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science for a changing world

Lessons from the drought: forest vulnerability, causes of tree mortality, and managing for resilience

Nathan L. Stephenson
Adrian J. Das
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U.S. Department of the Interior
U.S. Geological Survey

Road map:

- The current drought as a possible preview of the future

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- What's next for vulnerability mapping?

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The current drought as a possible preview of the future

The two components of drought are water supply and demand.

A leaky bucket analogy:

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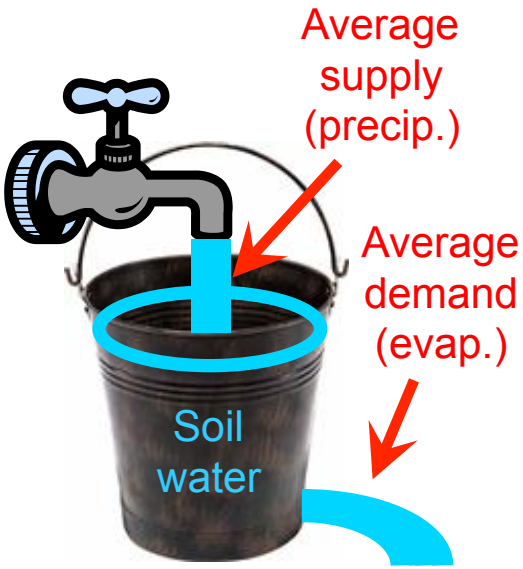
A leaky bucket analogy:

Average conditions



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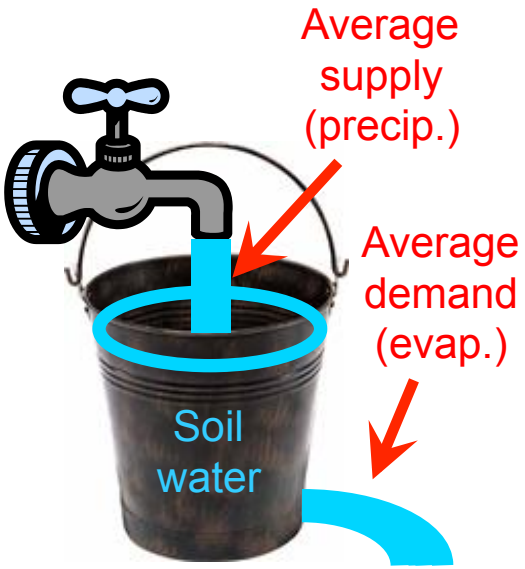
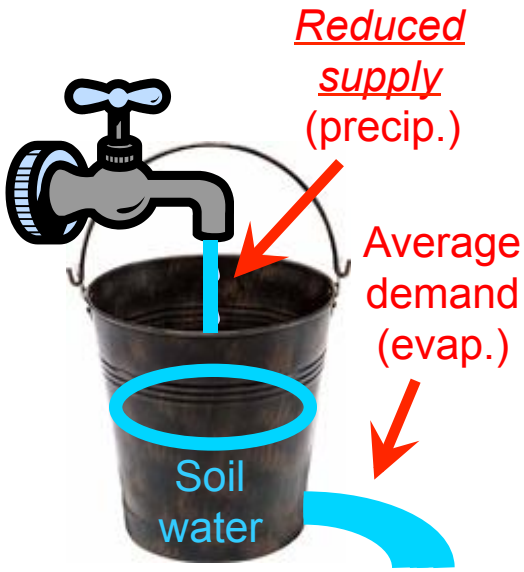


"Normal" drought



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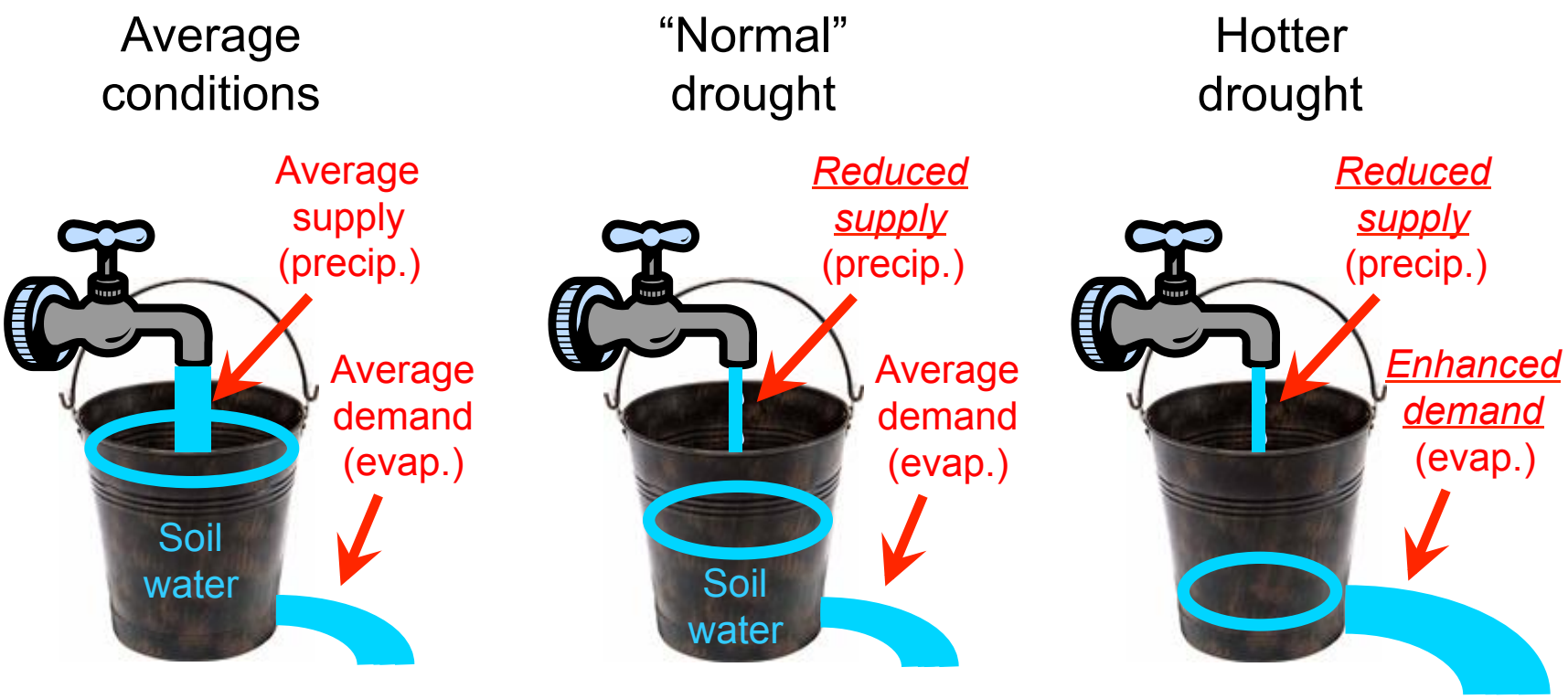

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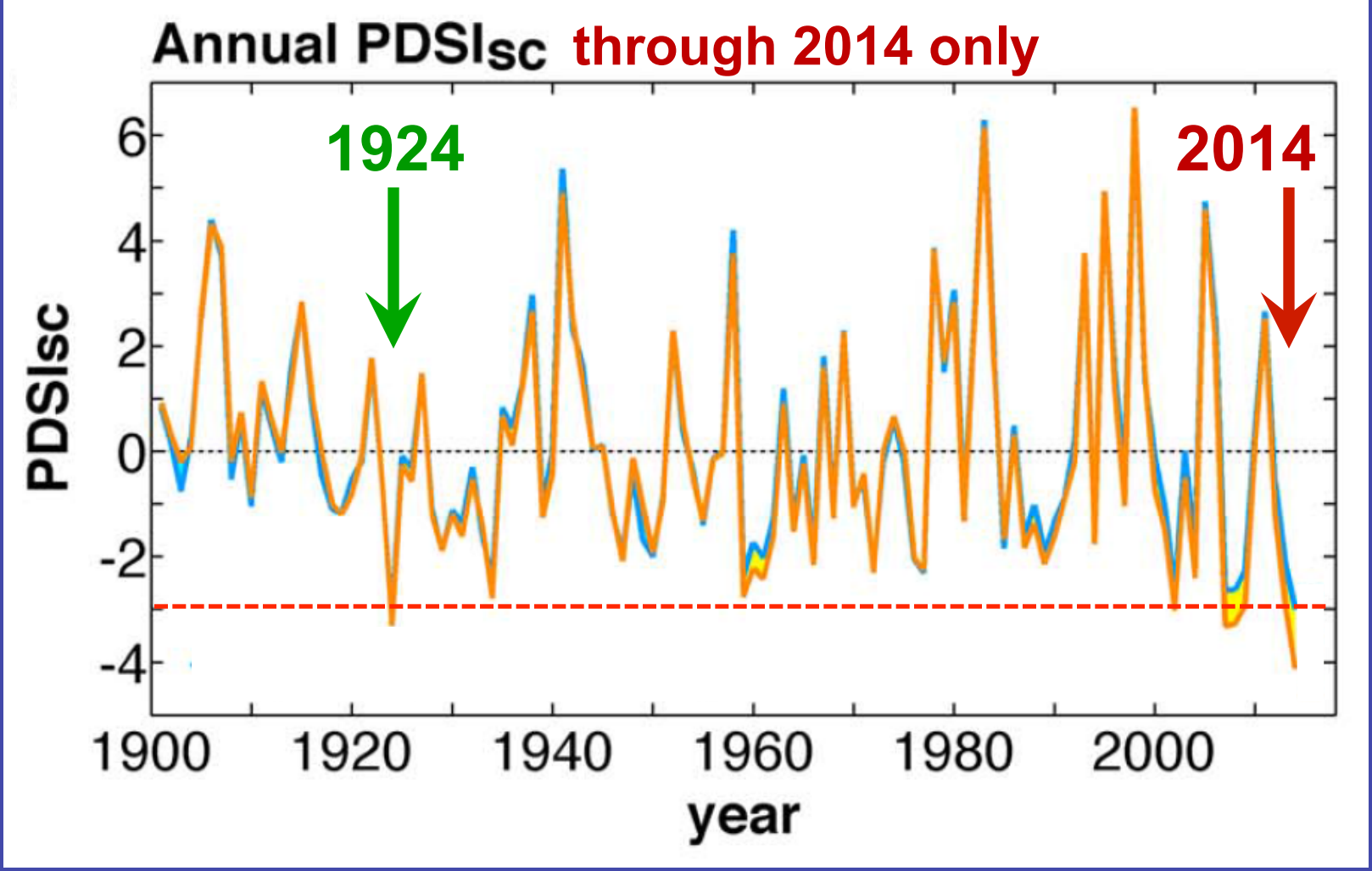
If all we had was a rain gauge, we'd think the current drought was comparable to the 1924 drought.



