Semi-arid Forest Restoration Treatments Improve Drought Resiliency: ECOSTRESS-based Assessment

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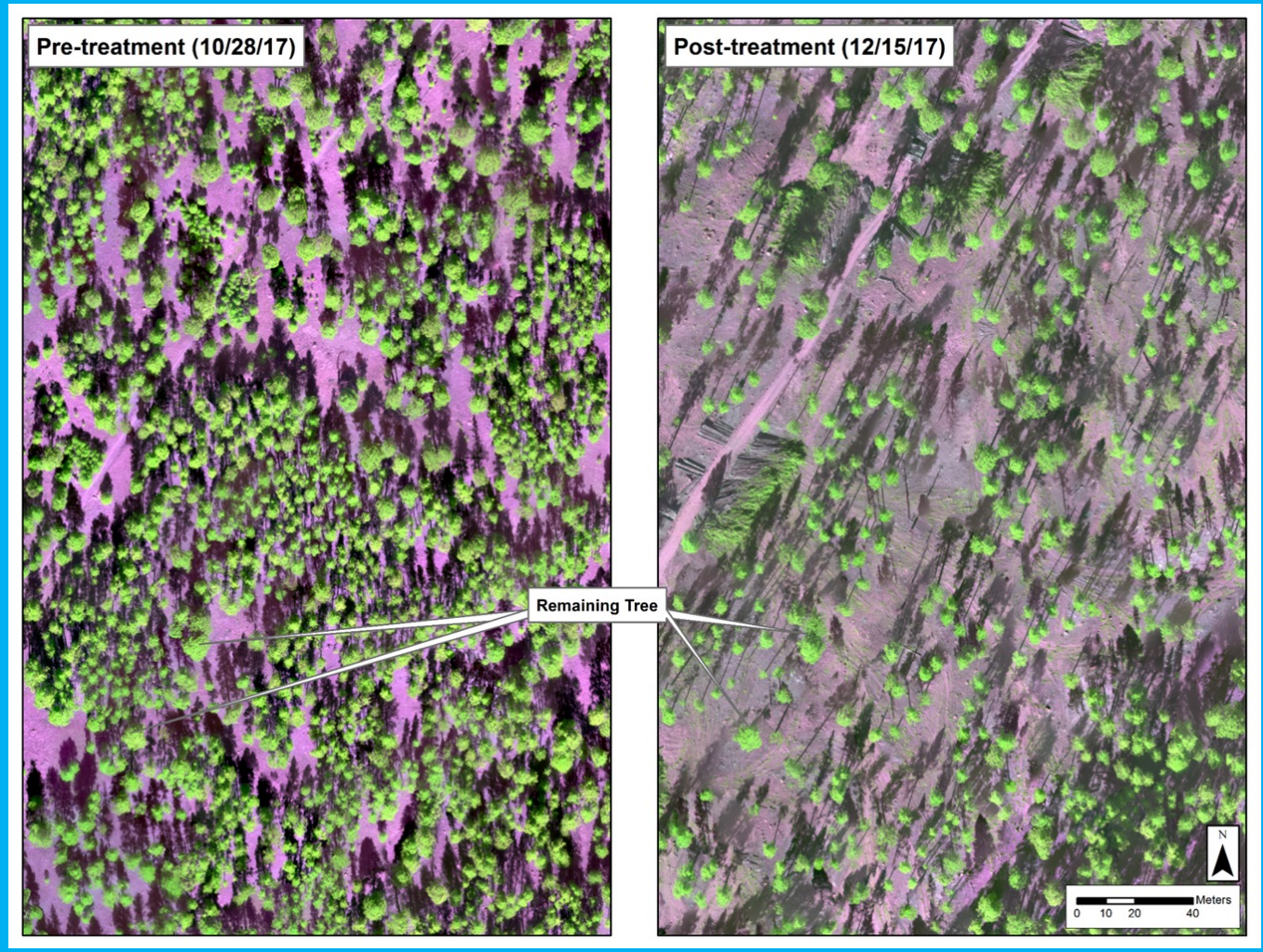
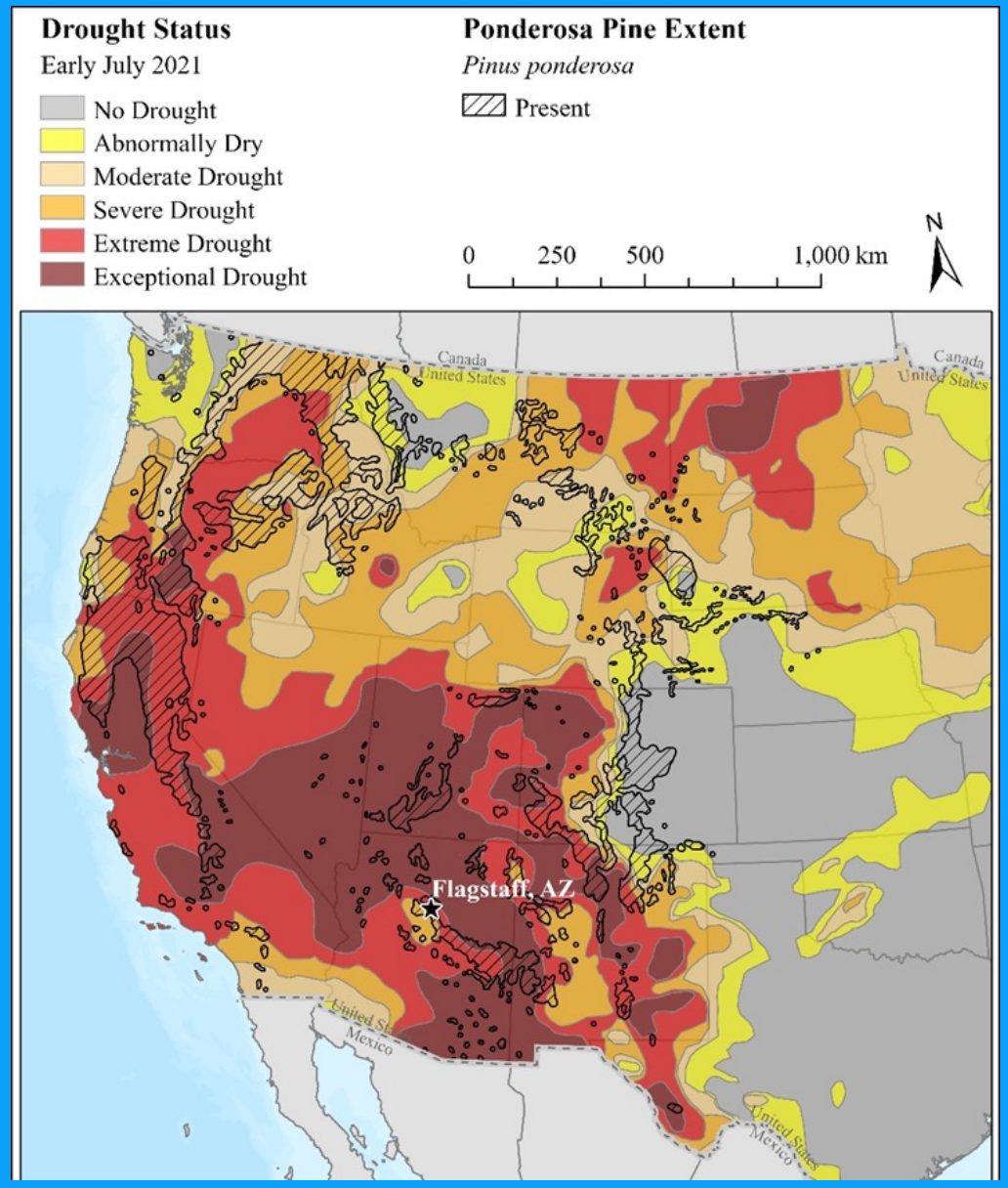
Project Goals

1) Local-scale ECOSTRESS validation of forest thinning benefits in drought resiliency

