

Mapping of land cover in Northern California with simulated HyspIRI and Landsat 8 imagery very early results

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Motivation

- Land cover is an essential global climate variable
- Land cover change helps understand underlying processes
 - natural – disturbance, disease, invasive species
 - socio-economic – deforestation, agricultural expansion, land abandonment
- Science, policy, and conservation communities
 - Need recent information
 - Class detail
 - Consistent spatial and temporal accuracy

Main goals

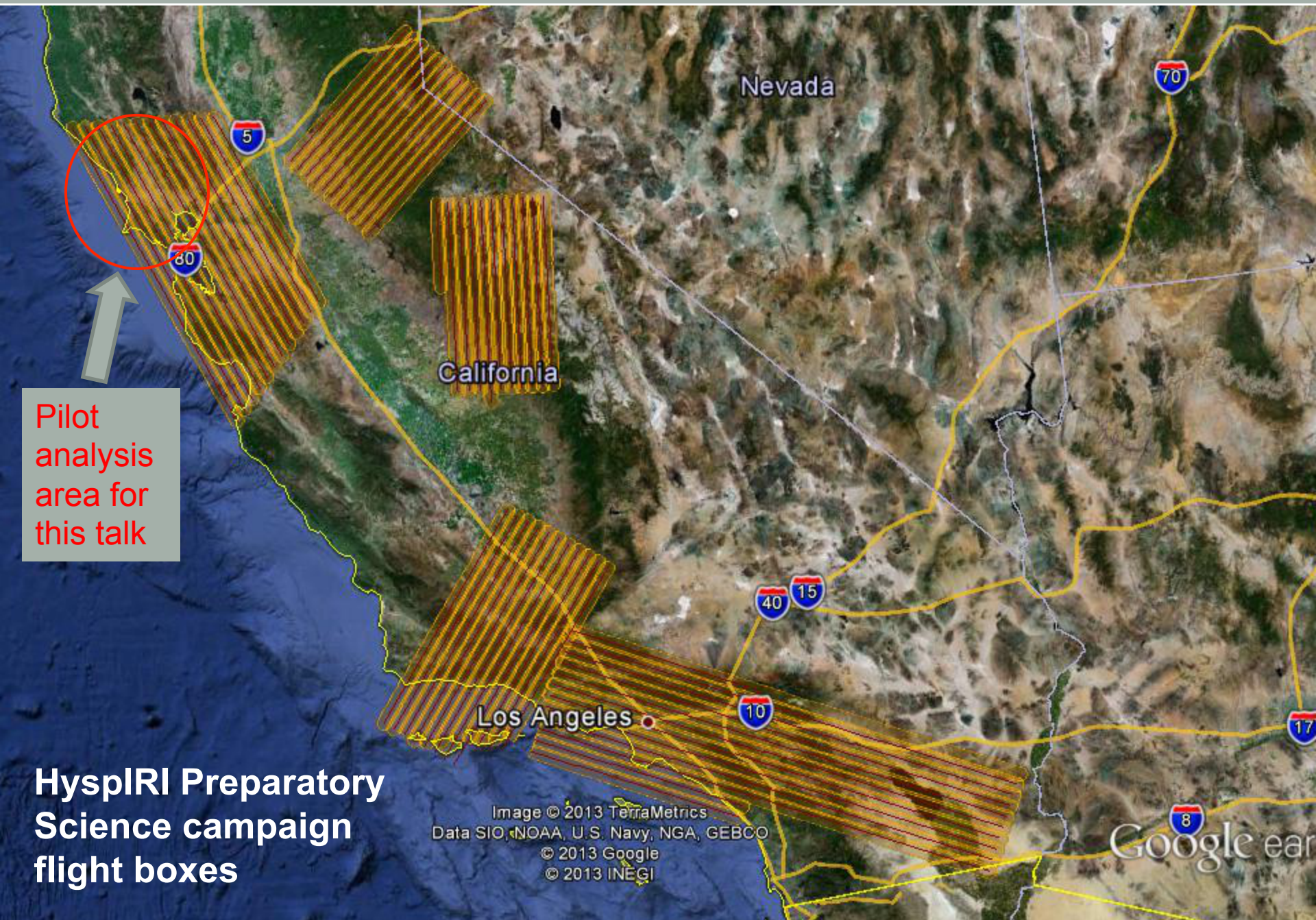
- Potential of HyspIRI for mapping land cover across a wide range of environmental and anthropogenic gradients in California
- Relative to Landsat, test improvement in class detail, accuracy and inter-annual stability of natural vegetation mapped from hyperspectral, multi-temporal HyspIRI data
- Explore how spectral-temporal variation within and among natural vegetation types is related to abiotic and phenological factors

