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

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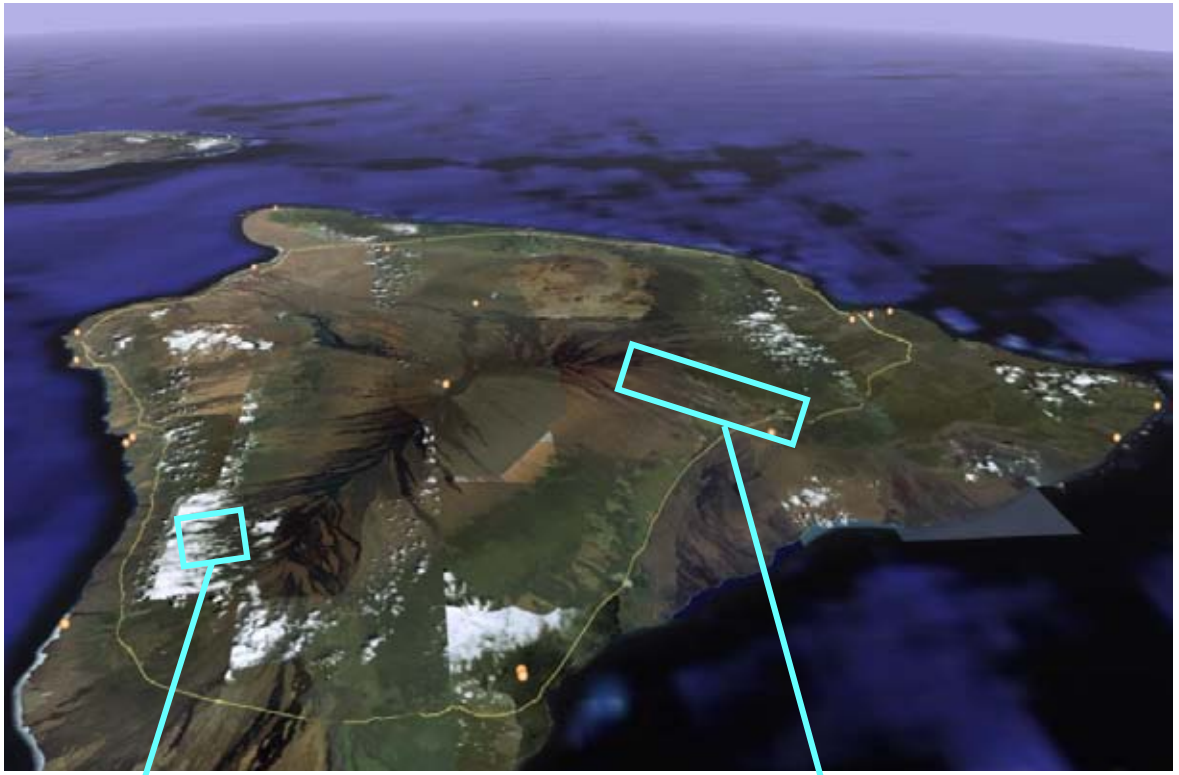
Introduction

