in California were based on a system of seed zones and elevation bands, and meant to constrain seed transfer to relatively local sources. By judiciously moving seeds to track the climatic adaptations of their source populations, we can take a proactive step to better adapt ecosystems to climate change. Provisional guidelines to incorporate climate-adaptation into seed transfer are contained in the Climate Adapted Seed Tool (CAST) and based on data from seed transfer experiments (provenance tests). CAST estimates of the performance (e.g., growth and survival) of candidate seed sources in units relevant to management (e.g., carbon sequestration) and allows users to examine how performance is projected to change over time, as the climate continues to warm. Robust provenance-test datasets for conifers indicate that populations tend to be adapted to the historical climate where they are found and that relatively small differences in climate—commensurate with the magnitude of recent and/or anticipated anthropogenic climate change—can result in substantial declines in growth and survival. Compared with conifers, provenance data for oaks are relatively sparse. Recently published analyses of provenance test data for 5-yr-old *Quercus lobata* suggest populations may be adapted to climates at least 4°C colder than local historical climate

conditions, suggesting that populations may be adapted to long-past climate conditions approaching the last glacial maximum. In light of available evidence, we will discuss and analyze potential climate-based seed transfer approaches for California oaks. How much inference can be gained from early measurements of provenance tests? Should climate-based seed transfer guidelines optimize trees for growth and survival, or should they attempt to place trees in conditions that approximate what their parents grew in prior to rapid anthropogenic climate change?

Gradient Nearest Neighbor (GNN) Mapping as Applied to California Oak Woodland

Hans-Erik Andersen, **David Bell**, and **Matt Gregory**, USDA Forest Service, Pacific Southwest Research Station

To effectively manage and conserve California oak woodlands, it is important understand ecosystem status and trends. By integrating USDA Forest Service Forest Inventory and Analysis field measurements and multispectral Landsat imagery, gradient nearest neighbor (GNN) imputation mapping provides 30-m resolution, annual (1990-2017) maps of forest vegetation provide useful information for ecosystem monitoring. Here, we explore how GNN maps can be used to monitor California oak woodland status and trends. To understand how to appropriately use GNN to monitor oak woodlands, we examine GNN accuracy and appropriate scale for estimating the area of oak woodlands. We then assess trends in oak woodland area over a 27-year period to identify areas of expansion and decline. Finally, we highlight how maps and other auxiliary data can be used to understand changes in oak woodland spatial patterns within individual landscapes associated with disturbances, such as wildfire. This approach to exploring map accuracy, quantifying landscape-level trends, and diagnosing disturbance impacts can support California oak woodland conservation and management by highlighting landscapes where oak woodlands are at risk or prioritize restoration efforts.

ABSTRACTS OF PLENARY SESSIONS

Plenary I — Setting the Tone: An Overview of Climate Change and Oaks

David Ackerly, Dean and Professor, College of Natural Resources, UC Berkeley

California's oaks range from the desert's edge to the wet forests of the northwest and the slopes of the high Sierra. Collectively, they have survived multiple ice ages, changing fire regimes, episodic drought, and land use transformation. Individually, the distributions of the various species reflect adaptations to the contrasting climates, soils, and fire regimes of different parts of the state. But, a changing climate, recent droughts and intense fires have triggered mortality and die back events, as well as range shifts and changes in forest composition. This talk will highlight emerging insights into the current and projected impacts of climate change and fire, and the implications for conservation and management strategies in the 21st century.

Plenary I — What Blue Oak Tree Ring Analysis Tells Us About California Climate and Ancient Oak Woodlands

David Stahle, Department of Geosciences, University of Arkansas

In a state famous for exceptional trees, the blue oaks of California may be among the most remarkable. Old blue oak trees are still widespread across the foothills of the Coast Ranges, Cascades, and Sierra Nevada. The most extensive areas of intact old-growth blue oak woodland appear to survive on rugged and remote terrain in the southern Coast Ranges and on the foothills west Mt. Lassen. Our sampling suggests that most mature blue oak recruited to the canopy in the middle to late nineteenth century. The oldest living blue oak tree sampled was over 459 years old, and several dead blue oak logs had over 500 annual rings. Precipitation sensitive ring-width chronologies up to 700 years long have been developed from ancient blue oak trees and remnant wood. These blue oak chronologies are strongly correlated with cool season precipitation totals, streamflow in the major rivers of California, and the estuarine water quality of San Francisco Bay. Over 40 blue oak chronologies are now available and can be used in conjunction with conifer chronologies to develop seasonally specific tree-ring reconstructions of precipitation that will help to better understand and manage water resources in California. The accurate environmental history of precipitation, fire, and forest dynamics embedded in blue oak tree rings help justify the conservation of these authentic old-growth native woodlands.

Plenary I — Multiple Stressors Create an Inflection Point for Oak Sustainability

Tedmund J. Swiecki and **Elizabeth A. Bernhardt**, Phytosphere Research

The present condition and current prospects for California's native oaks have been shaped by an accumulating and accelerating array of human-induced changes. The current extent, stand structure, and health of oak woodlands have been shaped by a dizzying array of changes including clearing, livestock grazing, changes in fire frequency and behavior, replacement of understory native plants with a variety of invasives, the introduction of destructive exotic insects and pathogens, and altered temperature and moisture regimes driven by climate change. Many of these factors interact and the combined stress they pose on both oaks and their supporting ecosystems increasingly threatens the sustainability of native oaks and the habitats where they reside. While past impacts cannot be changed,

the present represents an inflection point. Future outcomes for oaks and their associated habitats will be affected by ongoing action or inaction to address these factors. Action is needed at multiple levels – international, federal, state, and local – to curtail the movement of exotic pests and pathogens that damage and kill oaks. Widespread oak mortality caused by *Phytophthora ramorum* (the sudden oak death pathogen) and Goldspotted Oak Borer (*Agrilus auroguttatus*) has already irreparably altered oak habitats in northern and southern California, respectively. While these and many other introduced invasives spread naturally from points of introduction, both initial introductions and the largest jumps in distribution are due to human-mediated movement of infested or infected host materials, such as firewood and nursery stock. Effective coordinated efforts to prevent movement of destructive exotic agents are needed to both prevent new introductions and minimize the spread of agents already present in parts of the state. Many introduced pests and pathogens are not visible or are hard to detect when they are transported, so a systemic awareness of the threats posed by these exotic agents needs to be recognized at all levels of oak management. Exotic root-rotting *Phytophthora* pathogens are very common in nursery stock grown under typical nursery conditions, and research has documented that these destructive pathogens have been moved into oak habitats though habitat restoration plantings as well as landscape plantings at urban interfaces. This risk can be avoided by planting via direct seeding with appropriate phytosanitary precautions and conserving existing regeneration. Effects of pathogens and other biotic agents interact strongly with environmental factors that stress oaks. Many biotic agents, both introduced and native, are much more damaging to stressed oaks, and diseases such as root rot can exacerbate water stress by reducing uptake when water is present. Ongoing climate change has increased temperature and moisture extremes, resulting in record drought and heat conditions. These conditions may push the environmental limits for entirely healthy oaks and can readily kill oaks that are already compromised by biotic agents. Oaks are most likely to be pushed beyond their limits of adaptation at the extremes of their ranges. Hence, the restoration of oak cover in more mesic parts of their historic range, much of which was cleared and converted to exotic-dominated grasslands, will be important in maintaining native oak species and habitats.

Plenary I The Uncertain Future of California's Oak Woodlands

Frank W. Davis, Bren School of Environmental Science and Management, University of California, Santa Barbara

California oak woodlands have long been impacted by biotic invasions, altered fire regimes, and changes in land use and land management. Rapid climate change affects all of these processes and has myriad other direct and indirect effects on oak woodlands and associated species. Thus forecasting the future of oak woodlands is riddled with uncertainty, and that uncertainty can only be reduced through more integrated modeling, monitoring and experimentation.

This talk reviews recent research to help anticipate and manage climate-driven changes in oak woodlands, particularly research focused on future distribution and abundance of dominant oak species. Species distribution models indicate potentially large range shifts for most species. Actual range shifts are likely to be less pronounced due to microclimate buffering in rugged areas as well abiotic and biotic constraints on seed dispersal and tree establishment. Landscape models that incorporate dispersal, establishment and disturbance suggest that expansion of oaks into areas now dominated by chaparral or conifer forests depends on fire regimes and interannual rainfall variability. Projections will benefit from improving mechanistic vegetation models linking climate to oak physiology and growth.

