Acacia koa forest classification and productivity assessment at Kona Hema using fine resolution satellite imagery

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Changes in koa forest productivity are defined by changes in the availability of soil nutrients and water across the elevation and rainfall gradients in Hawaii. There is a strong need to delimit koa forest microregions with common productivity along the gradients in order to allow the application of specific forest management strategies suitable to the environmental conditions and plant requirements for optimal koa growth at each gradient.

Objectives

1) to develop methodologies using fine resolution satellite imagery to accurately classify koa forest types and to assess forest productivity across the elevation gradient.
2) to assess temporal changes of individual-tree growth in response to silvicultural treatments including thinning, fertilization and weed control through the analysis of high spatial resolution imagery from the GeoEye1 satellite (0.4 m pixel) in combination with digital aerial photography being obtained by TNC. This will allow development and validation of non-destructive methodologies for individual-tree monitoring and forest inventory that can be efficient in cost and time.

Fulfillment of both objectives will improve our understanding of the major environmental limitations for optimal koa growth and how they can be managed to achieve higher productivity in stands managed for timber production. It will also allow for the development of a spatially explicit koa forest productivity model at individual-tree and landscape scales in order to prioritize management of koa stands and to implement forest conservation strategies.

Approach and Early Results

We analyzed imagery from the IKONOS satellite at 1-m pixel resolution to classify koa forests at Kona Hema. A set of archived images covering 50 km^2 of the northern part of the Honomalino tract were obtained on December 20, 2007 from Space Imaging Inc at a cost of $900 (Fig. 1). A series of vegetation indices including the most commonly used NDVI (Normalized Difference Vegetation Index) were calculated to differentiate various koa forest types across the elevation gradient (Fig. 2). At selected plots in each gradient site, indicators of forest growth such as tree height and stand basal area were measured and correlated to koa spectral response of short-wave radiation measured by the satellite. Three 20 x 20 m plots representing monotypic koa stands were established at each gradient site. At each plot, all trees with dbh > 3 cm were measured to calculate stand basal area, and 6 dominant trees were measured for height. Plot averages of these indices of koa productivity (Fig. 3) were related to averages of vegetation indices and other texture metrics extracted from the IKONOS image.

Figure 1. IKONOS satellite image of Kona Hema at 1-m pixel spatial resolution. The image covers both the elevation gradient in the Honomalino tract as well as the silvicultural study in the Papa tract; treatments include thinning, grass control, and phosphorus fertilization.

