

# Forest Ecosystem Restoration in the Sierra Nevada

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Patricia Maloney



**UCDAVIS**

Tahoe Environmental  
Research Center

# Lake Tahoe Forests





# Mitigating a legacy of land-use

## Active forest management

Treating over 100,00 acres in both California and Nevada

## Goals of forest treatments:

1. Restore and maintain fire resilient landscapes
2. Mitigate insect and disease outbreaks
3. Increase forest resiliency to drought
4. Improve and protect carbon sequestration

•California  
Department of  
Forestry and Fire  
Protection

•California State  
Parks

•California Tahoe  
Conservancy

•Fallen Leaf Fire  
Department

•Lake Valley Fire  
Protection District

•Meeks Bay Fire  
Protection District

•Nevada Division of  
Forestry

•Nevada Division of  
State Lands

•Nevada Division of  
State Parks

•Nevada Tahoe  
Resource Team

•North Lake Tahoe  
Fire Protection  
District

•North Tahoe Fire  
Protection District

•South Lake Tahoe  
Fire Department

•Tahoe Douglas Fire  
Protection District

•Tahoe Regional  
Planning Agency

•United States  
Department of  
Agriculture Forest  
Service

## Lake Tahoe Basin

### Multi-Jurisdictional Fuel Reduction and Wildfire Prevention Strategy

August 2014



# Historical Land-Use



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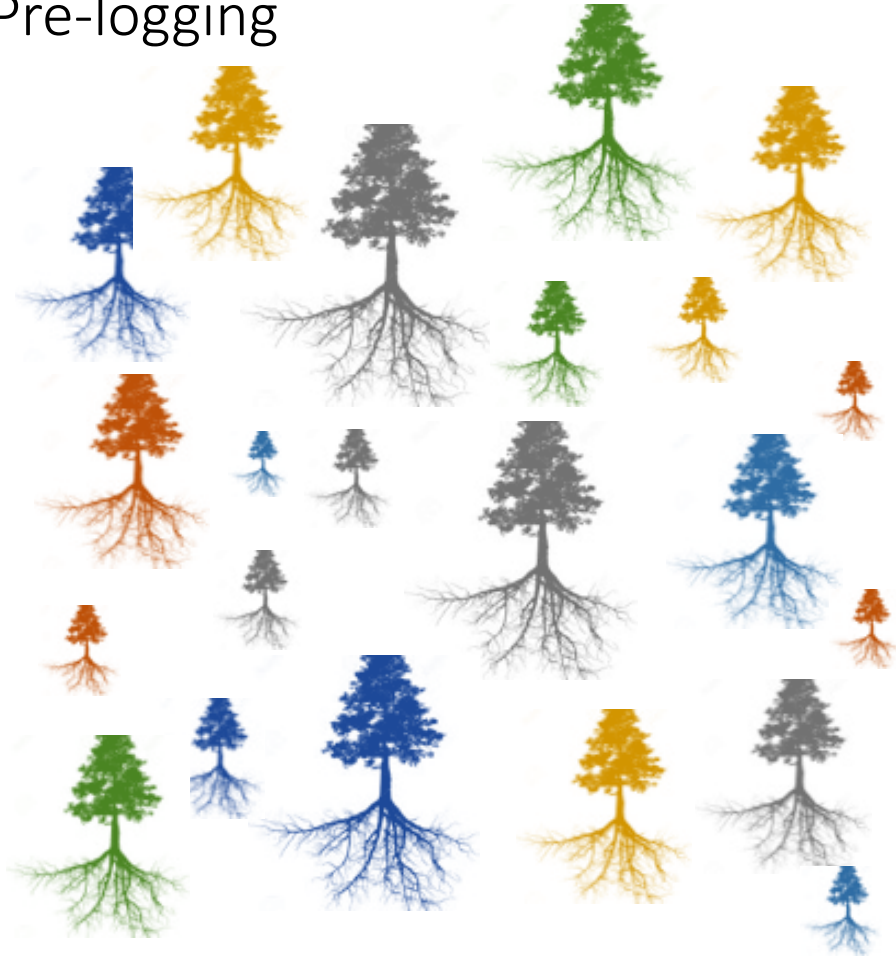


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# Genetic consequences of Comstock-era logging on sugar pine populations in the Lake Tahoe Basin

Pre-logging

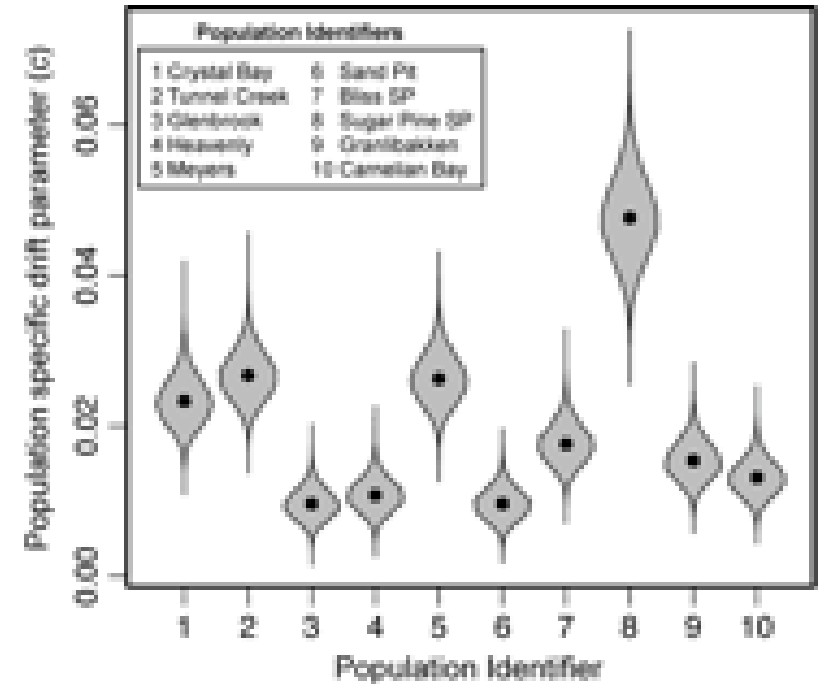


Post-logging



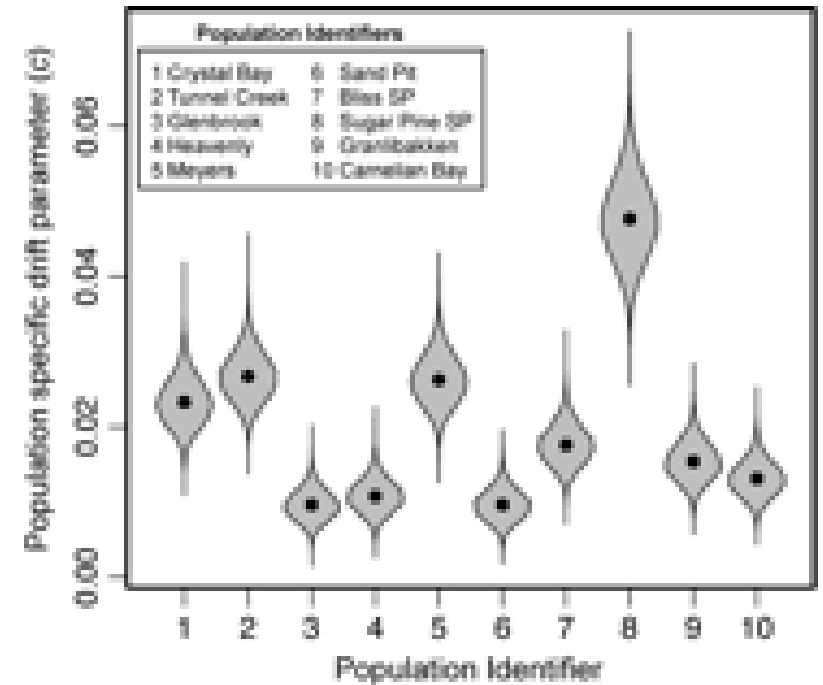
# What are the genetic consequences of historical logging in the Lake Tahoe Basin?

