A Decision Support System for Monitoring, Reporting and Forecasting Ecological Conditions of the Appalachian National Scenic Trail

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Appalachian Trail MEGA-Transect Partners

The north-south alignment of the A.T. represents a cross-section **MEGA-Transect** of the eastern U.S. forests and alpine areas, and offers a setting for collecting data on the health of ecosystems for early detection of undesirable changes in the natural resources.

Science and Management Questions:

What is the spatial distribution of RTE species, and are distributions shifting?

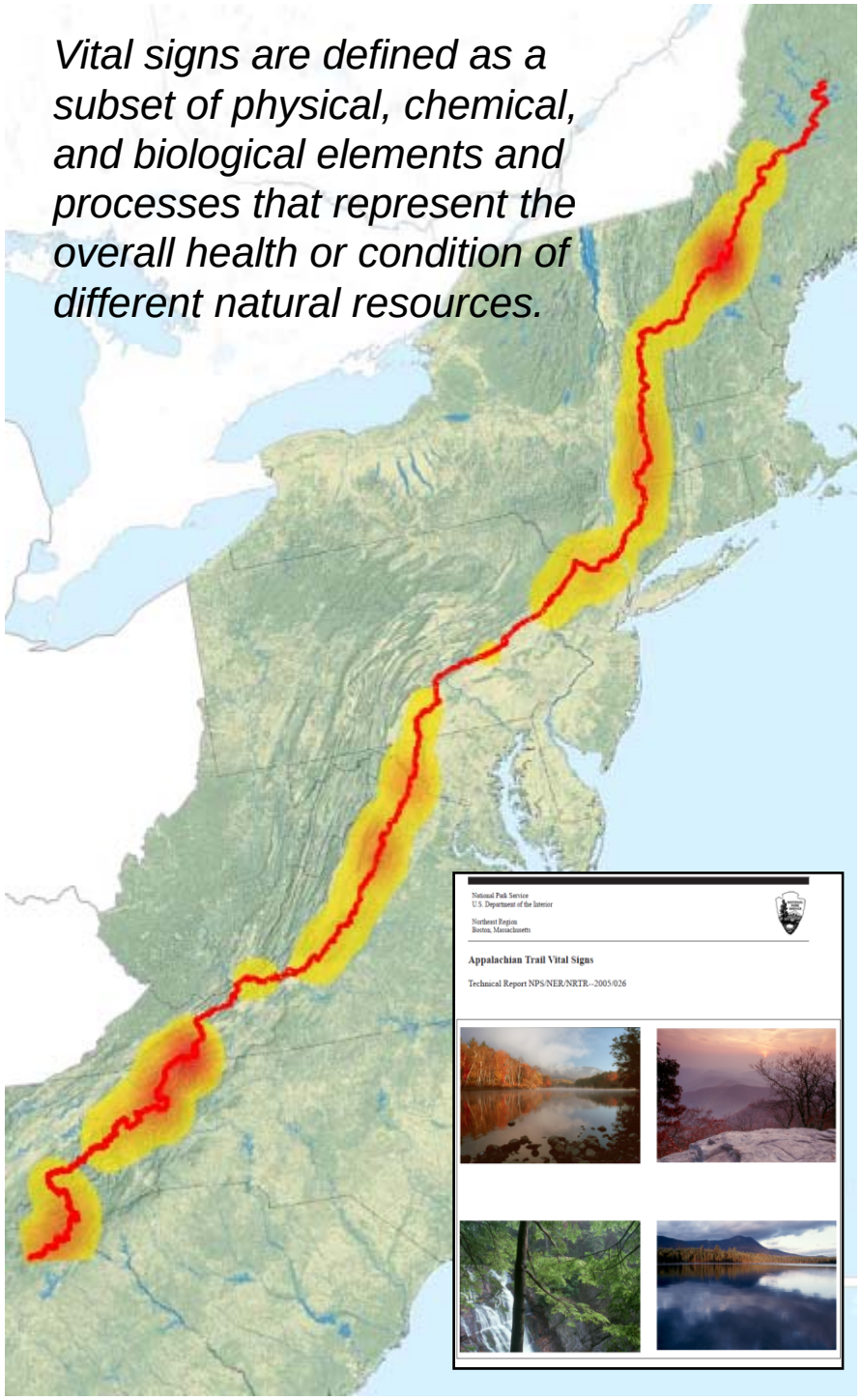
What are the trends in the geographic extent and distribution of invasive species?

What is the geographic distribution of forest and high-elevation vegetation communities and how are they changing?

What are the trends in land-cover, land-use change, and landscape dynamics, and their relationships to key resources and human activities?

How is climate change impacting the geographic distribution, composition and phenology of high-elevation, summit, and ecotonal species?

… …



Vital signs are defined as a subset of physical, chemical, and biological elements and processes that represent the overall health or condition of different natural resources.

NPS I&M
Appalachian Trail Vital Signs

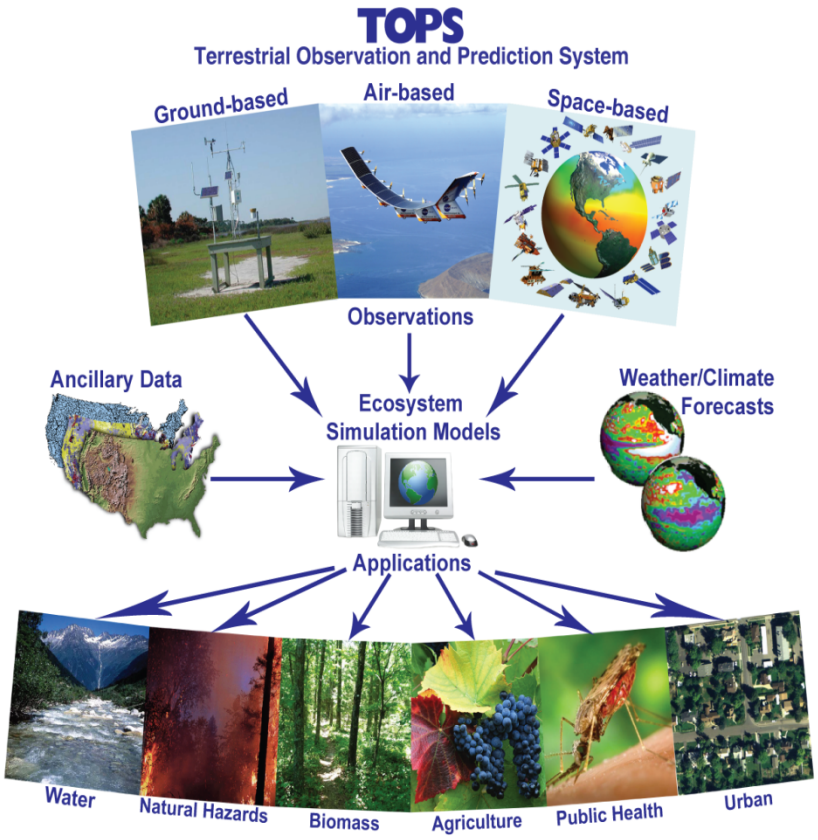
1. Ozone
2. Visibility
3. Atmospheric Deposition
4. Migratory Breeding Birds
5. Mountain Birds
6. Forest Vegetation
7. R.T.E. Species
8. Invasive Species
9. Visitor Usage
10. Alpine and High Ele. Vegetation
11. Landscape Dynamics
12. Phenology/Climate Change
13. Water Resources

TOPS data and modeling products consistent with the selected A.T. Vital Signs.

Key Elements of TOPS

- Monitoring
- Modeling
- Forecasting
- Local to Global

Predictions are based on changes in biogeochemical cycling



Nemani et al., 2009. Remote Sensing of Environment.

Objectives

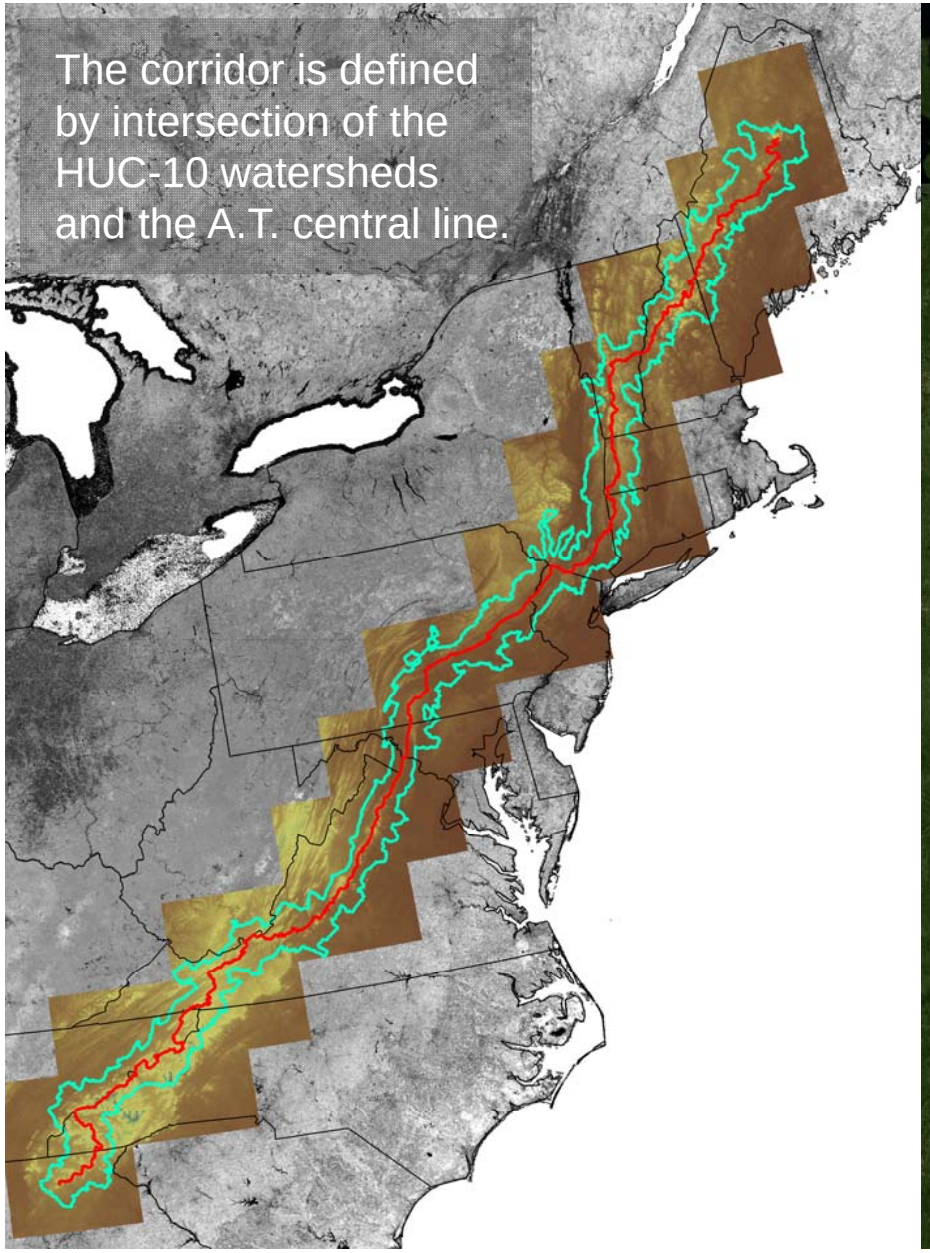
1. Develop a comprehensive set of seamless indicator data layers consistent with selected A.T. “Vital Signs”
2. Establish a ground monitoring system to complement TOPS and integration of NASA data with *in situ* observations
3. Assess historical and current ecosystem conditions and forecast trends with connection to habitat modeling
4. Develop an Internet-based implementation and dissemination system for data visualization, sharing, and management to facilitate collaboration and promote public understanding of the A.T. environment.

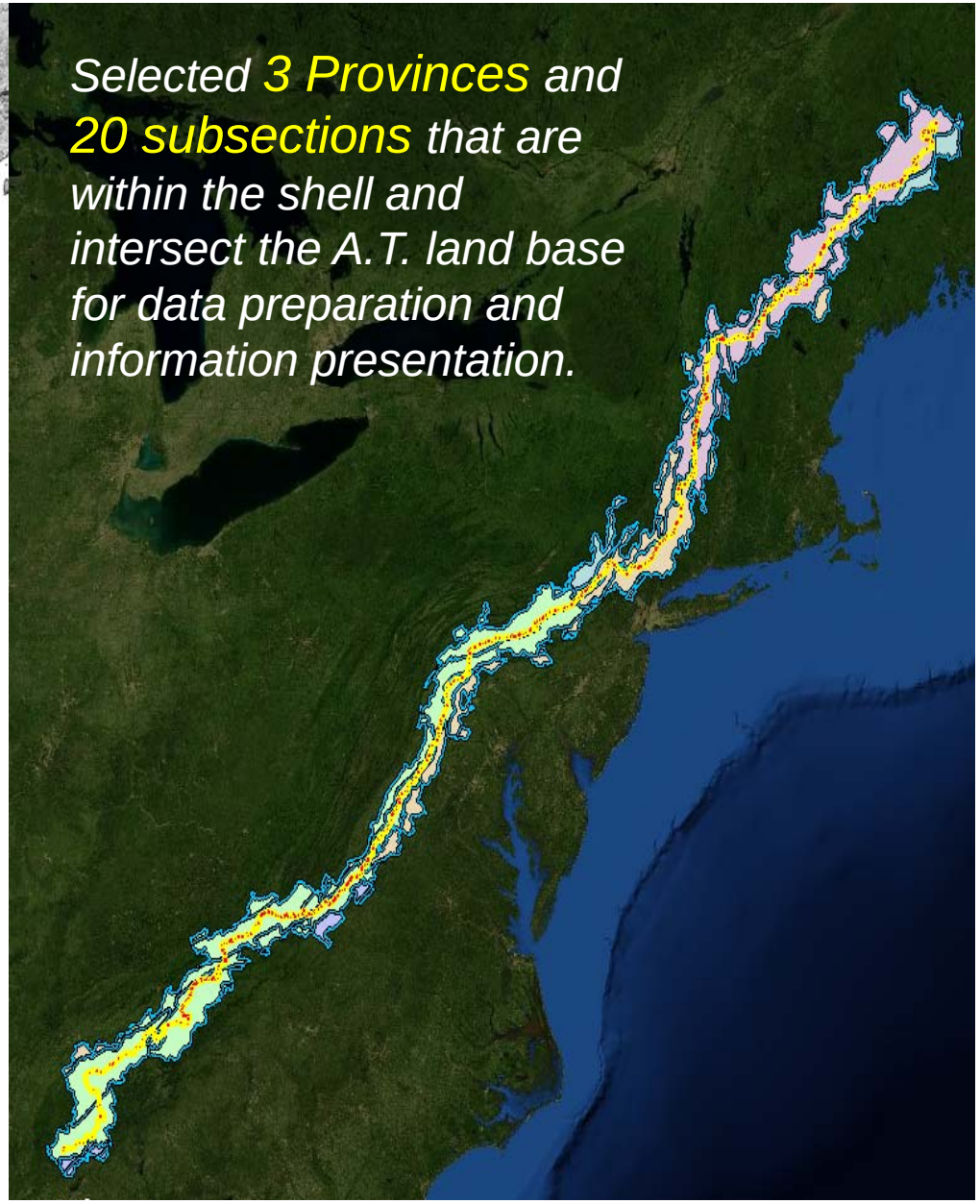
Decision Analysis Workshop (May 2010)

1. Identify **decision-makers, stakeholders, and scope of decisions**. Understand the range of decisions for which data products may be useful. Identify additional partners who could benefit from the tool.
2. Identify and describe objectives. Helps to **determine the level of aggregation** at which data and information will be most relevant and useful to management decision-making.
3. Identify and illustrate potential gaps between information that would be most helpful to decision-makers and planned A.T.-DSS data products. Where such gaps exist, illustrate methods for narrowing the gaps.



