Introduction
Climate warming has been thought to accelerate rates of tree mortality worldwide, and recent trends of tree mortality in subalpine forests of the Western U.S. have gained specific attention.

Most recent research has focused on insect and pathogen induced mortality rates of pine and spruce trees while increasing mortality of subalpine fir trees has received less attention.

The Goal of this study: to examine regional patterns of subalpine fir mortality using Geographic Information systems (GIS) and United States Forest Service (USFS) aerial detection survey (ADS) data to answer the following questions:

1. How does the spatial extent of analysis affect the ability to detect ecological patterns?
2. How does subalpine fir mortality presence/absence correlate with biotic vs. abiotic factors across space?

Methods
The U.S. Rocky Mountain ecoregion ranges from Northern New Mexico to the border of Canada in Montana and Idaho. Within the Rocky Mountain Eco region, we focus on the spruce-fir forest zones typically containing our focal species: subalpine fir. We also limited our study area to the land encompassed by U.S. Forest Service (USFS) regions 1, 2, and 4, because these are the most extensive National Forest regions in the U.S. Rocky Mountains and have conducted ADS surveys using a consistent protocol for > 10 years.

Data Processing Methods

1. The U.S. Rocky Mountain ecoregion is the targeted study area; pixels area flown and area affected by each tree mortality agent (MPB, SB, and SFM) from 1994 - 2015. Region 1, 2, and 4 data were merged, affected by all three observed tree-killing agents, Mountain Pine Beetle, Spruce Beetle, and Subalpine Fir mortality. All data are aggregated to a 510-meter pixel layer, therefore each pixel is given a value expressing how much of the grid cell contains tree mortality.

2. Inclusive study area of subalpine fir mortality (SFM) created by intersecting any area flown from 1994-2015 and the targeted study area maps using GIS to quantify tree mortality. Exclusive study area is created by intersecting only common area shared by all three observed tree-killing agents from 1999 - 2015. Focal study area is the union (joining together) of any area flown from Region 1, 2, and 4.

Results

How do biotic factors affect the likelihood of subalpine fir mortality (SFM)?

How do abiotic factors affect the likelihood of subalpine fir mortality (SFM)?

Discussion

Ecological patterns of subalpine fir mortality were strongest and most detectable at the finer, focal extent.

Subalpine fir mortality (SFM) was most prevalent in areas characterized by the least amount of drought-stress.

Conclusion

With observed global trends of accelerated tree mortality, discovering broadscale patterns of tree mortality can provide important insights into forest dynamics in a warming climate.

Our results suggest that areas with the most subalpine fir mortality are in characteristically cool and moist areas. On the other hand, drought-stressed sites exhibit the least amount of subalpine fir mortality.

Significant subalpine fir mortality in cool and moist areas may occur due to exposure to warming climate that induces drought-stress in dense stands of susceptible hosts for biotic tree killing agents.

These results of tree mortality at regional scales will help inform insights at stand and individual tree scales for which current work is underway.

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