Optimal Narrow Spectral Bands for Precision Weed Detection in Agricultural Fields using Hyperspectral Remote Sensing

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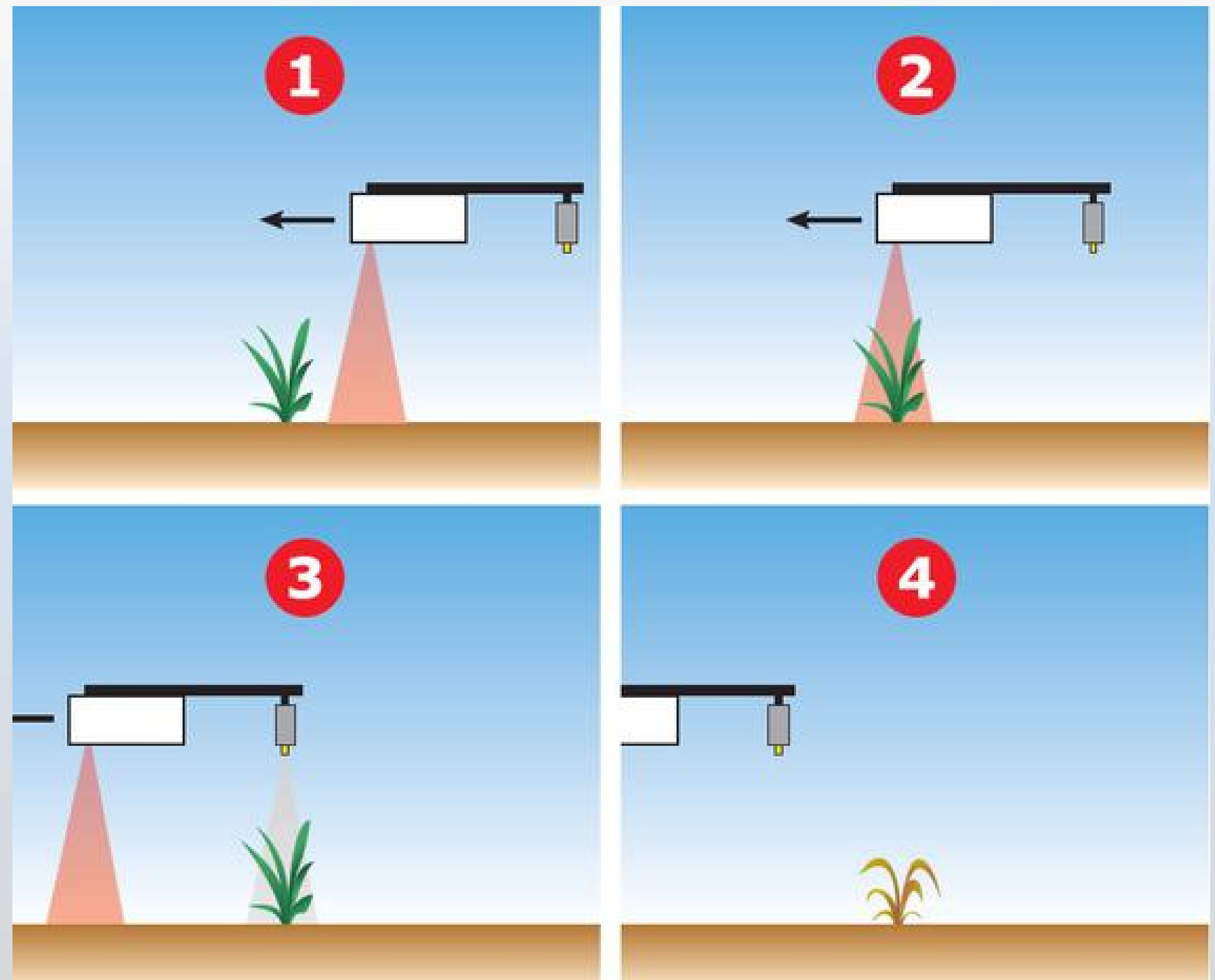
MREDI Montana Research & Economic Development Initiative

Outline

- Precision Weed spraying
  - How it works
  - Monitoring
  - Current Technology
- Spectral Profiles
  - Wide vs Narrow Bands
- Sensors
  - Multi vs Hyperspectral
- Research
  - Goals
  - Methods
  - Expected Results

Precision Weed Spraying

- Sensor activates solenoid
- Only Weeds are sprayed



http://www.weed-it.com/

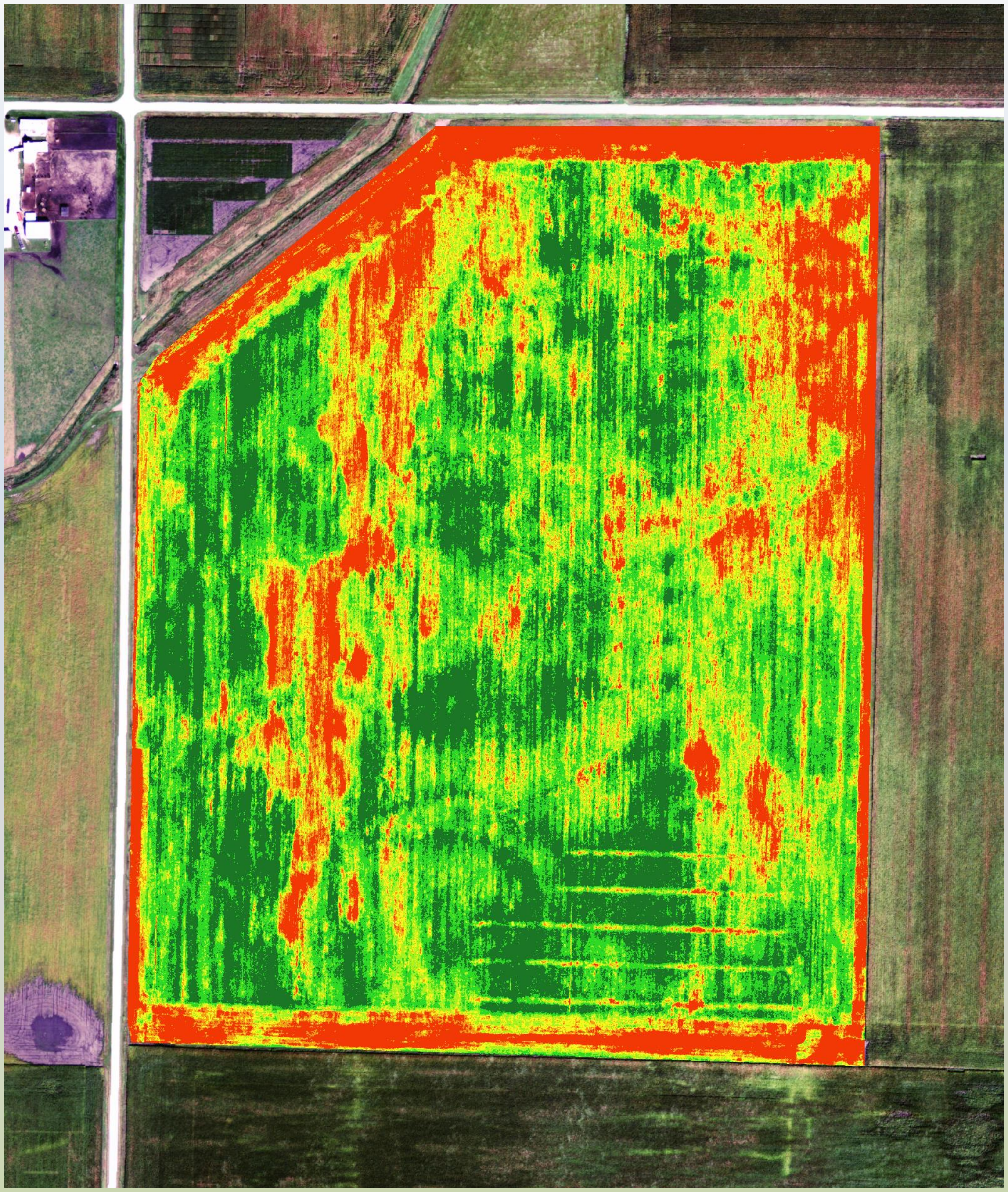
Precision Weed Spraying

- Cost reduction to producers
- Environmental Benefits
  - Less runoff of herbicides
  - Built in weed monitoring

http://www.weed-it.com/

Monitoring

- Integration of GPS with sprayer can create a weed map.
- Allows year to year comparison
- Weed population dynamics
- Feedback on the management effectiveness



