CQ4. Ecosystem Function and Diversity

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CQ4: Overarching Question

- **How do species, functional type, and biodiversity composition within ecosystems influence the energy, water and biogeochemical cycles under varying climatic conditions?**

CQ4. Sub Questions

- **How is physiological function affecting water and carbon exchange expressed at the ecosystem scale, especially down-regulation due to environmental stress factors? [DS 166, 196, 203, 206, 368]**

- **What is the vegetation phenological response to seasonal and interannual changes in temperature due to climate change and how does this response vary at the community/species level? [DS 196, 203, 206]**

- **What are the feedbacks between changes in canopy composition, crown mortality and retrieved canopy temperatures resulting from disturbances (e.g., disease, moisture deficiency, insect attack) in forest ecosystems? [DS 166, 196, 203, 206]**

- **How do climate-induced temperature and moisture changes impact the distribution and spread of invasive species? [DS 196, 203]**

- **Water use and availability?**

A Few Comments About Environmental Stress (1)

- **Environmental stress can be induced by environmental change, including:**
  - **Fragmentation, creating more edge environments**
  - **Large-scale climate change**
    - **Altered temperature regimes and precipitation patterns**
      - **Modified timing of the start, peak and end of the growth season**
      - **Changes in plant available soil moisture**
  - **Interannual variability**
    - **Short-term drought, El nino**

A Few Comments About Environmental Stress (2)

- **Environmental stress is often expressed in ecosystems in multiple ways, including:**
  - **Physiological**
    - **The xanthophyll cycle (PRI)**
    - **chlorophyll fluourescence**
    - **Changes in evapotranspiration**
      - **Actual ET vs Potential ET**
  - **Biochemical**
    - **Changes in plant pigments, nitrogen use, N/C ratios, leaf water**
  - **Community**
    - **Community composition and competition**
  - **Physical**
    - **Canopy temperature**
    - **Wilting**
    - **Mortality/leaf shedding**

