VQ1. Pattern and Spatial Distribution of Ecosystems and their Components

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VQ1: Overarching Question

- **What is the spatial pattern of ecosystem and diversity distributions and how do ecosystems differ in their composition or biodiversity? [DS 195]**

VQ1. Sub Questions

- **How are ecosystems organized within different biomes associated with temperate, tropical, and boreal zones, and how are these changing? [DS 191, 203]**

- **How do similar ecosystems differ in size, composition and biodiversity across terrestrial and aquatic biomes and on different continents? [DS 195]**

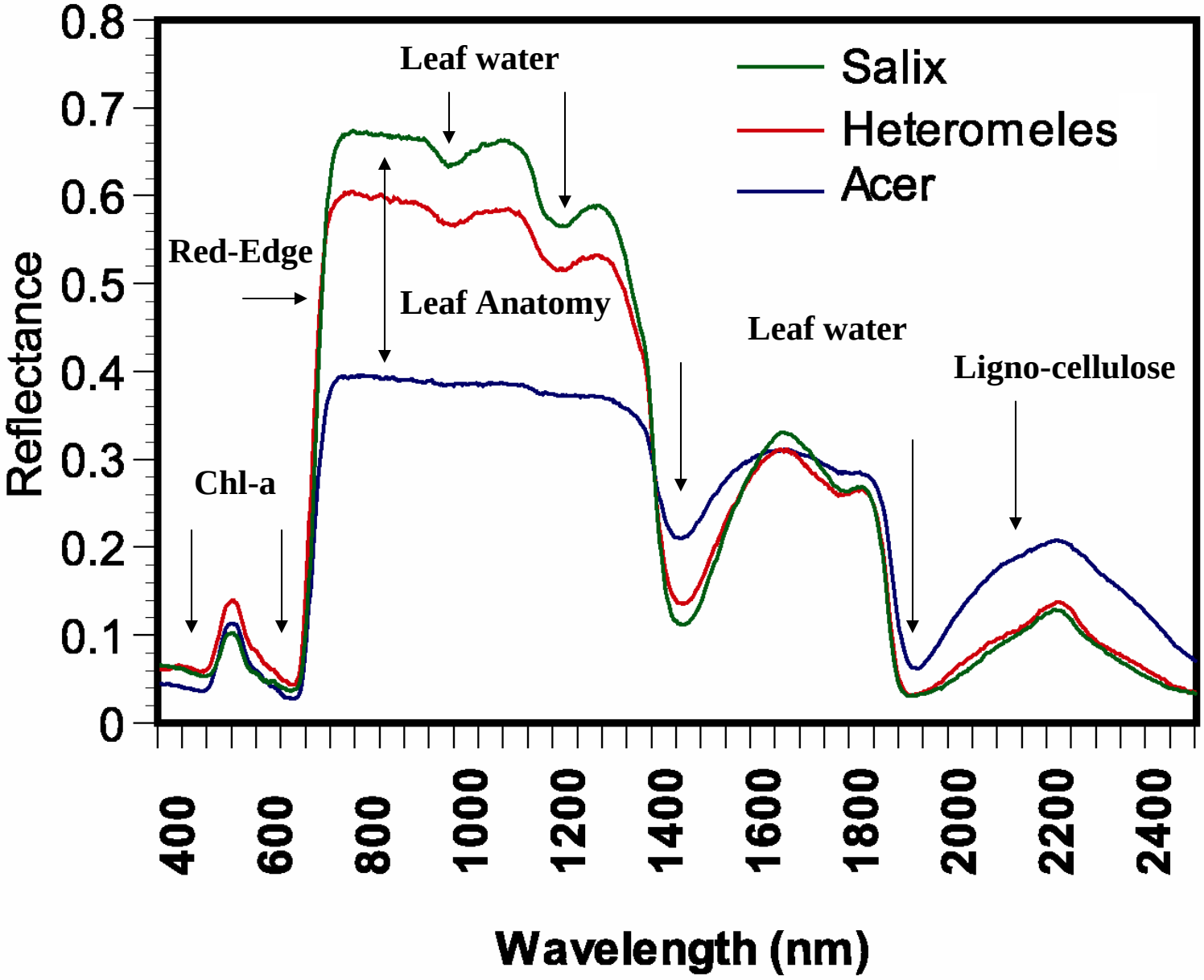
- **What is the current spatial distribution of ecosystems, functional groups, or key species within major biomes including agriculture, and how are these being altered by climate change, human uses, and other factors? [DS 191, 203]**

- **What are the extent and impact of invasive species in terrestrial and aquatic ecosystems? [DS 192, 194, 196, 203, 204, 214]**