General approach for classification

- **Spectral & Spatial Resolution**
 - Simulated HypsIRI @ 30 m and 60 m, 224 bands (VSWIR)
 - Simulated Landsat 8 OLI @ 30 m; 7 bands
- **Temporal Resolution**
 - Spring, Summer, Fall
 - 2013, 2014
- **Classification levels**
 - **Broad scale land cover (all flight boxes)**
 - Natural vegetation follows a lifeform scheme (e.g., forest, shrubs, grasslands)
 - Anthropogenic classes (e.g., urban types, annual and perennial crops)
 - **Fine scale (Yosemite NP and Bay Area boxes)**
 - NVCS alliance-level of natural vegetation, focused on forest types
- **Techniques**
 - Hyperspectral metrics – indices and based on contiguous bands
 - Multiple endmember spectral mixture analysis (MESMA)
 - Random Forests and Support Vector Machine classifiers

Preliminary analysis

- Study area
 - Northern California (Marin, Sonoma Counties)
- Classes
 - Broad-level land cover (lifeform for natural vegetation)
- Predictor variables – Summer June, 2013
 - HyspIRI 30 m and 60 m, 198 reflectance bands
 - Landsat OLI, 30 m, 7 reflectance bands
- Reference data
 - Google Earth visual interpretation with web tool (VIEW-IT)
- Classifier
 - Random Forests



Pilot
analysis
area for
this talk

**HyspIRI Preparatory
Science campaign
flight boxes**

Image © 2013 TerraMetrics
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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© 2013 INEGI

Google earth

Simulated Imagery

HyspIRI– 60 m



Landsat 8 OLI – 30 m

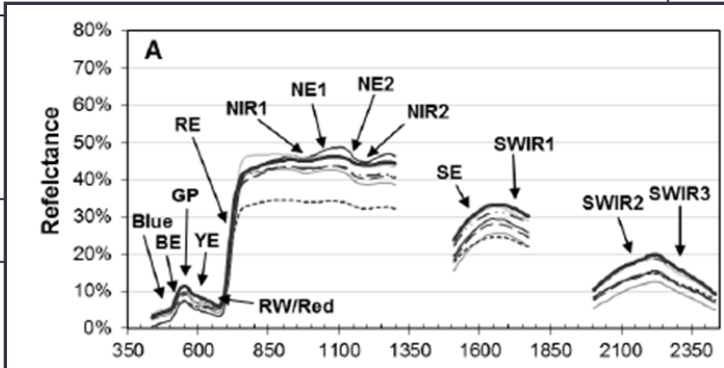


AVIRIS – 16 m



Gaussian function (Dennison/Boardman code)
applied to unorthorectified AVIRIS reflectance data,
latest version with variab

Table 1. Summary of hyperspectral metrics organized by methods (in bold) and dominant spectral features and region (in italics). Not in current analysis

Indices	Absorption-Based	Derivative	Spectral Mixture Analysis	
<i>Photosynthetic pigments, LAI, structure, physiology, stress (VIS-NIR)</i>				
SR, ARI2 NDVI, CRI1 SAVI, CRI2 ARVI, PRI RVSI	Blue-D,W,A,As Red-D,W,A,As	BE-Wvl,Mag,DArea GP-Wvl,Refl YE-Wvl,Mag,DArea RW-Wvl,Refl RE-Wvl,Mag,DArea		
<i>Water and structure (NIR)</i>				
WBI NDWI	EWT NIR1-D,W,A,As NIR2-D,W,A,As	NE1-Wvl,Mag NE2-Wvl,Mag		
<i>Lignin, cellulose, nitrogen (SWIR)</i>				
CAI NDLI NDNI	SWIR1-D,W,A,As SWIR2-D,W,A,As SWIR3-D,W,A,As	SE-Wvl,Mag		
<i>All chemical absorption and structure features (Full-spectrum)</i>				
			GV, Shade NPV, RMSE	

Wvl = wavelength, Mag = derivative magnitude, Refl = percent reflectance, D = depth, W = width, A = area (width x depth), As = Asymmetry.

