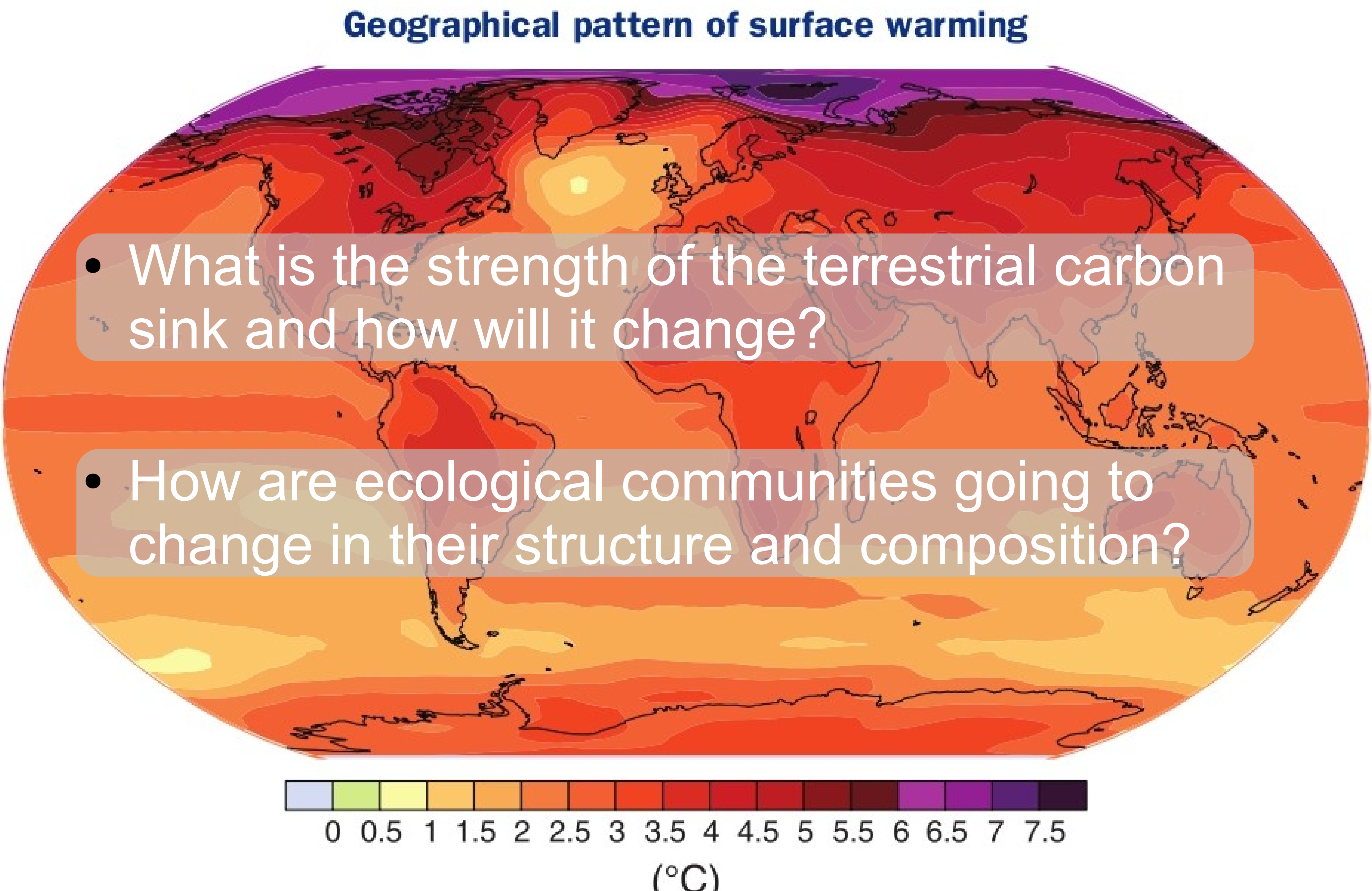
Brown Dog Case Study:

Long Tail Vegetation Data in Ecology and Global Change Biology

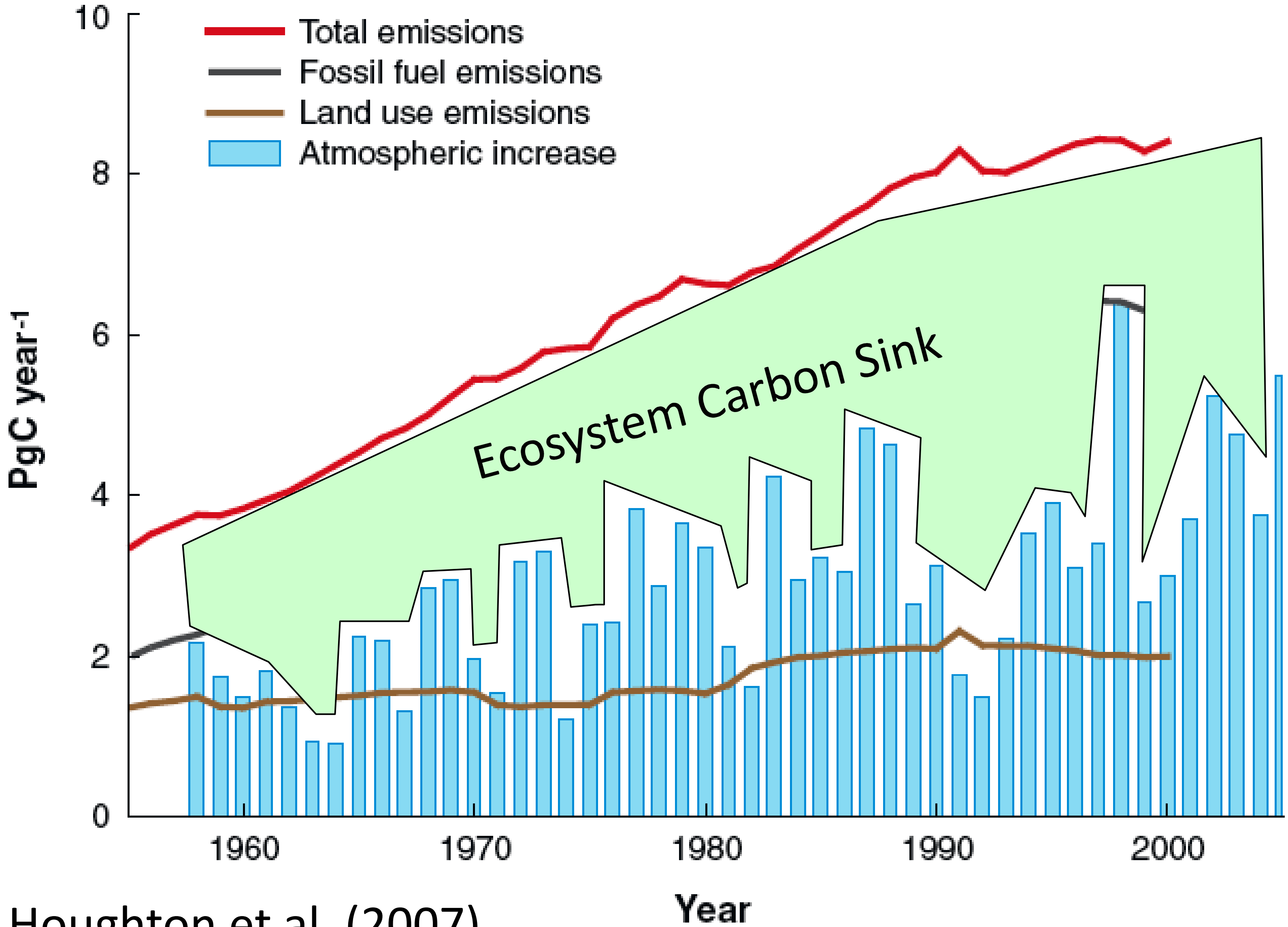
Dietze Lab, Boston University

Climate Change Impacts



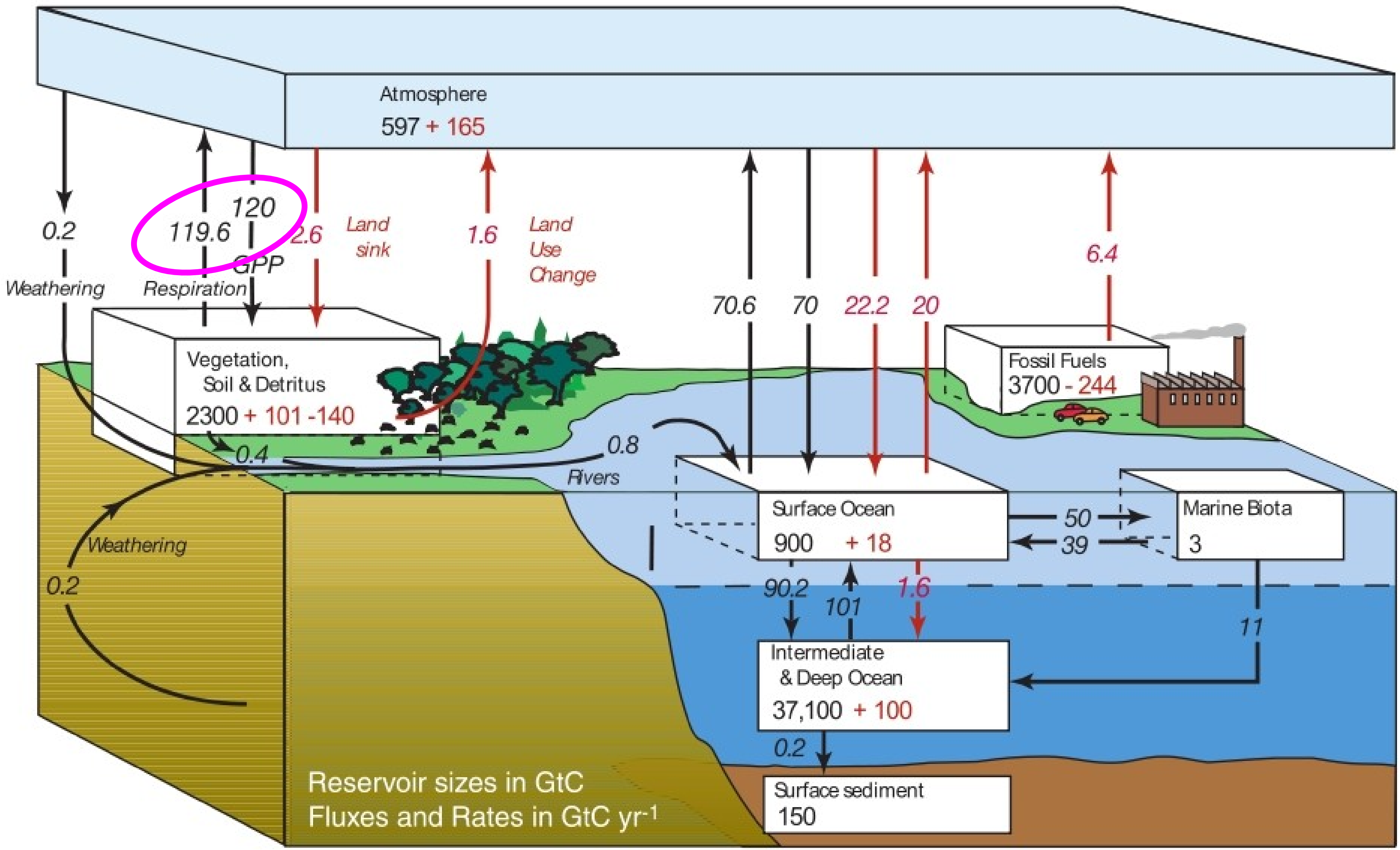
- What is the strength of the terrestrial carbon sink and how will it change?
- How are ecological communities going to change in their structure and composition?

Biology drives Physics



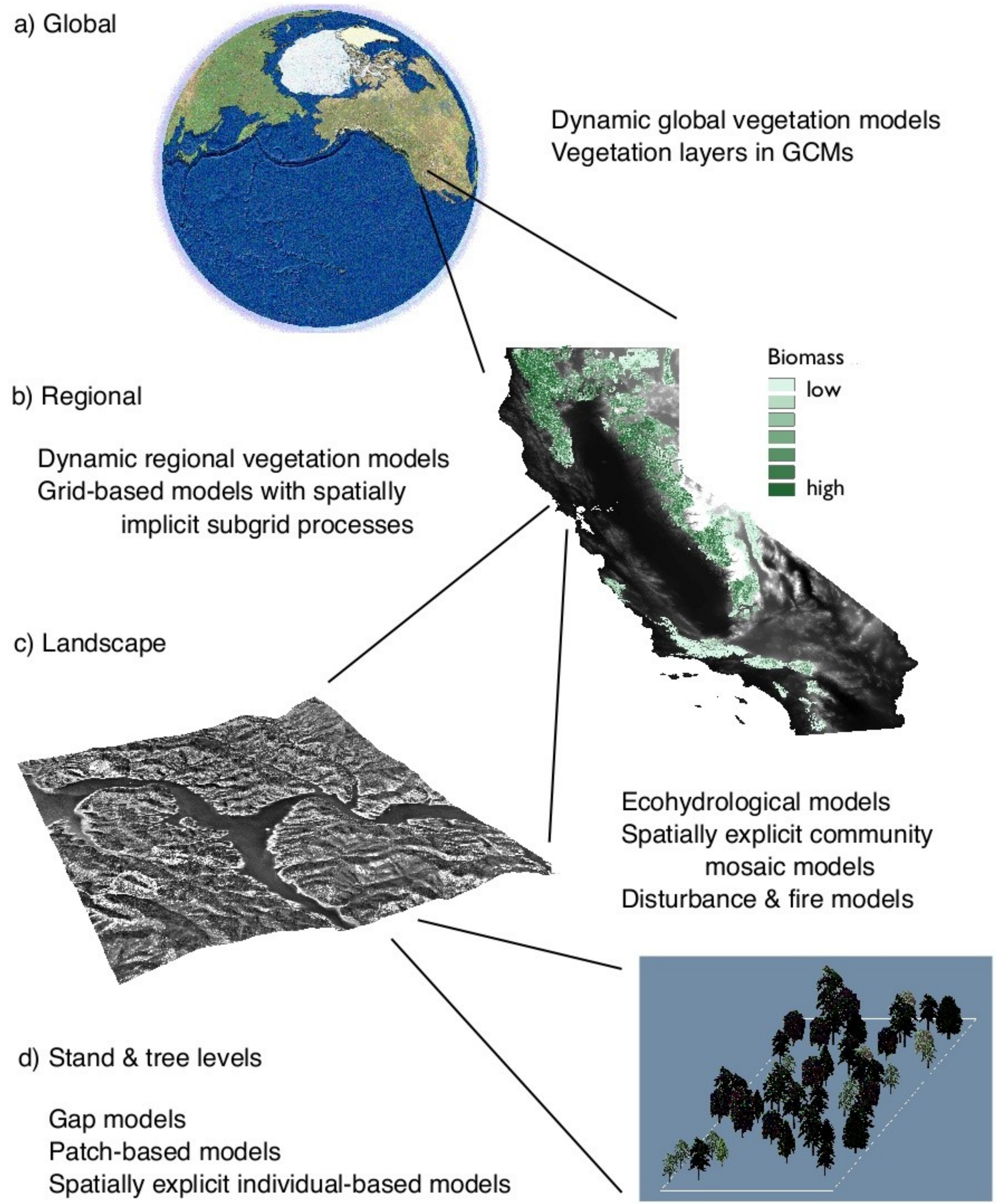
Houghton et al. (2007)

