

IMPACTS OF LAND-COVER CHANGE ON THE NATIONAL PARKS OF THE NORTHEAST TEMPERATE NETWORK

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ABSTRACT

The purpose of this proposal is to provide a landscape context for the 11 parks (Table 1) in the National Park Service's Northeast Temperate Network. Superintendents and resource managers have identified changes in land use surrounding Network Parks as a primary threat to park ecosystems. This project will quantify changes in land-cover types associated with the increase in human development around Network parks over the past 30 years. This information will aid resource managers and the National Park Service's Inventory and Monitoring program to identify and prioritize ecosystem stressors caused by human encroachment adjacent to parks. Providing this landscape context for park ecosystems, and quantifying the extent of land cover changes adjacent to parks is a critical step in the development and implementation of a long-term monitoring program. Activities will include an assessment of land-cover types using Landsat imagery from 3 time periods between 1973 and the present. Land cover types within and surrounding parks will be quantified for the three time periods, and changes in these land cover types over time will be calculated. The precise dates for each park will be based on image quality, availability, and cost. The amount of land assessed outside of each park will be determined after individual consultations with park managers, superintendents, and Inventory and Monitoring program staff.

INTRODUCTION

The human population in the United States is growing. The population in the United States increased nationwide by 13.2 percent between 1990 and 2000; in the Northeast, 5.5 percent (U.S. Census Bureau 2001). Current economic conditions have driven record numbers for new residential construction (U.S. Census Bureau 2003). New commercial districts will be built to meet the needs of the new residents. Human development is becoming a challenge to the natural resources of the United States as natural areas are increasingly fragmented and isolated from their counterparts.

The National Park Service Northeast Temperate Network (NETN) intends to document how the landscape has changed in the vicinity of their respective units. The NETN includes 11 parks located in different landscape settings (Figure 1) and sizes (Table 1). Acadia National Park is the largest with 15,414 hectares, while the Saugus Iron Works National Historic Site is the smallest with only 4.5 hectares. Suburban sprawl, sources of non-point water pollution, timber harvests, and increasingly fragmented natural habitats are a few factors outside of park boundaries that impact the ecosystems within the parks. Knowledge of historical trends of land-cover change, not only *how much* has changed but also *where* and *when* changes occurred, will help resource managers identify key resources and ecosystem stressors, and prioritize resource management efforts to further the development of a Vital Signs Monitoring Program. This proposal focuses on quantifying land-cover changes over the past 30 years within and surrounding park units in the NETN.

While land-use refers to how the land is being used by human beings, land-cover refers to the biophysical materials found on the land (Jensen, 2000). Understanding land-cover change will help to establish a landscape context for each park, giving natural resource managers a better understanding of how park ecosystems fit into the broader landscape, and will assist them to better prioritize ecosystem management. An assessment of land-cover changes over time will provide estimates of habitat changes within and around parks that can identify priority ecosystems to monitor within the park. The quantification of land-cover changes over time can be used to examine relationships between land-cover change and wetland plant communities (Lopez et al., 2002), water quality (Arnold and Gibbons, 1996), and general ecosystem health (Paruelo et al., 2001).

Land-cover data resulting from this effort will not only provide landscape context for each park, but will establish a baseline for monitoring land-cover changes over time. The NETN does not yet have a consistent record of land-cover from which to start a network-wide monitoring program. This project will provide this essential baseline data. With these data in hand, the NETN will have several options available. At minimum, a simple monitoring program of repeated land-cover assessments every 10 years using remote sensing imagery could be implemented. If dramatic land-cover change is evident for certain

parks, it may be useful to determine how the land-cover changed every 5 years since the early-1970's. A baseline land-cover dataset such as this may be used to fuel change models that predict how the landscape context of each park may change in the future. Further refinement by visually interpreting the land-cover data, in conjunction with the original source images and ancillary data, can produce land-use information that could be used for further study (Cihlar and Jansen, 2001). For example, a park addressing sources of non-point water pollution may need to know the locations of high-density residential areas and industrial areas. Analysis of the baseline land-cover data, combined with census data and visual interpretation of the source Landsat imagery, will produce an effective land-use map that should help in this instance.

OBJECTIVES

This proposal is consists of three primary objectives:

Objective 1: Document land-cover types within and surrounding the 11 NETN National Parks for 3 time periods from early 1970's, mid-1980's, to the present

Current and historical land-cover data will be extracted from Landsat MSS, TM, and ETM+ imagery, and analyzed using digital supervised classification techniques. The resulting land-cover data will be the foundation for the subsequent land-cover change assessment. Current and historical photography will be requested from each park. Georeferenced digital orthophotography and traditional aerial photography will be used to provide an independent reference to evaluate the accuracy of the land-cover assessment (accuracy assessment). Ground truthing will provide important first-hand knowledge of each study area, aiding in the interpretation of randomly selected ground control points within the orthophotography.

