Center for Environmental Research and Conservation
CERC
Seed Grants for Collaborative Research and Training

Delineating Detailed Ecological Land Units in the New York Bioscape
Using Multi-temporal Landsat Imagery: A Pilot Study
Summary Report

- ❑ Research Planning Grant (Program A)
- **X** Preliminary Implementation Grant (Program B)
- ❑ Conservation Training Grant (Program C)

Date of Submission of Summary Report: 9/8/03

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Total Project Budget: $20,000   **Amount received from CERC: $20,000**

Executive Summary (100 words or less):

This pilot project constructs detailed ecological land unit (ELU) data using multi-temporal Landsat images and other biophysical layers. Our intent is that the resulting data products will leverage additional funding to implement such a conservation analysis for the entire New York City metropolitan region. The study area includes much of lower New York State though the primary calibration and testing site is Black Rock Forest (BRF). The project also focuses on capacity building at BRF and Wildlife Trust (WT), through increasing their staff's digital data content, Information Technology systems, and geospatial skills. The project strengthens collaboration amongst Columbia University, Black Rock Forest, and Wildlife Trust.

Office use:

Approved   **Declined**   **Request for re-submission**
Budget:

Delineating Detailed Ecological Land Units in the New York Bioscape
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SUMMARY REPORT
CERC G/L # 0-42307

Principal Investigators:
John Mickelson, CIESIN, Columbia University
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Fred Koontz, Wildlife Trust
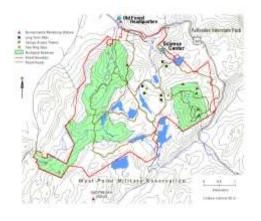
Project Period:
April15, 2002 - March 15, 2003

Figure 2.
Black Rock
Forest

Figure 3.
Study Area

Figure 1

Introduction:

This project seeks to advance our ability to resolve, map and analyze more accurate and precise digital geospatial data and information systems representing land cover and ecological communities patterns and processes. Specifically, we seek to establish the mechanisms and protocols for establishing adequately detailed spatial and thematic information and data baselines to be used for effectively mapping (locations and distributions), monitoring (conditions and changes), and modeling (historic paleo-ecological patterns, underlying drivers and system influences and projected future conditions and trends) integrated, multivariate environmental patterns and processes, across spatial and temporal scales in the NY metro region. Projects such as Wildlife Trust's NY Bioscape (*Cover Figure 1*) Initiative, NY DEC's Natural Heritage program and the Black Rock Forest Consortium's (*Cover Figure 2*) efforts will depend on such improved information to face effectively the challenges of surveying, managing, conserving and restoring the systems supporting their respective regions. This report summarizes the first year's progress for this *CERC Preliminary Implementation Grant*, including the extension of the work into the future, through the auspices of additional funding resources.

Results: Capacity Building

Progress on the project has been substantial and includes robust capacity building across the region as well as a doubling of the funding dollars represented by this grant. Resource development, stemming from the early stages of this grant, led to a project PI's becoming co-chair of a NY State Land Use\Land Cover (LULC) Study group, which led directly to the development of a NY State sponsored Land Use\Land Cover Working Group (http://www.nysgis.state.ny.us/reports/lulc/lulc_index.htm). Over 60 landscape characterization projects within NY State have been identified through these efforts and already work is underway at the State level, to help bring coordination, support and aid to the vast array of project foci and differing taxonomic systems. Such efforts will be invaluable in helping to make the information and spatial data being created by these varied agencies understandable, useable and available across project and spatial domains. Collaborations with over two-dozen of these Federal, State, regional and local agencies (*Table 1*) have already been developed by our PI's, in support of this CERC project.

While the underpinnings of our project approach have been well documented, (*1,2,4,7,9,10, 12*) many of our methods are experimental and we are eager to explore innovative approaches to further our ability to resolve finer and finer thematic units. To entertain critical discussion of current advances in the field, project staff attended the first *"Spectral Remote Sensing of Vegetation"* workshop, conducted by the US EPA, March 2003. The most current classification methods and image processing algorithms were overviewed, considered and debated by some of the worlds top vegetation scientists. This included state-of-the-art vegetation delineation techniques critical to acquiring indicators of overall ecosystem condition (*1,2,5,6*), environmental stress (*8,11*), and landscape change (*3,4*) at the local, regional, and global scale.

