

Proposal for Bren School of Environmental Science & Management Group Project

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Project Title

Developing a holistic approach to forest restoration in the southern Sierra Nevada in the face of unprecedented forest mortality

Proposers

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Client

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A) Objectives. Objectives. In the Sierra Nevada, forest restoration projects are increasingly proposed as a response to recent widespread tree mortality during the recent drought, and to climate projections that droughts and warmer droughts, especially, are likely to increase in the next decades. In the face of massive tree mortality and changing climate. Drought- and insect-driven mortality has reduced some tree species by 50-75% in the central and southern Sierra Nevada. Forest restoration includes a range of practices (e.g. prescribed burning, thinning, removing dead trees, and re-planting) that may contribute to the rate of recovery from recent disturbances, mitigate the impacts of current mortality on water resources, ecosystem health, and fire risk and reduce the vulnerability of forests to future disturbances. Management options however comprise a diversity of costs and benefits associated with stand-alone and integrated treatments. Resources are limited and ‘best’ practices will depend on who the stakeholder is and how ‘best’ is defined. Developing a solution is therefore a complex endeavor and there has been little study of what effective restoration given a diversity of goals, cost and benefits and treatment options.

This project’s overall goal is to develop a prioritization schema for how to structure Sierra Nevada forest restoration that can assess trade-offs between different restoration strategies in a patchwork landscape of public and private lands. The group will integrate what is known about the ecology, hydrology, and other environmental facets of the region’s forest landscape and how these influence the need for and impacts of different restoration strategies. The prioritization schema will focus at the scale of a typical forest management unit or small watershed (HUC12 level). Students will summarize restoration opportunities, including their costs and benefits for multiple stakeholders and land use objectives as well as economic and logistical feasibility. Initial analysis will focus on a single, data rich case study but schema should be designed to be applicable broadly to forested watersheds in the Sierra Nevada and recommend restoration practices that can be implemented by public and private landowners within the Sierra Resource Conservation District’s boundaries. Project outputs should focus on ecological options and integrate socioeconomic benefits as much as possible. Recommendations should include an immediate action plan that could be implemented economically over a short-term timescale, while also reflecting a long-term (>10 years) vision of ecological resilience for the area.

B) Significance. Drought, climate change, and forest mortality have created an unprecedented problem for Sierra Nevada forests. Recent Forest Service aerial surveys of tree mortality estimate more than 100 million trees have died across the range, with substantial mortality observed since the Spring of 2015. The magnitude of tree mortality in the central and southern Sierra, along with its causes and impacts, has garnered national press attention [1-3]. Tree mortality has direct impacts on the local forest ecosystem, from increased fire risk to decreased wildlife habitat, as well as reach beyond forest ecology. Both National Parks and National Forests are key entities in a robust outdoor recreation economy. National Forest lands, with their multiple-use mandate, also play a critical role in local wood-products industries. These diverse activities bring economic prosperity and cultural value to Sierra communities that, in the face of uncharted mortality and unknown future climate, are at risk of declining. While many effects of current changes in Sierra forests have yet to be directly quantified, the magnitude of this issue has created urgency among resource managers and community stakeholders to secure the future of these forests.

The Dinkey Landscape, located within the southern Sierra Nevada, can serve as a case study area for restoration in an unprecedented time of forest mortality, drought, and climate change. A breadth of relevant data are available for the area through the Dinkey Landscape Restoration Project and its collaborating members, which include the Sierra Resource Conservation District (RCD), U.S. Forest Service managers and researchers, Southern Sierra Critical Zone Observatory staff, and other stakeholders from public and private sectors. Findings, products, and recommendations made by the group project team will be directly used by the Sierra

RCD to inform future management decisions for integrating management on private lands with Sierra National Forest management practices, and shared with other Dinkey Collaborative members and stakeholders.

C) Background. The Sierra National Forest covers land from Yosemite National Park in the north to Sequoia-Kings Canyon National Park and Sequoia National Forest in the south. The western slope of the Sierra Nevada is dominated by mixed conifer forests, ecosystems long-adapted to regular fire return intervals. However, long-term fire suppression contributed to dense, overly populated forest stands that are more susceptible to both fire and drought. Furthermore, climate change will alter elevational temperatures and mountain hydrology, and is predicted to spatially shift vegetation species abundance and diversity over time. This will pose downstream effects on water cycling, soil health, fire risk, and forest mortality rates.



1. Sunset in the Dinkey Landscape at ~4000 m, highlighting the unprecedented tree mortality observed across the Sierra Nevada. Taken Dec. 2015 by M. Wholey.