User Defined and Selected Spatial Scope of Work

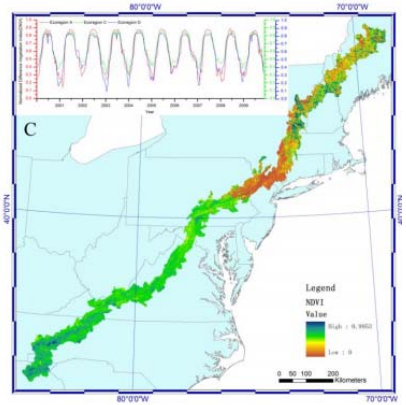




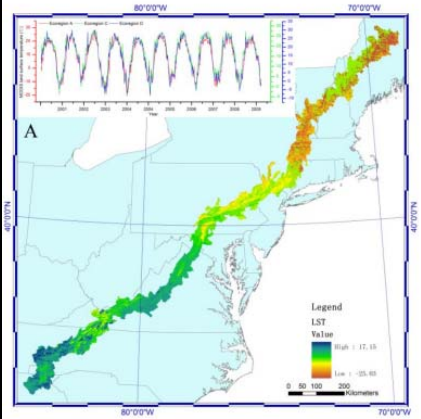
To Address Objective 1: Seamless data for vital signs *(forest health, landscape dynamics and LCLUC, phenology and climate change)*

- MODIS Data Products
  - *Landcover Dynamics (MOD12Q2):* 2001-2011
  - *Snow Cover 8-days (MOD10A2):* 2000 - 2011
  - *Land Cover Type (MOD12Q1):* 2001 - 2004
  - *Vegetation Indices (MOD13A2):* 2000 - 2011
  - *Leaf Area Index FPAR (MOD15A2):* 2000-2011
  - *NDVI (MOD13Q1):* 2000 – 2009
  - *Land Surface Temperature (MOD11A2):* 2000-2011
- GIMMS *(Global Inventory Modeling & Mapping Studies)* NDVI (8-km): 1981-2009
- NACP *(North American Carbon Program)* Modeled Carbon Flux (1-km): 1982-2006
- SOGS *(Surface Observation and Gridding System)* Metrological Data (1-km) from 1976-2008

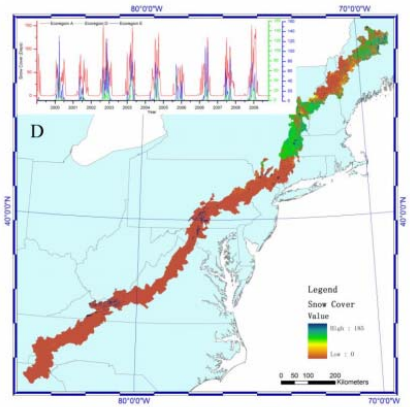
NLCD, LANDFIRE, NED, NWI, …



NDVI

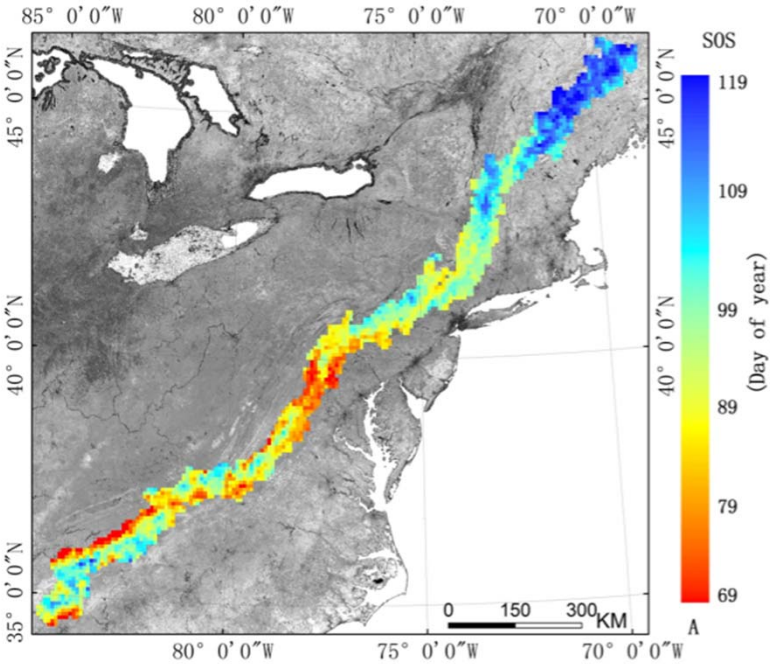


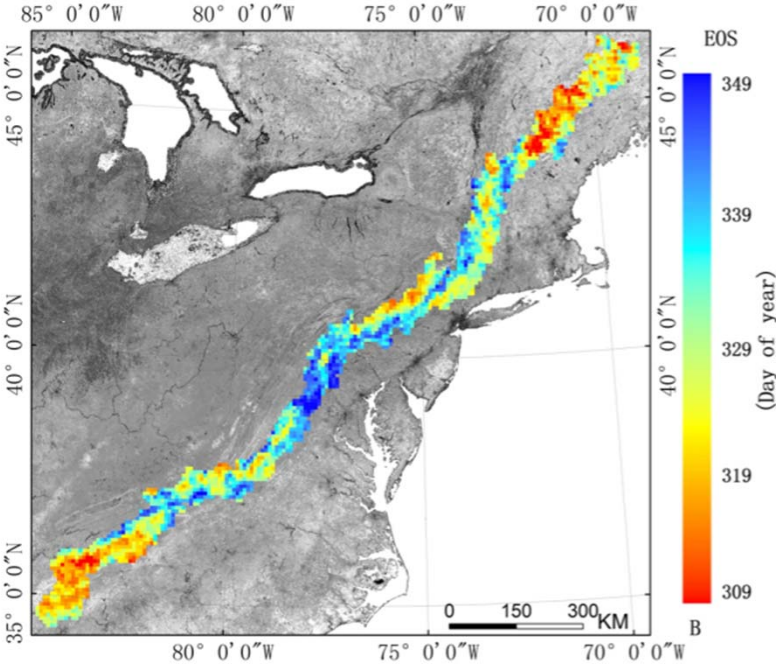
Land Surface Temp

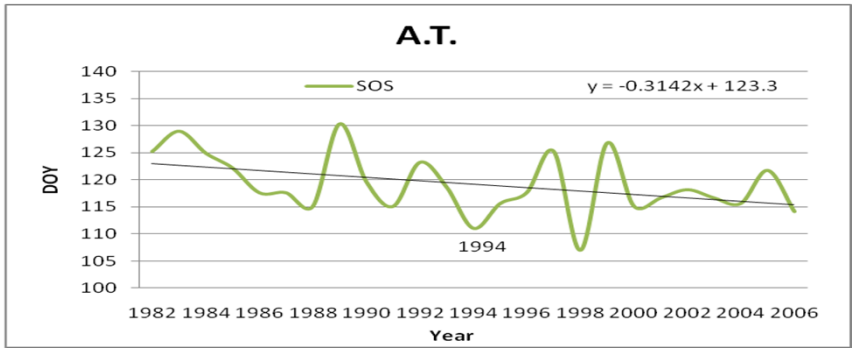


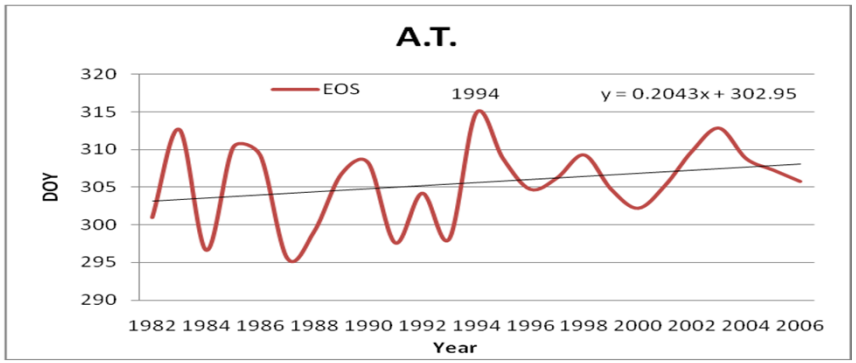
Snow Cover

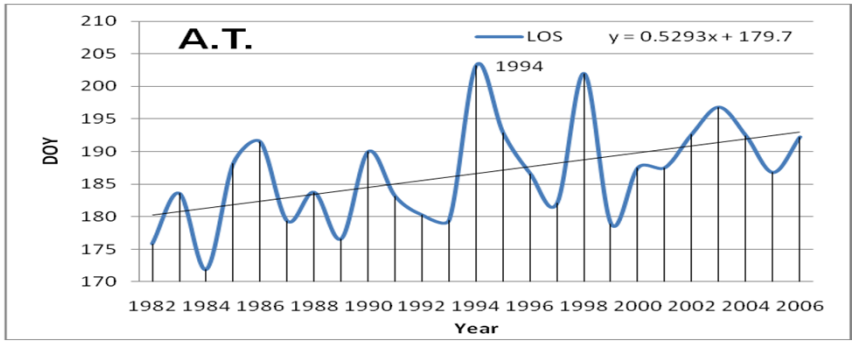
Spatial Distribution and Trend of Land Surface Phenology





