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EARTH SCIENCE DIVISION
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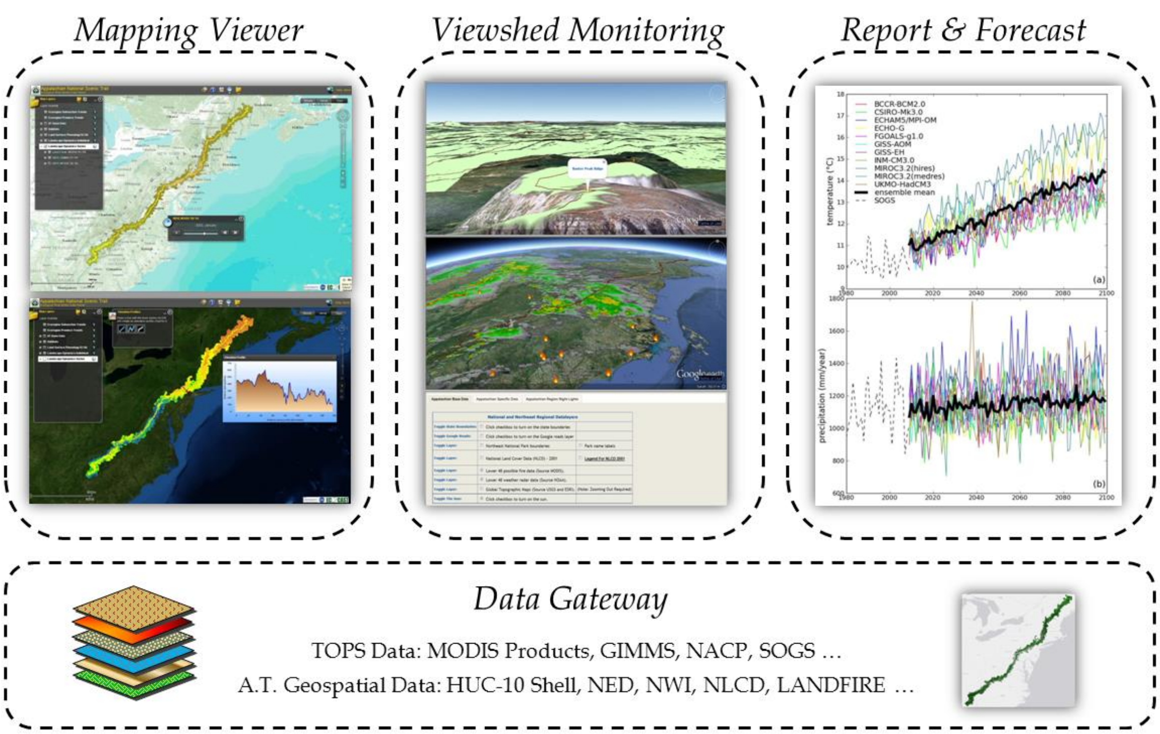
Decision Support through Earth Science Research Results

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

User Manual



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User Manual

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On behalf of the project team, we wish to express our the most sincere gratitude to the administrators, program managers, resource managers, professionals and volunteers from National Aeronautics and Space Administration, National Park Service, U.S. Forest Service, U.S. Geological Survey, Appalachian Trail Conservancy and A.T. MEGA-Transect partners. So many individuals representing different agencies and communities participated in various project team meetings, workshops, training programs, and discussions that helped shape the A.T.-DSS in framework structure, presentation format, information content and deliverables. The A.T.-DSS would not be possible without the dedication, support, insight and professionalism that the group offered toward the development of the A.T.-DSS at different stages of the project. We appreciate the enthusiasm from hikers and users of the Appalachian Trail system toward the A.T.-DSS.

About the Project

The purpose of the project entitled A Decision Support System for Monitoring, Reporting and Forecasting Ecological Conditions of the Appalachian National Scenic Trail, also known as A.T.-DSS, is to facilitate decision-making for the National Park Service (NPS) Appalachian National Scenic Trail (APPA), the Appalachian Trail Conservancy (ATC), and the U.S. Forest Service (USFS), and provide a means to convey meaningful information about the ecological conditions of the Appalachian Trail lands to the American public. The A.T.-DSS integrates NASA multi-platform satellite remote sensing data, NASA Terrestrial Observation and Prediction System (TOPS) models and data products, *in situ* observations and measurements from USDA Forest Service and A.T. MEGA-Transect partners to address identified natural resource priorities and support resource management decisions.

The project team employed TOPS data and modeling capacities to derive information about the past and current patterns and projections of the Appalachian Trail lands; focusing on the identified primary environmental vital signs of *phenology and climate change*, *forest health,* and *landscape dynamics*.

By integrating NASA Earth Observation System data and modeling products that link climate models (e.g., through TOPS) and ecological models (e.g., habitat suitability) with *in situ* observations, the A.T.-DSS provides critical geospatial data and information to improve the effectiveness of decision-making in management of the Appalachian Trail lands for biodiversity conservation. For example, the project team identified the Tree of Heaven (*Ailanthus altissima*), a wide-spread fast-growing deciduous invasive species of concern within the study area, for developing a prototype habitat suitability and risk analysis model, incorporating information such as climate change factors from TOPS predictions.

The project team developed an Internet based A.T.-DSS; including mapping and visualization tools, reporting and forecasting information, and data gateway. The Internet-based decision support tools and interfaces for accessing data and information can be found at http://www.edc.uri.edu/ATMT-DSS.

About this Manual

This *User Manual* is designed to facilitate the use of online A.T.-DSS by the users. It provides step by step instructions about the A.T.-DSS following the framework structure and functions, so that users from all perspectives can use the system and take advantages of the data and information that the project generated.

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Introduction

The Appalachian Trail

The Appalachian National Scenic Trail (A.T.) is a footpath stretching from Springer Mountain in Georgia to Mount Katahdin in Maine and spanning over 3,500 km of peaks, valleys, and ridges along the Appalachian Mountains. It intersects 14 states; 8 National Forests; 6 units of the National Park System; more than 70 State Park, Forest, and Game Management units; and 287 local jurisdictions. The A.T. passes through some of the largest and least fragmented forest blocks remaining in the eastern United States (Dufour and Crisfield 2008); forests containing rich biological diversity and the headwaters of important water resources.

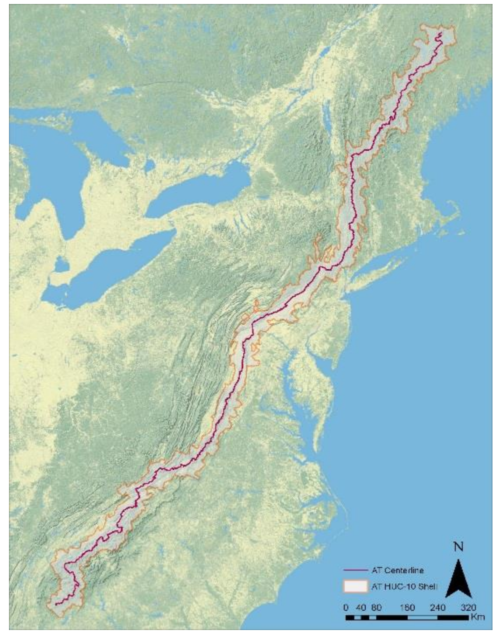

Figure 1 - The Appalachian Trail

The A.T.'s north-south alignment and gradients of elevation, latitude, and moisture represent a continental scale cross-section, or "MEGA-Transect," of eastern U.S. forest and alpine areas, offering a setting for collecting scientific data on the structure, function, species composition, and condition of ecosystems. The high elevation setting of the A.T. provides an ideal landscape for the early detection of undesirable changes in the natural resources of the eastern United States; for example, development encroachment, acid precipitation, invasions of exotic species, and climate change impacts.

Decision Support System 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 integrate NASA data with field observations.
3. Assess historical, current, and forecasted ecosystem conditions and trends by coupling TOPS with 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.

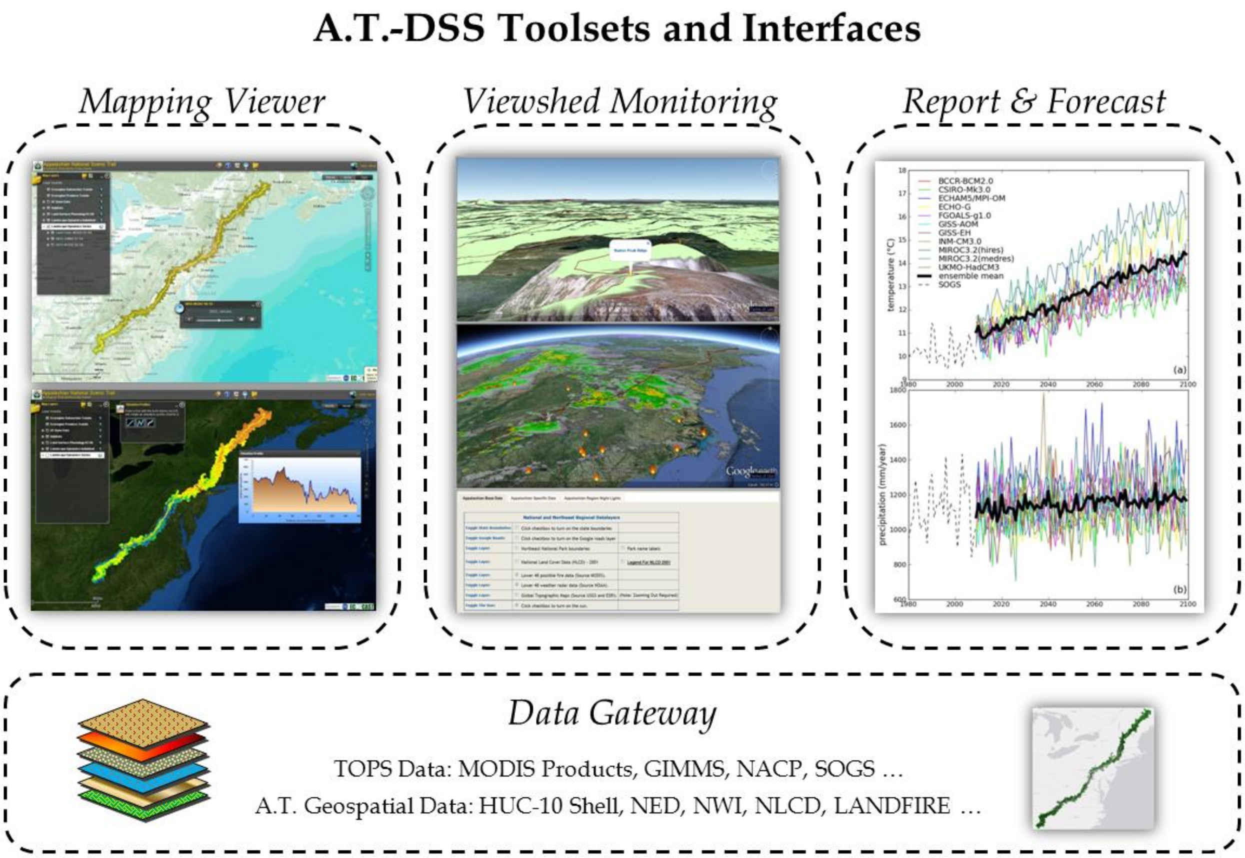

Figure 2 A.T.-DSS Toolsets and Interfaces

Mapping Viewer

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User Guide

The Mapping Viewer is an interactive mapping tool which provides an interface for users to access and visualize geospatial data relevant to the Appalachian Trail. The tool is built on the ArcGIS Flex viewer platform and allows panning, zooming, toggling data layers, and integrating data in combinations as per their immediate requirements. Several tools are provided to enhance the decision making process, such as the Time-series slider for observing land cover change and elevation surface profiling mapping. The software is fully customizable and allows system users to develop new visualization or analysis tools as priorities change.

Mapping Viewer Overview

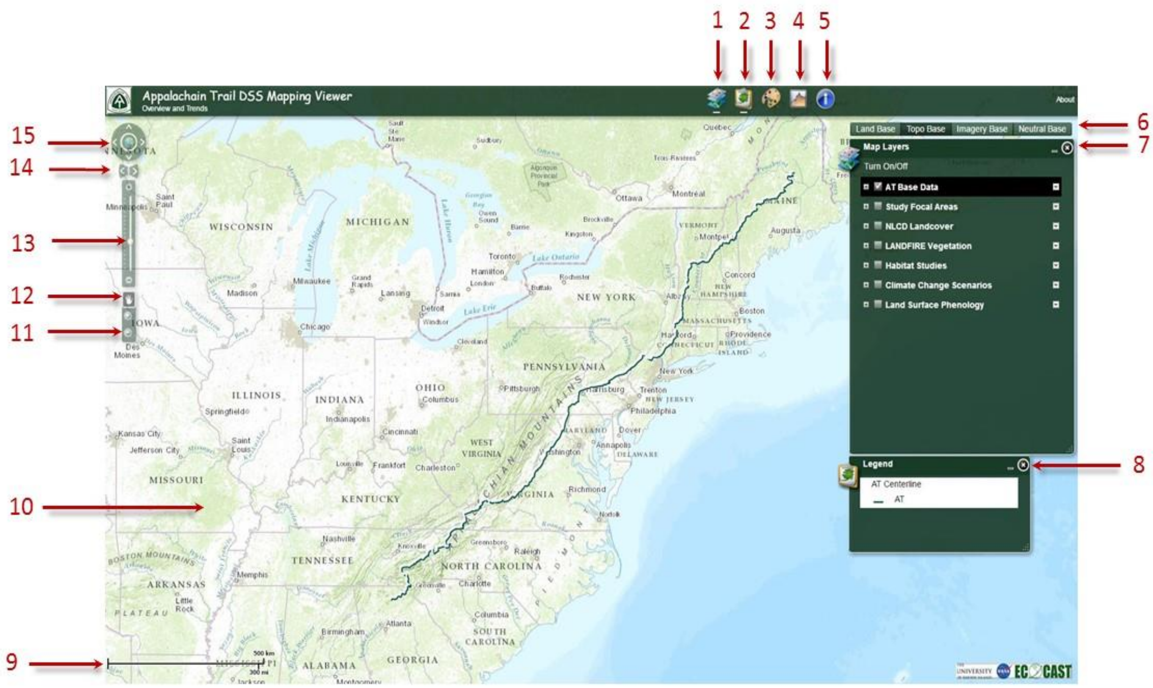


Figure 3 Mapping Viewer user interface

1. Map Layers
2. Legend
3. Draw and Measure
4. Elevation
5. Identify
6. Base Maps
7. Map Layers Widget
8. Legend Widget
9. Scale Bar
10. Map View
11. Zoom in/Zoom out
12. Pan
13. Zoom Adjust Slider
14. Next/Previous Extent
15. Full Extent and Pan Extent

Map Layers

Lists the layers of geospatial data available for display. It allows users to select and deselect map layers for display within the Mapping Viewer. Map layers are grouped into several common themes and organized hierarchically. These map layers can be selected to display individually and in combination as per user's desire.

Map layers are grouped together under specific themes relevant to Appalachian Trail datasets. These themes are represented by a title, under which applicable map layers are listed together. Each map layer displays geospatial information about Appalachian Trail.

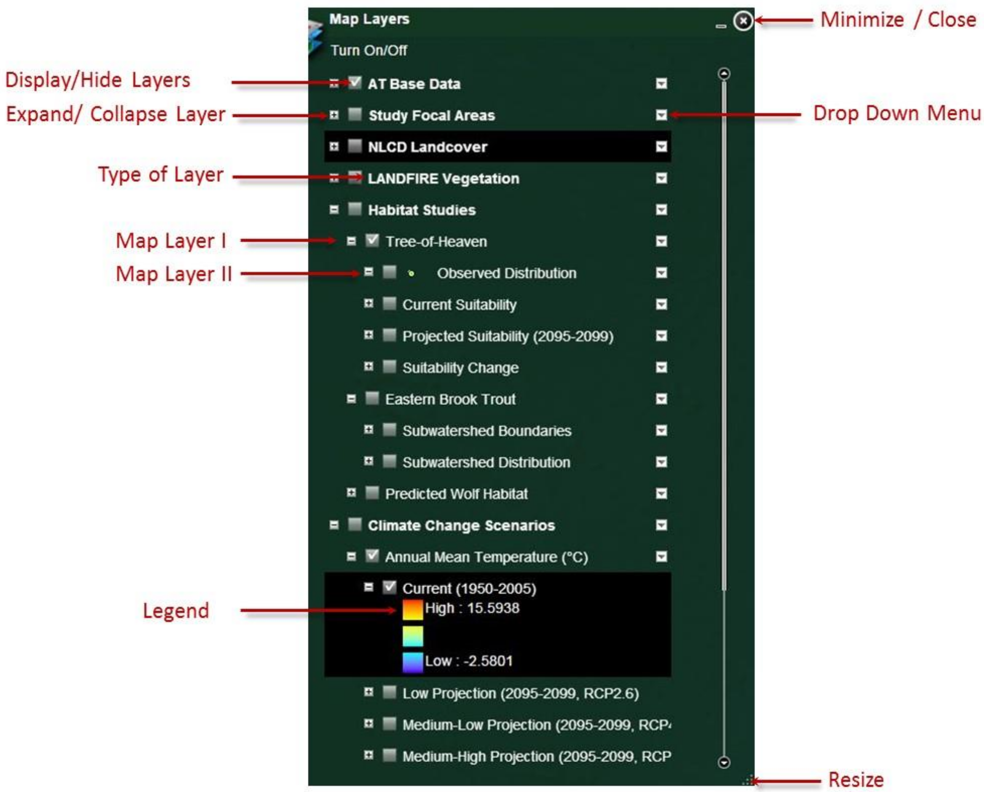


Figure 4 Map Layers widget

Each map layer can be turned on and off to display over the base map by clicking the checkbox in front of the layer's name.

There are **7** themes or *Type of Map* Layers listed in the *Map Layers* widget containing specific data regarding the Appalachian Trail.

- AT Base Data – It contains basic information about Appalachian Trail like center trail line, surface types, shelters and parking areas along the entire length of AT
    - AT Centerline
    - AT Surface Type
    - AT Shelters
    - AT Parking

- Study Focal Areas - Ecoregions are large areas of similar climate where ecosystems recur in predictable patterns. Uses of these data include biodiversity analysis, landscape and regional level forest planning, and the study of mechanisms of forest disease
    - Study Focal Area
    - Watersheds (HUC10)
    - Ecoregion Provinces
    - Province Outlines
    - Ecoregion Subsections
    - Subsection Outlines

- NLCD Landcover - The National Land Cover Database (NLCD) serves as the definitive Landsat-based, 30-meter resolution, land cover database for the Nation. NLCD provides spatial reference and descriptive data for characteristics of the land surface such as thematic class (for example, urban, agriculture, and forest), percent impervious surface, and percent tree canopy cover
    - Landcover '06
    - Landcover '01
    - Landcover '92
    - Landcover Change '01-'06
    - Impervious Surfaces '06

- LANDFIRE Vegetation - The LANDFIRE vegetation layers describe the following elements of existing and potential vegetation for each LANDFIRE mapping zone: environmental site potentials, biophysical settings, existing vegetation types, canopy cover, and vegetation height
    - Biophysical Settings
    - Canopy Cover
    - Canopy Height
    - Existing Vegetation Cover
    - Existing Vegetation Height
    - Existing Vegetation Type

- Habitat Studies – It contains information regarding distribution of habitats along the Appalachian Trail for selected species, including tree-of-heaven (*Ailanthus altissima*), eastern brook trout (*Salvelinus fontinalis*), and the eastern wolf (*Canis lupus*).
    - Tree-of-Heaven
        - Observed Distribution
        - Current Suitability

        - Projected Suitability (2095-2099)
        - Suitability Change
    - Eastern Brook Trout
        - Subwatershed Boundaries
        - Subwatershed Distribution
    - Predicted Wolf Habitat

- Climate Change Scenarios - Baseline (1950-2005) and projected (2095-2099) climate data from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) Coupled Model Inter-comparison Project Phase 5 (CMIP5) were provided by NASA's Terrestrial Observation and Prediction System (TOPS). The CMIP5 is an ensemble of 16 individual General Circulation Models (GCMs) that predict future conditions under a set of alternative scenarios defined by Representative Concentration Pathways (RCPs). RCPs represent the atmospheric concentration of greenhouse gasses, or radiative forcing values, in the year 2100 resulting from future scenarios with varying levels of global emissions and mitigation
    - Annual mean Temperature (°C)
        - Current (1950-2005)
        - Low Projection (2095-2099, RCP2.6)
        - Medium-Low Projection (2095-2099, RCP4.5)
        - Medium-High Projection (2095-2099, RCP6)
        - High projection (2095-2099, RCP85)
        - Change (Current – RCP6.0)
    - Temperature Seasonality (Std Dev*100)
        - Current (1950-2005)
        - Low Projection (2095-2099, RCP2.6)
        - Medium-Low Projection (2095-2099, RCP4.5)
        - Medium-High Projection (2095-2099, RCP6)
        - High projection (2095-2099, RCP85)
        - Change (Current – RCP6.0)
    - Annual Precipitation (mm)
        - Current (1950-2005)
        - Low Projection (2095-2099, RCP2.6)
        - Medium-Low Projection (2095-2099, RCP4.5)
        - Medium-High Projection (2095-2099, RCP6)
        - High projection (2095-2099, RCP85)
        - Change (Current – RCP6.0)
    - Precipitation Seasonality (Std Dev/ Mean)
        - Current (1950-2005)
        - Low Projection (2095-2099, RCP2.6)
        - Medium-Low Projection (2095-2099, RCP4.5)
        - Medium-High Projection (2095-2099, RCP6)
        - High projection (2095-2099, RCP85)
        - Change (Current – RCP6.0)

- Land Surface Phenology - Land surface phenology (LSP) is a measure of landscape dynamics reflecting the response of vegetated surfaces to seasonal and annual changes in the climate and hydrologic cycle. Because of the spatial resolution of remote sensing data, LSP is an indicator of mixtures of land covers and is distinct from traditional species-centric measures of phenology, such as seasonal flowering or budburst. The phenology metrics calculated include the timing of the onset of greenness as the start of the season (SOS), onset of senescence (time of the end of greenness) as the end of the season (EOS), and the length of the growing season (LOS).

- Start of Season, 1982-2006
    - Mean (Julian Day)
    - Slope (Days per Year)
- End of Season, 1982-2006
    - Mean (Julian Day)
    - Slope (Days per Year)

Legend

Collectively lists the relevant symbology information of each map layer, which is selected or displayed within the Mapping Viewer.

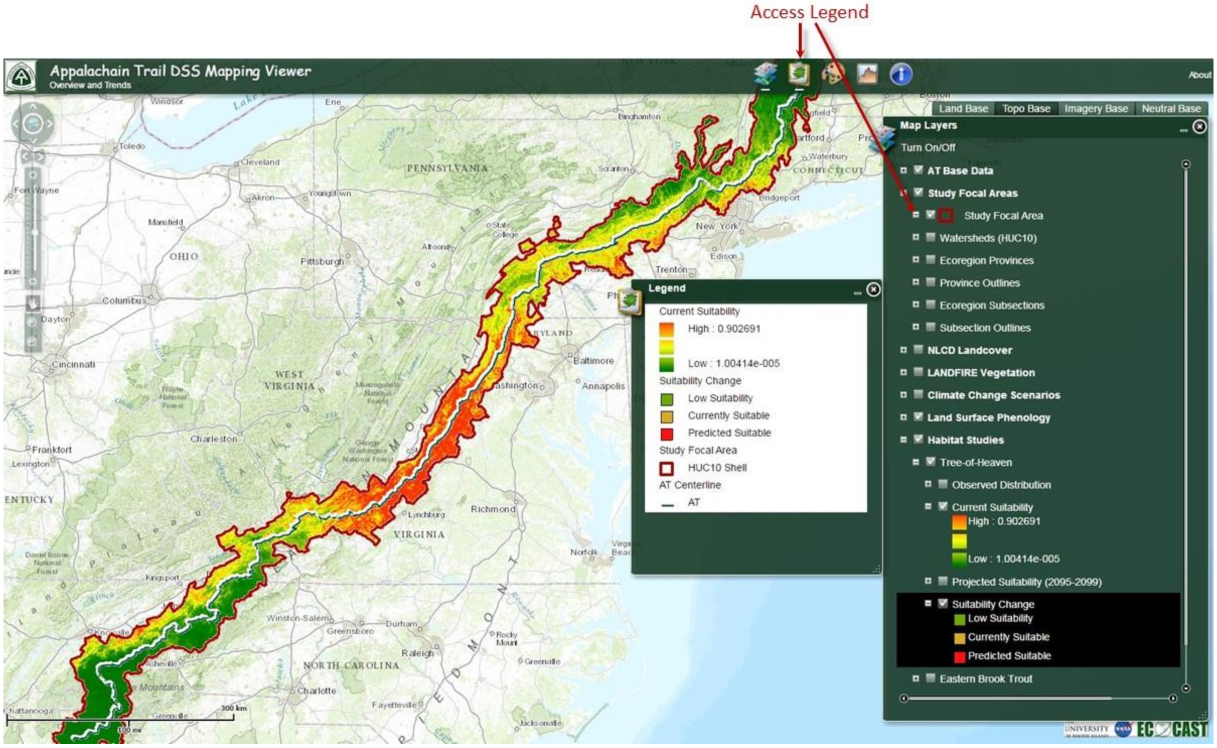


Figure 5 Legend can be displayed either in a separate legend widget or in the map layers widget itself. Current Suitability map layer, Suitability Change map layer, Study Focal Area map layer and AT Centerline map layer are displayed with their respective legend

Symbology –

It represents the classification of data into various categories. Every individual category is represented by a symbol, color and numerical or alphabetical value. Each map layer contains information that is represented in the form of Raster or Vector data.

Raster Data –

Raster images are consisted of individual pixels. Each pixel is associated with a spatial location or resolution element and is indicated by the attribute such as color, elevation, ID number etc.

Vector Data –

Vector data comes in the form of points, lines and polygons that are associated geometrically and mathematically. Points are stored using the coordinates like a two-dimensional point, which is stored as (x, y). Lines and polygons (closed shape lines) are stored as a series of point pairs.

