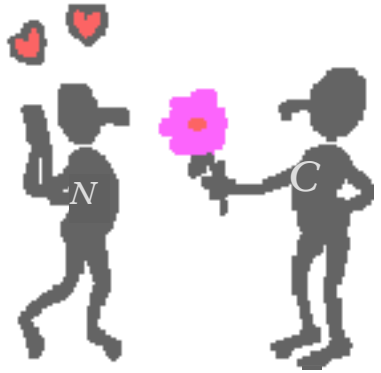
# *The Coupled Nature of C and N Cycles in Forest Ecosystems:*

## *Evidence and Uncertainties*

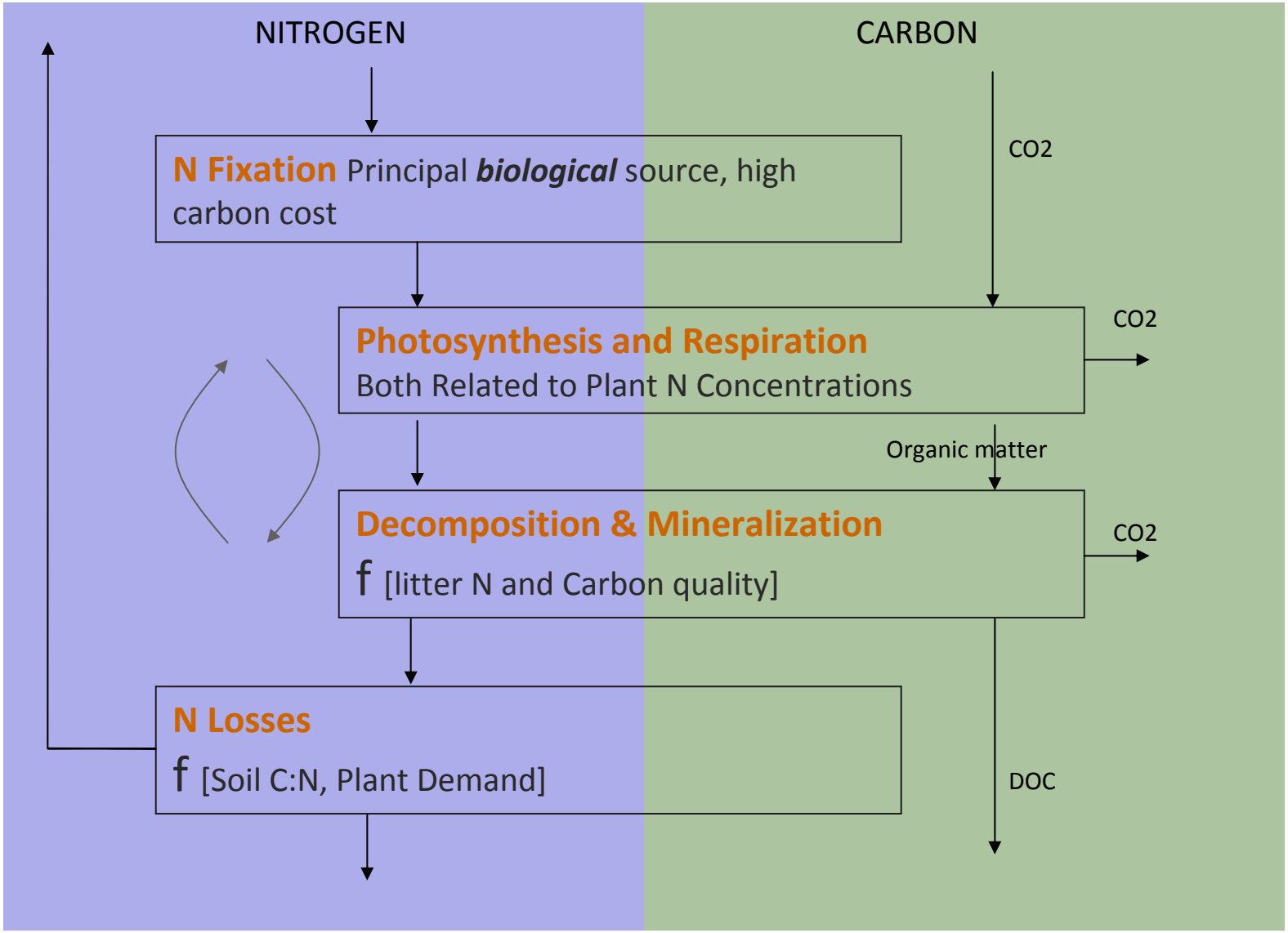



Scott Ollinger, University of new Hampshire

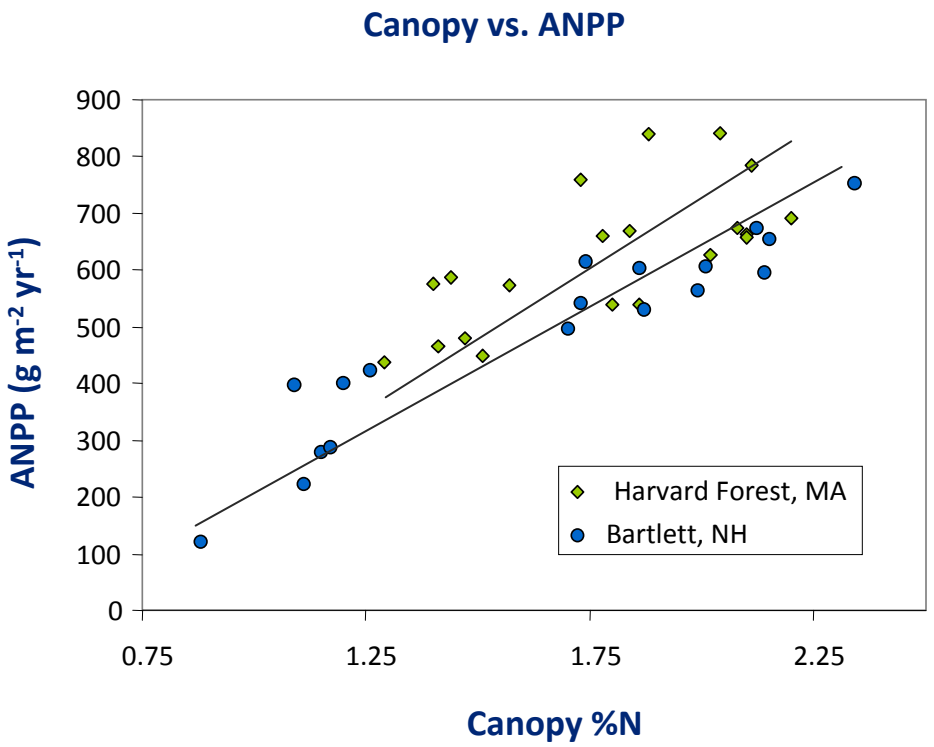
HyspIRI Workshop, Pasadena, CA, 8/12/2009

