

# Discriminating dominant plant species and functional types across ecosystems

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HyspIRI Science Workshop, 2011

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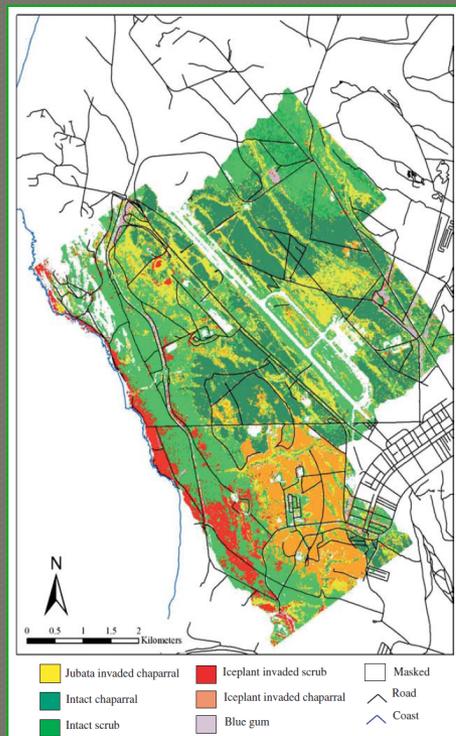
# Mapping Plant Species & Functional Types

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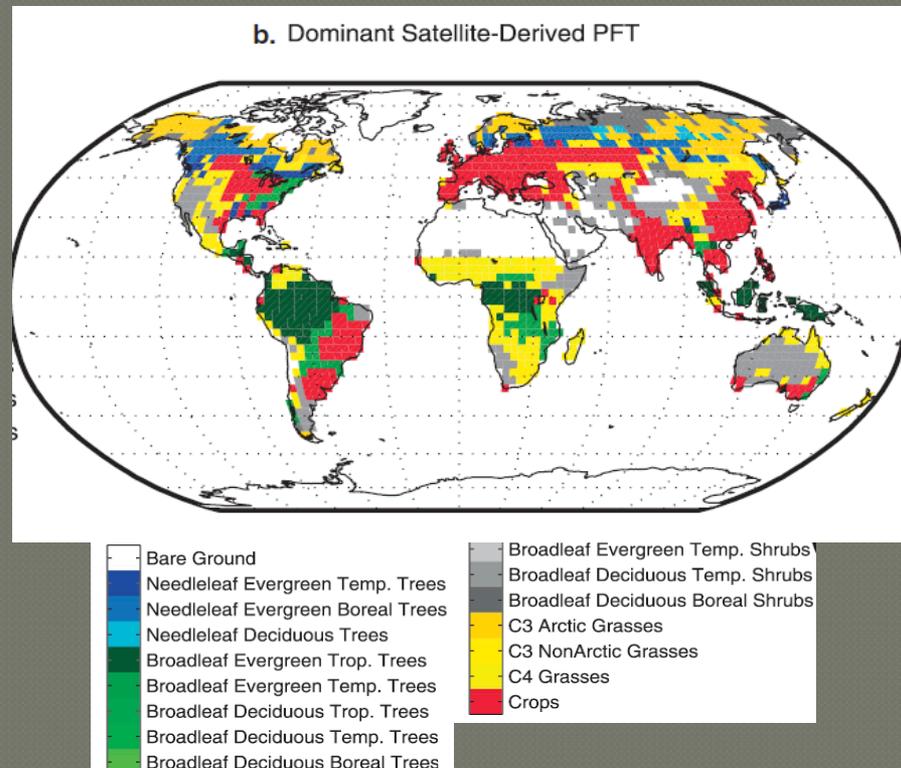
- Rationale/Relevance to HyspIRI
- Research Objectives
- Study Ecosystems
- MESMA at native and 60 m resolutions
  - Individual sites
  - Combined-sites
- Findings & Conclusions

# HyspIRI Mission Goals

- VQ1) What is the global spatial pattern of ecosystem and diversity distributions, and how do ecosystems differ in their composition or biodiversity? ...*What is the current spatial distribution of ecosystems, functional groups, or key species within major biomes?*



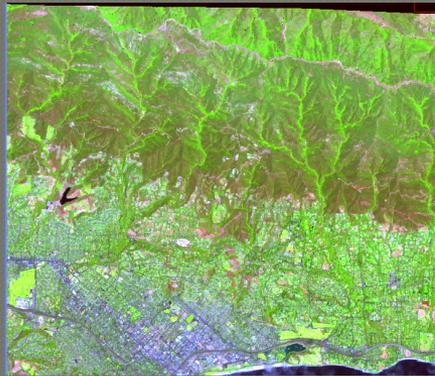
Underwood et al., 2007, *Environ Manage*



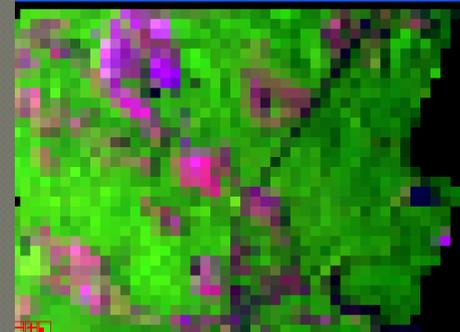
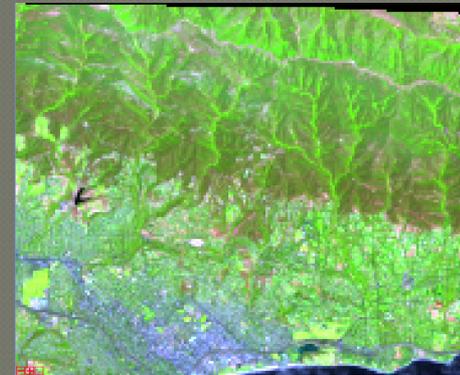
Bonan et al., 2002

# Research Objectives

What are the *spatial*, spectral and temporal data requirements for discriminating plant species & functional types across diverse ecosystems?



*Impact of  
60 m?*



# Study Sites



# Smithsonian Environmental Research Center (SERC)



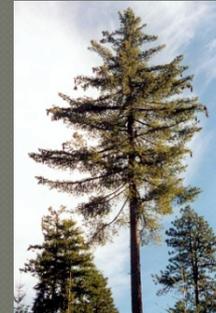
# Santa Barbara Front Range (SBFR)



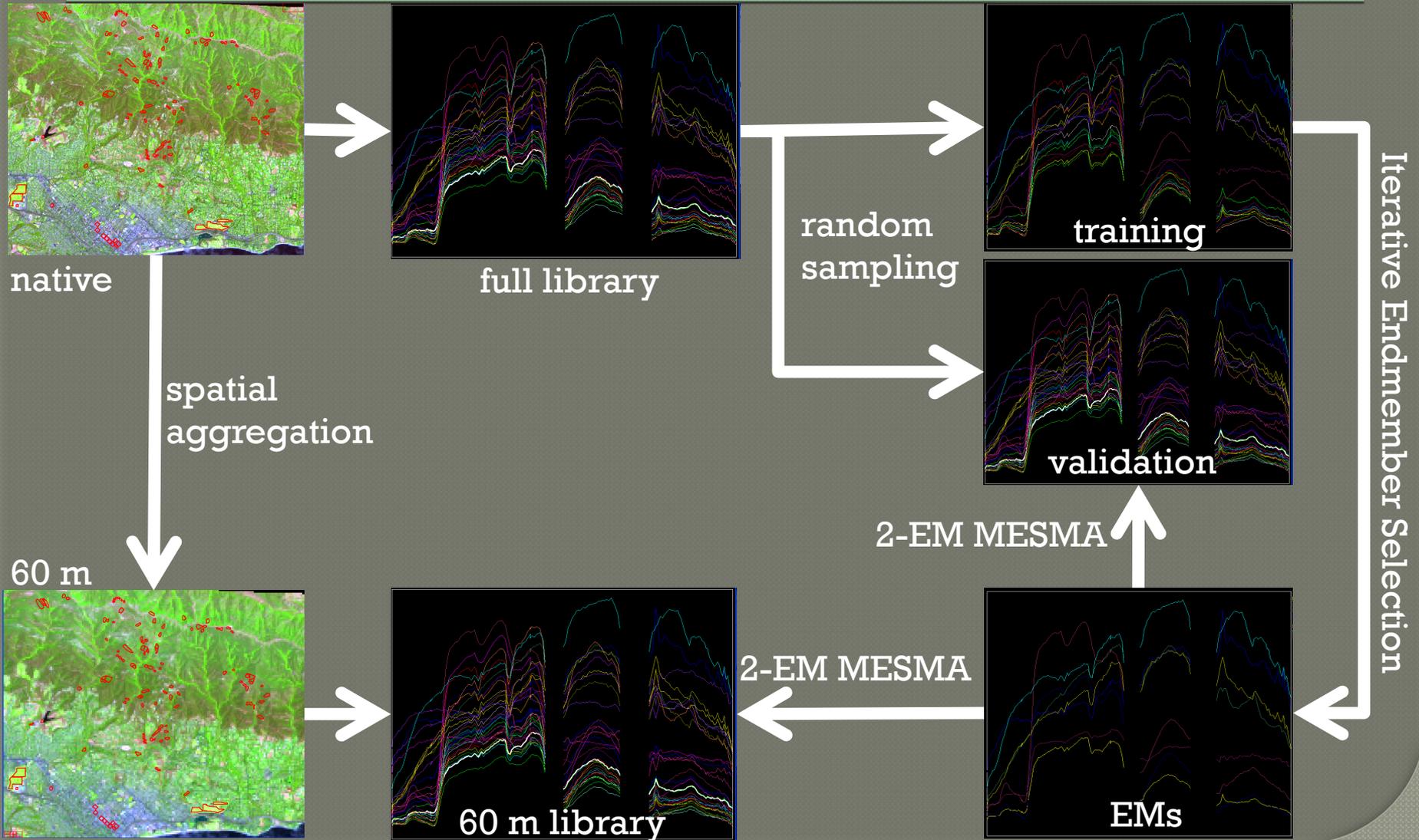
# Wind River Experimental Forest (WR)



