

Protocol Development Summary

Protocol: Monitoring Structure, Composition, and Extent of Terrestrial Vegetation Communities and Soils in the Arctic Network [Terrestrial Vegetation and Soils]

Parks Where Protocol will be Implemented: BELA, KOVA, CAKR, NOAT, GAAR

Justification/Issues being addressed:

Terrestrial vegetation communities have been identified as a top vital sign for the Arctic Network. Arctic ecosystems, particularly vegetation and underlying substrate, are extremely sensitive to external influences such as changes in climate, disturbances, and human impacts. While human activity in Arctic regions may cause localized changes in vegetation and soils (Hasselbach et al. 2005), the impact of global climate change may have regional consequences (Stowe et al. 2004). Several studies have begun to show changes in arctic and subarctic vegetation patterns due to climate change. Vegetation is the primary foundation for wildlife habitat, nutrient availability for other ecosystem processes, and is tightly linked to aquatic ecosystems. Spatial and temporal shifts in terrestrial primary productivity reflect changes in dominant plant species vigor, range and composition which are, in turn, the products of large scale processes and events. Changes in community structure are key to ecosystem processes and to our understanding of changes in climate, air quality, herbivore/ungulate use patterns, succession, fire and other disturbance. Elevated rates of soil organic matter decomposition and permafrost thaw may lead to greater nutrient availability, and therefore greater primary production, in these strongly nutrient limited systems.

Although ARCN's tundra and taiga biomes contain large reservoirs of soil N and P, temperature restrictions on microbial decomposition and the permafrost-locked state of other soil nutrient pools maintain these nutrients in forms unavailable for plant uptake. Current and predicted increases in ambient temperatures and/or shifts in fire regime may lead to substantially altered nutrient cycling due to associated increases in soil temperature and active layer depth. Arctic and subarctic plant growth has been shown to respond positively to increased ambient temperatures; an effect which may be as much due to more rapid cycling of nutrients as it is a direct response of vegetation to temperature. ARCN has also received considerable inputs of heavy metal pollution from mining operations, and is expected to receive higher inputs of S and N from local development and trans-Pacific transport. All of these contaminants have ecosystem-altering properties, especially for sensitive tundra and nonvascular-dominated communities.

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

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

1. Are changes in land cover and vegetation structure occurring, and if so, how and where?
2. How is forest and shrub distribution changing?

3. How is climate change altering biodiversity, species distribution, and community structure in the Arctic Network?
4. How has the nutrient composition of soils changed over time and what are the consequences (C, N, P, K, selected metals)?
5. How will long-term climate change affect reservoirs of soil carbon and impact large-scale nutrient dynamics within the Arctic Network?
6. Are contaminants levels in terrestrial ecosystems of the Arctic Network changing, and if so, how does this affect plant community structure and distribution? **
7. How does the time since fire and burn severity affect the species composition, vegetation structure, and ground cover among varying vegetation types? **
8. How is ungulate habitat changing with climate and extremely high caribou numbers on the landscape? **

** These monitoring questions are being addressed by other vital signs.

Monitoring Objectives:

1. Characterize changes in plant community structure (species cover, diversity, biomass, tall shrub and tree density, community structure relative to environmental gradients) over time using ground plots and extrapolating to a landscape scale using remote sensing products including satellite imagery, aerial photography and LIDAR.
2. Characterize changes in soil properties and chemistry (e.g., depth of active layer, soil structure and soil horizon characterization, % rock, moisture class, depth to ground/surface water, soil organic matter thickness, pH and electrical conductivity, soil temperature, C, N, P, K, selected metals) over time.
3. Characterize abiotic soil environmental parameters (as measured with HOBO® Micro Station Data Loggers) at intensive sites.