Williams et al. 2015, *Geophys. Res. Lett.*

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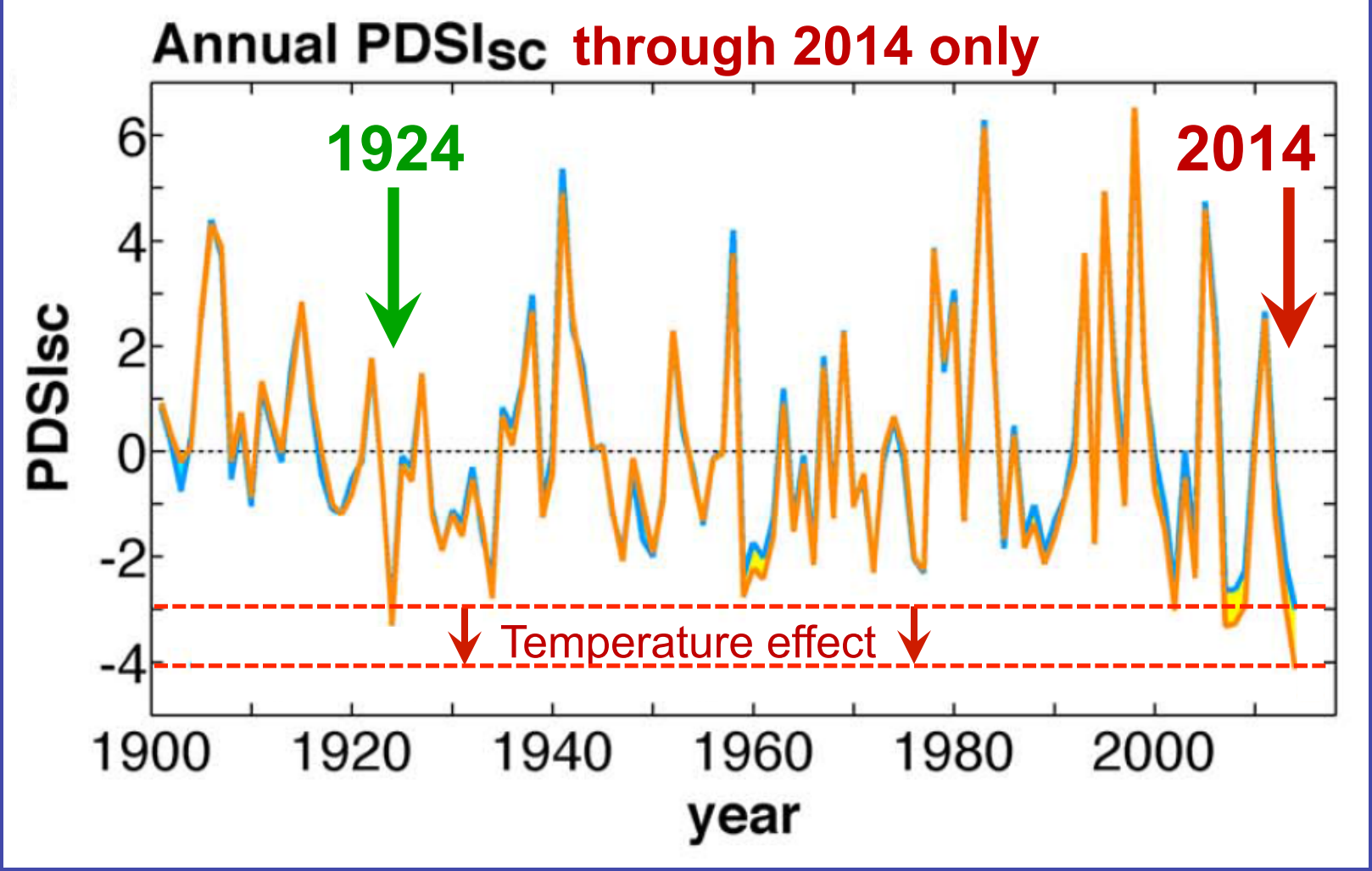
But temperature-induced increases in evaporative demand have pushed the drought to historical extremes ...



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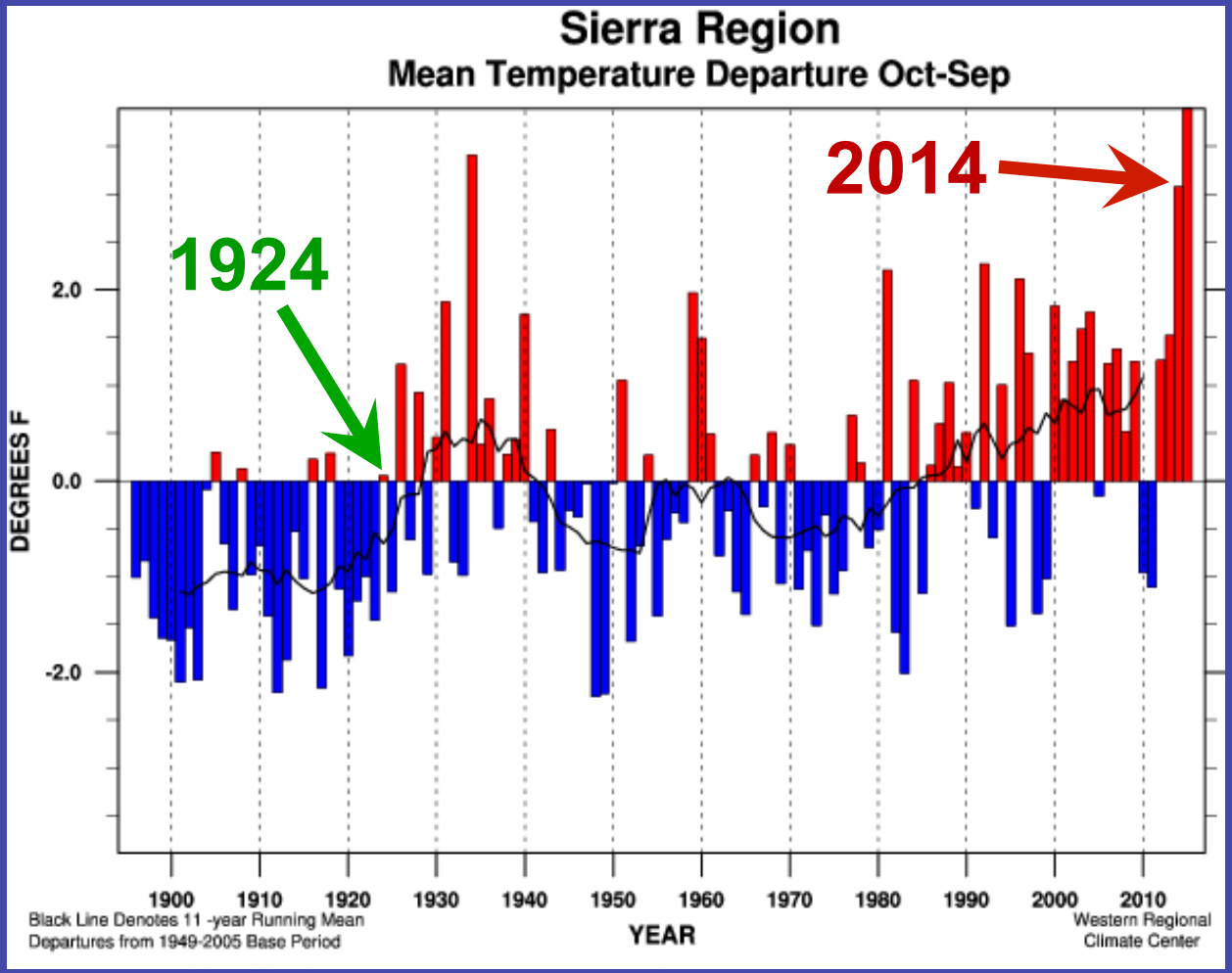
PDSIsc- Palmer Drought Severity Index

… exacerbated by the direct & indirect effects of extreme temperatures *per se*.