Objective 2: Quantification of regional land-cover change

We will quantify changes in land-cover types within and adjacent to NETN parks for three time periods (1973-present). Land-cover change will be quantified within and around the parks and neighboring protected areas using predefined buffer zones. The proposed buffers are 500-m, 1000-m, and 5000-m. These buffer distances will ultimately be determined by park superintendents, resource managers, and the NPS Inventory and Monitoring Program staff. Land-cover types within each buffer zone will be extracted and changes in area and percentage calculated between the three time periods.

Objective 3: Assessment of impacts of land-cover change on the NETN parks and neighboring protected lands

Park Superintendents and resource managers have identified changes in land-cover as a priority concern for parks in the NETN. External threats, caused primarily by increasing human development around parks, are a primary threat to park natural resources. Assessing regional changes in land-cover types will provide a landscape context for each park and elucidate how park ecosystems fit

into the regional landscape, offering a greater understanding of the importance of each park's natural resources and importance with respect to regional biodiversity. This landscape context will help park superintendents and resource managers prioritize resource concerns. The analysis of the impacts of land-cover change will be achieved by documenting and studying the land-cover dynamics within and around the parks and neighboring protected areas by defined buffer zones. Impacts of land-cover changes on each park's natural resources will be analyzed and reported. After taking into consideration land-cover types within existing conservation lands surrounding parks, gaps in land protection will be determined. This analysis will provide the NETN with additional knowledge that will assist with prioritizing ecosystems and ecosystem threats that will be included in the development of the NETN Vital Signs monitoring program.

METHODS

Data Acquisition

This project is scheduled to begin in July of 2003. A library of GIS data will be compiled for each park. Readily available GIS data offered by online State and Federal resources will first be reviewed, then downloaded and processed to suit. Next, requests will be made of each of the parks for the data not readily available by the same online State and Federal resources. It is anticipated that the best-available boundaries, digital georeferenced orthophotographs and aerial photographs, and associated metadata will be requested from each park. The NETN will provide GIS coverages and associated metadata with respect to the boundaries of conservation lands surrounding parks.

The land-cover analysis classification will exclusively use imagery from the Landsat series of satellites. Remote sensing offers a unique perspective on how the Earth's landscape is changing, over both large spatial and temporal scales. Advantages of using satellite remote sensing include repeat temporal coverage, availability of reliable automated interpretation techniques, and lower cost when compared to traditional aerial photography (Bird et al, 2000). Since the inception of the Landsat Program with the launch of Landsat-1 in 1972, a tremendous library of remotely sensed data has been archived that addresses nearly any terrestrial location on Earth. There are alternative sources of remotely-sensed satellite data available that offer a higher pixel resolution than the Landsat Program. These sources are particularly good for manually delineating land uses at large map scales. However, none of these alternatives counter the Landsat Program's 30-year archive of data. Neither do they offer as much spectral information for any given pixel, often making digital classification more difficult. After consideration of the Landsat Program's combination of an unsurpassed 30-year library of data, and the data's multiple spectral bands, moderate pixel resolution, and reduced cost, Landsat imagery is the best source for imagery for this project.

Sources and quality of Landsat images will be assessed for each park. The source, cost, and quality of the images will determine which dates are selected for the land-cover change detection. It is anticipated that Landsat scenes from 1973, 1988, and 2002 will be selected. Heavily forested parks may require two scenes per time period. Working at a spatial resolution of 30 m, urban development can be obscured by deciduous forest canopy. Leaf-off scenes permit a more accurate assessment of urban areas. Urban areas usually consist of impervious surfaces, including pavement, asphalt, and rooftops. Additional leaf-off scenes will be obtained on an as-needed basis for parks where it is apparent that much of the urban areas are obscured by tree canopy. Given the spatial scale of a single Landsat scene, parks may share the same scene. If this is the case, preference will be given to these shared scenes as opposed to purchasing separate scenes for each park. Every effort will be made to select scenes that have dates as close together as possible for a given time period for all the parks. The end result will be easier to assess when analyzing the NETN as a whole.

Pre-Processing

On receipt of the Landsat imagery, each scene will be imported to match the file format required by the image analysis software. ERDAS Imagine image processing software will be used for the preparation of the Landsat scenes and subsequent land-cover classification. The geographic accuracy of each scene will determine if it requires geometric rectification. In this event, GIS data that serves as a reference source will be secured from either the park or the State in which the park resides. The spatial accuracy of all Landsat scenes and resulting land-cover data will meet National Map Accuracy Standards.

Ground Truthing

Ground observation exercises are planned for each park included in this proposal. When the Landsat imagery for a park is ready for analysis, we will examine the image and select areas of interest. These sites will be located and documented during each park's ground observation exercises using georeferenced digital photographs acquired with a Kodak Field Imaging System. Highly accurate, differentially-corrected Global Positioning System (GPS) data will also be collected with a Trimble ProXR GPS unit for use with the verification of the spatial accuracy of the georectified Landsat scenes. The photographs and the GPS point and transect data will be combined to create a Virtual Field Reference Database (VFRDB) for each park. We will meet with each park's natural resources manager to discuss areas of concern to highlight in the park's report on land-cover change. The personal experience gained during the ground observation exercises, and the resultant VFRDB for each park, will prove invaluable during the land-cover classification and subsequent accuracy assessment. Ground truthing will take place during August of 2003 and continue during the summer of 2004.