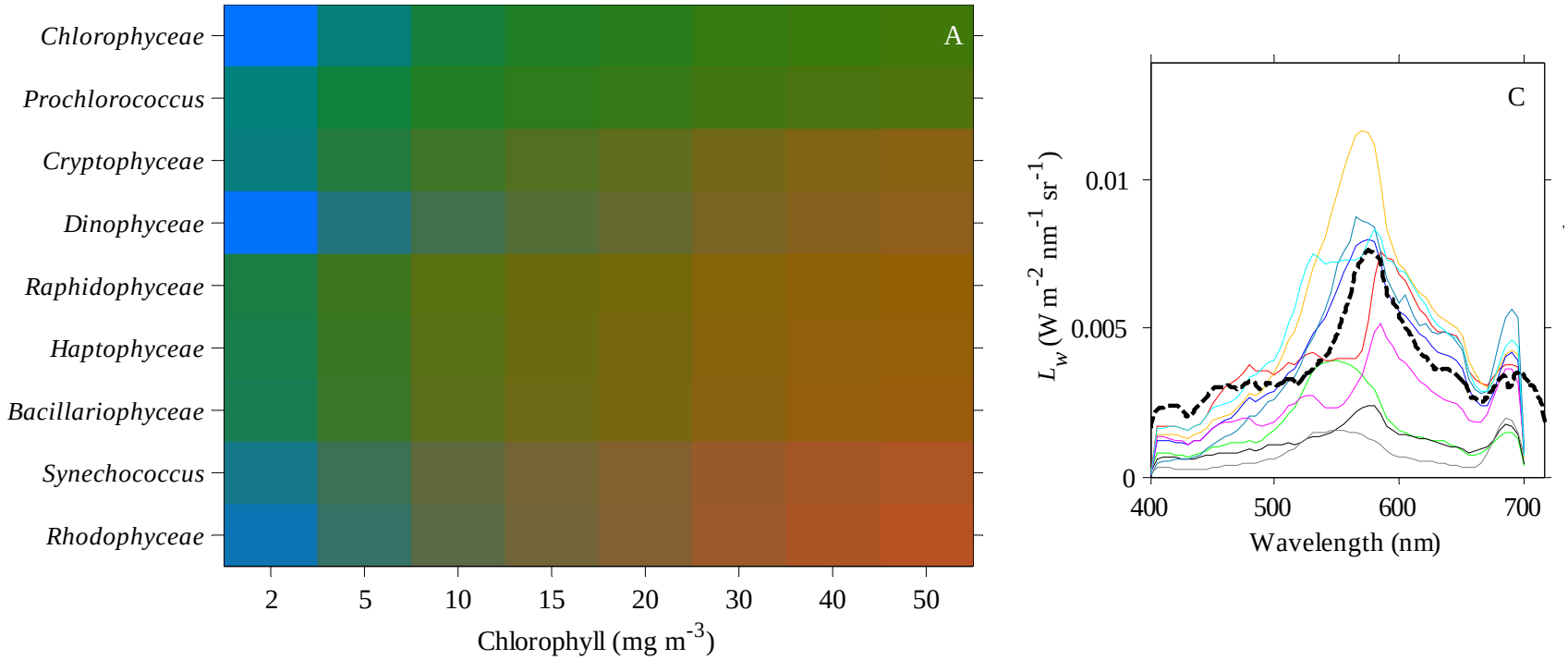
- **What are the locations, sizes, duration, and effects of harmful algal blooms? [DS 201, 208]**

- **How are changing geomorphology and composition linked to coastal ecosystem function and diversity [DS 41]?**

Spectroscopy of Leaf Chemistry and Anatomy



Phytoplankton Spectroscopy and Functional Groups

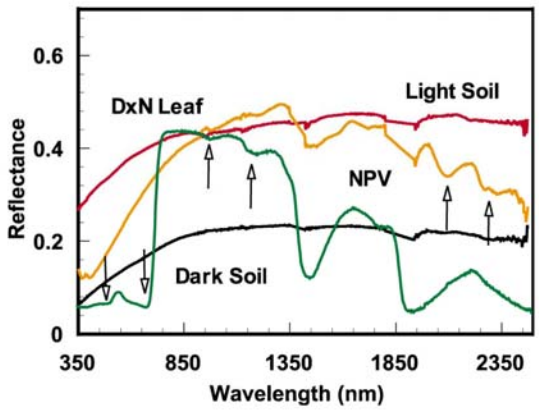


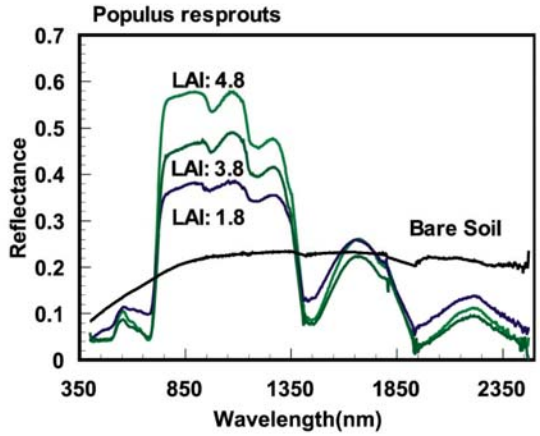
(A) Color of the sea surface as a function of surface biomass concentration (Chl *a* used as a proxy) for different phytoplankton taxa. Color was modeled from water-leaving radiance using the CIE color matching functions and mean absorption and backscattering properties for each taxa. (B) Water-leaving radiance, *Lw*, modeled for dense phytoplankton bloom conditions (30 mg Chl *a* m^{-3}) from a variety of phytoplankton taxa. (Dierssen et al. 2006)

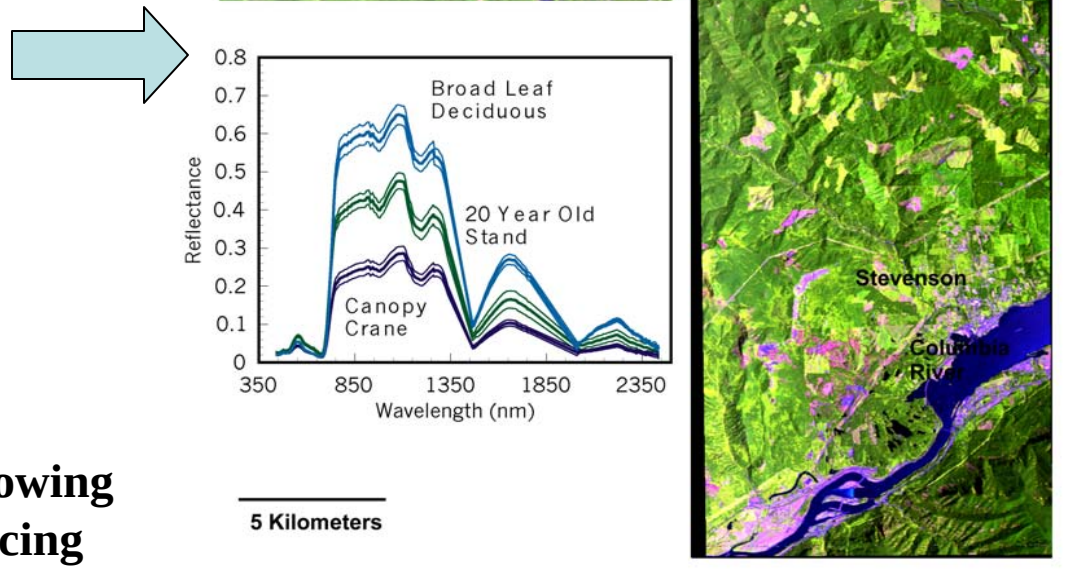
Dierssen et al., 2006

Scaling up to stands

Crown geometry, species composition, plant density and arrangement further modify spectra





