



Science and Management



This GIS fire progression map shows the area affected by the 2007 Lewis Peak Fire at Shenandoah National Park, Virginia, and documents the fire's rate of spread across the landscape. Fire began 5/1/07 (light pink area), by 5/2/07 it covered the dark pink area, and had spread over the red area by 5/3/07. See story, page 11.

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GIS — a Tool for Park Management

Mark Adams, GIS Specialist, Cape Cod National Seashore

As map information becomes more ubiquitous in cell phones, cameras, and via online services, the roles of Geographic Information Systems (GIS) and GIS technical staff are increasingly relevant to NPS park managers for several reasons. GIS analysts provide essential services such as vouching for the accuracy and currency of spatial data, translating managers' questions into specific map queries that address natural resource issues, and creating relevant GIS products that can guide decision making. GIS analysts are often asked by the public why everything is not already mapped and we answer that the world does not stand still. Monitoring change is necessary in order to prop-

erly carry out the NPS resource management mission. Landscape change results from trends in ecological succession, climate and sea level changes, and many ongoing habitat restoration projects. As scientists refine working models of how natural systems function, geographic databases must also be adapted to reflect critical criteria for change. GIS analysts continually refine mapping classifications to accurately track landscape change and make fine distinctions in land cover and habitat types relevant to management. GIS managers also provide expertise about measurement standards and the provenance of data sources. Global Positioning Systems (GPS) embed location information into

all kinds of other data but the underlying accuracy issues that arise (e.g. satellite geometry, differential correction, horizontal and vertical datums, coordinate systems and projections) are beyond the skills of most managers and resource management staff. GIS specialists are able to validate geographic information used in decision-making and create visual simulations and map diagrams that illuminate the information in straightforward and relevant ways.

For example, sea-level information is measured against tidal datums but position of coastal features is also represented in relation to historical elevation benchmarks surveyed to dif-

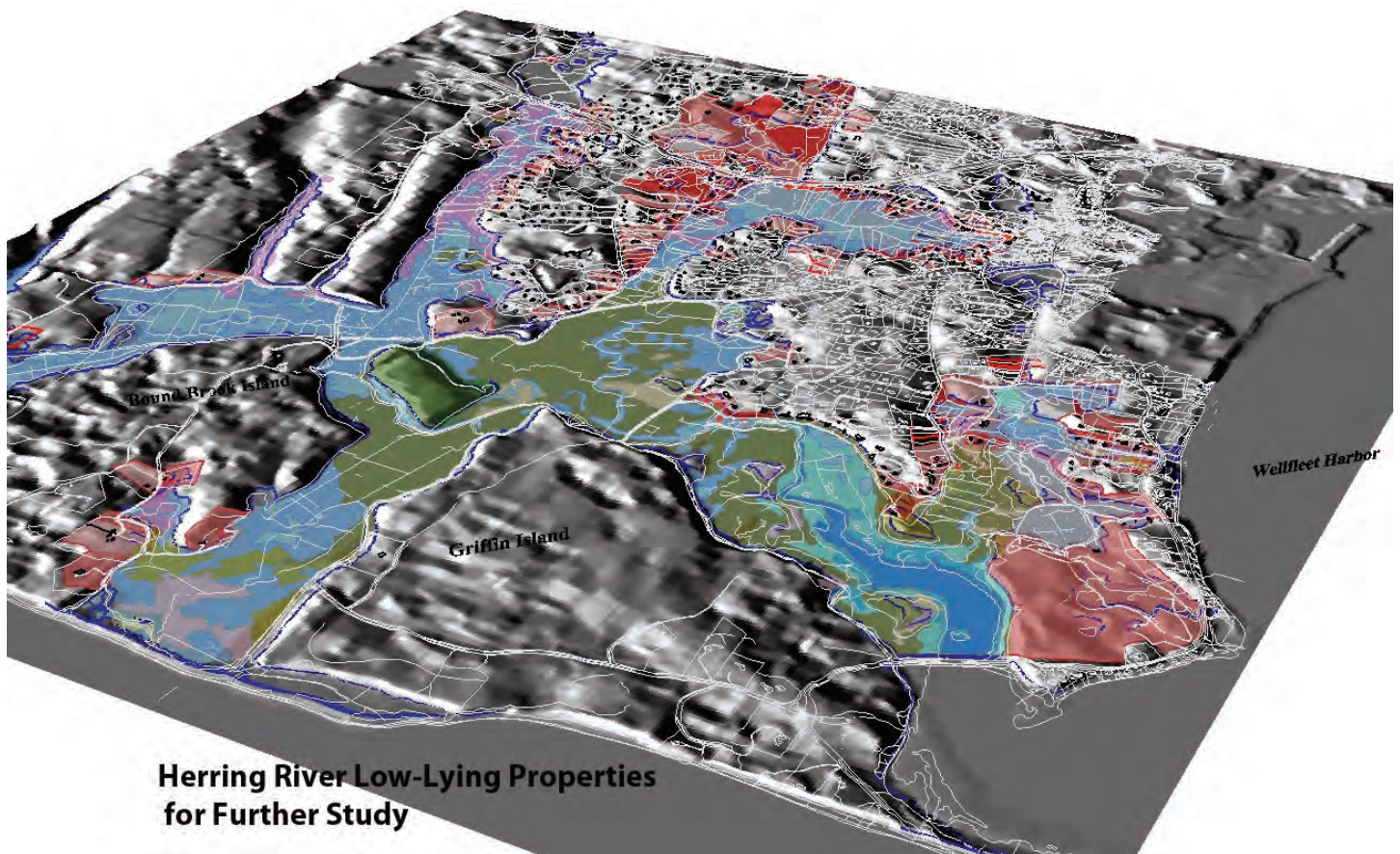
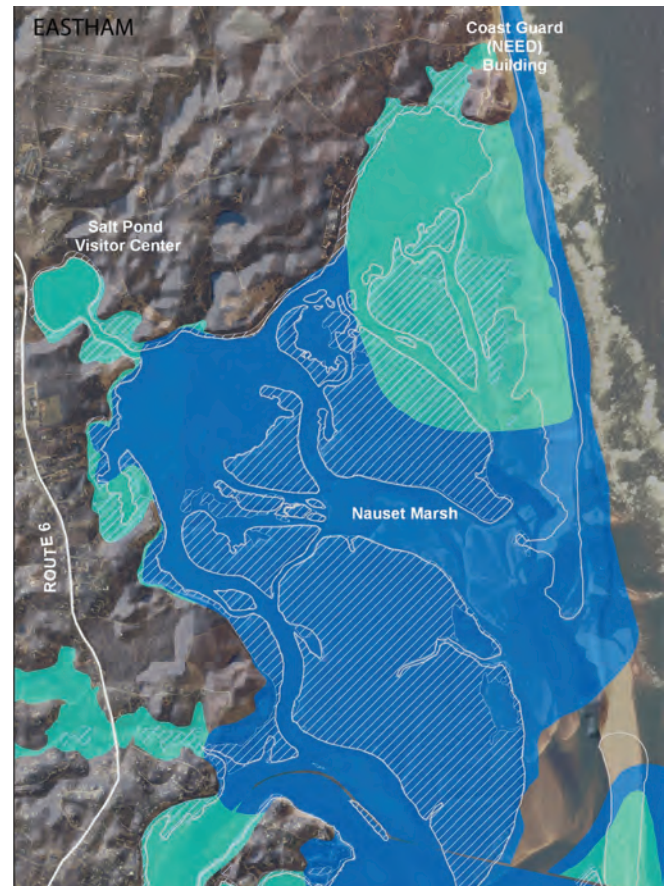
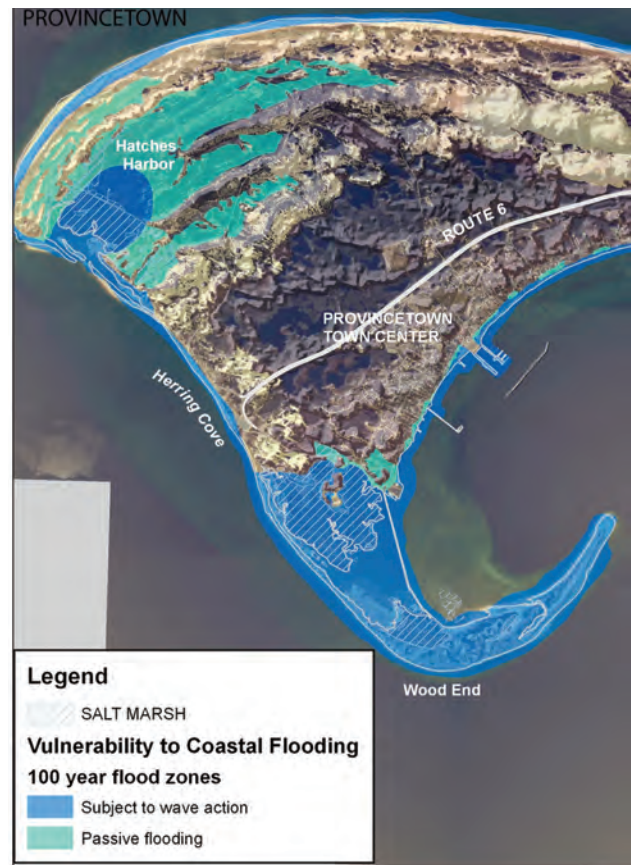


Figure 1. 3D simulation of Cape Cod National Seashore's Herring River floodplain with low-lying private properties highlighted in red for further analysis in relation to tidal restoration alternatives. The project anticipates redesign of a dike to allow salt marsh restoration to an area of up to 1100 acres, one of New England's largest potential wetland restoration projects. The NEPA process will identify mitigation necessary to protect private property and public facilities. Improved property elevations and modeled flood heights are stored in GIS attribute tables for queries.

ferent standards. Elevations are commonly recorded in relation to Mean Sea Level (MSL), North American Vertical Datum (NAVD88), and National Geodetic Vertical Datum (NGVD29) - among other vertical datums - and they all result in different values. GIS specialists must ensure that geographic data are reported in consistent formats and standards relevant to the project at hand. Sophisticated GPS survey equipment can now measure positions relative to global reference frames that must be converted in GIS for comparison to historical survey networks. Similarly, the U.S. National Vegetation Classification provides consistency for vegetative cover mapping but additional local classifications may be necessary to track changes relevant to habitat restoration or other management issues.

Another critical function of GIS is to create map visualization products in 3D that make subtle changes clear to managers. 3D mapping capabilities are now becoming quicker and friendlier - we need the full array of methods to display geographic information for a full range of audiences including managers, scientists, educators, and the general public. Figures 1 and 2 focus on shoreline change but similar needs for quantitative analyses and visualization of vegetative change on various scales are critical in many Northeast Region national parks.

Figure 2. Flood zones and salt marshes in Provincetown (right), Wellfleet (below left), and Eastham (below right), Cape Cod National Seashore, Massachusetts. Inundation of salt marshes is among various management concerns under various sea-level rise scenarios.