Global Carbon Cycle



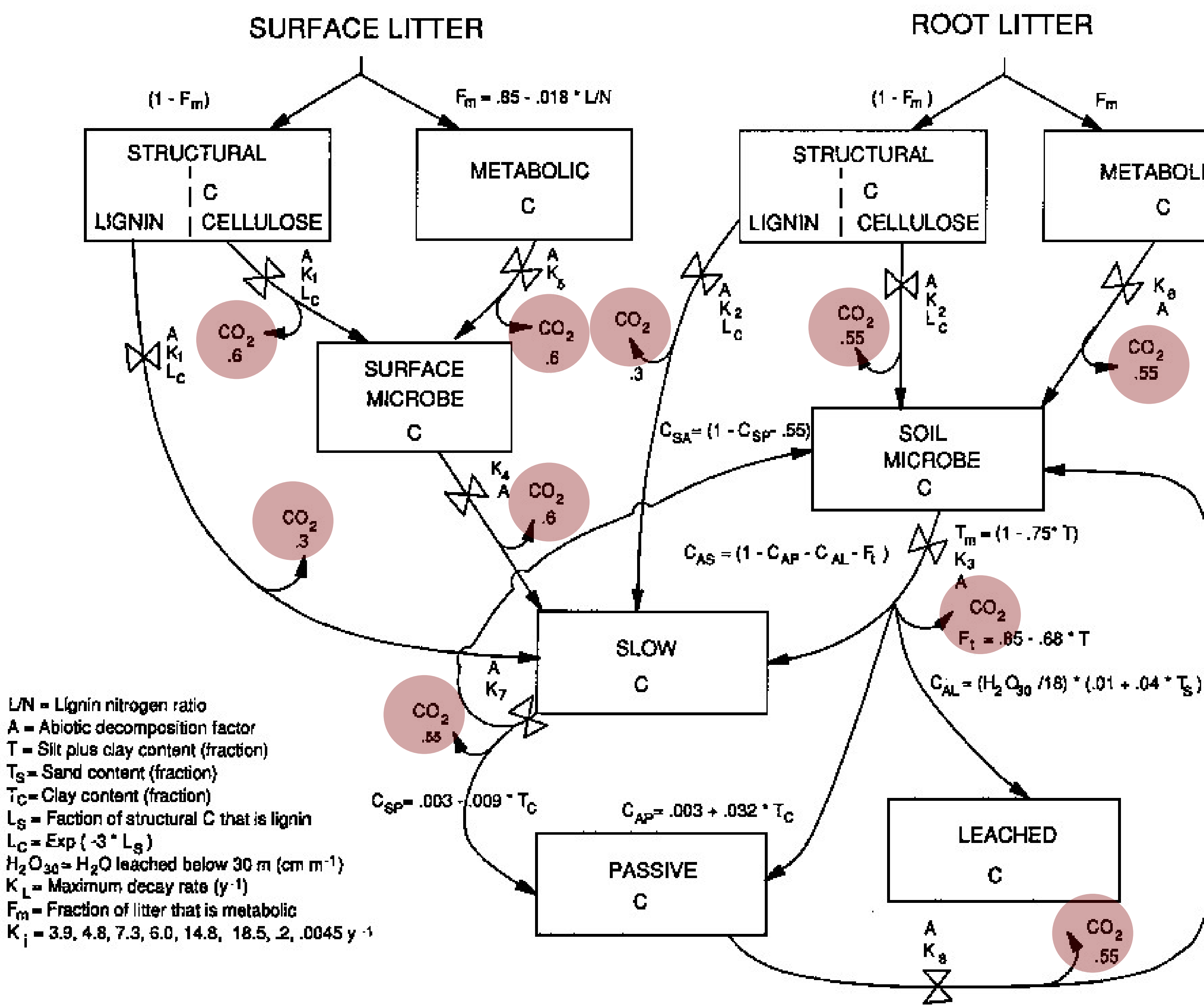
Terrestrial Biosphere Models

- Biogeochemistry
- Ecophysiology
- Land Surface
- Vegetation Community

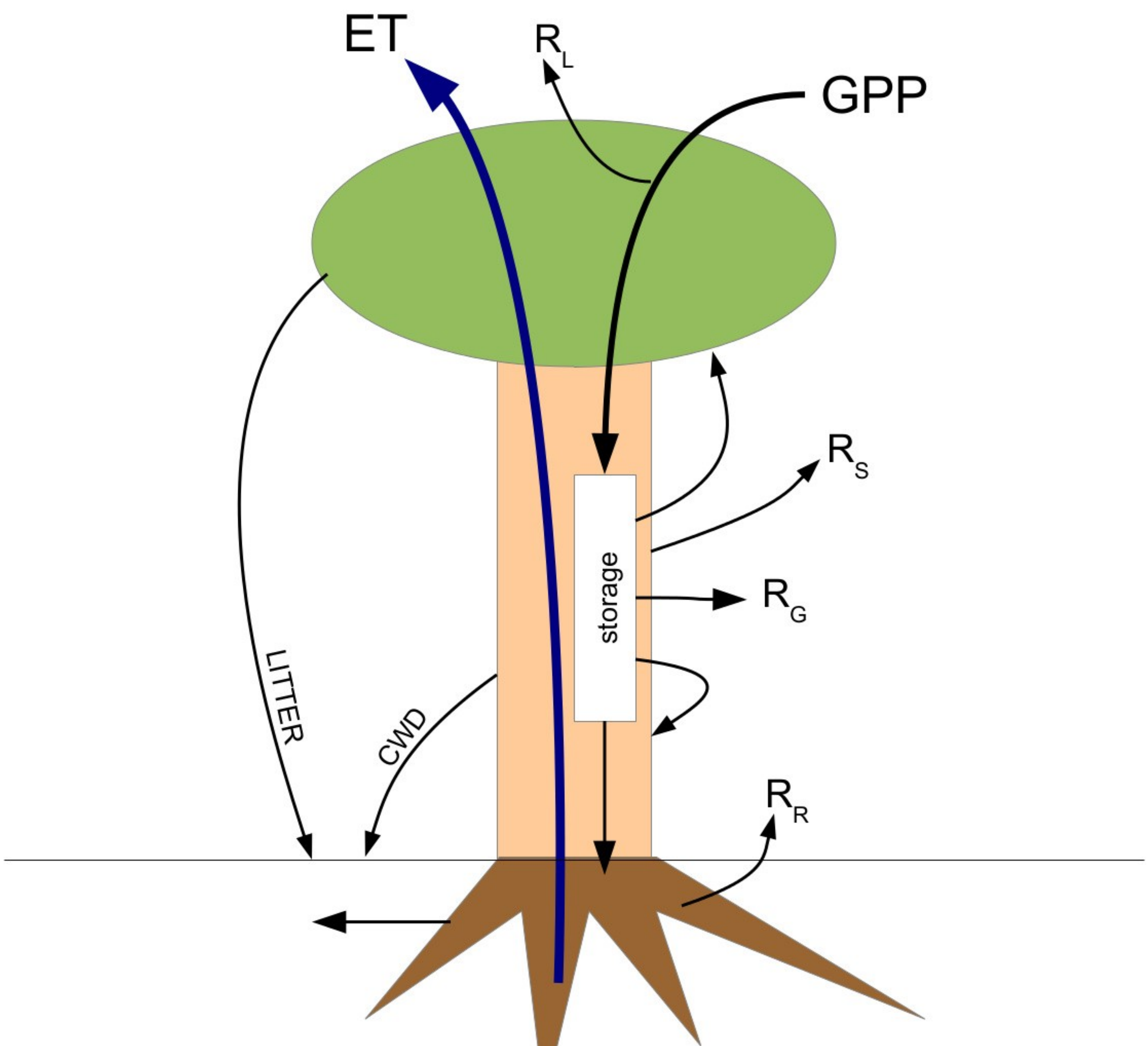


Dietze and Latimer (2012) Forest Simulators. *In* Encyclopedia of Theoretical Ecology. University of California Press.

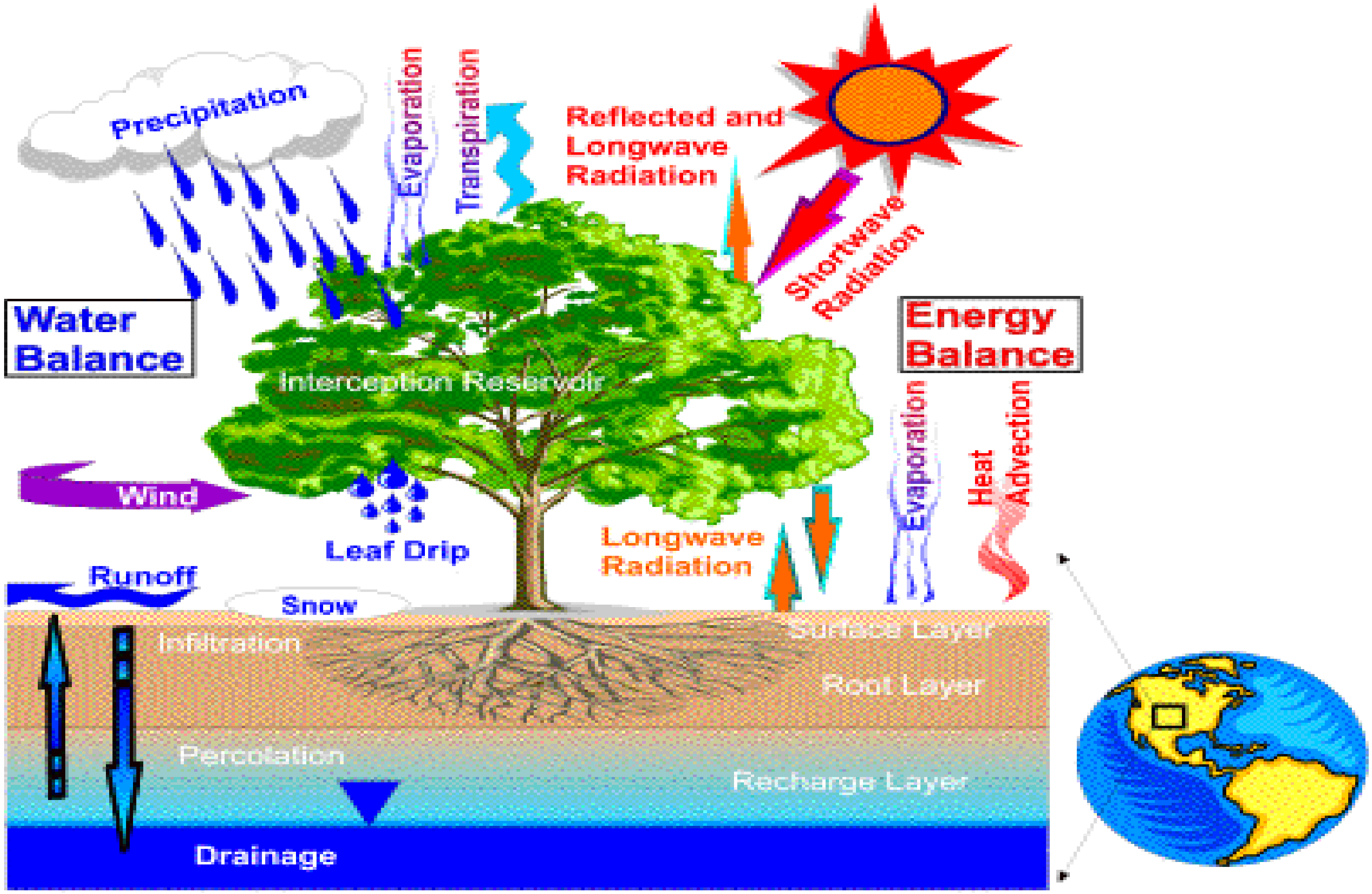
Biogeochemical Models



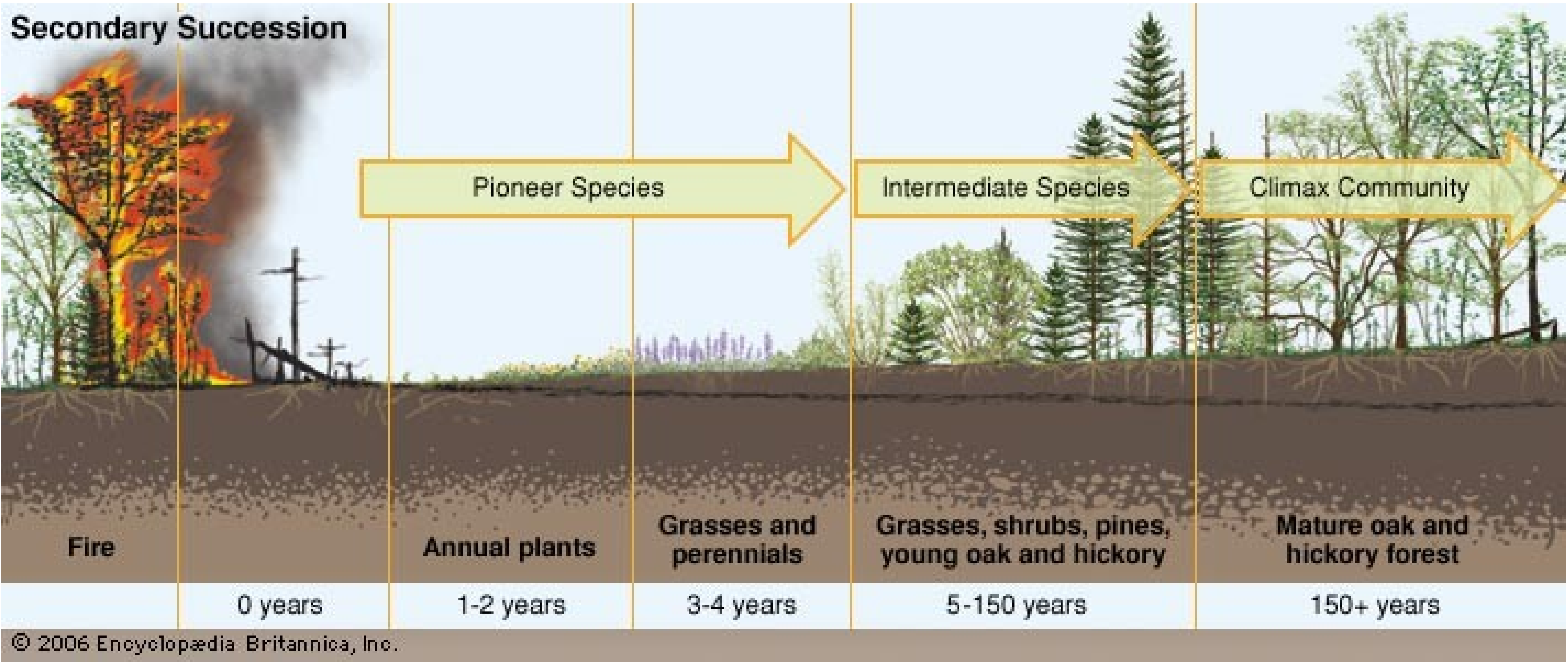
Ecophysiological Models

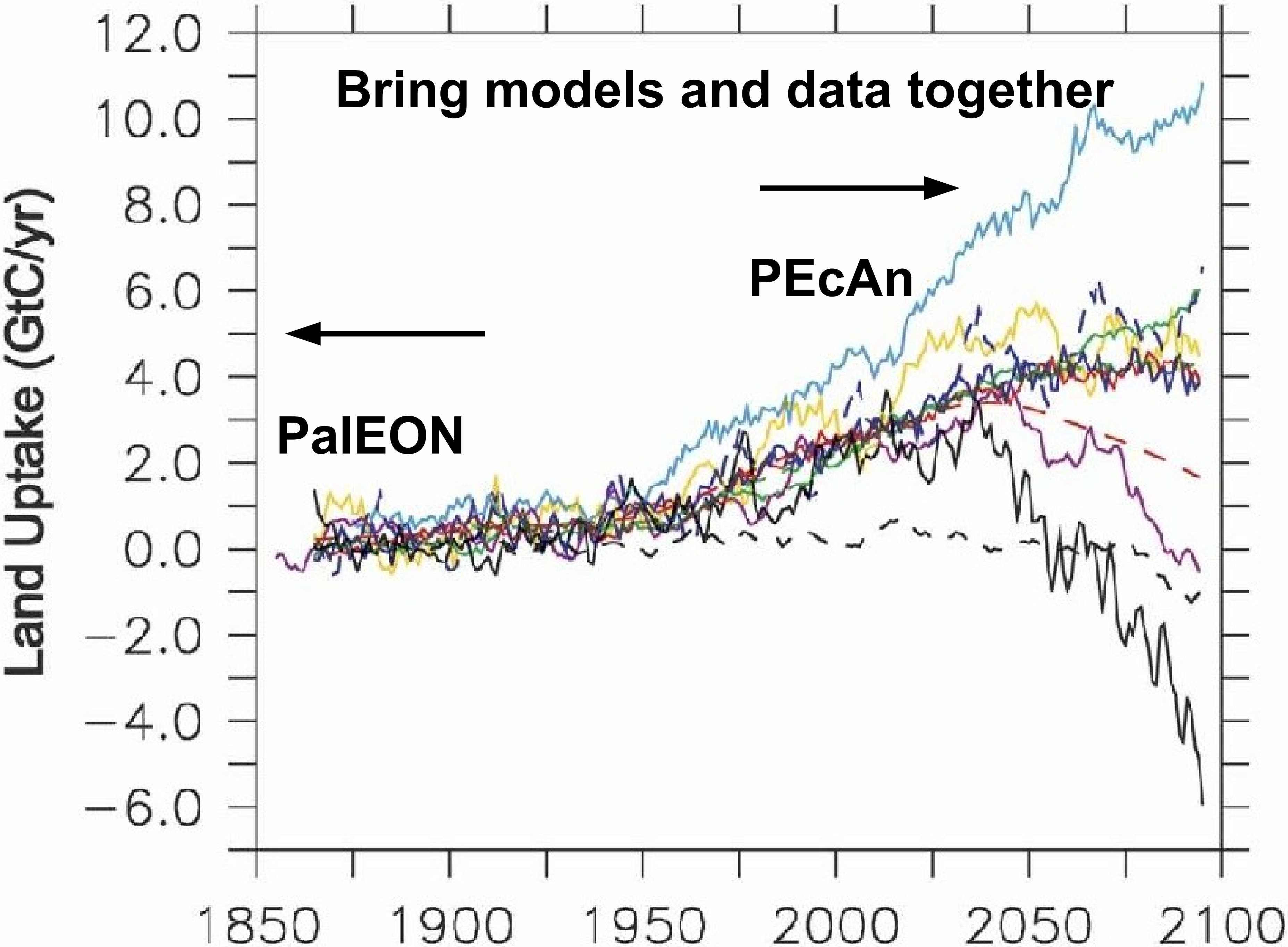


Land Surface Model



Vegetation Community



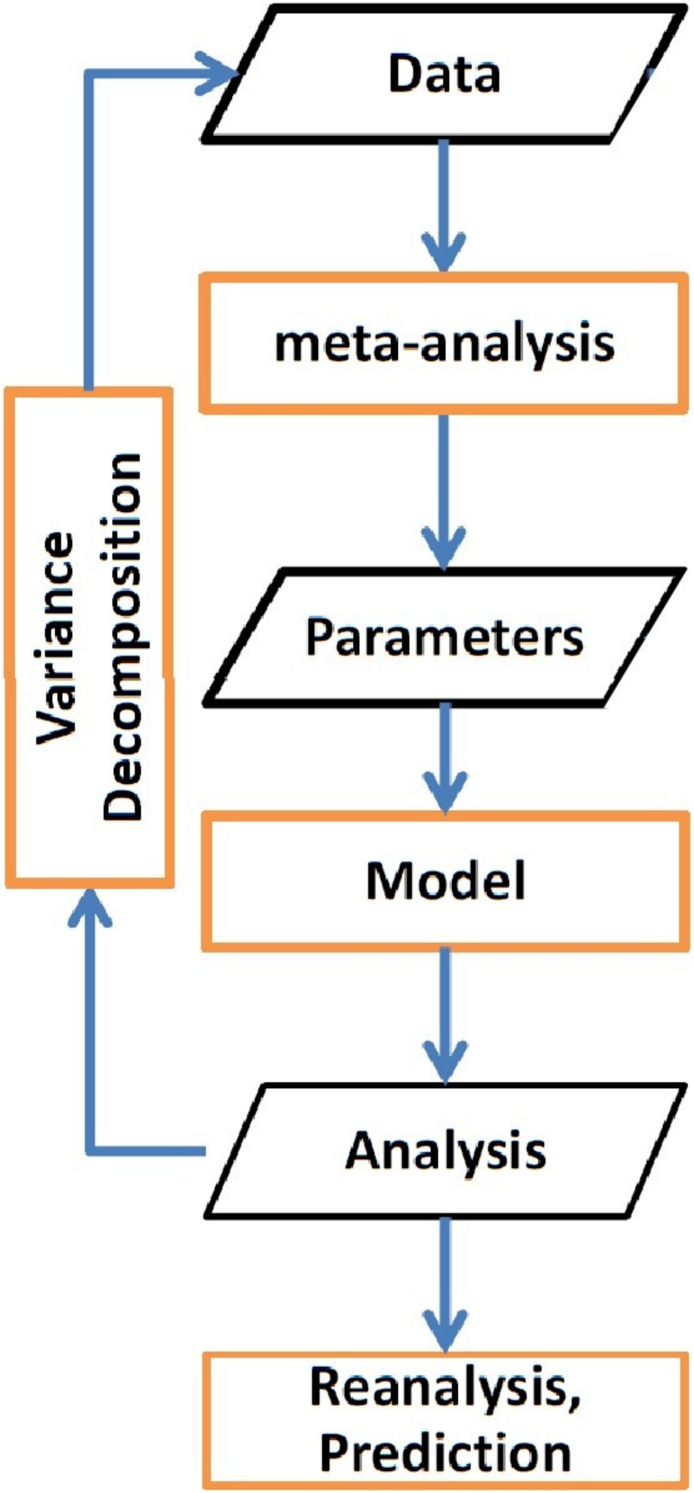


Friedlingstein et al 2006

Challenges

- Explosion in data volume and diversity
- No one data source provides a complete picture of the terrestrial biosphere
- Currently only make use of a subset of data
- Limited by ability to curate & use data

