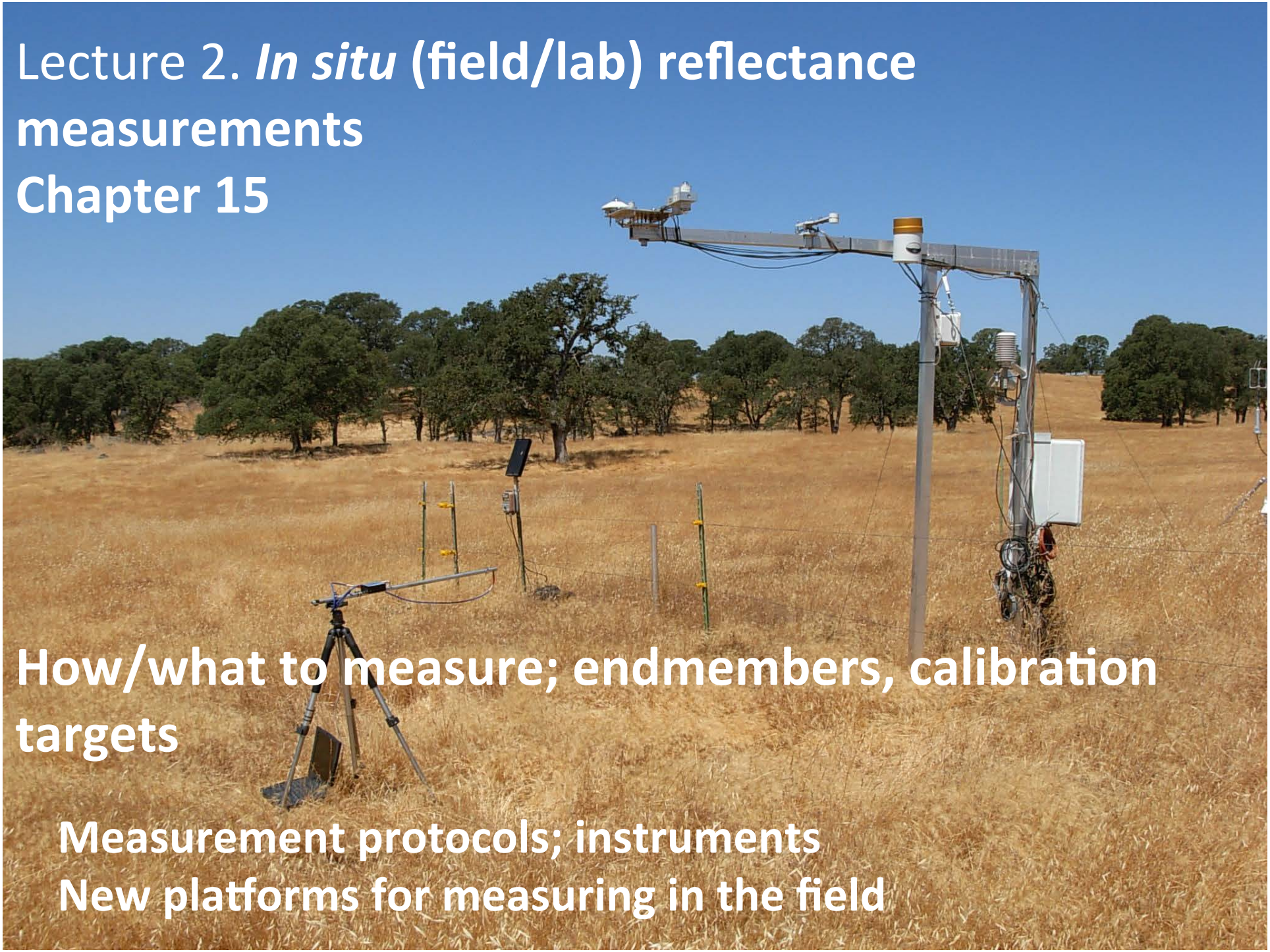
Lecture 2. *In situ* (field/lab) reflectance measurements
Chapter 15



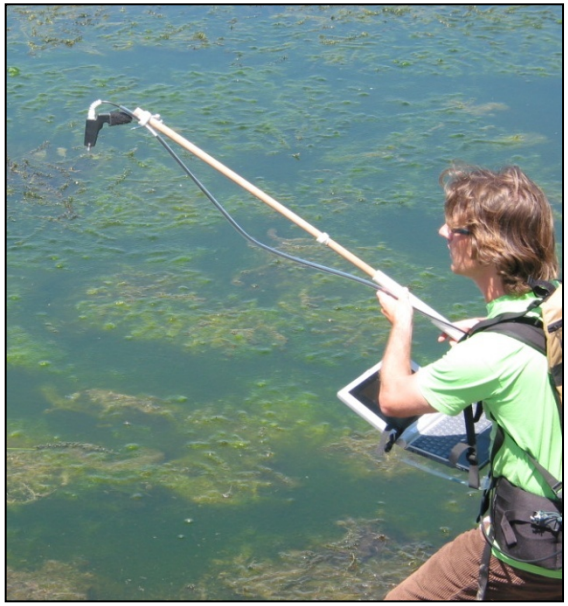
How/what to measure; endmembers, calibration targets

Measurement protocols; instruments

New platforms for measuring in the field

Field Spectrometry

- Quantitative measurement of reflectance in the field.
- permits more precise image analysis and interpretation
- perform feasibility studies to understand how/if materials can be detected using remote sensing
- make material identifications in the field that can be used as reference material



Field Data Collection is used to:

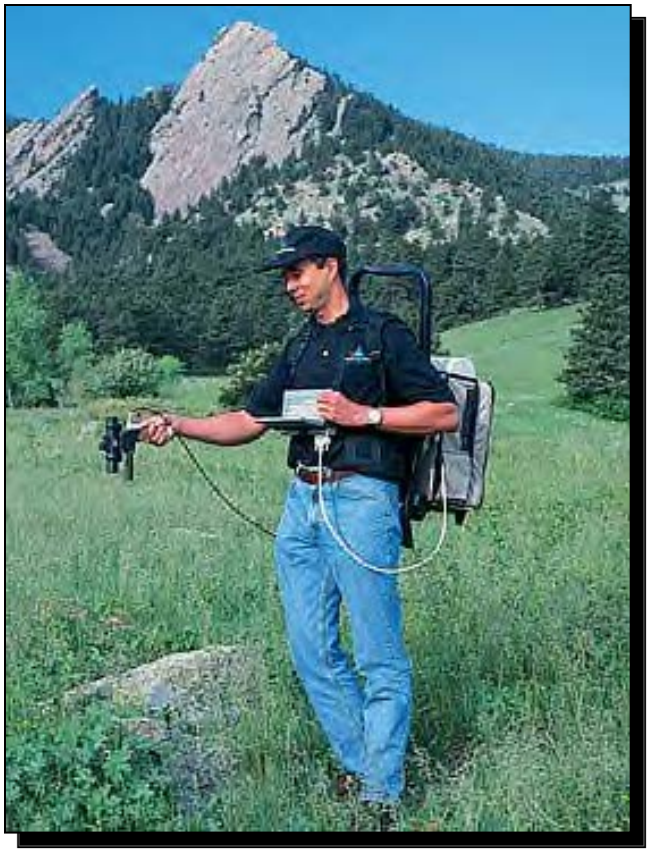
1) Corrected geometrically (x,y,z) and radiometrically (e.g., corrected to % reflectance)

Calibration allows comparison of remotely sensed data from different dates.

2) Develop spectral library (e.g., spectra of dominant materials in image to be used for training and validation of analyses)

3) Drive models (e.g., calibrated to field measured leaf-area-index, biomass), measures of cultural characteristics (e.g., land use/cover, population density).

In situ Measurement in Support of airborne or satellite data



Starting a Research Application: Reconnoiter the area; sketch major features and plan measurement locations so that a statistically significant data set can be acquired in the time allotted

GPS locations of major features

Preflight Preparation Fieldwork

Locate Objects Visible in Images and GPS them:

- Buildings
- Intersections
- Structures

Identify geolocation and calibration targets

Large areas

Homogeneous

Dark and light invariant targets

Located throughout study area

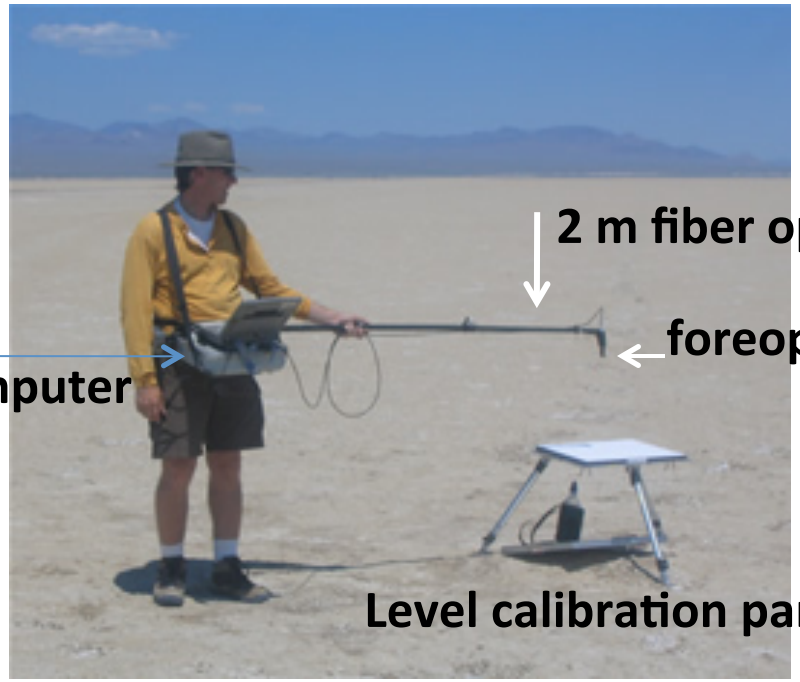
Calibration Targets are Used to Assess Retrieval of Instrument and Atmospheric Reflectance

