



Jet Propulsion Laboratory
California Institute of Technology

PRINCETON
School of Engineering
and Applied Science

IU INDIANA UNIVERSITY

Finding fields fast: A novel approach for mapping agricultural fields across continents

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Understanding Food Security in Sub-Saharan Africa

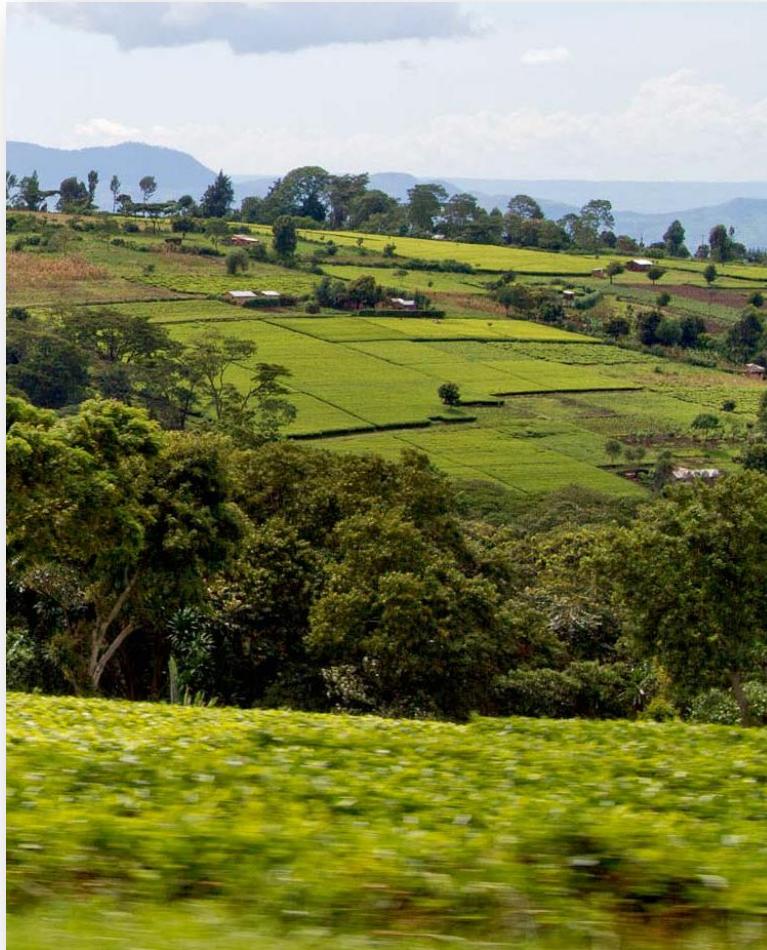
Smallholder-Dominated Agriculture



Fields typically < 2 hectares

Food Security is Determined at Household Level

Developing boundary conditions to study food security

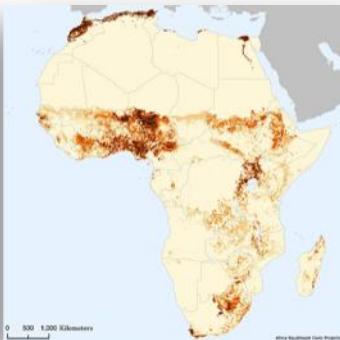
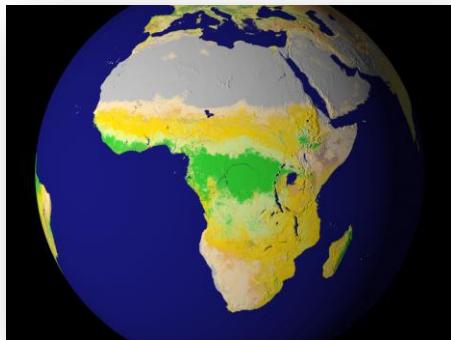


Quantify extent
of agriculture

Provide details of
smallholder
agriculture

Agricultural Land Cover Maps

Gridded Data Sets



Smallholder Agriculture



Resolution: 30 m – 1 km

Highly heterogeneous

Ag		Ag	Ag
Ag	Ag		Ag
		Ag	Ag
Ag	Ag	Ag	

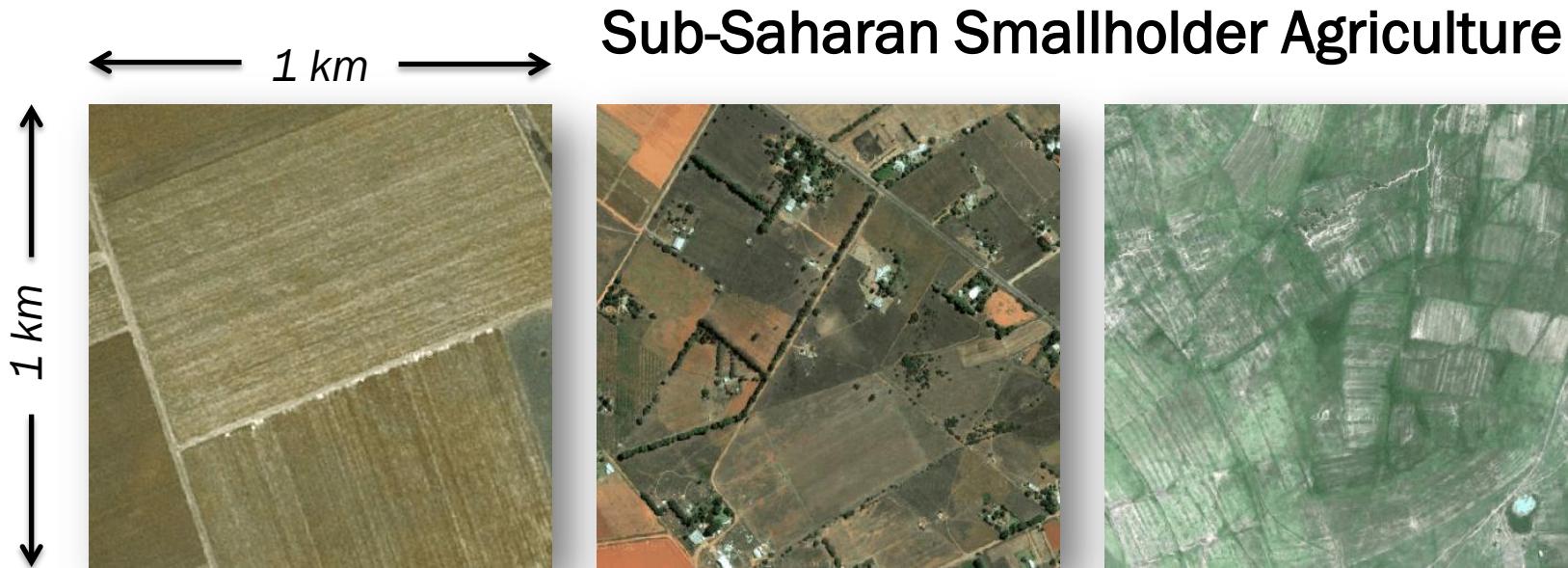
Agriculture
within a
grid cell?

Sub-Grid Cell Detail



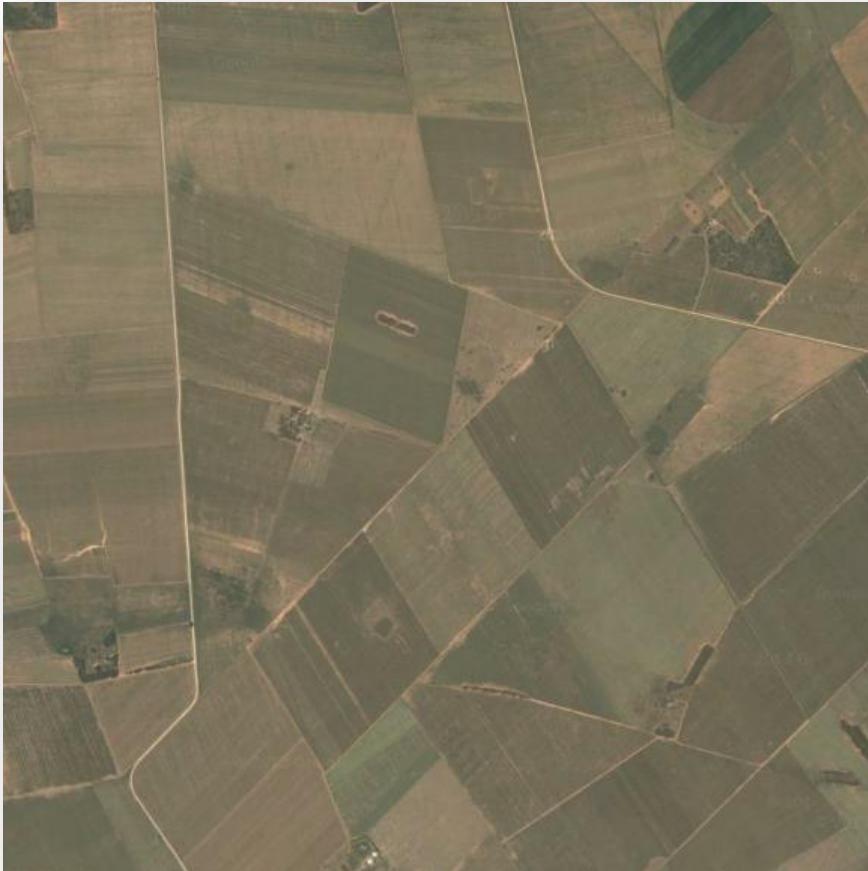
High levels of homogeneity between grid cells