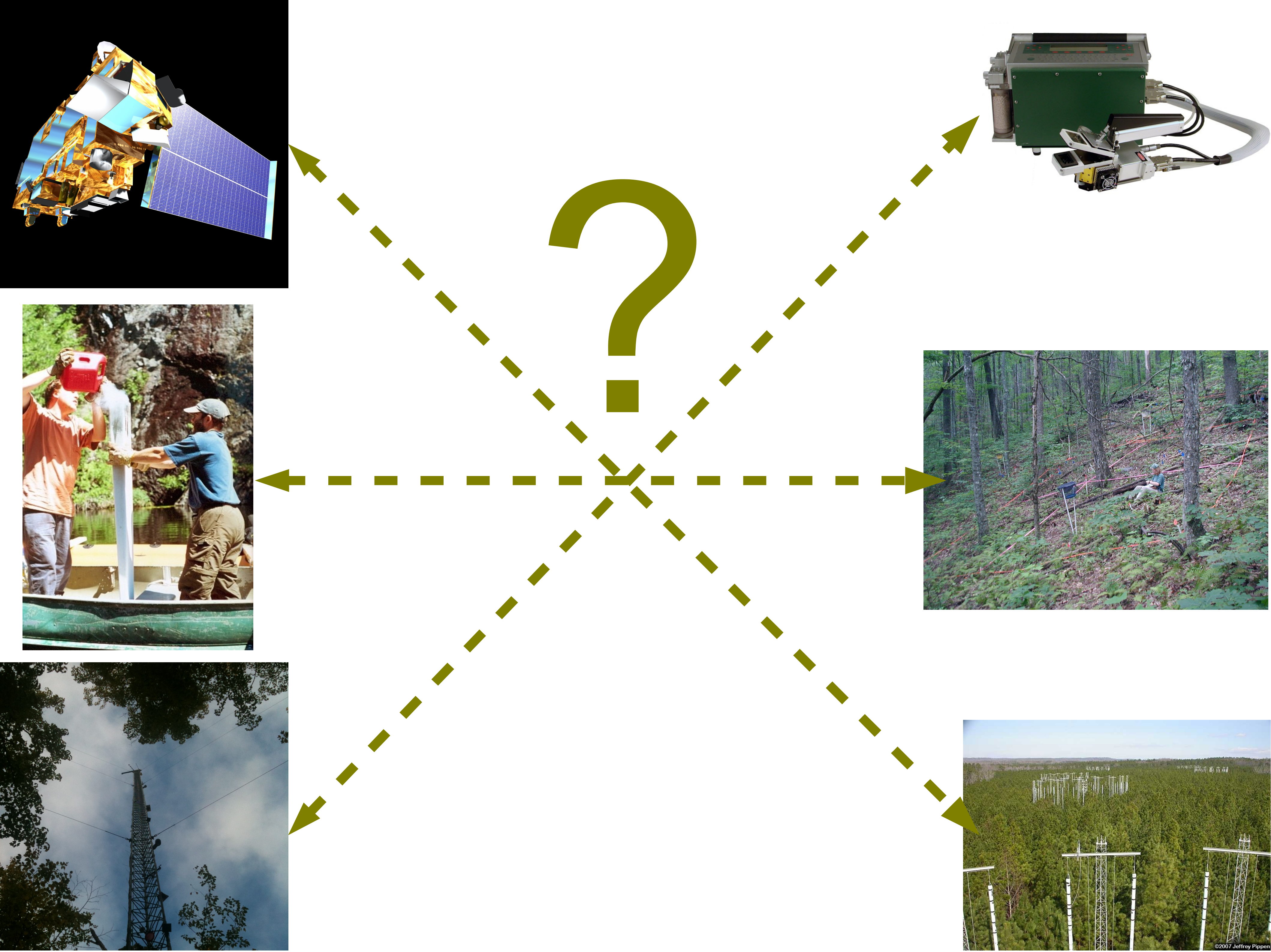
- Uncertainties as critical as mean projection
- Data collection driven by intuition

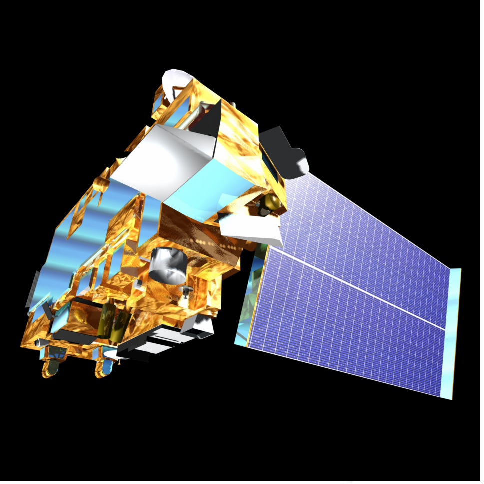


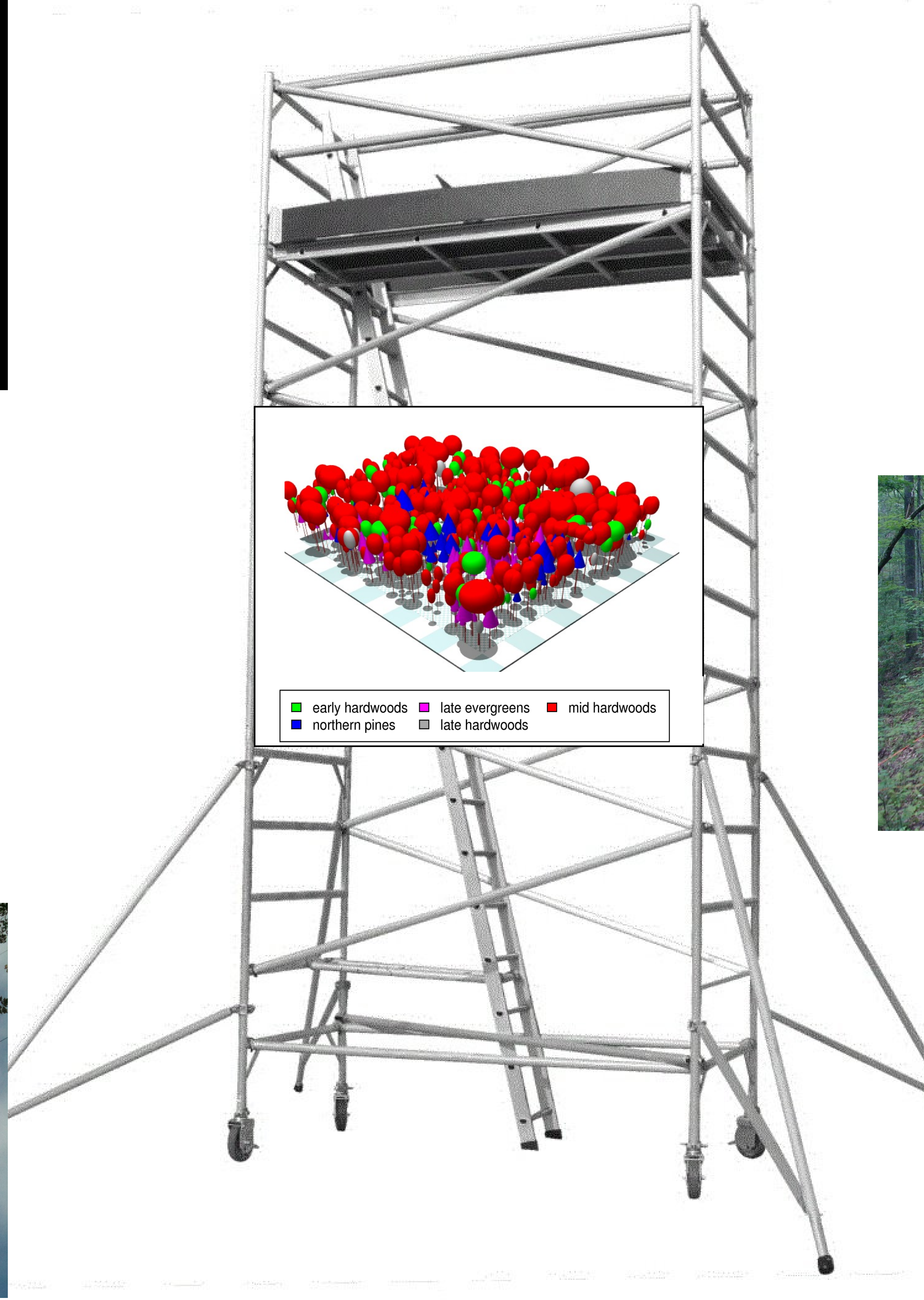
Predictive Ecosystem Analyzer

LeBauer et al. 2013. Ecological Monographs
Wang et al. *2013* Ecological Applications
Dietze et al. 2013. *Plant Cell & Environment*

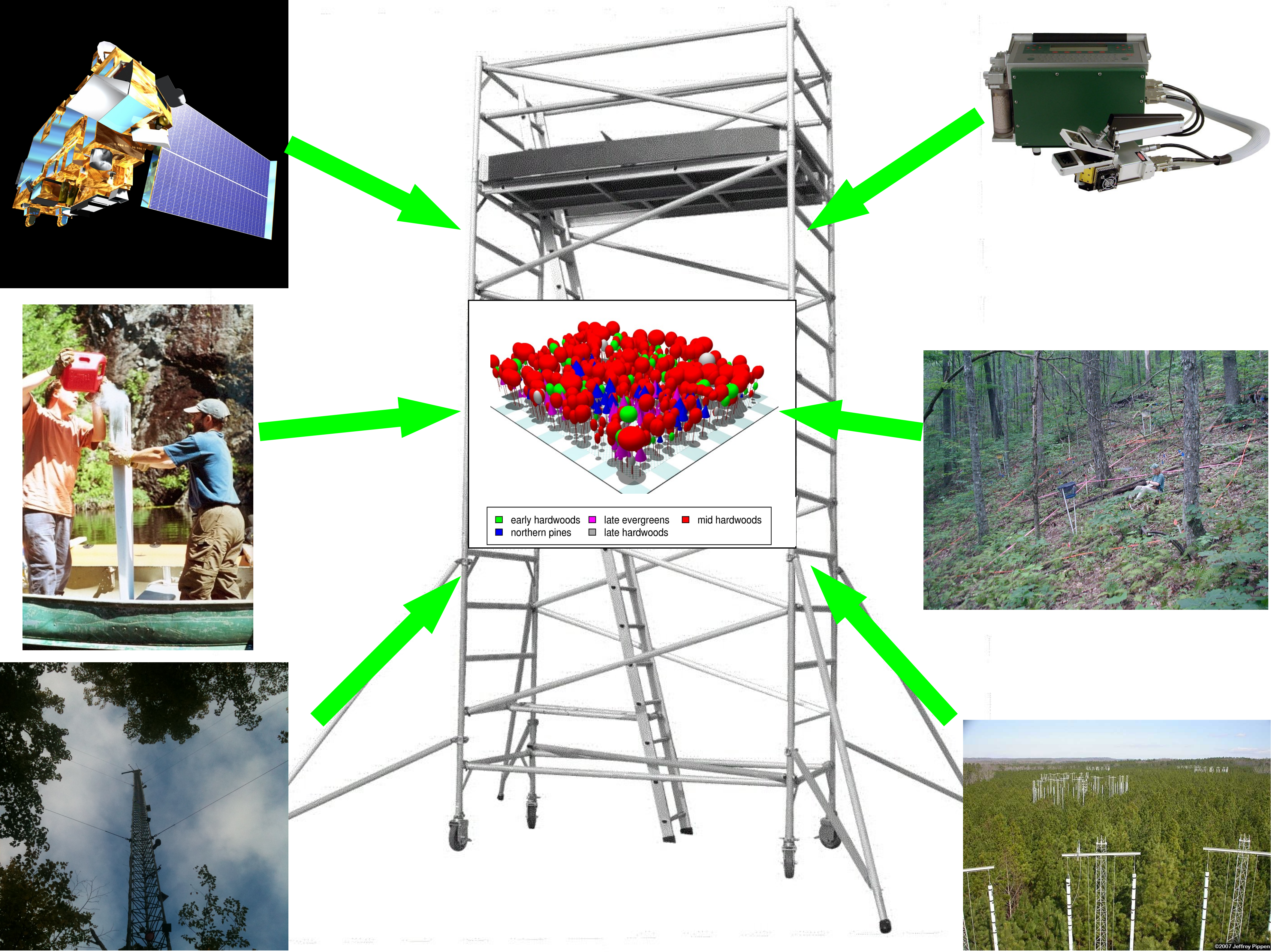
http://www.pecanproject.org/


?
©2007 Jeffrey Pippen



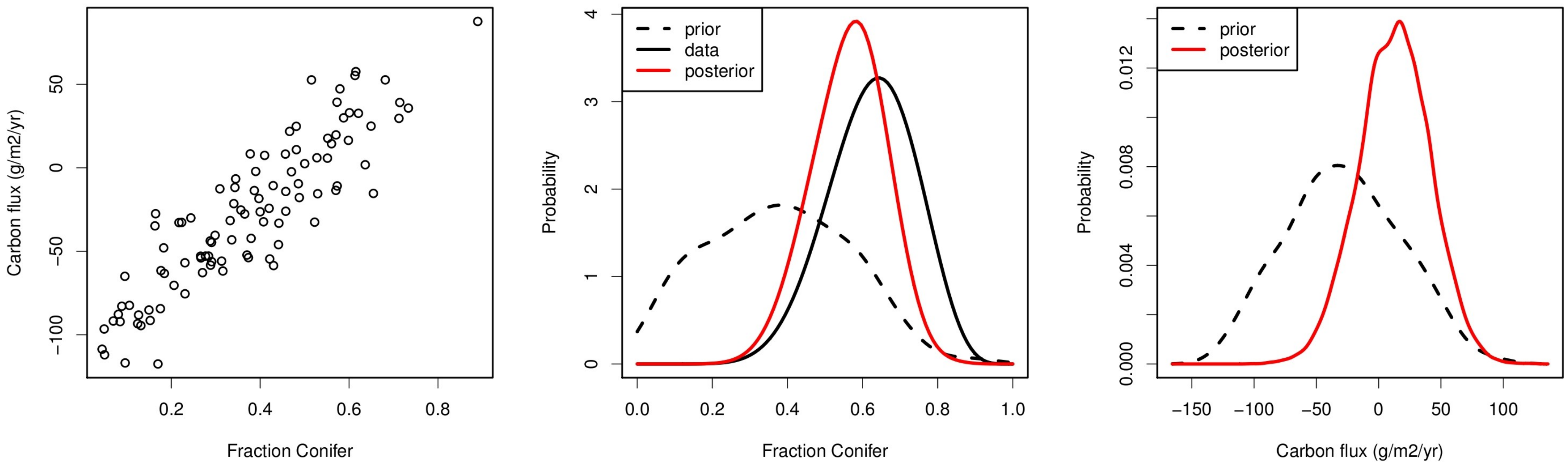

early hardwoods
late evergreens
mid hardwoods
northern pines
late hardwoods


©2007 Jeffrey Pippen



early hardwoods
late evergreens
mid hardwoods
northern pines
late hardwoods
©2007 Jeffrey Pippen