- High genetic drift in some sugar pine populations in the LTB. Genetic drift can result in important traits being lost from a population without respect to survival and fitness.
- Effects of drift are greater in small populations and can act faster to reduce genetic variation.
- Populations at Tunnel Creek, Crystal Bay, & Sugar Pine Point SP, have “0” heritability for water-use efficiency. Essentially these populations have lost their “memory” to pass this trait on to the next generation.
- Such genetic losses could affect sugar pine’s resilience and ability to respond and adapt to environmental change.



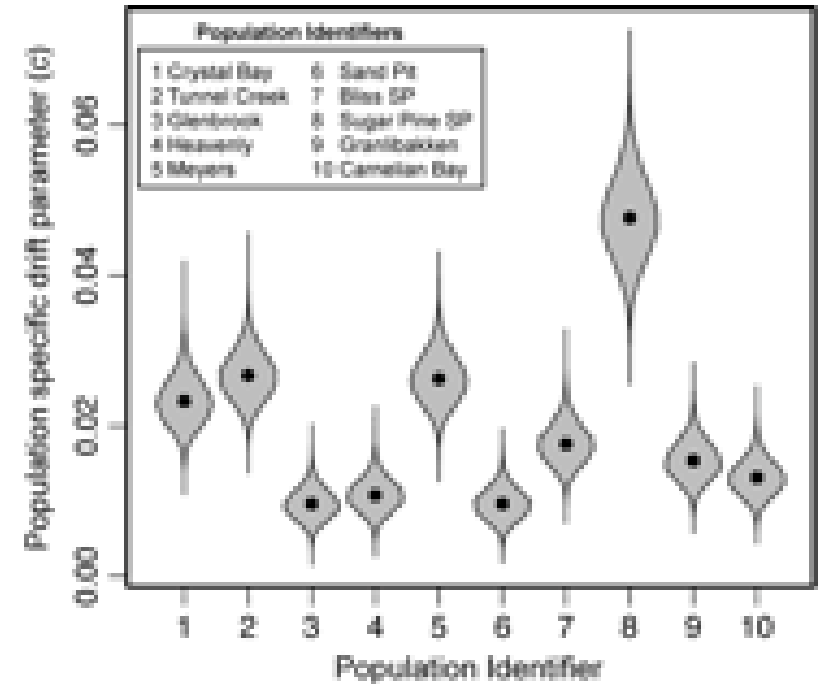
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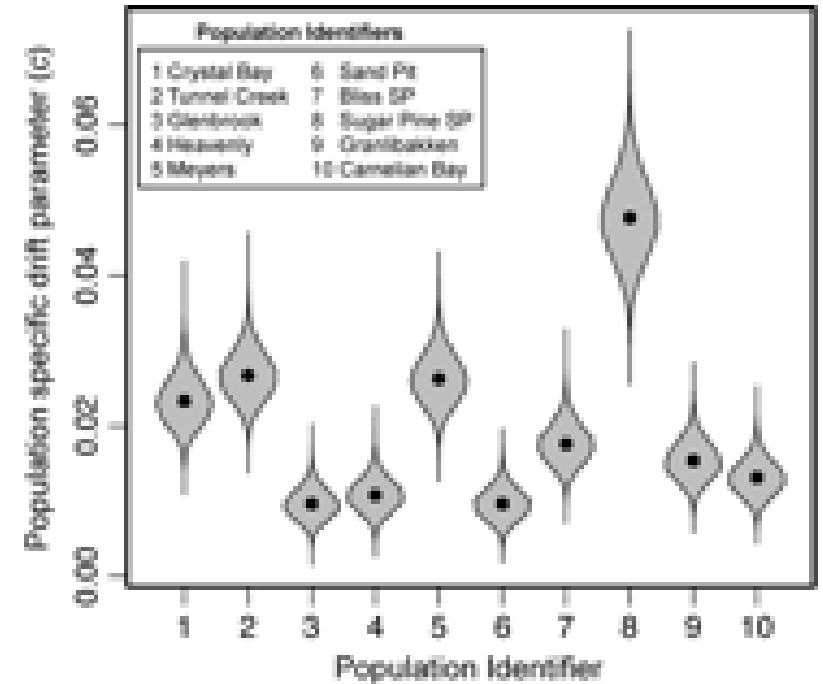
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# Ecological & Evolutionary Consequences of Environmental Change

- Shifts in species composition & structure
- Genetic shifts within existing species
- Is climate change exerting a selective pressure for drought resilient forest trees?





## Climate Change Induced Drought

From 2012 to 2016 drought and bark beetles killed more than 126 million trees in California and 72,000 in the Lake Tahoe Basin.





## Drought – Bark Beetle Interactions

- Bark beetles, such as mountain pine beetle (MPB), are known to preferentially attack drought-stressed trees.
- Trees have a physical-based defense by producing resin.
- Host chemistry can either defend against bark beetle attack or aid in locating a suitable host.
- When trees, such as those here in the Sierra Nevada are drought-stressed, they can emit chemicals such as ethylene that can signal tree vulnerability and detection by bark beetles such as MPB.