Current Technology

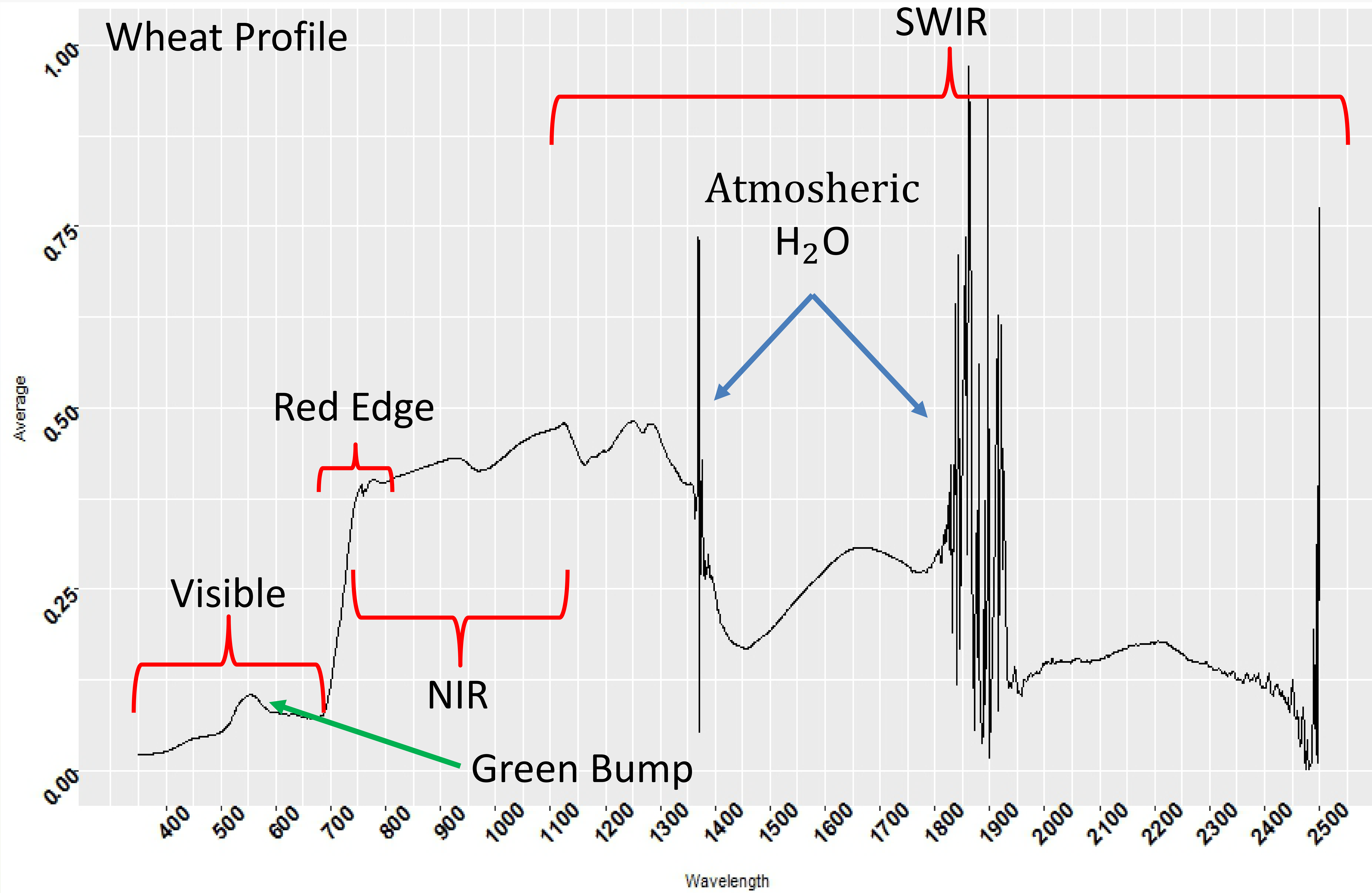
- Systems exist and are in use
- Examples WeedSeeker® and WEEDit®
- Most use active sensors

Issues

- System effective in fallow, pre-plant spraying, post-harvest weed control
- Hard to differentiate between crop and weed