Capturing Small-Scale Heterogeneity



High levels of heterogeneity between grid cells

Agricultural Field Boundary Map

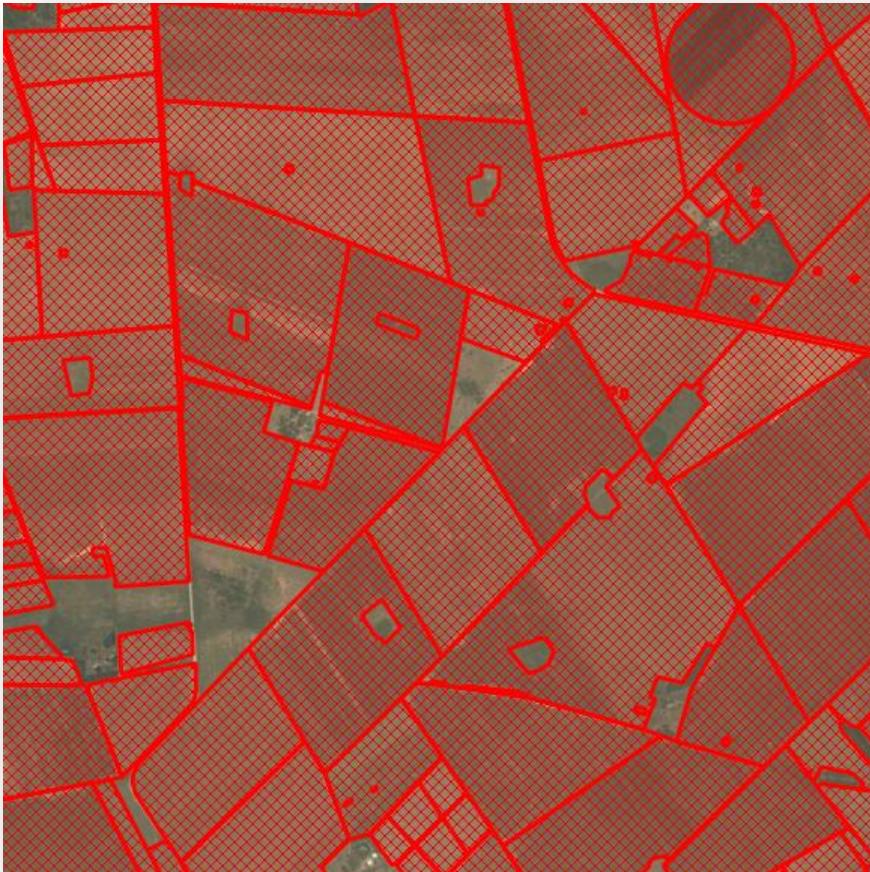


Distribution of
field sizes

Distribution of
agriculture across
landscapes

Village
organization
patterns

Agricultural Field Boundary Map

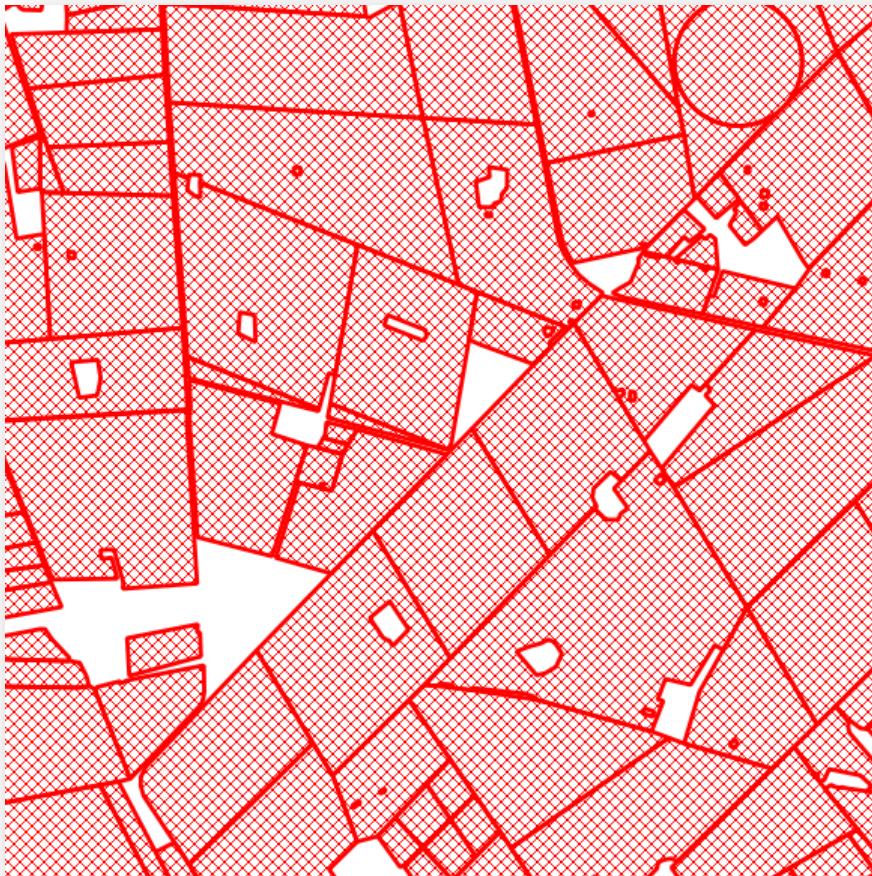


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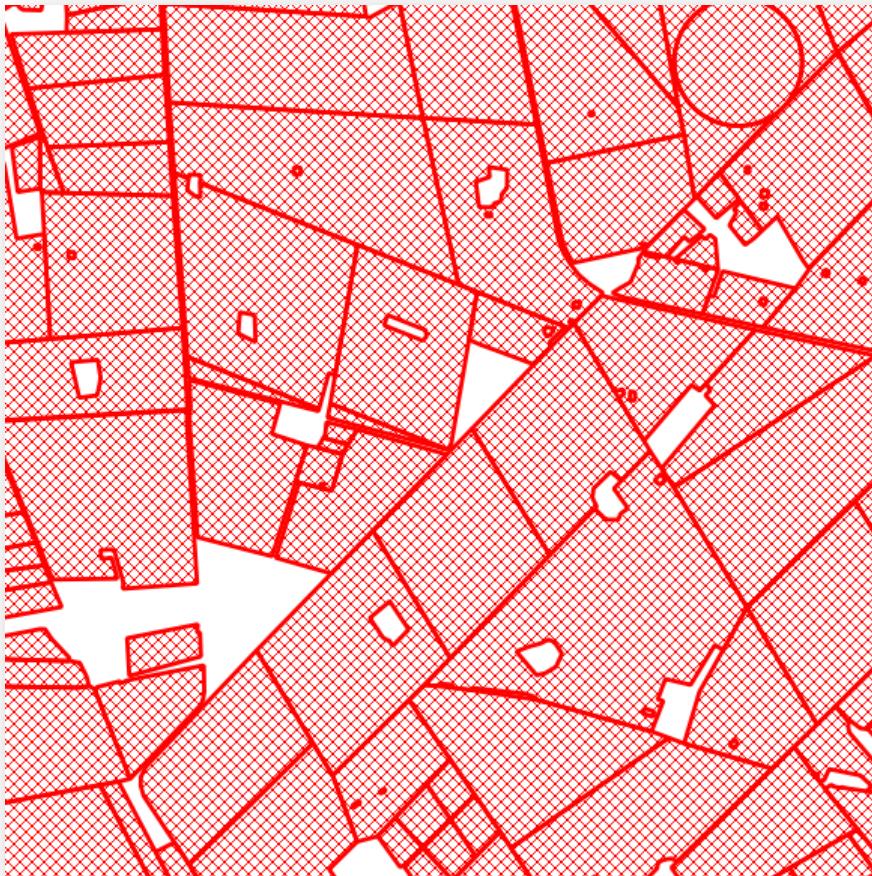


Distribution of
field sizes

Distribution of
agriculture across
landscapes

Village
organization
patterns

Agricultural Field Boundary Map



*How do we make
these maps?*

Hand-digitization

- Expensive
- Labor intensive
- Time consuming



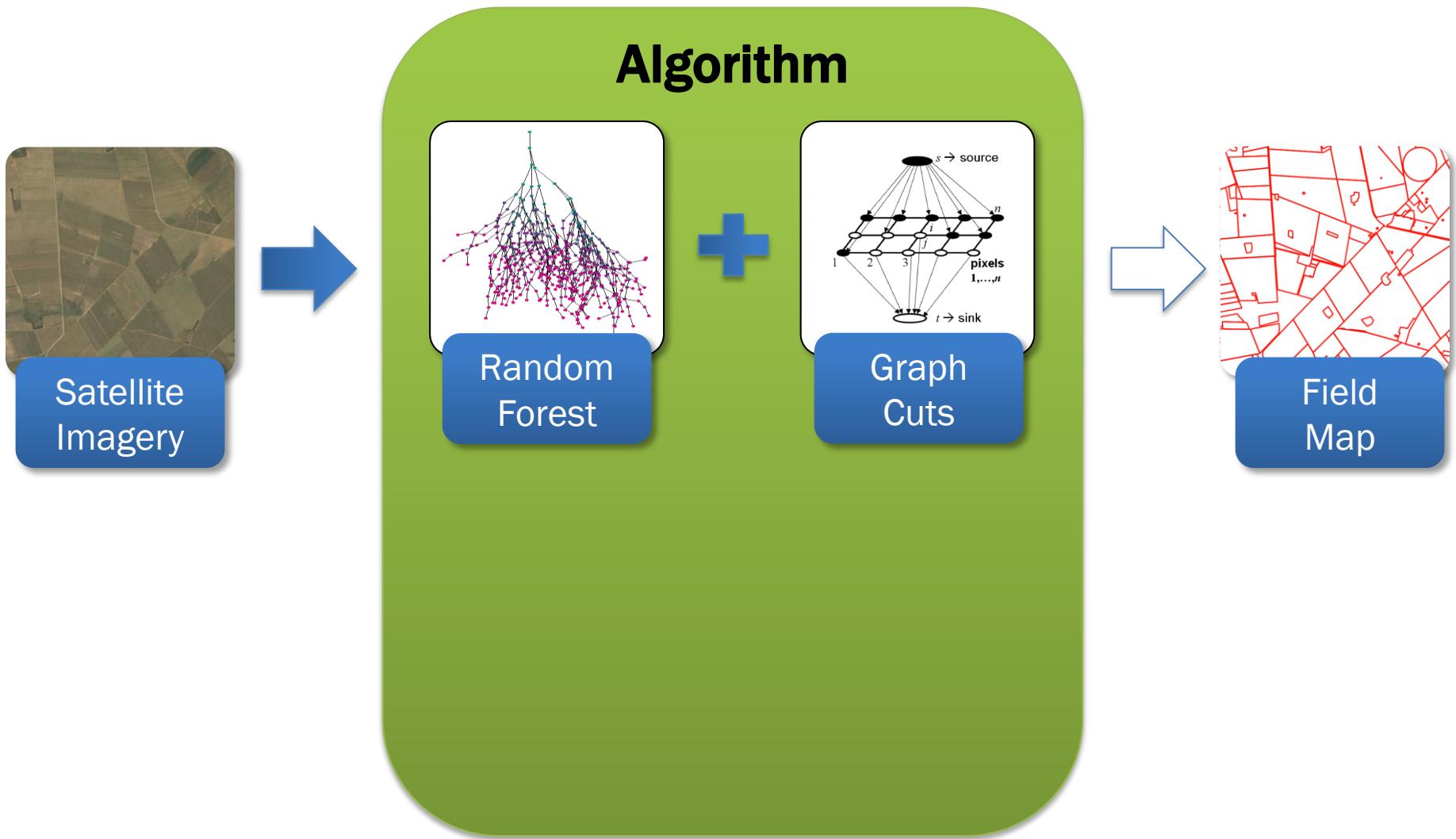
Computer
Algorithm

Project Goals

Develop field mapping algorithm
based on machine learning and
computer vision techniques
to map agricultural field boundaries
across Sub-Saharan Africa

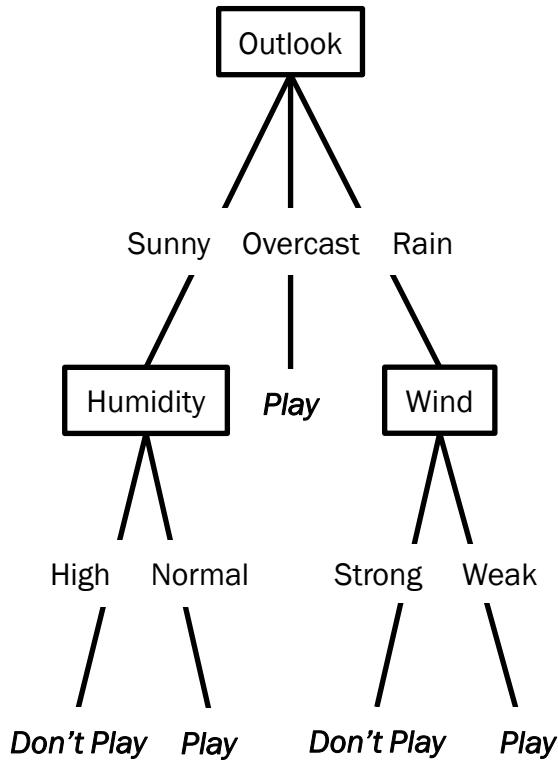


Field Mapping Algorithm



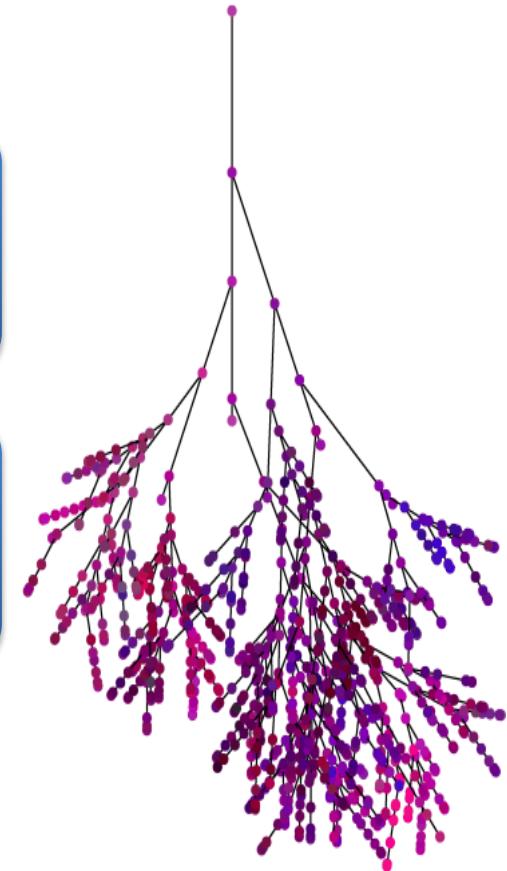
Machine Learning: Random Forests

Example: Play Tennis?

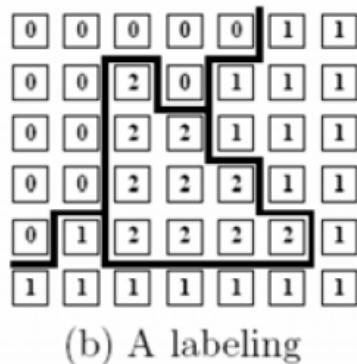
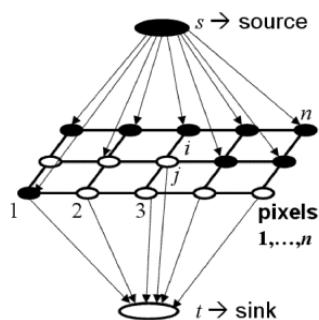
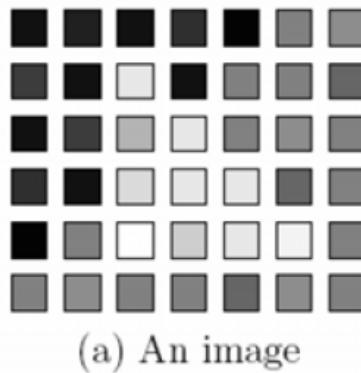
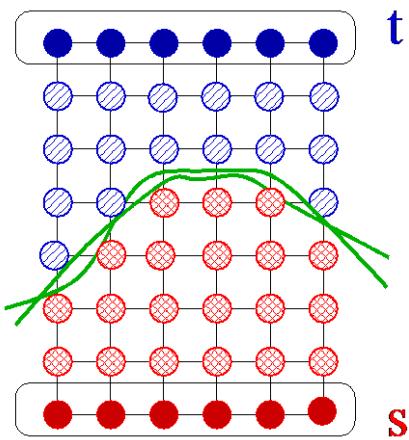