Western Regional Climate Center

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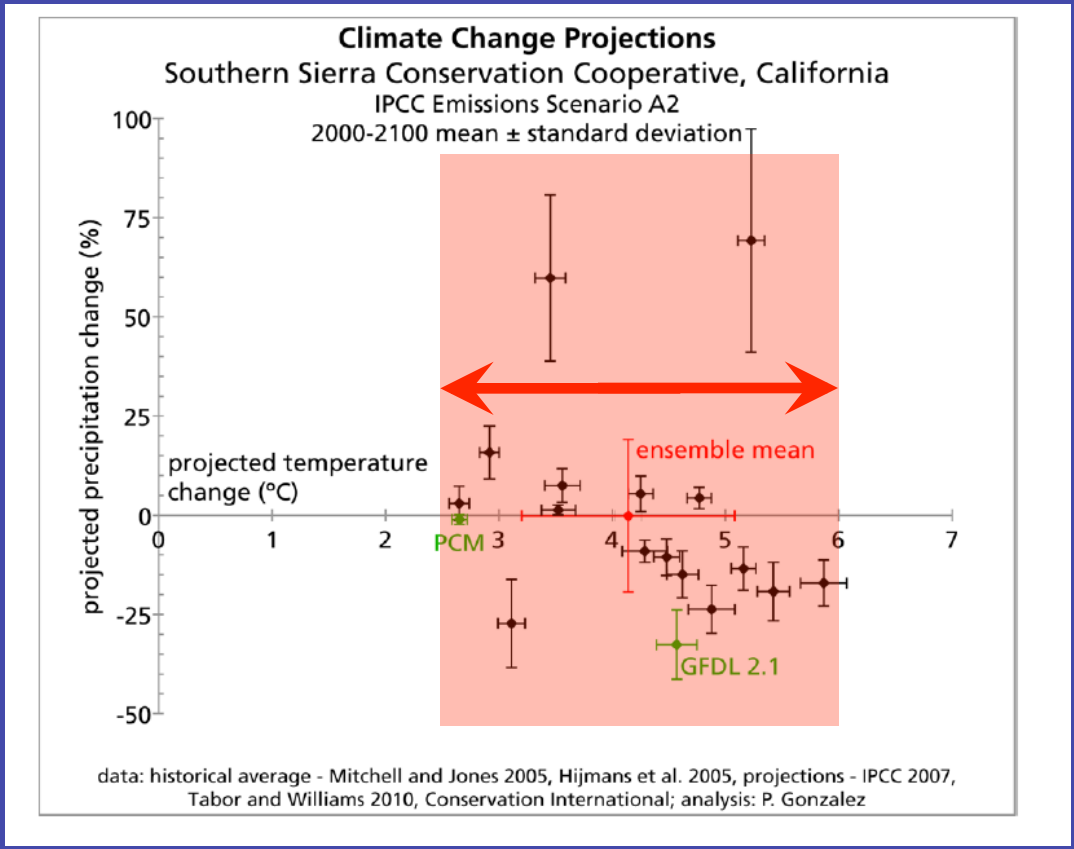
The Future:

We expect more frequent and more severe hotter droughts.

For the central and southern Sierra Nevada, projected warming by the end of this century ranges from ~2.5 to 6° C (~4.5 to 10.5° F).



Gonzalez 2012, NPS Climate Change Response Program

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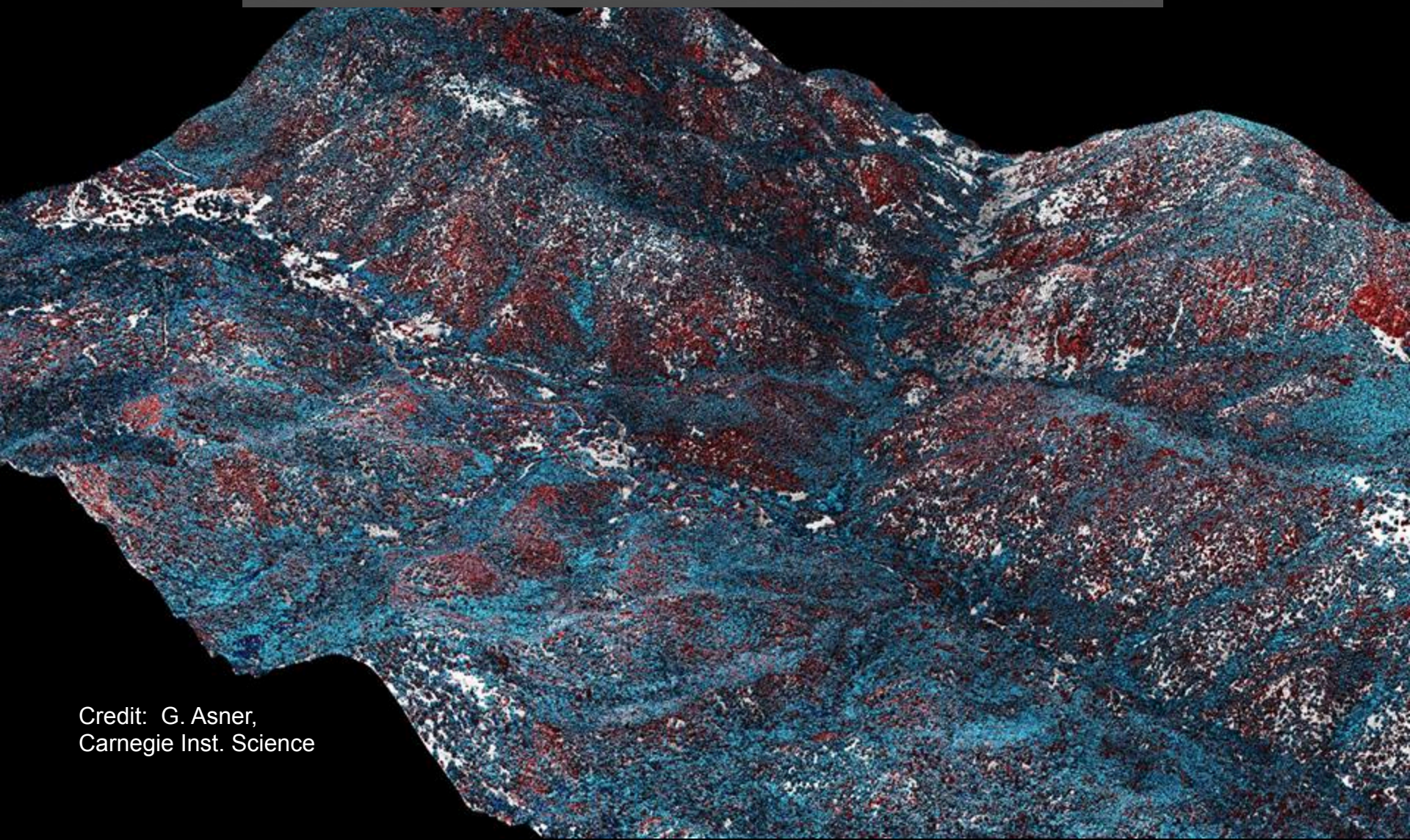
We need forest vulnerability maps to help guide triage



Credit: G. Asner,
Carnegie Inst. Science

We have tools for increasing forest resistance to hotter droughts (Phil's talk), but limited funds and capacity mean we must make strategic choices about where to apply the tools. *We need reliable maps*.

