WHITHER THE WEEDS
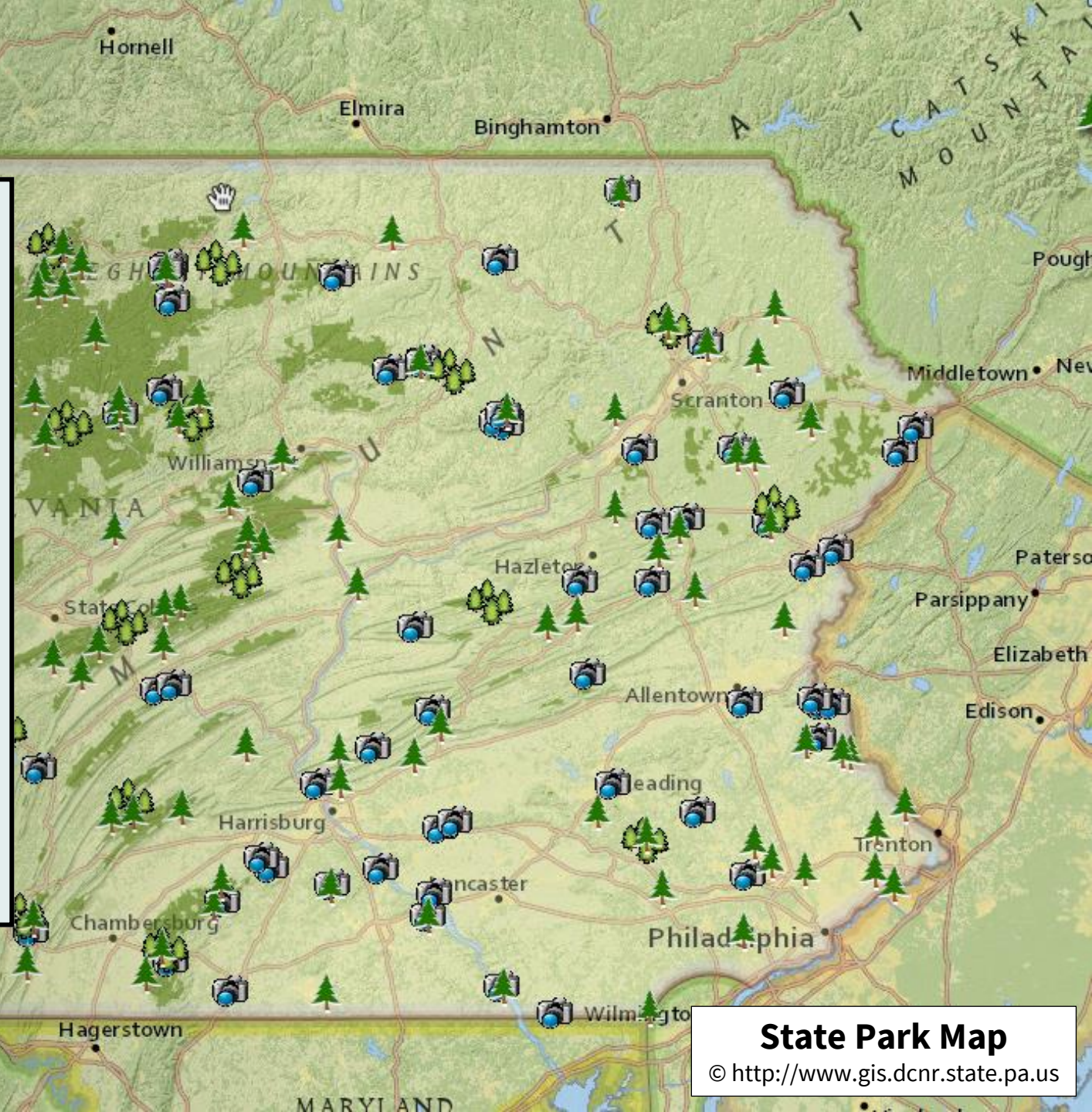
DESIGNING A GIS DATABASE TO SUPPORT INVASIVE SPECIES MANAGEMENT PLANNING IN PENNSYLVANIA STATE PARKS

State Park Map
© http://www.gis.dcnr.state.pa.us

Overview

- About me

Introduction

- Impact
- Importance
- Proposed Solution
- Scope

## Background and Lit Review

Goals, Objectives and Proposed Methodology

Anticipated Results

Timeline

Presentation Venue(s)

About Me

- **Originally from Portland, Oregon**

- **Interested and involved in Environmental Issues in high school and undergrad**
  - Riparian Zone restoration in Eastern Mt. Hood (Rock Creek Burn) National Park
  - Led English Ivy remediation in Alton Baker Park in Eugene, OR.
  - Interned with TreePeople in Los Angeles, performing Urban Canopy education and database work

- **Geospatial Analyst for Department of Defense**
  - Currently supporting USSPACECOM in Colorado Springs, CO

- **Studied Environmental Resource Policy at George Washington University (DC)**
  - Had to leave program when moved to CO