- 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

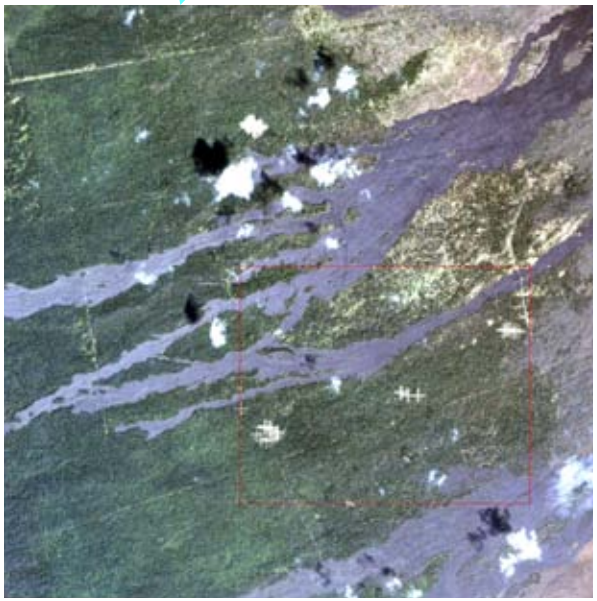
Objectives

- 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

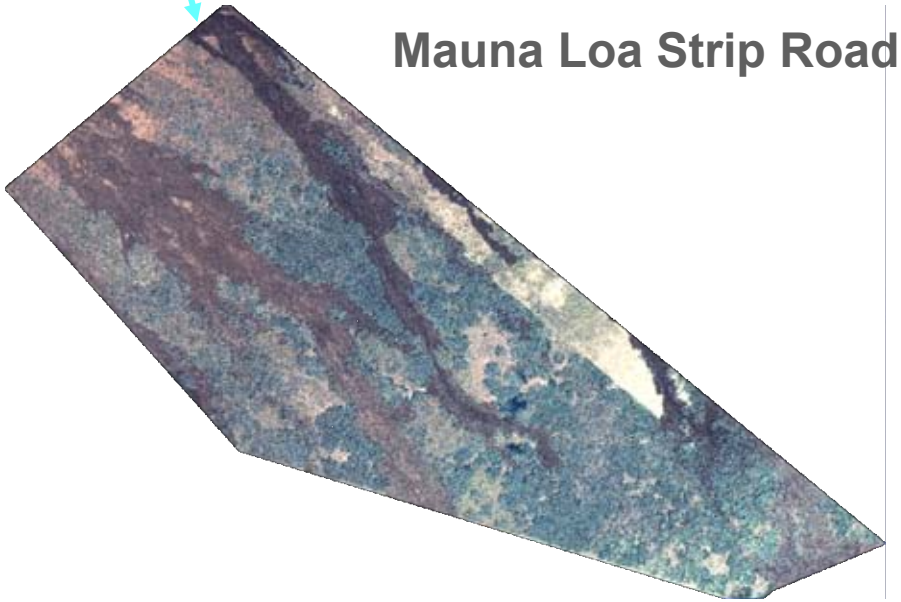
Location of Gradient Sites



Honomalino



Mauna Loa Strip Road



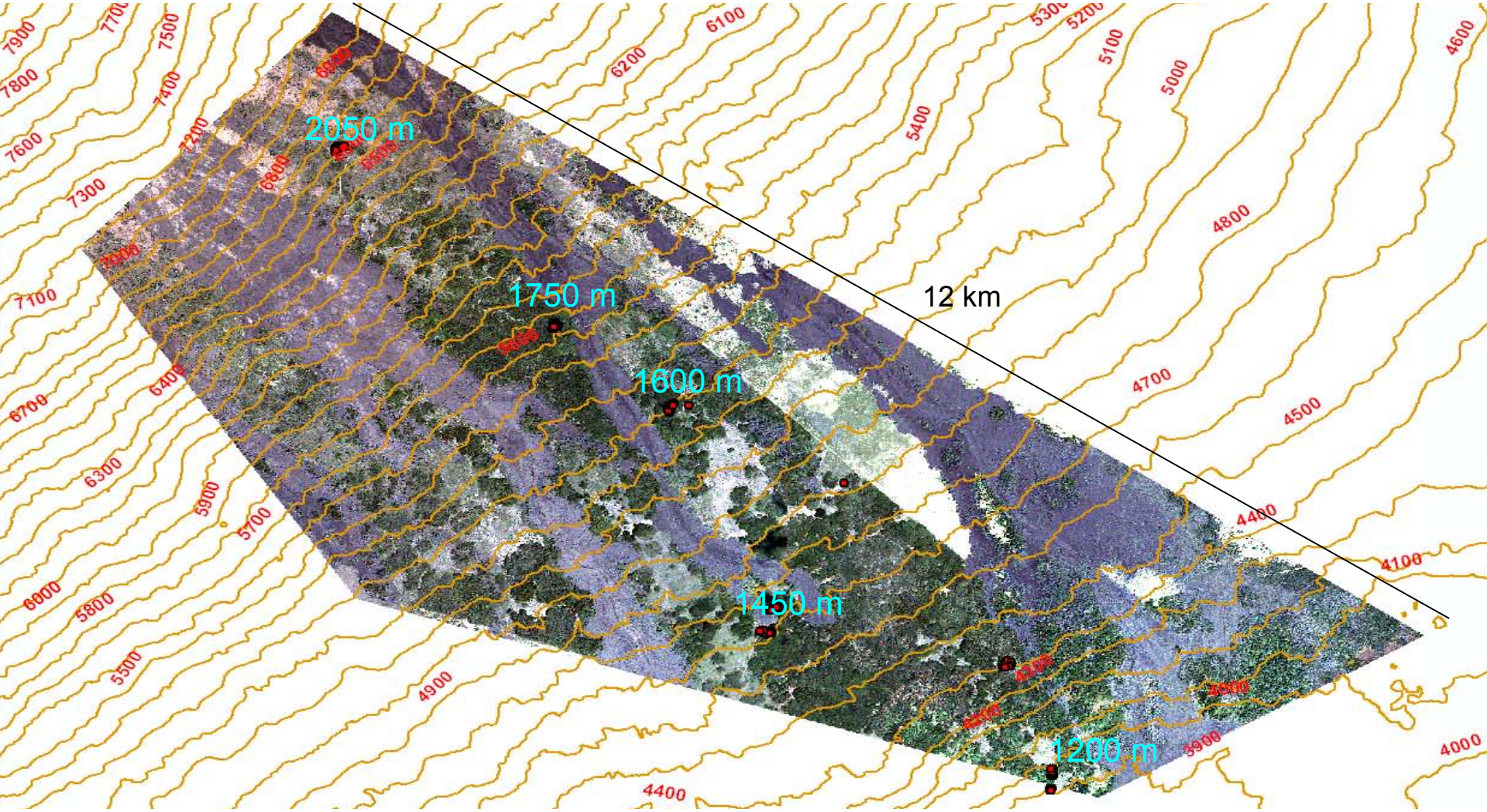
Location of Plots within Gradient Sites:

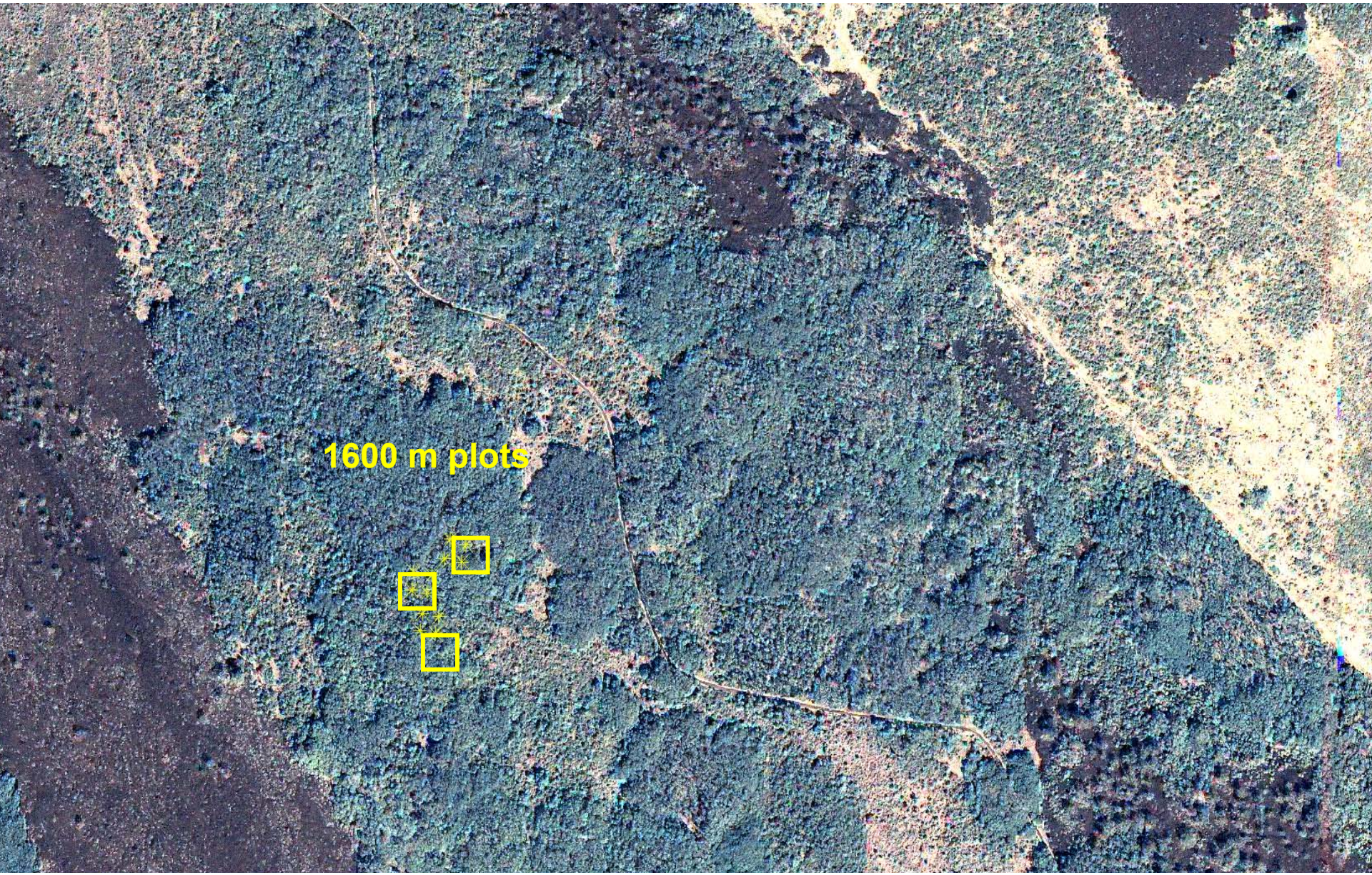
- **Monotypic koa stands growing in similar soil types and substrate age were selected across each elevation gradient site**

- **3 plots (20 x 20 m) were randomly selected at each site and geolocated using a Trimble GPS (submeter accuracy)**