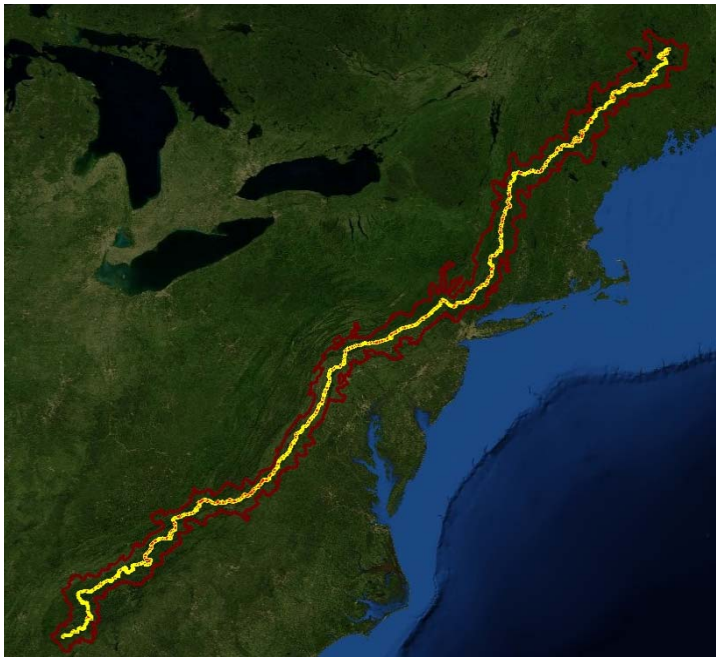


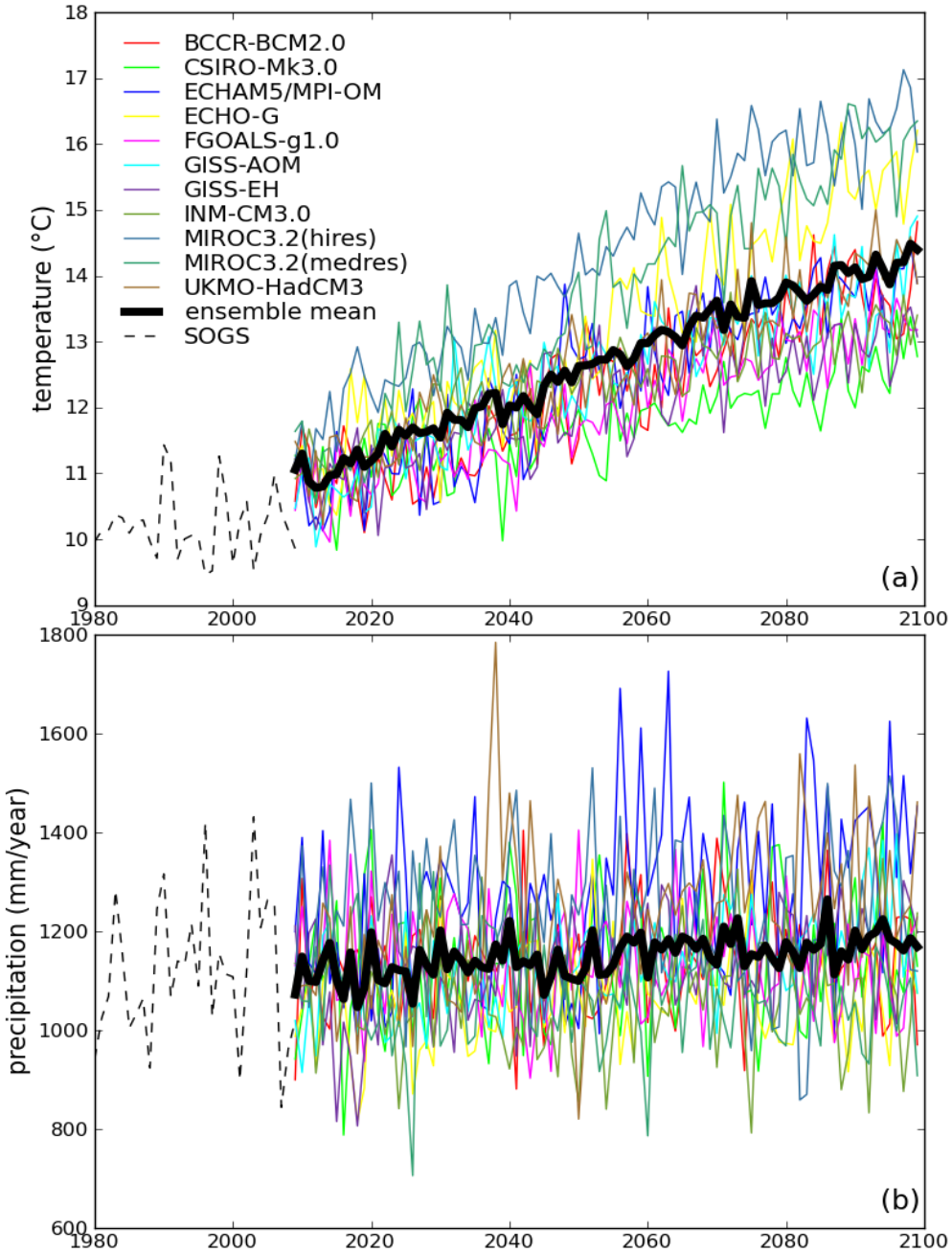




Climate Projection

- All models project steady temperature increase, ensemble mean shows an increase from 11°C to 14.5°C.
- No significant trend in precipitation.

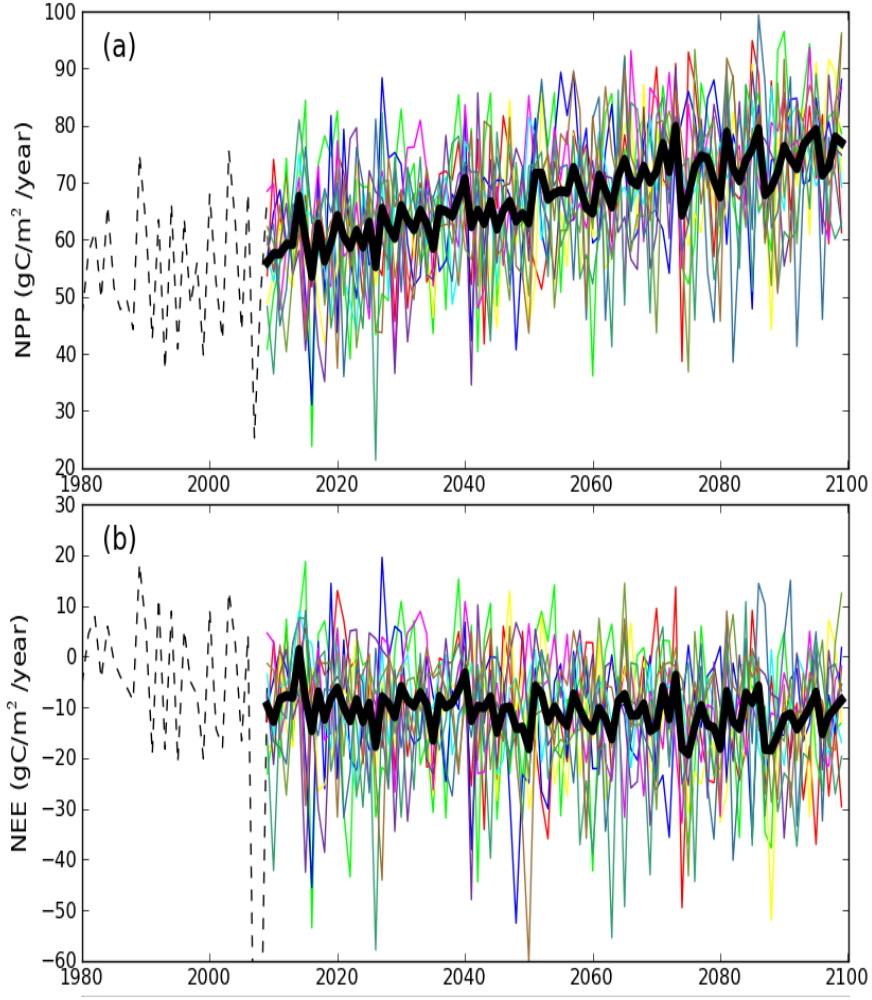




Hashimoto, et al., 2011. In Remote Sensing of Protected Lands, Wang, Y. (Ed.), CRC Press, Boca Raton, Florida.

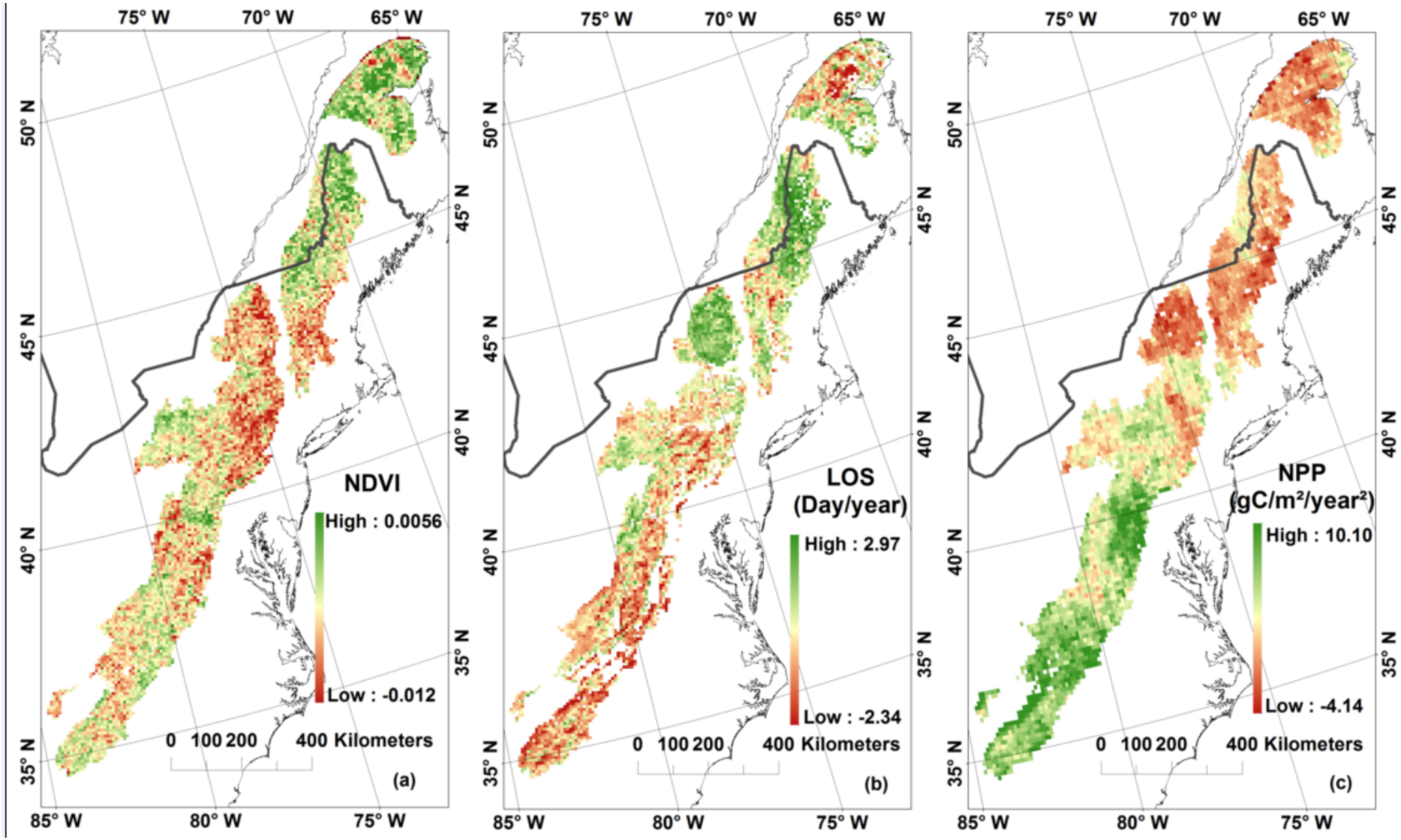
Vegetation Response to Projected Climate Change

- Increase in NPP attributable to CO_2 fertilization effect.
- NEE is constant at -10 gC/m^2/yr (Carbon source).

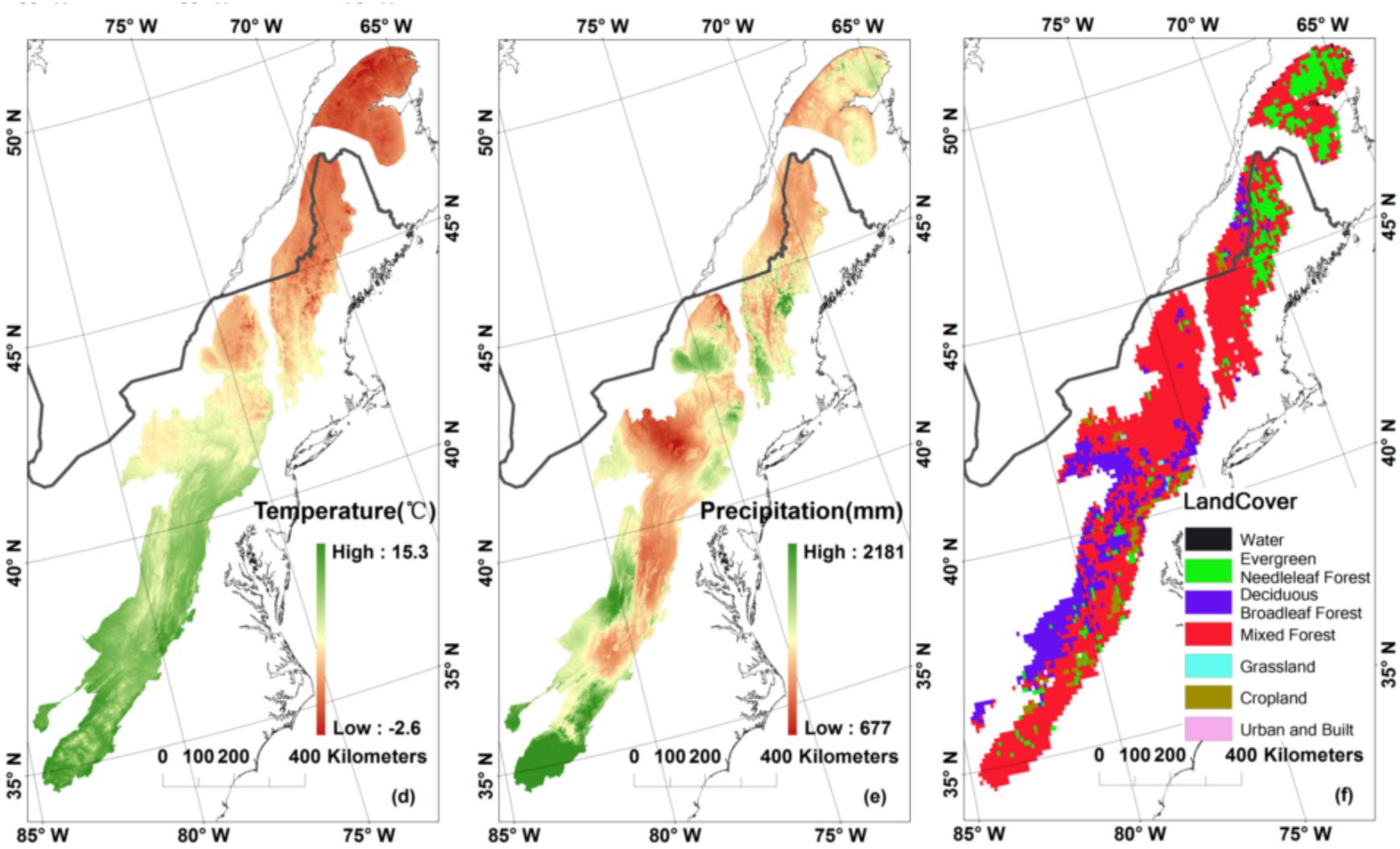


Hashimoto, et al., 2011. In Remote Sensing of Protected Lands, Wang, Y. (Ed.), CRC Press, Boca Raton, Florida.

