USDA United States Department of Agriculture

Hybrid Monitoring Approach: wall to wall mapping and area estimation

Developed by remote sensing specialists at the USFS Geospatial Technology and Applications Center (GTAC), located in Salt Lake City, Utah

Forest Service

Objectives

1. Increase awareness about using hybrid approach to map and monitor land uses across the landscape:
   - wall to wall mapping and
   - sample based estimation
2. Provide an example workflow using QGIS, Google Earth, and a spreadsheet software
3. Discuss follow up questions:
   - Change detection using wall to wall mapping
   - Area estimation
   - Lidar processing, modeling, application

Objective

Create land cover estimate and map for:

- Land management activities
- Generate products to develop improved carbon stock and carbon stock change estimates (e.g., for IPCC Emission Database)
- Etc.

General Process

Objective:

- Separate forest lands into sub-categories of artificial (tree crops) and natural forests.

Problem:

- Wall to wall mapping using classifier models (e.g., random forest algorithm) and Landsat composite is not accurate, because plantations and (natural) forests have a similar Landsat spectral signature.

Solution:

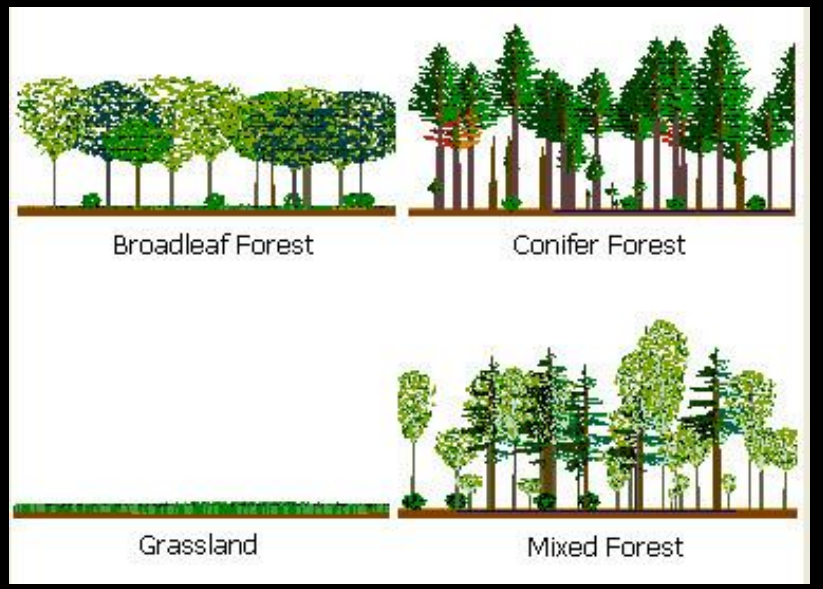
- Automate mapping where we can
- Estimate coverage using:
  - Probability based sample within the mapped Forest areas
  - High resolution aerial imagery (e.g., Google Earth)
  - Human brain-eye system
  - Estimate area using simple statistics

Workflow

1. Define land covers or land uses of interest
2. Determine which you can map:
    1. Which have distinct spectral signature (candidates for image classification)?
    2. Which are commonly confused?
3. Select sample design
4. Photo interpretation of plots
5. Generate simple statistics

Classification Scheme

- Decide on the *scheme*
  - Categorizes and labels the land cover *theme* (e.g. vegetation cover)
  - A well-designed classification *scheme* is critical to deriving acceptable and useful information
  - The complexity will affect project accuracy and cost
  - It's not easy—but time spent creating a well designed classification scheme is always well spent!