GIS for Everyone

*Hugh Devine, Professor and Chair, Graduate GIS Faculty, NCSU
and Nigel Shaw, GIS Technical Coordinator, Northeast Region*

The driving ambition of all NPS Geographic Information System (GIS) programs is to empower resource managers through the provision of easily attainable, accurate maps and data. In the Northeast Region, the NPS GIS program, with expertise from North Carolina State University and the University of Rhode Island, is bringing together several different technologies (data format conversion, GIS, graphics, and Internet) to create customized maps and reports that can be used, and even produced with a

standard web browser, by NPS staff with no training in GIS. This new technology is called Enterprise GIS (EGIS). "Enterprise" means that GIS data and functionality are readily accessible by staff throughout the organization to address a wide variety of needs.

The NER EGIS effort focuses on the management needs of individual parks and regional programs. The technical underpinning of the approach is to seamlessly connect data housed in

different management functions (natural resources, fire, lands, maintenance, cultural resources, law enforcement, etc.) using geographic location as the common link. The biggest challenge is to find and organize all relevant data that exist in different formats (e.g., maps, imagery, GPS points, reports, databases) and are maintained in different data systems (e.g., LCS, WFMI, FMSS). The linked data, along with selected GIS functionality, are then made available in map form to park managers via an Internet connection.

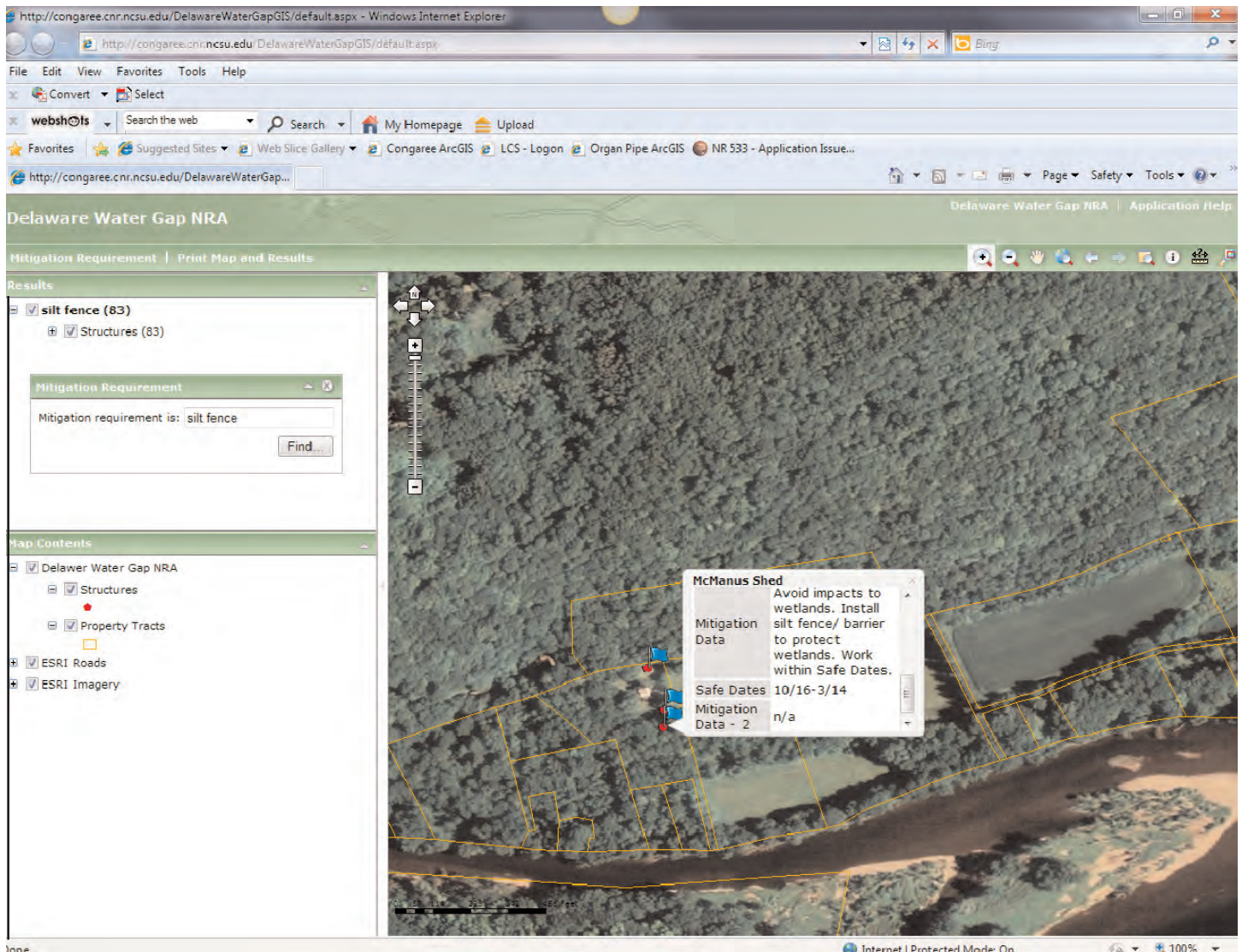


Figure 1. Delaware Water Gap NRA hazardous building Enterprise GIS application



Figure 2. Possible configuration of a trail concept under consideration at Martin Van Buren NHS (developed and displayed in Google Earth by Dan Dattilio)

Prototype EGIS applications are now in place in some NER parks and offices. These include a number of examples that demonstrate the data connections, functionality, and ease of use. Work also continues on data standardization, a critical piece of the EGIS infrastructure. Eventually, when much more data are standardized and readily accessible, park staff throughout the region should be able to put together the maps they need. In addition to the prototype projects and data standardization, and as part of the research effort, the NER GIS team has developed multiple approaches to the web delivery system and continues to explore even more efficient and flexible systems of map delivery.

An early example of an EGIS data application is the response to a request from the Delaware Water Gap National Recreation Area staff. The request involved producing maps and reports to display buildings that were both hazardous and required mitigation efforts

(e.g., silt fences) to protect selected natural resources. The project was supervised by Leslie Morlock and Kathy Commisso, the GIS staff at the park, and involved the integration of data from the Natural Resources Inventory, Lands (tract boundaries), and Maintenance (Facilities and Maintenance Software System) data sets. The data existed in separate data structures and were linked using the EGIS to produce a composite GIS map. This EGIS map was then moved to a web mapping service and enhanced with customized features allowing it to be queried for identification of buildings requiring mitigation before they could be removed. The enhanced map was then placed into an Internet server environment so that park management staff could access the maps and perform the queries without either training or specialized GIS software. Figure 1 shows the Internet view of the application. The user simply clicks on the query (in this case "Mitigation Requirement"), which displays the query box

where the user types in the kind of mitigation required (e.g., silt fence). When the "Find" button is then clicked, the buildings requiring silt fences are displayed (blue flags). In addition, when the mouse is placed over any of the identified buildings, the relevant description information appears in a separate data box (in this case the data for the "McManus Shed").

Another early example of EGIS was installed at Martin Van Buren NHS prior to the park's General Management Plan starting in 2006. The project was initiated and overseen by park Superintendent Dan Dattilio. In this case all the park GIS data were converted to Google Earth (GE) format so that this park data, along with the standard GE data, can be manipulated with the GE

tools already familiar to park staff. The functionality of Google Earth (the free version) allows them to: zoom; pan; add point, line, or area graphics; measure distance; and plot routes and roughly visualize and compare alternative scenarios. It does not support customized cartography or spatial analyses, nor is the ability to work with feature attributes very robust at this point, but it has proven useful for users with open-ended questions or requiring greater flexibility in their queries. Park staff use it to create highly detailed views of specific park information, such as the possible interpretive trail route under consideration in an early version of the GMP shown in Figure 2, or to use the park information in conjunction with the more extensive GE datasets (e.g. elevation, orthophotos, real-time traffic density) for a regional perspective.

Work in progress is a series of EGIS applications including projects enabling web access for Cultural Re-

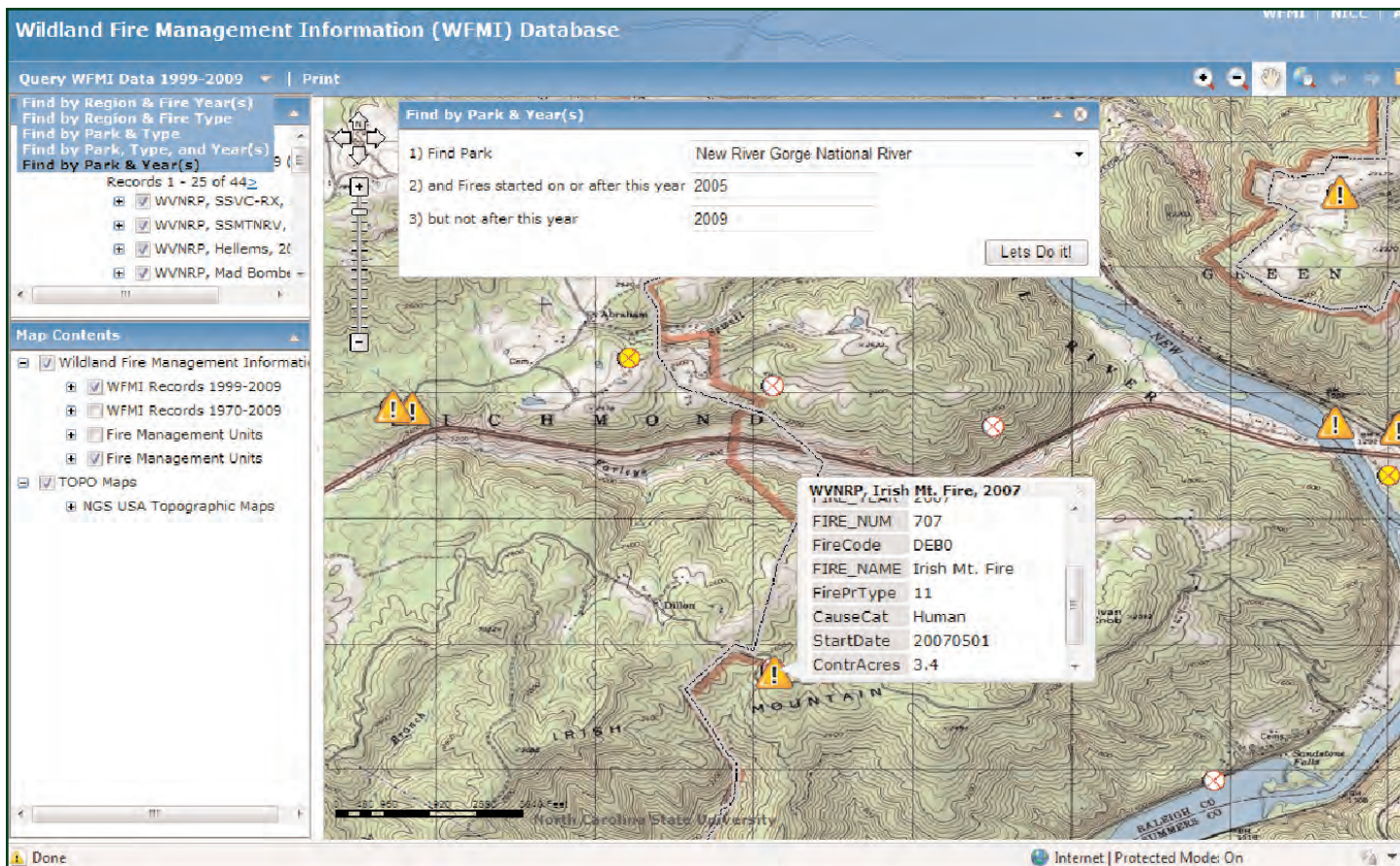


Figure 3. New River Gorge NR fire history with ESRI ArcGIS Server application

sources (List of Classified Structures assessments), Lands (Master Deed List access), Natural Resources (resource monitoring data), Facilities Management (buildings data), and Fire (pre-suppression planning). ESRI's ArcGIS Server is shown in Figure 3 with a New River Gorge National River fire history query. Specific functions

under development that support these EGIS applications include making a simple map on demand, data query and display, buffering features, and identifying feature intersections (e.g., where a particular habitat type and archeological site overlap). The NER GIS team also continues to explore the use of related web-based tech-

nologies to make these EGIS applications available to park staff.