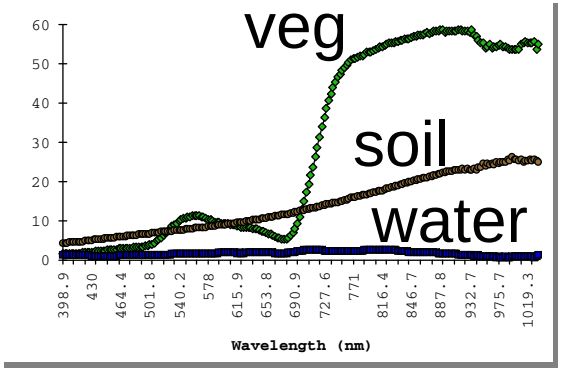


*** Multiple NIR scattering and shadowing modify leaf-scale reflectance, enhancing absorption features.**

***Concepts such as LAI are important descriptors in aquatic and terrestrial environments**

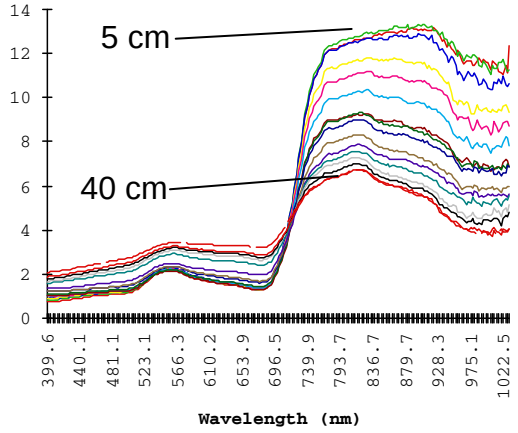
Modified from Davis and Roberts, 1999 & Roberts et al., 2004

Coastal Marsh Remote Sensing

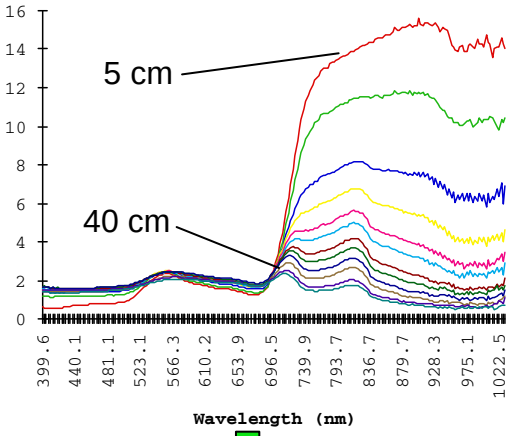


Spectra for top-of-canopy reflectance for two marsh grass subspecies with distinctly different structure. Water level is varied from 5 to 40 cm in increments of 5 cm, which affects the spectrum

Spartina cynosuroides



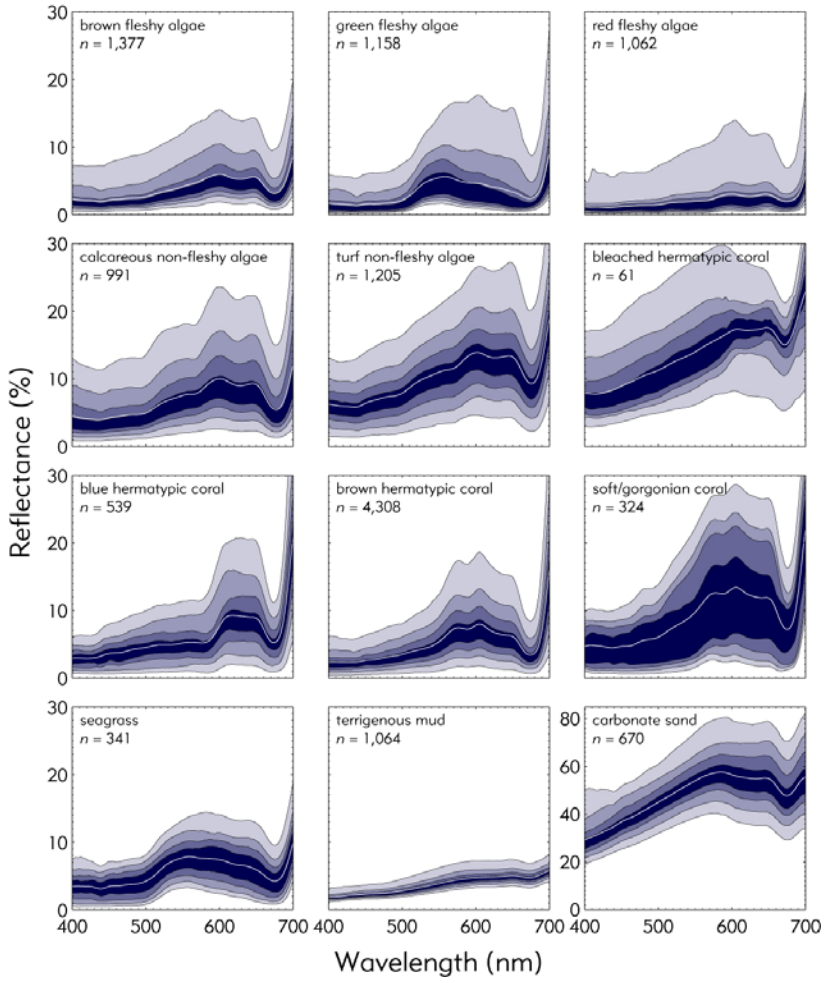
Spartina patens



Remote sensing of emergent aquatic graminoids depends on light interactions between the vegetation, water and soil. Radiative transfer can be used to determine species type, structure, and water level. Mapping these parameters provides information about ecosystem response to changing stressors.