Raster & Vector Data

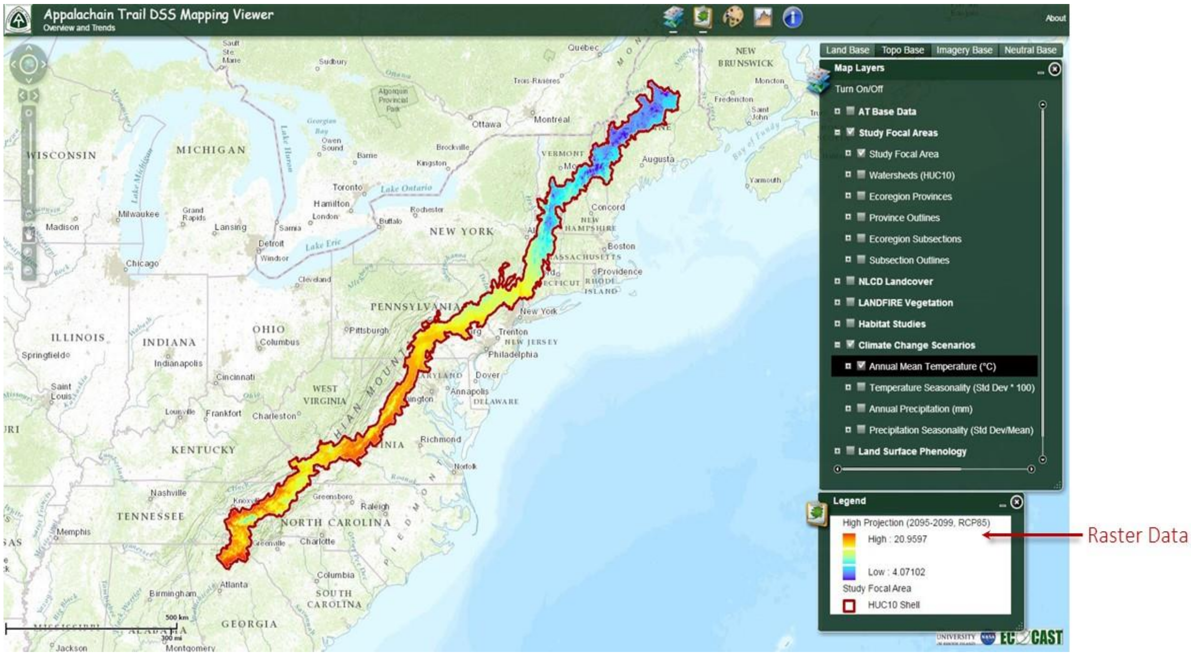


Figure 6 High projection (2095-2099, RCP85) map layer is an example of a raster dataset. Here, the symbology is defined between two extreme values (High: 20.9597, Low: 4.07102).

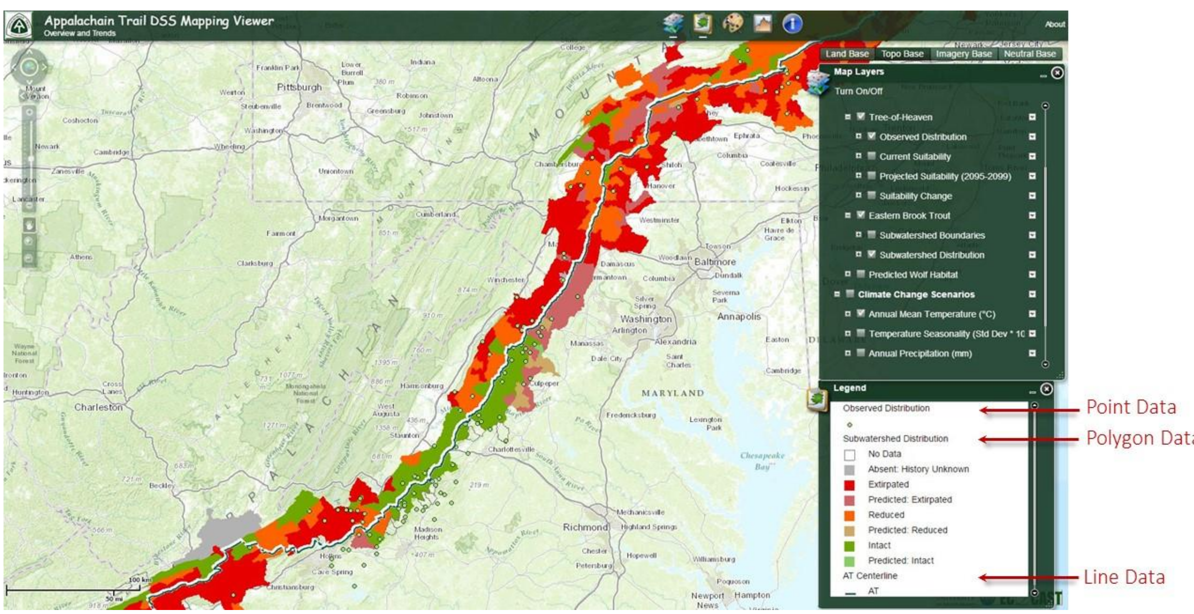


Figure 7 Observed Distribution (Point data), Subwatershed Distribution (Polygon data) and AT Centerline (Line data) are the examples of vector dataset. Here, the symbology is defined by individual colors, symbols and categories.

Vector Data Legend

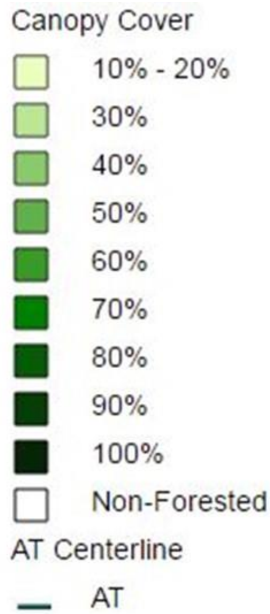


Figure 8 Legend: Canopy Cover

The Canopy Cover data is classified into 10 categories. Darkest shade of green symbolizes areas that have highest percentage (100%) of tree canopy cover and the lightest shade of green represents areas that have lowest percentage (10% - 20%) of tree canopy cover, and everything else falls in between these two extremes. Similarly, all the other map layers have a respective legend that symbolizes the classification of data.

Raster Data Legend

Figure 9 Legend: Annual Mean Temperature (°C)

Raster data is distributed between high and low pixel values of the entire image. It is also represented by the gradual variation of shades of color from one extreme to the other. Here the Annual Mean temperature (ºC) ranges between 15.5938 ºC to -2.5801 ºC. Highest value (dark red color) represents warmest temperature while lowest value (purple color) represents coolest temperature in the given range.

Draw and Measure

Provides an editable layer allowing users to annotate the *Map View* with text as well as draw point, line, and polygon features. Select the *Show Measurements* option to automatically calculate and display the length and areas of the new drawn features.

Note: Drawing and measurements generated by the user cannot be saved on the editable map layer for future use. They are created temporarily and will be automatically cleared or removed once the session on *Main Mapping Viewer* is closed.

User can close the *Draw and Measure* box to clear all the drawings, measurements and texts. The same graphics can be brought back onto the map by clicking on the *Draw and Measure* icon again. This option only works when the editable layer is in active session. Closed session drawings cannot be retrieved.

Editable layer will always be the topmost most layer and cannot be overlaid with any other layer.

Clear Drawing

Clears everything that has been drawn by the user on the editable layer. Cleared drawn shapes and text cannot be retrieved once cleared.

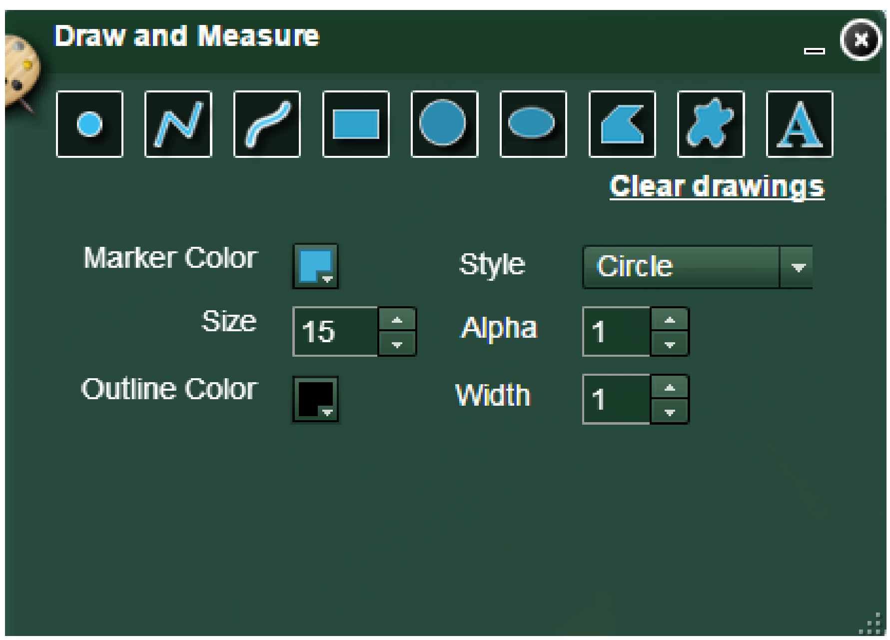


Figure 10 Draw and Measure tool

Drawing Tips

- Always select a feature (point, line & polygon) first before drawing.
- Every time for drawing similar features, first select the desired feature and then draw.
- It is necessary to select the desired color, width, style, measurements etc. prior to start drawing.
- Created or drawn features can be individually selected and moved around on the map. Click once on the feature to select it and hold the mouse click to grab the feature in order to move it around.
- Slowly click two times on the chosen shape to select it for rotating and resizing.

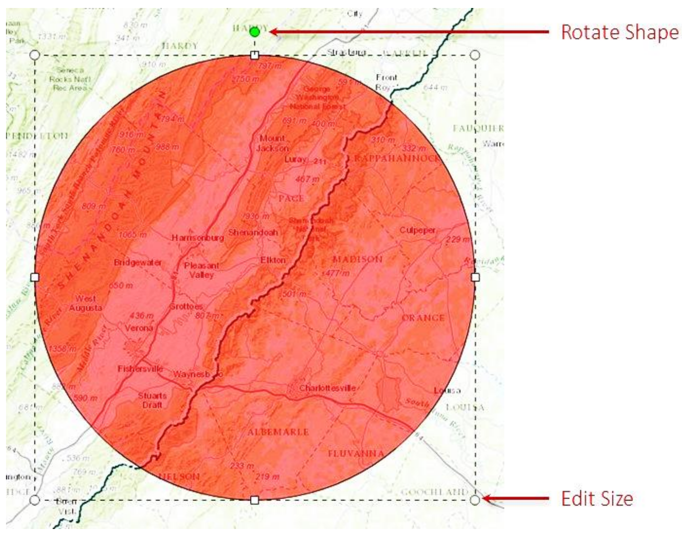


Figure 11 Rotate the shape by using top rotating button and resize the shape by using 8 resizing buttons provided on all the corners and edges of the square.

- These shapes can also be edited by selecting the feature first and then by editing their vertices.

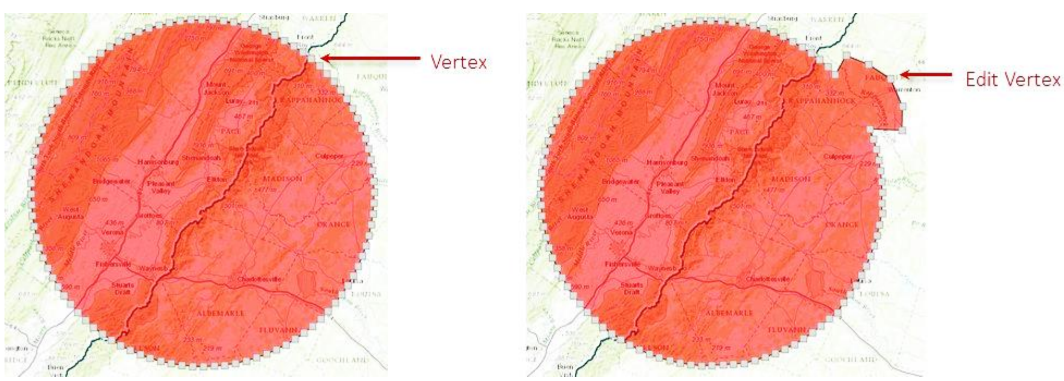


Figure 12 Individual vertex can be moved around to get a desired shape

- User can also delete individual vertex by right clicking on the selected vertex and selecting *Delete Vertex.*

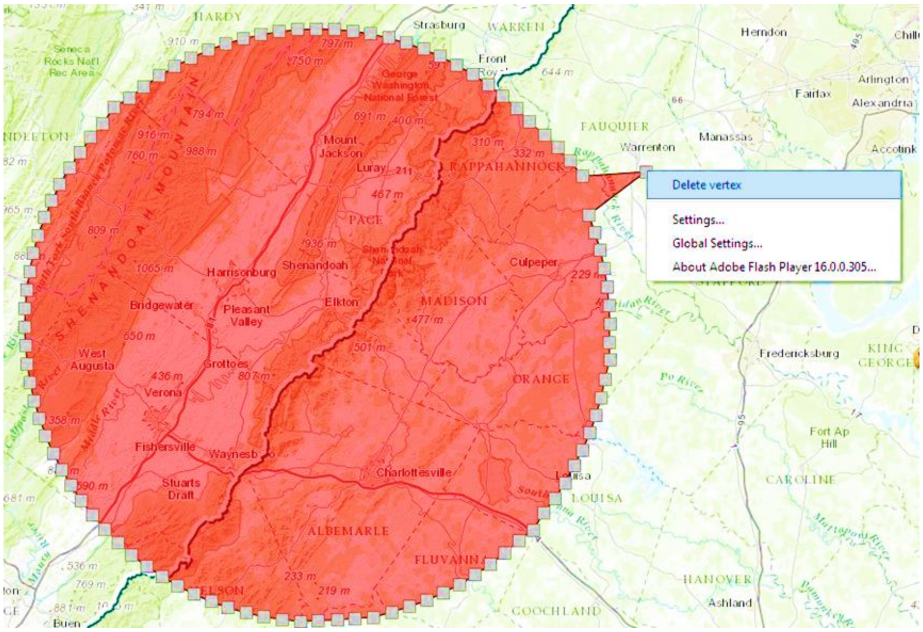


Figure 13 Delete vertex to change shape.

- Individual features can be deleted by selecting the feature first, right clicking on it and selecting *Clear* from the menu.

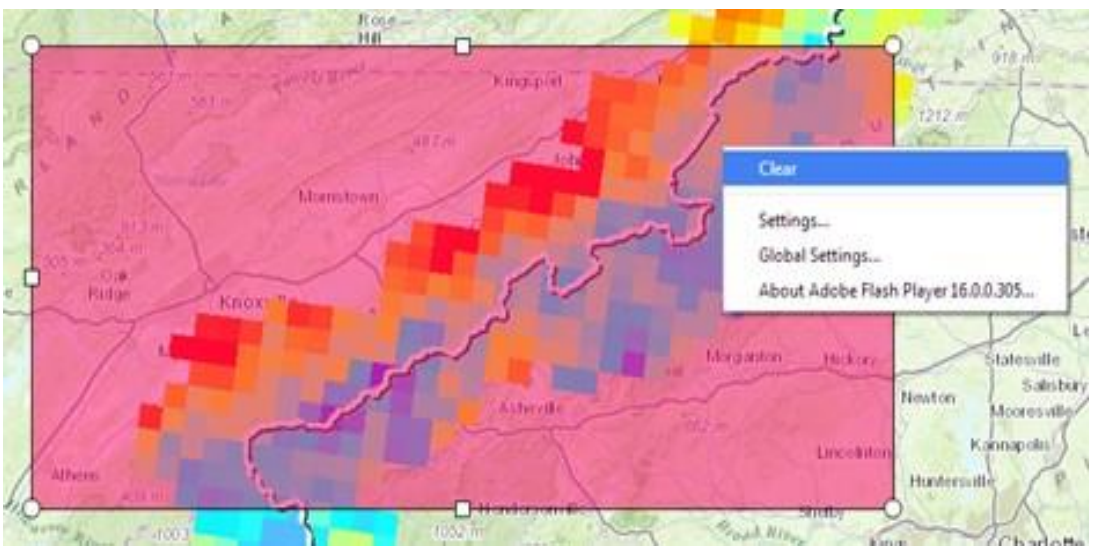
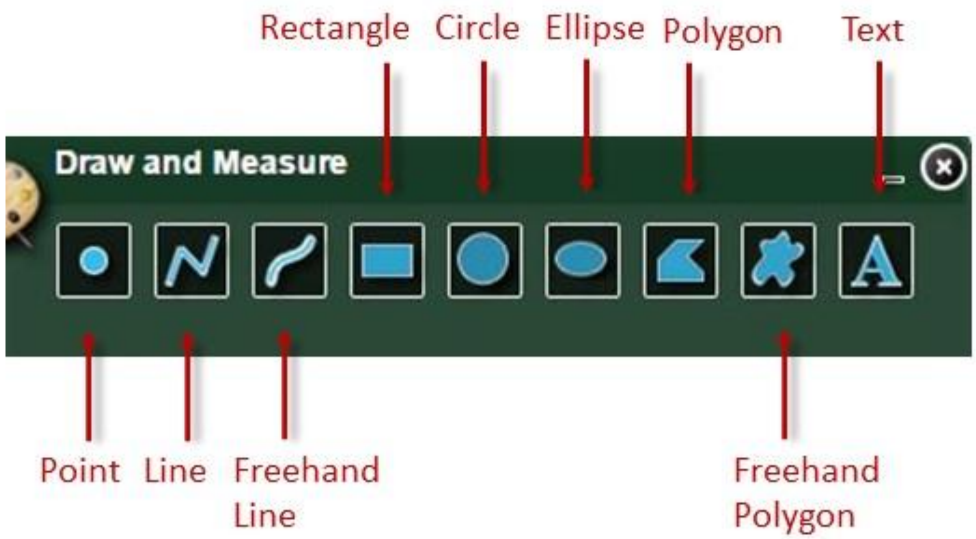
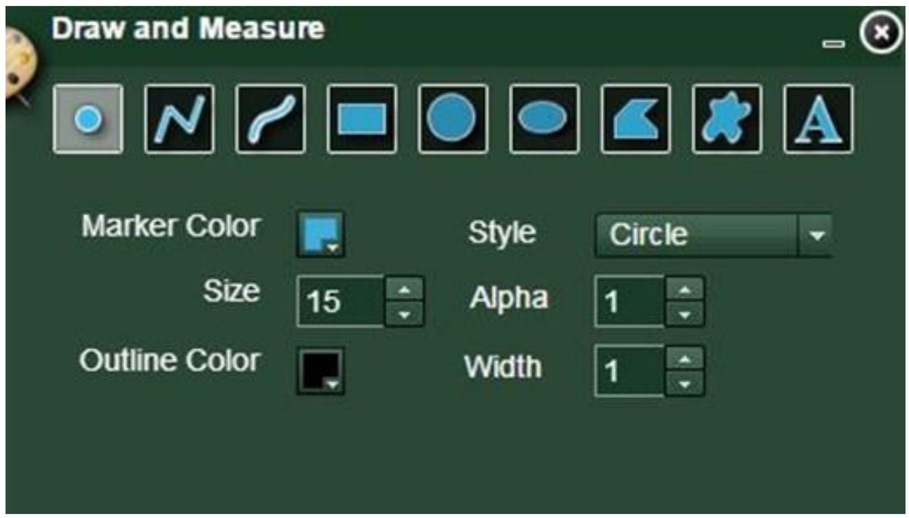


Figure 14 The entire shape can be removed from the map by selecting Clear from the right-click menu

Draw and Measure Tool Bar



Draw Point



Draws a point as desired on the map. Click anywhere on the map to draw a point. Always select Draw Point icon before drawing a new point. To delete a point, first select the point then right click on it to select *Clear* from the menu.

Marker Color 

Colors of the point marker can be changed by clicking on the drop down color menu box. Press the small downward pointing arrow to access the color menu.

Size 
Size of a point can be increased or decreased by clicking on the arrow buttons or by manually entering the size number in the size box. Sizes range from 1 to 50.

Outline color 

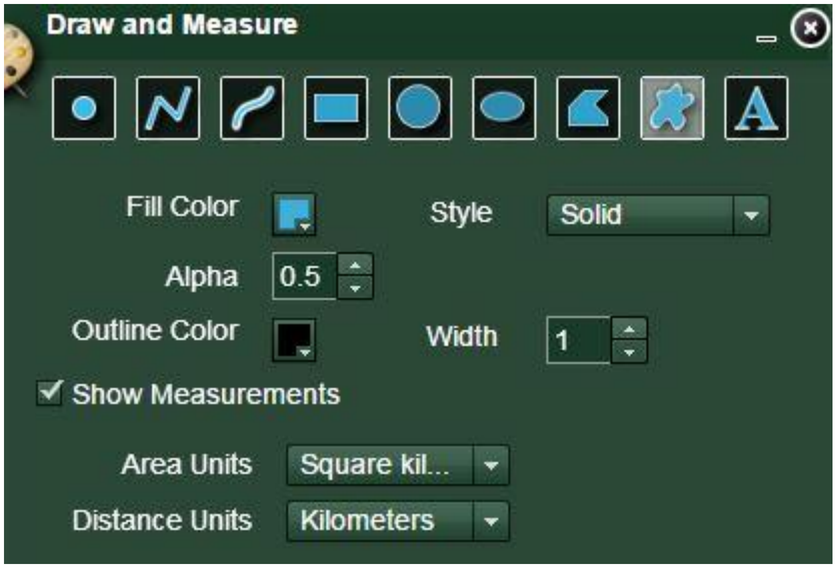
Color of the outline of a point can be changed by selecting a color from the drop down color menu. Press the small downward pointing arrow to access the color menu.

Style
Shape or style of a point can be changed as desired. Click on the small downward arrow button to access available shapes which are *Circle, Cross, Diamond, Square, Triangle*, or *X*.

Alpha
Changes the transparency level of a point. Transparency of a point can be increased or decreased either by clicking on the up or down arrow button  respectively or by manually entering the number in the *Alpha* box. Transparency level ranges from transparent (0) to opaque (1).

Width
Width of a point outline can be increased or decreased either by clicking on the up or down arrow button  respectively or by manually entering the number in the *Width* box. Size ranges from no outline (0) to thick outline (5)

Draw Freehand Polygon



To draw a freehand polygon on a map, press down the mouse and move around to get the desired shape. Release the click to stop drawing.

Fill Color 

Choose a distinct color to fill inside the drawn freehand polygon from the available array of shades. Make the selection prior to drawing a freehand polygon because color cannot be changed after drawing it.

Style
Choose a style to fill-in a freehand polygon from distinct available options like *Solid*, *Backward Diagonal*, *Cross*, *Forward Diagonal*, *Horizontal*, or *Vertical*.

Alpha
It changes the transparency level of a freehand polygon. Transparency of a freehand polygon can be increased or decreased either by clicking on the up or down arrow button  respectively or by manually entering the number in the *Alpha* box. Transparency level ranges from transparent (0) to opaque (1).

Outline Color 

Color of the outline of a freehand polygon can be changed by selecting a color from the drop down color menu.

Width

Width of an outline can be increased or decreased by clicking on the arrow buttons  or by manually entering the number in the size box. Sizes can range from thin (0) to thick (50).

Show Measurements

Click on the check box to display measurements related to the area or perimeter of a freehand polygon. Make the selection prior to drawing a polygon.

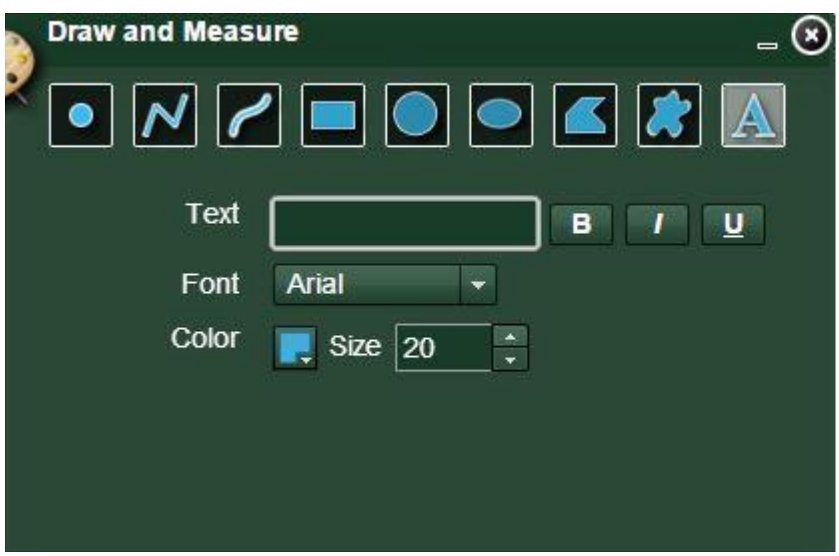
Area Units

Displays the area of a drawn freehand polygon in one of the available units. These units are *Square kilometers, Square miles, Acres, Hectare, Square meters, Square feet,* or *Square yards.*

Distance Units

Displays the perimeter of a drawn freehand polygon in one of the available units. These units are *Kilometers, Miles, Meters, Feet* or *Yards.*

Add Text



Text

Text can be added in the editable layer.

B – **Bold**
Makes the text bold as shown above.
I – *Italic*
Makes the text italic as shown above.
U – Underline
Underlines the written text.

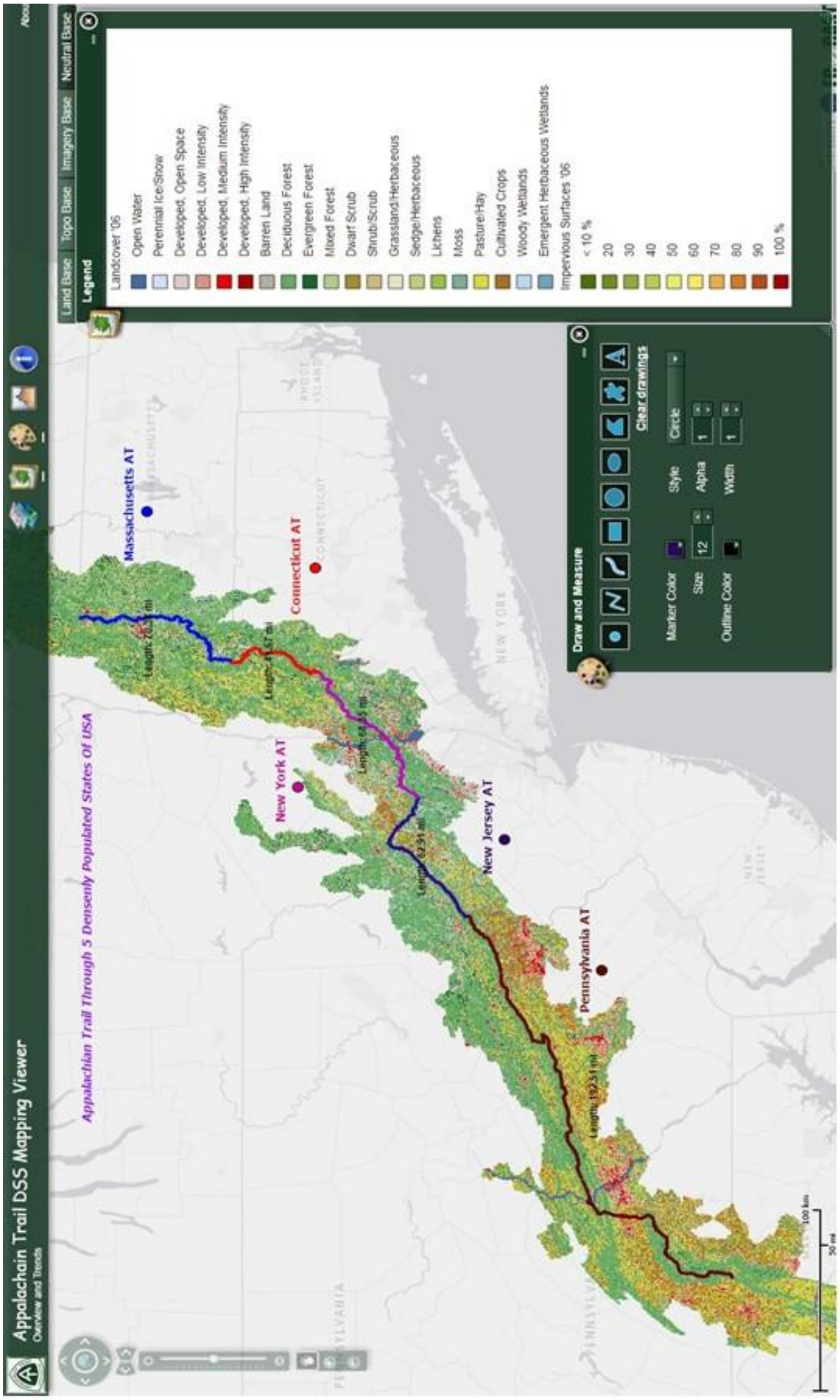


Figure 15 Draw and Measure example

Points and lines are used to display AT passing through five densely populated states.