Plenary II — 21st Century Management Strategies for Managing California Oak Populations

Victoria L. Sork, University of California Los Angeles, Department of Ecology and Evolutionary Biology

Jessica Wright, USDA Forest Service, Pacific Southwest Research Station

Oaks are an ecosystem foundational genus that comprise more biomass and species in the Northern Hemisphere than any other tree genus. Managing oak populations in the 21st Century, whether on private or public lands, has become increasingly challenging due to human-caused problems, such as introduced pathogens and pests, destruction and fragmentation of habitats, and the changing environment due to climate warming. For some of these problems, traditional management strategies, such as protecting remnant stands or preventing further spread of those pathogens and pests, are useful to preserve existing oak populations. However, at many locations, restoration ecologists and forest managers often need to replant, and they often do so with local seed sources because they are more likely to be adapted to those environments. But, with climate change, assisted population migration using seed from warmer climates may help establish tree populations adapted to future conditions. In the 21st Century, genetic and genomic tools offer new ways to assess the health of fragmented populations and the vulnerability of populations to climate warming. In this talk, we will review several genetic approaches, including: genetic diversity analysis, landscape genetics to identify barriers to gene flow, landscape genomics to identify spatial patterns of adaptive genetic variation, and experimental gene expression to identify genes associated with drought response. We will then discuss the use of genomic tools, provenance data and climate modeling to inform future management strategies. Given the increased need to preserve, manage, and restore oak populations in predicted future warmer, drier conditions, we will address how each approach could generate evidence that could be used in a genome-assisted gene flow strategy to improve tree growth and fitness. In the end, we will comment on the extent to which genome-based, climate-based, or other methods will be the best tools to inform management of private lands.

Plenary II — Past, Present, and Future Fire Regimes in California Oak Communities

Jon E. Keeley, U.S. Geological Survey, Western Ecological Research Center, Sequoia-Kings Canyon Field Station

Dawn M. Lawson, Biology Department, San Diego State University, San Diego, CA

Quercus is an important component of fire-prone woodlands, savannas and shrublands. With respect to fire, species represent both conservative retention of some traits and adaptive radiation of others. All produce short-lived fire-sensitive acorns and recruitment is not closely tied to fire, although fire may release advanced seedling banks from competition. All species resprout; shrubs and tree seedlings/saplings resprout from the basal crown and rhizomes and arborescent forms resprout epicormically from crown-fire scorched stems. Arborescent species have thick bark that provides cambial protection from understory burns whereas shrubs that have radiated into crown-fire shrublands have thin bark. Even among arborescent species there is marked radiation in fire-adaptive traits such as self-pruning of dead branches. Complicating understanding fire responses is the evidence that some species such as *Q. douglasii* often dominate savanna habitats that are thought to be an artifact of anthropogenic burning that has replaced their natural shrub associates with non-native grasses. Fire

frequency has declined over time due as much to grazing reducing herbaceous as to suppression increasing fuels. All woodland species benefit from low intensity surface fires but are surprisingly persistent in the face of high intensity crown fires. In some communities fires may play a role in reducing conifer competition. On state protected lands in California since the middle of the last century woodlands have constituted around a third of the area burned in the northern portion of the state but less than 10% in the southern part of the state. This century has experienced years of exceptional woodland burning many times greater than in the earlier part of the record, potentially tied to fuel accumulation, climate change and increased threat of ignitions due to population growth. Fire management requires balancing predicted increases in droughts, invasive species altering fuels, grazing and the ever-increasing expansion of the wildland-urban interface.

Plenary II — The Influence of Climate Change on Oak Pests and Pathogens

Richard C Cobb, Department of Natural Resources & Environmental Science, California Polytechnic State University, San Luis Obispo

Most of California's population resides within or adjacent to the state's oak woodlands. Thus, the health and economic stability of the state is coupled with these ecosystems, despite what is also often a relatively low timber value. Oak woodlands are threatened by numerous pathogens and insects, but the interactions with these biotic organisms and climate change and/or wildfire holds potential for far greater threats to their ecological function. Pathogens and insects of the canopy, cambium, and root systems of oak forests each has distinct manners in which they may be suppressed or magnified by wildfire and/or climate change. At the same time, oak pathogens and insects may suppress or magnify wildfire impacts or risk. I present a unified framework for approaching these interactions with management, policy, or research goals. While state and federal policy is critical to addressing wildfire, most land managers work at the stand level and must treat climate change as an overarching problem where solutions are multi-generational. In contrast, mitigating vegetation conditions conducive to biological tree mortality or directly suppressing harmful insects and pathogens are conducted at the stand level. This creates potential to combine approaches and make progress on multiple management goals. While many classes of insect and pathogen attack help elucidate tradeoffs between treating vegetation vs biological agents, I demonstrate these tradeoffs with a series of research and management case studies focused on *Phytophthora ramorum*, cause of sudden oak death and the most consequential pathogen to oak forests in the state.

Plenary II — Climate Change and the Management of California Oaks in the Urban Environment

Igor Lacan, Bay Area Environmental Horticulture and Urban Forestry Advisor, UC Cooperative Extension, San Mateo-San Francisco Counties

Adapting urban tree populations to the changing climate has become a ubiquitous goal of urban tree managers. In California cities, this process is complicated by the variety of oaks that have been planted in cities (with variable success), as well as by the diversity of urban tree habitats, many of which are hostile to trees when combined with our dry-summer climate.

I will review the methods that have been proposed for evaluating urban trees' adaptability to the changing climate. I will then focus on the "space for time substitution" that Joe McBride and I used to

assess the common street trees across California cities, demonstrate the method and discuss the results.

I will also review the newly-available on-line data sources (the California Urban Forest Inventory project from Cal Poly San Luis Obispo), and what we can learn about urban oaks in California from urban tree inventories. I will conclude by discussing the recent interest in “new” (to city landscapes) oak species, and the issue of water availability as a long-term challenge to urban oaks in California.

Plenary III California’s Working Oak Woodlands in a Changing Environment: Keeping Carbon in the Bank

Lynn Huntsinger, Professor of Rangeland Ecology and Management, **Russell L. Rustici,** Chair in Rangeland Management, UC Berkeley

California’s oak woodland and grassland rangelands are a massive storehouse for carbon. How can we keep them that way? Site characteristics and the overwhelming role of weather and climate should be considered in efforts to protect carbon stores and enhance sequestration. The carbon lost in the 2020 wildfires was equivalent to 25% of all the carbon emissions in California, yet this is not generally part of the state’s reported emissions. If it was, California’s success in reducing emissions would instead be a failure. Ecosystem management must take on the wildfire problem, in addition to protecting carbon stores and sequestration processes. In fact, understanding the many ecosystem services provided by working rangelands, and the need to continue multipurpose management rather than succumbing to the temptation of focusing on a single management purpose, supports the resilience of these complex systems. One-size fits all practices and investments, and over-generalized application of research results, are inappropriate given California’s heterogenous ecosystems and uncertain weather. Management goals and recommendation should be specific to ecological site, and ideally include budgetary analyses of use to landowners. Thinking forward about our ecosystems, rather than backward, is compelled by our changing climate, and requires us to decide what our future working landscapes should be and to manage for them.