- **Many of my MGIS projects have been focused on Invasive Plants**
  - Examples at right
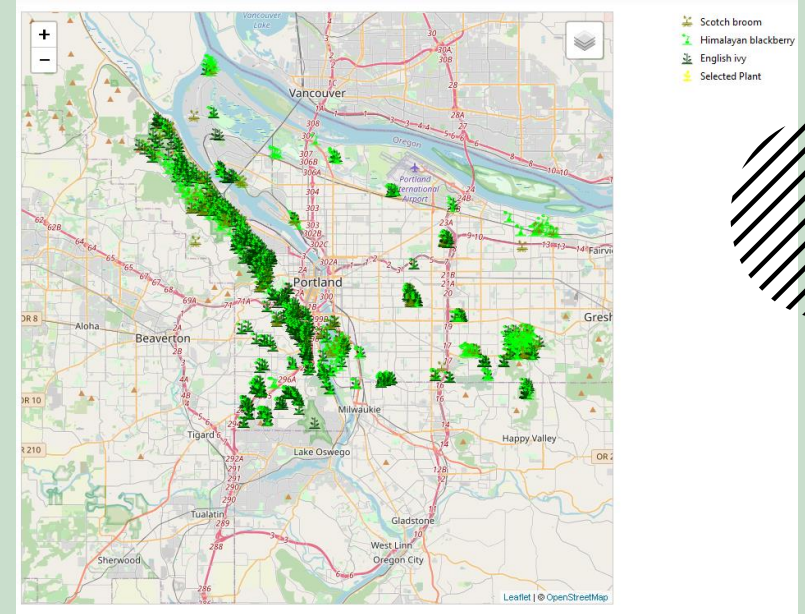
WebMap map for GEOG585
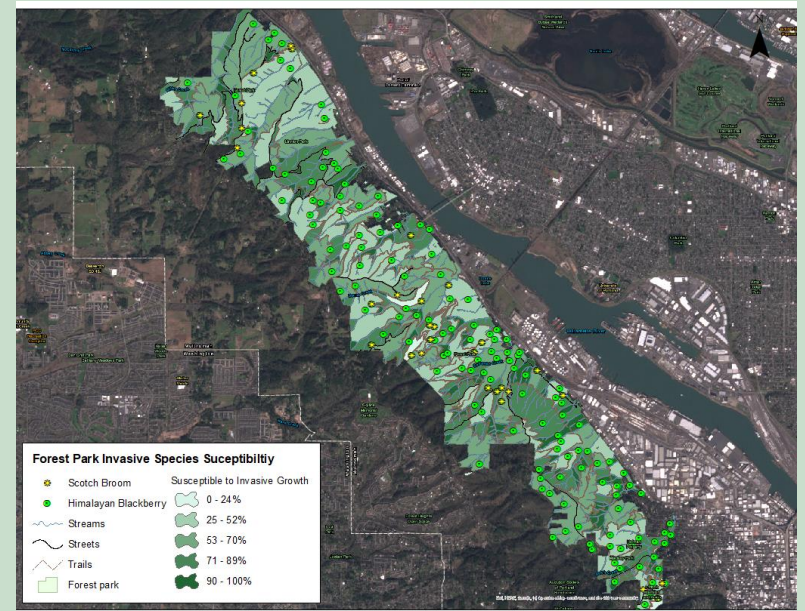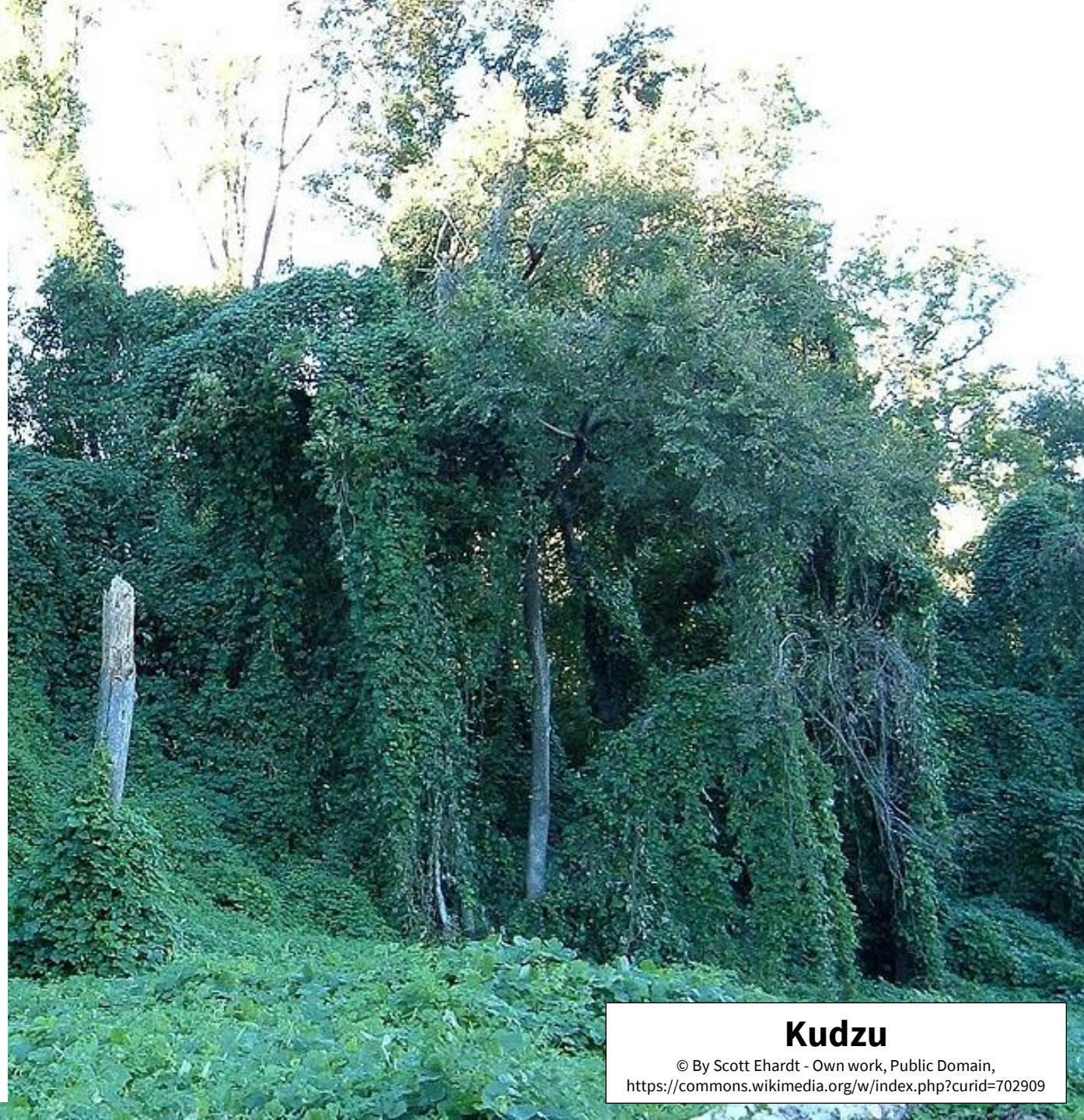

Final Project map for GEOG487

INTRODUCTION

- Executive Order 13112 defines invasive plants as plants that are "non-native (or alien) to the ecosystem under consideration and whose introduction does or is likely to cause economic or environmental harm or harm to human health." (Federal Register, 1999)

- In Pennsylvania invasive plants have direct impact on the degradation of native plant habitats, as well as "public health, crops, livestock, agricultural land, and other properties." (USDA, 2016)

- Invasive plants frequently are introduced to native ecosystems via anthropogenic (man-made) actions.