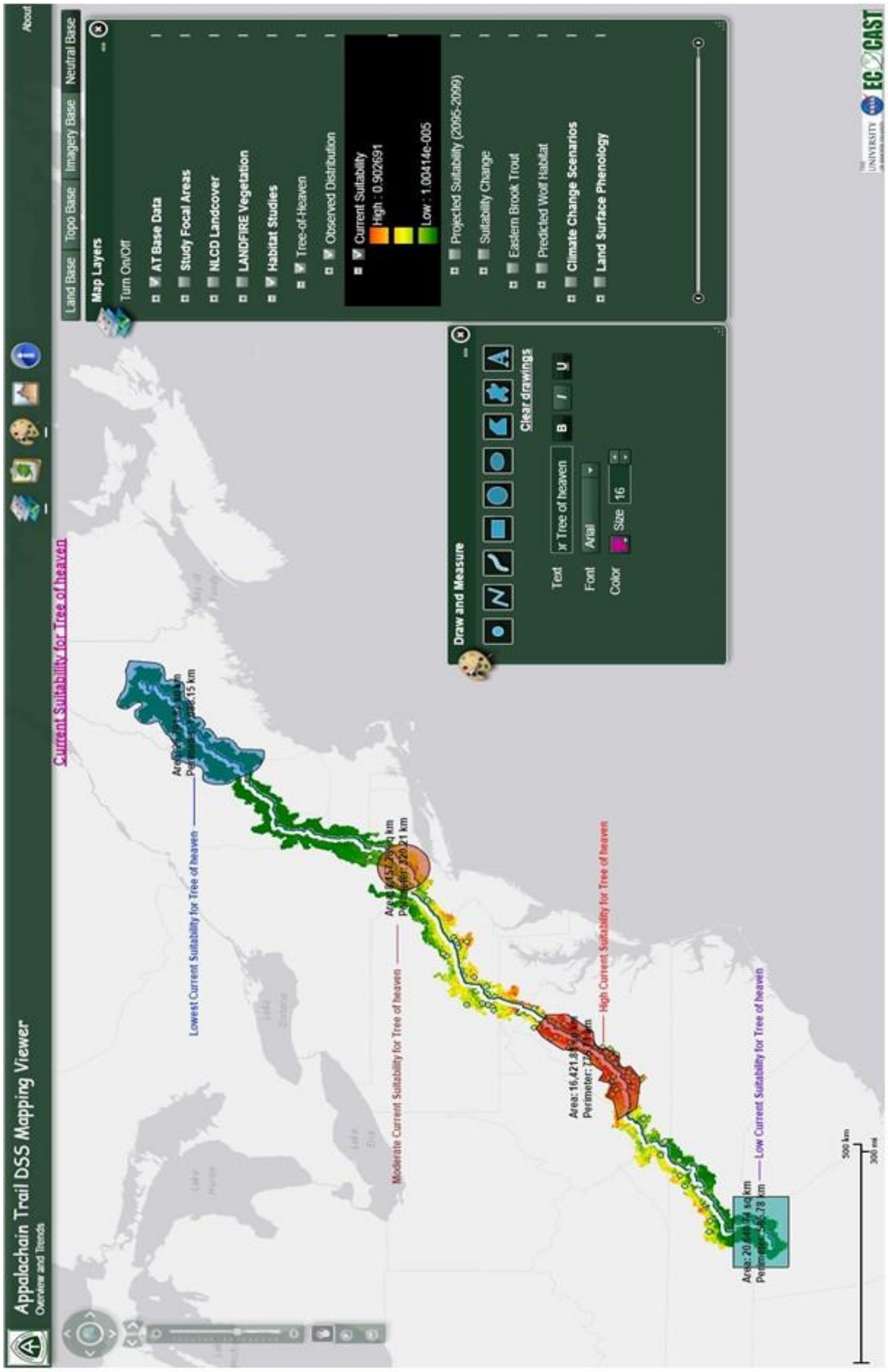


Figure 16 Draw and Measure polygon example

Polygons are created to display current suitability areas for Tree of heaven.

Elevation Profile

Draws a linear transect across an area of interest to generate an elevation profile, or cross-section, of local topography.

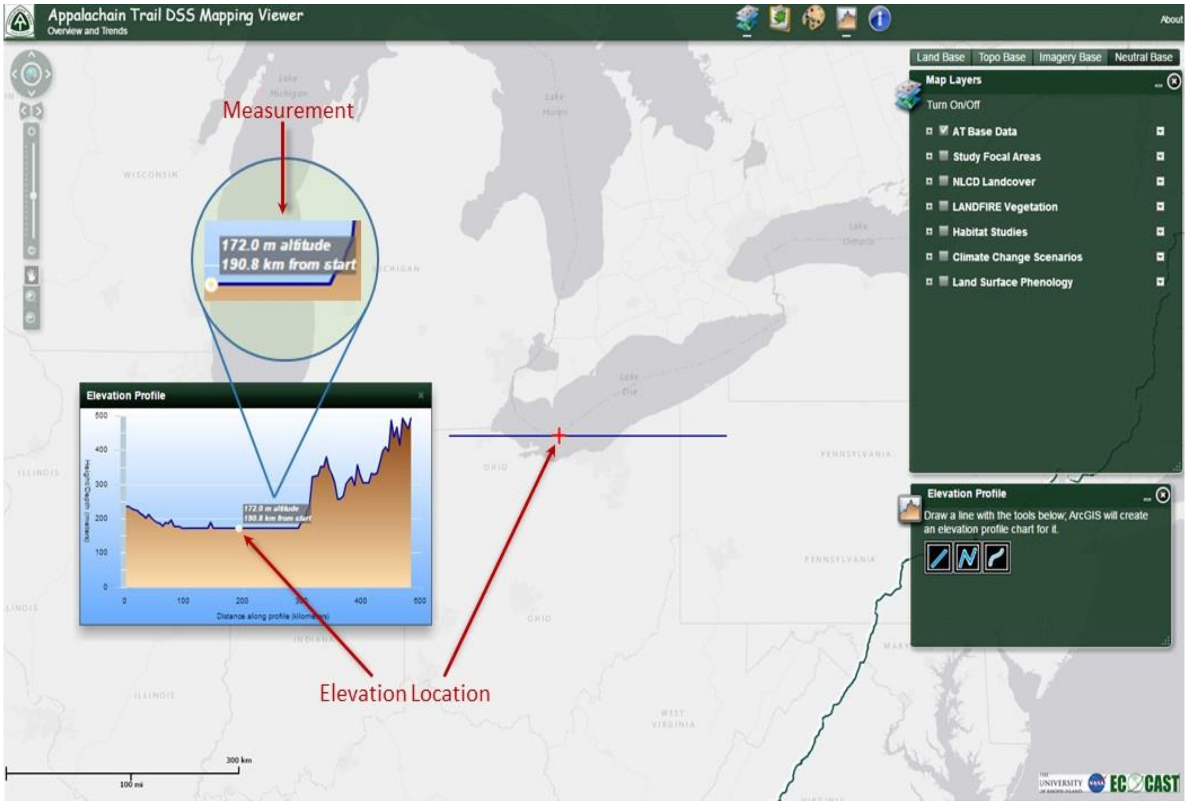
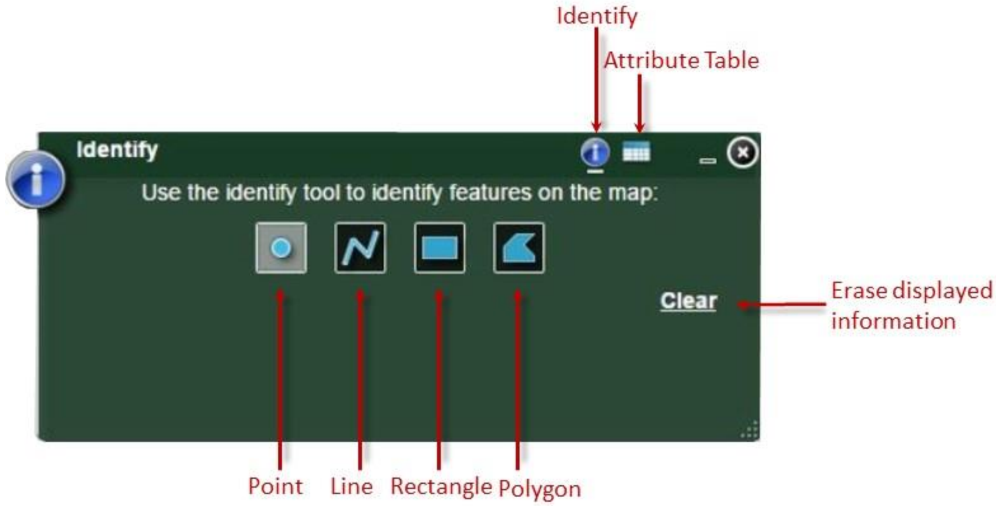


Figure 17 Landscape elevation details are displayed in elevation profile when with respect to the drawn line.

Identify Tool

Draws a point, line, or polygon to retrieve information about the features from the attribute table of one or more active map layers.



Toggle between *Identify* and *Attribute Table* screen by clicking on the icons.

Attribute Table

It is a table with rows and columns similar to a Microsoft Excel spreadsheet. A table is associated with every map layer containing information about its features like point, line and polygon. Each feature on the map is geographically referenced (latitude and longitude). Whenever a feature is created, it is automatically introduced as a row in the attribute table. The columns contain other feature based information like name, address, ID, type, elevation etc. Any information which is relevant to the features on a map layer is added into the attribute table. This is the information that is visible to the users when using Identify tool.

Identify tool extracts information from *Attribute Table* of a map layer and displays it in the *Identify* tool widget. When there are multiple active layers then information is extracted from each layer to be displayed in individual boxes. The boxes are arranged in the same order as the map layers are displayed in the current *Legend* widget.

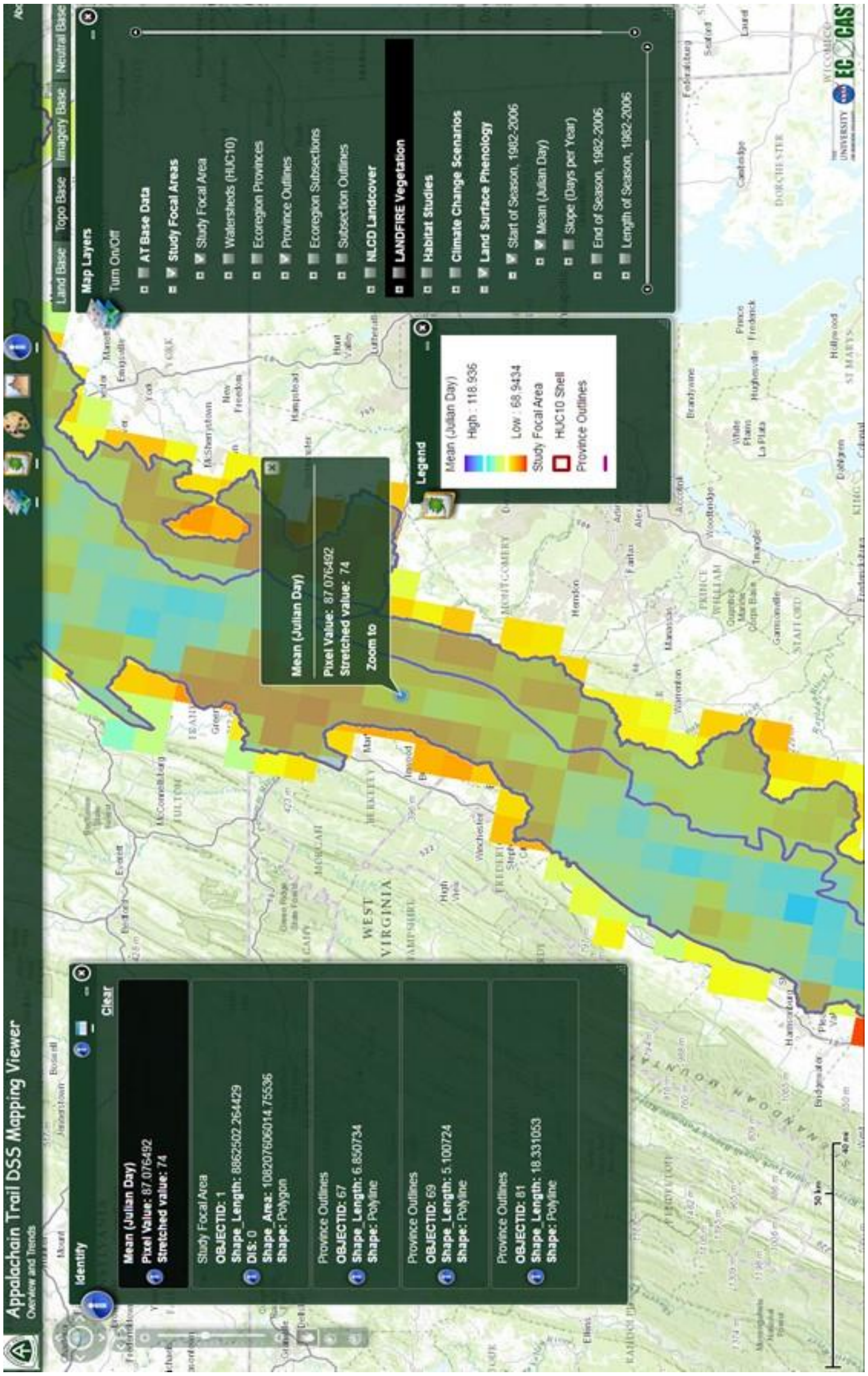


Figure 18 Identify tool example

Extracted information from each map layer is displayed in respective boxes and it can be viewed on map in the form of call-out boxes. To display information in a call out box, move the mouse pointer onto an individual map layer information box as shown above in the example and a call out-box pertaining to the applicable map layer will appear on the map.

Call-out boxes contain the same information as the boxes in the Attribute Table widget:

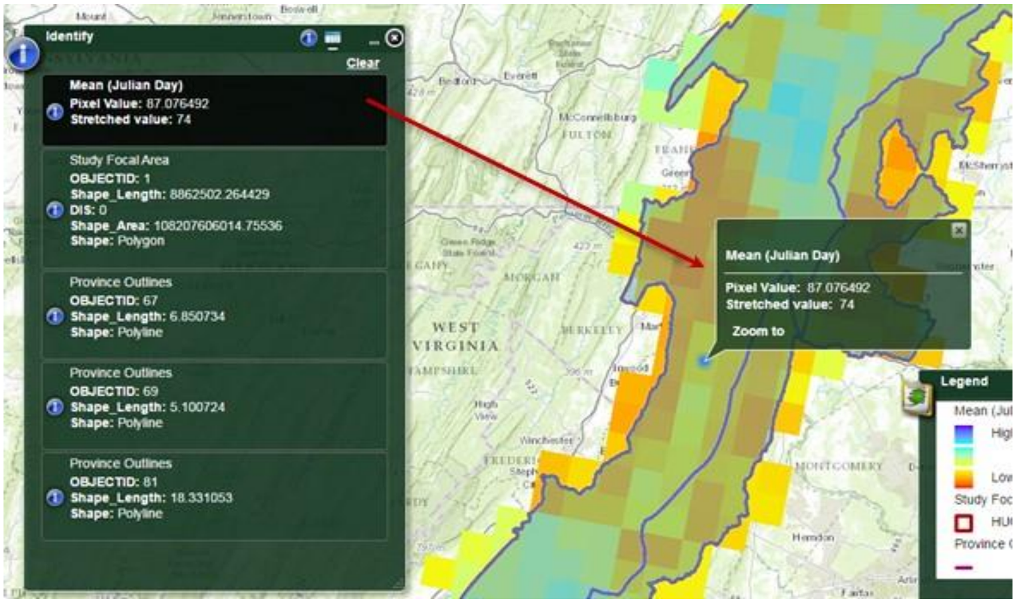


Figure 19 Mean information is displayed in the call-out box on the map when that Map layer box is highlighted in the Attribute table widget.

Information extraction is performed differently for Raster and Vector data.

Raster – Calculates and locates the central pixel of the drawn *Identify* shape (line, rectangle or polygon) and displays the information relevant to it.

Vector – Information is selected on the basis of the placement of the shape, which touches or intersects with the edges of adjacent polygons existing in an active map layer.

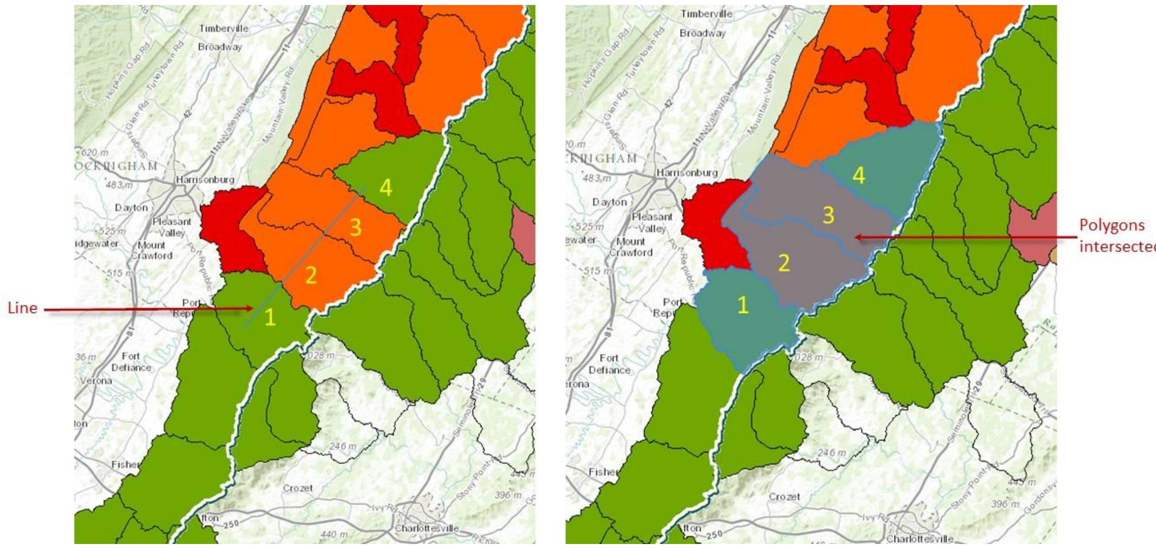


Figure 20 Example: Polygon features selected by drawing a line.

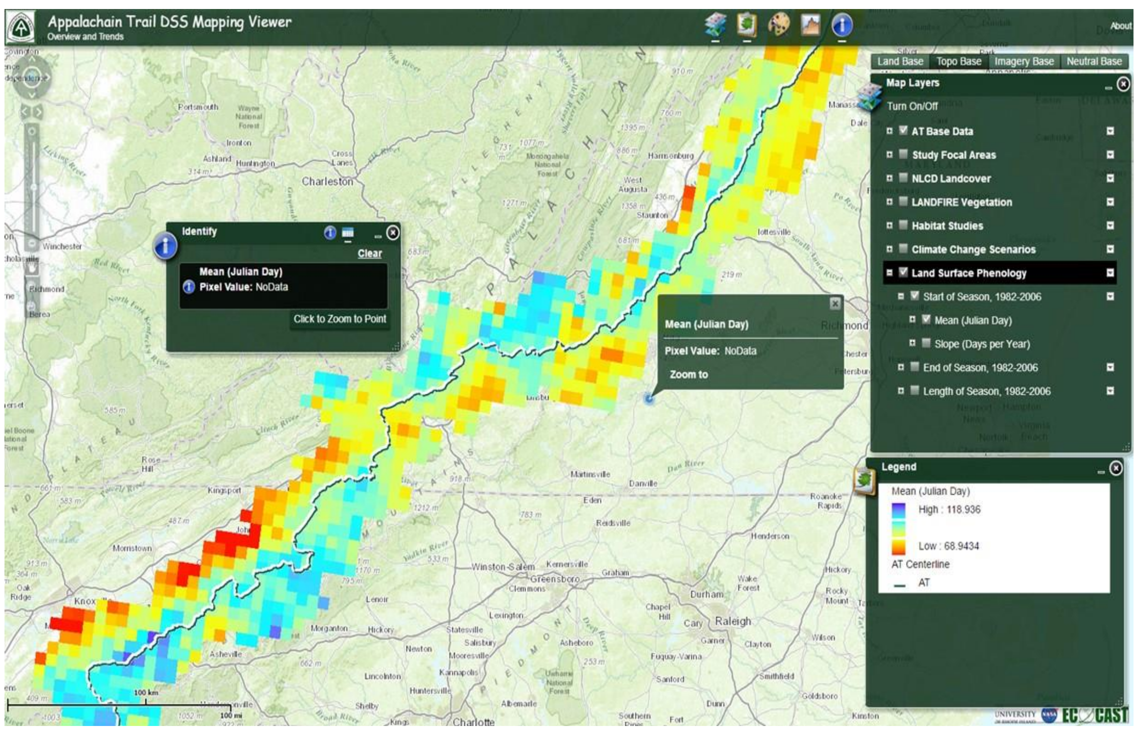


Figure 21 No data is displayed when there is no information regarding the pixel is available in the map layer's Attribute Table

Identify by Point

Click anywhere on the map layer to create a point and retrieve relevant information from the respective Attribute Tables of different active Map Layers. The extracted information is displayed collectively in the Attribute Table widget in individual Map Layer boxes. Scroll down to view all the extracted entries

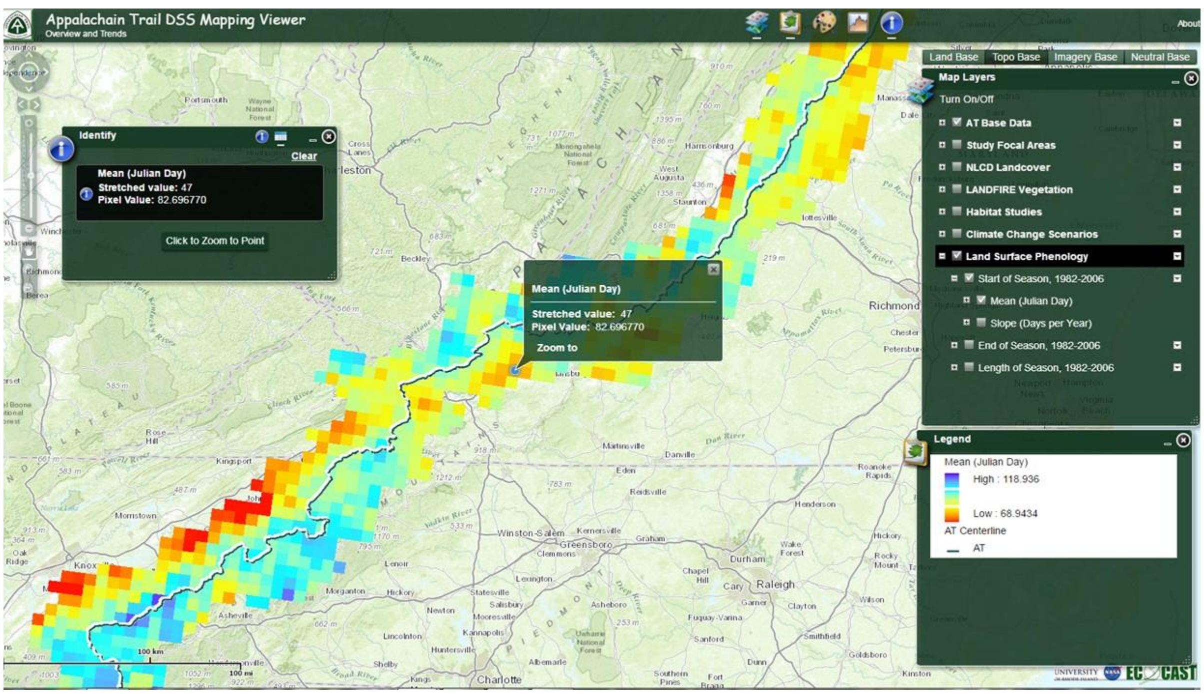


Figure 22 Example: query pixel value of raster at selected point.

Identify by Line

Draw a line to extract information pertaining to it. It is important to know that extraction of information from Raster and Vector data is performed differently.

Raster Data – The center or the midpoint of the drawn line represents the location of the extracted pixel and information relevant to it.