Machine Learning
Pixel-wise Classifier

Numerous
decision trees



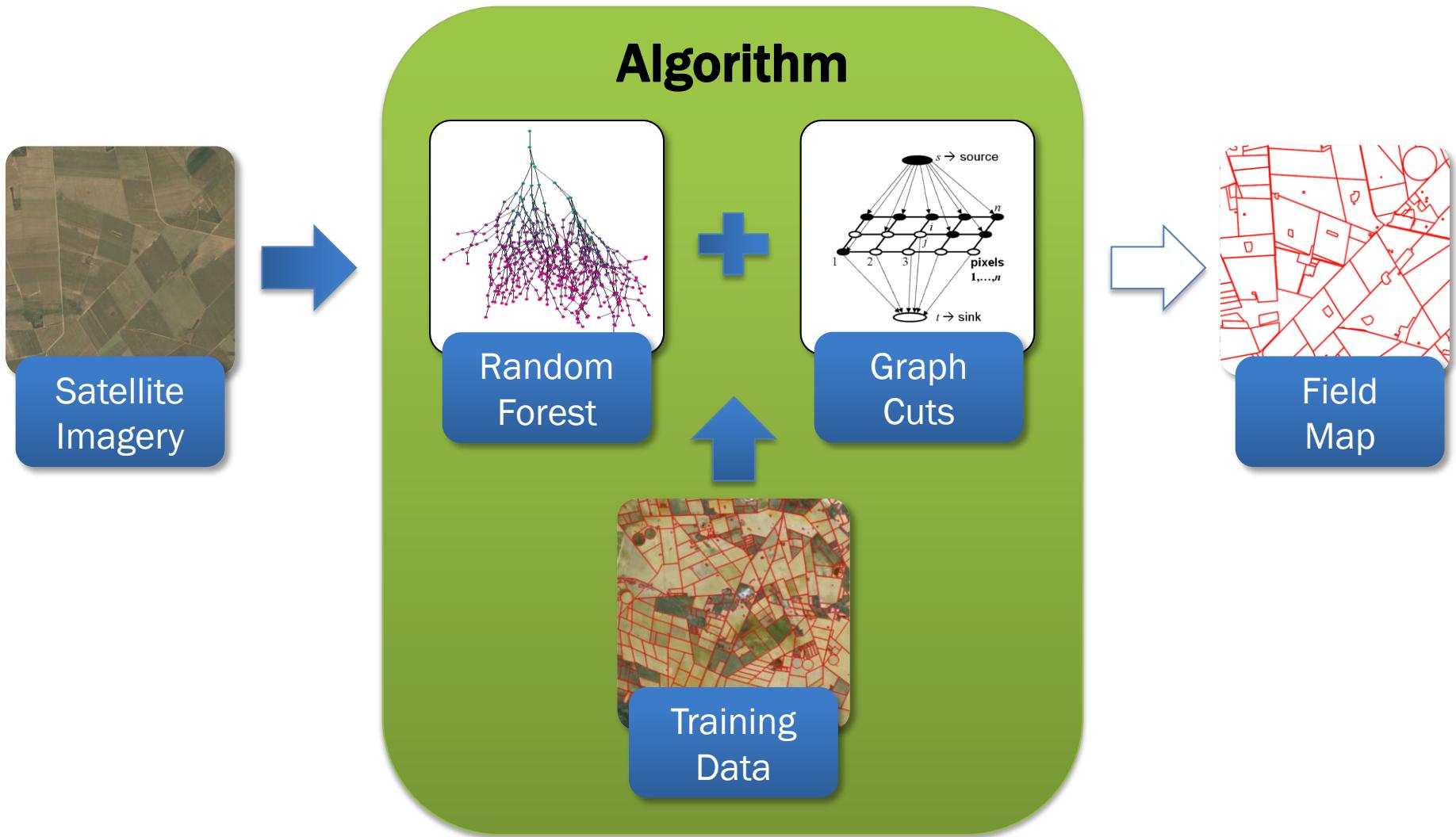
Computer Vision: Graph Cuts



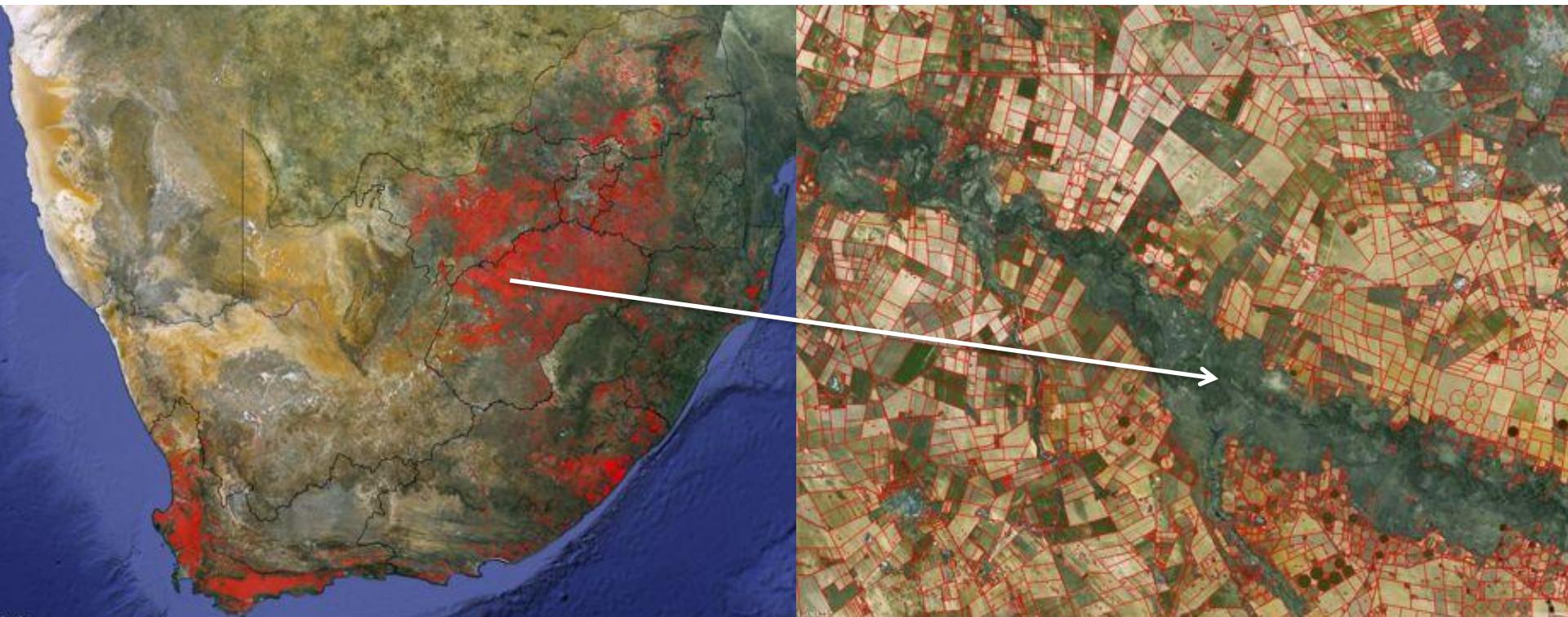
Computer
vision

Image
Segmentation

Field Mapping Algorithm



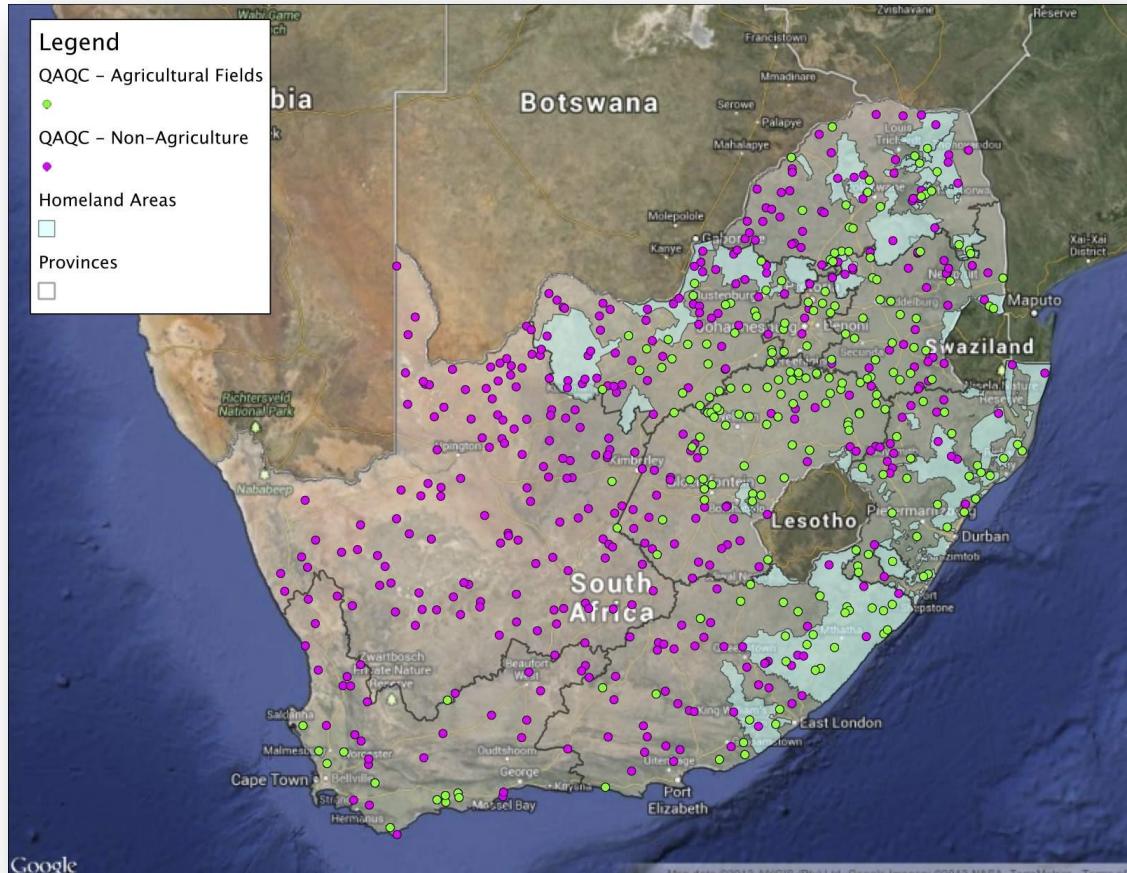
Training Data



Hand-digitization of every agricultural field in South Africa

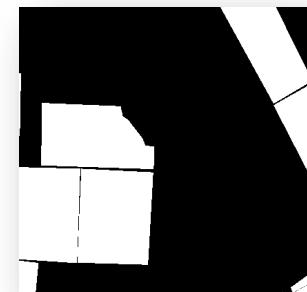
- GeoTerralmage (2008)

Training Data



Example of a scene:

1 km

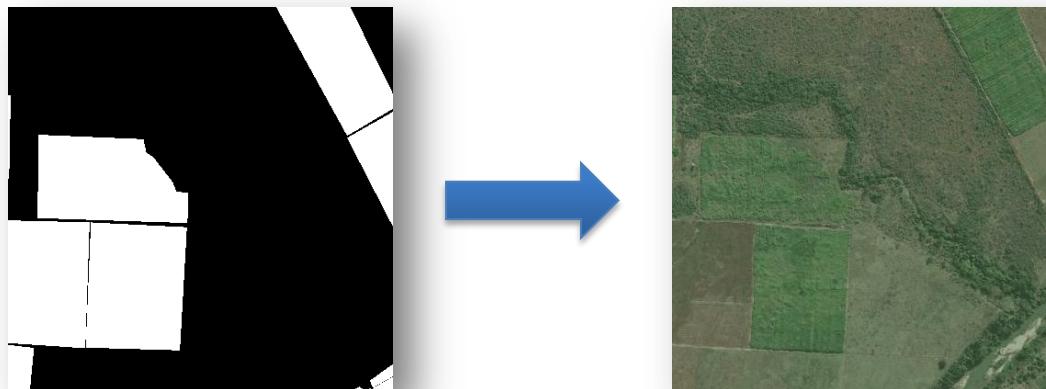


*White = Fields
Black = Non-Fields*

Training Data

What does a field look like?

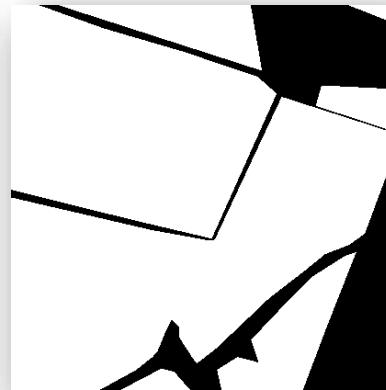
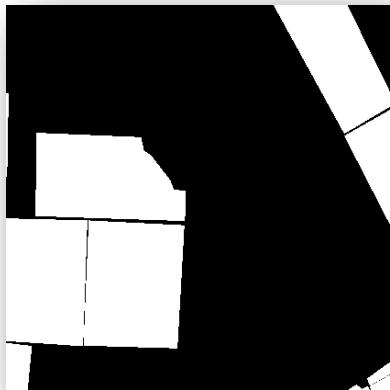
Each labeled scene is matched with a
Google Maps image



Building an image library to use as training data

Image Library

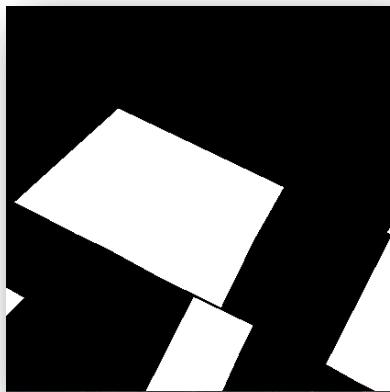
Labels (GeoTerralmage)



Google Maps images (RGB)

Expanding Image Library

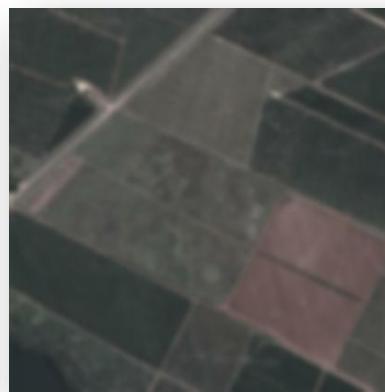
Labels



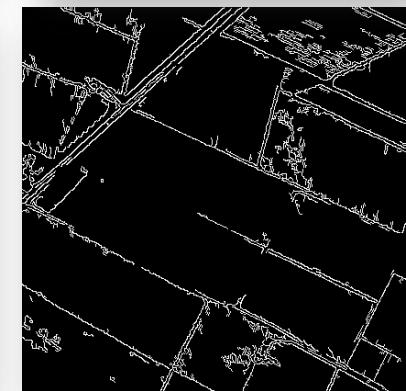
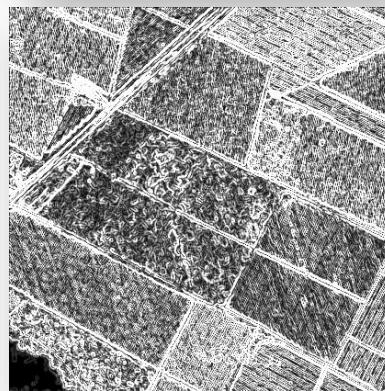
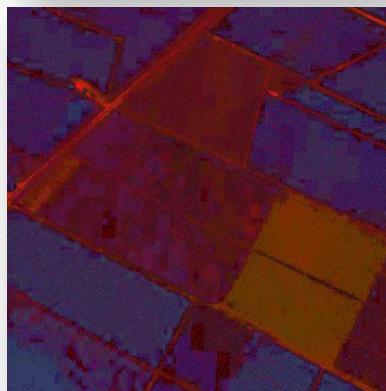
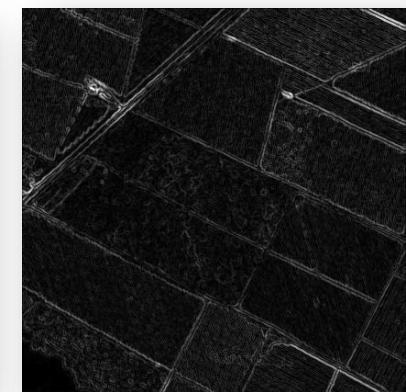
Grayscale