Japanese stiltgrass
© carol papas, www.post-gazette.com

Invasive Plant Impacts

- Giant hogweed sap causes extreme skin sensitivity to UV radiation which can lead to skin blistering, severe burns, and even blindness if eye contact is made

- Japanese stiltgrass and reed canary grass spread opportunistically, establishing dense patches that exclude other plant species, greatly decreasing biological diversity and hinder forest growth

- Kudzu outcompetes other plants by "smothering them under a solid blanket of leaves" (LandScope America, 2020)

- Multiflora rose and other invasive shrubs in forests diminish butterfly habitat and act as population sinks for native birds

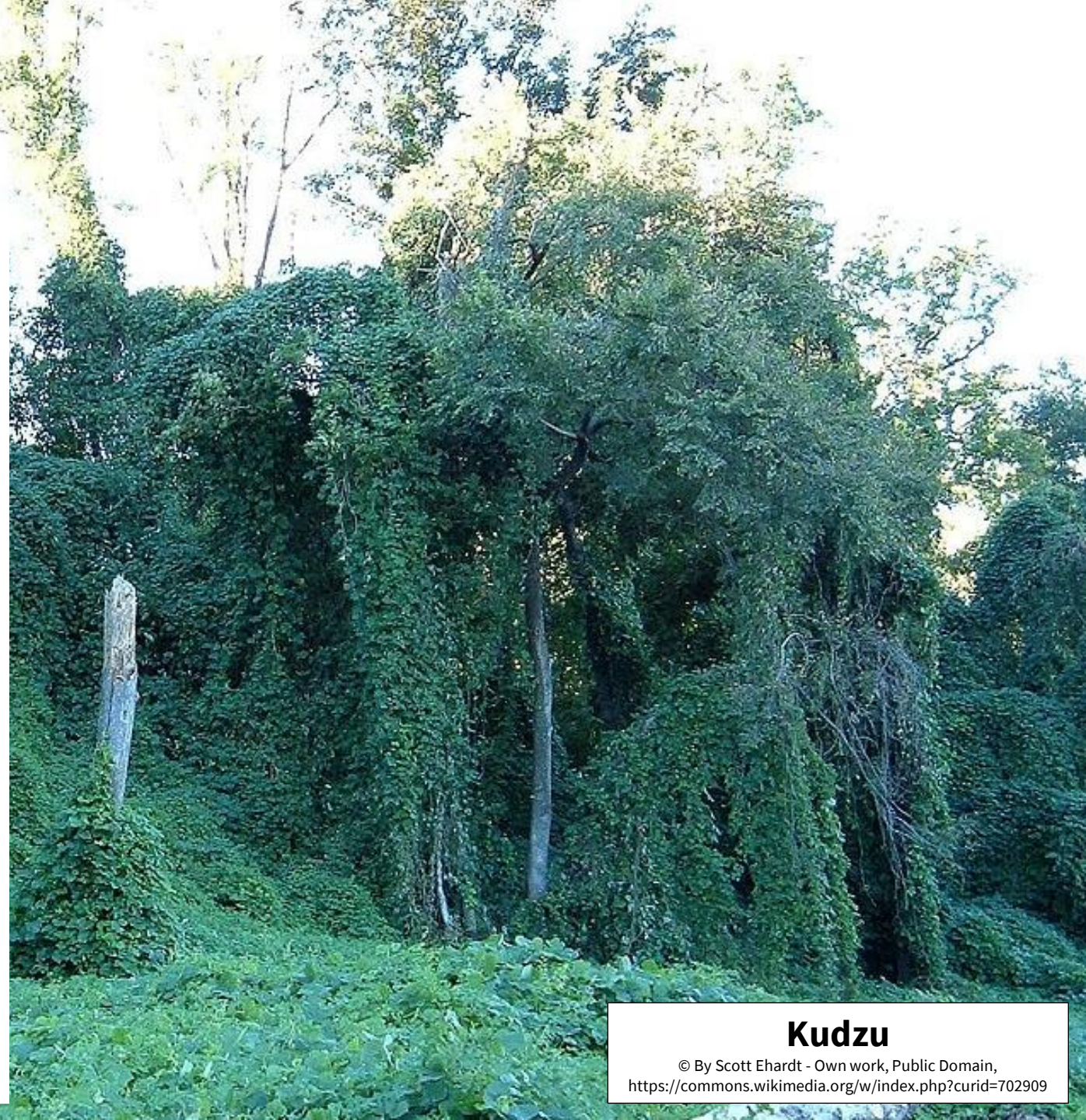- Poison hemlock causes severe skin irritation on people and is toxic to grazing livestock

Kudzu
© By Scott Ehardt - Own work, Public Domain,
https://commons.wikimedia.org/w/index.php?curid=702909

IMPACTS (CONT.)

- Pennsylvania Department of Conservation and Natural Resources (DCNR) is the organization that performs invasive plant remediation in State Parks.
- DCNR uses an Invasive Species Management Planning (ISMP) process to determine where to remediate invasive plants.
- ISMP is "site specific … (and) considers qualities of … Habitat Management Zones (HMZ) within the park and the invasive species present." (Gover, et al., 2016)
  - HMZs are effectively the diverse habitat land units that exist within parks (i.e. Riparian, Wetland, Young Forest, etc.)
- The ISMP process designates each HMZ and assigns values to three indices: Habitat Type, Stewardship Value, and Outreach Value
- The process is driven by subject matter expertise, workshop training, and Microsoft Excel workbook.

Kudzu
© By Scott Ehardt - Own work, Public Domain,
https://commons.wikimedia.org/w/index.php?curid=702909

IMPORTANCE

- There is currently no GIS application for the assessment portion of the ISMP process.

- The field work portion of remediation uses ArcGIS Collector to capture field data.

- Currently the assessment and remediation elements are not digitally inter-operable, meaning that DCNR personnel must transfer information and data between the two systems.

- The creation of a GIS database derived from the workbook will facilitate DCNR ISMP efforts and enable them to visualize remediation activities to Stakeholders.

- DCNR does have GIS capabilities for other elements of Park management, including GIS data portals and ArcGIS Online interactive map galleries.

Poison hemlock
© https://www.kingcounty.gov/

- Compile a normalized GIS database for the ISMP assessment process
  - This will allow search and query through a map-based interface.
- Options for creation of the database.
  - One option is to create the database using ESRI geodatabase format.
  - The other option is to create the database using Free and Open Source Software for Geospatial (FOSS4Geo), such as PostgresSQL/PostGIS.
  - While more familiar with ESRI formats, there are many resources available to learn the FOSS4Geo format (including MGIS GEOG868)
- The project scope will initially be limited to one select State Park
  - Maintaining a limited scope is necessary due resource, time, and manpower.
  - However, the limited focus should allow for robust normalized database development

reed canary grass
© http://www.naturalheritage.state.pa.us

Background & Lit review

- Invasive plants degrade native habitat
  - Out-compete native plant species for resources and growing space
  - Displace native plants, which in turn reduces habitat quality
  - Create monocultures which reduce habitat available for native wildlife and disrupts the food chain.
    - Example is garlic mustard, where "native butterflies lay eggs on garlic mustard, and they either die or the caterpillars don't properly grow." (DCNR, 2020)
- GIS in invasive species and habitat management
  - Multiple regression models to predict the invasion rate of a select species in Joshua Tree National Park (Cullors, 2013)
  - Multi-criteria decision analysis to prioritize landscape management at Ft. Bragg, N.C. (Hohmann et al., 2013)
  - Development of a GIS database to demonstrate the county level distribution of invasive plants in the southeastern United States (Fletcher & Reddy, 2018)
  - Study that developed a GIS tool to rank invasive species infestations based on their potential risk to native habitats (Tateyama, 2014).