CQ4. Sub Questions

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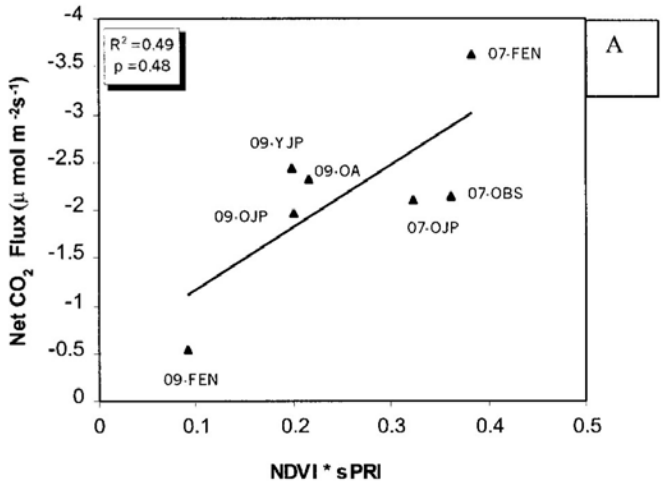
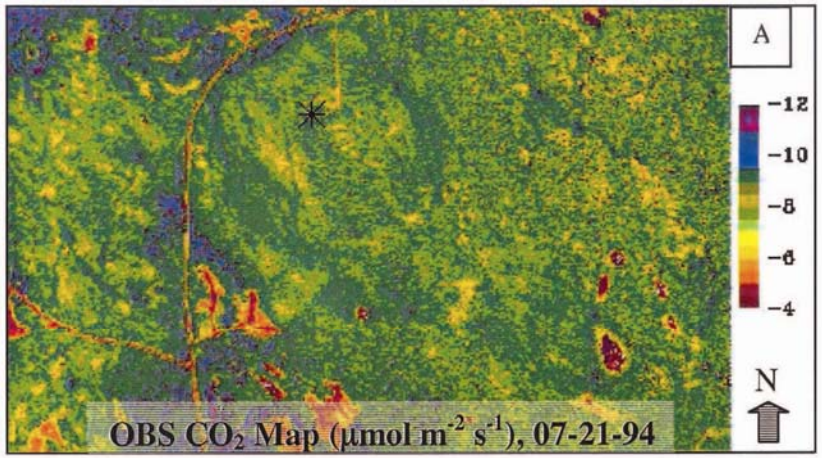
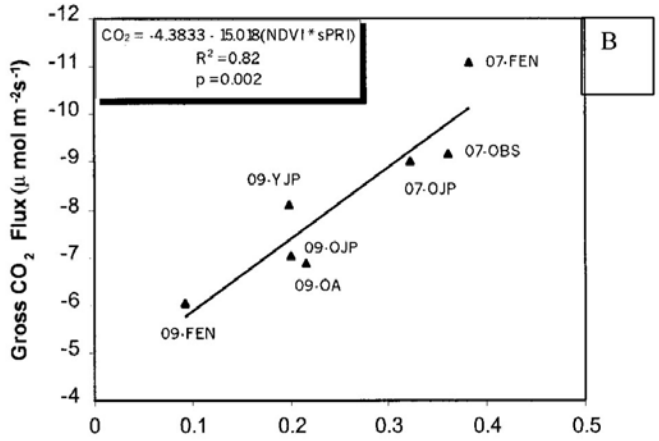
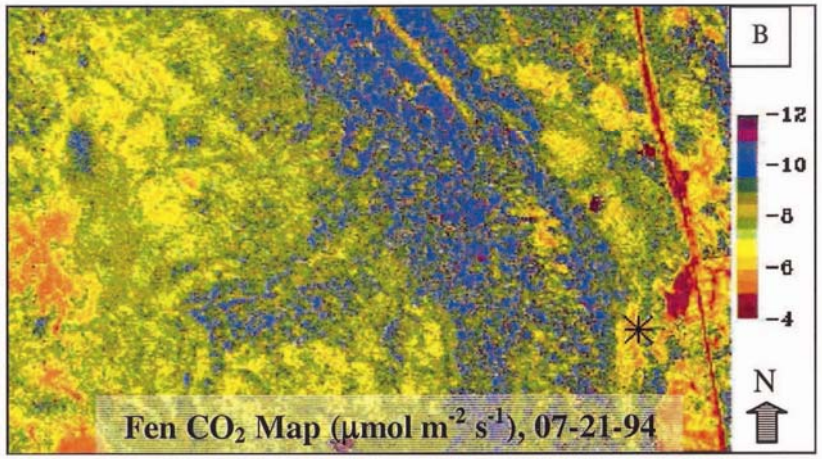
Estimating carbon uptake using PRI &NDVI