The Dinkey Landscape, covering 154,000 acres in the southern portion of the Sierra National Forest, encompasses the many factors that make Sierra ecosystems precious but complicated to manage. The Landscape includes diverse ecosystems, including oak woodlands, foothill chaparral, conifer forests and wetland meadows, all of which support a variety of wildlife. This is the heart of the territory for the Southern Sierra population of Pacific Fisher and the California Spotted Owl, two species of concern. Non-ecological features include heritage resources and the raw timber that supports a local mill. Management of this landscape is complicated by the extensive wildland-urban interface, sensitive species and other environmental regulations, and historic fire suppression.

D) Available data. **Ecological datasets** available through the US Forest Service include stand exams (before and after various forest treatments), aerial vegetation detection surveys, and wildlife surveys. Client and collaborators can be contacted for data acquisition. **Hydrologic and atmospheric datasets** for the region, including meteorology, canopy carbon dioxide and water vapor fluxes, snow depth, and soil moisture are freely available through the Southern Sierra Critical Zone Observatory's digital library. Stream flow and further meteorology data are collected by the US Forest Service Kings River Experimental Watersheds project, available through a digital library. **Baseline remote sensing data** are available online and includes digital elevation models. Additional aerial surveys may be available soon from the Forest Service. **Socioeconomic data**, including economic indicators, have been collected by the Sierra Institute for the Dinkey Landscape region through interviews and focus groups. **Timber harvesting and hazardous fuels treatments** spatial datasets are available for US Forest Service lands through the Forest Service Geodata portal. **Relevant peer-reviewed scientific journal articles** from agencies and research institutions, as well as **reports and practice**

standards from US Forest Service and Sierra RCD, are available. **Resource protection laws** (as applicable to private lands) should also inform restoration recommendations.

Ongoing work includes several assessments that may be available in the coming 18 months. The Forest Service is assessing the impact of land management treatments on forest tree mortality. The success of land management treatments in reaching objectives for tree spacing, wildlife habitat, and other goals in the Dinkey Landscape are also being evaluated. Hydrologic impacts of the drought and recovery of water stores are being tracked by both the Southern Sierra Critical Zone Observatory and the Pacific Southwest Research Station (US Forest Service). Other ecological data underway includes common garden experiments in pine survival from the lab of Emily Moran (UC Merced) or possible climate adaptation data from Pacific Southwest Research Station (Forest Service, see Wright, 2014).

E) Possible approaches. The general approach will be to synthesize existing resources into a recommended restoration strategy that meets goals and objectives identified by the Sierra RCD and the Dinkey Collaborative. Another resource is the ongoing relationship between the Southern Sierra Critical Zone Observatory and Bren – Naomi Tague is a PI on the project and Frank Davis has served an external project advisor. We anticipate that the students will greatly develop these ideas or generate new ones. A few specific ideas are:

- Incorporate ecological, economic, and infrastructure data to develop geospatial recommendations for where to prioritize resource investment
- Use existing climate, species distributions, and remote sensing data with climate envelope models to develop a “climate smart” reforestation strategy
- Identify economic markets for new or repurposed forest products, with reinvestment of the profits in land restoration projects

F) Deliverables. Two main deliverables are expected from this project. The first is a set of proposed ecological restoration strategies, and the tradeoffs between them, for the Dinkey Landscape as a case study for a complex landscape. The second deliverable is a geospatial framework that can be used to prioritize restoration practices at other sites, particularly private inholdings. Thus, deliverables from this project may include a list of identified problems and opportunities, an inventory and analysis of resources, and a recommended potential restoration options. Creation of maps using GIS software will be necessary to complete these deliverables. The recommended restoration program should include rough estimates of impacts on soil health, atmospheric carbon, and watershed health, as well as potential socioeconomic benefits and costs of the proposed program. Sierra RCD works with US Natural Resources Conservation Service to develop and implement conservation practice standards; the final written report and policy brief should include information necessary to easily adapt the outcomes of this project into these formats.

G) Internships. We have the capacity and desire for a 10-week summer internship for one student, with mentoring through Sierra RCD and US Forest Service and home base desk at the High Sierra Ranger District Office in Prather, CA. The position is designed for a motivated student who desires the chance to combine resources on-site. The intern will have the opportunity to work directly with resource management agencies and assist with ongoing Sierra conservation and forest management efforts, extending beyond the immediate scope of this project’s objectives. Please see client letter of intent for details. Funding is not currently available for internship pay, though we are looking at possible sources of funding.