Clark & Roberts, *Remote Sensing*, 2012

Land-cover reference data


VIEW-IT

view-it.sonoma.edu/viewit/startPoint/search.php?act=MakePoints&cName=Select+Country

VIEW-IT

Virtual Interpretation of Earth Web-Interface Tool

Point Interpretation Charts Change User Settings Admin Log Out



Press the button to draw a point in the center of the map.

Draw a point here

Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2013 Google
Data LDEO-Columbia, NSF, NOAA
Imagery Date: 4/9/2013 36°05'48.77" N 119°47'55.50" W elev 0 ft eye alt 287.88 mi

Google earth

Zoom Options: [Center View](#) [Area](#) View Options: [3D Terrain](#) [Panoramio](#) [Timeline](#) [debug?](#) Layers: [Zones](#) [Biomes](#) [Ecoregions](#) [Points](#) [Reset](#)

Land cover reference data

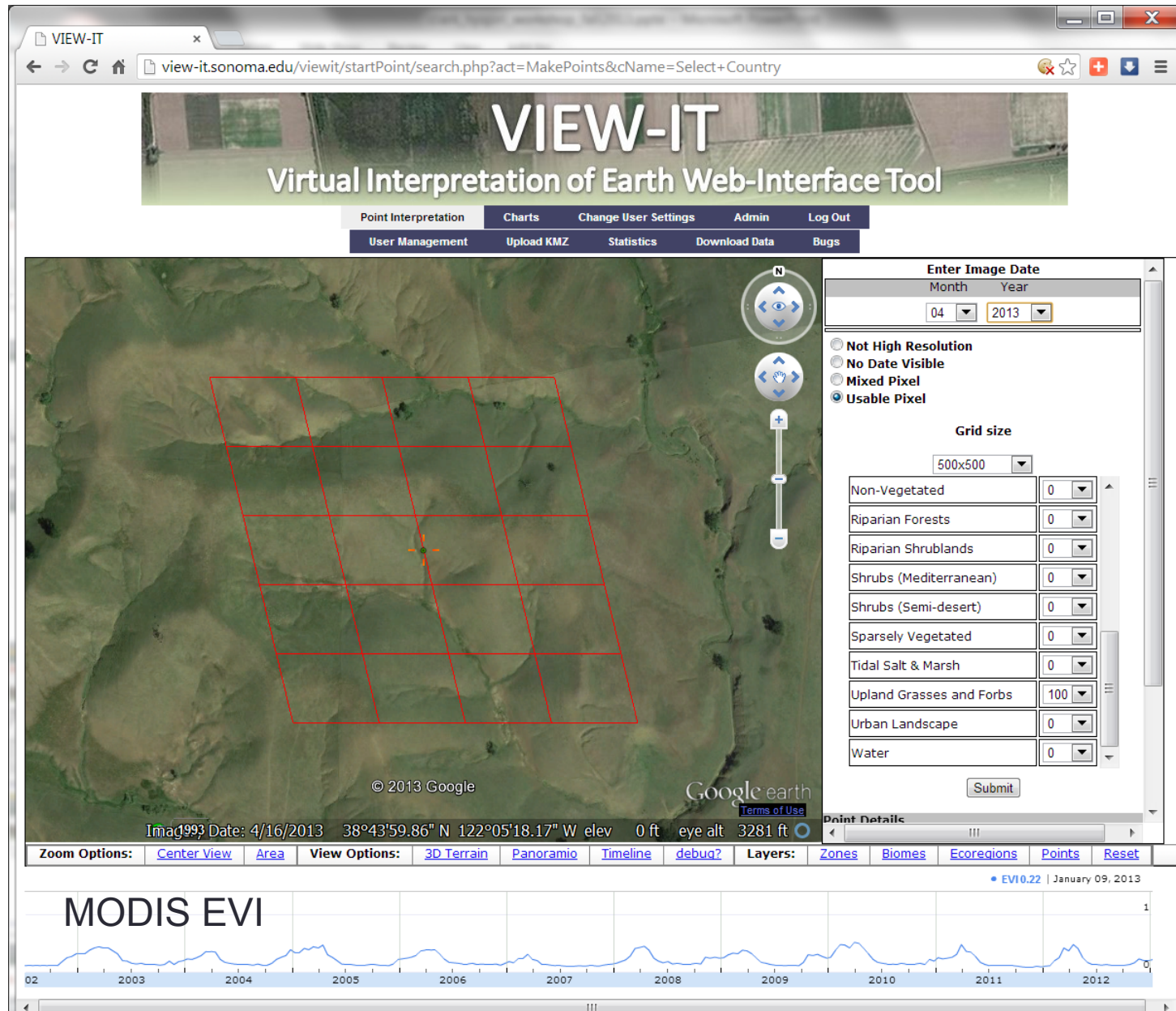


Image date

Grid sizes:
100, 250
500 m

% cover –
20 cover
types

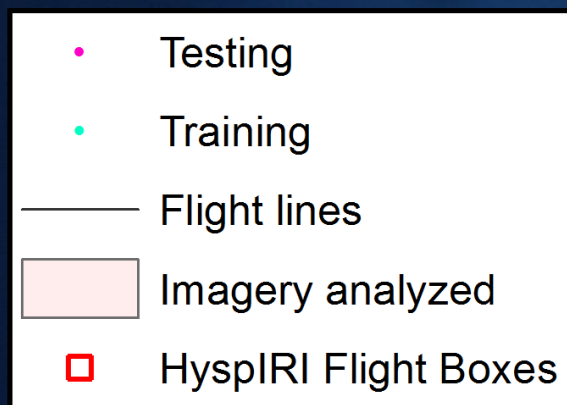
Decision tree to go from VIEW-IT percent cover to land cover classes

- 1) Water covers at least 80% of the area Water
- 1) Water covers less than 80% of the area 2
- 2) At least 30% of the area is covered by impervious surface + urban landscape 3
- 2) Less than 30% of the area is covered by impervious surface + urban landscape 5
- 3) At least 50% of the area is covered by an impervious surface 4
- 3) Less than 50% of the area is covered by an impervious surface Low Density Urban
- 4) At least 80% of the area is covered by an impervious surface High Density Urban
- 4) Less than 80% of the area is covered by an impervious surface Moderate Density Urban