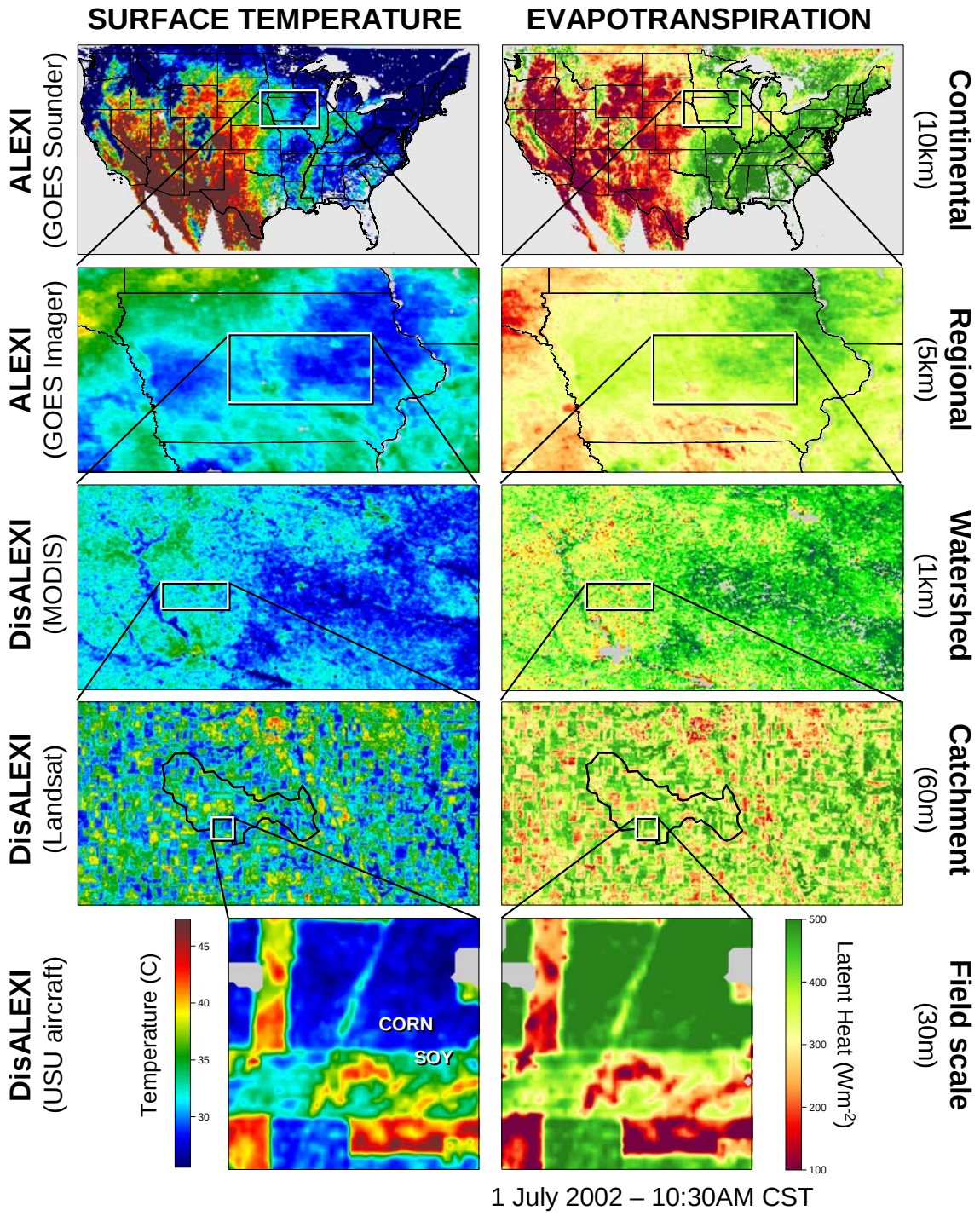
Developed a relationship between NDVI (FPAR) and PRI (quantum efficiency)
Calibrated with flux tower data