Additional supporting materials:

A. Citations. Due to the scientific and technical nature of many interdisciplinary environmental problems, authors are encouraged to include citations to support their proposal.

1. Fountain, H. (2016) Sierra Nevada Won't End California's Thirst. The New York Times. <http://www.nytimes.com/2016/04/12/science/california-snow-drought-sierra-nevada-water.html>
2. Serna, J., and St. John, P. (2017) With snow piling up in the Sierra, what will it take to end California's drought? Los Angeles Times. <http://www.latimes.com/local/lanow/la-me-drought-snow-sierra-20170103-story.html>
3. Stevens, M. (2016) 102 million dead California trees 'unprecedented in our modern history,' officials say. Los Angeles Times. <http://www.latimes.com/local/lanow/la-me-dead-trees-20161118-story.html>
4. Baker, S., Christofk, T., Hartsough, B., Lincoln, E., Mason, T., Springsteen, B., York, R., and Yoshioka, T. 2015. Forest biomass diversion in the Sierra Nevada: Energy, economics and emissions. *Calif Agr* 69(3):142-149. DOI: 10.3733/ca.v069n03p142.
4. Wright, J. (2014) Genetics of Forest Trees. Chapter 3.1 General Technical Report 247 - Science Synthesis to Support Socioecological Resilience in the Sierra Nevada and Southern Cascade Range.

Partial list of resources to consider

- Araya, S.N., Meding, M., and Berhe, A.A. (2016) Thermal alteration of soil physico-chemical properties: a systematic study to infer response of Sierra Nevada climosequence soils to forest fires, *SOIL*, 2, 351-366, doi:10.5194/soil-2-351-2016.
- Bart, R.R., Tague, C.L., and Moritz, M.A. (2016) Effect of Tree-to-Shrub Type Conversion in Lower Montane Forests of the Sierra Nevada (USA) on Streamflow. *PLoS ONE* 11(8): e0161805. doi:10.1371/journal.pone.0161805
- Erickson, V., Aubry, C., Berrang, P., Blush, T., Bower, A., Crane, B., et al. (2012) Genetic resource management and climate change: genetic options for adapting National Forests to climate change. USDA Forest Service, Forest Management. Washington DC. 19 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5368468.pdf
- Goulden, M.L., Bales, R.C. (2014): Mountain runoff vulnerability to increased evapotranspiration with vegetation expansion. *Proceedings of the National Academy of Sciences*. 111 (39). DOI: 10.1073/pnas.1319316111
- Jepsen, S.M., Harmon, T.C., Meadows, M.W., and Hunsaker, C.T. (2016): Hydrogeologic influence on changes in snowmelt runoff with climate warming: Numerical experiments on a mid-elevation catchment in the Sierra Nevada, USA. *Hydrology* 533, 332-342. DOI 10.1016/j.jhydrol.2015.12.010.
- McIntyre, P.J., Thorne, J.H., Dolanc, C.R., Flint, A.L., Flint, L.E., Kelly, M., et al. (2015) Twentieth-century shifts in forest structure in California: Denser forests, smaller trees, and increased dominance of oaks. *Proc Natl Acad Sci*. 112: 1458–1463. doi: 10.1073/pnas.1410186112.
- North, M. P., Stine, P., O'Hara, K., Zielinski, W., and Stephens, S. (2009). An ecosystem management strategy for Sierran mixed-conifer forests. USDA PSW GTR 220.
- Schwartz M.W., Butt N., Dolanc C.R., Holguin A., Moritz M.A., North M.P., et al. (2015) Increasing elevation of fire in the Sierra Nevada and implications for forest change. *Ecosphere*. 6: 1–10. doi: 10.1890/ES15-00003.1.

Sierra Resource Conservation District

January 23, 2017

Group Project Committee
Bren School of Environmental Science and Management
University of California, Santa Barbara

The Sierra Resource Conservation District is pleased to submit as a client the attached proposal, *“Developing a holistic approach to forest restoration in the southern Sierra Nevada in the face of unprecedented forest mortality”*.

Our District covers nearly 2 million acres of critical watersheds in the Southern Sierra Nevada important to the state of California. These include forestlands, oak woodlands, rangelands and irrigated lands in eastern Fresno County. After nearly six years of drought, the forests within our District have been severely impacted creating an environmental disaster and public safety challenges to our foothill and mountain communities due to an increase in tree mortality and catastrophic fires. It is estimated that over 100 million trees are dead across the mountain range, with more than 17 million trees dead in our area. These dead trees create an immediate impact on the ecology and water quality, which in turn create a great risk for environmental, domestic, and agricultural beneficial uses.