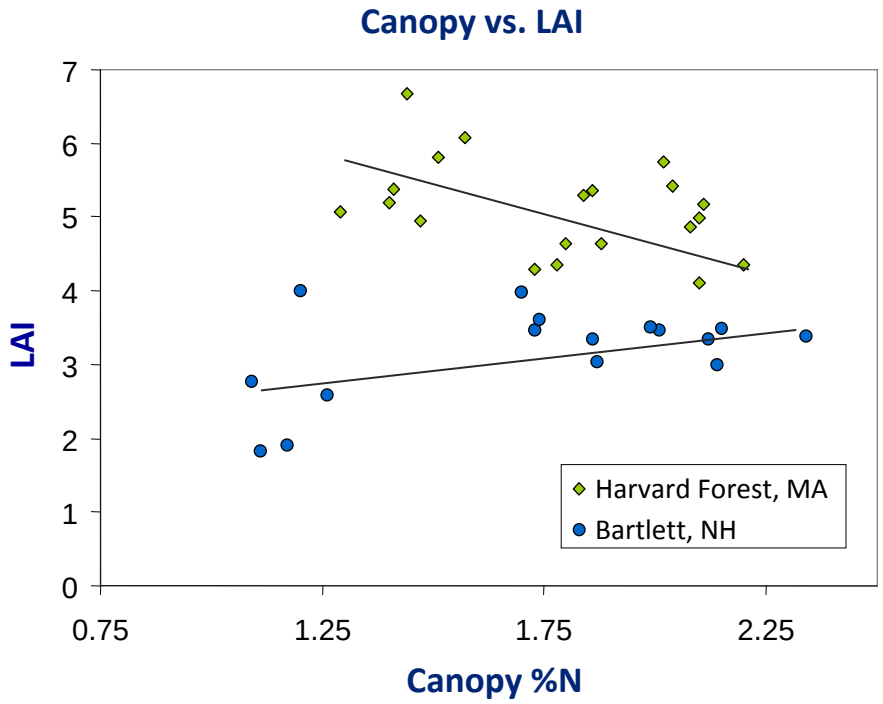
UNIVERSITY of NEW HAMPSHIRE

# *C & N: Joined by a Shared Set of Biological Reactions*

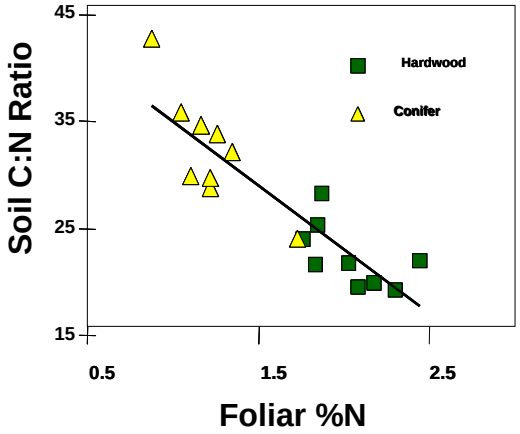


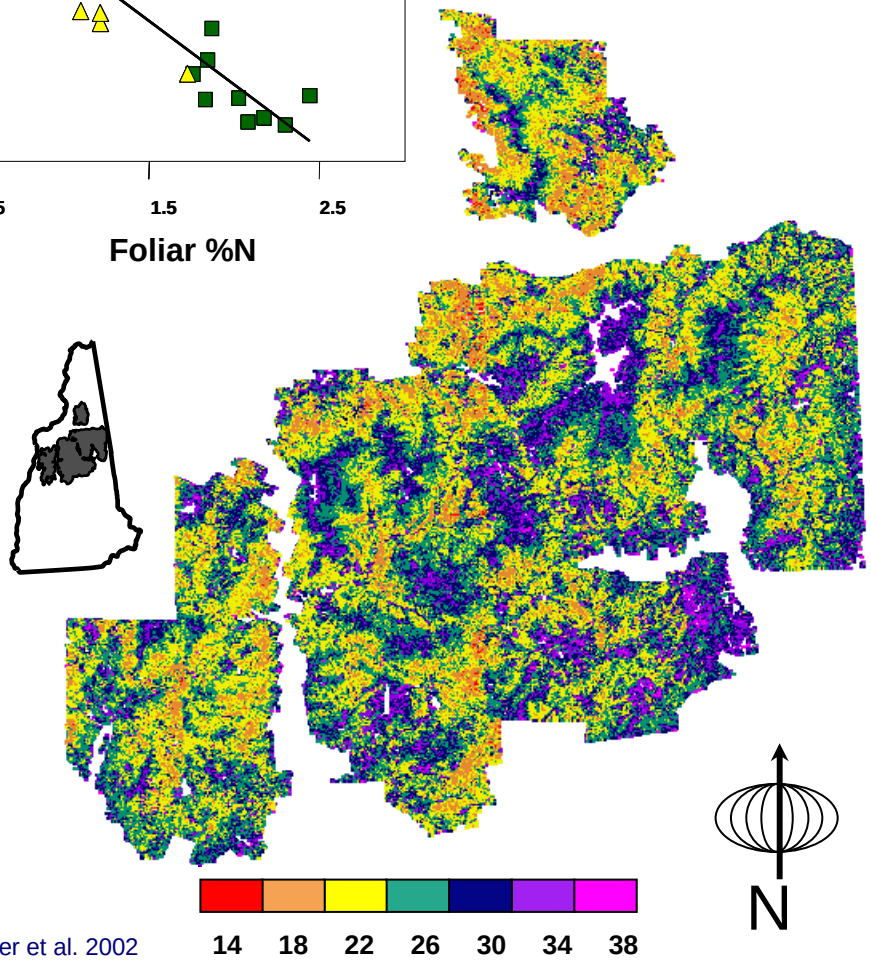
# *ANPP in Most Eastern U.S. Temperate Forests Scales with N Status, not LAI.*



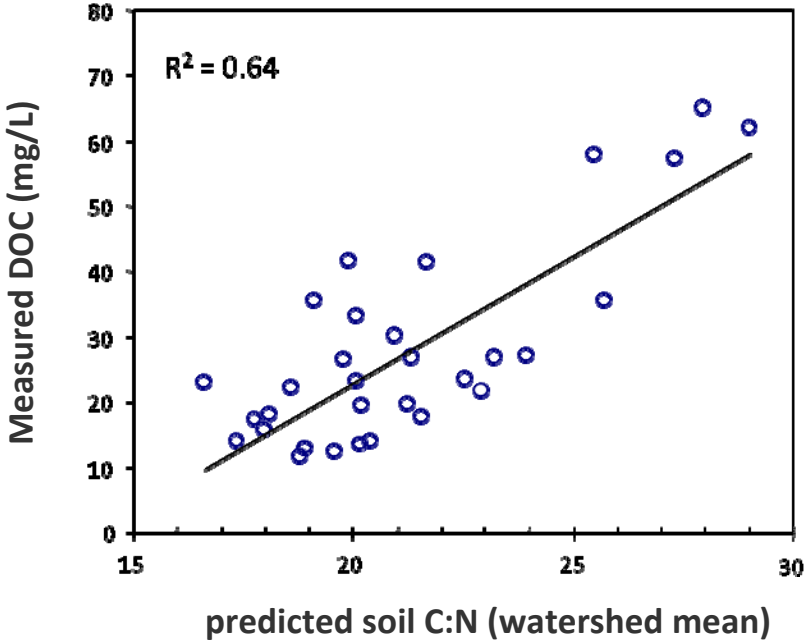
# *AVIRIS-Predicted Foliar Chemistry Used to Estimate Soil Nitrogen Cycling*