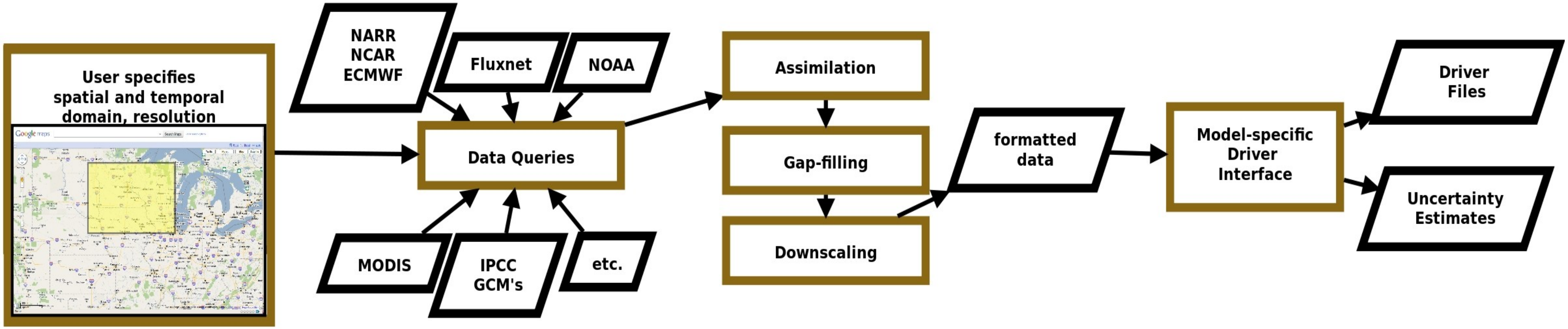
Data Assimilation



$$P(\theta|y) \propto P(y|\theta)\,P(\theta)$$

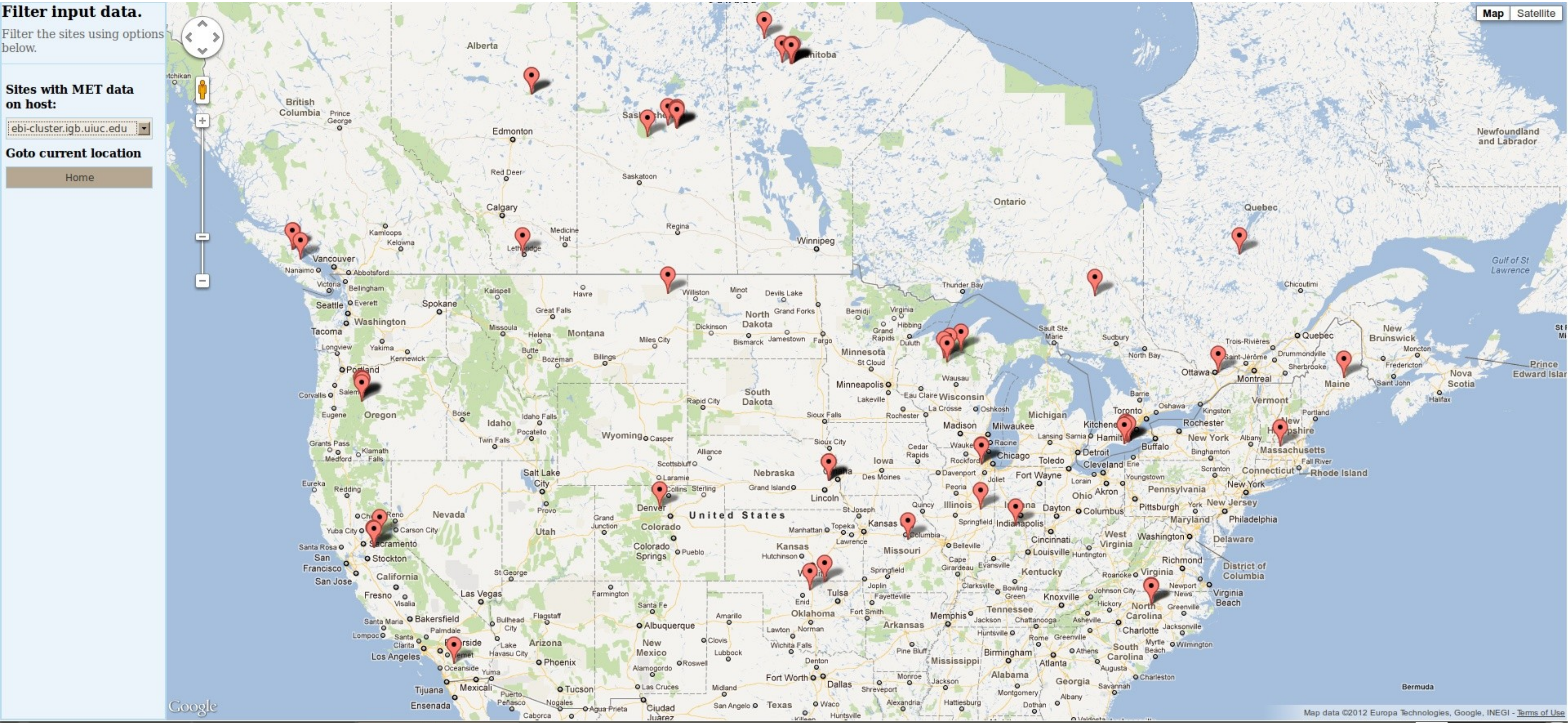
Updated State **Data** **Model**

Ecoinformatics



Manage the flows of information in and out of terrestrial ecosystem models

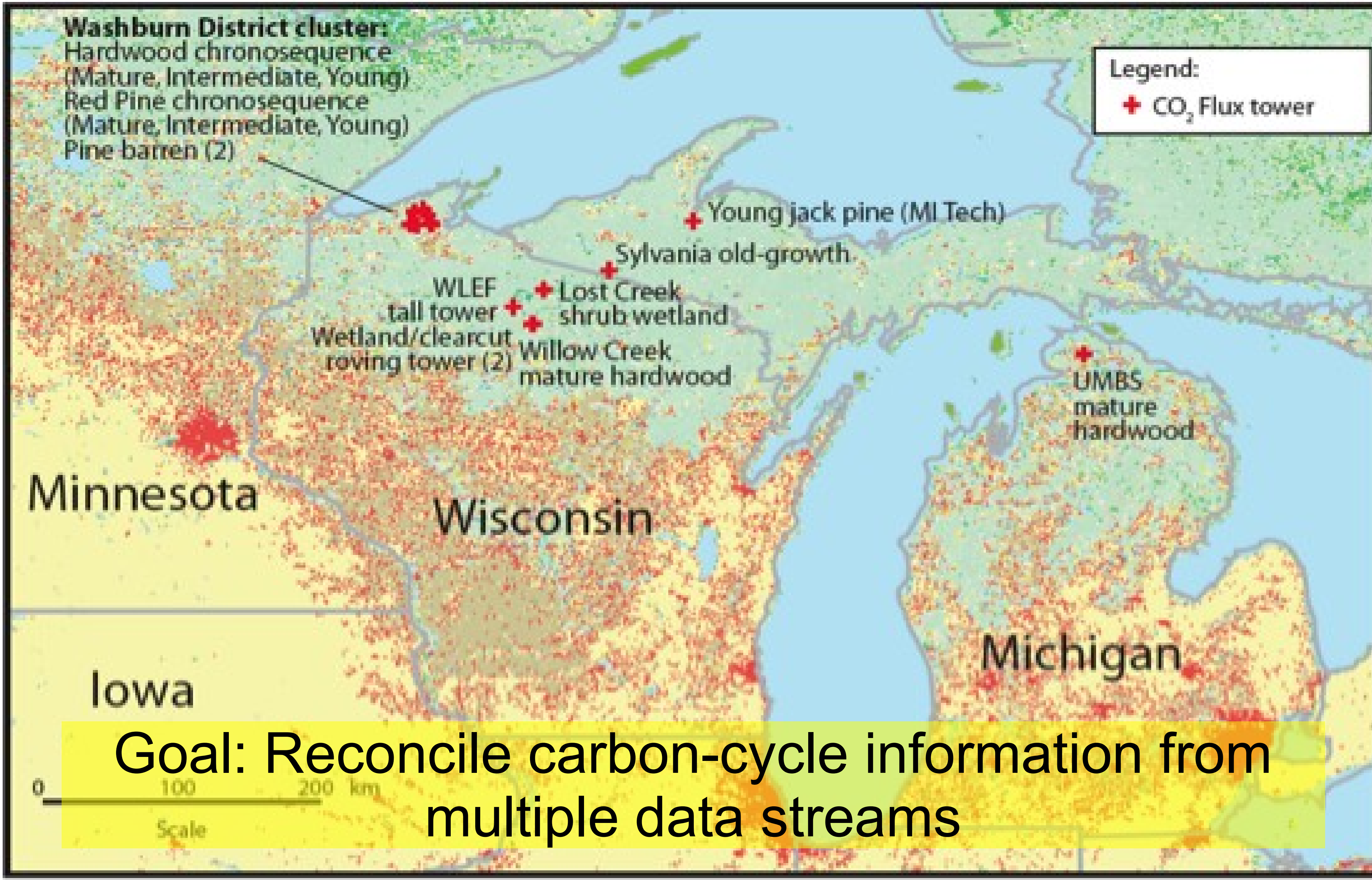
Accessibility



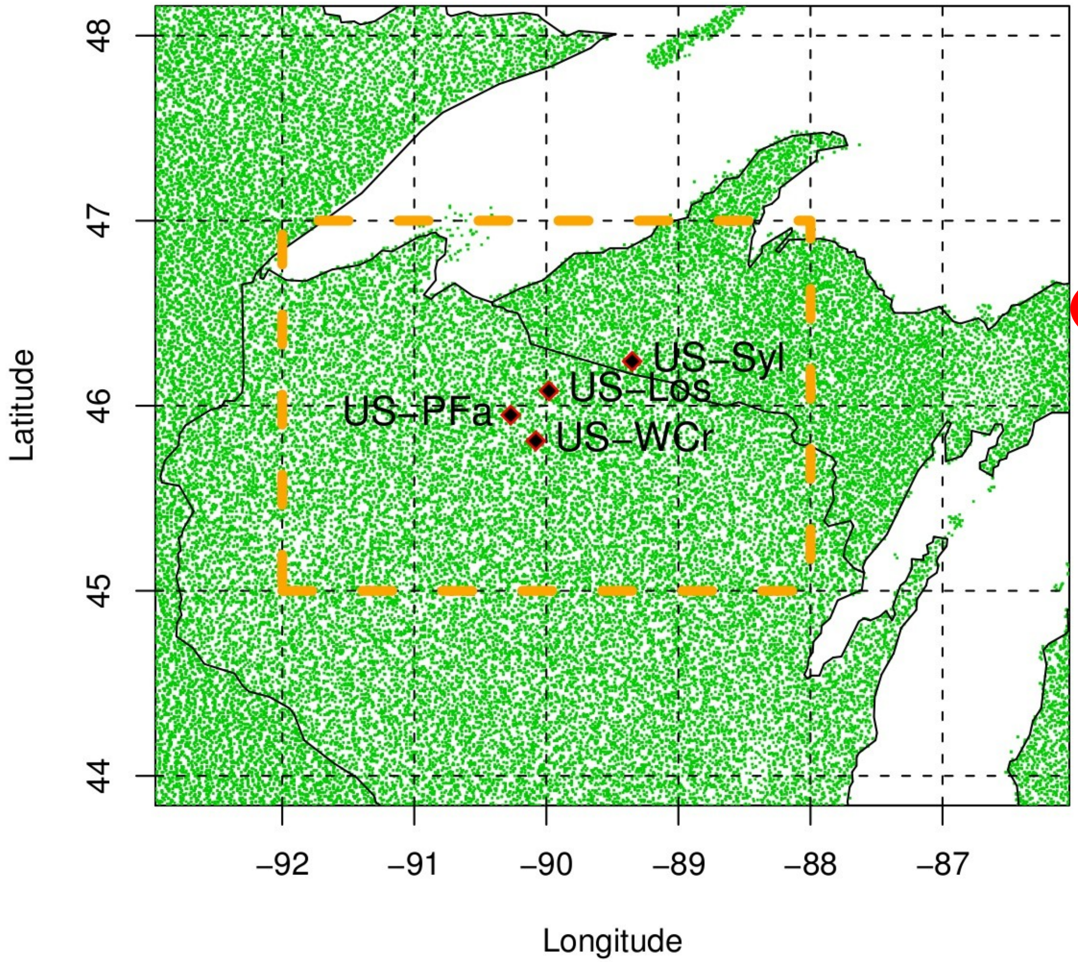
Models represent our current understanding of a system
Models can form the scaffold for data synthesis
Models are a critical for forecasting

Improving models needs to be a COMMUNITY effort

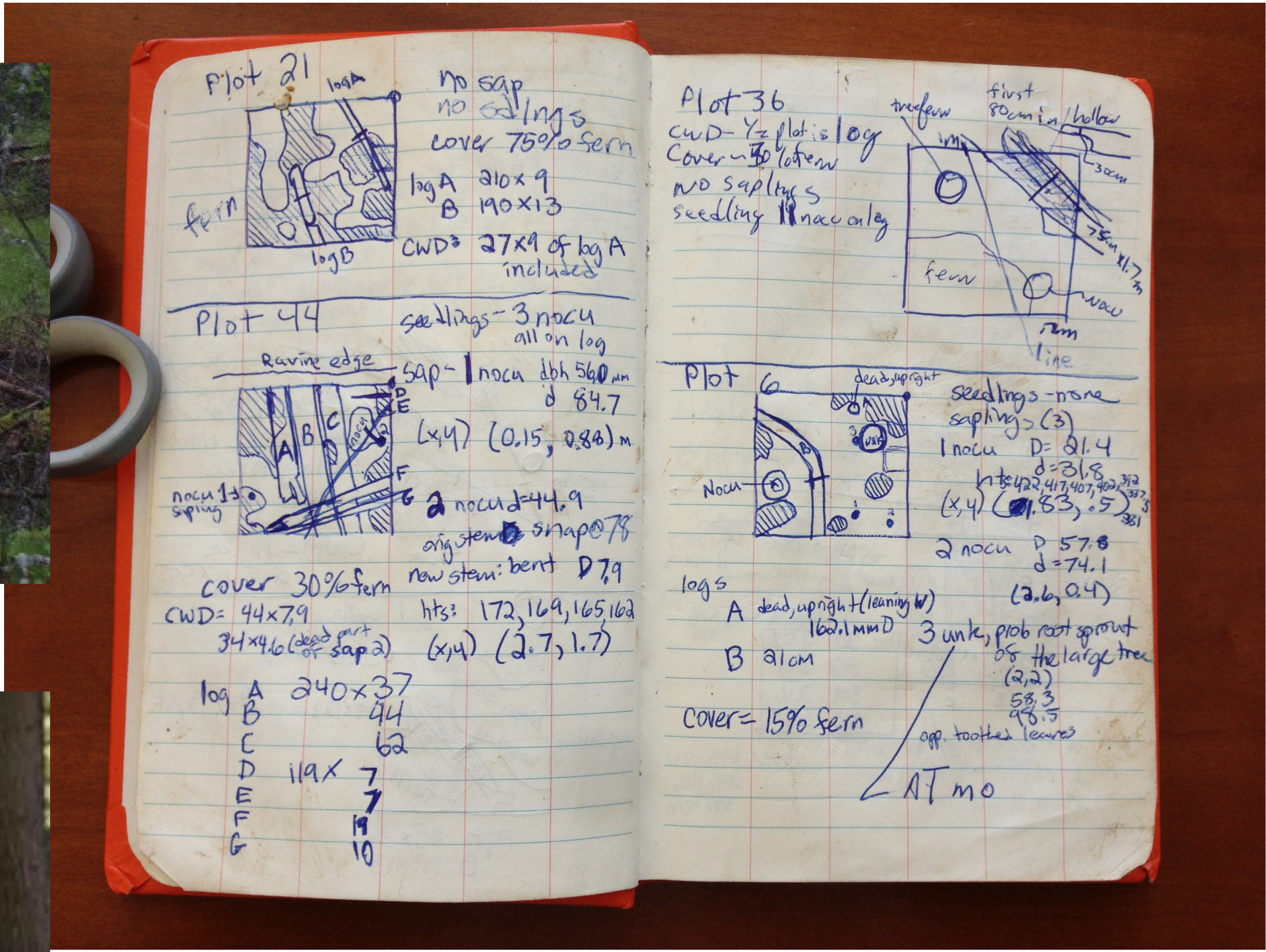
Testbed: ChEAS
(Chequamegon-Ecosystem Atmosphere Study)



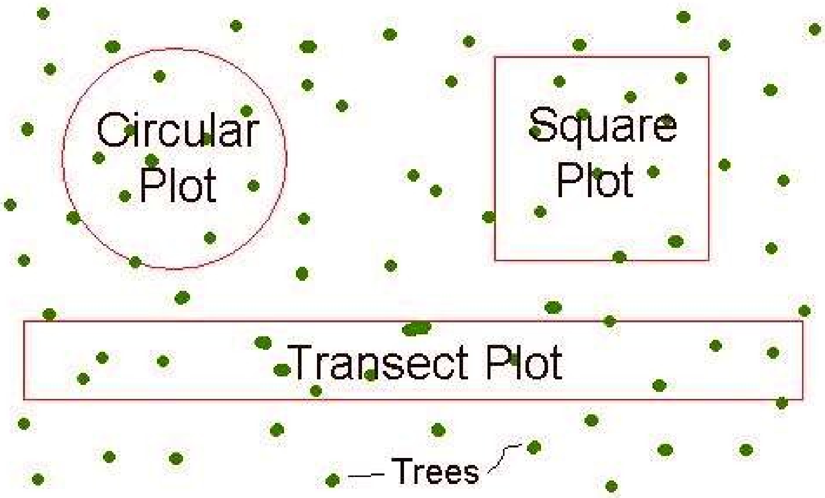
Goal: Reconcile carbon-cycle information from multiple data streams



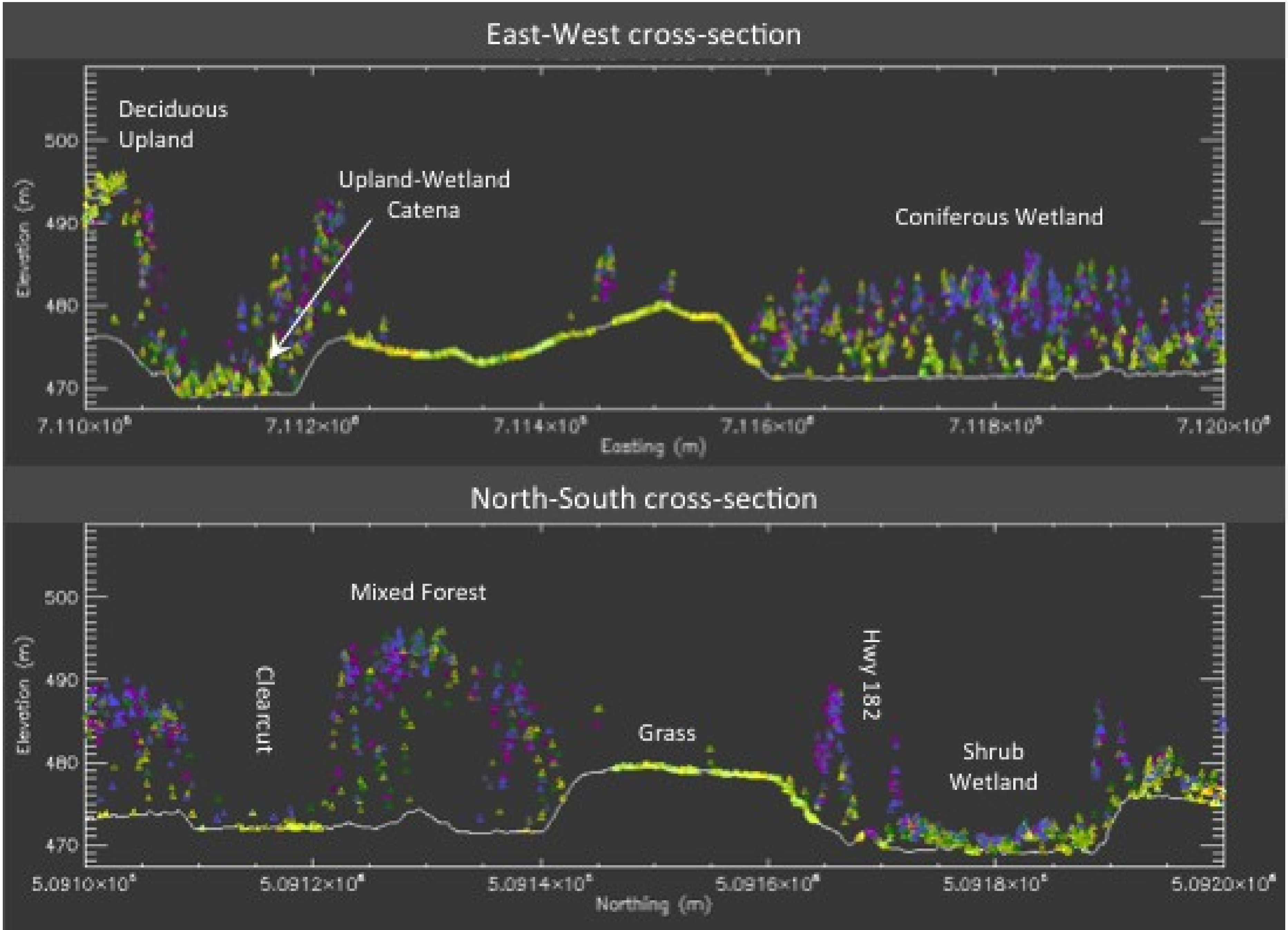
- 17 flux towers
- 250k inventory tree measurements
- Asst. ground meas.
- LIDAR
- Hyperspectral
- inSAR
- MODIS
- LandSAT



