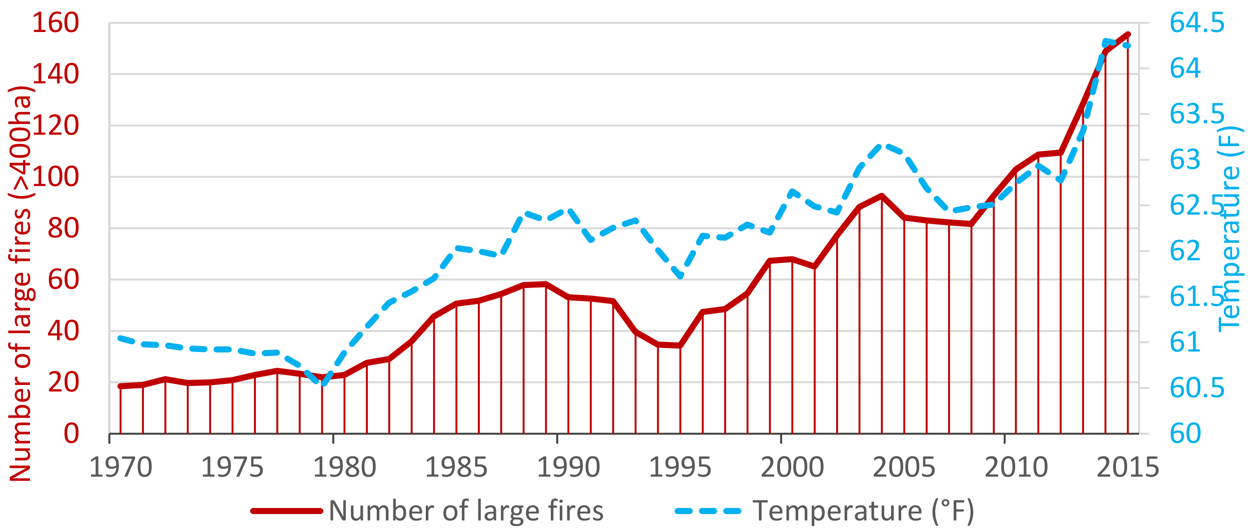
Natural Resources Committee
Subcommittee on Federal Lands
Ranking Member Hanabusa
Questions for the Record
Oversight Hearing
"Seeking Better Management of America's Overgrown, Fire-Prone National Forests."
May 17nd, 2017

Can you describe in detail the wildfire-temperature graph that you presented during your oral testimony?

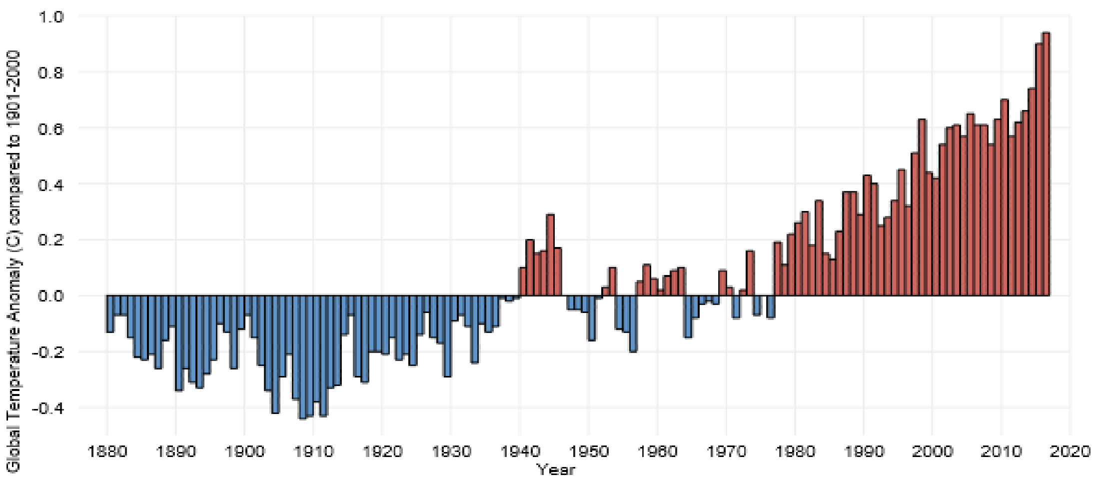
Here is the graph (Fig. 1).