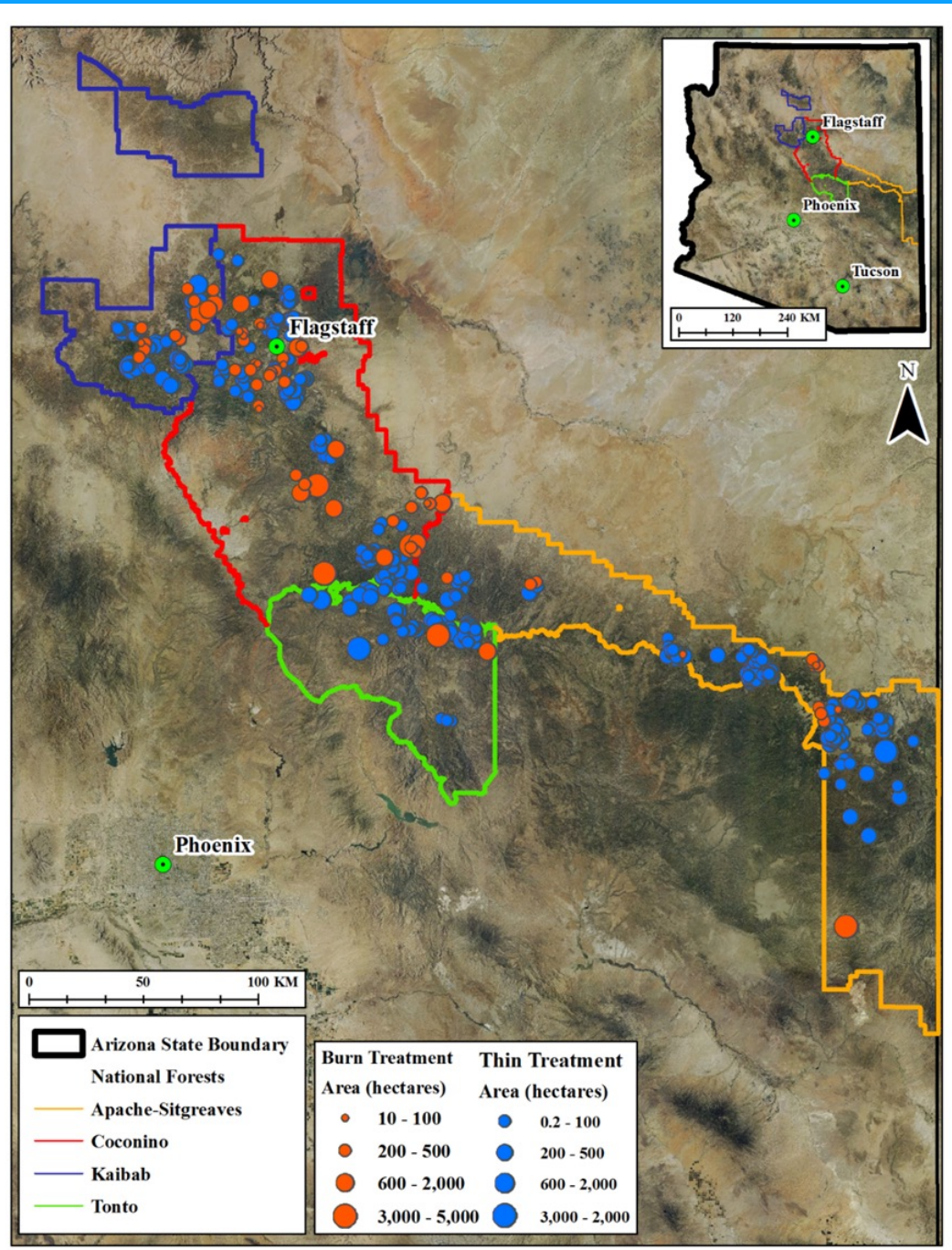
2) Regional-scale ECOSTRESS analysis across the state of Arizona



Regional Forest and ECOSTRESS

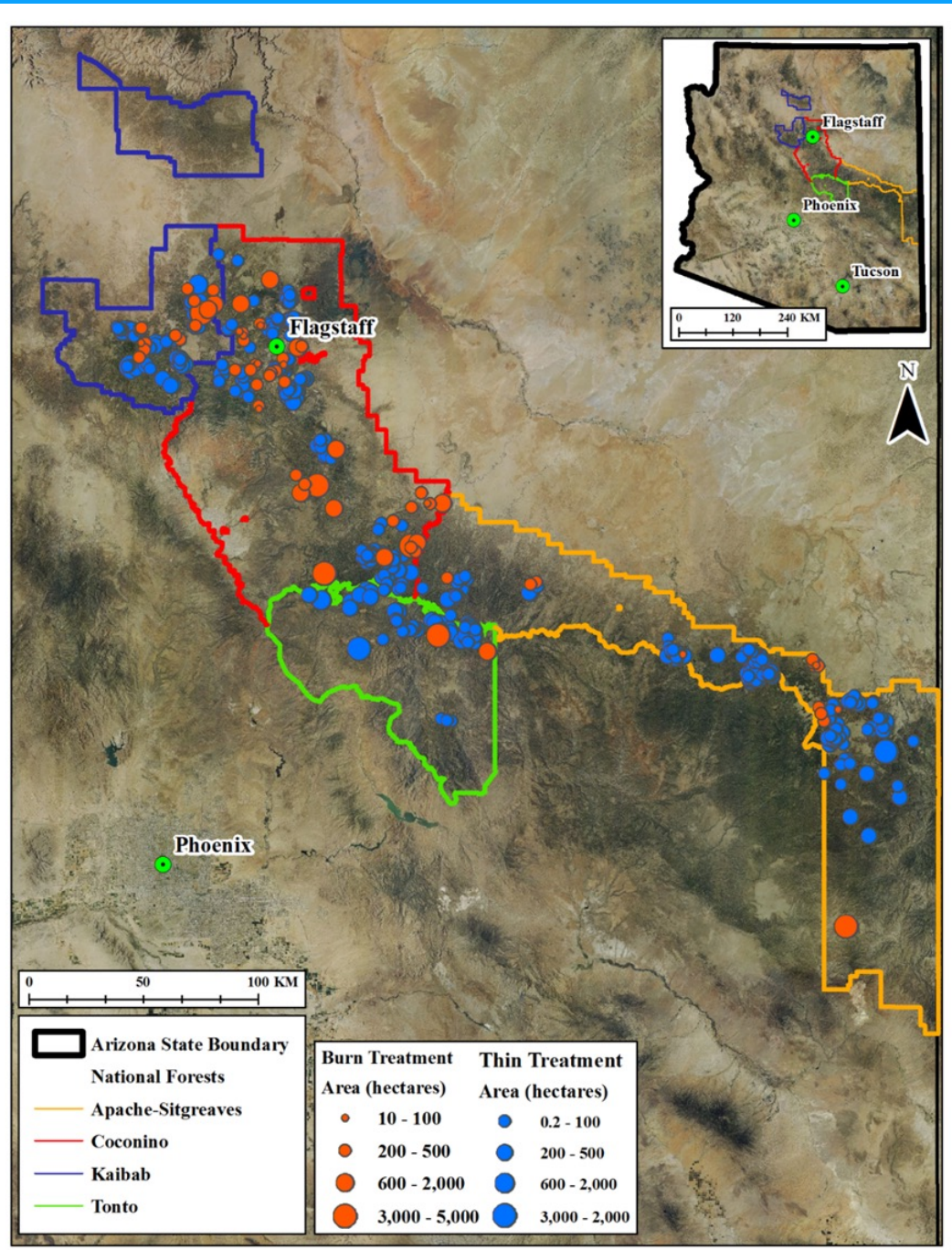


- Southwestern US forests are increasingly impacted by:
  - Regional drought
  - Catastrophic wildfires



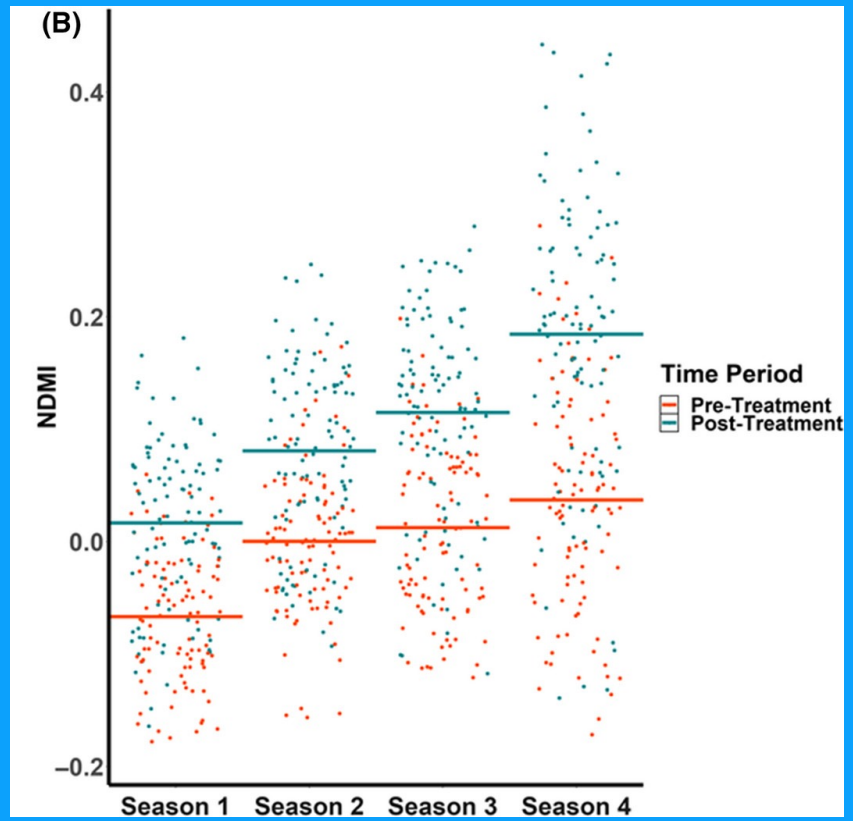
Arizona: Regional Treatment

- 3.5M ha across 4 National Forests
- First and largest restoration effort
  - Mechanical thinning
  - Prescribed burning