The authors would like to acknowledge Bill Slocumb, NCSU, and Roland Duhaime, URI, for their initiative and technical expertise in support of EGIS for the NER.

Mapping a Moving Target

*Mark Christiano, GIS Specialist, Gateway National Recreation Area and
Norbert P. Psuty, Director, Sandy Hook Cooperative Research Programs*

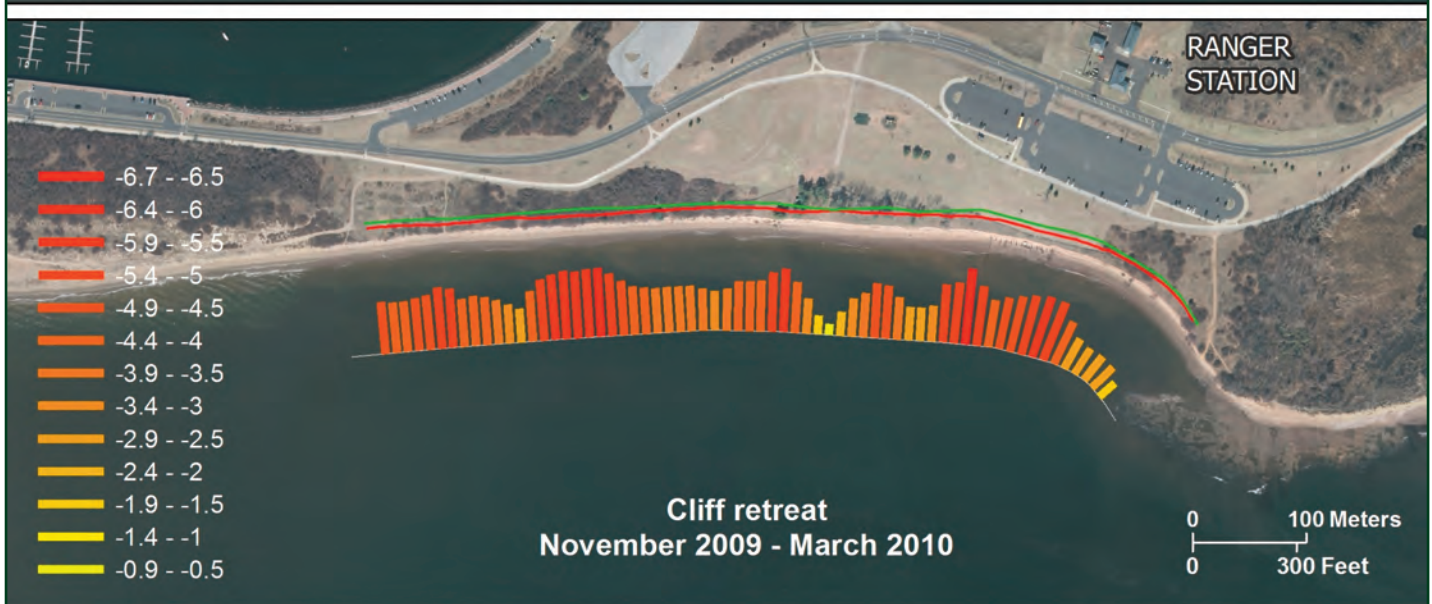
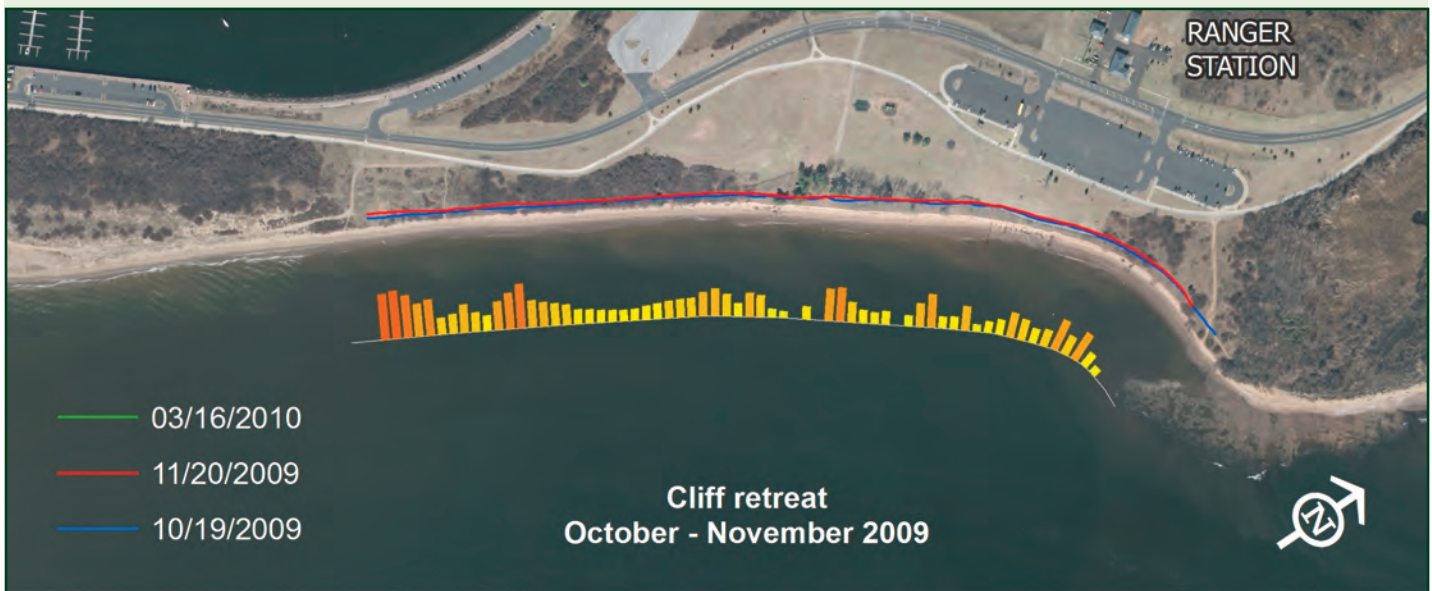
One of the major problems with any GIS dataset is that the second you create it, it's out of date. It represents a snapshot in time, but is no longer the field condition. Shorelines, for example, can change overnight.

Shorelines are affected by multi-year trends of water level such as El Niño, seasonal variations between summer and winter conditions, monthly lunar

cycles creating extreme high and low tides, and an endless number of man-made structures that have littered the New England coastline since colonial times. And these are the predictable impacts; we also have powerful Nor'easters and hurricanes that can radically and quickly change a shoreline. All of these impacts and more make mapping shorelines of national parks in the Northeast Coastal Barrier

Network (NCBN) one of the toughest GIS challenges in town.

The NCBN has identified coastal geomorphology as one of seven vital signs due to its significant role in park management. Shifting sands, erosion, and storm impacts can affect a park's natural and cultural resources, buildings and infrastructure, and even visitor safety. The fastest and most



	Oct 2009 - Nov 2009	Nov 2009 - Mar 2010
Average retreat:	1.8 m	4.2 m
Maximum retreat:	4.2 m	6.7 m
Minimum retreat:	0.0 m	1.0 m

The images above came from the 1D protocol at Great Kills Park. The top image represents the shore erosion before the storm and the second is after the storm. You can see by the bar chart that there was heavy erosion after the storm.

The image on the next page came from analysis of the 2D protocol data from Plumb Beach after the storm. The green area shows where sand has accumulated and the red area shows where it has eroded.

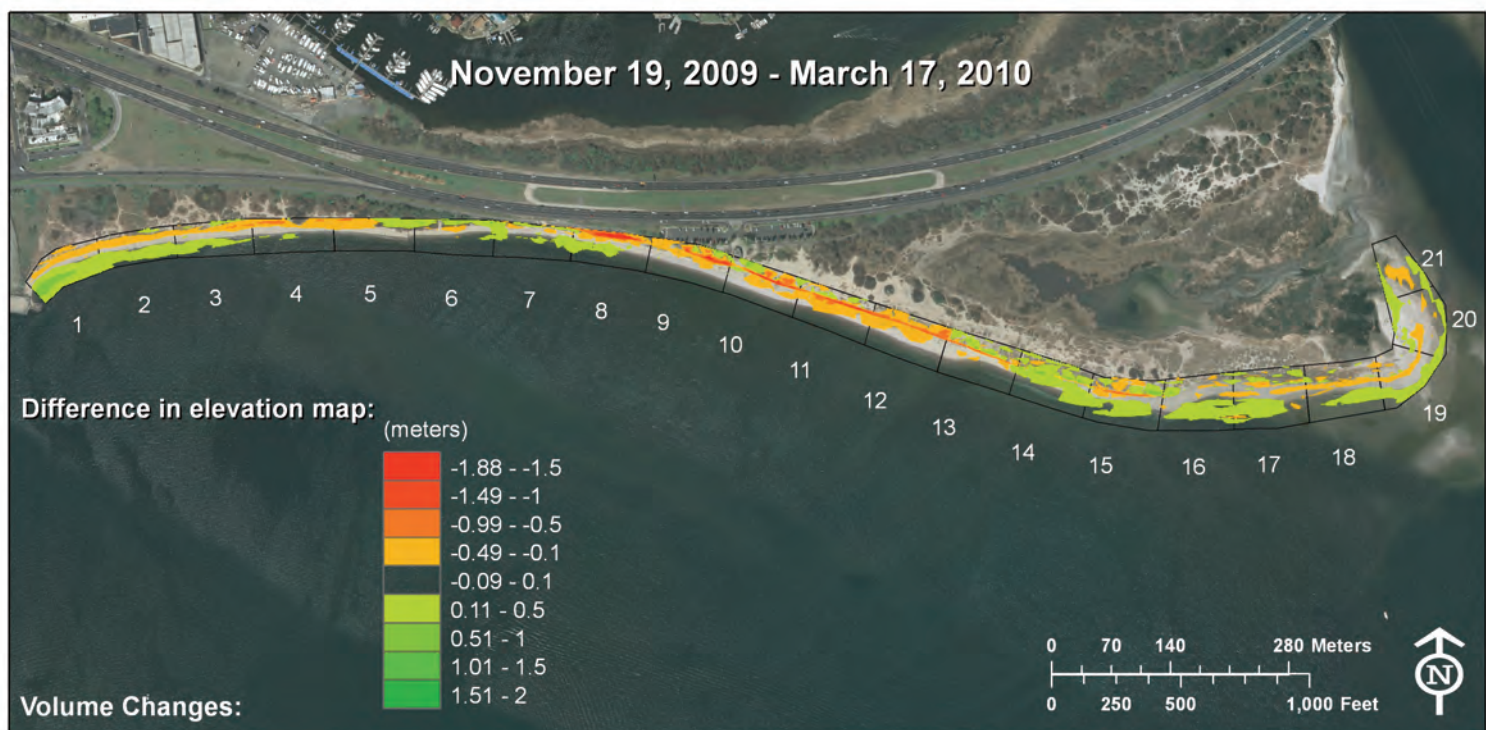
effective way to understand the complexities of coastal geomorphology is through GIS by mapping the shoreline. All of the elements that make up coastal geomorphology—varying sediment supply; offshore sand bars, shifting inlets, tides, storms, and engineering structures—will be reflected in the changing shoreline. By mapping the shoreline, these elements are compiled and modeled to provide park managers with the tools for planning and management.