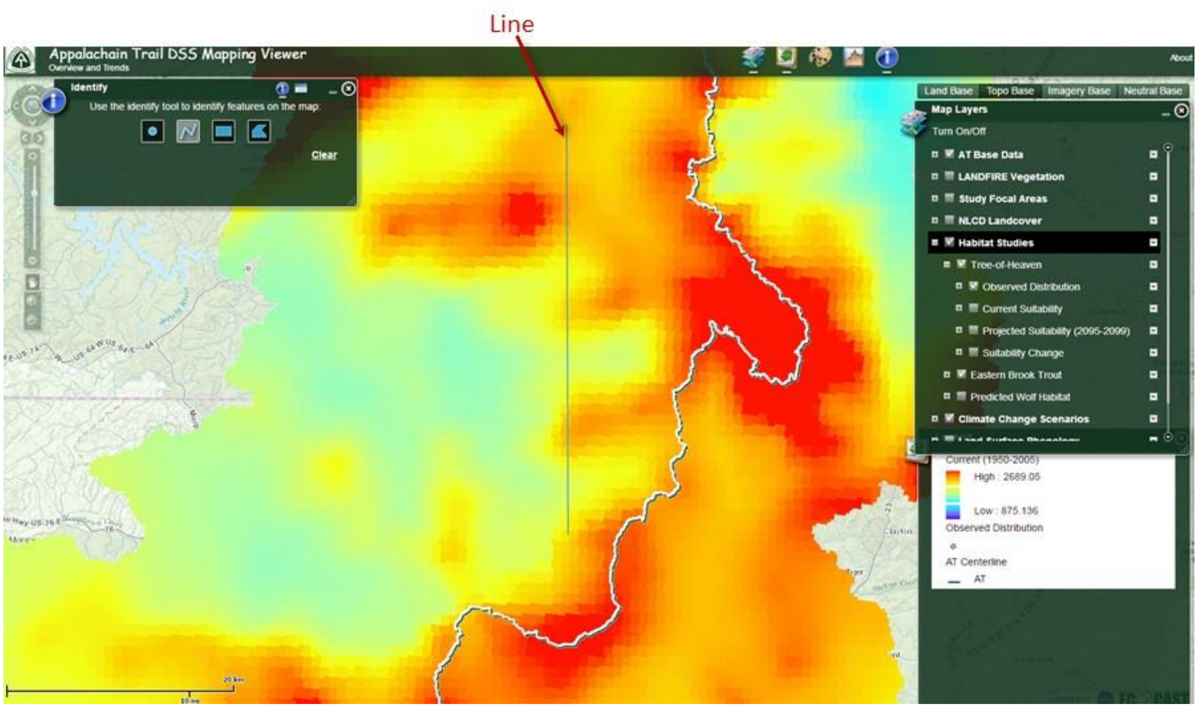


Figure 23 Identify raster value by line centerpoint

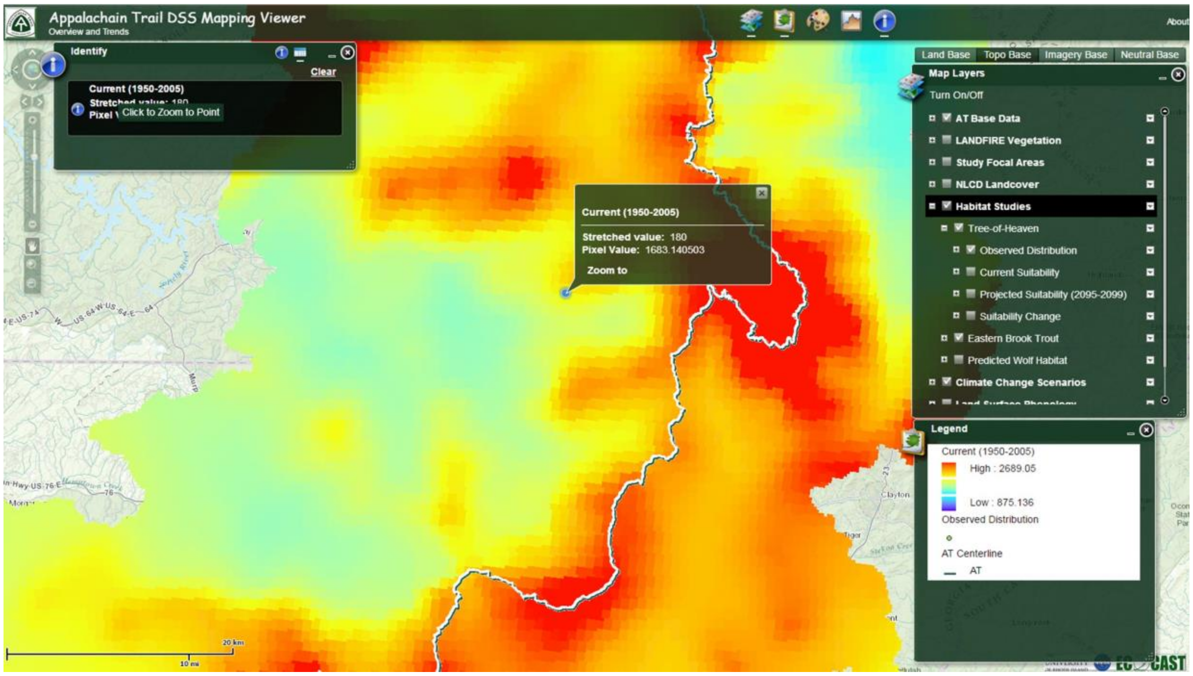


Figure 24 Using the Identify by line tool will return the raster value at the line centerpoint

Vector Data – Extracts information of all the points, lines and polygons that intersects with the drawn line.

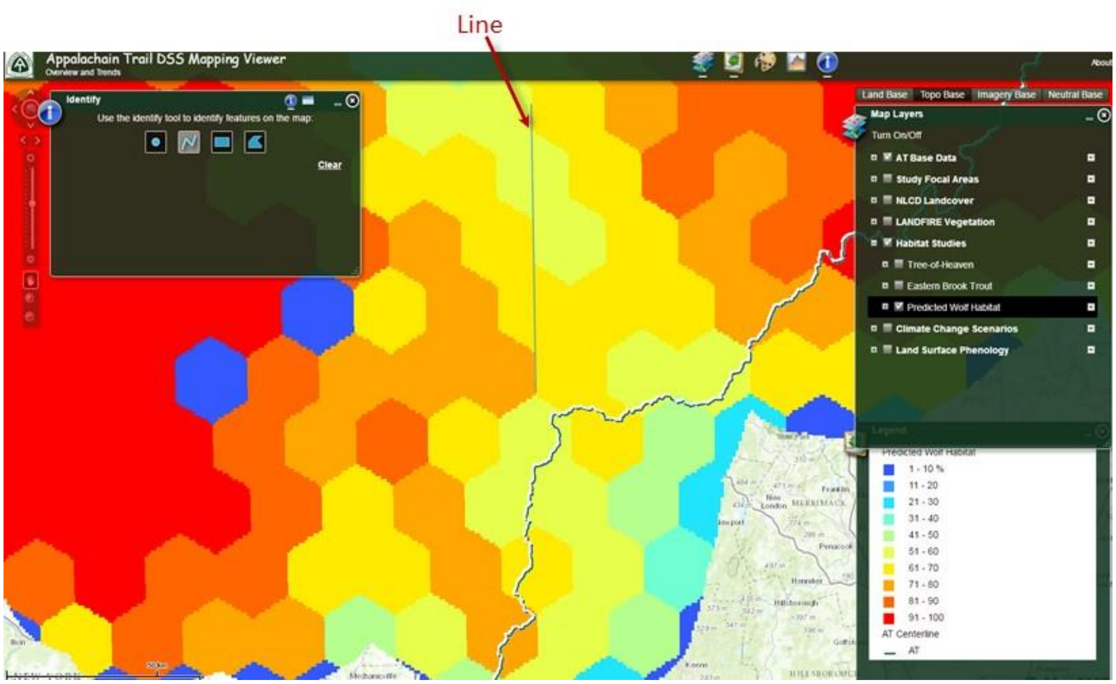


Figure 25 Identify vector data by line

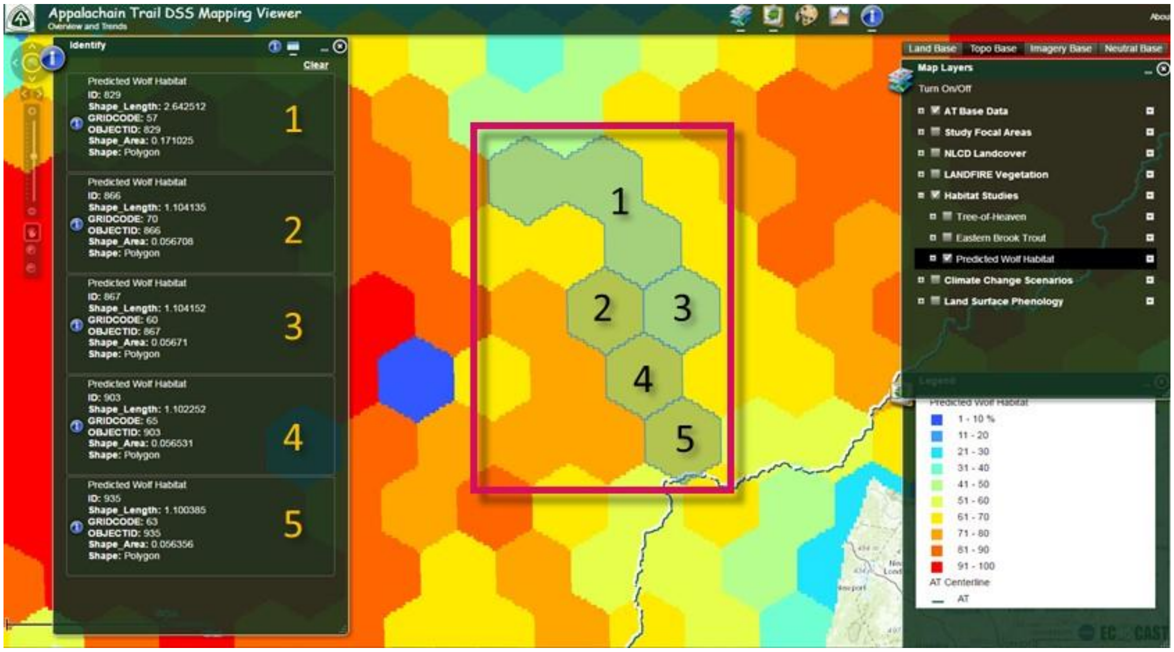


Figure 26 Polygons intersecting the line drawn by user are selected and attributes extracted.

Identify by Rectangle

Draw a rectangle to extract information pertaining to area under the drawn shape. It is important to know that extraction of information from Raster and Vector data is performed differently.

Raster Data – The central pixel is calculated from the drawn rectangle's edges.

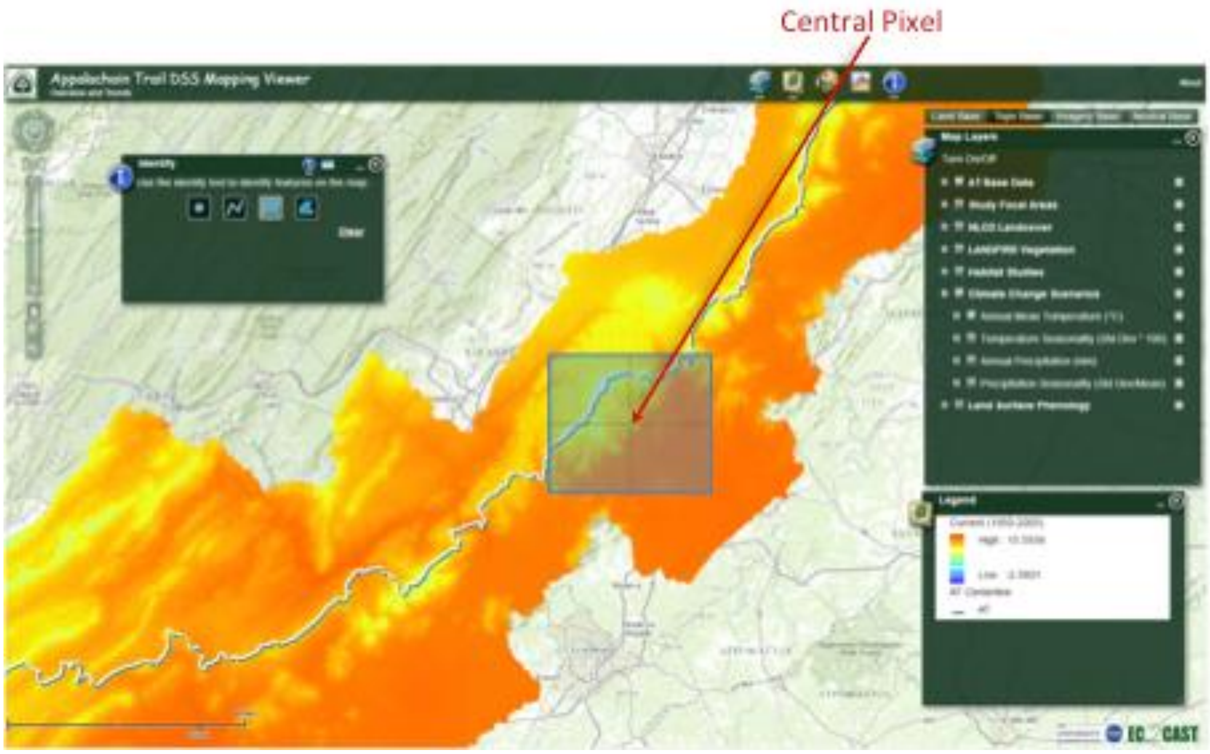


Figure 27 Rectangle drawn by user to identify pixel value within shape

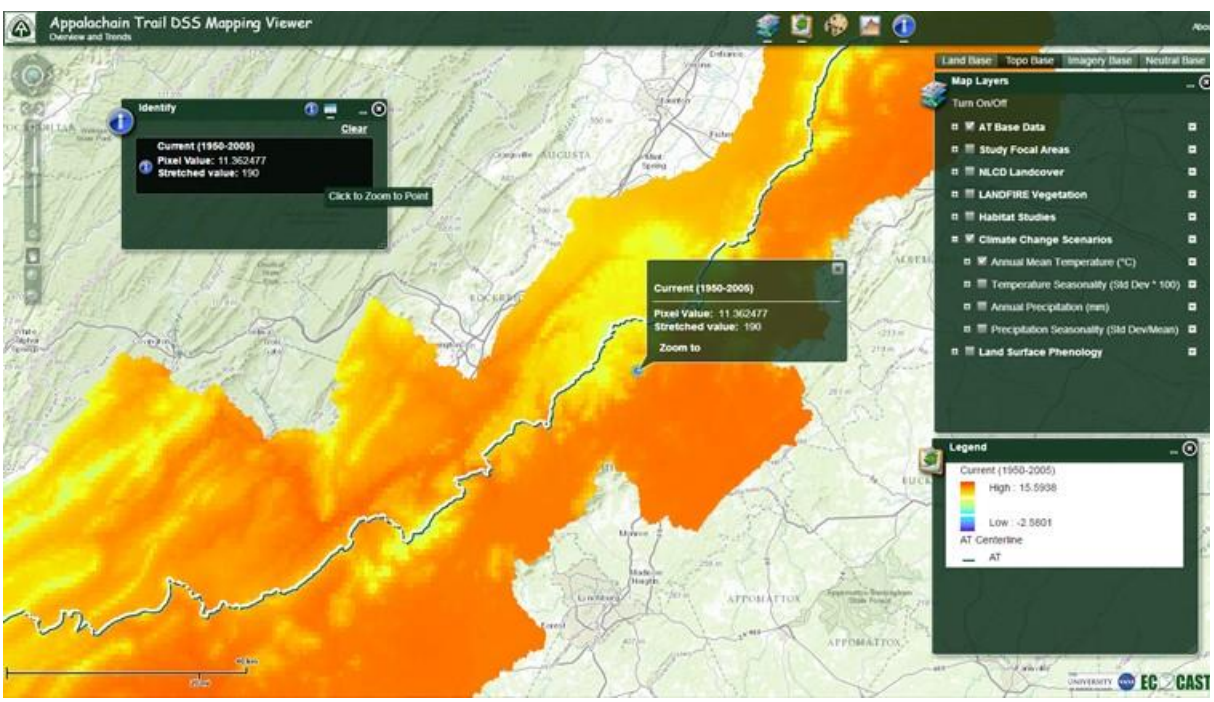


Figure 28 Rectangle queries will return the values of the central pixel from the rectangle boundaries

Vector Data – Extraction of information is performed on active map layers with respect to the area covered by the drawn rectangle, which intersects with a point, line or polygon features present in the active map layer.

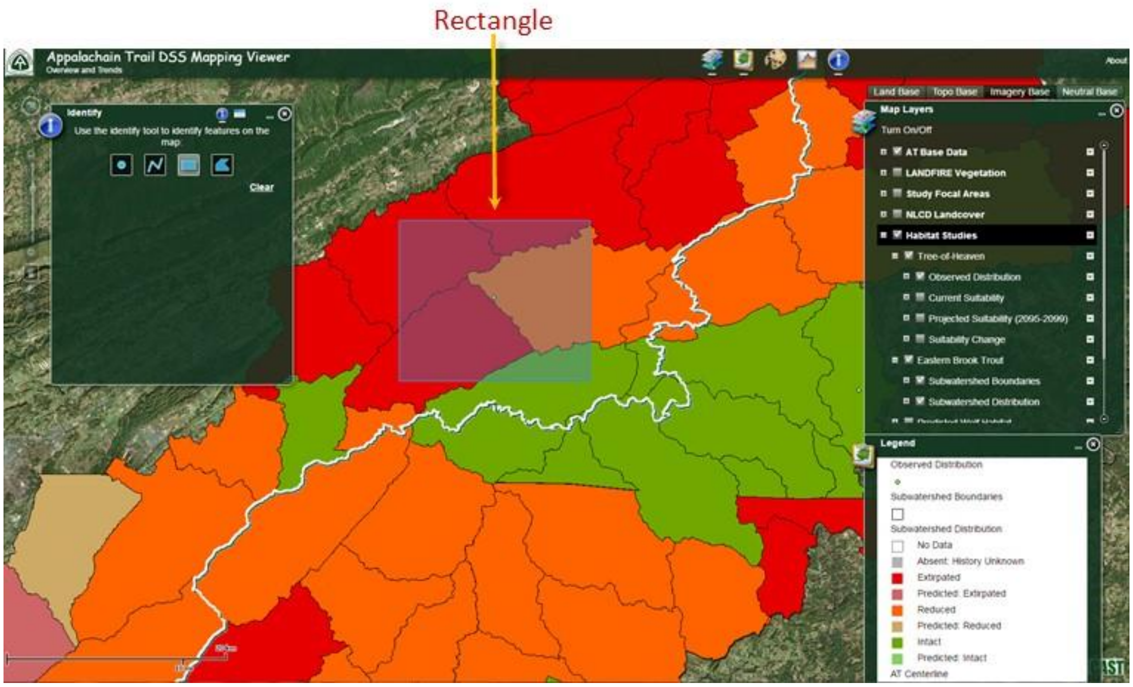


Figure 29 Rectangle drawn to extract information from multiple map layers

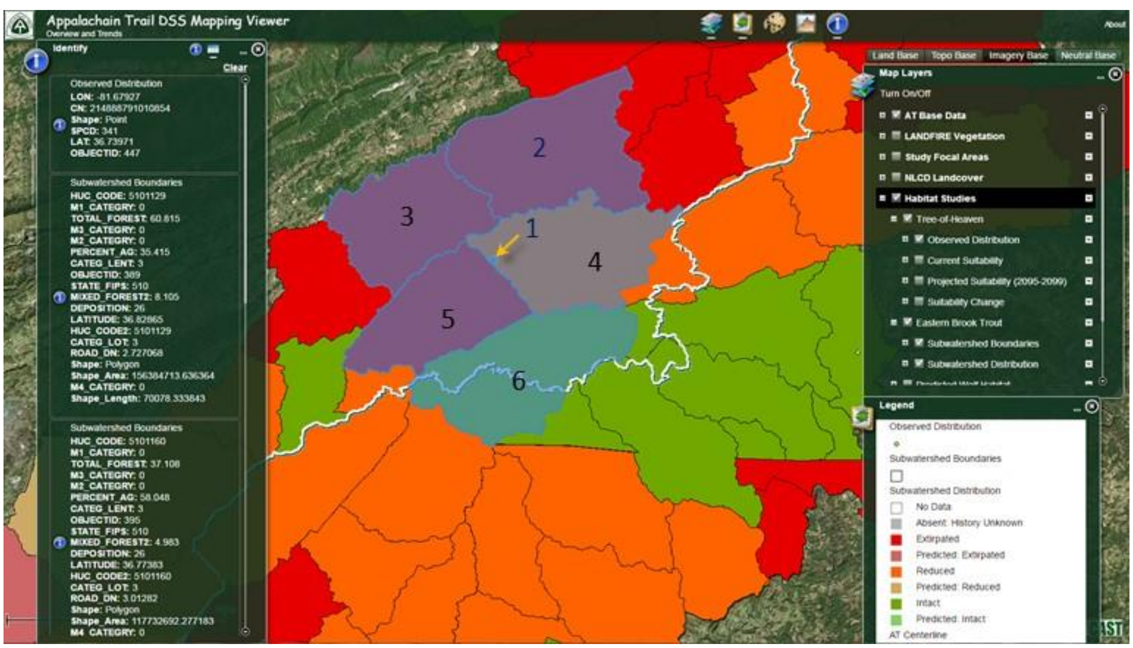
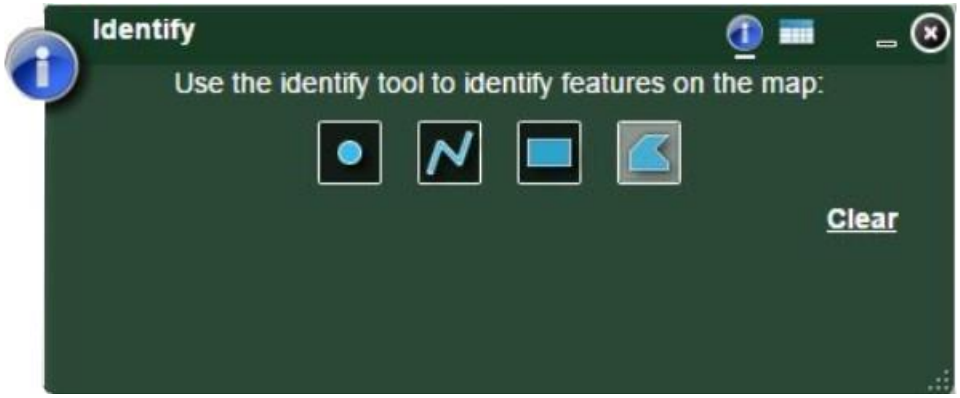


Figure 30 The query selects 1 point and 5 polygons intersecting the rectangle

Identify by Polygon



Polygon of desired shape and size could be drawn to extract information from respective Attribute Tables of active map layers using this tool. It is important to know that extraction of information from Raster and Vector data is performed differently.

Raster data – A pixel in the center of the drawn polygon selected to extract information pertaining to it.

Vector Data – Extraction of information is performed on active map layers with respect to the area covered by the drawn rectangle, which intersects with a point, line or polygon features present in the active map layer.

Base Maps

Maps provided by ESRI on which a map layer is projected. The system utilizes four types of base maps, which are Land Base (Physical), Topo Base (Topography), Imagery Base (Satellite) and Neutral Base (Political boundaries).

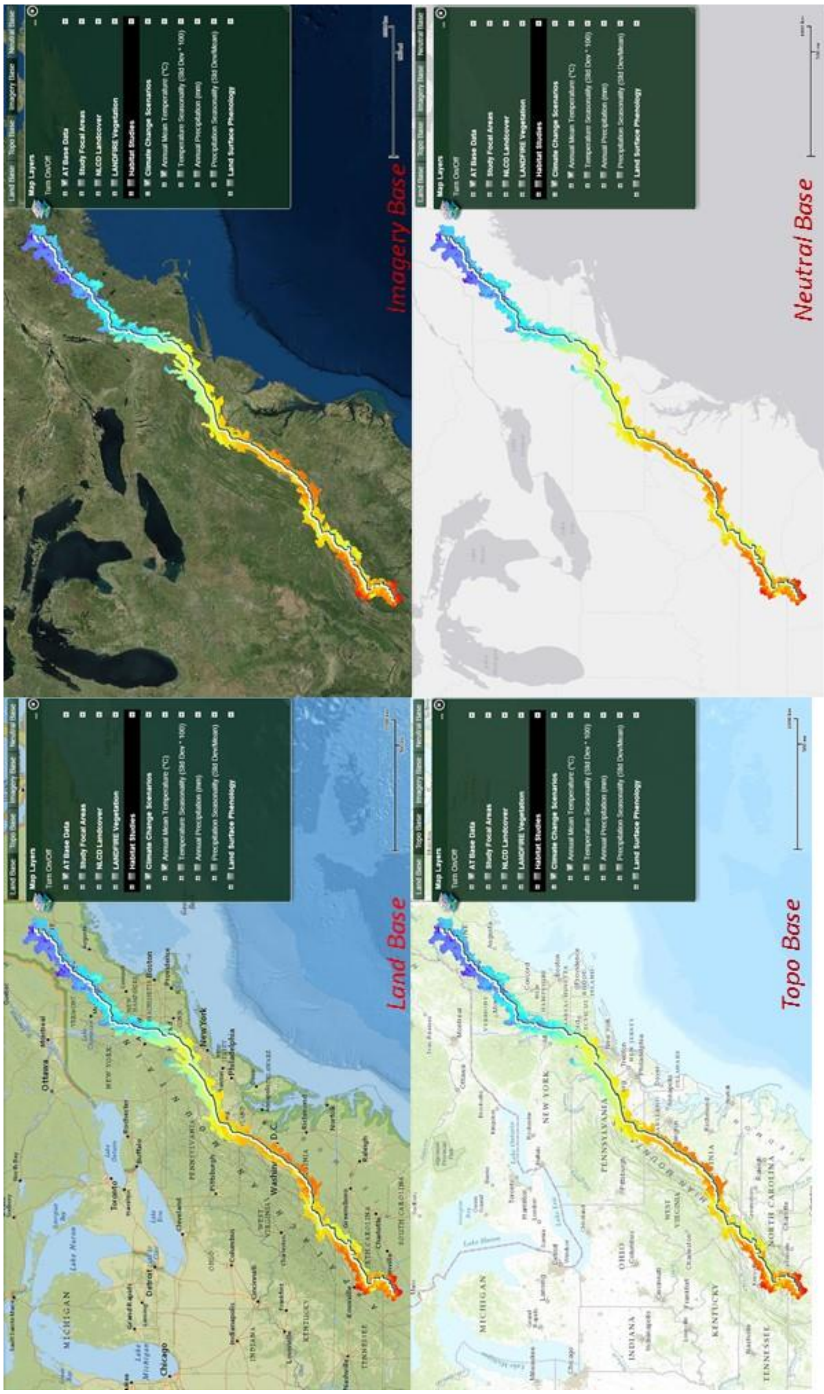
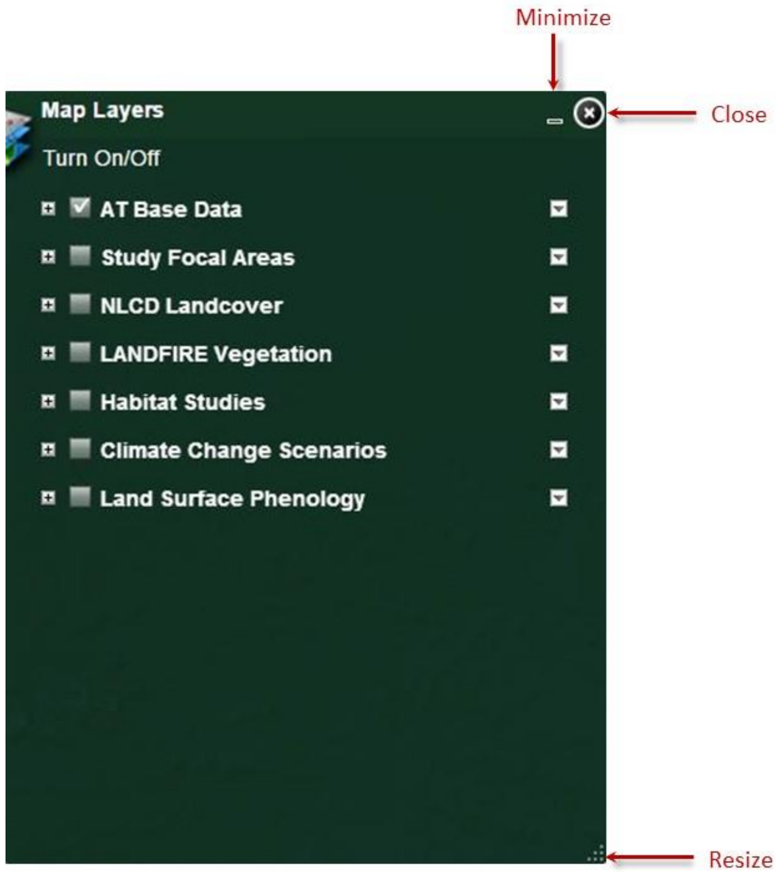


Figure 31 A.T.-DSS data may be overlaid across four different basemaps (provided by ESRI)

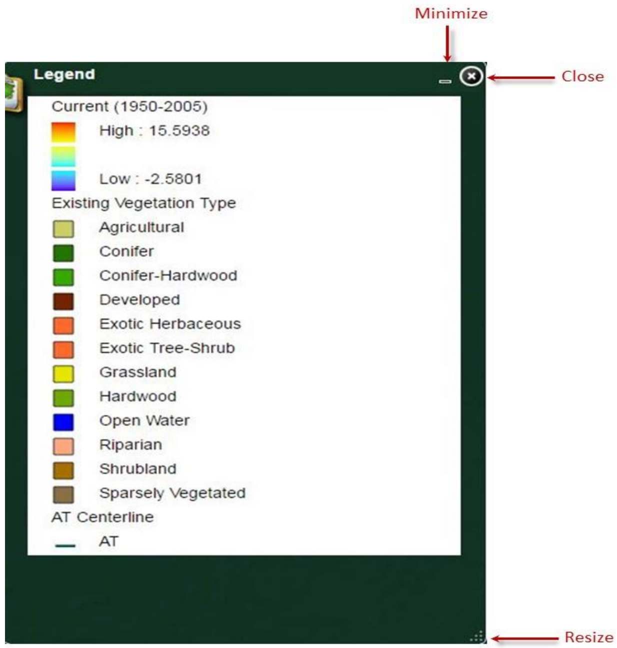
Navigation

Map Layers Widget

Minimize, close or resize the Map layers widget using quick access buttons.



