

Protocol Development Summary

Protocol:

LiDAR -based Monitoring of Vegetation Structure, Patch Condition, and Plant Community Composition on Network Parks [short name: Vegetation Structure and Composition]

Parks Where Protocol will be Implemented:

BITH, GUIS, JELA, NATR, PAAL, PAIS, SAAN, VICK

Justification/Issues being addressed:

A number of vital signs related to the diversity of terrestrial vegetation found within network parks were ranked as high priority for the network. These specific vital signs include non-native vegetation, salt marsh communities, riparian communities, forest health, and terrestrial vegetation. Ecologically speaking, vegetation comprises the foundation for most terrestrial ecosystems, and the status and function of vegetation components are central to the function of these systems. Changes in vegetation parameters can serve as useful indicators of changes in ecosystem function. From a resource-management perspective, “vegetation” comprises a highly-valued set of resources that are subject to impact from both natural and anthropogenic forces; thus vegetation is a central focus for management attention and effort.

The goal of this protocol is to develop a landscape-scale approach to monitoring the diverse vegetation communities across the network, using a common methodology. To a large degree, the general questions about vegetation status and trend may be effectively answered using data about the sizes, shapes, heights, densities, distribution patterns and locations of plants within vegetation units. In general, quantifiable changes in canopy heights, densities, structural heterogeneity, etc., are indicative of a system or community or population conditional change. For example, changes in plant height and size correspond to growth, changes in canopy density may indicate stress and pest damage, while spacing and distribution can indicate coverage change and stand/patch “condition”.

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:

Some of the specific monitoring questions that will be addressed by this protocol include:

- What is the current status, based on physical characteristics (distribution, coverage, canopy height, and density descriptions) of selected vegetation units on sampled parks?
- How are the physical characteristics (canopy properties and in-canopy distribution) of selected vegetation units changing over time in patches on sampled parks?
- What is the current major species composition and per-species distribution in selected vegetation units in selected units or patches on sampled parks?
- How are major species composition and per-species distribution changing in selected vegetation units on sampled parks? Is relative abundance shifting? Are formerly key or dominant taxa declining, and if so, what is replacing them?

- What are the current distributions and area coverage of selected vegetation units on sampled parks?
- How are distributions and area coverage of selected vegetation units changing, in terms of area-covered and specific point and boundary locations, over time on sampled parks?

Some of the specific monitoring objectives that will be accomplished are as follows:

1. Quantitatively describe (structural and derived major species composition, relative abundance and distribution) the current condition of selected vegetation units on sampled parks.
2. Quantify the type, magnitude and rate of changes occurring in structural (and/or major species composition and distributions, as appropriate) properties in selected vegetation units on sampled parks. Relate these reported changes to changes in vegetation condition or status (i.e., is it evidence of plant or stand stress, plant pest infection, and changes in recruitment?)
3. Using GIS, quantify and map the changes detected in area-covered, dimensions and locations of selected vegetation units on sampled parks. Aside from within-patch or unit conditional changes, the other salient question for many parks will be whether selected vegetation units are shifting in patch sizes and/or actual location on parks- such as in the case of spreading invasive species areas.

Basic Approach used in the GULN Vegetation Protocol:

The vegetation protocol consists of two general sampling elements: 1) technology-based sampling to detect structural change in a park's vegetation over time, and 2) a targeted ground-truth survey-based sampling to provide biological correspondence to support the technology-based monitoring.