Forest Inventory Plots

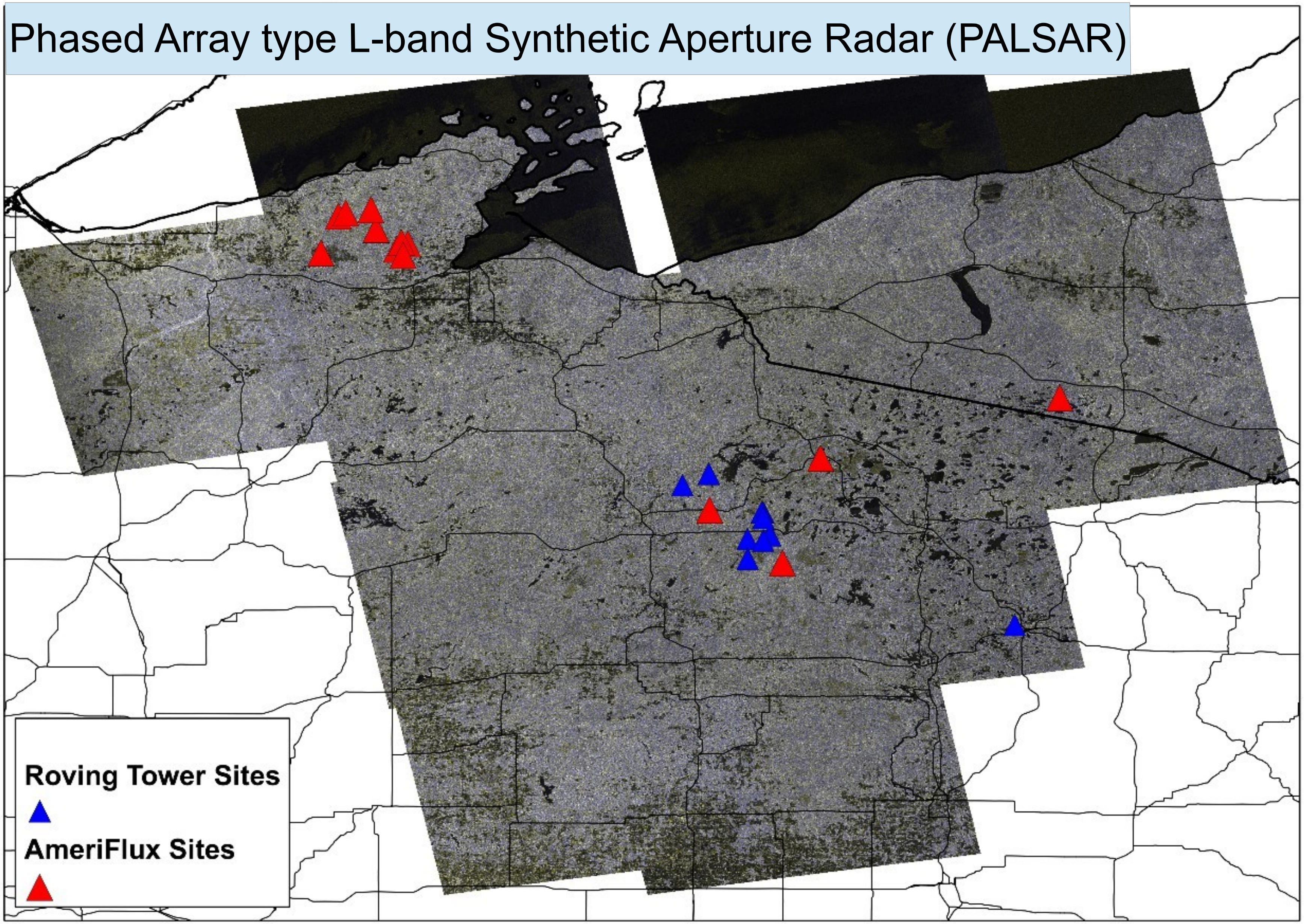


LIDAR

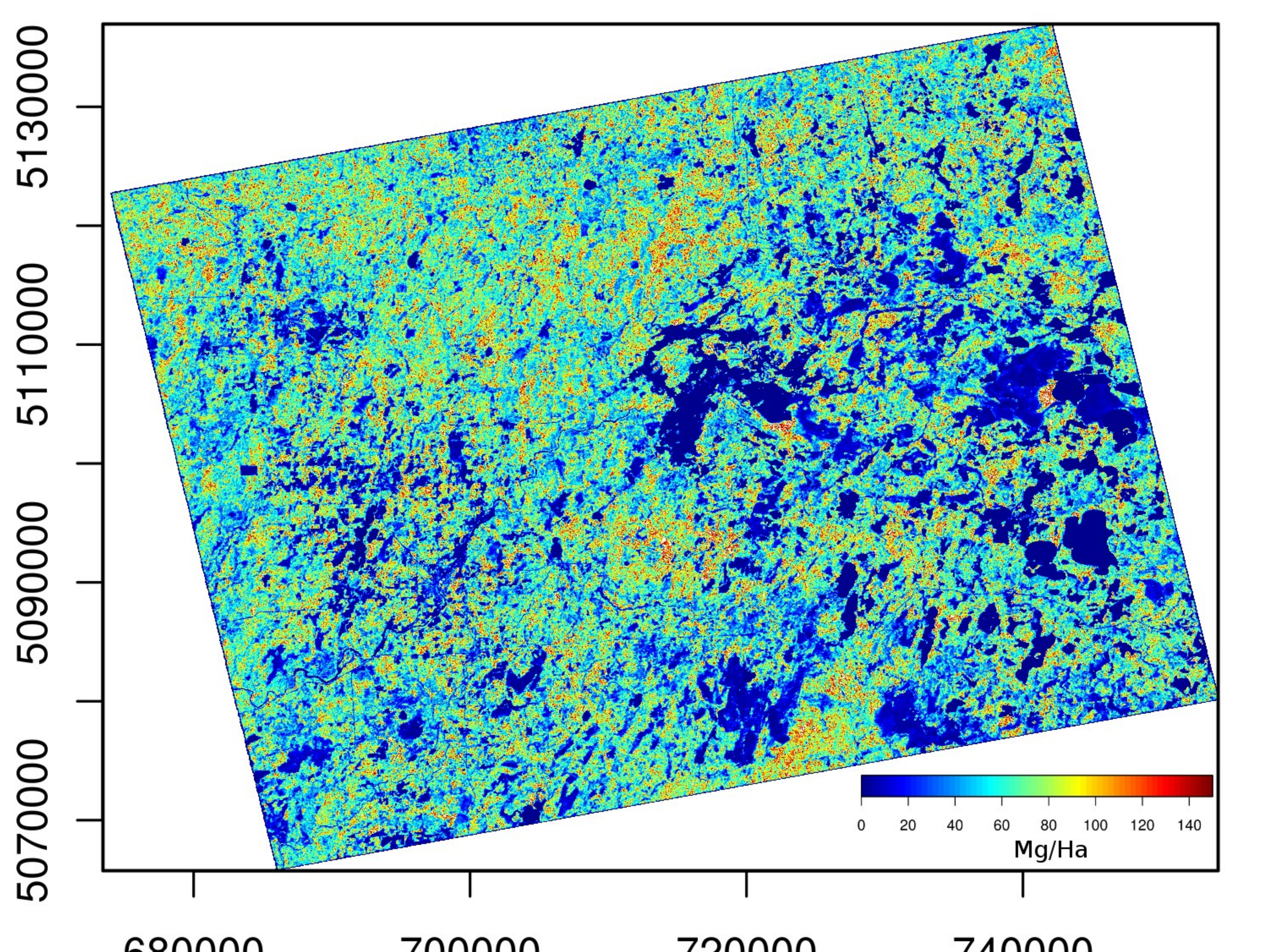

East-West cross-section
Deciduous
Upland
Upland-Wetland
Catena
Coniferous Wetland
Elevation (m)
500
490
480
470
7.110×10⁶
7.112×10⁶
7.114×10⁶
7.116×10⁶
7.118×10⁶
7.120×10⁶
Easting (m)
North-South cross-section
Mixed Forest
Clearcut
Grass
Hwy 182
Shrub
Wetland
Elevation (m)
500
490
480
470
5.0910×10⁶
5.0912×10⁶
5.0914×10⁶
5.0916×10⁶
5.0918×10⁶
5.0920×10⁶
Northing (m)

JAXA PALSAR

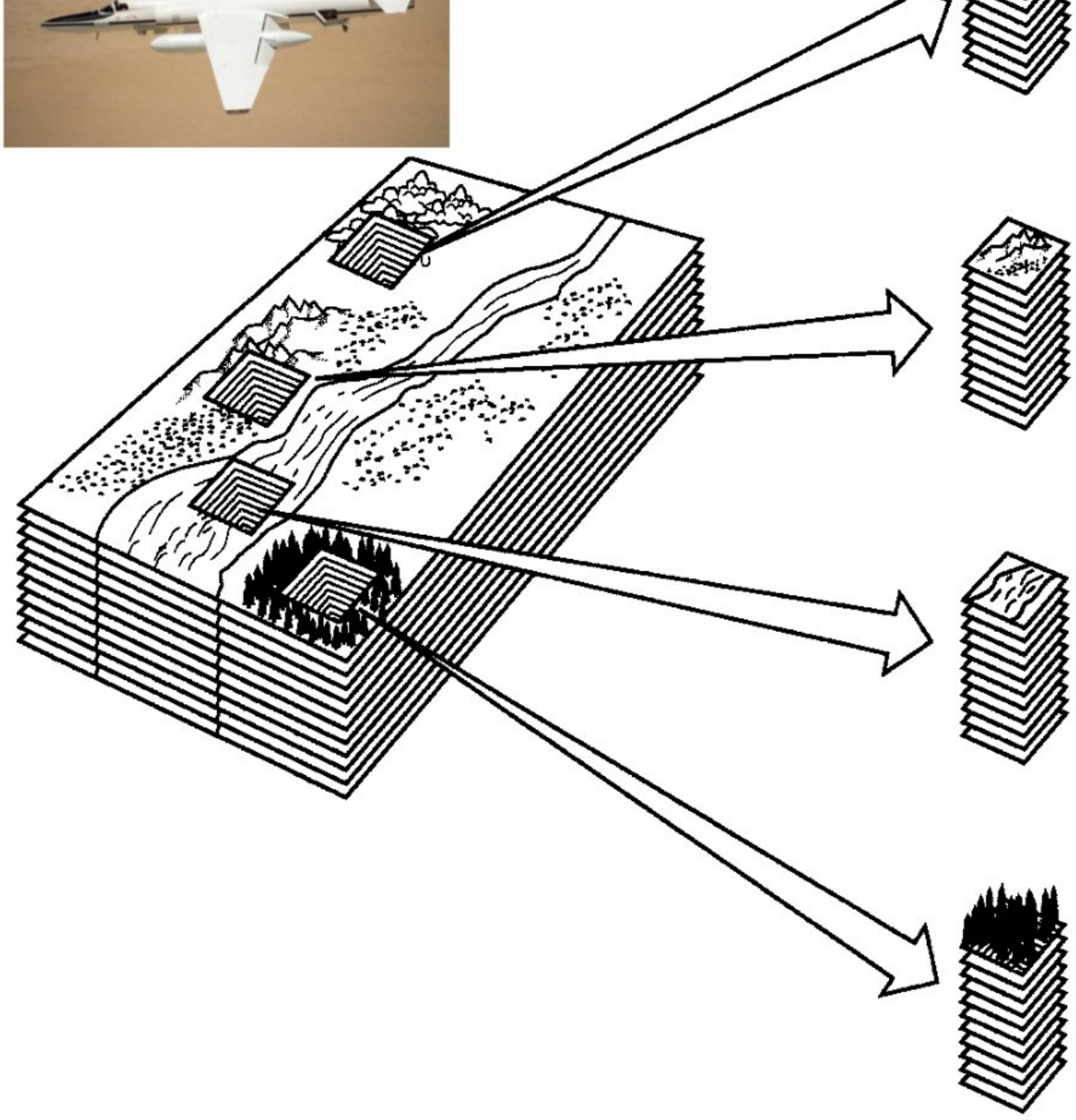
Phased Array type L-band Synthetic Aperture Radar (PALSAR)

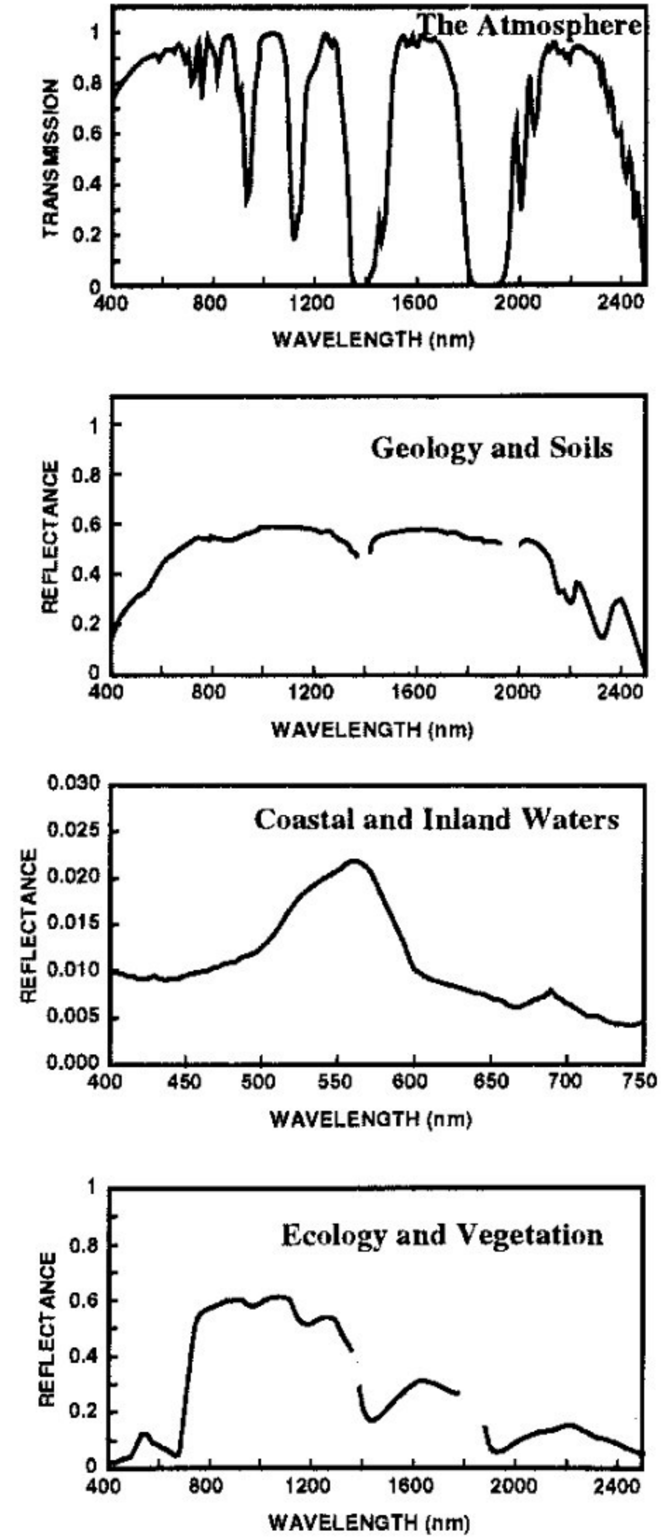


7-44m pixel, 24cm wavelength


5130000
5110000
5090000
5070000
680000
700000
720000
740000
0 20 40 60 80 100 120 140
Mg/Ha