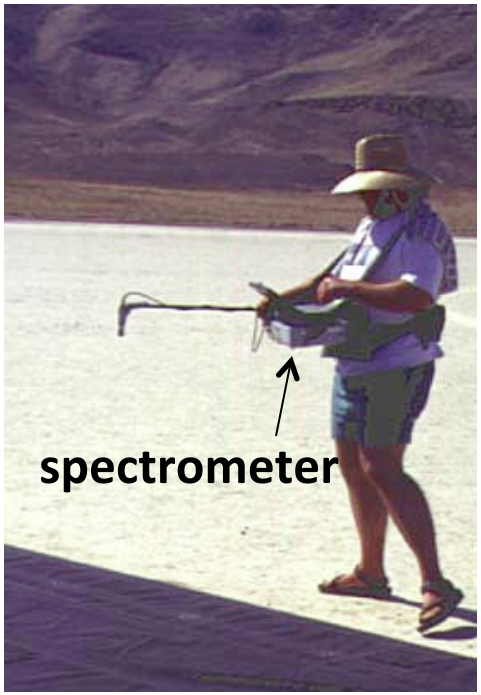
Preflight & Vicarious Calibration of Invariant targets

Spectral measurements must be calibrated against a "white" (~100% reference standard) to validate reflectance retrieval. A Spectralon™ panel is used to calibrate images to reflectance

Transects are measured across a parking lot for reflectance of "invariant targets" which are used for 2nd stage calibration improvement

Field Measurements with ASD Spectrometer

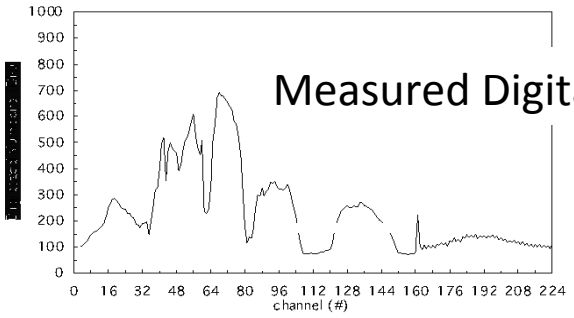




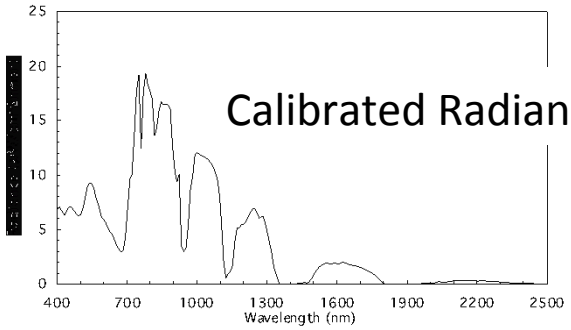
You will have a chance to use one of these in lab today.

Technical Approach to Calibrating Images

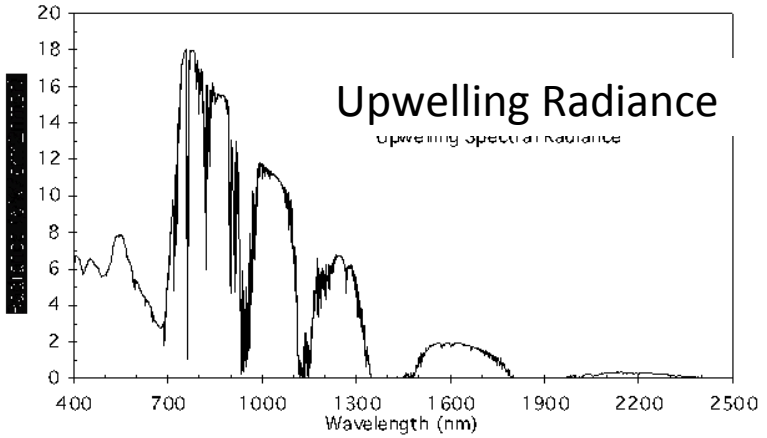
Measured Uncalibrated Data (DN)



Instrument Calibration to Radiance
(removes instrument noise)



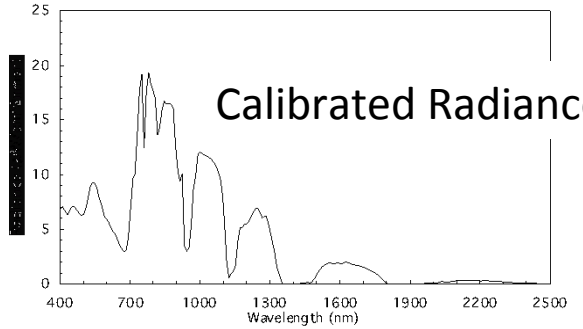
Actual Top of Atmosphere Radiance



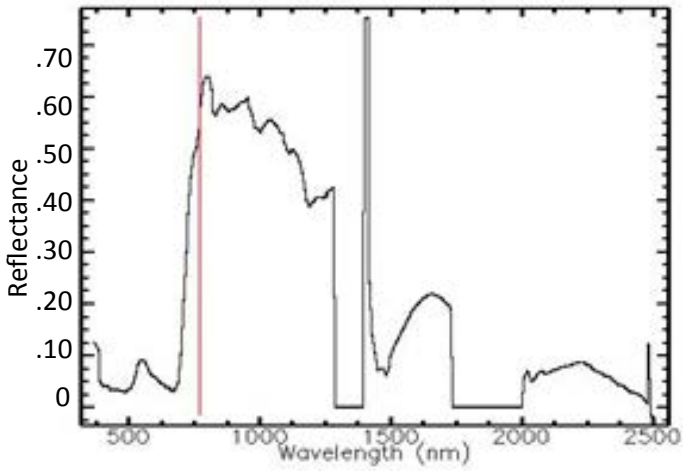
Result is agreement (although “smoothed”) between measured and best understood upwelling radiance.

Technical Approach to Calibrating Images

What is Actually Measured by Remote Sensing Instruments



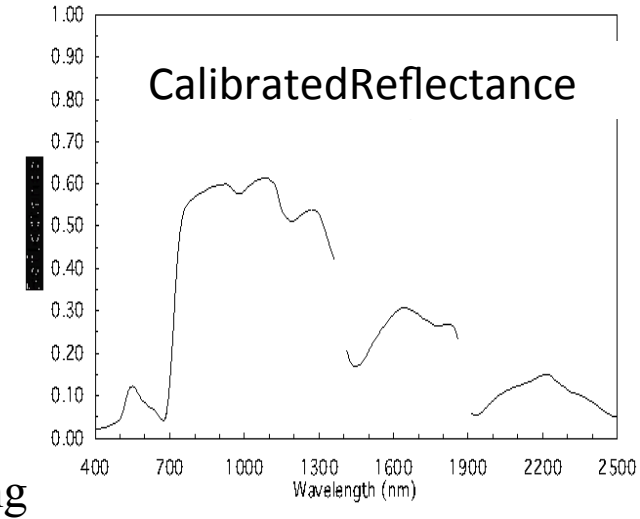
Atmospheric calibration to account for absorbances and scattering is done with a radiative transfer model



Reflectance calibrated spectrum (general shape correct but still has some noise in spectrum

2^{nd} stage calibration with field data

Noise Reduction Using Field Spectra



Spectrum derived from field data

Materials used to Calibrate % Reflectance

1. Barium sulfate ($BaSO_4$)is white in visible spectrum but has features in near infrared (NIR)
2. Pressed Polytetrafluoroethylene (PTFE) Powder, a powdered teflon material called “Halon”
3. Spectralon™ Labsphere, Inc. pressed polymer material like spun glass

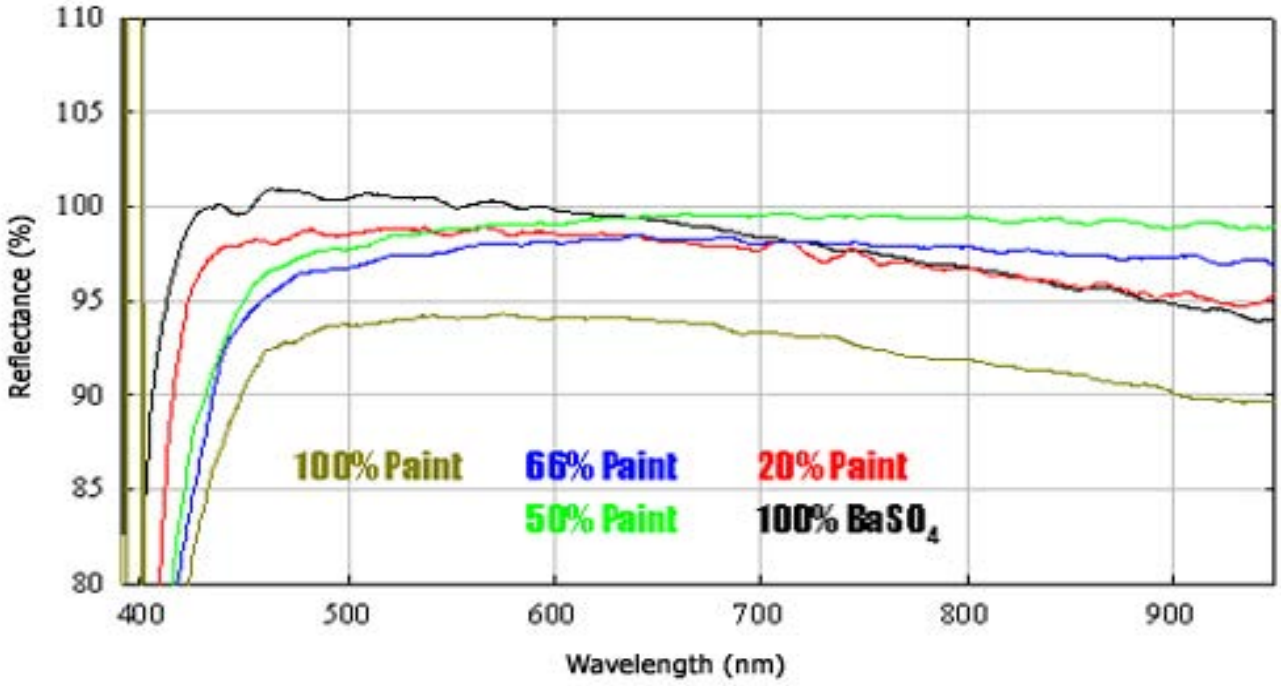
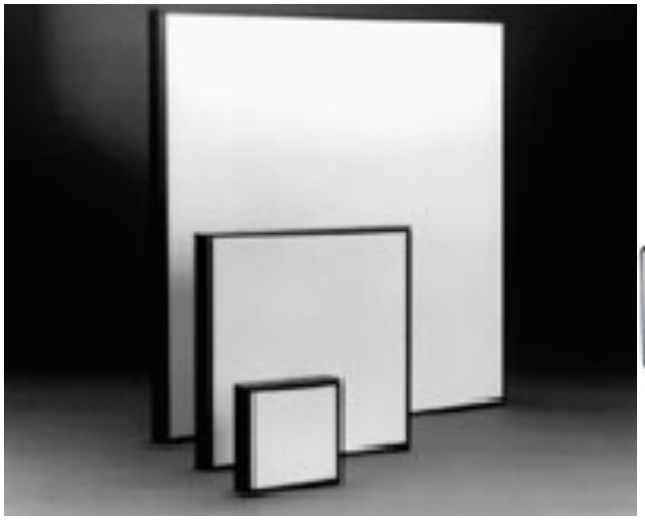