Plenary III Adapting Ranch Management to Prolonged Drought and Changing Plant Species Composition

Royce Larsen, UC Cooperative Extension, San Luis Obispo County

Over the centuries there have been many droughts of differing intensities and durations. The recent drought of 2012-2016 was warmer than other droughts, as well as dry. This combination made the recent drought worse than any other during the last 500 years, perhaps even 1200 years. The California Central Coast, with its oak woodland savanna’s and annual rangelands, was rated in the “exceptional drought” category for many months during this period. This caused many oak trees to die or become weakened, and the weakened trees continued to die into 2020. The lowest forage production recorded over the last 20 years was in 2014 at 95% below average. As a result, livestock numbers were reduced by 60-70%. As of 2020, most of the ranches still have not fully restocked their herds. Along with the forage reduction, there was a shift to a forb domination, filaree (*Erodium sp*.) and bur clover (*Medicago polymorhpa*) being the most prevalent species. Within the grass species

component though, there was a shift in dominance from soft chess brome (*Bromus hordeaceaus*) to red brome (*Bromus rubens*). However, the coastal areas had less drought impact, and ryegrass (*Lolium perenne*) and wild oats (*Avena sp*.) were still most common. Crude protein (CP) is higher in forbs than in the annual grasses, and both have higher CP during their early vegetative stages. However, once the forage dries in late spring the CP decreases rapidly. Crude protein in forage drops below the nutrient requirements for livestock throughout the summer period. There is a constituent of late summer growing plants, mostly forbs, that have high CP values. But many of these are toxic and may become a problem for livestock. When available forage is low, either because of quality or quantity, cattle tend to seek out feed that will meet their nutritional requirements and poisonings can occur. With droughts expected to increase in both intensity and duration, having enough forage to meet the nutritional requirements of livestock may become even more difficult requiring improved management practices or even changes in herd types, such as stockers instead of cow/calf operations.

Plenary III Working Lands for Conservation: A Vital Step for 30x30

Adina M. Merenlender, UC ANR Cooperative Extension Specialist and Adjunct Professor, Dept. of Environmental, Science, Policy and Management, UC Berkeley and UC ANR Hopland Research & Extension Center

Protected areas alone are not going to safeguard biodiversity especially as species need to cross park boundaries under rapid climate change. In fact, by 2070 most protected areas will retain approximately10% of their current climate characteristics, forcing many species to move or perish. Working lands conservation emphasizes the role of managing the matrix for species conservation to complement protected areas. Drawing on a summary of working lands research conducted by Claire Kremen at University of British Columbia, it's clear that public and private lands can work for conservation while sustaining production of food, water, fiber, fuel, and forest products. This research reveals how the use of "wildlife-friendly" agroecological practices can maintain agricultural productivity while lowering environmental externalities and support biodiversity. Working lands are noted as part of the solution set proposed by the California 30x30 initiative, "Overall, this Executive Order prioritizes the role of natural and working lands to combat climate change and establishes biodiversity protection as an administration priority." However, we need ways to ensure working lands are sustainably supporting a diversity of species and find ways to scaleup the adoption of stewardship practices that support the community of life. The IUCN developed criteria to identify "other effective area-based conservation measures" that fall outside of traditional protected areas but may contribute to Aichi Target11 (under the Convention on Biodiversity); and these criteria could offer a good starting point to identifying working lands that may contribute to the goals of 30x30. A review of the challenges and opportunities presented by a wide range of regulatory, voluntary, incentive, market-based, and governance instruments reveals more structures are needed to advance working lands for conservation and achieve the goals set out by 30x30.

Plenary III Why Keeping the Ranch in the Family Matters: The Rancher's Perspective

Steve Sinton, California Livestock Producer, Attorney at Law and co-founder, The California Rangeland Trust and **Daniel Sinton**, Writer and Director, The California Rangeland Trust

The obvious question is why a bunch of oak scientists, educators and enthusiasts would care whether a ranch remains in the family or not. The better question might be to ask "what happens to oaks when a ranch is sold?" The answer could be that not much changes, but with land prices rising so fast in California and ranches being offered for tens of millions of dollars, most buyers aren't going to pay the

mortgage with cows. The way to make money on expensive land is to develop it, either to crops that generate better revenues, subdivide it to cash out, or be in a position where you already have enough money that the ranch is a hobby or toy, not an occupation.

If ranches are developed, trees are usually in the way. We've seen examples where oaks have simply been cleared out, some have died under suspicious circumstances and others have simply been overgrazed to death. A very large portion of our best oak woodlands exist on private ranches. Those woodlands were some of the first lands taken by homesteaders and speculators because they were the best grazing lands. Our parks tend to be concentrated in the mountains, coast, urban areas, or in other types of habitat. So, ranches, and for obvious reasons, ranchers, are really critical to oak success.

We will look not only at what forces are at play to cause the demise of ranching families, but also at the historical and current threats to oaks on ranches that are still working. Ranchers who are in distress, whether economically, socially or by government regulation are the most likely to overgraze or sell out, but there are many ways to help them survive and even thrive. Each new generation presents an opportunity for ranches to be continued, but also a time when ranching traditions are ended. We will talk about strategies that can be used to help keep it in the family.

The role of scientists, educators and researchers remain a vital connection to ranching survivability. Ranchers need resources to understand and implement best practices and to understand emerging concepts related to carbon sequestration, soil health, plant diversity and the role each part of our environment plays in the business of raising cattle. Estate tax strategies, including gifting and conservation easements, need to be paired with finding ways to connect the next generation with the land and family legacy. Diversification without destruction is an important lesson to be told and retold if our oaks are to be protected without crippling the economic sustainability of the landowner. Marketing creativity can help landowners escape the control of large feeders and packers. Sophisticated research on the value of our working lands can stem the urge to regulate without regard to the consequences. There is a lot to be done to protect our oak woodlands, but there are also many ways to accomplish it.

Capstone Where Have We Been and Where Are We Going?

Paul F. Starrs, Distinguished Regents & Foundation Professor of Geography (emeritus), University of Nevada, Reno

Studies of oak woodlands, including their presence, biotic, economic, pastoral, scientific, and aesthetic values, began in Classical times. Around the world, oaks and their products are recognized and managed with care and ingenuity. In California, the first Oak Symposium was held in 1979, and it and subsequent symposia produced seven volumes of proceedings. At this meeting, topics include sustainability, climate, geography & history, population dynamics — including gene banks and pests, phenology, fire ecology, landowner goals, grazing, soil dynamics, indigenous management, fresh monitoring technologies, and woodland restoration, with several of those themes likely a mystery 43 years ago at the 1979 gathering. This commentary asks a question — How are our sensibilities concerning oak woodlands and their future changing through the years?

ABSTRACTS OF POSTERS

Birds, Beef and Oaks: Market Incentives for Rangeland Conservation — Poster #1

Matt Allshouse and **Pelayo Alvarez**, Audubon California

California has roughly 40 million acres of rangelands that provide food production, carbon sequestration, water infiltration, and habitat for a wide range of species. However, this historic California land use is under threat with an average of 15,000 acres a year being lost to development or crop conversion. Climate change, invasive species, aquifer depletion, and outdated grazing practices also degrade large portions of grasslands, increasing economic and ecological vulnerability. This in turn has contributed to steep declines in bird species across the United States.

Audubon launched its Conservation Ranching Initiative (ACR) in California in 2019. This program is designed to stem the conversion of rangeland ecosystems and improve their ecological function through a ranch certification program. This presentation will highlight the ACR program components which includes the development of ranch-specific Habitat Management Plans and a third-party certified set of practices to improve bird habitat, enhance plant diversity and cover, increase water infiltration, and carbon sequestration, and increase overall biodiversity. This ecological resilience can translate to economic resilience, as participating ranchers are able to use the Audubon certification logo on their beef products – providing a market incentive through increased sales or revenue. This presentation will highlight program practices, challenges and opportunities as the program grows in California and the United States.

Does Foliar Trichome Abundance, Morphology and Plasticity Vary with Climate in a Deciduous Oak? — Poster #2

Berenice Badillo, Department of Ecology and Evolutionary Biology, University of California Los Angeles, Los Angeles, CA, USA

Marissa Ochoa, Department of Ecology and Evolutionary Biology, University of California Los Angeles, Los Angeles, CA, USA; **Jessica W. Wright**, USDA Forest Service, Pacific Southwest Research Station, Davis, CA, USA; **Victoria L. Sork**, Department of Ecology and Evolutionary Biology, University of California Los Angeles, Los Angeles, CA, USA; Institute of Society and Genetics, University of California Los Angeles, Los Angeles, CA, USA

As global climate continues to warm dramatically, it is important to identify which traits affect a tree's ability to respond to warmer climates and drought, an increasingly frequent occurrence in California's Mediterranean climate. Foliar trichomes are one such trait because by increasing the thickness of the boundary layer that surrounds leaves, they can reduce excess transpiration. Utilizing an established common garden experiment in Chico and Placerville, California, we are assessing whether valley oak (*Quercus lobata*) trees are genetically differentiated and/or phenotypically plastic with respect to foliar trichome morphology and abundance, and, if so, assess if these differences correlate with climate variables of the maternal site. We sampled fully developed leaves from 9-year-old trees representing 74 families across valley oak's native range and dried them in coin envelopes before taking pictures of the abaxial side of the leaf at 1500x magnification. To estimate trichome abundance, pictures are divided into 4 quadrants by superimposing a grid in ImageJ and counting the number of hairs crossing the grid lines. Trichome morphologies are categorized as either simple (one hair) bifurcate (two branches) or stellate (3 or more branches). Our findings indicate trichome morphology is more branched and

trichome abundance is greater in trees from warmer, drier southern seed sources compared to cooler, wetter northern seed sources. We also find that plasticity in these traits is associated with warmer and more seasonal climates. Understanding which traits enhance the ability of trees to respond to rapid climate change helps inform the future management of oak populations.