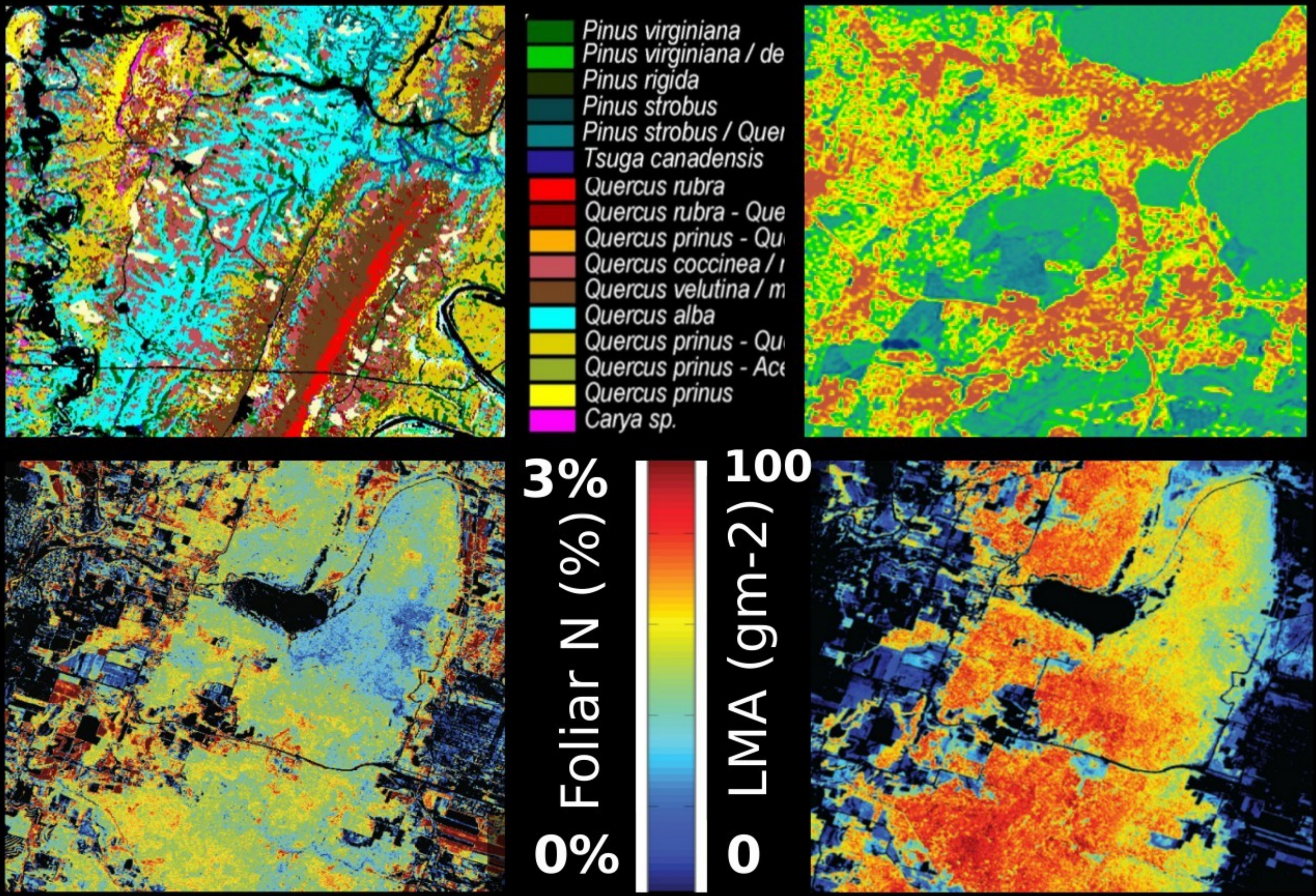
Hyperspectral

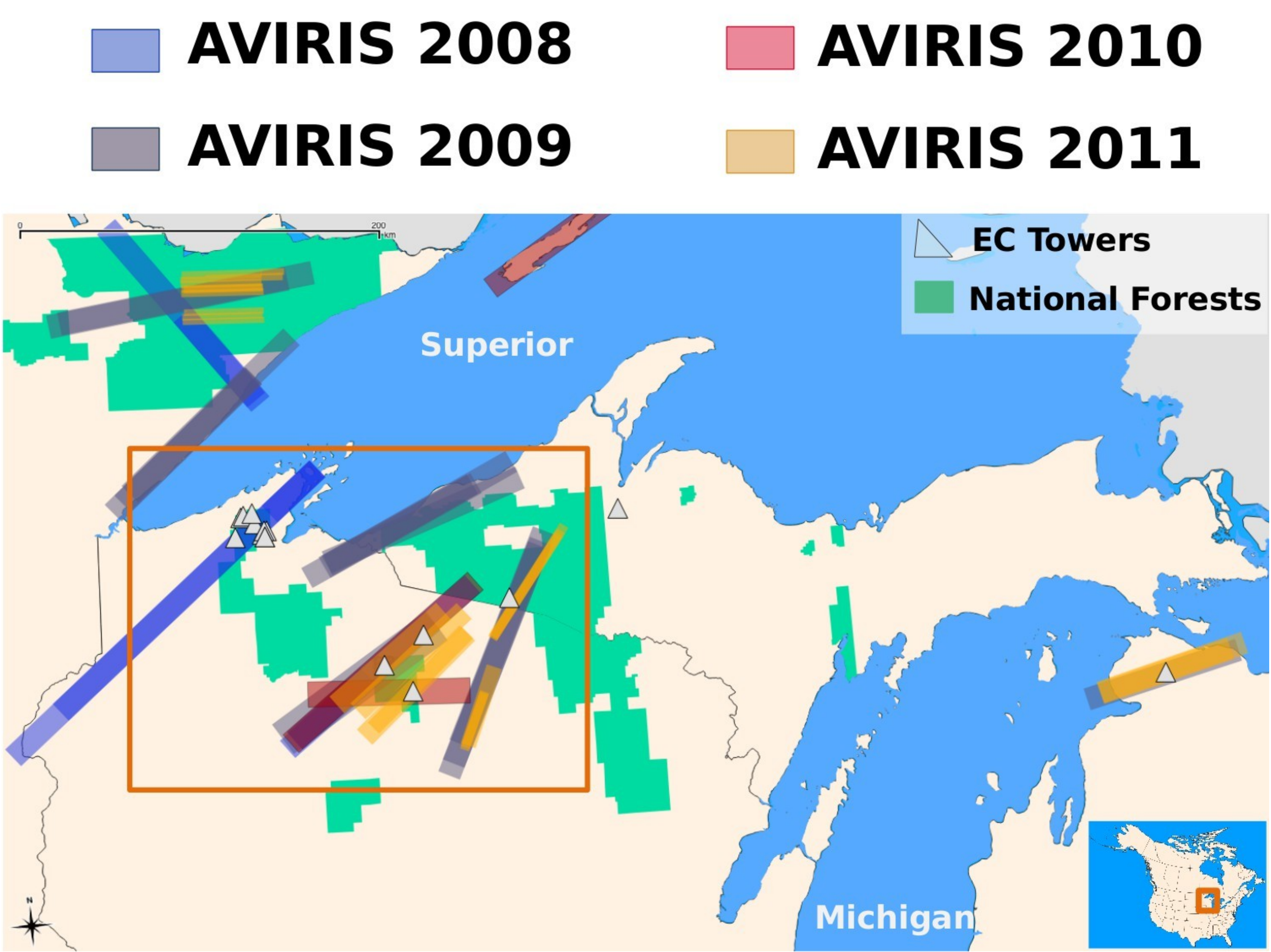




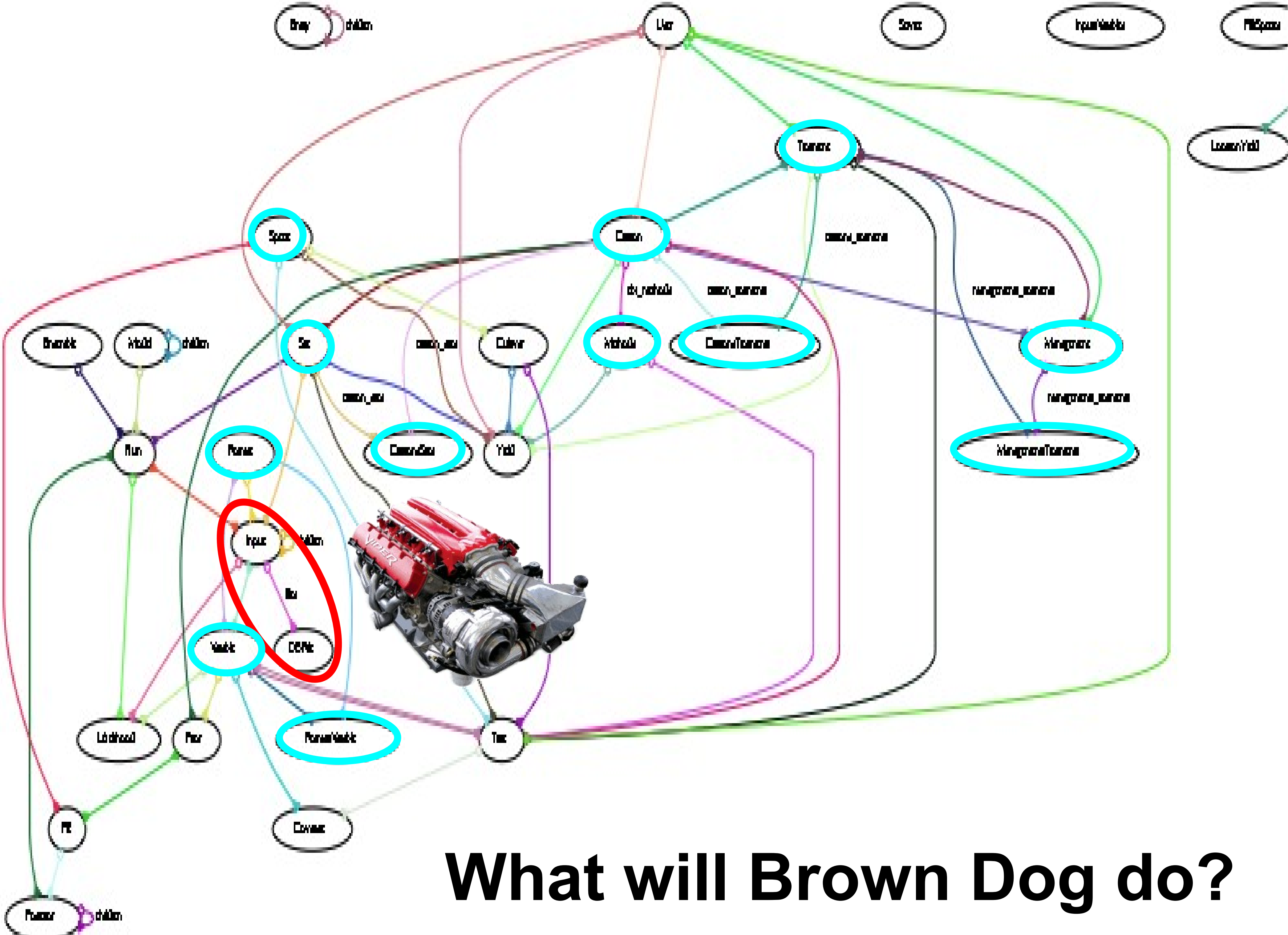
Green et al., (1998). *RSE*

NASA AVIRIS / MASTER & Ecosystem Studies

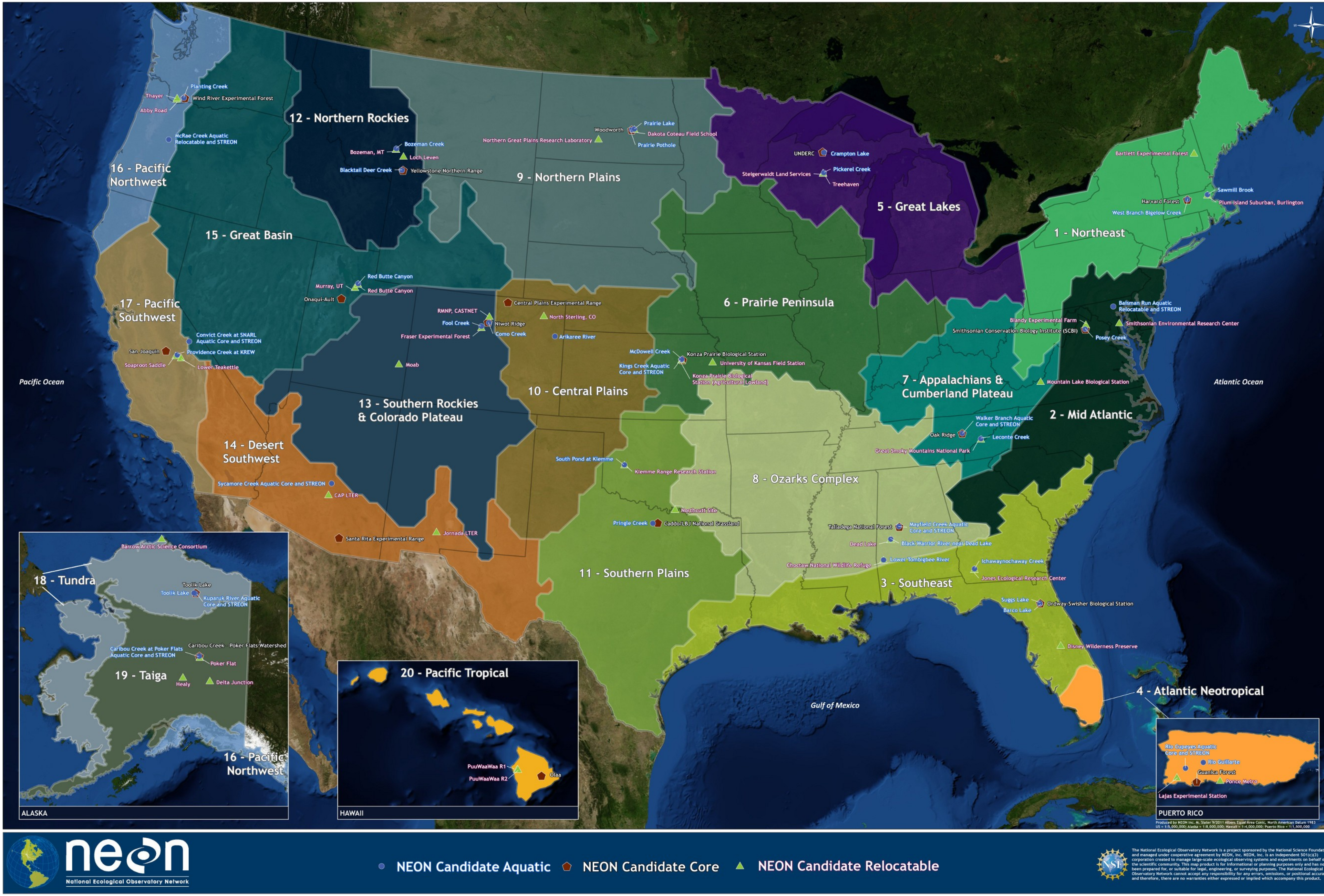




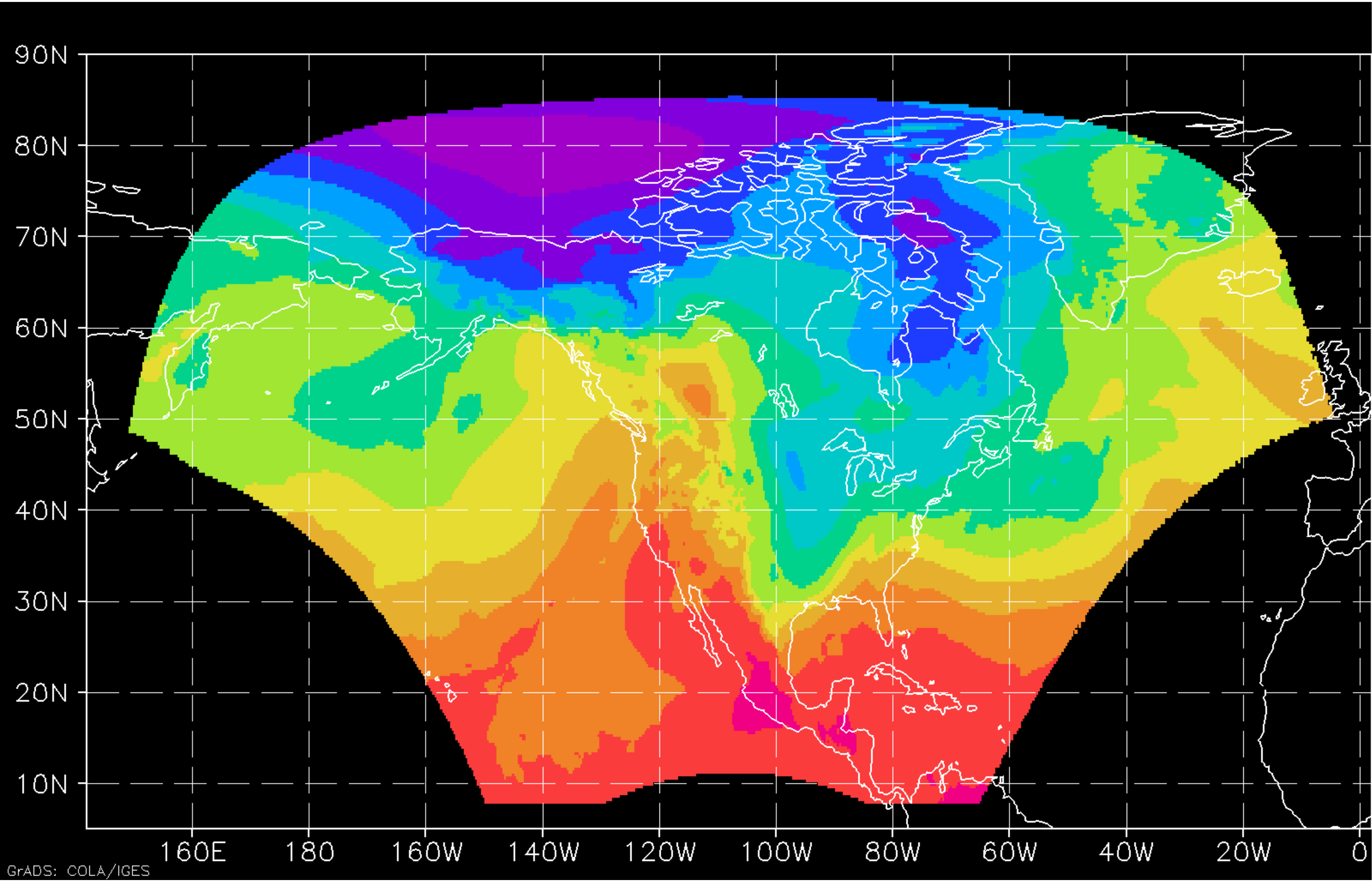
AVIRIS 2008
AVIRIS 2010
AVIRIS 2009
AVIRIS 2011
0
200
km
EC Towers
National Forests
Superior
Michigan
N



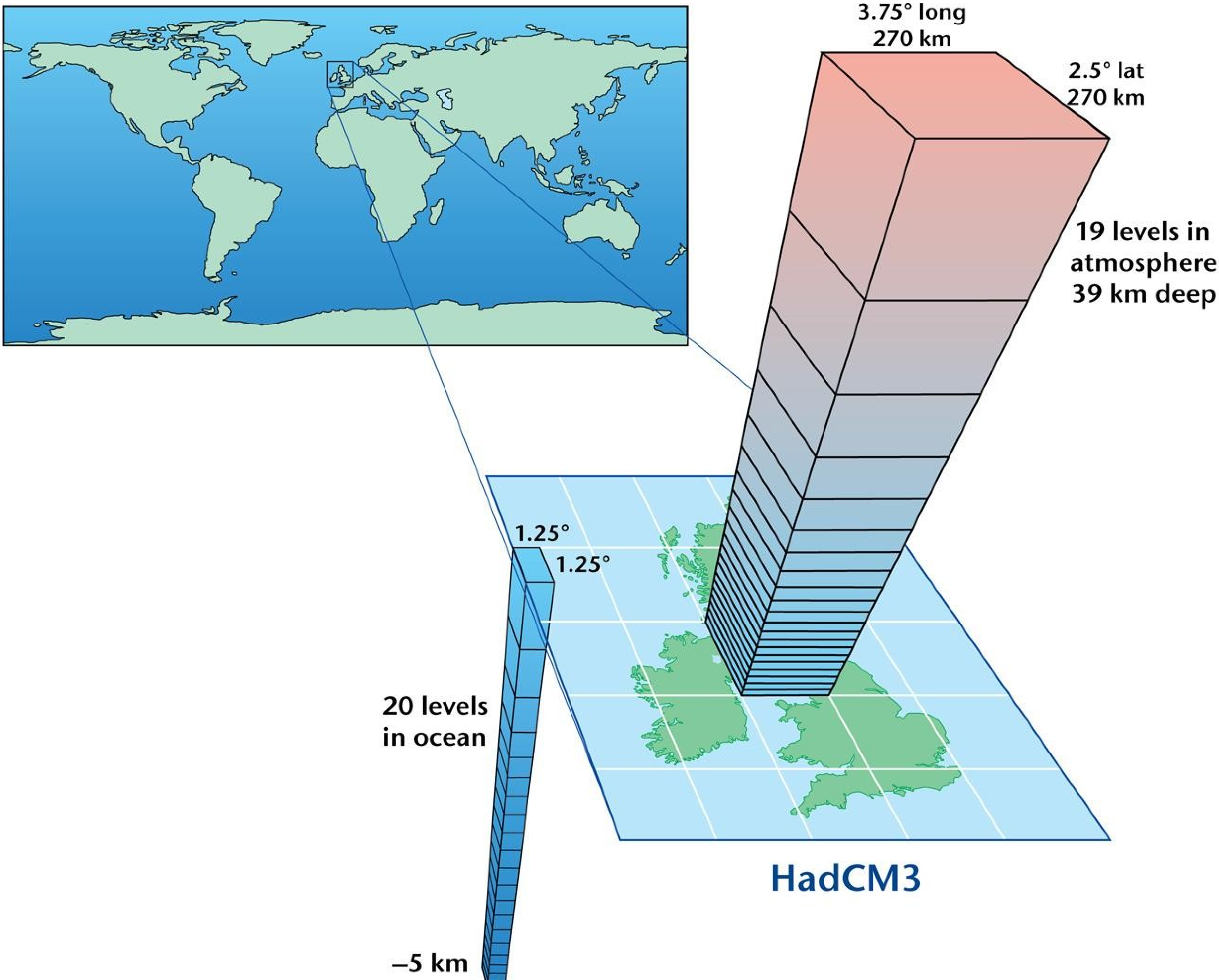
What will Brown Dog do?