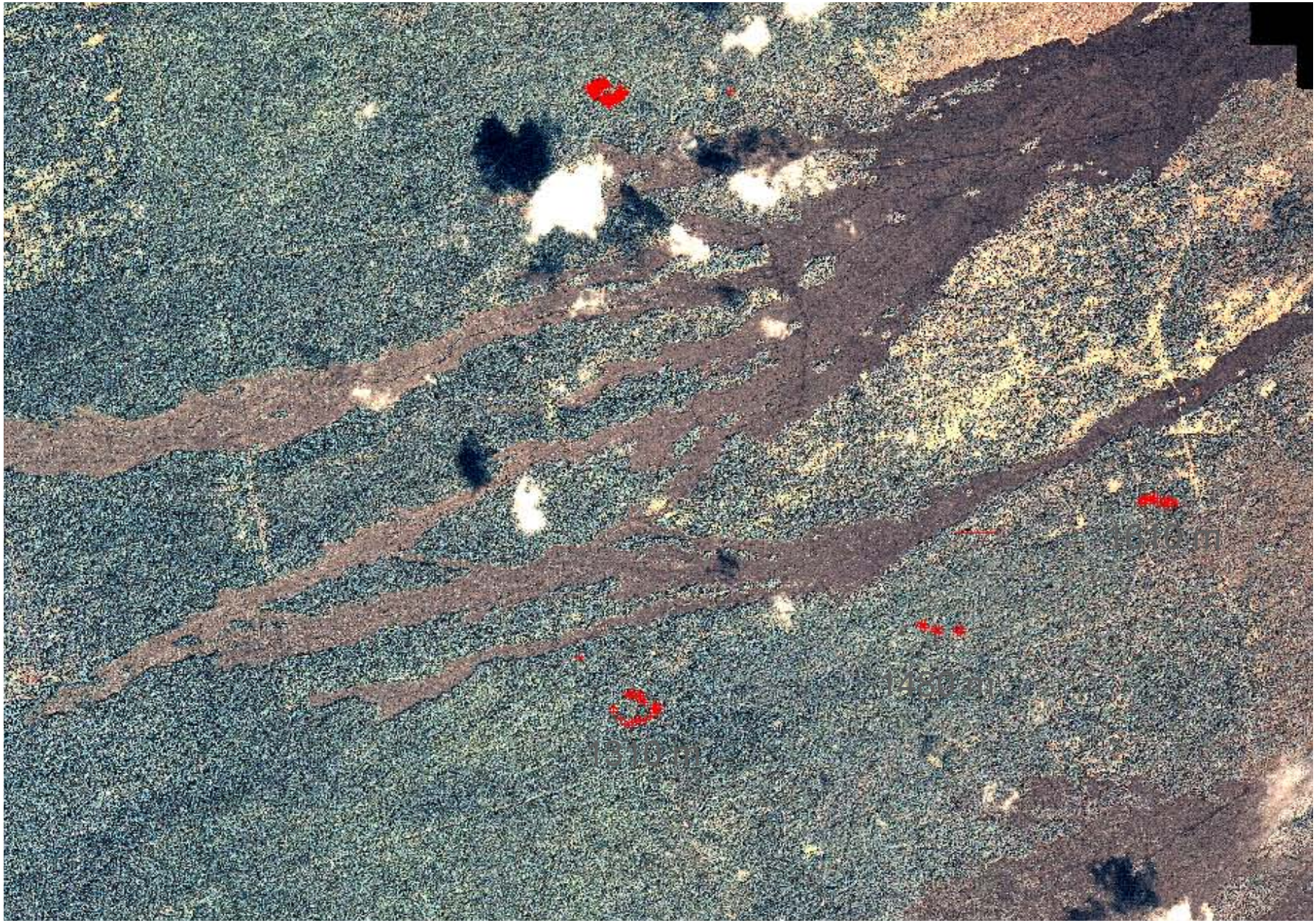

Monotypic Koa Stands at Mauna Loa Strip Road

5 sites at Mauna Loa Strip Road Elevation Gradient (850 m)

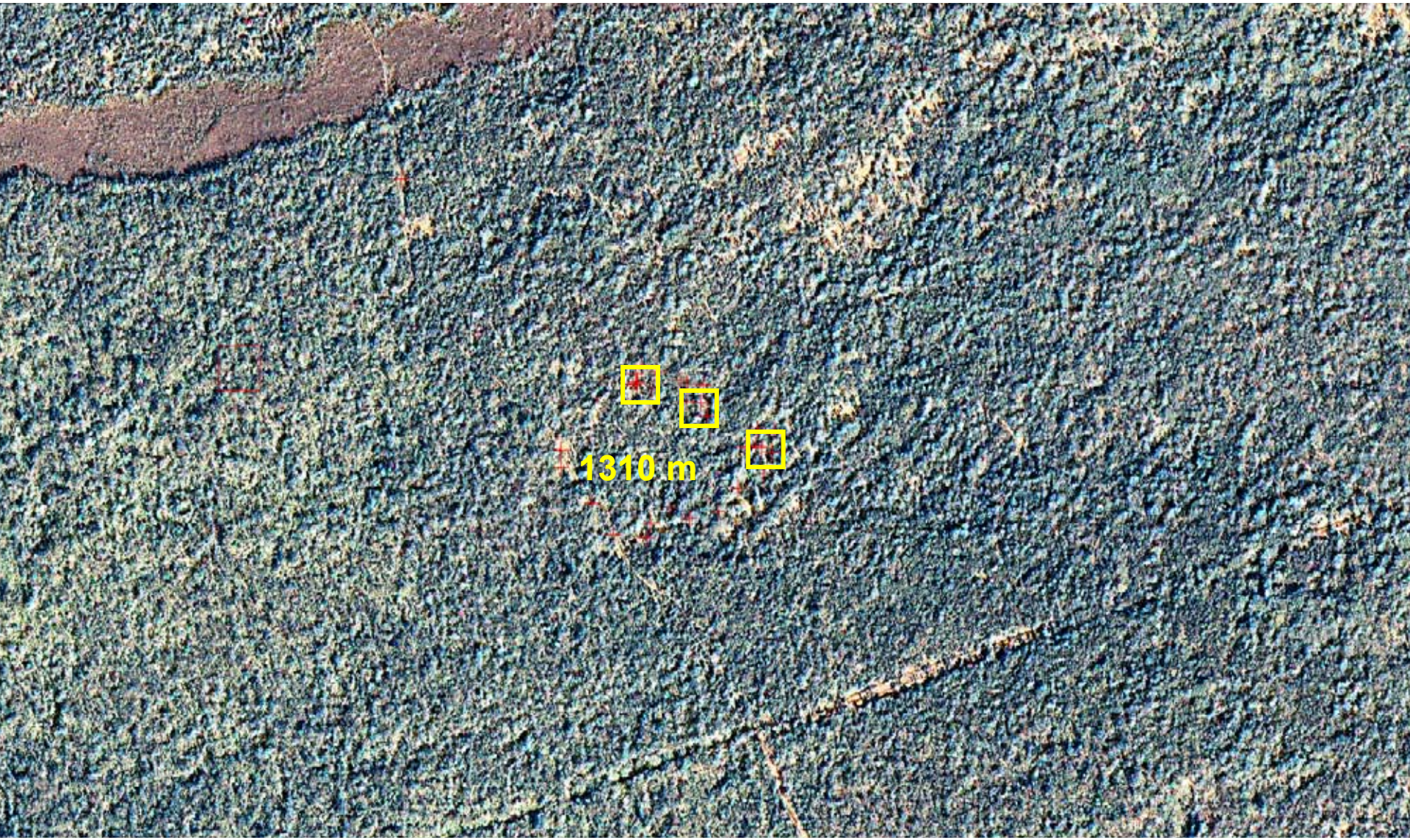



1600 m plots

3 sites at Honomalino Elevation Gradient (300 m)