Abiotic and Biotic Constraints to Blue Oak Restoration in the Sierra Foothills

Poster #3

Jeremy James, California Polytechnic State University San Luis Obispo, Department of Natural Resources Management & Environmental Sciences

Nikolas S. Schweitzer, University of California Sierra Foothills Research and Extension Center Staff Research Associate; **Iris Bookholtz**, California Polytechnic State University San Luis Obispo Department Student; **Poster Presented by Fiona O'Niell*

Restoring oak woodland at scale has proven to be difficult and is becoming increasingly challenging as California experiences more frequent and severe drought. The broad objective of this study was to examine the relative importance of biotic and abiotic factors limiting blue oak (*Quercus douglasii*) regeneration from planted acorns and seedlings in the Sierra foothills. We planted 16 hectares of previously cleared blue oak woodland fall 2020 at approximately 80 planting sites per hectare. We randomly assigned each planting site to be planted as an acorn or a seedling and receive a combination of treatments aimed at alleviating potential abiotic and abiotic stress. These treatment combinations included herbicide application or mowing to reduce the density of annual grasses, wire mesh to reduce herbivory, plastic cones to reduce to herbivory and provide a more favorable microenvironment, as well as irrigation to maintain greater soil moisture. In addition, we examined the potential to reduce annual grass impacts on steep slopes by using timed grazing over large pastures. Preliminary results following the first growing season suggested that acorns had significantly higher survival than transplanted seedling in part due to higher rodent activity around seedlings. Irrigation had a positive benefit particularly when irrigation was extended to the summer dry season. We also found evidence that plastic cones provided additional protection over wire mesh, suggesting an abiotic constraint that was potentially stronger than biotic constraints associated with herbivory. Lastly, scaling annual grass control treatment using grazing was largely unsuccessful due to incidental animal impacts on other treatment and restoration infrastructure. Collectively this study highlights the abiotic and biotic constraints that occur at scale in efforts to restore blue oak woodland while also highlighting how abiotic conditions (microclimate and soil water availability) can interact with biotic factors (predation by rodents) to greatly limit opportunities for blue recruitment in large scale restoration.

Accessing a Geographic-Object Based Image Analysis (GEOBIA) Workflow for Identifying and Classifying Individual Trees by Species in an Oak Savanna Woodland

Poster #5

Kenya Creer, California State University, Long Beach, Department of Geography

Through the acquisition, processing, and analysis of earth imagery, remote sensing has been at the forefront of mapping and monitoring biodiversity. While remote sensing has shown potential for mapping vegetation communities at a wide range of scales, success in accurate species-level classification has been uneven under the per-pixel paradigm. With the ascension of Geographic Object-Based Image Analysis (GEOBIA), concepts and tools have emerged and re-emerged to encourage the integration of expert knowledge with appropriate data and methodologies, allowing for more detailed

land cover mapping. In particular, knowledge of plant phenology and morphology combined with segmentation concepts have been useful in species-level classification of complex environments, like woodland-grasslands. However, in an oak savanna woodland, where tree canopy structures are complex, species level classification of individual trees crowns (ITCs) is not guaranteed. Using well-established methods for identifying individual trees, isolating tree crowns, and classifying tree crowns by species, presents many challenges for analysts who study sites differ from those where these methods developed and gained fame. Often, much tweaking is necessary to make these workflows viable, for while the study goals are the same, the context is not. This study will apply and access a local maxima detection and region growing technique – a popular GEOBIA workflow for ITC mapping - to help identify individual oak trees by species at a study site on River Ridge Ranch, Tulare County, California.

Genomic Patterns of *Quercus Iobata*

Poster #7

Sorel T. Fitz-Gibbon, Dept. of Ecology and Evolutionary Biology, University of California, Los Angeles

Shawn Cokus, Dept. of Molecular, Cell, and Developmental Biology, University of California Los Angeles; **Matteo Pellegrini**, Dept. of Molecular, Cell, and Developmental Biology, University of California Los Angeles; **Victoria L. Sork,** Dept. of Ecology and Evolutionary Biology, University of California, Los Angeles

DNA sequences of the genome of any organism provide a signature of the evolutionary history of that species. We have sequenced, annotated and analyzed the genome of the California endemic *Quercus lobata* (Valley Oak) and compared our results to the published genomes of two additional oaks, *Quercus robur* and *Quercus suber* and to the published results of an analysis of more than thirty genomes from across the phylogenetic range of angiosperms. Genomes of many plant species, such as the well-studied *Arabidopsis thaliana* (thale cress) and *Solanum lycopersicum* (tomato), have regions around the centromere with very low gene density, while the chromosome arms include tightly packed genes. In contrast, we found that oak genomes are more like grass genomes with gene density distributed more evenly along their chromosomes and large intergenic repeat rich regions throughout the chromosome arms. This pattern is also reflected in the methylation patterns across chromosomes which suggest broad distribution of intergenic heterochromtin. We also found very high peaks of methylation (mCHH) at the boundaries of genes, a trait suggested in maize to prevent highly expressed genes from triggering expression of neighboring, potentially parasitic, transposable elements. Among the angiosperms we compared, oaks are at the extremes in having both large intergenic regions and strong methylation peaks at gene boundaries. We suggest these two patterns may have played a role in the ability of oaks to spread to a wide range of habitats and contributed to their high number of species. We also explore potential roles of large numbers of protein coding genes containing a single DUF247 domain. Many of the greater than 150 DUF247 oak genes are arrayed in blocks of up to 50 near neighbors. DUF247s and other similarly distributed genes have been implicated in various reproductive mechanisms including self incompatibly and reproductive isolation. We explore potential roles for oak DUF247s.

Study of Blue Oaks for Climate Impacts, Health and Guidance for Central California Land Managers

Poster #8

Billy Freeman, Rangeland Manager, Sierra Foothill Conservancy

A Blue oak study is currently being implemented at the McKenzie Table Mountain Preserve near Prather, California. Data will be used by Sierra Foothill Conservancy and partners to affect broadscale Blue oak woodland management. A field day will be hosted at McKenzie Preserve where livestock producers, landowners, and land managers will engage in Oak monitoring while learning about research outcomes, ecosystem management and regenerative grazing.

This Blue oak study project is designed to support central California livestock producers, land managers and agency personnel in identifying regenerative land stewardship approaches for resource conservation. The project will accomplish this by studying Blue oak species populations and demonstrating the effect of regenerative grazing and conservation grazing on Blue oak populations. The study area represents an ecological site typical of central California Blue oak woodland that is capable of being enhanced by these approaches. Outreach to land manager groups will inform personnel on practices and instruct them on monitoring techniques. A desired outcome is to enable livestock producers to support the bottom line of their operations while accomplishing sustainable ecological objectives. A Field Day activity will provide an opportunity for producer-to-producer networking regarding these ecological approaches and inform about the partnering organization's role in natural resources stewardship.

An analysis of the monitoring data from the SFC sites will be performed by National Ecological Observatory Network (NEON) and University of California Cooperative Extension (UCCE). These findings will be presented during the Field Day event for producers and land managers. Additionally, the study data will be used by NEON and UCCE as part of other respective research projects. This data is intended to provide a long-term understanding of blue oak populations in the region of Central California. In addition, the work at SFC will empower land managers to monitor blue oak populations with simple and low-cost methods. Data from this project at SFC and other sites, and volunteer trainings, will help to identify and extend land management practices which best support healthy, regenerating blue oak populations.