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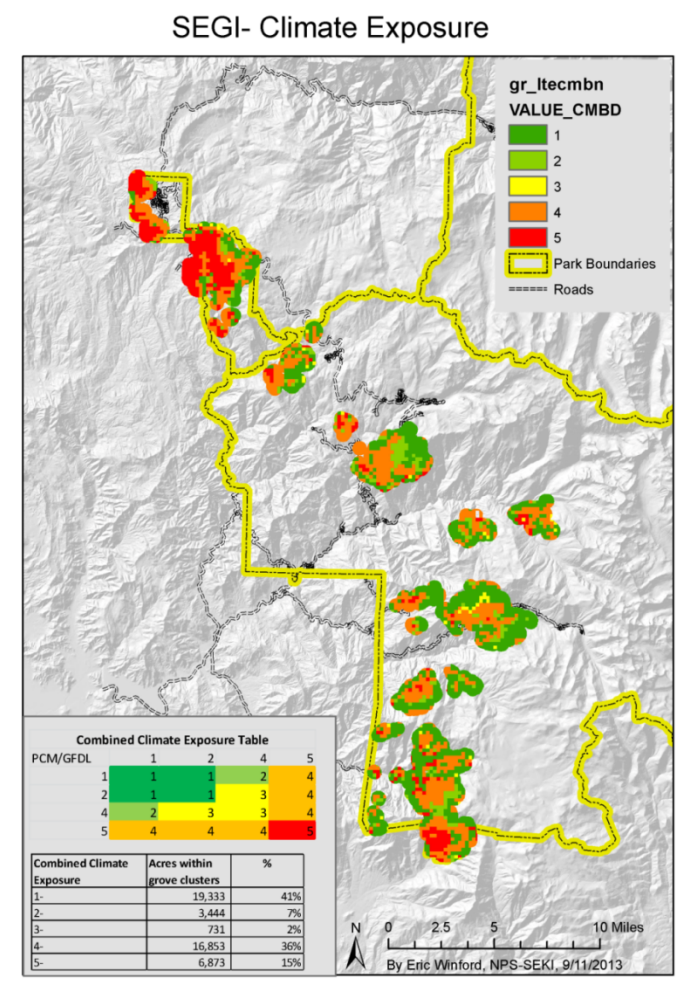
Photo credits: Arizona Wildfire Academy & USFS

Can climate envelope models help us map forest vulnerability?

Predicted giant sequoia vulnerability to hotter, drier future



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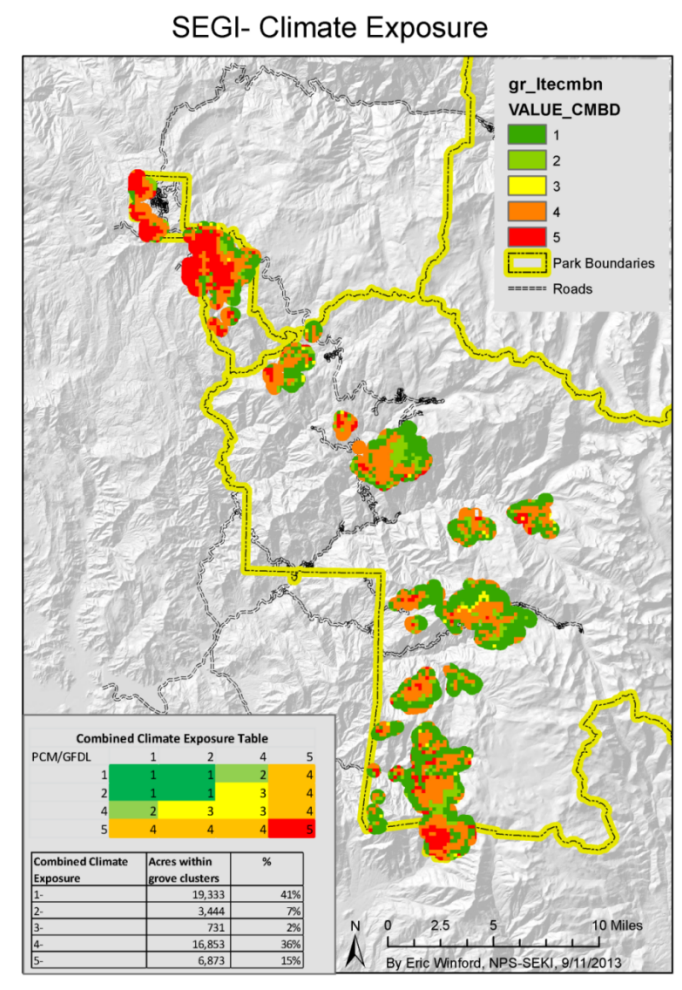

Observed giant sequoia foliage dieback during hotter drought, 2014

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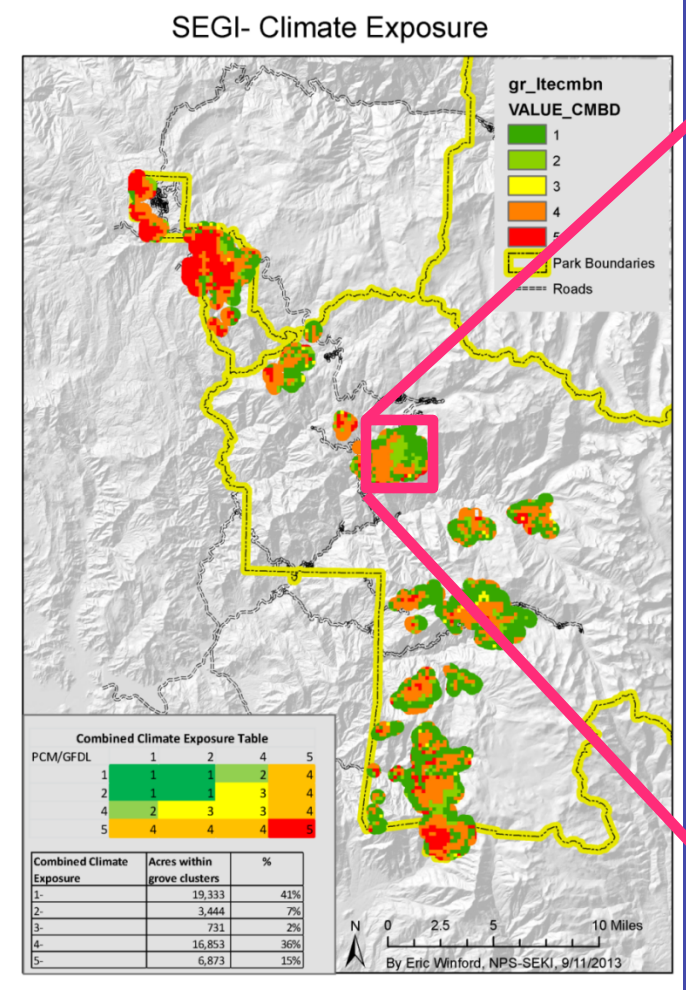

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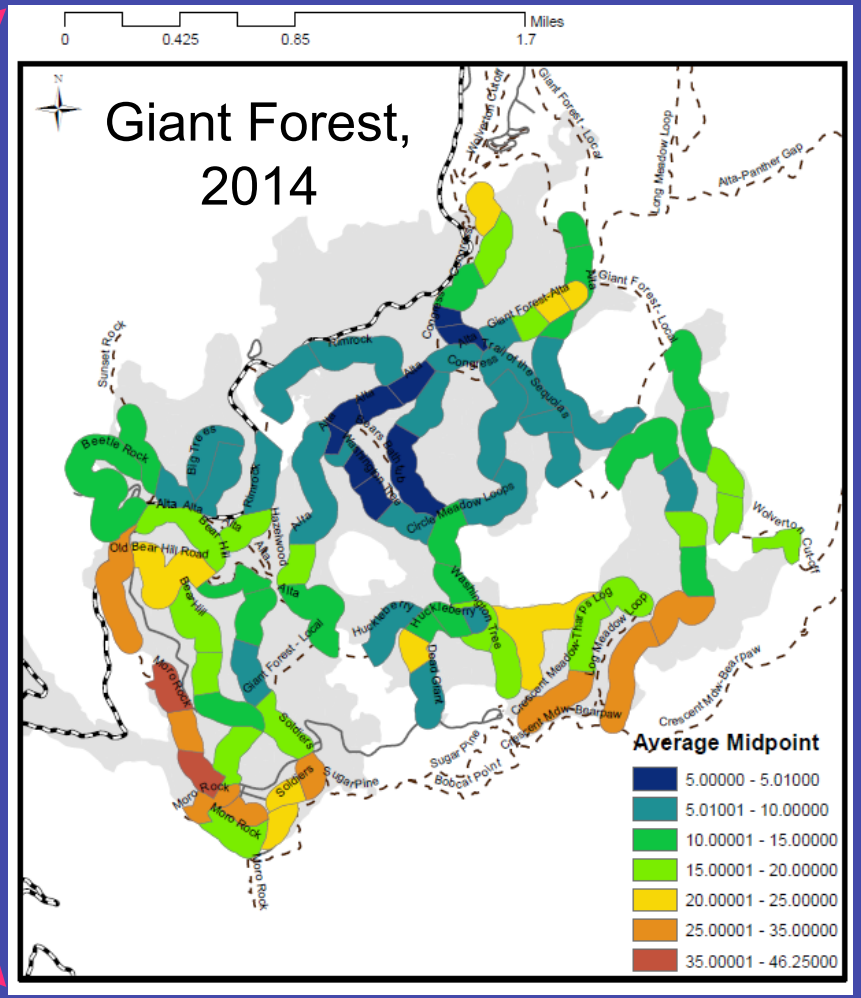
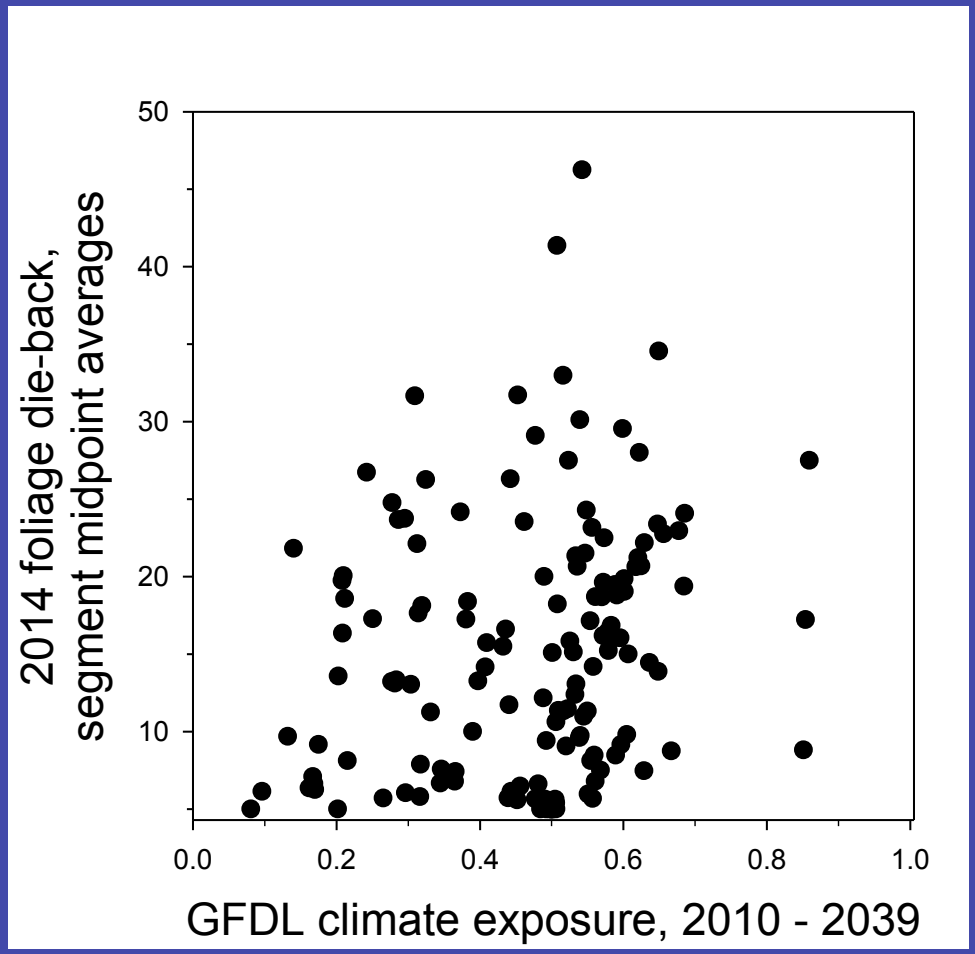