# Southern Sierra National Forest (SNev)



# Image & Library Processing



# Temperate Broadleaf Deciduous Forest (SERC)

acquired 29 May 2006 at 3.5 m

# EMs = 68

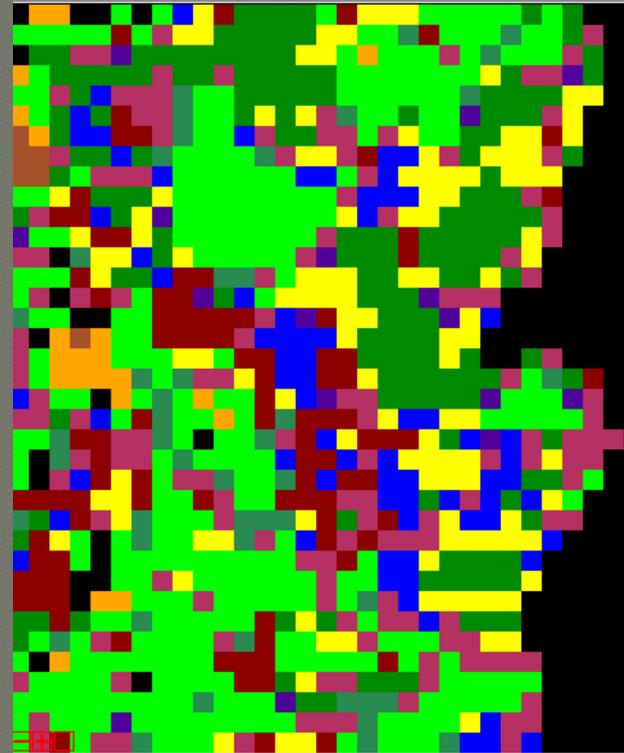
## Species-level

	native	60 m
# classes	11	8
kappa	0.778	0.823
overall accuracy	82.6%	85.7%

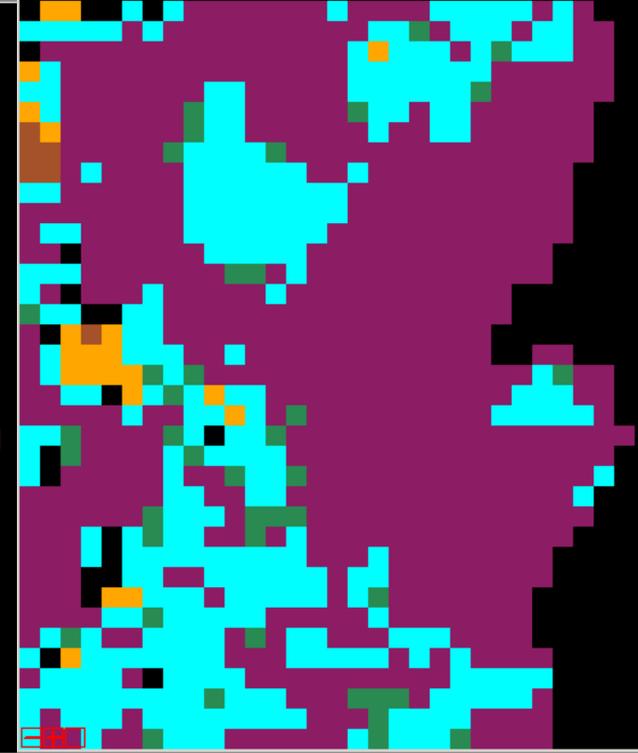
## PFT-level

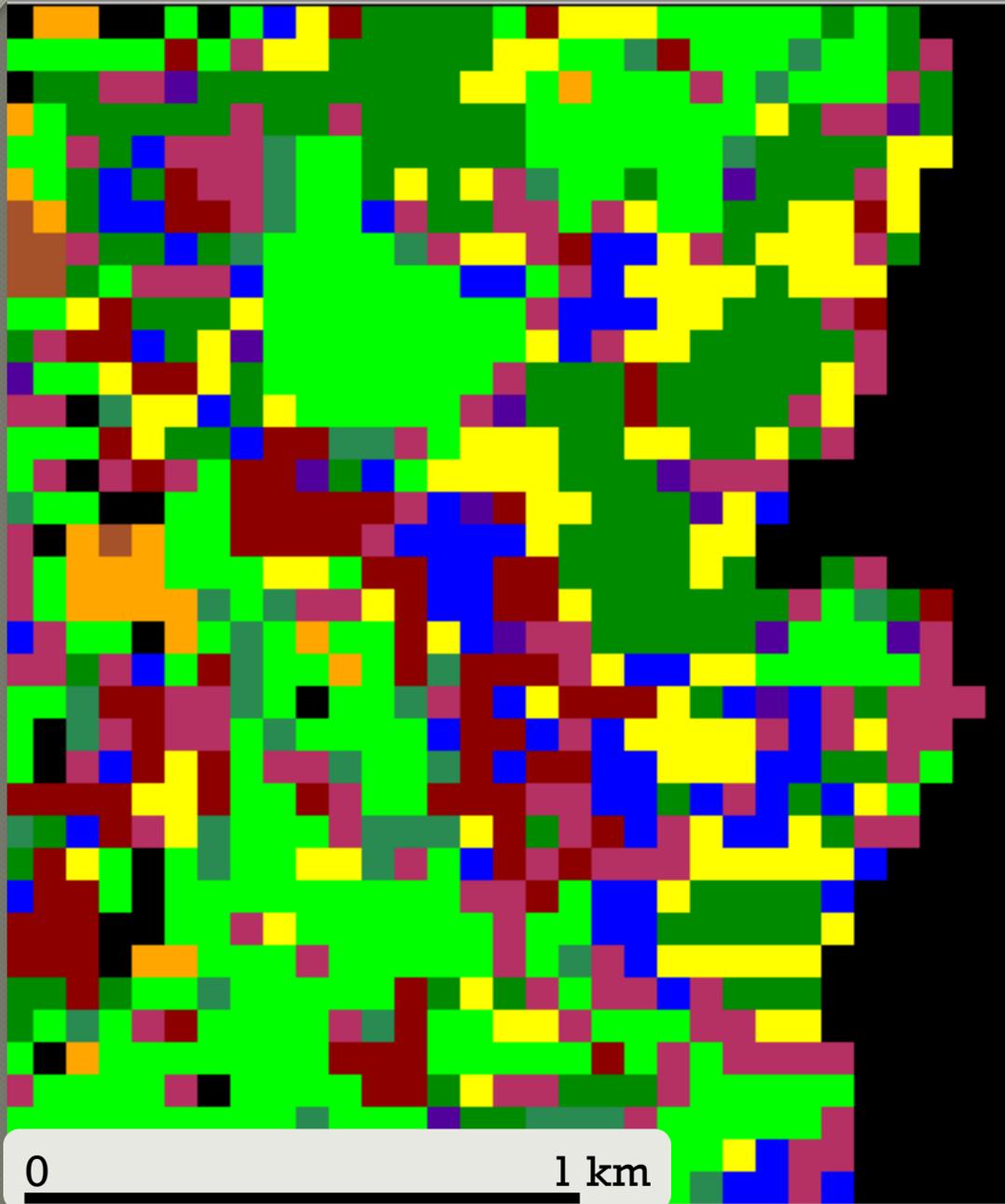
	native	60 m
# classes	5	5
kappa	0.909	0.872
overall accuracy	93.3%	90.5%

60 m species



60 m PFT





■ unclassified

~~■ Acer rubrum~~

■ crop

■ soil

■ Carya

■ Fagus grandifolia

■ Pinus

■ litter

■ Quercus

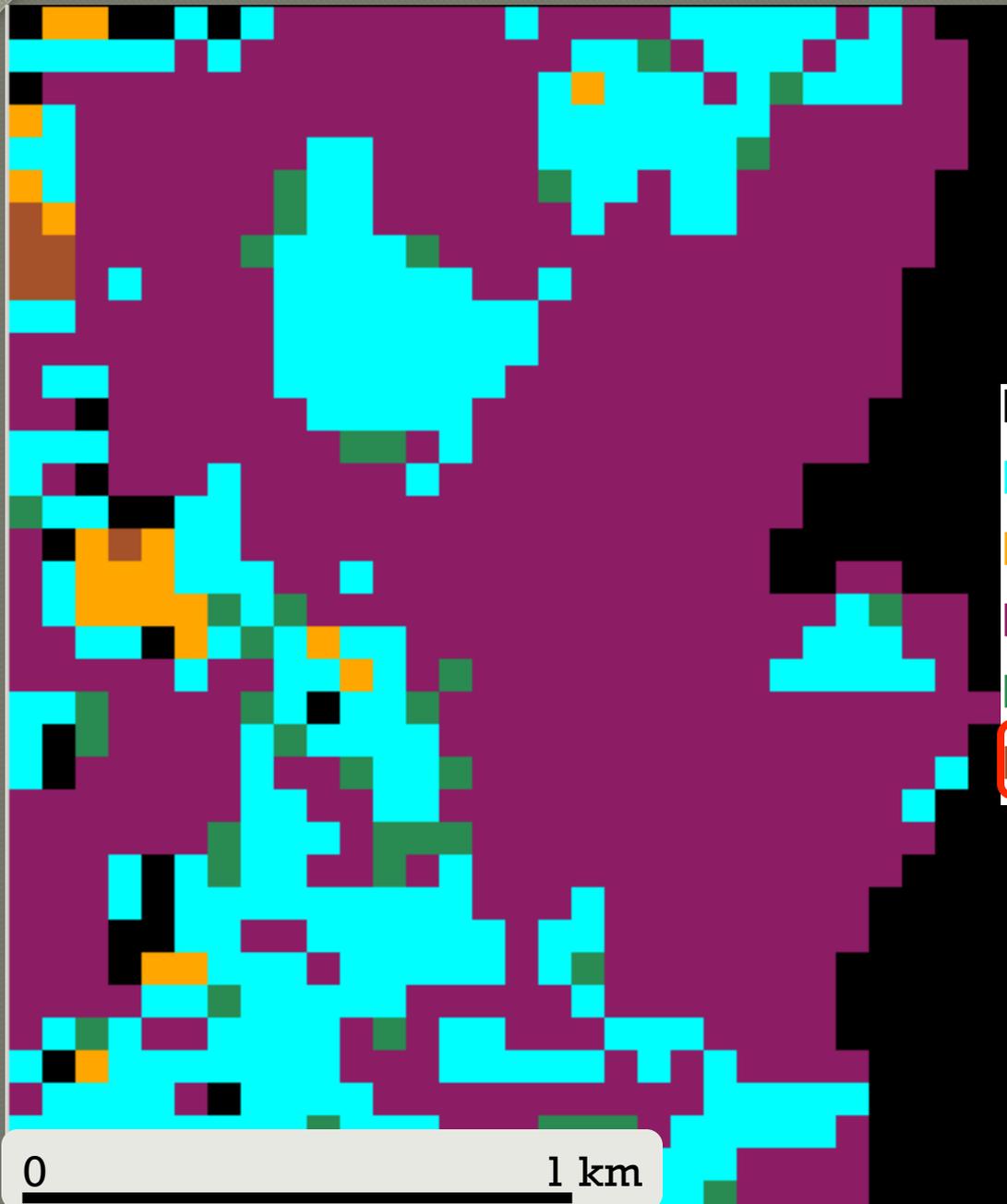
~~■ Platanus occidentalis~~

~~■ Liquidambar styraciflua~~

■ Liriodendron tulipifera

0

1 km



- unmodeled
- annual broadleaf herb
- litter
- deciduous broadleaf tree
- evergreen needleleaf tree
- soil