Growth of Five Species of Mexican Oaks at the Los Angeles County Arboretum & Botanic Garden

Poster #11

Donald R. Hodel, Emeritus, University of California Cooperative Extension, Los Angeles

James E. Henrich, Los Angeles County Arboretum & Botanic Garden, Arcadia, California

With more than 160 indigenous species of *Quercus*, Mexico is the primary center of oak diversity in the world. In late 2001 co-author Hodel visited northeastern Mexico and collected seeds of several, mostly evergreen species. Hodel germinated the seeds and grew them on. In 2005 the seedlings, in one- or two-gallon containers and just a few feet tall, were planted out at The Arboretum. After 15 years all have grown remarkably well, clearly demonstrating their adaptability and suitability to the southern California landscape. They received no special care other than an occasional irrigation and a minimum of structural pruning to achieve proper structure. They have flowered and fruited and have attained from 35 to 50 feet in height. Most had adequate, if not superb, conformation and structure without little or no pruning. All would make superb ornamentals for California; much prized for their strong, robust growth of good to excellent conformation with few or no structural defects, handsome leaves, mostly evergreen habit, and suspected marginally low-water use.

The Effects of Aridity and Herbivore Assemblage on Oak Savanna Understory Functional Traits

Poster #12

Maggie Klope, University of California, Santa Barbara

Large herbivore communities are rapidly changing globally, with populations of large wild herbivores declining while large domestic herbivore populations are increasing exponentially. Along with climate change, these alterations in large herbivore communities are two of the most important impacts on ecosystem functioning in oak savanna ecosystems. While large herbivores and climate are known to independently influence the cover and composition of herbaceous plant communities, manipulative experiments have rarely captured the interaction between realistic patterns of large herbivore assemblage change and climatic conditions. Using a multi-factor large herbivore exclosure experiment replicated along a topo-climatic gradient, we explored the interaction between climate and herbivore assemblage on community-level functional traits and functional diversity of herbaceous plant understories in an oak savanna ecosystem.

Our findings demonstrate interacting effects between changes in large herbivore assemblages and climate. We found a shift between more drought tolerance traits to drought avoidance traits with increasing aridity, and found that plant community responses to grazing changed from an herbivore avoidance strategy at arid sites to a more herbivore tolerant strategy at mesic sites. Even over a relatively large temperature gradient within this landscape, we observed that the effects of herbivores on community-level traits can sometimes counteract those of climate. Finally, we found that cattle and large wild herbivores can differ in the magnitude and direction of effects on functional traits and diversity.

What Shapes Phenology and Fecundity in a Masting Tree Species? Location, Location, Location

Poster #13

Andy Lentz, UC Santa Barbara Sedgwick Reserve

Frank Davis, University of California, Santa Barbara, Bren School of Environmental Science and Management; **Victoria L. Sork**, University of California Los Angeles, Department of Ecology and Evolution and Institute of the Environment and Sustainability.

Flower production and acorn production are critical components of viability of oak populations. Moreover, acorn production is a critical food resource for many insects and wildlife. For the last 14 years, we have been documenting the timing and quantity of male and female flowers and the corresponding acorn production in 100 valley oak adults located in an 80-ha oak savanna in the University of California Sedgwick Natural Reserve, Los Olivos, California. Given concerns about climate change affecting reproduction, we assessed the extent to which temperature has influenced the timing of the emergence of flowering, population synchrony in the timing of flowering, and the impact of these two processes on acorn production. Each year from 2007-2020 around February through April, we visited 100 (minus 1 that died) adult valley oaks twice per week to record the developmental status of buds, emergence of male catkins, and prevalence of female flowers. Each fall, we censused acorn abundance by counting acorns for 15 seconds twice per tree. Daily temperature and precipitation data was available from the weather station at Sedgwick reserve and, starting in 2011, temperature data recorded every 4 hours was from temperature sensors placed on 50 trees scattered throughout the study region. In addition, flower season temperatures were modeled for all 100 trees using digital elevation data from high-resolution LIDAR imagery. We found that the timing of leaf emergence and

flowering among individual trees was highly correlated across years, so we focused on the extent to which spatial location and temperature affected acorn production. We found that the location of a tree was a major factor determining flower phenology and which trees produced large and small acorn crops. Trees at warmer microsites during the flowering season flowered earlier than most other trees. Trees that flowered when many other trees flowered and that were closer to the water table produced more acorns. As climates get warmer and water table drops, acorn production may be affected. Thus, rapid climate change could have a disruptive effect on future acorn production.

Rapid Growth of Southern California Black Walnut (*Juglans californica*) through Stump Salvage and Transplantation

Poster #14

Richard B. Lewis, III, Psomas

Kai T. Palenscar, PhD, San Bernardino Valley Municipal Water District

California's native walnut taxa (*Juglans* spp.) are rare and declining across their ranges, and effective methods of regeneration are needed as part of a strategy to retain and restore these species and the plant communities where they dominate (California walnut groves). California walnut species exhibit slow growth from plantings of seed or standard nursery container stock, delaying the establishment of high-functioning woodland habitat characteristics—e.g., broad arboreal canopy, nesting opportunities (including cavities), and substantial fruit production—on habitat restoration sites. Alternatively, salvage of whole trees via excavation, root pruning, and establishment in large nursery boxes, is a labor-intensive process.

The development of the Three Oaks tract in the City of Walnut included 61 acres of oak-walnut woodland habitat restoration to mitigate impacts to this habitat type caused by development activities. As part of restoration implementation in 2006, the developer approved the experimental salvage and transplantation of several Southern California black walnut (*Juglans californica*) (walnut) trees, along with coast live oak (*Quercus agrifolia* var. *agrifolia*) (oak) and blue elderberry (*Sambucus nigra* ssp. *caerulea*). Psomas developed a methodology for the strategic salvaging of individual trees, including (a) pruning of suitable specimens to retain a limited portion of stem/trunk, (b) excavation and removal (via heavy equipment) of the trunks with a substantial amount of crown/root tissue attached; (c) transplantation into prepared pits and replacement of backfill soil; and (d) initial maintenance including irrigation and weed control. Some of the transplants were installed within the habitat mitigation site, while others were placed in nearby natural areas in undeveloped portions of the property. The plantings outside the mitigation site did not receive long-term maintenance. The purpose of this experiment was to determine if stump transplantation could be a cost-effective alternative to whole-tree salvage, while yielding superior growth results versus plantings from seed or standard nursery container stock.

The current landowner (Lennar Corporation) provided access to the Three Oaks property in July 2021 for Psomas to evaluate the performance of the salvaged individuals approximately 15 years following transplantation. A total of 12 transplanted walnuts and 2 oak trees were evaluated for canopy diameter/height, trunk diameter at breast height, phenology/fruiting, and other characteristics. The walnut tree growth was exceptional, with canopies measuring up to 34 feet diameter and trees reaching a height of up to 28 feet. Abundant fruit was present on multiple walnut individuals. Notably, the transplanted oak trees had attained a canopy diameter of up to 23 feet and a height of up to 25 feet and fruit production was observed.

This experimental approach demonstrates that stump transplantation can be an effective method to achieve rapid growth of these native hardwood species with the additional benefits of conserved local

genetics and enhanced habitat complexity (e.g., provision of nesting cavities and inclusion of coarse woody debris).

Evidence of Climate-associated Local Adaptation and Phenotypic Plasticity Across Populations of a Widely-distributed California Oak, *Quercus lobata*

Poster #15

Brandon W.S. MacDonald, University of California Los Angeles, Department of Ecology and Evolutionary Biology

Luke Browne, University of California Los Angeles, Department of Ecology and Evolutionary Biology (currently Yale University); **Jessica W. Wright**, USDA Forest Service, Pacific Southwest Research Station; **Victoria L. Sork**, University of California Los Angeles, Department of Ecology and Evolutionary Biology

The ability to tolerate temperature or fluctuations in temperature between seasons is key to the survival of a plant and to the sustainability of populations. The environment will select for individuals who have the highest fitness in their local environment resulting in locally adapted populations. Environmental heterogeneity may also favor individuals who can tolerate a range of conditions. Temporal climatic heterogeneity within a location can select for the evolution of phenotypic plasticity, defined as the ability of a genotype to produce multiple phenotypes in different environments that may optimize plant fitness in those conditions. We tested the hypotheses of local adaptation and phenotypic plasticity by examining leaf traits from 5,488 four-year old *Quercus lobata* trees, a wide-spread California oak, planted into two common gardens maintained by the USDA Forest Service. These gardens were established with acorns harvested from over 600 trees across the species' range in 2012. We measured several leaf traits known to be associated with plant response to climate. We found that these leaf traits showed genetic differentiation among maternal families and location of origin in a pattern that correlates with climatic variation, which is evidence of local adaptation. For two traits, leaf lobedness and trichome density, we also found significantly higher levels of plasticity in progeny from climates with a greater difference between winter and summer temperatures. Furthermore, maternal families with higher plasticity in trichome density tended to display lower levels of growth in the common gardens, suggesting a potential trade-off between plasticity and growth. These studies provide evidence of climate-associated selection on leaf traits and support for the hypothesis that seasonal climatic heterogeneity of a site has favored the evolution of phenotypic plasticity in some leaf phenotypes.

