Remote Sensing of Forest Health: Ecosystem Disturbance and Recovery Tracker (eDaRT)

Region 5 Remote Sensing Lab

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eDaRT Overview

A group of automated and interactive ecosystem dynamics analysis tools being developed for remote sensing analysts to rapidly generate on-demand map products and habitat assessments supporting local and regional scale forest management

Background: a need for near real-time vegetation monitoring

- eDaRT initially developed to track the timing and magnitude of change in CA spotted owl PACs
- Continued needs led to further development:
  - Cheap forest monitoring for adaptive management activities
  - Spatial resolution suitable for project planning
  - Complete coverage across large areas
  - A customizable tool to answer always evolving questions

eDaRT algorithm overview

- Disturbance detection algorithm that finds anomalies in vegetation health & structure*
  - fires, treatments, and mortality
- Landsat 5/7/8: 30 m, 8-16 day repeat

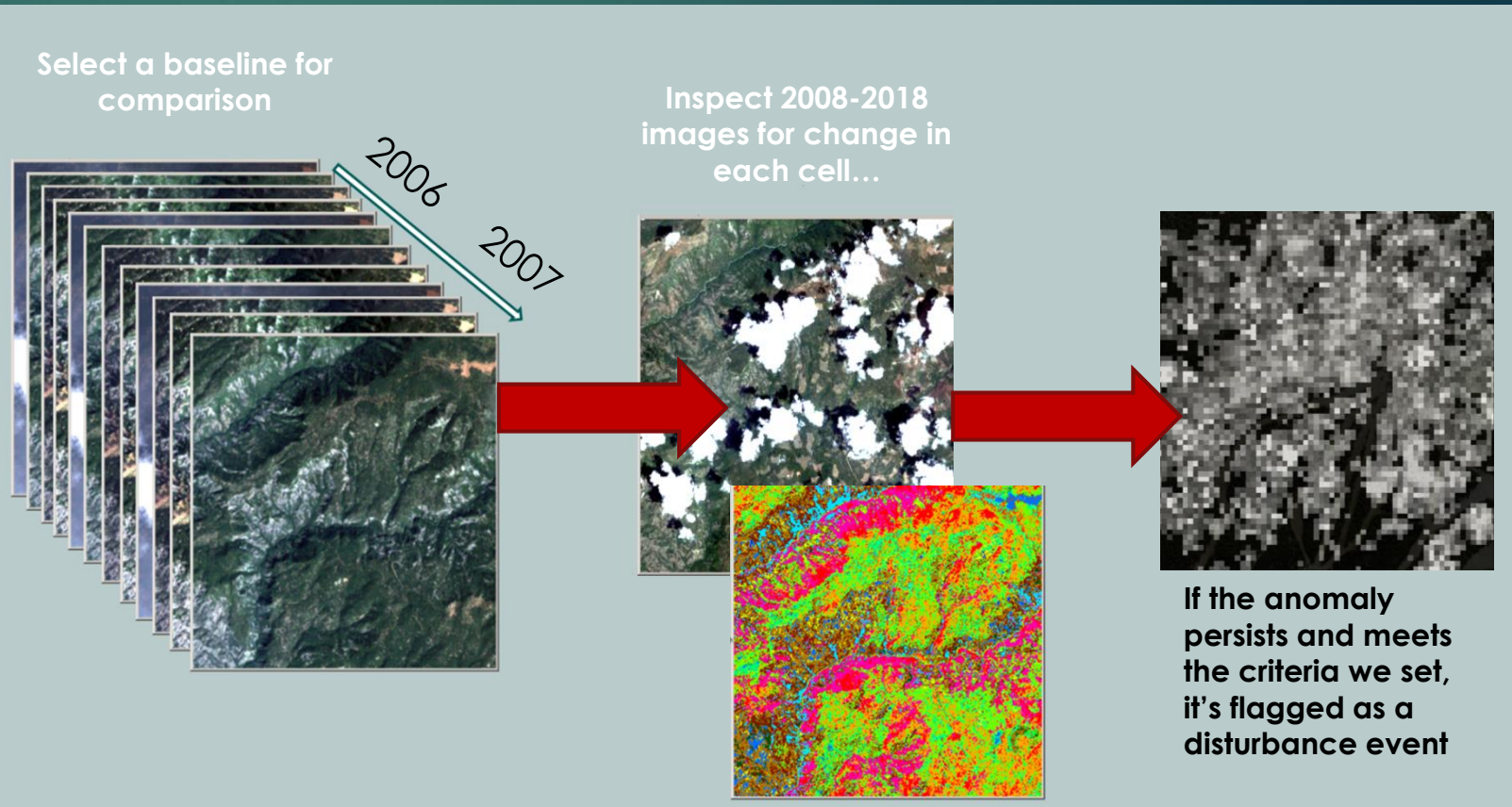
Spectral Bands and Indices

Original Landsat Bands

- ✓ Visible
- ✓ Near-Infrared
- ✓ Shortwave Infrared
- ✓ Thermal Infrared

Vegetation Indices

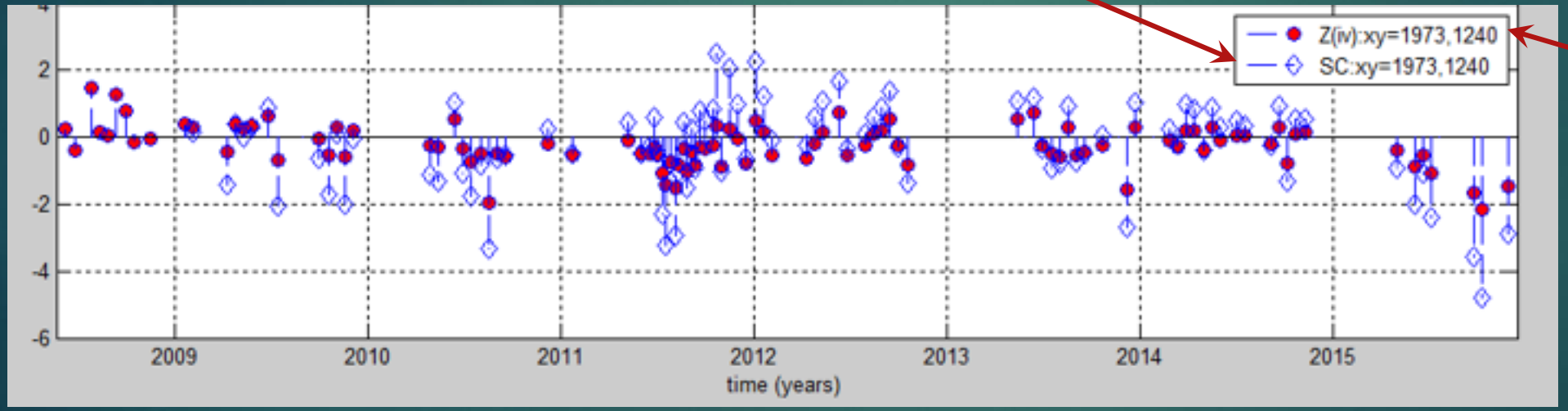
- ✓ Normalized Difference Vegetation Index (NDVI)
- ✓ Normalized Burn Ratio (NBR)
- ✓ Normalized Difference Infrared Index (NDII)
- ✓ Tasseled Cap Bands
  - ✓ Brightness, Greenness, Wetness, Angle