Gaussian Blur



Sobel



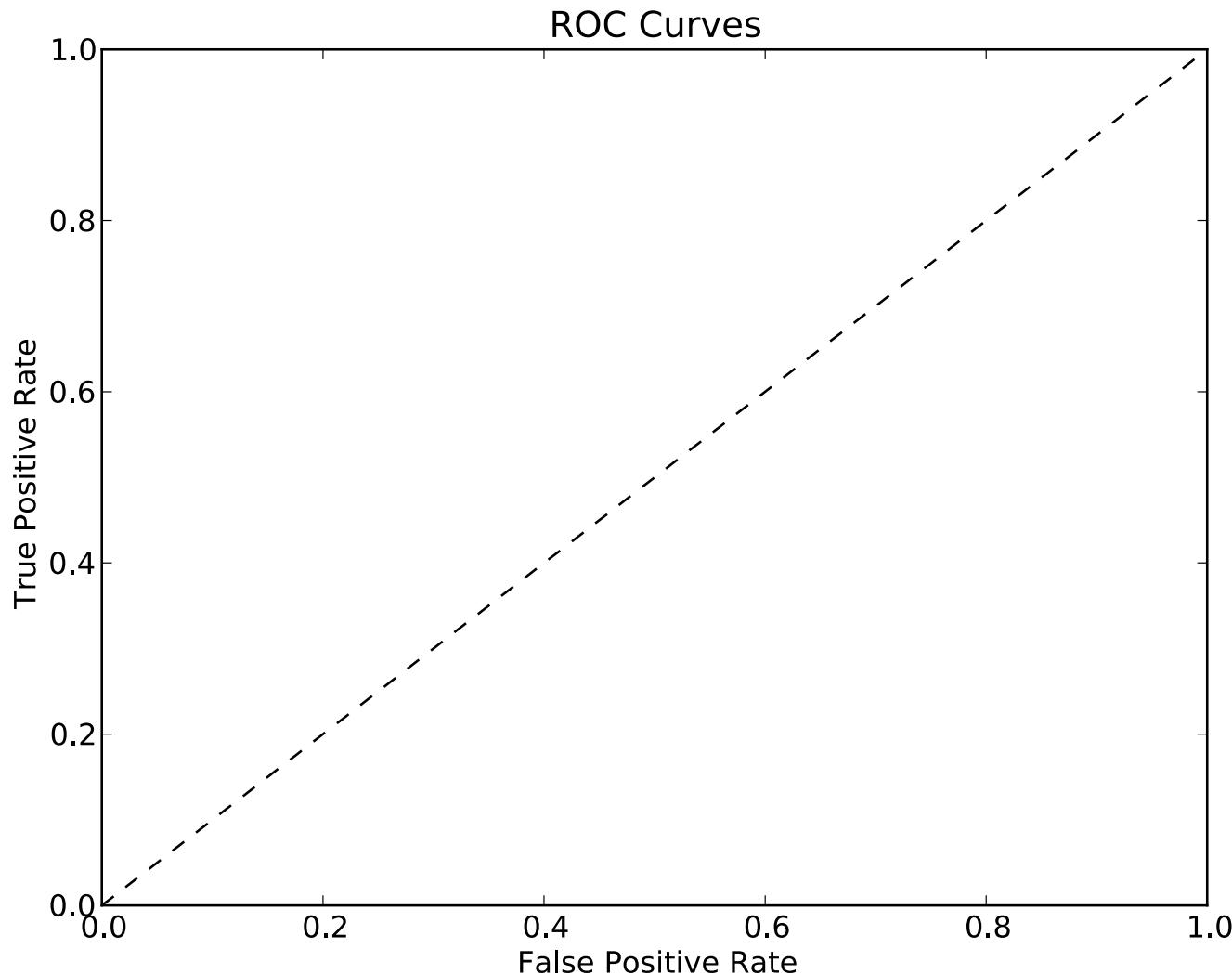
Google Maps - RGB

HSV

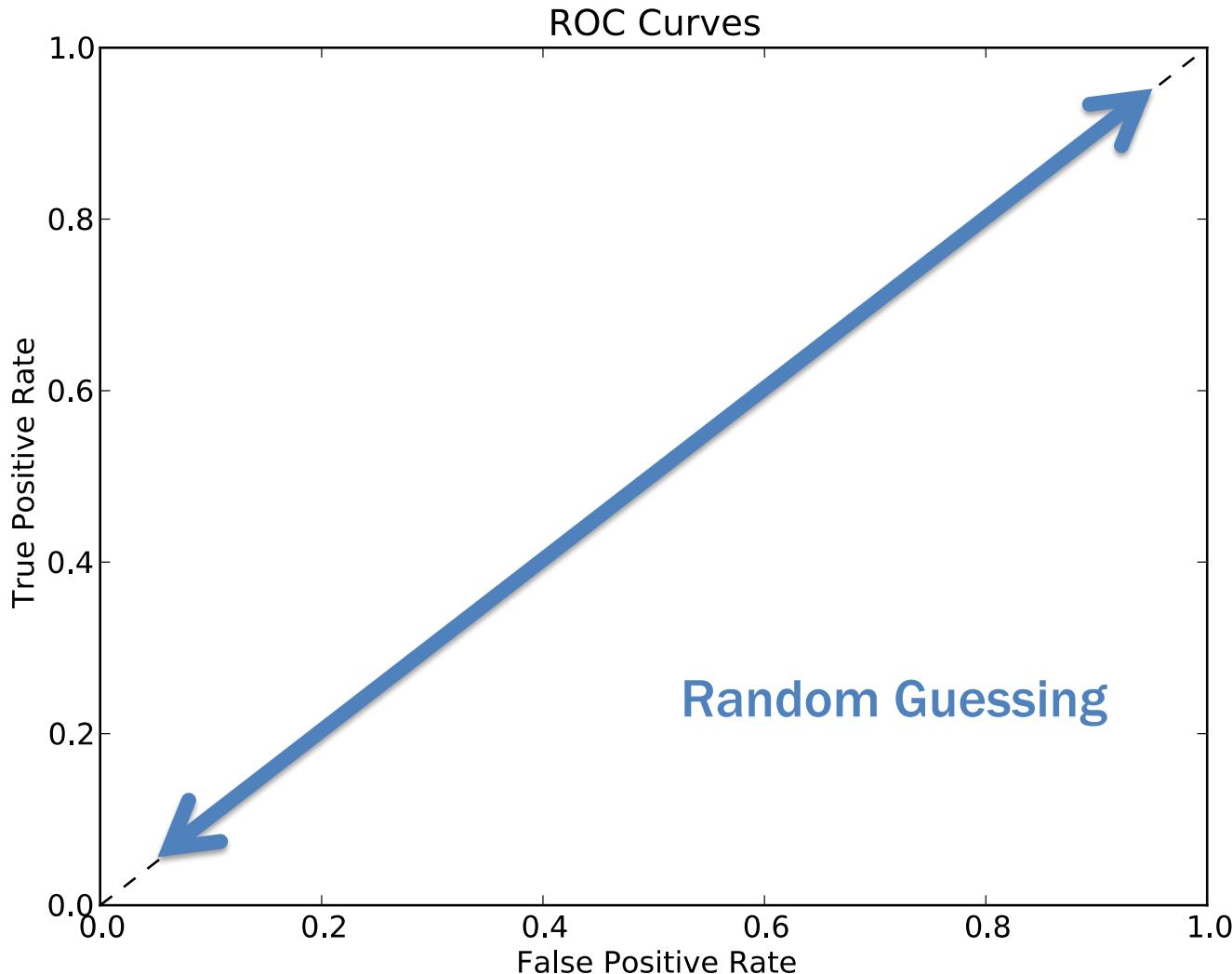
Scharr

Canny

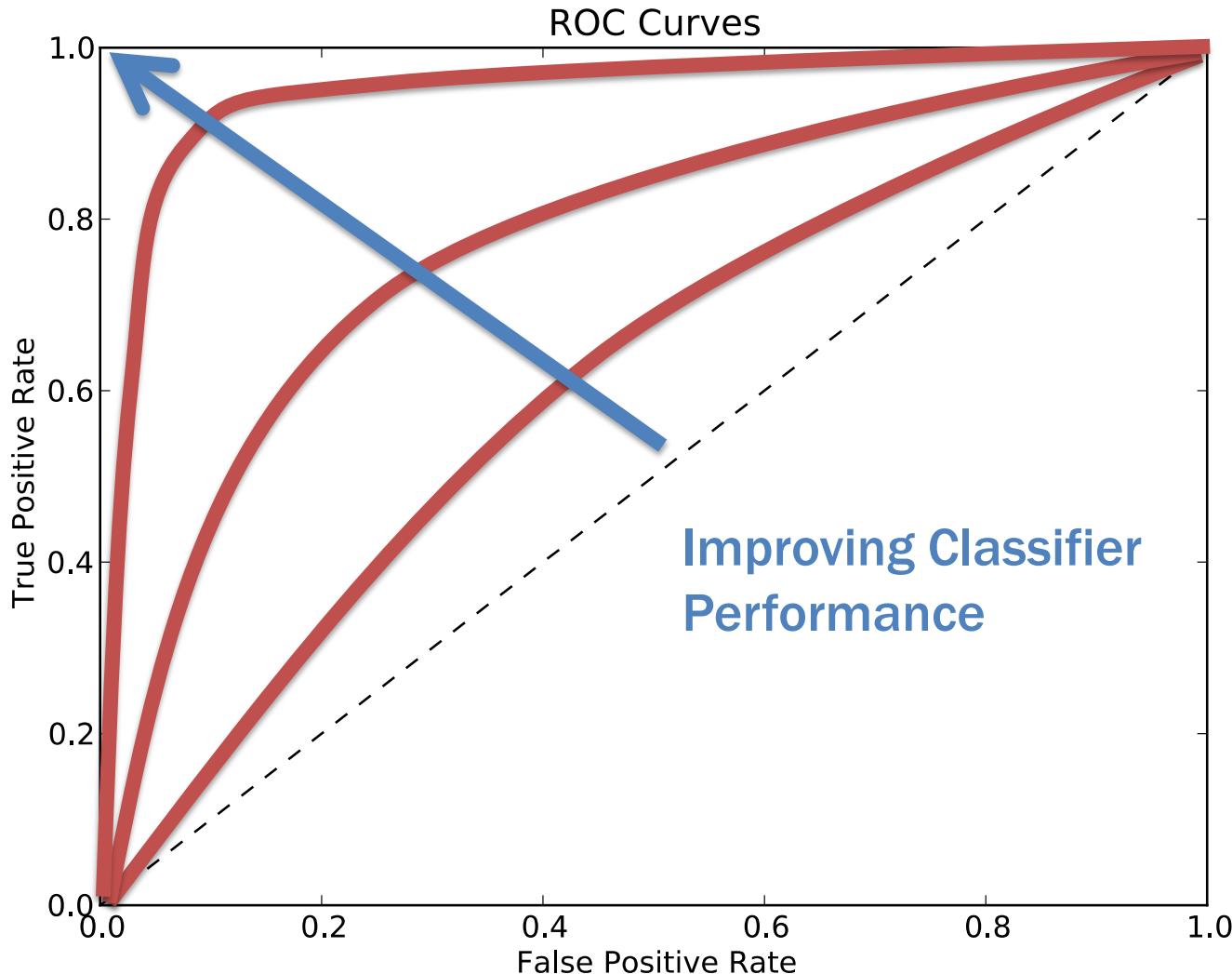
Classifier Results



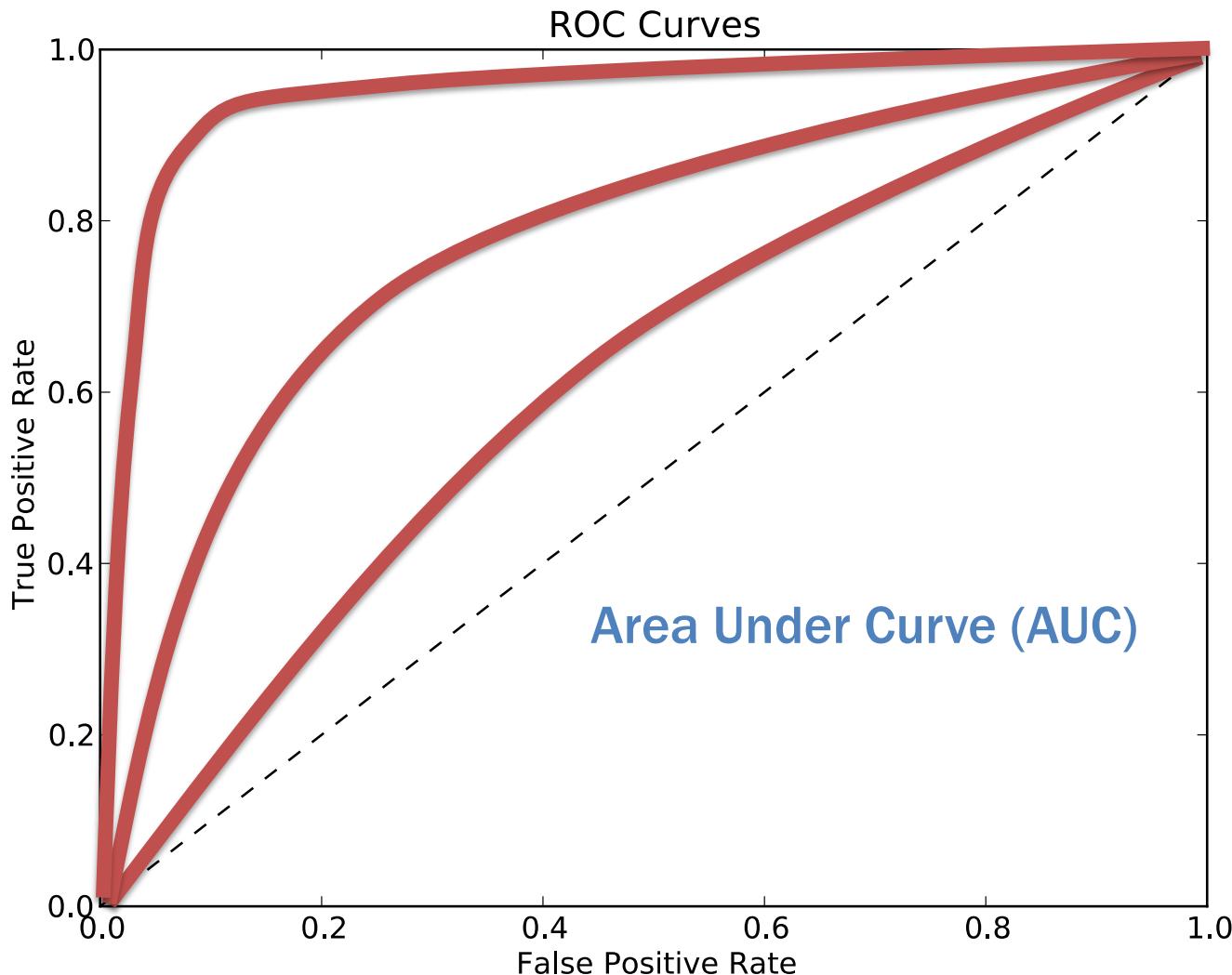
Classifier Results



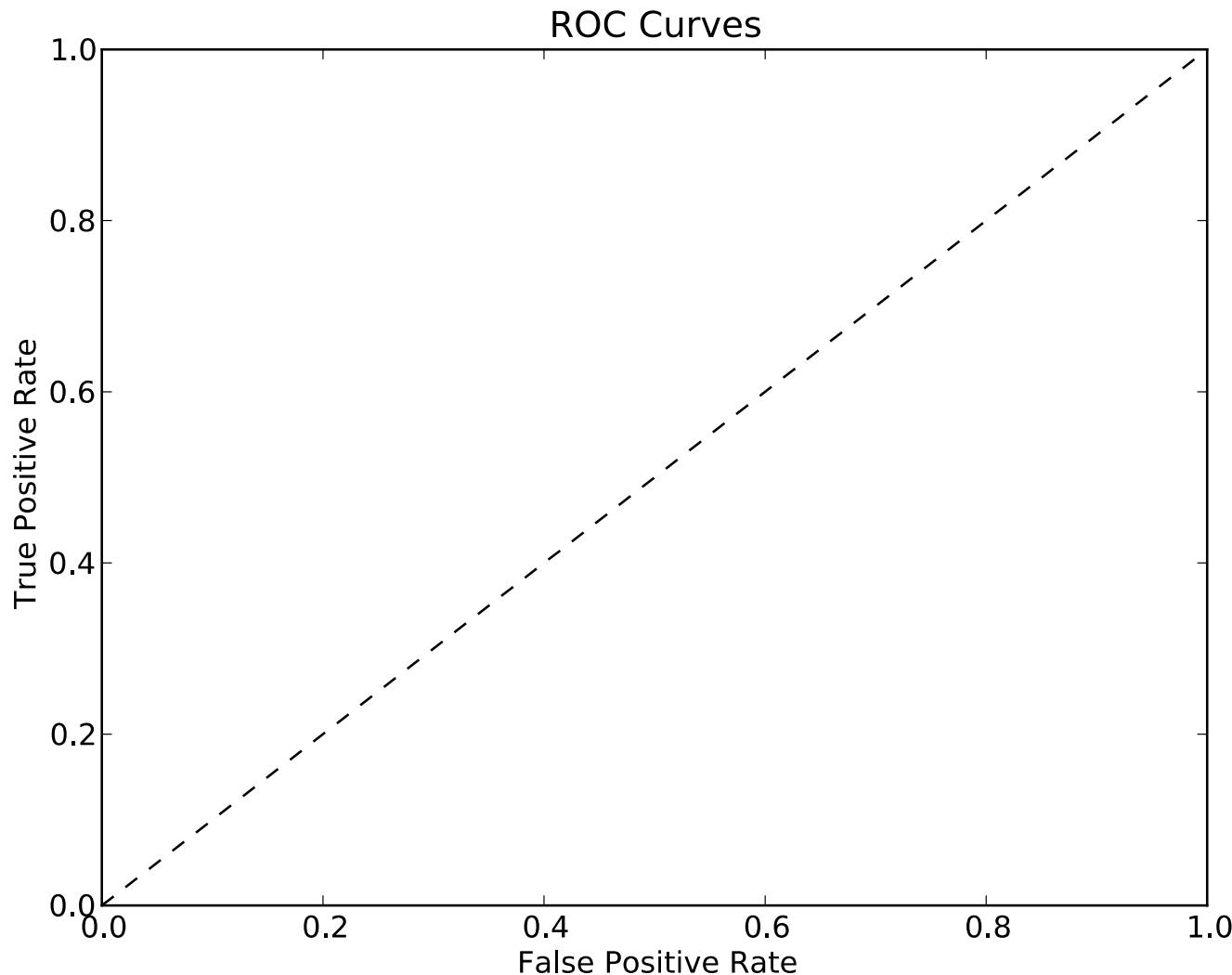
Classifier Results



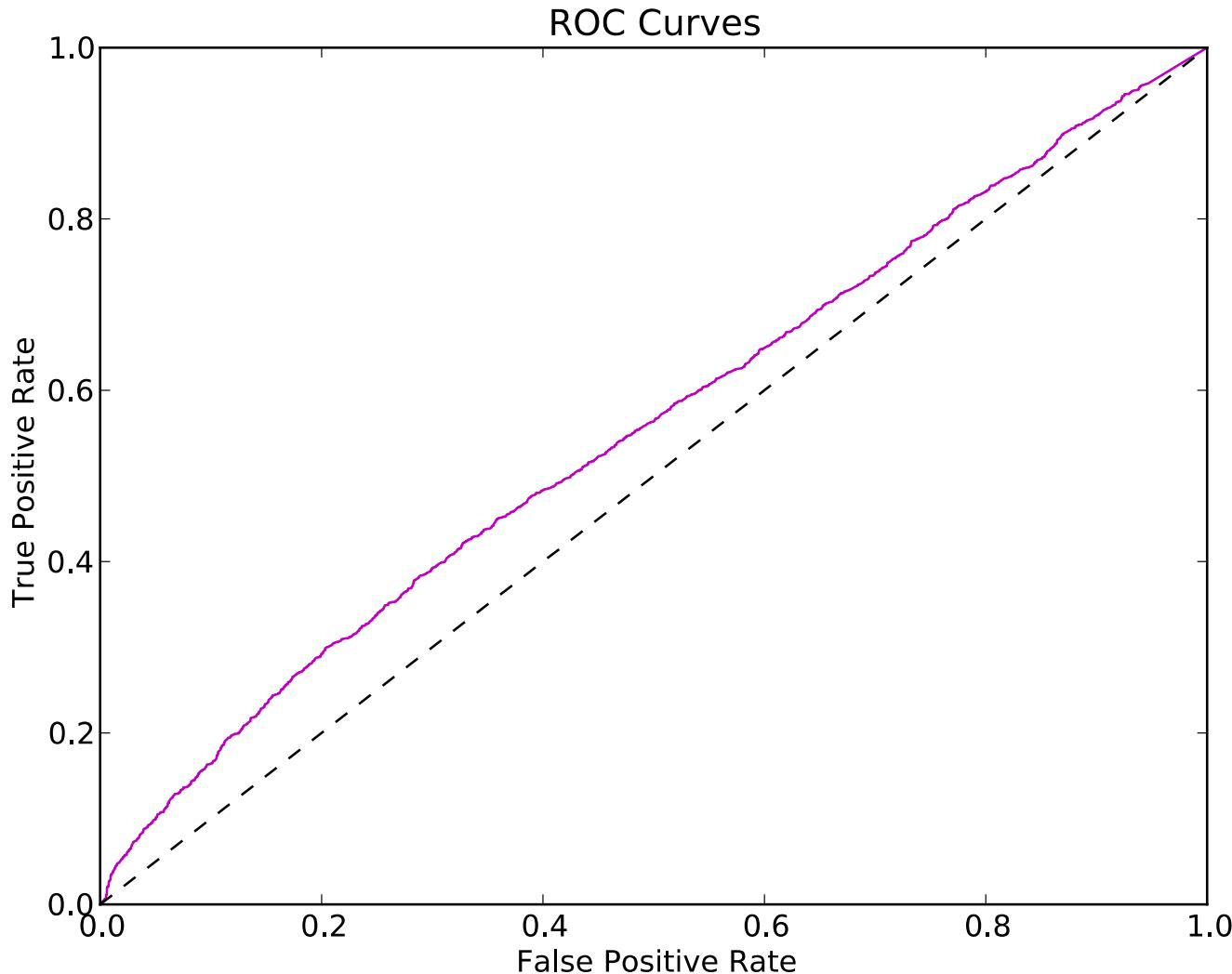