0

1 km

# Temperate Broadleaf Deciduous Forest (SERC)

acquired 29 May 2006 at 3.5 m

# EMs = 68

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	native	60 m
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## PFT-level

	native	60 m
# classes	5	5
kappa	0.909	0.872
overall accuracy	93.3%	90.5%

## Key Results

- canopy dominants separable at 60 m, but smaller classes become too mixed
- discrimination among deciduous broadleaf tree species is moderate
- good discrimination among functional types at 60 m

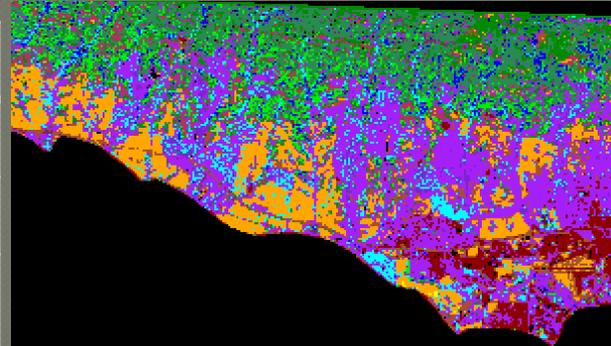
# Chaparral Shrubland/Oak Woodland/Urban (SBFR)

acquired 06 Aug 2004 at 16 m

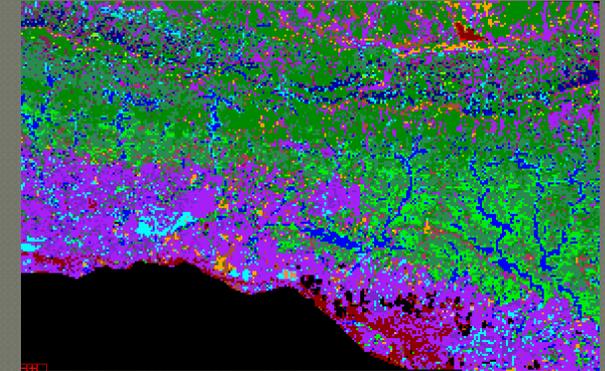
# EMs = 310

## Species-level

	native	60 m
# classes	22	22
kappa	0.793	0.767
overall accuracy	82.3%	79.6%

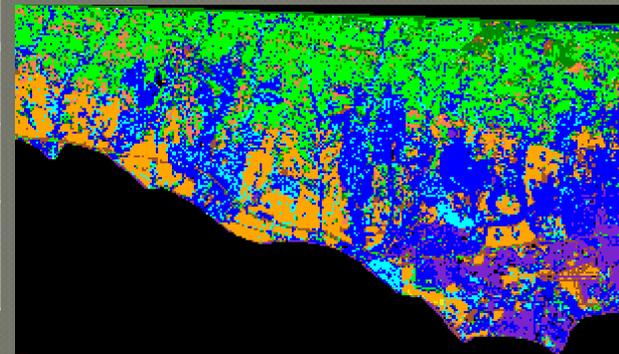


## 60 m species

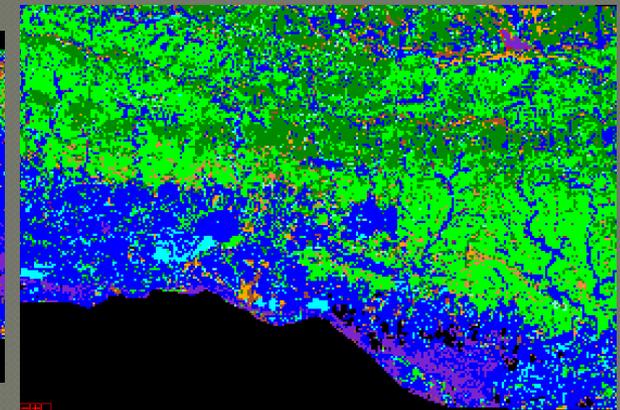


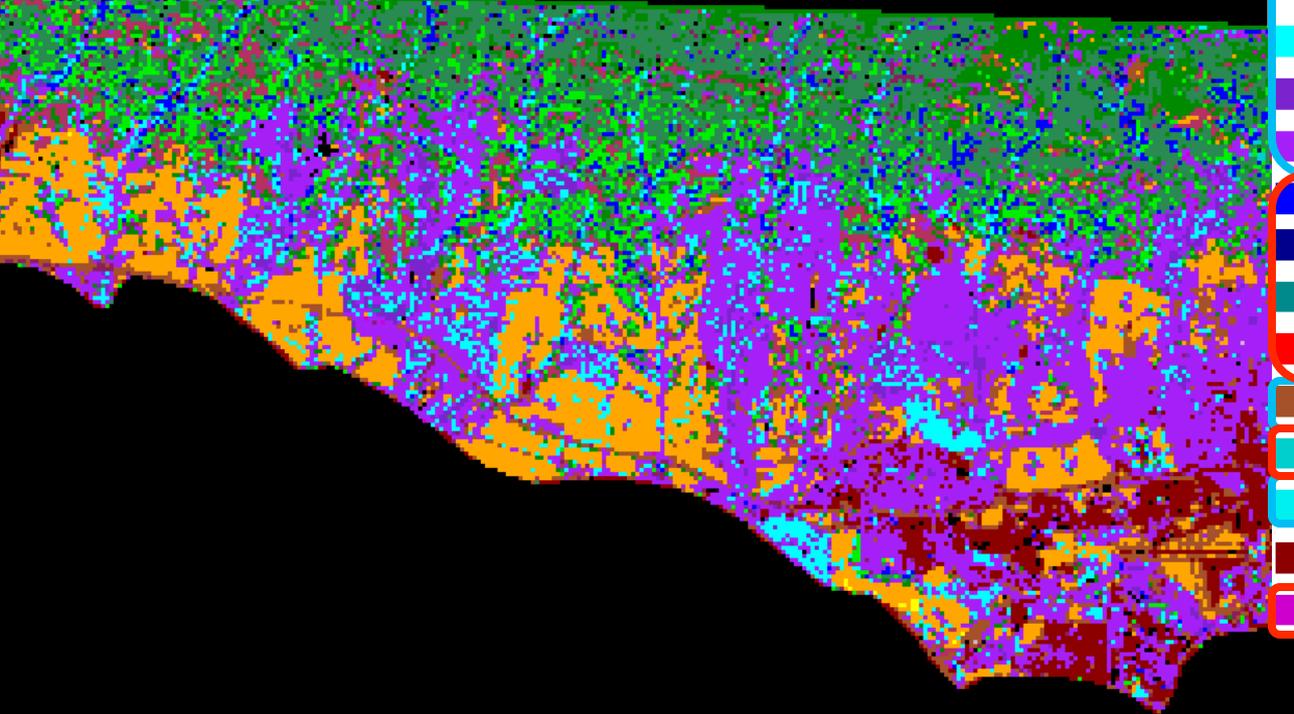
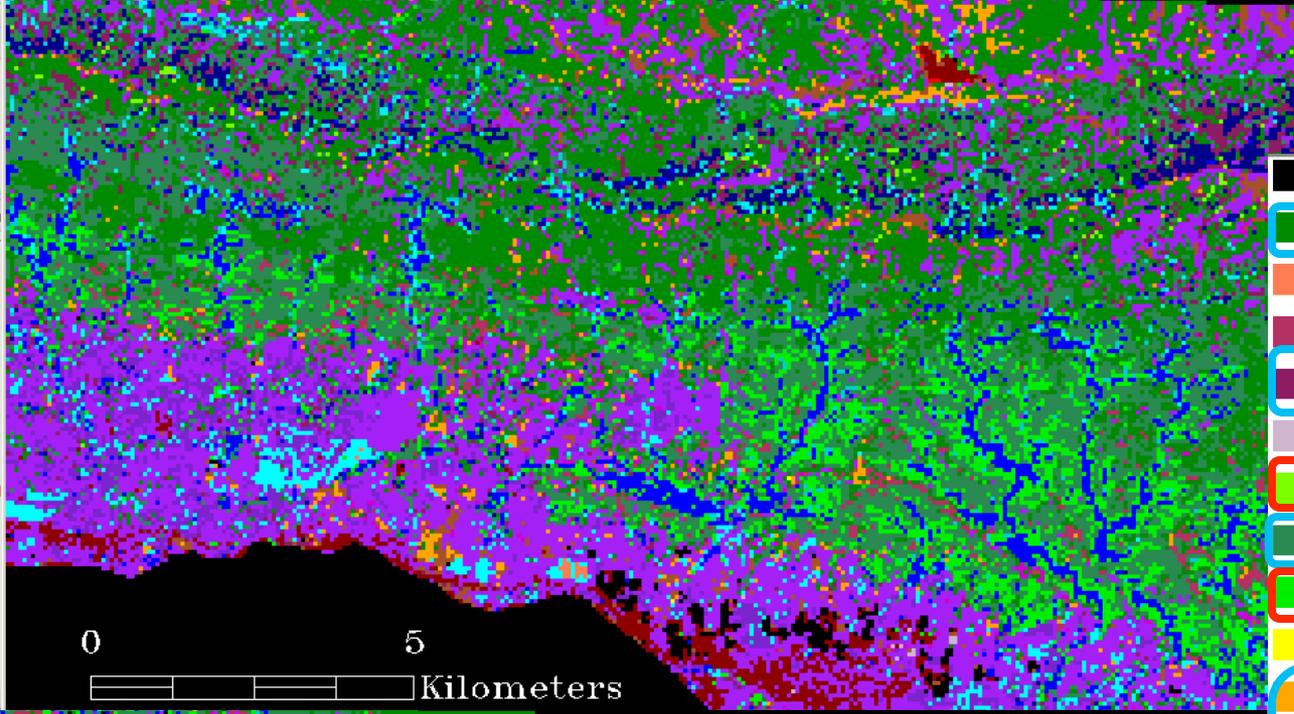
## PFT-level

