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Thank you for inviting me to testify about California forest management and the recent widespread tree mortality that has occurred in the Sierra Nevada. I have worked on issues related to forest conservation and management since 1991 with an emphasis on fire and forest ecology, forest restoration, and fire policy. In the following I provide background information on this event and what can be done to reduce the chances of it happening again. In short, there is a ***Pressing Need*** for large-scale forest restoration. I also responded to the Commission's inquiries listed below:

1. A broad overview of the causes and impacts of California's tree mortality crisis in the Sierra Nevada. Please include a discussion of how federal and state forest management practices have contributed;
2. A discussion on forest management practices that would result in more resilient forests and ecosystems;
3. The challenge California faces in that the state itself owns few of the forests within its borders. How could the state better work with private landowners, including small landowners, to promote healthier forest outcomes? Are there ways the state could engage the federal government to encourage it to undertake best practices for more resilient forests?
4. Other information that could aid its analysis of forest management in California, particularly in relation to preventing future mortality crises.

The scale and magnitude of tree mortality that we are seeing throughout the state, and most notably in the southern Sierra Nevada, is nothing more than a ***symptom of a much larger problem***, our forests are not in a resilient condition. Defining resilience is not simple but I will define it as the ability of an ecosystem to absorb impacts before a threshold is reached where the system changes into a different state (such as forest changing to a large shrubland after a severe wildfire). Past management actions, including fire suppression and logging focused on large trees have produced forests today that are much more vulnerable to fire and drought-related mortality. Climate change is also contributing to this but it is a smaller factor.

I have led and co-authored published journal articles describing what forests were like in 1911 from early US Forest Service inventories. These inventories covered areas > 30,000 acres and are robust in terms of data sampling and quality and were done in the central and southern Sierra Nevada (1,2). The 1911 forests were never harvested and fire suppression had just begun so they describe conditions that are unaltered by Euro-American people. The mixed conifer and ponderosa pine forests had low numbers of trees per acre but the trees that existed were relatively large and were dominated by pines. 1911 tree densities ranged from 20-80 trees per acre (trees with diameter > 12 inches), today

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forest densities are 2-5 time higher than this (others have estimated historical forest densities from General Land Office surveys but they have been proven to be inaccurate). With this huge increase in live biomass, competition for water has increased greatly. This increased competition combined with a 4-year drought results in trees dying outright or being killed by native bark beetles because trees cannot defend themselves under these conditions.

We can look to another area of California forests for some insights into the present problem. From 1999-2002 the forests in the southern California mountains experienced a similar drought, which also resulted in a huge tree mortality event. The area around Lake Arrowhead received a great amount of press and I testified to a US House of Representatives meeting on this tree morality event. The issues underlying this tree mortality were the same as today, fire suppression and past logging that had increased tree densities and then a severe 4-year drought happened. Hundreds of thousands of trees died and the state and federal government spent millions of dollars in response. Was this a natural event or something outside of what we expected? We can travel about 120 miles south from Lake Arrowhead to Baja California, Mexico, to find an answer. This area is in the same mountain range (the Peninsular Mountains), half of this range is in California and the other half in Mexico (the Sierra San Pedro Martir – SSPM). The SSPM has forests similar to those in southern California, the Lake Tahoe Basin, and the eastern Sierra Nevada (3). One of the most interesting things about the SSPM is it has not been logged and fire suppression did not begin until 1970 because there were no roads to this area until then. Hence, SSPM forests have not seen the dramatic changed observed in California forests. For this reason SSPM forests represent the largest relatively intact Mediterranean-climate forest ecosystem in the Northern Hemisphere and you can drive there today in 6 hours from San Diego.

The SSPM experienced the same drought as the forests in southern California but its response was very different. While we saw similar mortality as we are seeing today in the southern Sierra Nevada on the CA side of this mountain range, tree mortally in the SSPM averaged 0.5 trees per acre based on a set of research plots that we still have down there (4, 5). Think about this, less than 1 tree per acre died in the Mexican forest but in the southern California mountains, 20-50 trees/acre died from the same drought. After the drought ended a wildfire burned in the SSPM in 2003. We did another research project there and only 20% of trees in this forest died from a severe 4-year drought followed by a wildfire (6). The mixed conifer forests in the SSPM are incredibly resilient and I am sure forests in CA once had this same resilience but it has been lost in the last 100 years. In fact the forest density today in the SSPM is very similar to what was recorded in most of the 1911 forest surveys that I mention above. The goal of our present forest management should be to create conditions and processes similar to those found in 1911 or in the SSPM today. Even though climate is changing these conditions would still result in highly resilient forests.