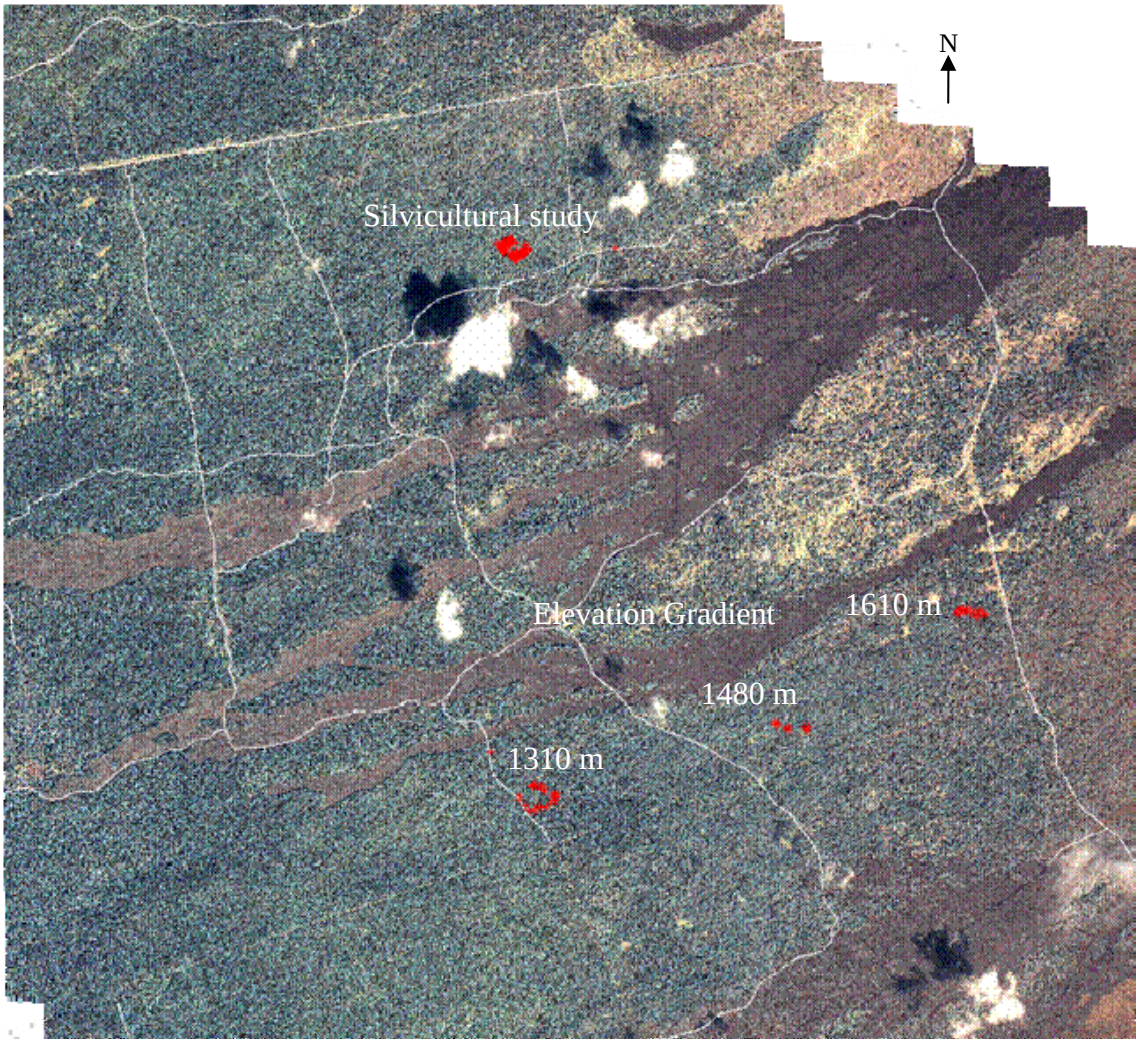


Figure 2. Classified image showing 2 main koa forest types in green and red. Orange and cyan represent ohia and grasses. Circles represent location of study sites at Honomalino and Papa.