giant hogweed
© invadingspecies.com

- GIS can also contribute to Floristic Quality Assessments (FQA).
  - FQA effectively indicates the impacts of invasive species.
  - Can be used to monitor effectiveness of land-management and restoration practices. (Lotze and Vannais, 2019)
- Studies that discuss the benefit of GIS in FQA include:
  - Using GIS to provide web-map access to forest biodiversity archives in Trento Province Italy (Geri, et al., 2016)
  - Field survey and GIS mapping of plant types within mountain forest habitat on Mount Tahan, Malaysia (Ismail, 2010)
  - Stratified random sampling of floristic diversity and forest cover in South Gujarat, India using remote sensed data and GIS mapping (Bhatt, et al., 2014)
  - An investigative study by Neldner, Crossley, and Cofinas to examine the sampling rigor in five GIS based vegetation surveys.

giant hogweed
© invadingspecies.com

Goals and Objectives

- The principle goal of this project is to create normalized GIS database for DCNR ISMP assessments.
  - This database will operate on the backend of the ISMP process

- Secondary goal is to enable integration between assessment and field data collection

- Tertiary goal is to support visualization of ISMP remediation progress and to assist FQA activities

Methodology

- The methodology for this project will depend in part on the requirements from DCNR.
    - The requirements will be developed through continuing formal sessions with relevant DCNR personnel to identify requisite attributes to capture in the database.
    - Will also consider North American Invasive Species Management Association (NAISMA) data collection standards
    - These standards were crafted with the intent of "creating the minimum mapping standards for invasive weeds … to increase the ability to share weed-mapping information."(NAISMA, 2018)
    - Relevant United States Forest Service (USFS) field guides follow the NAISMA standards as their "protocol … for the inventory monitoring and mapping of invasive plant populations" (USFS, 2008)
- The expected procedure will be to generate geospatial database files consisting of attribution and schema derived from the current ISMP excel workbook.
    - What the database format will be is still unknown (as previously discussed in the Proposed Solutions).
    - Shortfalls and unknowns are mainly driven by challenges connecting and communicating with DCNR personnel due to COVID-19 and other schedule impacts.
- There will be challenges converting the ISMP workbook calculations that derive the site-specific ranked work lists.
    - The calculations are performed using Macros (i.e. the file type extension is a .xlsm format). A capability like this should be incorporated into the GIS database. Directly importing .xlsm format workbooks into GIS format requires scripting (Python)
    - Alternatively, the database could be built, and scripting used to perform the arithmetically derived final prioritization index weighting and site assessment calculations.
- Specifics of either importing or script calculating as well as database storage options will develop through continued discussion with DCNR (and WWMP) personnel.
- Requires additional review and research of existing data models

Methodology Examples

[Detail of System Design] Morgan, B. J., & Greco,
S. E. (2019). A GIS data model for public gardens. Transactions in
GIS, 23(1), 87–103. https://doi.org/10.1111/tgis.12509

[Detail of System Design] Tateyama, M., "Prioritizing Invasive
Species Management in the Carlsbad Hydrologic Unit."
Master of Science University of Redlands, 2014,
https://doi.org/10.26716/redlands/master/2014.13.

[Detail of Project Workflow] Tateyama, M., "Prioritizing Invasive
Species Management in the Carlsbad Hydrologic Unit."
Master of Science University of Redlands, 2014,
https://doi.org/10.26716/redlands/master/2014.13.

Anticipated Results

- The development of a relational GIS database that captures the ISMP decision process.
  - The database will need to capture the calculations of the current ISMP workbook.
  - Examples of the workbook input tables can be seen in Tables 1 and 2. (Gover, et al. 2016)
  - Additional desired result is the interoperability with DCNR field data collected via ArcGIS Collector mobile application.
- Another desired result is the ability for DCNR to generate visualizations of site remediation results to senior level stakeholders..

Table 1. List and characterize the Habitat Management Zones (HMZ) in your park. Type in the name of the HMZ in the column "HMZ Name", then use the drop-down menus in the adjacent columns to select the Habitat Type, Stewardship Value, and Outreach Value. A formula will generate the Site Index for each HMZ. You can use this to sort if you wish to arrange HMZ by "site value"

	HMZ Name	Habitat Type	Stewardship	Outreach	Site Index
Begin					
Next					
Add Zone					
Help					
Reset					

Table 1. Habitat Management Zone identification

Table 3. For each species, its "Impact" and "Restoration Effort" index values are provided. The Impact index is potentially determined by the nature of the invaded site, which is characterized by Habitat Type. Where species are assigned an Impact index of "1", the corresponding Habitat Types are listed. If the species you are considering is not occurring in a listed Habitat Type, assign an Impact index of "0". The Restoration Effort index may be affected by the Extent of the species in question. To find the appropriate Restoration Effort index for the considered species, refer first to the Extent index you assigned in the worksheet "4_HMZ-SPP EXTENT", and use the index value from the corresponding Extent column.

	Present	Common Name	Scientific Name	Growth Form	MF	PF	ME	RC	LS	YF	WL	Extent=2	Extent=1	Extent=0
Begin		arthraxon	Arthraxon hispidus	AN	0	0	0	0	0	0	0	2	1	1
Next		Japanese hops		AN	0	0	1	1	1	1	0	2	1	0
Help		Japanese stiltgrass	Microstegium vimineum	AN	0	0	0	0	0	0	0	0	0	0
		jimsonweed	Datura stramonium	AN	0	0	0	0	0	0	0	3	2	2
		mile-a-minute	Persicaria perfoliata	AN	0	0	1	1	1	1	0	0	0	0
		exotic biennials	many	BI	0	0	0	1	1	0	1	2	1	1
		bull thistle	Cirsium vulgare	BI	0	0	0	0	0	0	0	2	1	1
		common teasel	Dipsacus fullonum	BI	0	0	0	1	1	0	1	1	1	1
		dames rocket	Hesperis matronalis	BI	0	0	0	0	0	0	0	2	1	1
		garlic mustard	Alliaria petiolata	BI	0	0	0	0	1	0	1	2	1	1
		musk thistle	Carduus nutans	BI	0	0	0	0	0	0	0	2	1	1
		plumeless thistle	Carduus acanthoides	BI	0	0	0	0	0	0	0	2	1	1