California Rangelands: Impacts of Drought on Net Primary Productivity (NPP)

Poster #16

Jeremy James, California Polytechnic State University, SLO Department of Natural Resources and Environmental Sciences

Jack Alexander, **Mary McCafferty**, and **Andrew Fricker**, California Polytechnic State University, SLO

Oak woodlands and related rangeland cover types comprise a large proportion of California's land area and therefore play a key role in the state's overall carbon budget. Increasing variation in precipitation input and an overall drying climate, however, pose a serious threat to the ability of these ecosystems to store carbon. In this study we quantified spatial variation in mean NPP and asymmetry of NPP response to periods of anomalously low and high water availability. Using Generalized Boosted Models (GBMs), we compared NPP with several biotic and abiotic predictors to identify variables strongly

associated with mean NPP and NPP asymmetry at three different spatial scales (4 km, 270 m, and 30 m). We then incorporate those variables into a linear mixed-effects model to compare NPP drivers across 7 key rangeland vegetation cover types in California. Our preliminary results indicate that spatial variation in mean cumulative NPP across our 7 vegetation cover types was most highly correlated with mean early Spring precipitation, mean annual maximum temperature, and mean mid-Spring maximum temperature. Temporal variation in annual cumulative NPP was most highly correlated with annual maximum temperature, south-facing exposure, and precipitation variance from the mean. Our 7 vegetation cover types exhibited substantial variation in NPP asymmetry, with increases in NPP during high water availability years greater in magnitude than decreases in NPP during low water availability years in Grassland areas. In other systems such as Oak Woodlands, however, NPP decreases during low water availability years were greater in magnitude than NPP increases during high water availability years. Our results are consistent with previous findings that precipitation and maximum temperature are the primary drivers of NPP dynamics, but we also explore important fine scale variation in the patterns within vegetation cover types. Additionally, we show that ecosystem carbon gain during anomalous wet years across the state are unlikely to balance carbon loss during anomalous dry years.

Population Genetics of the Serpentine Endemic, Leather Oak (*Quercus durata ssp. durata*)

Poster #17

Chris McCarron, UC Berkeley

Richard Dodd (PI); **Angel Fernandez Marti** (Post Doc); **Prahlada Papper** (PhD)

The insular nature of serpentine habitats presents an ideal study system for examining evolution, population genetics and biogeography of species or species complexes restricted to them. The leather oak (*Quercus durata* var. *durata*) is one such species, as it is one of the few serpentine endemics that is widespread throughout California. This research used restriction site-associated DNA sequencing (RAD-seq) on 188 samples from 26 separate outcrops, spanning a range of 26 counties throughout California. How such a species became widespread while being endemic to serpentine soils, what the geneflow among outcrops is now and, in the past, what the spatial patterns are for these trends, and how interconnected habitat has facilitated regional geneflow are all questions that are address by this research. This data has additional ties to and implications for research examining the white oak clade of California oaks along with *Q. durata*'s adaptations to serpentine soil.

Thirty Years of Valley Oak and Blue Oak Woodland Restoration at the Los Vaqueros Reservoir Watershed and Conservation Lands: A Review and Recommendations

Poster #18

Matt Wacker, H. T. Harvey & Associates

Charles McClain, H. T. Harvey & Associates; **Presented by Atalie Brown*

The Los Vaqueros Reservoir (Reservoir), owned by the Contra Costa Water District (District), is a 1,900-acre water supply reservoir constructed in 1997 and expanded in 2013. In addition to the Reservoir itself, the District owns the surrounding 18,535-acre Los Vaqueros Watershed (watershed), which spans Contra Costa and Alameda counties and is protected and managed by the District to maintain water quality in the Reservoir. The District also owns over 5,000 acres of additional conservation lands within San Joaquin, Alameda, and Contra Costa Counties. The watershed and conservation lands support extensive areas of oak woodland and savanna that have been protected and are being restored, enhanced, and managed by the District.

Since the 1990s, the District has planted more than 5,600 valley oaks (*Quercus lobata*) and 1,500 blue oaks (*Quercus douglasii*) on nearly 500 acres within the watershed, managed oak woodlands through a targeted livestock grazing program, and monitored the effectiveness of oak restoration, management, and enhancement efforts. We review this long-term monitoring dataset, identify the factors that have contributed to success or challenges of the District's oak restoration efforts, and, based on our review, provide management recommendations for restoring and enhancing oak woodland and savanna in Central California.

Access to Ectomycorrhizal Fungi Improves Early Growth of Locally Adapted Valley Oaks (*Quercus lobata*)

Poster #19

Massimiliano Menczer, Dept. of Ecology and Evolutionary Biology and Institute of the Environment, University of California, Los Angeles

Anna Boog, **Alayna Mead**, and **Victoria L. Sork**, Dept. of Ecology and Evolutionary Biology and Institute of the Environment, University of California, Los Angeles

Most forest soils contain an array of mycorrhizae that grow on the roots of trees and aid in their growth. A key question is how much do they aid in their grown. This study was designed to (1) investigate the effect of ectomycorrhizal fungi on early growth in oak seedlings and (2) assess whether oak seedlings are adapted to the mycorrhizae in the localities where their acorns were produced. Acorns of *Quercus lobata* were sourced from the UCSB Sedgewick Natural Reserve (SNR) located near Las Olivas in the Santa Ynez Valley of Santa Barbara Co., CA. and the UC Berkeley Blue Oak Ridge Reserve, located northwest of Mount Hamilton in Santa Clara County, CA and grown in the greenhouse for two years. In June 2021, 2-yr-old saplings were outplanted into two fenced plots at SNR: Half of the seedlings were isolated from the mycorrhizal network by sterilizing SNR soil and planting into the ground with mesh netting known to exclude mycorrhizae. The other half were planted into non-sterilized soil and mesh netting cut with holes. After six months, we found that local Sedgewick saplings had greater growth with than without the presence of the mycorrhizae. In contrast, the transplanted seedlings from Blue Oak Ridge had worse growth with exposure to the mycorrhizae network compared to the seedlings excluded from the mycorrhizae. These experimental results provide evidence of local adaptation in valley oak saplings to the local mycorrhizae.

Impacts of Novel Soil-borne Phytophthora Pathogens in Oak Riparian Restoration Sites

Poster #20

David Mitchell, Dept. of Plant Sciences, University of California, Davis

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Novel *Phytophthora* plant pathogens have been introduced into restoration sites in the San Francisco Bay Area. These soil- and water-borne pathogens pose a threat to restoration plantings and can disperse to adjacent ecosystems. Several of the *Phytophthora* taxa in these sites can be pathogens of oaks, among other native plants. We investigated relationships between *Quercus agrifolia* and *Quercus lobata* seedling health, soil properties, and soil *Phytophthora* detection in riparian restoration sites in Alameda and San Mateo Counties. We hypothesized that *Phytophthora* detection would be associated with soils prone to waterlogging, lower soil organic matter, and with seedlings with disease symptoms or that had died. Soils around seedling root zones were sampled and baited for *Phytophthora* in spring 2019. We did not find *Phytophthora* presence to relate to seedling health or survival; few relationships

with soil factors could be demonstrated due to low detection rate. Oak seedling health and survival were better explained by soil variables related to water availability and limited root zone. This work was the first stage in a larger study to assess *Phytophthora* impacts and management in these riparian sites. Subsequent work will increase sampling to better quantify *Phytophthora* presence and focus on interactions between disease and water-related stresses in these sites.

