Polaris Project Terrestrial Survey: 2012 Sample Collection Protocol

1. Introduction and Rationale

This document outlines the protocol for collecting vegetation and soil data as part of the Polaris Project Terrestrial Survey. In the interest of producing a consistent long-term data set, this protocol should be followed precisely. New samples or analyses may be added, but the basic sampling and sample processing procedures described here should not be modified unless absolutely necessary.

The objective of the Terrestrial Survey is to measure carbon stocks in vegetation and soils from boreal and tundra ecosystems in the Kolyma watershed. At some point in the future we will measure carbon fluxes, but our knowledge of the mean and especially the variation of terrestrial carbon is insufficient for understanding the transport and transformation of carbon in the Kolyma watershed. Recall that these are the primary objectives of the Polaris Project. Data collected will be tied into satellite imagery that covers a much wider footprint than we will be able to directly measure. We also will link the terrestrial stocks of carbon (and nutrients) to the biogeochemical processes we measure in lakes, streams, and rivers.

<u>A note on safety</u>**: Remember that we are working in one of the most remote corners of the largest country on earth and that if you get hurt it is a long way to quality medical assistance. Please be careful and pay attention to your surroundings. Brown bears are uncommon in the region, but have previously been encountered while conducting the terrestrial survey. Be alert for bears and always carry appropriate safety equipment.**

2. Classification Scheme

To separate terrestrial carbon into pools we need to establish a simple classification scheme for the various ecosystem components we are measuring. These pools and divisions aim to maximize ecological differences while still being tractable.

A. Overstory

Dahurian Larch (a.k.a. Cajander larch; *Larix cajanderi*) is the only tree species we will encounter. Note that European botanists tend to classify this species as subspecies (*cajanderi*) of *Larix gmellinii*. There is a species of pine (Dwarf Siberian pine, *Pinus pumila*) that grows in a shrubby form at some locations (*e.g.,* outside of the station), but we'll count it as a shrub.

We will differentiate three classes of larch trees based on a forestry standard known as the diameter at breast height (DBH). Breast height is defined as 1.4 m above the ground on the up-hill side of the tree (1.37 m was an old standard in forestry. Now it is 1.4 m). Trees are stems having >5 cm DBH. Saplings are taller than breast height but less than 5 cm DBH. Seedlings are trees shorter than breast height. Note that this means saplings might be 50 years old or more but that these definitions work well from a carbon accounting perspective.

B. Understory

Understory species will be grouped into these three classes:

1) Shrubs: Multi-stemmed woody plants. These could range in height from a few centimeters to several meters. Shrubs can be either deciduous or evergreen. The three dominant genera of deciduous shrubs are willow (*Salix*), alder (*Alnus*), and birch (*Betula*). Dominant evergreen shrubs include Labrador tea (*Ledum*) and bog cranberry (*Vaccinium vitis-idaea*).
2) Herbs: Non-woody plants. These include graminoids (sedges/grasses) and forbs (e.g., cloudberry, wildflowers).
3) Moss/lichens: Mosses are non-vascular plants. Lichens are a symbiotic association between fungi and algae. These often make up a mat covering the forest floor.

There are many more levels we could differentiate but these classes serve our purpose of getting a good measure of the different carbon pools without going into species identification. Make note of anything that deviates meaningfully from the categories above (e.g., a patch of mushrooms).

C. Belowground

The active layer is the soil region above the permafrost that thaws and freezes annually. We measure the depth of the thawed portion of the active layer (thaw depth) and its carbon content. Note that actual depth of the active layer can only be known when it is at its maximum thaw in late summer.

3. Plot Set-Up

We will establish three 20-m-long plots at each site. Having multiple plots within a site will allow us to account for intra-site variability and make statistically robust comparisons among sites. The number of stands we are able to sample during the field season will vary depending upon logistical constraints. The size of the terrestrial survey team should range from 3-5 people.

A. Information to Include in Field Data Sheets

- Date (mmddyy) and start time (four numbers in 24-hr format)
- Long name of sampling site
- Short name of sampling site (a three letter code - see below)
- GPS coordinates (Lat/Long in decimal degrees using the WGS 84 datum-if you don't know how to check your GPS to make sure it's at these settings, ASK!) at the 10 m point and both ends of the 20 m plots.
- Names of people on sampling crew
- Weather conditions – approximate air temperature, wind, clouds
- A site description including an overview of the flora and other conditions that may affect the data.

Make note of any deviations from the protocol, unusual features, etc. It is essential that the appropriate information be clearly recorded. Upon returning from the field, place your data sheets in the Master Terrestrial Survey Binder. Data will be entered into a computer spreadsheet daily and/or digital photos of each datasheet will be collected. Once entered into the computer, data should be backed up to two locations.

B. Sample Labeling Scheme

All Terrestrial Survey samples will be labeled according to the following scheme: T-Site-Plot-Location-Date. "T" designates the samples as part of the terrestrial survey. Each site will be designated by a three letter code. Plot will be designated as either 1, 2, 3. Location refers to the location along the plot (e.g., 5m). Date will be designated by a six letter code (mmddyy). For example, a soil sample collected behind the Northeast Science Station at the 0-m end of plot 1 on July 23, 2011 might be labeled: 'T-NSS-1-0m-072311'. Different types of samples may have additional labels.

