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Vegetation and Soils Monitoring Protocol Testing
Arctic Inventory and Monitoring Network
Progress Report, March 2010

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Abstract

The Arctic Inventory and Monitoring Network (ARCN) developed and field-tested a vegetation sampling protocol in 2009. It incorporates elements of the Central Alaskan Network's (CAKN) vegetation sampling design, the U.S. Forest Service Forest Inventory and Analysis (FIA) sample design, and the USDA NRCS standards for description of soils and landforms (Soil Survey Staff, 1993; Schoeneberger and Wysocki, 2008). Field data recording is accomplished largely on handheld field computers. Field testing yielded good results on 34 plots at two locations in 2009. The methods have been incorporated into draft standard operating procedures and are recommended for future monitoring in ARCN.

Introduction

Vegetation and soils have been identified as a vital sign for long-term monitoring in the Arctic Inventory and Monitoring Network (ARCN)(Lawler et al., 2009). After arriving on the job in Sept 2008, I began development of protocols for sampling vegetation and soils in ARCN during the winter of 2008-09, followed by protocol testing fieldwork in the summer of 2009, and database development and incorporation of data collected to date in the fall of 2009. This report summarizes the findings to date from this protocol testing effort and makes recommendations for future work. It is a record of the rationale behind the many decisions involved in developing the protocol, which is currently in substantially completed draft form.

Previous Work

As of the fall of 2008, vegetation and soils had been identified by collaborative process as an ARCN inventory and monitoring vital sign (Sanzone et al., 2006). Few decisions about a sampling plan had been made at that time, beyond a general decision that we would restrict sampling to deliberately chosen representative areas ("nodes") as opposed to sampling by a network-wide probabilistic design. This decision was driven by the logistics and expense involved in sampling in ARCN, and stood in contrast to decisions at that time by the Central Alaskan (CAKN) and Southwest Alaskan (SWAN) NPS I&M Networks to implement probabilistic sampling, albeit on only a part of their networks. As of the fall of 2008, CAKN had an approved vegetation sampling protocol (Roland et al., 2004) and SWAN was developing a protocol based on that of the North Coast and Cascades Network (Woodward et al., 2009). Development of the

ARCN protocol has involved my review of the CAKN and SWAN protocols, discussions with the lead authors of those protocols (Carl Roland and Amy Miller of NPS), discussions with the ARCN technical committee and other NPS staff, especially Peter Neitlich, the sole vegetation specialist on staff of the ARCN NPS units, and field testing by myself and colleagues.

Pre-Field Season Developments

A number of decision were necessary before protocol testing fieldwork could begin. The most important ones are listed below.

1. The "Terrestrial Vegetation and Soils" vital sign would emphasize vegetation. This decision may be surprising given my background (a Ph.D. in Soil Science). I obviously agree that soils are important to ecosystem function, but I have yet to encounter methods for sampling soils that one could use to monitor changes in a way that would be meaningful in a study area the size of ARCN (20 million acres). Thus soils will be described at vegetation plots as a form of site characterization, but not used for change detection by repeated sampling and laboratory analysis. Soil temperature will be monitored at ARCN climate stations as a part of the permafrost vital sign.

2. Nodes would be chosen deliberately from the subset of locations accessible by fixed-wing aircraft to be representative of a wide range of vegetation and landforms, and distributed across major elevation, latitudinal, and climatic gradients in the Network. I developed a set of approximately 20 to 30 potential node locations by consultation with local experts (primarily Torre Jorgenson of ABR Inc.) and examination of available data on climate, landforms, geology, and vegetation. Two nodes were chosen for testing in 2009: one near Kuzitrin Lake in Bering Land Bridge National Preserve (BELA), an example of tundra vegetation; and a second near Florence Creek Lake in Gates of the Arctic National Park and Preserve (GAAR), and example of taiga vegetation (Fig. 1).

3. Plot locations at the nodes would be determined as follows. The foot- or boat-accessible vicinity of a node would be stratified by major landform unit (e.g. ecological subsection). Plots would be laid out systematically along a transect with zig-zag form and a random start. This plot location design was chosen for the following reasons: a) A landform-based stratification is stable under environmental change (unlike a vegetation-based stratification). b) A transect-based design minimizes transit times between plots as compared to a more randomized design. c) A zig-zag transect form is an efficient compromise between rectangular layout (which concentrates effort in a single area) and a linear transect (which maximizes transit time to camp from the end of the transect and from camp back to a partly completed transect. d) A systematic layout with random start prevents bias in specific plot location, ensuring sampling of ecotones (which could reveal the important changes over time).