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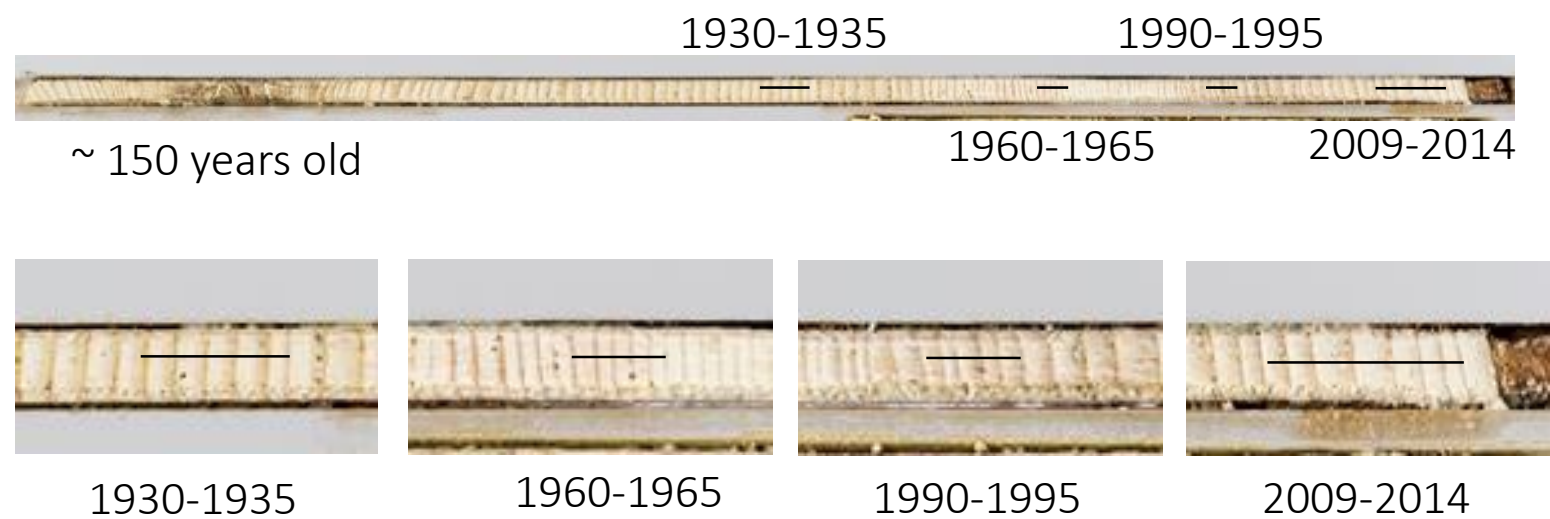


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TERC's forest and conservation biology lab cored from 100 live and 100 mountain pine beetle-killed sugar pine trees to conduct a retrospective analysis of their tree rings.

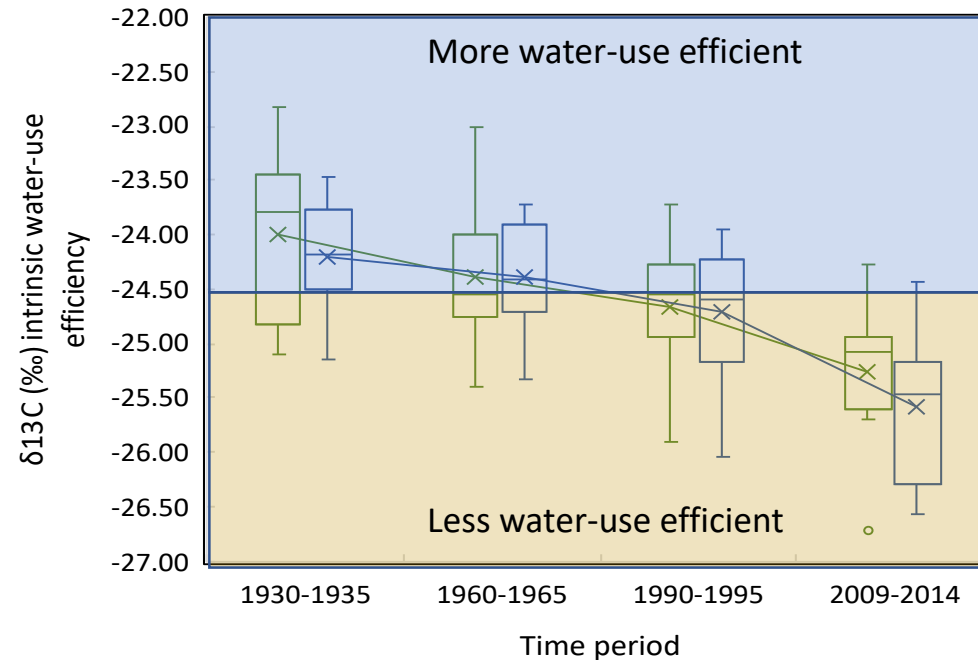


Retrospective analysis of water-use efficiency over the last 90 years



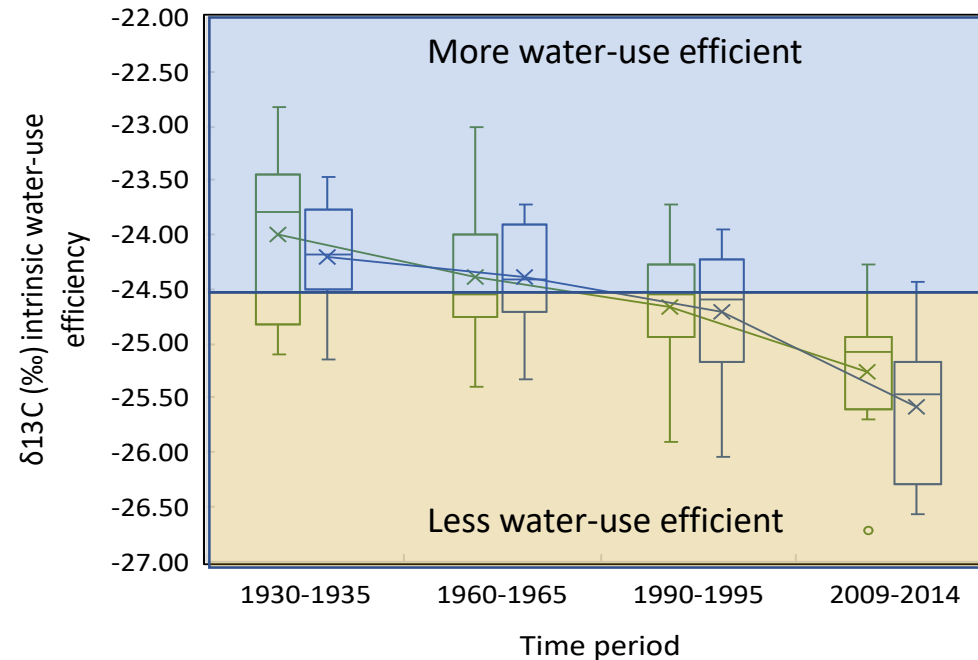
# Drought stress and susceptibility to MPB

- Sugar pine trees that were more water-use efficient, and perhaps better adapted to drought, survived the 2012-2016 MPB outbreak.
- In contrast those sugar pines killed by MPB utilized water less efficiently and were most susceptible to MPB attack.
- Trees under high drought stress often have reduced host defenses to bark beetle attack.