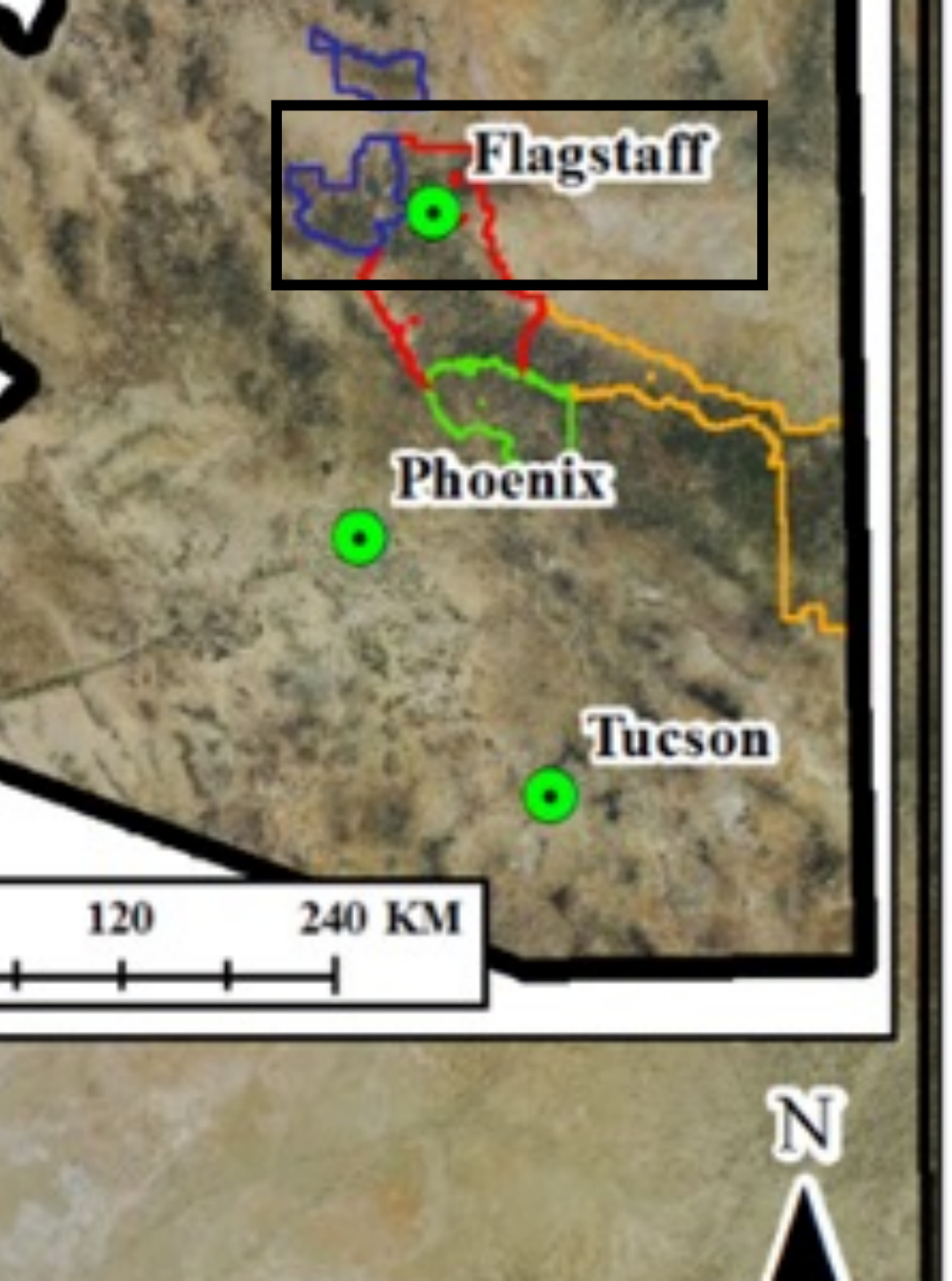


Regional-Scale Analysis

- Landsat time-series analysis
- ECOSTRESS LST and ET



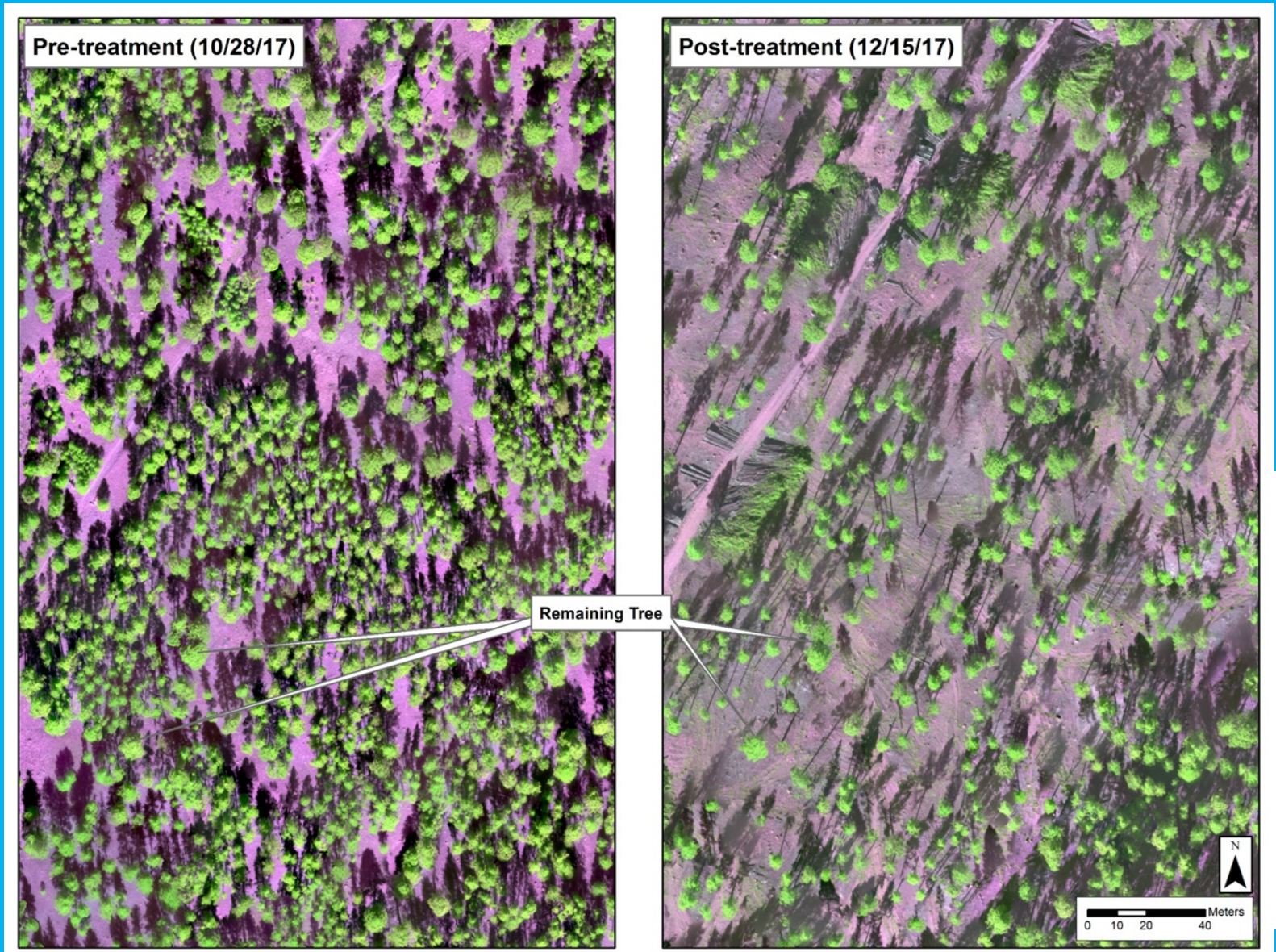
Sankey et al., 2021. Remote Sensing in Ecology and Conservation



Local Scale: Chimney Springs

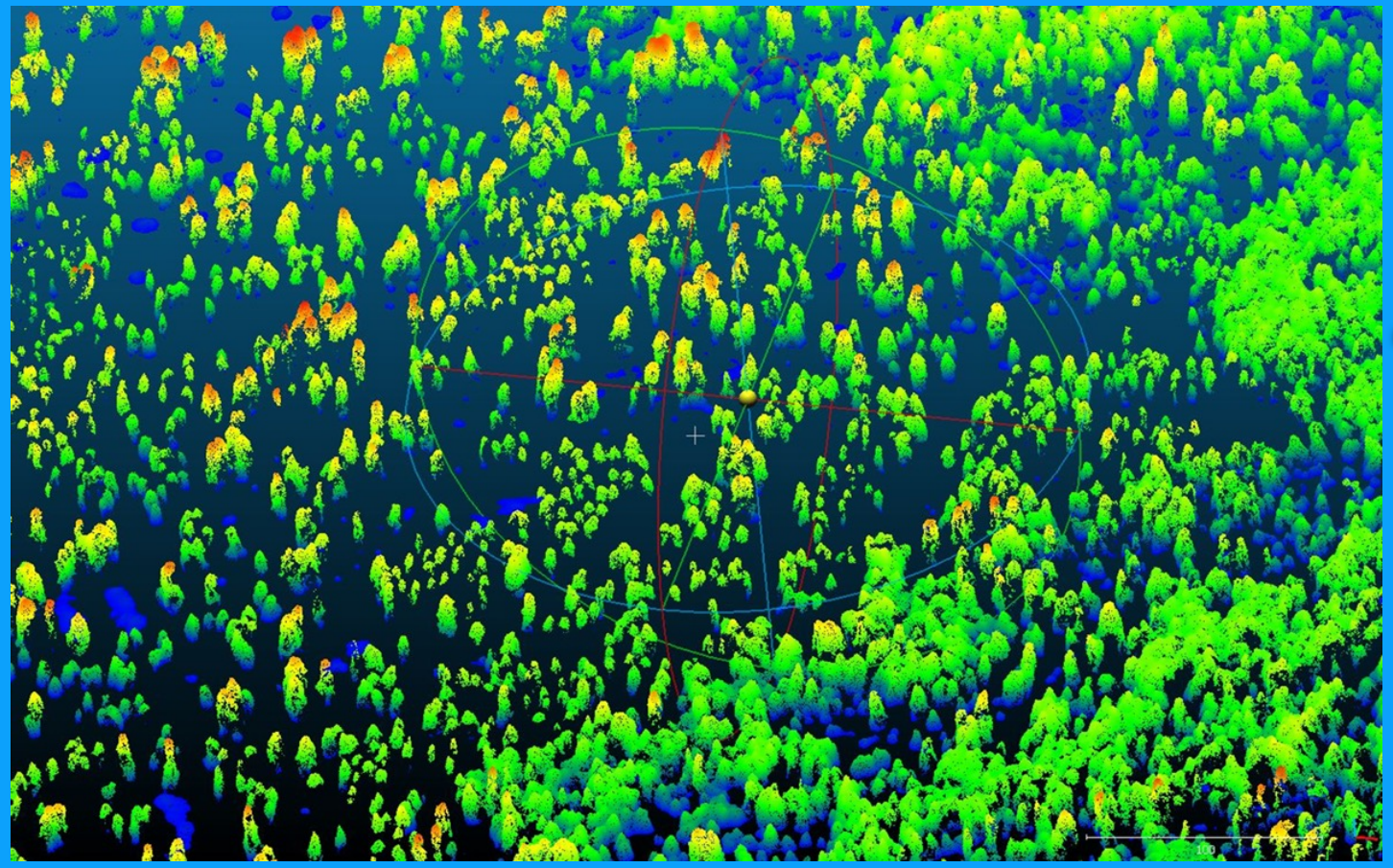
- Mechanical thinning in 2018
- We have monitored it since 2017 and pre-thinning