Large mixture of koa and ohia stands


1310 m

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 adquired in February 2008:

- Conversion of DN to surface reflectance values
- Calculation of 7 vegetation indices (VIs) using ENVI

SR	Simple Ratio
MSR	Modified Simple Ratio
NDVI	Normalized Difference Vegetation Index
SAVI	Soil Adjusted Vegetation Index
MSAVI	Modified Soil Adjusted Vegetation Index
ARVI	Atmospherically Resistant Vegetation Index
EVI	Enhanced Vegetation Index

- 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:

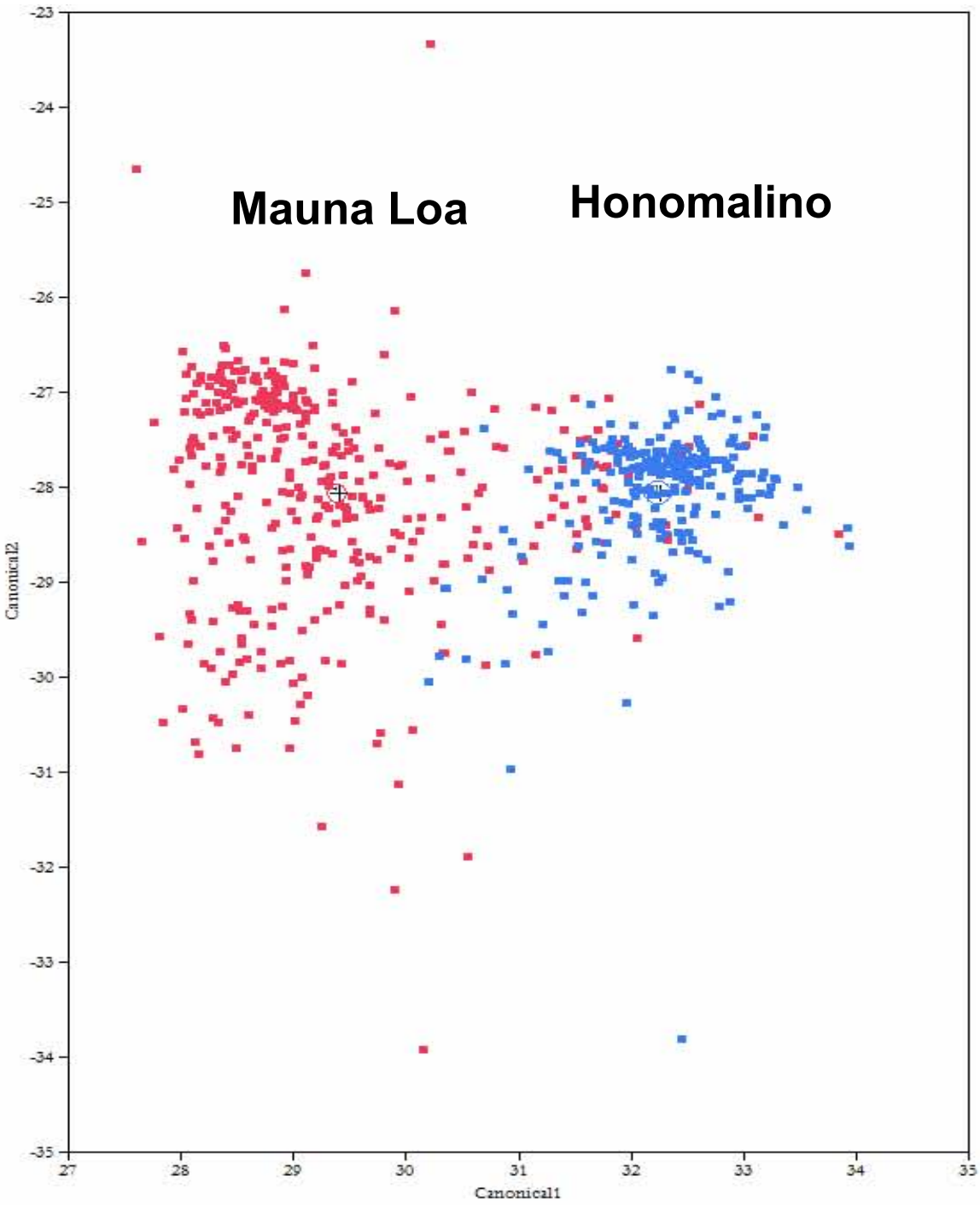
  - **Two were used as training sites using Maximum Likelihood**
  - **One was used for koa gradient class overlap assessment**