- 5) At least 80% of the area is covered by vegetation managed by regular human activity such as planting, tilling, cropping, mowing, and/or irrigating 6
- 5) Less than 80% of the area is covered by vegetation managed by regular human activity such as planting, tilling, cropping, mowing, and/or irrigating 7
- 6) At least 50% of the area is covered by an woody, perennial vegetation Perennial Agriculture
- 6) Less than 50% of the area is covered by woody, perennial vegetation Annual Agriculture
- 7) Area is at least 50% Sparsely Vegetated (including non-vascular plants, 5-10% cover) Sparsely-Vegetated
- 7) Area is less than 50% Sparsely Vegetated 8
- 8) Area is at least 50% Non-Vegetated (including rock, bare soil, <5% cover) Non-Vegetated
- 8) Area is less than 50% Non-Vegetated 9
- 9) Area is at least 50% Beach or Dune Beach/Dune
- 9) Area is less than 50% Beach or Dune 10

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Pilot study

Used runs 11-14
Summer - June 7, 2013
273 VIEW-IT grids



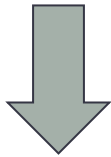
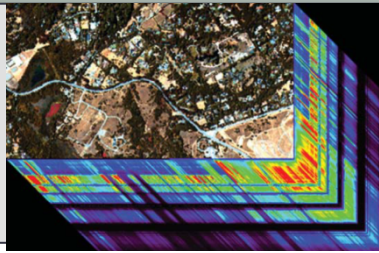
17
classes

Table shows
number of
pixels,
60-m HypIRI

Class	Training	Testing
Annual Crops	152	28
Beaches or Dunes	125	16
Conifer	513	184
Deciduous Broad-leaf	158	16
Dune Veg	277	2
Evergreen Broad-leaf	280	64
High Density Urban	1763	456
Low Density Urban	121	34
Mediterranean Shrubs	231	42
Mixed Forest	88	88
Moderate Density Urban	208	64
Perennial Crops	206	162
Riparian Forests	87	14
Riparian Shrublands	70	24
Tidal Salt & Marsh	615	216
Upland Grasses and Forbs	973	236
Water	238	80
Total	6105	1726

