Assessing Tree Mortality in a Southern Appalachian Red Spruce Forest using UAV-Survey Derived Orthoimagery

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INTRODUCTION

This study investigated the utility of a consumer grade UAV (Unmanned Aerial Vehicle) equipped with an RGB camera payload for assessing individual spruce tree (*Picea rubens* Sarg.) health within a 46-hectare sample plot of the red spruce forest on Whitetop Mountain, Virginia. The main goal of this research was to quantify forest health and instances of mortality, examine the associated spatial patterns, and provide data to the management organization to assist with forest treatments. We collaborated with USDA forest service personnel, and the regional interagency Southern Appalachian Spruce Restoration Initiative (SASRI) to conduct this analysis.

Figure 1. Dark-colored red spruce (*Picea rubens* Sarg.) is visible on the peak of Virginia's two highest mountains (Foreground: Whitetop Mountain, Background: Mount Rogers).

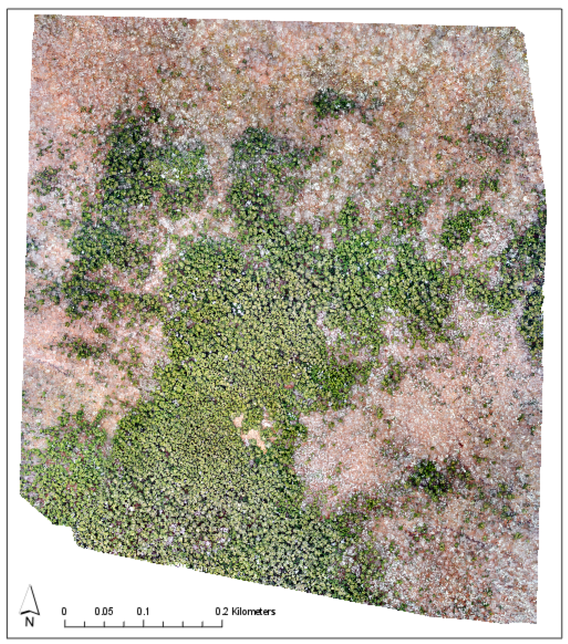

Figure 2. High quality digital orthoimagery was produced using a consumer grade UAV in conjunction with photogrammetric software Pix4D and was used for visual inspection and identification of individual spruce.

MATERIALS & METHODS

The 46-hectatre study area was flown using a consumer-grade UAV (DJI Mavic 2 Pro) equipped with a Hasselblad L1D-20c 10.3 RGB sensor. Two grids were flown with the same spatial extent. We used photogrammetric software Pix4D Mapper Pro with consumer grade UAV collected imagery of the sample plot to generate an orthophoto mosaic and used to in point cloud reconstruction and orthoimagery generation. The completed orthoimagery allowed us to visually locate and demarcate these health status classes: 1. standing dead red spruce trees among the forest canopy, 2. standing red spruce trees showing signs of decline via dead limbs, 3. healthy standing red spruce trees, 4. leaf-off deciduous trees (mostly yellow birch, personal observations) among the spruce stand, and 5. fallen red spruce trees, clearly in a horizontal position. We created a feature class for each of these categories. We did not use the leaf-off deciduous or fallen red spruce categories for this study, but we retained the data for possible future analysis.

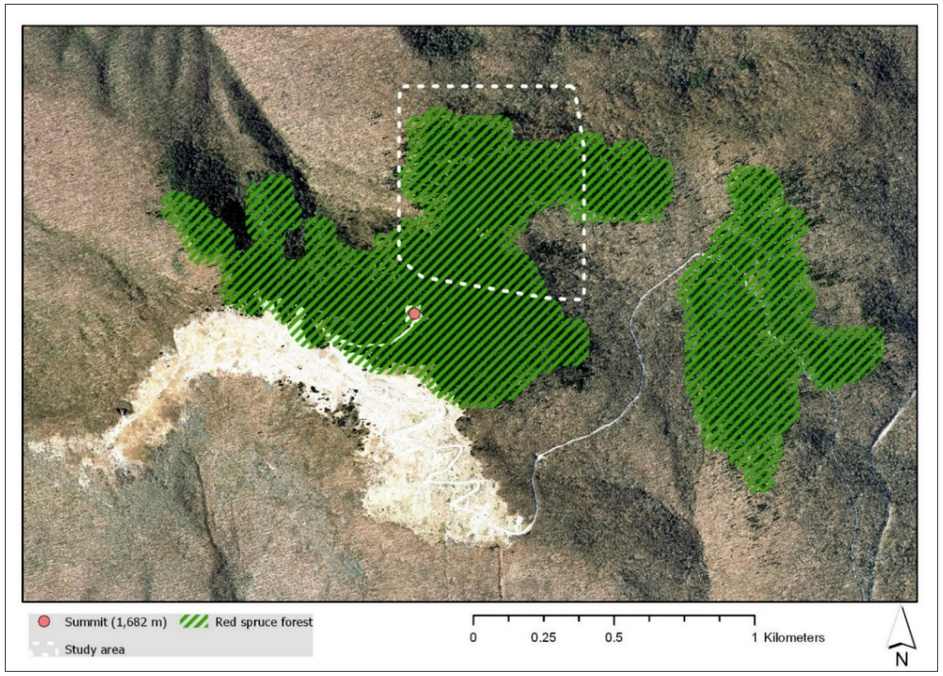

Figure 3. Whitetop Mountain showing the study area (46 ha), red spruce forest, and the grass bald.