Table 2. Species Impact Index
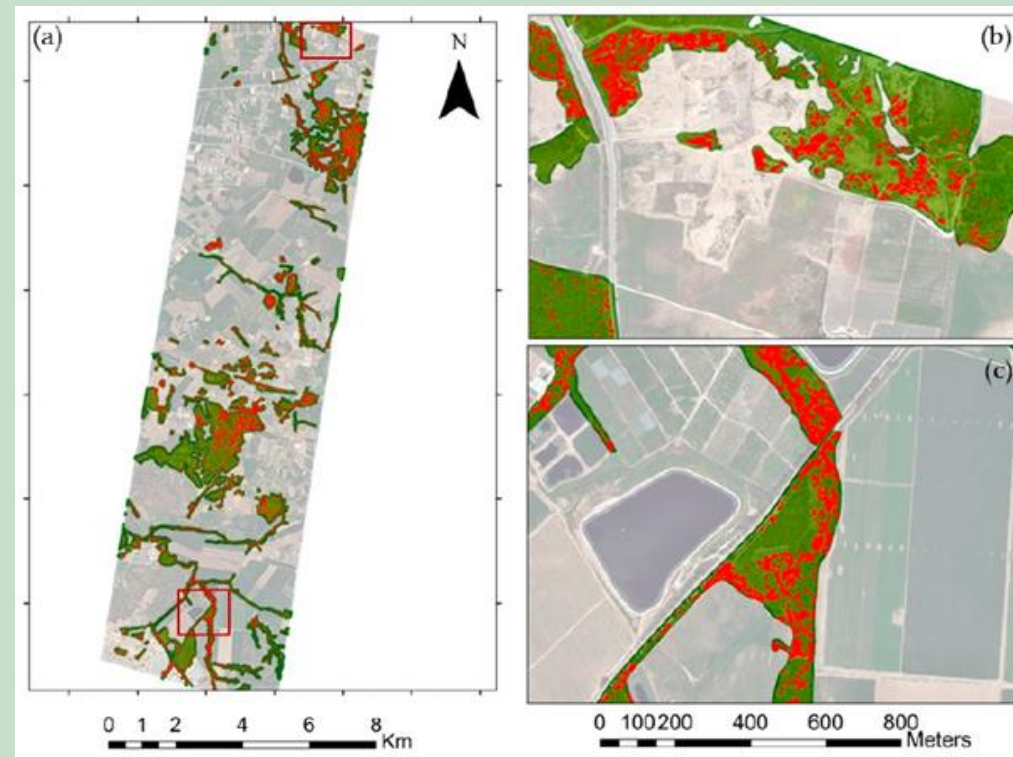
Figure 1. Notional Invasive Plant Concentration Map

Nescopeck
State
Park

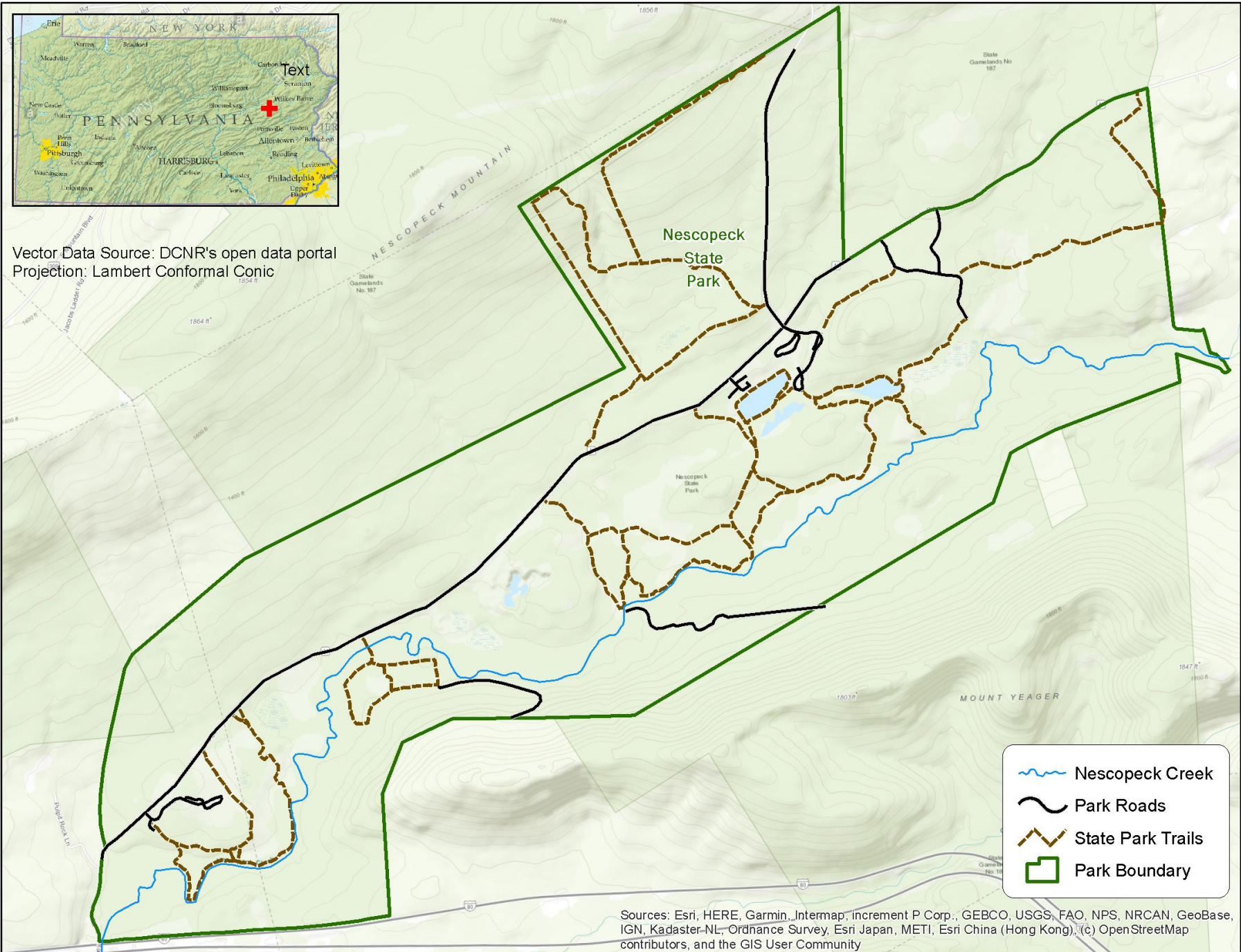Vector Data Source: DCNR's open data portal
Projection: Lambert Conformal Conic