The red line is the 9-year moving average of the annual number of large fires in US western forests (from Westerling 2016). The blue line is a 9-year moving average of yearly March-August temperature, which reflects the primary wildfire season, in the West region (from NOAA: https://www.ncdc.noaa.gov/temp-and-precip/climatological-rankings/). While the range in temperatures from 61.2°F in 1970 to 64.3 °F in 2015, is 3.1°F, the change in the average temperature between the decades of 1970-1979 and 2015-2015 is 1.9°F. These temperatures are from the western US, they are not global temperatures. The decadal trend in the number of large wildfires in western US forests shows a strong correlation with the decadal trend in temperatures in the US West, where a 2°F rise in decadal average temperature is associated with an increase in wildfires, from about 20 large wildfires per year in the 1970s to well over 100 large wildfires per year since 2010. In the arid west, warmer temperatures typically promote drier fuels, which are more likely to burn. A decrease in logging since the 1980s cannot explain this pattern of regional wildfires, which consistently rises with regional temperature rises, and dips with regional temperature dips across the 45-year period.

Has there been a hiatus in global temperature rise?

No. That theory has been repeatedly debunked (Lewandowsky et al. 2015, Santer et al. 2017). Below are global temperatures anomalies relative to the 1901-2000 period, from NOAA: https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature). The years 2014, 2015, and 2016 were the three warmest globally during the 1880-2016 period. Global temperatures continue to rise with GH gas emissions, and there is no hiatus in warming.



Are California forests now net carbon emitters? If so, what can we do about it?

In the United States, forests were a net carbon sink from 1990 to 2012, equivalent in magnitude to over 10% of U.S. greenhouse gas emissions (U.S. EPA 2014). California experienced severe drought from about 2012 to 2016, during which California ecosystems (forests, shrublands and grasslands) appear to have become slight net carbon emitters. Return to non-drought conditions is likely to shift ecosystems back to carbon sinks, yet rates of change in carbon will depend on vegetation response.

Two recent studies represent the first state-wide assessments of rates of change in aboveground carbon in California forest, shrubland and grassland ecosystems (Battles et al. 2014, Gonzalez et al. 2015). Both studies show that California ecosystems as a whole exhibited modest rates of change in carbon (-0.3% to -0.6% per year) during the 2001 to 2010 period. Release of carbon is likely larger than these estimates in response to the subsequent drought from 2012 to 2016. Live carbon stock loss was primarily due to wildfires, in forests in the Klamath and Sierra Nevada mountains, and to wildfire-related transitions of shrublands to grasslands, so not all carbon losses were in forests. Non-wildfire related conversion of forest to rangelands and agriculture accounted for about 40% of the reduction in carbon stored per area 2001 to 2008 (Battles et al. 2014). Both studies likely underestimate live tree carbon densities in the most carbon-dense forest types in California, and only Battles et al. 2015 takes into account belowground carbon, which is an important carbon pool in temperate forests.

Wildfire in forests and shrublands are a primary source of carbon loss in California ecosystems. Area burned is tightly linked to warming and drying (Westerling 2016), which is likely the biggest determinant of future emissions of carbon from forests. As such, reduction in anthropogenic greenhouse emissions plays the largest role in reducing the frequency of drought, warming, large wildfires, and related carbon emissions.

In general, forest treatments, such as thinning and prescribed fire, reduce total ecosystem carbon storage compared to untreated forests. Treated forests only store more carbon if they burn at low severity, compared to untreated forests that burn at high severity. Because few treatments burn, simply due to the vast extent of forests in the West and the low probability of any one area burning in a given year (Barnett et al. 2016), the potential carbon benefit from treatments is likely low (Restaino and Peterson 2013). In forests where the probability of burning is high and which are adapted to frequent low-severity fire (i.e. dry forest types in the SW US), models show treatments increased total ecosystem carbon relative to untreated stands after 40 years at 2% per year wildfire probability, and after 50 years at 1% per year wildfire probability (Hurteau et al. 2016).

Schaedel et al. (2017) show that early pre-commercial thinning shows promise for both reducing fire severity and enhancing carbon storage in larch forests, and further research should explore this potential in other forest types. In contrast to thinning smaller trees, commercial logging of larger valuable trees will not necessarily reduce fire severity, however (Cochrane et al. 2013). Salvage logging of dead trees due to fire, drought or insect mortality will likely play a small role in offsetting carbon emissions, due to slow decay of large dead wood, and will depend on forest growth relative to decomposition rates. Fate of the wood removed from forests (e.g. biomass burning vs construction), plays an important role in determining emissions related to logging. In general, forest management that favors fewer large, old trees over many small trees, and which enhances resilience to drought stress and reduce fire severity, is likely to augment carbon storage in the long term (Gonzalez et al. 2015). Lastly, forest land retention and replanting of climate-adapted species in places where natural regeneration is limited, will help reduce conversions of forest to non-forest land, which account for large carbon losses outside of wildfire.

In your experience, are forests universally overgrown and unhealthy? Is there a one-size-fits-all solution to forest management and wildfire mitigation?