Legend Widget
Minimize, close or resize the Legend widget using quick access buttons.



Scale Bar
Scale representing the measurement of distance in Kilometers and Miles on the Base Map based on the current zoom level.

Zoom in and Zoom out by area selection
Quickly zoom in or zoom out of the map by drawing a rectangle as an area selection tool.

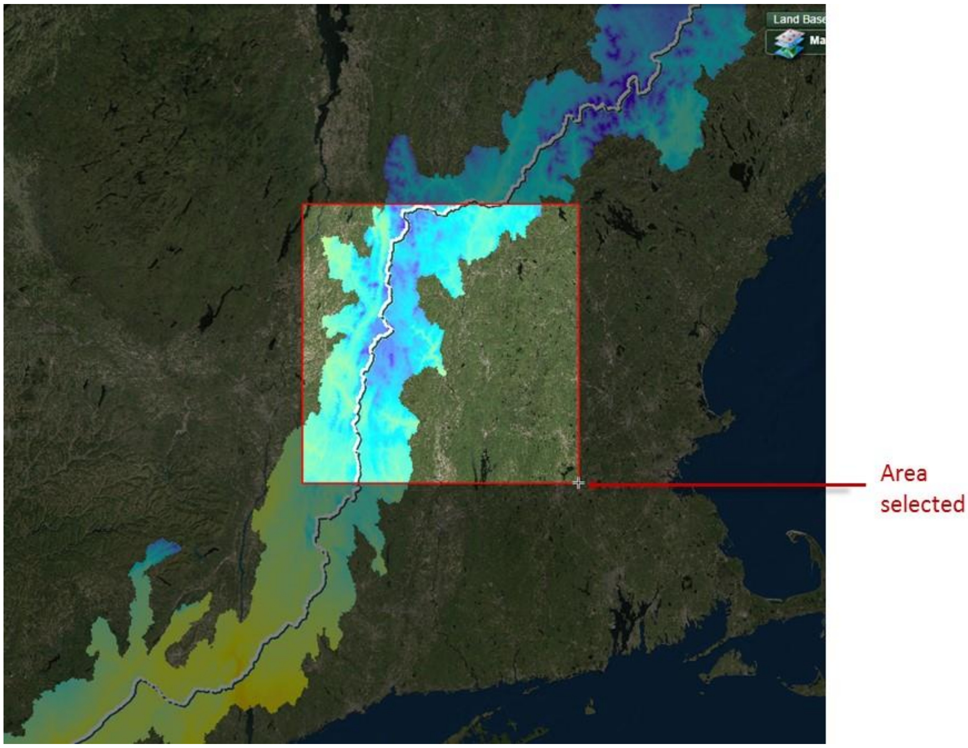
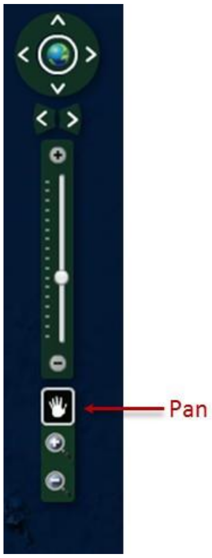


Figure 32 Zoom by rectangle extent

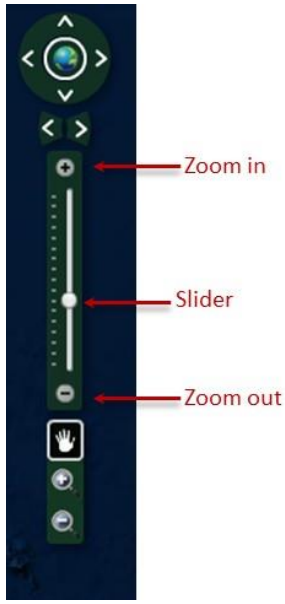
Pan

Right click and hold the mouse button to slide the base map around on the screen in the Map View window.



Zoom Slider

Quickly Zoom in and out of the map using the slider button



Next/Previous Extent
Allows user to switch back and forth between series of previously selected extents or map resolution levels, like a go back or forward function.

Full Extent and Shift Pan
Full Extent instantly switches from the current view back to its startup view full view of AT in Map View. Press the globe icon to activate Full Extent.

Pan Extent freely slides or pans the map in the east, west north, and south directions within the Map View. This option also comes in handy when using the keyboard arrow (left, right, up down) keys to pan the map.

Viewshed Monitoring & 3D Visualization

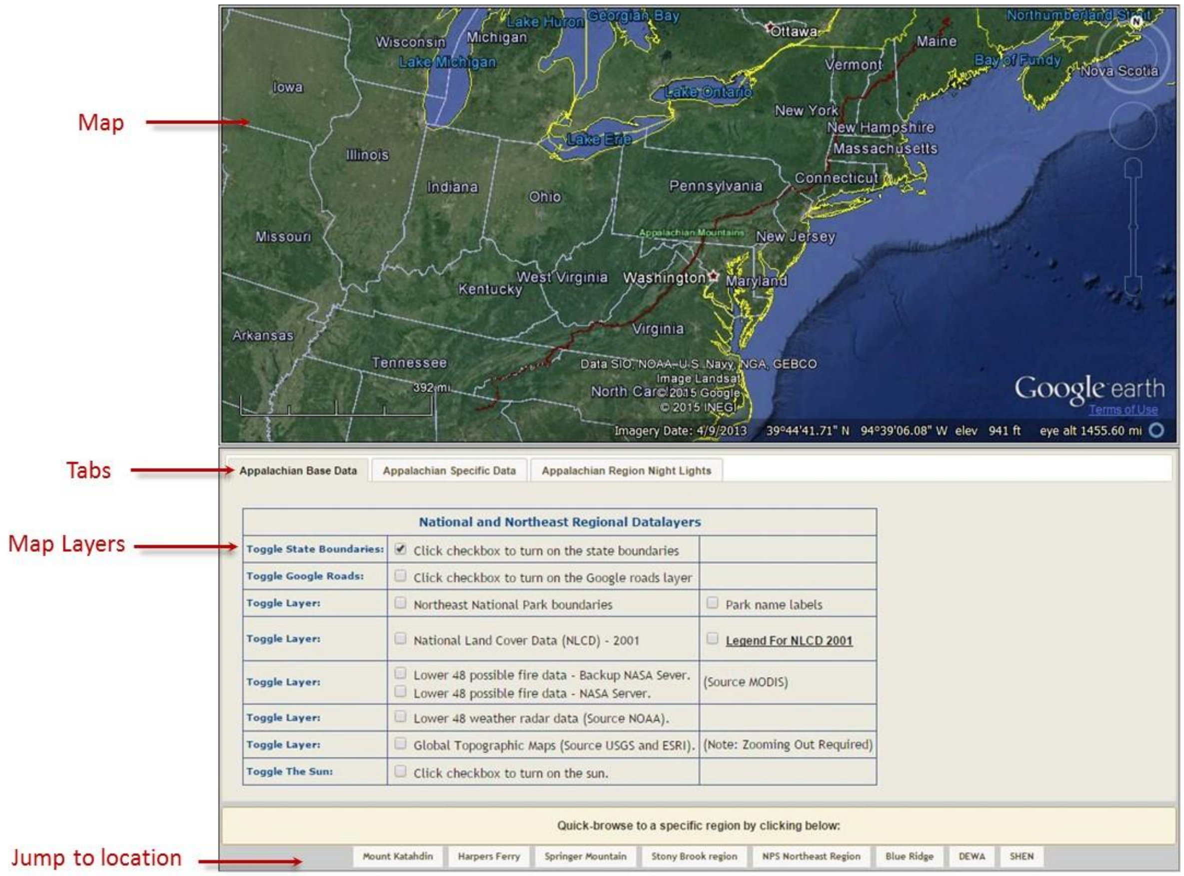


Figure 33 Viewshed interface

Note – Google Earth plug-in download is essential for 3D visualization of viewshed monitoring to work. The web service works in coordination with Google Earth.

Map

Area where AT DSS map layers are displayed on Google Earth map

Tabs

Appalachian Base Data, Appalachian Specific Data and Appalachian Region Night Lights.

Each tab contains multiple distinct map layers that can be turned on and off using the check box.

- Appalachian Base Data - It is consisted of 8 map layers containing some basic information of Appalachian Trail like boundaries, roads, NLCD, weather etc. in association with live feeds from NOAA, NASA server, USGS and ESRI.
- Appalachian Specific Data – It is consisted of 8 map layers containing some explicit information about AT like Trail centerline, parking, shelters, sub-ecoregions etc.

- Appalachian Region Night Lights – It is consisted of 18 map layers containing information about distribution of nightlights from 1992 to 2009 in the form of composites of satellite imagery

- Display criterion of map layers over base map with respect to the tabs.
  Appalachian Base Data (Top)
  Appalachian Specific Data (Middle)
  Appalachian Region Night Lights (Bottom)

Jump to Location
User can quickly jump to a specific location by clicking on the given locations at the bottom bar of the window.

Viewshed
Viewshed is the portion of landscape visible from a vista location. Double click on the icon to display the name and viewshed of a location**.** It is displayed in light green color.

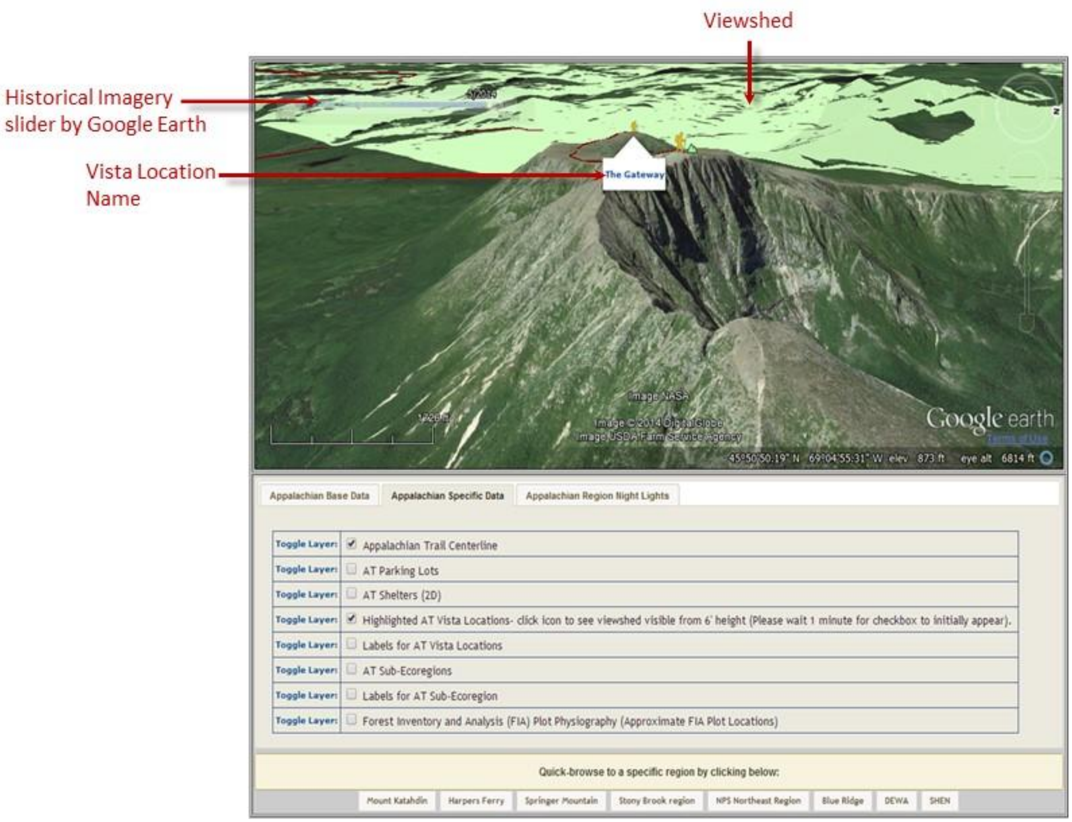


Figure 34 Visualizing a viewshed

Smartphone Application

Figure 35 Mobile application for the A.T-DSS

The A.T.-App allows users to access A.T.-DSS geospatial information from a mobile device. Simply install the free ArcGIS app on your Droid or iOS device and navigate to the link provided. Please note that the data provided are NOT suitable for navigation. See the Appalachian Trail Conservancy for the latest trail and safety information.

1.) Install the free ArcGIS App for Smartphones & Tablets from the Google Play or iOS App Store
2.) Open the following URL within your smartphone or tablet browser: http://bit.ly/1i5O9tL
3.) When the "Complete action using" prompt appears, select ArcGIS

Data Gateway

It provides users with direct access to geospatial data products incorporate by the A.T. DSS. A GIS such as QGIS is needed to view and manipulate these data. Alternatively, many products can be viewed within a web browser via the Mapping Viewer. Please note, the Data Gateway is currently under development. Data availability may vary as we work to expand these resources.

A.T. Geospatial Data

Title	Description	Type	Date	Metadata	Download
A.T. Centerline	This data set represents the most current depiction of the Appalachian National Scenic Trail centerline Source: Appalachian Trail Conservancy		02/2013		at_centreline.zip
A.T. HUC-10 Shell	The A.T. HUC-10 shell was adopted to provide an ecologically relevant area of interest for the A.T.-DSS. It was established by selecting all HUC-10 level watersheds that are within 5 statute miles of the A.T. land base. Source: U.S. National Park Service		03/2003		at_shell.zip
A.T. Watersheds	This data set contains the boundaries of all HUC-10 level watersheds within 5 statue mile of the A.T. land base. Source: U.S. Geological Survey		03/2010		at_huc10.zip
A.T. Ecological regions	This data set delineates ecological sections and subsections along the A.T. for the analysis of ecological relationships across ecological units. Source: U.S. Forest Service		03/2010		at_ecoregions_usfs.zip
A.T. Elevation	This high resolution elevation data for the A.T. shell is a mosaic of seamless National Elevation Dataset (NED) tiles. Source: U.S. Geological Survey		08/2010		Contact project team
A.T. Wetlands	This data set represents the extent, approximate location, and type of wetlands and deep water habitats in the area surrounding the Appalachian Trail. Source: U.S. Fish & Wildlife Service National Wetlands Inventory		09/2009		Contact project team

U.S. State Boundaries	This map layer portrays the State boundaries of the United States, and the boundaries of Puerto Rico and the U.S. Virgin Islands. Source: U.S. Geological Survey		09/2009		State_boundaries.zip

NLCD

Title	Description	Type	Date	Metadata	Download
A.T. Land Cover (1992)	Land cover classification from the 1992 National Land Cover Database subset to the A.T. shell.		01/2012		at_nlcd_lc92.zip
A.T. Land Cover (2001)	Land cover classification from the 2001 National Land Cover Database subset to the A.T. shell.		01/2012		at_nlcd_lc01.zip
A.T. Land Cover (2006)	Land cover classification from the 2006 National Land Cover Database subset to the A.T. shell		01/2012		at_nlcd_lc06.zip
A.T. Land Cover Change (2001-2006)	Changes in land cover classification from the 2001 to 2006 National Land Cover Databases subset to the A.T. shell.		01/2012		at_nlcd_chnage06.zip
A.T. Impervious Surface (1992)	Percent developed impervious surface from the 2006 National Land Cover Database subset to the A.T. shell.		01/2012		at_nlcd_Im06.zip

LANDFIRE

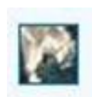
Title	Description	Type	Date	Metadata	Download
Existing Vegetation Type (EVT)	The existing vegetation type (EVT) data layer represents the current distribution of the terrestrial ecological systems classification.		01/2012		at_lf08_evt.zip
Existing Vegetation Cover (EVC)	The Existing Vegetation Cover (EVC) layer represents the average percent cover of existing vegetation for a 30-m grid cell.		01/2012		at_lf08_evc.zip
Existing Vegetation Height (EVH)	The existing vegetation height (EVH) is determined by the average height weighted by species cover and based on existing vegetation type (EVT) life-form assignments.		01/2012		at_lf08_evh.zip
Canopy Cover (CC)	Canopy cover (CC) describes percent cover of tree canopy in a stand		01/2012		at_lf08_cc.zip
Canopy Height (CH)	Canopy height describes the average height of the top of the canopy for a stand.		01/2012		at_lf08_ch.zip
Biophysical Settings (BpS)	The biophysical settings (BpS) data layer represents the vegetation that may have been dominant on the landscape prior to Euro-American settlement and is based on both the current biophysical environment and an approximation of the historical disturbance regime.		01/2012		at_lf08_bps.zip
Environmental Site Potentials (ESP)	The environmental site potential (ESP) data layer represents the vegetation that could be supported at a given site based on the biophysical environment.		01/2012		at_lf08_esp.zip

TOPS

Title	Description	Type	Date	Metadata	Download
MOD10A2	Snow Cover 8-days:2000-2009		2012		MOD10A2img.zip
MOD11A2	Land Surface Temperature (LST): 2000-2009		2012		MOD11A2img.zip
MOD12Q1	Land Cover Type:2001-2004		2012		MOD12Q1img.zip
MOD13A2	Vegetation Indice (VI):2000-2009		2012		MOD13A2img.zip
MOD15A2	Leaf Area Index FPAR:2000-2009		2012		MOD15A2img.zip
MOD12Q2	Land Cover Dynamics:2001-2006		2012		MOD12Q2img.zip
NACP	North American Carbon Program Modeled GPP, NPP and NEP: 1982-2006		2012		NACPimg.zip
GIMMS	Global Inventory Modeling and Mapping Studies NDVI:1981-2006		2012		Gimms.zip
SOGS	SOGS 1-km Metrological data		2012		sogs.zip

Climate

Title	Description	Type	Date	Metadata	Download
Climate Baseline (1950-2005)	Consists of four raster datasets: mean temperature, minimum temperature, maximum temperature, and total precipitation. Each raster contains 12 separate bands corresponding to the months of the year. Values for the baseline climate layers are averages of conditions from 1950-2005.		2012		baseline_1950_2005.zip
RCP2.6 Climate Projection (2095-2099)	Consists of four raster datasets: mean temperature, minimum temperature, maximum temperature, and total precipitation. Each raster contains 12 separate bands corresponding to the months of the year. Climate projections were provided by the International Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) Coupled Model Intercomparison Project (CMIP5). The CMIP5 provides an ensemble of General Circulation Models (GCMs) that predict future conditions under a set of alternative scenarios defined by Representative Concentration Pathways (RCPs). RCP2.6 is the lowest emission scenario with concentrations peaking mid-century before gradually declining due to mitigation.		2012		rcp26_ensemble_2095_2099.zip
RCP4.5 Climate Projection (2095-2099)	Consists of four raster datasets: mean temperature, minimum temperature, maximum temperature, and total precipitation. Each raster contains 12 separate bands corresponding to the months of the year. Climate projections were provided by the International Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) Coupled Model Intercomparison Project (CMIP5). The CMIP5 provides an ensemble of General Circulation Models (GCMs) that predict future conditions under a set of alternative scenarios defined by Representative Concentration Pathways (RCPs). RCP4.5 is a low-moderate emission scenario with concentrations stabilizing after 2100.		2012		rcp45_ensemble_2095_2099.zip

RCP6 Climate Projection (2095-2099)	Consists of four raster datasets: mean temperature, minimum temperature, maximum temperature, and total precipitation. Each raster contains 12 separate bands corresponding to the months of the year. Climate projections were provided by the International Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) Coupled Model Intercomparison Project (CMIP5). The CMIP5 provides an ensemble of General Circulation Models (GCMs) that predict future conditions under a set of alternative scenarios defined by Representative Concentration Pathways (RCPs). RCP4.5 is a low-moderate emission scenario with concentrations stabilizing after 2100.		2012		rcp60_ensemble_ 2095_2099.zip
RCP8.5 Climate Projection (2095-2099)	Consists of four raster datasets: mean temperature, minimum temperature, maximum temperature, and total precipitation. Each raster contains 12 separate bands corresponding to the months of the year. Climate projections were provided by the International Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) Coupled Model Intercomparison Project (CMIP5). The CMIP5 provides an ensemble of General Circulation Models (GCMs) that predict future conditions under a set of alternative scenarios defined by Representative Concentration Pathways (RCPs). RCP8.5 is the highest emission scenario with concentrations continuing to rise after 2100.		2012		rcp85_ensemble_ 2095_2099.zip

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Climate and Vegetation Variation

Patterns in climate and vegetation along the A.T. HUC-10 shell area for the time period from 2001-2006

An excerpt from: "Monitoring and Forecasting Climate Impacts on Ecosystem Dynamics in Protected Lands Using the Terrestrial Observation and Prediction System (TOPS)" by Hashimoto, H., F.M. Melton, S.H. Hiatt, C. Milesi, A.R. Michaelis, P. Votava, W. Wang, and R.R. Nemani, 2011. In Remote Sensing of Protected Lands, Wang, Y. (Ed.), CRC Press, Boca Raton, Florida. (ISBN 9781439841877).

Below is the summary of current patterns in climate and vegetation along the A.T. HUC-10 shell area and along the latitudinal gradient from 2001 to 2006, We present data on temperature, precipitation, LAI, and NPP; all of which were, derived from TOPS . The mean temperature derived from Surface Observation and Gridding System (SOGS) increases from north to south, with a difference of over 10°C between the northern terminus and southern terminus of the trail. Precipitation derived from SOGS decreases steeply from 35°N to 37°N (by 500 mm/year), increased from 37°N to 41°N, and decreases again north of latitude 41°N during the time period. Most of the study area receives more than 900 mm/year of precipitation. Annual peak MODIS LAI (MOD15A2) shows a large decline from 39°N to 41°N due to the amount of cropland and urban area in the landscape. MODIS NPP (MOD17EN) decreases from south to north, and the decrease can be explained by the temperature gradient, with the exception of a decline induced by the cropland and urban area around 40°N. A comparison between climate variables and NPP shows that the latitudinal gradient of NPP is mostly controlled by temperature through its effect on modulating growing season length (Jenkins et al., 2002).

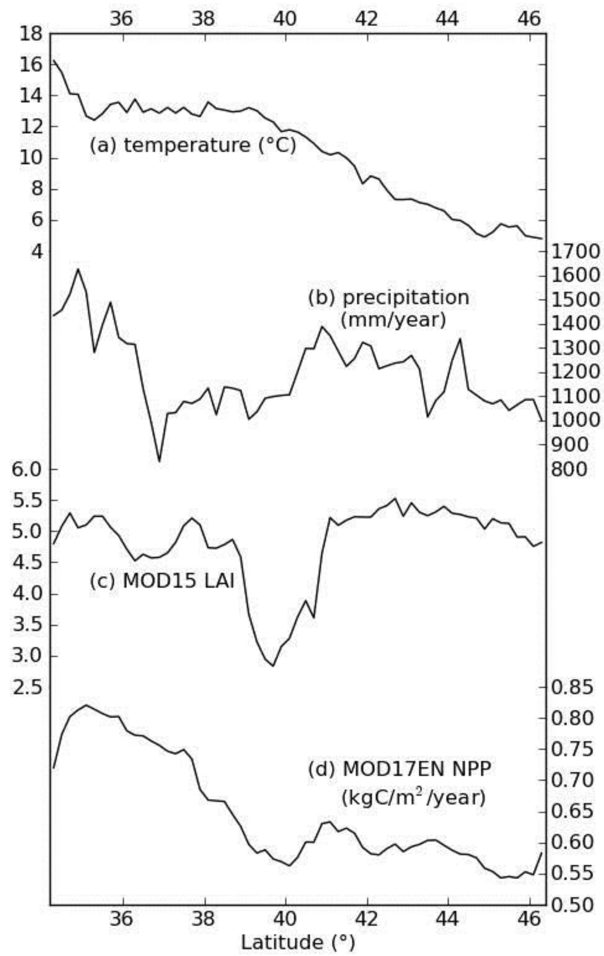


Figure 36 This figure illustrates the latitudinal distribution of (a) mean temperature, (b) precipitation, (c) MOD15A2 Leaf Area Index (LAI), and (d) MOD17EN Net Primary Production (NPP) of the A.T. HUC-10 shell area during the 2001-2006 time period.

Gridded climate surfaces are a key input to many component models within TOPS (Nemani et al., 2009), and TOPS includes functionality for deriving gridded climate surfaces from networks of meteorological stations. To create a gridded climate surface, the automated TOPS data acquisition system first fetches the necessary weather data from weather stations in the region of interest. Next, the data are pre-processed which includes checking for consistency against historical averages, filling missing values from additional sources, flagging missing values, and finally converting these observation records to data structures suitable for processing by the Surface Observation and Gridding System (SOGS, Jolly et al, 2005), a component within TOPS. SOGS is a climate gridding system that uses maximum, minimum, and dewpoint temperatures, in addition to precipitation, to create spatially continuous surfaces for air temperatures, precipitation, vapor pressure deficits, and incident radiation.

We used meteorological observations from the Global Surface of Summary Data (GSSD) version 7 and from the U.S. Cooperative Summary of Day data (TD3200) for the period 1982-2006. The daily data were gridded using SOGS to produce spatially continuous 8-km daily meteorological surfaces, including maximum and minimum temperature, precipitation, and shortwave radiation. These spatially continuous meteorological surfaces were used to define the climatology for the study area, as well as inputs to ecosystem models used to assess changes in vegetation productivity and runoff.