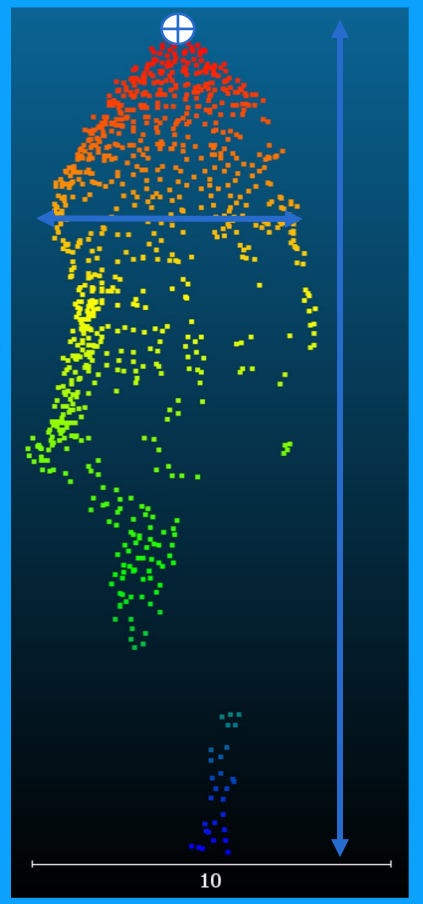
Thinning Impacts on Forest canopy cover and density