*Koltunov et al. 2009; 2015

Algorithm overview: Finding a changing regime

First, look for change wrt to historic baseline



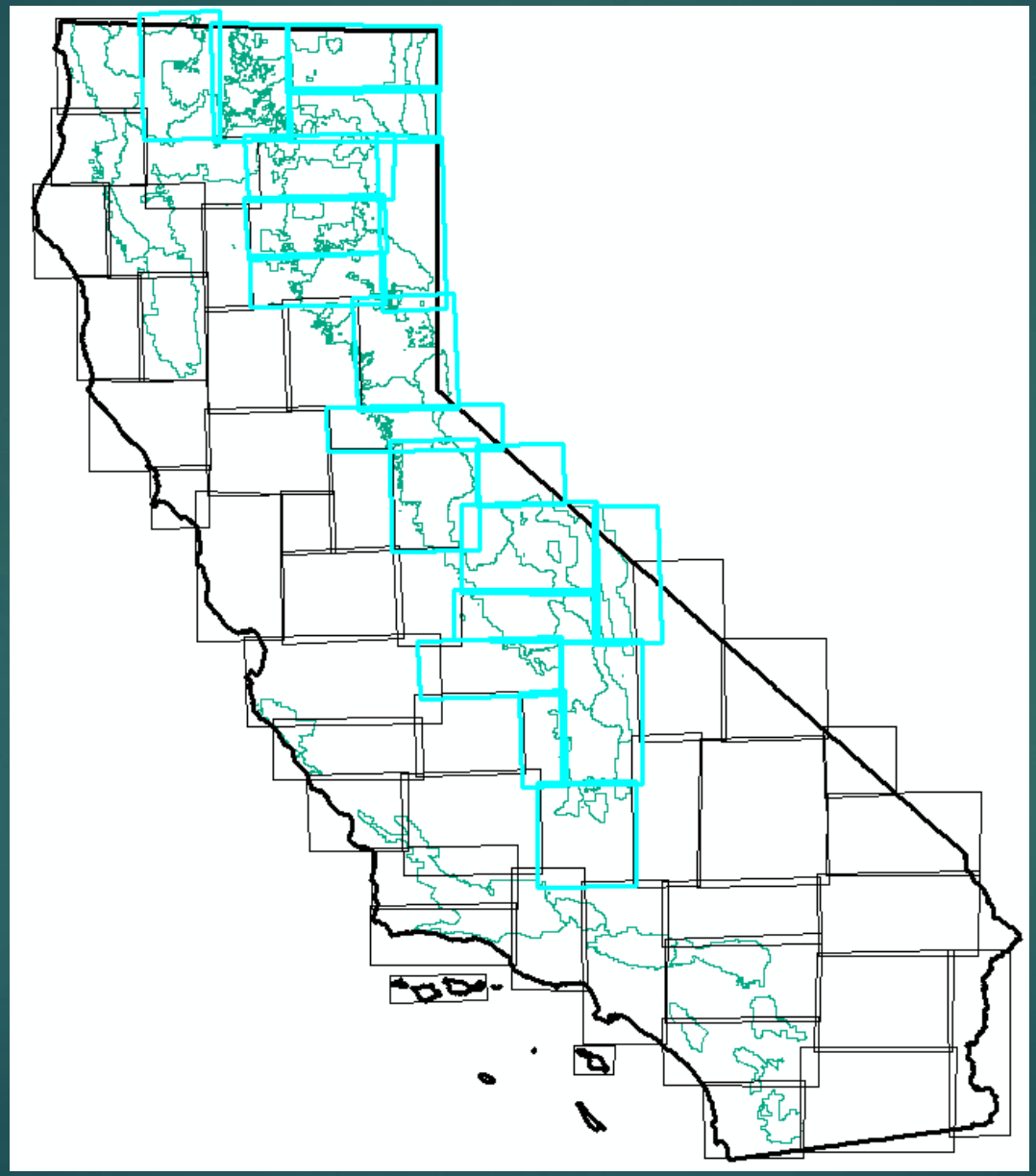
Then, use temporal filter of z-scores to look for persistence of trajectory – "relative anomalness"

eDaRT algorithm overview

Problems addressed:

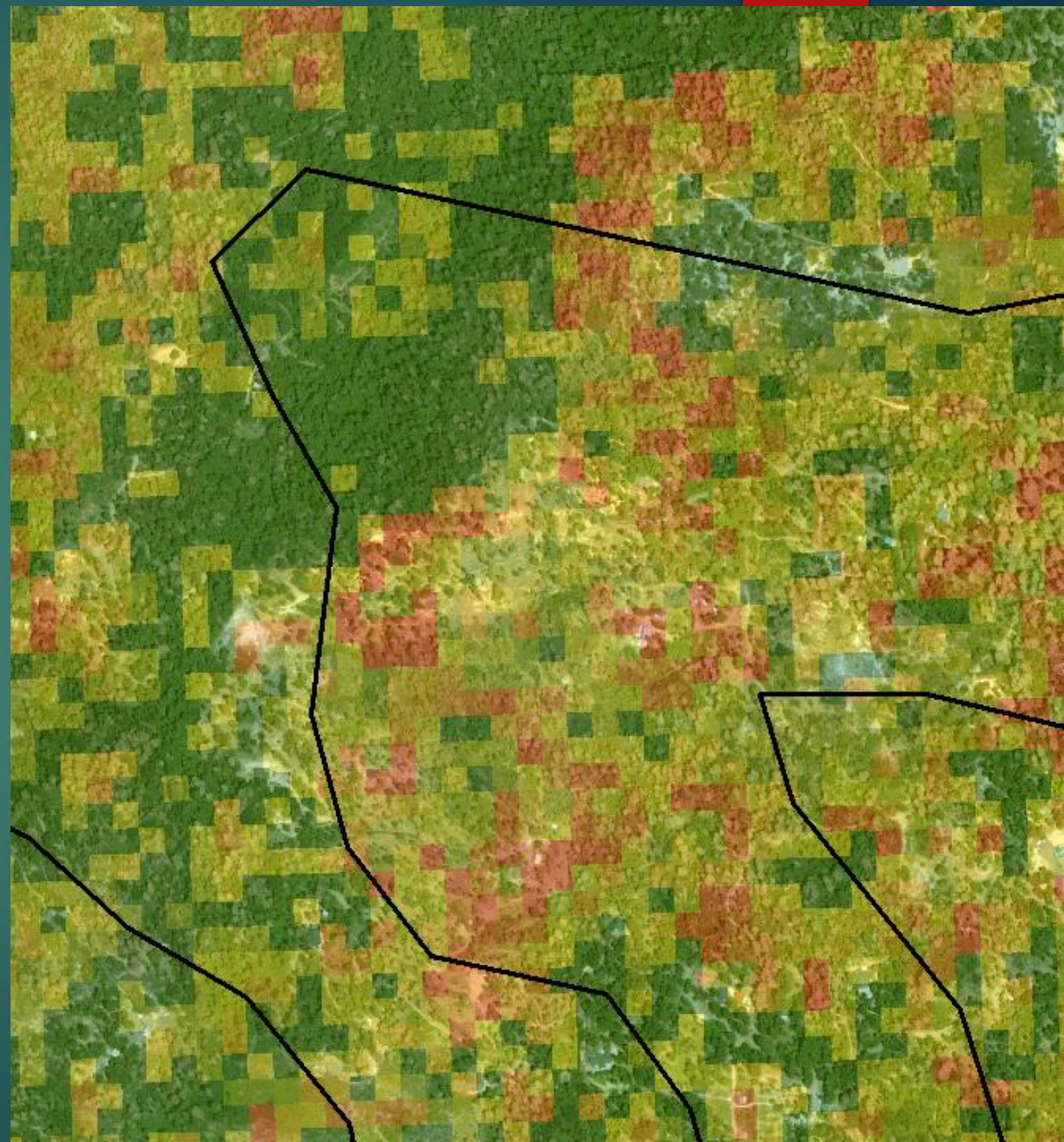
1) Everything changes due to phenology, sensor factors, etc.
   - **Approach:** 100% empirical statistical model: Dynamic Detection Model (Koltunov et al. 2009) looks at past & present state of pixels of similar land cover type
2) Estimating event magnitude
   - **Approach:** Use z-scores as a proxy.
3) Processing 10's of terabytes of data in a timely manner
   - **Approach:** Auto-run components, parallel processing

State-wide eDaRT scenes & Sierra Nevada-Cascade Mortality focus area



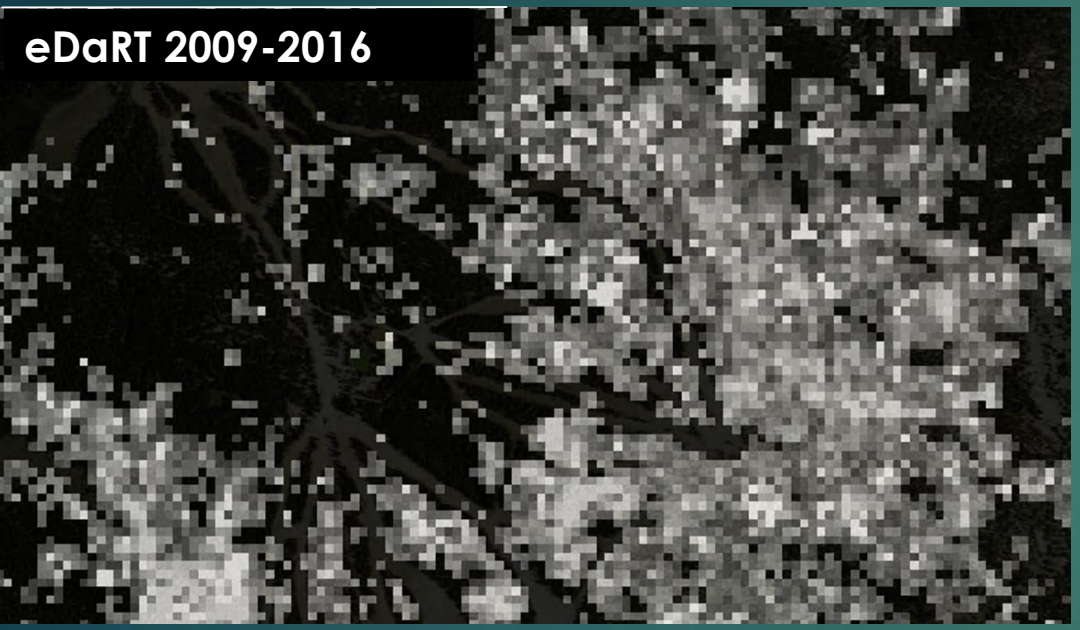
2016 Worldview Image
S of Shaver Lake, near Sierra Cedars