Classifier Results



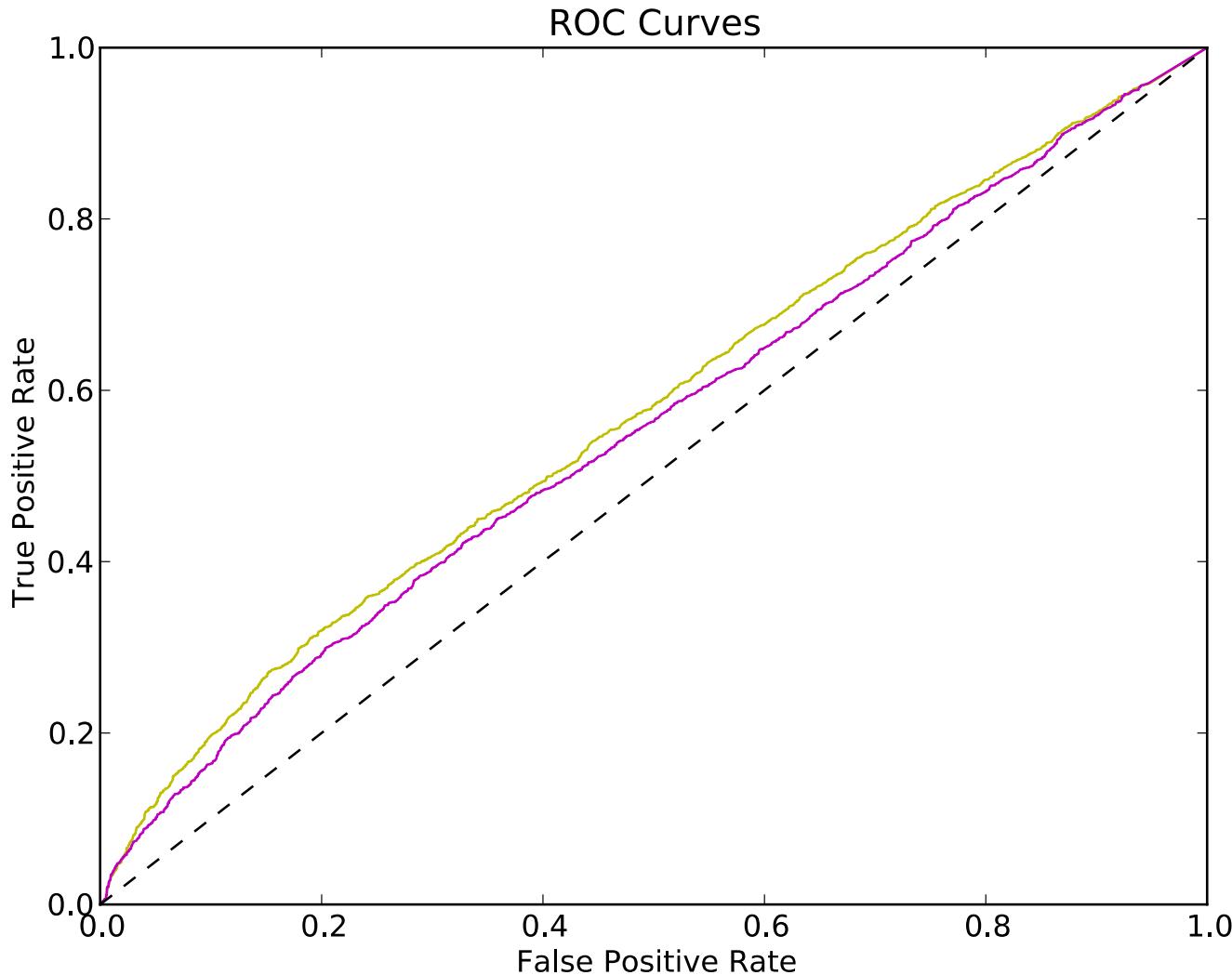
Classifier Results



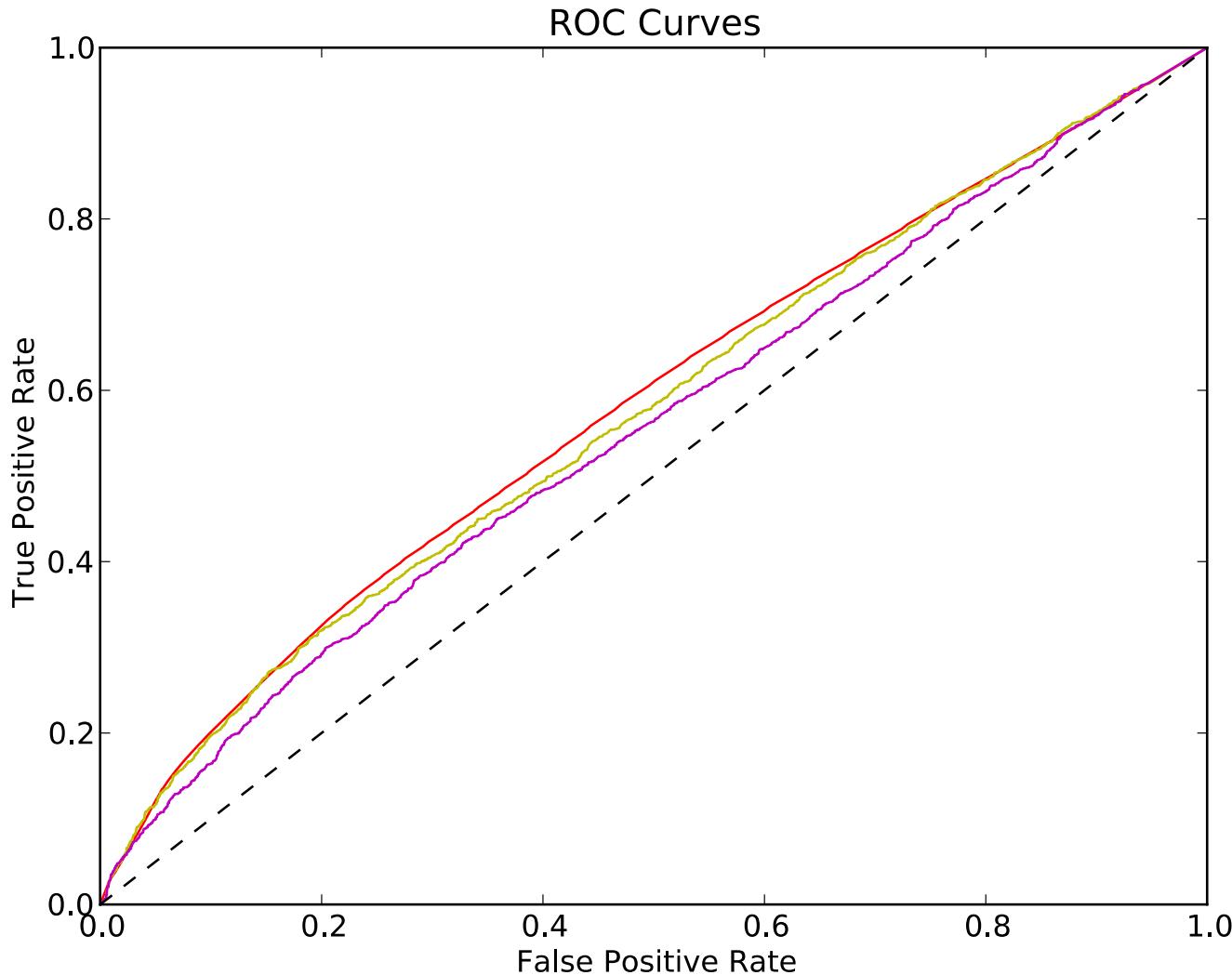
Classifier Results



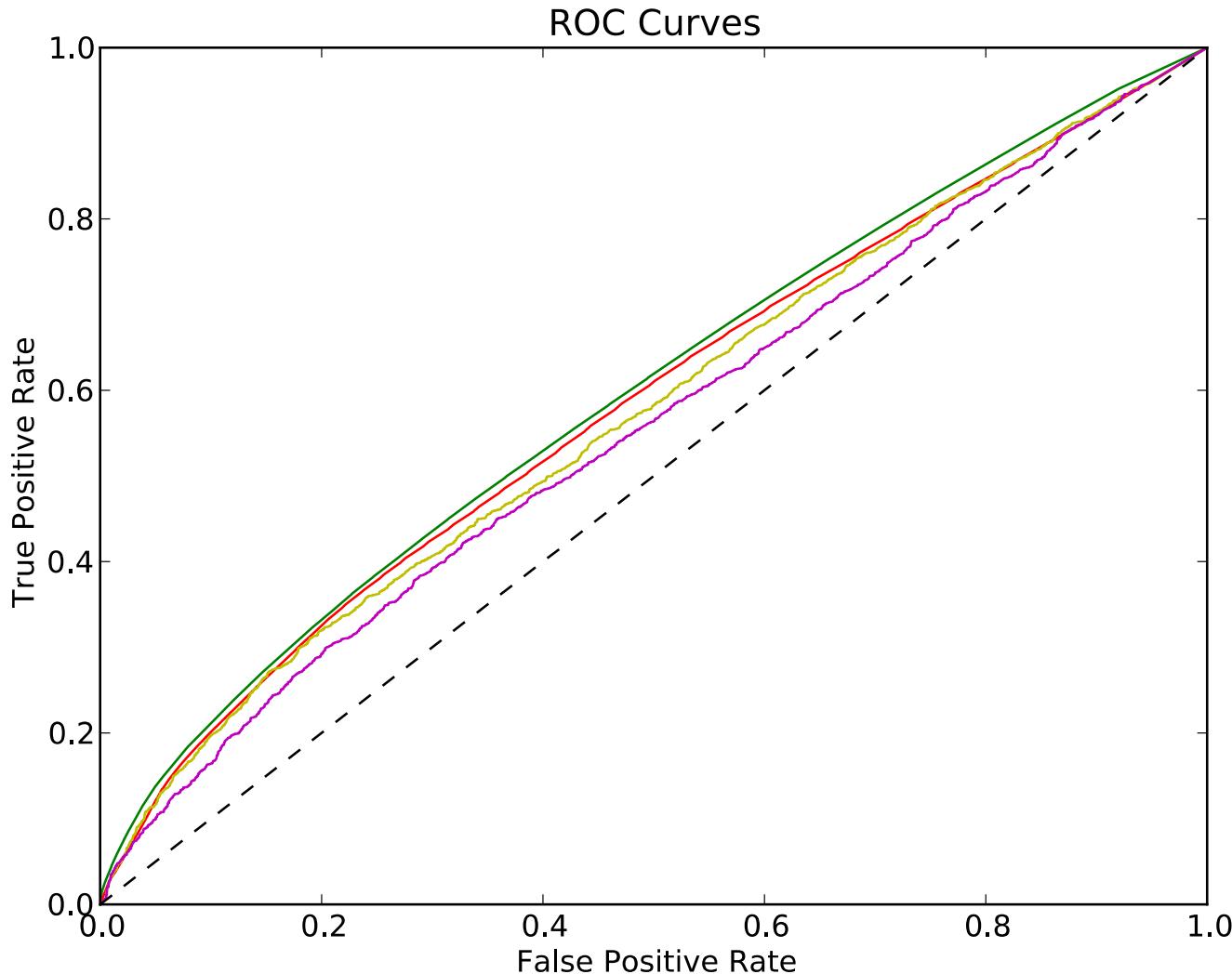
Classifier Results



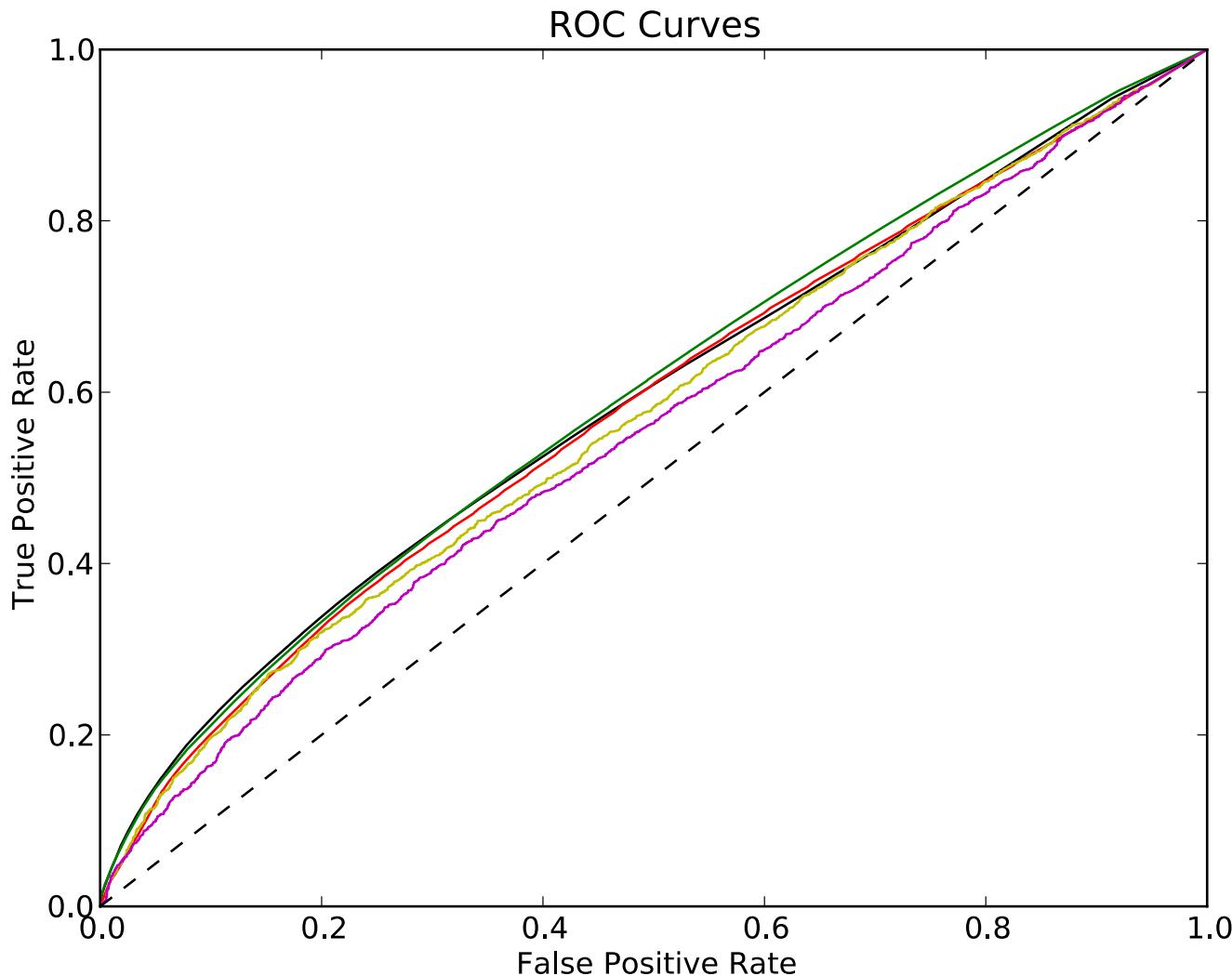
Classifier Results



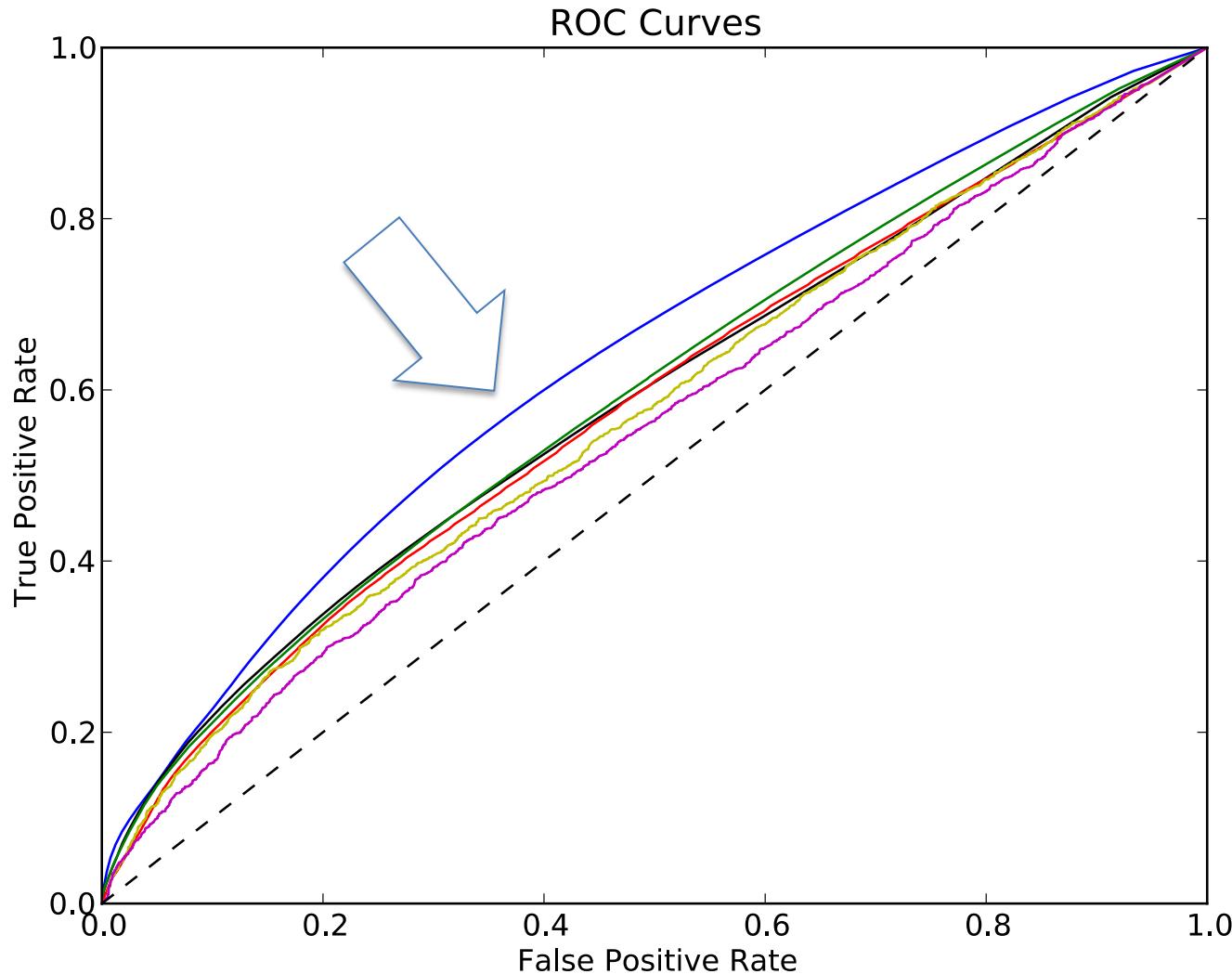
Classifier Results