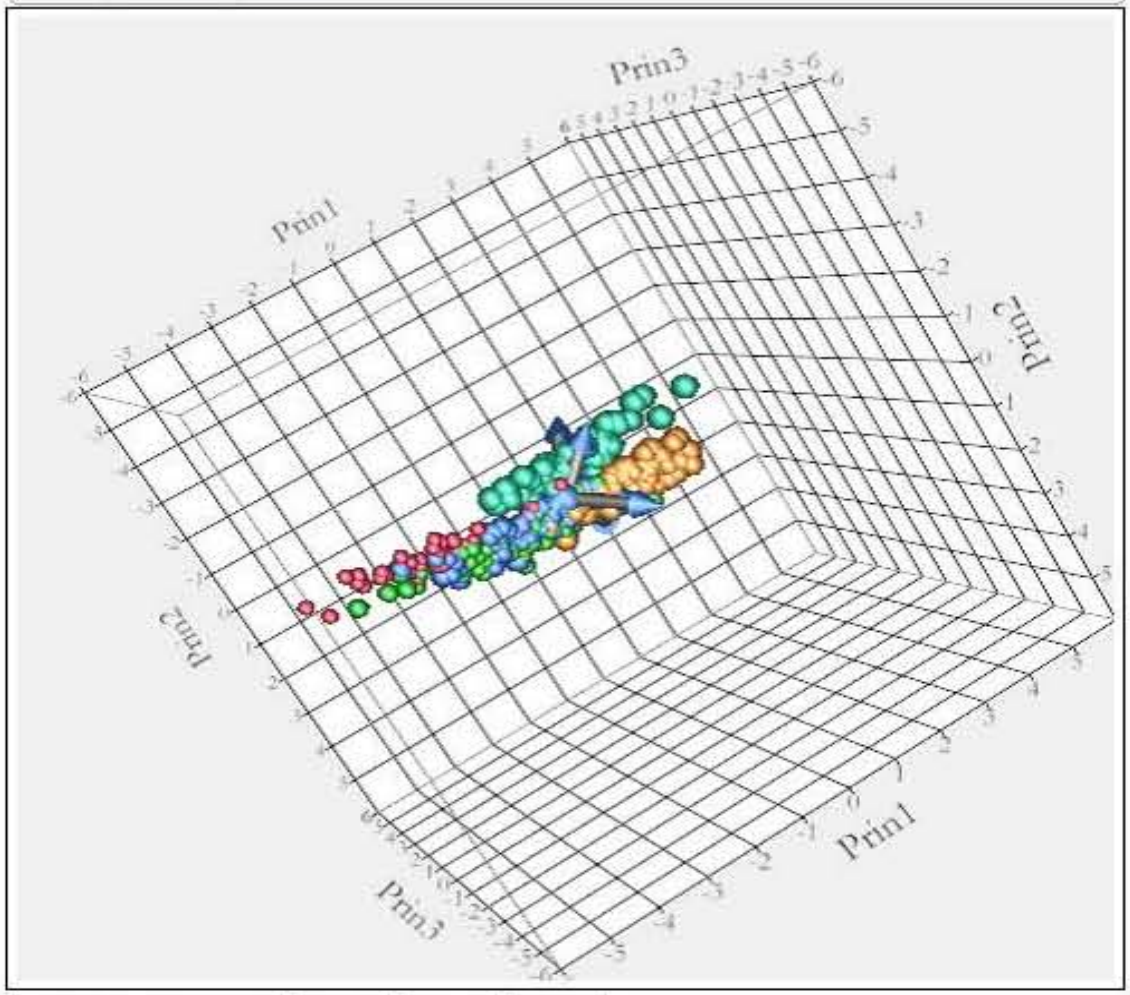
Results

Exploratory Analysis

Discriminant Analysis

Spectral differences were found between gradient sites





Mauna Loa

Exploratory Analysis

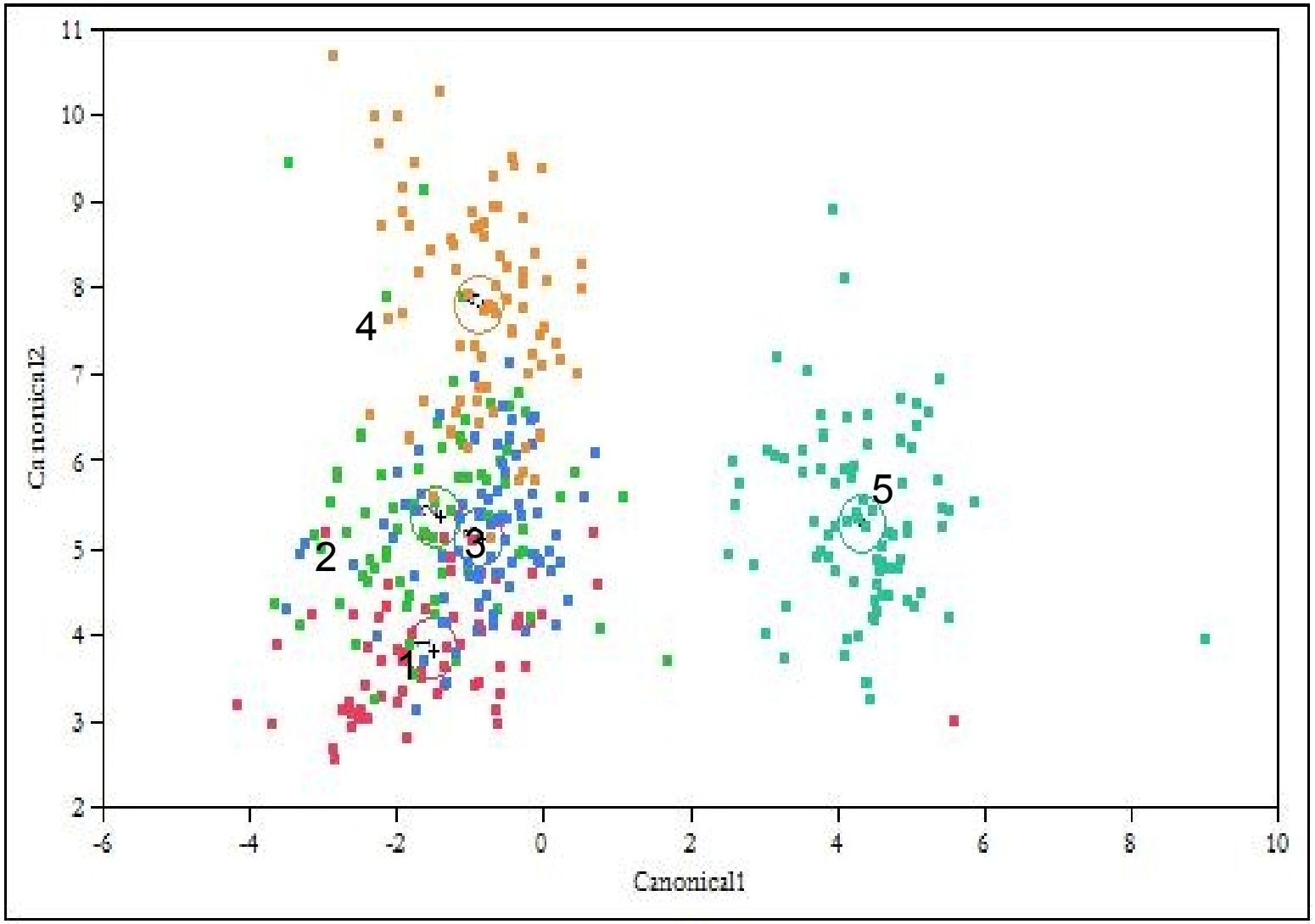
PCA indicated broad separation of koa gradient sites.