Our District is very involved on how best to approach this socio-economic and environmental crisis in an effective and efficient manner. We are currently involved with the Fresno County Tree Mortality Task Force under the Governor’s Emergency Declaration; a key partner with the U.S. Forest Service’s Dinkey Creek Landscape Collaborative within the Sierra National Forest; and cooperating with CAL FIRE within their State Responsibility Areas (SRA), as well as other agencies and NGOs.

Working with a Group Project through the Bren School of Environmental Science and Management will provide our District the ability to gather additional data as to the current conditions of public and private forest lands and the impact to our watersheds. We hope to gain additional knowledge of these conditions and begin establishing priorities on how best to mitigate the impacts and move towards restoration. And, we believe this opportunity will complement our combined efforts between educational, research, interagency, NGO stakeholders and the communities that we serve.

Our District is working with the Natural Resource Conservation District (NRCS) to review Conservation Practice Standards (CPS) for private landowners to develop a stewardship program. We have also been invited by the California State Water Resources Control Board (SWRCB) to develop a restoration/reforestation watershed program. We believe that this proposal will be complementary to our efforts to establish Best Management Practices (BMPs) and private land stewardship values and that this proposal will greatly contribute to our District’s success.

Sincerely,



Steve Haze, District Manager

SRCD Project Office: (559) 855-5840
PO Box 693, Auberry, CA 93602
<http://sierrarc.com>



Southern Sierra Critical Zone Observatory
Sierra Nevada Research Institute
University of California, Merced
5200 North Lake Road
Merced, CA 95343

January 5, 2017

Steve Haze
District Manager
Sierra Resource Conservation District
P.O. Box 693
Auberry CA 93602

Dear Mr. Haze,

We are writing to state cooperative support of the Sierra Resource Conservation District's proposal, entitled "Developing a holistic approach to forest restoration in the southern Sierra Nevada in the face of unprecedented forest mortality". If the proposal is accepted by the Group Project Committee of the Bren School of Environmental Science & Management at the University of California, Santa Barbara, our personnel will cooperate with you and the student group by:

- Providing a list of relevant reports and peer-reviewed journal articles that Southern Sierra Critical Zone Observatory researchers have published, along with facilitating access to any articles which are inaccessible for Bren students;
- Assisting with access and navigation of the Observatory's data portal and digital library as needed;
- Advising remotely on topics requiring research expertise from Observatory personnel as requested by Bren students; and
- Aiding the client in coordinating a student field trip to the project area, including a tour of Observatory sites and instrumentation if requested.

Outreach objectives of the Southern Sierra Critical Zone Observatory include serving as a source of relevant, reliable information for resource managers and decision makers; and training the next generation of environmental professionals. We look forward to working with you.

Sincerely,

Michelle Gilmore
Outreach Manager

Erin Stacy
Field Manager

January 25, 2017

Steve Haze
District Manager
Sierra Resource Conservation District
P.O. Box 693
Auberry, CA 93602

Dear Mr. Steve Haze,

The High Sierra Ranger District of the Sierra National Forest, California are writing to confirm our support of the Sierra Resource Conservation District's proposal, entitled "Developing a holistic approach to forest restoration in the southern Sierra Nevada in the face of unprecedented forest mortality".

The High Sierra Ranger District of the Sierra National Forest is located in the foothills of the southern Sierra Nevada in Prather, CA. The High Sierra District office is the primary party responsible for the administration and implementation of projects in the Dinkey Collaborative Forest Landscape Restoration Project (CFLRP). Specialty staff areas (i.e., silviculture, wildlife, aquatics, hydrology, fuels, and range) on the High Sierra Ranger District design projects with Dinkey collaborative members and provide monitoring of key resource areas in support of the collaborative projects. Additional staff areas include archeology, fire, and recreation that also work to support the Dinkey Collaborative restoration goals.

If the proposal is accepted by the Group Project Committee of the Bren School of Environmental Science & Management at the University of California, Santa Barbara, our personnel will cooperate with you, and support the student group and the student intern by:

- Providing existing natural resource datasets and spatially-explicit project data
- Mentoring the student group and summer student intern
- Providing desk space at the High Sierra Ranger District office for the student intern

We look forward to supporting the students through mentorship, a summer working environment that provides an opportunity to engage with the National Forest System at the District level, and by providing relevant natural resource data to the development and creation of their project.

Sincerely,

Lauren S. Pile
Ecologist & Dinkey Collaborative Monitoring Coordinator

Sarah LaPlante
Deputy District Ranger