4. Protocols within the plots would generally follow CAKN's design (Roland et al, 2004), except that certain data elements would be omitted. CAKN's protocol has been well tested under conditions similar to ARCN's. Our primary concern with CAKN's vegetation monitoring protocol is that it is too ambitious for ARCN to follow completely, hence the decision to abbreviate it. ARCN has more difficult logistics and has committed a lower level of personnel and funding support for the vegetation vital sign than CAKN. In ARCN we have decided that many potential broad-scale vegetation changes (e.g. shrub or tree expansion) tracked by plot sampling in CAKN's vegetation vital sign would be more efficiently addressed in ARCN by remote sensing under the "Terrestrial Landscape Patterns and Dynamics" vital sign. CAKN's total area is similar to ARCN's, but CAKN has a road system within its two largest units, it has large areas in rock and ice that will not be sampled, and it has chosen to only partially monitor its largest unit (Wrangell-St. Elias National Park and Preserve). Also, CAKN has an employee (Roland) devoted primarily to its vegetation vital sign, while in ARCN I am also responsible for three vital signs including vegetation.

5. Modifications of CAKN's sampling protocol for measurements taken at the plots are as follows:

Modification	Rationale
Frequency frame sampling would be omitted	This is the single most important modification. Frequency sampling is very time-consuming, it generates a large load of nonvascular plant samples to identify, and frequency data is difficult to interpret because it is not related in any simple way to the ecologically important quantities biomass or cover. ARCN's emphasis in this vital sign is on cover, which is closely correlated with biomass and can be more readily upscale by remotely sensed data.
Point-intercept sampling at 100 points with 25 cm spacing (rather than the variable spacing at CAKN)(Fig. 2)	A consistent spacing is preferred, and 25 cm works well with the central soil pit described below.
Point-intercept sampling would include some nonvascular species or species groups, rather than simple moss and lichen groups as in CAKN	Non-vascular species are very important in ARCN, and with omission of the frequency sampling from CAKN's protocol they would otherwise be missed. Their incorporation into point sampling gives us the ecologically important cover measure plus data for biomass estimation (see the next table entry)
Added to CAKN's protocol a single measurement of moss-lichen mat thickness taken at each point intercept location by the technique of Moen et al (2007)	When combined with cover measurements by point intercept described above, we are able to estimate nonvascular plant biomass.
A comprehensive vascular plant species list of the plot was not compiled. The point-intercept measurements (100 points per plot) on the average detect only species with 1% cover or more.	Our focus is on vegetation structure, which is minimally influenced by trace species. A comprehensive species list greatly adds to the workload of a plot. This decision may be revisited.
The soil description would be a single description at plot center following USDA soil description protocols (Soil Survey Staff, 1993), rather than CAKN's multiple shallow pits around the periphery with unconventional descriptions.	A full soil description allows transfer of information by nationally standardized techniques. A centrally located description best characterizes the plot and can be accomplished without disturbing the point-intercept transects and disturbing less than 1% of the full circular plot; the disturbed area could be readily omitted from tree analysis if desired.
Tree seedling and sampling would follow the national FIA protocol (USFS, 2007)	CAKN samples saplings on the frequency plots, which are omitted here.
Tree core samples would be omitted	Tree-rings are conserved onsite in live trees; if the data are desired in the future, they may be sampled then, and the tree ring data will be more valuable because it will cover the monitoring period.
Plot centers would be marked by buried magnets rather than stakes	To reduce impacts on wilderness.

Photography would include a panoramic set of photos taken from a tall pole looking down on the plot	To improve the photographic record of the plot and facilitate locating the plot on high-resolution imagery
Site geomorphic description would follow the nationally accepted USDA NRCS system (Schoeneberger and Wysocki, 2008) rather than CAKN's locally devised system	To facilitate data transfer.

6. All data (except for soil profile descriptions) would be recorded on field data recorders that could function for a week's time in a remote camp without heavy recharging equipment. Research into small handheld units led us to the choice of the Trimble Nomad field computers, and forms needed to collect the data and transfer it to a desktop database were developed. Since the spreadsheet software included with the units – Microsoft Excel Mobile – inexplicably omits choice lists as an option, I located a shareware alternative that proved highly successful. We eliminated CAKN's field Access database from consideration because 1) its complexity makes it difficult to modify; and 2) it requires a field laptop computer to run, which in turn forces one to carry heavy laptop replacement batteries and recharging equipment (a solar panel and storage battery).