2009-2016 eDaRT Mortality & ADS Polygon



High elevation white pine example

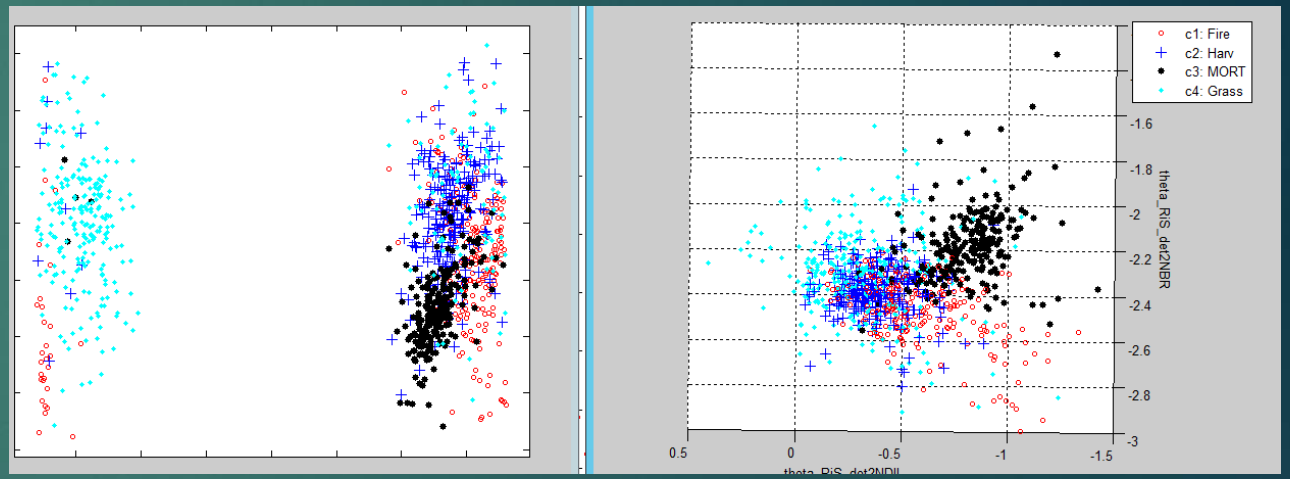
Forest health:
eDaRT assessment in whitebark pine on June Mt., Inyo NF shows 97% accuracy in detecting actual mortality



eDaRT enhancements(v2.8)

- Landsat 8 support and pre-planning for Sentinel 2A and 2B
- Automatic disturbance type classifier (in testing)
- Better estimation of the magnitude of the disturbance: A mortality magnitude index (MMI)
  - adding additional spectral metrics
  - switching from normalized z-scores to residuals
- Data roll-out plans