Define Land Cover: Sample Classification Scheme

Vegetated /Non-Vegetated	Terrestrial /Aquatic	Natural/ Artificial	Forest/ Non-Forest	Proposed Class	Description
Vegetated	Terrestrial	Natural/Semi-Natural	Forest	Evergreen Forest	Lands dominated by woody vegetation with >60% canopy cover and height exceeding 2m;
				Deciduous Forest	Lands dominated by woody vegetation with >60% canopy cover and height exceeding 2m
				Savanna	Lands with >10% but less than 30% canopy cover and height exceeding 2m; understory consists of herbaceous and other
			Non-Forest	Shrubland	Lands with woody vegetation less than 2m in height and >10% canopy cover but less than 60%. Shrub foliage either evergreen or deciduous
				Grassland	Lands where tree and shrub cover is <10% with herbaceous cover
		Artificial	Forest	Plantation	The crop grown include fast-growing trees such as rubber, oil palm, pine, and others
			Non-Forest	Other Ag. Land	Agricultural land other than rice
	Aquatic	Natural/Semi-Natural	Forest	Mangrove	Coastal sediment habitats with various large and extensive trees up to medium height and shrubs
			Non-Forest	Wetland	Lands with permanent mixture of water and herbaceous or woody vegetation, either salt, brackish, or freshwater
		Artificial		Rice Paddy	Irrigated or flooded field where rice is grown
Non-Vegetated	Terrestrial	Natural/Semi-Natural		Barren Land	Less than 10% vegetative cover; Lands exposed soil, sand, rocks, or snow
				Water Bodies	Oceans, lakes, seas, reservoirs, rivers – salt or fresh
	Aquatic	Artificial		Built-up Area	Lands covered by building and other manmade structures

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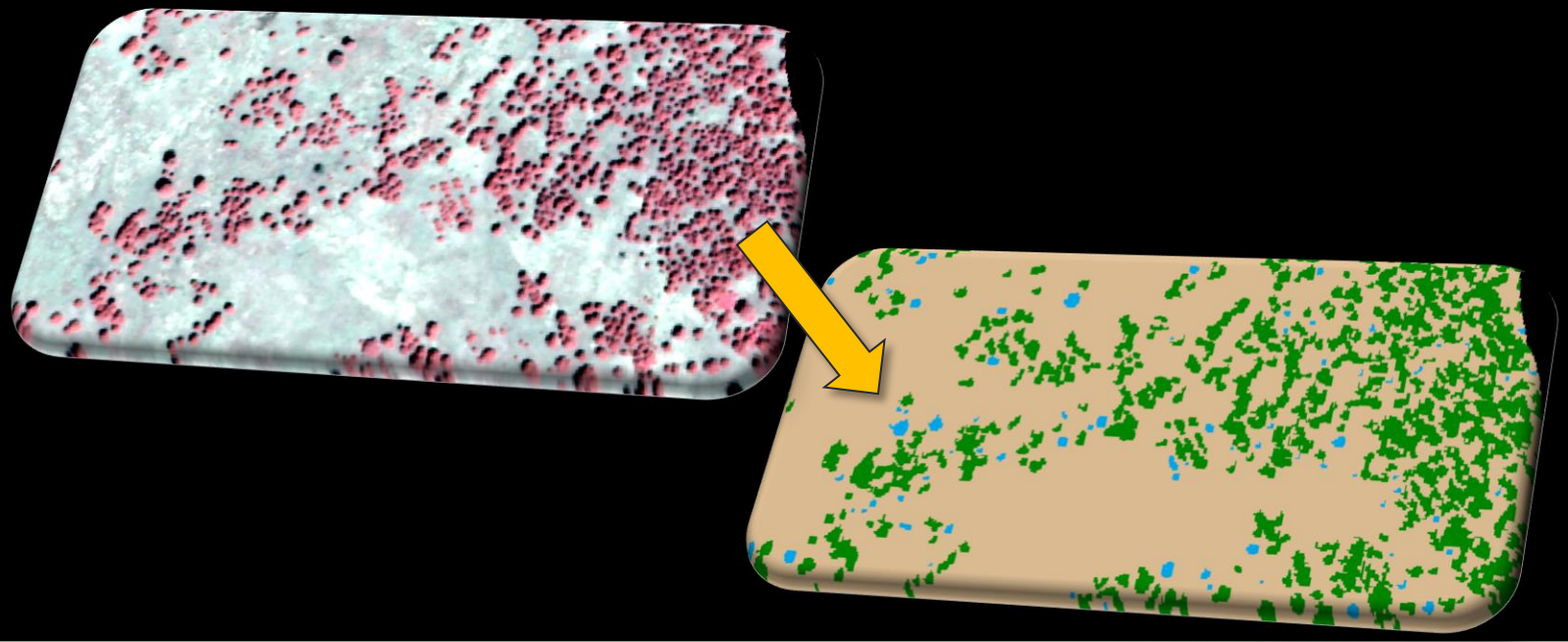
Remote Sensing in Resource Monitoring

- Sampling mode – *e.g., CollectEarth*
  - Statistical estimates of change
    - Image interpretation of a sample (plots) is used to estimate change for a landscape (population)
    - Appropriate for examples like comparing regions (Countries, Provinces, Parks, Watersheds), etc.