All is not lost. I have worked with other forest scientists in the USA to install and evaluate forest restoration treatments that can be used to increase the resilience of CA forests. These restoration treatments include prescribed fire alone, mechanical thinning alone, thinning followed by prescribed fire, and untreated controls. We wrote a summary paper (7) that found that these treatments can be designed to reduce fire hazards with few unintended impacts, since most ecosystem components (vegetation, soils, song birds, small mammals, bark beetles) exhibit very subtle changes or no measurable effects at all. What this tells managers and policy makers is these restoration treatments

can be used without harm, this is **GREAT NEWS**. Longer term treatment impacts to wildlife with large home ranges are not as clear, and often hinge on two key variables: expected wildfire probability and vegetation recovery following wildfire. Although mechanical treatments (such as tree thinning) do not serve as complete surrogates for fire, their application often meets restoration objectives while mitigating fire hazards, especially in areas that already have an extensive road network. Allowing local managers to select the most appropriate treatments for their area is the best approach because of diverse land management objectives, infrastructure, and current conditions. The amount of forest restoration that that is occurring today on the US Forest Service lands in the Sierra Nevada needs to increase by approximately 10 times to increase forest resilience long-term. Once lands are restored moving them into a maintenance regime by using fire is probably the best solution since so much area is in need of restoration (8).

Another way to increase forest resilience in CA forests is to allow managed lightning fires to burn in remote areas under less-than-extreme fire weather conditions. This has been happening in areas of Yosemite and Sequoia-Kings Canyon National Parks for about 45 years. Managers write a plan describing what types of conditions are needed to allow a lightning fire to burn with careful monitoring. If the fire begins to burn outside of desired conditions it can be suppressed. If only one side of the fire is not meeting management objectives, it can be suppressed and the other side allowed to burn. Current federal fire policy allows for this, but the extent to which it has actually been implemented is limited. No doubt there is risk in such a system but there is also a huge cumulative risk of suppressing all fires in fire dependent forests. Another challenge is inaccessibility for mechanical treatment. This is usually due to slopes being too steep for machines to operate or to legal constraints (wilderness designation). This is the case for a large portion of CA forests, particularly in the southern Sierra Nevada (9). In these areas fire is the only tool that could be applied to increase forest resilience.

We have found co-benefits when you allow lightning fires to burn in remote forested areas. The first is fires become self-limiting with no suppression. Ninety percent of fires that try to reburn an area that was previously burned at 9 years or less go out on their own (10). This happens because fuel loads are very low in the previously burned areas to allow fire to spread. This is the way that fires used to burn in forests throughout the State before we started fire suppression. Another benefit of this managed wildfire program is water production and tree drought resistance. We found that 45 years of managed wildfire in a large watershed in Yosemite National Park resulted in less tree morality from the current drought and either higher or unchanged stream water output from this watershed; in contrast 3 other similar control watersheds that had no managed wildfire all produced less stream water over the same period (11). There is a possible triple-win where managed wildfire produces more or unchanged stream water output, less tree mortality when drought and fires occur, and can store and sequester carbon sustainably for the long-term.

What can the State do to help small private landowners and the federal government to increase forest resilience?

Small private land owners are a challenge since they don't normally have the expertise or resources to do restoration treatments needed on their lands. One idea would be to create new 'forest health districts' similar in structure to the existing irrigation districts that have been around for decades. For

example, the Nevada County Irrigation District is was formed in the 1920's in the foothills of the Sierra Nevada near Grass Valley and provides water to the members of the district. It is an independent public agency governed by an elected local board. Why not facilitate the creation of 'forest health districts' with a similar structure? Boards could be locally elected and could be a powerful force to promote and incentivize more resilient forests on small private lands. The University of California Cooperative Extension system already has Extension Foresters located throughout the state and they could provide local expertise to these new districts. Unless a system is created to educate small private landowners and assist in efficiently managing their lands I am afraid that nothing will change. The State may have to create a peer-reviewed grant program that could assist these new districts to get the work done but it could provide big benefits.

The State PUC regulates our electrical system and could continue or increase subsidies to biomass electrical energy generation. Generating electricity from natural gas has taken many of our existing biomass plants off-line and retarded investment in new plants. Biomass plants are a *key infrastructure* to assist in large scale forest restoration since they can process small diameter trees. With a huge surplus of these types of fuels we need places to process them. Since this is a renewable fuel it would also assist in the States climate plan. This is one policy change that could be done quickly.

