

# Mapping bugs from space: Monitoring tree mortality and potential fire hazard in Oregon forests

Robert E. Kennedy<sup>1</sup>, Garrett W. Meigs<sup>1</sup>, Warren B. Cohen<sup>2</sup>  
<sup>1</sup>College of Forestry, Oregon State University | <sup>2</sup>PNW Research Station, USDA Forest Service

Recent burn mosaic overlapping zone of extensive spruce budworm activity, Mt. Hood, OR, October 2009

Mountain pine beetle kill SE of Gearhart Wilderness, Fremont-Winema NF, Southern Oregon, November 2009

## Research objectives

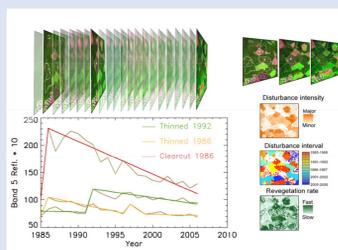
1. Characterize insect activity with field, aerial, and satellite obs.
2. Map insect activity for Oregon Cascades
3. Use maps to explore insect-fire interactions

## Satellite tools

### LandTrendr: Landsat based detection of Trends in Disturbance and Recovery

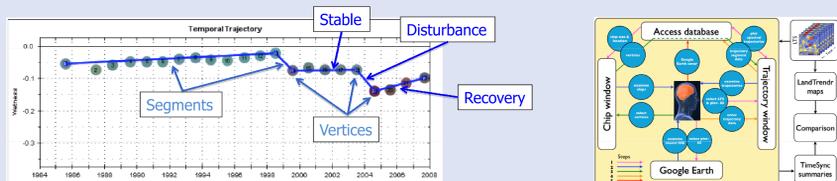
- A powerful new tool for change detection
- Detects both abrupt events and long-term trends
  - Leverages the Landsat data archive (now free!)
  - Improves detection of subtle change, including insects, thinning, drought, encroachment

- How it works:
- Mathematically observe the "life of a pixel" for 20+ years
  - Automatic segmentation smoothes out year-to-year noise
  - Maps are derived from start, end, and slope of segments



### TimeSync: Independent corroboration & photo interpretation at ~2400 plots in PNW

With no suitable reference data that cover every year and every place, TimeSync facilitates manual expert interpretation of landscape dynamics directly from the satellite record and from high-resolution airphotos, creating segments that are directly comparable with LandTrendr.



## Field and aerial survey (ADS)

Three zones, OR Cascades

- Mt. Hood WSB
- Central MPB
- Southern red zone MPB

Stratified sampling

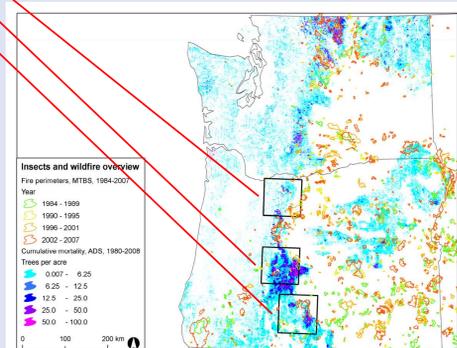
- aerial survey and LandTrendr
- defoliator vs. bark beetle
- early (1980s) vs. late (2000s)

Field methods

- fixed and variable radius plots
- standard fuels transects
- n = 38 plots
- ~3000 georeferenced photos

Aerial survey summary

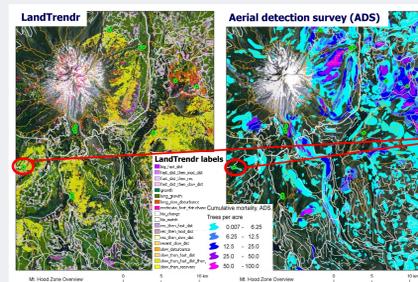
- annual flights of OR and WA
- identify all known disturbance agents
- all surveys since 1980 digitized
- new "cumulative mortality tool" summarizes all tree mortality in one GIS layer



Map of cumulative mortality with MTBS fires  
 Sources: Keith Sprengel, FHM; mtbs.gov

## Results: Signals of spectral change

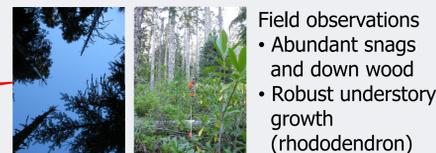
Mt. Hood Zone: Western Spruce Budworm, 1980s-1990s



- Landscape maps
- LandTrendr (LT) map shows "slow disturbance followed by recovery" (yellow)
  - ADS flights record WSB, but it is not a mortality agent so is not shown in cumulative mortality maps. Mortality in the NE area is not WSB.