Park Boundary

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Nescopeck State Park
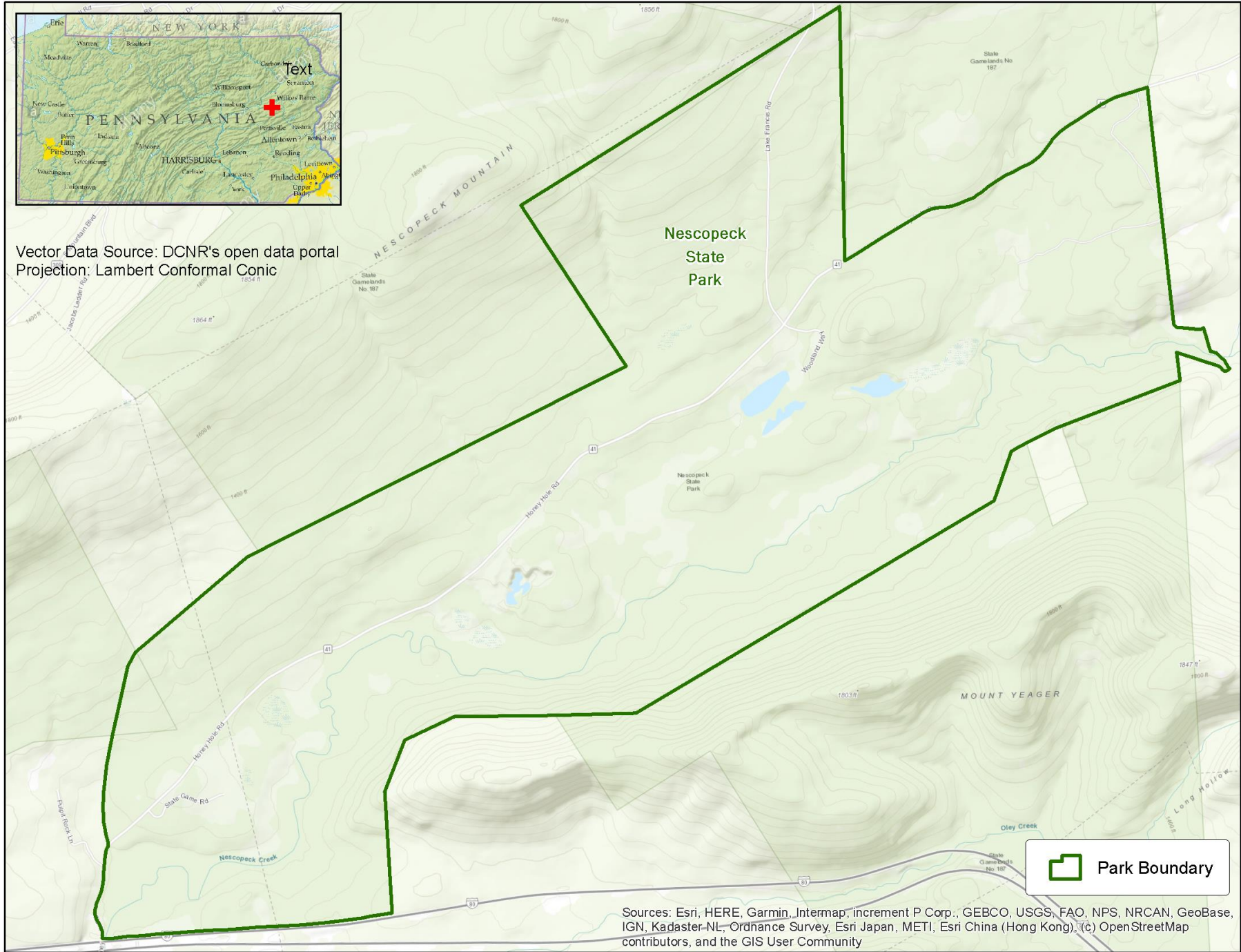
Vector Data Source: DCNR's open data portal
Projection: Lambert Conformal Conic