Rahman et al., 2001

- **Multi-scale estimates of ET using temperature**

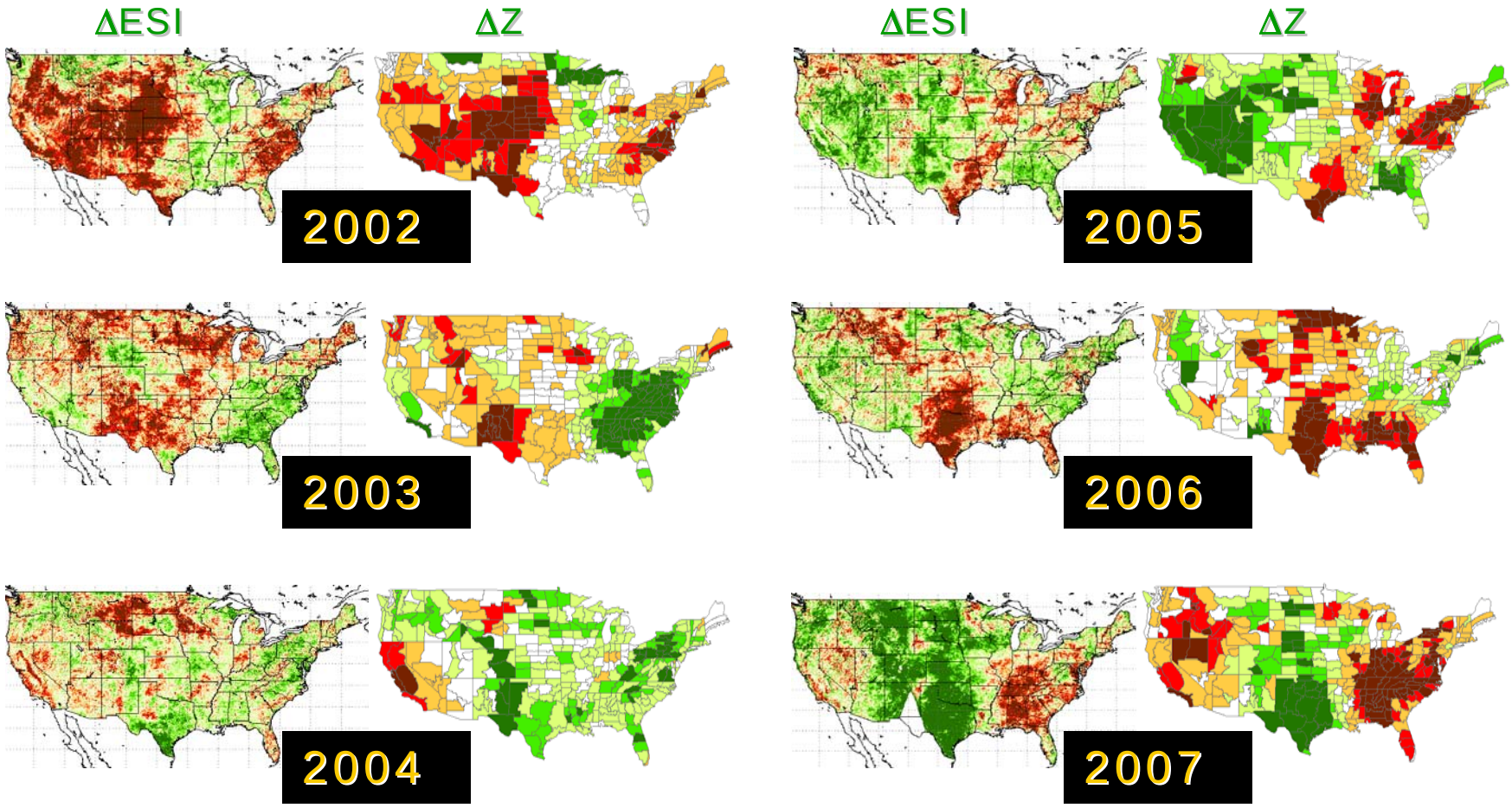
- **Synergisms between crop ID, albedo and physiological stress measures**