The following objectives are addressed in other Vital Signs, but address basic terrestrial vegetation objectives:

4. Determine vegetation change over time associated with contaminants (e.g., changes to lichen and bryophyte communities associated with increasing inputs of sulfur, nitrogen or metals in active mining areas). (*Vital Sign: Wet & Dry Deposition*)
5. Determine the effects of fire and burn severity on the species composition (species diversity and % cover), vegetation structure (tree diameters and heights), and ground cover (% cover and depth) of varying vegetation types. (*Vital Sign: Fire extent, severity and effects*)
6. Characterize changes in ungulate habitat quality and quantity over time, particularly reindeer and caribou winter range condition (e.g., sensitive lichen communities measured both by plots and with exclosures, biomass of forage species or groups of interest). (*Vital sign: Caribou*)

Basic Approach:

We envision a terrestrial monitoring program that uses a combination of ground data and remote sensing data to provide extensive coverage at a landscape level in the parks. Detailed measurements of community structure would be taken on the plot level at a

series of nodes chosen for accessibility and cost to ensure that revisits might occur even as costs of logistics continue to climb. Each node would include a large number of ground plots in a diverse set of vegetation associations. Ground data would help calibrate remote sensing products, and remote sensing will be used to model landscape-level patterns. Data from both levels will be analyzed in concert with input from other linked vital signs such as climate, aquatic nutrient flows, landscape patterns, ungulates, and contaminants.

Plant Community Structure and Soils—Vegetation composition will be quantified through highly repeatable plot-based measurements of plant cover on permanent plots at chosen ARCN nodes and sites harboring rare or unique species and communities. The proposed plot level work would involve collection of floristic data and measurement of a suite of ecosystem variables relating to some or all of the categories identified above. Initially, core plots should serve as calibration sites for aerial photography, much as ground data has been collected to calibrate vegetation mapping based on LANDSAT imagery. Photographing the plots from the air, then characterizing their species composition on the ground will allow us to assess how well species composition can be characterized on the photos. Further work at the plots will involve collection of ecosystem data including biogeochemical characteristics and soil properties.

If possible, we intent to use generalized randomized tessellations (GRTS) to select thirty vegetation sampling nodes within ARCN. This spatially-balanced sampling design will allow us to infer our findings to these critical regions within BELA, KOVA and NOAT. Nodes will be revisited at a minimum every ten years. Using GRTS for allocation of Nodes, based on the following strata:

- Access – include both fixed wing and helicopter (helio for KOVA, BELA and CAKR)
- Subsection physiography
- Alaska Ecosystem (broad vegetation classes)
- Climate zones as a function of growing season temperature and precipitation.

Other Factors to consider:

- 20% of the nodes would be High Management Interest Areas
- Allocate plots within each park unit
- Co-location with shallow lake monitoring, weather station monitoring, wildlife monitoring should be considered.

Sample Numbers and Sampling Frequency:

Number of Nodes: 30

Number of Plots per Node: 24

Field Season: mid-June – mid-August, 2-3 field stints

Number of personnel: 2 Crews (2 people each) - each crew visiting 3 nodes per year = 6 nodes per year

Return Interval: 30 Nodes total, sampled within 5 years. Repeat measure of plots every 10 years.

Aerial Photography Transects - The proposed aerial photo protocol would modify that used by Jorgensen et al (2007) in their characterization of thermokarst extent in the state of Alaska. Aerial photos would be acquired along transects and shot at fixed intervals across the landscape. Transects could be randomly arrayed across the landscape, or flown parallel to each other, whatever arrangement facilitates acquisition of a representative sample most effectively. Analysis of vegetation community composition and the relationship of composition to landscape-level phenomena such as fire and thermokarst would be conducted by selecting either random or gridded pixels within photos for analysis of cover type. These transects would be permanently located and could be used for a variety of other vital signs as well, including Landscape Patterns and Dynamics (lake creating/drying/surface area), and rare and unique communities and species. This analysis would initially be done manually, although automated processes may be available eventually. Transects would be situated to intersect all permanent ground plots.

Principal Investigators and NPS Lead:

The P.I. for protocol development will be the Vegetation Ecologist Dave Swanson.

Development Schedule, Budget, and Expected Interim Products:

As this vital sign is large and complex, it is expected to roll out in several phases. In particular, the plant communities and soils will be one phase, and the areas of special concern (fire, range condition, contaminants) will be phased in separately.