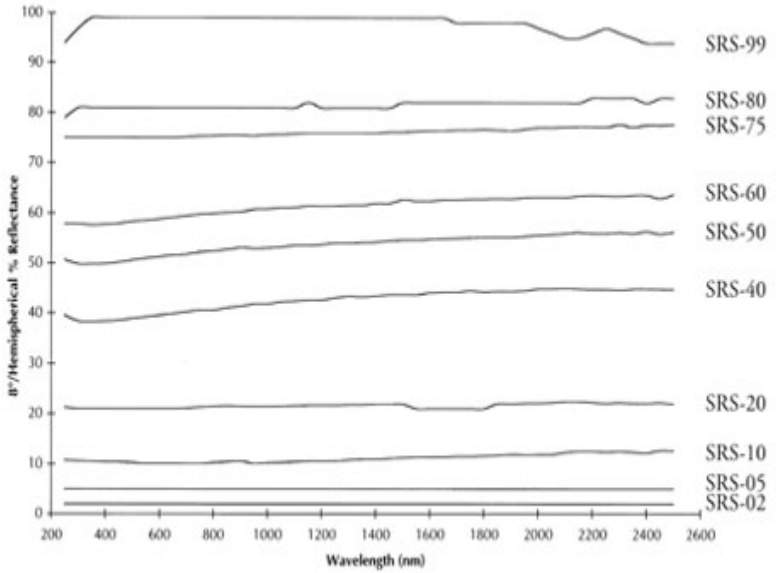
FIGURE 1 Reflectance of pure paint and pure barium sulfate mixed with water. Spectralon® was set as 100%.

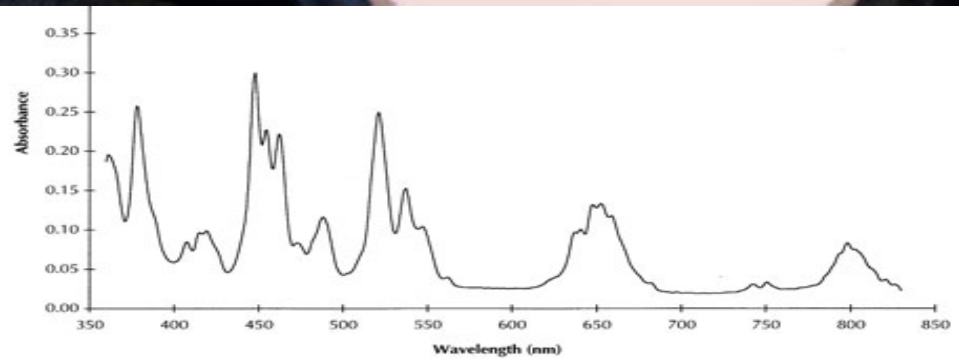
Spectralon: Approved NIST Standard



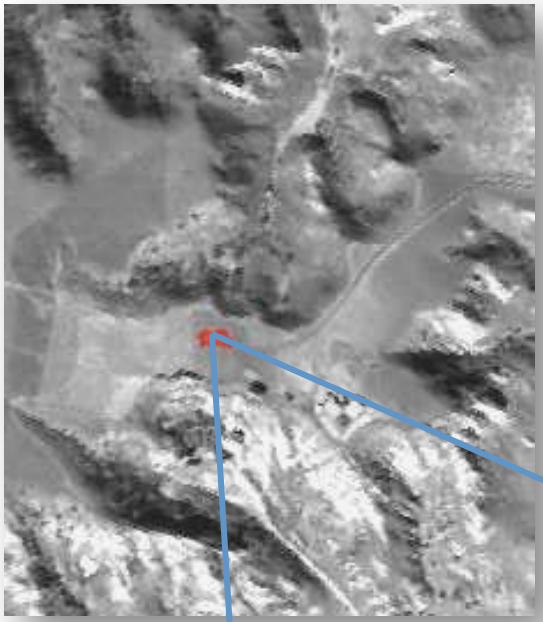
Gray panels of known reflectance

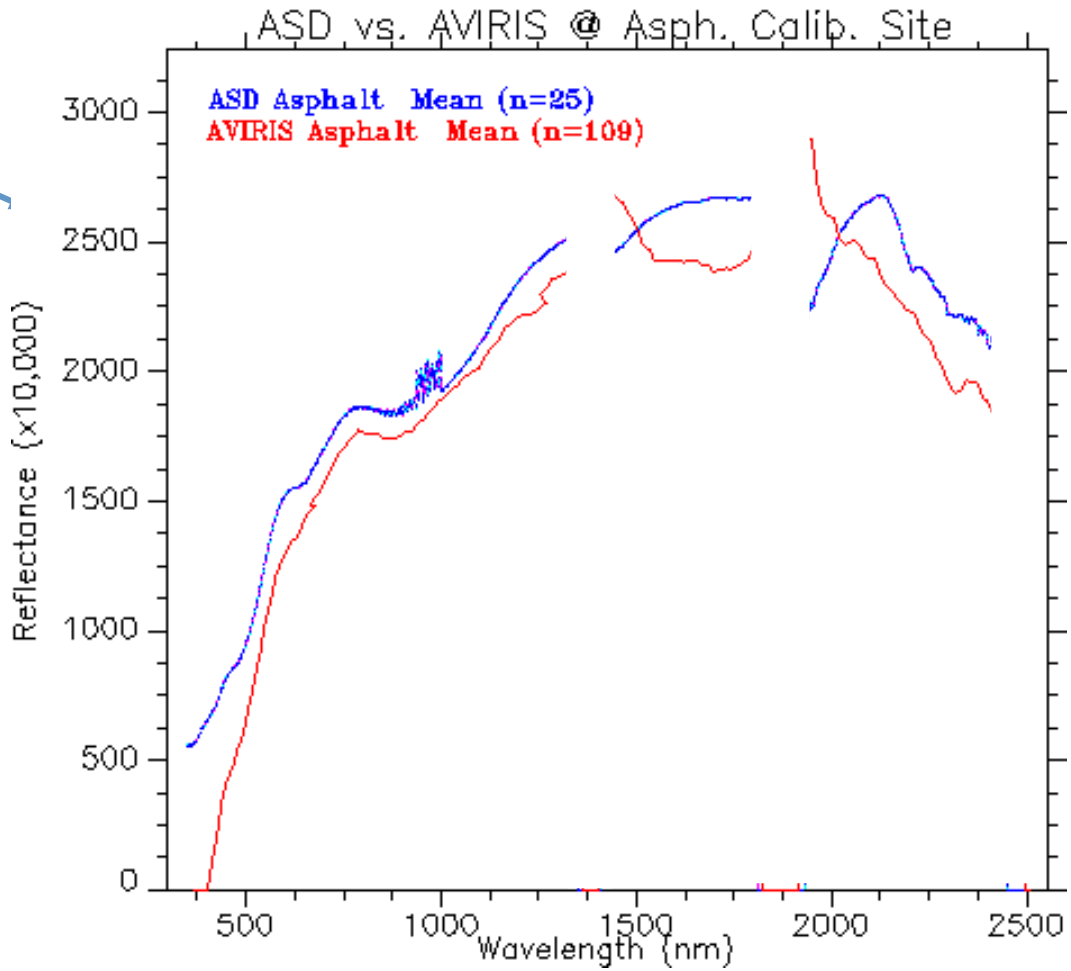
Rare Earths used to Calibrate Wavelength
Holmium Oxide for UV-VIS-NIR
Dysprosium Oxide for NIR
Erbium Oxide - for VIS-NIR





Comparison of ASD & Low Altitude AVIRIS Spectra at an Asphalt Calibration Site





TRNP Leafy Spurge Project
CSTARS Lab, UC Davis, CA
Prepared by Michael O'Neill, 1999

Vicarious Calibration Measurements for **Hyperion** in the Argentina Andes

- Field spectrometers come in several varieties: visible-near infrared and full range

- Band widths in the visible part of the spectrum are from ~1 or 2.0 nm to 10 to 15 nm in the NIR and SWIR portions of the spectrum

- Quality of electronics, calibration sensitivity, fiber optics quality, robustness of operating software, overall mass and weight as well as battery life are things to consider when using a field spectrometer for your work.