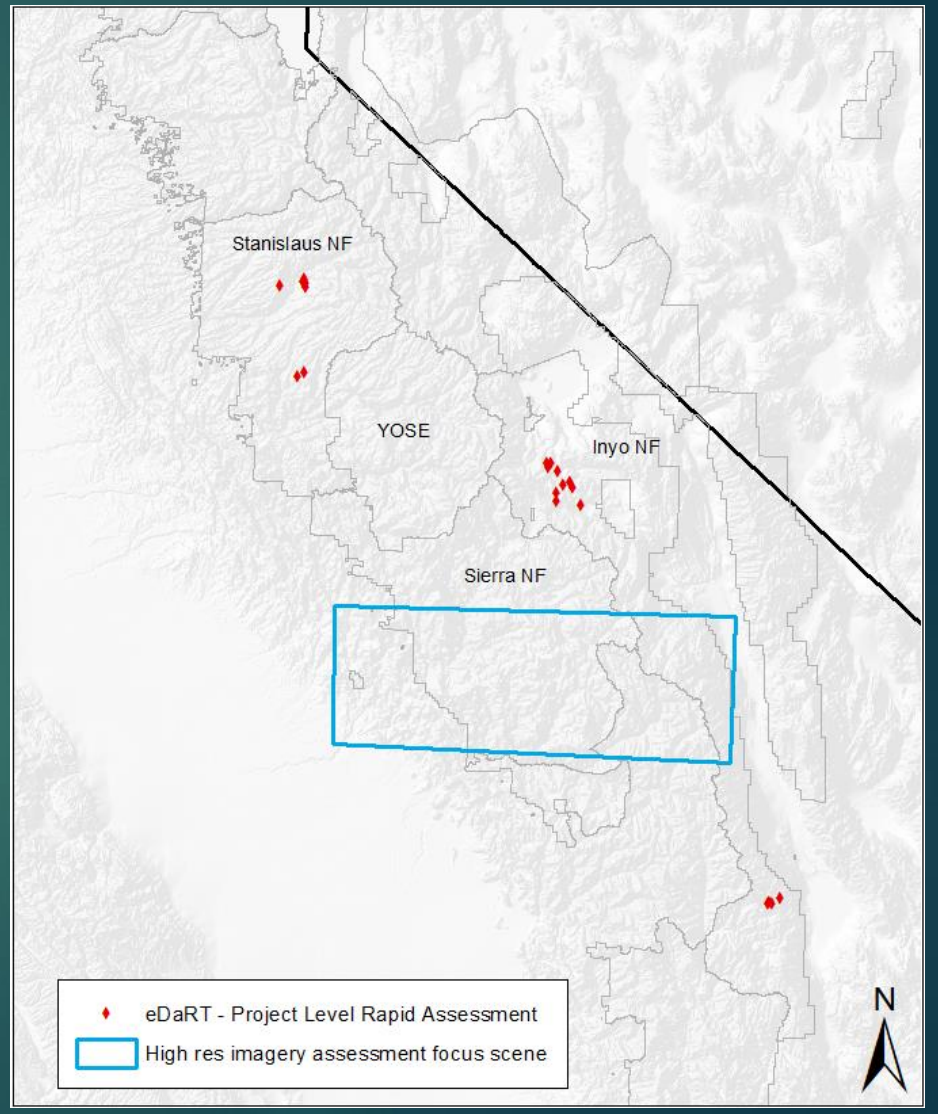
fr.264 sc.406: Residuals for different disturbances (angles in spherical coordinates)