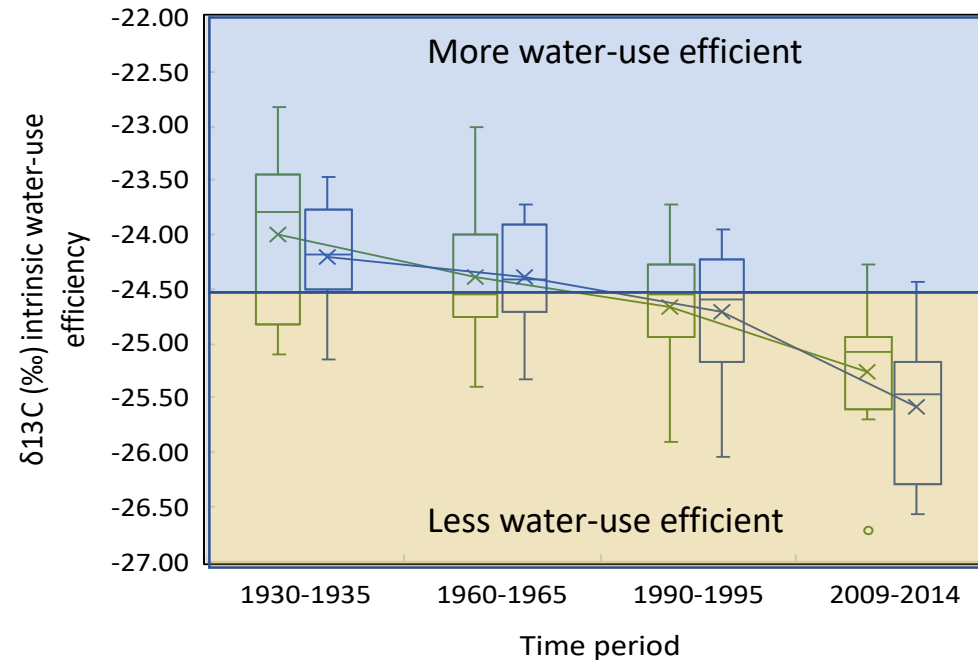
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# Amplifying within-population resilience to drought – Collections from local drought “survivors”

**Collected from 100 surviving sugar pines in 2017 & 2021**



# Amplifying within-population resilience to drought

In 2019-2020 UCD & the CCC out-planted the progeny of 100 local and diverse sugar pine trees, essentially those trees that survived drought & a MPB outbreak.

## Los Angeles Times

WEDNESDAY, NOVEMBER 21, 2018

### Leader of Navy is ousted in clash

Pentagon chief fires Richard V. Spencer, giving Trump a win in SEAL controversy.

BY MICHAEL M. GREGG

WASHINGTON — Defense Secretary Mark Esper on Monday fired the Navy's top official, ending a swirling clash between President Trump and top military leadership over the loss of a SEAL command of war.

Esper said he had lost confidence in Navy Secretary Richard V. Spencer and alleged that Spencer gave a bad job to the White House before he had to resign the SEAL job.

Trump has chastised the chief of Navy's Chief of Naval Operations, Admiral Johnathan G. Richardson, who was acquitted of murder in the shooting death of an Islamic State militant captive last month of giving with the capture while in Iraq.

Spencer's firing was a dramatic turn in the long-running and politically charged controversy. It is a move that is a sign of the relationship with the high-end military and raised questions about the appropriate role of a commander in chief in military matters.

The situation remained open in recent days.

On Wednesday, the Navy had notified Richardson that he would have a SEAL, never based to determine whether he should be allowed to return to the service.



A bet on Sierra survivors

UC Davis biologist Patricia Maloney is leading an effort to plant thousands of seedlings from drought-surviving sugar pine in the Lake Tahoe area, hoping they carry genetic resilience to climate change.

### Nunes dodges query about meeting

Lawmaker declines to say CNN over report on allegation he sought info from ex-Ukrainian official.

By Louisa Kuo

WASHINGTON — For the last few weeks of intense public impeachment hearings, President Trump, Rep. Devin Nunes and other House members have been dodging the question of whether Trump and the other members of the House sought to get information from an ex-Ukrainian official.

Rep. Devin Nunes said he did not know the answer to the question.

## A bet on Sierra survivors

In climate race, scientists are propagating trees with staying power

By Todd Garono

LOS ANGELES — The sugar pine, with its haunting cones and blackish trunks that stretch out high above the forest floor, is one of the most resilient trees of standing guard over Lake Tahoe's clear waters.

But drought, bark beetles and climate change have ravaged this beloved conifer, whose population was already diminished by logging, development and other human activities.

From 1992 to 2016, drought and bark beetles killed more than 22 million trees in California, most of them residents in the Sierra Nevada. On the dry, south-facing slopes on the Sierra's north side, sugar pines were hit especially hard as mountain pine beetles up



VOLUNTEERS with the California Conservation Corps head into the thickets to begin planting thousands of sugar pine seedlings near Kings Beach this month.

## Forest scientists bet on hardest trees

(Times Staff Writer)

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But it's not the dead trees that interested Maloney. It's the survivors.

She wanted to know how they managed to stay healthy and green despite experiencing the same parched conditions that killed their neighbors. She knew it had to do with inside character traits that gave them a selective advantage over their peers.

Maloney is now leading an effort to plant thousands of seedlings descended from drought-surviving sugar pines from around Lake Tahoe, hoping they carry genetic resilience to drought, waning snowpack and other effects of global warming.

It's part of a growing recognition by scientists and land managers that the sugar pine is a resilient and hardy tree that they can no longer just restore remnants to their previous state, but must help it adapt and accelerate how plants and animals adapt.

That ability can be passed along to the next generation, Maloney said. But they probably have other advantages that they want to study, such as when they lose their spring growth, how moisture their roots are and what chemicals they used to keep their roots alive and what other traits they have.

On Monday, Jan. 30, three years ago, Maloney decided to do a study that she wanted to do quickly enough to adapt quickly to her selective advantage, such as moving animals to higher ground or other ways to give them from high up in their reserves, collecting them to find out what they are.

"I really want to know



ARTURO GARCIA of the Conservation Corps plants seedlings during the "assisted regeneration" effort.



"The community has an affinity for sugar pines and a curiosity for why these guys are doing so well and the other ones that don't," she said. "Constantly that with the history of logging, and it's so difficult to convince people that a new approach was needed."

"With climate change, you can't go back to how it was, because that's not how it's going to be," she said.

Planting for a future climate

The implications of this work stretch far beyond the forest. Much of the water that supplies California's cities, farms and towns comes from melting Sierra Nevada snow, which is being lost with these insights as dead trees open up the forest canopy. Scientists say that could trigger even further runoff, threatening what is already happening from climate change. As they move, the select trees will also contribute to global warming by emitting carbon they once absorbed.

The Sierra Nevada and other western mountain ranges are already feeling the effects of the heat-trapping gases humans have spewed into the atmosphere. The region is experiencing higher temperatures, more precipitation falling as rain instead of snow and earlier spring runoff. Trends that climate scientists expect only to accelerate in the decades to come.

If greenhouse gas emissions continue to rise unchecked, temperatures in the Sierra Nevada are projected to heat up by 8 to 16 degrees Fahrenheit, an average for the end of the century, according to the latest projections.

We consider this approach as "assisted regeneration" of local and diverse seed sources.

## Opinion

# Who Should Pick the Winners of Climate Change?

Michael S. Webster,<sup>1,\*</sup> Madhavi A. Colton,<sup>1</sup> Emily S. Darling,<sup>2</sup> Jonathan Armstrong,<sup>3</sup> Malin L. Pinsky,<sup>4</sup> Nancy Knowlton,<sup>5</sup> and Daniel E. Schindler<sup>6</sup>

Many conservation strategies identify a narrow subset of genotypes, species, or geographic locations that are predicted to be favored under different scenarios of future climate change. However, a focus on predicted winners, which might not prove to be correct, risks undervaluing the balance of biological diversity from which climate-change winners could otherwise emerge. Drawing on ecology, evolutionary biology, and portfolio theory, we propose a conservation approach designed to promote adaptation that is less dependent on uncertain predictions about the identity of winners and losers. By designing actions to facilitate numerous opportunities for selection across biological and environmental conditions, we can allow nature to pick the winners and increase the probability that ecosystems continue to provide services to humans and other species.