- Mapping mode – image classification
  - Wall-to-wall change map of study area
    - Appropriate when spatially explicit information required for management decision / action / map updates (fire fighting, modifying a land use map)

Image Classification

The automated process of categorizing pixels or image objects into thematic classes (e.g., conifer, deciduous, herbaceous)



Review - Optical Remote Sensing Basics

Remote sensing relies on the fact that different targets have unique responses to Electromagnetic (EM) energy

We can distinguish landcover types spectrally and track them through time

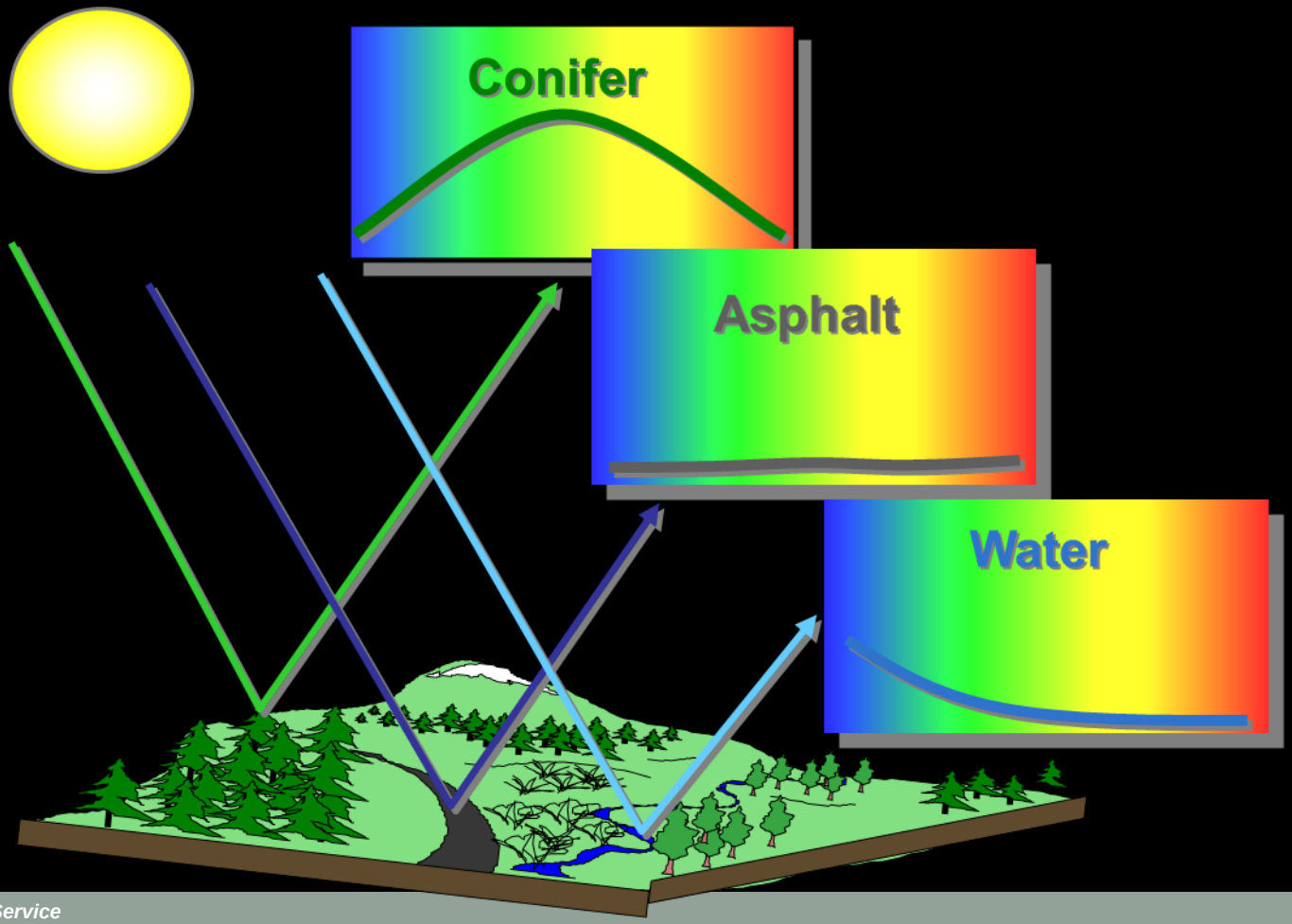
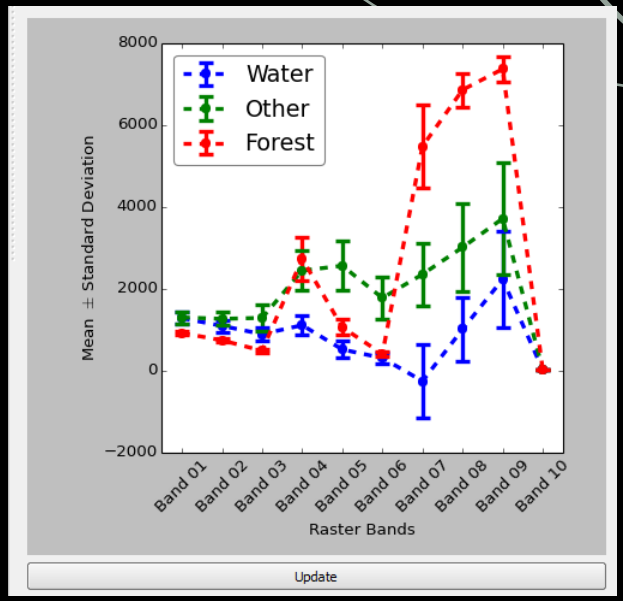