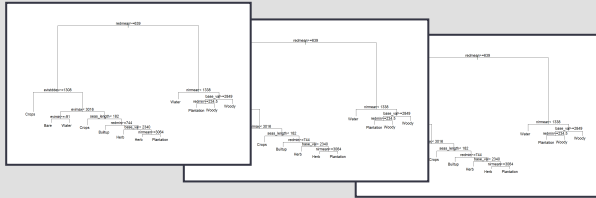
Predictor variables

- Reflectance bands
- Hyperspectral metrics



Random Forest Classifier

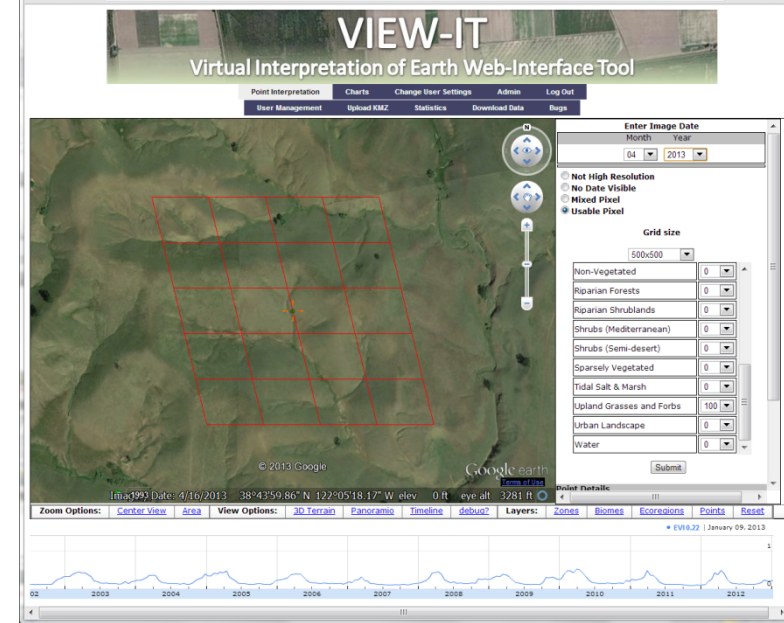
999
trees ea.



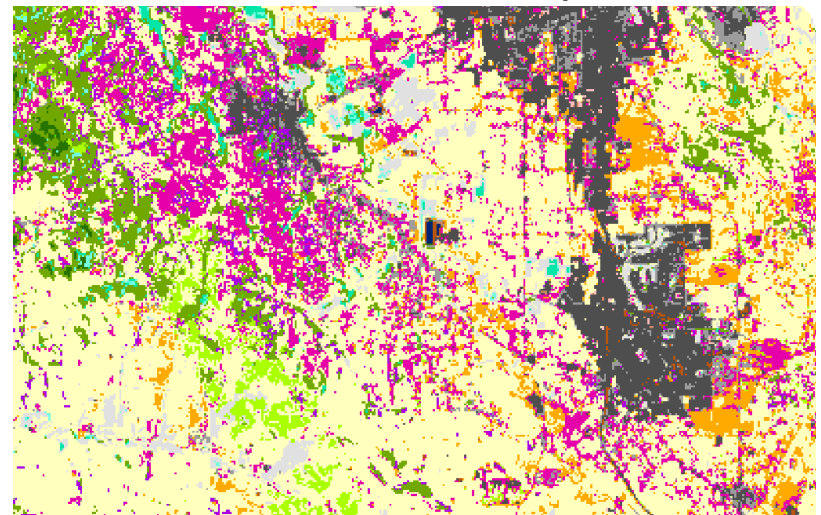
Land cover
map production
(2013 & 2014)



Reference data collection



Classified maps



Independent test of accuracy

Sensor (spatial resolution)	HyspIRI (60 m)	HyspIRI (30 m)	Landsat 8 OLI (30 m)
Overall Accuracy	65.5%	68.8%	68.8%
Kappa	0.61	0.64	0.63
# of test pixels	1726	6897	6880
# of bands	198	198	7