Classification System

The classification system for this study will seek to match the equivalent of Anderson Level II (Anderson 1976) for the actual land-cover data. The land-cover change analysis will be conducted at Anderson Level 1. The classification scheme will be modified to accommodate as much of the NPS Vegetation Mapping Project's classification system as the data permits (Table 2).

The Landsat scenes will be processed using supervised classification. Supervised classification involves the analyst defining spectral signatures to be associated with each land-cover type, then instructing the software to identify and sort the pixels accordingly.

Accuracy Assessment

The accuracy of the land-cover results will be assessed against an independent, digital, geographically referenced (georeferenced) source whenever possible. The reference source will ideally be digital orthophotographs from the same year as the land-cover data. Alternative independent reference sources include georeferenced historical aerial photographs and historical GIS layers. The color infrared orthophotographs scheduled to be flown and processed in 2003 for selected parks by the NPS Vegetation Mapping Program will be ideal for the accuracy assessment of the 2002 land-cover data. If photography or GIS datasets are not available for the accuracy assessment, a likely scenario for the early-1970's and mid-1980's land-cover data, the accuracy assessment will be conducted using the original source Landsat imagery as the reference.

Land-Cover Change Analysis

We will complete our land-cover change analyses using image differencing modeling protocols developed by Wang, 2003. It involves subtracting one georeferenced image or GRID from another, then tabulating the results that answer questions such as "How much agricultural land has been converted to a developed area between 1988 and 2002?" The differences between the 1973 & 1988, 1988 & 2002, and 1973 & 2002 land-cover datasets will be calculated for each land-cover type. Map generalization techniques will be used when necessary (Petit and Lambin 2001).

The analysis will end with an examination of land-cover change within specific distances of each park and nearby protected areas (buffer zones). We propose applying 500-meter, 1000-meter, and 5-kilometer buffer zones around each park to study the impacts of surrounding land-cover change on the properties of the NETN parks. It is clear that each park in the NPS NETN is different. In light of this, buffer zone distances used in the final stage of the analysis will be determined for each park by the superintendent, resource manager, and Inventory and Monitoring staff.

DELIVERABLES

We will deliver the preliminary customized reports indicated in the project timeline (Table 3, next section), with a customized final report at the conclusion of the project. Copies of each report will be sent to the NETN coordinator. The comprehensive network-wide report for the NETN coordinator will be the final deliverable of this project. All reports will be issued in digital format, on digital media (CD or DVD), using the latest standard file formats. The media that the final report is issued on will have an html interface to assist with finding desired data and written information.

The final report will consist of the following:

- GRID land-cover and equivalent ArcInfo vector polygon files for each park addressing each of the 3 time periods as well as the change analysis results. Spatial resolution of the files will correspond to spatial resolution of source imagery. All files will be accompanied by Federal Geographic Data Committee (FGDC) compliant metadata.
- Source GIS data with metadata if permitted by issuing agency.
- Source Landsat imagery if permitted by issuing agency.
- Tabulated land-cover change data within defined buffer zones
- Written report that assesses land-cover changes and associated impacts over 3 time periods within each park and nearby protected areas, as well as within the buffer zones surrounding each park and protected areas. These buffer zones will be determined by park management and Inventory and Monitoring program staff.

TIMELINE

This project will maintain a timeline that consists of four phases (Table 3). Phase I, concluding August 31, 2004, consists of a series preliminary reports submitted to each park and the NETN coordinator. The Phase I preliminary reports will document the current status of each park's land-cover classification. Pertinent data will be included with the report. Phase II, ending January 31, 2005, consists of the final land-cover classification results, reflecting comments from each park, in addition to the preliminary land-cover change results. The land-cover change analysis and associated tabular data will be completed during Phase III. This project will conclude on July 15, 2005 with the end of Phase IV. At this time, each park manager will receive a customized report for their respective unit. The NETN coordinator will receive copies of the park manager reports in addition to a comprehensive report addressing the NETN as a whole.

RESEARCH TEAM AND FACILITIES

This project will be accomplished through a partnership with the Laboratory for Terrestrial Remote Sensing (LTRS) at the University of Rhode Island. The LTRS has accumulated extensive experience in studying land-cover change and impacts on natural communities, including projects encompassing the Chicago Wilderness Region (61,000 hectares) (Wang and Moskovits, 2001), State of Rhode Island (275,000 ha) (Novak and Wang, 2003) and the coastal districts of the East African nation of Tanzania (6.6 million ha) (Wang, et al., 2003). The LTRS possesses all necessary hardware equipment and software systems to conduct the project. The LTRS enjoys a close working relationship with the Environmental Data Center. The Environmental Data Center is the Field Technical Support Center for the New England Cluster of the National Park Service.