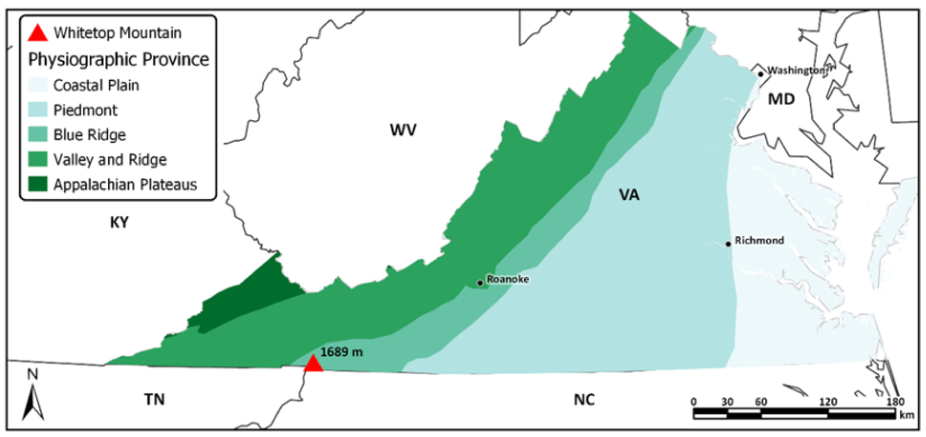

Figure 4. Whitetop Mountain within Virginia's Blue Ridge physiographic province.

RESULTS

We identified 9,402 red spruce trees and assessed their health using UAV-survey produced digital orthoimagery. Of those, 8,700 were classified as healthy (92.5%), 251 declining/dying (2.6%), and 451 dead (4.8%) (See figure 7). To examine spatial aspects of forest health, we mapped individual spruce trees in each class and performed density analyses to produce kernel density maps (figure 5).

Figure 5. Researcher Ryley Harris with his UAV on Whitetop Mountain, Virginia.

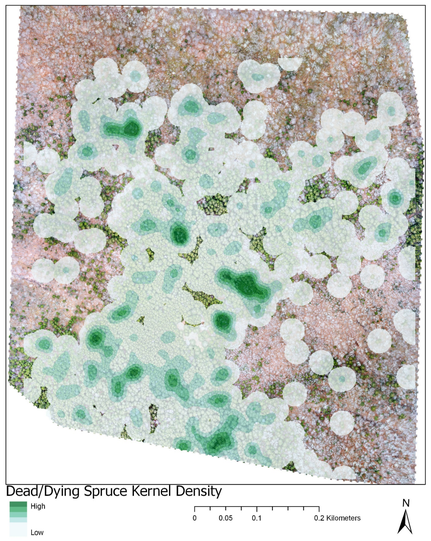

Figure 6. Kernel density of dead/dying red spruce trees within the study area.

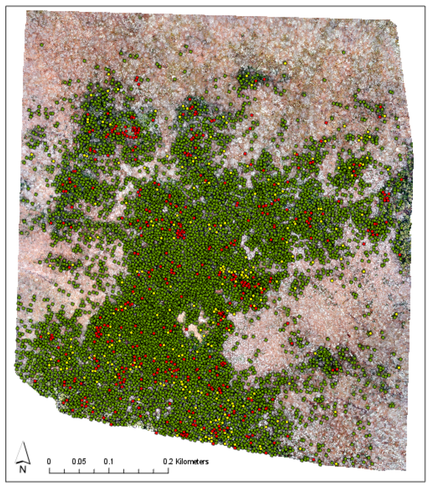

Figure 7. Individual spruce within the sample plot, categorized visually based on their apparent health.

DISCUSSION

This study contributes to the limited body of literature surrounding the health of southern Appalachian red spruce forests, especially in Virginia, and the utility of consumer grade RGB-sensor equipped unmanned aerial vehicles for assessment of forest health. The new high-resolution data presented here on spruce mortality at Whitetop illustrates a point in time and provides a baseline for comparison of future surveys. The spatial insights describing the distribution of both live and dead/declining spruce trees within the sample plot on Whitetop Mountain will allow interagency land management collaborators to take a targeted approach when addressing and manipulating ecological dynamics to promote spruce growth. The density map that includes the entire spruce dataset provides insight into which areas and trees are under the most stress from competition for light, water, and nutrient resources. The density map also provides the precise location of active release of spruce saplings that have remained suppressed in the understory for decades.