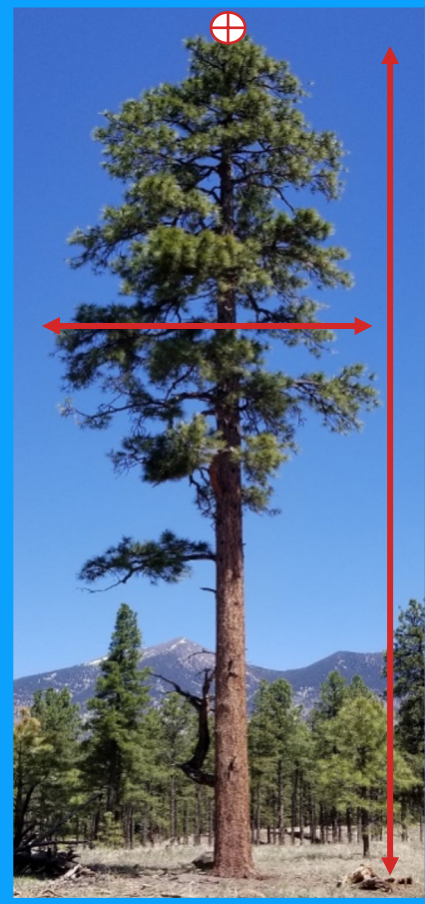


Belmonte, Sankey et al., 2020. Remote Sensing in Ecology and Conservation

Lidar data: Thinning impacts on Forest Structure



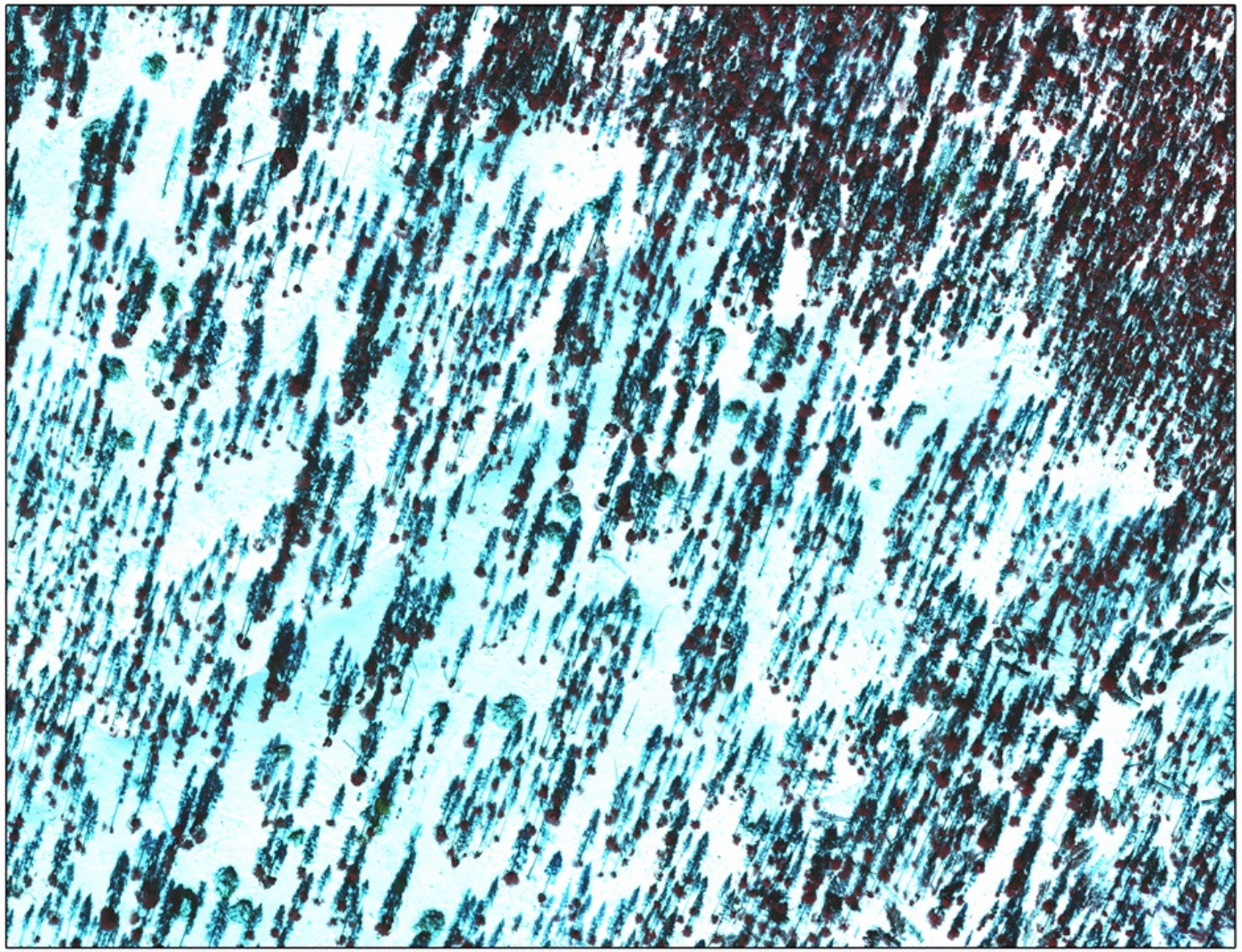


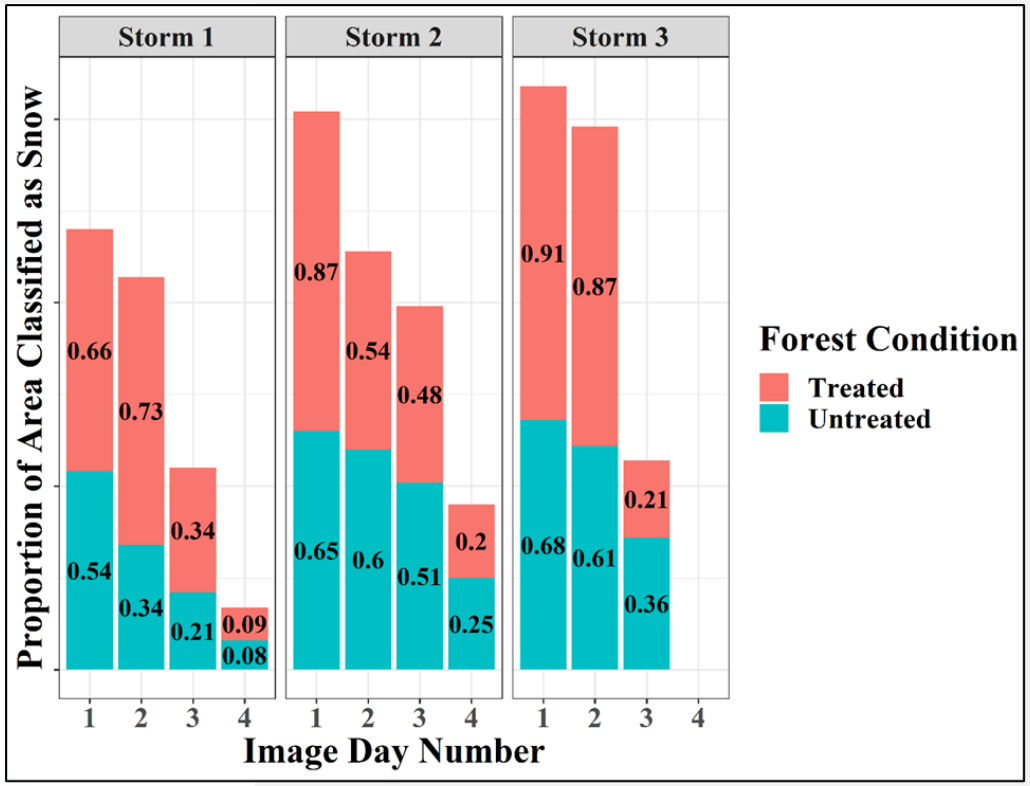


- Individual tree location, height, crown diameter, BA

Belmonte, Sankey et al., 2020. Remote Sensing in Ecology and Conservation

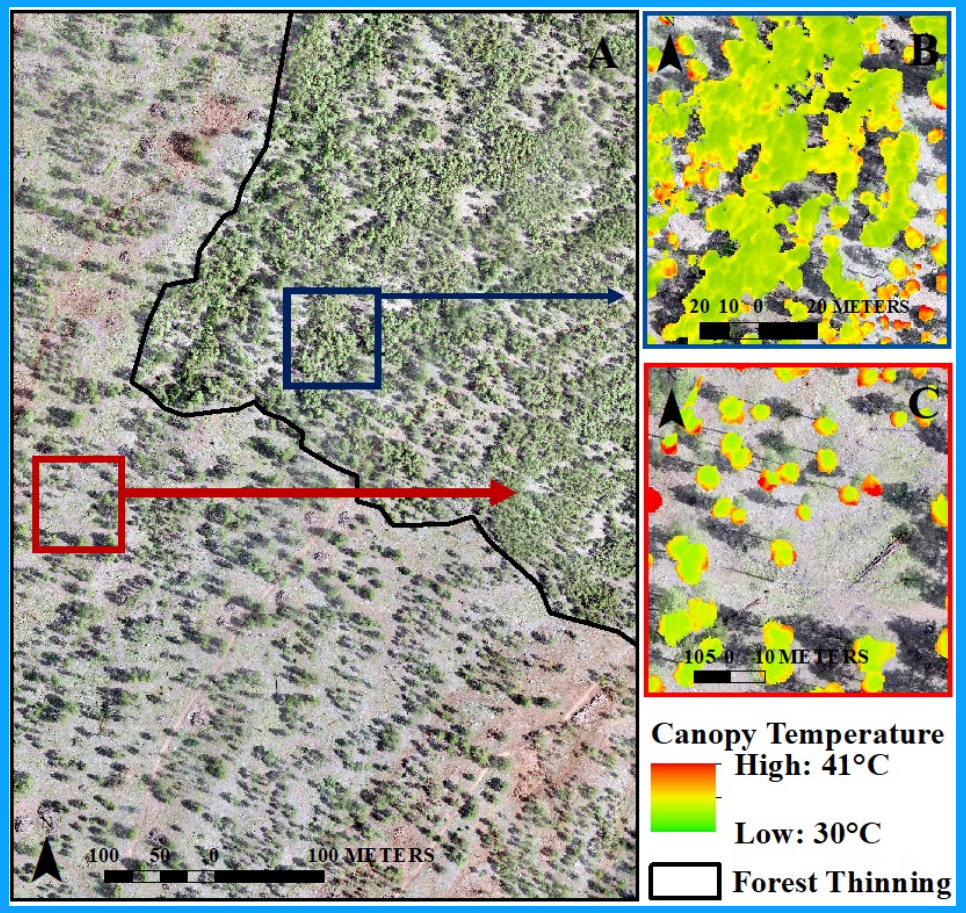
Thinning impacts on snow cover persistence

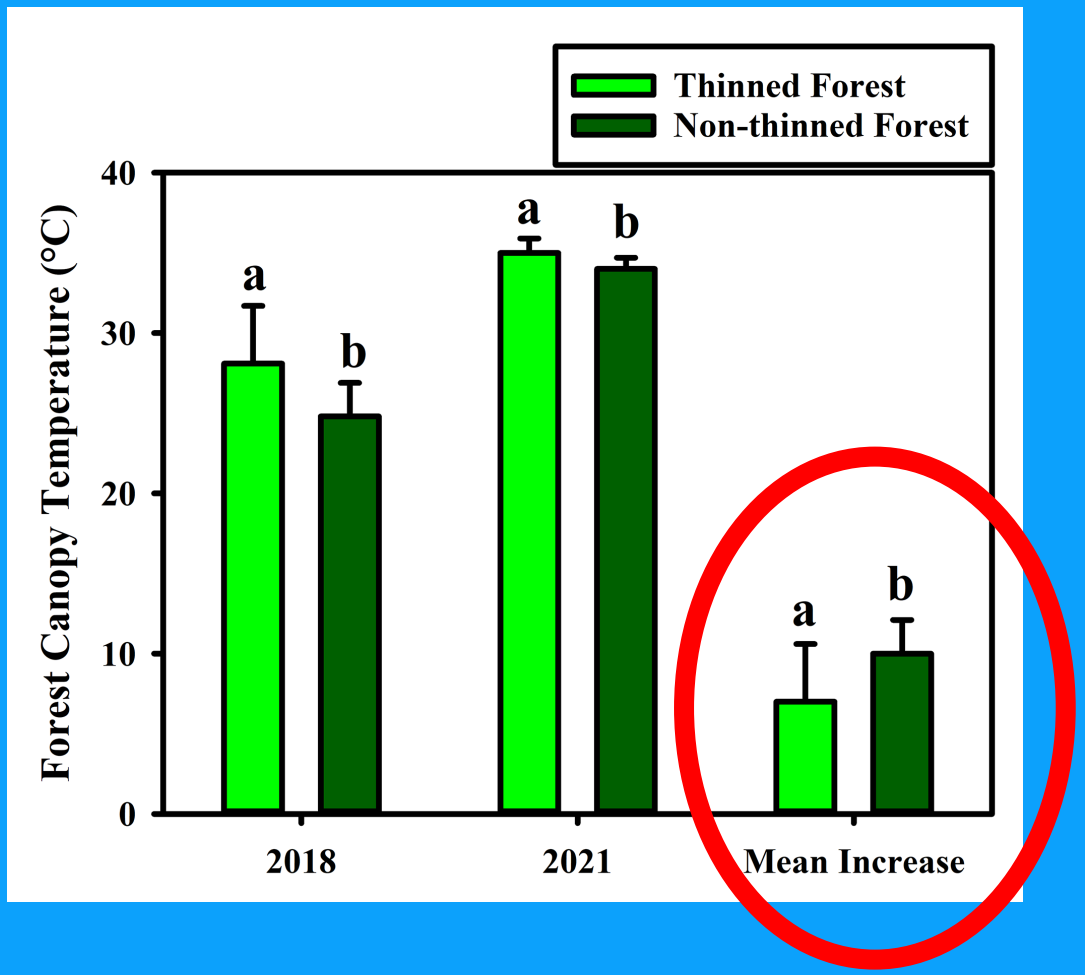




Belmonte, Sankey et al., 2021. Remote Sensing

Thinning impacts on drought resiliency

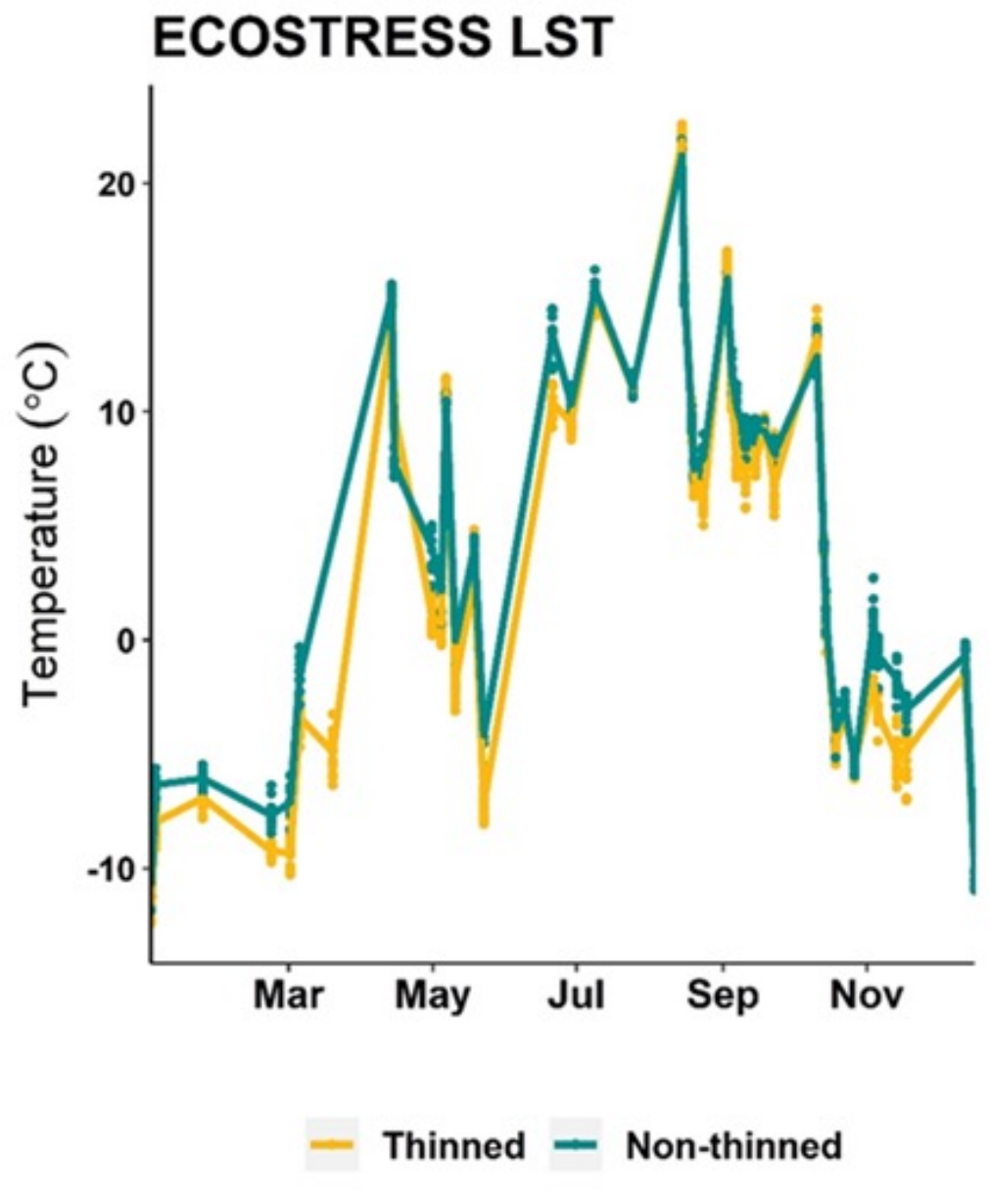




- **Temperature increase significantly greater in non-thinned forest**

Sankey and Tatum, 2022. Scientific Reports

Validating ECOSTRESS LST



- **Local-scale UAV LST images:**
  - **Across a tree density gradient**
  - **Across seasons and years**
    - **2020-2024**

