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Creating More Resilient FORESTS Through Active Management

Despite their stately nature and presumable permanence on the landscape, forests are actually always in a state of flux. Growing and dying, one species succeeding another, with the occasional disturbance, such as a wildfire or insect infestation, to wipe the slate clean and allow the process to start anew. And beyond these successional dynamics, forests change in structure, composition and ecological function over longer times as climates naturally vary.

Summary

Drought, combined with higher temperatures, is contributing to "megadisturbances" that threaten western forests and require a new approach to silviculture management. Malcolm North, Connie Millar and Jessica Wright, researchers with the U.S. Forest Service's Pacific Southwest Research Station, have examined how changing climate conditions will likely transform the forests of the future and make recommendations on how to achieve resiliency.

Reduced density and diversification of species has shown promise in creating resistance to traditional and new threats. More detailed recommendations by North call for mimicking the effects of naturally occurring and regular fires. Southern-facing slopes benefit from wider spacing of larger trees. Cool, moist areas that experience less fire intensity can support denser growth. Managing individual stands for ladder fuels must be combined with regional approaches that include varying stand density and the presence of open spaces.

Healthy forests typically are able to accommodate the minor, as well as the occasionally abrupt and more severe, disturbance and over time adapt to naturally changing climates in diverse ways. Ecologists ascribe this ability as "resilience." However, when the magnitude of the disturbance, the frequency of the occurrence, pace of change, or a number of other extraneous factors make it difficult for a forest to adapt, then ecosystems can change quite drastically.

Connie Millar and Malcolm North, researchers with the U.S. Forest Service's Pacific Southwest Research Station, have been studying how disturbances and climatic conditions have shaped Californian and Great Basin forest ecosystems from both a historical and pre-historical perspective. Their research is giving land managers insights on how to successfully shift forest structure and species composition to create landscapes that are better able to survive today's disturbances, as well as weather tomorrow's uncertainties.

How Much Stress Can a Forest Take?

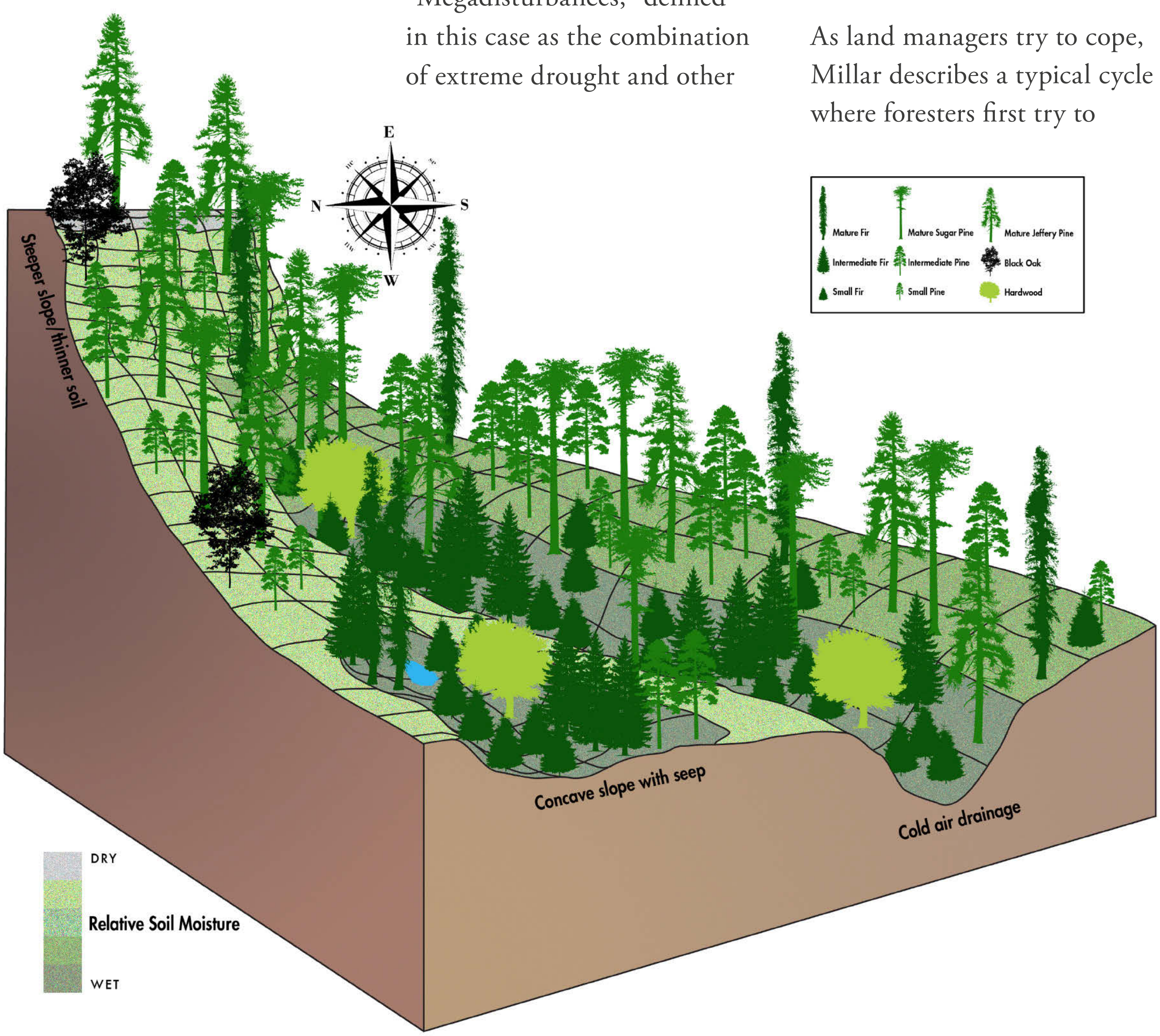
The evolving understanding of forest dynamics has led to greater recognition that fires, insects and diseases are essential parts of a normal, functioning ecosystem and are, in fact, necessary for forest health.