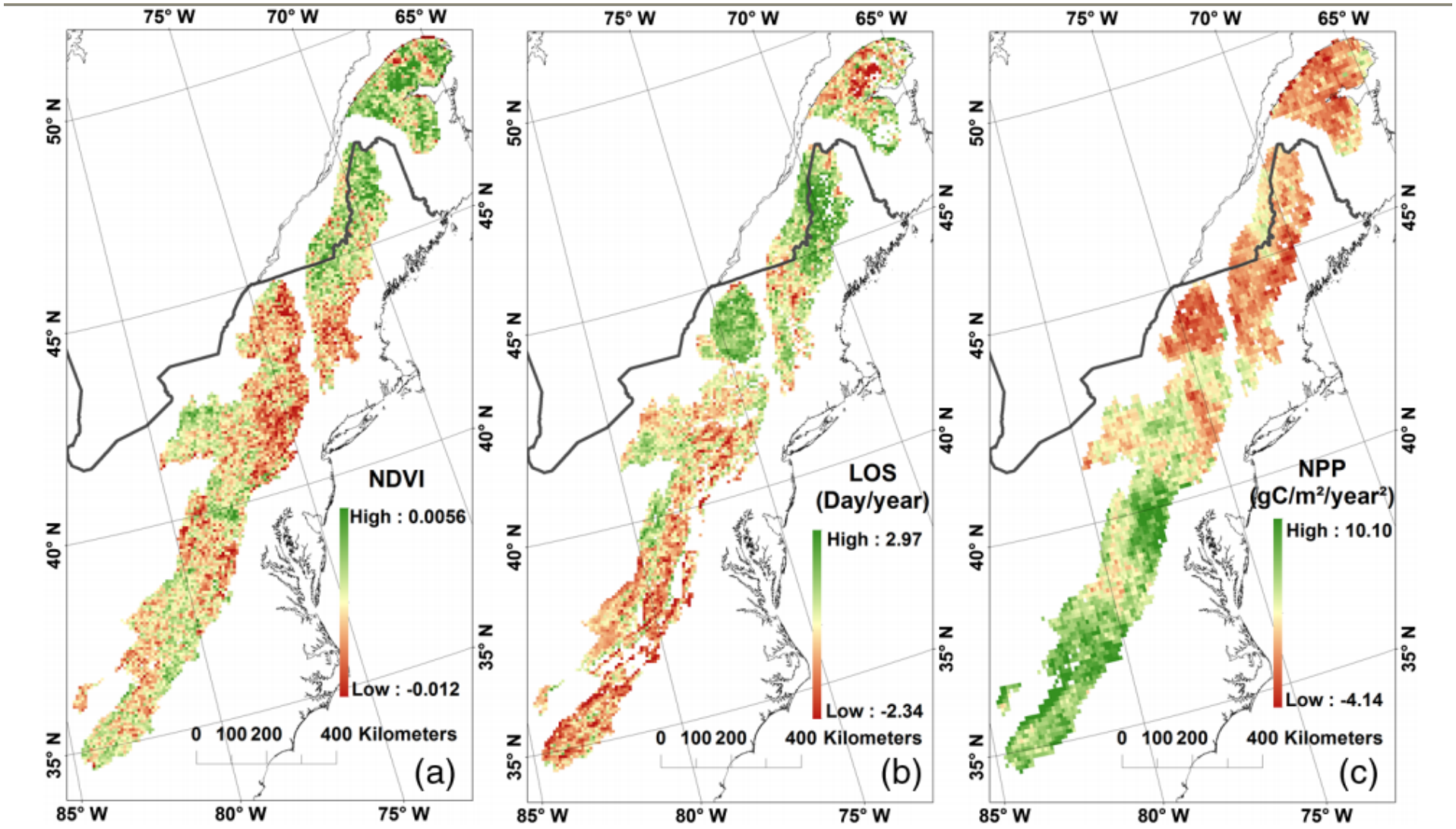
Spatial patterns of mean peak NDVI, LSP, NPP of the Appalachian Mountains regions

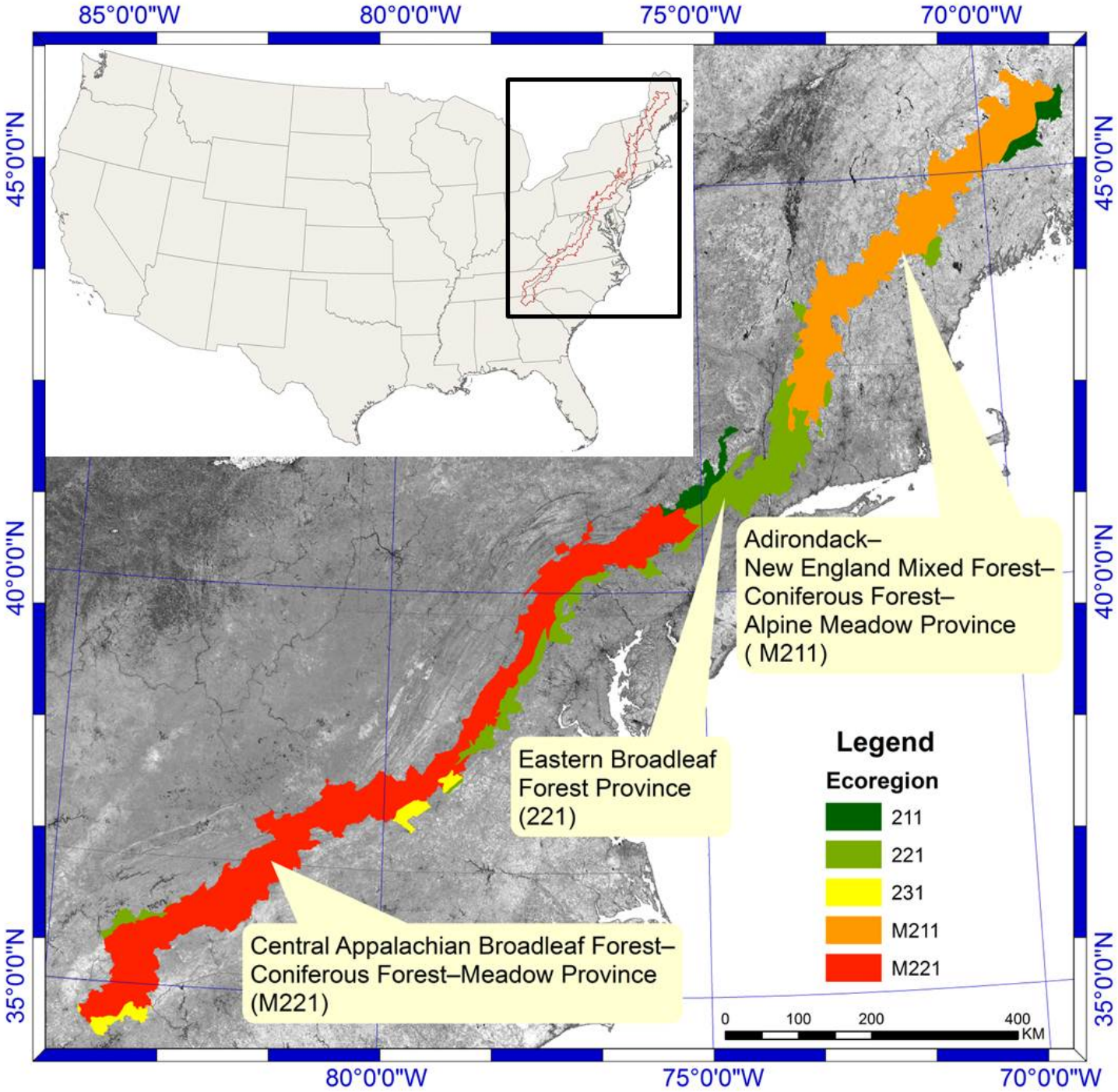


Spatial patterns of mean peak Temperature, Precipitation, and Land Cover of the Appalachian Mountains regions

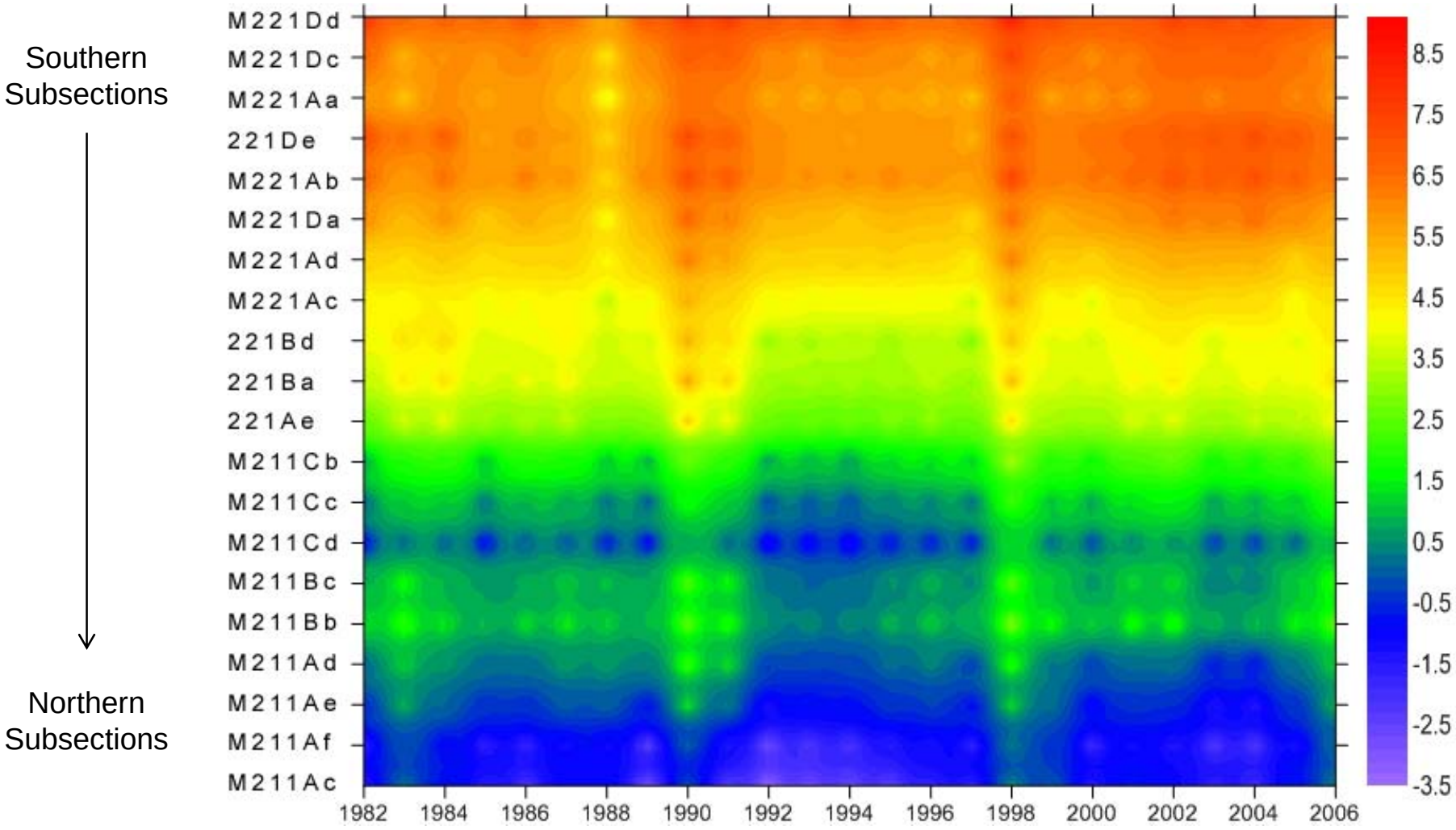


Trends in peak NDVI, LOS, and NPP of the Appalachian Mountains regions

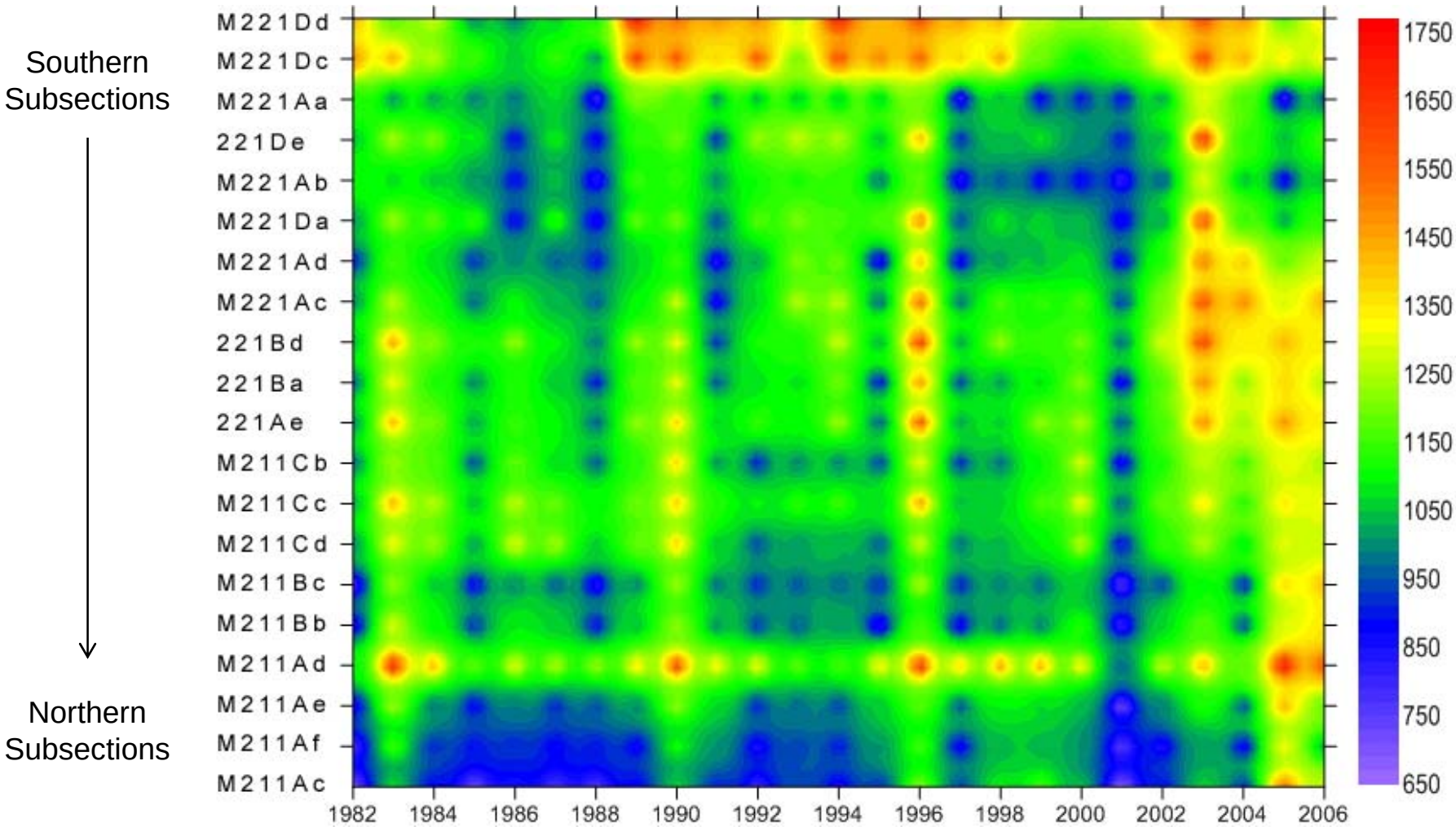



85°0'0"W
80°0'0"W
75°0'0"W
70°0'0"W
45°0'0"N
40°0'0"N
35°0'0"N
Adirondack–
New England Mixed Forest–
Coniferous Forest–
Alpine Meadow Province
(M211)
Eastern Broadleaf
Forest Province
(221)
Central Appalachian Broadleaf Forest–
Coniferous Forest–Meadow Province
(M221)
Legend
Ecoregion
211
221
231
M211
M221
0
100
200
400
KM