	native	60 m
# classes	12	12
kappa	0.842	0.819
overall accuracy	87.6%	85.6%

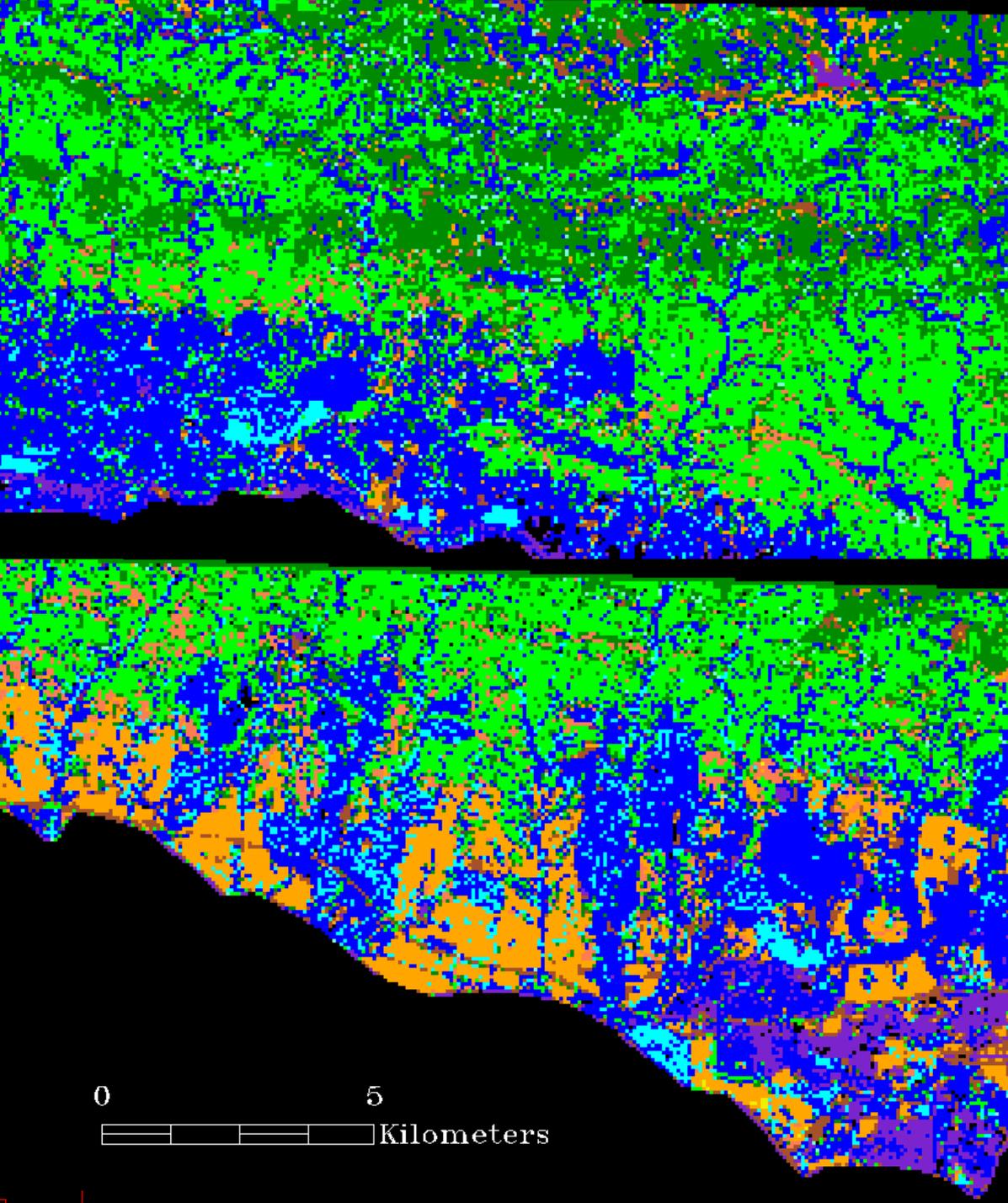


## 60 m PFT





- Unclassified
- Adenostoma fasciculatum
- crop
- Artemisia californica
- Arctostaphylos gl.
- burn scar
- Ceanothus cuneatus
- Ceanothus megacarpus
- Ceanothus spinosus
- herb litter
- grass litter
- golf course
- young orchard
- mature orchard
- Quercus agrifolia
- Quercus dumosa
- riparian
- rock
- soil
- Platanus racemosa
- Umbellularia californica
- urban
- Yucca whipplei



- Unclassified
- annual broadleaf herb
- grass litter
- herb litter
- deciduous broadleaf tree
- deciduous needleleaf shrub
- evergreen broadleaf shrub
- evergreen broadleaf tree
- evergreen needleleaf shrub
- evergreen succulent shrub
- rock
- soil
- urban

0 5 Kilometers

# Chaparral Shrubland/Oak Woodland/Urban (SBFR)

acquired 06 Aug 2004 at 16 m

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	native	60 m
# classes	22	22
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PFT-level

	native	60 m
# classes	12	12
kappa	0.842	0.819
overall accuracy	87.6%	85.6%

## Key Results

- overall accuracy diminishes slightly at 60 m, but spatial patterns in distribution are preserved
- most classes improve or stay stable from native to 60 m
- classes which become less accurate at 60 m tend to occur in thin patches with higher perimeter to area ratios

# Mixed Conifer Forest (SNeV)

acquired 11 July 2003 at 4 m

# EMs = 99

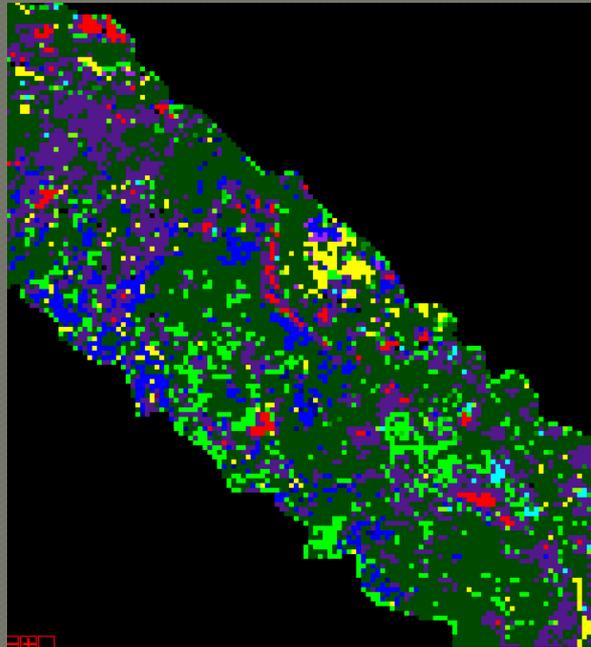
## Species-level

	native	60 m
# classes	14	14
kappa	0.327	0.395
overall accuracy	41.6%	47.5%

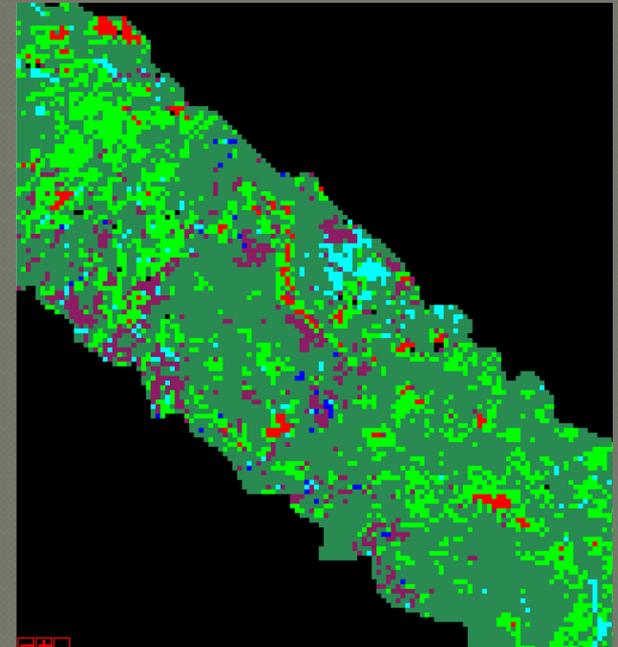
## PFT-level

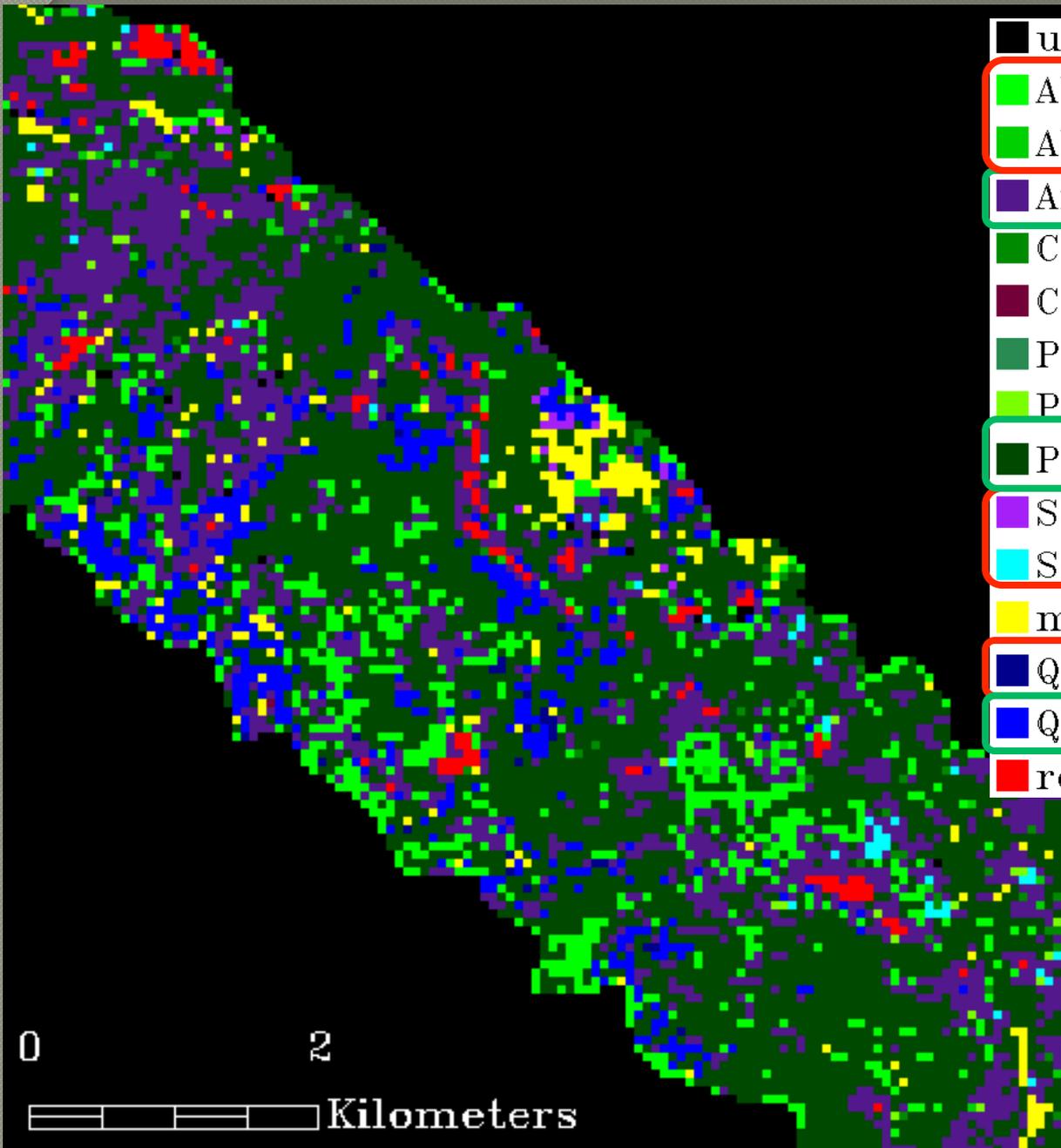
	native	60 m
# classes	6	6
kappa	0.471	0.526
overall accuracy	63.9%	68.4%