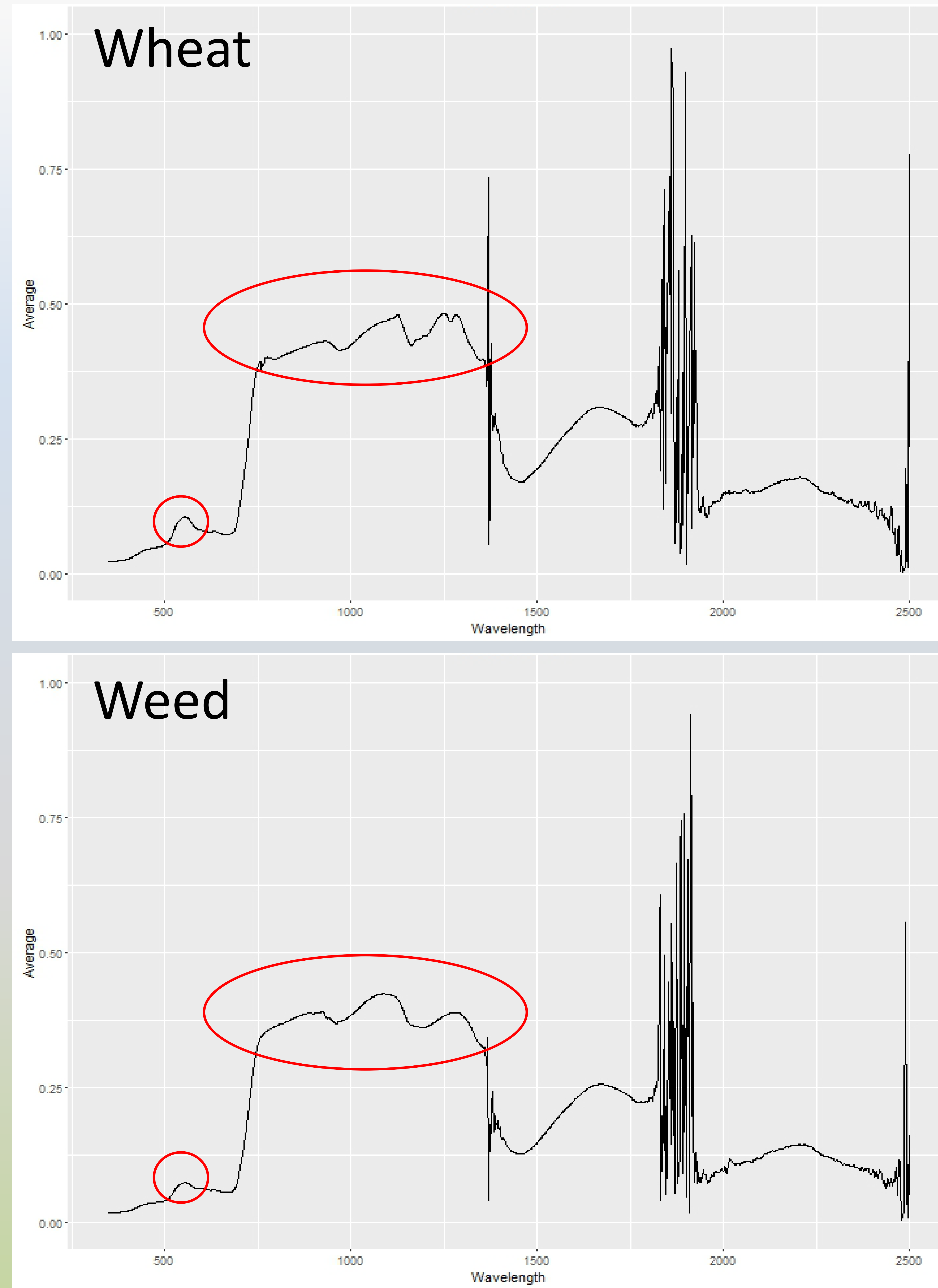
http://www.weed-it.com/

Spectral Profiles



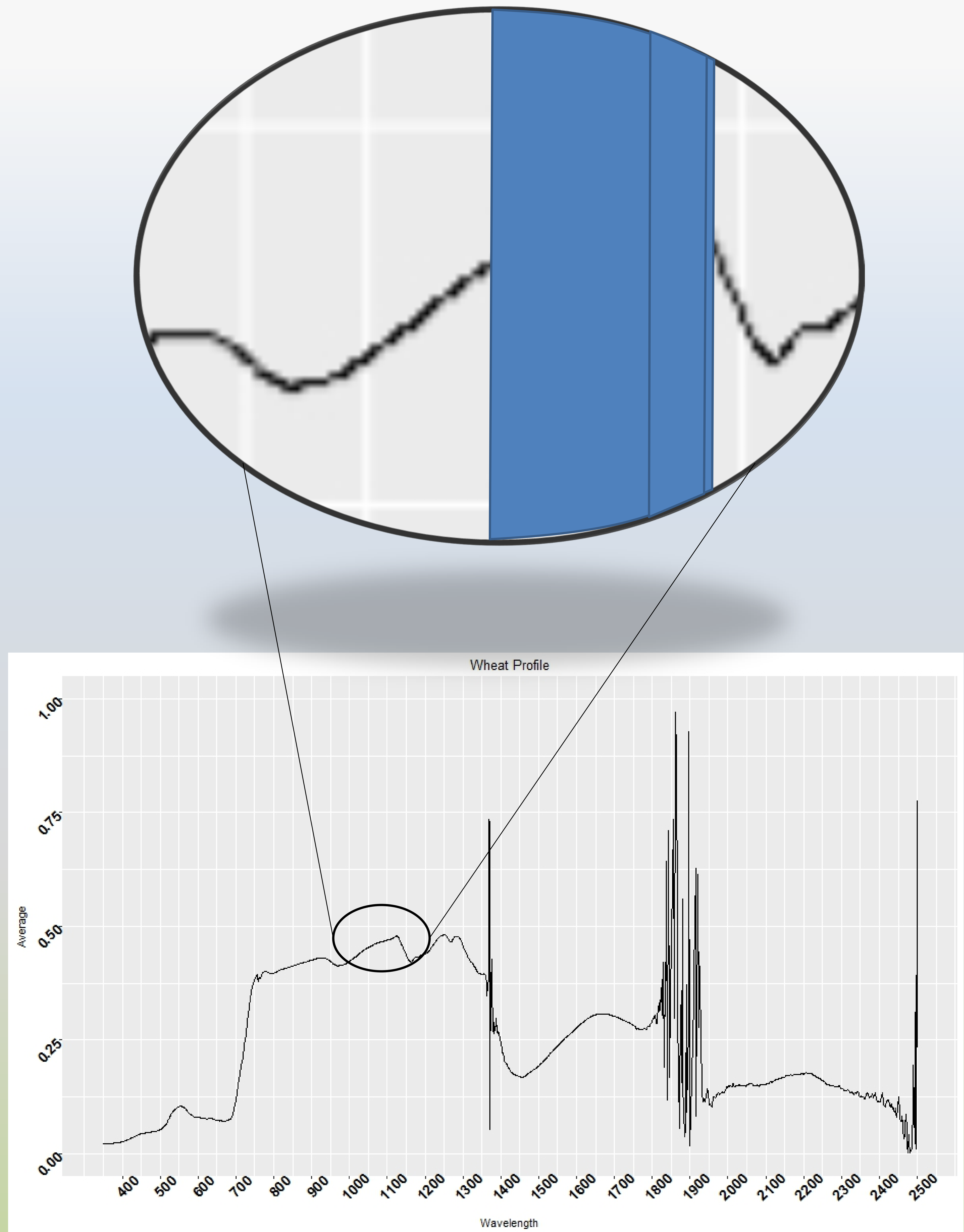
Spectral Profiles

- Similar spectral profiles
- Distinct differences
  - Green
  - IR
  - Red Edge?



Narrow and Wide Bands

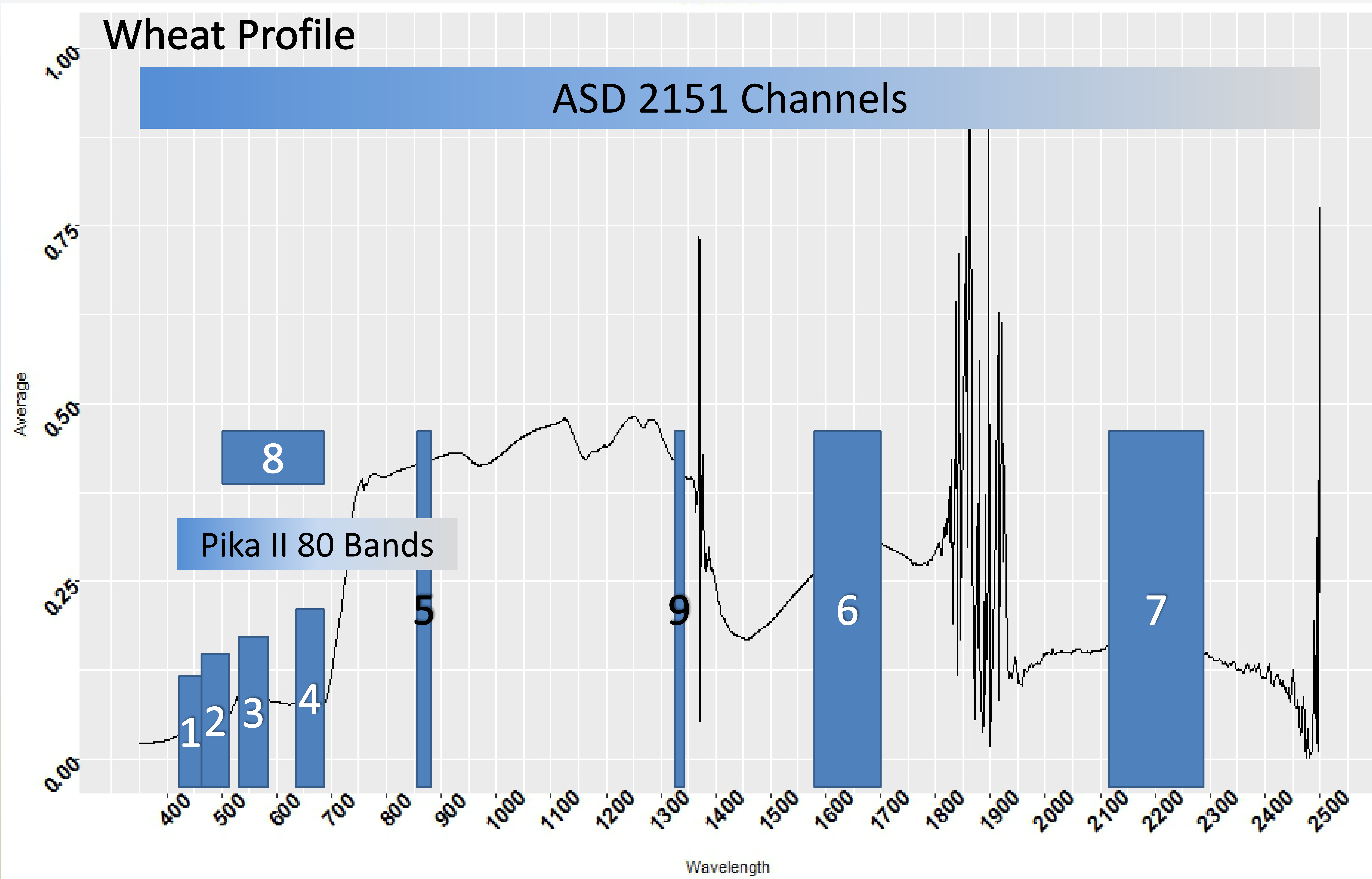
- Wide Bands
  - Can limit differentiation of similar signatures
  - Multispectral sensors
- Narrow Bands
  - Gain high spectral resolution
  - Hyperspectral sensors