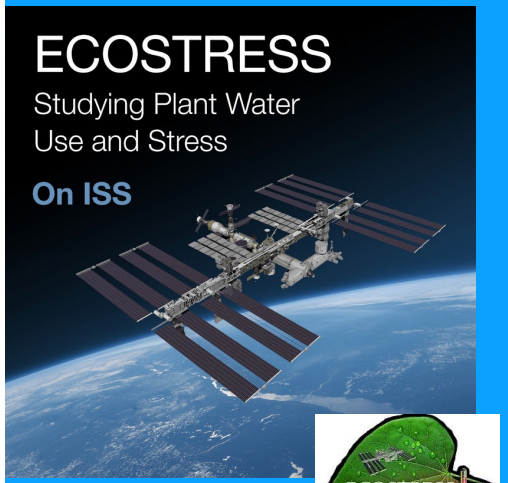
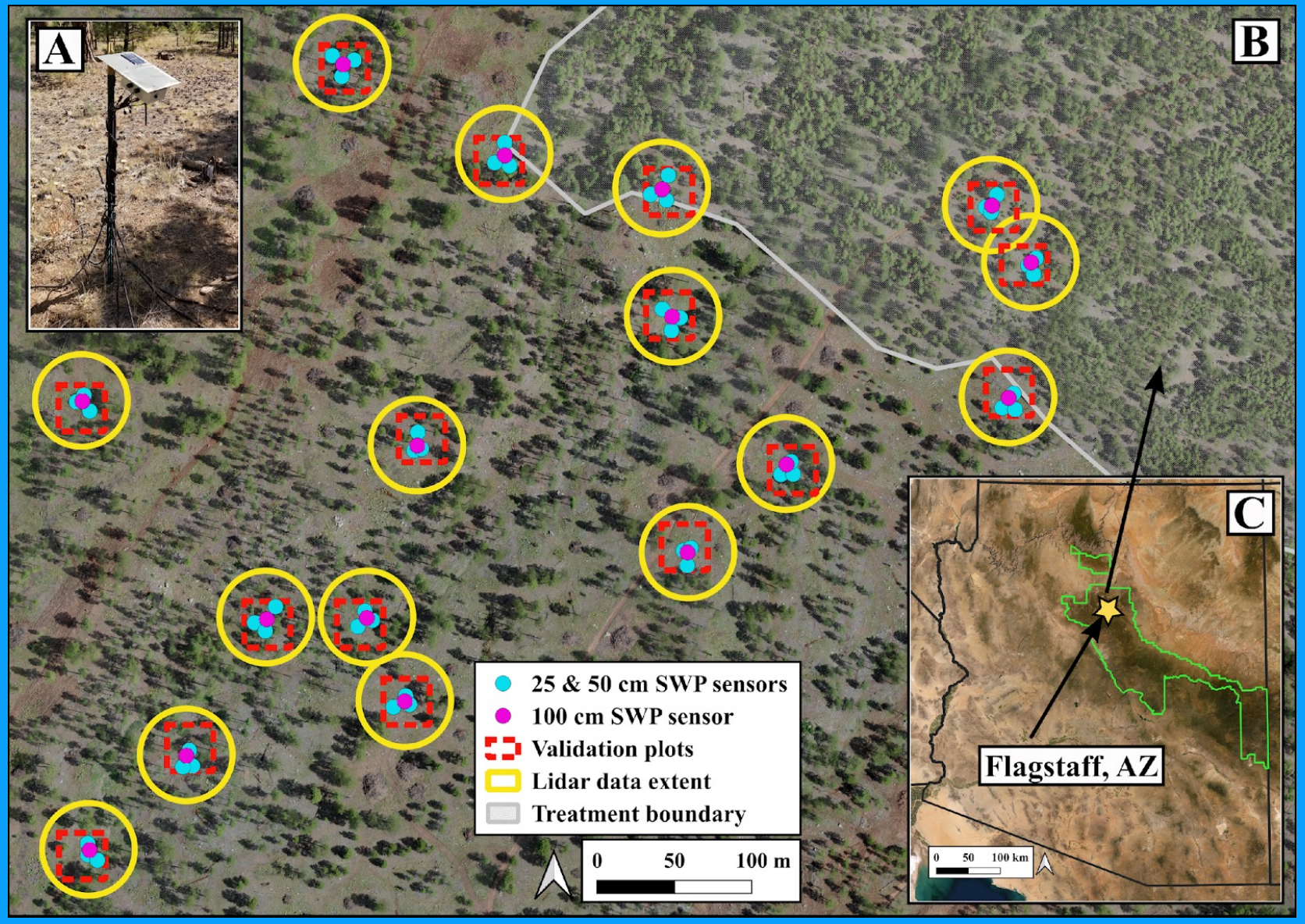


Image credits: NASA

Validating ECOSTRESS Soil Moisture Product



We have:

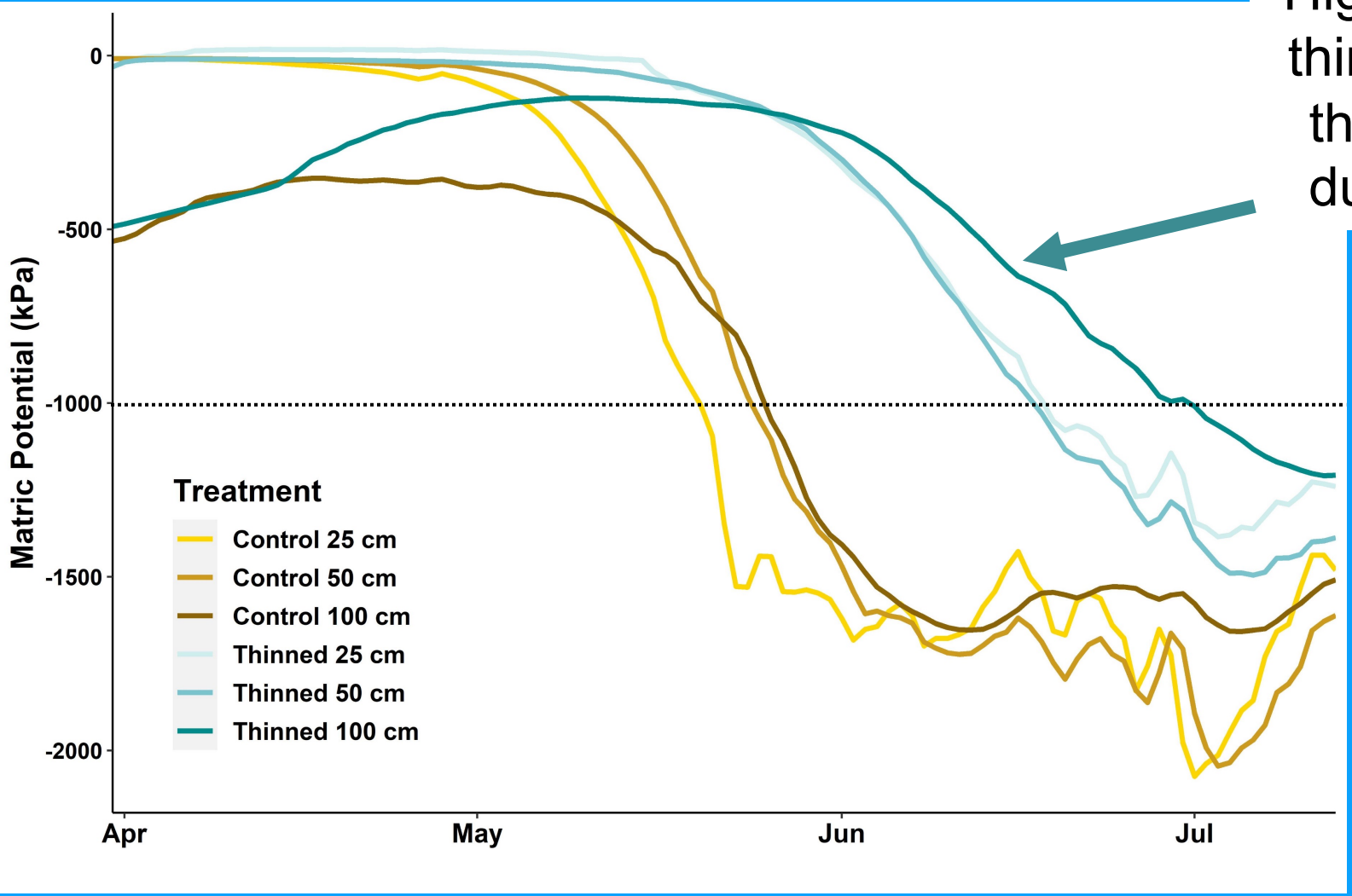
- **Total of ~130 soil moisture sensors**
- **3 depths: 25cm, 50cm, and 100 cm**
- **Data starts in late 2018**