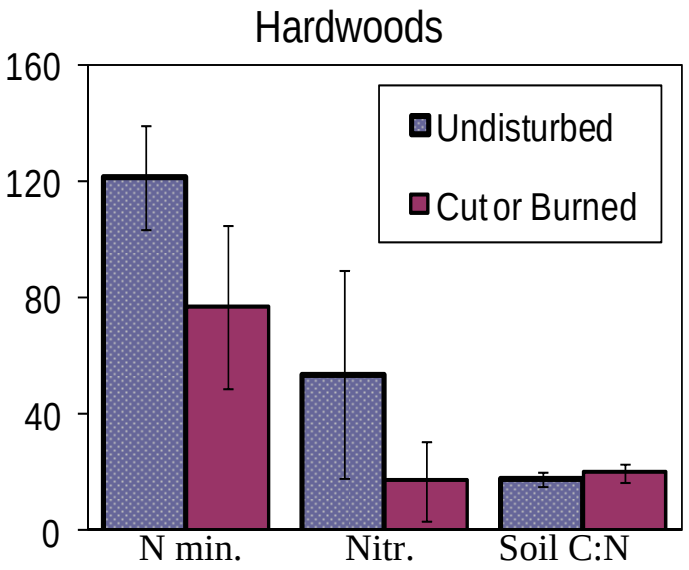



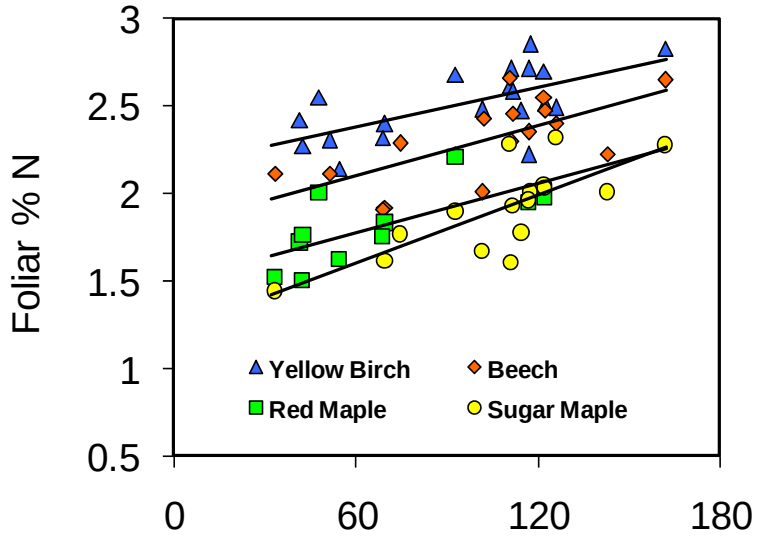

Ollinger et al. 2002

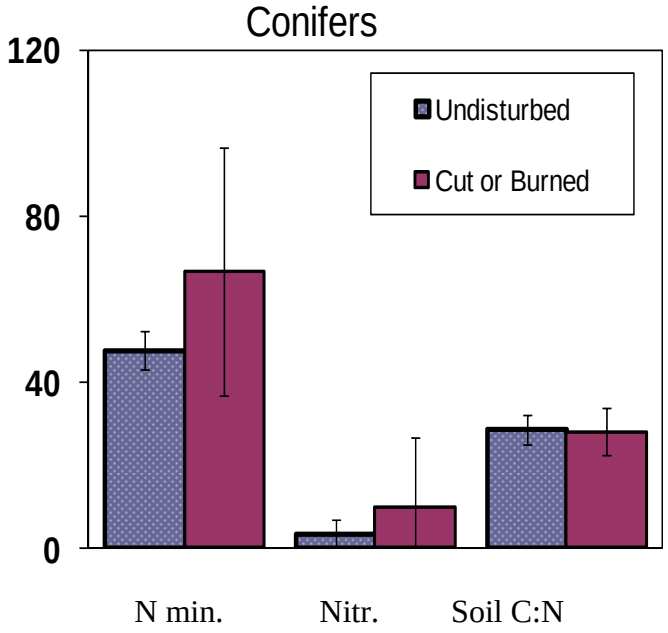
## Predicted C:N versus Stream DOC

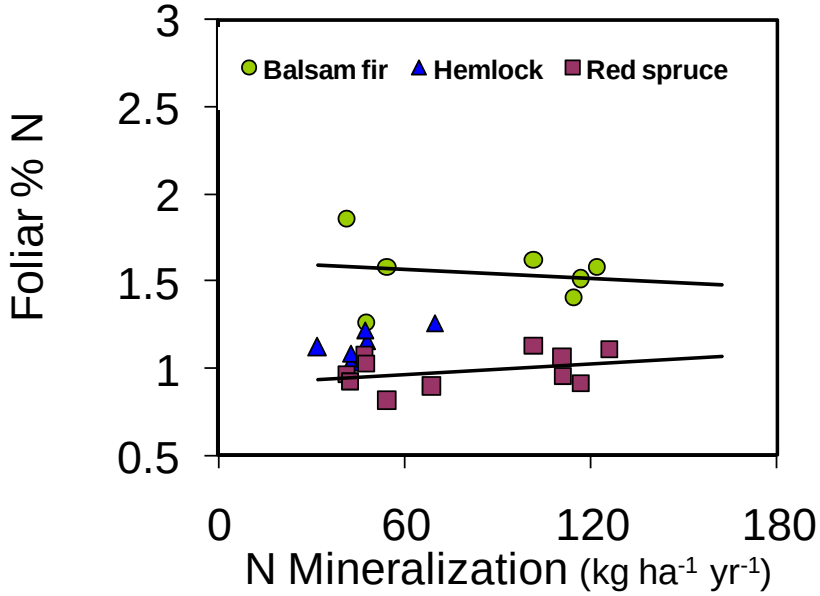


# Disturbance History and Species Effects



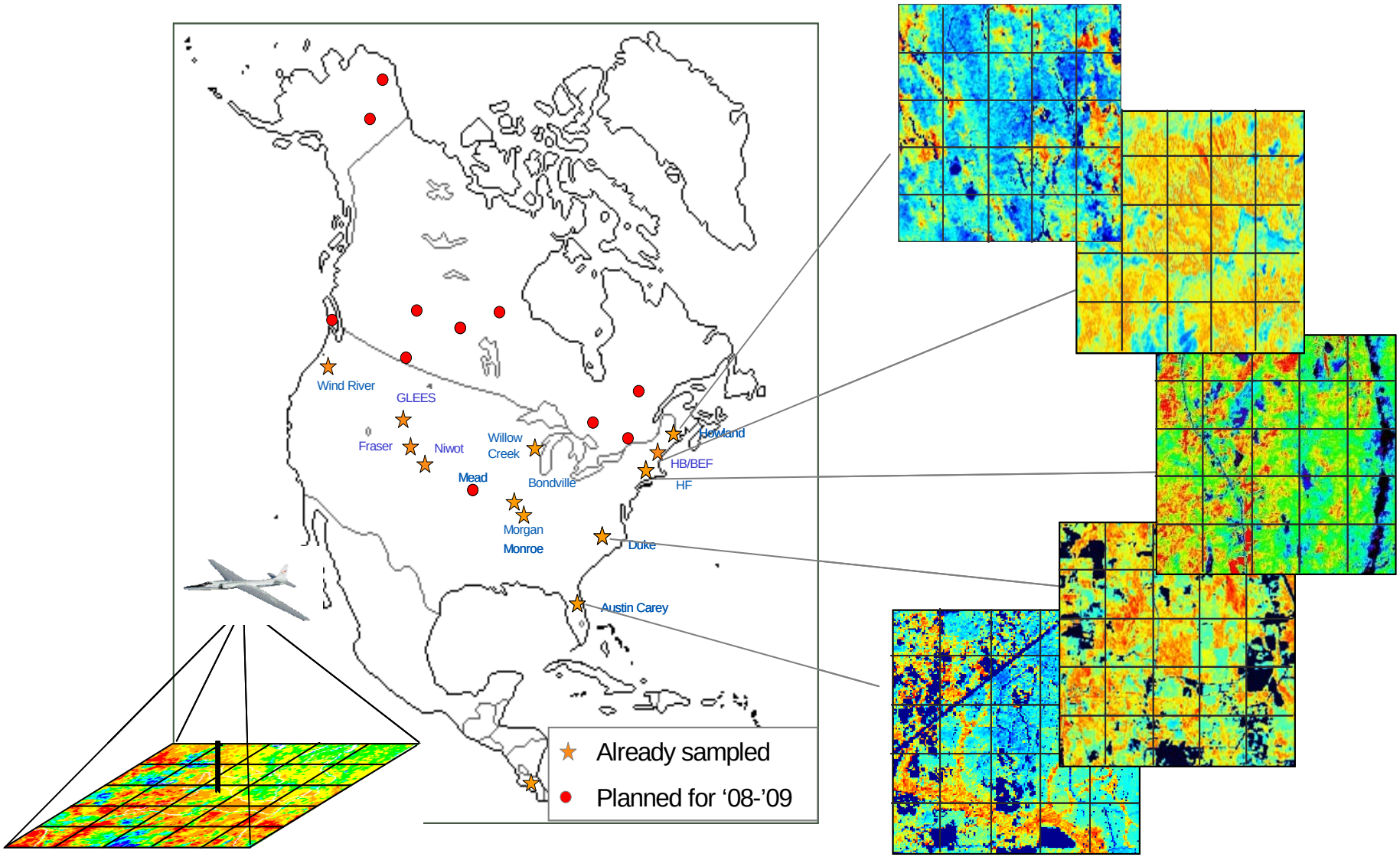
Nitrogen availability is a key constraint on carbon cycling in terrestrial ecosystems and it is largely in this capacity that the role of nitrogen in the climate system has been considered.

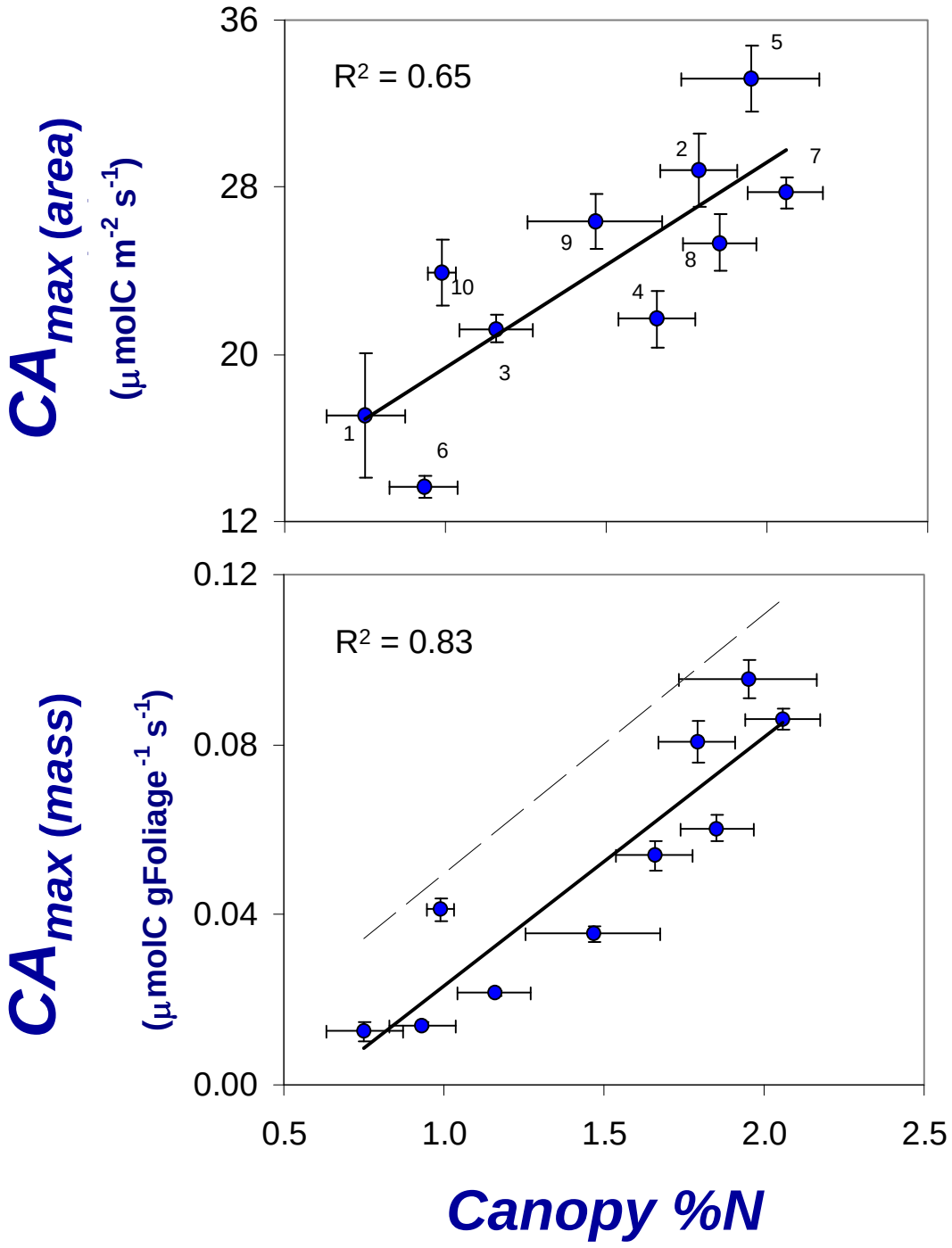
Nevertheless, broad-scale analyses rarely include spatial variation in plant N status as a driving variable. ***WHY?***

***1.*** *Uncertainty about how leaf-level photosynthesis-nitrogen relationships aggregate to whole canopies and ecosystems.*

***2.*** *There are no methods to remotely sense canopy nitrogen concentrations at broad spatial scales.*

# *APPROACH: Continental synthesis of $CO_2$ Flux data, field measurements, imaging spectroscopy and global satellite sensors*