Almost no correlation between predicted & observed.
Modeled vulnerability is probably of little help
at the scales useful to managers.



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In general – and for reasons that are the topic of a different talk – climatic envelope models of forest vulnerability may not be up to the task.

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But if current models are inadequate, how can we get vulnerability maps?

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The Leaf to Landscape project:
Understanding and mapping forest vulnerability to hotter droughts

Photo credit: A. Ambrose, UC Berkeley

Goal: Take advantage of the hotter drought to let the trees themselves provide the foundation for vulnerability maps (NPS, USGS, CAO, UCB, USFS)

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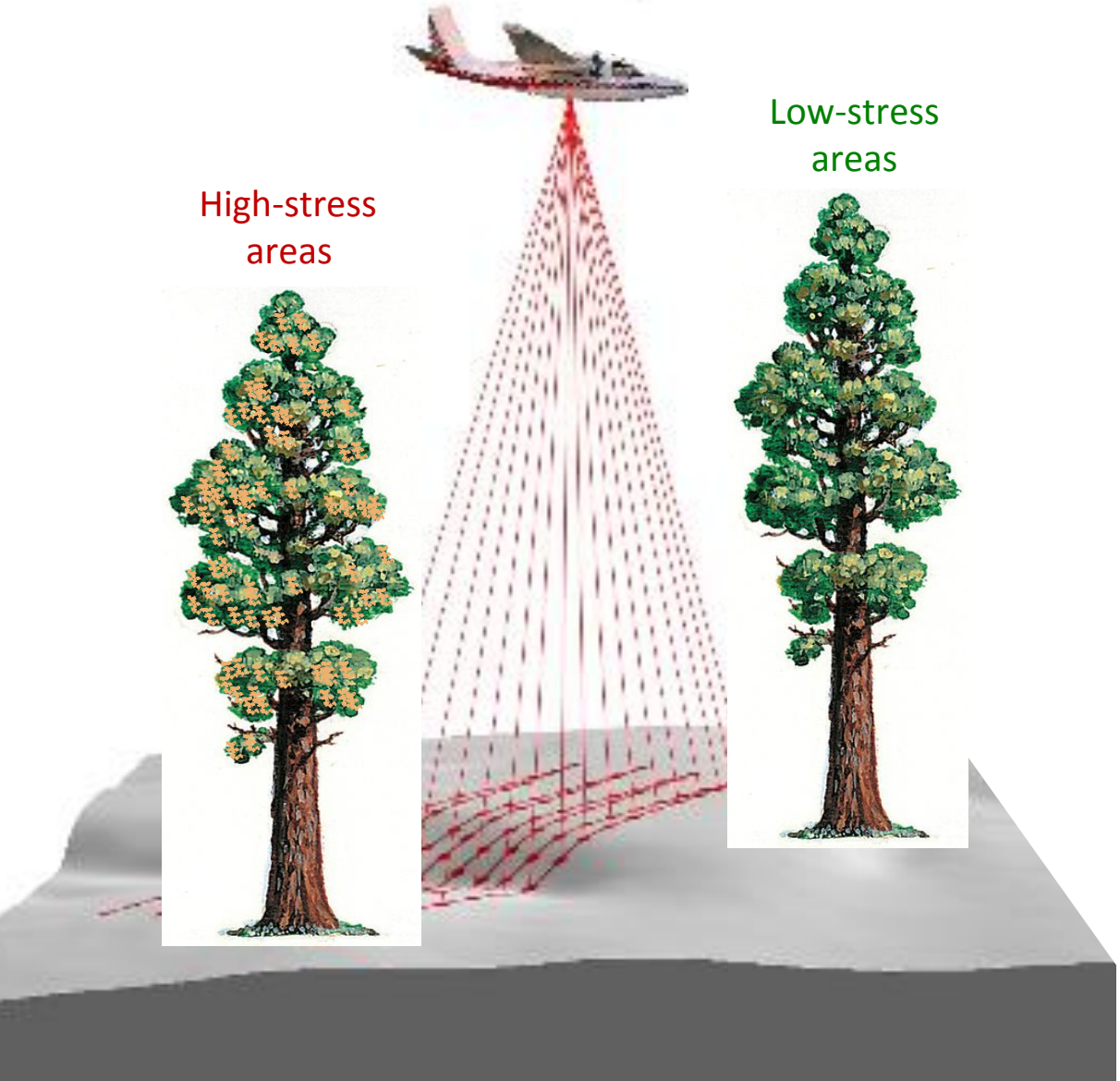
- LiDAR + hyperspectral remote sensing of forests