At Gateway National Recreation Area, Dr. Norbert Psuty, Director of the Sandy Hook Cooperative Research Programs at Rutgers University, and his team have been working with the NCBN staff to develop GIS protocols for monitoring shorelines. The protocols help park staff quickly and consis-

tently map the shoreline year after year and understand the coastal elements affecting their park. The first protocol developed is called “1D”: mapping the shorelines in the fall and the spring using a mapping-grade GPS unit. The goal is not to collect the extreme high tide, but the neap-tide, high-tide swash line because it has the least vertical variation throughout the year. The end result is a GIS data layer that can be used with other park layers and imagery for mapping and modeling. By integrating the data, we can see where habitat is gained or lost and park staff can identify areas of concern for additional study. “The systematic collection of coastal topography in Gateway has resulted in an unmatched level of information on sediment supply, on topographical evolution, and impacts of coastal

change on natural and cultural resources in the park,” said Dr. Psuty. “It is leading to a program of sediment management where sediment transfers will assist in the buffering of long-term vectors of change caused by negative sediment budgets and impacts of sea-level rise.”

Dr. Psuty and his team are also developing “2D” and “3D” protocols. The 2D protocol creates transects perpendicular to the shoreline allowing for a profile analysis and, by extension, can be used to calculate changes in the volume of the sand along the coastline. The 3D protocol is a complete survey of a small specific area, usually of high risk or interest to the park where points are taken every few meters across the entire landscape. Gateway staff use the 3D level of



Compartment:																				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Accretion:																				
674.24	323.57	206.79	48.82	142.84	193.87	190.29	54.97	149.18	103.96	55.2	15.5	166.23	564.19	404.47	411.62	435.38	254.27	243.15	218.39	126.9
Erosion:																				
184.97	217.74	199.8	278.22	173.62	51.36	44.01	489.42	587.13	481.3	559.78	613.37	221.08	29.13	255.69	79.8	180.9	157.89	108.04	130.17	108.71
Net volume change:																				
489.27	105.83	6.99	-229.4	-30.78	142.51	146.28	-434.5	-438	-377.3	-504.6	-597.9	-54.85	535.06	148.78	331.82	254.48	96.38	135.11	88.22	18.19

monitoring at the Critical Zone, Gun-
nison Beach and Kingman-Mills at
Sandy Hook; Great Kills at Staten Is-
land; and Plumb Beach at Jamaica
Bay. The Critical Zone is an area of
shoreline at Sandy Hook of high ero-
sion that is threatening park infrastruc-
ture, visitor use, and threatened and
endangered species habitat. The 2D
and 3D protocols require highly accu-
rate X and Y and Z (elevation) coordi-
nates, a level of accuracy not found
with mapping-grade GPS units. In-
stead a Real Time Kinematic (RTK)
GPS unit is used. The RTK provides
centimeter accuracy in elevation.

In addition to field collection of data,
LiDAR (Light Detection and Ranging)
data are collected every other year for
the NCBN parks. A LiDAR aerial sur-
vey, done by a contractor, includes a
long stretch of shoreline, giving the big
picture, in contrast to the smaller, fre-
quent, targeted mapping covered by
the NCBN protocols. "LiDAR allows
the NCBN to create highly accurate el-
elevation models of our beach and dune
systems – models that can be com-
pared through time – allowing us to

monitor changes in shoreline position,
dune elevation, sediment volume, and
a host of other parameters," says Den-
nis Skidds, data manager for the
NCBN. "This information is then made
available to park natural-resource
managers, who can, in turn, use it for
such purposes as identifying impend-
ing threats to habitats or infrastructure,
or assessing the efficacy of manage-
ment and restoration efforts."

GIS, while allowing us to understand
long term trends, is also an incredibly
useful tool in rapid damage assess-
ment. An excellent example was the
Nor'easter storm the weekend of
March 12, 2010. For three days, the
New York - New Jersey area was
pounded by strong winds and driving
rain. All across Gateway NRA, sands
were shifted and structures long
buried were exposed, while other
structures normally high and dry were
flooded and buried under sand. At
Great Kills in Staten Island, ten to fif-
teen feet of cliff face was ripped away
and fell into the ocean taking with it
trees and a Coastal Ocean Dynamics
Applications Radar station. At Sandy

Hook there was so much sand move-
ment that unexploded ordnance buried
in the dunes around 1905 was ex-
posed. Luckily, no one was injured
and it was safely detonated.

Using mapping-grade GPS units, the
GIS team was able in one day to doc-
ument all of the damage by mapping
the new shorelines and to assess the
damage by comparing the data sets to
previously collected layers. Maps and
reports now show the new location of
the shoreline and identify areas where
park infrastructure was threatened or
compromised.

GIS has been an invaluable tool to
map the complex and ever changing
nature of shorelines. It allows us to re-
spond to short-term sudden changes
that can affect visitor safety and re-
source protections. GIS also allows
us to document and model the long-
term trend of the park coastal geomor-
phology necessary for park planning
and management. GIS allows us to
map the moving target of shoreline
change.

Disappearing Riverbank at Jamestown

Dave Frederick, GIS Specialist at Colonial National Historical Park

Jamestown was the first permanent
English settlement in North America.
However, the area had been used for
thousands of years before the
colonists' arrival in 1607 by Virginia In-
dians. The site presently is adminis-
tered jointly by the National Park
Service and Preservation Virginia.

In 1999, Colonial National Historical
Park (NHP) sought to develop a com-
prehensive shoreline study manage-
ment plan to protect valuable cultural
resources from loss. Virginia Institute
of Marine Science, College of William
& Mary, Gloucester Point, Virginia
(VIMS) was contracted to create the
Shoreline Management Plan (SMP).
Generally, the entire Colonial NHP
shoreline on the James River is sub-

ject to wind-driven wave forces that
cause moderate to severe shoreline
erosion. Storm activity, in particular,
over the last several years (i.e. Hurri-
cane Gordon in 1994, Hurricanes
Bertha and Fran in 1996, Hurricane
Bonnie in 1998, the 1998 Twin
Nor'easters, and Hurricane Isabel in
2003) has eroded the shoreline along
the James River. Storms are a large
part of the force of change along Colo-
nial NHP's James River and The Tho-
rofare shorelines. Two types of storms
can impact the shore — hurricanes
and nor'easters. During a hurricane,
storm surges, which can exceed 16
feet on the open coast, and high winds
can transport large amounts of sedi-
ments. Nor'easters have weaker wind
fields and generally have surges less

than 7 feet. However, these extratropi-
cal storms usually have longer dura-
tions and can span several tidal
cycles, significantly elevating water
level during times of high tide.

Protection of the natural and cultural
resources was a high priority to be
identified in the SMP. One example of
the loss of resources, at Black Point, is
a good study (fig. 1). During the
Jamestown Archeological Assessment
(1992-1997), a Phase I archeological
survey of the entire Jamestown Island
was conducted by the College of
William and Mary Center for Archaeol-
ogy. A campsite dating to 10,000 BP
was located at Black Point. As the site
was already compromised by the en-
croaching erosion and frequently sub-

merged during nor'easters and hurricanes, the site was fully excavated to preserve the artifacts and hearth stones. The campsite was recreated in an exhibit in the Historic Jamestowne Visitor Center (2007).

For the Black Point area, the use of historic digitized shorelines, historic aerial photography, "modern" aerial photography, and landscape photography shows dramatic change (fig. 2). Data used and created during the development of the SMP included an oblique, low-level aerial video of the park's shoreline in 1997, an oblique aerial video taken in 1993, and oblique slides from 1974. Shoreline type and land use were categorized and coded onto mylar copies of 7.5 minute USGS topographic maps, digitized, and then input to the GIS.

Understanding long-term shoreline change is critical in assessing shoreline reaches. The method used for this assessment involves digitizing historic shorelines into a database. Four shorelines were plotted for the SMP

utilizing data in Virginia Institute of Marine Science's (VIMS) Geographic Information System (GIS) database; these shorelines are dated 1874, 1942/52, 1979/83, and 1990. The shore information came from topographic maps produced by the U.S. Geological Survey. Other "layers" of GIS information contained in the Colonial NHP archives were added to the database. The data layers include cultural resources (archeological) and infrastructure.

The SMP was completed in 2005. The implemented plan was successful in helping to stabilize the shoreline by allowing natural grasses to come in and protect cultural resources for the future.

Thank you to Tamia Rudnicki of Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, Virginia for her excellent work on creating the GIS database and metadata.



