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

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.
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

The corridor is defined by intersection of the HUC-10 watersheds and the A.T. central line.

Selected **3 Provinces** and **20 subsections** that are within the shell and intersect the A.T. land base for data preparation and information presentation.
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
  - Leaf Area Index FPAR (MOD15A2): 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, …
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.

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).

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
Mean Dew Point Temperature ($^\circ C$) for Subsections of the A.T. HUC-10 Shell

Southern Subsections

Northern Subsections
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

Publicly available data from 4,858 FIA plots within the study area (swapped and fuzzed)
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 widespread 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**
Environmental Variables:
Topography

[Map showing various environmental variables with color-coded distribution.]

Canopy Cover Mean
Canopy Cover Std Deviation
Distance to Development
Agriculture Count
Soil Drainage
Flood Frequency
Elevation
Aspect
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/

Viewsheds & Monitoring

Mapping Viewer

Report & Forecast

Data Download

TOPS Data: MODIS Products, GIMMS, NACP, SOGS …
A.T. Geospatial Data: HUC-10 Shell, NED, NWI, NLCD, LANDFIRE …
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).
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.

<table>
<thead>
<tr>
<th>Site Name</th>
<th>$R$</th>
<th>$P$</th>
<th>Count</th>
<th>Site Name</th>
<th>$R$</th>
<th>$P$</th>
<th>Count</th>
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<tbody>
<tr>
<td>Dripping Rock to Cedar Cliffs</td>
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<td>Mt. Clinton to Mt. Eisenhower</td>
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<td>Apple Orchard Mountain</td>
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<td>0.1203</td>
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<td>Mount Rogers</td>
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<td>Mount Guyot</td>
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<td>Hickory Spring</td>
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<td>Maple Hill</td>
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<td>Standing Indian</td>
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<td>Hughes Gap to Roan Mountain</td>
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<td>0.2417</td>
<td>645</td>
<td>Breadloaf Mountain to Pine Kob</td>
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<td>Lake Buel Road Wetlands</td>
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<td>Roan Mountain to Doll Flats</td>
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<td>Wayah Bald</td>
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<td>Ten Mile River to Bulls Bridge</td>
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<td>Rich Knob</td>
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<td>Mt. Collins</td>
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<td>Double Springs Gap to Clingmans Dome</td>
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<td>Zealand Notch</td>
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<td>349</td>
<td>Shining Rocks</td>
<td>0.0028</td>
<td>0.9934</td>
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</tbody>
</table>
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.
Thank You!