Sensor Differences

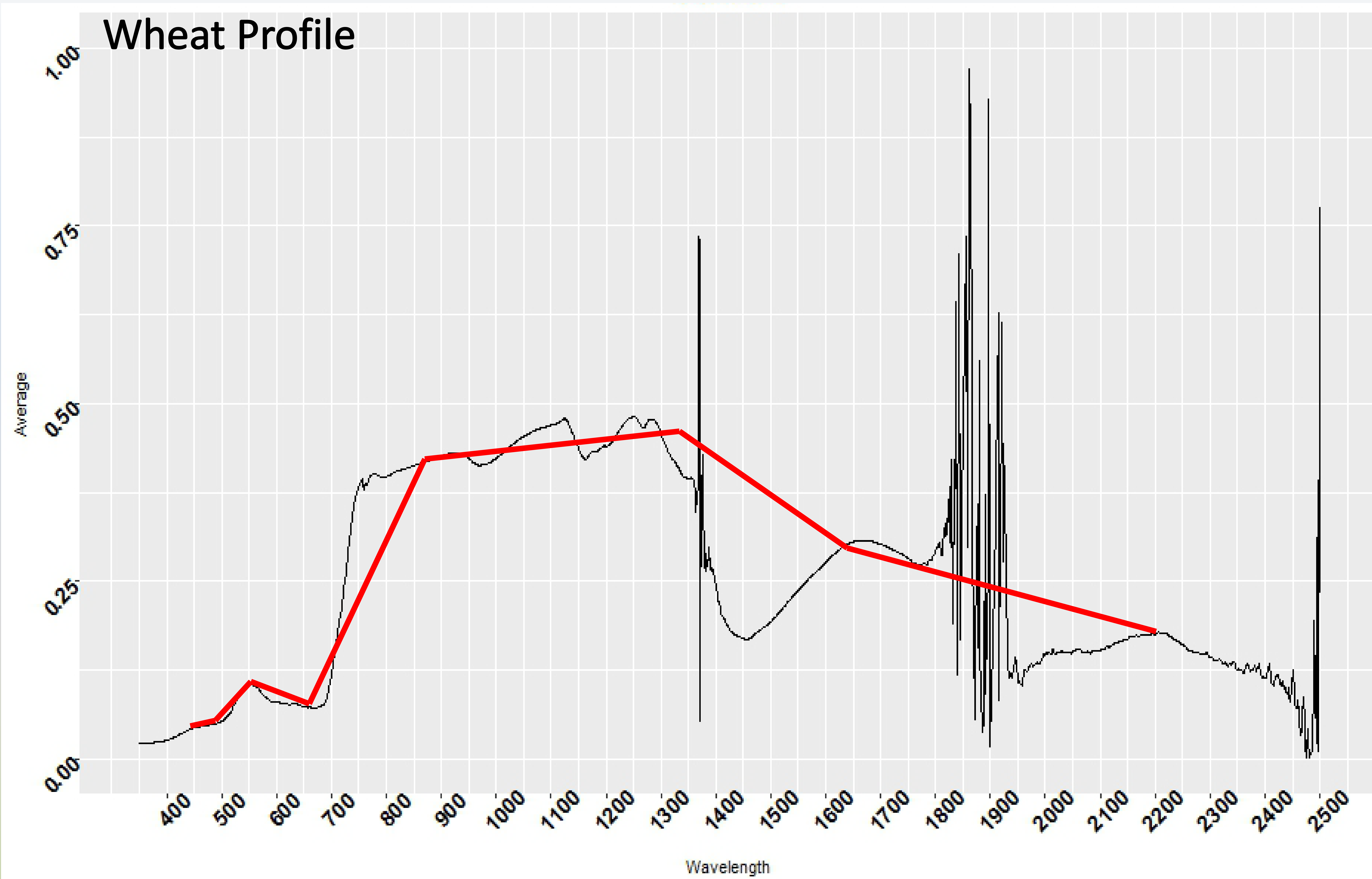
- Multispectral
  - Wide bands (20nm-100nm)
  - Different regions of spectrum
- Hyperspectral
  - Narrow bands (2nm-10nm)
  - Continues across spectrum

MultiSpec Vs Hyperspectral



Landsat 8 Multispectral Bands for comparison

MultiSpec Vs Hyperspectral



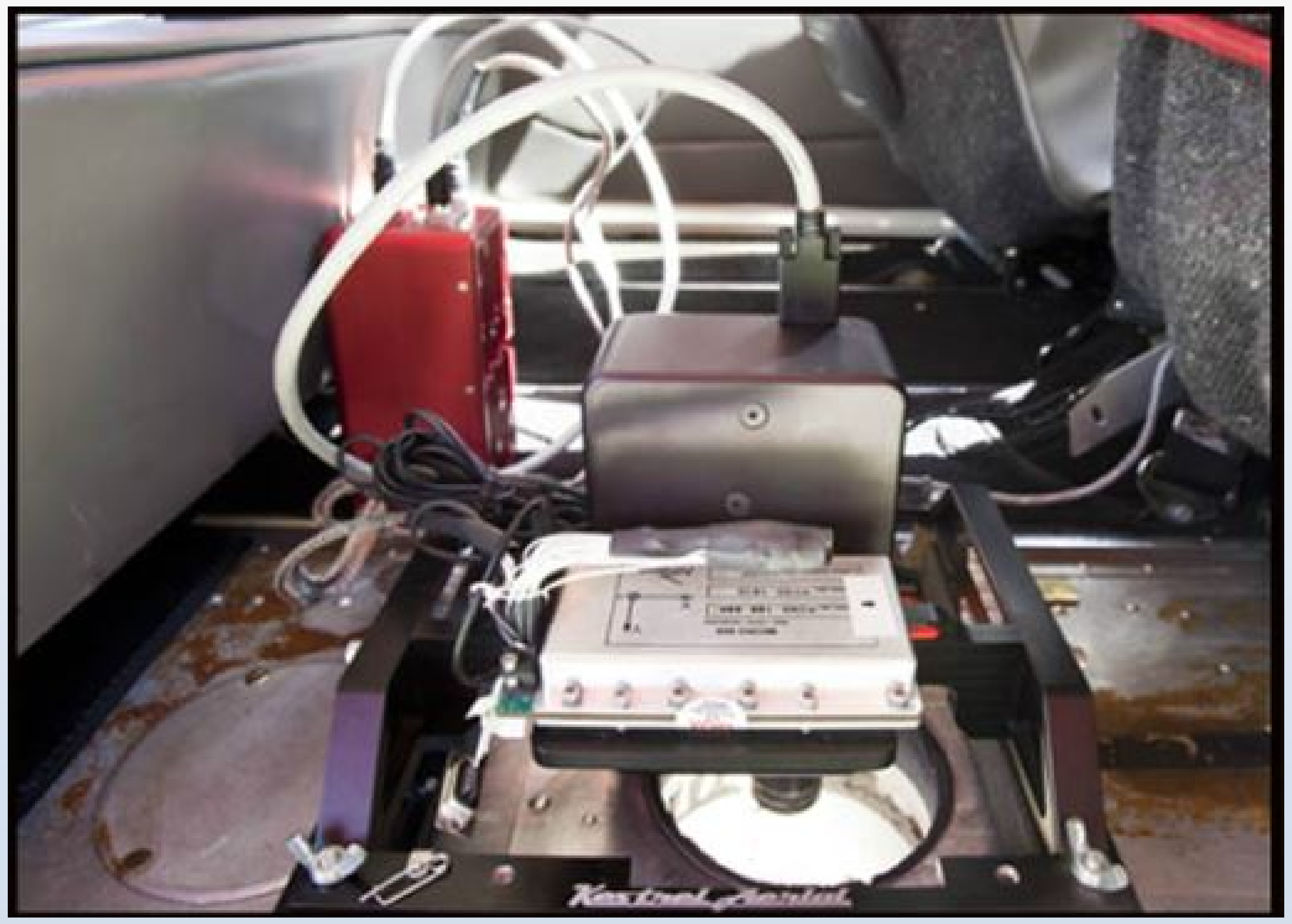
Vegetation curve derived form Landsat 8 Multispectral Bands

Sensors

- Current hyperspectral sensors cannot feasibly be mounted to tractors
  - Cost
  - Large Data sets
  - Sensor/computer pay load
- Solution
  - Fly with current hyperspectral technology and apply findings to on-tractor designs
  - Use hand held sensor for ancillary data

Sensors

- Pika II
  - Arial platform
  - ~0.5m pixels
  - Hyperspectral
  - 80 channels
  - 424nm - 929nm