Dr. Y.Q. Wang, an Associate Professor at the University of Rhode Island, will be the principal investigator and lead the project. Dr. Wang has been working in the field of remote sensing land-cover change detection and impact analysis in the past several years. He has been leading projects funded by NASA, USAID, and USDA in land-cover change study and dynamic modeling. He manages two staff and seven graduate students that constitute the LTRS.

Gregory Bonyng, the co-investigator, earned his B.A. in Biology from Wesleyan University in 1998, and his M.S. in Environmental Science in 2001 from the University of Rhode Island. His M.S. work addressed using high resolution multispectral imagery to assess the extent of the urban forest in Providence, RI. A Research Associate who specializes in digital image analysis and associated GIS & GPS technology, Mr. Bonyng shares his skills with the LTRS and the Environmental Data Center. His current work addresses land-cover change in the Mt. Kilimanjaro region of Tanzania.

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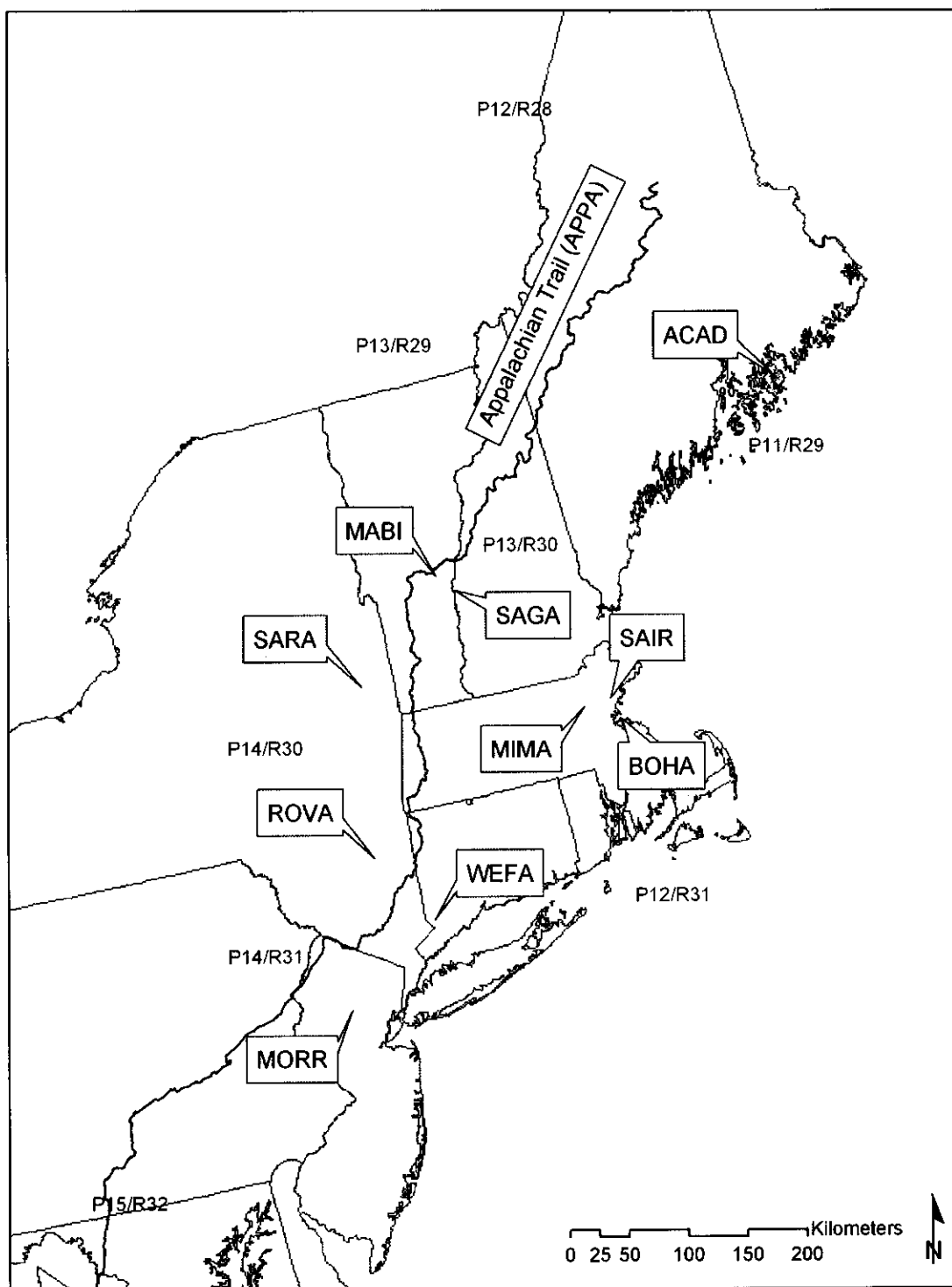


Figure 1. The National Park Service Northeast Temperate Network

The eleven NPS NETN units designated for this project are represented by their four-letter NPS codes, and shown with Landsat WRS-2 Path/Row references.

Table 1. The NETN parks included for this proposal.