C. Plot Establishment

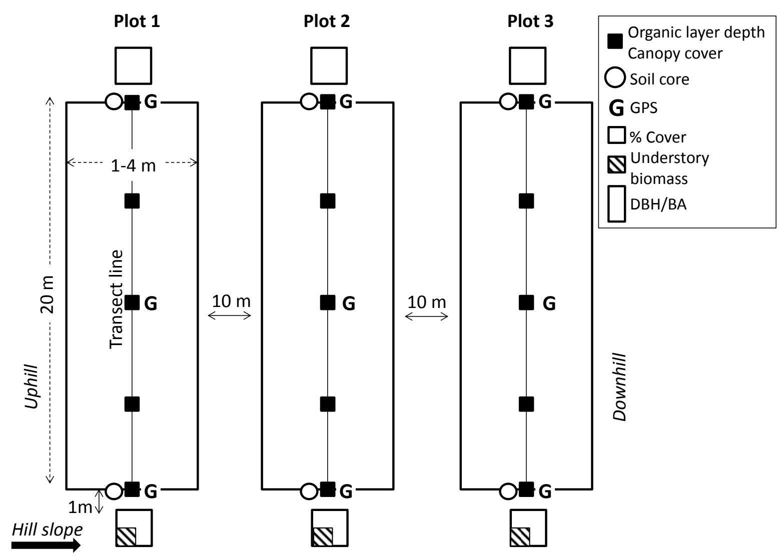

Figure 1. Plot set-up for Terrestrial Survey sampling.

We will set up three plots at each site (Figure 1). Plots will be 20-m long and 1 to 4 m wide, depending on stand density. Each plot will be centered around a 20-m transect line run down the center of the length of the plot. Plots will run parallel to slope contours and to one another and will be separated by a distance of at least 10 m. Plot 1 for each site will be the plot furthest to the left (and uphill if on a slope) when standing at the 0-m end of the plot (Figure 1). If there is no obvious slope, then run plots along a N-S transect, and name the plot to the W as Plot 1. For tree diameter measurements, sample all trees to the left and right of this transect line within a distance of 0.5 m (1 m total width) if the stand is high density (> 2 trees m^{-2}), 1 m (2 m total width) if the stand is moderate density (1-2 trees m^{-2}), and 2 m if the stand is low density (< 1 tree m^{-2}).

4. Forest Measurements

We will measure biomass in trees and the understory, and organic matter content of the active layer. The steps below move from aboveground to belowground measurements. Ask for instruction if you are unfamiliar with any of the tools (e.g., clinometers, densiometer). The tools we use are simple in the sense that they have few if any moving parts, but data cannot be rescued later if you measure incorrectly in the field. Remember that there are no stupid questions (except 'Who is Townes van Zandt?' Get that one right immediately).

A. Tree Diameter Measurements

Within each 20 m long plot, we will measure DBH (diameter at breast height) of all trees tall enough to have a DBH, and basal diameter (BD) of any tree shorter than DBH height. DBH is defined as 1.4 m above the ground on the uphill side of the tree. Measurements will be taken with a DBH tape or caliper to the nearest 0.1 cm. These measurements will form the basis of our above and belowground carbon budgets for these forests using published allometric relationships (*e.g.*, Alexander et al. 2012).

B. Snags

Measure the DBH/BD and estimate the decay stage (See Appendix 1) of all standing dead trees within the 20 m long plots. Estimate the height of each snag *as a percentage of the overall canopy height*. Note whether the top of the snag is broken off or mostly intact. You can collect snag data while sampling live tree diameters.

C. Height and Age

At each site, tree height, DBH/BD, and age will be determined for 10 trees that represent the age class structure of the stand. For each selected tree, measure height using a tape measure and a clinometer and DBH/BD using a DBH tape or caliper. We will also acquire a wood slab/core from these trees for estimating stand age and productivity. For trees < 5 cm, cut a wood slab as close to the ground as possible and parallel to the slope of the ground. For larger trees, collect a core using an increment borer. As with the slabs, collect the core as close to the ground as possible and parallel to the slope. Core straight into the tree so that you intersect the pith. Recall that, despite appearances, increment borers are very delicate items and they are surprisingly expensive ($400 each). Record the diameter of the stem from where you take the core (DCH – diameter at core height) and the height at which you take the core. Use calipers to note the bark thickness for the sample. Make sure to label all wood slabs and secure wood cores in pre-labeled straws for safe storage. Label the straw using the three letter site ID and the tree ID. If two cores are taken from the same tree mark the cores 'A' or 'B'. The tree ID is two digits, e.g., '01', '02', '03', and so on. For instance the writing on a sample straw might be: 'NSS 01 A'. Write on the left side of the straw and put your sample in with the bark-side facing toward the writing.

D. Forest Canopy Cover

Use a densiometer to record canopy cover (%) at 5-m intervals along the center transect of each plot. At each point, measure and record four densiometer readings facing North, South, East, and West.