From Martha Anderson



Thermal Drought: SEASONAL ANOMALIES
April - September

$$ESI = 1 - \frac{AET}{PET}$$

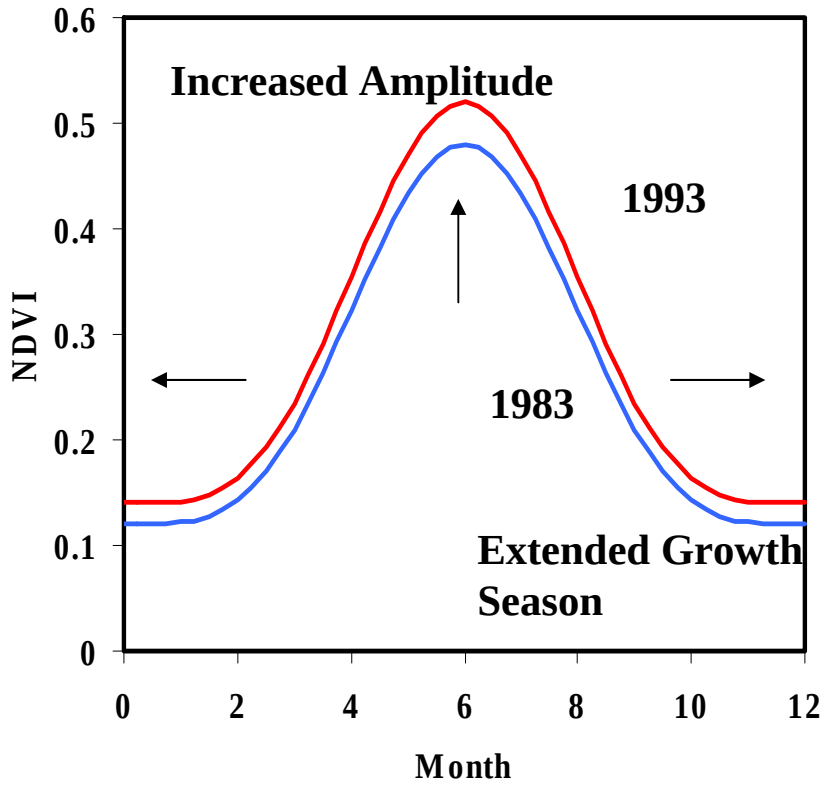


Anderson et al., 2007

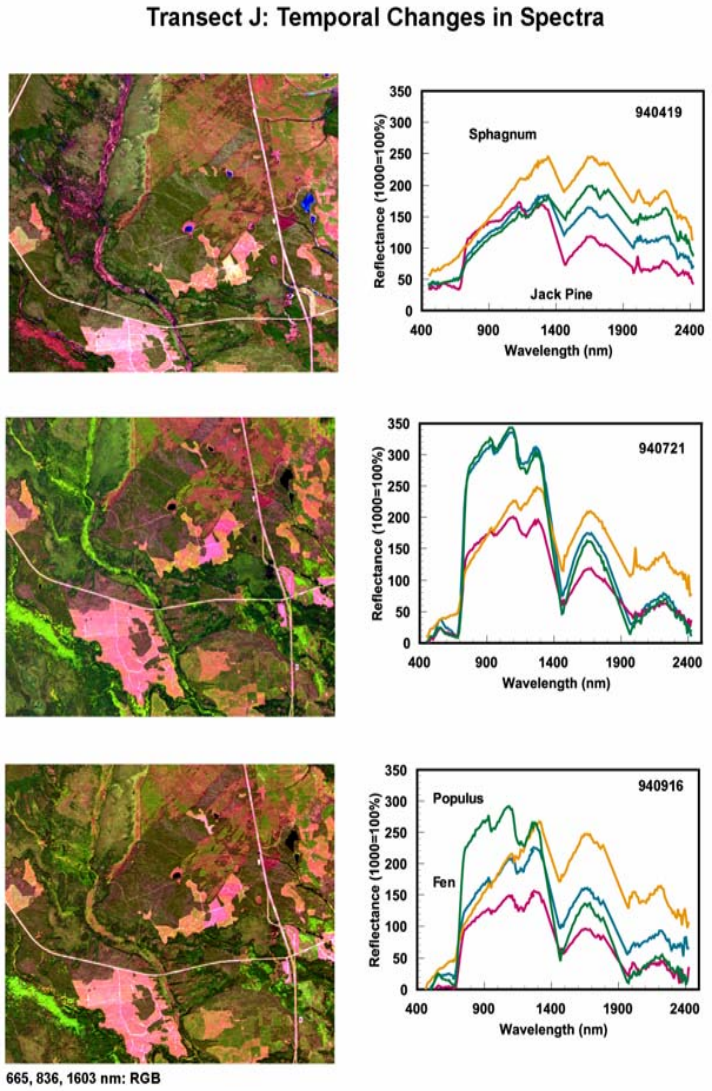
CQ4. Sub Questions

- **What is the vegetation phenological response to seasonal and interannual changes in temperature due to climate change and how does this response vary at the community/species level? [DS 196, 203, 206]**

