Using LandTrendr remote sensing to monitor insect effects on tree mortality and surface fuels in Oregon forests

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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 processes
- Leverages the free Landsat archive
- Improves detection of subtle change, including insects, thinning, drought, encroachment, growth

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

Field sampling

Two zones in the Oregon Cascades
- Mt. Hood, affected predominantly by western spruce budworm (WSB: Choristoneura occidentalis)
- Cascade Lakes, affected predominantly by mountain pine beetle (MPB: Dendroctonus ponderosae)

Field methods
- Stratified sampling
- Aerial survey and LandTrendr
- defoliation (WSB) vs. bark beetle (MPB)
- early (1980s) vs. late (2000s)

Aerial Detection Survey (ADS)
- Annual flights of OR and WA, digitized since 1980
- Identify all known disturbance agents
- New "cumulative mortality tool" summarizes all tree mortality in one GIS layer, used for MPB here
- Additional "cumulative defoliation" layer developed in the IDL language, used for WSB here (Figs. 2,3)

Study areas

Results: Example spectral trajectories

Figure 4. Example spectral trajectories and plot photographs. WSB: Normalized Burn Ratio derived from Landsat bands 4 and 7 (Key and Benson 2006). Vertical arrows indicate aerial detection of insect activity:

- Red stage pine beetle
- Blue: western spruce budworm

Results: Relation to field data

Figure 5. LandTrendr linear relationships with tree mortality (A) and fuels (coarse woody debris; B). LandTrendr disturbance magnitude from slow and abrupt disturbance identified by aerial detection survey and field observations on defoliation (western spruce budworm) and/or bark beetle (mountain pine beetle). Gray points indicate plots not included in regression because tree mortality and CBC recruitment occurred outside of LandTrendr temporal coverage.

Discussion: Spectral trajectories

Although spectral trends exhibited variability from site to site, insect-affected sites generally conformed to four spectral trajectories (three shown to left in Figure 4 plus an additional trajectory of abrupt followed by slow disturbance).

Mountain pine beetle sites appeared to show a consistent temporal evolution of gradual spectral decline and recovery (Figure 4c).

Discussion: Relation to field data

The linear fits (Figure 5) provide compelling evidence of relationships between LandTrendr disturbance magnitude and field estimates of tree mortality (% basal area) and surface fuels (coarse woody debris).

Comparing satellite and ADS data with field measurements of insect impacts, we found that spectral changes were related to mass-based estimates (percent change in tree basal area mortality and coarse woody debris) whereas ADS changes were related to count-based estimates (trees per acre).

Future studies will improve on these relationships by leveraging multi-date, regional-scale inventory data (i.e., Region 6 Current Vegetation Survey).

Implications

These results demonstrate diverse spectral and physical manifestations of insect activity in conifer forests, highlighting the utility of insect mapping methods that capture a wide range of spectral signals.

This study also confirms the key role that satellite imagery can play in understanding the interactions among insects, fuels, and wildfire.

We welcome collaboration with researchers and managers across the region!

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References


Figure 3. Aerial detection survey and LandTrendr maps of forest disturbance across study landscapes. Red lines show spatial extents in two study areas. Panel (a) and (c) show WSB and MPB defoliation and western spruce budworm (WSB) from 1980-2008. Panel (b) and (d) show LandTrendr (Kennedy et al. 2010). Base map: ESRI Imagery World 2D from http://server.arcgisonline.com.

Figure 4. LandTrendr schematic adapted from Kennedy et al. 2007