In addition, personal discussions with industry colleagues added greatly to the distillation of our image-processing tree, including how best to:

- Improve gain\inter sensor calibration between LS5 and LS7ETM+
- Register the best shadow\atmospheric corrections available
- Consider most current expert systems\decision tree classification algorithms
- Compare notes on image segmentation software - eCognition

- Consider addition of texture\pattern\feature analysis which can improve impervious surface mapping

The results of our work will be presented at the 2nd annual EPA Remote Sensing of Vegetation workshop, Spring 2004, which will focus on multi-temporal approaches to vegetation assessments.

In addition to developing an integrated and inter-relatable taxonomic approach, one of the main thrusts of our new project partnerships has been to expand the availability and interchange of the two most important and expensive data sources for remote sensing based LULC mapping; satellite imagery and ground control references. Virtually every project of this type is dependent on the two; the first - imagery of appropriate spatial, spectral and temporal coverage and resolution necessary to delineate the patterns or processes of interest, and the second - ground control, to defensibly reference, calibrate and test any resulting classification or segmentation. Combined, these data needs constitute the major financially expenses involved with remote sensing landscape characterization (*8*). A finite number of existing (archived) satellite images of the type being used for many of the regional studies, namely, Landsat Thematic Mapper "TM", from the Landsat 5 and Landsat 7 mission, exist within the time window of the majority of studies (past 10+ years). Since the most recent Landsat data are without copyright restrictions, meaning freely redistributable, and since many projects can make effective use of the same image, sharing and redistributing the imagery (currently priced at approximately $600\scene), makes great sense. We are currently negotiating with the following research centers, to consider the cross utilization of a matrix of some 80 Landsat (and other) satellite scenes, for our beta classification site (World Reference System II, Row 14, Path 31, *Cover Figure 3*.)

- Rutgers University – *Center for Remote Sensing and Spatial Analysis*
  - NY\NJ Highlands project
- Cornell University- *Institute for Resource Information Systems (IRIS)*
  - Spin offs from the NY GAP and Hudson River Submerged Aquatic Vegetation programs
- SUNY Syracuse - *School of Environmental Science and Forestry (ESF)*
  - VegBank – www.vegbank.org ESA Vegetation plot database project
  - Forest Health assessments
- NYS DEC
  - *Landscape Characterization Unit*
  - *NYS Heritage Program*
    - Rare plants and Ecological Communities Program
- The Nature Conservancy – Eastern NY Office \Albany Office
  - *Shawagunk Ridge Biodiversity Partnership* \ Mohonk Preserve
  - Ecological Land Units project
- University of New Hampshire – *Complex Systems Lab*
  - Catskills region, Hyperspectral foliar chemistry study
  - Hemlock Woolly adelgid study

Once each agency has assessed and listed their current image holdings (for Scene 14\31) and considered which additional dates they would like to have access to, the matrix will be compiled with a ranking of those scenes most sought by the widest array of collaborators, and the remaining scenes can be purchased, "filling in" the matrix with our remaining data buy dollars. We expect that this may more than triple our data buying power.

A similar approach is being taken with ground control\vegetation plot data, though immediately, due to data confidentiality issues, we began by looking for "gifted" plot and other vegetation relevee information, which contain appropriate X, Y coordinate information, from the collaborating agencies. We expect to have access to detailed compositional, structural and biogeographic information for nearly two thousand vegetation plots (*Table 2*) across the New York region. This represents, at a minimum, two to three complete field seasons and the outlay of enormous financial resources. In order to foster these kinds of data being make available for the long term, we are supporting the development of a field data banking mechanism being developed by the Ecological Society of America (ESA), in collaboration with the Nature Conservancy (NatureServe), called Vegbank (http://vegbank.nceas.ucsb.edu/vegbank/index.html) "VegBank is the vegetation plot database of the Ecological Society of America's Panel on Vegetation Classification. VegBank consists of three linked databases that contain (1) the actual plot records, (2) vegetation types recognized in the U.S. National Vegetation Classification and other vegetation types submitted by users, and (3) all plant taxa recognized by ITIS/USDA as well as all other plant taxa recorded in plot records. Vegetation records, community types and plant taxa may be submitted to VegBank and may be subsequently searched, viewed, annotated, revised, interpreted, downloaded, and cited." While the database currently contains less than a thousand plot records, if adopted and utilized widely enough, it could form the basis of an enormously valuable global resource for landscape ecologists, remote sensing engineers and a wide array of other earth researchers, needing to know the specific composition, structure and processes for a particular point on the earth. This could form the basis of baseline evaluations of changes over extended time periods into the future.