60 m species



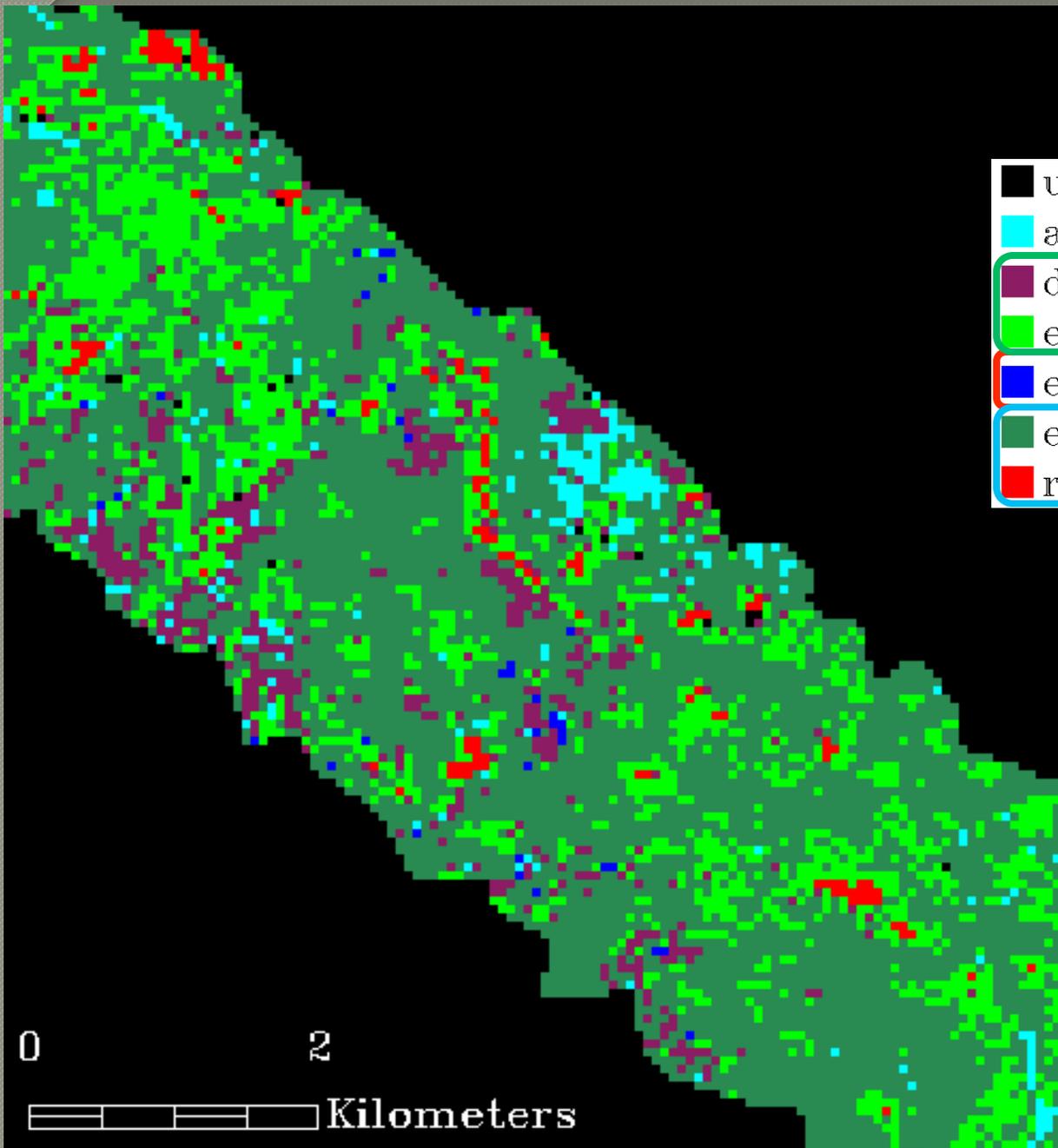
60 m PFT





- unmodeled
- Abies concolor
- Abies magnifica
- Arctostaphylos glauca
- Calocedrus decurrens
- Ceanothus cordulatus
- Pinus jeffreyi
- Pinus lambertiana
- Pinus ponderosa
- Salix spp.
- Sequoiadendron giganteum
- meadow
- Quercus chrysolepsis
- Quercus kelloggii
- rock

0 2  
Kilometers



- unmodeled
- annual broadleaf herb
- deciduous broadleaf tree
- evergreen broadleaf shrub
- evergreen broadleaf tree
- evergreen needleleaf tree
- rock

0 2  
Kilometers

# Mixed Conifer Forest (SNeV)

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	native	60 m
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overall accuracy	41.6%	47.5%

## PFT-level

	native	60 m
# classes	6	6
kappa	0.471	0.526
overall accuracy	63.9%	68.4%

## Key Results

- poor accuracy at species level may be due to high spectral variability (likely reflectance retrieval)
- much confusion among conifer tree species
- highly mixed stands make classification more challenging