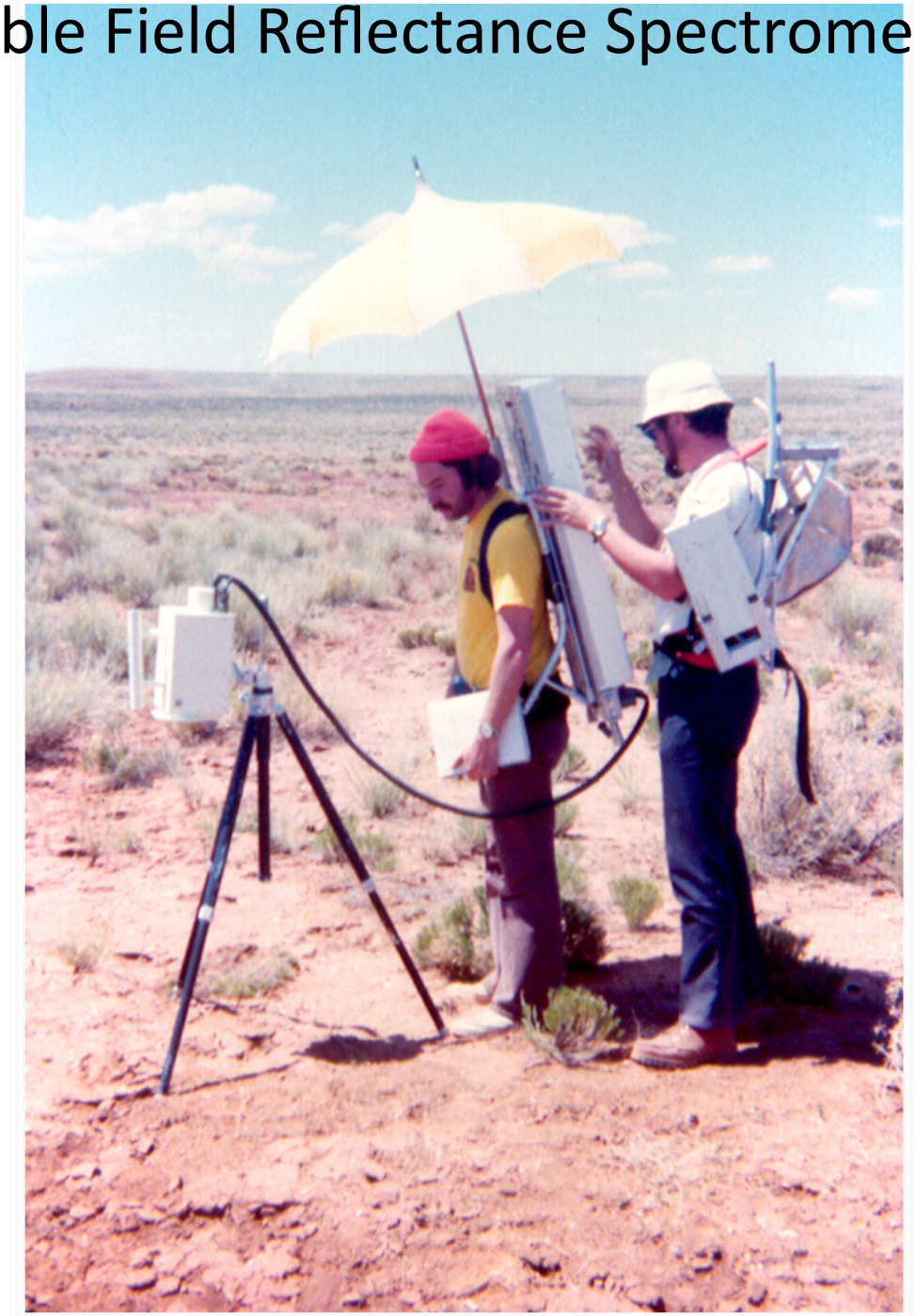
Definitions of terms for spectrometers

Spectrograph: An instrument that separates light into its different wavelengths (or colors).

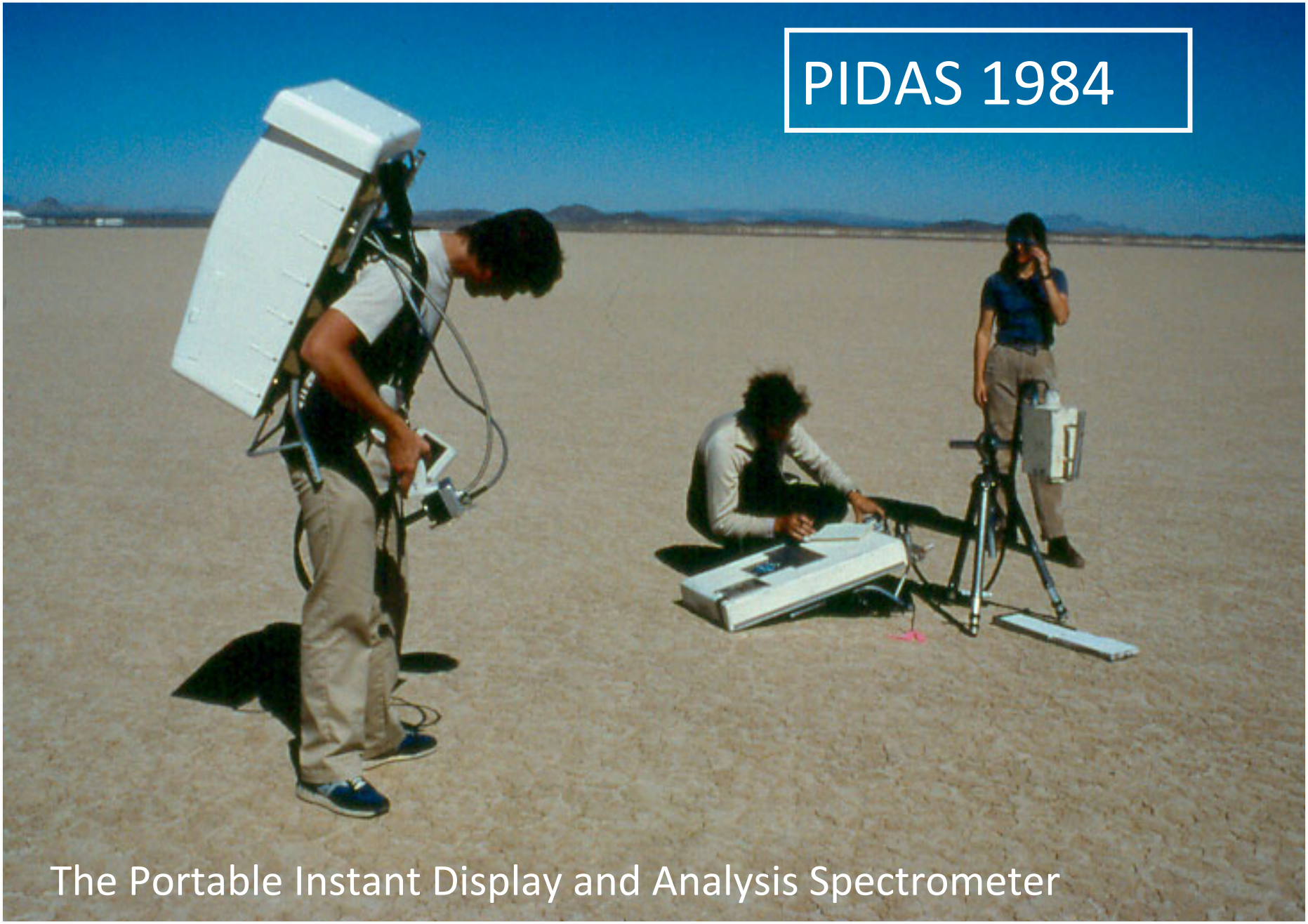
Spectrophotometer: instrument used to measure the intensity of electromagnetic radiation at different wavelengths. Typically have internal light sources.

Spectrometer: An optical instrument for measuring the absorption of light by chemical substances' typically by plotting a graph of absorption vs. wavelength (or frequency) and the patterns identified used determine the identity of substances.

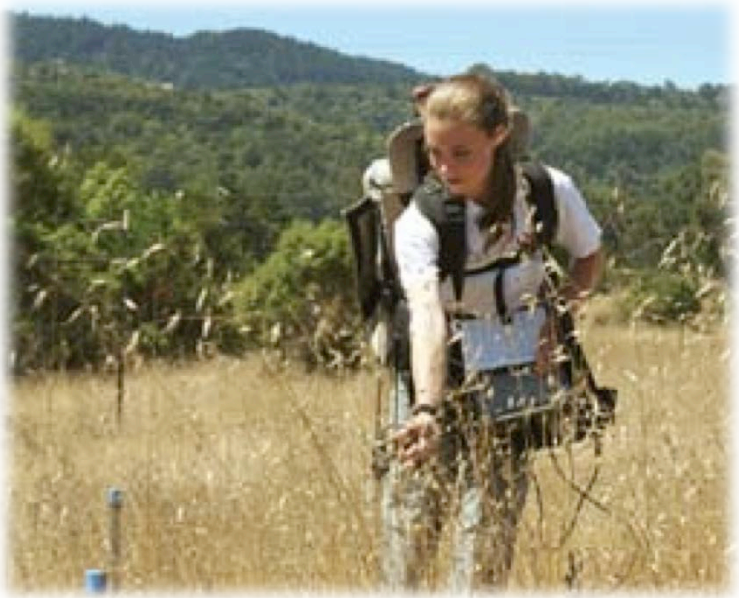
The First Portable Field Reflectance Spectrometer