Park	Code	Hectares	Most Recent Orthophoto Availability	
			Date	Type
Acadia National Park	ACAD	15,414	(to be determined)	
Appalachian National Scenic Trail (10 segments)	APPA	10 segments to be determined	(to be determined)	
Boston Harbor Islands National Park Area	BOHA	464*	(to be flown Spring 2003)	(1 m CIR)
Marsh-Billings-Rockefeller National Historical Park	MABI	245	(to be flown Spring 2003)	(1 m CIR)
Minute Man National Historical Park	MIMA	345	(to be flown Spring 2003)	(1 m CIR)
Morristown National Historical Park	MORR	666	(to be determined)	
Roosevelt-Vanderbilt National Historical Sites	ROVA	249	(to be flown Spring 2003)	(1 m CIR)
Saint-Gaudens National Historic Site	SAGA	47.6	(to be flown Spring 2003)	(1 m CIR)
Saratoga National Historical Park	SARA	1,165	(to be flown Spring 2003)	(1 m CIR)
Saugus Iron Works National Historic Site	SAIR	4.5*	(to be flown Spring 2003)	(1 m CIR)
Weir Farm National Historic Site	WEFA	17.5	(to be flown Spring 2003)	(1 m CIR)
BOHA and SAIR are lower priority due to their environs and will be completed time permitting.				
¹ Source: National Park Service vector digital data; November 2002.				
² Availability of current orthophotos is not guaranteed, pending permission for use. CIR orthophotos scheduled for Spring 2003 are being flown for the National Park Service's Vegetation Mapping Program.				

Table 2. Tentative Classification System

Code Category	
100	Urban or Built Up Land
200	Agricultural Land
210	Cropland
220	Pasture
300	Forest Land
310	Deciduous Forest
320	Evergreen Forest
330	Mixed Forest
400	Brushland
500	Water
600	Wetland
310	Deciduous Forested Wetland
320	Coniferous Forested Wetland
330	Scrub-Shrub Wetland
700	Barren Land
710	Sandy Areas
720	Rock Outcrops
730	Strip Mines, Quarries, & Gravel Pits
740	Bare Soil

Table 3. Timeline

Time		Description
July 2003	August 2004	initial land-cover classification and ground truthing completed; status report and preliminary data sent to parks and NETN coordinator
September 2004	January 2005	land-cover classification finalized after feedback received from parks; preliminary change analysis sent to parks and NETN coordinator
February 2005	March 2005	change analysis and associated tables completed
April 2005	July 15, 2005	final reports and metadata written; html interface prepared for CD's

Budget

		Year 1	Year 2	Sum
Salary and Benefits	1 Research Associate III	\$65,460	\$66,995	\$132,455
Data	Landsat MSS (10 @ \$200)	\$2,000	\$0	\$2,000
	Landsat TM (7 @ \$425)	\$3,400	\$0	\$3,400
	Landsat ETM+ (11 @ \$600)	\$6,600	\$0	\$6,600
Travel	Ground Truthing	\$2,000	\$4,000	\$6,000
	annual ASPRS Conference	\$2,500	\$2,500	\$5,000
Lab Fee		\$14,400	\$14,400	\$28,800
SUBTOTAL		\$96,360	\$87,895	\$184,255
URI Overhead (25%)		\$24,090	\$21,974	\$46,064
TOTAL		\$120,450	\$109,868	\$230,319

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This project is scheduled to begin in July of 2003. A library of GIS data will be compiled for each park. Readily available GIS data offered by online State and Federal resources will first be reviewed, then downloaded and processed to suit. Next, requests will be made of each of the parks for the data not readily available by the same online State and Federal resources. It is anticipated that the best-available boundaries, digital georeferenced orthophotographs and aerial photographs, and associated metadata will be requested from each park. The NETN will provide GIS coverages and associated metadata with respect to the boundaries of conservation lands surrounding parks.

The land-cover analysis classification will exclusively use imagery from the Landsat series of satellites. Remote sensing offers a unique perspective on how the Earth's landscape is changing, over both large spatial and temporal scales. Advantages of using satellite remote sensing include repeat temporal coverage, availability of reliable automated interpretation techniques, and lower cost when compared to traditional aerial photography (Bird et al, 2000). Since the inception of the Landsat Program with the launch of Landsat-1 in 1972, a tremendous library of remotely sensed data has been archived that addresses nearly any terrestrial location on Earth. There are alternative sources of remotely-sensed satellite data available that offer a higher pixel resolution than the Landsat Program. These sources are particularly good for manually delineating land uses at large map scales. However, none of these alternatives counter the Landsat Program's 30-year archive of data. Neither do they offer as much spectral information for any given pixel, often making digital classification more difficult. After consideration of the Landsat Program's combination of an unsurpassed 30-year library of data, and the data's multiple spectral bands, moderate pixel resolution, and reduced cost, Landsat imagery is the best source for imagery for this project.