Black Point 1978



Black Point 1982



Black Point November 1985



1999



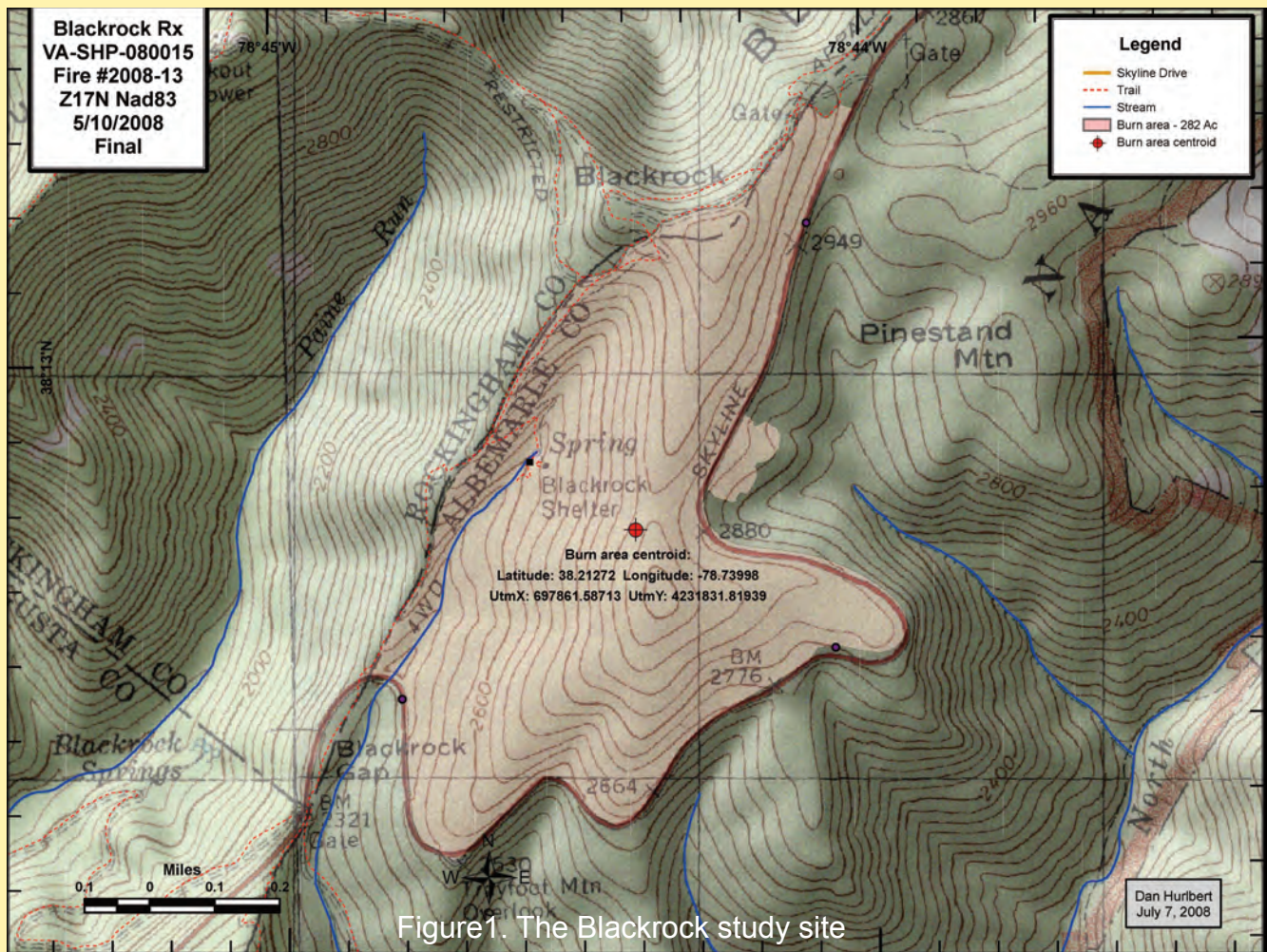
2005



Figure 1. (above) Photos of the same spot over time. Figure 2. (left) Map of shoreline loss at Black Point.

GIS and Fire Management

Dan Hurlbert, GIS Specialist at Shenandoah National Park



When we think of the tools used by wildfire professionals to combat fire on the landscape, we usually envision persons in yellow scratching at the ground with a Pulaski, or helicopter retardant drops, or a wild-fire engine driving the fire perimeter putting out spot fires. Seldom do we think about or even understand the “spatial gear” essential in today’s arsenal of fire tools. Geographic Information Systems (GIS) and related technologies such as Global Positioning Systems (GPS) and data management form the foundation of these tools and outfit the “gear bag” that many in the fire community rely on for answers.

Since 2001, the Northeast Region’s Fire/GIS program has been evolving as the growing demand for GIS services determine its direction. Current needs are centered in five large parks, each managing a cluster of smaller parks scattered across four vital signs monitoring networks. These include Acadia National Park (NP) of the Northeast Temperate Network,

Delaware Water Gap National Recreation Area (NRA) and New River Gorge National River (NR) of the Eastern Rivers and Mountains Network, Cape Cod National Seashore (NS) of the Northeast Coastal and Barrier Network, and Shenandoah NP of the Mid-Atlantic Network. Though the parks and networks are diverse, the fire programs share a similar story.

Fire Ecology – Fire is Good!

Understanding fire’s role in shaping the landscape begins with fire ecology. Fire ecologists study the degree that fire impacts resources on the landscape with the knowledge that fire can be both a destructive force and a beneficial ingredient to a healthy ecosystem. As a planning tool, GIS brings together seemingly unrelated data

sources onto a cohesive mapping interface, guiding the decision process to consider all possible strategies.

This is apparent in recent years' work re-establishing *Pinus pungens* (table mountain pine) stands in Shenandoah National Park. Understanding site disturbance regimes and their relationship to slope direction and vegetation cover class spatially guides the fire ecologist in identifying sites where fire would be most beneficial. Unlike areas, especially on eastern and southern slopes, where periodic wind and ice events have opened the canopy allowing more light to reach the forest floor, undisturbed western and northern slopes may require the heat of fire to encourage this species' serotinous cone structure to distribute seeds. The potential for table mountain pine regeneration following a fire disturbance increases when the burn intensity is adequate for cone opening and seed dissemination. After thorough GIS analysis, the Blackrock study site (fig.1), a 300-acre tract of declining table mountain pine stands, was selected and ignited, resulting in burn severity classes that varied across the burn unit from unburned to moderately-high (fig.2)

Satellite imagery of the study site will guide this summer's (2010) establishment of monitoring plots in areas represented by each burn severity level. Data from these plots will quantify post-fire vegetative recovery and subsequently measure the success at re-establishing the table mountain pine stands. Throughout the process, GIS is used to identify possible burn areas, map burn severity, determine monitoring plot locations, and analyze the results.

In addition to fire being useful for enhancing species' regeneration, it is also useful for removing vegetative cover so that native plant species will "see the light." On Assateague Island National Seashore, spatial technologies are used to map and display the distribution and abundance of *Phragmites australis*, a highly competitive grass. *Phragmites* invades native plant habitat and reduces its value for marsh-dependent fish and wildlife. Prescribed burning after herbicide treatment removes the dense remnants of *Phragmites* reeds, allowing light to reach the native seed bank and, hopefully, restore native habitat.

Planning for the Unexpected

Planning for the unplanned ignition is one of the many roles of a park's Fire Management Office (FMO). The FMO is the first line of defense in combating a wildfire, and its decisions require access to the latest spatial infor-

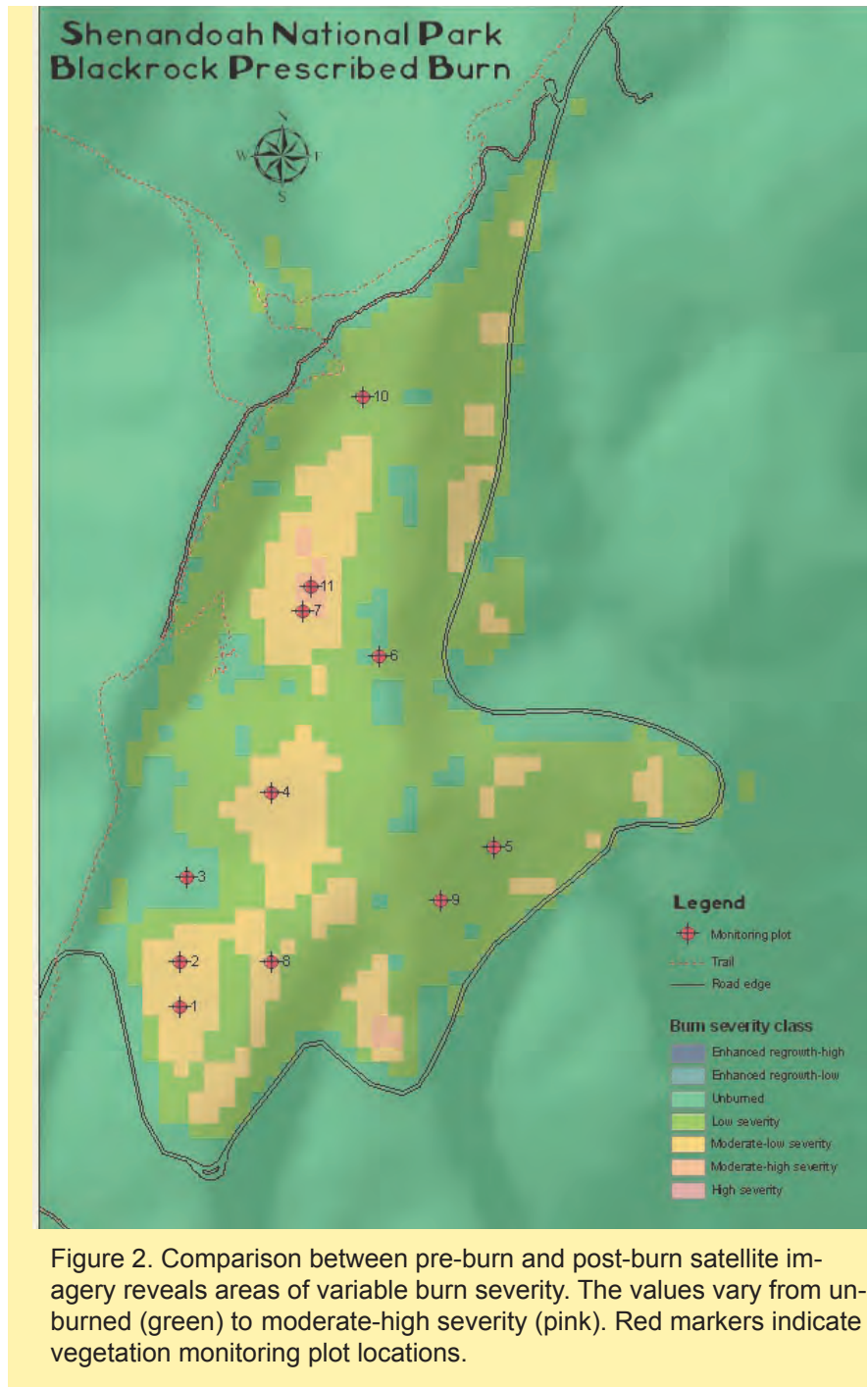


Figure 2. Comparison between pre-burn and post-burn satellite imagery reveals areas of variable burn severity. The values vary from unburned (green) to moderate-high severity (pink). Red markers indicate vegetation monitoring plot locations.

mation available. It is the role of the GIS Specialist to create this spatial information, maintain its currency, and deploy it as a standard set of map products during a wildfire incident. Beyond the incident, the data and maps live on as input to fuel models, landscape rehabilitation plans, and fire decision support tools (fig.3).