# Mixed Conifer/Broadleaf Temperate Rainforest (WR)

acquired 18 July 2003 at 3.3 m

# EMs = 66

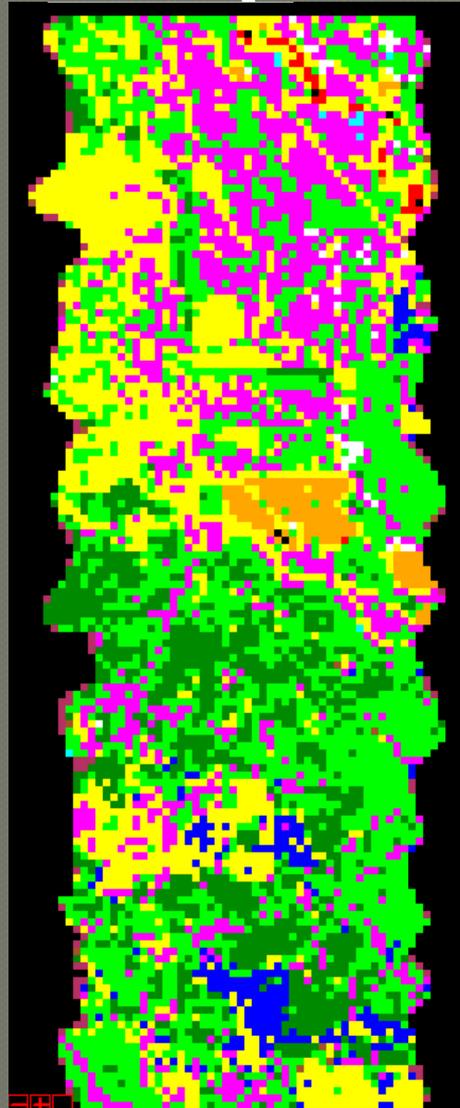
## Species-level

	native	60 m
# classes	11	6
kappa	0.533	0.751
overall accuracy	66.4%	82.1%

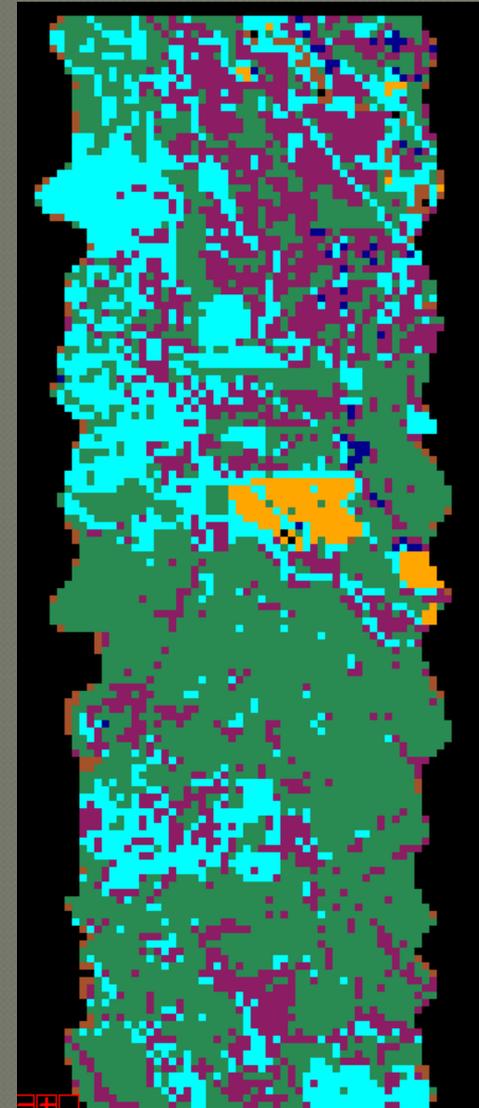
## PFT-level

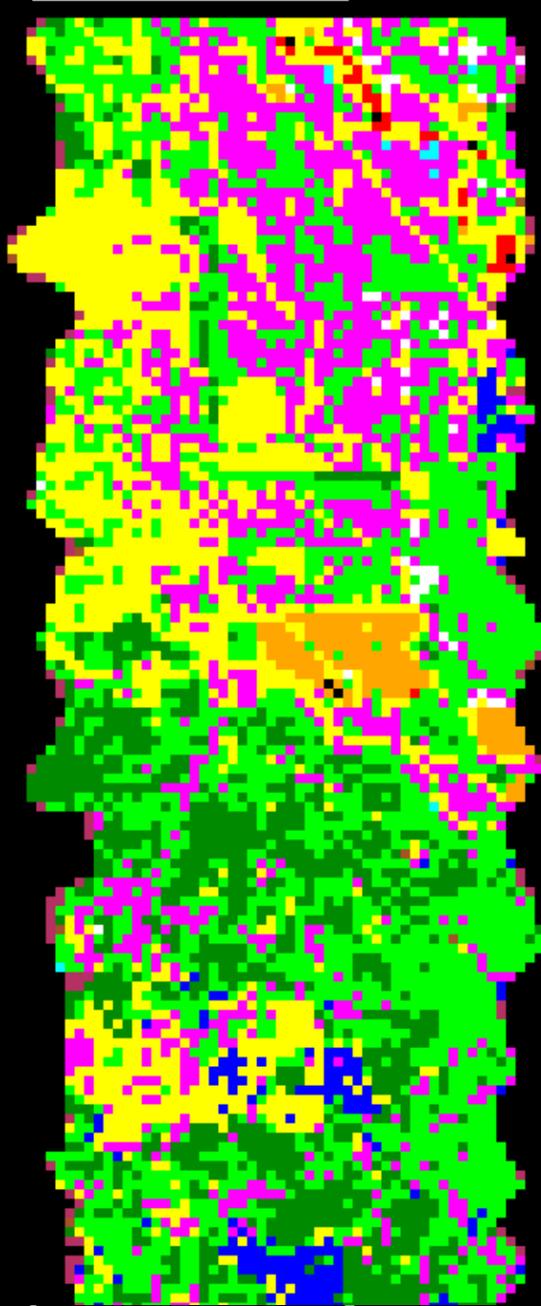
	native	60 m
# classes	6	3
kappa	0.815	0.957
overall accuracy	91.4%	98.0%

60 m species



60 m PFT



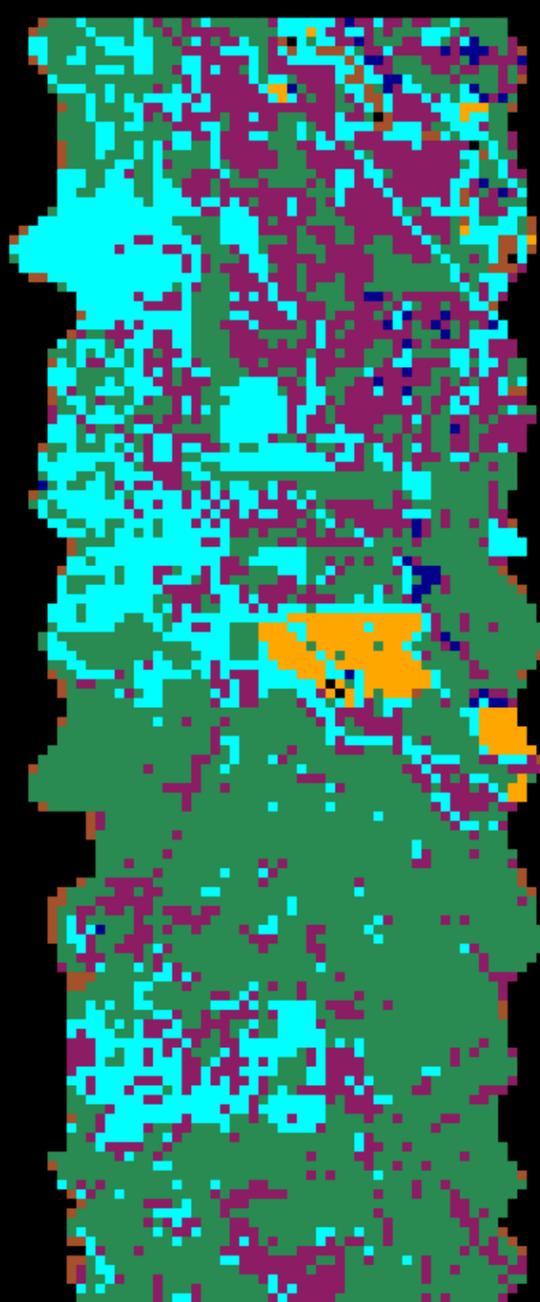


0

2

 Kilometers

- unmodeled
- ~~Abies grandis~~
- ~~Acer circinatum~~
- Acer macrophylla
- Alnus rubra
- litter
- Populus trichocarpa
- Psuedotsuga menziesii
- ~~Pteridium aquilinum~~
- ~~rock/soil~~
- ~~Thuja plicata~~
- Tsuga heterophylla



- unmodeled
- litter
- ~~■ deciduous broadleaf shrub~~
- deciduous broadleaf tree
- ~~■ annual broadleaf herb~~
- evergreen needleleaf tree
- ~~■ rock~~

0

2

————— Kilometers

# Mixed Conifer/Broadleaf Temperate Rainforest (WR)

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## Species-level

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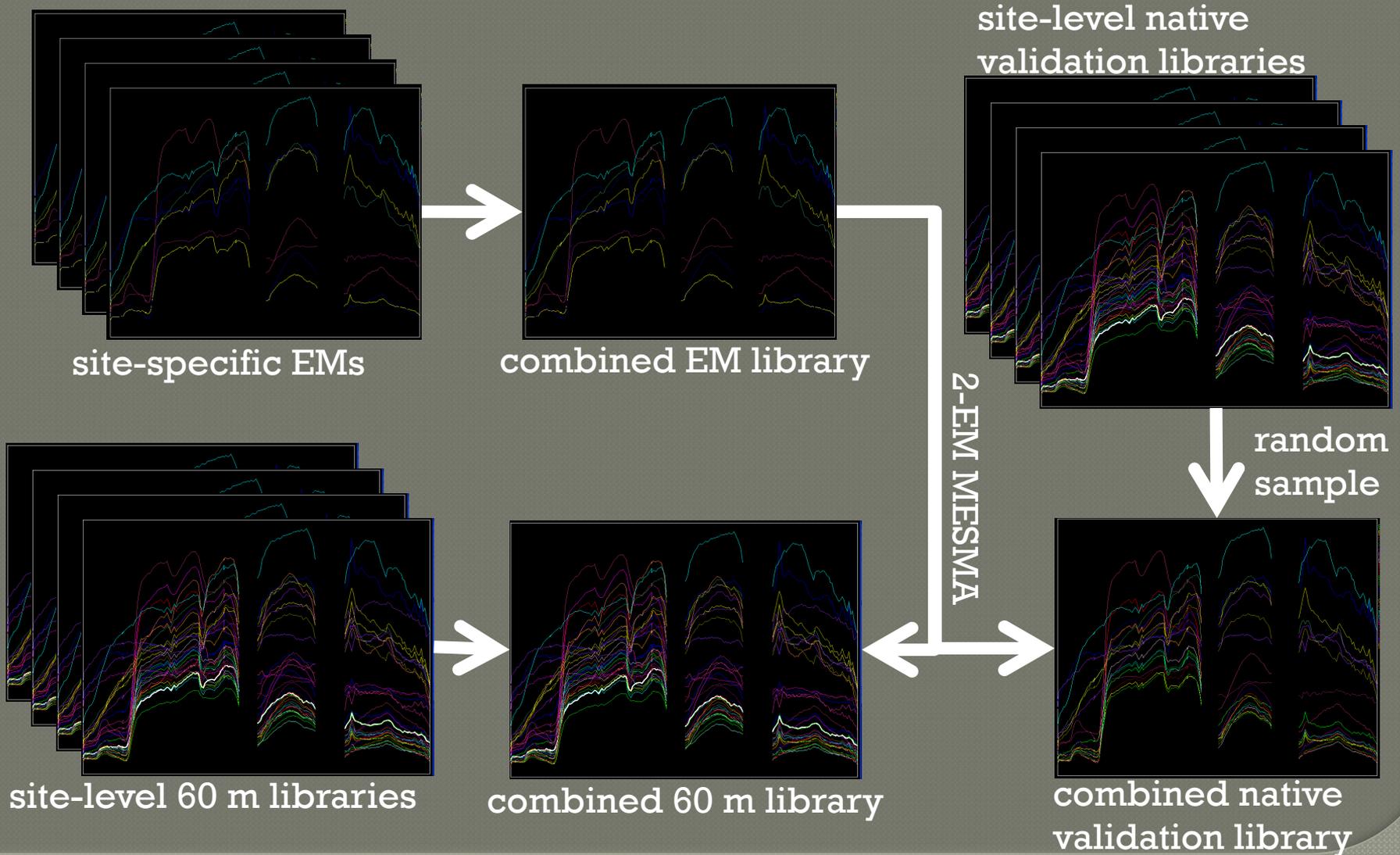
## PFT-level

	native	60 m
# classes	6	3
kappa	0.815	0.957
overall accuracy	91.4%	98.0%

## Key Results

- sunlit canopy frequently mistaken for fern, leading to over-mapping of this class
- some confusion between two most dominant classes (TSHE & PSME)
- excellent discrimination of functional types

