Refining Aerial Detection Survey (ADS) High-intensity Tree Mortality Estimates in the Pacific Northwest

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Introduction

- Significant tree mortality due to pine bark beetles has been tracked and reported using aerial detection survey (ADS) in Oregon and Washington for over 60 years. Aerial observers in Region 6 train annually to calibrate trees per acre (TPA) estimates of recent mortality and maintain consistent data.
- Mountain pine beetle (MPB) in lodgepole pine is the principal agent/host attributed to high-intensity tree mortality (>5 trees per acre killed) in a typical survey year in Region 6.
- Ground checks have revealed that TPA coded in these areas of concentrated, high intensity tree mortality often underestimate the damage that is occurring. Ground truth studies have shown intensity of tree mortality coded from the air can range from one-tenth to one-half TPA measured in ground plots (Meigs et al. 2011).
- To make the many difficult decisions required of forest managers (i.e. determine priorities for treatment/restorative activities, assess wildfire risk, etc.) it is critical that the most accurate ADS information be supplied to forest managers and the public. Products developed from this project will provide aerial observers with tools and training needed for greater accuracy of data.

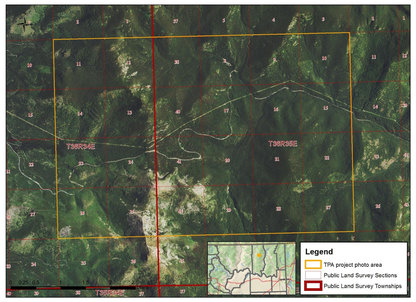


Figure 1. Washington study area in Ferry County.

- In order to refine mortality estimates and develop new training aids, the Oregon Department of Forestry and the Washington Department of Natural Resources, in cooperation with USDA Forest Service aerial survey program, established two study areas in 2014 where recent high intensity MPB-caused mortality was visible (Fig. 1).
- **Objectives** of this study were to:
  1) refine TPA coding used in ADS in areas with high levels of pine bark beetle mortality, and
  2) develop a reference and educational tool that can be used to assist aerial observers in recognizing differing intensities of tree mortality (i.e. a series of photographs with dead TPA identified at various verified levels of intensity).

Materials & Methods

- Contract aircraft acquired geo-referenced, 12-inch resolution, color orthophotos in September 2014 covering both study areas that were established in current MPB outbreak areas. A 50-square-mile study area was located in the Lookout Mountain area in Baker County, Oregon and a 24-square-mile study area was located on Sherman Pass in Ferry County, Washington (Fig. 1).
- In thirteen selected areas of the orthophotos, recently dead trees in the canopy were marked and counted using GIS to calculate dead TPA that would be observable from the air. These data were compared to TPA estimates made by aerial observers in 2014. Only recently dead trees, as would be assessed from the air, were counted (all grey trees and those generally understood to be more than one year dead were excluded).
- Aerial observers also captured oblique "observer view" photos in the study areas while conducting the 2014 annual survey, which were later geo-referenced using GIS software. In eight of these areas, both live and dead trees were marked and counted on the corresponding orthophotos using GIS to calculate percent mortality (Fig. 2). Some polygons in Washington were randomly sampled.
- A total of 1,554 acres of orthophotos were analyzed. Polygon size varied from two acres (a recorded point) up to 265 acres (a portion of a larger polygon) with an average size of 120 acres. A total of 81,898 living and dead trees were marked.

Figure 3. Outlines of 1/8th acre transect ground plots in the Washington study area.

- In the Washington study area, fifty-six 1/8th acre transect plots were installed in seven areas (Fig. 3). All recently dead trees in the plots were counted and classified by canopy position. Only dominant and co-dominant dead trees observed on the ground were used to compare to TPA derived from orthophotos and TPA estimated by aerial observers.
- TPA and percent mortality values were overlaid on the "observer view" photos to be used for training observers (Fig. 4).

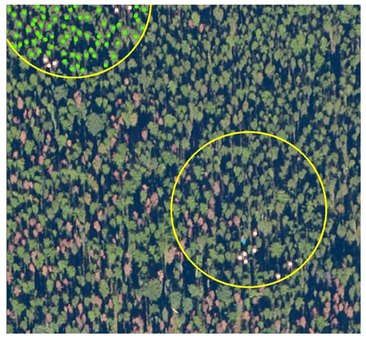


Figure 2. Screen shot showing process of digitizing live (green) and recently dead (red) trees on an orthophoto.

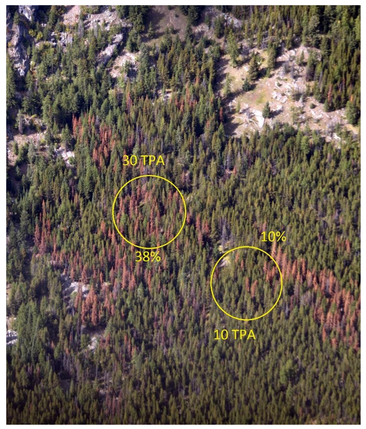


Figure 4. One acre circles showing recently dead TPA and percent mortality based on orthophoto analysis.