(Kearney, Stutzer, and Turpie, in press)

Spectroscopy of corals and algae

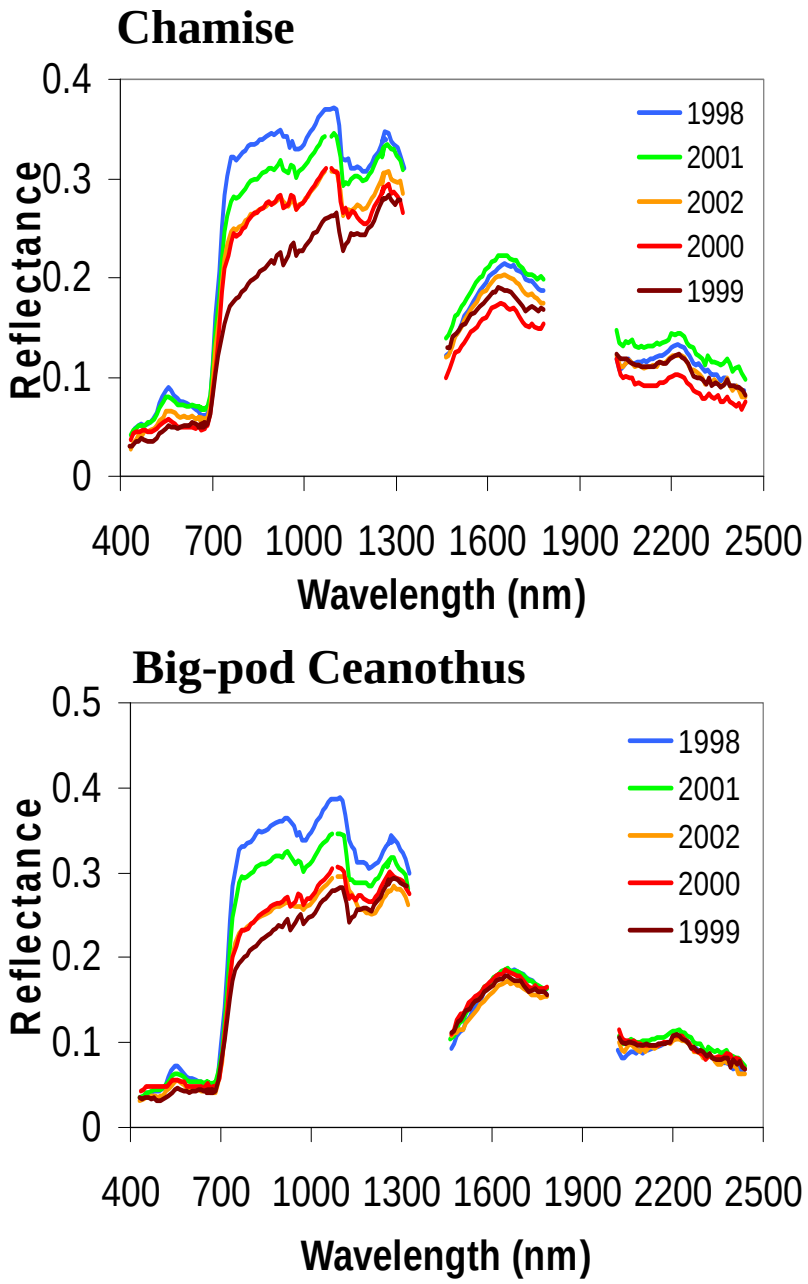


- Rough
- High productivity/calcification
- "Healthy"

- Smooth
- Low productivity/calcification
- Not "healthy"

Pigments and "architecture" discriminate types of algae and coral and provides a measure of coral health

