Symposium Organizers: Amarina Wuenschel and Chris Fettig

NAC20 Program Topic: Natural areas management in light of climate change

Symposium Description: We propose a symposium related to managing for drought in California that corresponds to a recent chapter in the USDA Forest Service-produced General Technical Report 'Drought Impacts on U.S. Forests and Rangelands: Translating Science into Management Responses'. This symposium will contain an overview of the topic, four additional presentations related to drought management in widespread California ecosystems (montane forests, redwood forests, oak woodlands, chaparral and coastal sage scrub, and grasslands) and conclude with a facilitated discussion. Presentations are germane to the conference topic 'Natural areas management in light of climate change' given that global climate models project severe droughts will become the norm in California.

Drought presents significant challenges for natural resource managers in California, and future droughts will likely exert even greater impacts. Managers can intervene by altering plant structure and composition, increasing annual water yield, and conducting public outreach and education regarding water conservation. Due to strong environmental gradients in California, drought management should be tailored to individual ecosystems. For example, in forests and woodlands, drought management focuses on the use of mechanical thinning and prescribed burning both to decrease stand densities and to promote the growth and vigor of desirable tree species. In chaparral, frequent disturbances are stressors, so soil disturbances need to be limited as much as possible to reduce the spread of nonnative annuals that promote wildfires. Invasive plants are also an important problem in grasslands, where they should be removed and replaced with native grasses and forbs. In grasslands, prescribed fire may be useful to manage nonnative species and increase perennial plant cover to make grasslands more drought resilient.

By including a diverse group of presenters, experts in their respective ecosystems, this symposium will flesh out the fuller story of drought management across California, and convey specific,

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actionable, science-driven management options for each ecosystem as well as touch on commonalities across ecosystems. An overview will provide context on the recent 2012-2016 drought relative to historic droughts in California and serve to convey the need to manage for future drought. Our symposium will act as a much-needed forum for delivery of recently published knowledge to practitioners.

Presentation Title: Droughts and Drought Impacts in California: An Overview

Presenter: Steven Ostoja.

Co-Authors: Christopher J. Fettig, Amarina E. Wuenschel, Jennifer Balachowski, Ramona J. Butz, Anna L. Jacobsen, Malcolm P. North, R. Brandon Pratt, Richard B. Standiford, Jonathan P. Long and Jon E. Keeley

Abstract: Drought is a basic feature to California's climate. Moreover, droughts have been an important influence on California's ecosystems for millennia. Over the past century, the state has experienced several extreme drought events; but in the past 5 decades there has been a notable increase in drought frequency and severity. A notable hallmark of this was the 2012-2016 drought, which based on tree ring records, was the most severe in >1000 years. Droughts like this one can contribute to wide-spread ecological and economic impacts that touch many different industries and sectors. In California the most recent severe drought facilitated wide-spread mortality of trees and shrubs in forests and woodlands, was blamed for poor rangeland condition and leading to agricultural and forestry industry impacts.

In this presentation we will examine how historical drought has differentially shaped California's natural ecosystems. We will also consider what is expected with future climate change especially in regard to extreme climate events like drought and heat waves. Mindful that the future climate change will bring increased frequency and severity of drought; attention will be given to how ecosystem components may be impacted directly and indirectly. We will conceptually introduce how management strategies and approaches can work to prepare forest and associated ecosystems with greater adaptive capacity in the face of future impactful drought events. Such considerations are of value so context-specific management strategies can be considered preemptively with the goal to ameliorate the impacts brought from climate change. Finally, some treatment will be given to what climate mediated impacts could mean for various societal and industry interests if management efforts are not prioritized preemptively

Presentation Title: Managing the Effects of Drought and Facilitating Recovery from Drought in California's Montane and Subalpine Forests

Presenter: Chris Fettig

Abstract: In montane and subalpine forests of California, recent droughts have contributed to widespread bark beetle outbreaks, extensive tree mortality, reduced tree growth, and increased wildfire hazard, all of which in turn affect biogeochemical cycling and hydrologic processes. Reducing forest densities will increase the resilience of montane and subalpine forests to drought and other disturbances exacerbated by drought. The main tools are mechanical thinning and fire, the latter consisting of prescribed fires or wildfires that are allowed to burn under appropriate weather conditions (i.e., managed wildfire). Facilitating recovery and restoration of drought-impacted forests requires a flexible approach. For small patches of tree mortality (e.g., <20 hectares), intervention may be minimal. If green-tree seed sources are not nearby (generally within ~250 m for wind-dispersed conifers), intervention may be limited to planting more drought-tolerant seedlings. In more extensive patches of tree mortality, decisions about salvage harvesting, prescribed burning, planting, and controlling competing vegetation may vary with dead-tree patch size, potential natural seedling recruitment, management goals and fire hazard.

The montane and subalpine forests of California provide immeasurable ecological goods and services, many of which warrant special protection and management considerations. In this presentation, several USDA Forest Service and California Department of Forestry & Fire Protection publications will be reviewed that guide thinking about managing forest structure to emulate the 'natural' heterogeneity of forests, to minimize the undesirable impacts of drought, and to facilitate recovery from drought. Key elements include: (1) increasing the pace and scale of thinning, prescribed burning and managed wildfire, (2) rebuilding the forest products industry in California to facilitate adequate biomass removals, (3) improving forest structure for wildlife habitat, (4) restoring ecologically-sensitive areas (e.g., meadows), (5) facilitating legislative and administrative reforms that act as barriers to project implementation, and (6) implementing monitoring and adaptive management.