Sources and quality of Landsat images will be assessed for each park. The source, cost, and quality of the images will determine which dates are selected for the land-cover change detection. It is anticipated that Landsat scenes from 1973, 1988, and 2002 will be selected. Heavily forested parks may require two scenes per time period. Working at a spatial resolution of 30 m, urban development can be obscured by deciduous forest canopy. Leaf-off scenes permit a more accurate assessment of urban areas. Urban areas usually consist of impervious surfaces, including pavement, asphalt, and rooftops. Additional leaf-off scenes will be obtained on an as-needed basis for parks where it is apparent that much of the urban areas are obscured by tree canopy. Given the spatial scale of a single Landsat scene, parks may share the same scene. If this is the case, preference will be given to these shared scenes as opposed to purchasing separate scenes for each park. Every effort will be made to select scenes that have dates as close together as possible for a given time period for all the parks. The end result will be easier to assess when analyzing the NETN as a whole.

Pre-Processing

On receipt of the Landsat imagery, each scene will be imported to match the file format required by the image analysis software. ERDAS Imagine image processing software will be used for the preparation of the Landsat scenes and subsequent land-cover classification. The geographic accuracy of each scene will determine if it requires geometric rectification. In this event, GIS data that serves as a reference source will be secured from either the park or the State in which the park resides. The spatial accuracy of all Landsat scenes and resulting land-cover data will meet National Map Accuracy Standards.

Ground Truthing

Ground observation exercises are planned for each park included in this proposal. When the Landsat imagery for a park is ready for analysis, we will examine the image and select areas of interest. These sites will be located and documented during each park's ground observation exercises using georeferenced digital photographs acquired with a Kodak Field Imaging System. Highly accurate, differentially-corrected Global Positioning System (GPS) data will also be collected with a Trimble ProXR GPS unit for use with the verification of the spatial accuracy of the georectified Landsat scenes. The photographs and the GPS point and transect data will be combined to create a Virtual Field Reference Database (VFRDB) for each park. We will meet with each park's natural resources manager to discuss areas of concern to highlight in the park's report on land-cover change. The personal experience gained during the ground observation exercises, and the resultant VFRDB for each park, will prove invaluable during the land-cover classification and subsequent accuracy assessment. Ground truthing will take place during August of 2003 and continue during the summer of 2004.

Classification System

The classification system for this study will seek to match the equivalent of Anderson Level II (Anderson 1976) for the actual land-cover data. The land-cover change analysis will be conducted at Anderson Level 1. The classification scheme will be modified to accommodate as much of the NPS Vegetation Mapping Project's classification system as the data permits (Table 2).

The Landsat scenes will be processed using supervised classification. Supervised classification involves the analyst defining spectral signatures to be associated with each land-cover type, then instructing the software to identify and sort the pixels accordingly.

Accuracy Assessment

The accuracy of the land-cover results will be assessed against an independent, digital, geographically referenced (georeferenced) source whenever possible. The reference source will ideally be digital orthophotographs from the same year as the land-cover data. Alternative independent reference sources include georeferenced historical aerial photographs and historical GIS layers. The color infrared orthophotographs scheduled to be flown and processed in 2003 for selected parks by the NPS Vegetation Mapping Program will be ideal for the accuracy assessment of the 2002 land-cover data. If photography or GIS datasets are not available for the accuracy assessment, a likely scenario for the early-1970's and mid-1980's land-cover data, the accuracy assessment will be conducted using the original source Landsat imagery as the reference.

Land-Cover Change Analysis

We will complete our land-cover change analyses using image differencing modeling protocols developed by Wang, 2003. It involves subtracting one georeferenced image or GRID from another, then tabulating the results that answer questions such as "How much agricultural land has been converted to a developed area between 1988 and 2002?" The differences between the 1973 & 1988, 1988 & 2002, and 1973 & 2002 land-cover datasets will be calculated for each land-cover type. Map generalization techniques will be used when necessary (Petit and Lambin 2001).

The analysis will end with an examination of land-cover change within specific distances of each park and nearby protected areas (buffer zones). We propose applying 500-meter, 1000-meter, and 5-kilometer buffer zones around each park to study the impacts of surrounding land-cover change on the properties of the NETN parks. It is clear that each park in the NPS NETN is different. In light of this, buffer zone distances used in the final stage of the analysis will be determined for each park by the superintendent, resource manager, and Inventory and Monitoring staff.

DELIVERABLES

We will deliver the preliminary customized reports indicated in the project timeline (Table 3, next section), with a customized final report at the conclusion of the project. Copies of each report will be sent to the NETN coordinator. The comprehensive network-wide report for the NETN coordinator will be the final deliverable of this project. All reports will be issued in digital format, on digital media (CD or DVD), using the latest standard file formats. The media that the final report is issued on will have an html interface to assist with finding desired data and written information.

The final report will consist of the following:

- GRID land-cover and equivalent ArcInfo vector polygon files for each park addressing each of the 3 time periods as well as the change analysis results. Spatial resolution of the files will correspond to spatial resolution of source imagery. All files will be accompanied by Federal Geographic Data Committee (FGDC) compliant metadata.
- Source GIS data with metadata if permitted by issuing agency.
- Source Landsat imagery if permitted by issuing agency.
- Tabulated land-cover change data within defined buffer zones
- Written report that assesses land-cover changes and associated impacts over 3 time periods within each park and nearby protected areas, as well as within the buffer zones surrounding each park and protected areas. These buffer zones will be determined by park management and Inventory and Monitoring program staff.