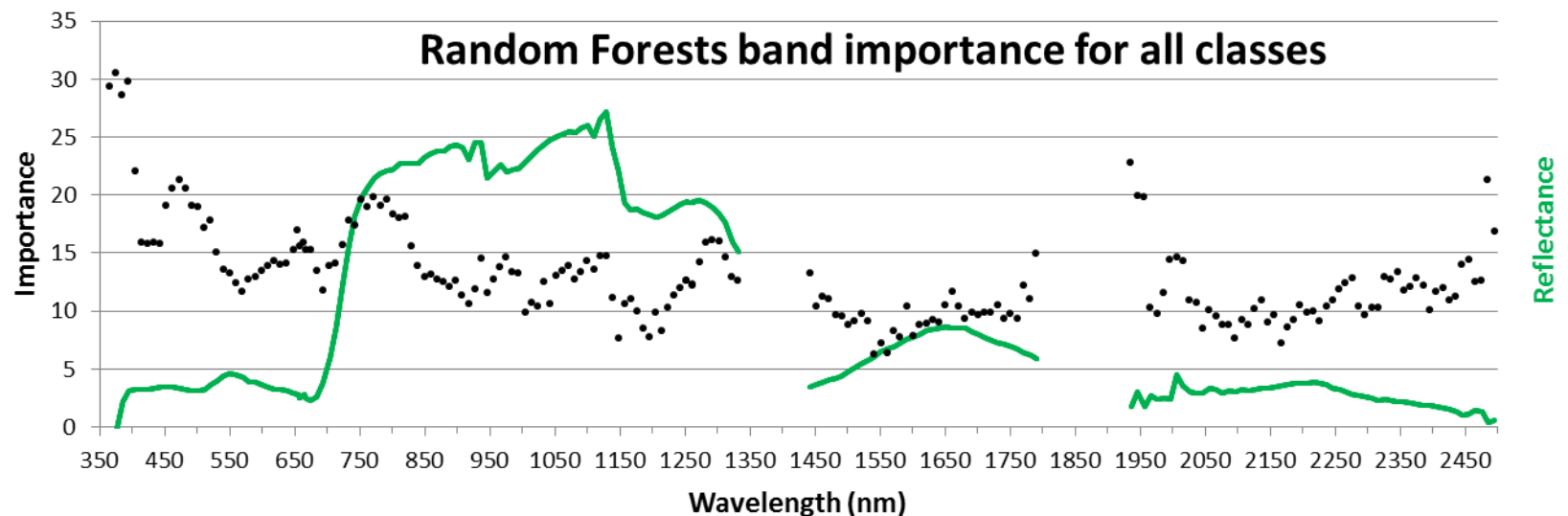
Same cluster centers chosen for extracting testing pixels

-- Preliminary results, do not cite --

HyspIRI 60-m Error Matrix

-- Preliminary results, do not cite --

	Annual Cr	Beaches o	Conifer	Deciduou	Dune Veg	Evergreen	High Dens	Low Densi	Mediterra	Mixed For	Moderate	Perennial	Riparian F	Riparian S	Tidal Salt	Upland Gr	Water	Total	User
Annual Crops	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	4	0	7	0%
Beaches or Dunes	0	6	0	0	0	0	0	0	0	0	0	0	0	0	6	0	63	75	8%
Conifer	0	0	164	0	0	5	0	0	0	1	0	0	0	3	0	0	0	173	95%
Deciduous Broad-leaf	6	0	20	0	0	0	0	0	0	0	0	0	0	0	0	73	0	99	0%
Dune Veg	0	4	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	6	33%
Evergreen Broad-leaf	0	0	0	0	0	30	0	0	21	1	0	0	12	6	1	0	0	71	42%
High Density	0	6	0	0	0	0	384	1	0	0	16	0	0	1	16	0	0	424	91%
Low Density	5	0	0	0	0	0	0	25	2	0	1	3	0	0	0	0	0	36	69%
Mediterranean Shrubs	0	0	0	0	0	12	27	0	0	0	2	0	0	2	13	12	0	68	0%
Mixed Forest	0	0	0	0	0	0	0	0	0	86	0	0	0	0	0	0	0	86	100%
Moderate Density	0	0	0	0	0	0	24	2	0	0	44	7	0	0	35	1	0	113	39%
Perennial Crops	0	0	0	0	0	10	11	0	2	0	0	79	0	0	0	0	0	102	77%
Riparian Forests	0	0	0	0	0	0	0	0	4	0	0	0	1	7	0	0	0	12	8%
Riparian Shrublands	0	0	0	0	0	0	0	0	10	0	0	0	1	4	0	0	0	15	27%
Tidal Salt & Marsh	2	0	0	0	0	0	9	0	0	0	1	0	0	0	144	1	1	158	91%
Upland Grasses and Forbs	15	0	0	16	0	7	1	5	1	0	0	73	0	1	0	145	0	264	55%
Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	16	17	94%
Total	28	16	184	16	2	64	456	34	42	88	64	162	14	24	216	236	80	1130	
Producer	0%	38%	89%	0%	100%	47%	84%	74%	0%	98%	69%	49%	7%	17%	67%	61%	20%		65.5%