Get Familiar with the Invasive Pests Threatening California Oaks

Poster #21

Beatriz Nobua-Behrmann, University of California Cooperative Extension, Orange and Los Angeles Counties

Julie Clark de Blasio, University of California Cooperative Extension, Ventura County; **Randall Oliver**, University of California Integrated Pest Management Statewide Program

More than 21,000 oaks have died in urban and natural areas of California during the last ten years as a consequence of invasive tree pests' attacks. This extended tree mortality causes significant economic, ecological, cultural, and aesthetic losses to the region. Among the most relevant invasive insect pests currently threatening California trees are the goldspotted oak borer (GSOB), the invasive shothole borers (ISHB), and the Mediterranean oak borer (MOB). GSOB and ISHB have been present in Southern California since the early 2000's, and they continue to spread throughout the region. MOB has been recently discovered in Napa County and surrounding counties, but the full extent of its distribution is still undetermined.

All three of these pests can survive in down wood for long periods of time, and often are invertedly spread to new locations through the movement of infested firewood and green waste. Actions to prevent the spread of these pests include buying firewood locally where it will be used ensuring the correct disposal of green waste (which includes chipping infested wood and, in some cases, solarizing or composting the chips).

As with any invasive species, finding infestations in the early stages allows for proper containment, management and, in some lucky cases, eradication. The key to make this early detection possible is to educate all stakeholders, including arborists, pest control advisers, government agencies, campground managers, and the general public, on how to identify and report the presence of these pests.

The University of California Cooperative Extension will be presenting and staffing a booth at the 8th California Oak Symposium with information about these three pests, including how to identify their presence, prevent the spread, and manage current infestations. More information on these pests can also be found at their respective webpages (www.ISHB.org, www.GSOB.org, and www.MOBpc.org), which include current information regarding distribution, identification, host species, and management, as well as tools to report suspected new infestations.

Linking Hydraulic Responses to Gas Exchange and Water Stress in California Oaks

Poster #22

Marissa Ochoa, University of California, Los Angeles, UCLA Ecology & Evolutionary Biology

Camila Medeiros, **Victoria L. Sork,** and **Lawren Sack**, University of California, Los Angeles, Department of Ecology and Evolutionary Biology

Across the globe species in Mediterranean-type ecosystems face mortality because of continued alterations in temperature and precipitation regimes from climate change. Plant hydraulic traits are

useful measures of plant adaptations to drought. Studies across oak (Quercus) species have established that leaf traits are involved in their ability to tolerate plant drought tolerance. Here, we tested relationships of leaf hydraulic conductance and stomatal conductance with climatic aridity for nine Quercus species grown at the California Botanic Garden (formerly known as Rancho Santa Ana Botanic Garden) in Claremont, California. We sampled eight *Quercus* species, 3 – 4 individuals per species representing the sections *Quercus, Protobalanus,* and *Lobatae*, from the months of March through June of 2019.

To obtain leaf hydraulic and stomatal conductances, well-hydrated and dehydrated leaves representing a range of water potentials were collected and used for each method. Leaf hydraulic conductance was measured using the evaporative flux system and was calculated as the flow rate through the leaf divided by leaf water potential and normalized by leaf area. Stomatal conductance was measured using a porometer on the abaxial side of the leaf. After each measurement, leaf water potential was obtained using a pressure chamber and curves were obtained as the plot of conductances versus negative water potential. By plotting curves representing vulnerability to embolism, we were able to quantify leaf hydraulic vulnerability and stomatal vulnerability to stomatal closure. We present the relationships of hydraulic traits with climatic aridity. Overall, these results suggest high variability within this genus that can be explained by climatic adaptation.

Urban Oaks: Challenges and Benefits of Reforesting Sacramento

Poster #23

Loren O'Rourke, Sacramento Tree Foundation

Planting native oak species on underutilized urban public lands in Sacramento has a unique set of difficulties. Poor soil quality, lack of irrigation infrastructure, invasive species, and vandalism name a few of the routine problems encountered by the Sacramento Tree Foundation's NATURE program. In our experience, the benefits are worth the effort.

When facing these obstacles, we have learned to use our greatest asset: the people of Sacramento. When communities engage in the improvement of their local parks and open spaces a sense of ownership and stewardship is fostered. By planting native trees in the urban landscape, we create the opportunity to influence future oak enthusiasts while also creating a shady grove for the enjoyment of all. The recruitment of local volunteers, especially young people is at the core of the Tree Foundation's mission. We strive to bring the community along in every aspect of our work: from collecting acorns, growing seeding, planting trees, and maintaining planting sites.

The NATURE program's model of volunteer recruitment and urban forest stewardship can be applied to towns and cities across the nation. This presentation will exemplify what we have learned and gained from growing oaks in California's City of Trees. Special attention will be given to the social and environmental benefits of native trees in an urban environment.

Ectoparasites Influence Woodrat Survival and Recruitment in a California Oak Woodland

Poster #24

Anne Y. Polyakov, Department of Environmental Science, Policy, and Management, University of California, Berkeley

William D. Tietje, Department of Environmental Science, Policy, and Management, University of California, Berkeley

An understanding of host-parasite relationships underpins the management of host species and public health concerns. During 2005-2014, we indexed the abundance of fleas (order Siphonaptera**)**, botfly warbles (family Oestridae**)**, and ticks (family Ixodidae) on big eared woodrats (*Neotoma macrotis*) live-trapped during October and May in a blue oak (*Quercus douglasii*)-coast live oak (*Q. agrifolia*) woodland in coastal-central California. During our 18 live-trapping sessions, the proportion of 4,368 unique woodrats on which we detected one or more ectoparasites (parasite prevalence) of any of the three groups was 37% (range 22% - 50%). Parasite prevalence was significantly different ($p < 0.05$) among sex and age groups, with parasites detected on 31% of adult females, 37% of adult males, and 53% of juvenile woodrats. The prevalence of fleas and botfly warbles was higher on juveniles than on adults, while tick prevalence was higher for adult males than for adult females or juveniles. Parasite prevalence was not correlated with seasonal temperature or rainfall. Parasite load (the count of parasites per woodrat) of fleas and botfly warbles was similar among age or sex groups, while parasite load of ticks was higher for adult males than adult females or juveniles. Finally, parasite load was negatively correlated with woodrat mass and with woodrat abundance. Ectoparasites are known to affect survival and fecundity of mammals. Our results may provide insight into the interplay between parasites, hosts, and a changing environment.

Abundance and Diversity of Resident and Wintering Birds in Undisturbed California Oak Woodland

Poster #27

Anne Y. Polyakov, University of California at Berkeley, Department of Environmental Science, Policy, and Management

William D. Tietje, University of California at Berkeley, Department of Environmental Science, Policy, and Management

California oak woodlands are located in the center of a major north-south migratory passage and, in addition to being home for populations of resident birds, millions of migratory birds seek winter refuge and maintain breeding grounds in these areas. Due to increasingly pervasive and intense drought and fires that are burning more frequently and intensely than ever before, information on bird use of oak woodland for wintering and breeding is especially important today. As part of a long-term study of the population dynamics and habitat relationships of small terrestrial vertebrates in an undisturbed oak woodland in coastal-central California, observers conducted bird point count surveys at 86 sites during winter 1997-1999 and spring 1997-2003. They recorded 41,510 detections of 84 bird species. Species evenness (aka relative abundance; an indication of ecosystem stability) was higher for resident species (0.67) than for migratory species (0.45) in winter; there was no difference in spring. In both winter and spring, species richness and overall abundance were higher for residents than for migratory birds. The most abundant winter resident species were the oak titmouse (*Baeolophus inornatus*), Bewick's wren (*Thryomanes bewickii*), and American robin (*Turdus migratorius*), while the most abundant migrants were the dark-eyed junco (*Junco hyemalis*), hermit thrush (*Catharus guttatus*), and the ruby-crowned kinglet (*Regulus calendula*). In the spring, the most abundant resident species were the oak titmouse and Western scrub jay (*Aphelocoma californica*), while the most abundant migratory species were dark-eyed junco, ash-throated flycatcher (*Myiarchus cinerascens*) and violet-green swallow (*Tachycineta thalassina*). The high number and diversity of both resident and migratory species that utilize California oak woodland demonstrates its importance as a critical bird wintering area and breeding grounds.