References

Jenkins, J. P., B. H. Braswell, S. E. Frolking, and J. D. Aber. 2002 Detecting and predicting spatial and interannual patterns of temperate forest springtime phenology in the eastern U.S. Geophysical Research Letters, 29, no. 24: 54.

Jolly, W. M., J. S. Graham, A. Michaelis, R. R. Nemani, and S. W. Running. 2005. A flexible, integrated system for generating meteorological surfaces derived from point sources across multiple geographic scales. Environmental Modelling & Software 20, no. 7: 873-882.

Nemani, R., H. Hashimoto, P. Votava, F. Melton, W. Wang, A. Michaelis, L. Mutch, C. Milesi, S. Hiatt, and M. White. 2009. Monitoring and forecasting ecosystem dynamics using the Terrestrial Observation and Prediction System (TOPS). Remote Sensing of Environment, 113, no. 7, pp. 1497-1509.

Time series temperature, precipitation, and GIMMS NDVI averaged over the A.T. HUC-10 shell area from 1982-2006

An excerpt from: "Monitoring and Forecasting Climate Impacts on Ecosystem Dynamics in Protected Lands Using the Terrestrial Observation and Prediction System (TOPS)" by Hashimoto, H., F.M. Melton, S.H. Hiatt, C. Milesi, A.R. Michaelis, P. Votava, W. Wang, and R.R. Nemani, 2011. In Remote Sensing of Protected Lands, Wang, Y. (Ed.), CRC Press, Boca Raton, Florida. (ISBN 9781439841877)

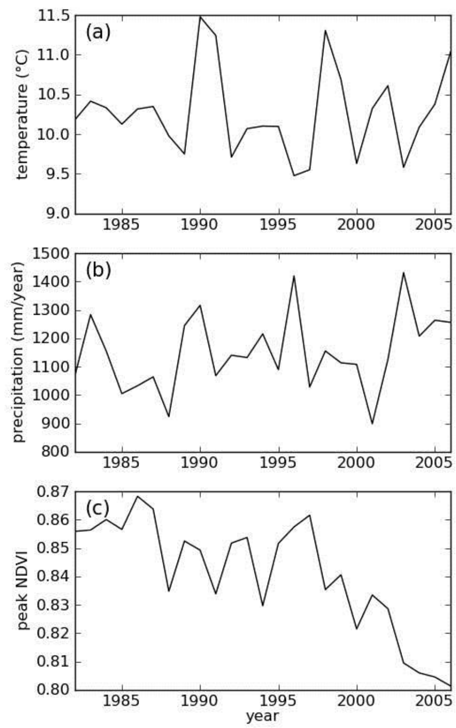


Figure 37 This figure illustrates time series of (a) temperature, (b) precipitation, and (c) Global Inventory Modeling and Mapping Studies (GIMMS) Normalized Differential Vegetation Index (NDVI) averaged over the entire A.T. HUC-10 shell area for the period 1982

Global Inventory Modeling and Mapping Studies (GIMMS) NDVI data show a significant decrease over the time period from 1982 to 2006. Given that neither temperature nor precipitation shows a correlation with NDVI, we hypothesize that the observed decrease in NDVI is due to the combination of urban expansion and recent outbreaks of hemlock wooly adelgids (Adelges tsugae) (Orwig et al., 2008; Eschtruth et al., 2006; Lovett et al., 2006) and other insect pests. These are presumed to be the primary drivers of the observed trend in NDVI, as opposed to climate variability. Consistent with the patterns observed in the AVHRR GIMMS data along the A.T., analyses of Landsat data have shown a decrease in forest cover in the eastern U.S. mainly due to the growth of urban areas since the 1970s (Potere et al.,2007; Wang et al., 2009; Drummond and Loveland 2010; Hansen et al., 2010). Furthermore, forest inventory studies have found that forest regrowth caused the aboveground biomass in the eastern US to increase (Caspersen et al. 2000; Smith et al., 2009). Thus, we suggest that while photosynthetic activity increased at the forest stand level, an overall loss of forest cover due to urban development, outbreaks of forests pests and pathogens, and other disturbances caused a decrease in peak NDVI since the 1970s.

Though the signal of the forest cover loss is prominent in the satellite data, the net carbon exchange of forests (flux from forests to the atmosphere) in the eastern U.S. is still expected to become a sink over time according to the modeling studies, as well as airborne CO2 composition analysis (Peters et al., 2007). For the purpose of assessing vegetation conditions over the A.T. HUC-10 shell area, TOPS ingested and preprocessed time series from the Moderate Resolution Imaging Spectroradiometer (MODIS) and from the Advanced Very High Resolution Radiometer (AVHRR). AVHRR data are useful for analyzing interannual variation in vegetation because of its long record, starting from 1981, and global-scale coverage. In particular, we used the Global Inventory Modeling and Mapping Studies (GIMMS) (Tucker et al. 2005), which is a dataset derived from AVHRR that has been used extensively for global-scale vegetation monitoring and detection of trends in vegetation condition (e.g., Goetz et al., 2005, Nemani et al., 2009). The GIMMS data sets provides a global time series of Normalized Differential Vegetation Index (NDVI) measurements at a spatial resolution of 8km x 8km. NDVI is calculated from the red and near-infrared spectral bands, and provides a measure of vegetation greenness on the land surface.

We used monthly composites of GIMMS data for the A.T. HUC-10 shell area from 1982 to 2006.

References

Jenkins, J. P., B. H. Braswell, S. E. Frolking, and J. D. Aber. 2002 Detecting and predicting spatial and interannual patterns of temperate forest springtime phenology in the eastern U.S. Geophysical Research Letters, 29, no. 24: 54.

Jolly, W. M., J. S. Graham, A. Michaelis, R. R. Nemani, and S. W. Running. 2005. A flexible, integrated system for generating meteorological surfaces derived from point sources across multiple geographic scales. Environmental Modelling & Software 20, no. 7: 873-882.

Nemani, R., H. Hashimoto, P. Votava, F. Melton, W. Wang, A. Michaelis, L. Mutch, C. Milesi, S. Hiatt, and M. White. 2009. Monitoring and forecasting ecosystem dynamics using the Terrestrial Observation and Prediction System (TOPS). Remote Sensing of Environment, 113, no. 7, pp. 1497-1509.

Projected changes (2010-2099) of mean temperature and precipitation for the A.T. HUC-10 shell area using ecosystem modeling and downscaled climate scenarios

Excerpt from: "Monitoring and Forecasting Climate Impacts on Ecosystem Dynamics in Protected Lands Using the Terrestrial Observation and Prediction System (TOPS)" by Hashimoto, H., F.M. Melton, S.H. Hiatt, C. Milesi, A.R. Michaelis, P. Votava, W. Wang, and R.R. Nemani, 2011. In Remote Sensing of Protected Lands, Wang, Y. (Ed.), CRC Press, Boca Raton, Florida. (ISBN 9781439841877)

All the models project a steady temperature increase across the A.T. HUC-10 shell area, ranging from 2°C to 6°C by the end of the 21st century . The ensemble mean temperature increased from 11°C to 14.5°C, while precipitation did not show any significant trend or decadal variation.

We used TOPS to project the regional impacts of climate change along the A.T. to the end of the 21st century by downscaling general circulation model (GCM) scenarios, and using the scenarios to drive dynamic ecosystem models to assess the vegetation response to the projected climate scenarios. We used climate scenarios derived from the World Climate Research Program (WCRP) Coupled Model Intercomparison Project (CMIP3) multi-model datasets. The datasets are based on the climate scenarios produced for the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) (IPCC 2007).

We used the outputs from 11 models for the Special Report on Emission Scenarios A1B (SRES A1B) scenario, which assumes a future with high economic growth, a well-balanced energy sources resource portfolio, and new technology development, with atmospheric CO2 concentration stabilizing at 720 ppm. TOPS downscaled the SRES A1B outputs from the 11 GCMs onto an 8-km grid using the bias-correction algorithm described by Wood et al. (2002). The variability of 21st century outputs deviated from the mean of 20th century experiments (20C3M) was adjusted to that of TD3200 station data, and anomaly was calculated at each station and interpolated into spatially continuous meteorological surfaces. The spatially interpolated anomaly was then added to SOGS gridded data to produce the downscaled projection.

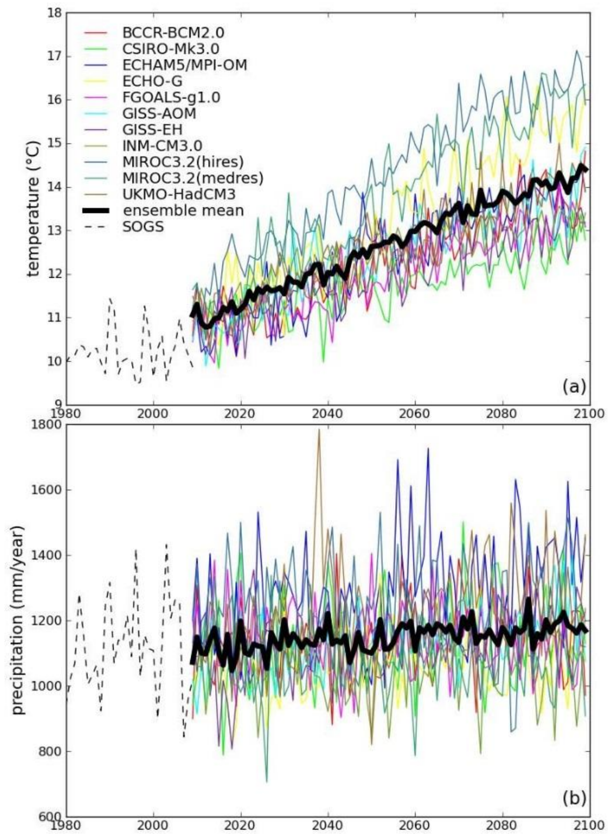


Figure 38 This figure illustrates the projections of (a) mean temperature and (b) precipitation until 2099 downscaled from Coupled Model Intercomparison Project (CMIP3) multi-model dataset of SRES A1B scenario. The colored lines correspond to 11 GCMs

References

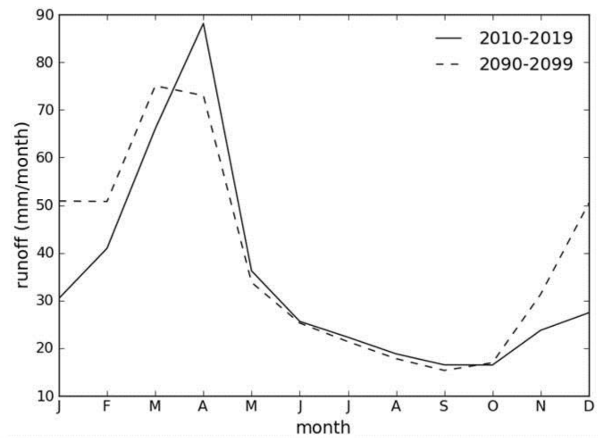
IPCC. 2007. The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Ed. S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Wood, A. W., E. P. Maurer, A. Kumar, and D. P. Lettenmaier. 2002. Long-range experimental hydrologic forecasting for the eastern United States. Journal of Geophysical Research 107, no. D20: 4429.

Projected (2010-2099) monthly distribution of runoff for the A.T. HUC-10 shell area using ecosystem modeling and downscaled climate scenarios

An excerpt from: "Monitoring and Forecasting Climate Impacts on Ecosystem Dynamics in Protected Lands Using the Terrestrial Observation and Prediction System (TOPS)" by Hashimoto, H., F.M. Melton, S.H. Hiatt, C. Milesi, A.R. Michaelis, P. Votava, W. Wang, and R.R. Nemani, 2011. In Remote Sensing of Protected Lands, Wang, Y. (Ed.), CRC Press, Boca Raton, Florida. (ISBN 9781439841877)

Changes in the seasonal distribution of runoff have a great impact on downstream water availability and potentially affect water allocation planning. Although the projected annual runoff does not show a clear trend, the peak in runoff is projected to take place earlier in the year, advancing from April to March by the end of the 21st century. In addition, the cumulative winter runoff is projected to increase, while peak runoff will decrease. This projected change in runoff can be attributed to increased winter snowmelt caused by higher temperatures.



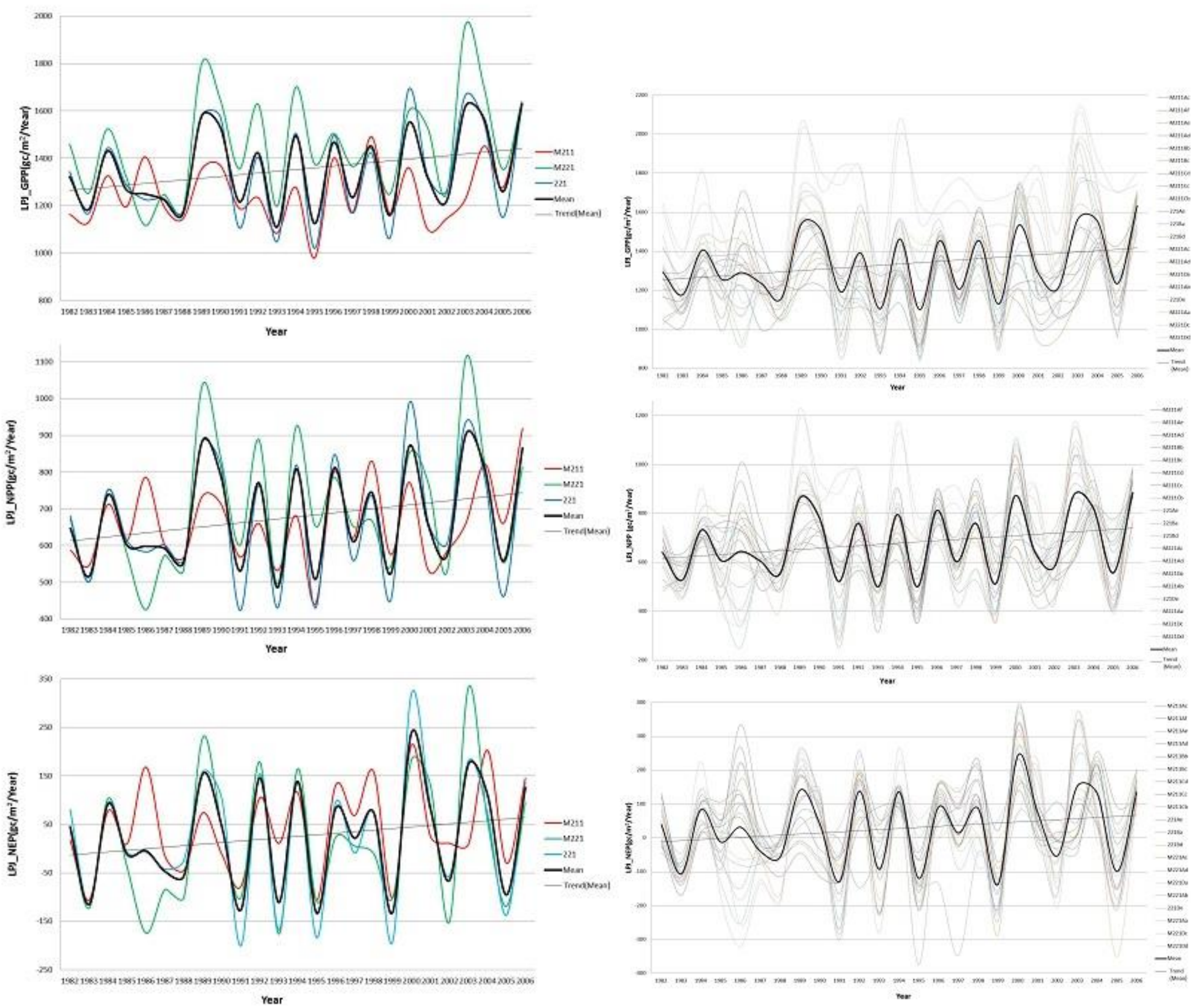
This figure illustrates the monthly distribution of runoff for the study area. The straight line is the mean from 2010 to 2019. The dashed line is the mean from 2090 to 2099.

Forest Health

Ecosystem productivity, such as gross primary production (GPP), net primary production (NPP), net ecosystem production (NEP) and net ecosystem exchange (NEE), are fundamental properties of ecosystems. For example, NEP is defined as the difference between the amount of organic carbon (C) fixed by photosynthesis in an ecosystem (gross primary production, or GPP) and total ecosystem respiration (the sum of autotrophic and heterotrophic respiration). NEP represents organic C available for storage within the system or loss from it by export or nonbiological oxidation. The ecosystem productions of GPP, NPP, NEP and NEE can be used as measures of forest health of the A.T. HUC-10 Shell area.

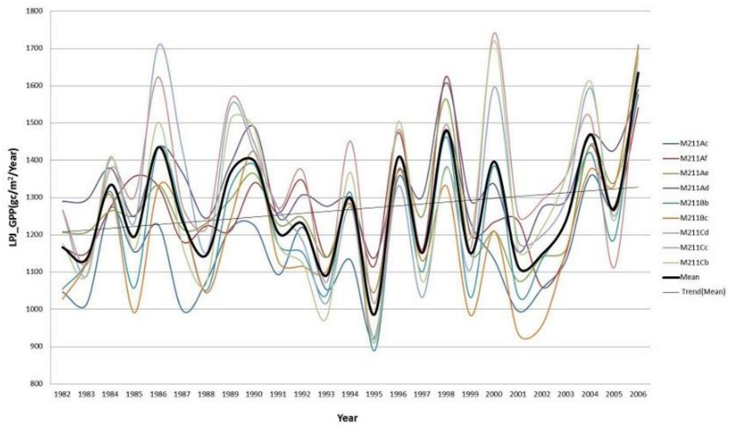
Ecosystem productivity within the A.T. HUC-10 Shell area

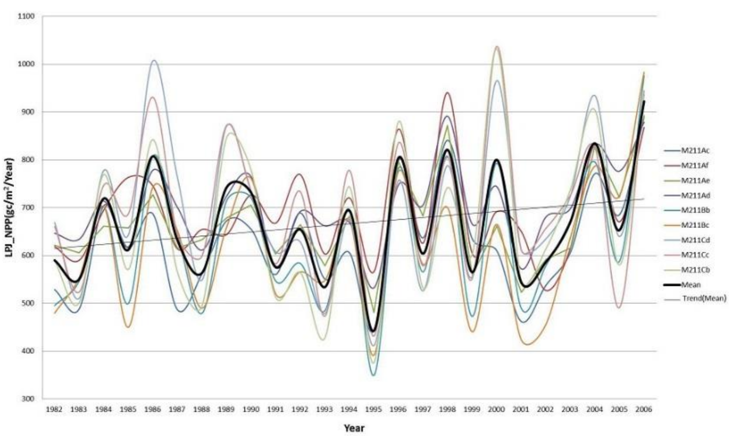
These figures summarize the GPP, NPP, and NEP of the ecoregion provinces along the A.T. corridor, and the subsections within them.

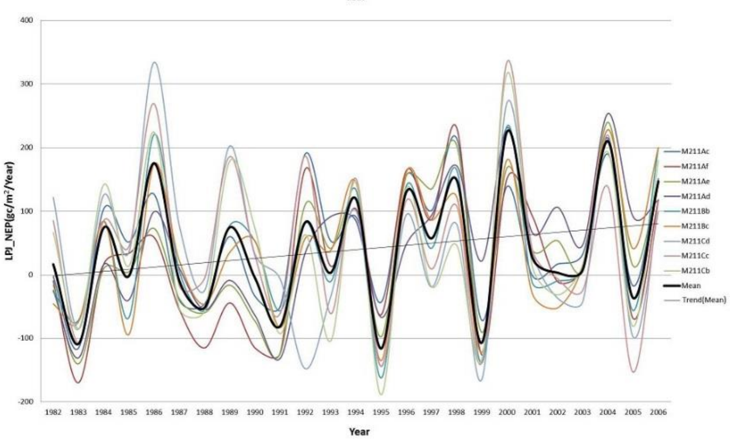


Ecosystem productivity of the A.T. HUC-10 Shell area within the Adirondack-New England Mixed Forest-Coniferous Forest-Alpine Meadow Province (M211)

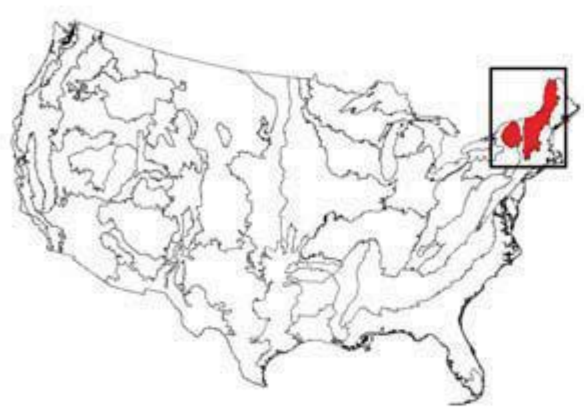
These figures illustrate the variation and trends in GPP, NPP, and NEP from 1982 to 2006 for regions of the A.T. HUC-10 shell within the Adirondack-New England Mixed Forest-Coniferous Forest-Alpine Meadow Province (M211) and the encompassed M211A-White Mountains; M211B-New England Piedmont; and M211C-Green, Taconic, Berkshire Mountains sections.







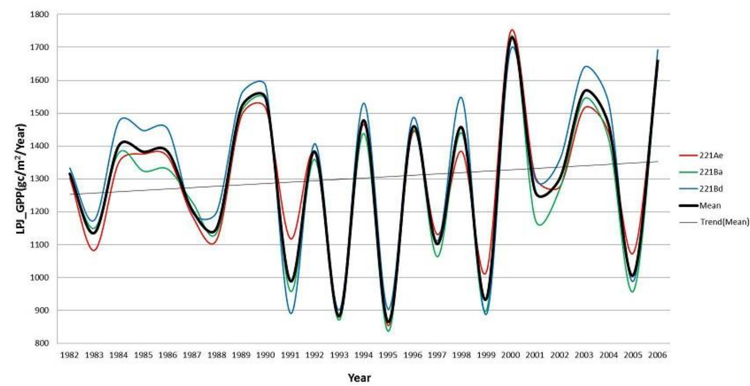
This province has a modified continental climatic regime with long, cold winters and warm summers. Annual precipitation evenly distributed. Landscape is mountainous and was previously glaciated. Forest vegetation is a transition between boreal on the north an broadleaf deciduous to the south.

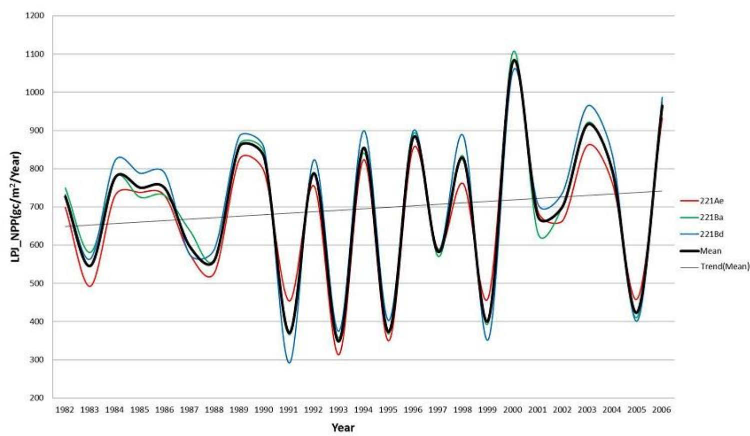


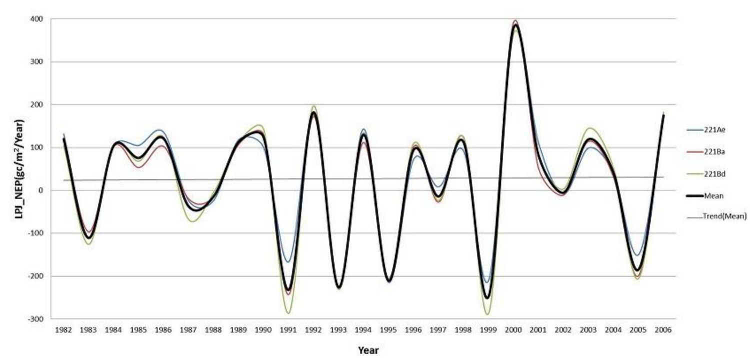
Excerpt from: McNab, W.H.; Cleland, D.T.; Freeouf, J.A.; Keys, Jr., J.E.; Nowacki, G.J.; Carpenter, C.A., comps. 2007. Description of ecological subregions: sections of the conterminous United States [CD-ROM]. Gen. Tech. Report WO-76B. Washington, DC: U.S. Department of Agriculture, Forest Service. 80 p

Ecosystem productivity of the A.T. HUC-10 Shell area within the Eastern Broadleaf Forest Province (221)

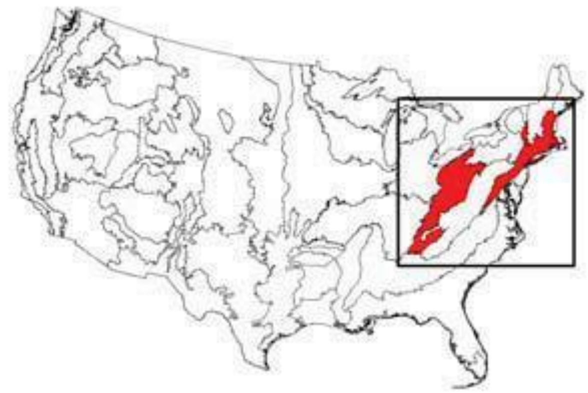
These figures illustrate the variation and trends in GPP, NPP, and NEP from 1982 to 2006 for regions of the A.T. HUC-10 shell within the Eastern Broadleaf Forest Province (221) and the encompassed 221A-Lower New England and 221B-Hudson Valley sections.







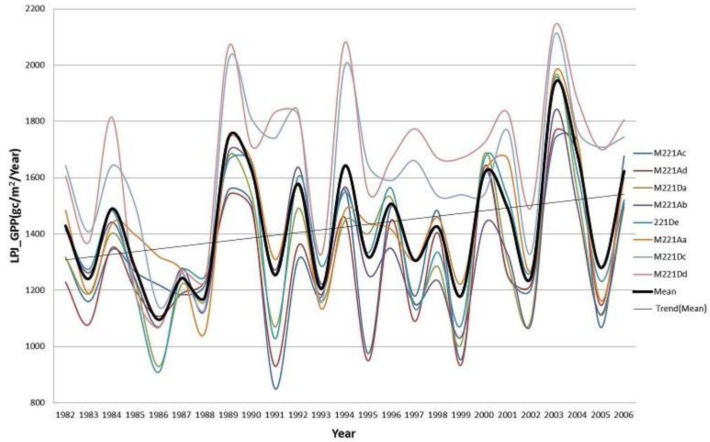
This province has a continental-type climate of cold winters and warm summers. Annual precipitation is greater during summer, water deficits infrequent. Topography is variable, ranging from plains to low hills of low relief along Atlantic coast. Interior areas are high hills to semi-mountainous, parts of which were glaciated. Vegetation is characterized by tall, cold-deciduous broadleaf forests that have a high proportion of mesophytic species.