Field Sampling, summer 2009

The two test nodes were sampled as planned, Kuzitrin Lake during 11-17 July and the Florence Creek Lake during 15-20 Aug. Sampling was successful and generated baseline monitoring data. A few lessons learned from fieldwork are as follows.

1. Laser point samplers are easier to use than mechanical samplers. We tested in the field both the mechanical point device developed by CAKN, and a laser pointer device developed by ABR Inc. for use in the SWAN's coastal monitoring vital sign. The laser is a lightweight waterproof pointer designed for SCUBA divers. Our 3-person crew tried both samplers and decided that the laser device was easier and faster to use. It is also cheaper and smaller to transport. The upward viewing densitometer used by CAKN for tree and tall shrub overstory cover measurement was retained. For the second sampling trip in August we devised a rod with adjustable laser height to improve convenience for people with different heights working in different types of vegetation.

2. A simplified set of non-vascular plants, consisting of major easily-identified species and species groups, should be identified on the point-intercept transects. We initially began by attempting to identify all non-vascular hits to the species level and found that it did not match our goal of 3 to 4 plots per day, even with two lichen experts in the crew (Peter Neitlich and Abbey Rosso). We decided that the important ecological information could be obtained from a simplified set of common species and species groups. We composed the list in the field based on our common experience and used it in all plots from there on.

3. The gear necessary for 3 people to sample a node for one week was near the limit of what can be carried in a de Havilland Beaver (a relatively large but widely available floatplane suitable for small lakes). This outfit included a foldable canoe (which will not be needed at all nodes) and a large cooler for preservation of moss samples collected for the wet and dry deposition vital sign (which we do expect to sample at most nodes). Thus we will need to be careful about gear when sampling nodes that are more distant and require more fuel to reach than the 2009 nodes.

4. The Trimble Nomad data recorders are durable and easy to use in the field. A few lightweight replacement batteries are adequate for an entire sampling trip. A field laptop is also convenient for data backups, and will last an entire trip without replacement battery if used only for backups.

5. Our simplification of the CAKN sampling protocol allows a crew of 3 to sample 3 to 4 plots per day, or about 15-20 in a week. This also amounted to 4 to 8 plots per local physiographic unit; these numbers appeared to us in the field to be adequate (though minimally so) to represent the variability in a physiographic unit.

Data Processing, Fall 2009

Transfer of data from the field recorders to an Access database was very smooth. All data entries on the field recorders were made from pre-set choice lists, and as a result there were no spelling or similar errors. A relational database containing a full data dictionary was composed to accommodate the data, and all data were appended. The only notable revision affecting the field forms developed the prior spring was a minor change in the method for tracking unknown plants (the macros that prepare data for appending to the database were revised to facilitate joining of the main plants data table to the unknowns list via a sequential collection number for each day and the name of the day's data file).

Issues Remaining

1. We have been guided by the concept that these vegetation node plots would contain mainly structural data that would be used to calibrate remotely sensed data. The techniques for that upscaling remain to be determined.

2. The FIA sapling and seedling sample protocol calls for counts to be made on a small subplot (Fig. 2). CAKN's protocol counts seedlings on their frequency plots and saplings on the entire plot. My preference would be to follow the national (FIA) protocol, but I recognize that in situations with sparse seedling and saplings it is both feasible and valuable to count on the whole plot (e.g. to document treeline advance). However, a sampling design where the collection of additional data on a different-sized plot is triggered by plot conditions raises a variety of problems that must be solved.

3. Compilation of a complete species list, including trace species off the point transects, may be worth the extra time required. The main "pros" of compiling the list is that it provides additional ecological information and it makes sense to gather the extra data while the sampling crew is already at the site. There are several counter arguments: it is not clear how the data would be used, because composition data collected under a non-probabilistic design is difficult to extrapolate; we have decided to cover plant biodiversity monitoring with a different set of plots (the lichen plots); and the additional data element could add significantly to the workload. This decision should probably be discussed further.

4. The current sample design is weak with regards to detection of network-wide changes in vegetation composition, because composition is difficult to extrapolate by statistical methods under our non-probabilistic design or by remote sensing. ARCN has a nearly comprehensive set of lichen composition plots (covering all except Gates of the Arctic National Park and Preserve), established by probabilistic design, that could form the basis for vegetation composition monitoring. We are proceeding with this idea, but details need to be worked out.