One such risk assessment and fire behavior tool, the Wildland Fire Decision Support System (WFDSS), is being deployed throughout the Northeast Region by wildland fire managers during the 2010 fire season. Fire offices at Acadia NP, Cape Cod NS, Delaware Water Gap NRA, New River Gorge NR, and Shenandoah NP have been working diligently with cooperators at North Carolina State Univer-

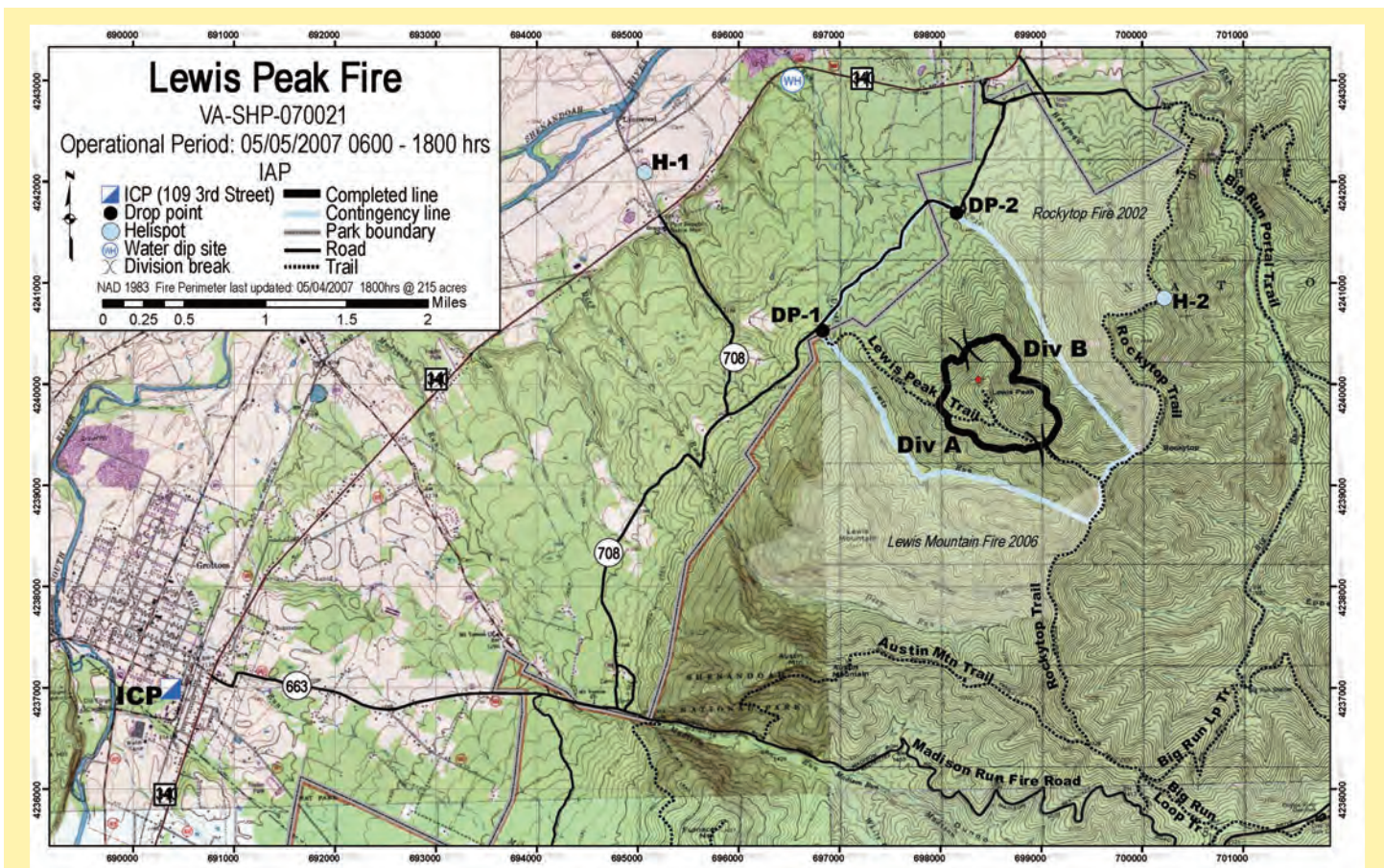


Figure 3. Wildland fire incident support map used during the 2007 Lewis Peak Fire at Shenandoah National Park.

sity's Center for Earth Observation to get their GIS data and knowledge base ready. To support fireline decisions, WFDSS draws on inputs from the Landscape Fire and Resource Management Planning Tools Project, Wildland Fire Management Information reporting system, Enterprise GIS data standard for buildings, and local park GIS data sets for accurate analysis.

Education and Outreach

Reducing wildfire risk to homeowners living at the wildland urban interface begins with knowing where woodland home communities exist. Realizing this need, the Wildland Hazard Assessment Methodology (WHAM) was developed by staff at Shenandoah NP. Implemented from 2004 to 2008, WHAM plays a supporting role in the fire program by serving six important needs:

- fire education and prevention program for the homeowner
- planning tool for communities and local rural fire departments
- storehouse of data on wildland fuel conditions
- critical information concerning values at risk to an approaching wildfire
- identification of high risk properties near proposed burn units
- support for funding requests for fuels reduction projects.

To date, WHAM assessment teams employed through the Student Conservation Association's Fire Education Corps and using the latest GIS and GPS mapping technology have completed over 5,600 assessments at seven park units scattered across four NPS regions. In the Northeast Region these include Delaware Water Gap NRA (393 assessments), Shenandoah NP (620 assessments), Acadia NP (1,612 assessments), and New River Gorge NR (202 assessments).

A similar effort with a more regional scope is the USDA Forest Service's Northeastern Wildfire Risk Assessment (NWRA). Using GIS analysis as its backbone, the NWRA effort addresses the need of local, state, and national land management agencies to understand and communicate wildfire risk to woodland home communities. The project is supported by a multi-disciplined, steering committee whose goals are to

- identify areas prone to wildfire
- identify where hazard mitigation practices are most effective at reducing wildfire risk
- identify and prioritize communities at risk from wildfire
- focus resources in the areas of greatest need.

The results of the committee's geospatial working group will include an area-wide assessment and state-specific assessments (summer 2010). Currently in review, maps and data from this project will be shared with NER's five large fire parks.

Forecasting Land Use Change in the Upper Delaware River Basin

*Claire Jantz, Assistant Professor, Shippensburg University and
Leslie Morlock, GIS Specialist, Delaware Water Gap National Recreation Area*

Throughout the United States, lands administered by the National Park Service (NPS) are being subjected to increasing pressure along their borders from housing and commercial developments and the infrastructure needed to support these new population centers. The change in land use in the surrounding landscapes and ecosystems challenges the protection of the resources the NPS units have been legislated to protect. The Upper Delaware Scenic and Recreational River (SRR) and the Delaware Water Gap National Recreation Area (NRA)/ Middle Delaware SRR are prime examples of NPS units facing these challenges every day. Staff of these two parks are tasked with protecting the upper and middle Delaware River, the longest free-flowing river east of the Mississippi. The Delaware River watershed provides a wide variety of scenic, natural, cultural, and recreational resources and supplies drinking water for ten percent of the nation's population. This scenic area is less than 100 miles from the New York-Northern New Jersey-Long Island metropolitan area. Some southern counties in the watershed are considered part of this metropolitan area, illustrating the strong economic and commuting ties that exist between this relatively rural region and a major urban center. As development occurs around Delaware Water Gap NRA/ Middle Delaware SRR, park infrastructure is stressed, water quality is threatened, and natural communities that the park and nearby state lands pro-

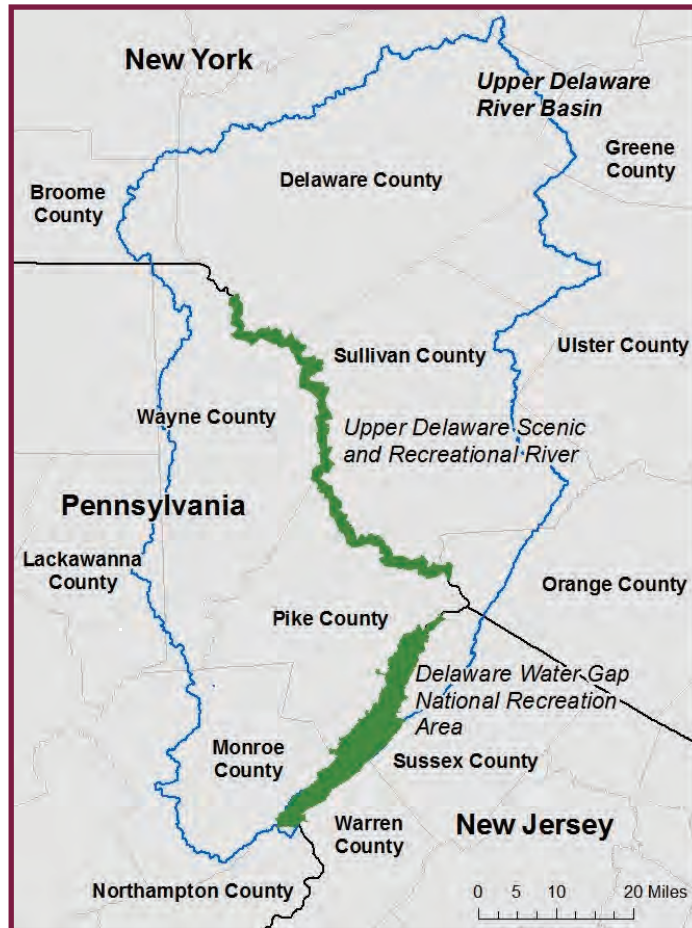


Figure. Study area. All labeled counties will be included in the region-wide study that is currently under development.

tect become isolated and fragmented. Upper Delaware SRR is faced with the administrative challenge of managing these resources without a federally-owned land base surrounding the river they protect, emphasizing the need for regional cooperation and planning.

Understanding how development has occurred in a region and predicting future patterns can be beneficial to both local governments and NPS managers as a tool for encouraging and striving

towards sustainable growth. Geographic Information Systems (GIS), remote sensing, and modeling are all powerful technological tools that can aid managers and planners in their decision making. The need was identified to develop land use strategies that can accommodate population and economic growth without sacrificing the natural resources and quality of life that attracts visitors and residents to the area. In 2003, this project began with a consortium, the River Valley GIS Group, consisting of GIS professionals and planners from local counties, the NPS, Shippensburg University, the National Aeronautics and Space Administration (NASA) and NASA contractors, and the Woods Hole Research Center. The task of the group was to develop a tool to tackle some of the complex problems in land use planning facing the region.

The initial phase of the project focused on the counties surrounding the Upper Delaware SRR: the Pennsylvania counties of Pike and Wayne, and the New York counties of Sullivan and Delaware. As the project moved forward, the study area has been expanded to include portions of thirteen counties intersecting the Upper Delaware River Basin (fig 1). This project has produced and will produce many useful products, including maps and assessments of where development has occurred between

1984 and 2005, and where it is likely to occur in the future, given different policy and growth scenarios.

Utilizing the knowledge from previous research and experience, the group settled on a model called SLEUTH as a tool for predicting growth patterns in the rural river valley. This freely available, public domain model was developed by Dr. Keith Clarke, a geographer at the University of California, Santa Barbara, with funding from the U. S. Geological Survey (USGS) Urban Dynamics Program. Since its public release in 1997, the SLEUTH urban growth model has been used to simulate urban development patterns in locations across the United States and the world (additional information on the SLEUTH model and the community that uses the model can be found on its website <http://www.ncgia.ucsb.edu/projects/gig/>).

Implementation of the model occurs in two general phases: calibration, where historic growth patterns are simulated; and forecasting, where the historic patterns of growth are projected into the future. Other inputs include transportation networks and a data layer that describes where development is more or less likely to occur (exclusion/attraction layer). The county planners have been integral in developing the exclusion and attraction layer by providing data and local expertise on what is driving local growth pressure. Based on all of these inputs, the model “learns” to replicate the historic patterns of development (calibration) and the results are used for forecasting future urbanization.