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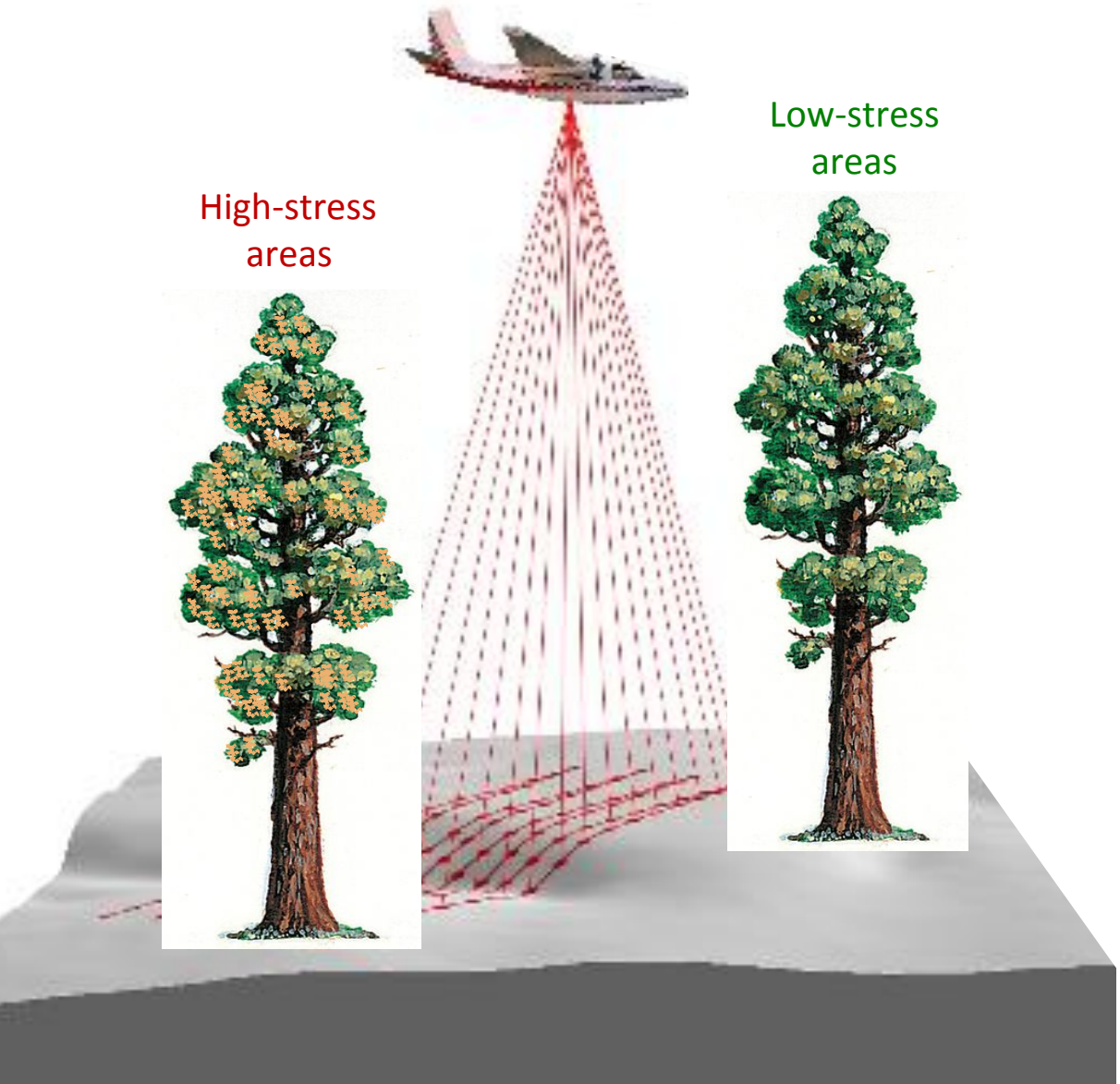
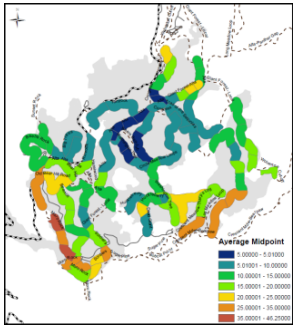


♦ Ground-truth mapping of foliage dieback & tree death



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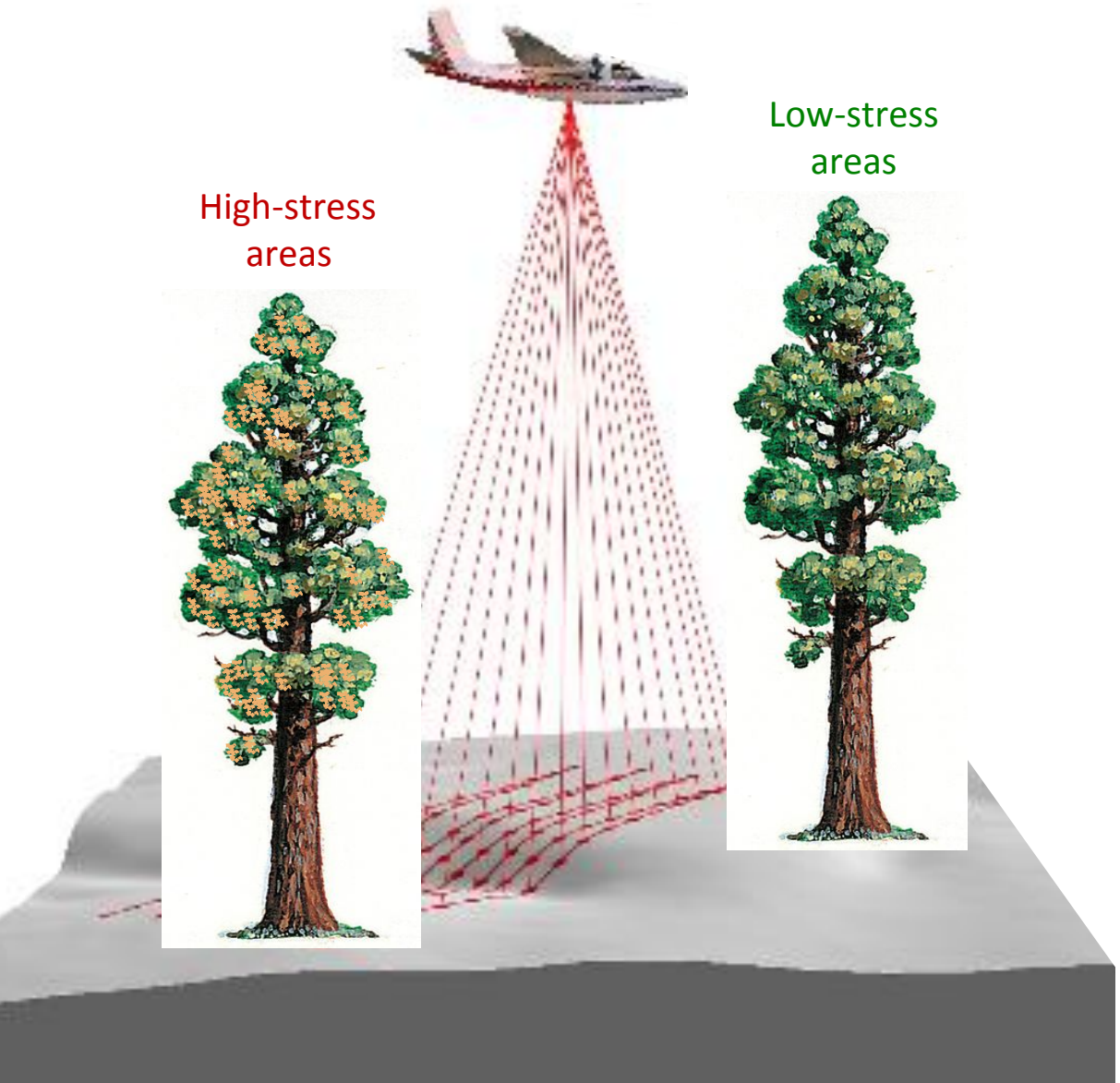

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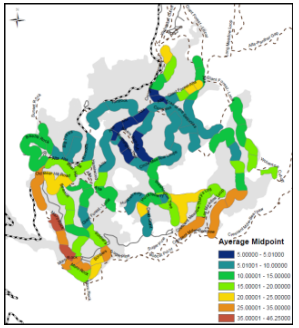

♦ Ground-truth of foliage water content and water stress

We got some dedicated remote sensing last summer.

Credit: G. Asner, Carnegie Inst. Science

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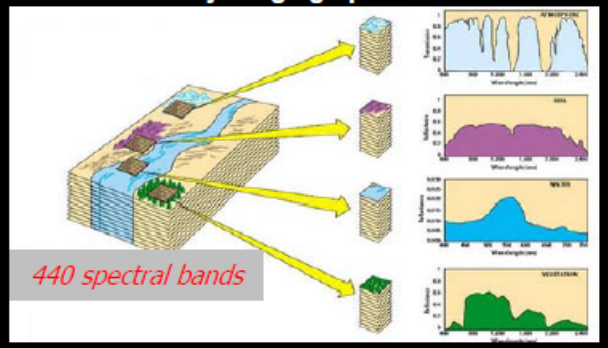
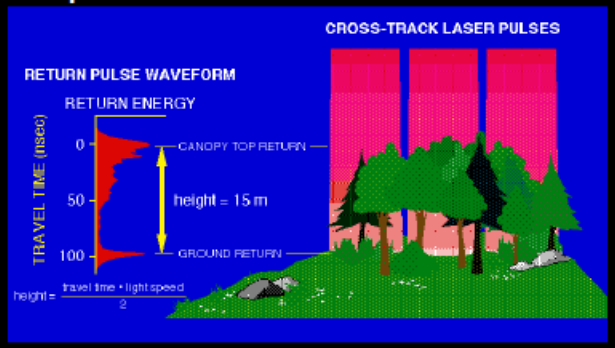
3 Fully Integrated Subsystems