# Combined-Sites (C-S) Analysis



# Combined-Sites Results

# EMs = 475 (pooled)

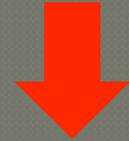
Species-level

# classes = 33	native	60 m
Kappa	0.580	0.702
overall accuracy	60.2%	72.9%

PFT-level

# classes = 9	native	60 m
Kappa	0.686	0.776
overall accuracy	73.2%	81.2%

8 classes



15 classes



10 classes



3 classes



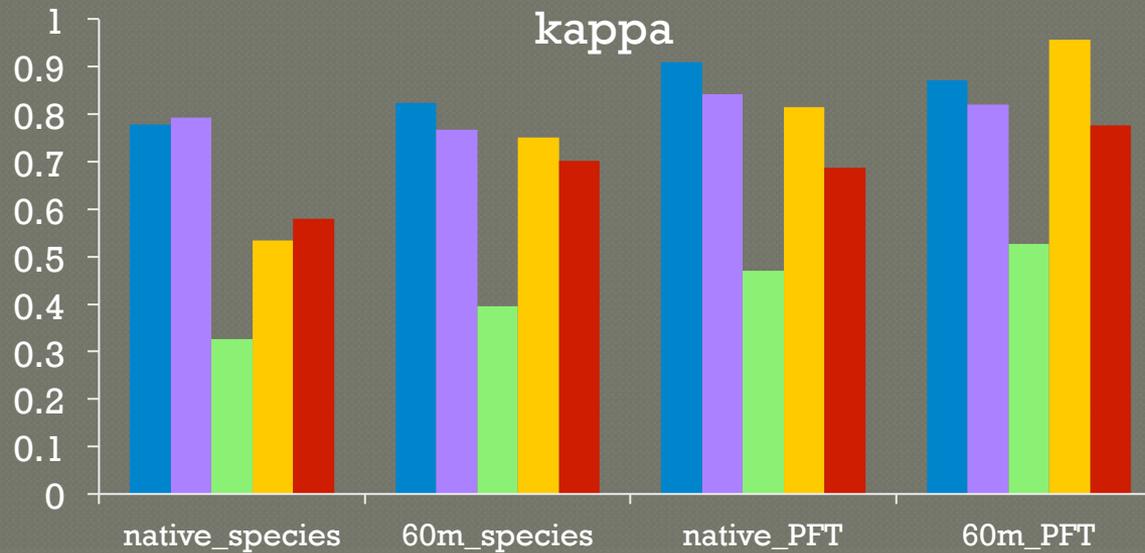
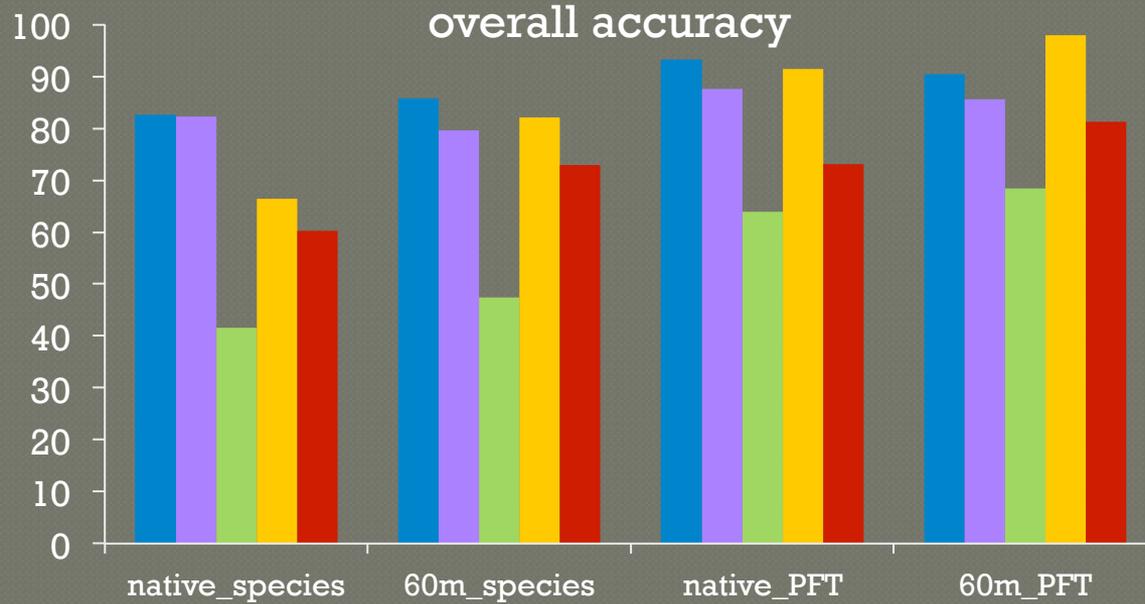
4 classes



2 classes



# Cross-Ecosystem Results



# Limitations & Assumptions

- reference data
  - assumes a minimize patch size
  - maps may be more accurate than is reflected in results
- reflectance retrieval: need a robust algorithm
- greater global diversity in ecosystems than examined here

# Conclusions

- accuracy stable/improved from native to 60 m spatial resolution
- EMs selected from fine resolution regional data can be applied to 60 m data from multiple ecosystems
- future work:
  - intermediate spatial scales (20 m & 40 m)
  - species/PFT spectral separability analysis

Thanks!  
Questions?

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Department of Geography  
University of California, Santa Barbara

# Sub-selection from pooled EMs

	native species		60 m species		native PFT		60 m PFT	
	all EMs	subset EMs	all EMs	subset EMs	all EMs	subset EMs	all EMs	subset EMs
kappa	0.580	0.471	0.702	0.580	0.686	0.554	0.776	0.634
overall accuracy	60.2%	49.6%	72.9%	61.4%	73.2%	61.9%	81.2%	68.7%

# native combined-sites PFT error matrix

	ABH	litter	DBT	EBS	EBT	ENS	ENT	rock/soil	urban	unmodeled	User's Accuracy
ABH	2153	41	132	172	212	0	780	2	1	0	<b>61.6</b>
litter	13	1707	2	18	2	13	29	37	4	0	<b>93.5</b>
DBT	81	11	2946	33	29	0	1032	0	0	0	<b>71.3</b>
EBS	6	36	84	1681	137	161	240	20	1	0	<b>71.1</b>
EBT	352	38	316	453	2778	19	903	9	7	0	<b>57.0</b>
ENS	0	30	1	303	13	593	39	2	0	0	<b>60.5</b>
ENT	60	20	293	87	1	0	3993	0	2	0	<b>89.6</b>
rock/soil	1	118	1	15	4	2	6	1651	36	0	<b>90.0</b>
urban	3	9	0	0	0	0	7	15	396	0	<b>92.1</b>
unmodeled	13	2	6	2	3	0	6	29	10	0	
Producer's Accuracy	<b>80.3</b>	<b>84.8</b>	<b>77.9</b>	<b>60.8</b>	<b>87.4</b>	<b>75.3</b>	<b>56.8</b>	<b>93.5</b>	<b>86.7</b>		<b>73.2%</b>

# 60 m combined-sites PFT error matrix

	<b>ABH</b>	<b>litter</b>	<b>DBT</b>	<b>EBS</b>	<b>EBT</b>	<b>ENS</b>	<b>ENT</b>	<b>rock/soil</b>	<b>urban</b>	<b>unmodeled</b>	<b>User's Accuracy</b>
<b>ABH</b>	379	3	12	5	24	0	69	0	0	0	<b>77.0</b>
<b>litter</b>	0	103	0	0	0	0	0	3	0	0	<b>97.2</b>
<b>DBT</b>	4	0	38	0	4	0	9	0	0	0	<b>69.1</b>
<b>EBS</b>	0	1	3	163	19	16	7	0	0	0	<b>78.0</b>
<b>EBT</b>	54	1	10	23	349	1	39	7	0	0	<b>72.1</b>
<b>ENS</b>	0	1	0	32	2	63	2	0	0	0	<b>63.0</b>
<b>ENT</b>	0	1	0	2	0	1	174	0	0	0	<b>97.8</b>
<b>rock/soil</b>	0	4	0	0	2	1	0	258	1	0	<b>97.0</b>
<b>urban</b>	0	0	0	0	0	0	0	0	51	0	<b>100.0</b>
<b>unmodeled</b>	1	0	0	0	0	0	0	1	0	0	
<b>Producer's Accuracy</b>	<b>86.5</b>	<b>90.4</b>	<b>60.3</b>	<b>72.4</b>	<b>87.3</b>	<b>76.8</b>	<b>58.0</b>	<b>95.9</b>	<b>98.1</b>		<b>81.2%</b>