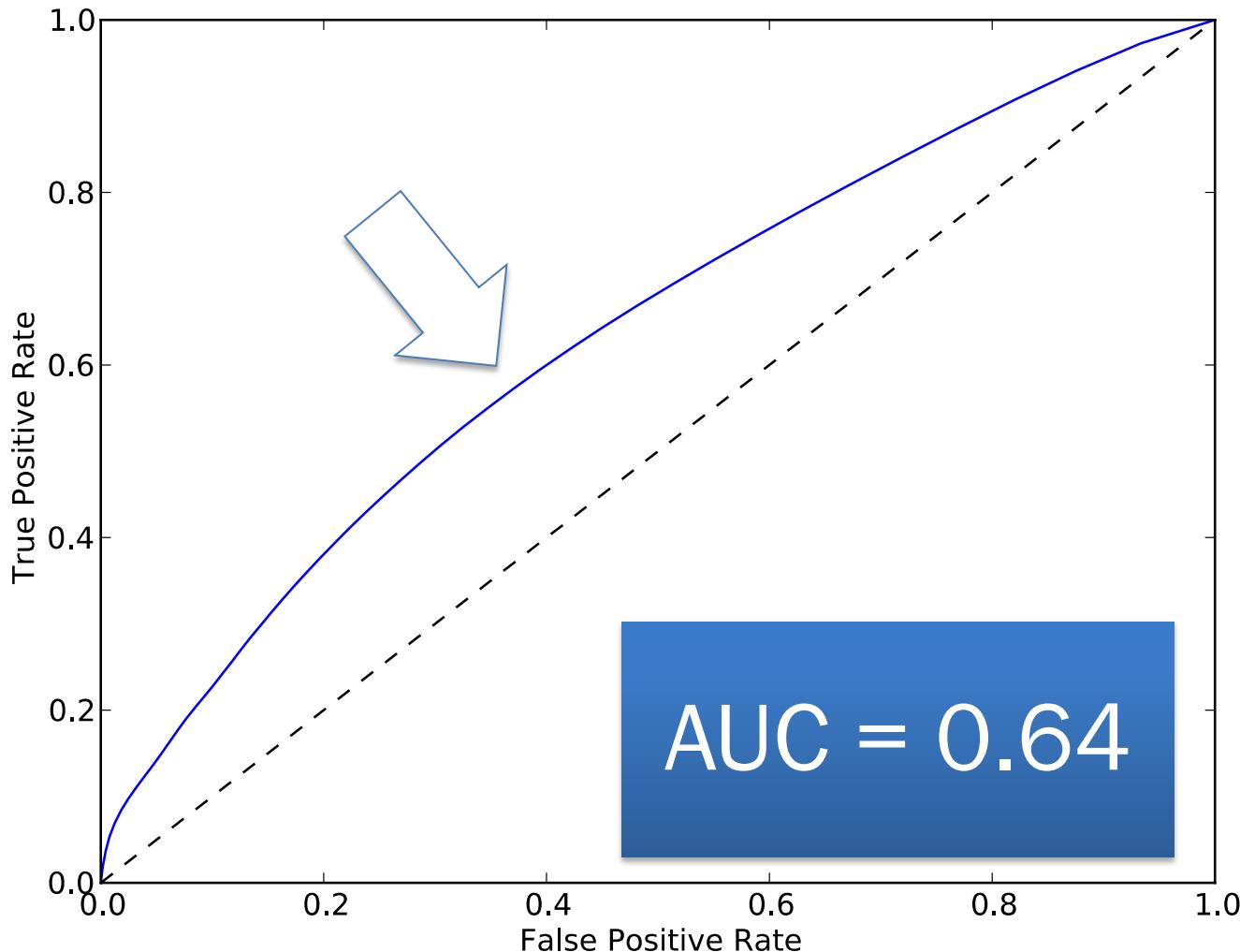
Classifier Results



Classifier Results



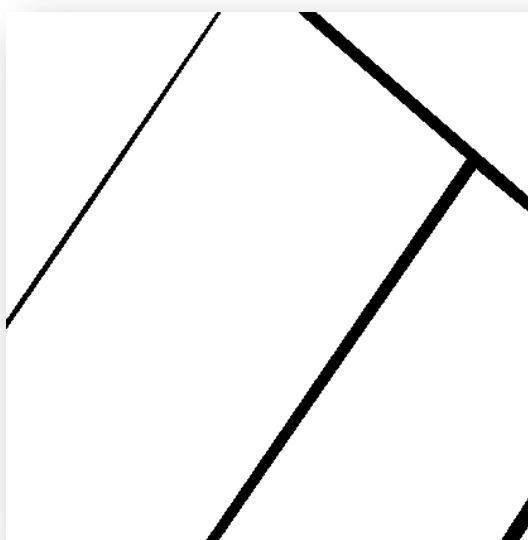
Classifier Results



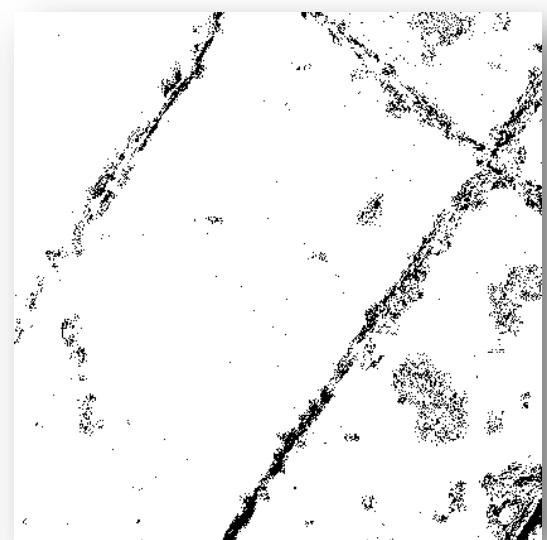
Predicted Labels



Google Maps



True Labels



Predicted Labels

Predicted Labels



Google Maps

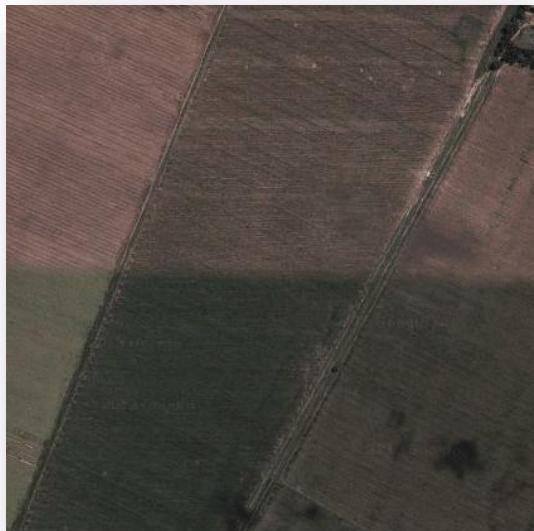


True Labels

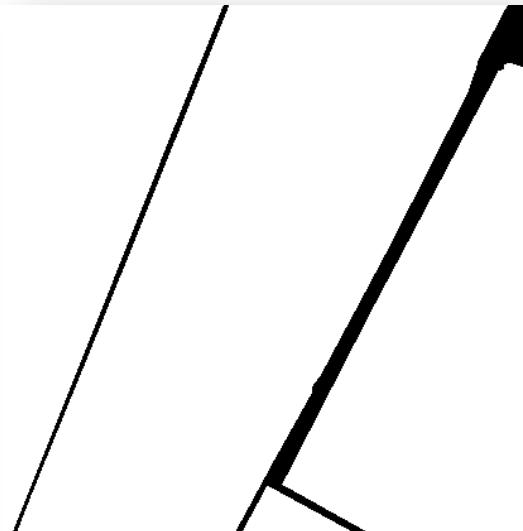