for 3-D Analysis of Ecosystem Composition, Chemistry and Physiology

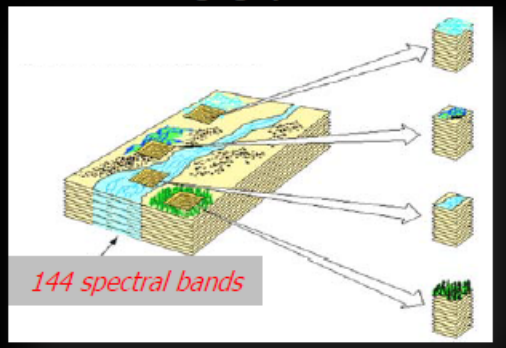
VSWIR Hi-fidelity Imaging Spectrometer

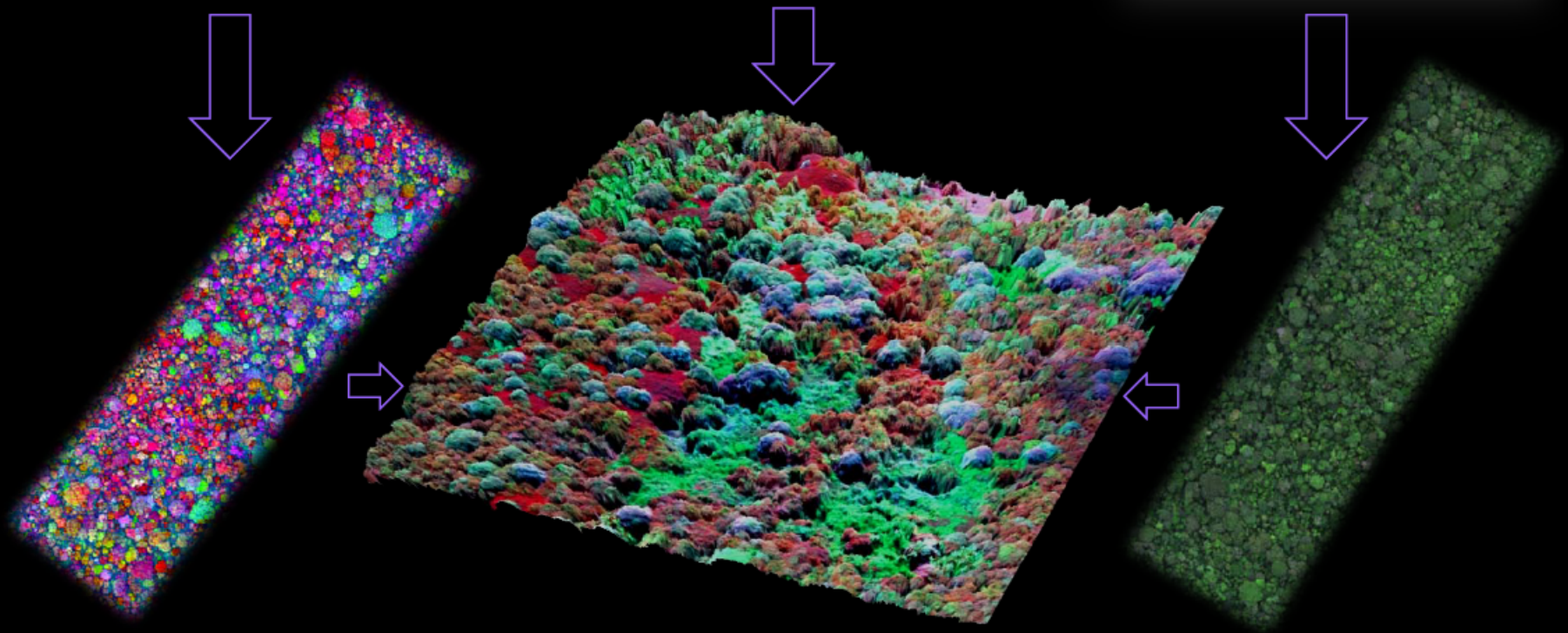


Multi-pulse Waveform LiDAR

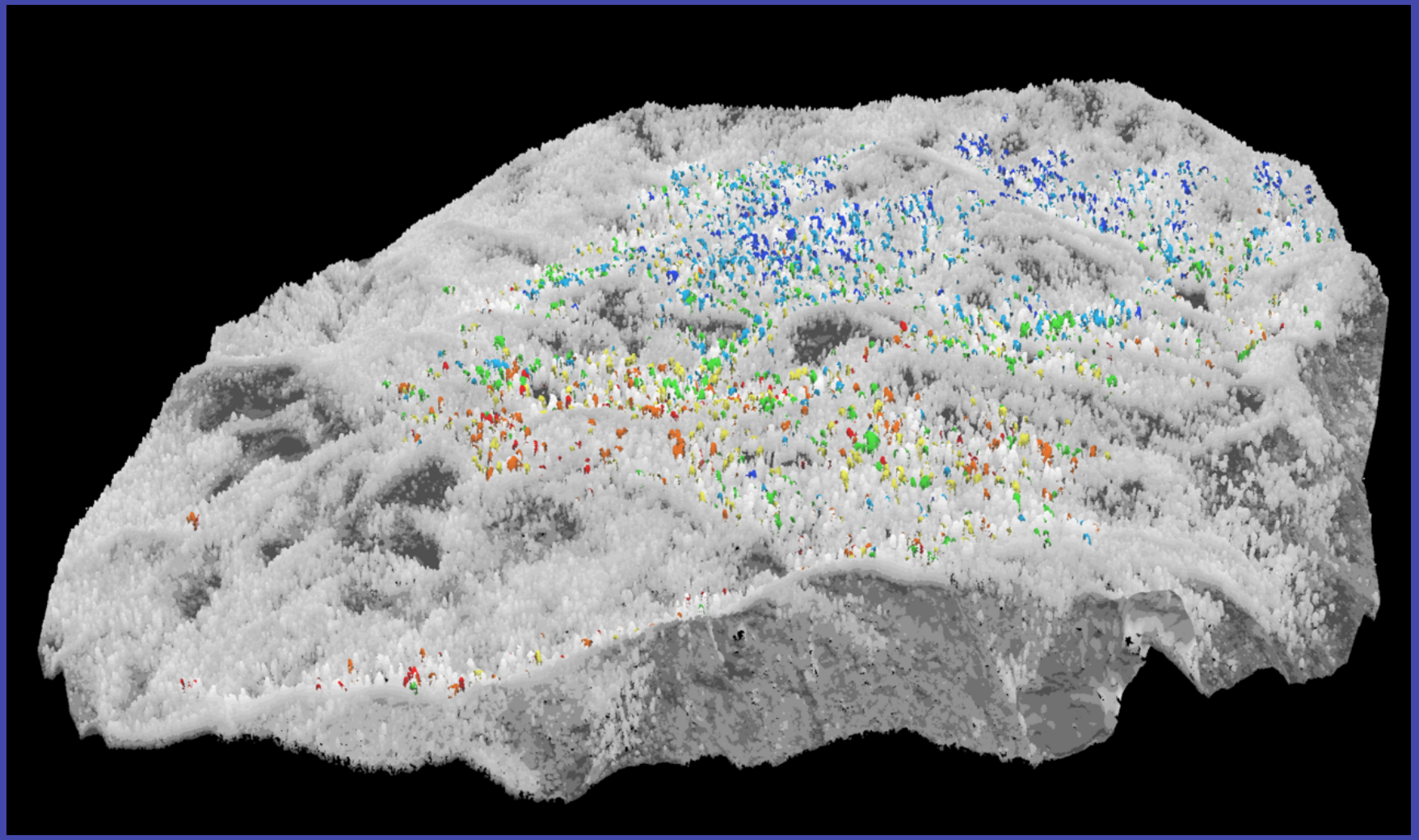


VNIR Zoom Imaging Spectrometer





Preliminary giant sequoia canopy water content
Giant Forest, summer 2015



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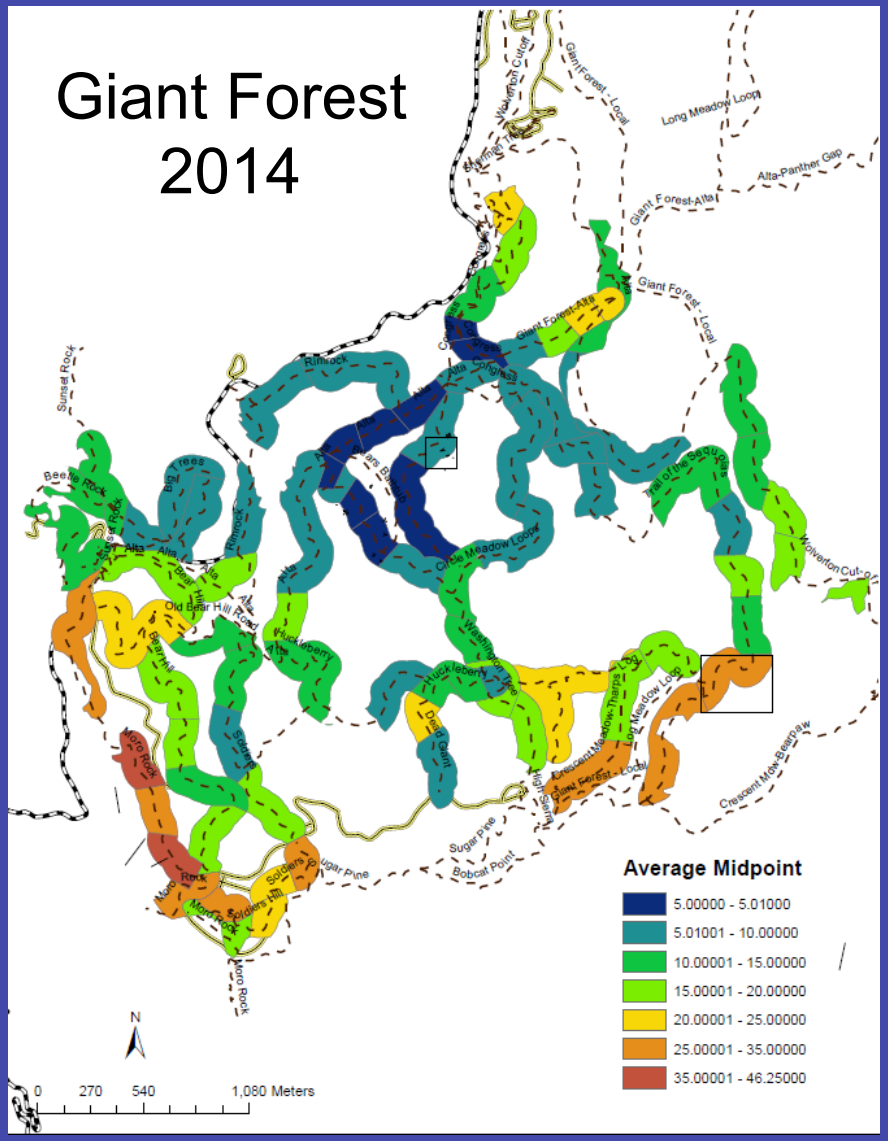
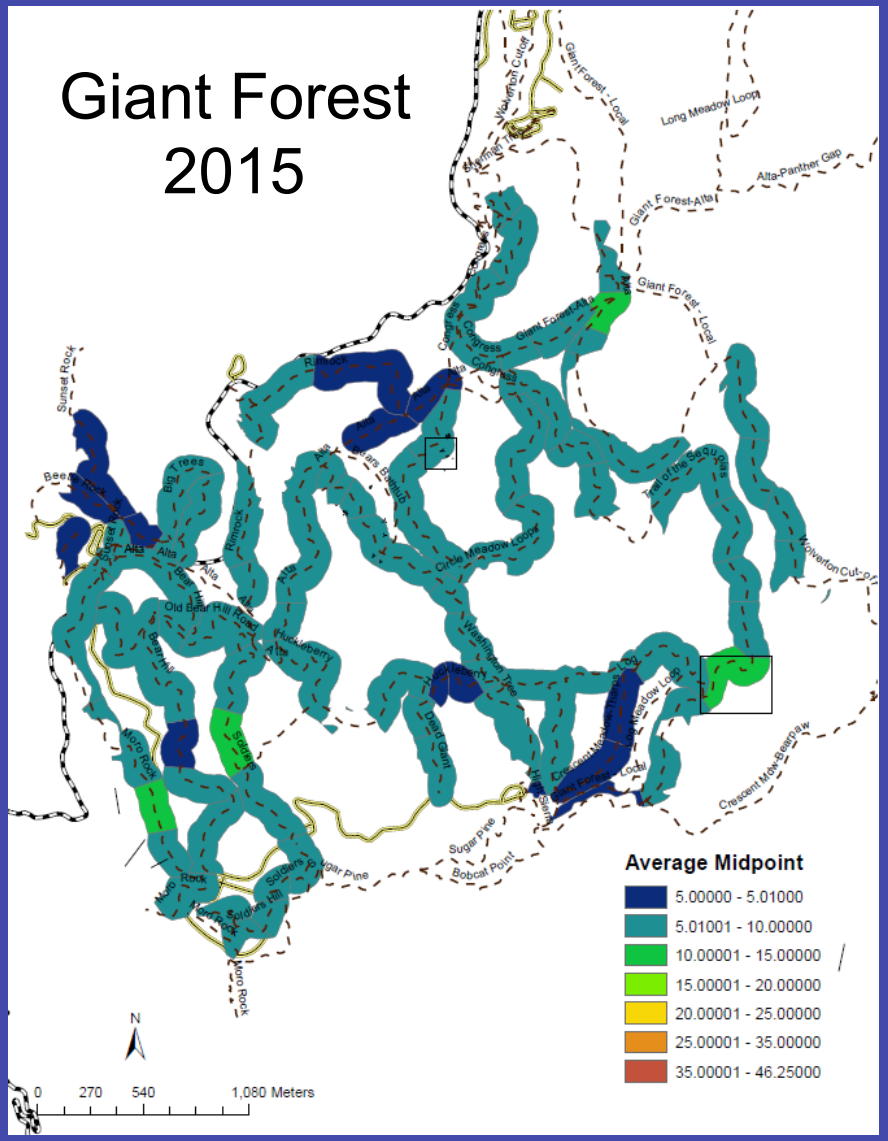
We've also continued our ground-truthing, such as for sequoia foliage die-back …





… and within our permanent monitoring plots (Adrian's talk):