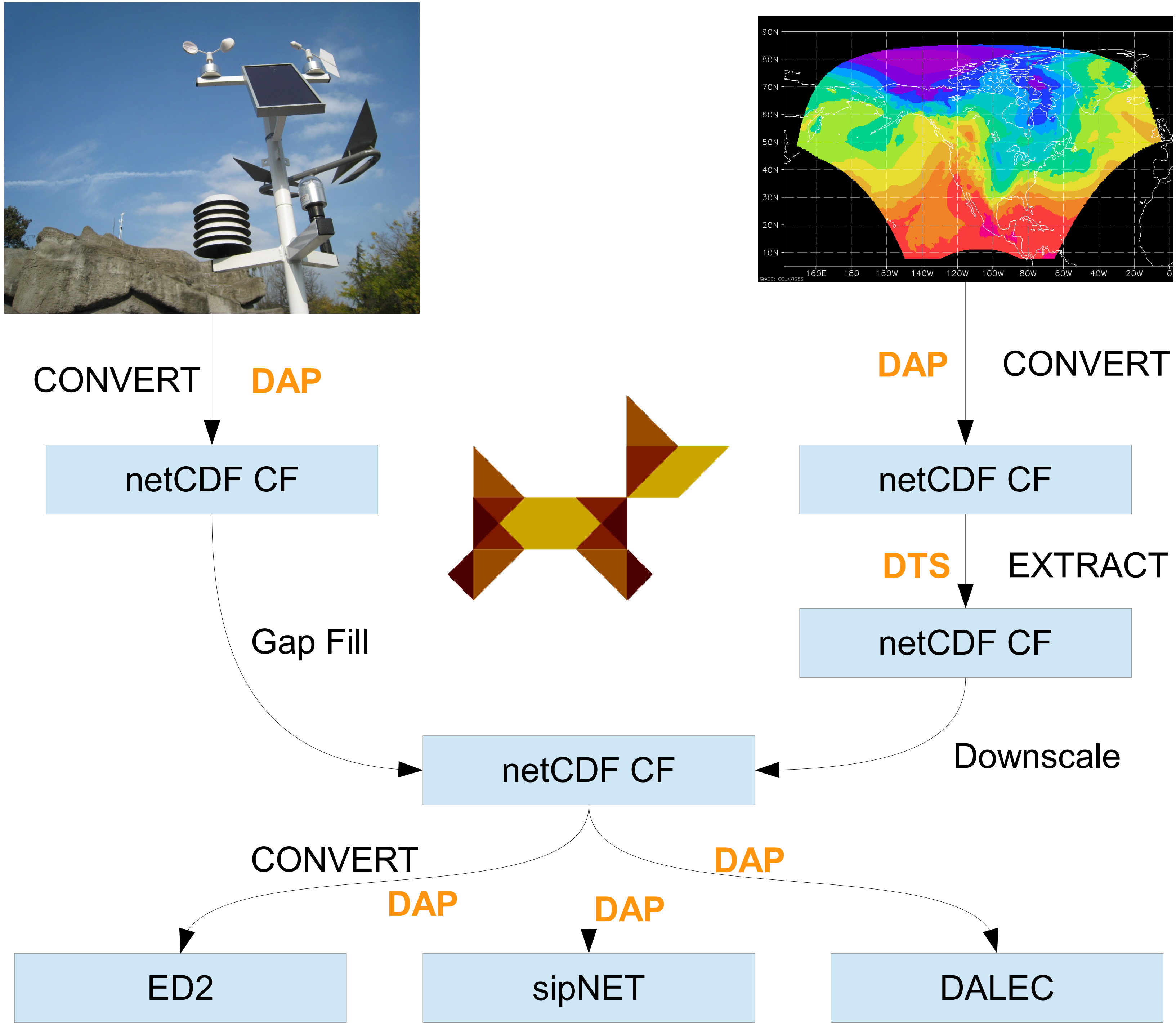


12 - Northern Rockies
9 - Northern Plains
5 - Great Lakes
1 - Northeast
16 - Pacific Northwest
15 - Great Basin
6 - Prairie Peninsula
17 - Pacific Southwest
7 - Appalachians & Cumberland Plateau
2 - Mid Atlantic
10 - Central Plains
13 - Southern Rockies & Colorado Plateau
14 - Desert Southwest
8 - Ozarks Complex
11 - Southern Plains
3 - Southeast
4 - Atlantic Neotropical
18 - Tundra
19 - Taiga
16 - Pacific Northwest
20 - Pacific Tropical
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
Planting Creek
Thayer
Wind River Experimental Forest
Abby Road
McRae Creek Aquatic Relocatable and STREON
Bozeman Creek
Bozeman, MT
Loch Leven
Blacktail Deer Creek
Yellowstone Northern Range
Woodworth
Prairie Lake
Dakota Coteau Field School
Northern Great Plains Research Laboratory
Prairie Pothole
UNDERC
Crampton Lake
Steigerwaldt Land Services
Pickerel Creek
Treehaven
Bartlett Experimental Forest
Sawmill Brook
Harvard Forest
Plum Island Suburban, Burlington
West Branch Bigelow Creek
Red Butte Canyon
Murray, UT
Onaqui-Ault
Central Plains Experimental Range
North Sterling, CO
RMNP, CASTNET
Fool Creek
Niwot Ridge
Como Creek
Fraser Experimental Forest
Arikaree River
Moab
Convict Creek at SNARL Aquatic Core and STREON
San Joaquin
Providence Creek at KREW
Soaproot Saddle
Lower Teakettle
McDowell Creek
Konza Prairie Biological Station
Kings Creek Aquatic Core and STREON
University of Kansas Field Station
Balsman Run Aquatic Relocatable and STREON
Blandy Experimental Farm
Smithsonian Conservation Biology Institute (SCBI)
Smithsonian Environmental Research Center
Posey Creek
Mountain Lake Biological Station
Walker Branch Aquatic Core and STREON
Oak Ridge
Leconte Creek
Great Smoky Mountains National Park
South Pond at Klemme
Klemme Range Research Station
Sycamore Creek Aquatic Core and STREON
CAP LTER
Santa Rita Experimental Range
Jornada LTER
Pringle Creek
Caddo/LBJ National Grassland
Talladega National Forest
Mayfield Creek Aquatic Core and STREON
Dead Lake
Black Warrior River near Dead Lake
Lower Tombigbee River
Choctaw National Wildlife Refuge
Ichawaynochaway Creek
Jones Ecological Research Center
Suggs Lake
Barco Lake
Ordway-Swisher Biological Station
Disney Wilderness Preserve
Barrow Arctic Science Consortium
Toolik Lake
Kuparuk River Aquatic Core and STREON
Caribou Creek - Poker Flats Watershed
Caribou Creek at Poker Flats Aquatic Core and STREON
Poker Flat
Healy
Delta Junction
ALASKA
PuuWaaWaa R1
PuuWaaWaa R2
Olaa
HAWAII
Rio Cupeyes Aquatic Core and STREON
Rio Guilarte
Guanica Forest
Ponce Metro
Lajas Experimental Station
PUERTO RICO
neon
National Ecological Observatory Network
NEON Candidate Aquatic
NEON Candidate Core
NEON Candidate Relocatable


90N
80N
70N
60N
50N
40N
30N
20N
10N
160E
180
160W
140W
120W
100W
80W
60W
40W
20W
0
GrADS: COLA/IGES


N
W
E
S
22 Auckland
22 Hobbiton
18 Wellington
Tasman Sea
22 Christchurch
22 Queenstown
18 Dunedin


3.75° long
270 km
2.5° lat
270 km
19 levels in
atmosphere
39 km deep
1.25°
1.25°
20 levels
in ocean
–5 km
HadCM3

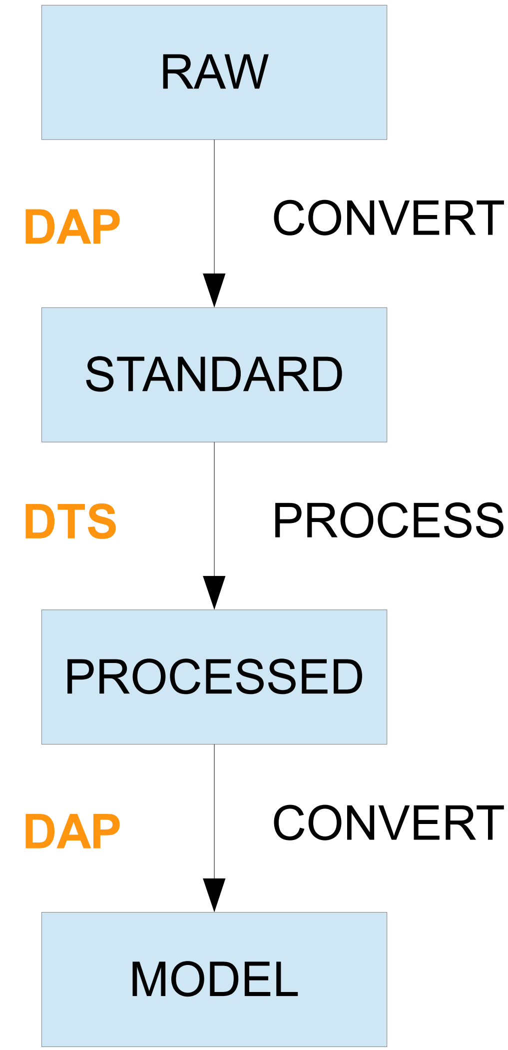

CONVERT
DAP
DAP
CONVERT
netCDF CF
netCDF CF
DTS
EXTRACT
Gap Fill
netCDF CF
Downscale
netCDF CF
CONVERT
DAP
DAP
DAP
ED2
sipNET
DALEC

Currently supported...

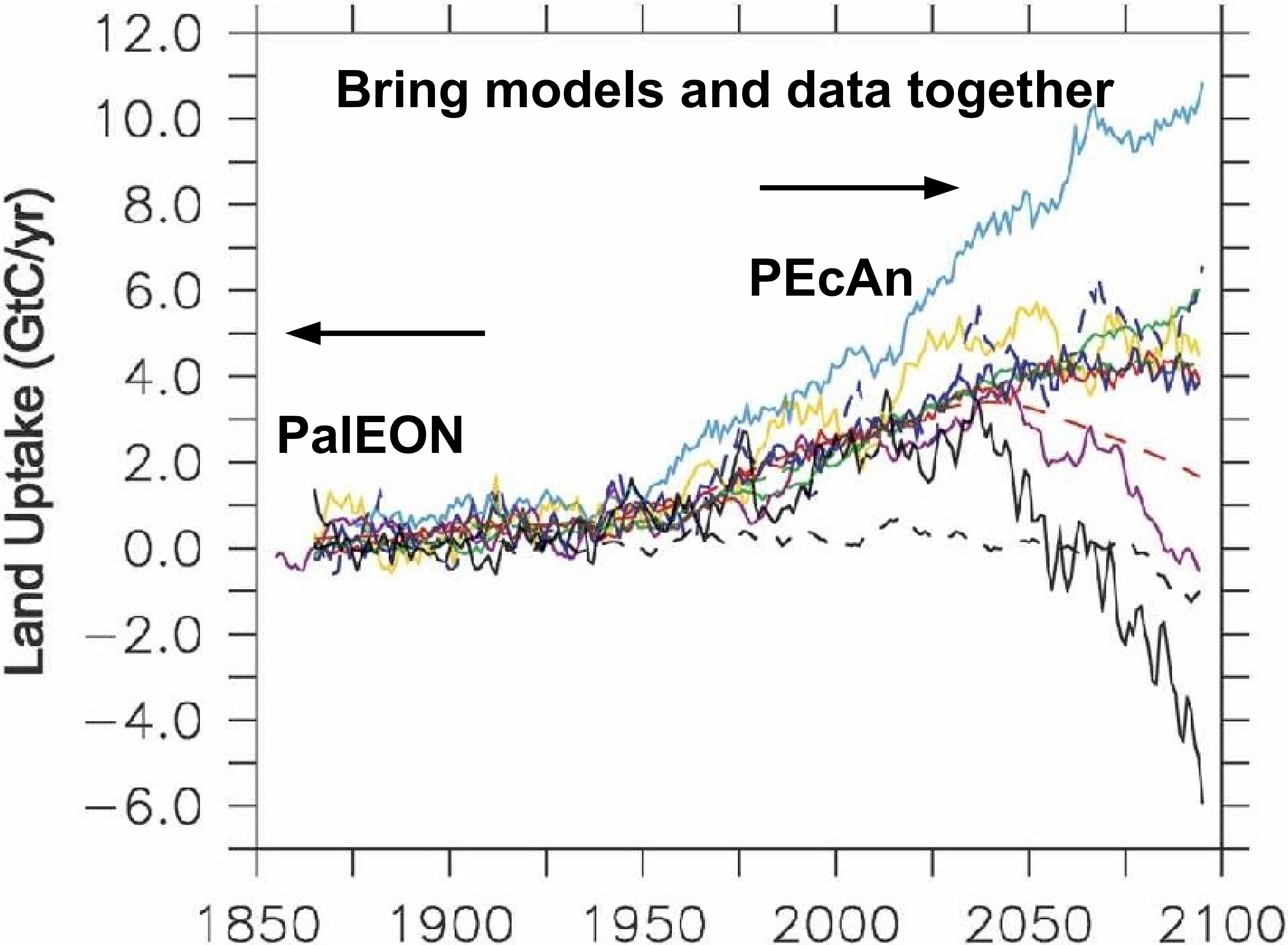
- Site-level
  - Ameriflux
  - Free Air CO_2 Enrichment (FACE) experiments
  - CSV-formatted
    (provided Format registered with PEcAn) **DTS?**
- Regional
  - North American Regional Reanalysis

Vegetation

- Initial Conditions
  - Field Inventory
  - Lidar, Radar → structure
  - Hyperspectral → composition
  - Landsat → land cover
- Dynamics
  - Repeat Inventory → demography
  - MODIS → phenology
  - Landsat → disturbance
  - Lidar, Radar, Hyperspec → change




http://pecanproject.org
https://github.com/PecanProject
NSF ABI #1062547, Arctic #1023477, EBI



Friedlingstein et al 2006

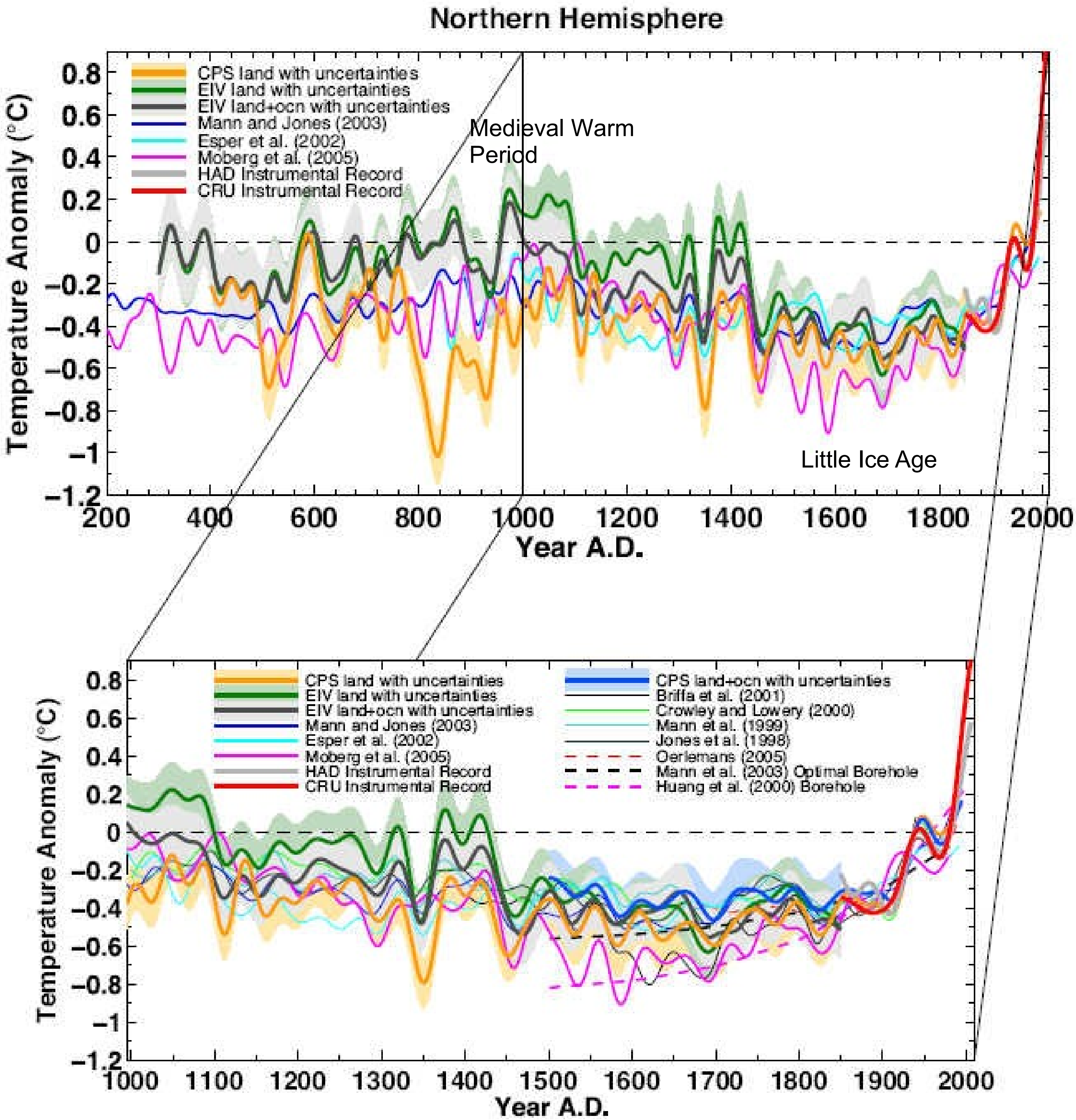
Jason McLachlan	Notre Dame
Michael Dietze	Boston University
Steve Jackson	U. Arizona
Chris Paciorek	UC Berkeley
Jack Williams	U. Wisconsin

60+ PalEON team members

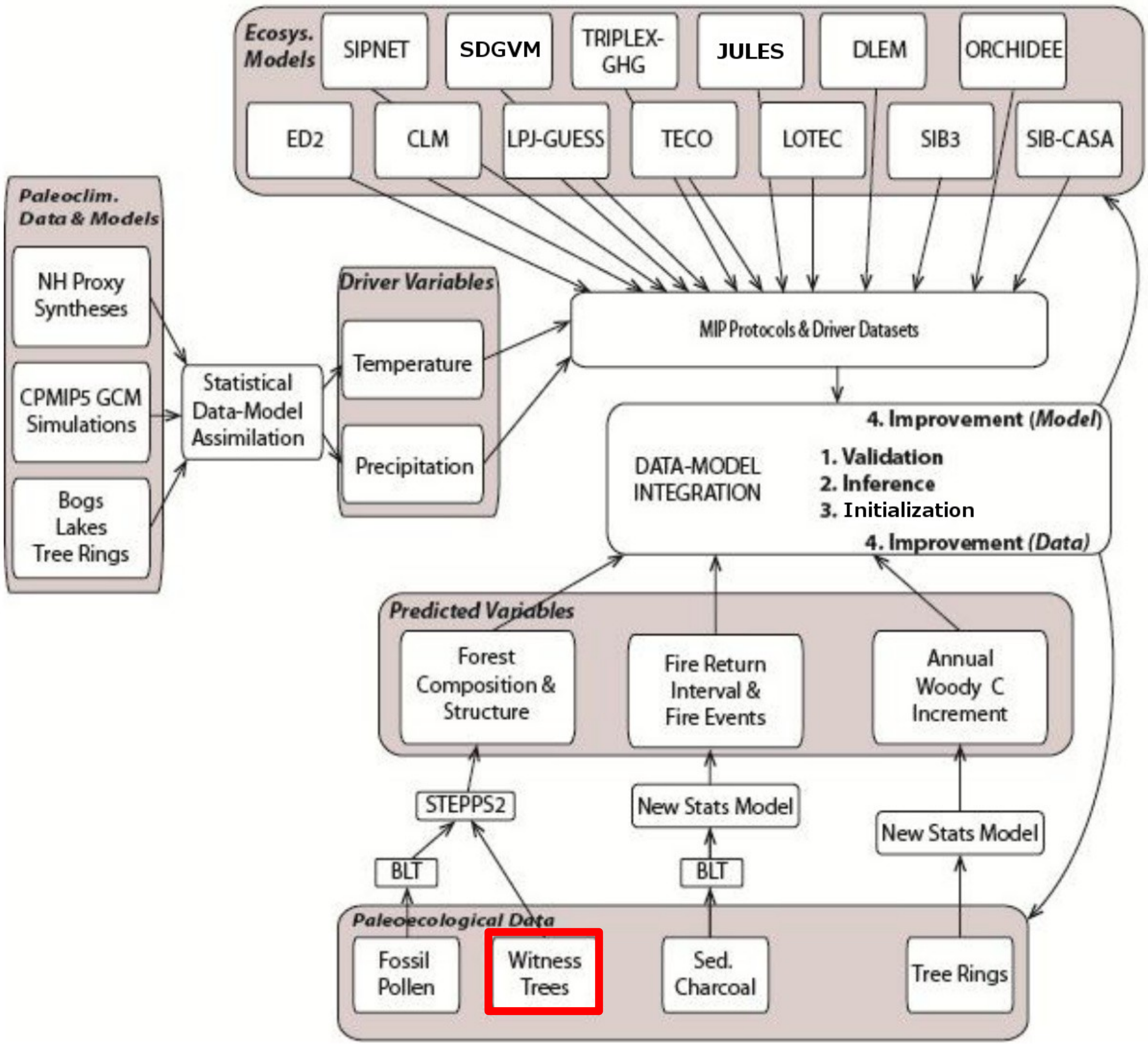
NSF grants #1065848, #1055732, #1065702, #1065656, and #1065646 & Notre Dame Environmental Change Initiative