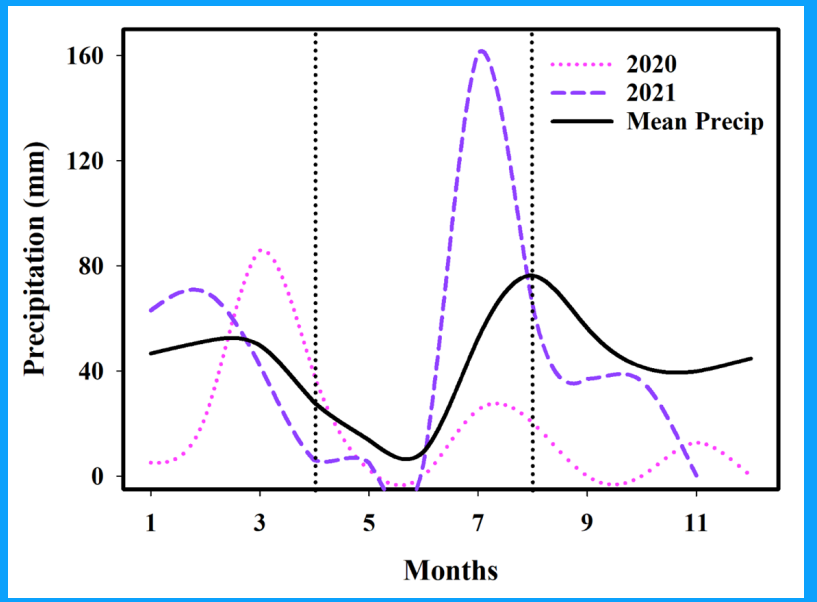
Validating ECOSTRESS Soil Moisture Product

- **Meter Terros (Decagon MPS6)**
- **Hourly soil water potential**
- **N=75 in thinned forest**
- **N=54 in non-thinned forest**

ECOSTRESS Soil Moisture Data for Drought Monitoring

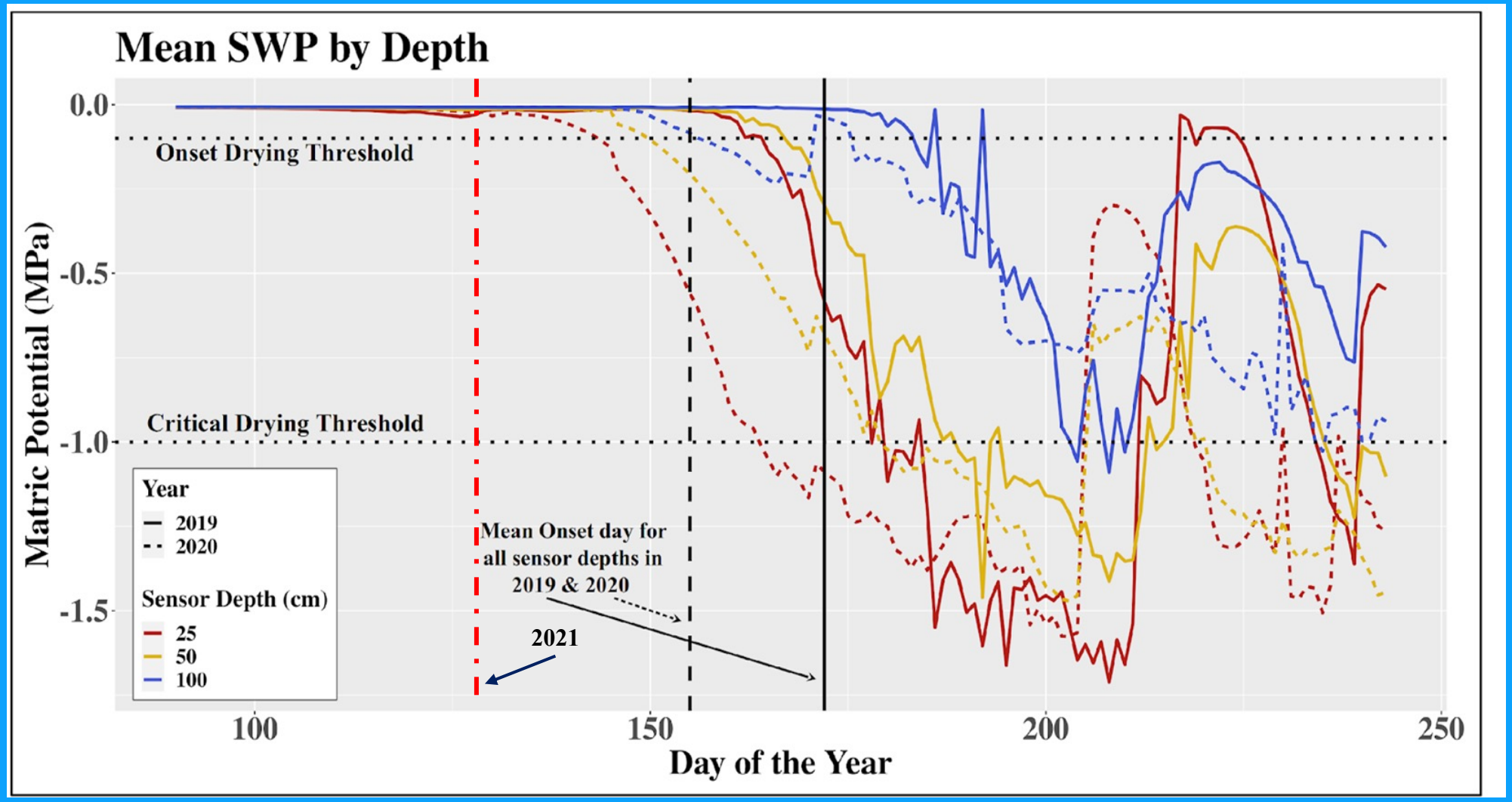
Higher soil moisture in thinned stands across the soil depth profile during 2021 drought





Sankey and Tatum, 2022. Scientific Reports

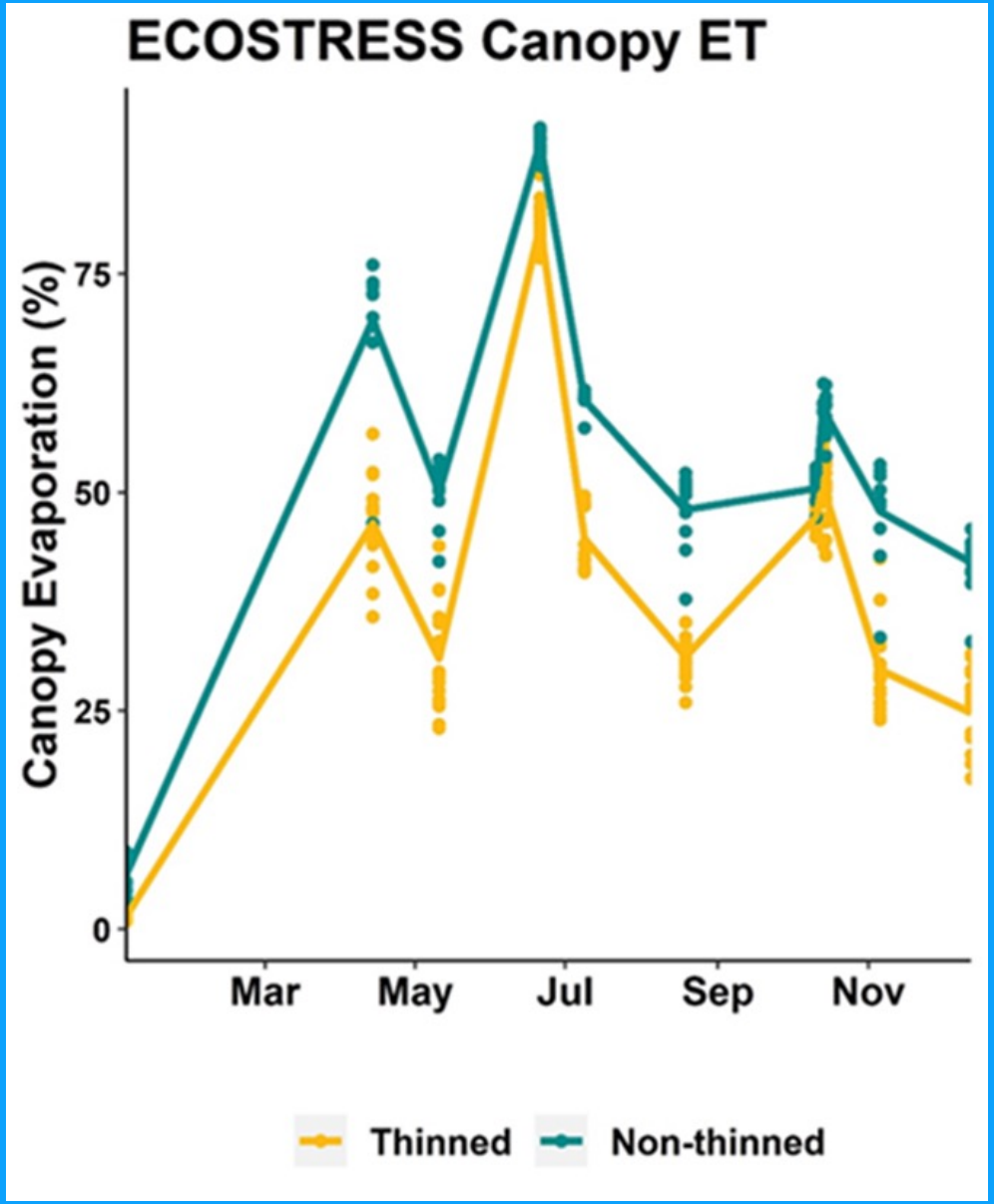
Additional Soil Moisture Metrics to link to ECOSTRESS



- **Soil drying onset started earlier in 2021 due to drought than in 2020 and 2019**
- **Non-thinned forest stands spent 26 extra days below a threshold critical for ponderosa pine**

How does forest thinning influence ET?