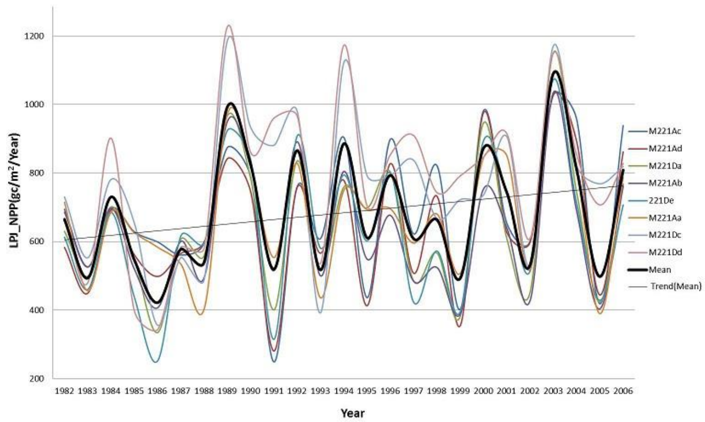


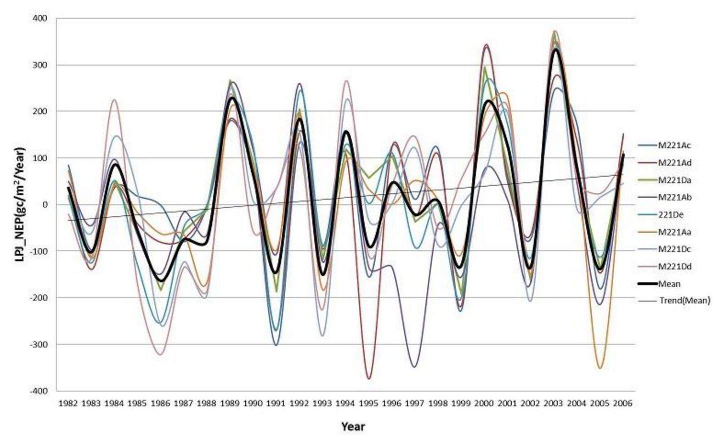
Excerpt from: McNab, W.H.; Cleland, D.T.; Freeouf, J.A.; Keys, Jr., J.E.; Nowacki, G.J.; Carpenter, C.A., comps. 2007. Description of ecological subregions: sections of the conterminous United States [CD-ROM]. Gen. Tech. Report WO-76B. Washington, DC: U.S. Department of Agriculture, Forest Service. 80 p

Ecosystem productivity of the A.T. HUC-10 Shell area within the Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow Province (M221)

These figures illustrate the variation and trends in GPP, NPP, and NEP from 1982 to 2006 for regions of the A.T. HUC-10 shell within the Central Appalachian Broadleaf Forest--Coniferous Forest--Meadow Province (M221) and the encompassed M221A-Northern Ridge and Valley and M221D-Blue Ridge Mountains sections.





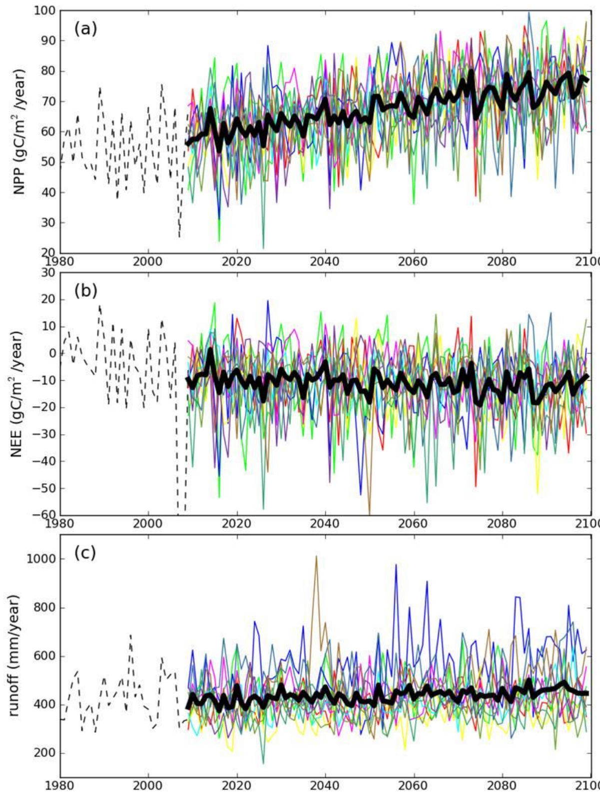


This province has a modified continental climatic regime with long, cold winters and warm summers. Annual precipitation evenly distributed. Landscape is mountainous and was previously glaciated. Forest vegetation is a transition between boreal on the north and broadleaf deciduous to the south.

Excerpt from: McNab, W.H.; Cleland, D.T.; Freeouf, J.A.; Keys, Jr., J.E.; Nowacki, G.J.; Carpenter, C.A., comps. 2007. Description of ecological subregions: sections of the conterminous United States [CD-ROM]. Gen. Tech. Report WO-76B. Washington, DC: U.S. Department of Agriculture, Forest Service. 80 p

Projection of future changes (2010-2099) of NPP, NEE and Runoff of the A.T. HUC-10 shell area using ecosystem modeling and downscaled climate scenarios

An excerpt from: "Monitoring and Forecasting Climate Impacts on Ecosystem Dynamics in Protected Lands Using the Terrestrial Observation and Prediction System (TOPS)" by Hashimoto, H., F.M. Melton, S.H. Hiatt, C. Milesi, A.R. Michaelis, P. Votava, W. Wang, and R.R. Nemani, 2011. In Remote Sensing of Protected Lands, Wang, Y. (Ed.), CRC Press, Boca Raton, Florida. (ISBN 9781439841877)



This figure illustrates the projections of NPP (a), Net Ecosystem Exchange (NEE) (b), and runoff (c) until 2099 downscaled from Coupled Model Intercomparison Project (CMIP3) multi-model dataset of SRES A1B scenario. The colored lines correspond to 11 General Circulation Model (GCM) data. The black thick line is the ensemble mean of the 11 GCM data. The dashed line is past time series data derived from TOPS Surface Observation and Gridding System (SOGS) data.

The simulated Net Primary Production (NPP) for the A.T. HUC-10 shell area is projected to increase monotonously until the end of the 21st century. The ensemble mean NPP increases from 60 gC/m2/year to 80 gC/m2/year. The increase can be attributed to the effect of increasing atmospheric CO2 concentrations and CO2 fertilization of vegetation in the region.

However, Net Ecosystem Exchange (NEE) is predicted to be constant at a rate of approximately -10 gC/m2/year through the 21st century. The negative NEE indicates a flux of carbon from terrestrial ecosystems to the atmosphere. This means that the predicted increase in respiration due to rising temperature exceeds the predicted increase in NPP.

No trend is detected in the predicted watershed outflow due to the small variation in projected precipitation.

The results suggest that the current carbon sink in the Eastern U.S. could turn into a carbon source in the future under the SRES A1B, which assumes a mild future growth in greenhouse gas emissions. If we were to use the projections that follow the trajectory of the highest emission scenarios, the forests along the A.T. would be expected to start releasing even more carbon and eventually decline in growth.

To evaluate the regional impacts of these climate scenarios on ecosystems along the A.T. HUC-10 Shell area, we ran the dynamic ecosystem model LPJ (Sitch et al. 2003; Gerten et al. 2004) to simulate the ecosystem response to changes in climate from 1980 to the end of the 21st century. LPJ is carbon and water cycle biophysical model with a dynamic vegetation simulation component, which includes representations for photosynthesis, respiration, allocation, fire, establishment, evapotranspiration, and outflow. LPJ requires monthly temperature, precipitation, radiation, and CO2 concentration data as inputs. The simulated outputs should be considered as a potential vegetation response, and does not account for human activities, such as urbanization and agricultural expansion. We spun-up the model with SOGS climate data assuming that the soil carbon is in equilibrium during the last three decades from 1980 to 2009, and then conducted the model simulation experiment from 2009 to 2099 using the downscaled GCM data.

References

Gerten, D., S. Schaphoff, U. Haberlandt, W. Lucht, and S. Sitch. 2004. Terrestrial vegetation and water balance-hydrological evaluation of a dynamic global vegetation model. Journal of Hydrology 286, no. 1-4: 249-270.

Sitch, S., B. Smith, I. C. Prentice, A. Arneth, A. Bondeau, W. Cramer, J. O. Kaplan, et al. 2003. Evaluation of ecosystem dynamics, plant geography and terrestrial carbon cycling in the LPJ dynamic global vegetation model. Global Change Biology 9, no. 2: 161-185.

Landscape Dynamics

Land surface phenology (LSP) is a measure of landscape dynamics. LSP reflects the response of vegetated surfaces to seasonal and annual changes in the climate and hydrologic cycle. LSP is strongly linked to climatic factors. LSP has been studied in the context of ecosystem responses to climate change and for monitoring changes in vegetation life cycle events. Because of the spatial resolution of remote sensing data, LSP is an indicator of mixtures of land covers. It is distinct from traditional species-centric measures of phenology, such as seasonal flowering or budburst. Because LSP is based on remote sensing observations at regional and global-scales, it provides key biological indicators for detecting the response of terrestrial ecosystems to climate variation. LSP metrics are primarily based on time series images of vegetation indices from optical sensors such as AVHRR, SPOT and MODIS. LSP metrics typically retrieve the time of onset greenness as the start of the season (SOS); onset of senescence (time of the end of greenness) as the end of the season (EOS), timing of the peak of the growing season, and the length of the growing season (LOS).

LSP metrics of the A.T. shell area between 1982 and 2006

We calculated the average SOS, EOS and LOS for the entire A.T. HUC-10 Shell corridor and the subsections within the three provinces to obtain the interannual variability and trends of LSP between 1982 and 2006. Although there were no clear overall SOS trends for either the entire A.T. corridor or the provinces during the time periods, variations in anomaly years (e.g., 1998 and 1999) were observable in calculated mean values. The results indicate that the SOS varied from the 84 day of year (or March 25) to the 141 day of year (or May 21, Fig. 1A). The SOS presented a pattern of latitudinal variation roughly followed the boundaries of ecological subregion provinces along the A.T. corridor. Along the A.T. corridor earlier SOS at approximately the 90 day of year occurred in the M221 province and later SOS at approximately the 140 day of year occurred in the M212 province. The SOS was approximately the 125 day of year in the 221 province. The EOS varied from the 292 (or October 19) to 334 (or November 30) Julian days with an inverse pattern of spatial distribution as those of the SOS (Fig. 1B). The LOS varied from 151 to 241 Julian days. The LOS in the southern end was 90 days longer than that in the northern end (Fig. 1C). Positive SOS trends occurred in different areas along the corridor (Fig. 1D). The strongest trend of delaying EOS (>1 daysyr-1) was found close to both the southern and northern ends and central A.T. corridor where elevations are higher (Fig. 1E). The trends for the LOS were mainly effected by EOS. Most of the A.T. corridor area experienced lengthened growing season during the time period except for some locations within the M221 province. Strong increases of LOS (>1 daysyr-1) were found within the M212 province and some locations within the M221 province (Fig. 1F). The result in Fig. 2 showed that SOS advanced by 1.39 days over the entire A.T. corridor from 1982 to 2006.The trends of delayed EOS were observed for the A.T. corridor during the analysis period.

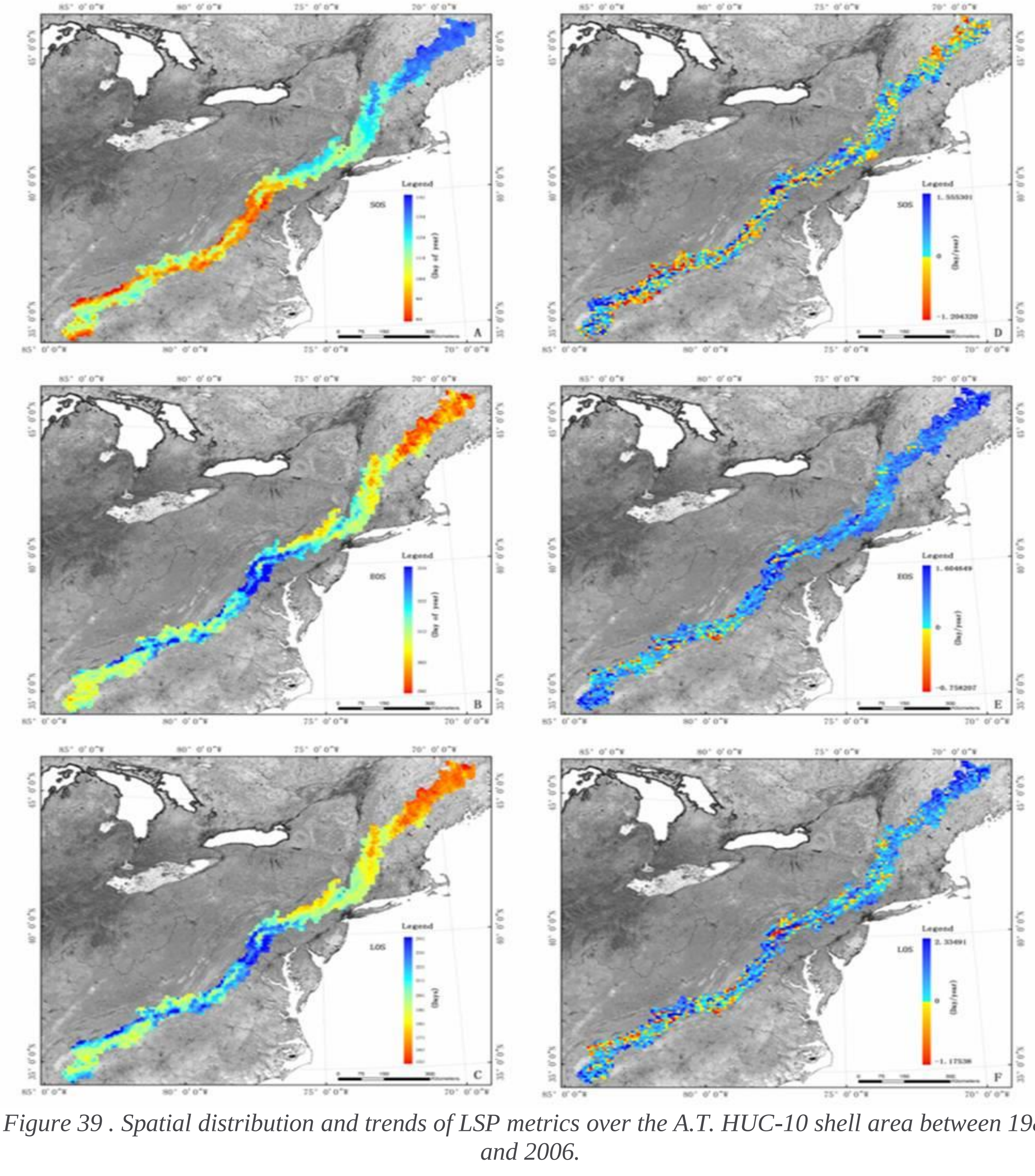


Figure 39 . Spatial distribution and trends of LSP metrics over the A.T. HUC-10 shell area between 1982 and 2006.

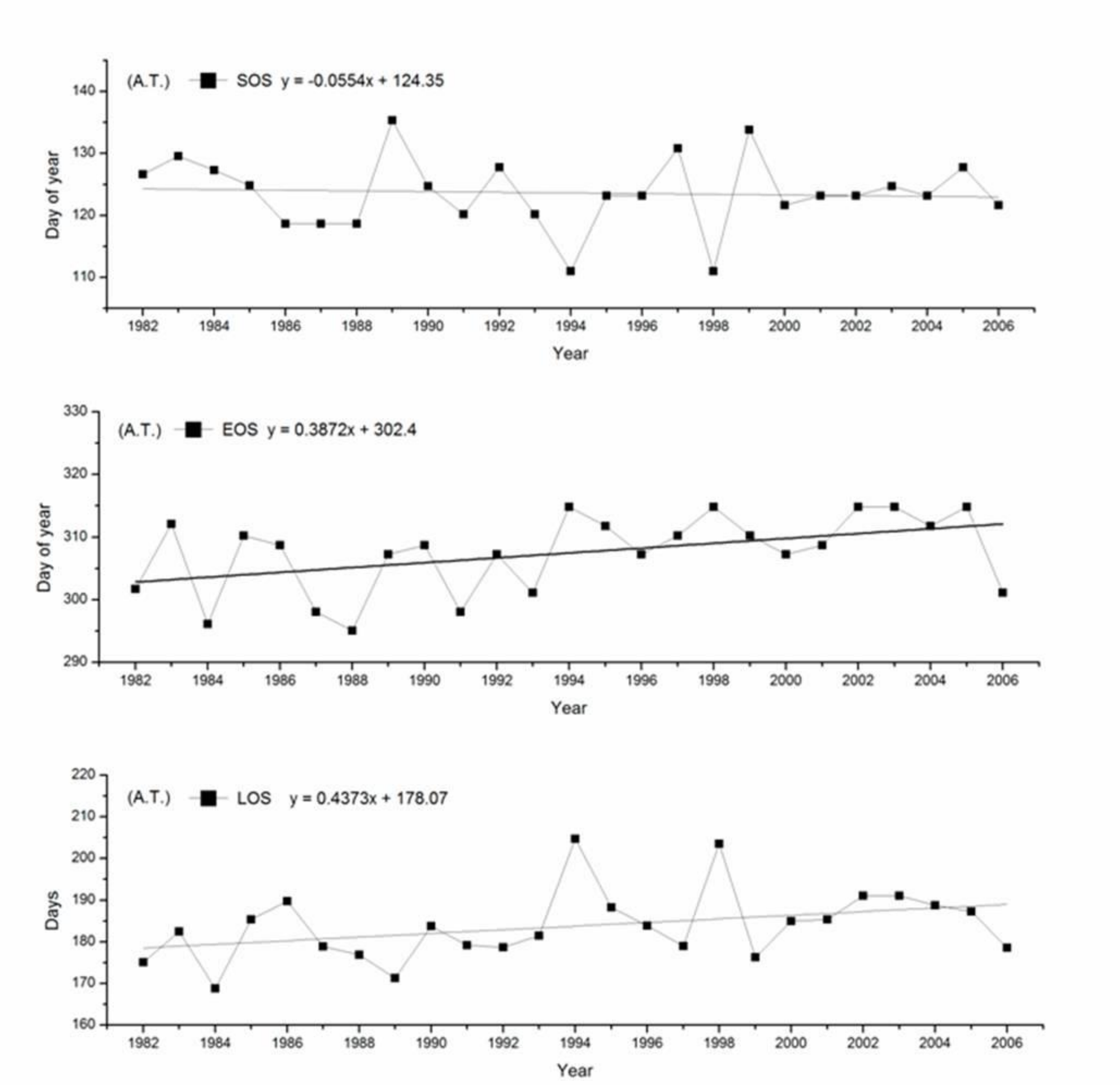


Figure 40 Variation and trends of LSP over the A.T. HUC-10 shell area between 1982 and 2006.

Land surface phenology of A.T. HUC-10 shell area within the Adirondack-New England Mixed Forest-Coniferous Forest-Alpine Meadow Province (M211)

The figure showed that the trends of SOS delayed by 0.99 days within the M211 province from 1982 to 2006. The most delayed EOS occurred in the segment within the M211 province as 20 later days than the average of years. The trend of EOS was delayed by 13.2 days during the analysis period. The most extended LOS occurred in the M211 province by 12.1 days during the 25 years. The LOS in the northern M211 province was 19 days shorter in 1988 and 27 days longer in 1998 than the average.

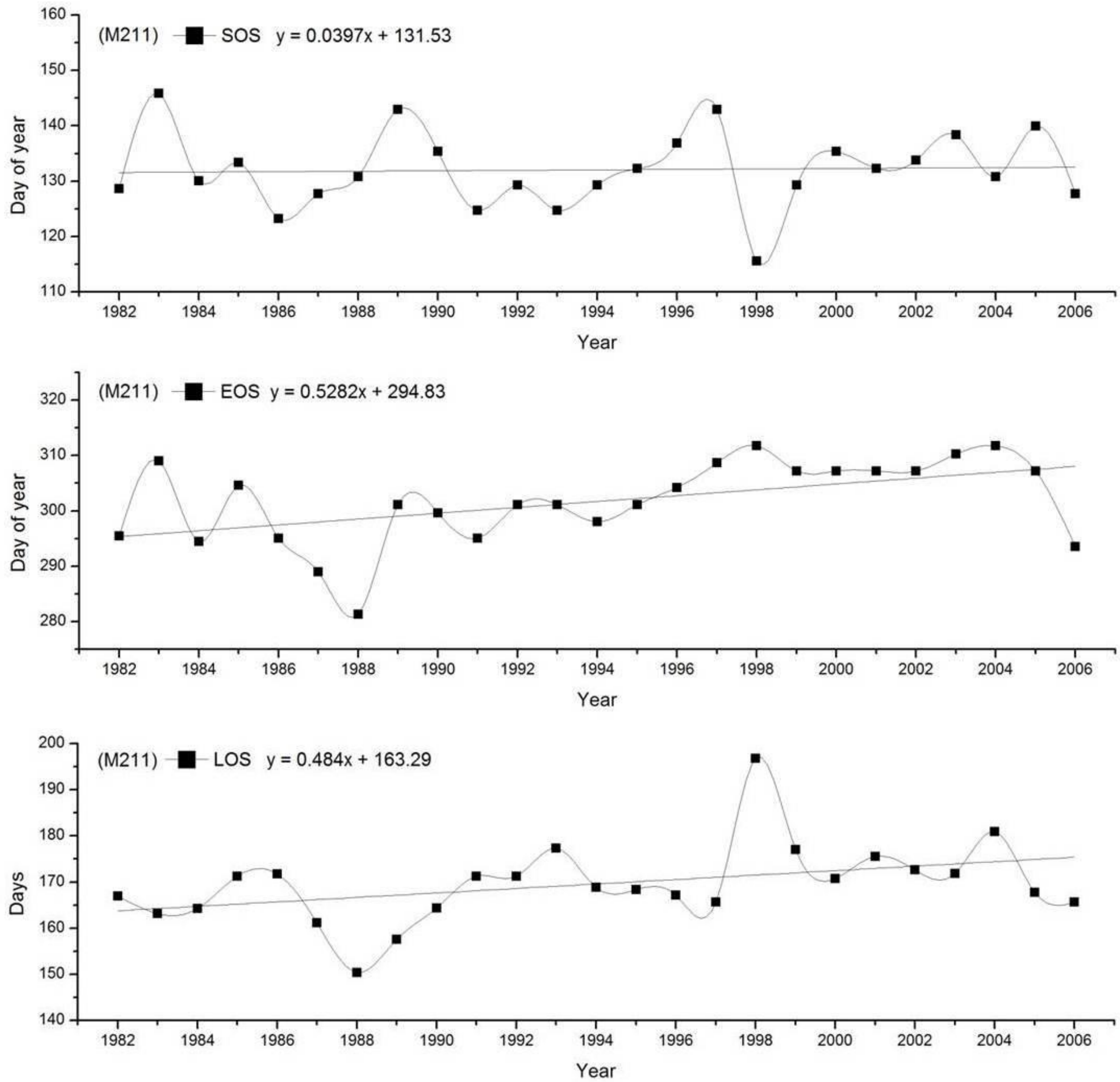
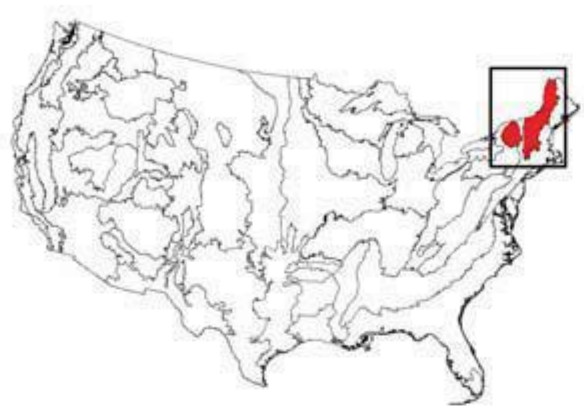


Figure 41 Variation and trends of land surface phenology metrics (SOS, EOS, LOS) of the A.T. HUC-10 shell area within the Adirondack-New England Mixed Forest-Coniferous Forest-Alpine Meadow Province (M211) between 1982 and 2006.

This province has a modified continental climatic regime with long, cold winters and warm summers. Annual precipitation evenly distributed. Landscape is mountainous and was previously glaciated. Forest vegetation is a transition between boreal on the north an broadleaf deciduous to the south.*



Excerpt from: McNab, W.H.; Cleland, D.T.; Freeouf, J.A.; Keys, Jr., J.E.; Nowacki, G.J.; Carpenter, C.A., comps. 2007. Description of ecological subregions: sections of the conterminous United States [CD-ROM]. Gen. Tech. Report WO-76B. Washington, DC: U.S. Department of Agriculture, Forest Service. 80 p

Land surface phenology of A.T. HUC-10 shell area within the Eastern Broadleaf Forest Province (221)

The figure showed that the trends of SOS delayed by 0.70 days within the 221 province from 1982 to 2006. The trend of EOS was delayed by 9.87 days during the analysis period. The extreme late EOS occurred in 1986, 1990, 1994, 2002 and 2005 in the 221 province. The LOS trend for the 221 province extended 8.99 days during the 25 years. However for the segment in southern 221 province the shortest and longest LOS occurred in 1999 and 1994, respectively, for 23 days shorter or longer than the average.