PFRS 1974

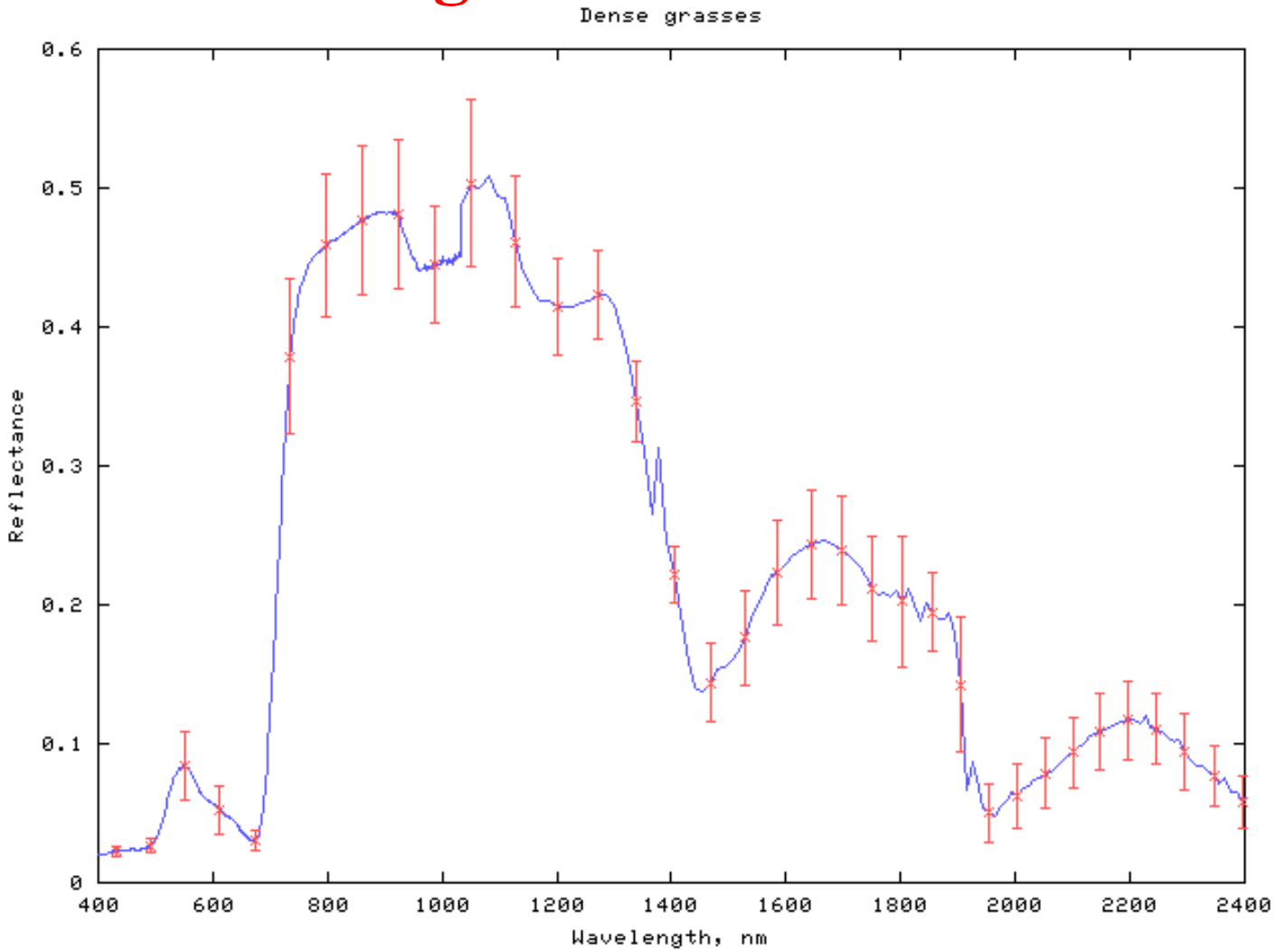

PIDAS 1984
The Portable Instant Display and Analysis Spectrometer

Field Spectroscopy: building a spectral library



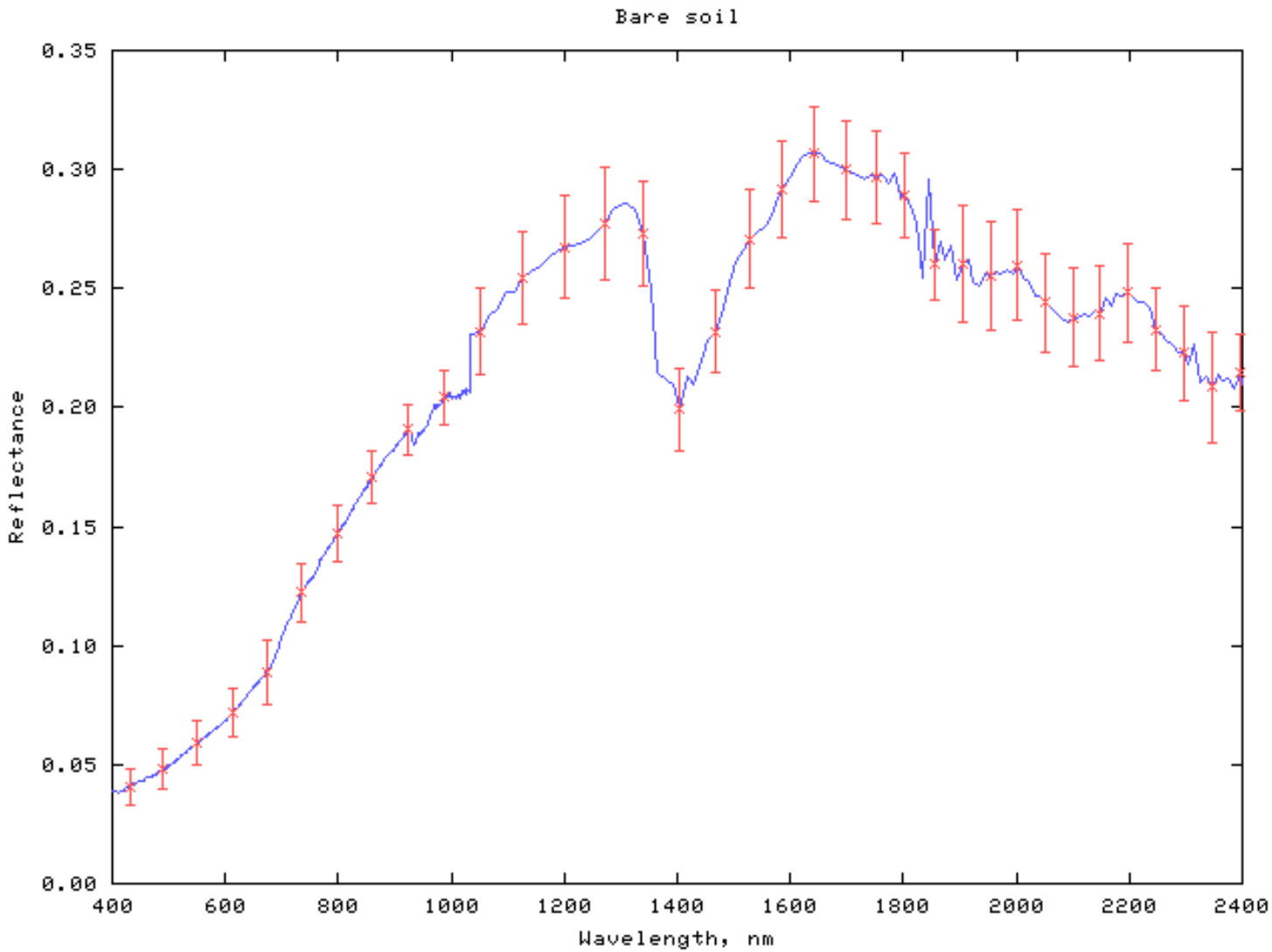
Capture variation within each land cover type, such as “grass”

Collect enough measurements to understand the variability: Mean +/- standard deviation of all dense grass measurements



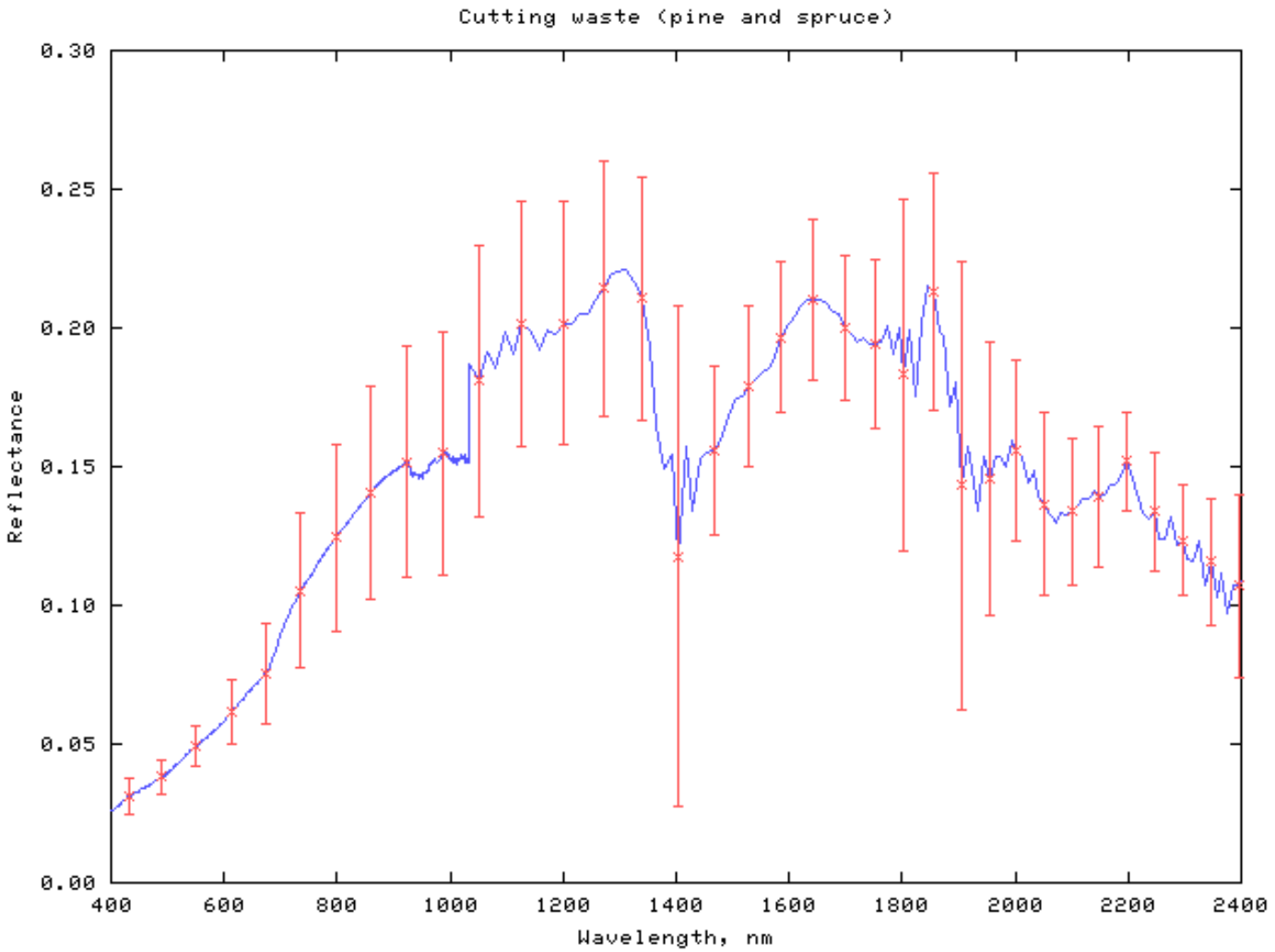
“Bare Soil” may be deceiving; be sure to collect the features you identify. Are these bare soils? What does the shadow tell you about the quality of the spectra?