### Trends

Predict-and-prescribe management may erode diversity by focusing on 'winners'.

Conservation strategies based on portfolio theory reduce risk by protecting diversity.

Adaptation networks are a new approach to conservation based on portfolio theory.

Diverse, connected, and large adaptation networks maximize the adaptive capacity of species.

- Scientifically study the survivors / “winners”
- Out-plant progeny of drought “survivors”
- Use remote sensing technologies, geospatial datasets, and high resolution microtopographic maps to improve microsite selection for restoration plantings and increase seedling survivorship.
- Monitor seedling survival as well as track the fate of 100 genetic individuals.
- Common garden study
- Measure a suite of ecologically important traits (e.g., water-use efficiency, chemical defense, disease resistance, growth, resource allocation, etc.)

# Current Work

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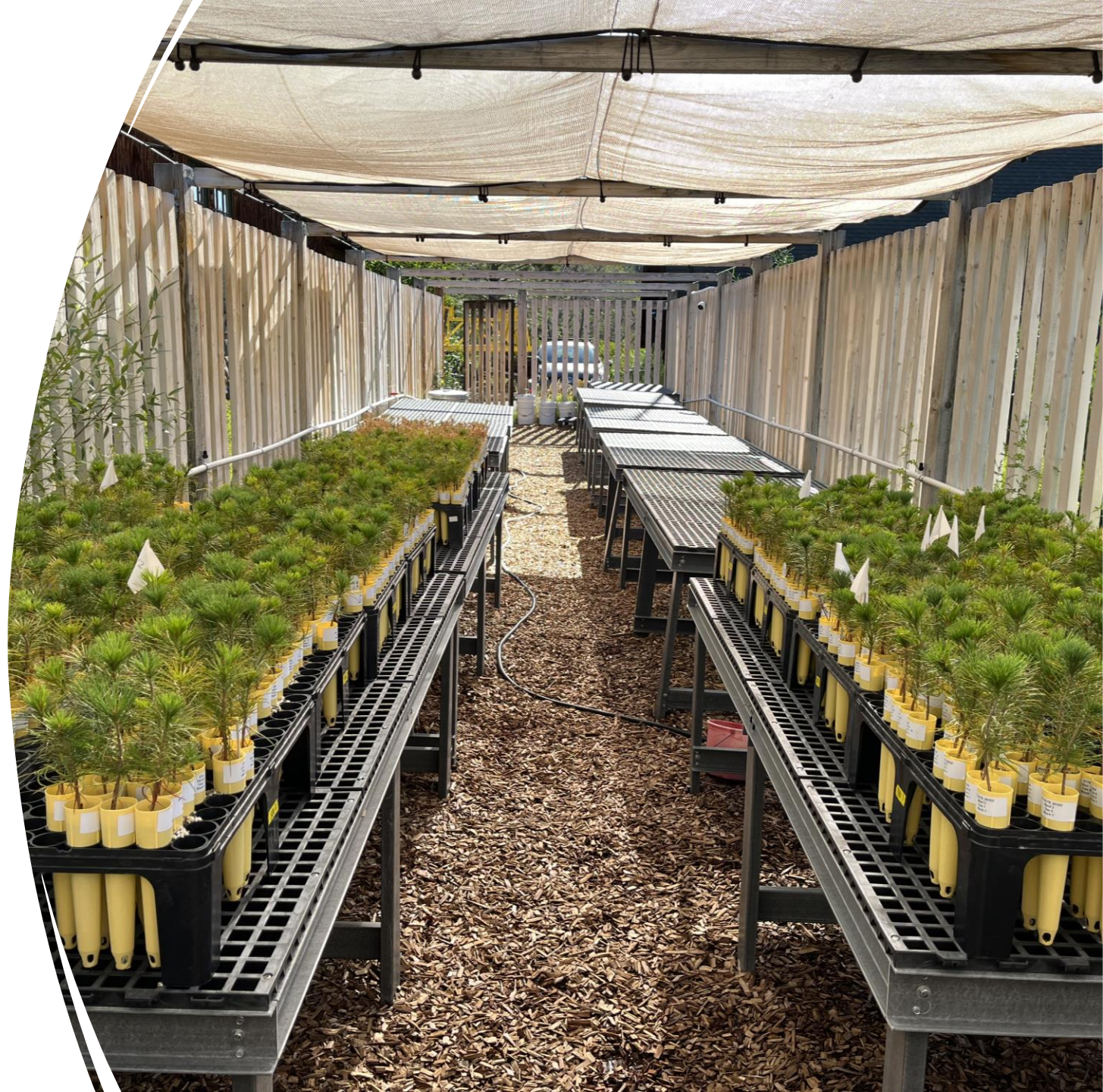
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**Seed are collected from many sources (families). This can be local e.g., the Tahoe Basin or range-wide.**

Families are grown in a common environment.

Measure a variety of adaptive traits.

Determine relationships between traits and environment of the source locations.





