Remote Sensing of *Acacia koa* Forest Growth, Productivity, and Health Across Elevation and Climate Gradients

Rodolfo Martinez Morales, PhD Student  
Dr. Travis Idol  
Dr. James B. Friday  
Department of Natural Resources and Environmental Management  
Dr. Qi Chen  
Department of Geography
Introduction

- Most studies of koa forest productivity across elevation and rainfall gradients in Hawaii have been done at individual-tree or plot levels.

- Integration of this information is needed for the assessment of koa productivity at the landscape and regional scales.

- Fine resolution imagery (1-m pixel Ikonos satellite) allows analysis of vegetation reflectance patterns.

- Differences in reflectivity among koa forests across the gradients can be used to classify unique micro-regions for productivity assessment.
Objectives

• Develop methodologies for koa forest productivity assessments over entire landscapes across independent environmental gradients

• Determine important relationships between measured and remotely-sensed estimated koa forest productivity indices

• Investigate the potential to use satellite imagery to assess koa forest health and disease
Location of Gradient Sites

Honomalino

Mauna Loa Strip Road
Location of Plots within Gradient Sites:

• Monotypic koa stands growing in similar soil types and substrate age were selected across each elevation gradient site

• 3 plots (20 x 20 m) were randomly selected at each site and geolocated using a Trimble GPS (submeter accuracy)
Monotypic Koa Stands at Mauna Loa Strip Road
1600 m plots
3 sites at Honomalino Elevation Gradient (300 m)

Large mixture of koa and ohia stands
Methods

Ongoing field data collection at individual plots:

- dbh inventory for all trees with diameter > 2 cm
- LAI (allometry and optical) and tree height

Analysis of Ikonos 4-m multispectral imagery acquired in February 2008:

- Conversion of DN to surface reflectance values
- Calculation of 7 vegetation indices (VIs) using ENVI
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR</td>
<td>Simple Ratio</td>
</tr>
<tr>
<td>MSR</td>
<td>Modified Simple Ratio</td>
</tr>
<tr>
<td>NDVI</td>
<td>Normalized Difference Vegetation Index</td>
</tr>
<tr>
<td>SAVI</td>
<td>Soil Adjusted Vegetation Index</td>
</tr>
<tr>
<td>MSAVI</td>
<td>Modified Soil Adjusted Vegetation Index</td>
</tr>
<tr>
<td>ARVI</td>
<td>Atmospherically Resistant Vegetation Index</td>
</tr>
<tr>
<td>EVI</td>
<td>Enhanced Vegetation Index</td>
</tr>
</tbody>
</table>
Extraction of VI information for 25 pixels at each plot

Exploratory data analysis in JMP statistical software
- Principal components (PCA)
- Discriminant analysis (DA)

Image Classification in ENVI
Out of the 3 plots per gradient site:
- Two were used as training sites using Maximum Likelihood
- One was used for koa gradient class overlap assessment
Results

Exploratory Analysis

Discriminant Analysis

Spectral differences were found between gradient sites
Mauna Loa

Exploratory Analysis

PCA indicated broad separation of koa gradient sites.

• **Prin1** captured 90% of variation, but all VIs had similar influence.

• **Prin2** captured 8% of variation and indicated that ARVI, EVI and MSAVI had the greatest influence.
• All 5 sites at different elevation along Mauna Loa Rd. could be separated
• Sites at 1600 and 1750 m overlap most
3 main regions were differentiated across the gradient (red, yellow, and orange areas)
# Class Overlap Assessment

<table>
<thead>
<tr>
<th>Gradients</th>
<th>2050 m</th>
<th>1750 m</th>
<th>1600 m</th>
<th>1450 m</th>
<th>1200 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>2050 m</td>
<td>78.57</td>
<td>8.7</td>
<td>8.7</td>
<td>0</td>
<td>16.13</td>
</tr>
<tr>
<td>1750 m</td>
<td>21.43</td>
<td><strong>69.57</strong></td>
<td>82.61</td>
<td>0</td>
<td>3.23</td>
</tr>
<tr>
<td>1600 m</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1450 m</td>
<td>0</td>
<td>21.74</td>
<td>8.7</td>
<td><strong>100</strong></td>
<td>58.06</td>
</tr>
<tr>
<td>1200 m</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td><strong>22.58</strong></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
2 main regions were differentiated across the gradient (green and red; brown indicates ohia lehua coverage)
Conclusions

• Although NDVI is most commonly used in vegetation studies, ARVI, EVI and MSAVI provided greater capability to classify koa gradient sites

• Remote sensing can be a useful tool for differentiating koa forest production across environmental gradients at landscape and regional scales
What’s Next

- Relate VIs with LAI, basal area and height to determine unique statistical models for each gradient

- Use statistically significant models for spatial interpolations at the landscape level at classified koa forest areas

- Make similar analysis in other areas such as Laupahoehoe Forest in Mauna Kea and Kokee State Park in Kauai for comparison of different environmental gradient conditions
Many Thanks to:Cathy Rodriguez and the Forest Team at Hawaii CC, Gaoussou Diarra, Ayami Shiraishi and Paul Scowcroft for helping on the field inventory.
• Shawn Steinman, Dr. Kentaro Hayashi and Dr. Greg Bruland for their collaboration on the statistical analysis

• Sierra McDaniel for the field orientation on the Mauna Loa strip road koa stands

• Laura Nelson for collaborating on our research efforts at Honomalino

• Project funded by the USDA CSREES TSTAR program