Bare soil spectra from a boreal forest in Sweden



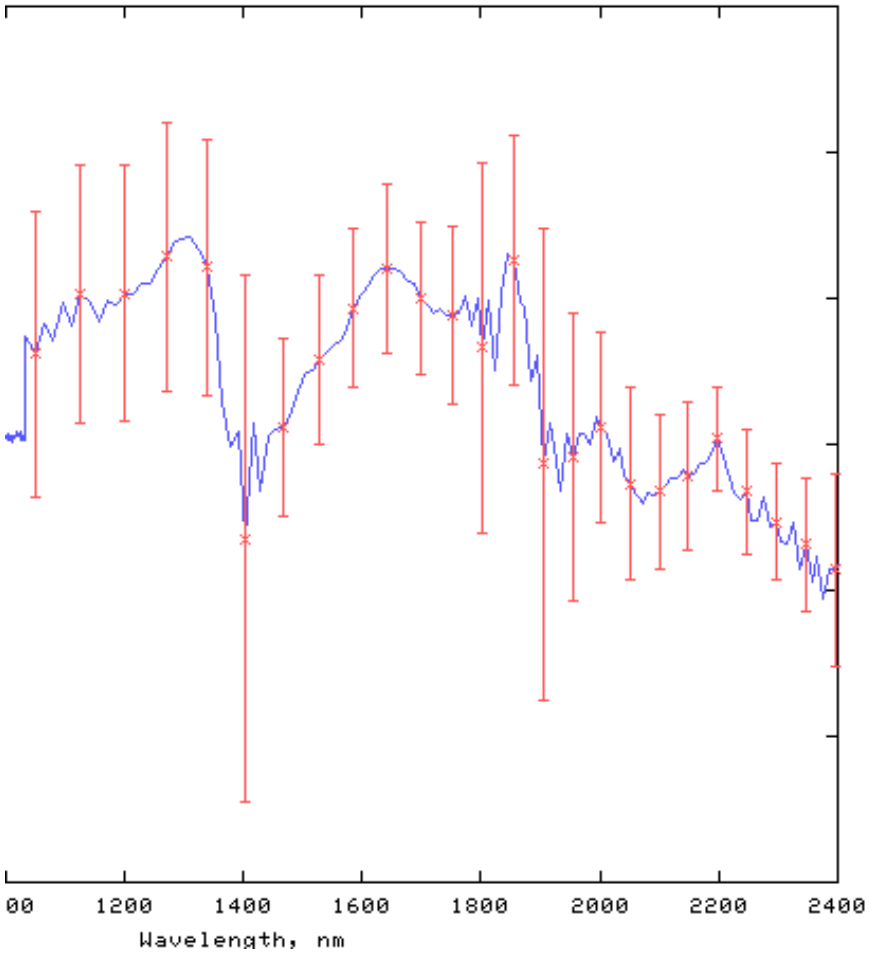
Woody material & dry plant litter is often confused with bare soil. Capture the variability in your samples

Mean +/- standard deviations for woody debris and dry plant litter

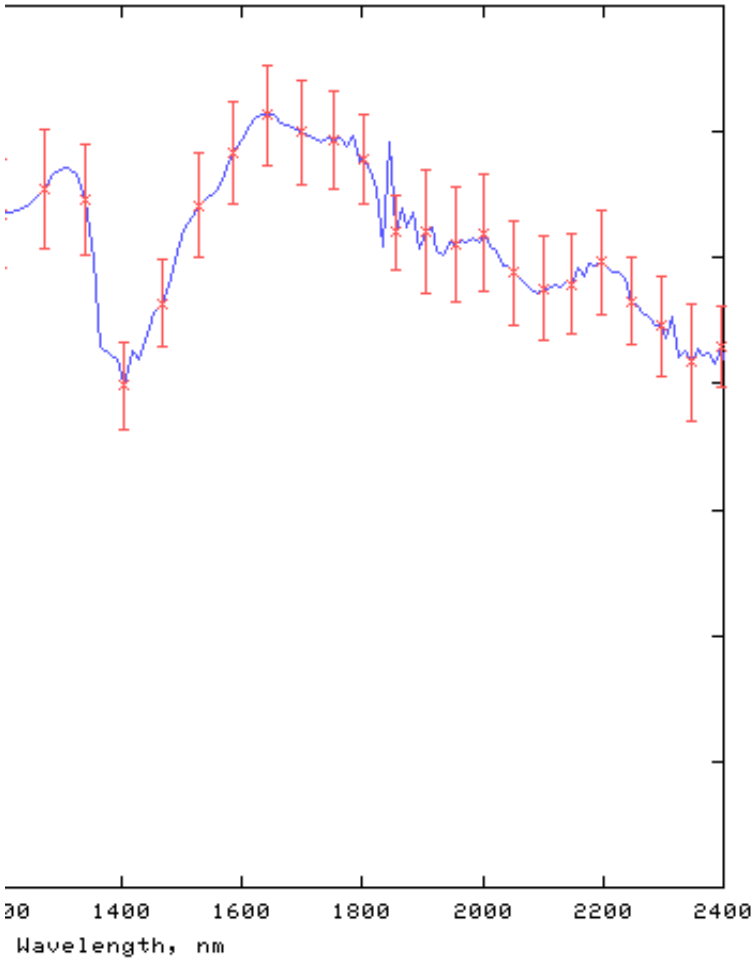


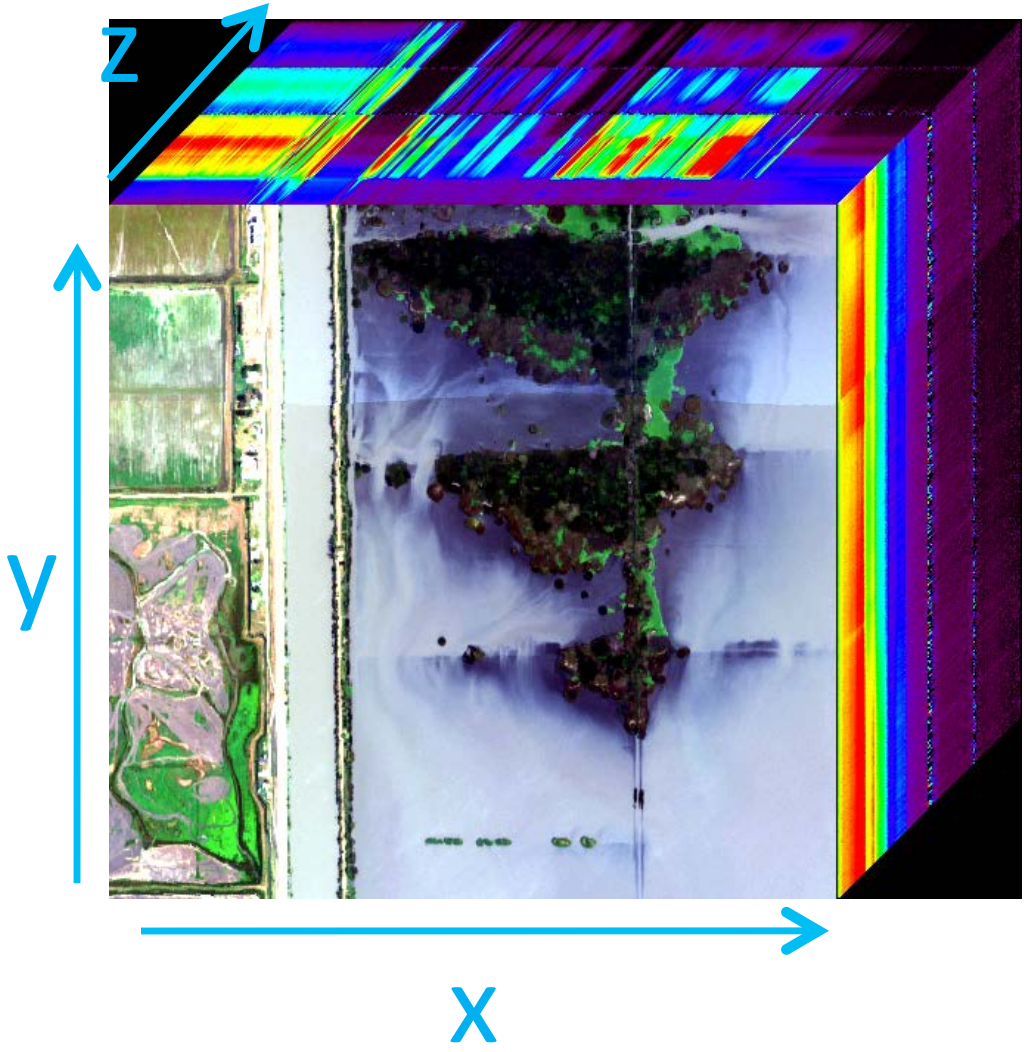
Field spectra can help you classify & understand your image data

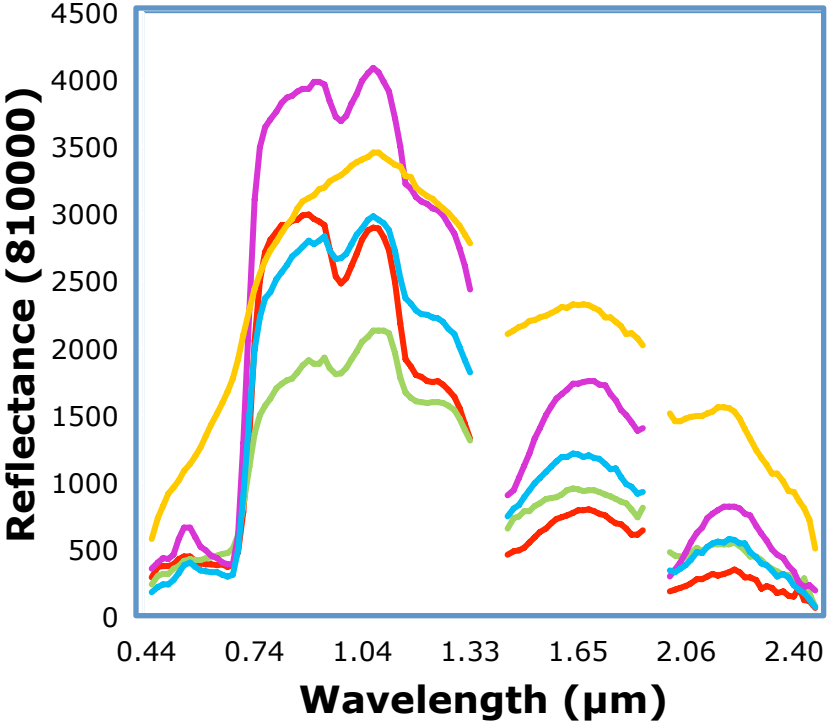
Logging debris cut waste: pine and spruce