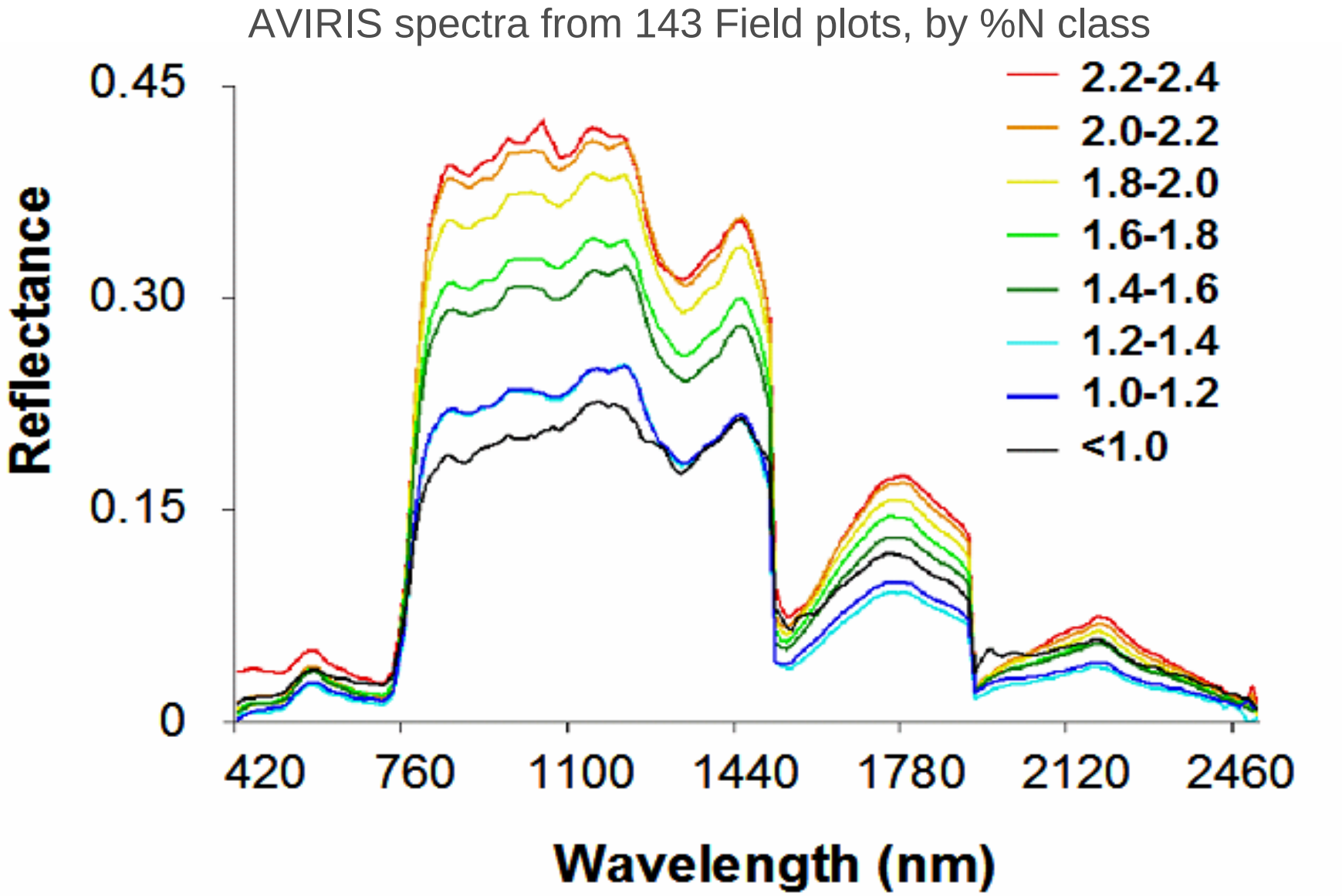



| | |
|---|---|
| 1 | Wind River Experimental Forest, WA |
| 2 | Willow Creek, WI |
| 3 | Howland, ME |
| 4 | Bartlett Experimental Forest, NH |
| 5 | Harvard Forest, MA |
| 6 | Niwot Ridge, CO |
| 7 | Morgan Monroe State Forest, IN |
| 8 | Duke Forest Deciduous, NC |
| 9 | Duke Forest Pine, NC |
| 10 | Donaldson Tract, FL |

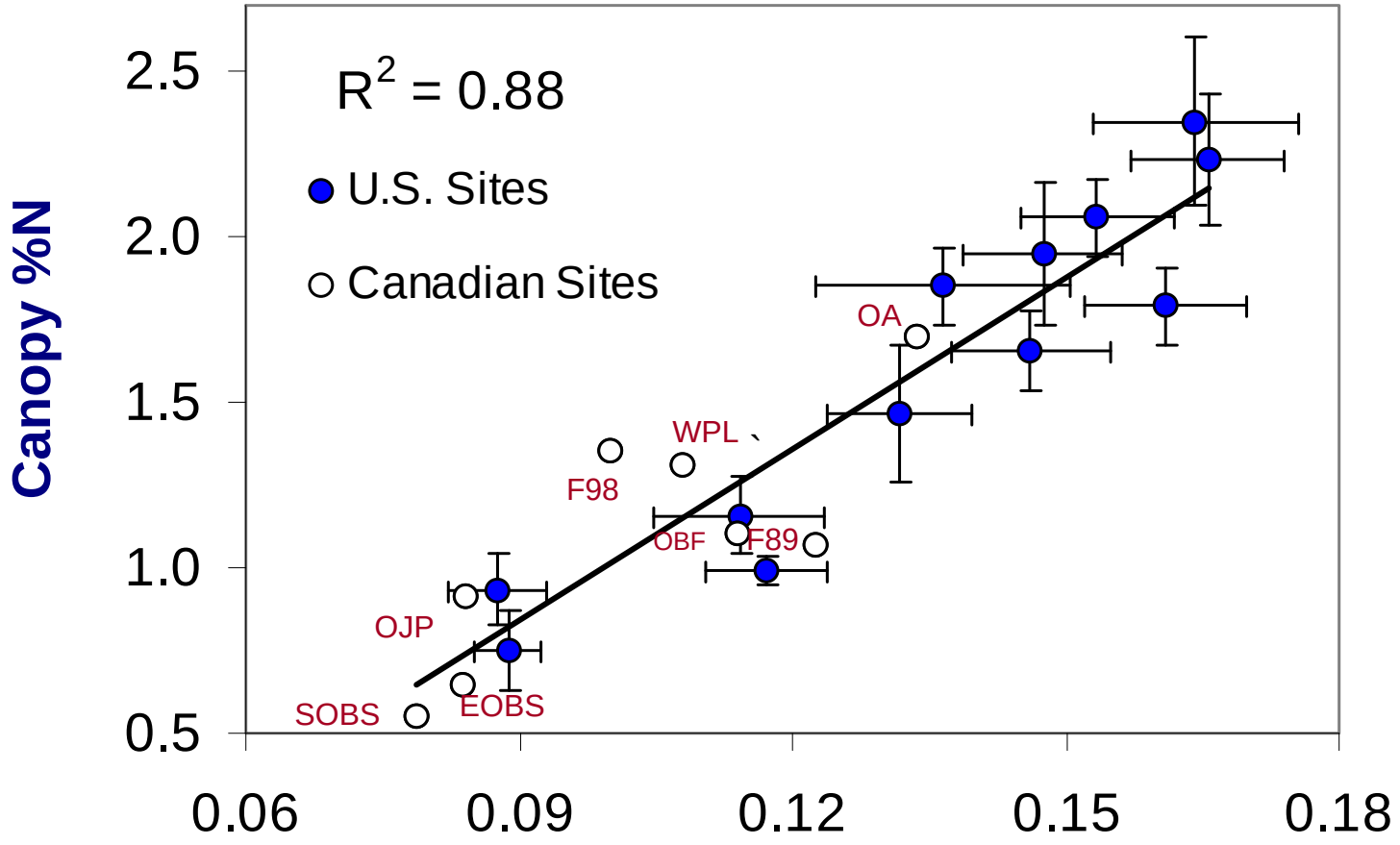
***Dashed Line: Leaf-level trend from Wright et al. 2004 global leaf traits data set.***