No, forests in the western US are not universally overgrown. This is a widely held misconception that is not supported by a large body of research, which shows significant variation in forests and the degree to which they are overgrown due to past fire suppression (Schoennagel et al. 2004). There are two contrasting forest types across the West, which are as different as say, a lake and a river. Dry forest types, which grow at low-elevations and on dry east-sides of mountains, have higher tree densities due to past fire suppression of frequent low-severity fires that used to keep them open. Dry forest types are what we refer to when we talk about being overgrown, and associated increase in fire severity. Dry forests constitute about one-third of western forests (Schoennagel and Nelson 2011), and about half of the area burned since 1980s (Schoennagel et al. 2017). Dry forests are where thinning and prescribed fire can effectively restore them to open pre-suppression conditions and reduce fire severity.

In contrast, moist/cool forest types, which grow at high-elevations and on moist w-sides of mountain divides, account for another 1/3 of western forests. What is normal in these wet or high-elevation forests is to burn at high severity very infrequently (100-300 yrs). These forests are naturally dense and burn severely. Neither their high tree density, nor burning at high severity is a consequence of past suppression or poor management, it is simply how these forests work. At mid-elevations is another forest type intermediate between these two, and the degree to which they are overgrown due to past fire suppression in different locations is the subject of debate.

Because of these differences in forests types, there is no one-size-fits-all solution to forest management and wildfire mitigation.

Do all forest ecosystems require the same type of treatment?

No, not all ecosystems require the same type of treatment to reduce fire severity and restore forests to their pre-fire suppression condition. It's important to match forest types and their adaptations to wildfire in designing management that is appropriate ecologically, and will effectively meet management goals. Thinning can restore open forests and low-severity fire to dry forest types found at lower elevation, warm-dry zones. Thinning in these zones may also confer other benefits like helping buffer against drought and bark beetles, but it is no guarantee. Thinning is not ecologically appropriate in moist/cool forests, which are naturally dense and adapted to high-severity fires, and would create novel ecological conditions. Furthermore, fire frequency is very infrequent in moist or high-elevation forests, so it is unlikely that thinning treatments in these forests would have the opportunity to modify fire behavior within the short period of treatment efficacy. Few studies in high-elevations forests have shown thinning to be effective in reducing bark beetle mortality, in contrast to results in lower-elevation ponderosa pine forests.

Studies have shown that larger treatments, like those implemented under the Collaborative Forest Landscape Restoration program, have a higher probability of subsequently burning and therefore are likely more effective in modifying fire behavior, among many other benefits (USFS 2015, Barnett et al. 2016).

Importantly, re-treatment of thinned areas is necessary. With the National Fire Plan in place since 2000, many thinning treatments are beginning to lose their potential to reduce fire severity. As plans are made to increase thinning effort, commitments to maintaining previously thinned areas is critical to maintaining forest management investments.

Please explain the relationship between insect infestation like bark beetle and wildfire?

This relationship is best explained if broken down into a series of related questions. The first question to ask is: Do trees killed by insects like bark beetles increase *the probability of burning*? A number of regional studies consistently and independently show that bark beetles in high-elevation forests do not increase the chance of beetle-affected areas burning. Fires don't follow bark beetles, but simply burn where it is hot and dry, regardless of bark beetles. For example, in Colorado, we experienced one of the largest and most severe mountain pine beetle outbreaks in the 2000s where an estimated 800 million trees died (compare to the current 110 million dead trees estimated for California) across 3.4 million acres of high-elevation forests. However, only 1.7% of the beetle-affected areas subsequently burned during a 13-yr period (Liang et al. 2016). During the "red phase" of the outbreak, when needles are dead and red and still on the trees which is considered the most flammable phase, there were no major fires in Grand County CO, home of the largest and most severe bark beetle outbreak in the West, because it did not get hot and dry enough at those high elevations.

The second questions to ask is: If a fire does burn in bark beetle-attacked forests, does severity and timing of the attack consistently affect *subsequent fire severity*? In high-elevation forests where most studies on this topic have been conducted, the answer is it depends on many factors, with no consistent trends (Harvey et al. 2014a, Harvey et al. 2014b, Agne et al. 2016, Andrus et al. 2016). It is not known yet if the relationship of bark beetles to wildfire may be different in low elevation forests.

Regardless of the question of fire severity, fires in bark beetle-attacked forests are harder to fight due to increased hazards and fast rates of spread, and indirect attack is more likely, as occurred on the 2016 Beaver Creek fire in northern Colorado. Therefore, communities near areas of bark beetle outbreaks should manage fuels in and around homes so that communities are better prepared to withstand a wildfire, as fire fighters will be less likely to engage in direct attack to help protect structures.