- **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.**

Eigenvectors

ARVI	0.35439	0.53621	0.61800	0.23708	0.37656	-0.07777	0.03014
EVI	0.36856	-0.46131	0.40794	0.37869	-0.57390	0.09337	-0.03395
MSAVI	0.37708	-0.42680	-0.10490	-0.04362	0.57864	0.55277	-0.14957
MSR	0.38936	0.24420	-0.35940	0.06539	-0.14455	-0.19758	-0.77161
NDVI	0.38849	0.24281	0.08898	-0.75012	-0.34020	0.27958	0.16002
SAVI	0.38237	-0.37281	-0.03439	-0.25574	0.21734	-0.74365	0.21901
SR	0.38424	0.24482	-0.54989	0.40758	-0.08859	0.09728	0.55373

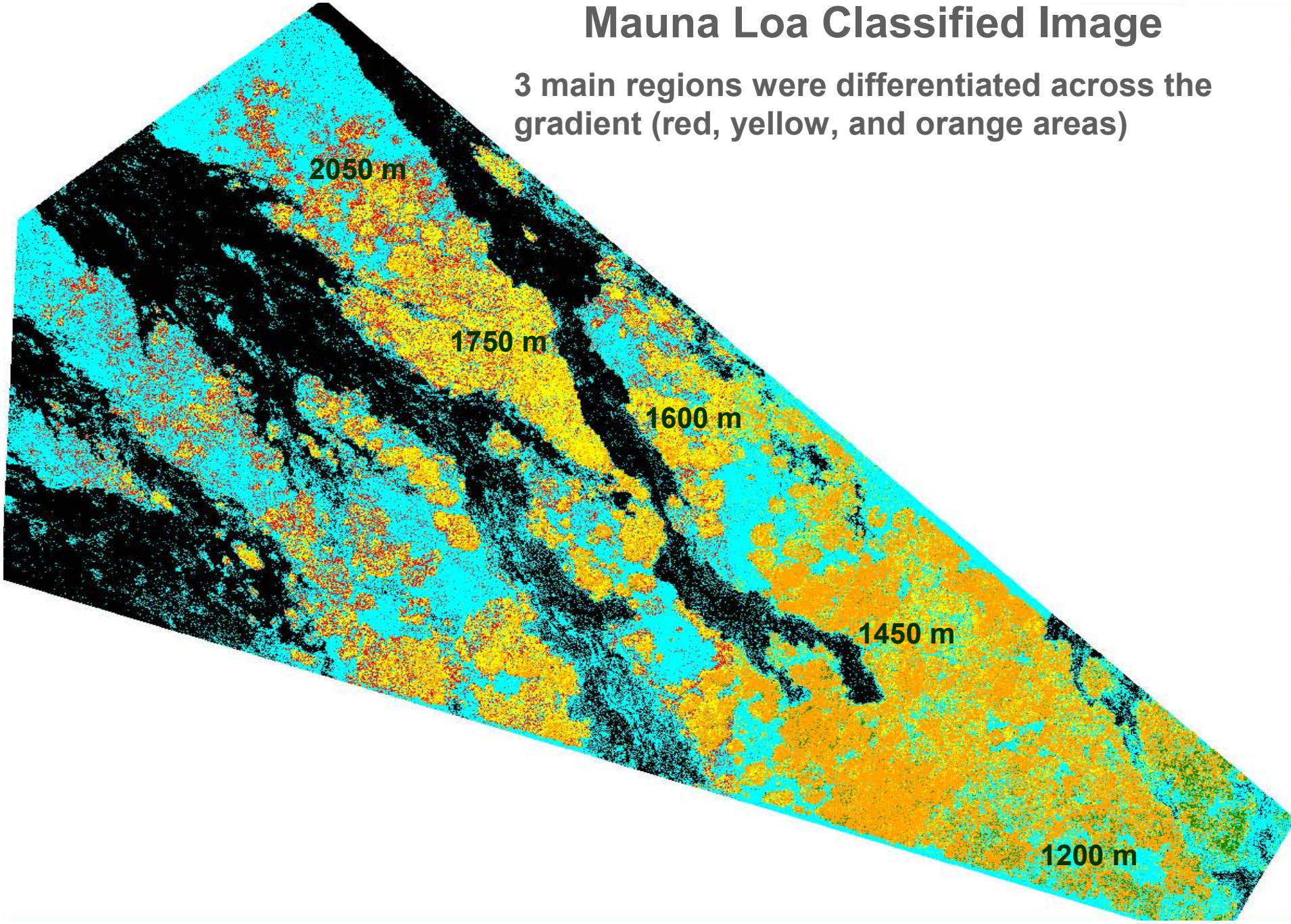
Discriminant Analysis