Bare soil




z
y
x


Reflectance (810000)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0.44
0.74
1.04
1.33
1.65
2.06
2.40
Wavelength (µm)
cattail
tule
floating
other
senescent veg

Halite ($NaCl$)

Sylvite (KCl)

Bischofite ($MgCl_2 \cdot 6H_2O$)

Borax ($Na_2B_4O_7 \cdot 10H_2O$)

Calcite ($CaCO_3$)

Nathcolite ($NaHCO_3$)

Natron ($Na_2CO_3 \cdot 10H_2O$)

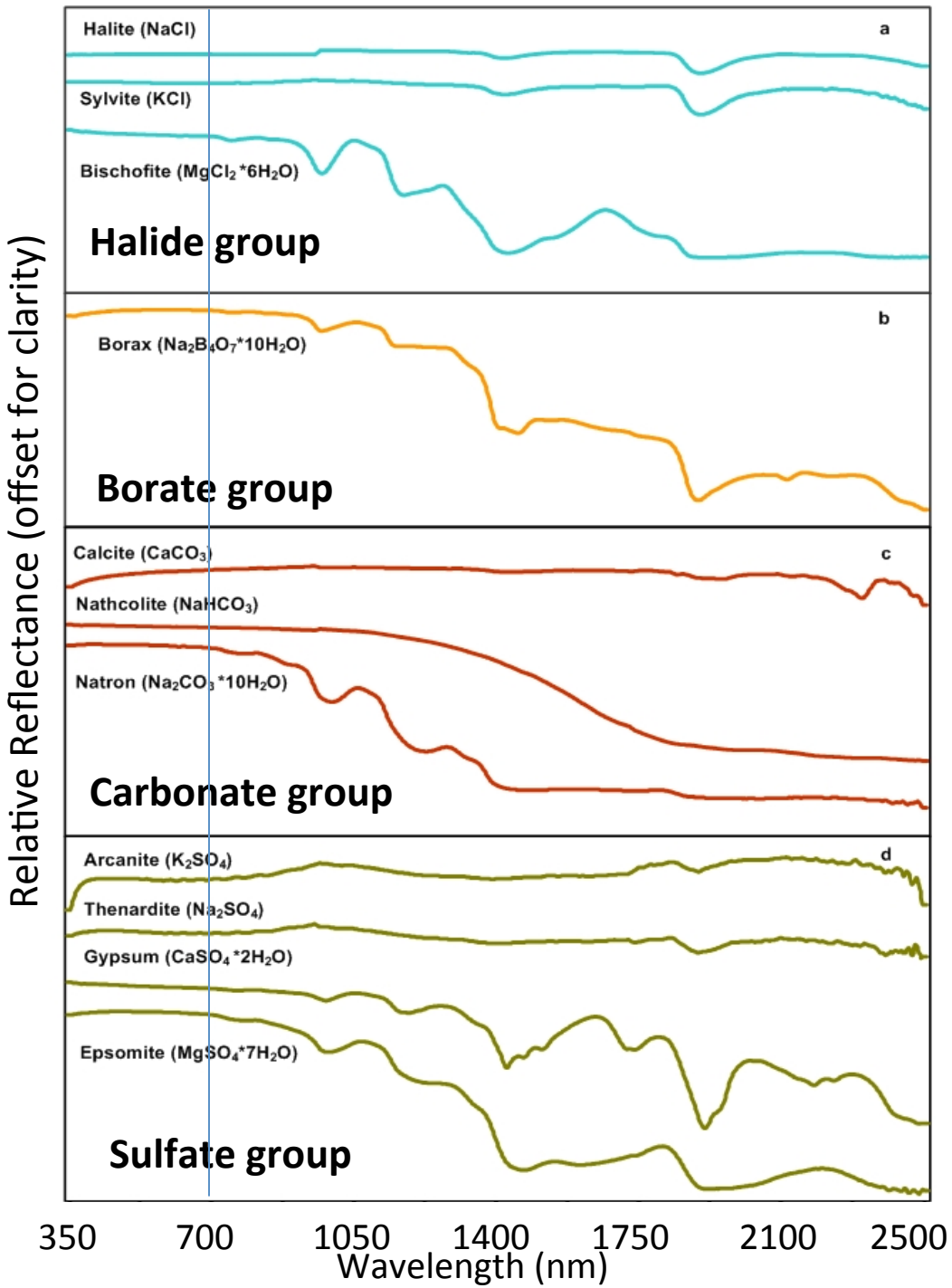
Arcanite (K_2SO_4)

Thenardite (Na_2SO_4)

Gypsum ($CaSO_4 \cdot 2H_2O$)

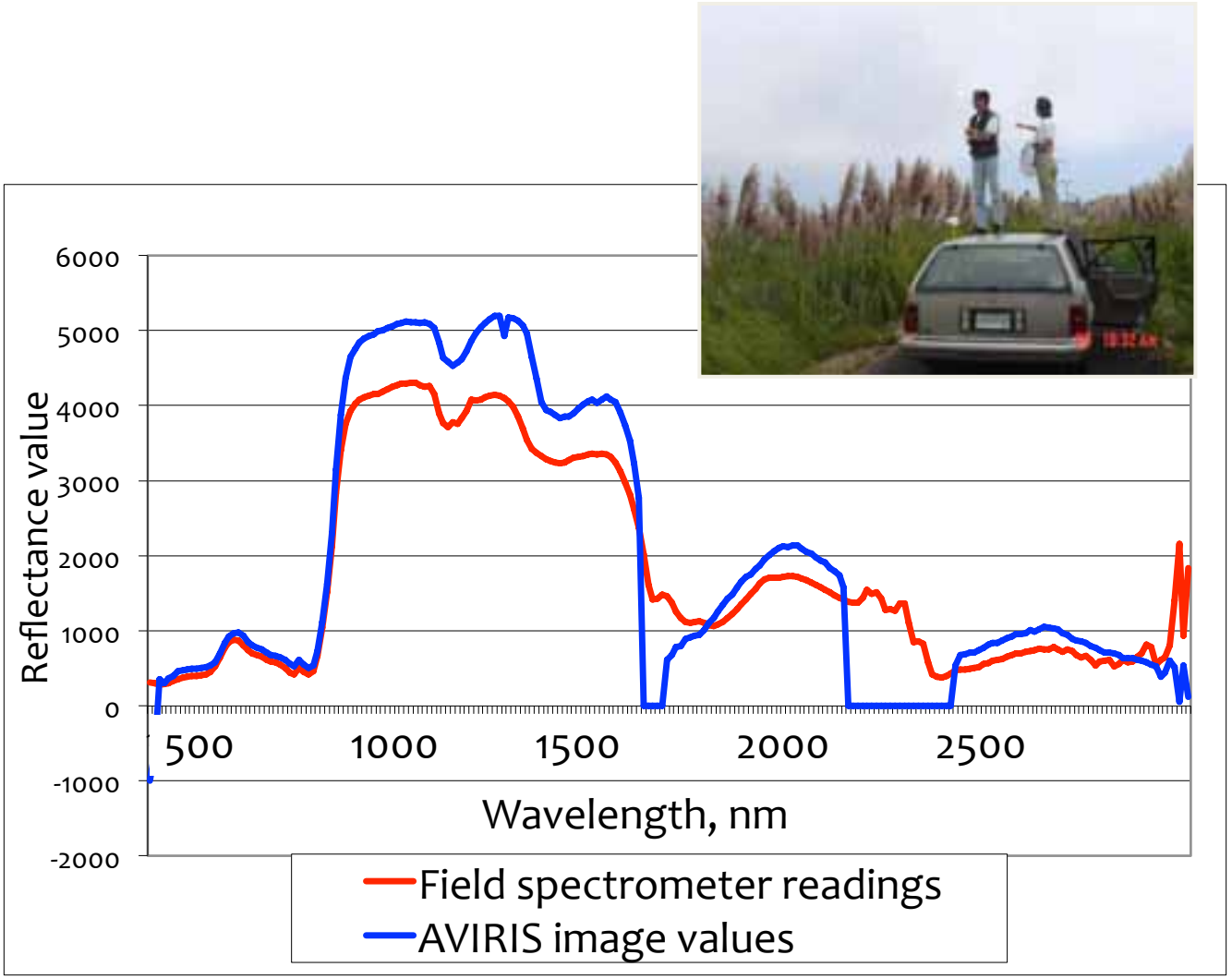
Epsomite ($MgSO_4 \cdot 7H_2O$)