Predicted Labels

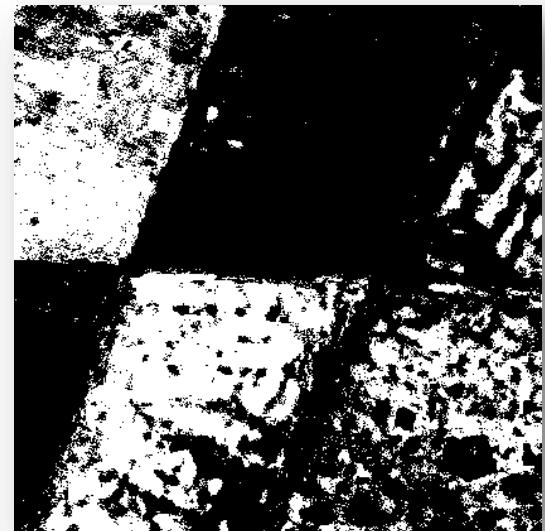
Predicted Labels



Google Maps



True Labels



Predicted Labels

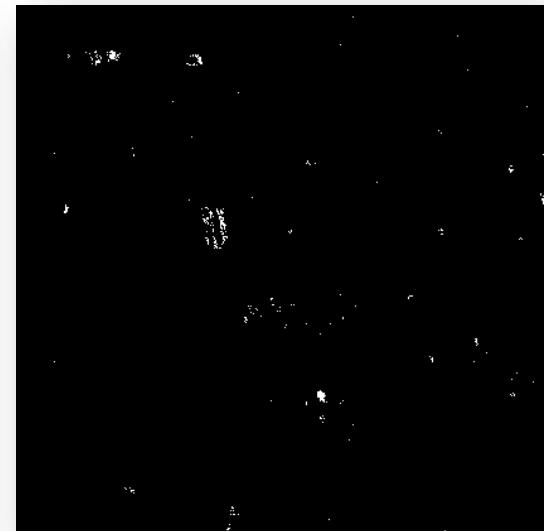
Predicted Labels



Google Maps



True Labels

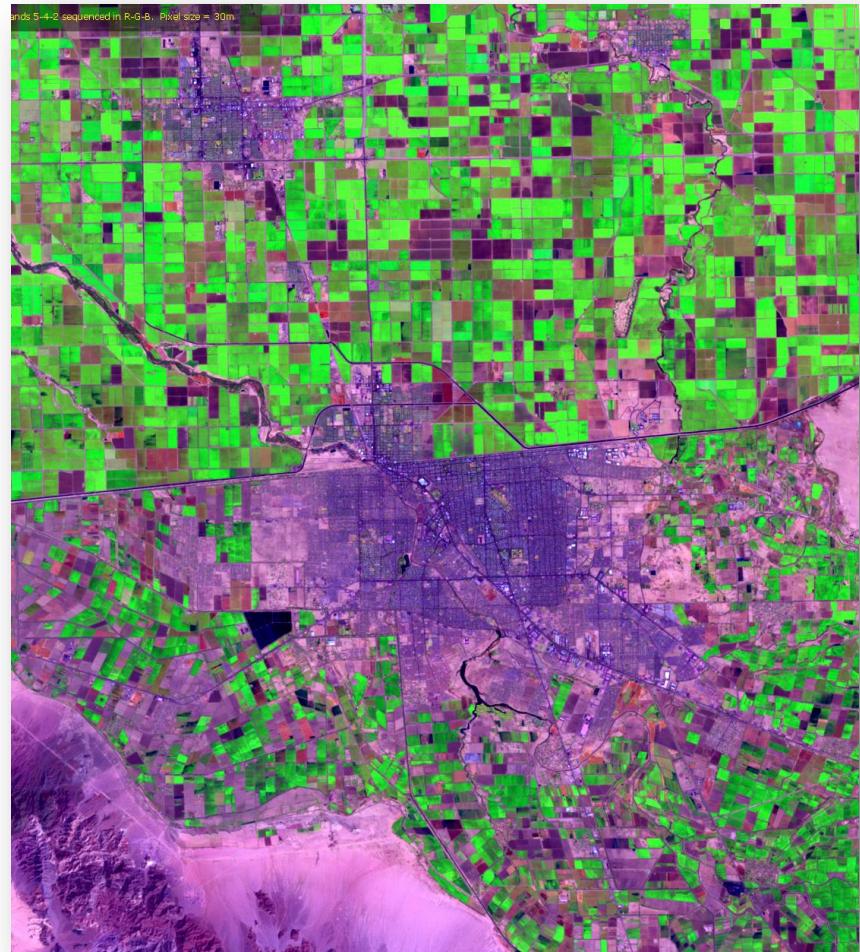


Predicted Labels

Future Work

Continue improving
classifier performance

Multi-spectral data
(Landsat)