- All 5 sites at different elevation along Mauna Loa Rd. could be separated
- Sites at 1600 and 1750 m overlap most

Mauna Loa Classified Image

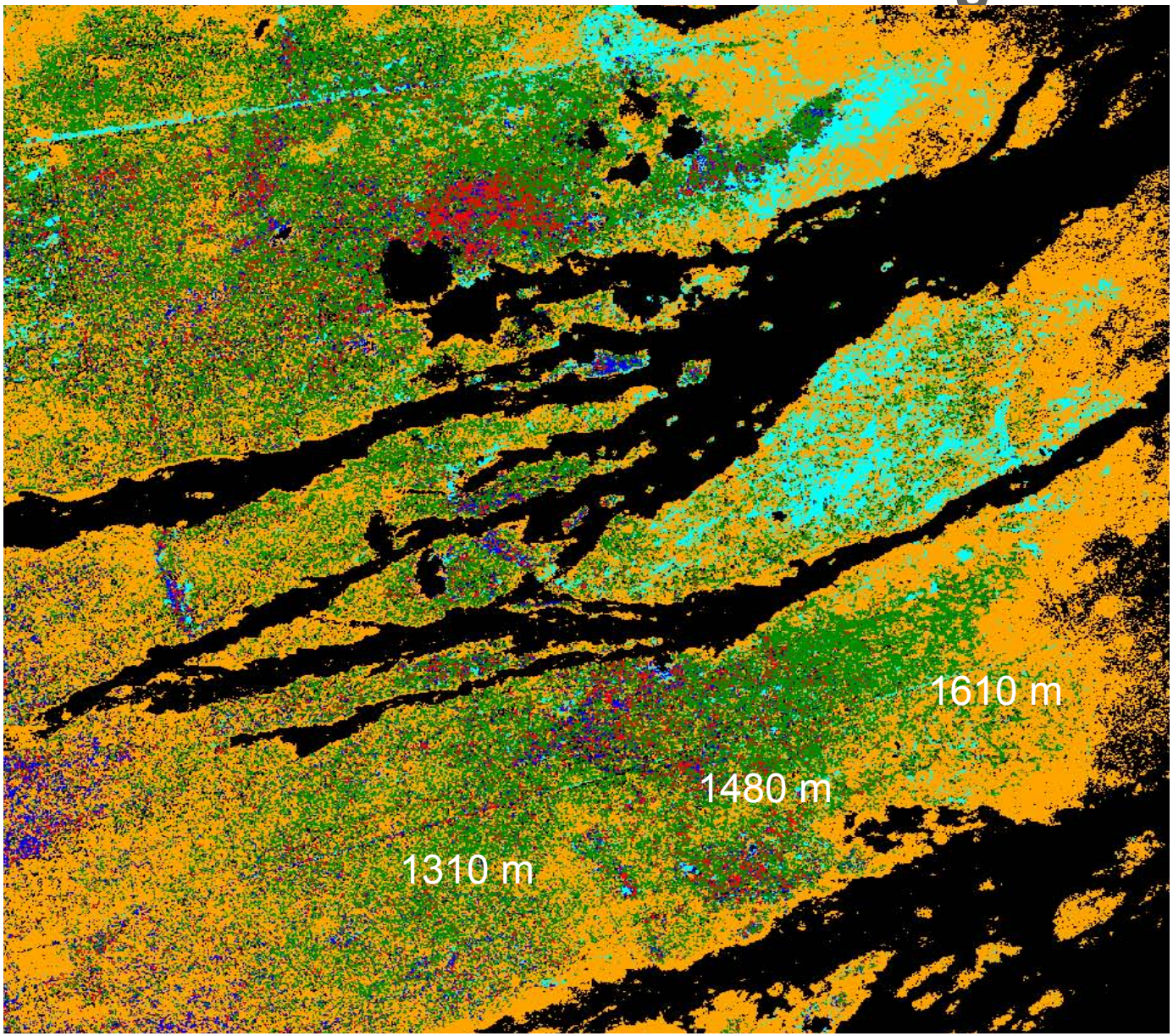
3 main regions were differentiated across the gradient (red, yellow, and orange areas)



Class Overlap Assessment

Gradients	2050 m	1750 m	1600 m	1450 m	1200 m
2050 m	78.57	8.7	8.7	0	16.13
1750 m	21.43	69.57	82.61	0	3.23
1600 m	0	0	0	0	0
1450 m	0	21.74	8.7	100	58.06
1200 m	0	0	0	0	22.58
Total	100	100	100	100	100

Honomalino Classified Image



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

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