Hochberg et al. 2003

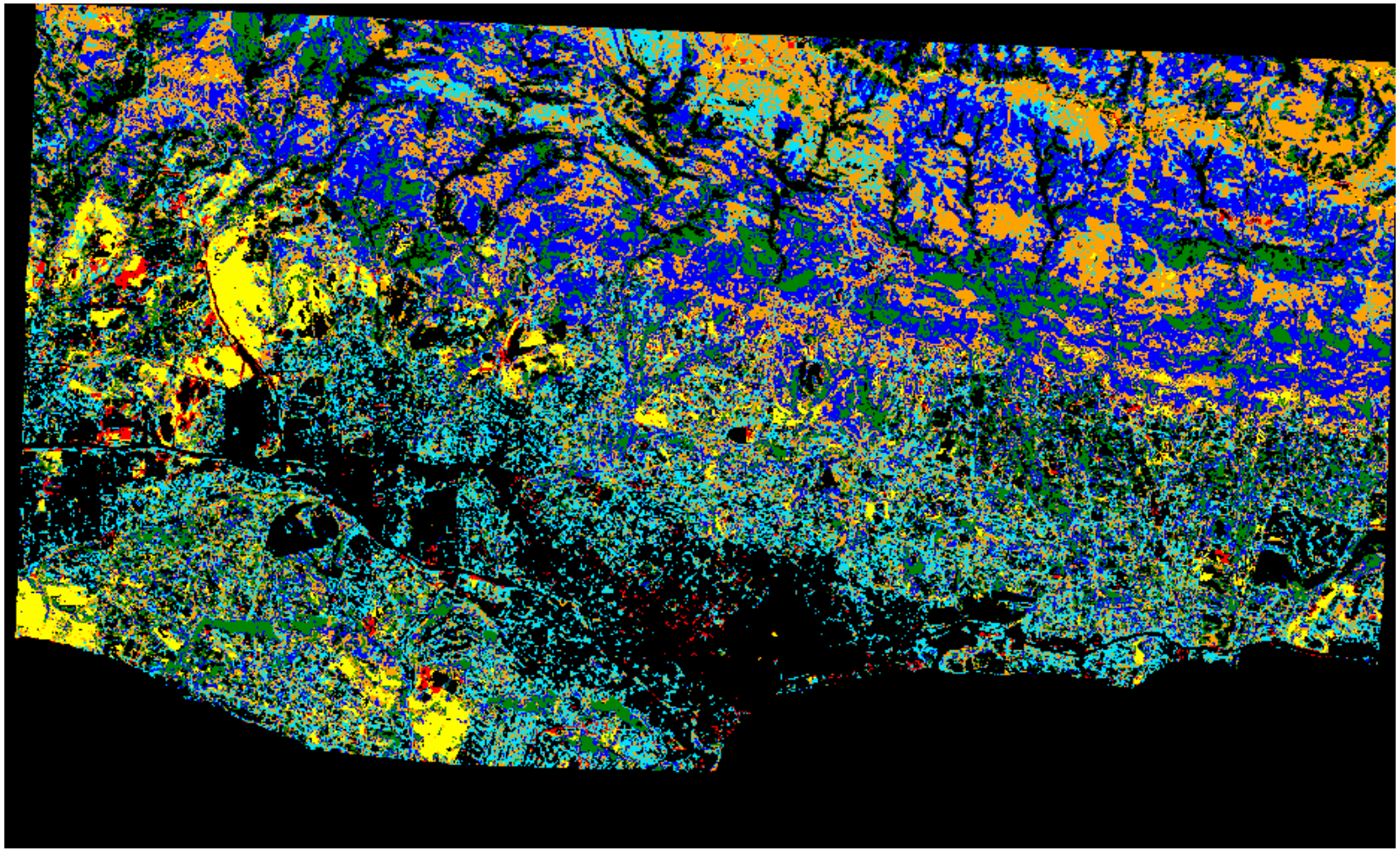


The Temporal Domain

- **PFT and species vary in their seasonal responses to environmental cues**
- **Seasonal variation is likely to critical for discriminating species and PFT**
- **Seasonal variation is a critical response variable to environmental change**
- **In aquatic systems, temporal dynamics are even more pronounced**

From Dennison and Roberts, 2003b, *Remote Sens. Environ.*

Vegetation Mapping
Santa Ynez Front Range



Adenostoma fasciculatum
Ceanothus megacarpus
Arctostaphylos spp.
Quercus agrifolia
Grass
Soil

Accuracy: 89%

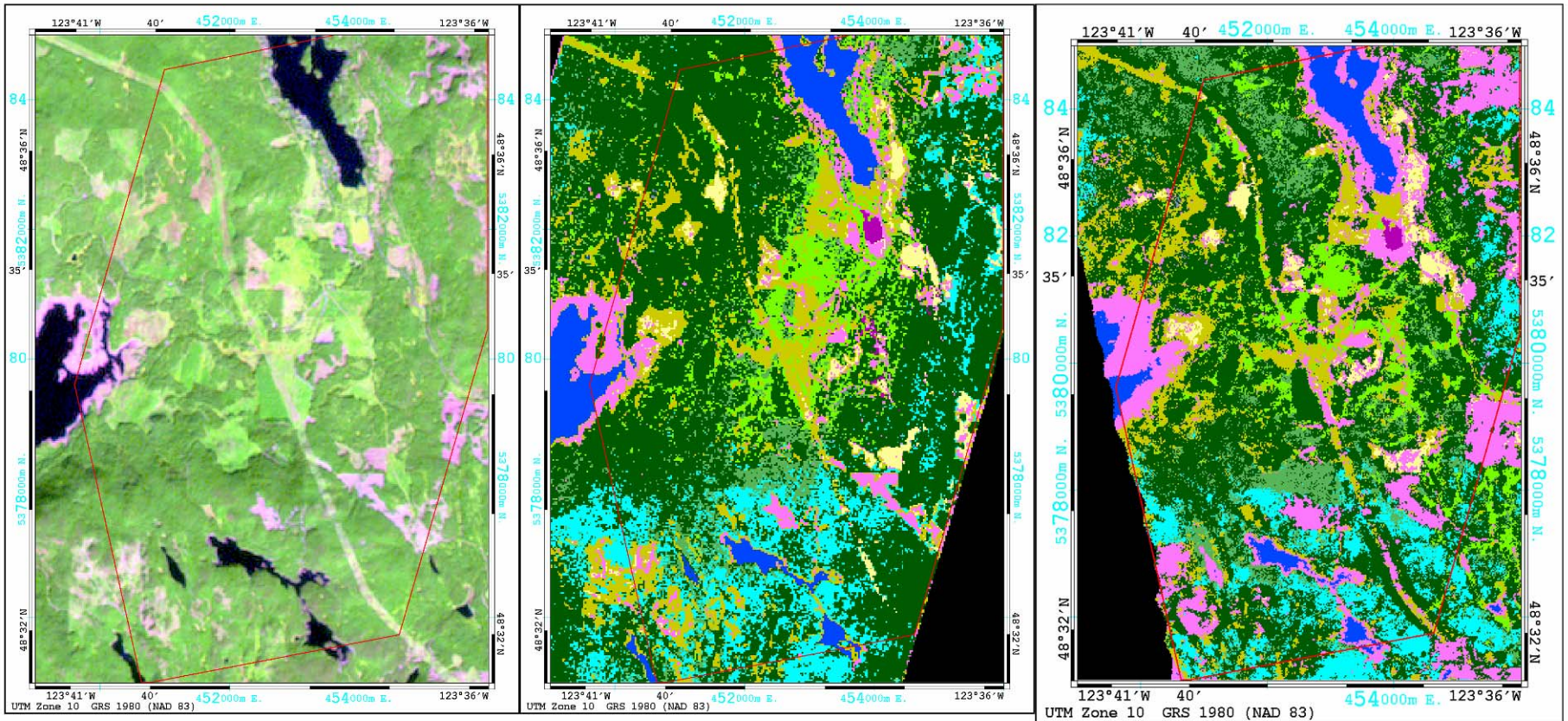
Dennison and Roberts, 2003a

PFT from Imaging Spectroscopy (Goodenough et al., 2003)