Increasing the pace of logging has been suggested as a means of stalling regional bark beetle outbreaks. This is unlikely to be effective (Six et al. 2014). Bark beetle outbreaks are triggered by warming temperatures and drought, and logging hasn't been shown to reduce the occurrence of regional outbreaks. Unlike in the US where logging has lagged since the 1980s, British Columbia has maintained active logging operations, where trillions of board feet have been logged per year since the 1970s (compared to about 10 billion board feet in the US until the 1990s). Despite active logging, forests in British Columbia experienced one of the largest mountain pine beetle outbreaks in North America, coincident with the outbreak that occurred in the western US. Thinning has been shown to reduce the severity of bark beetle attack *within thinned stands* in some low elevation forests, but will not stop regional outbreaks from occurring.

Would an increase in commercial logging operations on national forests reduce the number, severity, or length of the fires experienced across the National Forest System?

No. A large body of research shows us that increased warming and drought are the root causes of the recent increase in area burned across the US, and of longer fire seasons (Dennison et al. 2014, Westerling 2016). To reduce the increasing threat of drought and wildfire to forests, the forest products industry, and people living near fire-prone lands, reducing carbon emissions is necessary and the only effective approach. Increased logging cannot meaningfully reduce area burned in the West. Thinning in dry forests can reduce fire severity and make fires there more manageable in thinned stands, but will not alter the root cause of increased area burned in the West, which is warming. Climate change and its effects on people and resources is a very serious problem, but it is solvable if we take action now to reduce greenhouse gas emissions.

After some fires, or in forests impacted by disease drought, the Forest Service often authorizes salvage logging projects. Does this practice have any long term impact on the ecosystem?

Yes. Salvage of burned or beetle-killed trees removes long-term sources of nutrients and habitat for many species (Dellasala et al. 2006). Logging bark beetle-killed areas also impacts live mature non-host trees, which constitute the next forest. Post-fire logging following severe fire often increases erosion and slows or impedes the recovery of streams and other aquatic ecosystems (Wagenbrenner et al. 2015). There are economic benefits to salvage logging, but there are no direct ecological benefits.

Recently, a group of scientists – including one of your colleagues at the University of Colorado – explored 20 years' worth of data to determine the principal causes of wildfire throughout the country. The key finding from that report picked up by the media is that, nationally, humans cause 84% of all wildfires. Does that mean education efforts can reduce wildfire occurrence?

This study found that 84% of the total number of wildfires in the last 20 years across the US were ignited by humans (Balch et al. 2017). In the western US, most wildfires (60%) and area burned (70%) are from lighting, yet humans still play an important role. Interestingly, this study revealed how humans and climate change are interacting. The climate is now more conducive to burning many more months out of the year, which is providing opportunity for humans to ignite more fires, when previously we could not. For example, two recent wildfires near my home in Colorado were started by people leaving campfires unattended, and one of those fires was in February.

More education about the consequences of human ignitions, beyond Smokey Bear's simple admonishment, is needed. Stronger consequences for people igniting wildfires could also help reduce fire risk. If we could reduce some of the 84% of wildfires started by humans, we could have a significant impact on the costs and risks of wildfire.

For the first time in its over 100-year history, the Forest Service now routinely spends over half of its annual budget of wildfire suppression. Why are we spending more and more money each year on forest fires?

We are spending more on fires because there are more wildfires due to warming (Fig. 1), and there are many more people in harm's way (Schoennagel et al. 2017). The wildland-urban interface (WUI), where homes and wildland veg intermix, is only about 15% of the area burned in the West, but fires in this zone consume about 95% of suppression costs. Neither more logging, nor streamlined environmental reviews, nor more fuel-reduction treatments, nor more prescribed fire, will significantly decrease the persistent rise in area burned across the West driven by climate warming. We've treated 64 million acres in the US, predominantly in the West, and area burned continues rise, tracking warming in the West. While we need to fix the suppression budget so that the Forest Service do not go bankrupt on wildfires and they can more effectively manage the land, budget fixes will not make wildfires go away.

Placing more treatments near the WUI would reduce risk to people and the costs of firefighting. For example, I conducted a study in 2009 which showed that only 11% of treated area was near the WUI (Schoennagel et al. 2009). We need to do better at prioritizing fire-mitigation treatments near the WUI. Finding ways to treat the 70% of the WUI that is private could reduce fire risk and cost. For example, Idaho's FireSmart program in Kootney County, which used National Fire Plan funds to pay local contractors to create defensible space around homes is a win-win in reducing fire risk where it costs the most to defend, while providing jobs to an economically depressed area (Stidham et al. 2014). Other programs like Wildfire Partners, who help homeowners mitigate fire risks around homes, and Community Planning Assistance for Wildfire (CPAW), who work with communities to reduce wildfire risks through improved land-use planning, are important models for adapting to wildfire in the WUI. Limiting further WUI growth and planning for fire-adaptation in existing communities are important priorities for reducing the risks and costs of wildfire.

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