TIMELINE

This project will maintain a timeline that consists of four phases (Table 3). Phase I, concluding August 31, 2004, consists of a series preliminary reports submitted to each park and the NETN coordinator. The Phase I preliminary reports will document the current status of each park's land-cover classification. Pertinent data will be included with the report. Phase II, ending January 31, 2005, consists of the final land-cover classification results, reflecting comments from each park, in addition to the preliminary land-cover change results. The land-cover change analysis and associated tabular data will be completed during Phase III. This project will conclude on July 15, 2005 with the end of Phase IV. At this time, each park manager will receive a customized report for their respective unit. The NETN coordinator will receive copies of the park manager reports in addition to a comprehensive report addressing the NETN as a whole.

RESEARCH TEAM AND FACILITIES

This project will be accomplished through a partnership with the Laboratory for Terrestrial Remote Sensing (LTRS) at the University of Rhode Island. The LTRS has accumulated extensive experience in studying land-cover change and impacts on natural communities, including projects encompassing the Chicago Wilderness Region (61,000 hectares) (Wang and Moskovits, 2001), State of Rhode Island (275,000 ha) (Novak and Wang, 2003) and the coastal districts of the East African nation of Tanzania (6.6 million ha) (Wang, et al., 2003). The LTRS possesses all necessary hardware equipment and software systems to conduct the project. The LTRS enjoys a close working relationship with the Environmental Data Center. The Environmental Data Center is the Field Technical Support Center for the New England Cluster of the National Park Service.

Dr. Y.Q. Wang, an Associate Professor at the University of Rhode Island, will be the principal investigator and lead the project. Dr. Wang has been working in the field of remote sensing land-cover change detection and impact analysis in the past several years. He has been leading projects funded by NASA, USAID, and USDA in land-cover change study and dynamic modeling. He manages two staff and seven graduate students that constitute the LTRS.

Gregory Bonyng, the co-investigator, earned his B.A. in Biology from Wesleyan University in 1998, and his M.S. in Environmental Science in 2001 from the University of Rhode Island. His M.S. work addressed using high resolution multispectral imagery to assess the extent of the urban forest in Providence, RI. A Research Associate who specializes in digital image analysis and associated GIS & GPS technology, Mr. Bonyng shares his skills with the LTRS and the Environmental Data Center. His current work addresses land-cover change in the Mt. Kilimanjaro region of Tanzania.

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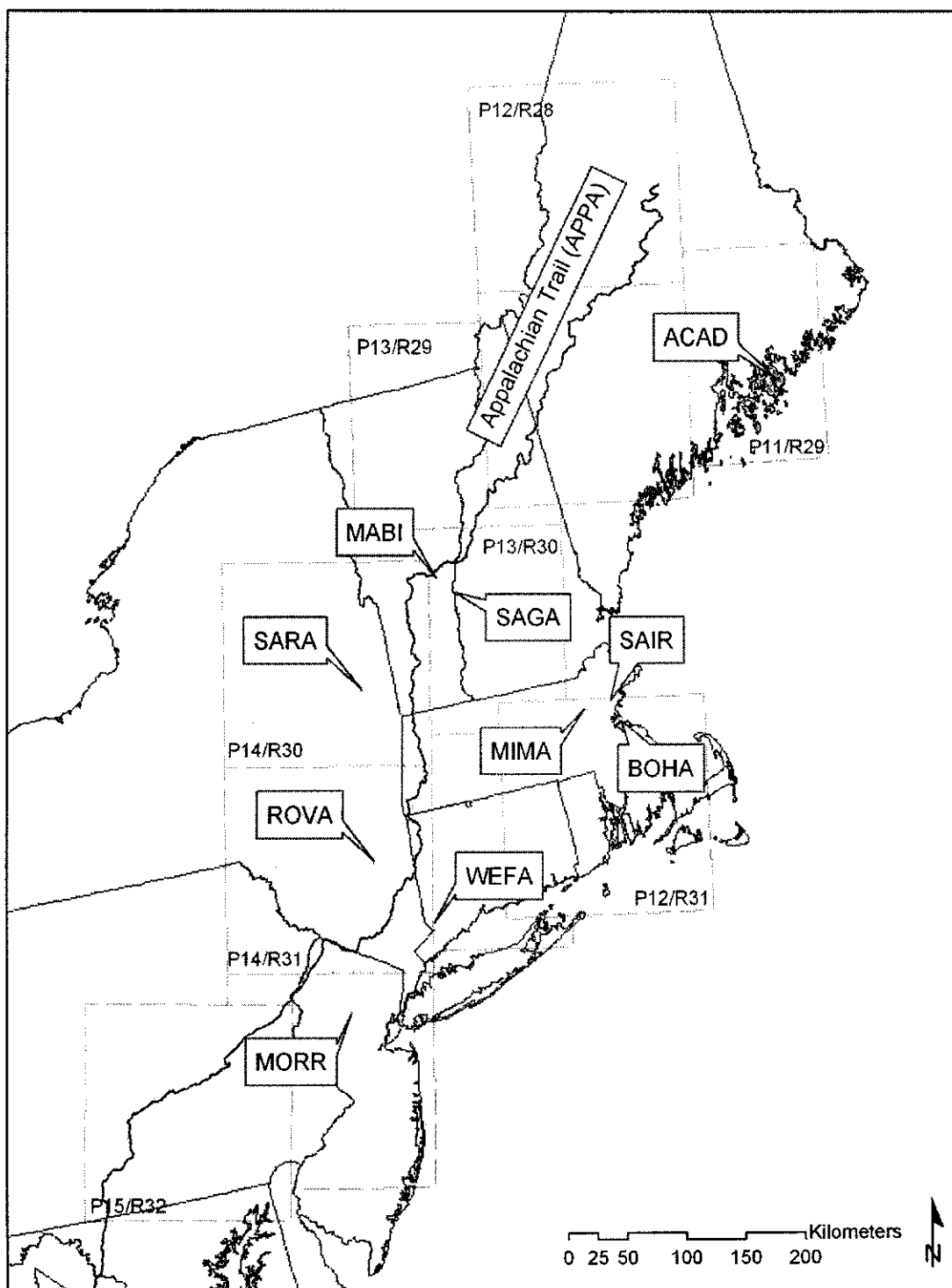