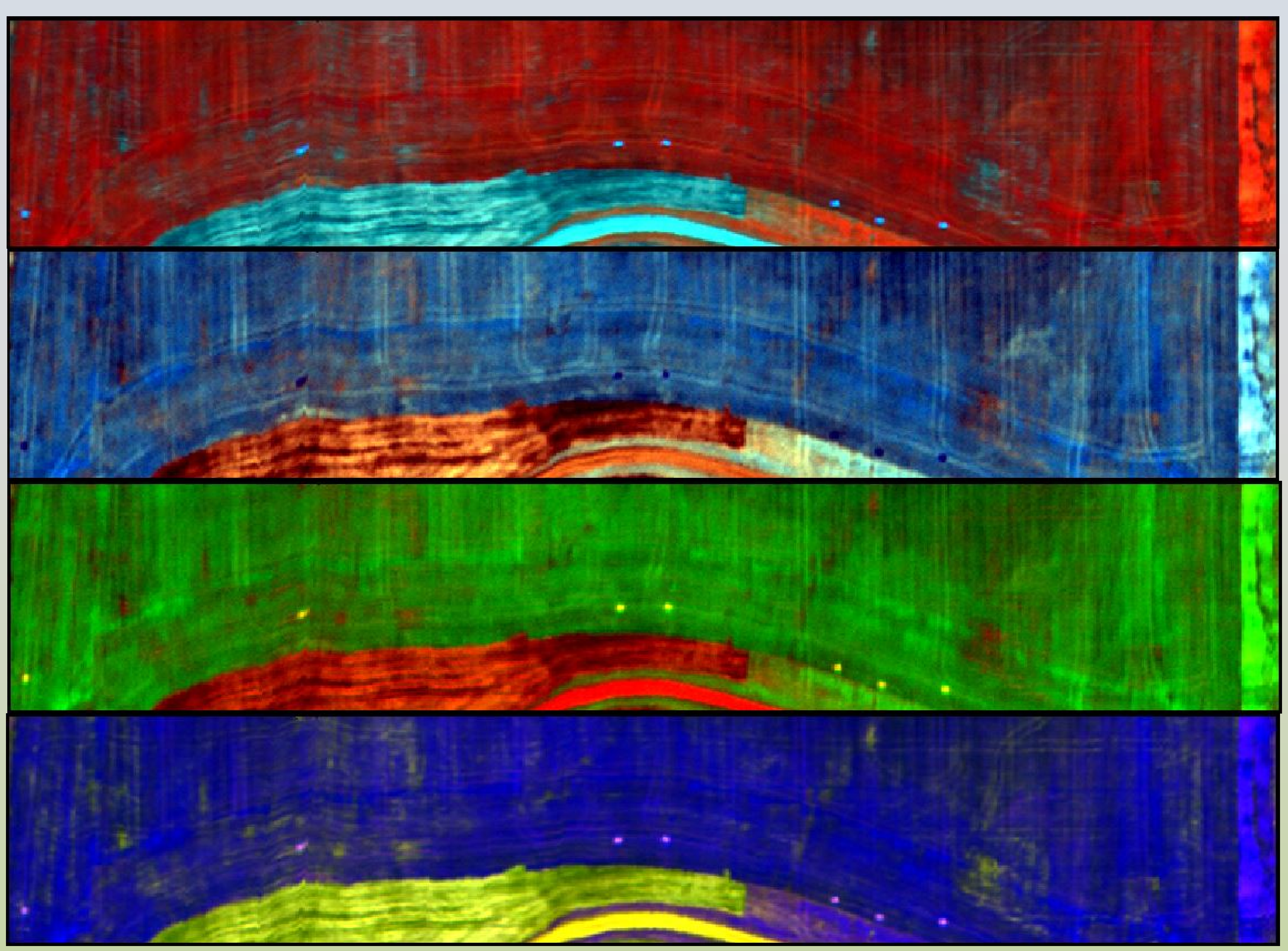


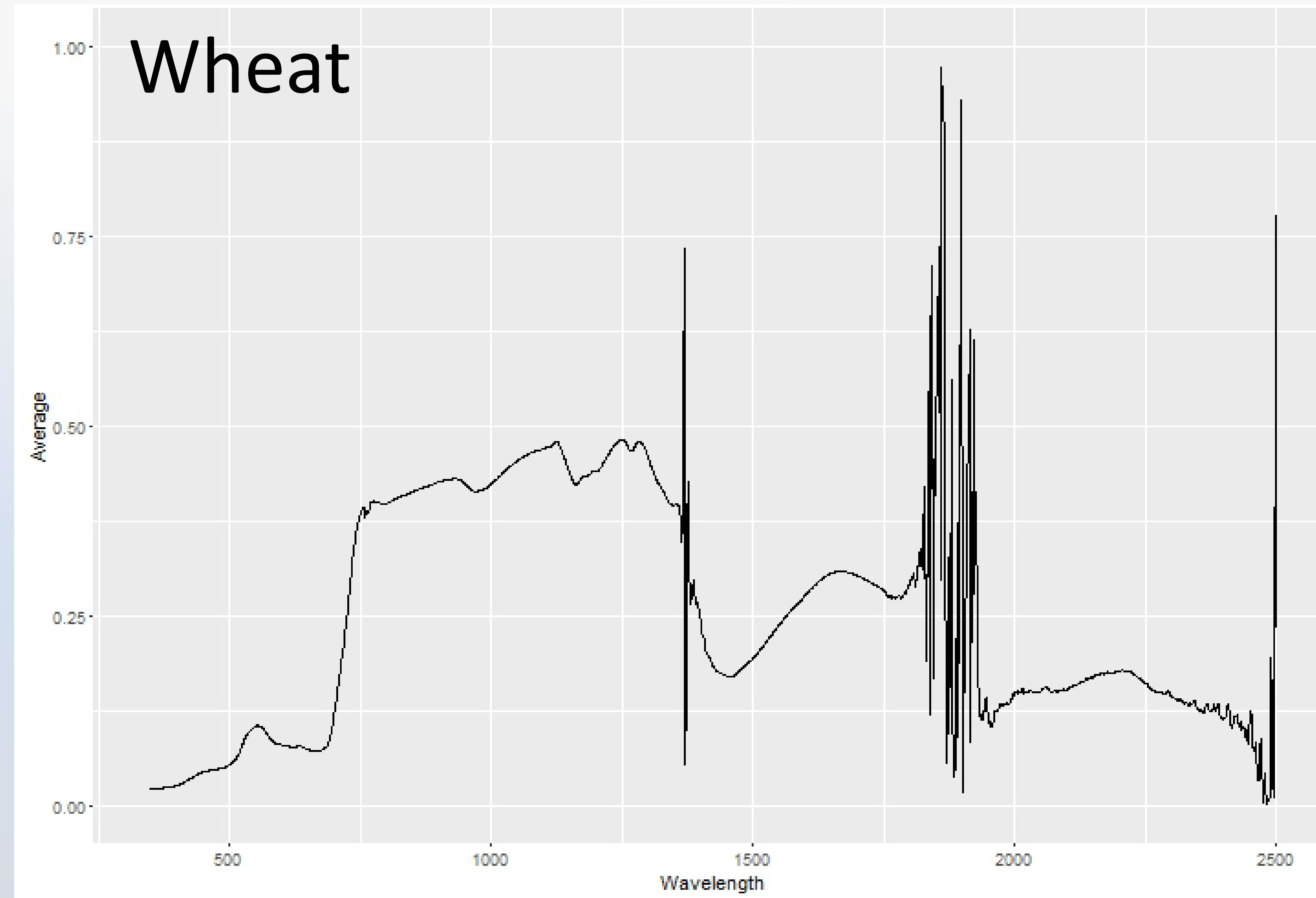
http://kestrelaerial.com/services/hyperspectral-scanning/