Landsat 7 (75%)

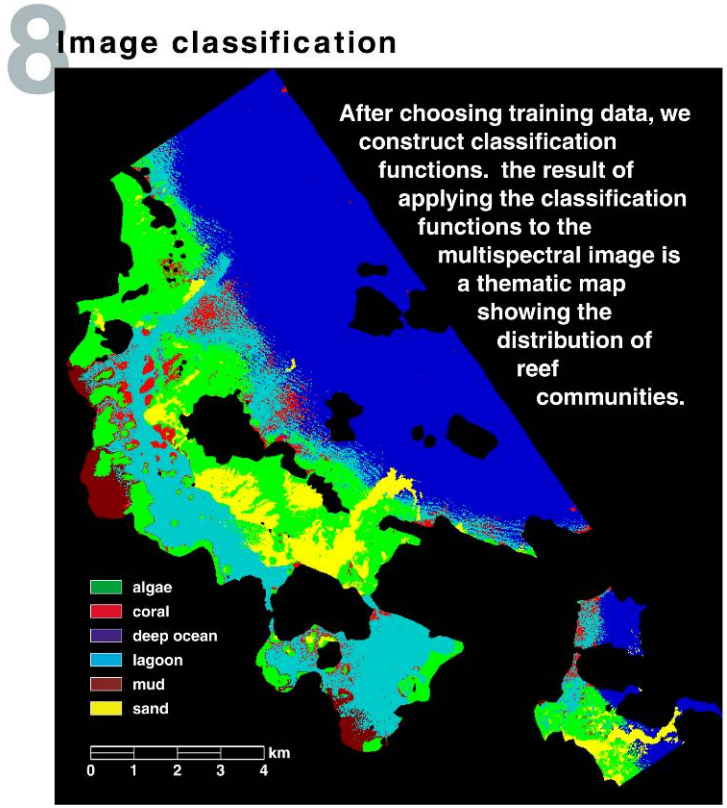
Hyperion (90%)

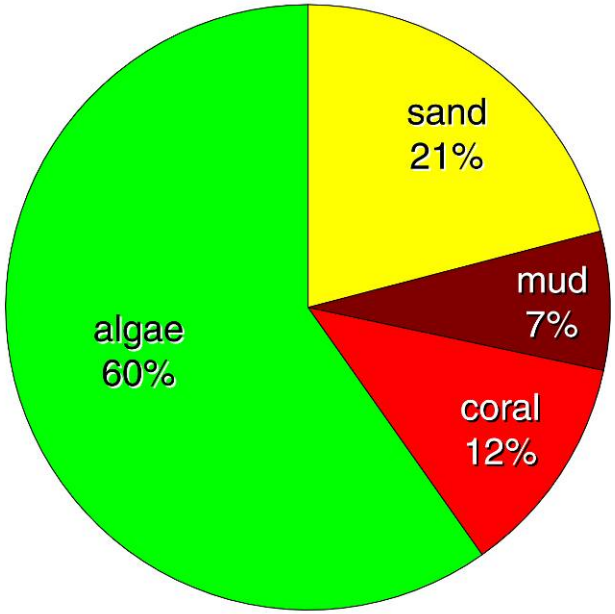
AVIRIS (92%)