Results

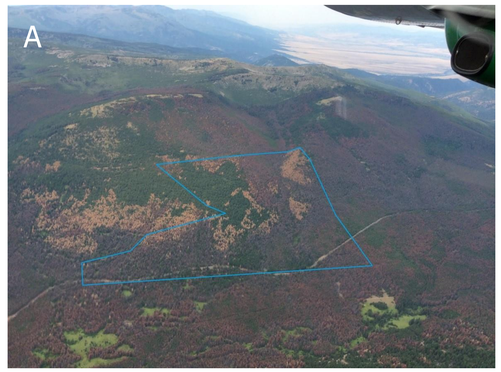
- In eight analysis areas represented by high quality "observer view" photos, percent mortality derived from corresponding orthophotos ranged from 5 to 42 percent of the area. In all thirteen analysis areas, TPA mortality derived from corresponding orthophotos ranged from 0.5 to 28 TPA. 2014 aerial observer TPA estimates ranged from 0.5 to 100 in the ten areas where ADS polygons overlapped analysis areas (Table 1).
- TPA estimates by aerial observers (ADS polygon TPA) were divided by dead tree counts in corresponding orthophotos to determine TPA estimate accuracy. TPA accuracy ranged from an under estimate of one third to a tenfold over estimate. Average over estimation was 2.8 times greater than orthophoto TPA (Table 1).
- In the seven areas where ground plots were installed, ADS polygon TPA slightly over estimated orthophoto TPA, averaging 1.3 times greater. ADS polygon TPA under estimated ground plot canopy TPA by an average of 30%. Dead tree counts from orthophotos also under estimated ground plot canopy TPA by an average of nearly 50% (Table 2).

Table 1. Analysis of live and recently dead canopy trees marked in 2014 Oregon and Washington orthophotos (81,898 trees).

Area #	Acres	% of area sampled	% Dead (orthophoto)	Dead TPA (orthophoto)	ADS polygon TPA	TPA estimate accuracy (ADS TPA/ Photo TPA*100)
OR 1	265	100	42%	18.7	100	534%
OR 2	85	100	NA	16.0	NA	NA
OR 3	235	100	15%	24.9	25	101%
OR 4	169	100	18%	24.6	25-50	102-203%
OR 7	26	100	21%	19.9	25-50	126-252%
OR 12	137	100	NA	1.0	10	1,032%
OR 13	183	100	NA	1.5	1	66%
OR 14	245	100	NA	0.5	0.5	107%
OR 15	2	100	NA	4.0	2.5	62%
WA 1	106	10	7%	11	NA	NA
WA 2	46	11	9%	28	50	179%
WA 3	40	10	5%	19	50	263%
WA 4	14	100	20%	27	NA	NA
Total	**1,554**					
Average	**120**					**280%**

Table 2. Comparison of recently dead trees per acre (TPA) between ground plot data, orthophotos, and aerial survey polygons within the 2014 Washington study area. Each area is represented by eight 1/8th acre plots.

				TPA estimate accuracy		
Area #	Canopy dead TPA (ground plots)	Dead TPA (orthophoto)	ADS polygon dead TPA	ADS to ground plots (ADS TPA/ ground TPA*100)	orthophoto to ground plots (photo TPA/ ground TPA*100)	ADS to orthophoto (ADS TPA/ photo TPA*100)
1	61	45	50	82%	74%	111%
2	75	33	50	67%	44%	152%
3	79	74	50	63%	94%	68%
4	101	53	50	50%	52%	94%
5	58	22	50	86%	38%	227%
6	29	17	0	NA	59%	NA
7	31	3	0	NA	10%	NA
			Average	**70%**	**53%**	**130%**



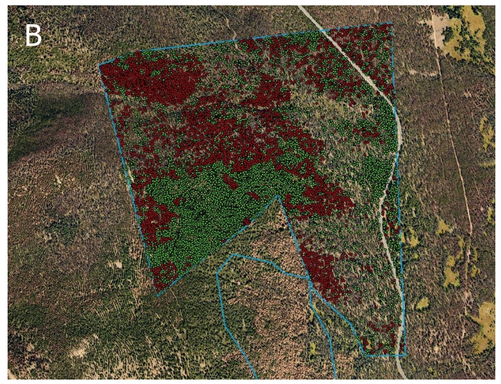


Figure 5. Oblique view from survey aircraft with area of interest super imposed (A) and same area of interest with live (green) and dead (red) trees marked for analysis (B).

Discussion & Further Study

- In general, observers recorded higher TPA values for dead trees than were counted in analysis of corresponding orthophotos. This is likely due to the need for observers to make rapid assessments in these high intensity mortality areas while surveying an average of 28 acres per second. The method used in this study to calculate TPA from orthophotos took hours compared to minutes needed cover the same area with observers on survey flights. However, orthophotos appear to be useful for calibration and training if they are acquired in the same season as survey flights.
- Both aerial observer TPA and orthophoto-derived TPA under estimated actual canopy mortality in ground plots, even when understory mortality was excluded. This is due in part to crowns of adjacent trees merging together in dense stands where individual stems can only be discerned from the ground. These differences are in line with previous ground-truth studies showing actual mortality observed from the ground is typically 2-3 times greater than mortality visible from the air and can be as high as ten-fold higher (Meigs et al. 2011).
- Data from this project will be used to produce a series of calibrated "observer view" photos representing a wide range of mortality intensities that can be used as training aids for observers. Training photos will be labelled with both TPA and percent mortality because the US Forest Service aerial survey program is currently working toward adopting a nationwide standard of percent mortality to replace TPA estimates (Fig. 4).

Reference

Meigs, GW, RE Kennedy, and WB Cohen. 2011. A landsat time series approach to characterize bark beetle and defoliator impacts on tree mortality and surface fuels in conifer forests. Remote Sensing of Environment 115: 3707-3718.

Acknowledgments

Ben Smith and Robert Noyes (USDA Forest Service) for excellent photographs, geo-referencing work, and contributions as aerial observers. Harrison Brookes for assistance with ground plots. Eagle Digital Imaging, Inc., Corvallis, OR for acquisition of orthophotos under contract. Funding was provided by the USDA Forest Service Forest Health Monitoring Program (Grant#: WCFHM-13-01).