* harmful

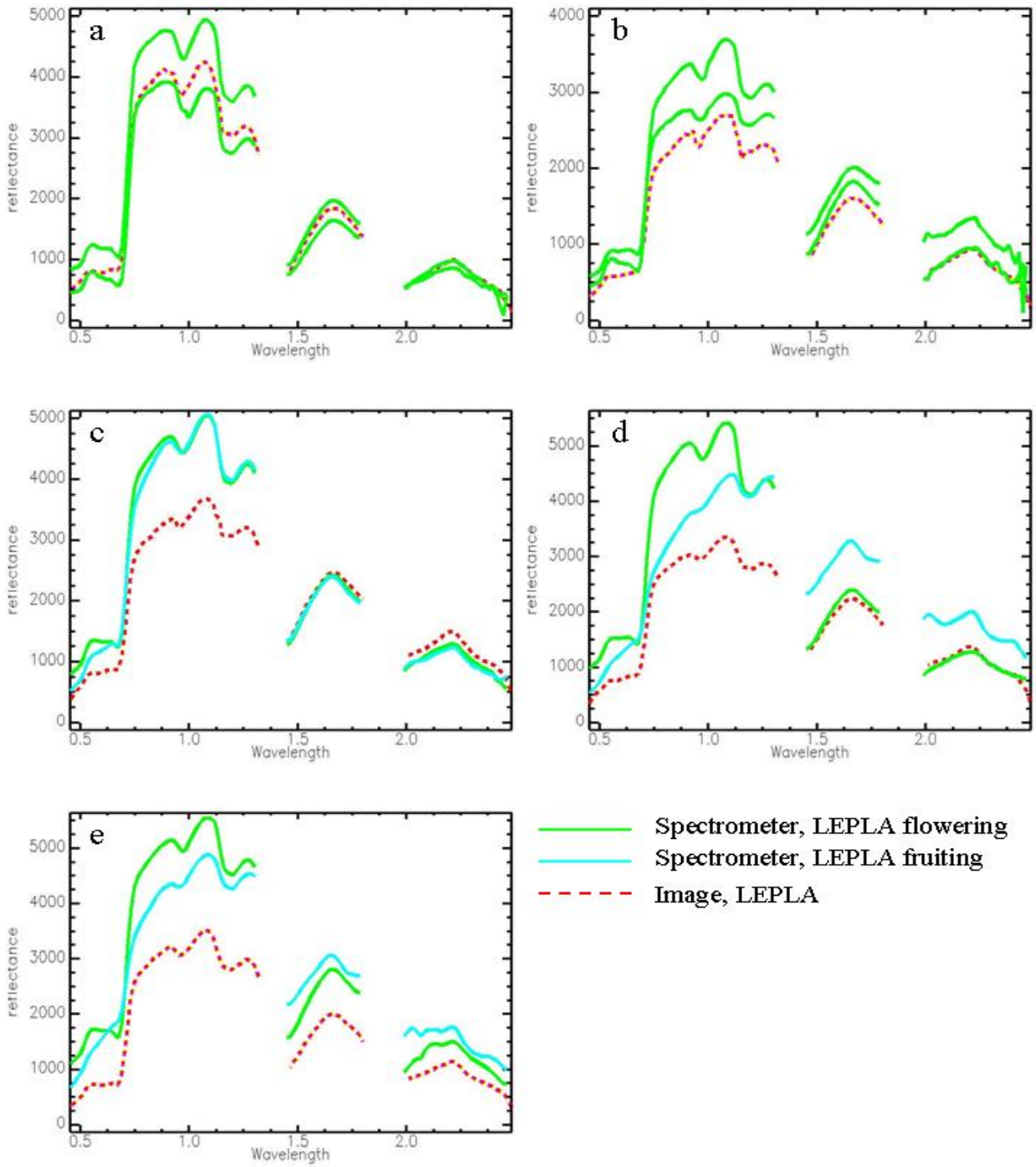


Above canopy measurements remain a major unsolved problem

Arundo donax: Getting above the plant canopy



DiPietro, D., S. L. Ustin, E. Underwood, 2002. Mapping the invasive plant *Arundo donax* and associated riparian vegetation using AVIRIS. Proceedings of the 11th Earth Science Airborne Workshop, Jet Propulsion Laboratory, Pasadena, CA, March 6-8, 2002



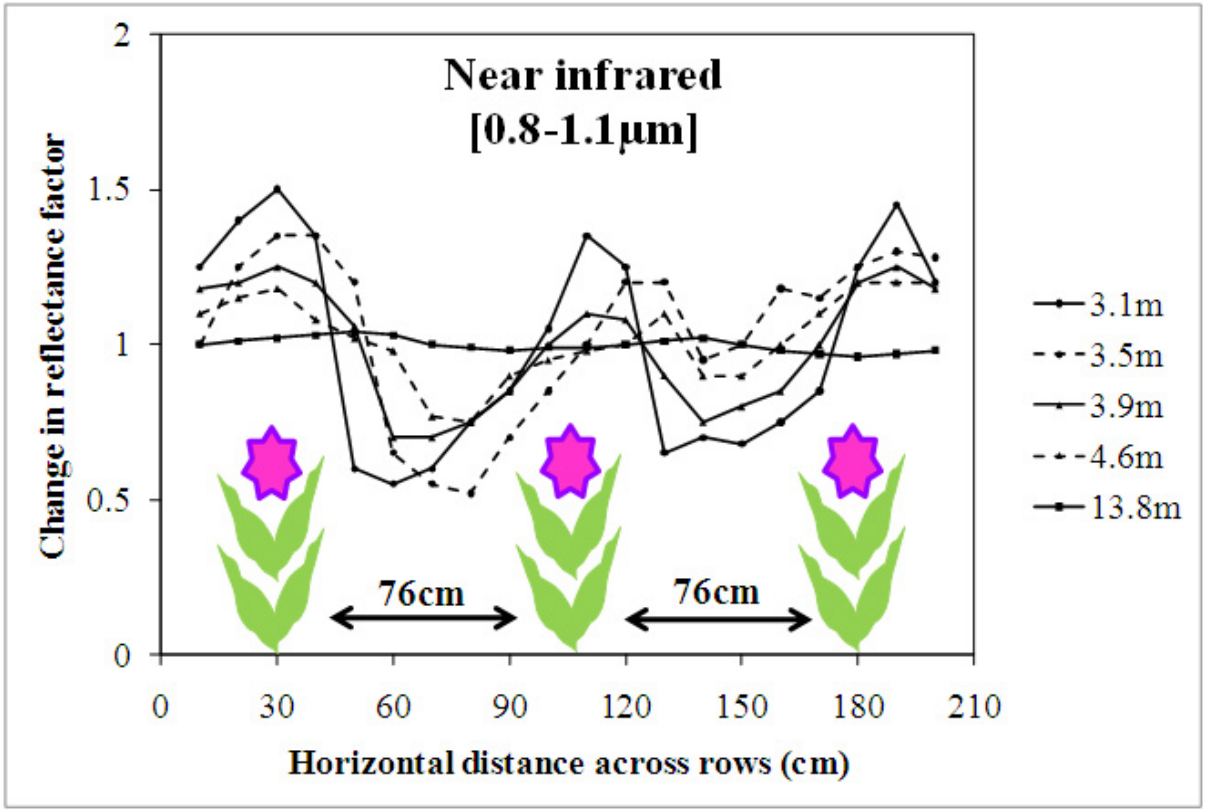
Environmental Heterogeneity

Simultaneous Growth Stages of *Lepidium latifolium*

ME Andrew and SL Ustin 2006. Weed Science, 54 (6): 1051-1062.

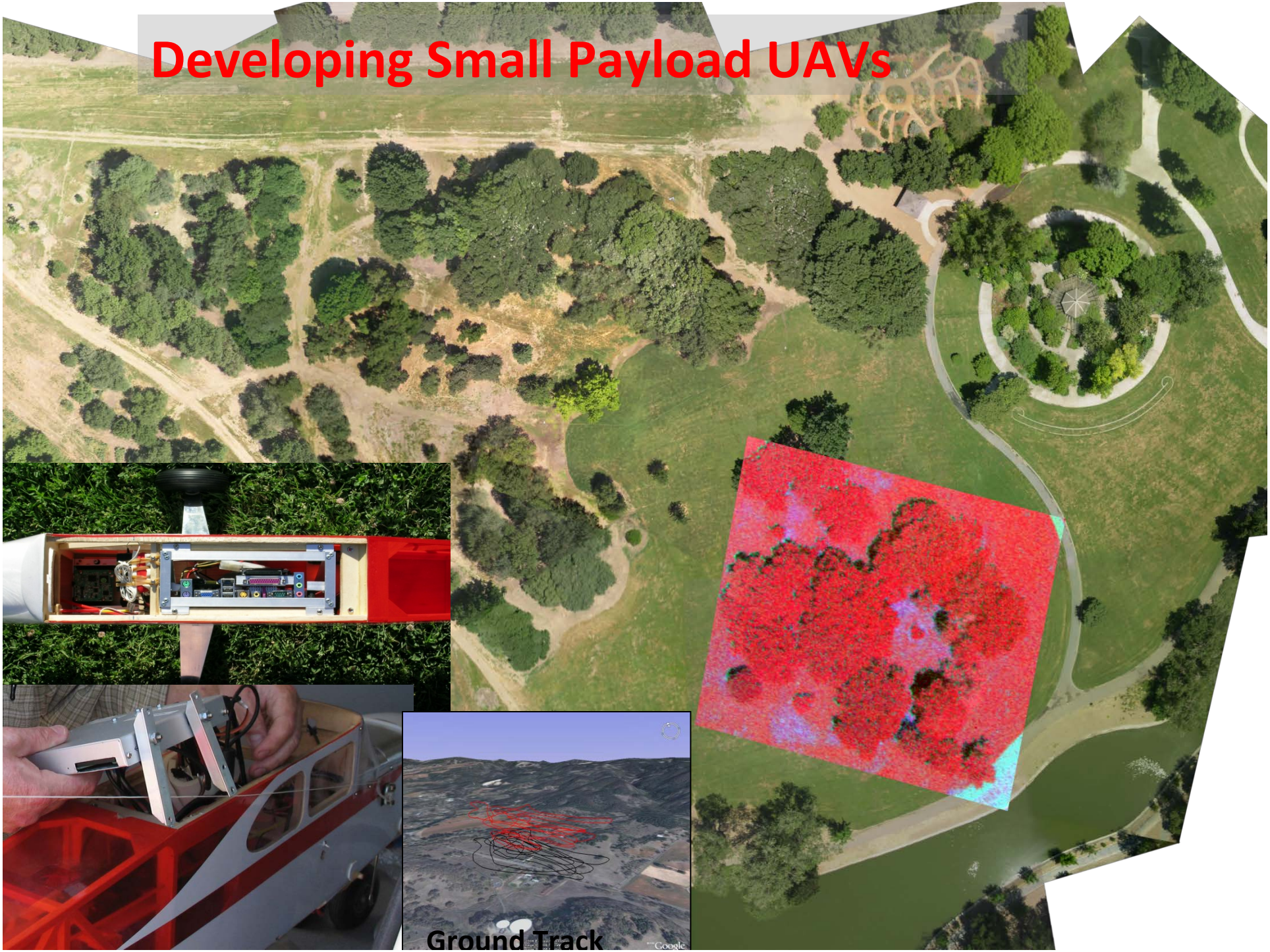
Can we Interpret Spatial Heterogeneity?

Can we get adequate spectral sampling on the ground?



Schematic of tram system, showing cart traversing the ecosystem on an elevated rail. Using upward- and downward-pointing foreoptics, a dual-detector spectrometer enables simultaneous sampling of upwelling and downwelling radiation (illustrated by cones), providing “on-the-fly” correction for changing sky conditions needed for accurate calculation of spectral reflectance.

Developing Small Payload UAVs



Miniaturized Imaging Spectrometers

Silicon 128, 256, 512 elements
InGaAs 256 elements
Extended InGaAs 256 elements

Dimensions with standard detector

Length	55 mm
Width	24 mm
Height	48 mm
Weight	~1 lb.

Imaging Spectrometers 350-1050 nm range

VTOL UAV
MW Power Systems, Ltd. UK

Yasuyuki Watabe

Falcon-PARS