Image Classification: Spatial Modeling Process



Theory

Sample Design

Candidate variables

Reference Data

Predictor Variables: (e.g., image enhancements)

Fitting/Training

Model

Applying Model

Map of predicted values

Adapted from Guisan and Zimmerman (2000) & Franklin (2009)

Which can you map?

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Confused land covers: Similar Spectral Signature (Landsat)

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Distinct Signature with high resolution imagery

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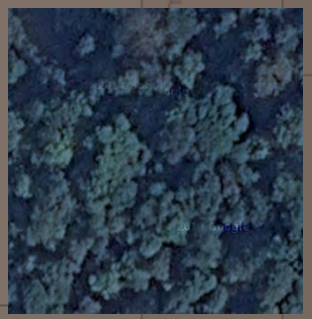
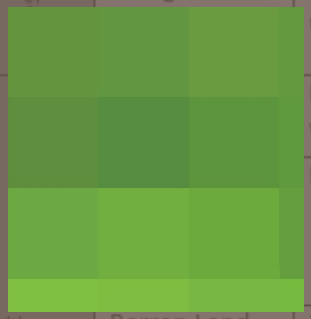
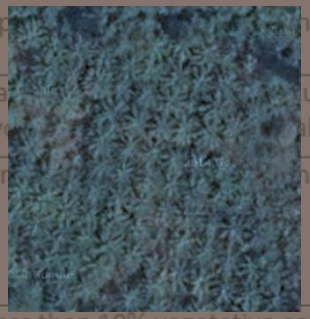
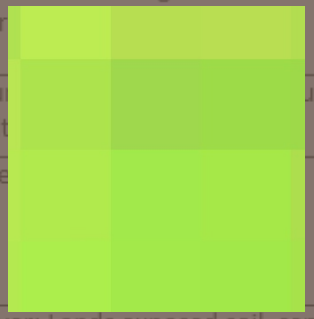
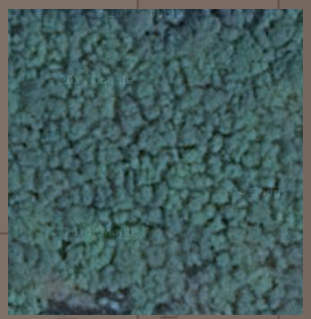
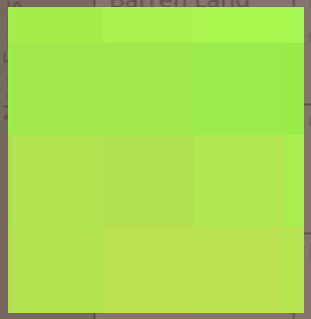
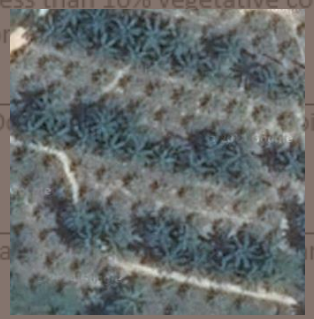
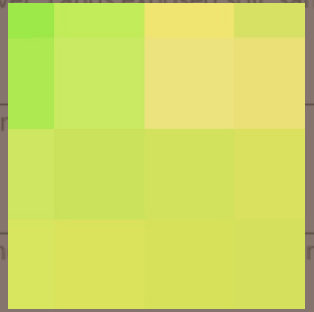
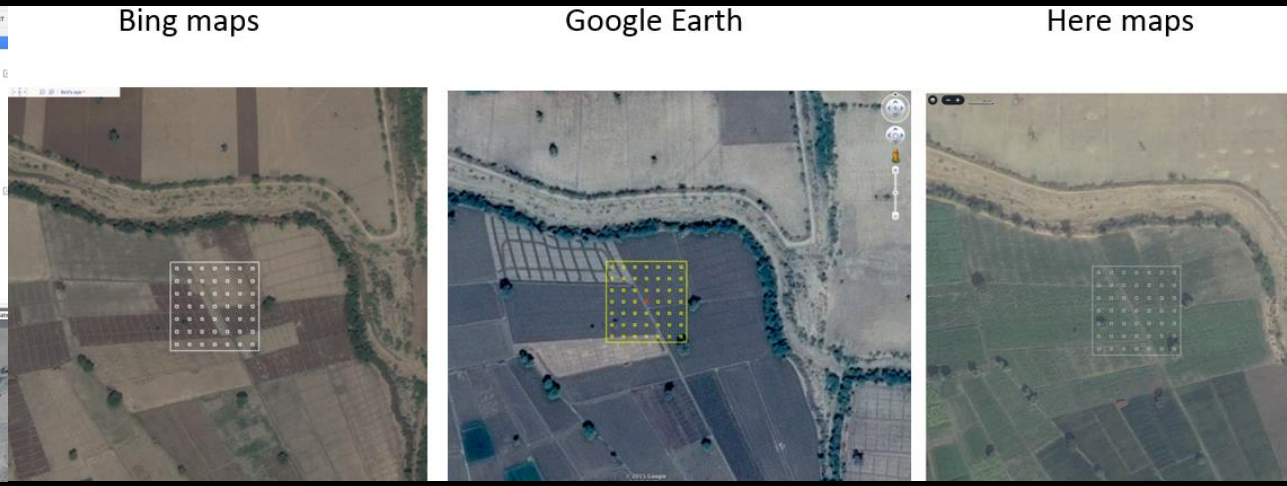









Supplemental Data Resources

- Google Earth Engine (Landsat archive, NDVI Charts)
- Bing Maps
- Google Earth
- Here Maps



Workflow

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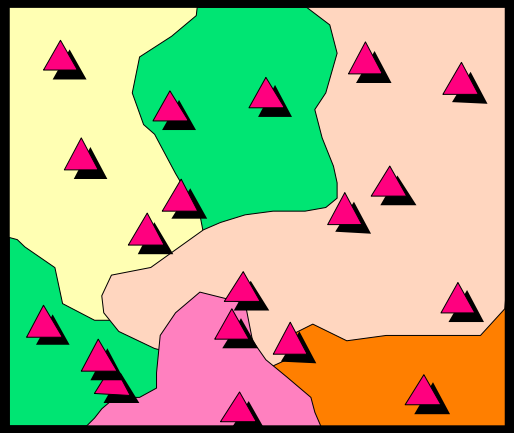
Sample Design