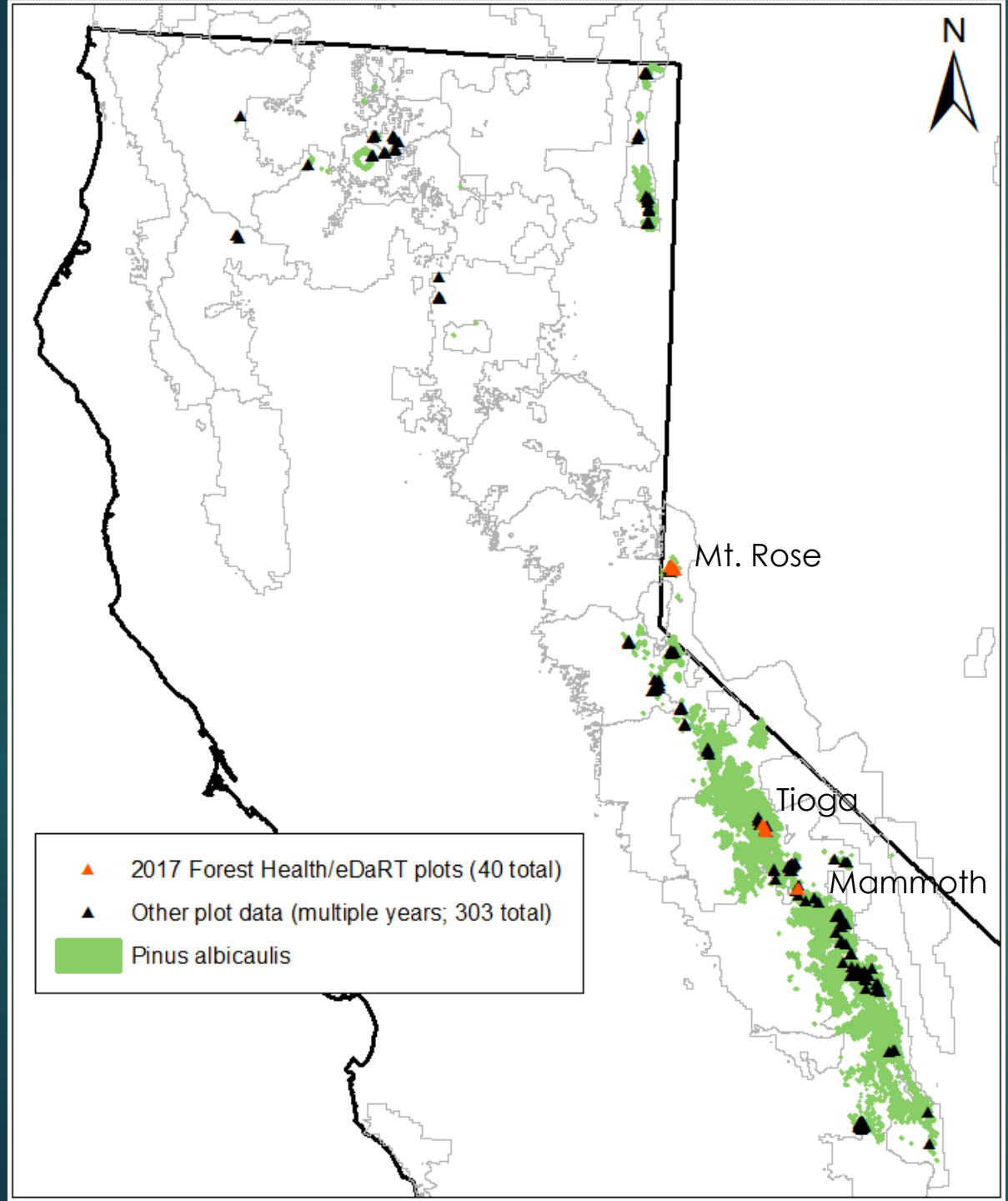


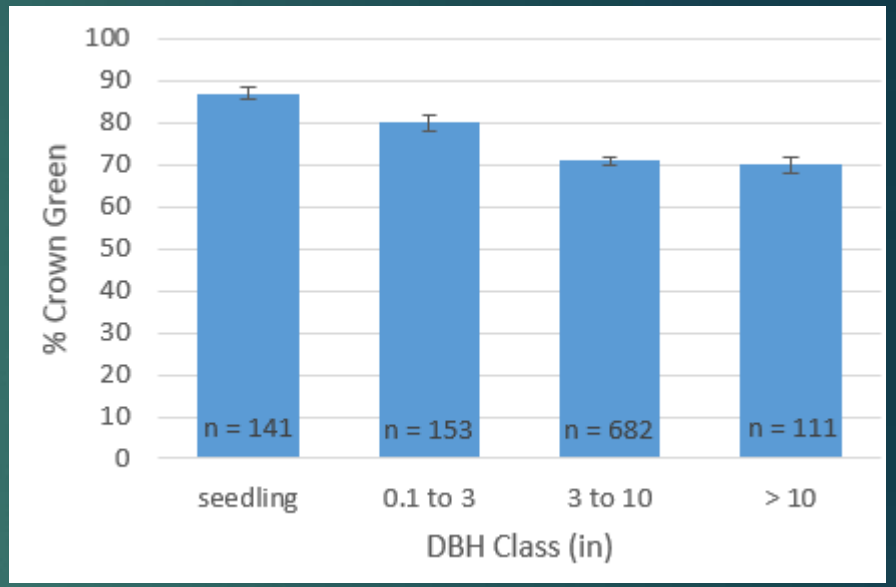
Manuscript in preparation for Remote Sensing of Environment (March 2018)

Calibration/Validation

- High res imagery
  - Most efficient, but interpretation limited to observable changes and limited availability spatially and temporally
- Field validation
  - Cons: mis-registration of plots with imagery; expensive
  - Pros
    - extremely important to project managers
    - a reality check for the vertical and horizontal structure of disturbance in translating the trajectories of bands
    - Quantifying low to moderate level mortality to develop a Mortality Magnitude Index
  - To date:
    - 2016 & 2017 rapid assessment as mortality unfolded
    - 2017 – Whitebark pine – Modified CSE for forest health & RS apps
  - Plans – 2018 & beyond:
    - Distinguish signs of disturbance agents, moisture stress, needle drop
    - Vertical structure, e.g. crown density, fine twig retention, shrubs/herbs