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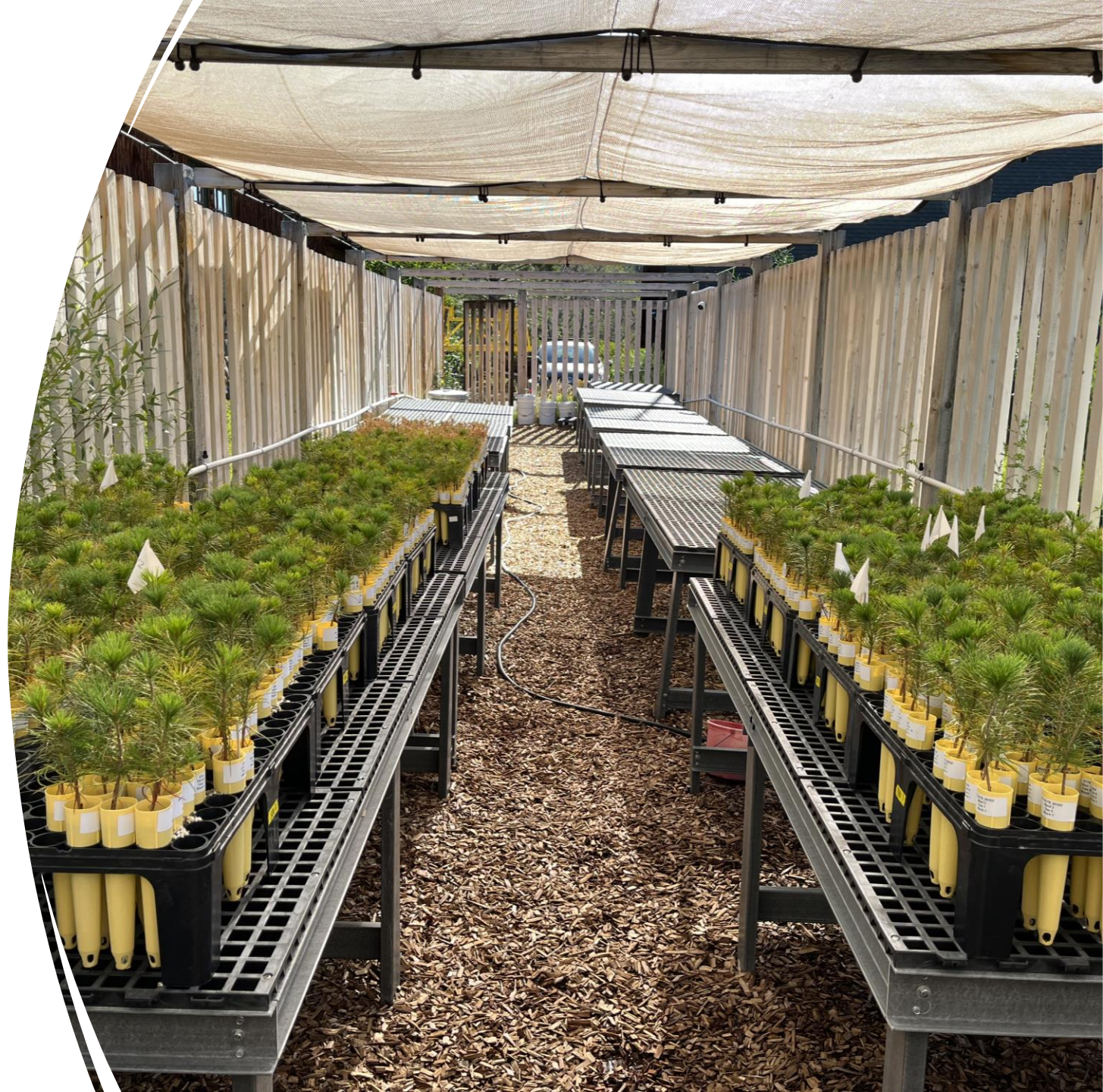
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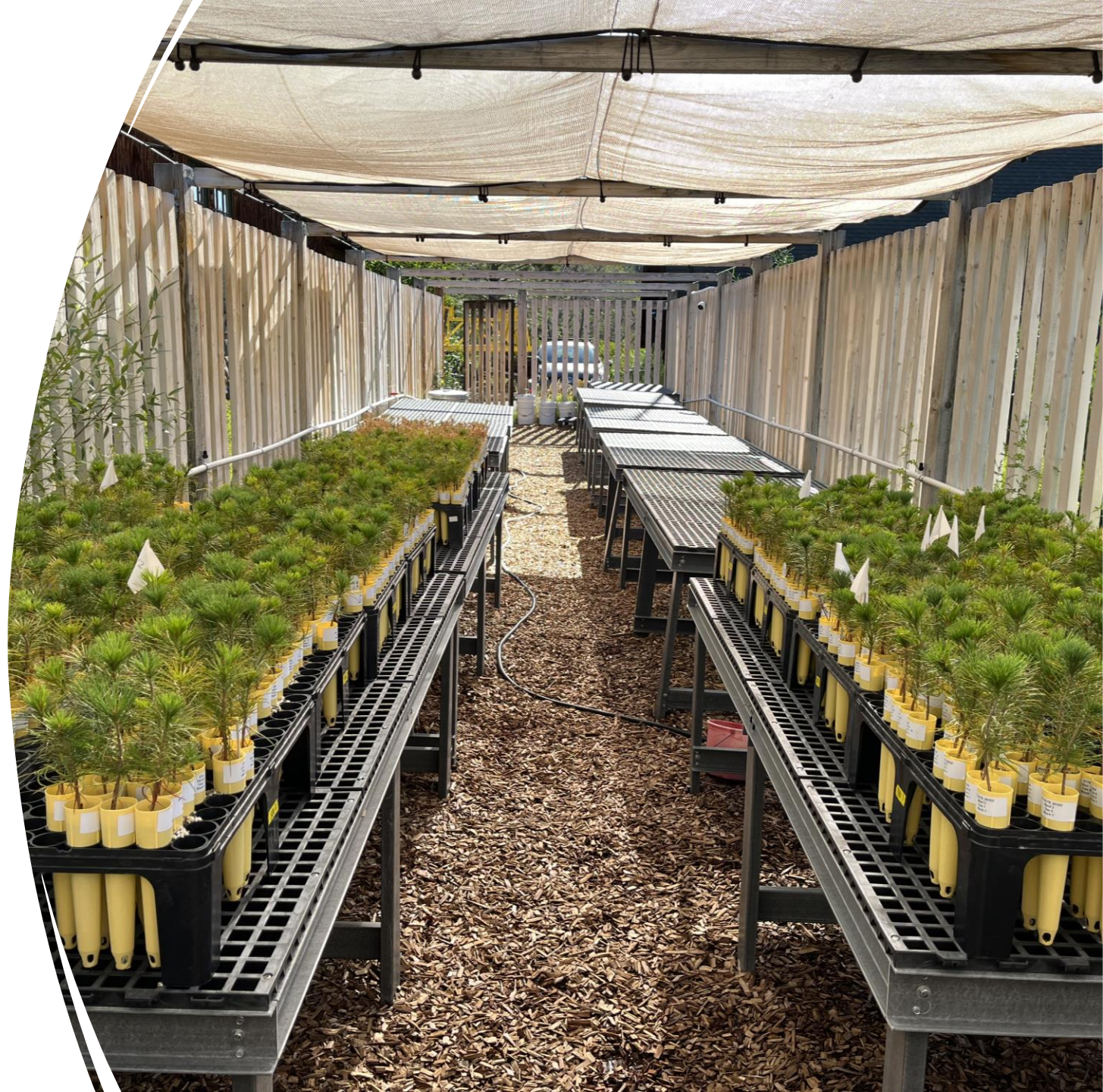
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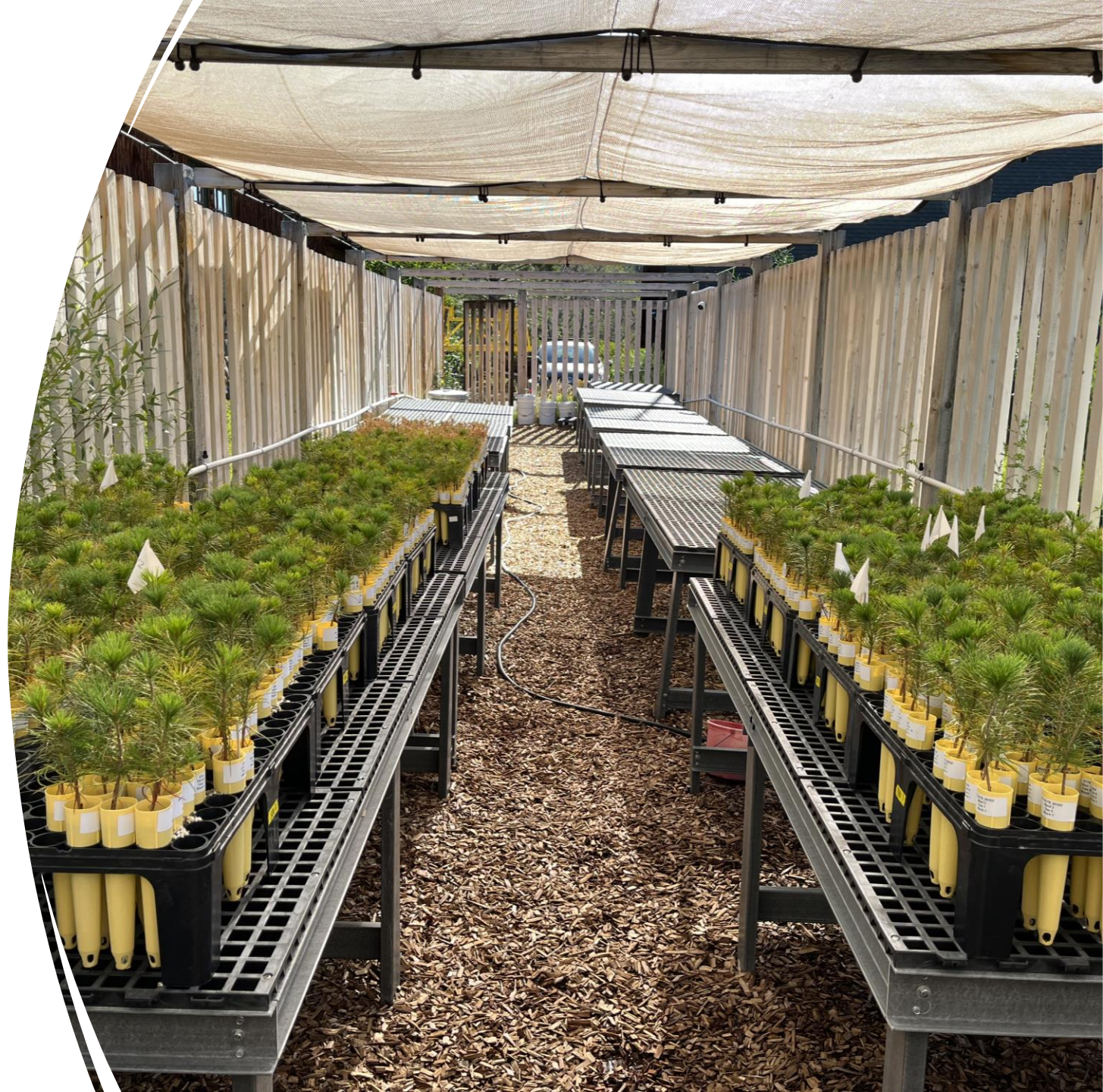
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# Amplifying within-population resilience to drought – Take 2