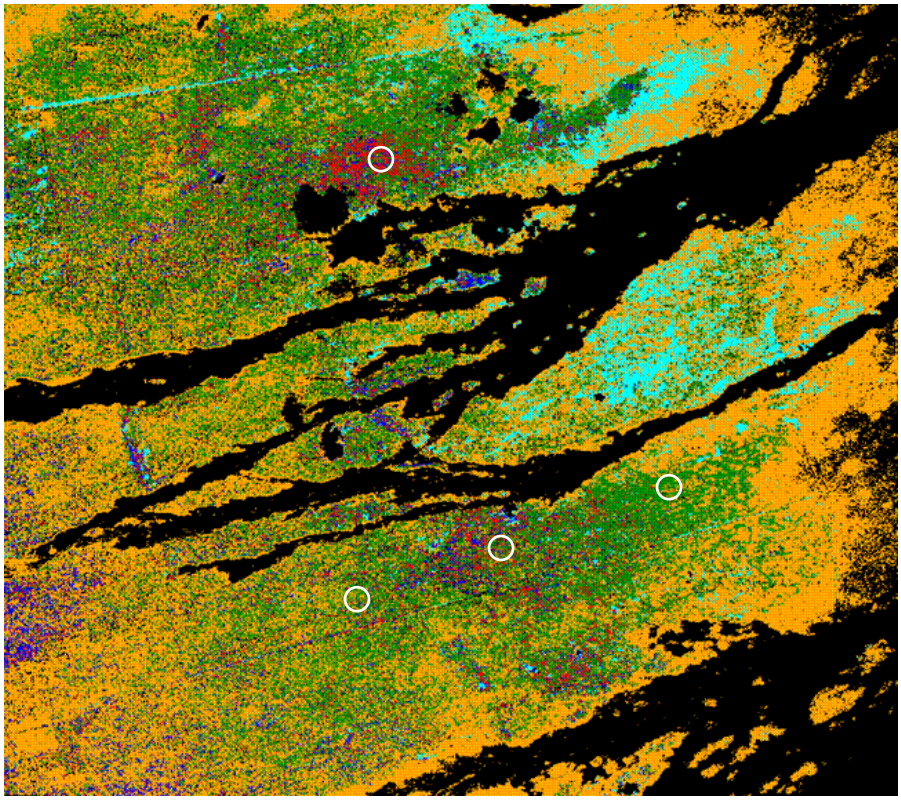
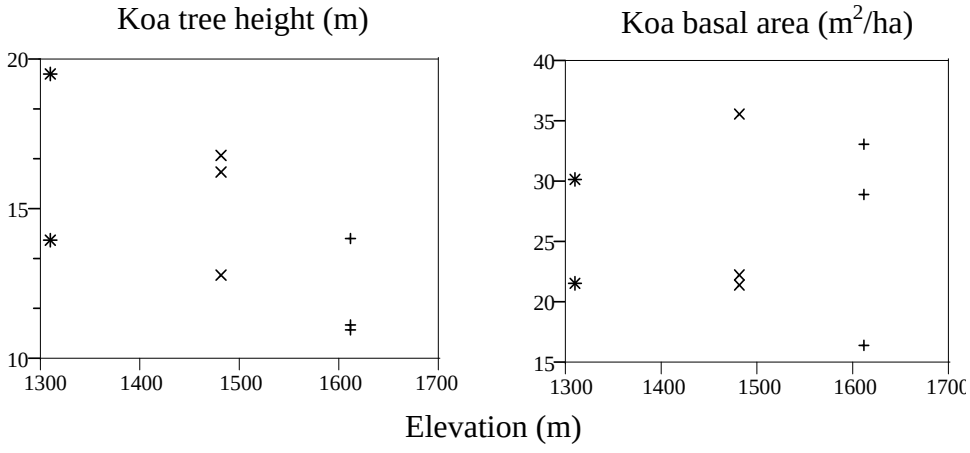


Figure 3. Indices of koa productivity across the elevation gradient in the Honomalino tract. While tree height decreases gradually with elevation, basal area does not have a clear trend. Log transformed tree height was significantly related to vegetation indices and texture metrics with a coefficient of determination 0.58 indicating that this image data could be used for interpolations of koa tree height at the landscape scale.



Future Directions

The information we generate will be used to develop a model of koa productivity based upon high-resolution satellite images. Because the IKONOS image includes the Papa tract, we will test our koa productivity model against measurements made in this stand.

The Nature Conservancy is commissioning the collection of very high-resolution aerial photos with 2.2 cm resolution in the visible spectrum and 20 cm resolution in the near-infrared. We will apply our analysis techniques to these images to investigate single-tree responses to the silvicultural treatments. This will allow us to determine if growth responses are due to an increase in photosynthetic activity (as reflected in spectral responses) or mainly due to a shift in the allocation of new biomass to leaf and stem growth.

Finally, we hope to obtain images from a brand-new satellite (GeoEye1) that has a higher resolution than IKONOS. The increased resolution may allow us to delineate tree species at the individual tree scale as well as identify dieback due to insect attack or diseases, a real concern for koa and ohia forests.