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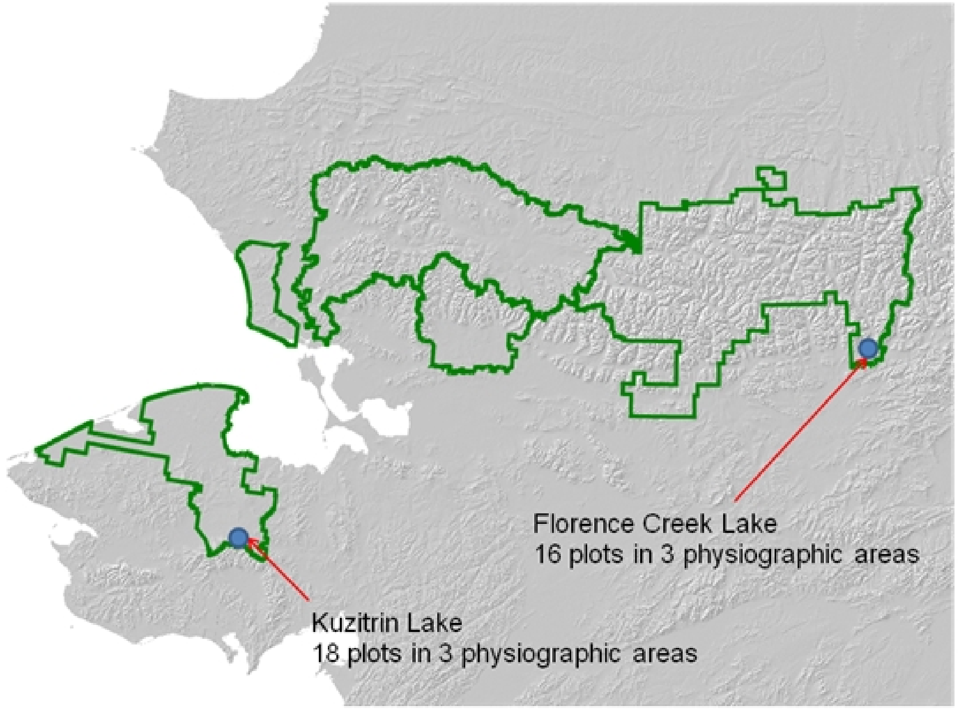

Fig. 1. Sample locations, 2009

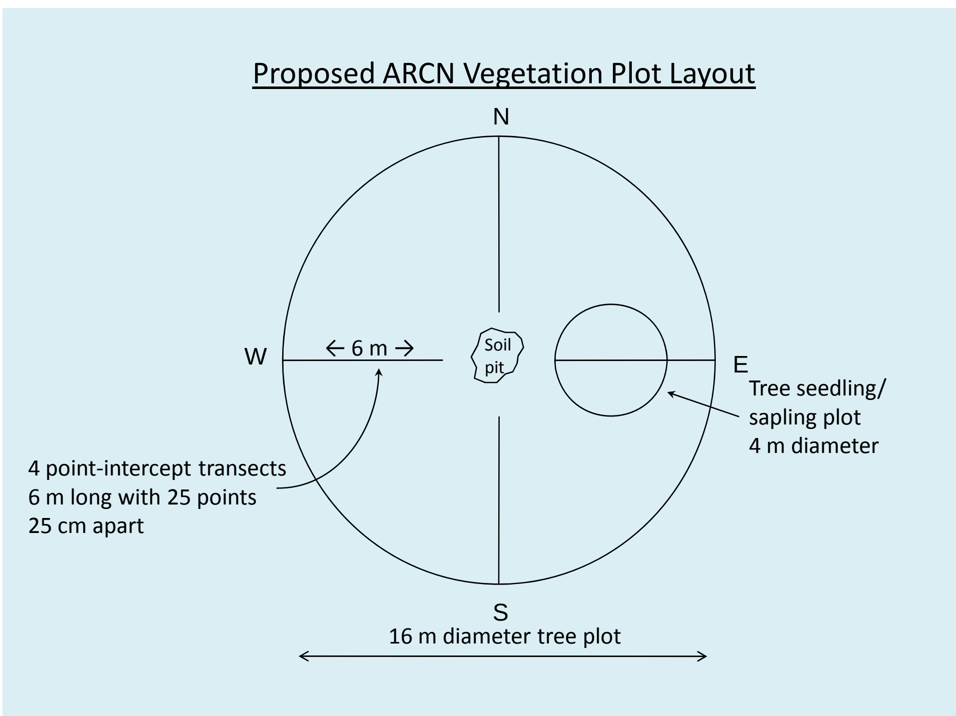

Fig. 2. Proposed ARCN vegetation plot layout.