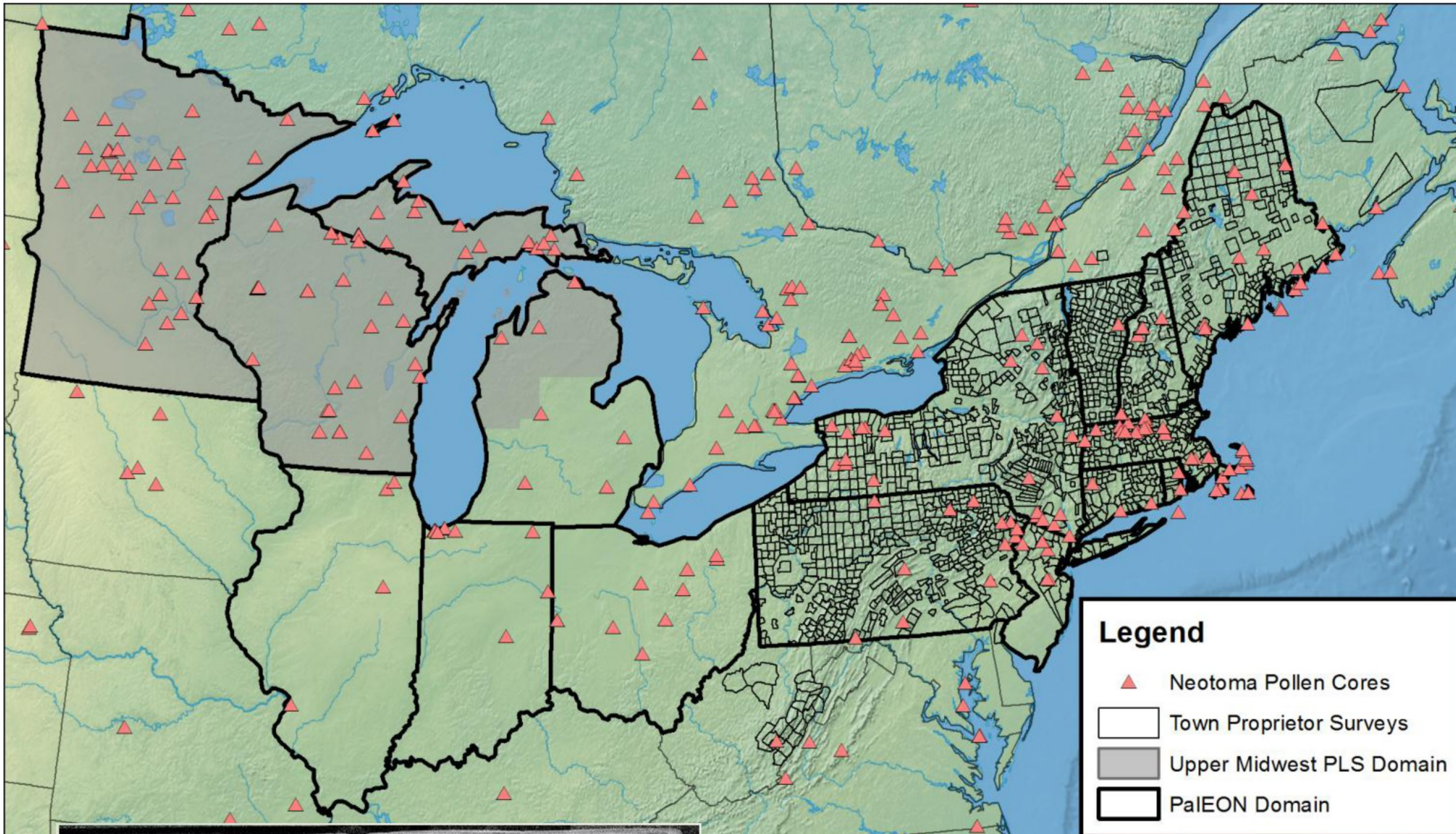
PalEON Goals

- Validation
  - *How well do current models simulate decadal-to-centennial ecosystem dynamics when confronted with past climate change, and what factors most limit model accuracy?*
- Inference
  - *What net carbon fluxes are compatible with an observed species composition and disturbance regime? Was the terrestrial biosphere a carbon sink or source during the Little Ice Age and Medieval Climate Anomaly?*
- Initialization
  - *How sensitive are ecosystem models to initialization state and equilibrium assumptions? Do data-constrained simulations of centennial-scale forest dynamics improve 20th-century simulations?*
- Improvement

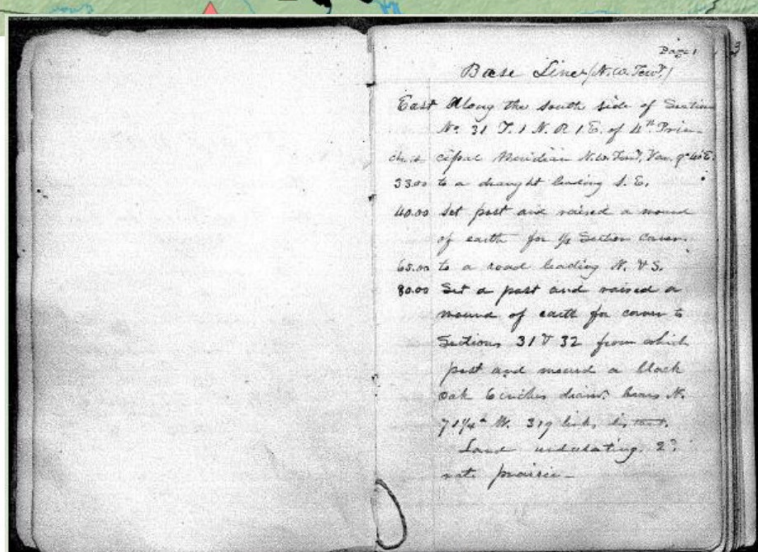


Mann et al 2008 PNAS


Ecosys. Models
SIPNET
SDGVM
TRIPLEX-GHG
JULES
DLEM
ORCHIDEE
ED2
CLM
LPJ-GUESS
TECO
LOTEC
SIB3
SIB-CASA
Paleoclim. Data & Models
NH Proxy Syntheses
CPMIP5 GCM Simulations
Bogs Lakes Tree Rings
Statistical Data-Model Assimilation
Driver Variables
Temperature
Precipitation
MIP Protocols & Driver Datasets
4. Improvement (Model)
DATA-MODEL INTEGRATION
1. Validation
2. Inference
3. Initialization
4. Improvement (Data)
Predicted Variables
Forest Composition & Structure
Fire Return Interval & Fire Events
Annual Woody C Increment
STEPPS2
New Stats Model
New Stats Model
BLT
BLT
Paleoecological Data
Fossil Pollen
Witness Trees
Sed. Charcoal
Tree Rings



(Goring, Mladenoff, Cogbill)


Page 1

Base Line (N.W. Terr.)

East Along the south side of Section No. 31 T. 1 N. R. 1 E. of 4th Principal Meridian N.W. Terr. Var. 9°40' E.

33.00 to a draught leading S.E.

40.00 Set post and raised a mound of earth for 1/4 Section corner.

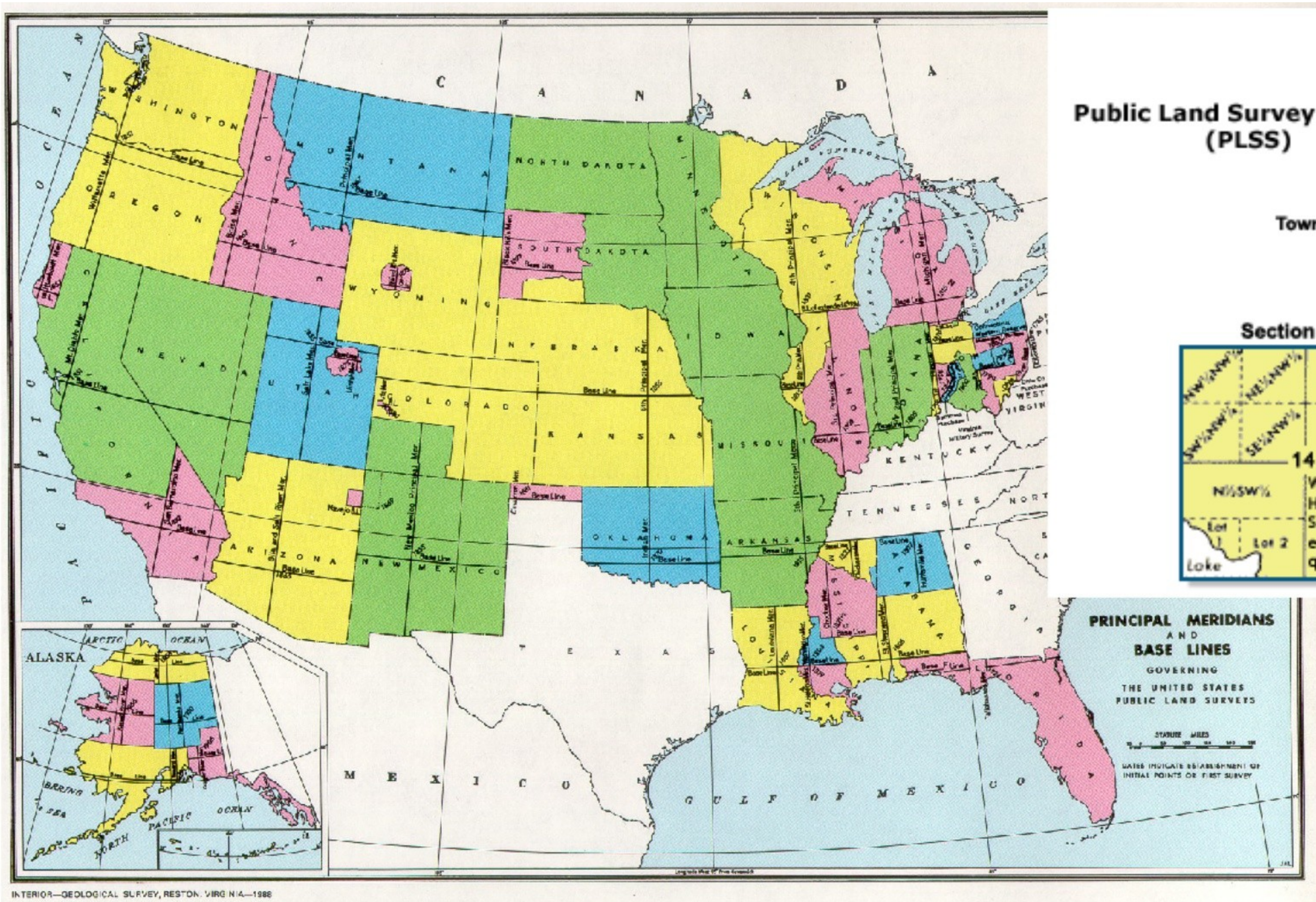
65.00 to a road leading N. & S.

80.00 Set a post and raised a mound of earth for corner to Sections 31 & 32 from which post and mound a black oak 6 inches diam. bears N. 71 1/4 W. 31? links distant.

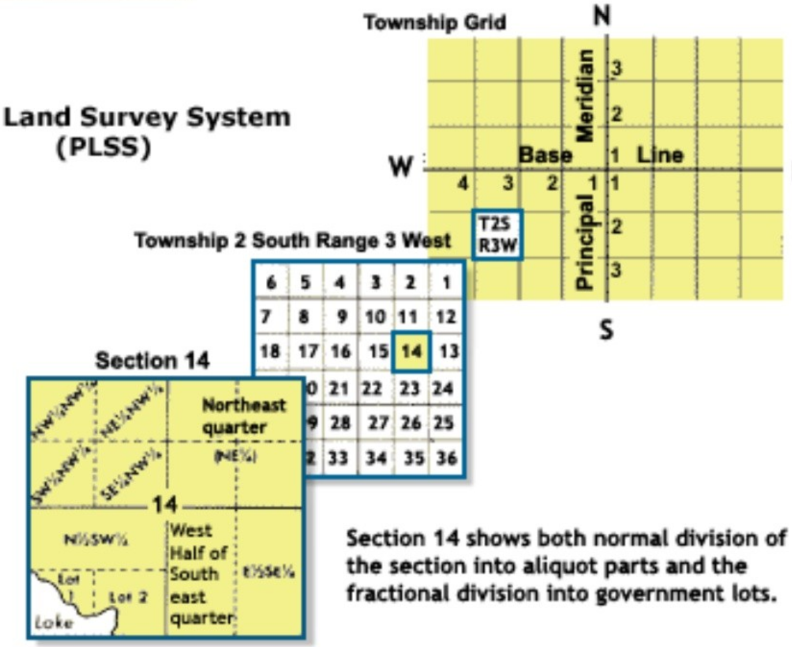
Land undulating. 2d rate prairie.

Similar to Census Project

- Less structured
- Smaller dictionary

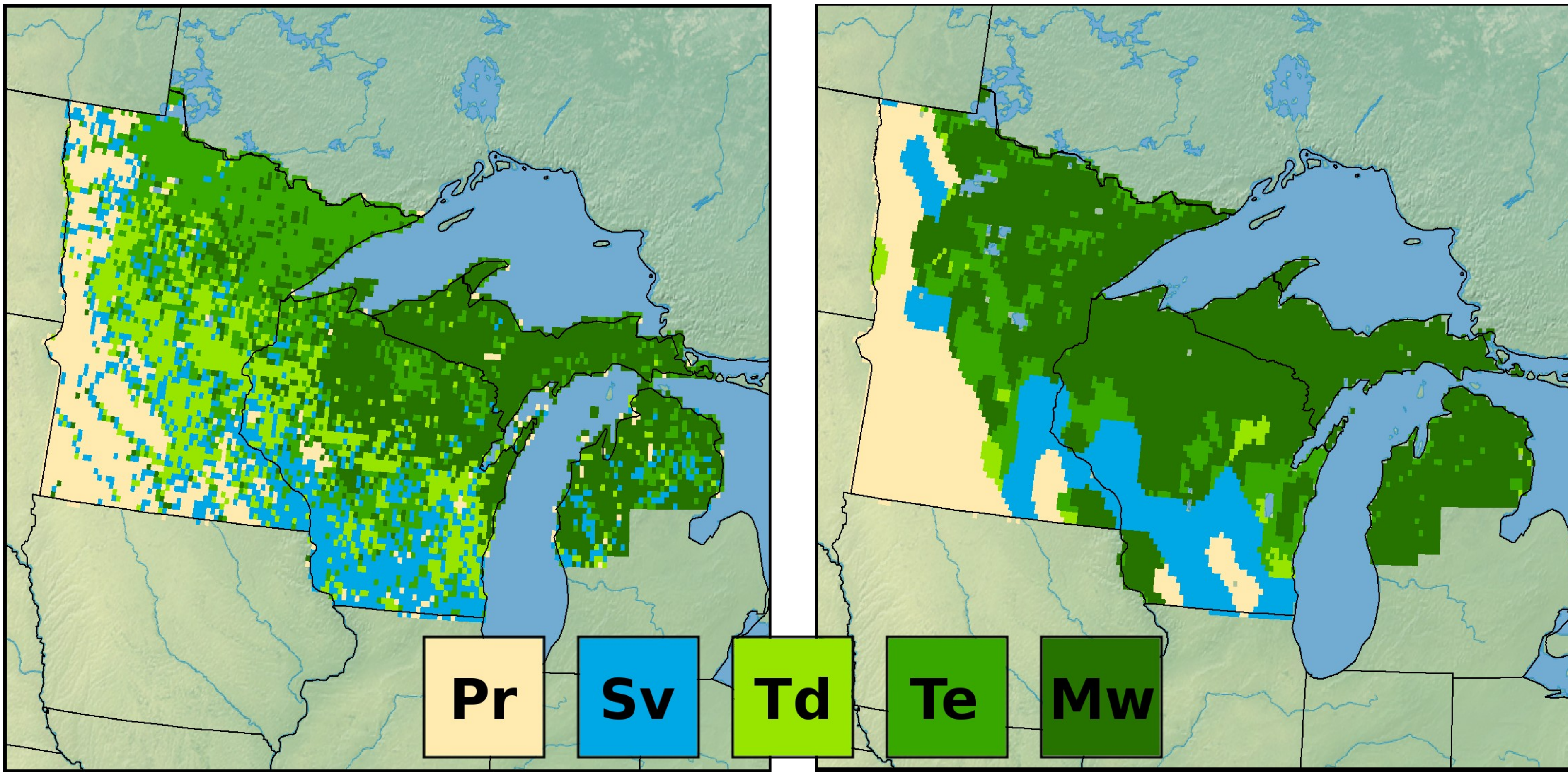


Public Land Survey System (PLSS)



Section 14 shows both normal division of the section into aliquot parts and the fractional division into government lots.

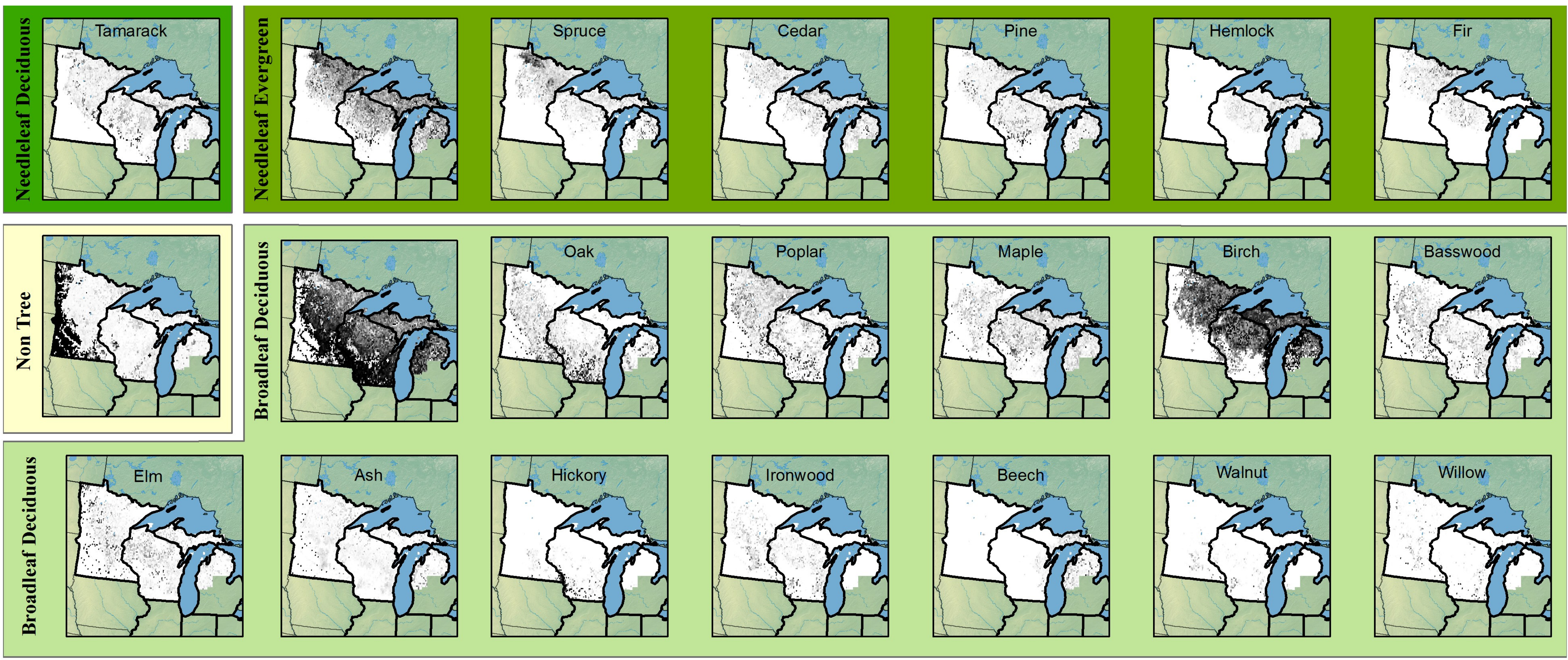
Historical Vegetation   Potential Vegetation



Goring in prep

Ramankutty & Foley

Species Composition



Vegetation Structure