Technology-based sampling will use an airborne lidar (Light Detection And Ranging) system. Data are collected in a fly-over sampling event on a selected park at a specified season and state-of-foliation. The lidar data are geospatially explicit and link to a park's GIS layers with GPS locations. Consequently, structural vegetation metrics will be explicitly spatially linked to other biological data, such as bird and herpetofauna communities. Details on the USGS EAARL lidar sensor, lidar-based vegetation metrics, and vegetation delineation methodologies can be found at: <http://ngom.usgs.gov/dsp/index.html>

Lidar data are processed using an auto-classification modeling routine which results in a set of multi-variate, 3-dimensional structural patches that represent the sampled vegetation. Each patch belongs to one statistically-distinct class, and has a location and boundary enclosing a recognizable area on the park's landscape. Detection of structural change is via a two-level comparative analysis of lidar models acquired at different times. Level-1 analysis detects changes in the whole-park model. Level-2 analysis is based on the detailed examination of patch and within-patch changes seen at locations specified by park management. Following identification of patches that have experienced structural change, a detailed ground-truth evaluation to reveal explicit biological changes will be performed on changed patches selected for further analysis by park managers. Monitoring will consist of repeating lidar data-collection,

modeling, and comparative analysis to detect changes in the size, location, dimension, and class of patches seen on a park's data set.

Ground-truth surveys identify major species composition, distribution, status, and abundance, and are based on standard plant ecological field methods. Ground-truth assessment provides (1) a biological description of patches of management interest, and 2) assessment of biological change in a patch which has shown detectable structural change in model analysis. Ground-truthing will be performed as needed to assess detected change in given patches. For example, a park may elect to assess a patch which exhibits statistically significant change to determine whether the change is of interest. Detected structural changes may indicate species-composition change, the onset of a forest pest, results of a management activity such as fire, or storm-related damage.

Principal Investigators and NPS Lead:

Protocol development is underway in collaboration with the USGS Coastal and Marine Geology Program (Dr. John Brock, Amar Nayagandhi, and Dr. Monica Palaseanu-Lovejoy), ground-truth sampling and analysis by Louisiana State University (Dr. Lowell Urbatsch, Dr. Kyle Harms), USGS Patuxent Wildlife Research Center (Dr. Dan Twedt), and Southern Illinois University (Dr. Loretta Battaglia). The GULN Network lead is Dr. Robert Woodman.

Development Schedule, Budget, and Expected Interim Products:

Development of the vegetation structure protocol is linked directly to the GULN coastal geomorphology protocol since the same lidar data are used for both protocols. Consequently, the cost of data collection and protocol development on the coastal parks includes both protocols.

Lidar data collection and analytical development focusing on the vegetation structure protocol began in FY2006 on JELA (\$129,000); in FY2007 on VICK, portions of NATR, GUIS, and PAIS (\$155,457); in FY2008 on VICK and NATR (\$94,000); Methodological documentation and SOP's for creating lidar-derived vegetation metrics, vegetation delineation, and change analysis (using data from GUIS) will be completed by the end of FY2009 (\$50,000). Ground-truth development, data collection, and analysis was funded on JELA in FY2007 (\$94,000); and continued for VICK in FY2008 (\$18,000). Vegetation community analysis, documentation of methodologies, and correspondence to JELA lidar vegetation classification will be completed by the end of FY2009. A draft protocol available for review is expected during FY2010.

Relevant Literature:

Oakley, K. L., L. P. Thomas and S. G. Fancy. 2003. Guidelines for long-term monitoring protocols. *Wildlife Society Bulletin* **31**:1000–1002.

Nayegandhi, A., Brock, J.C. 2008. Assessment of Coastal Vegetation Habitats using Lidar. *In*: Yang X.(ed) "Lecture Notes in Geoinformation and Cartography - Remote Sensing and Geospatial Technologies for Coastal Ecosystem Assessment and Management": Springer Publication pp 365-389.

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Palaseanu-Lovejoy, M., Nayegandhi, A., Brock, J.C., Wright, C.W., Woodman, R., *in press*,
“Delineation of vegetation communities using airborne lidar data and Independent
Component Analysis at Jean Lafitte National Park, Louisiana, USA”. To be submitted to
the special issue of the Journal of Remote Sensing of Environment - Application of
Remote Sensing to Park and Protected Area Monitoring.