And while drought, too, has always existed as part of the cyclical nature of weather patterns, researchers have dubbed the new combination of heat and drought “global change droughts” or “hotter droughts.” This new breed of hotter drought intensifies stress on trees, making them more vulnerable to other factors, such as insects and diseases. Higher temperatures also increase water loss through evaporation, as well as reduce snowpacks, which play a vital role in storing water that sustains landscapes through drier seasons.

Millar, a senior research ecologist, co-authored a research paper in 2015 titled “Temperate Forest Health in an Era of Emerging Megadisturbances.” In it, she discusses how much disturbance a forest can tolerate, what the long-term effects might be, and how to minimize losses.

“Megadisturbances,” defined in this case as the combination of extreme drought and other stressors, can drive abrupt tree mortality, according to Millar. She and her co-author predict that some forests will continue to rebound from these stresses. Over the long term, however, most temperate forests are likely to adjust and adapt The effects will range from minor changes in forest density, age and species composition, to more significant changes that include major transformations to vegetation types that can better survive in the new environmental conditions.

As land managers try to cope, Millar describes a typical cycle where foresters first try to



maintain tracts that reflect the current norm. This can lead to some success, but if changes in climate and stressors are part of a longer-term trend, the forests will ultimately be rendered unstable and not adapted to current conditions. Once a threshold is exceeded, substantial mortality can occur and recovery can be slow or a new forest type can take hold.

"We have to understand that historic conditions may not be appropriate now as a guide," Millar said. "If we want to use historic conditions as a guide, we must find a time in the past that is most like where we're headed in the future."

Millar's work in paleoecology, a field of study that examines ecological shifts across millennia, recommends management practices that influence the transition to a more resilient forest. Resource managers must anticipate the evolution of the forest and even facilitate it by taking measures to reduce the probability of sudden die-back, for example, by thinning forests to reduce competition for resources. The goal is a more gradual transition. This sort of managed change prevents the total collapse of the ecosystem and builds the evolved forest back up to a point where the forest, albeit changed, continues to flourish.

Researchers at the Pacific Southwest Research Station are conducting studies in the Stanislaus-Tuolumne, Sagehen and Teakettle Experimental Forests to better understand how to create a forest structure that can be sustained over time, is resilient to disturbances, and supports wildlife and recreation.

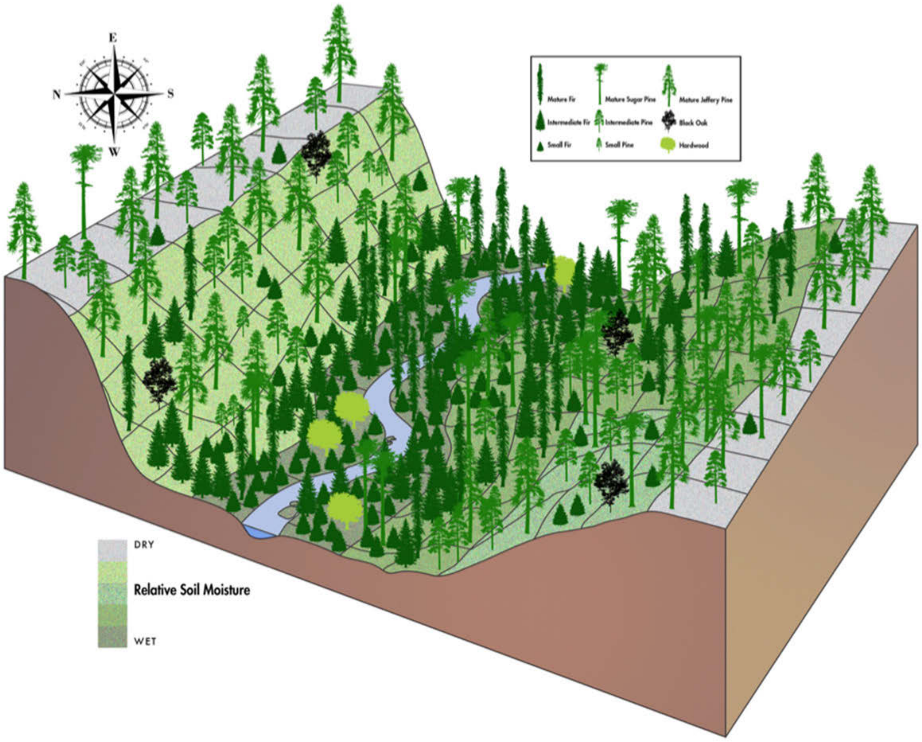
While those findings are not yet published, one thing is becoming clear: Land managers need to be ready to evolve their approach to woodland maintenance and reforestation in response to emerging conditions.