# Multiple Endmember Spectral Mixture Analysis (MESMA)

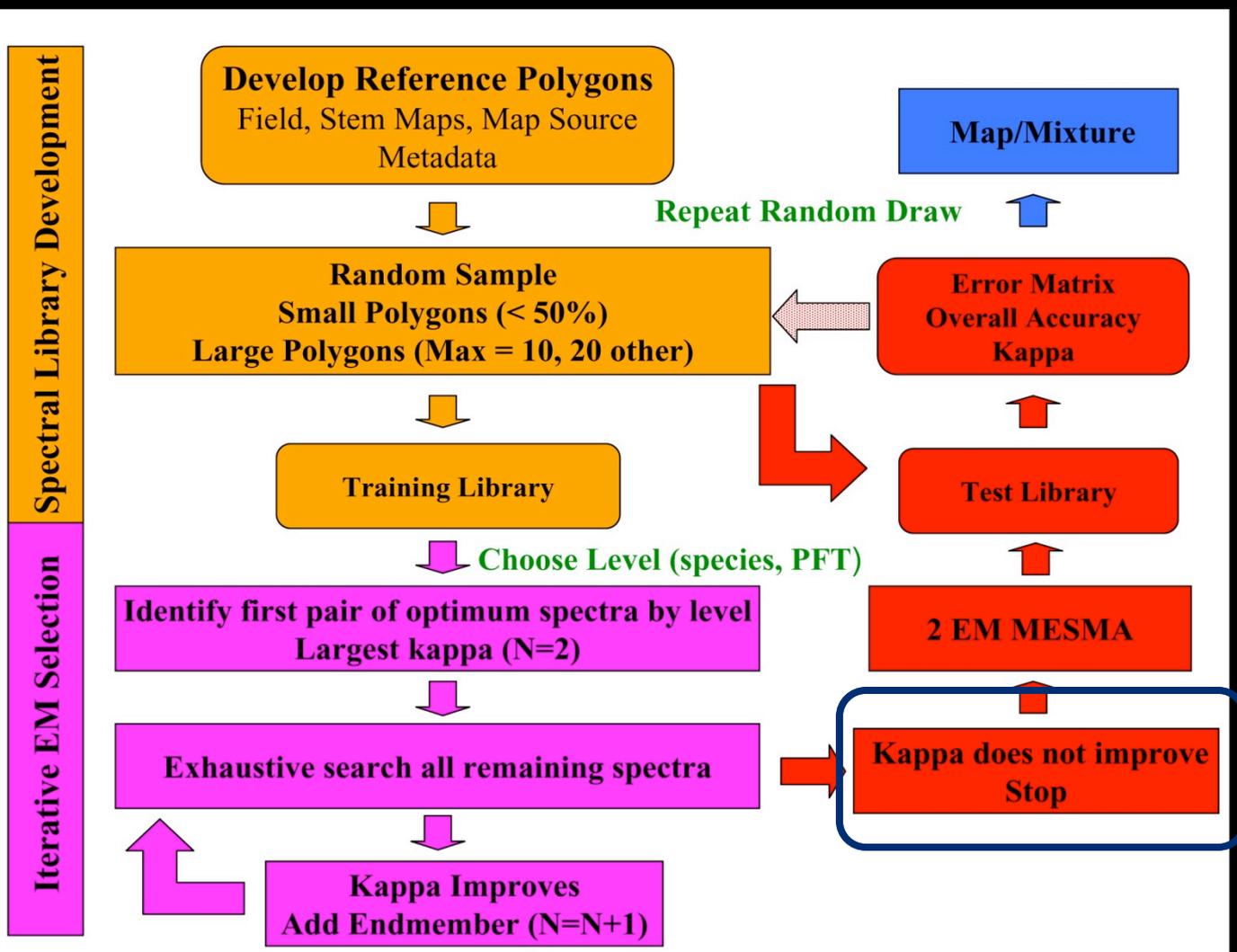
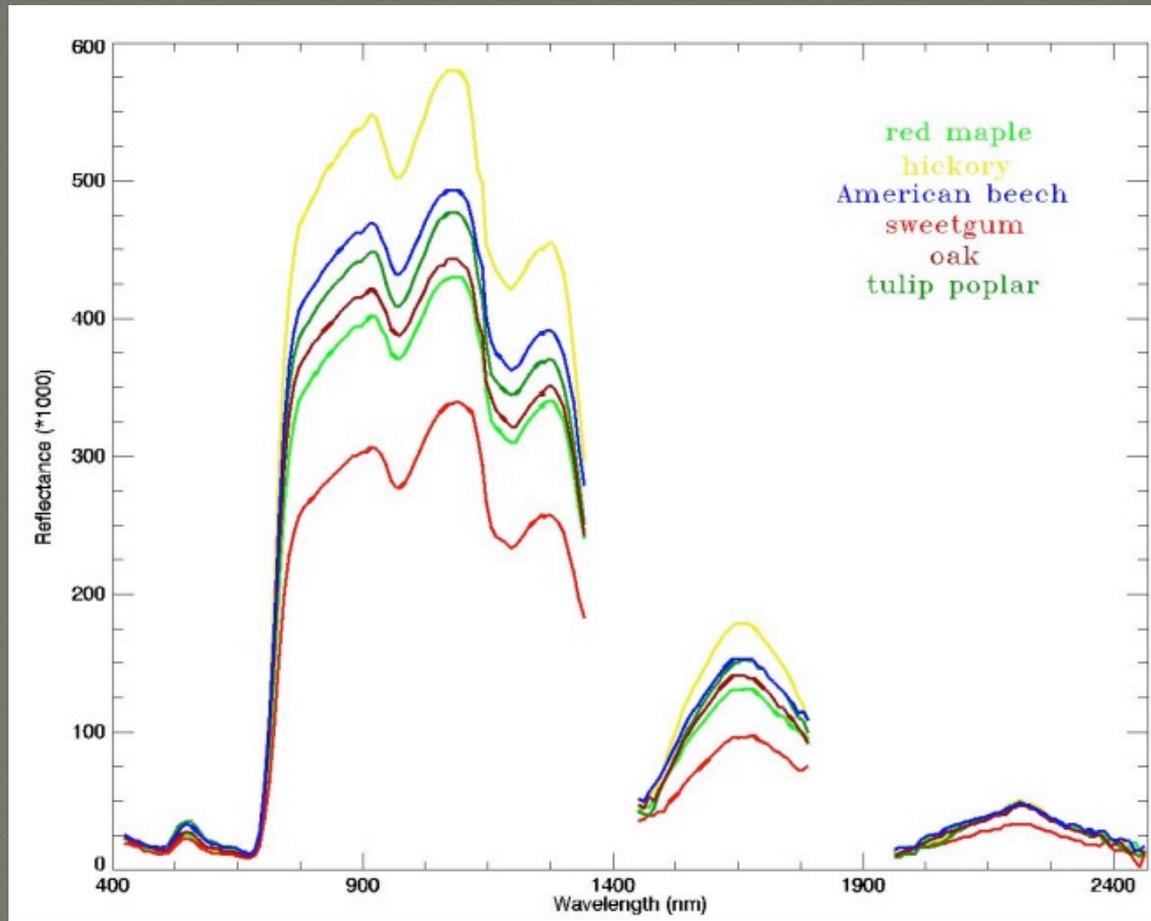
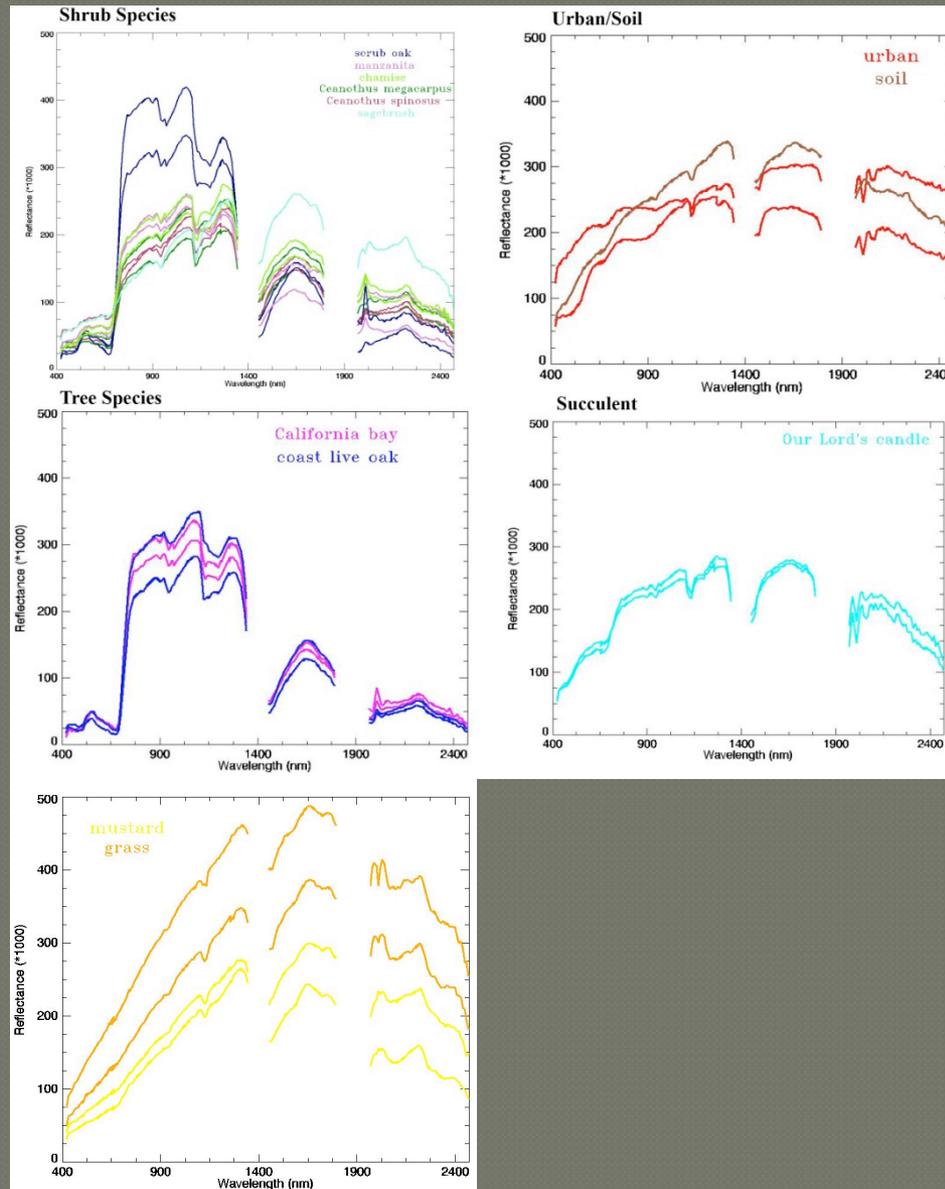


figure from Roberts et al., 2010

# SERC EMs

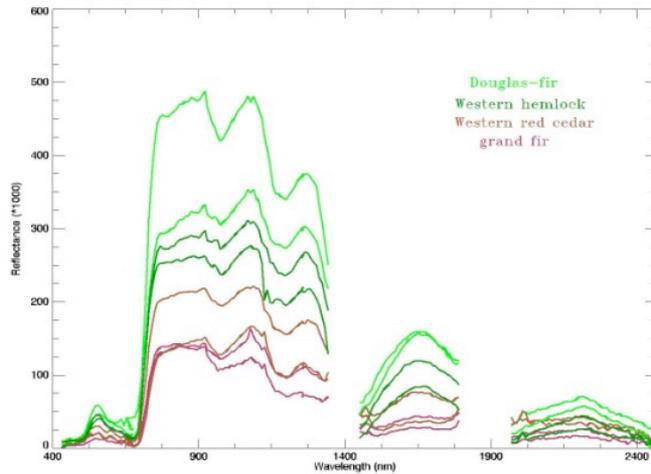


# Santa Barbara Front Range EMs

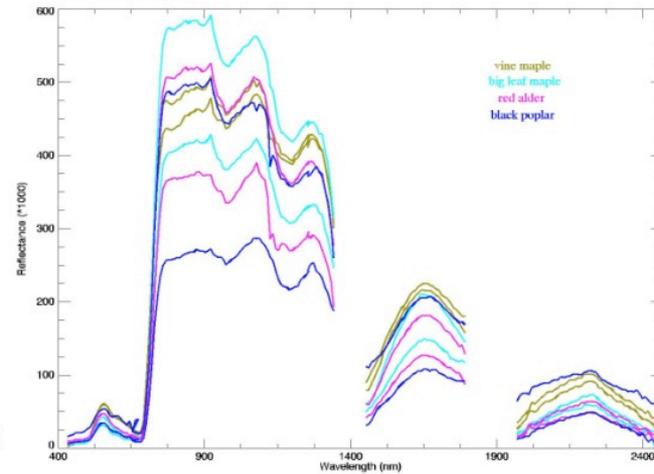


# Wind River EMs

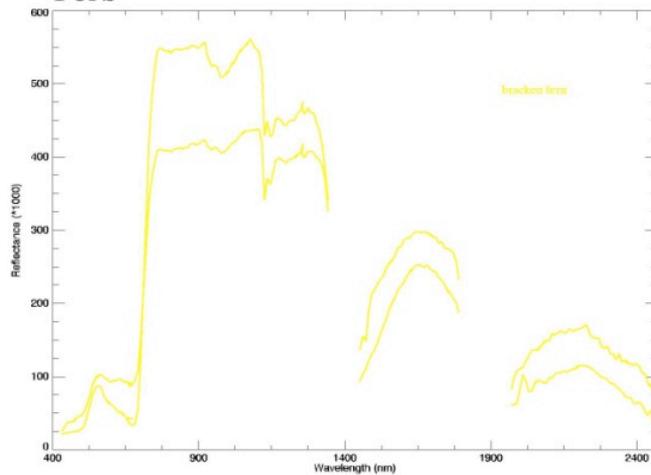
## Needle Leaf



## Broadleaf



## Forb



## Senesced grass and rock/soil