The University of Maryland, in conjunction with NASA's Goddard Space Flight center is prototyping a similar, on-line system for sharing satellite data, called *Satella* (http://satella.geog.umd.edu/). This peer-to-peer query and transfer protocol application is being developed in the hopes to make access to remotely sensed data much easier and less expensive. Such systems, if used and supported, could greatly enhance the availability of high quality LULC data to regional projects in NY.

Results: Additional Funding

This project has secured additional funding in an amount matching the dollars granted under the CERC program, through the auspices of Wild Life Trust. This will extend the work through June 2004, during which time we will integrate the vast amount of plot and image data, methodological and collaborating agency resources that have been developed during the initial stages of the project. Much of the work to be done includes performing the integration, filtering, classification and accuracy assessment of the detailed ecological land units sought. Additional vegetation plot data will also be acquired, filling in gaps spatially as well as compositionally (by classes) with the hopes that invasive species information (Purple Loosestrife - *Lythrum salicaria* and Common Reed - *Phragmites australis)* can be included within the classification efforts. If successful, we will produce the most accurate and detailed ecological land information that exists for the region, as well as the methodological engine that will drive the construction of the same level of detail for the entire NY Bioscape region.

A stumbling block in satellite image acquisition occurred in the later portion of the project, by way of an intra-image gain and band-to-band shutter miscalibration, for Landsat 5 imagery acquired by the USGS Eros Data Center (EDC) over the past 2 years (2001-2003). This includes all of the Landsat

5 scenes being considered for this project and represents nearly 60% of the total image budget. Fortunately the EDC, which also distributes the data, was able to develop and has just released a suitable re-calibration algorithm, allowing us to move ahead with the final data purchase and exchange with our collaborating partners. Discovery of the error, early Winter, 2002 allowed the waste of enormous project resources to averted, since work stemming from the miscalibrated imagery would have lead to enormous thematic allocation errors, requiring the work to be redone, using the recalibrated data.

The main focus of the extended work will be the production, calibration and accuracy assessment of digital ecological land information datasets for Landsat scene 14\31. We will produce a classification that will employ a taxonomic schema developed with the assistance of project collaborators. The resulting raster images will be produced and distributed in ERDAS ® Imagine format for use in common and widely used desktop GIS and image processing programs like ESRI's ® ArcView and ArcInfo GIS software. Products will include a cross-walked table, relating the final classification units to those for the other main land use\land cover types currently in use within the region.

Results: Black Rock Forest

This seed grant from CERC has benefited the Black Rock Forest Consortium by enhancing its scientific and management capacity in three ways. First, one of our staff members and a second field assistant received training in GPS field and analysis techniques, especially data logging. Subsequently they gained much field experience in GPS inventory work, providing ground-truthing that enhanced delineation of the ecological land units (ELU), the primary goal of this project. Through this involvement they have also increased their facility with correcting data and downloading data into a GIS. Secondly, the Consortium was able to upgrade its GIS workstation with this grant and has since added excellent new software to increase our analytical capabilities. Third, the project has increased the digital database for the forest in three ways: through new geo-referenced plot data for the forest obtained from the Natural Heritage program in Albany, through the addition of new GPS coordinates for a number of long-term forest inventory plots, and through digitization of some of the inventory data that previously existed only in hard copy form. These increased capabilities will benefit a number of institutions, researchers, and other visitors to the Black Rock Forest over the coming years. Staff members are continuing with the GPS and GIS work started in this project and will be pleased to contribute to the further development of the New York Bioscape project.