Active Forest Management Required

For foresters who are ready to proactively manage for the changing climate, "An Ecosystem Management Strategy for Sierran Mixed Conifer Forests," a general technical report authored by Malcolm North and his colleagues at the Pacific Southwest Research Station, offers solid guidelines.

"Simply restoring the forests to their previous conditions is not the right approach," said North, a research forest ecologist. "Given the reality of a changing climate and recurring drought, we need a new management strategy, one that goes beyond short-term fuel treatment objectives and incorporates long-term ecological restoration and habitat improvement. We are conducting research now that will better inform those strategies and practices."

Reforestation approaches where new trees are planted close together with future plans for thinning, while once the norm,



may not always be the most effective or expedient method, according to North.

Instead, North asserts that complexity – or heterogeneity – is the forest's friend and ally, improving trees' ability to respond to stress and support wildlife. Complexity includes varying stand density, including openings of various sizes, a mix of tree sizes and ages, and the presence of shrubs and meadows.

Given enough space, sunlight, nutrients and water, trees have the capacity to grow and thrive. They become stressed when lacking any of these elements, which make them more susceptible to attack by insects and diseases, as well as drought or wildfire.

Similarly, because insect and disease populations tend to target one type or species of tree, diversity will also help reduce the possibility of one insect or disease killing all the trees in a region.

Ramiro Rojas, a deputy regional silviculturist with the Forest Service's Pacific Southwest Region, has seen North's recommendations put into practice and reports good results.

"Where we are able to reduce density and create heterogeneity, those stands seem to have far more survivors, both large and small trees," Rojas said. "Where there's more density, they don't do as well."

Rojas emphasized that the Pacific Southwest Research Station's previously mentioned general technical report provides a basic framework, not a one-size-fits-all solution. Foresters who choose to implement North and his colleagues' recommendations must do so based on their unique, local circumstances, Rojas said. For example, sometimes there is a tension between creating forest tracts that can survive drought, fire and pests, and maintaining a habitat suitable for important species, like the spotted owl or fisher, which require more density.

Other factors affect the success of implementation of the recommendations within the report, Rojas noted. For example, the quality of the soil, elevation of the forest, size of the trees and the localized intensity of the drought all come into play.

Moving Trees Uphill

If forests are going to be replanted, which species and which seed sources make the most sense under projected climate scenarios? Jessica Wright, a research geneticist with the research station, is studying whether shifting to trees from warmer climates leads to greater survivorship in the face of stressors.

"The traditional approach was to plant seeds from the same seed zone when replanting," Wright said. "But now it is being considered appropriate to move seeds uphill 500 feet to compensate for the warmer temperatures we are seeing."

Wright pointed to an online resource called the Seedlot Selection Tool (https://seedlotselectiontool.org/sst/) for help in replanting that is suited for changes in climate.

The Seedlot Selection Tool is a collaboration between the U.S. Forest Service, Oregon State University and the Conservation Biology Institute. It is a web-based mapping application designed to help natural resource managers match seedlots with planting sites based on climatic information. It allows the user to control many input parameters, such as selecting particular climate variables (i.e., temperature and precipitation), and climate change scenarios. The generated maps include the seed zones, allowing the user to compare the results of the tool with traditional planting approaches.

"We just planted more than 1,000 pine trees as part of a post-wildfire reforestation project using trees from warmer and drier locations," Wright said. "We are monitoring to see how they are perform. The idea is to answer the question: Do these trees from warmer places perform better here in this time of changing climate?"

Mimicking Nature — The Role of Fire

North and his co-authors recommend creating landscape diversity in the Sierra Nevada by mimicking the forest conditions that would be the result of regular, natural fires.