Nescopeck Creek
Park Roads
State Park Trails
Park Boundary

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
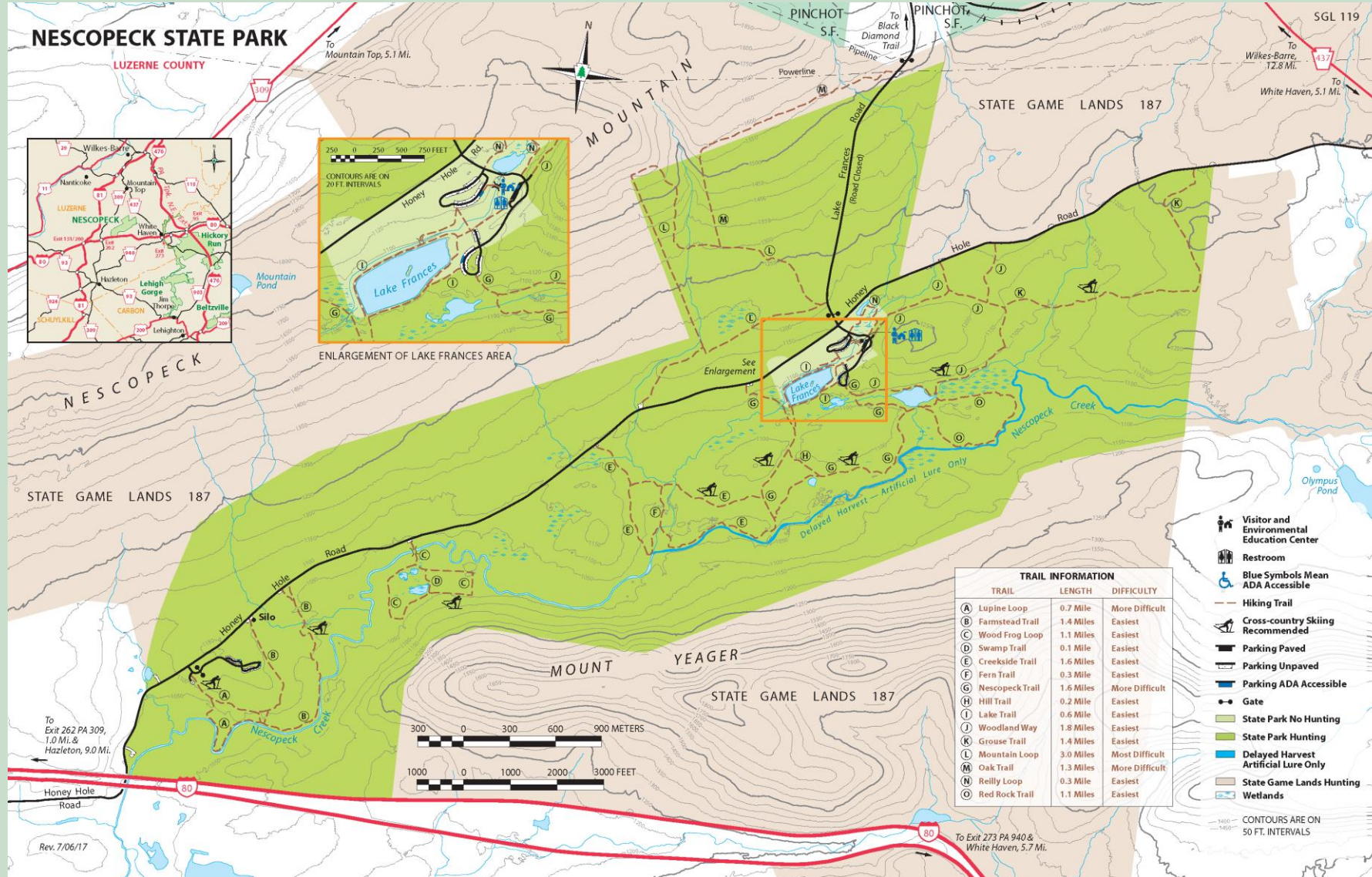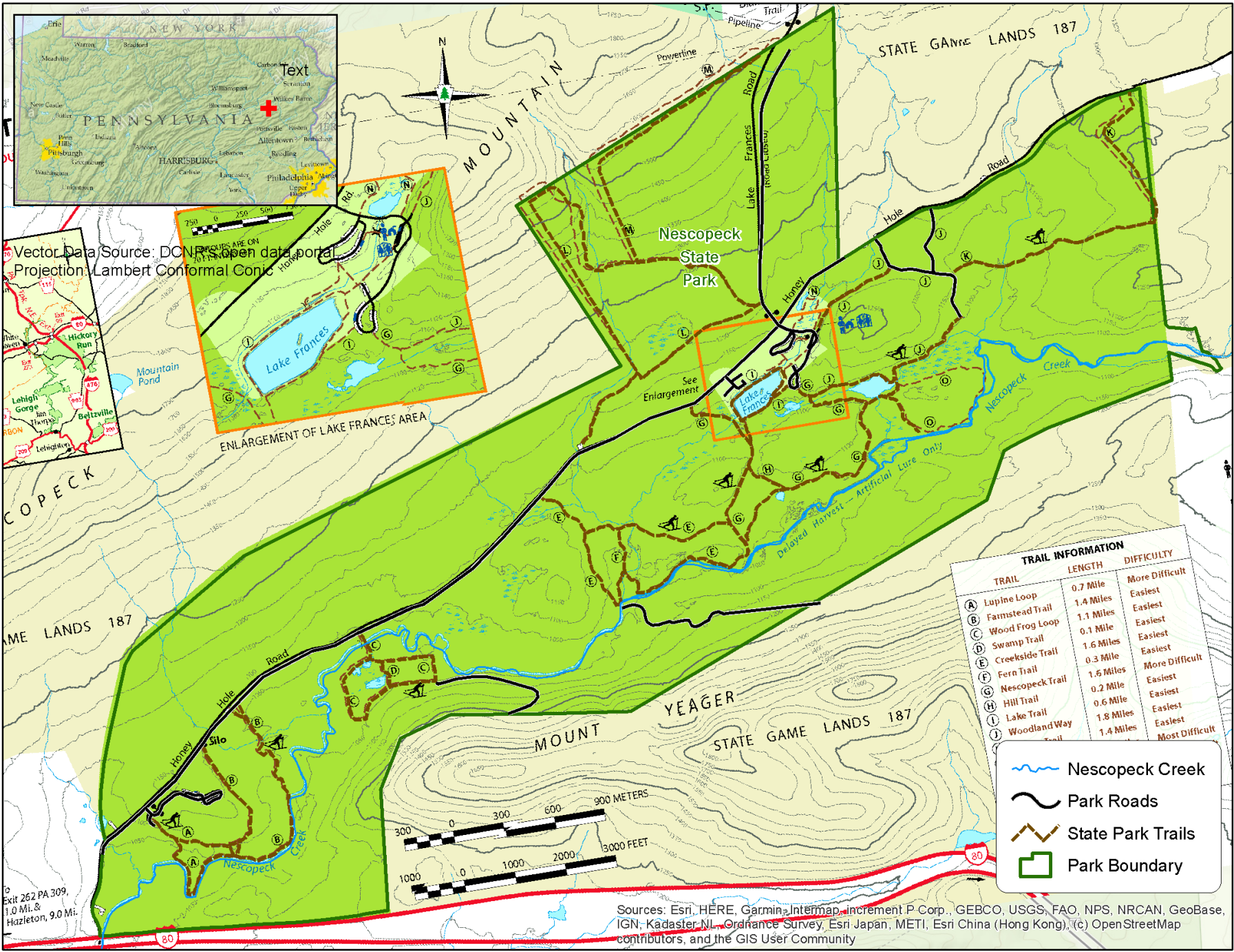
NEW YORK

PENNSYLVANIA

Erie
Warren
Bradford
Meadville
Carbondale
Scranton
Williamsport
Wilkes Barre
New Castle
Butler
Indiana
Altoona
Pottsville Easton
Allentown Bethlehem
Pittsburgh
Penn Hills
Greensburg
Lebanon
Reading
Harrisburg
Washington
Uniontown
Carlisle
Lancaster
York
Philadelphia
Upper Darby
Levittown

Text

250   500 (m)
BOUNDS ARE ON
2013 data portal

Lake Frances

ENLARGEMENT OF LAKE FRANCES AREA

Hickory Run

Lehigh Gorge Jim Thorpe
Beltzville

Mountain Pond

Exit 262 PA 309,
1.0 Mi. &
Hazleton, 9.0 Mi.