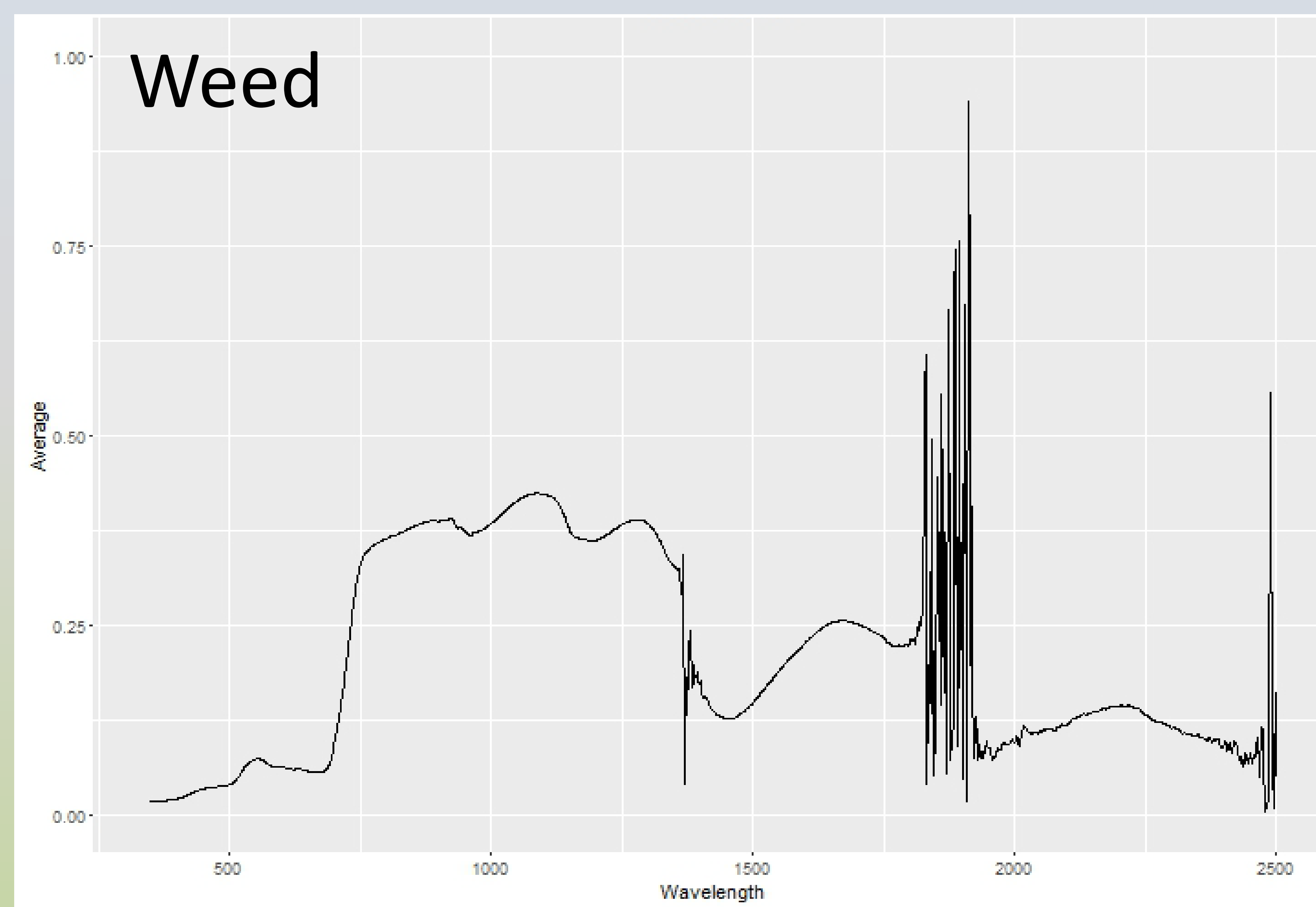
- ASD
  - Back pack mounted
  - FOV 1m @ 2m
  - Hyperspectral
  - 2151 channels
  - 350 nm - 2500 nm