***Is there hope for continental-scale detection of canopy N?***

# *CANOPY % N AND FULL SPECTRUM REFLECTANCE*

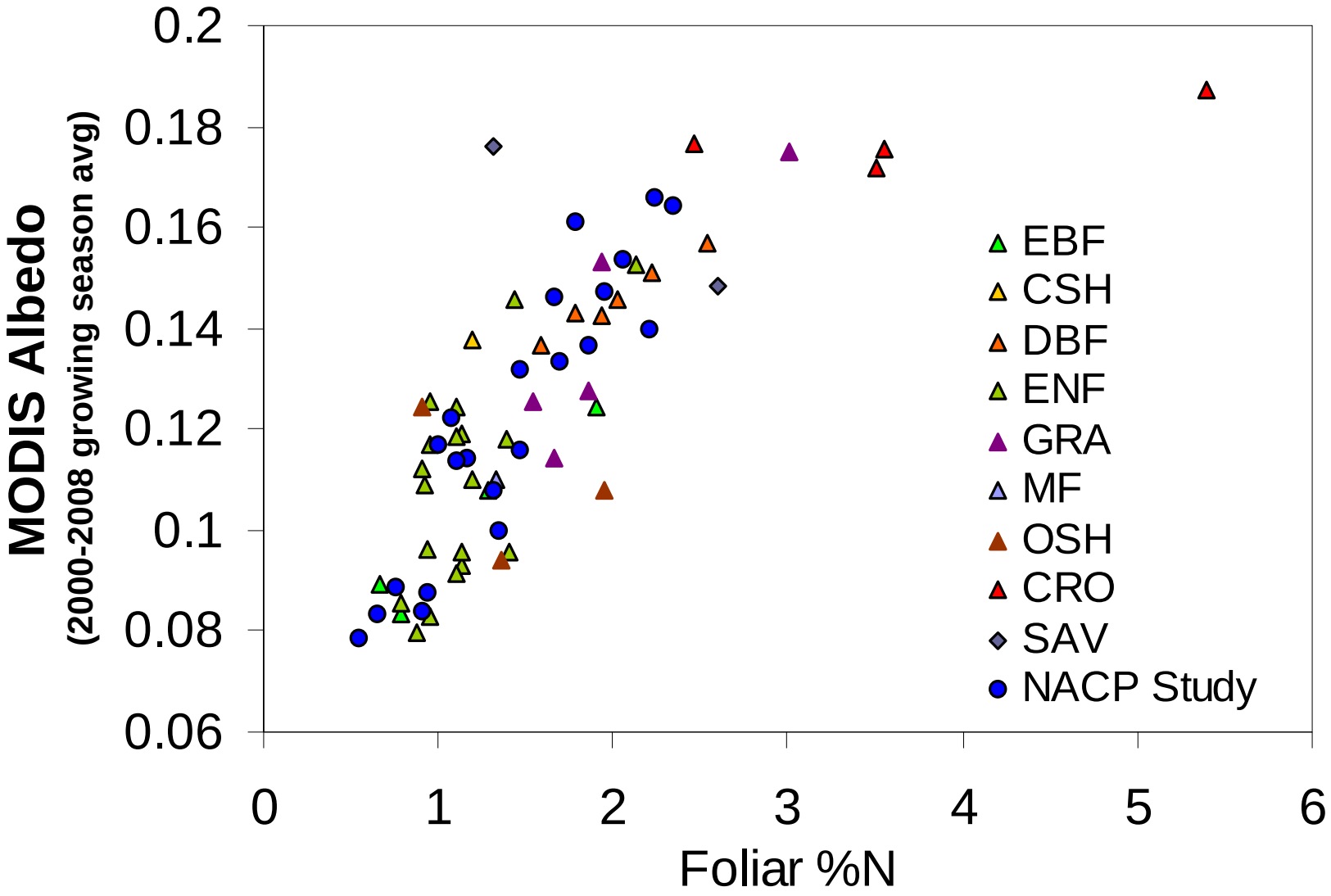


# Canopy N and MODIS Shortwave Albedo




Ollinger et al. 2008, PNAS

# *Extension to other biomes using FLUXNET*



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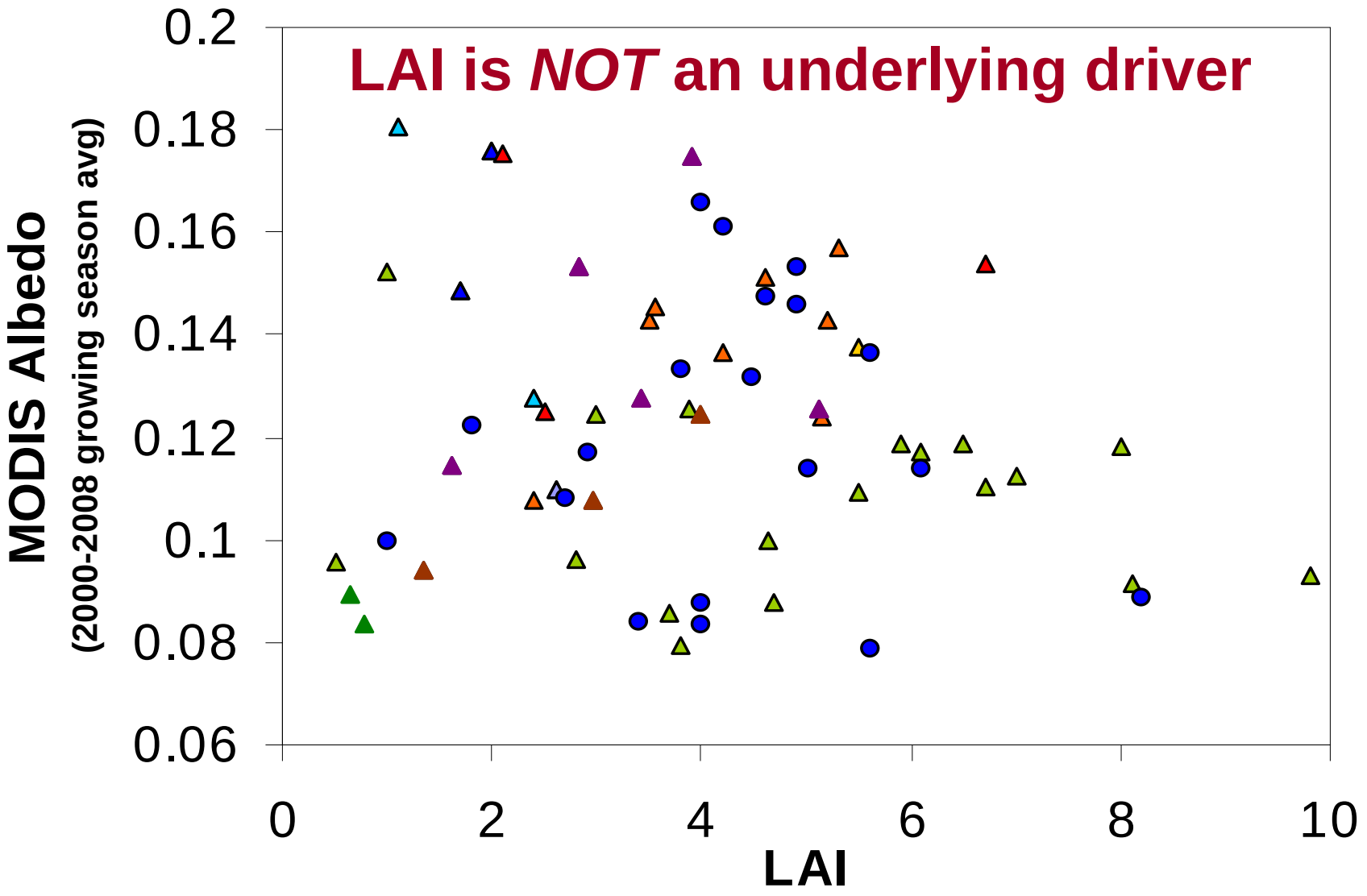
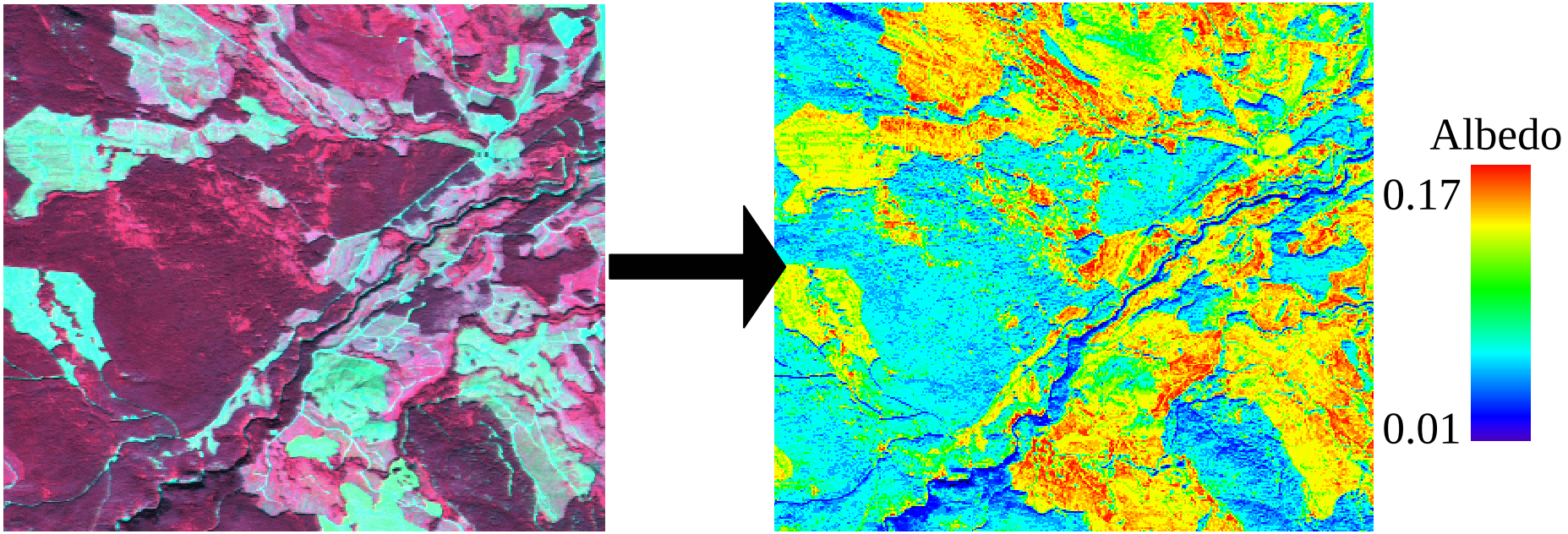
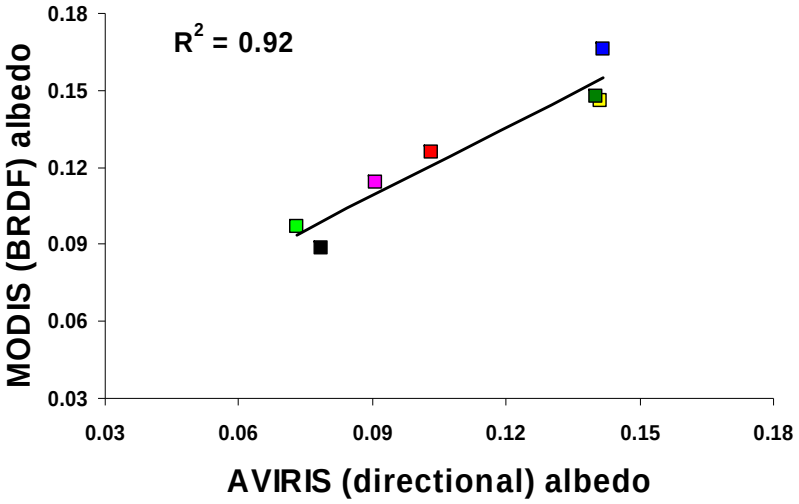