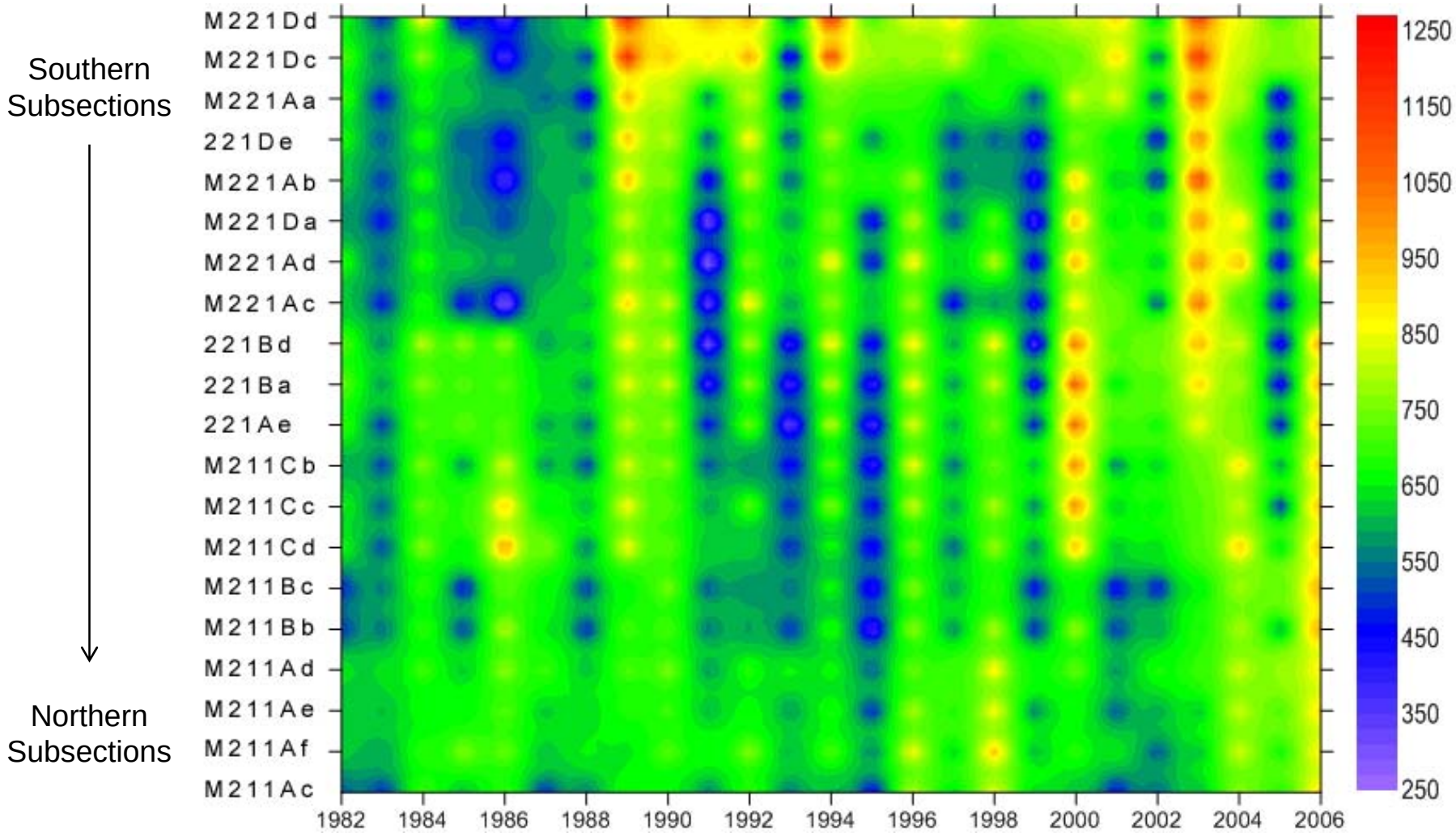
Mean Dew Point Temperature (C°) for Subsections of the A.T. HUC-10 Shell



Annual Precipitation (mm) for Subsections of the A.T. HUC-10 Shell Area

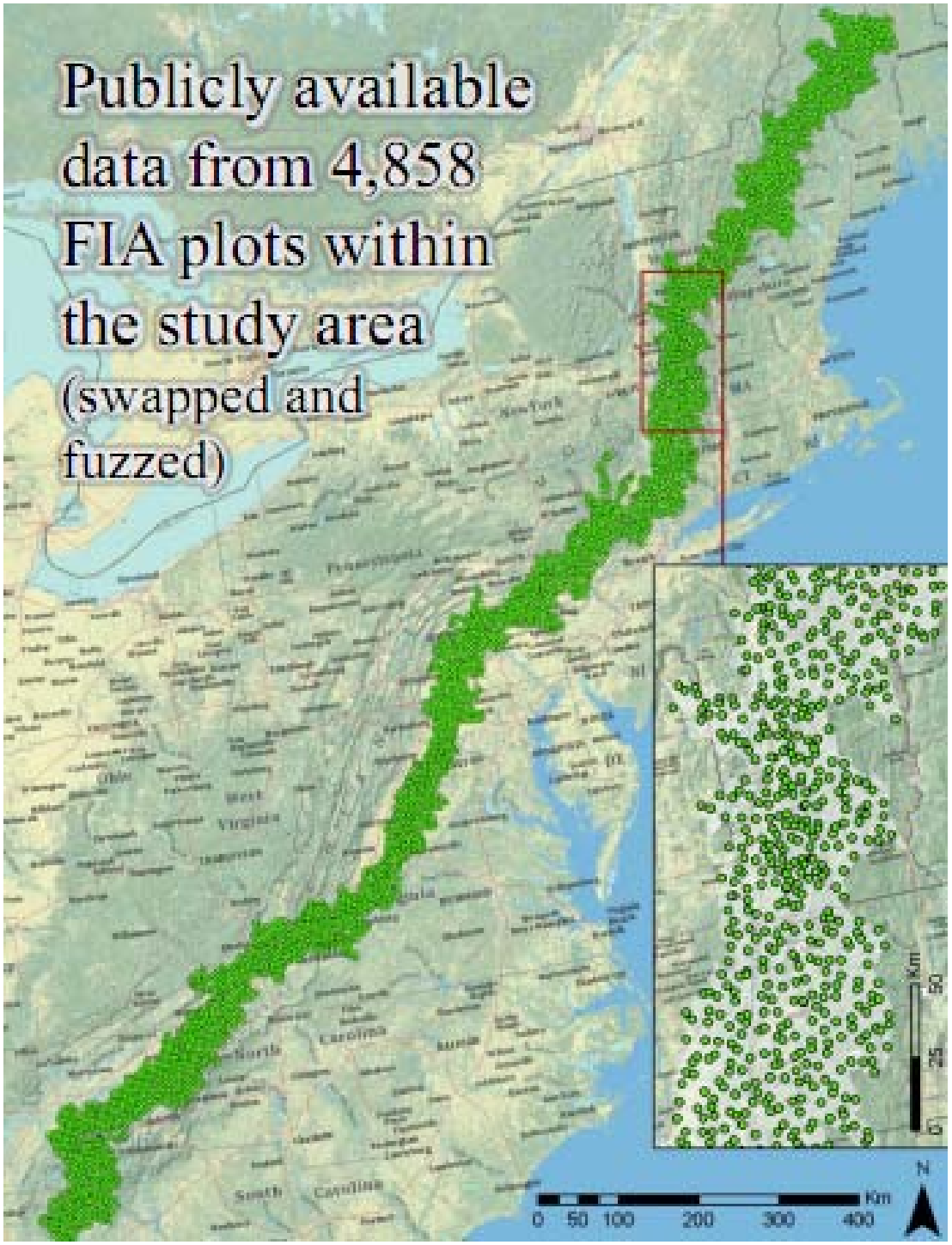


Mean Net Primary Production for Subsections of the A.T. HUC-10 Shell Area



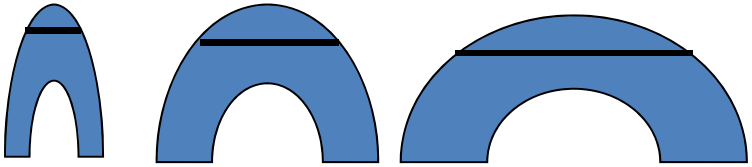
To Address Objective 2: Ground-based Monitoring and Integration of *in situ* and TOPS Data

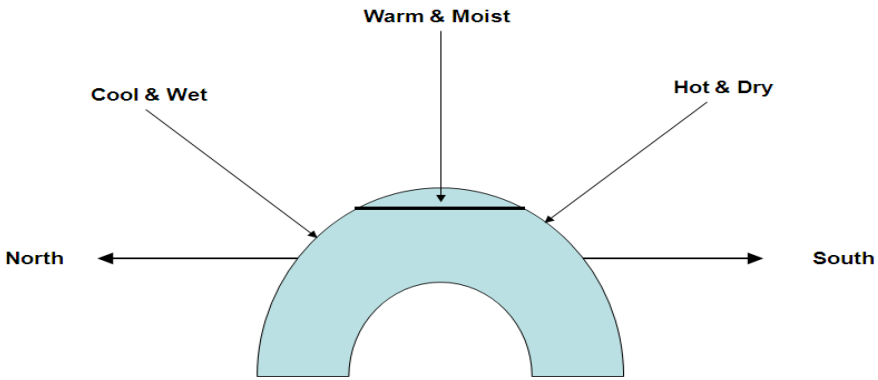
- Used existing USDA Forest Service's FIA data as the in situ measurements
- Collected field data from selected segments
- Collected field data for selected ecotone plots



In situ Data Collection for Selected Segments and Ecotons

The ecotonal zone becomes narrower and closer to top of ridge as percent slopes increase. Aspect, elevation, soil type & condition, latitude, etc. are major factors in the width of ecotones on ridges.





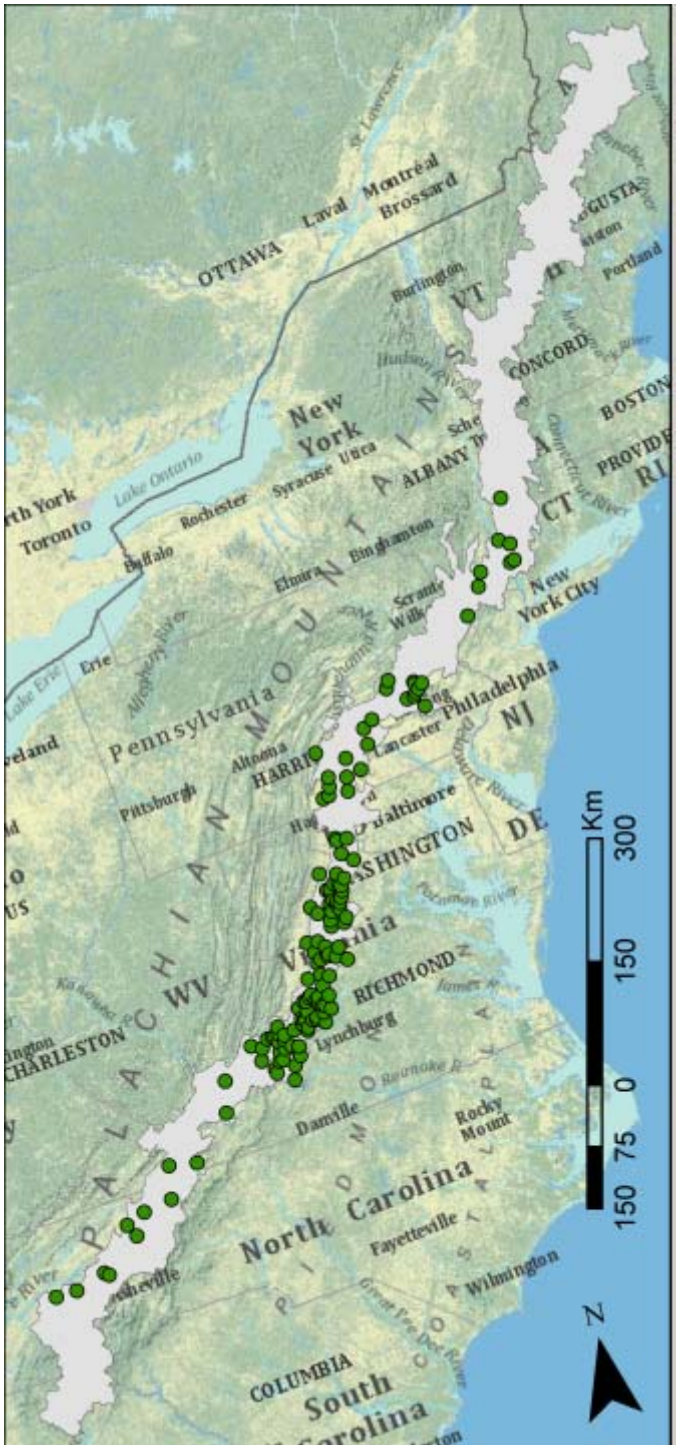
To Address the Objective 3: Habitat Modeling - Develop the Application Prototype

Tree of Heaven (*Ailanthus altissima*), a wide-spread fast-growing invasive species and a concern within the study area.