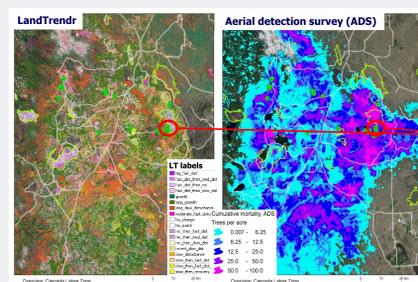
Example point: Mixed-conifer WSB

LT: Slow, moderate mortality then recovery



- Spectral trajectory (TimeSync)
- strong spectral signal: decline and recovery
  - agreement with aerial detection of defoliator

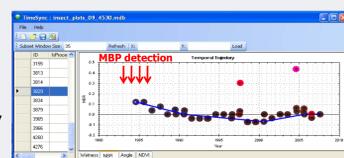
Central OR Zone: Older Mountain Pine Beetle, 1980s



- Landscape maps
- LT map shows diffuse red "long slow disturbance" and yellow "slow D then recovery"
  - ADS map shows heavy mortality patches throughout zone, attributed mostly to MPB

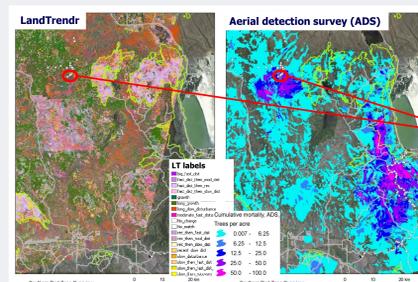
Example point: Lodgepole pine MPB

LT: Previous long, slow mortality then recovery



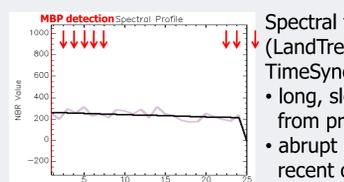
- Spectral trajectory (TimeSync)
- strong spectral signal and agreement with aerial detection of MPB, but much longer decline

Southern OR Zone: Recent/current Mountain Pine Beetle, 2000s



- Landscape maps
- LT map shows diffuse red "long slow disturbance" as well as pink "abrupt disturbance" from logging and fires
  - ADS map shows heavy mortality patches in two areas, attributed to MPB

Example point: Lodgepole pine MPB  
 Ongoing moderate mortality



- Spectral trajectory (LandTrendr only, TimeSync not done)
- long, slow decline from prev. outbreak
  - abrupt drop with recent outbreak
- Agreement with aerial detection of MPB, but much longer decline

## Discussion: Links with ADS & fire

Our satellite maps do not replace the aerial survey data; they compliment each other. ADS data provide thematic richness and depth, while satellite-based maps provide measurement consistency and high spatial detail. Additionally, satellite maps provide information on post-mortality regrowth and fire.

Our challenge is to determine how to use the strengths of all data sources to explore insect-fire interactions.

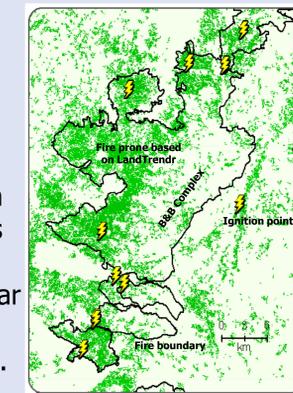
Based on initial comparisons among field, ADS, and LandTrendr data, we see general agreement, but spatial patterns and timing vary. The manifestation of insect mortality in the satellite signal includes both short- and long-term components.

We are analyzing satellite and field data to build better linkages between these signals and on-the-ground fuel and mortality conditions.

By establishing this link, we can use the satellite record to look back in time to characterize the conditions that led to large fires. As a simple proof of concept, we identified the spectral trajectories of pixels near the ignition points of a recent fire (the B&B Complex), an area of known prior insect mortality. We then mapped all pixels that had similar trajectories (green areas in map at right). All other major fires originated in similar conditions, suggesting that the satellite data are capturing conditions that foster initial fire spread.



Gnarly Ridge Fire near Mt. Hood burned in 2008 in a zone of heavy previous budworm activity



## Next steps

In the near term, we continue to characterize quantitative relationships between satellite data and field-measured forest mortality and fuels, as well as between the aerial survey and satellite maps.

Our longer term goal is to expand our research to other areas in the western U.S., facilitated both by the consistency of satellite data across large areas and by the wide range of insect and forest conditions in the Oregon study area.

We welcome collaboration with other researchers across the region.



Adult mountain pine beetles and galleries in a dead lodgepole pine near Bald Butte, Paisley RD, Fremont-Winema NF

## Contact:

robert.kennedy@oregonstate.edu  
 http://www.fsl.orst.edu/larse  
 541-750-7498