- 30 plots; most plots are 1 ha (100 m x 100 m).
- Every tree >0 cm diameter at breast height is mapped and tagged.

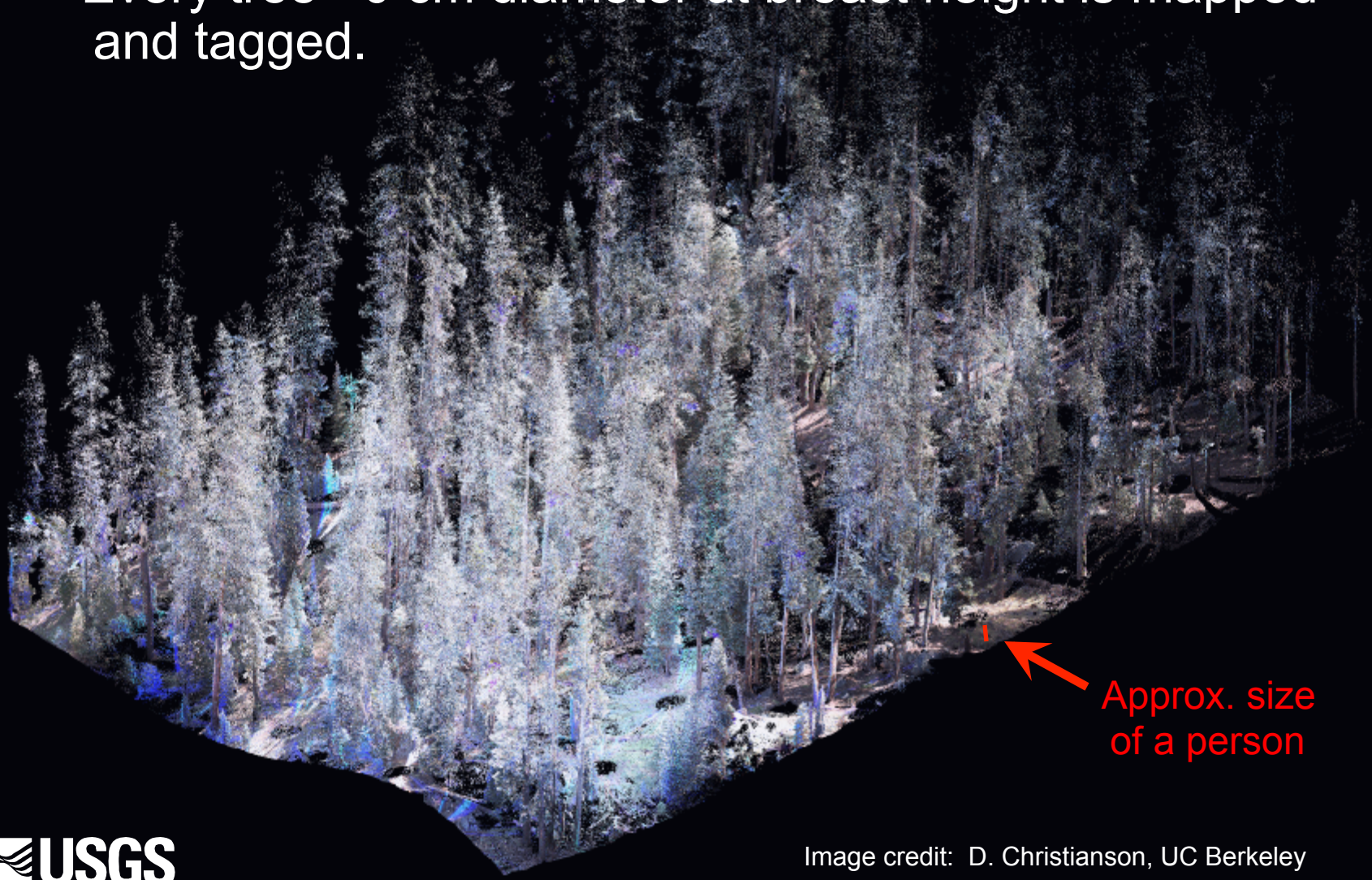


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Image credit: D. Christianson, UC Berkeley

In and near these long-term plots, we climbed and sampled foliage of dozens of precisely-GPSed trees of ~10 species, for water content, nitrogen, water stress, etc.


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- Interpret the data we have so far (and expect surprises!)
- Track forest *recovery* from the drought
- For regions with the right data, produce maps

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Thanks for your attention!