1. Relate the observed distribution of *Ailanthus* to a set of ecogeographical variables.
2. Map the current distribution of suitable habitats and identify high-risk regions.
3. Integrate results from projected climate change scenarios to simulate potential shifts in the distribution of *Ailanthus* habitats.

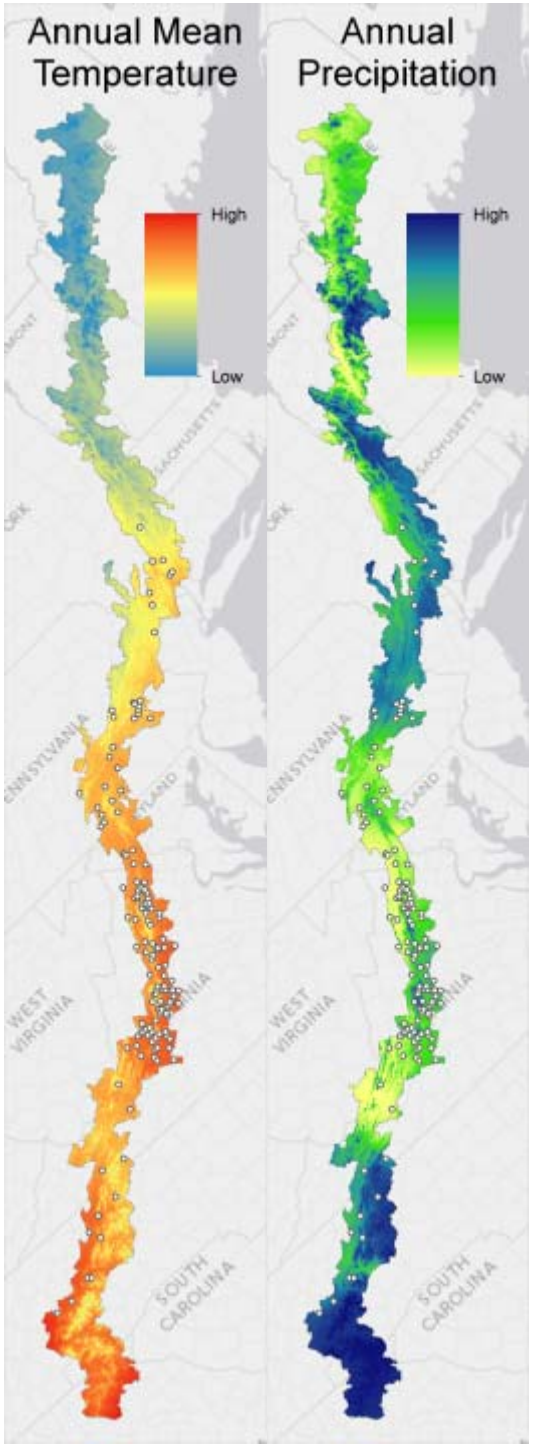
Where are they and the Current habitats

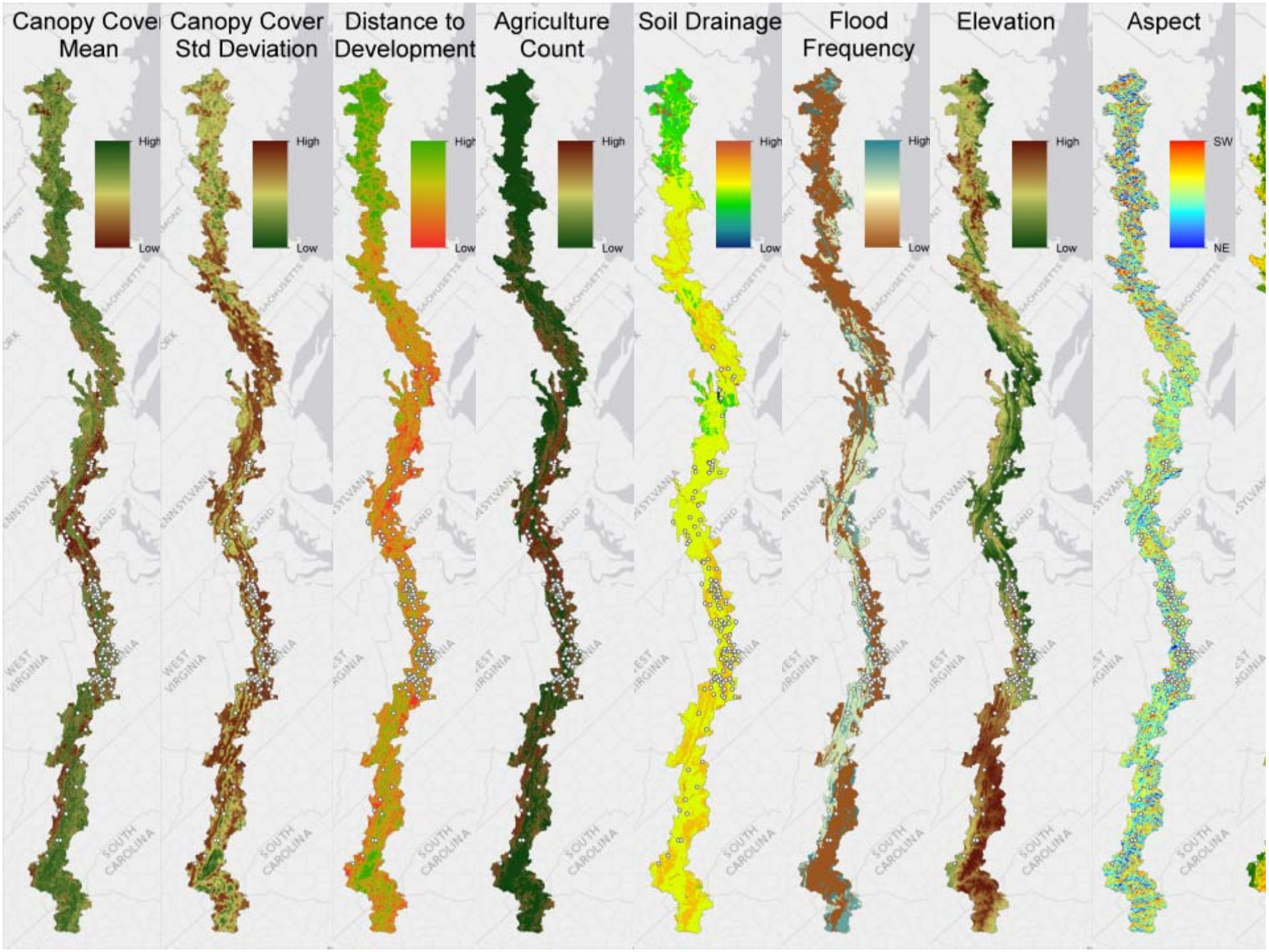
- Large database of *in situ* forest measurements from FIA plots
- Plot locations swapped and fuzzed to protect confidentiality
- *Ailanthus* observed at 136 plots within the A.T. HUC-10 Shell area.

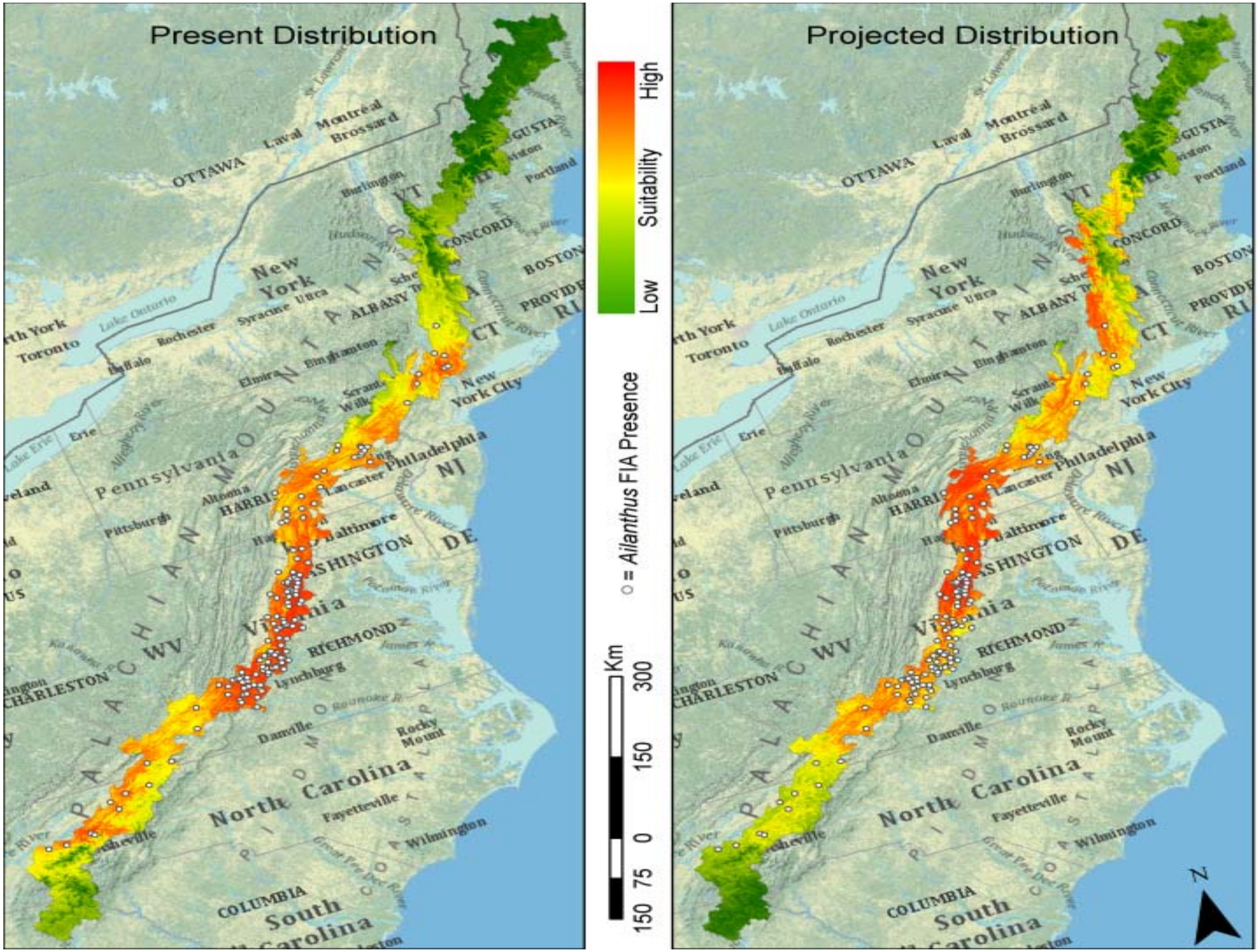


Environmental Variables: Climate

- Current: Bioclim data
  - Suite of biologically meaningful climate variables
  - Annual trends
  - Seasonality
  - Extreme or limiting environmental factors
  - Projections available for various time periods, scenarios, and models
- Projections: TOPS



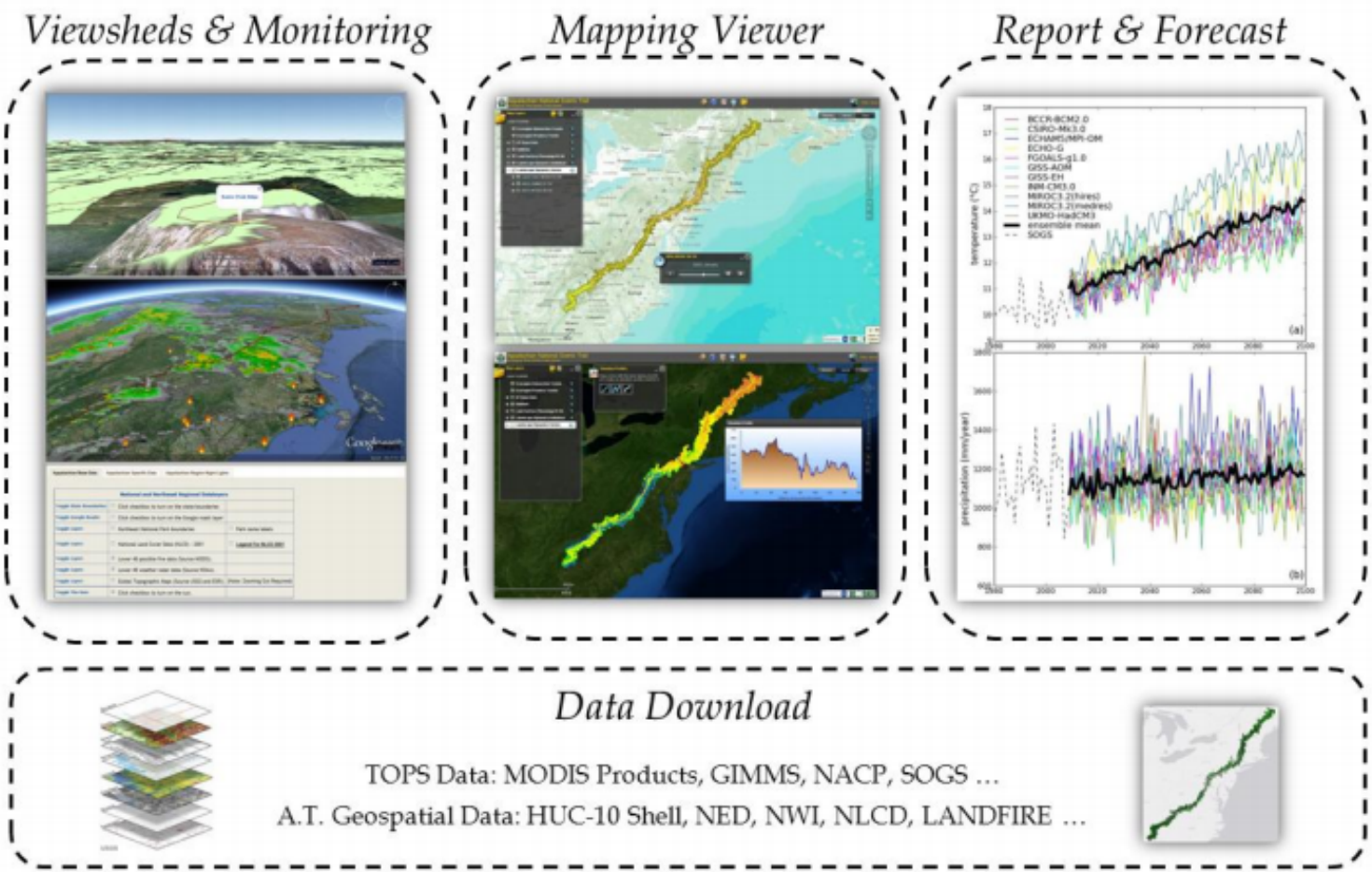

Canopy Cover Mean
High
Low
Canopy Cover Std Deviation
High
Low
Distance to Development
High
Low
Agriculture Count
High
Low
Soil Drainage
High
Low
Flood Frequency
High
Low
Elevation
High
Low
Aspect
SW
NE
WEST VIRGINIA
SOUTH CAROLINA