Vector Data Source: DCNR's open data portal
Projection: Lambert Conformal Conic

Nescopeck State Park

MOUNTAIN

STATE GAME LANDS 187

Powerline
Pipeline

Lake Frances Road (Road Closed)

Hole Road

Honey Hole Road

See Enlargement

Delayed Harvest – Artificial Lure Only

Nescopeck Creek

STATE GAME LANDS 187

MOUNT YEAGER

STATE GAME LANDS 187

COPECK

GAME LANDS 187

Honey Hole Road

Silo

Nescopeck Creek

300   600   900 METERS
300   0
1000   2000   3000 FEET
1000   0

80

TRAIL INFORMATION

TRAIL		LENGTH	DIFFICULTY
A	Lupine Loop	0.7 Mile	More Difficult
B	Farmstead Trail	1.4 Miles	Easiest
C	Wood Frog Loop	1.1 Miles	Easiest
D	Swamp Trail	0.1 Mile	Easiest
E	Creekside Trail	1.6 Miles	Easiest
F	Fern Trail	0.3 Miles	More Difficult
G	Nescopeck Trail	1.6 Miles	Easiest
H	Hill Trail	0.2 Mile	Easiest
I	Lake Trail	0.6 Mile	Easiest
J	Woodland Way	1.8 Miles	Easiest
	Trail	1.4 Miles	Most Difficult

Nescopeck Creek

Park Roads

State Park Trails

Park Boundary

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
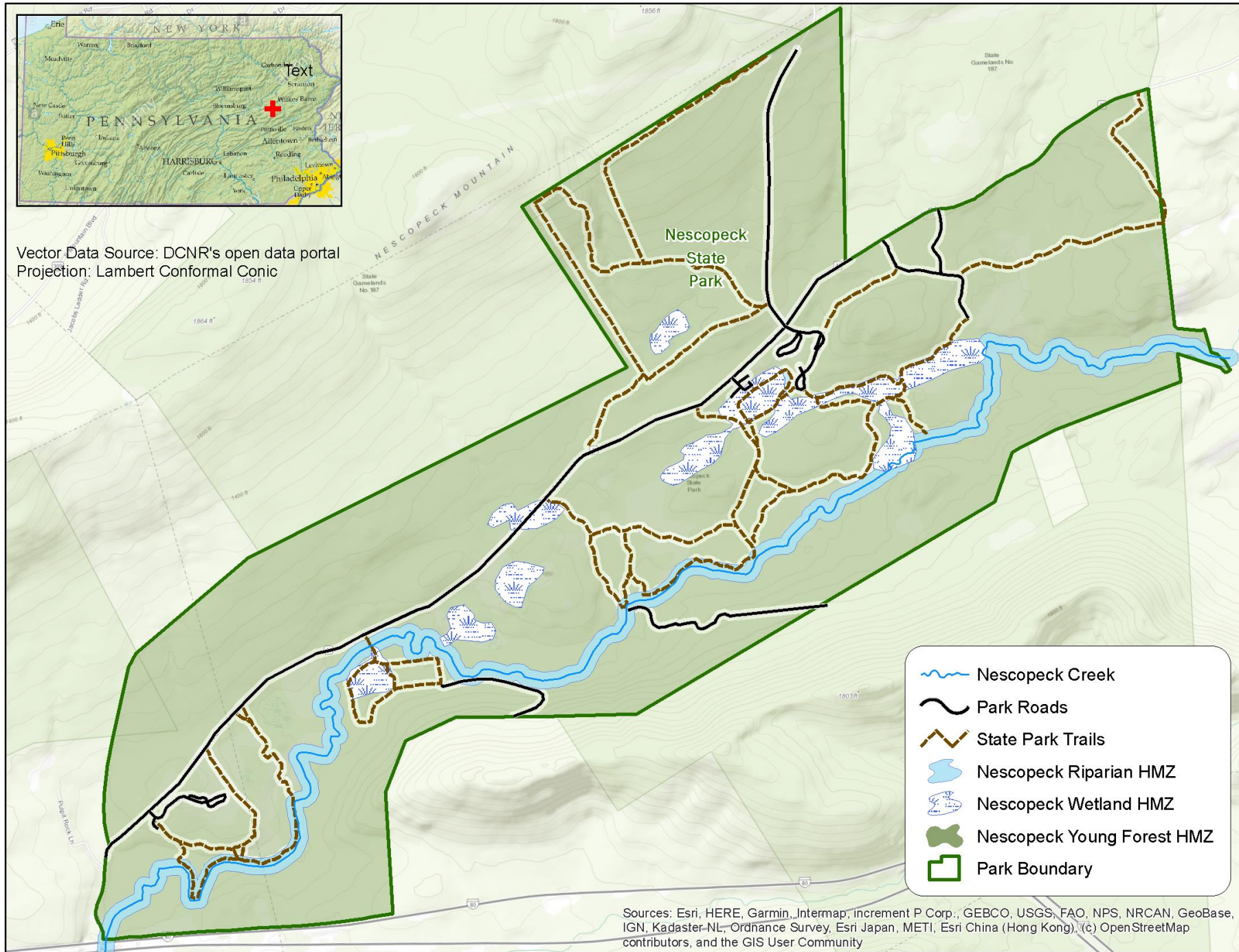
Text

Vector Data Source: DCNR's open data portal
Projection: Lambert Conformal Conic

Nescopeck
State
Park

Legend

— Nescopeck Creek

— Park Roads

⌁ State Park Trails

▢ Nescopeck Riparian HMZ

▢ Nescopeck Wetland HMZ

▬ Nescopeck Young Forest HMZ

▢ Park Boundary

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
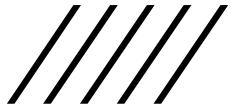
Proposed Project Timeline
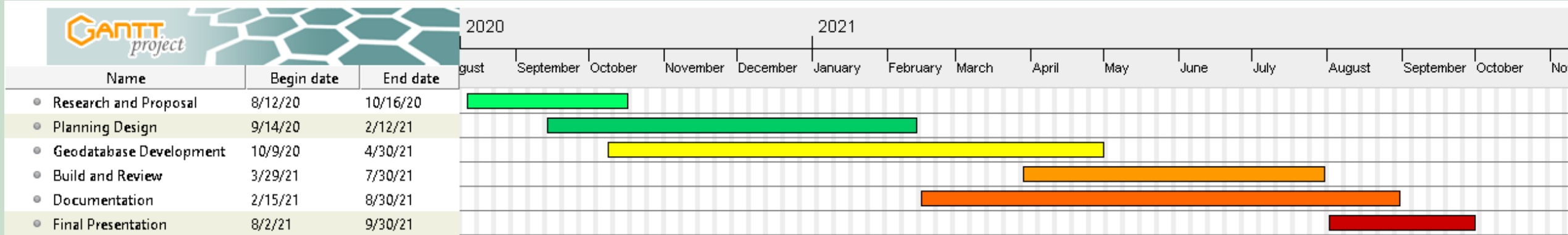
Presentation Venues

- The proposed venue for presenting the final project is the Society for Conservation GIS (SCGIS) 2021 Annual Conference.
  - The 2020 SCGIS Annual Conference was virtual
  - Good chance the 2021 Conference will also be virtual.
  - Based on 2020 schedule, user presentations September of 2021.

- Alternately, this project could be presented at that North American Invasive Species Management Association (NAISMA) 2021 annual conference.
  - NAISMA's 2020 Annual Conference was also virtual
  - Not unreasonable to assume 2021 Conference will be virtual
  - Again, based on 2020 schedule, user presentations October 2021.

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