High Latitude Phenology



Myneni et al., 1997: Nature
Tucker et al., 2001: Int. J. Biometeol



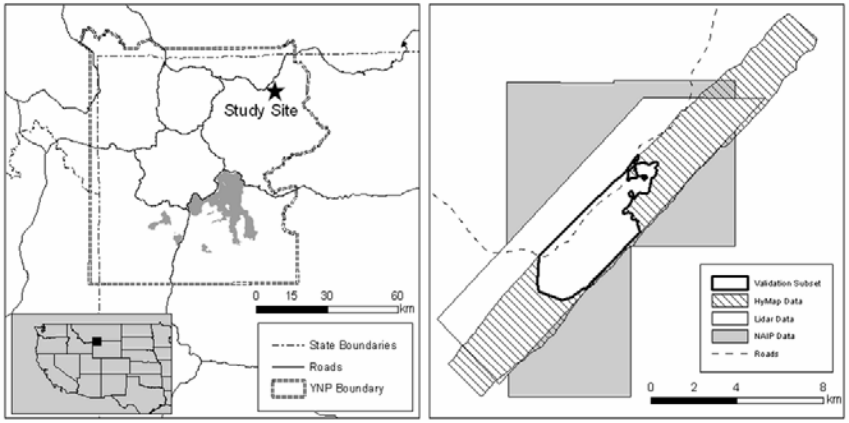
The extended growth season and increased NDVI amplitude are likely a response to higher temperatures
Important compositional changes and feedbacks such as forest/tundra albedo feedbacks are likely important

Roberts et al., 1999

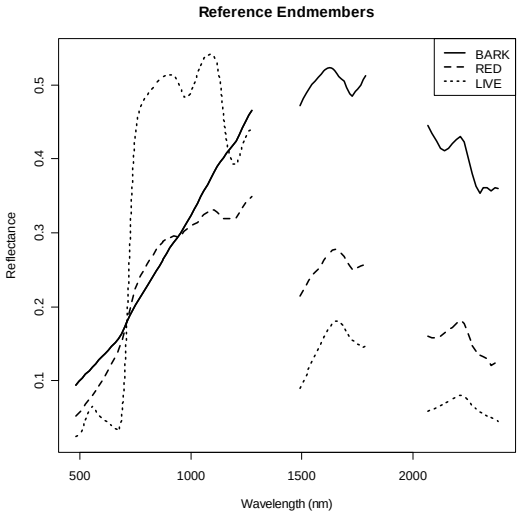
CQ4. Sub Questions

- **What are the feedbacks between changes in canopy composition, crown mortality and retrieved canopy temperatures resulting from disturbances (e.g., disease, moisture deficiency, insect attack) in forest ecosystems? [DS 166, 196, 203, 206]**

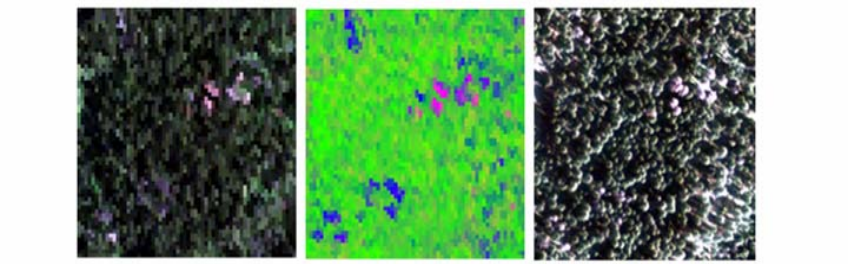
Crown Mortality: Pine Beetles (Halligan, 2007)