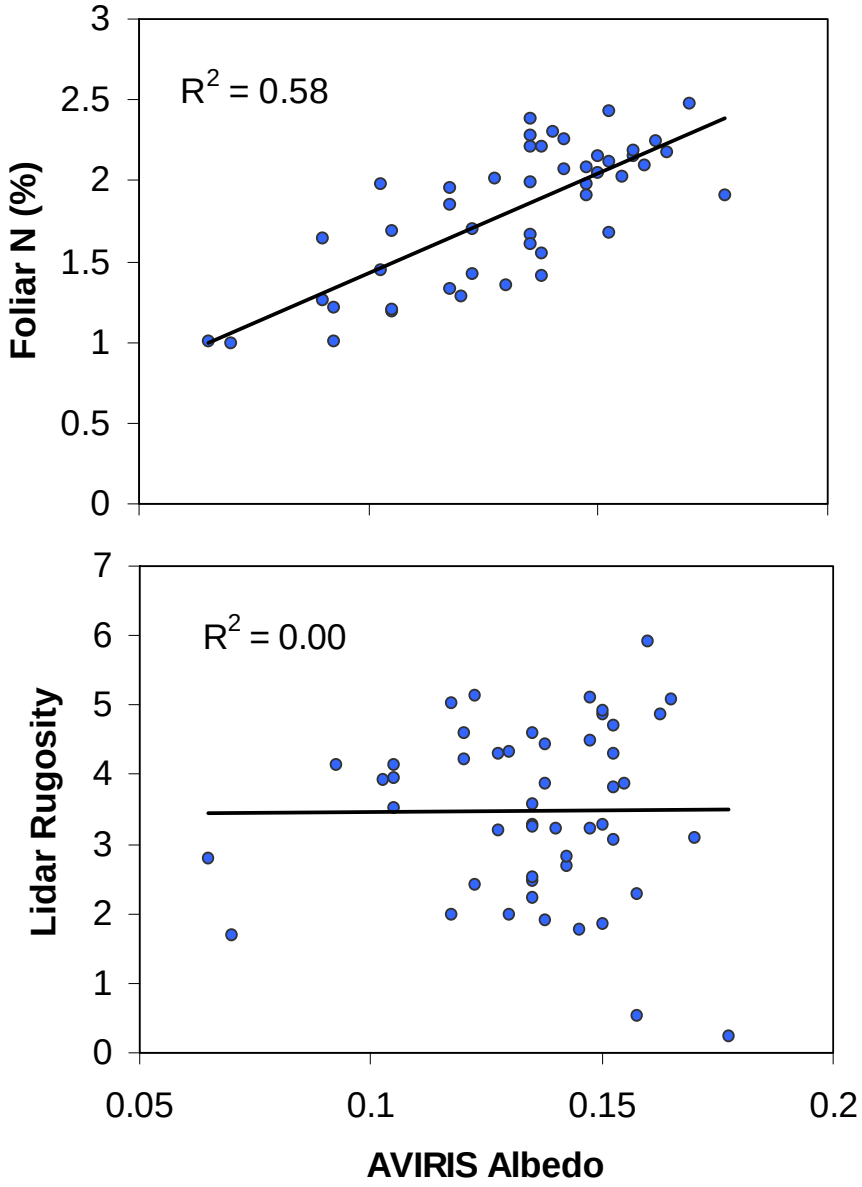
# AVIRIS reflectance (left) used to calculate shortwave surface albedo (right).



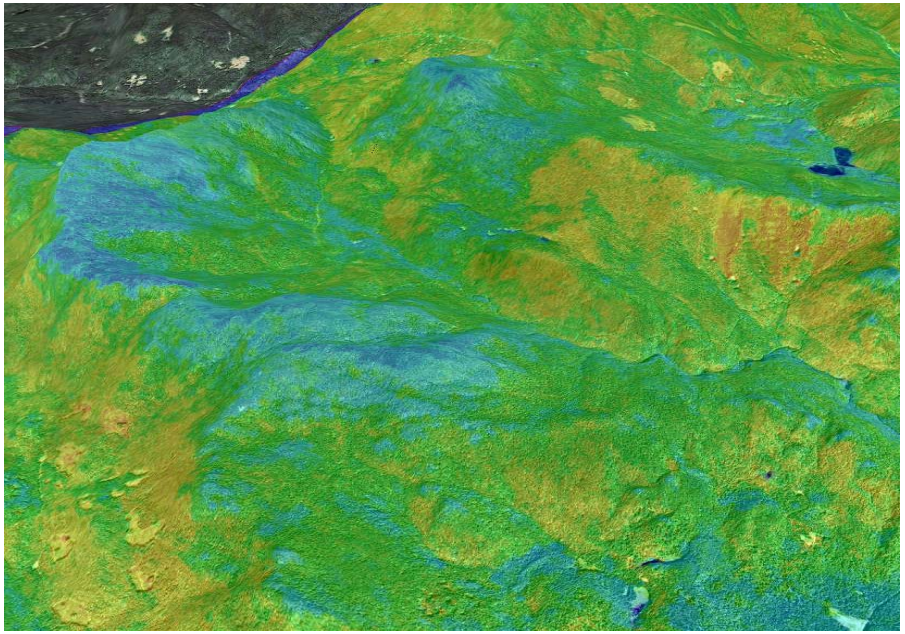

- Bartlett, NH
- Hubbard Brook, NH
- Harvard Forest, MA
- Howland, ME
- Wind River, WA
- Campbell River (Harvested), BC
- Campbell River (Mature), BC

# Landscape-scale patterns of %N and canopy structure




At 20 m spatial resolution, the N-based relationship holds.

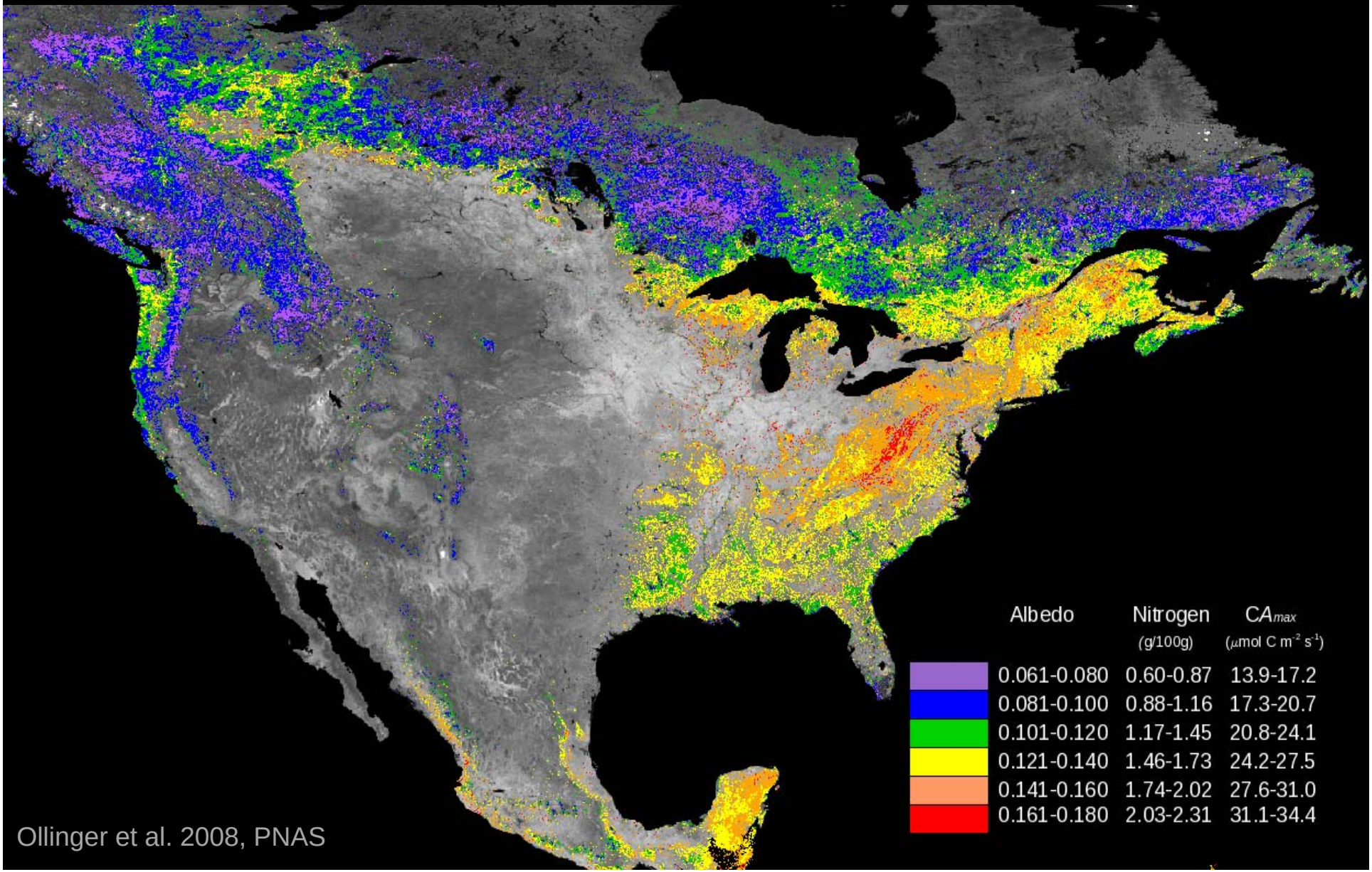
No effect of canopy surface roughness (Rugosity)



# *DOES NITROGEN PLAY A PREVIOUSLY UNRECOGNIZED ROLE IN THE CLIMATE SYSTEM?*

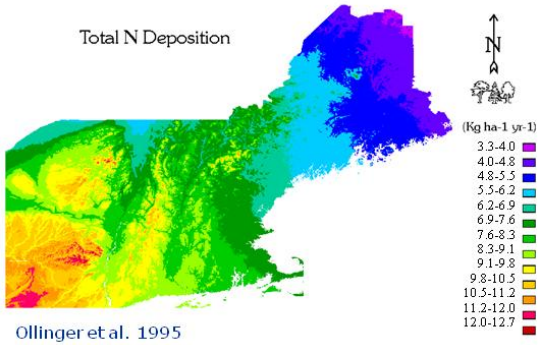
- C cycle effects and albedo effects typically viewed as separate mechanisms.
- Our results indicate that they are more intimately related and are linked via plant nitrogen status.
- This suggests a potential feedback in the climate system involving the N cycle as a regulator of both C cycling *AND* energy exchange.