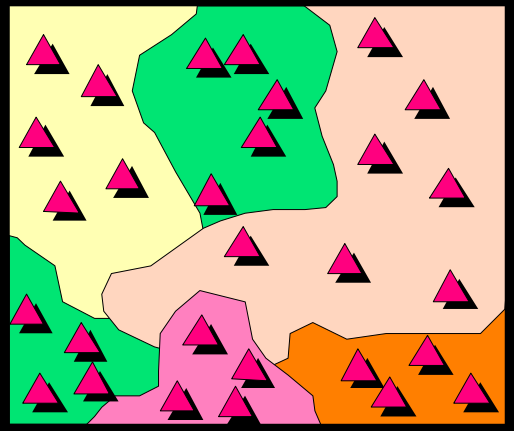
- Random
- Stratified random
- Uniform
- Stratified uniform

Sampling Methods

Several Major Types (slide 1 of 2):



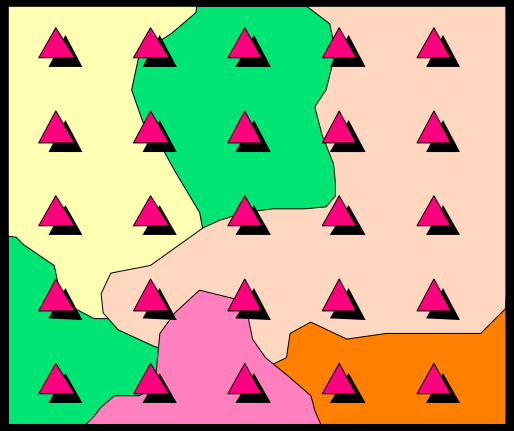
Simple Random Sampling:
observations are randomly placed.



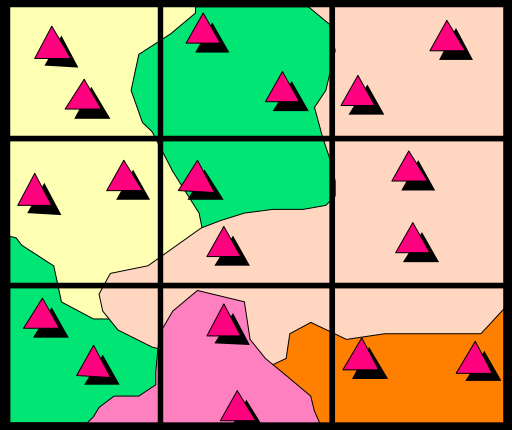
Stratified Random Sampling:
A minimum number of observations
Are randomly placed in each category.

Sampling Methods

Several Major Types (slide 2 of 2):



Systematic Sampling: observations are placed at equal intervals according to a strategy.



Systematic Non-Aligned Sampling: a grid provides even distribution of randomly placed observations.