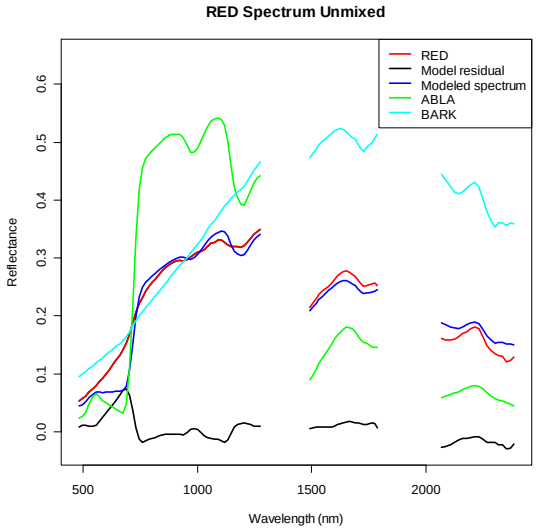
Study Site in Yellowstone National Park



Spectra of red and grey attack phases



Hymap image of crown mortality (left), NAIP image (right), residual center. Blue pixels in the center show Grey phase attack, magenta red phase



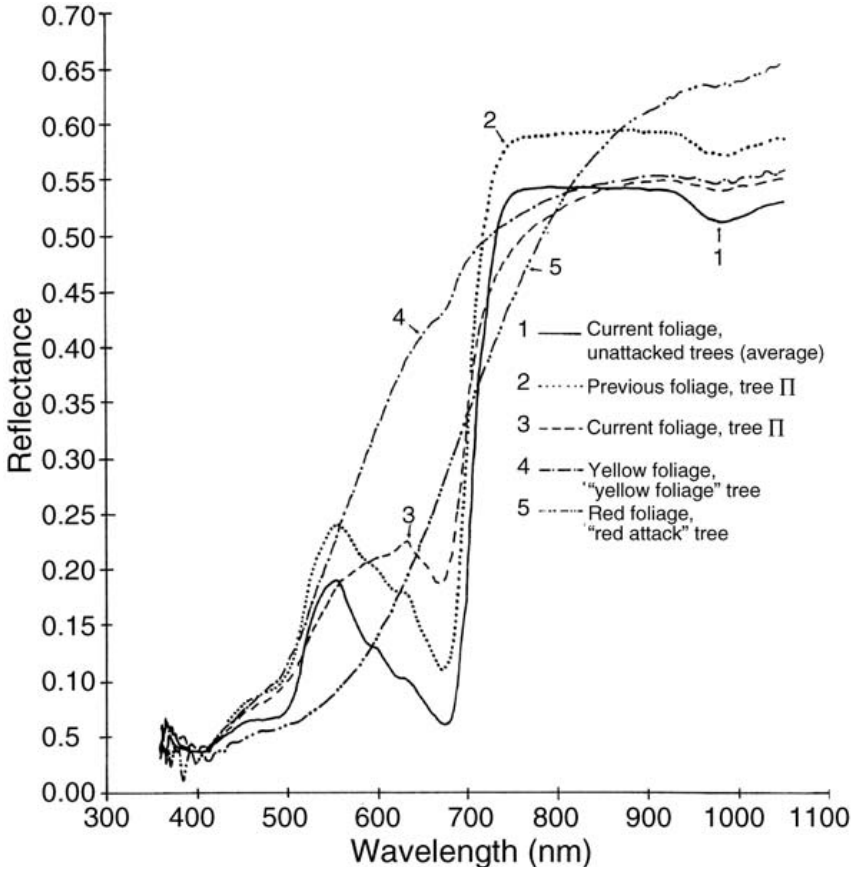
Modeled red-phase attack

Pine beetles are spreading in response to higher temperatures

Crown Mortality

True color image showing multiple Stages of crown mortality

From Wulder M et al., 2005, Forest. Ecol. Management



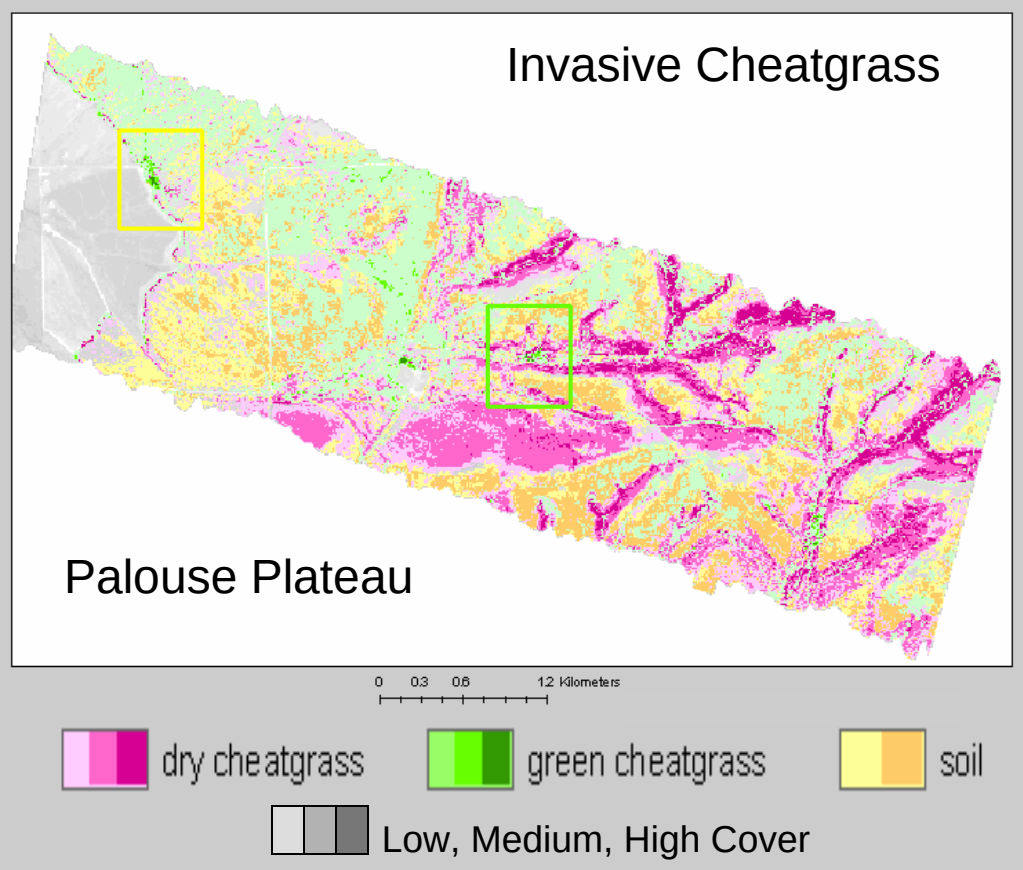
Spectra of uninfected (Current), green (2 &3), yellow and red-phase attack

The spectroscopic impact of forest pathogens is clear. Changes in trace gasses fluxes and emissivity are less clear

CQ4. Sub Questions

- **How do climate-induced temperature and moisture changes impact the distribution and spread of invasive species? [DS 196, 203]**

Cheat Grass, Disturbance and Change



From Susan Ustin

- **Cheat grass is spreading through a combination of disturbance and strategic moisture use (early growth and maturation)**
- **Cheat grass alters fire regimes, facilitating its spread**
- **Early Cheat grass ET reduces soil moisture, reducing competition**
- **HyspIRI is critical for estimating ET and mapping Cheat grass through phenology**

Summary

- **Temperature is a major factor modifying the timing of important ecosystem processes**
- **Ecosystem response to environmental changes in temperature and moisture are expressed in the form of physiology, canopy composition and competition**
- **Environmental changes in temperature and moisture facilitate large scale shifts in ecosystems, invasive species and feedbacks**
  - **Forest-tundra feedback**
- **HyspIRI will improve our ability to quantify these changes and lead to improved observations (ie, temperature estimates better accounting for crown mortality)**
- **Much of the potential of combined thermal and VNIR/SWIR is unexplored**