HyspIRI
60m
True-Color

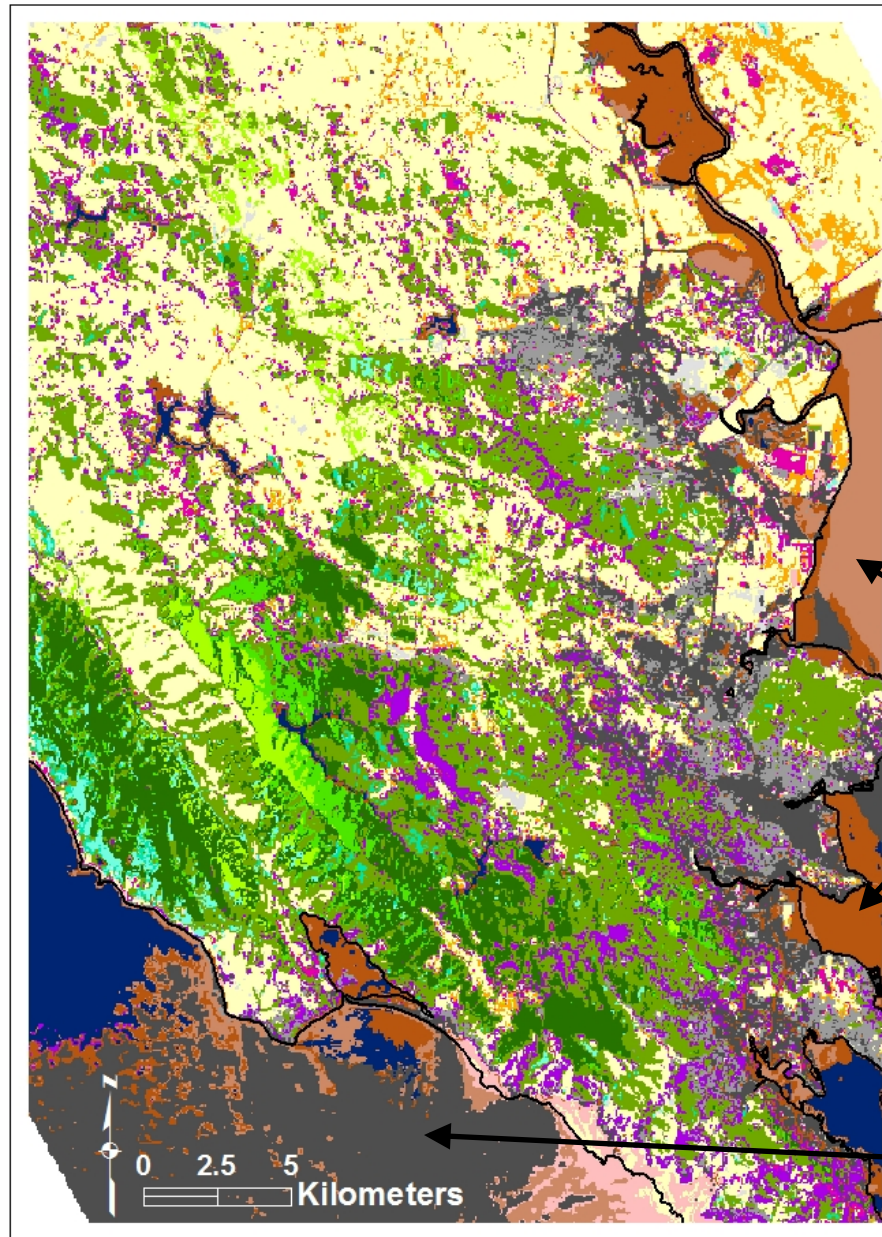


↓
*San
Francisco*

Classified land cover

Lifeform Classification

- Annual Crops
- Beaches or Dunes
- Conifer
- Deciduous Broad-leaf
- Dune Veg
- Evergreen Broad-leaf
- High Density
- Low Density
- Mediterranean Shrubs
- Mixed Forest
- Moderate Density
- Perennial Crops
- Riparian Forests
- Riparian Shrublands
- Tidal Salt & Marsh
- Upland Grasses and Forbs
- Water