British Columbia, Canada

CRESPO analysis of AVIRIS data



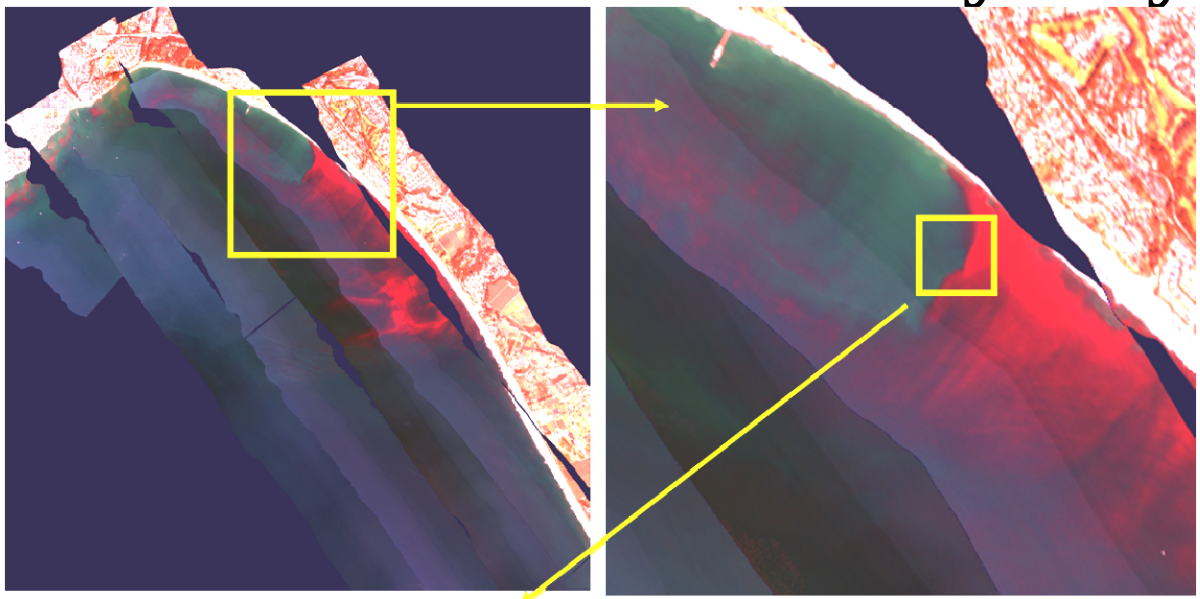


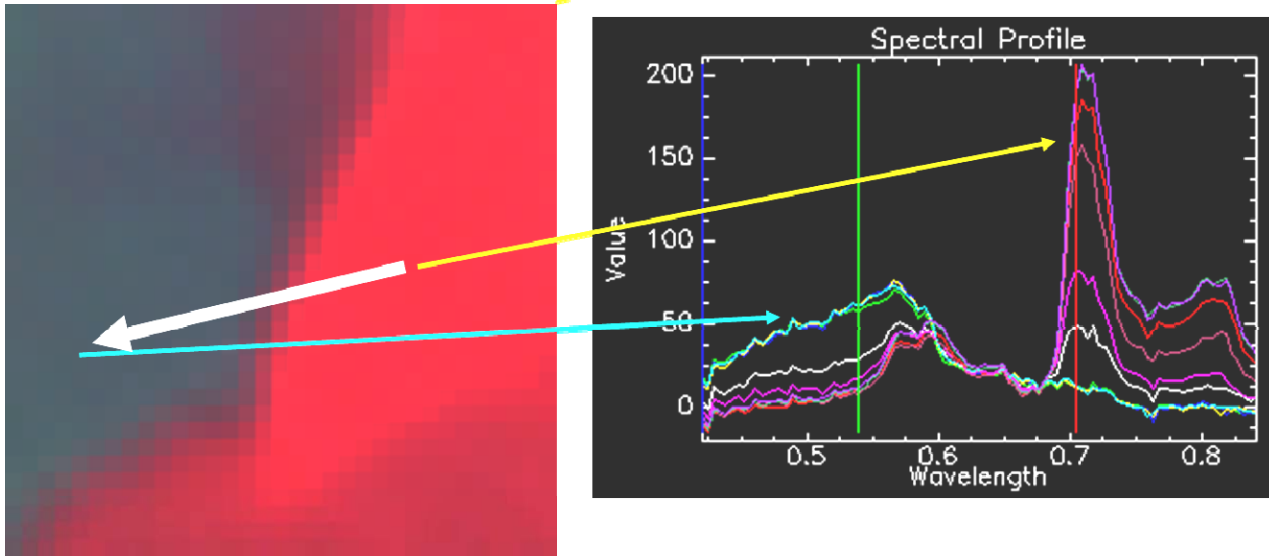
End product for CRESPO image processing:

PERCENT COVER OF REEF COMMUNITIES

Spectroscopic differences are used to map percent cover of important reef communities from a selection of bands. From Eric Hochberg

Mapping Harmful Algal Blooms in Monterrey Bay





Harmful Algal Bloom in Monterey Bay threatens beach areas.

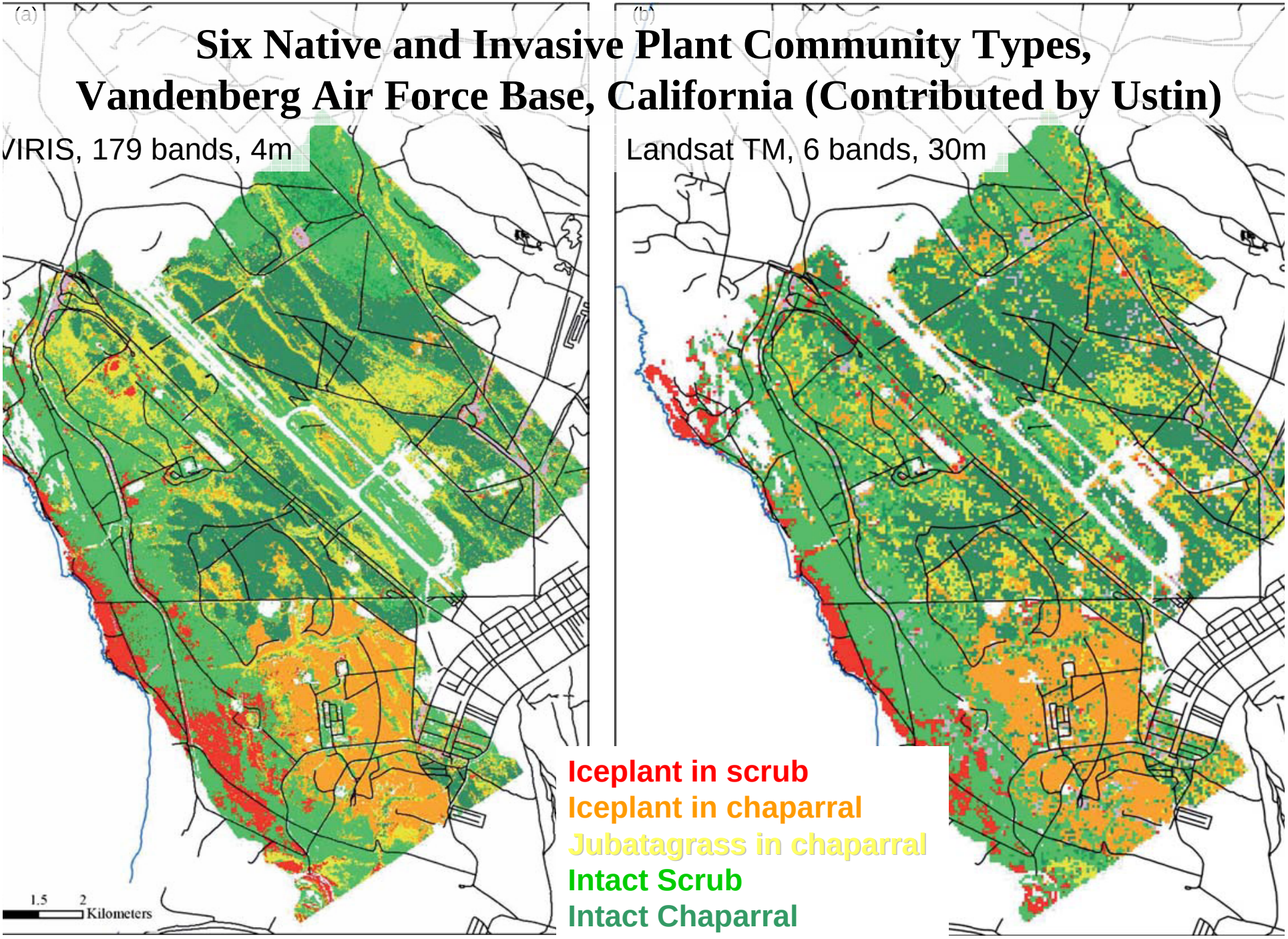
- Bloom near coast and on the order of 2 x 5 km would not be resolved in 1 km VIIRS data.