Present Distribution
Projected Distribution
High
Suitability
Low
○ = Ailanthus FIA Presence
Km
150 75 0 150 300
N
OTTAWA
Laval
Montréal
Brossard
Burlington
VT
CONCORD
BOSTON
Portland
New York
ALBANY
Syracuse
Utica
Rochester
Toronto
Lake Ontario
Buffalo
Elmira
Binghamton
CT
New York City
Erie
Lake Erie
Pennsylvania
Altoona
Pittsburgh
Lancaster
Philadelphia
NJ
Baltimore
DE
WV
RICHMOND
Lynchburg
CHARLESTON
Danville
Roanoke
Rocky Mount
North Carolina
Fayetteville
Wilmington
COLUMBIA
South Carolina

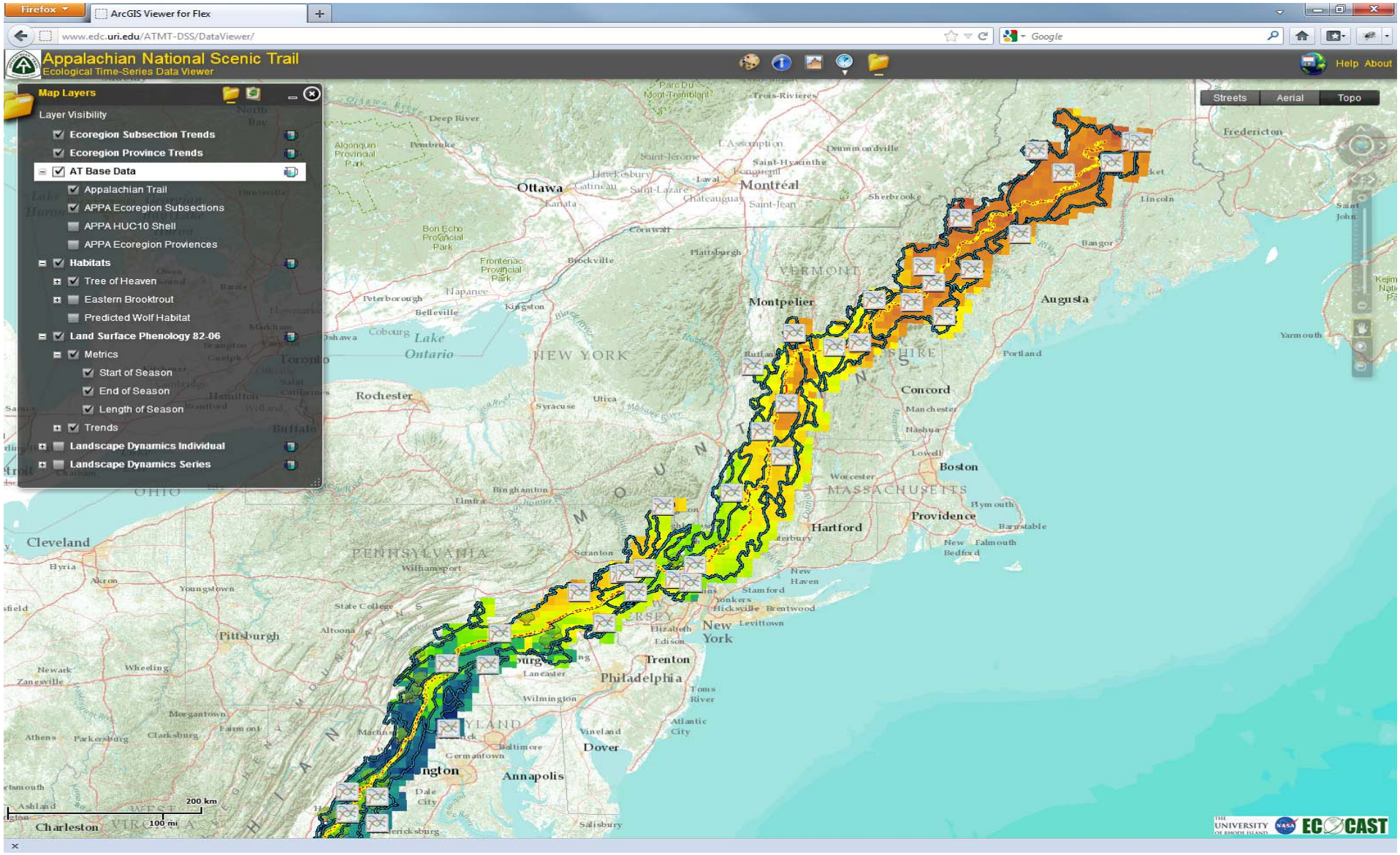
To Address Objective 4: Internet-based A.T.-DSS

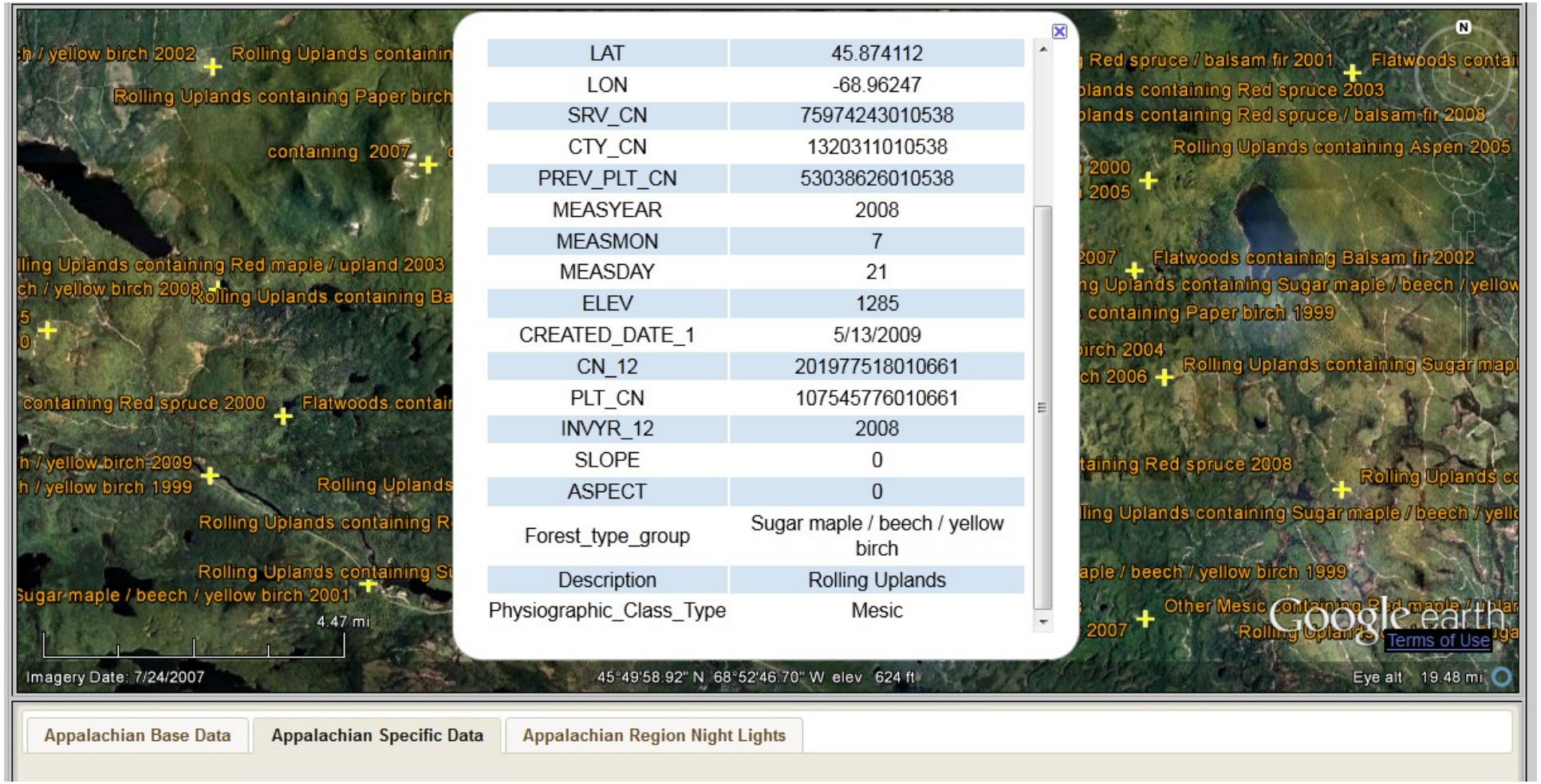
A system for implementation, dissemination , visualization, mapping, data sharing, and facilitating collaboration in decision support and public understanding of the A.T. environment.