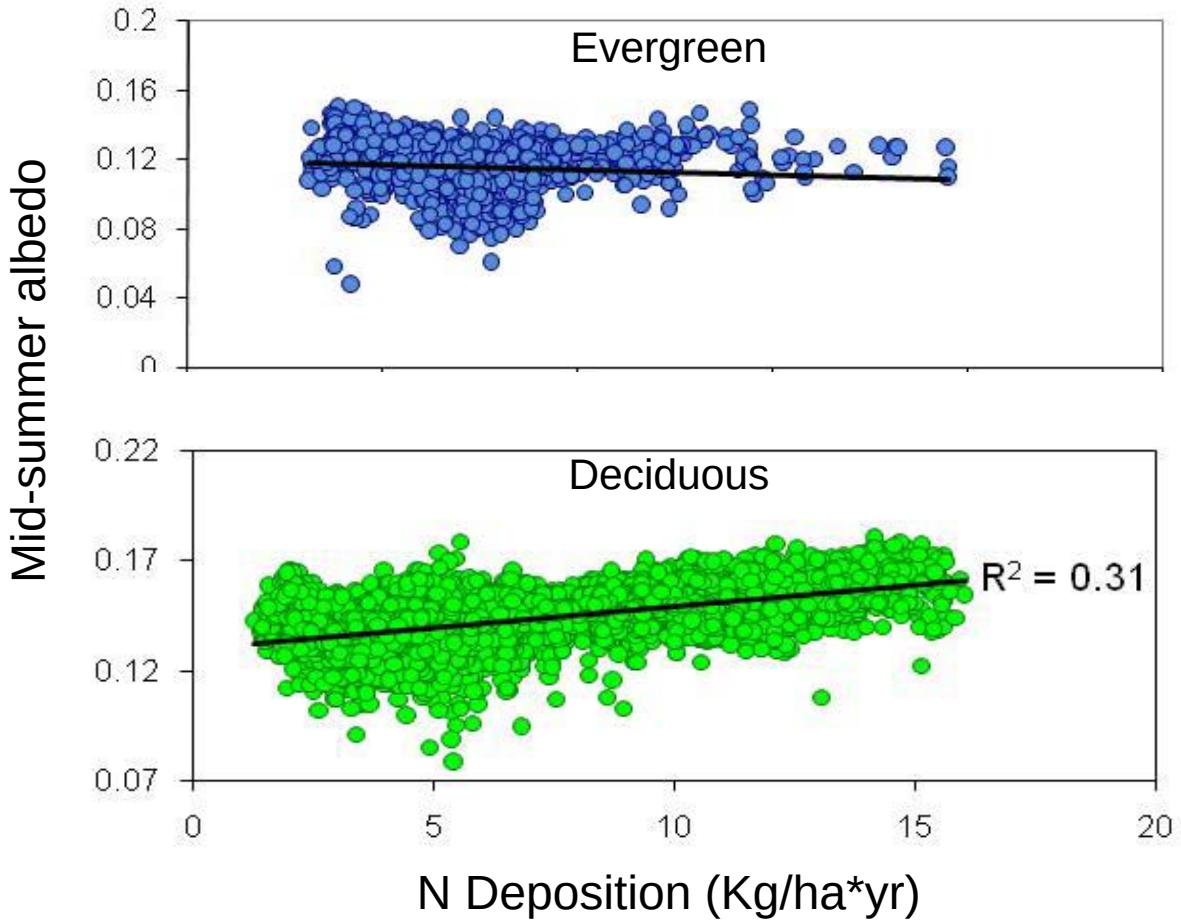
# *Predicted Canopy Nitrogen and Photosynthetic Capacity in N. American Forests*




Ollinger et al. 2008, PNAS

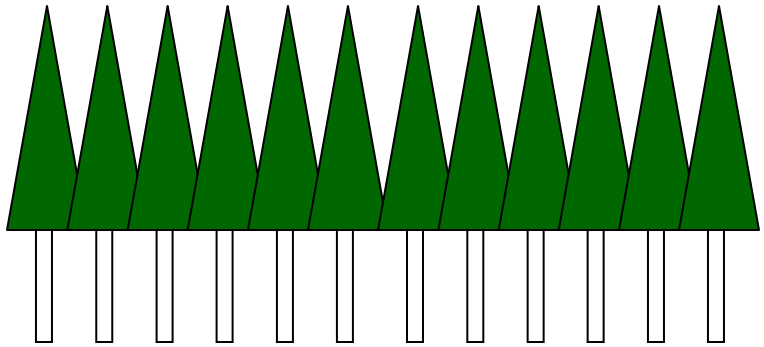
# *Nitrogen Deposition and Mid-Summer Shortwave Albedo*

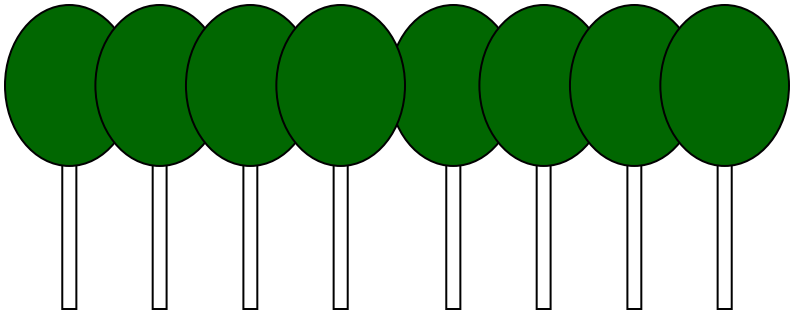


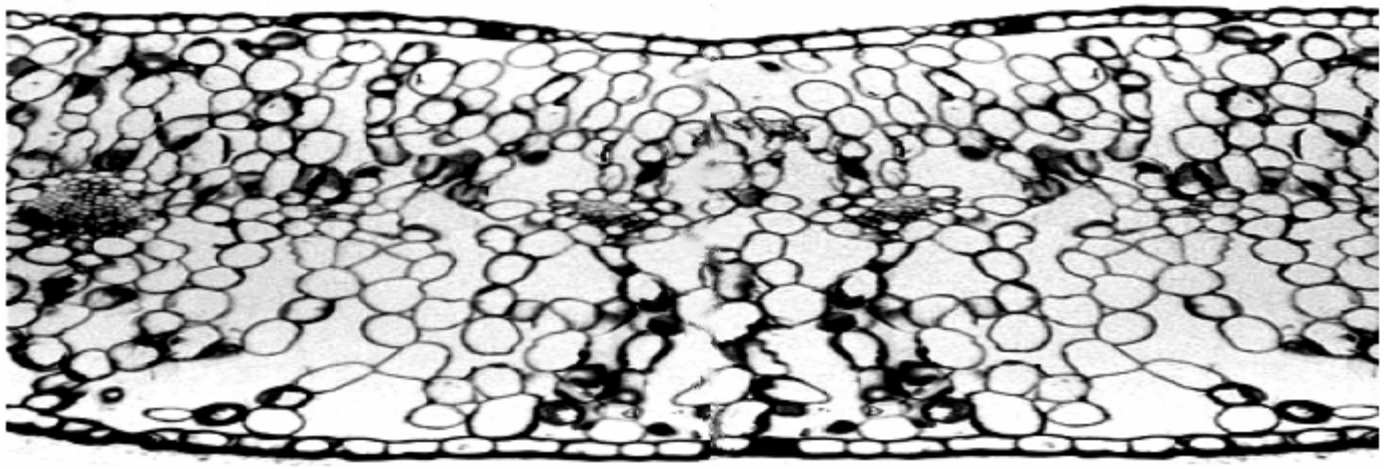
# *WHY ARE NITROGEN AND ALBEDO RELATED?*

- Co-variation between leaf N concentrations and canopy structure?



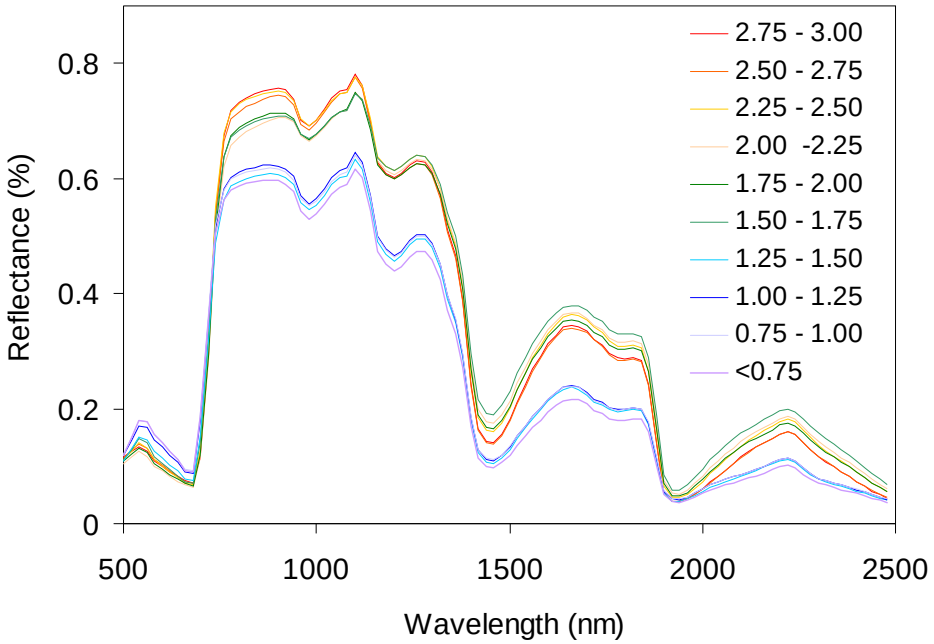


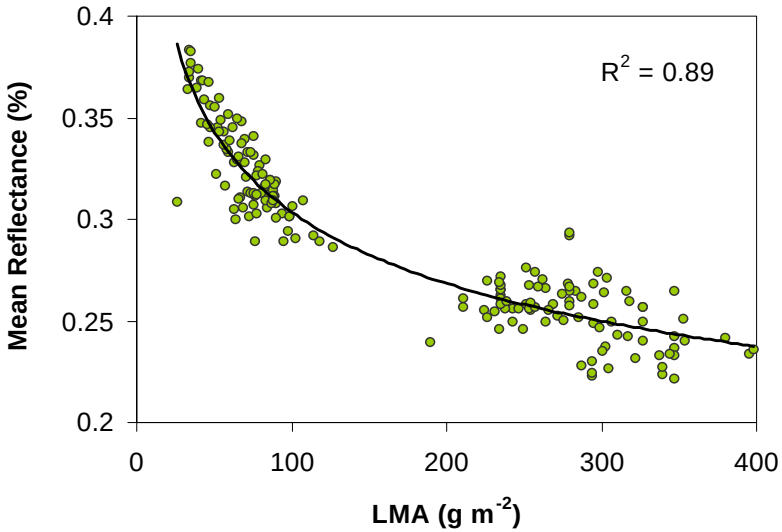
- Co-variation between nitrogen and the cellular structure needed to support different rates of photosynthesis?