Valley Oak Dendrochronology in the Tehachapi Mountains, California

Poster #28

Matthew L. Trumper, Department of Geography, Environment, and Society, University of Minnesota, MN USA

Daniel Griffin, Department of Geography, Environment, and Society, University of Minnesota, MN USA; **Michael D. White**, Department of Biological Sciences, San Diego State University, CA USA

Complex topography can facilitate climatic and hydrologic microenvironments that buffer plants against climate change and extreme drought. However, the extent to which topographic position mediates tree growth response to climate is still poorly understood. Thus, spatial patterns of tree vulnerability to climatic drought are difficult to predict. Dendrochronology, the use of precisely dated tree rings to study environmental processes and history, has been critical for assessing tree growth response to climate variability across topographical gradients. We developed new tree-ring data from valley oak (*Quercus lobata*) growing in upland and riparian landscape positions along a 1,300-meter (4,265-feet) elevational transect in the Tehachapi Mountains of California to understand how topography acts as a mediating factor on tree growth, drought sensitivity, and biological reaction to environmental extremes. Because valley oak is understood to be highly dependent on groundwater, we hypothesized that higher groundwater availability at the riparian sites may mediate valley oak drought vulnerability. Preliminary results show that valley oak ring width patterns vary substantially in their mean state, decadal trend, and drought sensitivity as a function of landscape position and elevation. Growth-climate analyses indicate consistently weaker correlations between valley oak radial growth and precipitation at riparian sites compared to upland sites, consistent with our hypothesis that increased groundwater availability at riparian sites may act to decouple valley oak productivity from precipitation variability. This study adds to a growing body of literature examining vegetation drought vulnerability in California and North America, where climate extremes and associated tree dieback are an early harbinger of future drought-induced tree mortality.

Physiological Response to Summer Drought: a Long-term Comparative Study of an Evergreen and a Deciduous Oak Species

Poster #29

Claudia Tyler, University of California, Santa Barbara

Shelly Cole Moritz and **Bruce E. Mahall**, University of California, Santa Barbara

Summer drought poses a potential barrier to natural oak seedling recruitment and the transition from seedling to sapling stages. To evaluate this barrier, we conducted a long-term study of two oak species, *Quercus lobata* (a deciduous species) and *Q. agrifolia* (an evergreen species), measuring growth and physiological parameters. Within our 13-year study period was a 7-year drought, which included some of the driest years on record. Our understanding of the performance of these oaks may be useful in guiding predictions of the impacts of a future drier climate.

We conducted our studies on seedlings/saplings and neighboring adult trees at the UC Sedgwick Reserve in Santa Barbara county. Seedlings were established from acorns planted in winter 1998. From 2002 to 2015, in late summer, we assessed water relations, gas exchange and chlorophyll fluorescence.

Over the 13-year period, patterns remained surprisingly constant. Young individuals of both species had significantly lower predawn xylem pressure potentials (PDXPPs) than nearby adult trees in nearly

all years. Young individuals of *Q. lobota* reached lower PDXPPs than *Q. agrifolia* in many years, while trees of the two species did not differ.

In both species young individuals had lower maximum rates of gas exchange per unit leaf area (A_{max}) than trees in nearly all years. Gas exchange rates also varied between species: A_{max} was higher in *Q. lobata* than in *Q. agrifolia* in both adults and seedlings.

Chlorophyll fluorescence (Fv/Fm) suggest that leaves of seedlings and trees of both species are protected from photoinhibitory damage during summers. Although in the earliest years (2002, 2003) seedlings had lower Fv/Fm values than conspecific adults, subsequently, there were no differences between the age classes. However, in most years, lower values for Fv/Fm in young *Q. agrifolia* compared to *Q. lobata* suggest that the former were under more stress in late summer.

Influences of Temperature and Rainfall on Relative the Abundances of Amphibians and Reptiles in a California Oak Woodland

Poster #30

Autumn Valentine, Cheadle Center for Biodiversity and Ecological Restoration

Chris Evelyn, Cheadle Center for Biodiversity and Ecological Restoration

Climate change is predicted to have major influences on temperature and rainfall intensities and patterns. Being small ectotherms, the activity patterns of amphibians and reptiles (collectively herpetofauna) are closely tied to these weather conditions. For example, the timing and duration of weather influences basic life-history behaviors, such as feeding and reproduction. Understanding the relationships between weather events and amphibian and reptile activity patterns under the current climate regime is necessary to predict responses under projected future weather events and patterns. We address this issue by analyzing a dataset of winter and spring surface activity by herpetofauna in a blue oak (*Quercus dougglassi*) and coast live oak (*Q. Agrifolia*) woodland in coastal-central California. During January to May, 1995 to 2002, we recorded nearly 9,000 herpetofauna observations by use of 136 plywood coverboards systematically placed within each of eight 5.7-ha study plots. Species-specific activity was modeled as a response to the ambient temperature and the amount rainfall that occurred during the five days prior to the observation. Information from our study can be used to inform resource agencies and conservation organizations when setting management priorities.

Spread Knowledge, not SOD! Sudden Oak Death Outreach with the UC Master Gardener Program of Sonoma County SOD Specialists

Poster #31

Kerry E. Wininger, University of California Cooperative Extension Sonoma County

Approximately 50 million trees had died from sudden oak death (SOD) in 2019, with ~200 million infected in California, where Sonoma County leads in cases. Per October 2021's Northwestern CA Preliminary Report, SOD killed more trees than any other disease or insect that year in this area. 2021 SOD Blitz estimated true-infection rates in Mendocino and Sonoma counties remain elevated despite showing record-breaking drops statewide, and new outbreaks continue to appear in this region.

Thanks to funding from the USDA Forest Service, the Sudden Oak Death Outreach Program of Sonoma and Mendocino Counties provides practical, evidence-based information to a diverse audience. We aim to understand the impact of SOD in these counties, promote forest health to preserve habitat & high value trees, and slow spread. Homeowners, arborists and land managers rely on our community education and citizen science research for up-to-date information about disease biology, diagnosis, spread & management options.

Master Gardener SOD Specialists are volunteer educators, receiving specialized training to work with homeowners, community groups, students & public land users via education events, a staffed hotline, info booths, written communication, and the yearly SOD Blitz events. The program coordinator works with landowners, tree-care professionals, tribal groups, educators and natural resource managers on disease detection and management, provides Master Gardener trainings, supervises interns and creates visibility at events, in the media and online. Program Advisors Mike Jones & Steven Swain supply expertise in education, help develop workshops and give scientific direction to the program.

By empowering knowledgeable and passionate volunteers to interact with the public, the Sudden Oak Death Outreach Program of Sonoma County helps spread the word about SOD in the wider community at a very low cost, helping to mitigate the many impacts of this disease.

Tree Ride, an Original Composition — Music

Justin Ralls

Tree Ride is an original composition written by internationally recognized and award-winning composer Justin Ralls. Ralls' music is inspired by the natural world and engages ecologically and socially relevant themes in opera, orchestral, chamber, solo works, film music, and intercultural collaborations. Justin holds a Ph.D. in Music Composition from University of Oregon, specializing in Nature, New Music, and Indigenous Thought, and a Master of Music from the San Francisco Conservatory of Music.

Tree Ride is inspired by John Muir's famous essay "Wind-storm in the Forests of the Yuba." The first time Muir consciously chose to make himself the subject of his writing, he recounts the ecstasy of climbing a Douglas fir to "obtain a wider outlook and get my ear close to the Aeolian music of its topmost needles." Muir's prose uses music as a persistent metaphor to relate his experience of listening to the wind. He describes the "profound bass" of branches and "boles booming like waterfalls; the quick tense vibrations of the pine-needles, now rising to a shrill, whistling hiss, now falling to a silky murmur." Tree Ride begins smack dab in the tumultuous exuberance of the storm; perhaps Muir is already swinging in his tree. This opening sound world abruptly shifts, morphing into an elegiac and lyric orchestral crescendo—Muir and the listener swaying from the purely elemental realm and into the imaginative. The shifting textures work much like the wind, keeping the listener's experience always in flux.

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