Presentation Title: Managing Effects of Drought and Facilitating Recovery in California: Coast Redwood Forests

Presenter: Ramona Butz

Abstract: Within the redwood forests of northern California, annual water use by large redwoods is high, and the greatest demands for water occur during summer months when rain is sparse. Summer fog serves an important role in ameliorating water deficits. During drought, redwood forests continue to tap fog as a water source, and deep, loamy forest soils slowly release the water captured from winter rains. Coast redwoods tend to be poor regulators of water use, making them sensitive to ambient humidity and the presence or absence of cloud cover. During prolonged drought, decreased canopy water content and fog drip can lead to decreased germination and survival rates of seedlings, and reduced radial growth, limited foliar water uptake, and even death in mature trees.
Although mature redwood forests are generally fairly drought tolerant, the effects of drought events of increased intensity and duration can be minimized through a number of management strategies. The loss of redwood trees to natural disturbances (e.g., wildfire, windthrow, floods, severe drought), extensive timber harvest, or other land-use practices converts forests to more open habitats reducing fog capture, thus altering the hydrological balance and creating more drought-prone conditions. Drought mitigation in coast redwood forests includes: (1) reduction of competing vegetation, such as Douglas-fir (*Pseudotsuga menziesii*), through prescribed burning and mechanical thinning, (2) reduction of practices that create forest structures that are too open, thereby losing their ability to capture moisture from fog, (3) minimization of soil disturbance, (4) reduction of road densities, (5) creation of small gaps for light availability for regenerating seedlings, and (6) protection of old-growth reserves.

Presentation Title: Managing Effects of Drought and Facilitating Recovery in California Oak-dominated Forests and Woodlands

Presenters: Jonathan Long, Yana Valachovic

Abstract: Oaks have many adaptations, including drought tolerance and resprouting abilities that afford them increased resilience to drought and associated natural disturbances. Shifts toward increased dominance of oaks are expected in many parts of California based upon projections of increased warming and drought. Such trends have become evident during the recent, widespread drought event that killed many pines and other conifers in the southern Sierra Nevada. Drought and fire-induced mortality are natural regulatory processes that may restore more sustainable forest conditions by reducing densities of oaks and competing conifers, especially if that mortality tends to kill smaller trees and trees in poorer soils, at low elevations, on south-facing slopes. However, mortality events could be degradative where they kill mature trees and inhibit regeneration. For example, in southern California, the combination of drought, wildfire, and expanding insect pests like the goldspotted oak borer may lead to reductions among some oak species. Meanwhile, sudden oak death is a novel stressor in northern California coastal forests. A goal for managing resilience throughout the state is to conserve mature oaks that provide ecosystem services such as acorn production and habitat for wildlife. That goal can be advanced by thinning overly dense oak stands, remove competing conifers, reducing fuels, and supporting use of fire, including cultural burning directed by tribes and informed by traditional knowledge. Treatments also need to create openings for regeneration to ensure sustainable conditions over the long-term. Several recent synthesis reports have proposed and developed these strategies, including the recent General Technical Report on management for drought in the US, a report on restoring California black oak for tribal values, and the 4th California Climate Change Assessment. Reducing competition for water by non-native annual grasses may also be important strategies in grazed woodlands and in urban forests. More active efforts to plant young oaks and water mature trees may be also appropriate in intensively managed areas. Meanwhile, in more remote locations, managing naturally ignited fires and using prescribed burns will be important strategies for resilience. However, managers and the public may want to help inventory and safeguard especially old and large legacy trees that have disproportionate ecological and social value to minimize potential losses from combined stressors.

Presentation Title: Managing Drought-Prone Chaparral Landscapes

Presenter: Jon Keeley

Abstract: Beginning in 2012 California experienced one of the most intense droughts in history. The duration of the drought varied throughout the state. In the Sierra Nevada it lasted three years and was a factor in massive mortality of trees in mid-elevation conifer forests. In southern California the drought continued through most of 2018 and resulted in massive dieback of chaparral shrublands. There is good reason to believe this dieback was a major factor contributing to the size of the 2017 Thomas Fire and the 2018 Woolsey Fire, the largest fires in the region in recent history. This presents a significant management challenge because dead woody fuels likely contribute to extreme fires, and in this climate these fuels decompose slowly, plus future climate change is predicted to increase the incidence of severe droughts.

Our work has used remote sensing methods (Landsat NDVI) for detecting and verifying vegetation dieback in southern California shrubland landscapes, and then relating these to fire severity patterns in the 2018 Woolsey and 2017 Thomas fires (using Monitoring Trends in Burn Severity, MTBS data). This provides insight into relationships between severe drought, vegetation dieback and subsequent fire severity, and to what extent this information could be used to inform land and fire management activities in the region.

Management options must consider the wildland-urban interface risks associated with prescription burning on this landscape, thus making this obvious management option for dealing with drought an unlikely strategy. Future focus must deal with drought impacts by concentrating on the urban environment and considering the 5 P's of 1) people as the primary problem, 2) prevention of fire ignitions during extreme wind events, 3) planning future developments, 4) protection of structures by home-hardening, and 5) predicting capacity for fire trajectories during extreme wind-driven fire events.