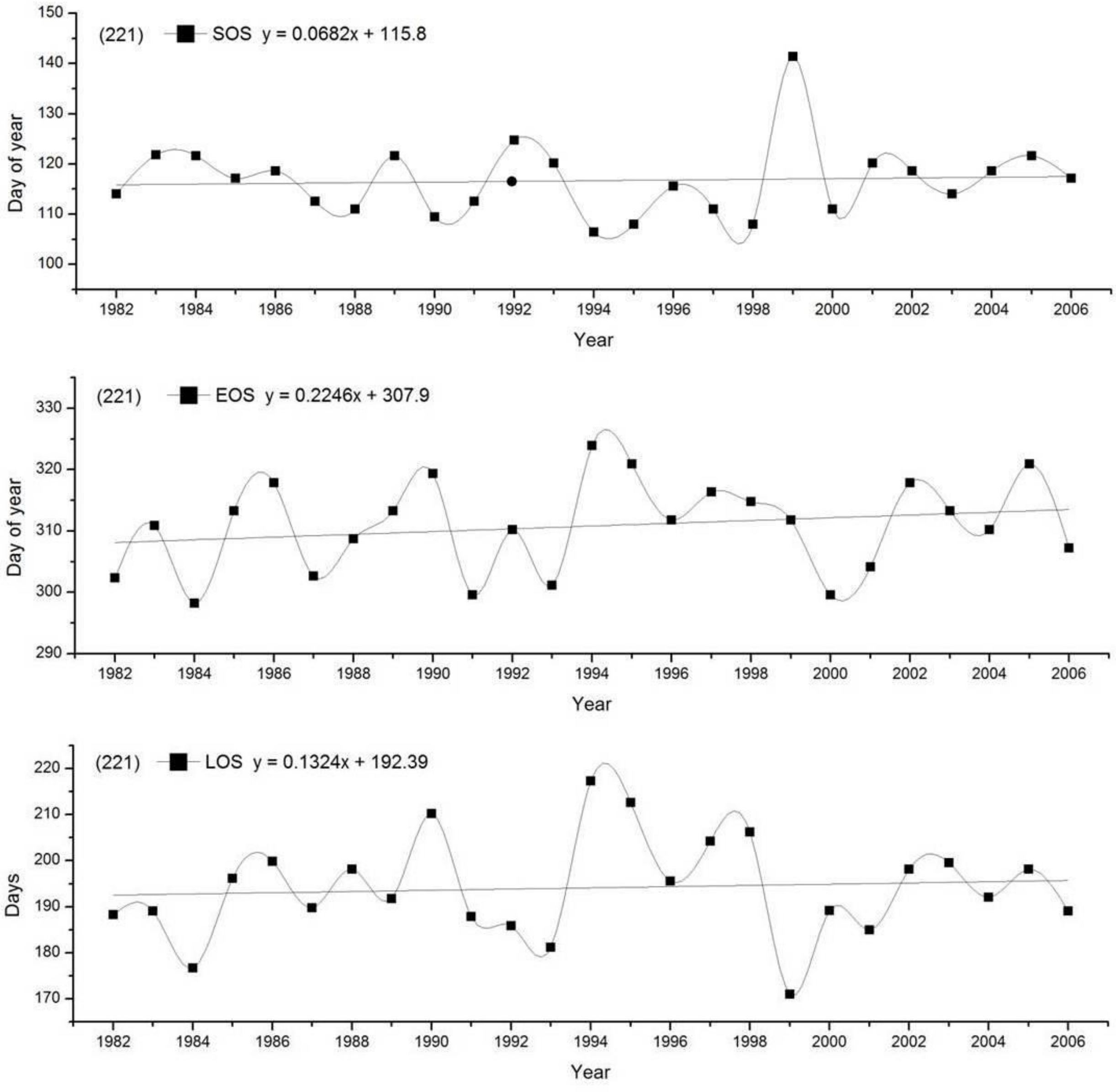
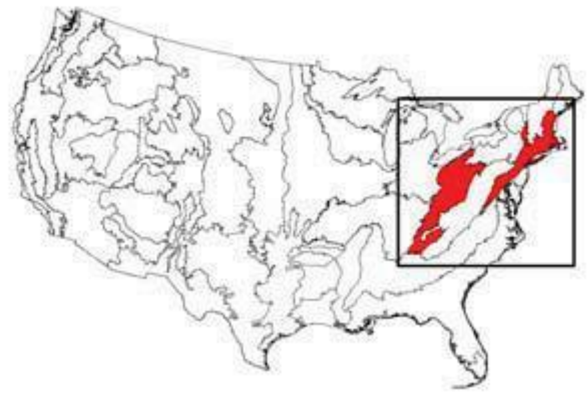


Figure 42 Variation and trends of land surface phenology metrics (SOS, EOS, LOS) of the A.T. HUC-10 shell area within the Eastern Broadleaf Forest Province (221) between 1982 and 2006.

This province has a continental-type climate of cold winters and warm summers. Annual precipitation is greater during summer, water deficits infrequent. Topography is variable, ranging from plains to low hills of low relief along Atlantic coast. Interior areas are high hills to semi-mountainous, parts of which were glaciated. Vegetation is characterized by tall, cold-deciduous broadleaf forests that have a high proportion of mesophytic species.



Excerpt from: McNab, W.H.; Cleland, D.T.; Freeouf, J.A.; Keys, Jr., J.E.; Nowacki, G.J.; Carpenter, C.A., comps. 2007. Description of ecological subregions: sections of the conterminous United States [CD-ROM]. Gen. Tech. Report WO-76B. Washington, DC: U.S. Department of Agriculture, Forest Service. 80 p

Land surface phenology of A.T. HUC-10 shell area within the Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow Province (M221)

The figure showed that the trends of SOS delayed by 1.71 days within the M221 province from 1982 to 2006. The trend of EOS was delayed by 5.62 days during the analysis period. The extreme late EOS occurred in in 1984, 1988 and 2006 in the M221 province. The least change in LOS occurred in the southern segment in the M221 province by extended 3.31 days during the 25 years.

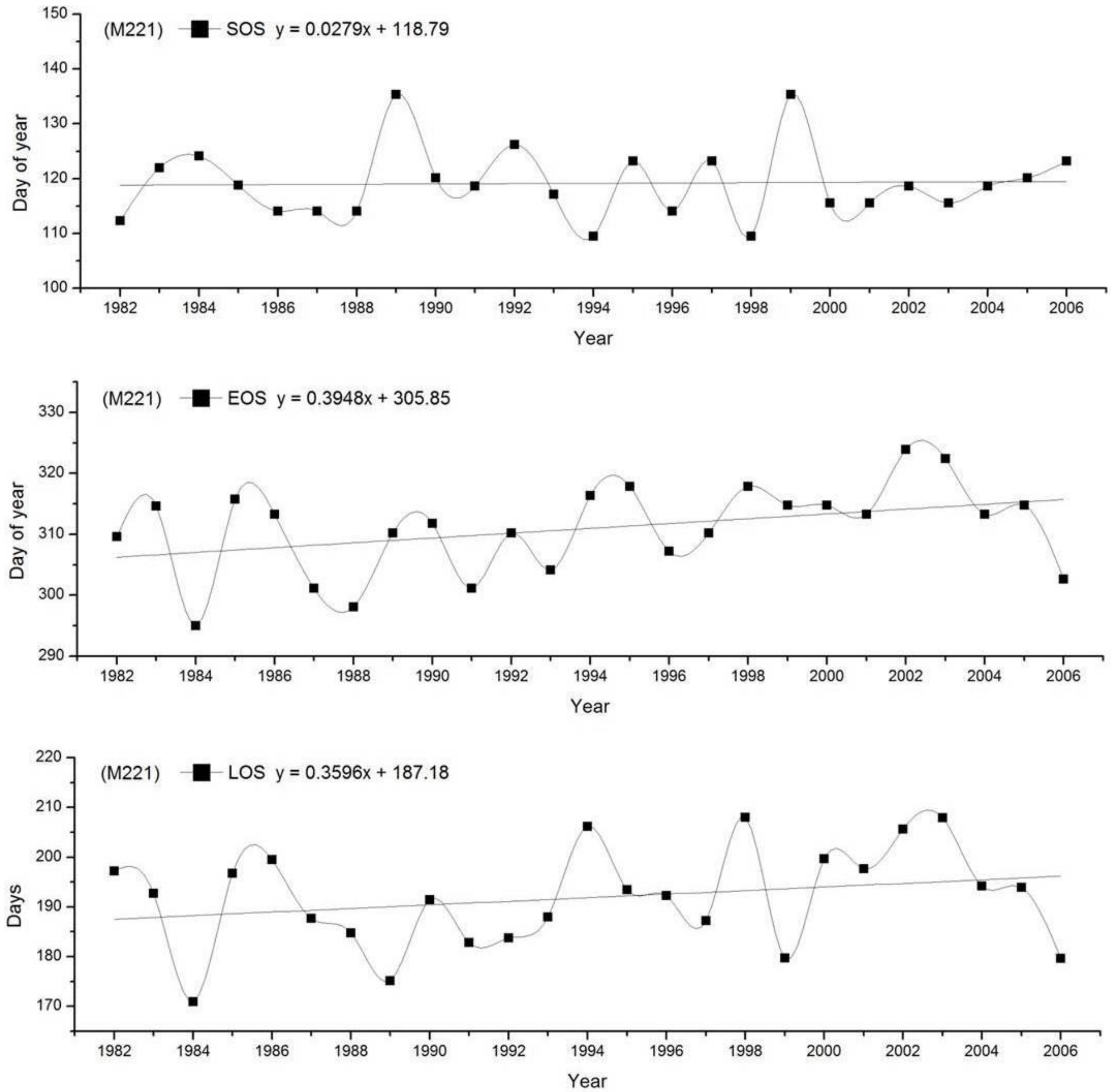
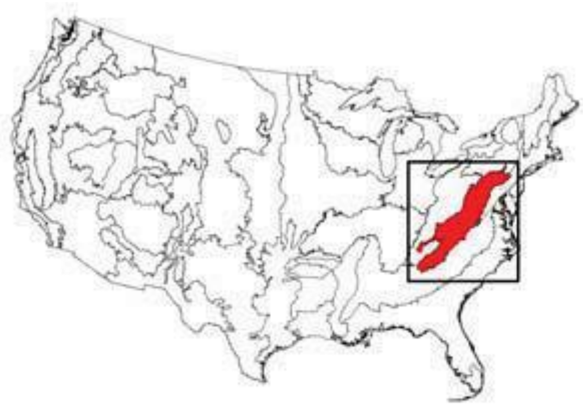


Figure 43 Variation and trends of land surface phenology metrics (SOS, EOS, LOS) of the A.T. HUC-10 shell area within the Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow Province (M221) between 1982 and 2006.

This province has a modified continental climatic regime with long, cold winters and warm summers. Annual precipitation evenly distributed. Landscape is mountainous and was previously glaciated. Forest vegetation is a transition between boreal on the north and broadleaf deciduous to the south.



Excerpt from: McNab, W.H.; Cleland, D.T.; Freeouf, J.A.; Keys, Jr., J.E.; Nowacki, G.J.; Carpenter, C.A., comps. 2007. Description of ecological subregions: sections of the conterminous United States [CD-ROM]. Gen. Tech. Report WO-76B. Washington, DC: U.S. Department of Agriculture, Forest Service. 80 p

Subsection Summaries

GPP

Gross Primary Productivity (GPP) is a measure of the amount of organic carbon (C) fixed by photosynthesis in an ecosystem. GPP is a fundamental property of ecosystems and provides a measure of forest health. GPP was calculated from the 1 km 8-day product (MOD17A2) from 2000 to 2011, which is based on a light use efficiency model that incorporates MODIS LAI/FPAR data and meteorological data from a General Circulation Model (Nemani et al., 2009). Urban areas were excluded from this summary.

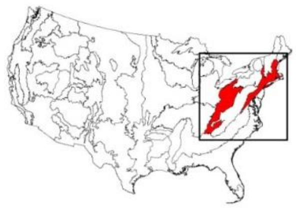
Phenology

Land surface phenology (LSP) is a measure of landscape dynamics reflecting the response of vegetated surfaces to seasonal and annual changes in the climate and hydrologic cycle. LSP has been studied in the context of ecosystem responses to climate change and for monitoring changes in vegetation life cycle events. LSP is derived from the Normalized Differential Vegetation Index (NDVI), which provides a measure of vegetation greenness on the land surface. NDVI was calculated from the 500 m 16-day MODIS Vegetation Indices product (MOD13A2) to evaluate interannual changes in peak NDVI (Nemani et al., 2009) from 2000 to 2011. Vertical lines indicate the timing of the annual onset of greenness, i.e. the start of the growing season (SOS). Urban areas were excluded from this summary.

Snow Cover

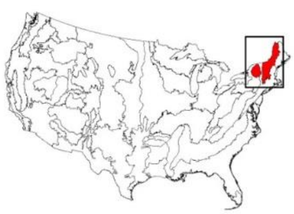
Snow cover is summarized as a percentage of the total subsection area, with a trend line fit to the annual snow cover on April 1st. Snow cover was calculated from the 500 m 8-day MODIS snow cover product (MOD10A2) from 2000 to 2011. In this product, snow is detected using a Normalized Difference Snow Index that is estimated using daily data from red, near infrared and shortwave infrared wavelengths. In the MOD10A2 8-day composite snow cover product, a pixel is identified as snow if snow is present on any of the eight days (Nemani et al., 2009). Urban areas were excluded from this summary.

211-Northeastern Mixed Forest Province: This province is characterized by a modified continental climatic regime with maritime influence along the Atlantic Ocean. Winters are moderately long with continual ground snow cover. Annual precipitation is generally equally distributed with a peak during summer. Vegetation of this area consists of forests that provide a transition between boreal conifers and broadleaf deciduous. *The A.T. HUC-10 shell intercepts 6 sections and 8 subsections within this province.*



221-Eastern Broadleaf Forest Province: This province has a continental-type climate of cold winters and warm summers. Annual precipitation is greater during summer, water deficits infrequent. Topography is variable, ranging from plains to low hills of low relief along Atlantic coast. Interior areas are high hills to semi-mountainous, parts of which were glaciated. Vegetation is characterized by tall, cold-deciduous broadleaf forests that have a high proportion of mesophytic species.
The A.T. HUC-10 shell intercepts 4 sections and 14 subsections within this province.

231-Southeastern Mixed Forest Province: This ecoregion has generally uniform maritime climate with mild winters and hot, humid summers. Annual precipitation is evenly distributed, but a brief period of mid to late summer drought occurs in most years. Landscape is hilly with increasing relief farther inland. Forest vegetation is a mixture of deciduous hardwoods and conifers.
The A.T. HUC-10 shell intercepts 2 sections and 5 subsections within this province.



M211-Adirondack-New England Mixed Forest-Coniferous Forest-Alpine Meadow Province: This province has a modified continental climatic regime with long, cold winters and warm summers. Annual precipitation evenly distributed. Landscape is mountainous and was previously glaciated. Forest vegetation is a transition between boreal on the north and broadleaf deciduous to the south.
The A.T. HUC-10 shell intercepts 3 sections and 13 subsections within this province.

M221-Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow Province: This province has a temperate climate with cool summers and short, mild winters. Annual precipitation is plentiful and evenly distributed with short, infrequent periods of water deficit. Landscapes of the province are predominantly mountainous but sections vary in predominant elevation, Ice storms are an important broad scale disturbance. High-intensity rain storms are associated with remnants of occasional hurricanes; lightning-caused fires are uncommon in the humid environment of this province. Loss of American chestnut resulting from an introduced pathogen was a major disturbance to the canopy of most forests during the 1920s. geologic substrate, and physiography. Forest vegetation is characterized by a closed canopy of deciduous, xerophytic tree species, mainly oaks, although many mesophytic species occur on lower

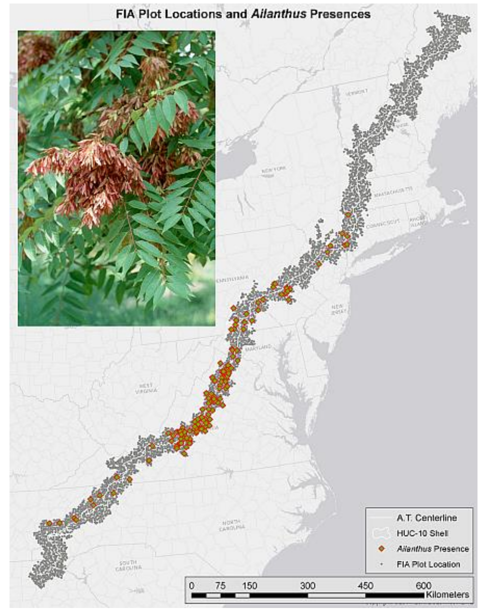
slopes and in mountain valleys; broadleaf forests change to coniferous or shrub lands at higher elevations.
The A.T. HUC-10 shell intercepts 4 sections and 10 subsections within this province.

Province and section descriptions adapted from:
McNab, W. H., & Avers, P. E. (1994). Ecological subregions of the United States, section descriptions. USDA Forest Service, Ecosystem Management.
Nemani, R., Hashimoto, H., Votava, P., Melton, F., Wang, W., Michaelis, A., ... & White, M. (2009). Monitoring and forecasting ecosystem dynamics using the Terrestrial Observation and Prediction System (TOPS). Remote Sensing of Environment, 113(7), 1497-1509.

Habitat Modeling

Assessing current and projected suitable habitats for tree-of-heaven along the Appalachian Trail

Excerpt from Clark, J., Y. Wang, and P.V. August, 2014. Assessing current and projected suitable habitats for tree-of-heaven along the Appalachian Trail. Phil. Trans. R. Soc. B 20130192.
http://dx.doi.org/10.1098/rstb.2013.0192



This study examined the current habitat suitability and projected suitable habitat for the invasive species tree-of-heaven (*Ailanthus altissima*) as a prototype application of the A.T.-DSS. Species observations from forest surveys, geospatial data, climatic projections and maximum entropy modelling were used to identify regions potentially susceptible to tree-of-heaven invasion. The modelling result predicted a 48% increase in suitable area over the study area, with significant expansion along the northern extremes of the Appalachian Trail.

Objectives

i. Relate field-based observations of the distribution of *Ailanthus* to a set of environmental variables.
ii. Map the current distribution of suitable habitats and identify high-risk regions along the A.T.
iii. Integrate projected precipitation and temperature data from TOPS based on IPCC climate change scenarios to simulate potential shifts in the distribution of *Ailanthus* habitats.

Tree-of-heaven

- *Ailanthus altissima* (Mill.) Swingle is a deciduous member of the Simaroubaceae family
- Native to the temperate regions of central China; populations established on every continent except Antarctica
- Exotic tree species pervasive throughout the U.S. due to its rapid growth, high fecundity, hardy tolerance, and strong competitive ability
- Quickly colonizes disturbed areas; suppresses growth of native species
- Vulnerability to frost damage restricts from higher latitudes and elevations
- Early detection crucial for minimizing the costs of control and risk of further dispersal and establishment

Geospatial Data Sources

- Forest Inventory & Analysis Database
    - Provides a nationwide systematic sample of forested ecosystems well-suited for broad scale ecological analysis.
    - Measurements include tree species, size, conditions, and physiographic site attributes.
    - Data for 3,926 FIA plots available within the A.T. shell between 2002 and 2010.
    - *Ailanthus* observations recorded at 136 of those FIA plot locations.
- Climate data and forecasts
    - Climate baseline (1950-2005) and projections (2090-2095) provided by NASA's Terrestrial Observation and Prediction System (TOPS)
    - Downscaled from Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) Coupled Model Intercomparison Project Phase 5 (CMIP5)
    - Representative Concentration Pathway (RCP) 6.0 selected for model projection (moderate-high emission scenario)
    - Ecologically relevant bioclimatic variables derived from monthly precipitation and temperature data using R package "dismo"
- Ancillary Geospatial Data
    - Elevation and derived topographic variables including slope, transformed aspect, and slope position from NED
    - Urban areas, agriculture, canopy cover, and wetlands from NLCD 2006
    - Soil hydrology from STATSGO

Maximum Entropy (MaxEnt) Modeling

- Machine-learning-based method
- Presence-only, absences do not indicate conditions unsuitable for invasive populations
- Maximum entropy distribution = least constrained
- Generates 'features' based on distribution of environmental variables across presence points
- Many iterations, balancing gain against regularization to prevent overfitting
- Variable 'clamping' restricts values of projected variables to range of current variables
- Suitability threshold applied to continuous probability distributions to derive binary classes

Variable Selection

- Eliminate highly correlated variables (Pearson correlation coefficients)
- Evaluate performance across model iterations based on variable response curves, contributions and permutation importance, and jackknifing
- Selections should make ecological 'sense' given known species characteristics

Model Evaluation

- Performance: 10-fold cross validation on test area under curve (AUC) of receiver operating characteristics (ROC)

- Complexity: sample size adjusted Akaike information criteria (AICc)
    - Simplicity particularly desirable when transferring (projecting) to new conditions
- Consistency: ecologically significant variables selected and resulting distribution in agreement with existing knowledge

Results

- Climatic variables consistently selected as highest performing
- Landcover variables performed poorly across broad geographic area; eliminated from final model
- Restricting MaxEnt to 'hinge' feature types increased model transferability
- Final model selected from array of >15
- Moderate complexity; incorporates 4 climatic and 4 topographic variables
- Strong indication potential extent of *Ailanthus* habitats likely to increase as climate changes
- Increasing invasive pressure on sensitive high elevation areas in northern ecosystems
- Independent test data needed to fully evaluate model performance

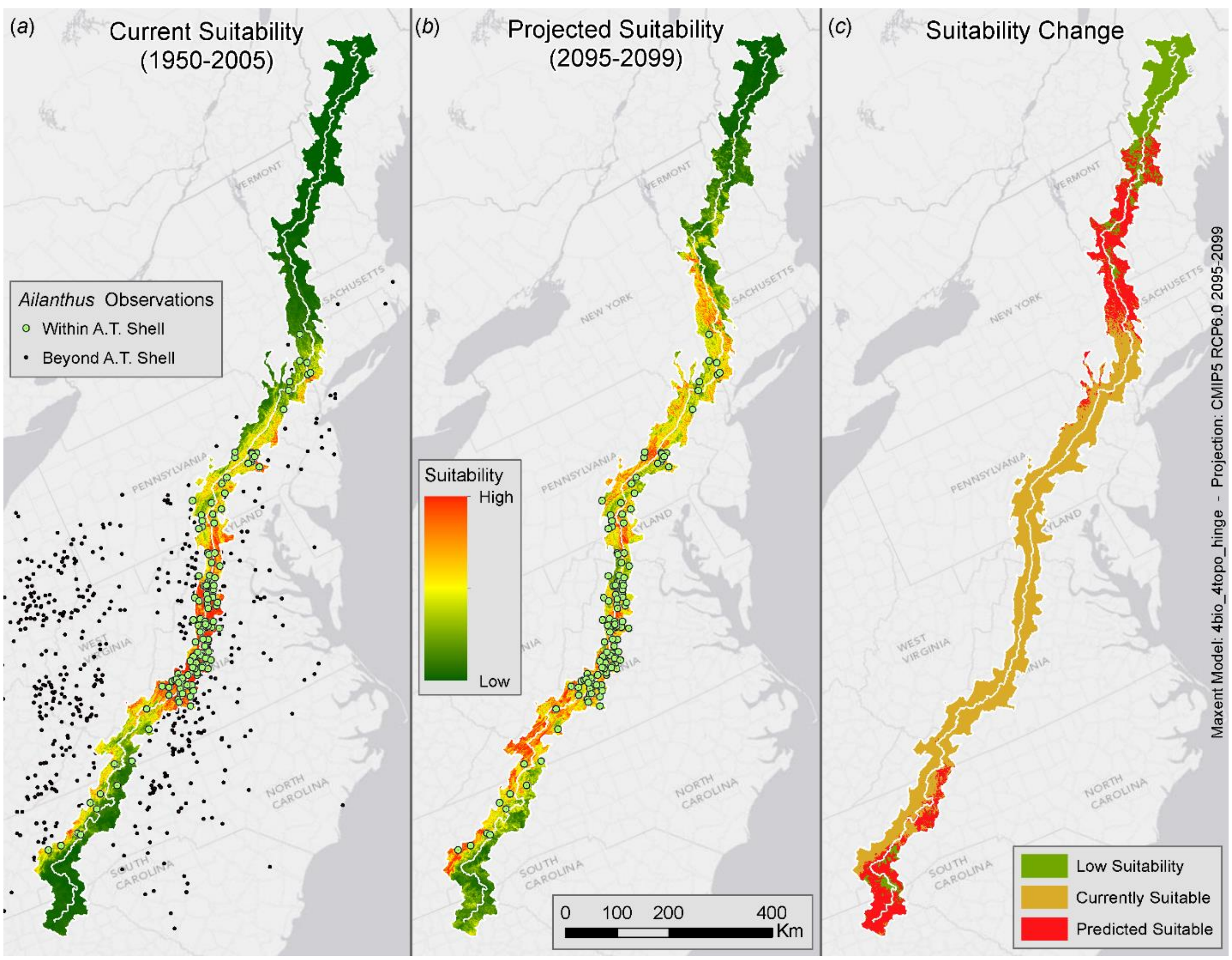


Figure 44 Predicted current and projected distribution of suitable Ailanthus habitat from maximum entropy modeling results.


THE APPALACHIAN TRAIL GOES GEOSPATIAL!
Mt. Katahdin
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ABOUT THE APPALACHIAN TRAIL MEGA-TRANSECT DECISION SUPPORT SYSTEM (A.T. DSS)
The Appalachian Trail (A.T.) traverses most of the high elevation ridges of the eastern United States from Springer Mountain in Northern Georgia to Mt. Katahdin in central Maine. The A.T. is 2,175 miles or 3,500 kilometers long and crosses 14 states in the Eastern U.S. It intersects 8 National Forests; 6 units of the National Park System; more than 70 State Park, Forest, and Game Management units, and 287 local jurisdictions. It's 250,000 acres of protected lands harbor rare, threatened, and endangered species.
The A.T.'s gradients in elevation, latitude, and moisture sustain a rich biological assemblage of temperate zone forest species. The A.T. and its surrounding protected lands harbor forests with some of the greatest biological diversity in the U.S., including rare, threatened, and endangered species, and diverse bird and wildlife habitats; and are the headwaters of important water resources for millions of people. 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 perfect setting for collecting scientific data on the health of the ecosystems and the species that inhabit them. The high elevation setting of the A.T. and its protected corridor provide an ideal barometer for early detection of undesirable changes in the natural resources of the eastern United States, from development encroachment to recreational misuse, acid precipitation, invasions of exotic species, and climate change.
The purpose of the A.T. MEGA-Transect DSS is to improve the decision-making system that exists between the Appalachian Trail Park Office (ATPO), the Appalachian Trail Conservancy (ATC), the National Park Service (NPS) and the USDA Forest Service, and provide a means to convey meaningful information to the American public. The A.T. MEGA-Transect DSS integrates NASA multi-platform sensor data, NASA Terrestrial Observation and Prediction System (TOPS) models, and in situ measurements from A.T. MEGA-Transect partners to address natural resource priorities and improve resource management decisions.
OBJECTIVES
The A.T. MEGA-Transect DSS focuses on three primary inventory and monitoring vital signs: Phenology and Climate Change; Forest Health; and, Landscape Dynamics, plus four supplementary vital signs: Mountain Birds; Migratory Breeding Birds; Water Resources; and Alpine and High Elevation Vegetation.
The objectives of the A.T. MEGA-Transect DSS include:
- Develop a comprehensive set of seamless indicator data layers consistent with selected A.T. "Vital Signs"
- Establish a ground monitoring system to complement and integrate TOPS data with in situ observations
- Assess historical and current habitat conditions and forecast trends through habitat modeling with TOPS data
- 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
TOPS
INTERNET-BASED IMPLEMENTATION AND DISSEMINATION
The A.T.-DSS is an Internet-based system that is being developed using off-the-shelf software system such as the Google Earth API and ArcGIS server technology. These technologies are used to provide mapping, visualization, data sharing, and resource management tools to facilitate collaboration and promote public understanding of the A.T. Environment.
http://www.edc.uri.edu/ATMT-DSS/
SYSTEM TRANSITION
The ultimate destination for the database and modeling results of the A.T. MEGA-Transect DSS will be the National Biological Information Infrastructure (NBII), managed by USGS Biological Informatics Office. This transition will benefit from both the existing infrastructure and administrative capability of the NBII, which is a broad, collaborative program to provide increased access to data and information on the nation's biological resources.
nbii
CONCLUSION
Upon completion, the A.T. MEGA-Transect DSS will allow users to build a comprehensive understanding of the current status and trends for the A.T. region in terms of driving factors and responsive conditions, and help characterize habitat condition and primary drivers for simulation and prediction exercises.
ACKNOWLEDGEMENTS
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NASA
USGS
science for a changing world
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