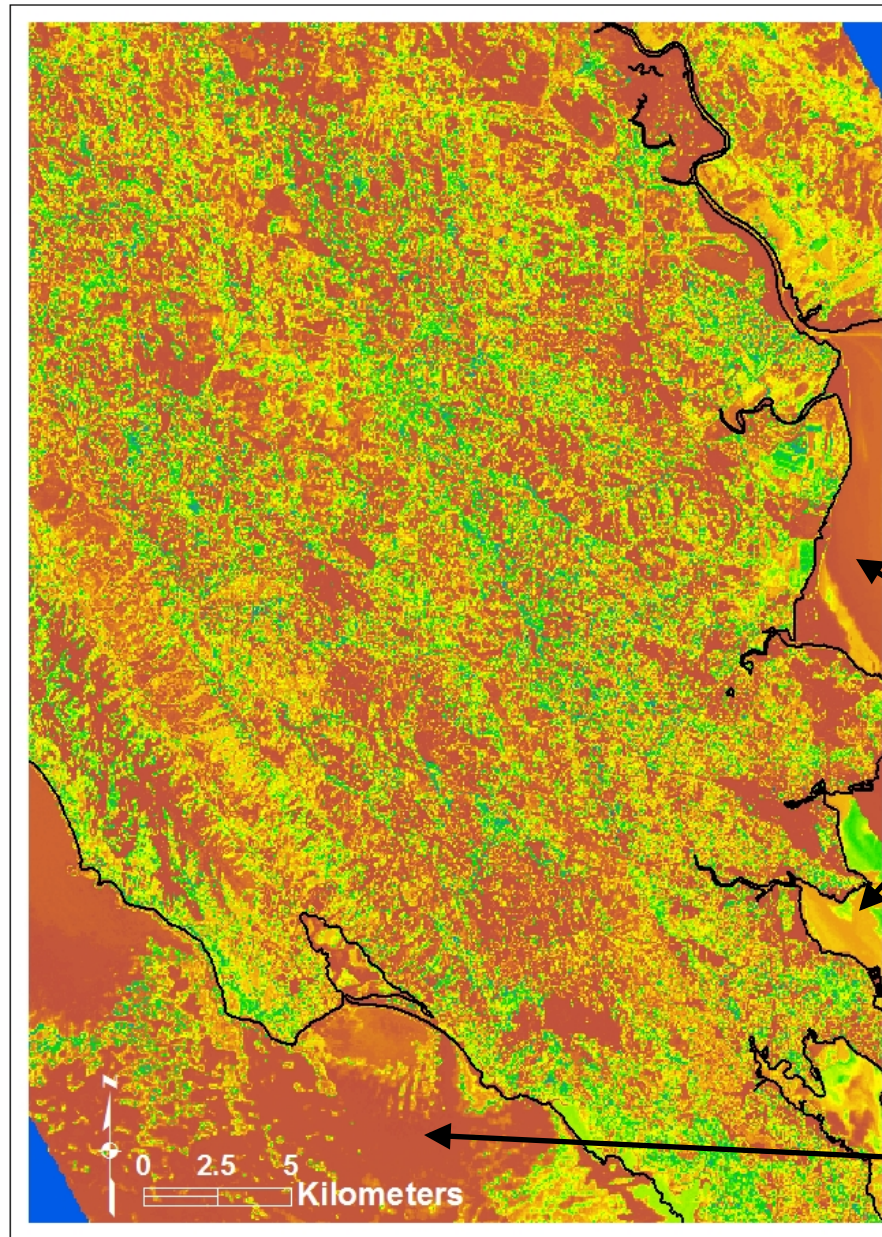
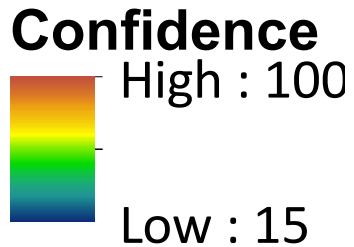


Class in each pixel is determined by majority vote out of 999 decision trees in Random Forests

Sediment in bay

Clouds

Confidence =
% of votes from all
999 decision trees in
Random Forests
received by
the majority class



Scene overlap
handled by picking
the class with
highest “confidence”
between overlapping
pixels

Sediment
in bay

Clouds

Next steps

- VIEW-IT reference data collection with SSU students
- Refine land-cover class definitions (percent cover rules)
- Use new code to extract pixels without oversampling
- Cloud mask
- Simulated imagery for all runs – spring, summer, fall
- Explore hyperspectral metrics, not just bands
- Look at view zenith angle effects (BRDF) on class accuracy
- Experiment with mosaicking techniques based on class “confidence” and/or view zenith angle
- Alliance-level mapping within forest mask