Previously I wrote about the connections of forests, fire, and stream water. Water is becoming the #1 natural resource in the State and it will only increase in significance as climates continue to change. Presently *no funding from water users is invested into the upper watersheds* of the state that provide the very water that we use. The State could propose legislation to ask CA residents to help pay for the restoration and maintenance of our key mountain watersheds through a very, very small monthly charge on our water bills through our local water agency. This would need to be done strategically to place the treatments or managed wildfires in the mountain areas with the most potential for positive impacts to stream water flow but it could be done. This would be a powerful way for the State to invest in a more sustainable and predictable water supply and insure forest C benefits long-term. It would be critical that if such a funding stream were generated, it would be strongly tied to actual implementation of-the-ground restoration projects, as opposed to increased planning. We have a fairly clear understanding of forest restoration, we need large-scale implementation.

Regarding federal forest land the State could partner with the US Forest Service to increase the pace and scale of needed forest restoration projects. The State has a climate plan that includes a large amount of funds that could be used to for forest restoration treatments on federal lands. The current tree mortality event in the southern Sierra Nevada *is possibly putting the State's climate plan at risk*. Professor John Battles from UC Berkeley has worked to analyze the carbon impacts of the recent drought using a system of inventory plots in the southern Sierra Nevada. They actually measured the mortality in terms of tree sizes and species. He estimates that 100 mega grams/hectare of biomass has been killed by the drought and bark beetles and this material will fall to the ground in 8-15 years. These materials will either decompose or burn resulting in emissions of approximately 50 mega grams of C/hectare in the next few decades. This is a massive amount of C emissions from a large area of forests and could dramatically impact the State's climate plan.

To seriously begin to address this problem the State and the US Forest Service could pick two 150,000

acre areas in the Sierra Nevada to implement landscape-level restoration treatments including prescribed fire, mechanical thinning, or combinations of these two methods. Mechanical and prescribed fire treatments could be strategically placed in a small percentage of these areas to assist in the management of lightning fires or very large prescribed fires. Once initial forest restoration has been completed we cannot walk away and believe there is nothing more to do. In fact the maintenance of these areas will never end, they will require future fires and possibly mechanical treatment. Moving some of the restored areas, or portions of them, to a managed lightning fire regime is logical (8). This would keep them resilient and allow additional untreated areas to be restored.

While the current tree mortality event is focused in the southern and central Sierra Nevada, the forest conditions contributing to it are similar in the northern Sierra. The northern Sierra Nevada just did not experience as strong of reductions in precipitation that the southern Sierra Nevada did. Future drought would likely allow for continued northward expansion of widespread tree mortality. Other CA forested mountains that are vulnerable to a similar mortality event include the Southern Cascades, Klamath, and interior North Coast Ranges. It is in the State's interest to work with the federal agencies to increase forest restoration and managed wildfire, otherwise C emissions from our forests will increase dramatically, forests will continue to decline, and the States climate plan may fall apart.

Other information that could aid its analysis of forest management in California, particularly in relation to preventing future mortality crises.

The underlying federal forest and fire policy that is in place today is in need of improvement if we are to significantly improve forest resilience in CA. I recently led a paper that produced some policy ideas that could be used to reform fire and forest policy at the federal and state levels (12). One of the most difficult challenges to revising forest fire policy is that agency organizations and decision making processes are not structured in ways to ensure that fire management is thoroughly considered in management decisions. Current resource-specific policies are so focused on individual concerns that they may be missing the fact that there are "endangered landscapes" that are threatened by fire, drought, insects, and changing climate. We propose that forest restoration should be at least equal to other land management priorities because large-scale restoration is necessary for the sake of forest ecosystem integrity now and into the future, independent of other forest management goals. This would require new federal legislation but is possible.

Another needed change is focused on State and local county impacts on the current and future wildland-urban interface (WUI) in CA. Aggressive firefighting adjacent to populated areas deflects the true cost of development by placing the burden on the federal taxpayer instead of the developer or homeowner, which further subsidizes continued development in the WUI. Because the federal government has not historically regulated development policies in the privately owned WUI, state and local jurisdictions could pay for fire suppression in the interface. State and local jurisdictions should charge landowners to cover some of the fire suppression costs that their development activities impose, as California has successfully done. This should enable a significant increase in critical forest restoration funding since it would eventually reduce building in the WUI because of high local fire suppression costs.

I believe the State could be a powerful political force in promoting some of these changes.

Thank you for inviting me to testify. The Commission's interest in this area is timely and important. If we do not change the way we manage CA forests it is guaranteed that future droughts and wildfires will continue to adversely impact our forests. Our children's grandkids will not experience a similar forest environment if we do not change course and increase forest restoration. The good news is we have the techniques and science to begin this transformation, there is **GREAT HOPE**. What is needed is leadership and the political will to get this done. I would be happy to answer any questions posed by the Commission, either at the hearing itself or at a later time.

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