Figure 1. The National Park Service Northeast Temperate Network

The eleven NPS NETN units designated for this project are represented by their four-letter NPS codes, and shown with Landsat WRS-2 Path/Row references.

Table 1. The NETN parks included for this proposal.

Park	Code	Hectares	Most Recent Orthophoto Availability	
			Date	Type
Acadia National Park	ACAD	15,414	(to be determined)	
Appalachian National Scenic Trail (10 segments)	APPA	10 segments to be determined	(to be determined)	
Boston Harbor Islands National Park Area	BOHA	464*	(to be flown Spring 2003)	(1 m CIR)
Marsh-Billings-Rockefeller National Historical Park	MABI	245	(to be flown Spring 2003)	(1 m CIR)
Minute Man National Historical Park	MIMA	345	(to be flown Spring 2003)	(1 m CIR)
Morristown National Historical Park	MORR	666	(to be determined)	
Roosevelt-Vanderbilt National Historical Sites	ROVA	249	(to be flown Spring 2003)	(1 m CIR)
Saint-Gaudens National Historic Site	SAGA	47.6	(to be flown Spring 2003)	(1 m CIR)
Saratoga National Historical Park	SARA	1,165	(to be flown Spring 2003)	(1 m CIR)
Saugus Iron Works National Historic Site	SAIR	4.5*	(to be flown Spring 2003)	(1 m CIR)
Weir Farm National Historic Site	WEFA	17.5	(to be flown Spring 2003)	(1 m CIR)
BOHA and SAIR are lower priority due to their environs and will be completed time permitting.				
¹ Source: National Park Service vector digital data; November 2002.				
² Availability of current orthophotos is not guaranteed, pending permission for use. CIR orthophotos scheduled for Spring 2003 are being flown for the National Park Service's Vegetation Mapping Program.				

Table 2. Tentative Classification System

Code	Category
100	Urban or Built Up Land
200	Agricultural Land
210	Cropland
220	Pasture
300	Forest Land
310	Deciduous Forest
320	Evergreen Forest
330	Mixed Forest
400	Brushland
500	Water
600	Wetland
310	Deciduous Forested Wetland
320	Coniferous Forested Wetland
330	Scrub-Shrub Wetland
700	Barren Land
710	Sandy Areas
720	Rock Outcrops
730	Strip Mines, Quarries, & Gravel Pits
740	Bare Soil

Table 3. Timeline

Time		Description
July 2003	August 2004	initial land-cover classification and ground truthing completed; status report and preliminary data sent to parks and NETN coordinator
September 2004	January 2005	land-cover classification finalized after feedback received from parks; preliminary change analysis sent to parks and NETN coordinator
February 2005	March 2005	change analysis and associated tables completed
April 2005	July 15, 2005	final reports and metadata written; html interface prepared for CD's

Budget

		Year 1	Year 2	Sum
Salary and Benefits	1 Research Associate III	\$65,460	\$66,995	\$132,455
Data	Landsat MSS (10 @ \$200)	\$2,000	\$0	\$2,000
	Landsat TM (7 @ \$425)	\$3,400	\$0	\$3,400
	Landsat ETM+ (11 @ \$600)	\$6,600	\$0	\$6,600
Travel	Ground Truthing	\$2,000	\$4,000	\$6,000
	annual ASPRS Conference	\$2,500	\$2,500	\$5,000
Lab Fee		\$14,400	\$14,400	\$28,800
SUBTOTAL		\$96,360	\$87,895	\$184,255
URI Overhead (15%)		\$14,454	\$13,184	\$27,638
TOTAL		\$110,814	\$101,079	\$211,893