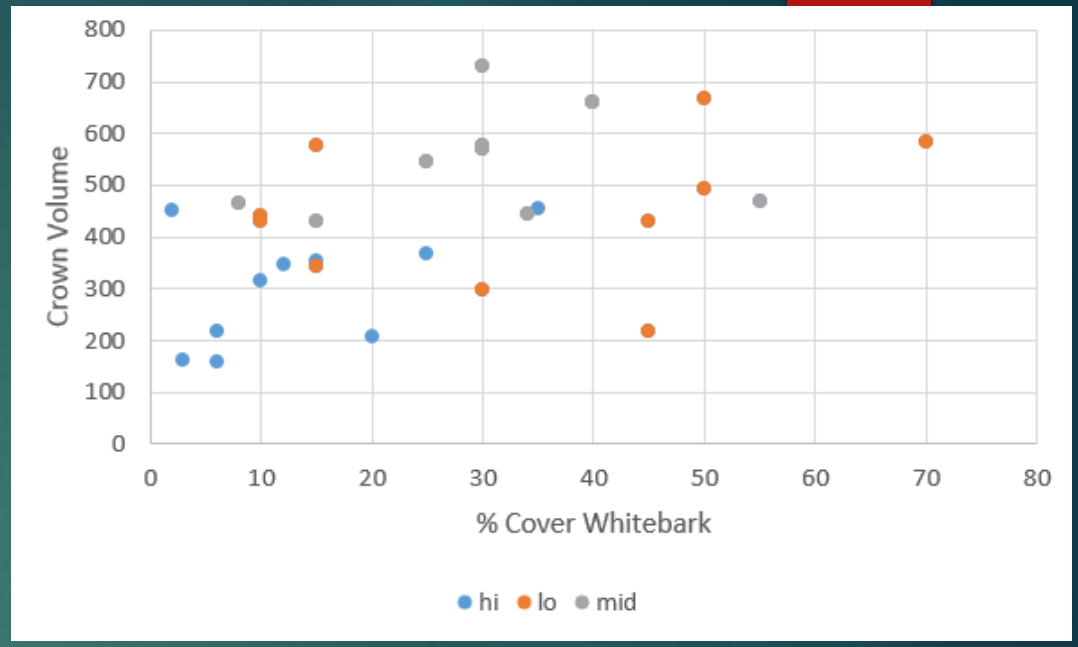






2017 Forest Health/eDaRT plots – prelim results in whitebark pine

Structure matters.



Low elevation: erect trees

Mid elevation: loose clumps

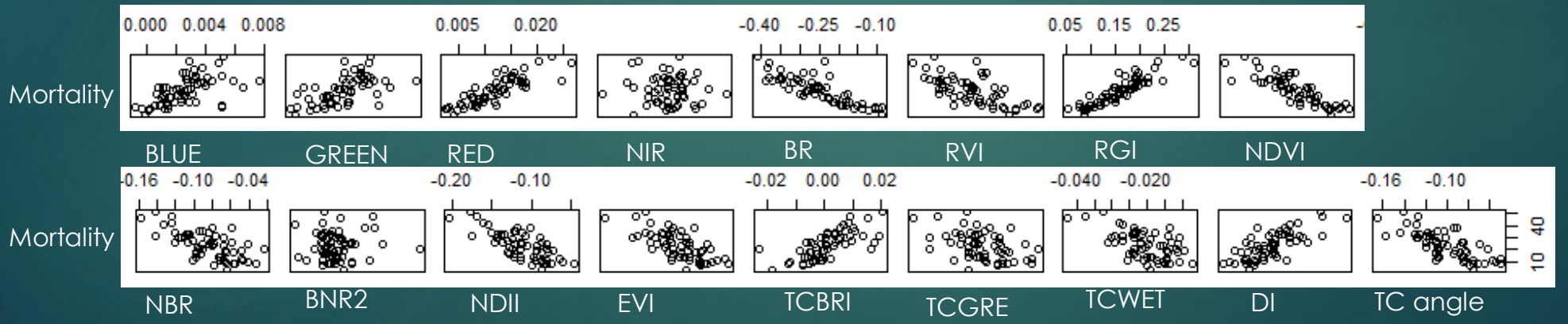
High elevation: krummholz mats

Why?

…Because some vegetation indices are more sensitive to soil exposure, but others are better correlated to LAI (irrespective of fractional cover/soil exposure)

…Also, the seasonality and tempo of change can help discern tree v. shrub/herbaceous stress

…And help explain remaining error in initial testing of a Mortality Magnitude Index (Xiaolin Zhu et al.)



Thank you!

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References

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- Koltunov, A, C Ramirez, SL Ustin. 2015. eDaRT: the Ecosystem Disturbance and Recovery Tracking system prototype supporting ecosystem management in California. In 2015 NASA Carbon Cycle and Ecosystems Joint Science Workshop, April 19-24, 2015, College Park, MD, USA.
- Tempel, DJ, JJ Keane, RJ Gutierrez, JD Wolfe, GM Jones, A Koltunov, CM Ramirez, WJ Berigan, CV Gallager, TE Munton, PA Shaklee, SA Whitmore, MA Peery. 2016. Meta-analysis of California spotted owl (*Strix occidentalis occidenatlis*) territory occupancy in the Sierra Nevada: Habitat associations and their implications for forest management. The Condor 118(4) 747-765.