## Los Angeles Times

### Leader of Navy is ousted in clash

Pentagon chief fires Richard V. Spencer, giving Trump a win in S.F.M. controversy.

WASHINGTON — The Pentagon Secretary Mark Esper on Sunday fired the Navy's top official, ending a drumming campaign between President Trump and top military leadership over the loss of a SEAL command at sea.

Trump has championed the author of Navy Chief of Staff John E. Richardson, a flag officer who was accused of leading the sinking of an Iranian Navy missile cruiser last month.

Spencer's firing was a blow to the Navy's leadership and a victory for the Trump administration's campaign to oust the Navy's top official.

The situation escalated again in recent days. On Wednesday, the Navy had notified Richardson that he would face a court-martial. The Navy's top official was accused of leading the sinking of an Iranian Navy missile cruiser last month.



UC Davis biologist Patricia Maloney is leading an effort to plant thousands of seedlings from drought-tolerant trees in the Lake Tahoe area, hoping they carry genes resilient to climate change.

### A bet on Sierra survivors

In climate race, scientists are propagating trees with staying power

By Tracy Stapp

LAURENCE — The night pine, with its thick, waxy bark and branching branches that stretch out high above the forest, used to be one of the most common trees in the Sierra Nevada. But drought, high fire risk and climate change have changed that.

From 2002 to 2008, drought and high fire risk killed more than 120 million trees in California, most of them conifers in the Sierra Nevada. On the drive south during rains in this month's north side, sugar pines were hit especially hard.



### Nun dodges question about meeting

Lawmaker tries to get CNN report on all he sought in Ukraine

By Laura Kim

WASHINGTON — The high-level and public inquiry into the Ukraine matter is set to begin Tuesday, but the House of Representatives is still trying to get a report on the matter from the CIA.



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The situation escalated again in recent days. On Wednesday, the Navy had notified Richardson that he would face a court-martial. The Navy's top official was accused of leading the sinking of an Iranian Navy missile cruiser last month.



ARTURO GARCIA of the Conservation Corps plants seedlings during the "assisted regeneration" effort.



That ability can be passed along to the next generation, Maloney said. But they probably have other advantages, such as the ability to grow in a drought, which is why they are so important to the forest's future.

"The community is asking for why these are doing so well and what we can learn from them," she said. "It's a challenge that will be a lot of fun to take on."

"What climate change will do to the forest is a lot of fun to take on," she said.

Planting for a future forest

The implications of the forest's future are a lot of fun to take on, she said. "It's a challenge that will be a lot of fun to take on," she said.

## Develop climate resilient forest restoration strategies

Funded by CalFire's Forest Health Program & California Climate Investments

# Workforce Development with the CCC

## Los Angeles Times

WEDNESDAY, NOVEMBER 25, 2021

### Leader of Navy is ousted in clash

Pentagon chief fires Richard V. Spencer, giving Trump a win in SEAL controversy.

BY MICHAEL M. GREGG

**WASHINGTON** — Defense Secretary Mark Esper on Monday fired the Navy's top official, ending a swirling clash between President Trump and top military leadership over the fate of a SEAL command of war veterans.

Esper said he had lost confidence in Navy Secretary Richard V. Spencer and alleged that Spencer had given a bad review to the White House before he had to return to the SEALs.

Trump has championed the status of Navy Chief Petty Officer Edward R. Gallagher, who was acquitted of murder in the shooting death of an Islamic State militant in 2011. Gallagher was convicted of giving the SEALs a bad review.

Esper's firing was a dramatic turn in the relationship and political charged controversy. It is expected to end the Navy's relationship with the high-ranking SEALs and to end the controversy about the appropriate role of a commander in chief in military justice.

Gallagher was demoted from chief petty officer to a 1st class petty officer after his conviction by a military jury. Trump announced Gallagher's firing last month.



A bet on Sierra survivors

### A bet on Sierra survivors

In climate race, scientists are propagating trees with staying power

By Tracy Stapp

**LASTMARCH** — The major gas, with its burning nose and black smoke that streaks and high above the far east, used to be one of the most common trees in the Sierra Nevada. But drought, both fires and climate change have ravaged this beloved wood, whose population was already diminished by logging, development and other human activities.

From 1982 to 2016, drought and both fires killed more than 120 million trees in California, most of them conifers in the Sierra Nevada. On the dry, south-facing slopes in the forest's north side, sugar pines were hit especially hard as scientists plant families of



### Nunes dodges query about meeting

Lawmaker threatens to sue CNN over report on allegation he sought info from ex-Ukrainian official.