Optimal Band Selection

- Reduced data processing time
- Can apply it to future technology

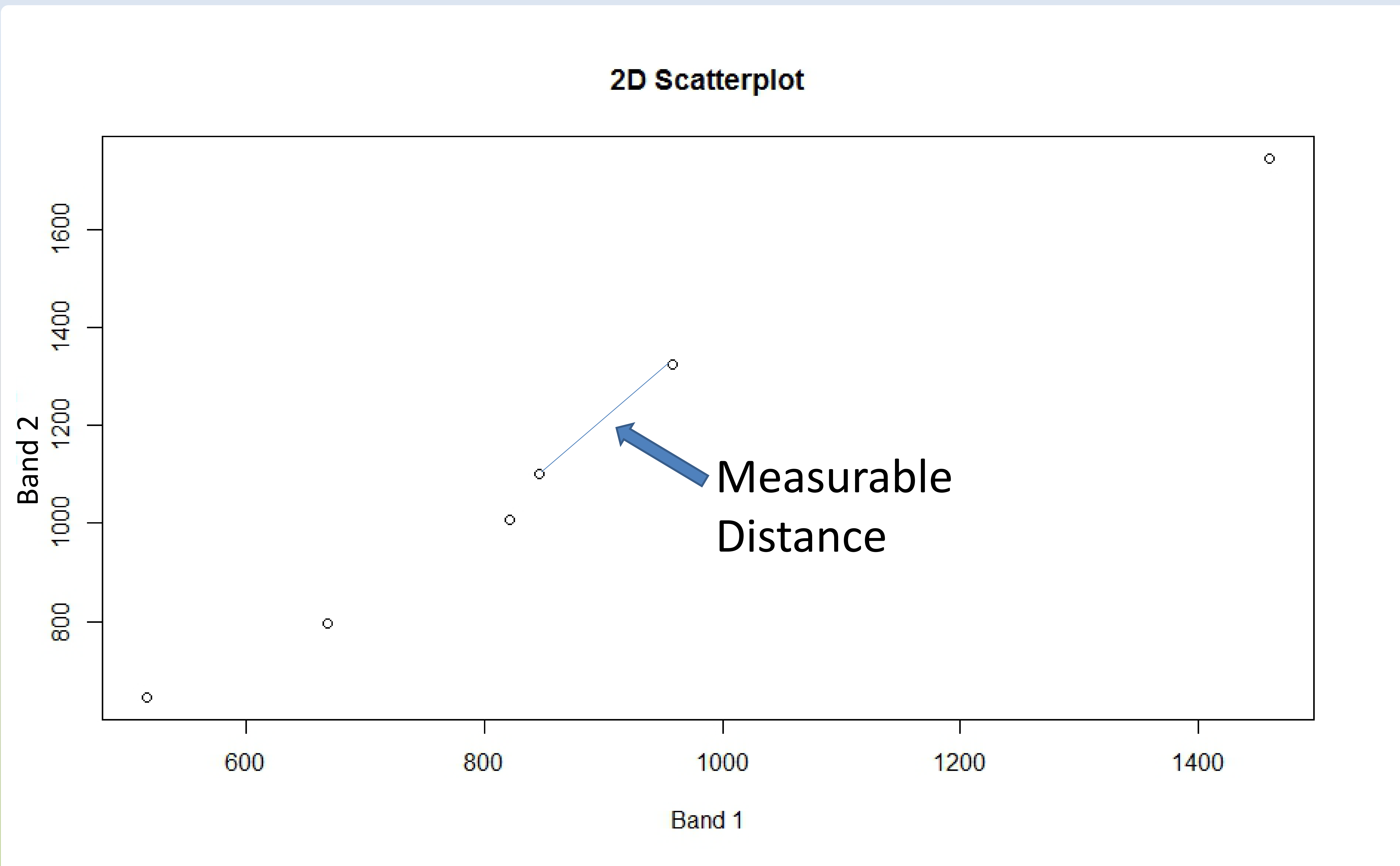






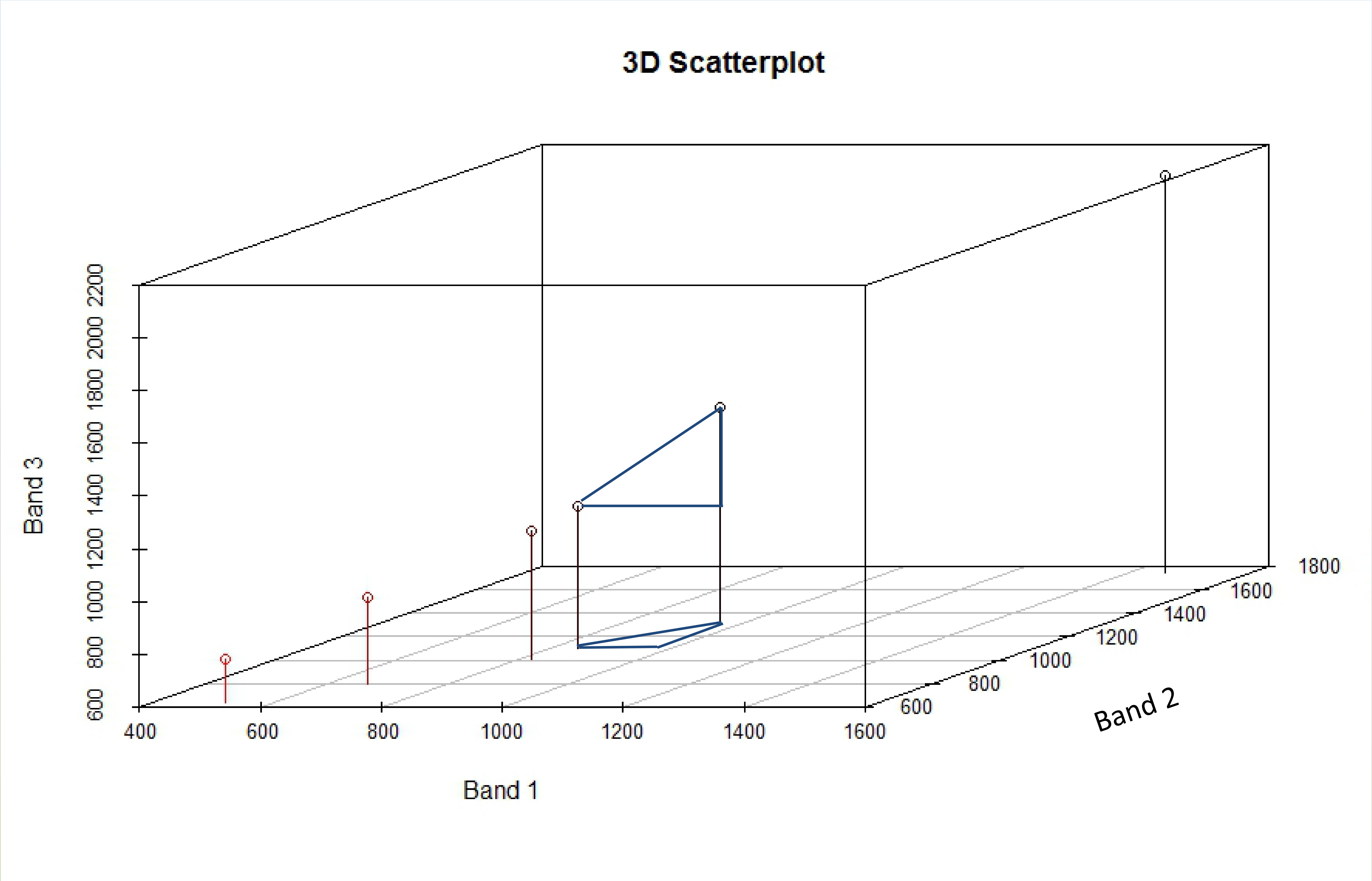
Distance Metrics in Spectral Separability

- Point a single point on the spectral curve
- Spectral response for a band on one axis



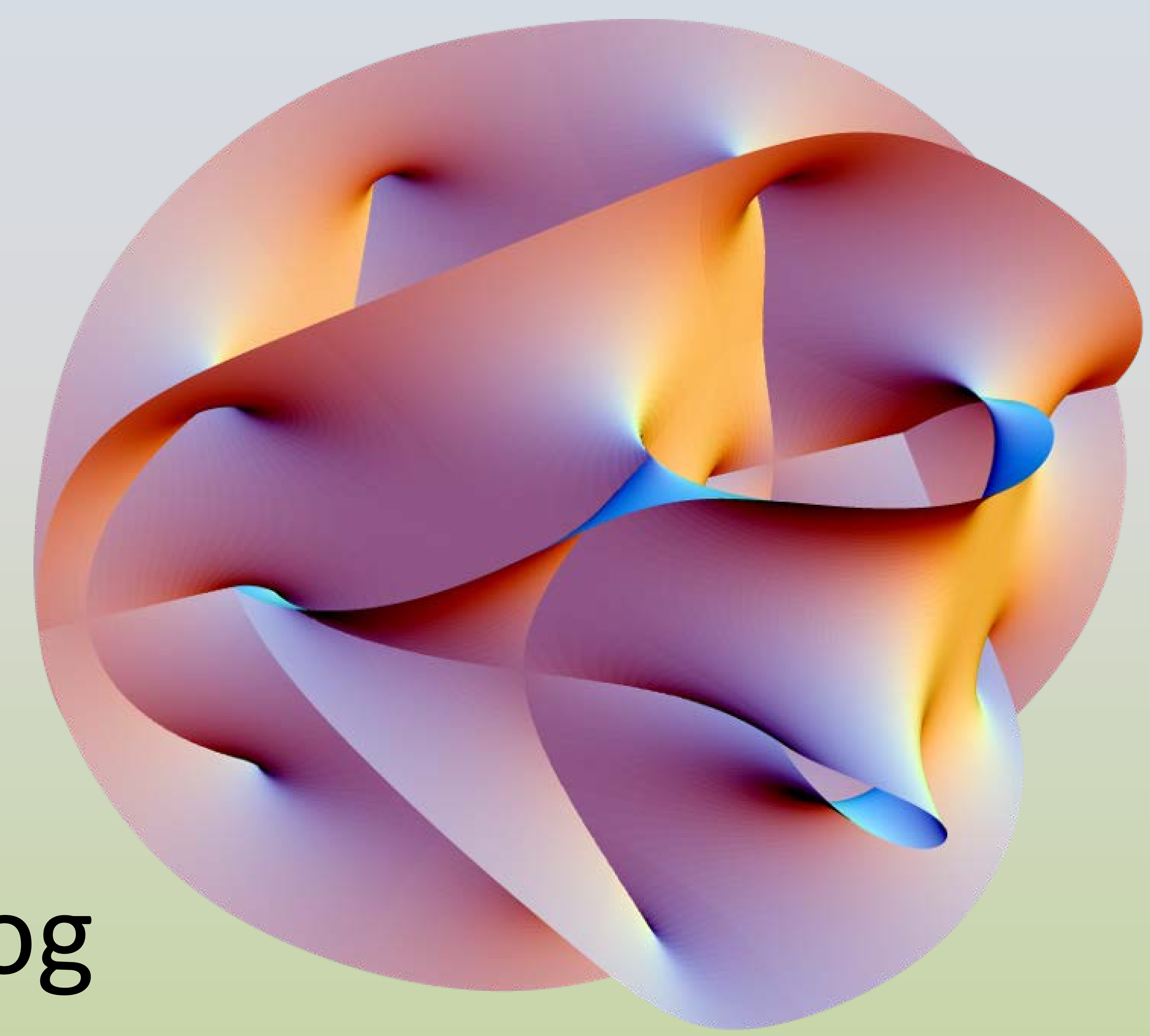
Distance Metrics in Spectral Separability