http://www.edc.uri.edu/ATMT-DSS/

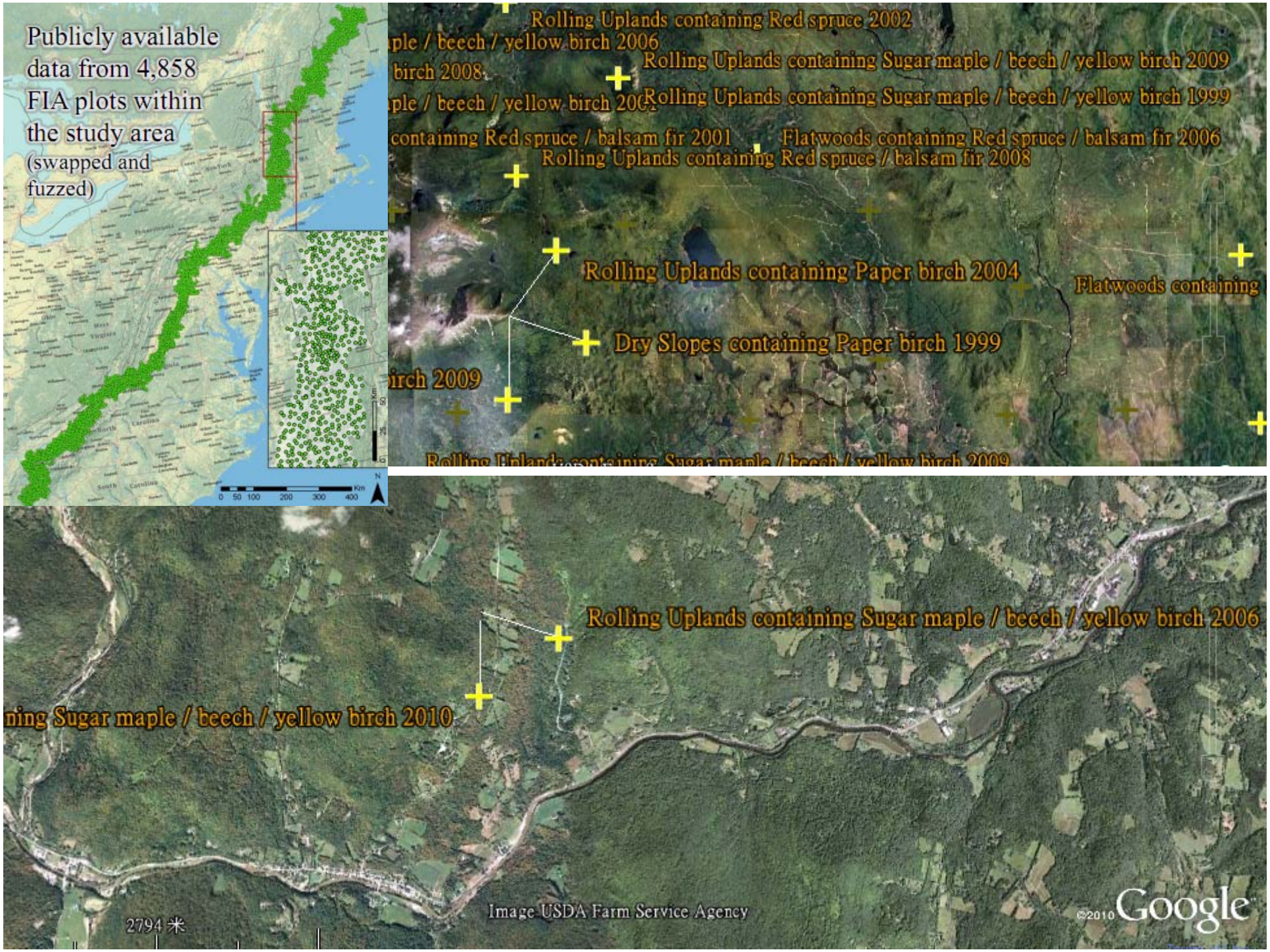


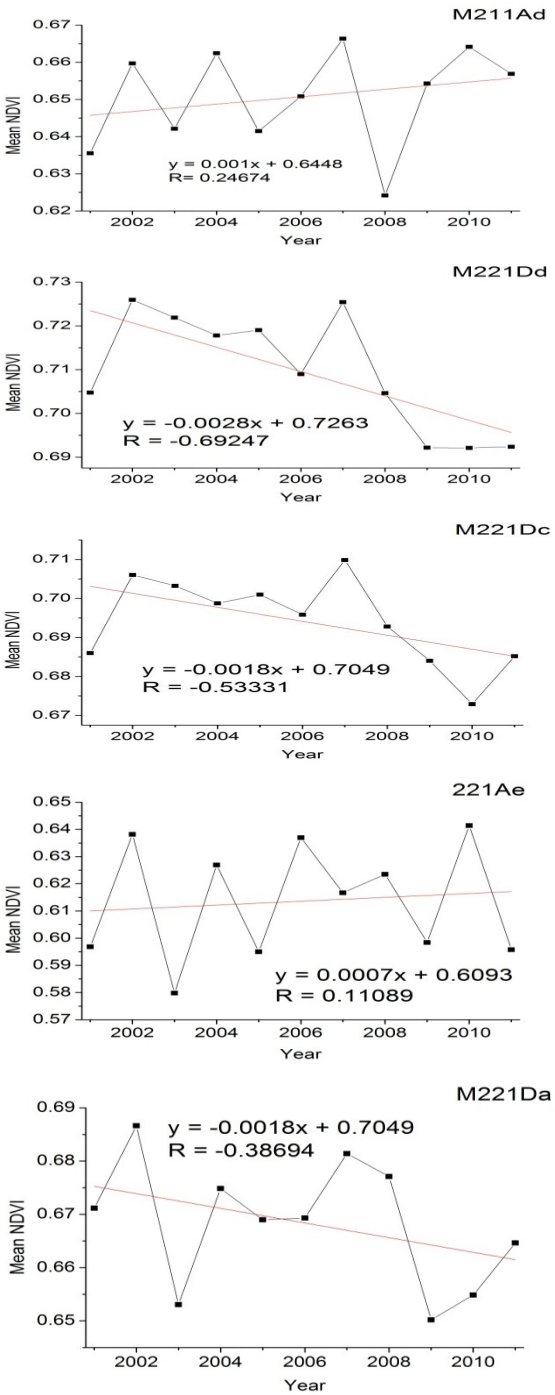
An interactive mapping tool that capitalizes on the latest technology and was developed using the ArcGIS viewer for Flex. The software is fully customizable and allows users to develop new visualization and analysis.





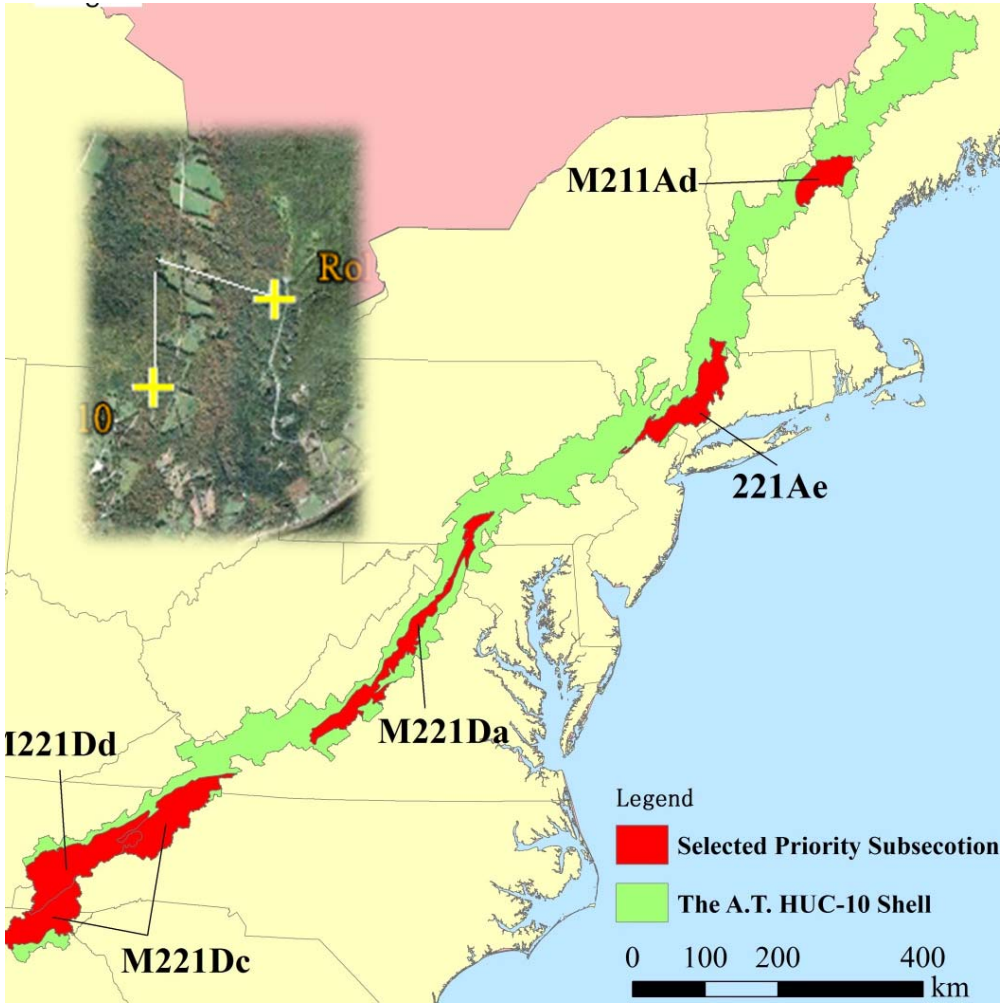
We developed an Internet-based visualization tool/interface for examining FIA plots data and in connection with NASA data and modeling derivatives.


Publicly available data from 4,858 FIA plots within the study area (swapped and fuzzed)
Rolling Uplands containing Red spruce 2002
Rolling Uplands containing Sugar maple / beech / yellow birch 2009
Rolling Uplands containing Sugar maple / beech / yellow birch 1999
Flatwoods containing Red spruce / balsam fir 2006
Rolling Uplands containing Red spruce / balsam fir 2008
Rolling Uplands containing Paper birch 2004
Dry Slopes containing Paper birch 1999
Rolling Uplands containing Sugar maple / beech / yellow birch 2006
Image USDA Farm Service Agency
©2010 Google



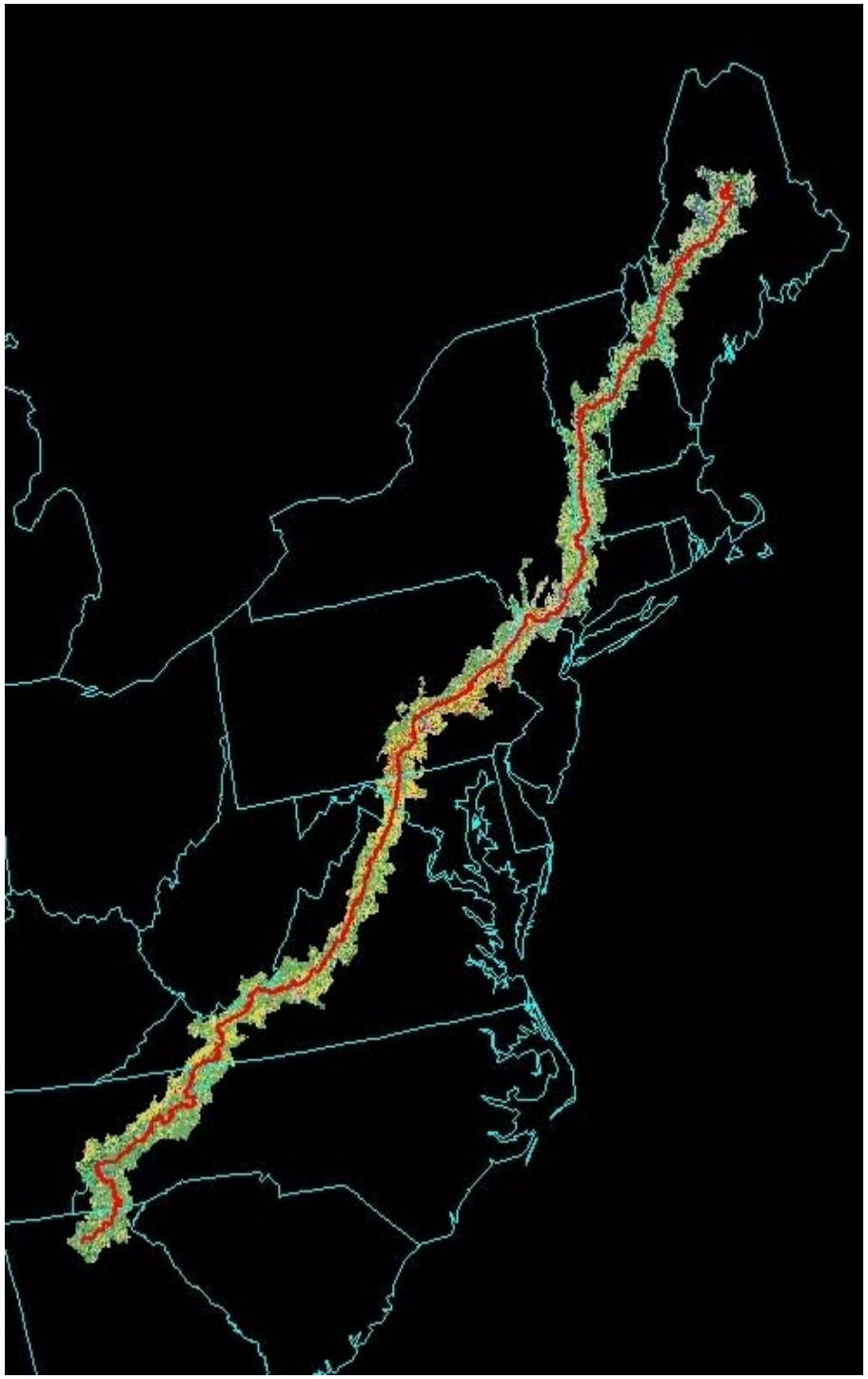
Possible Applications

Five subsections include 93% of very high priority areas for biodiversity conservation.



MODIS data reveal the trend of annual mean NDVI for subsections with high priority areas of biodiversity conservation

Site Name	*R*	*P*	Count	Site Name	*R*	*P*	Count
Dripping Rock to Cedar Cliffs	-0.6122	0.0453	182	Mt. Clinton to Mt. Eisenhower	-0.2489	0.4605	238
Thunder Ridge	-0.5775	0.0628	108	Blood Mountain	0.2462	0.4656	157
Coon Den Falls to Laurel Fork	-0.5598	0.0733	315	Big Bald	-0.2454	0.4670	132
Apple Orchard Mountain	-0.5333	0.0912	167	Holts Ledge	0.2253	0.5053	115
South Wilderness	-0.4965	0.1203	129	Mount Rogers	-0.1540	0.6513	590
Silers Bald	-0.4743	0.1405	108	Mount Guyot	0.1412	0.6788	120
Hickory Spring	-0.4604	0.1541	100	Maple Hill	0.1289	0.7057	116
Hop Brook	-0.3989	0.2243	161	Standing Indian	-0.1195	0.7263	237
Hughes Gap to Roan Mountain	-0.3855	0.2417	645	Breadloaf Mountain to Pine Kob	0.0868	0.7996	151
The Pinnacle	0.3723	0.2596	113	Lake Buel Road Wetlands	-0.0824	0.8096	99
Roan Mountain to Doll Flats	-0.3638	0.2714	467	Hawksbill Mountain	-0.0662	0.8466	110
North Descent	-0.3619	0.2741	174	Bigelow Mountain	-0.0563	0.8695	217
Luftee Gap to Mount Kephart	-0.3551	0.2840	414	Yellow Creek Gap	-0.0509	0.8820	120
Mt. Monroe to Mt. Madison	-0.3427	0.3022	681	Mt. Lincoln to Mt. Lafayette	-0.0392	0.9089	125
Wayah Bald	-0.3230	0.3327	145	Ten Mile River to Bulls Bridge	-0.0349	0.9189	189
Rich Knob	-0.2902	0.3867	127	Stony Man Mountain	0.0321	0.9253	142
Mt. Collins	0.2667	0.4278	132	Double Springs Gap to Clingmans Dome	-0.0289	0.9327	362
Pine Mountain	-0.2605	0.4392	403	Zealand Notch	0.0204	0.9525	185
Temple Ridge to Chestoa	-0.2568	0.4458	339	Hudson River	0.0105	0.9756	80
Whitetop Mountain	-0.2560	0.4473	349	Shining Rocks	0.0028	0.9934	110



Remaining Issue

The project team has no problem to develop the technical components as proposed. The major issue that the project has been facing is the post-project system transition due to the termination of a USGS facility which was planned as the hosting facility after the NASA funding. This unexpected termination of USGS facility due to the USGS reorganization and budget cut affect the delivery of project results.

The project is on track to be at ARL 7 or ARL 8 by project end depending the solution for the hosting issue.

University of Rhode Island

Appalachian Trail Conservancy — Join the Journey™

National Park Service

NASA

Appalachian Trail National Scenic Trail

Forest Service — U.S. Department of Agriculture

USGS — science for a changing world

nbii — National Biological Information Infrastructure

National Geographic

MEGA-Transect Partners

- National Parks Conservation Association — Protecting Our National Parks for Future Generations
- Smithsonian Institution
- Cornell Lab of Ornithology
- NorthWoods Stewardship Center
- The American Chestnut Foundation
- The Heinz Center
- Foundations of Success
- American Hiking Society
- National Geographic
- Northeast Temperate Network