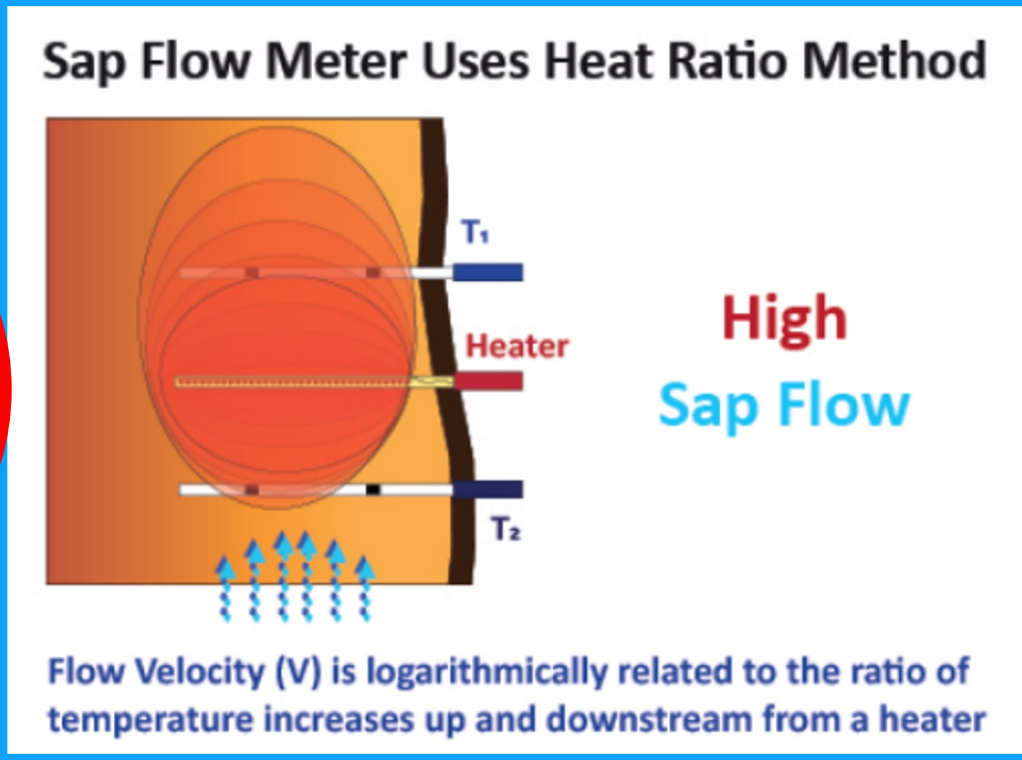
Validating ECOSTRESS ET



- **Local-scale sap flow data:**
  - **Across tree density gradient**
  - **Across seasons and years**
    - **2022-2025**

Image credits: NASA

Sap Flow Sensors for validating ECOSTRESS ET



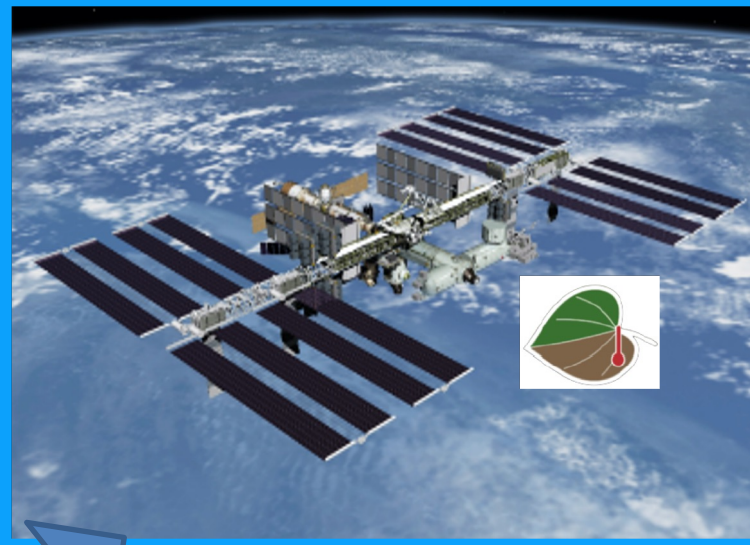
- **Total of 45 sap flow sensors**
- **N=20 in thinned forest**
- **N=25 in non-thinned forest**

Sapflow Scaling

K-means imputation of **daily sapflow** for uninstrumented trees to estimate canopy sapflow per ha

dbh, sapwood area, density, **daily sapflow**

dbh, sapwood area, density, **no sapflow**



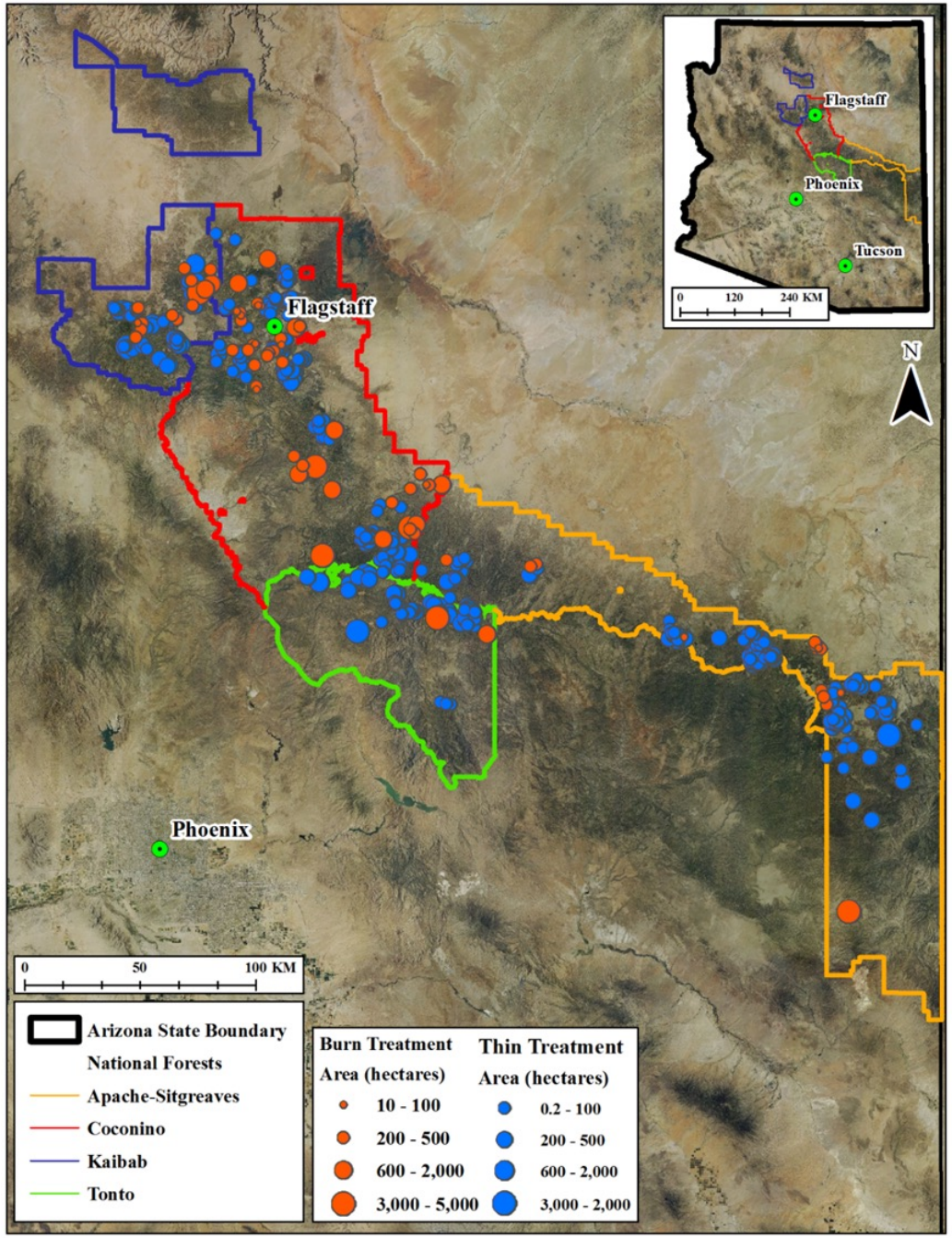
Plot Radius = 15 m
0.07 ha plot

Plot Boundary

Instrumented trees
Uninstrumented trees

Bowen Ratio Weather Stations for sub-canopy ET

- **We have installed one in thinned and one in non-thinned forest stands**



Regional-Scale Analysis

- Upscaling local results to regional data
- ECOSTRESS LST
- ECOSTRESS ET
- ECOSTRESS Build 7.1 Soil Moisture product

Sankey et al., 2021. Remote Sensing in Ecology and Conservation

Questions?

Soil Moisture and Forest Structure

Most important variables:

- Canopy cover (<30%)
- Tree density (<100 trees/ha)
- Mean crown height
- Mean diameter at DBH