Results: Product Dissemination

Once completed, the procedures and methods will be distributed through professional journals and industry workshops to be attended by the project partners. Resulting cover type datasets, in the form of an ELU map, will initially be produced by late Fall 2003, shared with and critiqued by regional partners and collaborators and will eventually be made available to all interested parties. The project will also likely be represented within the Remote Sensing Applications section of the CIESIN web page, now being developed, which can provide broad distribution of the datasets through the Internet. The project will also be presented at the CERC Seminar Series, Tuesday, October 7, 2003.

Table 1 Collaborating Agencies

Agency	Office	Field(s) of Interest\Interaction
Brooklyn Botanic Garden	Brooklyn, NY	Spp. Home Range Maps, ecological health issues
Cornell University – Cornell Institute for Resource Information Systems (CIRIS)	Ithaca, NY	GAP program, LULC mapping, plot data\image sharing
Hudsonia	Annandale, NY	Biodiversity mapping and training
Institute for the Application of Geospatial Technology (IAGT) –	Cayuga, NY	Geospatial technology appls., possible image sharing
The Nature Conservancy – Eastern NY Chapter Berkshire Taconic Program,	Troy NY Sheffield MA	Ecological land units, mapping, conservation, possible plot\image sharing
Natural Resource Defense Council – NY Harbor Bight Project	New York, New York	Conservation, upland\marine interface, applications
NYS DEC - Landscape Characterization Unit	Troy, NY	NY Forest & Park resources, mapping, plot data\image sharing
NY Natural Heritage Program	Troy, NY	Conservation, rare & endangered spp., spp. mapping, plot data sharing
Rockland County NY – Planning Department	New City, NY	Land use planning, LU mapping, regional applications, monitoring
USGS – Land Cover Characterization Program	Sioux Falls, SD	LULC mapping, image sourcing\sharing
NY GAP Program -	Ithaca, NY	Gap Assessment Program, LULC mapping, sharing plot and image data
NASA Terrestrial Ecology Program -	Washington, DC	Technology transfer, regional remote sensing applications
Queens College –	New York, New York	Forest cover type mapping (LI), taxonomy development
Rutgers University- CRSSA	New Brunswick, NJ	Forest remote sensing, sharing imagery
SRBP – Mohonk\TNC	Shawangunk, NY	Veg. Relevee plots, data sharing, ecological healt monitoring, conservation planning
State of NY DEC – Habitat Inventory Unit	Albany, NY	Forest and environmental mapping, management, plot data sharing, taxonomy development
Syracuse ESF	Syracus, NY	Forest health plots, plot data & imagery sharing, taxonomy, VegBank
USDA FS - FIA Division	Newton Sq., PA	Forest Inventory Plot information distribution (data sharing)
USDA FS – Northeastern Area State and Private Forestry Forest Inventory Unit	Durham, NH	Land Type Association (LTA) mapping, forest resource mapping
University of Connecticut	Storrs CT	Insect habitat affinity, invasive spp.
University of New Hampshire – Complex Systems Labs- Institute for the Study of Earth Oceans and Space	Durham, NH	Foliar chemistry (hyperspectral), forest health, plot data sharing, image sharing
Westchester County – GIS Department	White Plains, NY	LULC mapping, water quality issues, land planning
Wild Metro	New York, New York	Regional baseline assessments, conservation

Table 2. Ground Control Points \ Reference Plot Data – by Agency

Agency	# of Points	Type of Survey	Contact	Contact #'s
NY Heritage	674 +	Obs Points	Tim Howard	(518) 402-8945
Syracuse ESF	583	Forest health plots	Ben Rubin\Paul Hopkins	(315) 470-4761 (518) 470-6696
NY DEC	100's	NY Forest & Park plots	Gerry Rasmussen	(518) 402-8961
Brooklyn Botanic Garden	100's\1000's	Spp. Home Range Maps	Steve Clemants	(718) 623-7309
USDA FS	100's	FIA (data overlays to be processed by USFS)	Eliz. LaPointe Andrew Lister	(610) 557-4038
UNH – Complex Systems	10's\100's	Foliar chemistry (Hyperspectral), forest health	Mary Martin	(603) 862-4508
SRBP – Mohonk\TNC	200+	Veg. Relevee plots	John Thompson \ Michael Batcher	(845) 255-5969 (518) 686-5868

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