Establishing historic patterns of urbanization was the first phase of the project. Collaborator Dr. Eric Brown de Colstoun, of Science Applications International and NASA Goodard Space Flight Center, developed impervious surface maps from Landsat 5 Thematic Mapper (TM) satellite images for 1984, 1995, and 2005. The rural and forested landscape of the region posed some challenges for interpreting impervious versus non-impervious surfaces in the images. In some locations, impervious surfaces, such as roads or very low density housing, were hidden by tree cover, especially in the summer months. Other areas, such as agricultural fields, may appear as impervious during the winter months when there is little vegetation on the fields. Sampling sites of higher resolution aerial photography were used as “training data” to generate the impervious surface maps, and images from both winter and summer months were used to resolve some of the issues discussed above. Students at Shippensburg University also removed areas that are impervious, such as rock outcrops, but do not represent development. These maps provide both an important baseline for the extent of impervious surface in the study area for 2005 (Figure 2) and an assessment of where and how growth has occurred in the region since 1984.

NPS and county staff helped collect and deliver to Shippensburg University all of the data (e.g. roads, slope, protected areas, population density, and soils) needed to put together the other data layers necessary for inputs into the model and

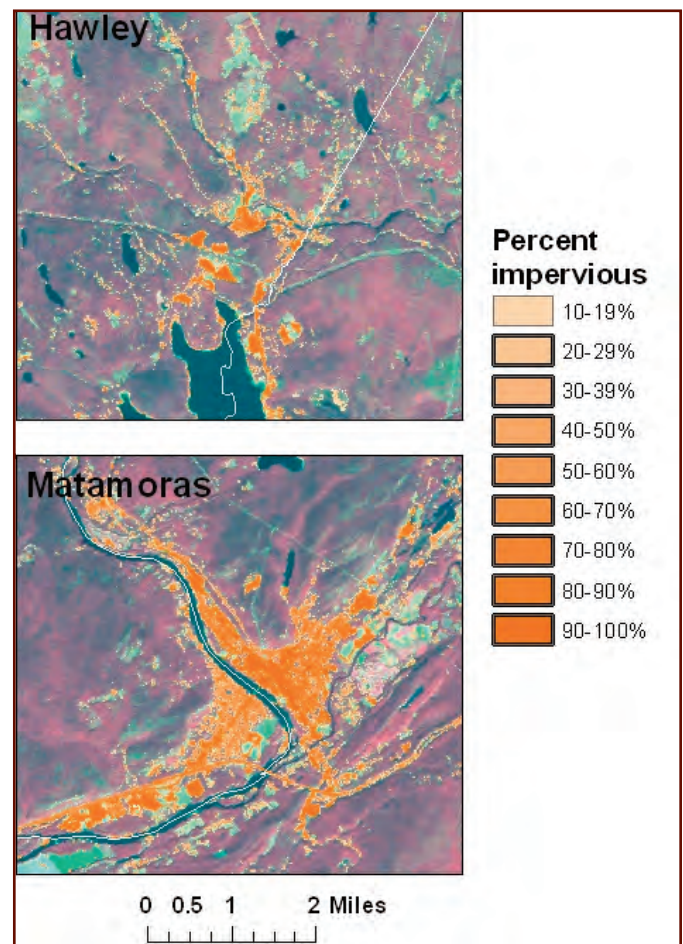


Figure 2. An example of the impervious surface data for 2005. The image shows, in orange, the location and intensity of impervious surfaces that are derived from the Landsat image.

developing the exclusion/ attraction layer. An individual exclusion/attraction layer was developed for each of the four counties included in the original study, and calibrations and forecast scenarios to 2030 were run separately for each county. For example, Pike County, which borders both Upper Delaware SRR and Delaware Water Gap NRA/ Middle Delaware SRR, and which has been one of the fastest growing counties in the state of Pennsylvania for over a decade, identified five alternative future scenarios (figs. 3 and 4):

Scenario 1: Baseline/current trends

Scenario 1A: A “what if” scenario removing the influence of the growth pressure originating from the New York-Northern New Jersey-Long Island metropolitan area

Scenario 2: Best for protection of natural resources, where natural resource lands have high levels of protection

Scenario 3: Protection of natural resources while accommodating growth, where natural resource lands are protected, and growth directed into designated growth zones

Scenario 4: Amenity growth, where growth occurs

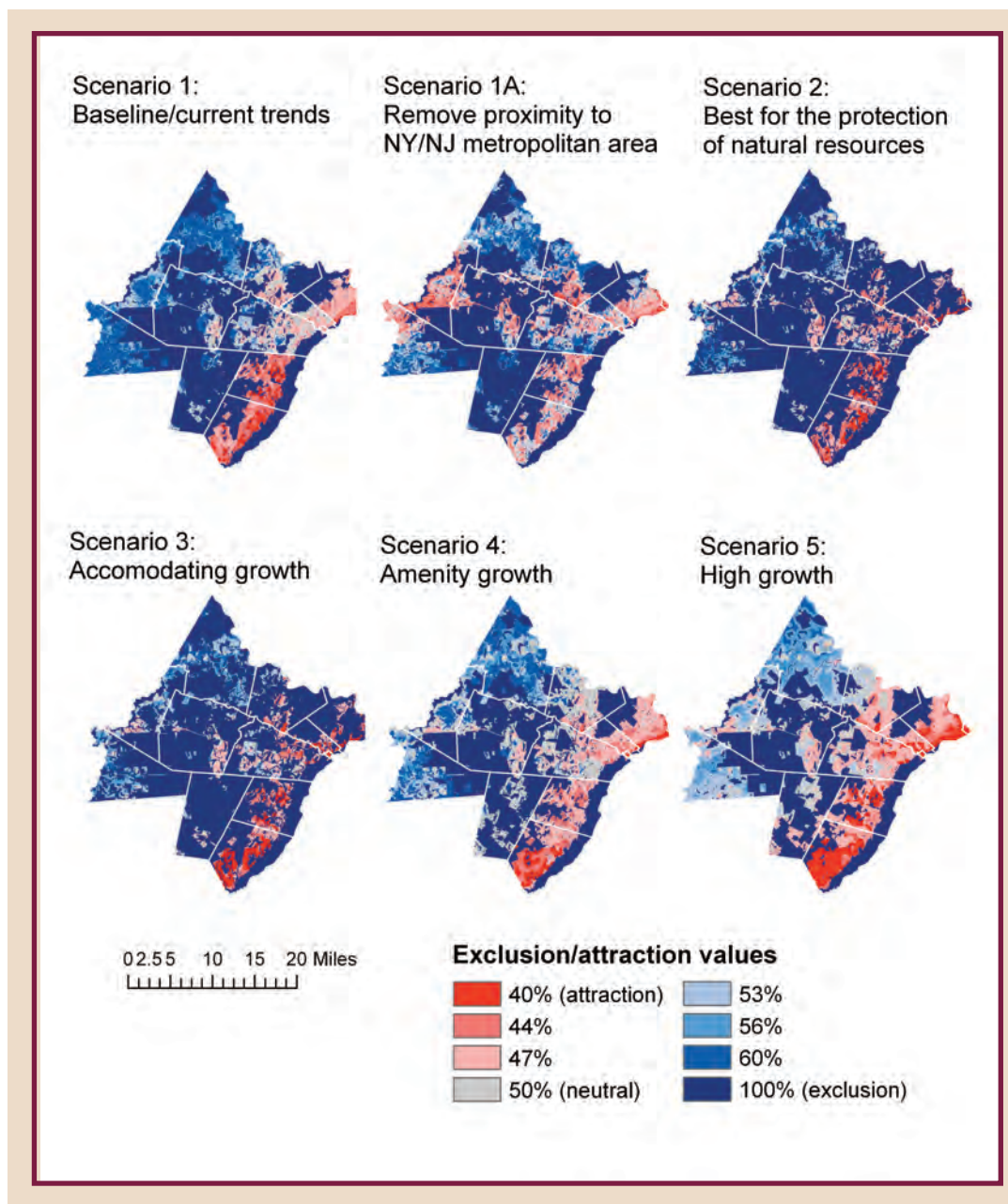


Figure 3. Scenario maps for Pike County. Each map represents different assumptions about growth pressure and land use policies in the future. Red indicates areas of high growth pressure and blue indicates areas of low growth pressure.

around natural amenity features, such as lakes and park boundaries

Scenario 5: High growth, where there are few protections placed on natural lands

As this project moves forward, Shippensburg University and the NPS are working with a total of thirteen counties in New York, New Jersey, and Pennsylvania that intersect the Upper Delaware River Basin to establish a regional exclusion/attraction layer and future scenarios for the entire region. The challenges with a regional-scale project include differences in the data available among the different counties and state. In addition, differing state laws, proximity to

urban centers, or the location relative to the New York City water supply areas make establishing a representative baseline difficult. Other challenges stem from the variations in growth rates and patterns that occur across the region; some counties continue to grow in population while others are losing population. All of the counties are struggling to seek a balance between protecting land while still promoting economic development. The collaboration between the counties, the NPS, and researchers has proven invaluable to the region as a whole. As we move forward, facing new development challenges in the form of natural gas development, transmission corridors, and economic

downturns, it is encouraging to work together, using GIS and other technological tools, to benefit the basin and the protection of the unique resources it provides.

For more information, see:

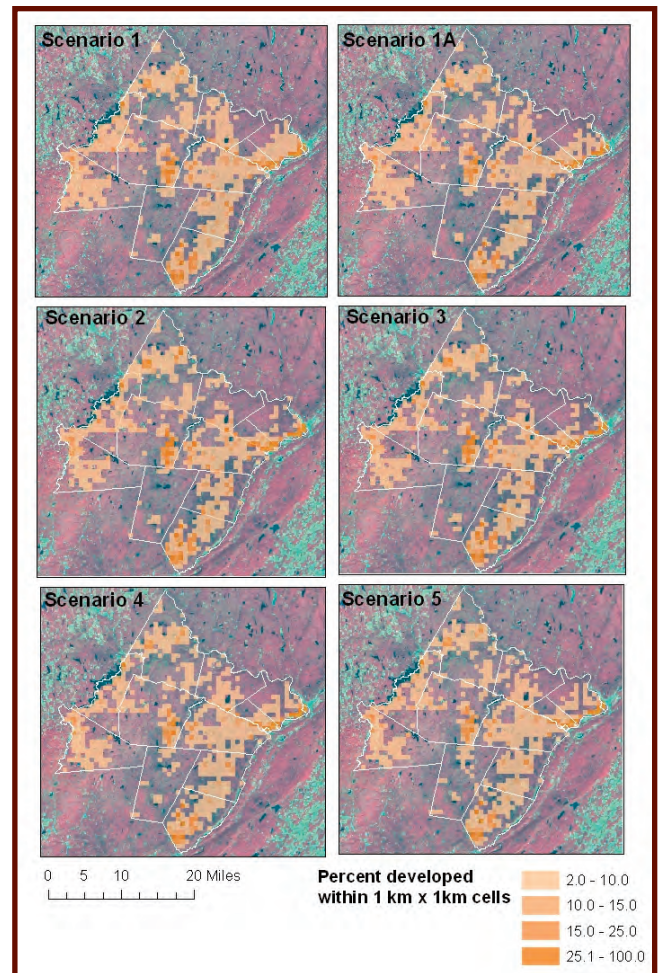
Jantz, C.A., M. Mrozinski and E. Coar. Forecasting Land Use Change in Pike and Wayne Counties, Pennsylvania. April 2009. 45 p. Available on-line at http://webspace.ship.edu/cajant/research_upper_delaware.html.