Following this model, cool or moist areas, where historically fire would have burned less frequently or at lower severity, would have higher density and greater canopy cover. In contrast, upper, southern-facing slopes, which receive more sunlight, would have low densities of large fire-resistant trees.

When planting trees, then, North's research suggests introducing a diverse mix of trees planted at varying densities, based on their position on a slope, or the steepness of the slope, as well as the availability of water.

For individual groupings of trees, known as stands, vertical diversity can be achieved by organizing groups of trees based on their canopy height, or strata, according to North. For example, a group of intermediate-sized trees that could serve as ladder fuels might be thinned or removed if they are growing under taller trees. The same-size trees in a discrete group, however, might be left alone if the group does not present a ladder fuel hazard for taller trees.

This strategy would produce within-stand vertical differentiation, as well as discrete tree clusters, which would contribute to horizontal heterogeneity.

The results from this study will be compared to the predictions made by the Seedlot Selection Tool to determine how well it predicted plant performance, and particularly which climate variables were most closely associated with plant survivorship.

Conclusion: The Time to Act Is Now

The current environmental conditions and projections that call for higher temperatures, drought and related disturbances will require a more active and thoughtful approach to forest management if we are to adequately maintain the resources forests provide. Monitoring and ongoing research will continue to shed light on the effectiveness and best applications of these efforts, but the important thing is to start implementing the most promising of those practices now.

“There has to be a sense of urgency,” Rojas said. “We cannot lose hundreds of thousands of acres of forest every decade.”

What’s Next?

Malcolm North and several of his colleagues at the Pacific Southwest Research Station are currently examining how extensive tree mortality from a decade-long drought in California might affect wildfire and the future development of the forest as it responds to and re-establishes in areas where most of the large overstory trees have died. Studies suggest that managed fire is probably the best, most economical means of thinning and restoring forests over the large expanses of affected forests, but such broad use isn’t always feasible. North is working with scientists and land managers to address fire implementation issues, such as air quality, liability, risk aversion and cost.

Key Findings

- The emergence of “hotter droughts” are creating previously unseen conditions that are likely to change forests as we know them in the Sierra Nevada.
- Hotter droughts, combined with other disturbances, can cause abrupt tree mortality. Some forests can recover, but other regions could transition to a landscape with far fewer trees, unless steps are taken to intervene.
- Historical norms may no longer serve as a guide for coping with tree mortality, and foresters must find ways to manage for new climate projections.
- Managing the transition of forests to new norms can prevent a total collapse of an ecosystem.
- Mimicking the role of fire in shaping forests can create a more resilient ecosystem.

Land Management Implications

- Trying to maintain current forest structures may be futile in the face of long-term climate changes and the related stressors of insects, drought and diseases.
- Shaping forests that are best suited to survive means anticipating what climate change will bring.
- The Pacific Southwest Research Station’s general technical report “An Ecosystem Management Strategy for Sierran Mixed Conifer Forests” (GTR-220) provides guidelines on how to structure forests to create resiliency, but individual conditions must be taken into account.
- The Seedlot Selection Tool (https://seedlotselectiontool.org/sst/), used in conjunction with current seed zones, can help in selecting trees for replanting that are suited for projected changes in climate.

Scientist Profiles

Malcolm North is a research forest ecologist with the U.S. Forest Service's Pacific Southwest Research Station. His work includes research examining different management practices and the effect of forest structure, composition and function. His lab focuses on forest and fire ecology of Sierra Nevada mixed-conifer forest. He has worked at several experimental forests, examining new silvicultural practices and their ability to increase forest resilience to fire and drought.

Connie Millar is a senior research ecologist with the U.S. Forest Service's Pacific Southwest Research Station. Her research team focuses on the role of historic and ongoing climate change in high-elevation forest ecosystems, including the Eastern Sierra Nevada. She is also involved in the integration of science with policy, and is particularly interested in interpreting and communicating the current research on climate change and its ecological effects in conservation and restoration.

Jessica Wright is a research geneticist with the U.S. Forest Service's Pacific Southwest Research Station. She uses genetic tools to understand population responses to threats including climate change, pathogens and stress in forest ecosystems. Her current research intends to understand the genetics underlying tree responses to climate and how populations might be impacted by a changing climate.

For Further Reading

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- Millar, C; Stephenson, N. 2015. *Temperate Forest Health in an Era of Emerging Megadisturbance*, Science, 304: 823-826.
- Achieving Long-Term Forest Health and Resilience in California, http://www.fire.ca.gov/treetaskforce/downloads/FHRWG%20White%20Paper.pdf

Web Resources

- Stanislaus-Tuolumne Experimental Forest https://www.fs.fed.us/psw/ef/stanislaus_tuolumne/

Learn more about the Pacific Southwest Research Station at **https://www.fs.fed.us/psw** or scan the QR code to the left with your smart device.