- Additional channel at 709 nm to aid bloom identification.

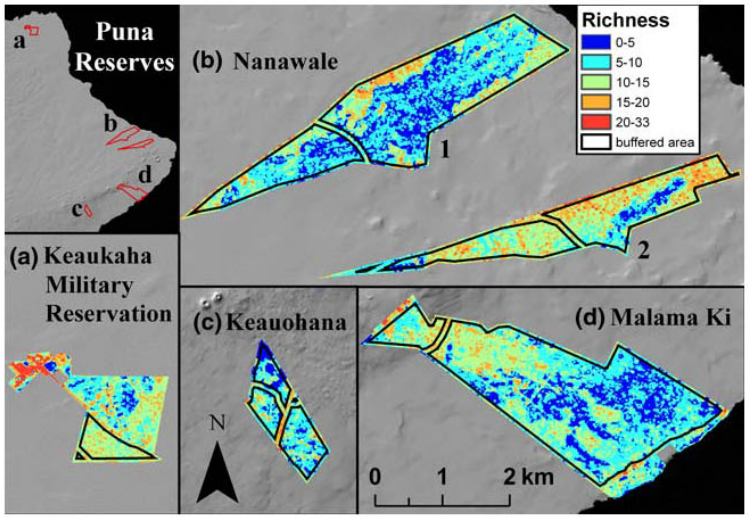
PHILLS-2 airborne hyperspectral data from Paul Bissett, Florida Environmental Research Institute. (October 2002 *Ceratium spp. bloom*)

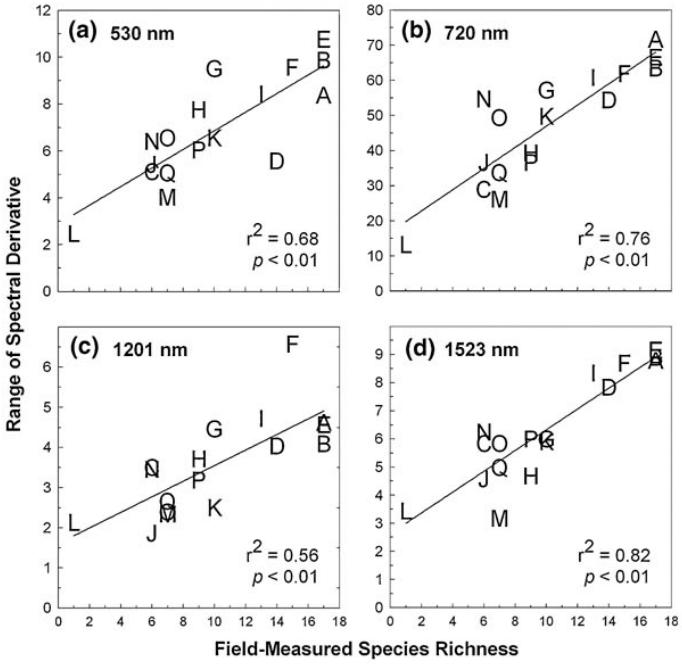
From Paul Bissett

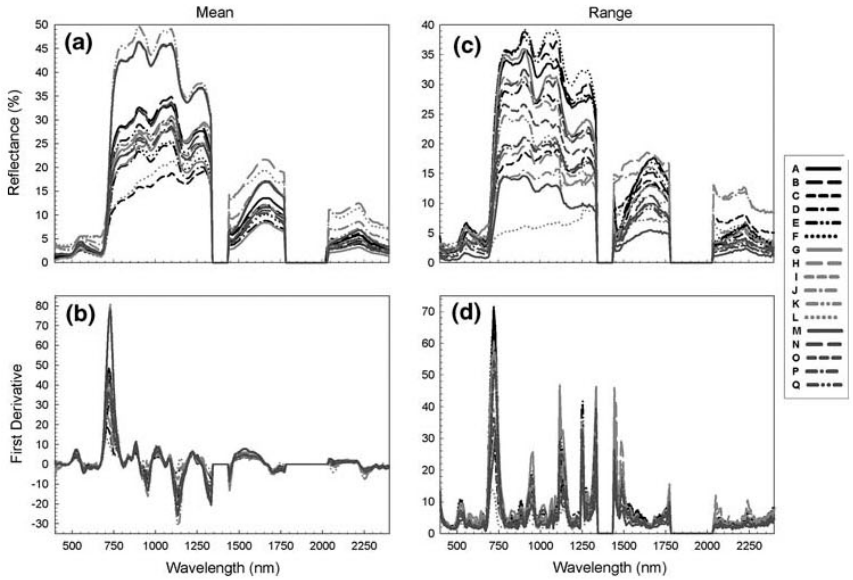
Six Native and Invasive Plant Community Types, Vandenberg Air Force Base, California (Contributed by Ustin)



Spectroscopic Measures of Species Richness







***Biochemistry and canopy structure impact spectra**
***Biochemical and structural diversity rise with species diversity in forests**
***Biochemical and structural diversity are expressed by spectral diversity**

Carlson et al., 2007

Summary

- **The Decadal Survey calls for critical improvements in our ability to determine the distribution of terrestrial and aquatic ecosystems and the organisms within them, and for monitoring their responses to change**
- **The Decadal Survey also calls for improved monitoring tools for mapping functional groups and species, and mapping invasive species**
- **There is a direct link between organism biochemistry, architectural arrangement and spectral reflectance. This link provides the leverage for improved discrimination and direct assessment of biodiversity**
- **HyspIRI provides the spectral and temporal requirements for meeting these requirements at sufficiently fine spatial resolution**