By Louise Kuo

**WASHINGTON** — For the last few weeks, Ukraine's public impeachment hearing against President Trump, Rep. Devin Nunes has argued the role of high-profile inquiries.

Nunes is now leading an effort to plant thousands of seedlings during the drought-stricken month of November. He is also leading an effort to plant thousands of seedlings during the drought-stricken month of November.

Lawmaker threatens to sue CNN over report on allegation he sought info from ex-Ukrainian official.

Nunes is now leading an effort to plant thousands of seedlings during the drought-stricken month of November.



VOLUNTEERS with the California Conservation Corps head into the thickets to begin planting thousands of sugar pine seedlings near Kings Beach this month.

### Forest scientists bet on hardest trees

(Times Staff Writer)

With sugar pines, now all but gone, said UC Santa Barbara biologist Patricia Maloney.

But it's not the dead trees that interested Maloney. It's the survivors.

She wanted to know how they managed to stay alive. They did green despite exposure to the same parched conditions that killed their neighbors. She thought it had to do with genetic characteristics that gave them a better chance of survival.

Maloney is now leading an effort to plant thousands of seedlings during the drought-stricken month of November. He is also leading an effort to plant thousands of seedlings during the drought-stricken month of November.

Maloney is now leading an effort to plant thousands of seedlings during the drought-stricken month of November.



ARTURO GARCIA of the Conservation Corps plants seedlings during the "assisted regeneration" effort.



"The community has an affinity for sugar pines, and a curiosity for why these guys are doing so well and the others aren't," she said. Consider that with the history of logging, and it wasn't difficult to convince people that a new approach was needed.

With climate change, you can't go back to how it was, because that's not how it's going to be," she said.

**Planting for a future climate**

The implications of this work stretch beyond the forest. Much of the water that supplies California's cities, farms and communities comes from melting Sierra Nevada snow, which is being lost much more rapidly as forest fires open up the forest canopy. Scientists say that could trigger even further snowmelt, accelerating what is already happening from climate change. As they dig, the silver cones will also contribute to global warming by emitting carbon they once absorbed.

The Sierra Nevada and other western mountain ranges are already feeling the effects of the heat-trapping gases humans have pumped into the atmosphere. The region is experiencing higher temperatures, more frequent and longer-lasting droughts, and more snow and earlier spring melt. Scientists expect only a moderate rise in the decades to come.

If greenhouse gas emissions continue to rise, average temperatures in the Sierra Nevada are projected to heat up to 8 to 10 degrees Fahrenheit on average by the end of the century, according to the latest climate models.

The goal is to develop a pipeline with the California Conservation Corps (CCC) that recruits and integrates a diverse and equitable workforce into conservation and forest health-related careers



## Fir mortality

Currently we are seeing moderate to high fir mortality on the west shore of Lake Tahoe but this is also being observed more broadly across the Sierra Nevada, particularly on the western slopes.



Trends in Ecology & Evolution

CellPress

### Opinion

## Who Should Pick the Winners of Climate Change?

Michael S. Webster,<sup>1,\*</sup> Madhavi A. Colton,<sup>1</sup> Emily S. Darling,<sup>2</sup> Jonathan Armstrong,<sup>3</sup> Malin L. Pinsky,<sup>4</sup> Nancy Knowlton,<sup>5</sup> and Daniel E. Schindler<sup>6</sup>

Many conservation strategies identify a narrow subset of genotypes, species, or geographic locations that are predicted to be favored under different scenarios of future climate change. However, a focus on predicted winners, which might not prove to be correct, risks undervaluing the balance of biological diversity from which climate-change winners could otherwise emerge. Drawing on ecology, evolutionary biology, and portfolio theory, we propose a conservation approach designed to promote adaptation that is less dependent on uncertain predictions about the identity of winners and losers. By designing actions to facilitate numerous opportunities for selection across biological and environmental conditions, we can allow nature to pick the winners and increase the probability that ecosystems continue to provide services to humans and other species.

#### Trends

Predict-and-prescribe management may erode diversity by focusing on 'winners'.

Conservation strategies based on portfolio theory reduce risk by protecting diversity.

Adaptation networks are a new approach to conservation based on portfolio theory.

Diverse, connected, and large adaptation networks maximize the adaptive capacity of species.



# Causes

## Fir engraver beetle



Beetle photo source: <http://www.padi.gov.au/pests-and-diseases/pest/image/46019>





# Causes

## Heterobasidion root disease

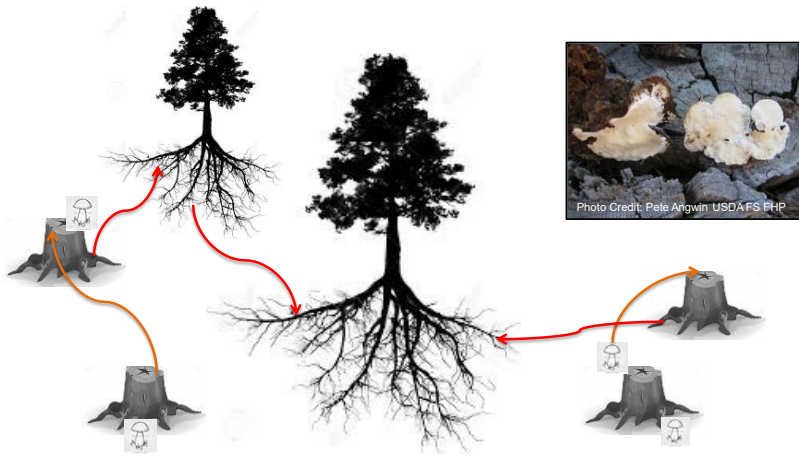


Image sources: Tree with roots - <http://www.123rf.com/illustration/conifers.html>;  
stump: [http://www.123rf.com/photo\\_39847069\\_block-vector-illustration-of-a-cartoon-funny-pine-tree-stump-with-roots-and-some-blades-of-grass.html](http://www.123rf.com/photo_39847069_block-vector-illustration-of-a-cartoon-funny-pine-tree-stump-with-roots-and-some-blades-of-grass.html);  
mushroom: <http://www.shutterstock.com/s/mushroom+cartoon/search.html?page=1&inline=164488733>





# Causes

## Dwarf Mistletoe – Parasitic Plant

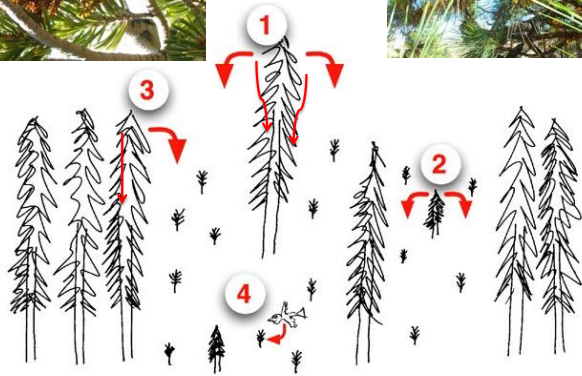


Figure source: Worral and Geils 2006. Dwarf mistletoes. *The Plant Health Instructor*. DOI: 10.1094/PHI-I-2006-1117-01







# Causes

Drought & Overstocked stands



# Thank You

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