Extend Mapping Across Africa

*Crowd-sourcing: Users hand-digitize
small representative areas*



Use as training data to expand algorithm

Extending Mapping Across Africa



Extending Mapping Across Africa



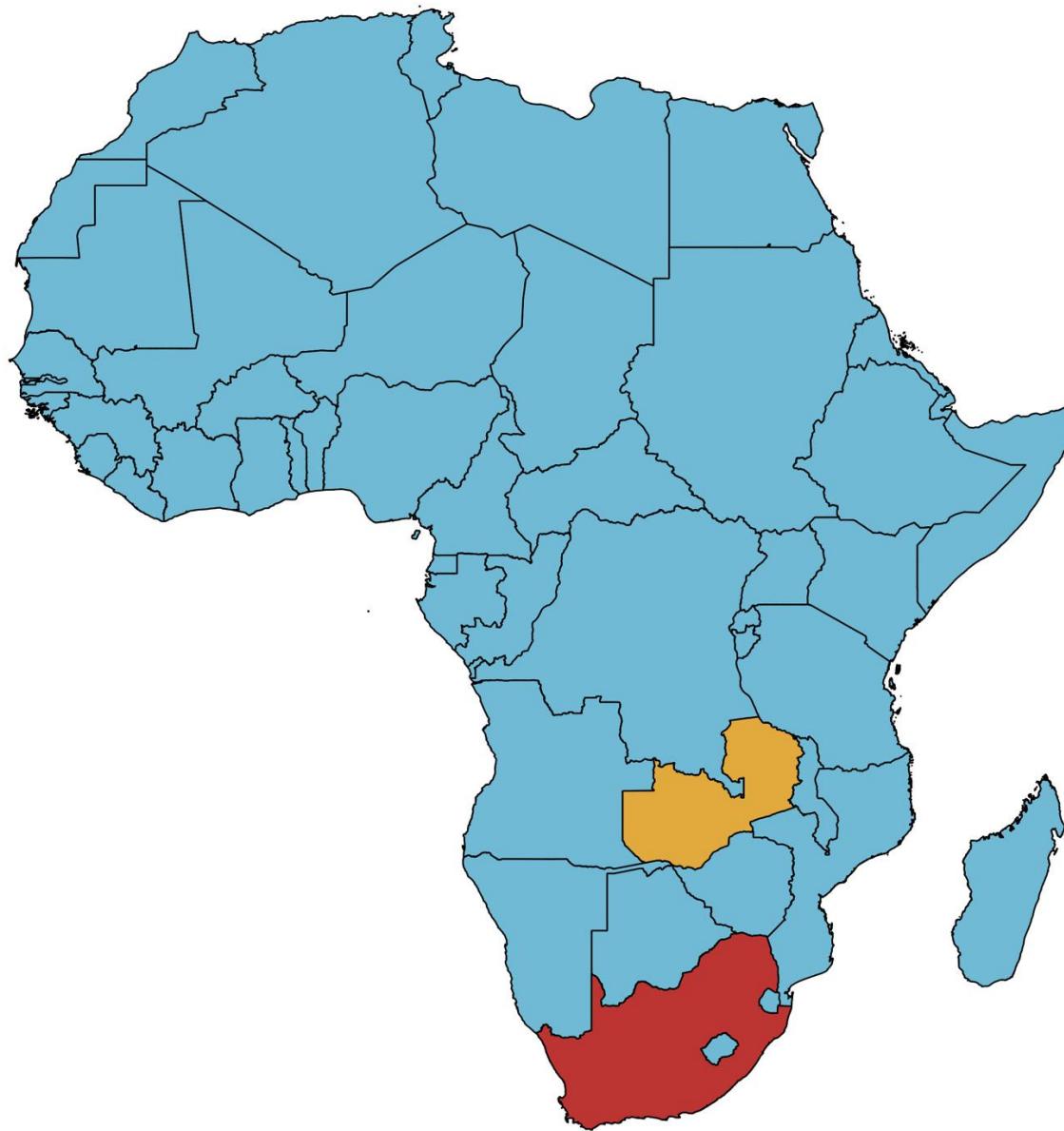
Extending Mapping Across Africa



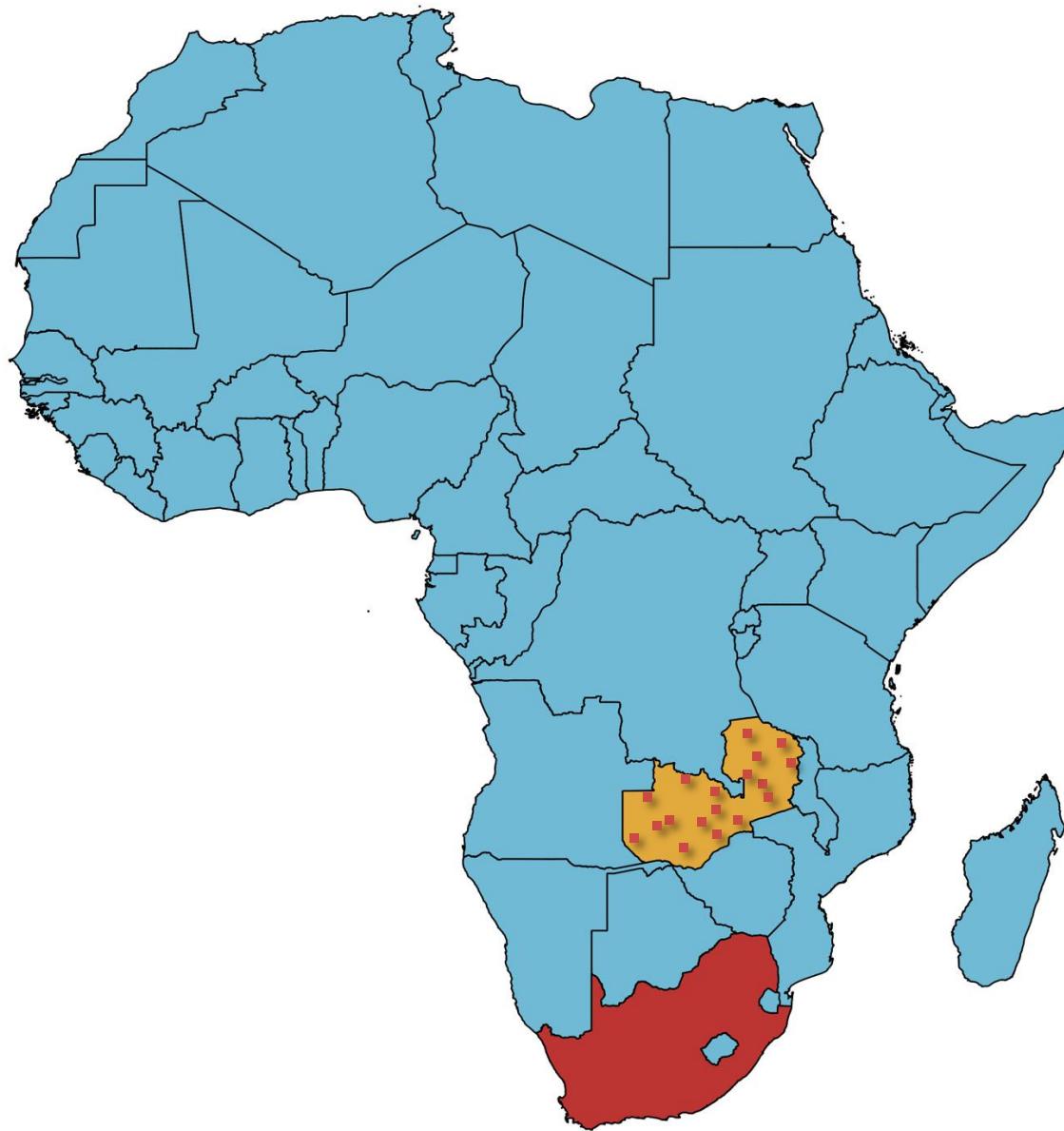
Extending Mapping Across Africa



Extending Mapping Across Africa



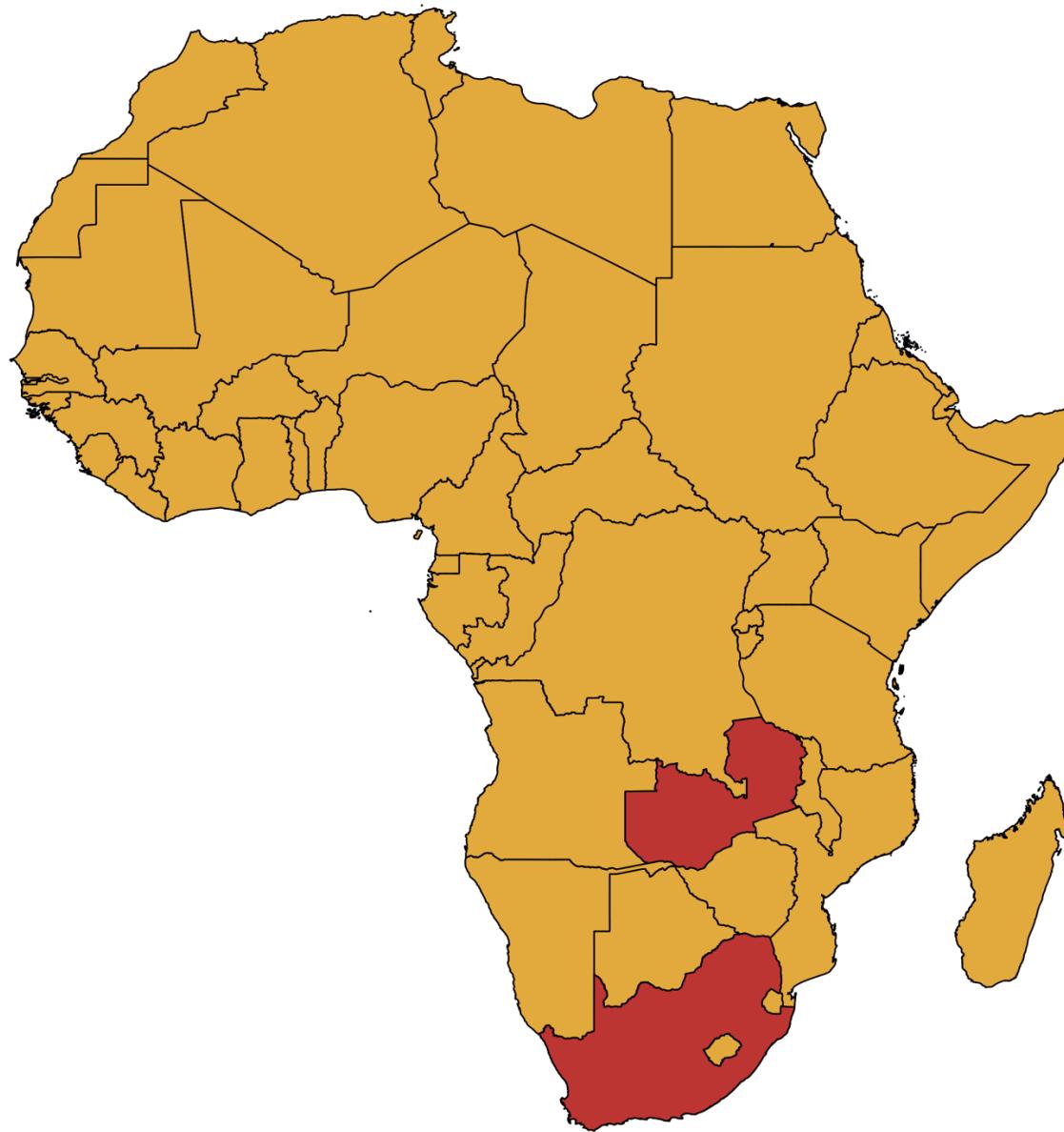
Extending Mapping Across Africa



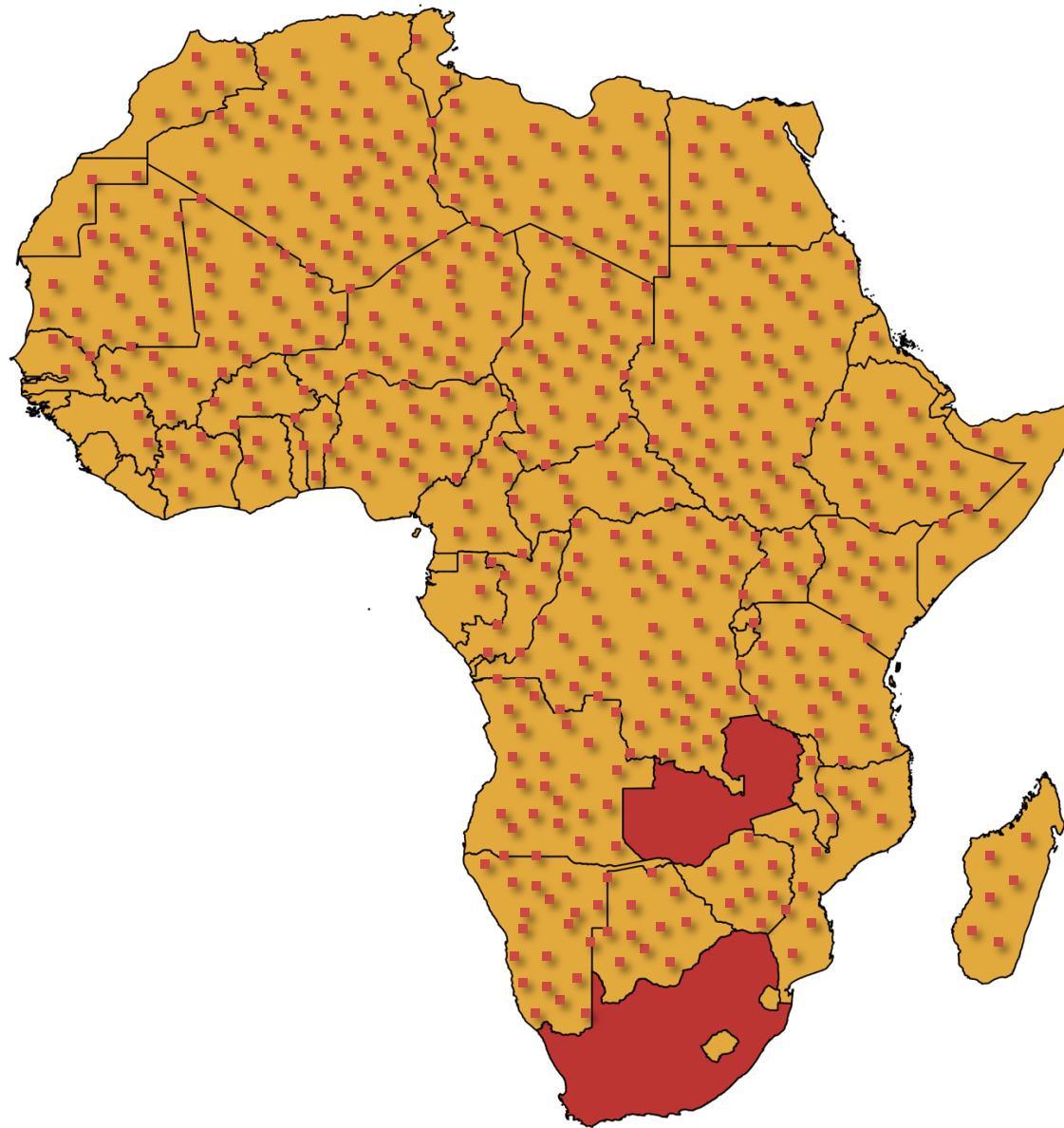
Extending Mapping Across Africa



Extending Mapping Across Africa



Extending Mapping Across Africa



Extending Mapping Across Africa



A photograph of a large, gnarled tree with sparse green leaves standing in a field of tall, dry yellow grass. The sky is clear and blue. A semi-transparent white rectangular box is overlaid on the lower-left portion of the image, containing the text "Thank you" in a bold, dark blue sans-serif font.

Thank you