- Each band adds a dimension



Distance Metrics in Spectral Separability

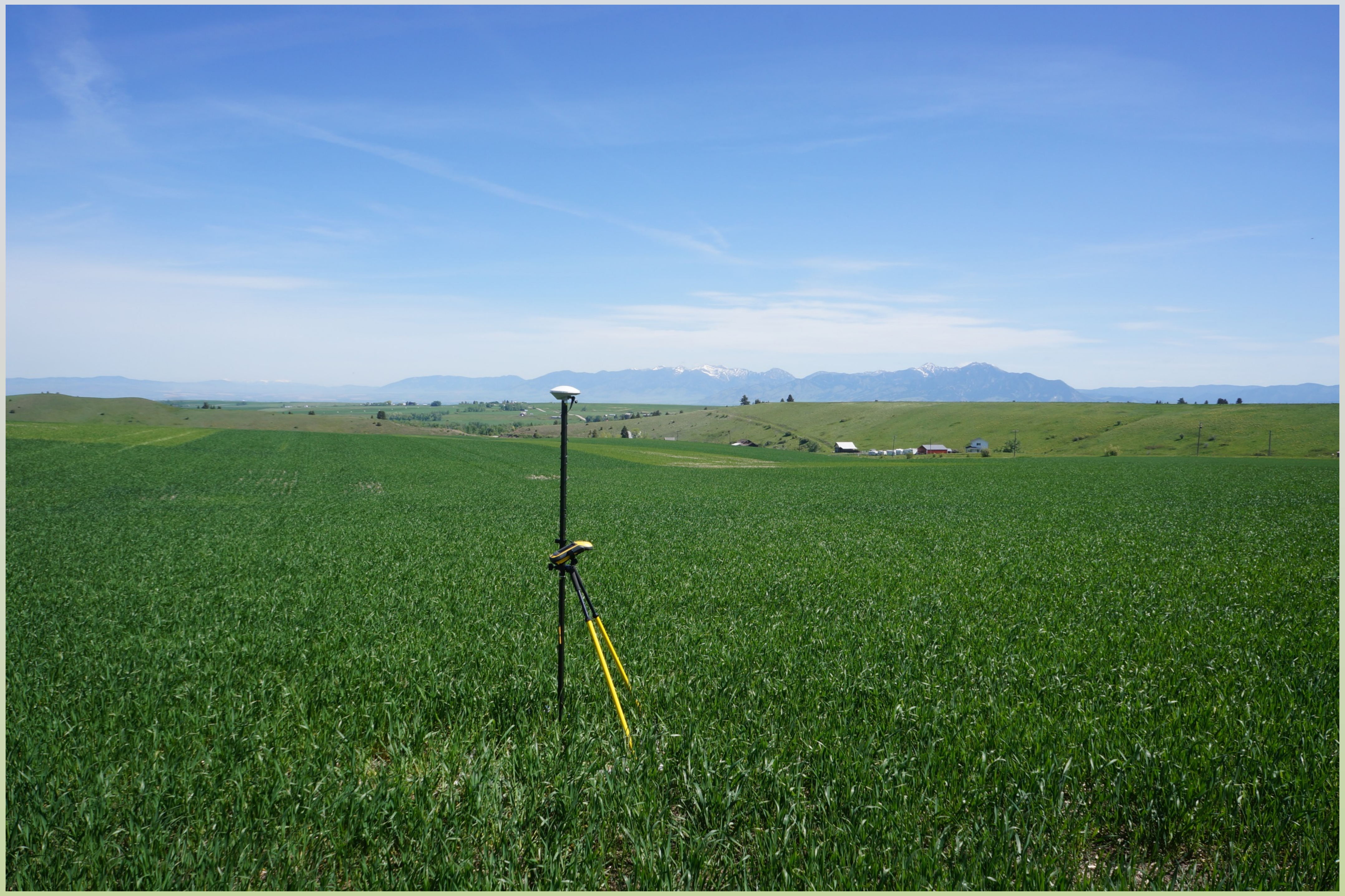
- For multiple bands this can get very complicated
- Different metrics to quantify these distances
  - Euclidean
    - $D = \sqrt{\sum_{i=1}^{n}(d_i - e_i)^2}$
  - Divergence
    - Based on means and covariance
  - Transformed Divergence
    - Scaled version of divergence
  - Jefferies-Matusita
    - Mean, covariance, and natural log



http://sacred-activations.com

Goals

- Identify portions of the electromagnetic spectrum to identify weeds in dryland wheat.
- Analytical methods can be applied to other cropping/weed systems.



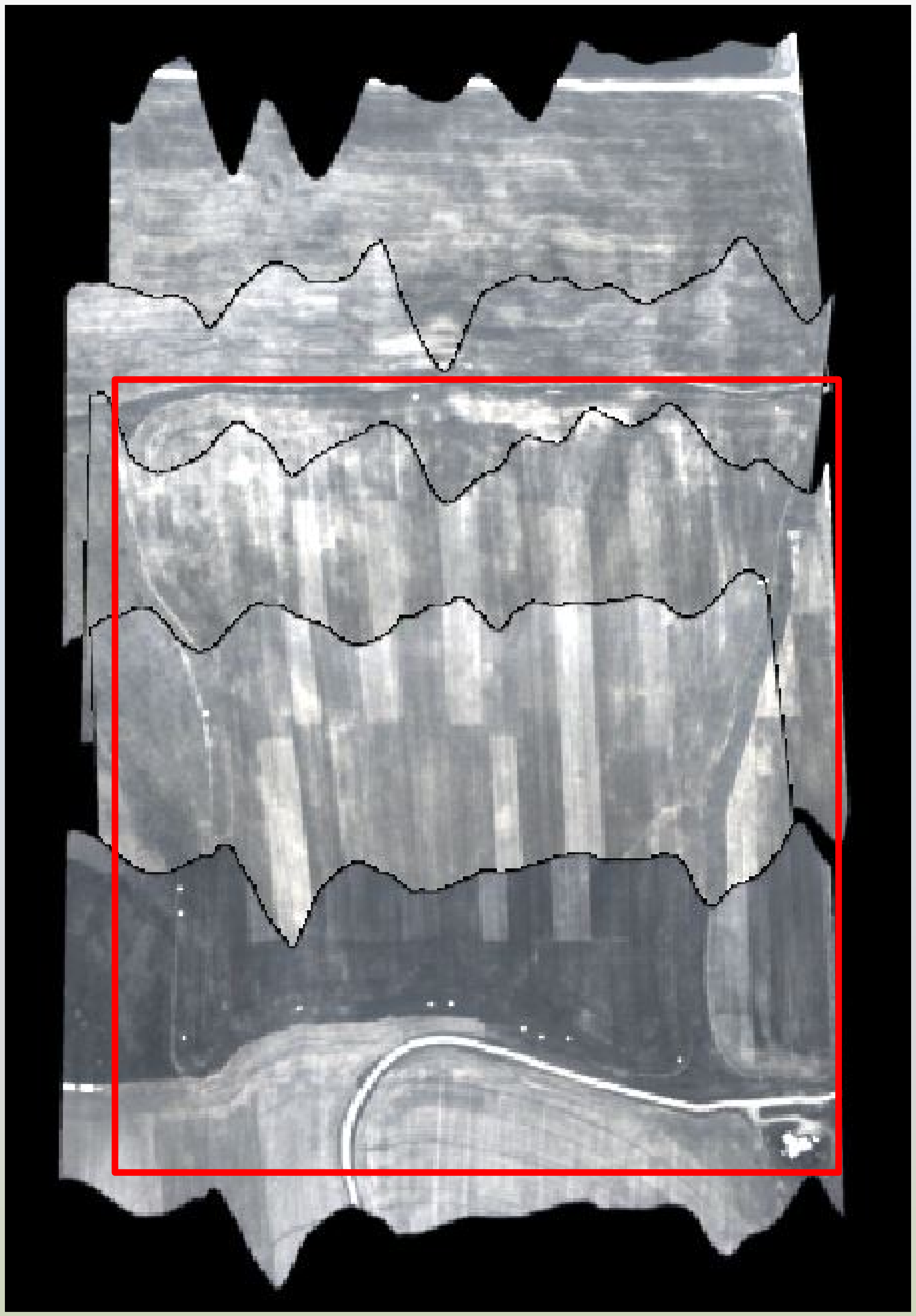
Questions

- Can narrow spectral band combinations identify weeds *in situ*, given the variability of plants?
- How many bands necessary?
  - Compare band combinations across multiply classification techniques
- Can a set of narrow bands be widened and still accurately identify weeds?
  - Wider bands can cut cost of sensors or filters.

Methods: Data Collection

- Tarps
  - Solution to roll, pitch, yaw
  - Used for Atmospheric correction
- Field Data
  - Azimuth, weed type, patch size, etc.
- GPS
  - Tarp and weed patch center

Methods: Processing



Swaths

- Georectified
  - Using Tarps and GCP
- Combined
  - In the Mat Lab by Cooper McCann
- Exported
  - To usable file format for analysis

False color IR Hyperspectral Image of wheat field

Methods: Analysis

- Extracted and combined spectral data from infested and un-infested locations
- Used 4 spatial distance metrics
- Used 11 classification techniques
- Compared using kappa statistic and McNemar’s test

Statistics

- Kappa z-test
  - Kappa measures agreement taking into account random chance of correct classification
  - Popular in the literature but though by some to be undesirable
- McNemar's Test
  - Uses 2x2 matrix
  - Null states same proportion of pixels will be correctly classified by method 1 and method 2
  - Found to work with smaller samples than kappa

http://www.jeffbullas.com/category/statistics-2/

Expected Outcomes

- Answer to, does it work?
- Wider bands, cost efficient work
- Method that can be applied to other crop/weed systems
- Commercial collaborators can apply findings and methods to adapt sensors regionally
- Dead weeds

Special Thanks

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- **State legislators**

Questions??

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