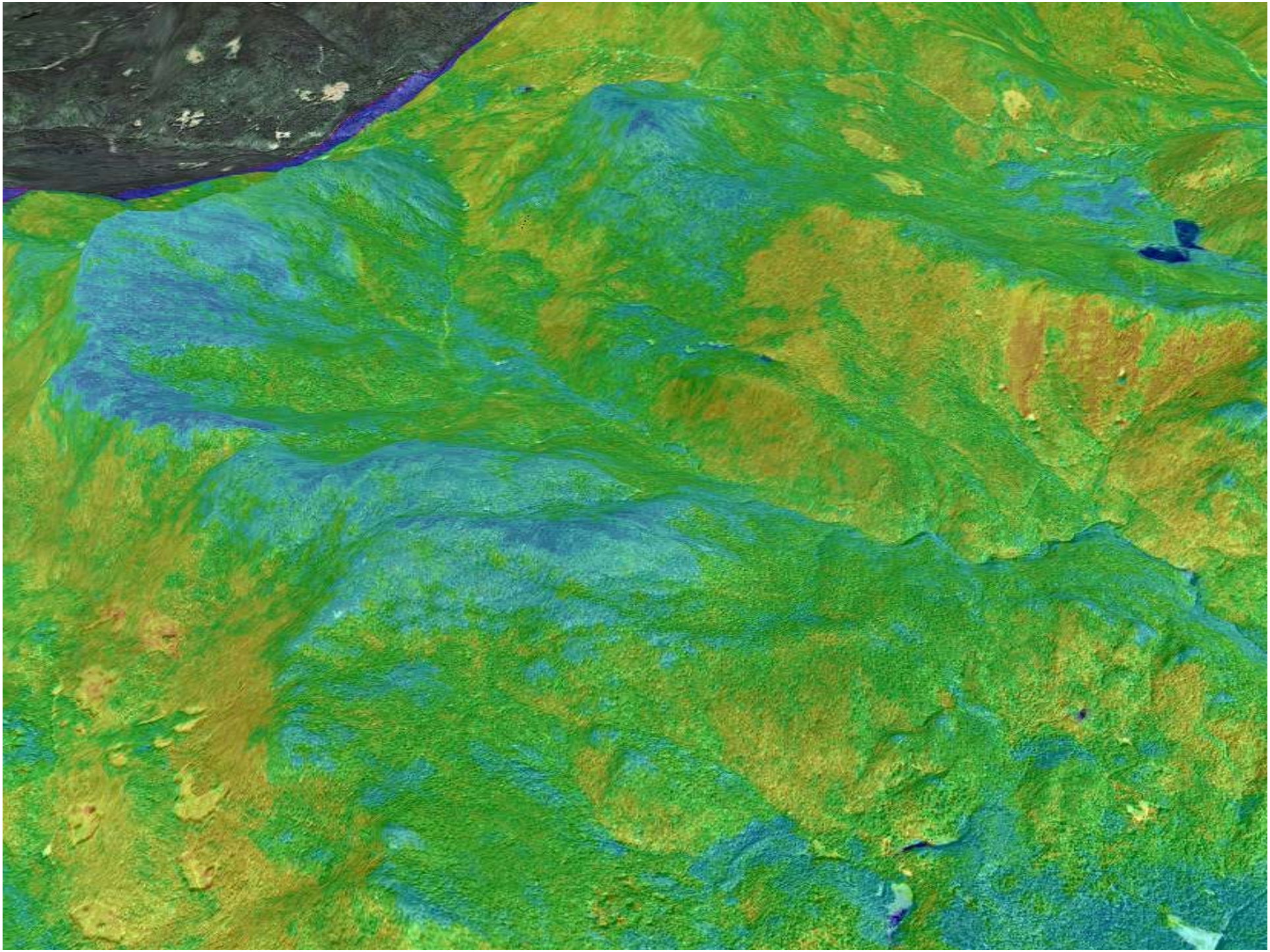
# Leaf-Level Spectra from a Sub-set of Sites

## (MMSF, Niwot, Fraiser, GLEES)




Multiple regression of albedo vs. leaf %N and LMA: $R^2 = 0.84$

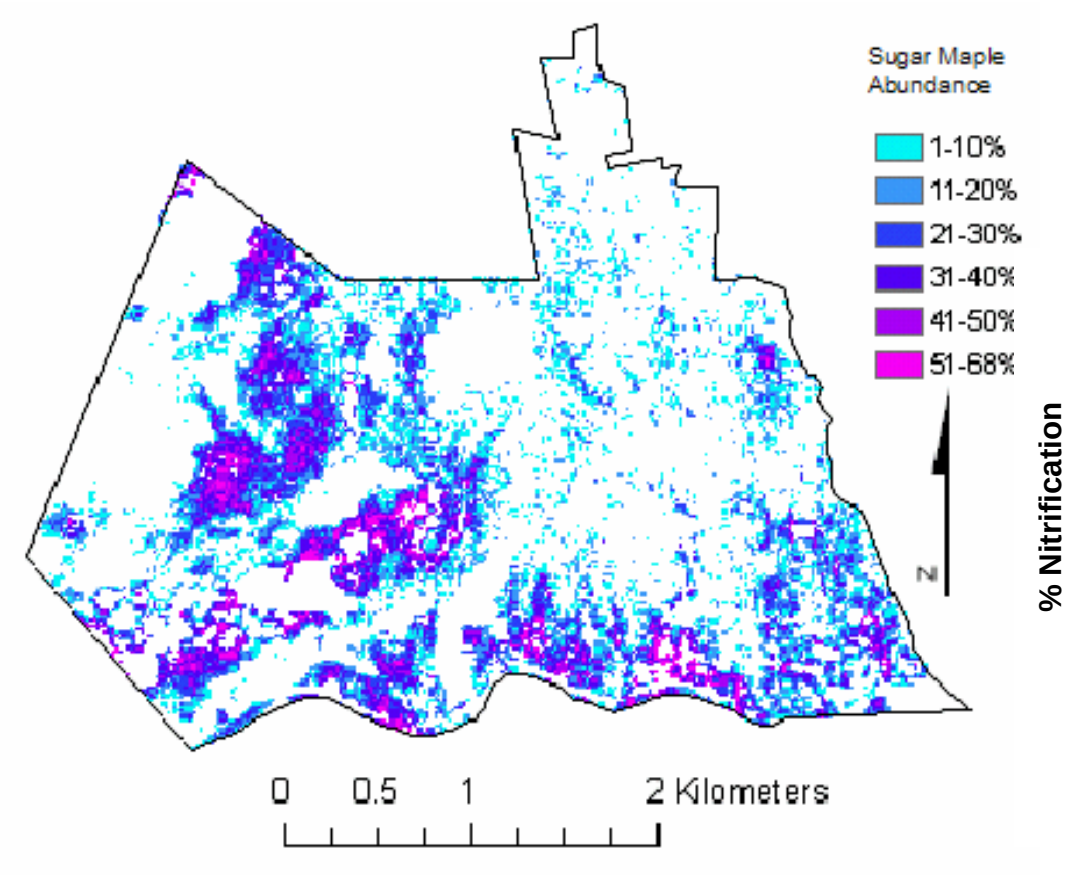


# *Take Home Messages:*

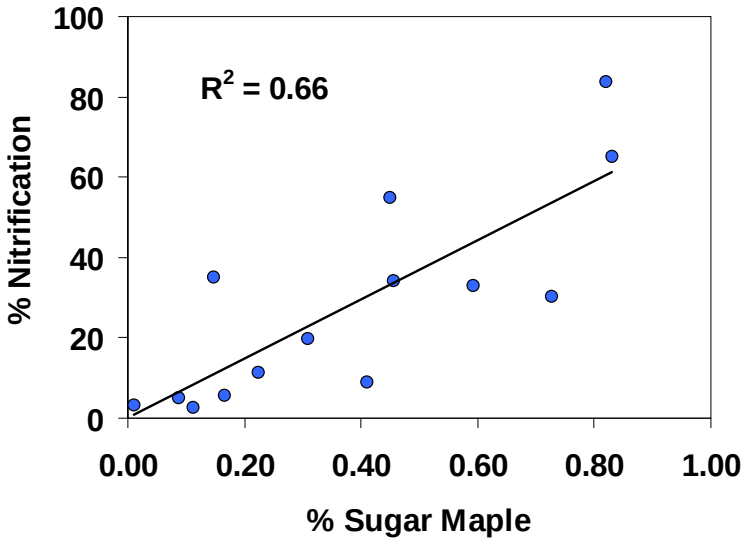
*1.Carbon and Nitrogen, and maybe even energy, are coupled in many terrestrial ecosystems.*

*2.We should do remote sensing/imaging spectroscopy to learn about how nature works, not just for the sake of doing more remote sensing.*

*Interactions between biogeochemical cycles and tree species composition*




Influence of Sugar Maple on the Nitrogen Cycle




Plourde et al. 2007