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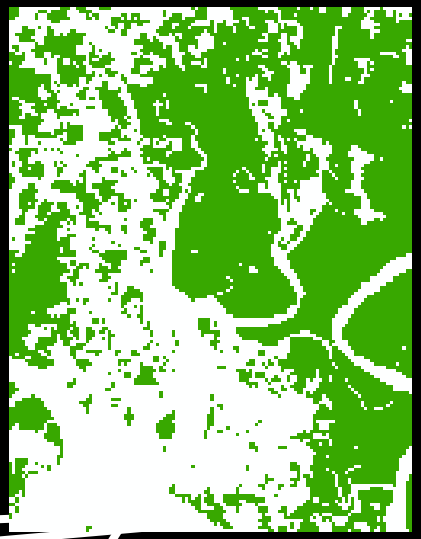
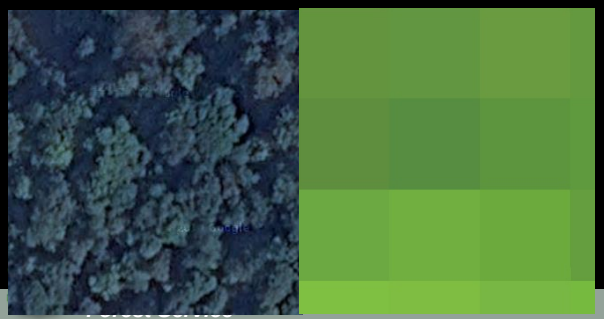
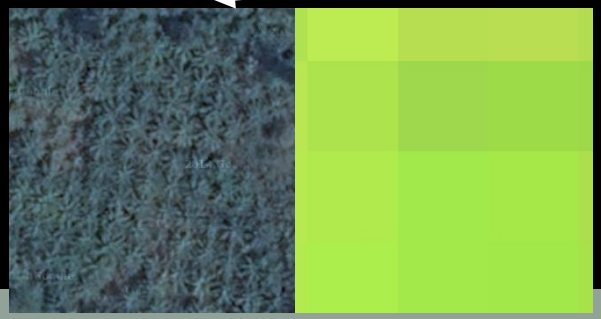
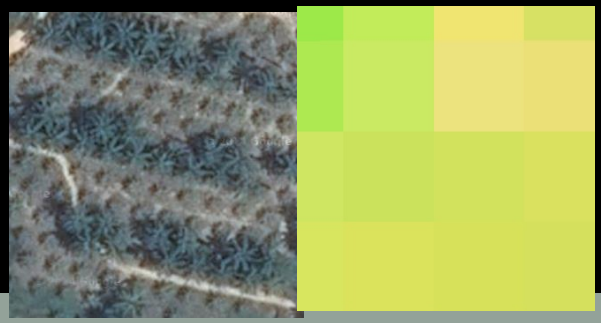
Estimation: what is the benefit?

- Takes advantage of the human brain-eye system
  - Computer algorithms make pretty good guesses
  - Humans are unsurpassed
  - Seven image elements
    - Size, shape, tone/color, texture, shadow, association, and pattern



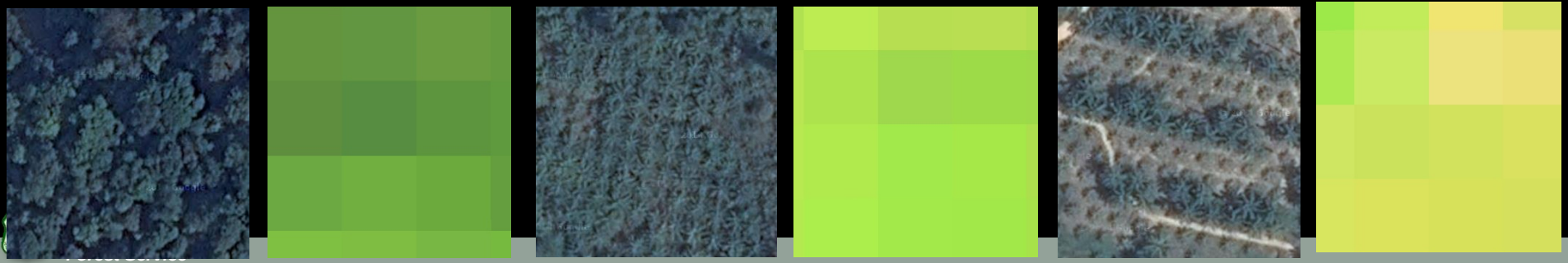






Estimation: what is the benefit?

- Takes advantage of the human brain-eye system
- Takes advantage of high resolution aerial imagery
  - Google Earth and more



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Estimation Example:

In a jar with 300 gumballs, how many gumballs are red?

Define ‘red’

Probabilistic sample of data: randomly sample 30 gumballs

Image interpretation of 30 gumballs; document how many of each color category:

11 red and pink (11/30 = 37%),

4 white (3/30 = 13%),

6 orange and yellow (6/30 = 20%),

3 orange (3/30 = 10%),

Generate simple stats

11 red and pink => 11 out of 30 = 37%),

37% of 300 total = 111 red and pink gumballs

Limitation

- Area estimates lack location specific information.
  - 1/3 of forest (green) below is plantation

>> but we don't know which pixels within the forest (green) areas are plantation

Alternative to hybrid (map and estimation)?

- Find predictor variables to add to the classifier model that distinguishes between sub land cover categories
  - Seasonal changes in NDVI
  - Land ownership/parcel data
  - Etc…

If you have questions please contact
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