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Jantz, C.A. and S.J. Goetz (2007). Can Smart Growth Save the Chesapeake Bay? *Journal of Green Building* 2 (3): 41-51.

We thank all of our project partners, especially the county planning staff in Pike, Wayne, Sullivan, and Delaware counties. Funding and support for this project has come from the Pennsylvania Department of Conservation and Natural Resources Community Conservation Partnership Program, Delaware County Planning Department, NASA, and the National Park Service.

Figure 4. Forecasted growth by 2030 in Pike County for each of the county-defined six scenarios.



The View from Saratoga

Chris Martin, Integrated Resource Manager, Saratoga National Historical Park

Visitors come to national parks to experience what is within the park. However, what they see when looking outward from the park is also a memorable part of their experience – a jarring one if external development presents a sharp contrast to the park itself. The Inventory and Monitoring (I&M) report “Land Use Change Over Time” from the Northeast Temperate I&M Network documents the recent rapid alteration of such landscape perspectives for many parks. Visual encroachment on the historic scene was a particular concern at Saratoga National Historical Park. In the case of Saratoga NHP, the areas of concern were of interest to both local residents and visitors. These landscapes provided many of the interpretive opportunities from within the park, and were

important for protecting park resources and buffering impacts of external development.

In a proactive move to assess the park's surroundings with respect to potential development, staff arranged for a GIS-based viewshed analysis in 2001. This initial project, part of the General Management Plan process, was performed by Roland Duhaime of the University of Rhode Island and included development of a high resolution elevation dataset for the area. The results prompted park managers to contract for refinements to the analysis that allowed them to hone in on particular concerns in 2004. Modifications included adding vegetation heights (using the USGS National Land Cover Dataset) as well as local land use reg-

ulations, environmental suitability for development criteria, NY State Real Property Service property class code, and distance zone parameters. Parcels within the viewsheds were prioritized from 1 to 5 in terms of concern based on all these variables. In 2006, additional modifications were made including creating elevation data for the Saratoga Monument, a major park feature at 155 feet, to determine its “viewability.” The “background” dataset was removed from the distance classification analysis because it stretched many miles from the park, and the zone of visibility was redefined as being 3-5 miles from specific points within the park. Class 5 parcels - little/no risk - were shown on the map only as land area, a backdrop to category 1-4 parcels of higher concern. A

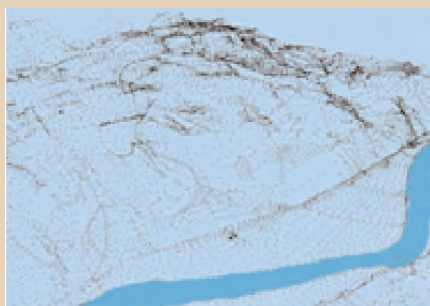
new layer, 'Limited Agricultural Development' was added to include parcels which have already been preserved through various preservation methods.

A local land conservancy group, Saratoga PLAN, picked up and expanded upon the park-based effort, applying (successfully) for American Battlefield Protection Program (ABPP) funding. Their 2007 publication "Battles of Saratoga Preservation and Viewshed Protection Plan, Phase 1: Historic and Scenic Resource Inventory and Analysis" has as a major component a GIS analysis that drew upon the ABPP mapping of Revolutionary War battlefields, the NPS viewshed maps, and built-in additional criteria and attributes. For this report, the PLAN group identified and ranked locations of historical significance and the associated scenic resources. They then performed a combined analysis using the ranked scenic resources, the viewshed analysis, and the development threat level (from the 2006 report) to derive what they called the "composite layered analysis." This

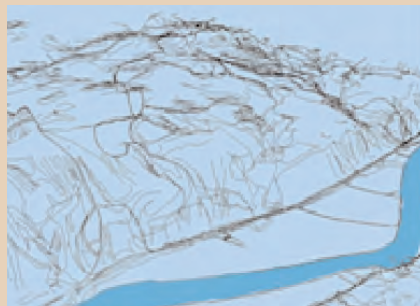
product identifies the priority cultural landscape areas and individual features that provide the contextual setting for the interpretation of the events associated with the battles, siege, and surrender at Saratoga.

In 2009, Saratoga PLAN obtained funding to take the analysis data and craft a protection plan for what has become known as the "Old Saratoga on the Hudson Region." This area includes the battlefield as its centerpiece and is made up of the towns on either side of the Hudson River north and south of the battlefield and Old Saratoga Units. The plan describes how to implement the 2007 plan into actual on-the-ground preservation. It is something that local governments can adopt into their existing plans and hopes are that people at many levels inside and outside of government can work collaboratively to protect the resources identified in these plans. Yet another grant paid for a recently completed feasibility study which looks at the funding side of all this proposed protection. This study came up with

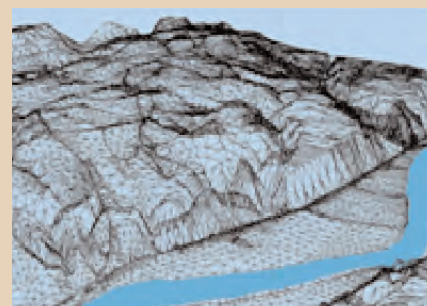
estimates on what it would cost to implement the plans and looked at feasibility. The report concludes that the total dollar amount needed is not insurmountable, and there are a number of land protection groups ready to assist with the implementation of land protection strategies (mostly through the purchase of land development rights). In 2006 The Historic Saratoga-Washington on the Hudson Partnership was established by the state to support local efforts within the Upper Hudson Corridor to preserve, enhance and develop the historic, agricultural, scenic, natural and recreational resources of the region. It has recently requested funding to implement the Battles of Saratoga Preservation and Viewshed Protection Plan. This represents seed money for the local not-for-profits to use in securing development rights, agricultural easements, scenic easements, and acquisition of high priority parcels identified in the plan. If allocated, the funds will be administered by the Partnership through the NY State Natural Heritage Trust.



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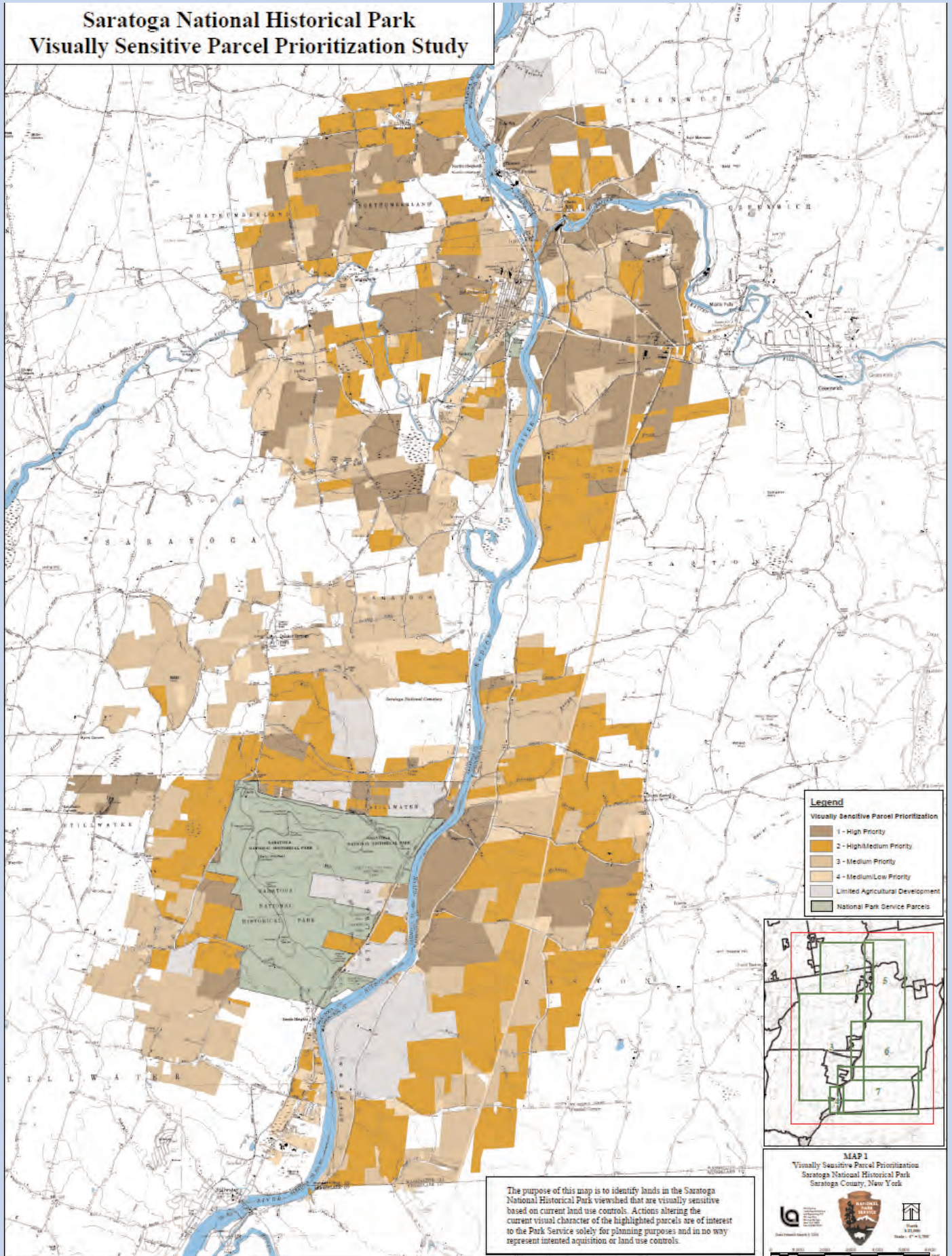
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This series of images shows the development of the elevation data for Saratoga National Historical Park from (1) points to (2) breaklines to (3) a TIN (triangulated irregular network) to (4) a raster surface and, finally, to (5) an orthophoto draped over the raster surface. The Hudson River is in the lower right of these images.

Saratoga National Historical Park Visually Sensitive Parcel Prioritization Study





GIS planning map used in the field to direct ground crews and inform tactical operations to manage fire. See *GIS and Fire Management*, page 11. (photo: Barb Stewart, NER Fire Education Specialist)

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Please let *Science and Management* know of projects and practices at your park or network that might be useful to colleagues elsewhere. Contact the editor at bmb4@psu.edu.

Sound science is the foundation for good resource management decisions. The National Park Service invests in science programs to responsibly protect and manage the precious resources entrusted to our care. The power of this research is multiplied when the information is shared. This publication, *Science and Management*, is brought to you from the Northeast Region's Natural Resources and Science Division. Its goal is to share with park staff, scientists, and the public, the innovative resource management work being done throughout the region.

Dennis Reidenbach, Regional Director