E. Woody Debris

Carbon pools in downed woody debris will be estimated using the line intercept method (Brown 1974). To make these estimates, we will record the number of times woody debris intercepts the transect line in each plot. Woody debris less than 7 cm diameter is classified as fine woody debris (FWD); larger diameter debris is classified as coarse woody debris (CWD). We will record the number of times Class I (0.0-0.49 cm, diameter) and II (0.5-0.99 cm) FWD intersect the first 5 m of the 20-m transect lines. Class III (1.0 – 2.99 cm) FWD will be tallied along the first 10 m of each subsection, and classes IV (3.0-4.99 cm), V (5.0-6.99 cm), and all CWD will be tallied along the entire 20-m length. Diameter and decay class of CWD will be recorded according to Manies et al. (2005) (Table 1). Trees will be considered CWD and not snags if they are at an angle < 45° to the forest floor.

Table 1. Decay classes of coarse woody debris (CWD; Manies *et al.* 2005).

CWD Decay Classes	*Characteristics*
1	Bark and wood intact, knife able to penetrate samples
2	Wood beginning to get mealy, still hard for knife to penetrate sample
3	Wood mealy throughout, knife can penetrate sample somewhat
4	Wood can be broken into pieces, knife easily penetrates sample
5	Sample no longer holds shape and splits into small pieces

5. Understory Vegetation Measurements

We will quantify understory percent cover and biomass at each end of the three 20-m transect lines within each site (Figure 1). Percent cover will be estimated in a 1 m^2 plot located 1m distance away from the 0-m and 20-m ends of the transect. If the plot location lands on a tree taller than breast height, move the plot further away from the transect. Biomass will be estimated in a 0.25 m^2 quadrat located within the percent cover plot (Figure 1).

A. Understory Percent Cover Estimates

Separate each 1 m^2 plot into four quadrats. If you are facing the transect, the quadrat to your upper left is quadrat 'a', and move clockwise to label quadrats 'b', 'c', and 'd'. In each quadrat estimate percent cover by functional type to the nearest 5% (in a 1 m^2 quadrat the area of your clenched fist is about 1%). For each quadrat, your percentages must add up to 100%. Also record thaw depth and the number of tree seedlings in each quadrat.

B. Understory Biomass

In percent cover quadrat 'd', use clippers to remove and sort all the aboveground biomass by functional type. We have developed allometric equations for Pinus, Alnus, Betula and Salix (Appendix B), so for these three shrubs, use calipers to measure BD of all individuals that occur within the quadrat. Once you record BD, you can clip and remove the shrub from the plot. You do not need to save these shrubs for biomass estimation because we can determine biomass from their BD. For all other vegetation, clip, sort by functional group and place the vegetation into ziploc and garbage bags. If there is high moss coverage in the plot, you can subsample a 5 x 5 cm^2 area, making sure to note the exact size of the area from which you are subsampling. Cut the moss sub-sample from the ground, clip off and save all green moss.

6. Soil Sampling

A. Thaw Depth

Using the permafrost probe, measure thaw depth every meter along the center transect of each plot. Take a depth measurement by pressing the probe into the ground until it strikes the frozen surface (rarely deeper than 100 cm in July for most areas around Cherskii). ***Be careful not to bend or stress the permafrost probe, and do not attach the extensions unless you need them.*** Record thaw depth to the nearest cm. Label each measurement by the plot number followed by meter location (e.g. 1-6 for the point located at meter 6 in plot 1). If you land on a tree, move the measurement adjacent to the transect line.

B. Organic Layer Depth

Organic layer depth will be measured at 5-m intervals along each transect by cutting down to frozen ground with a serrated knife and visually identifying and measuring the depth to the organic-mineral boundary. If the soil is frozen above the organic-mineral boundary (i.e., the entire thawed area is organic) note this in your field notes with the letter “F”, along with the depth to frozen ground.

C. Soil Cores

Collect one soil core from each end of the plot, for a total of six cores per site. Cut a ‘brownie’ (10 x 10 cm) using a serrated knife for the organic layer and use a soil auger (2-cm diameter) to collect the top 10 cm of mineral soil. Record the field dimensions of the brownie and depth of the mineral core. If the mineral layer is deeper than 10 cm, only collect the top 10 cm. **Accurate volume measurements are essential for good bulk density and carbon pool determination**. For each brownie, record the depth of the litter layer, green moss, brown moss, fibric, and humic layers. Wrap each sample in aluminum foil to maintain depth horizons. Place each core in a plastic bag and label each bag using the site name and plot number and location (0 m or 20 m).

7. List of Field Gear

Always have:

- Radios (or satellite/cell phone if you are out of radio contact)
- First-aid kit
- Bear spray or gasoline/lighter for bears

Sampling gear:

- Sharpies, pencils, datasheets, field book, clipboards
- Permafrost probe
- GPS with extra batteries
- Three 30 m transect tapes
- Flags and flagging tape
- Write-On Whirl-Pak bags (7-oz)
- Two DBH tapes
- Calipers
- Clinometer
- Compass
- Soil Auger
- Soil saw
- Serrated soil knife
- Aluminum foil
- Ruler
- 1m^2 understory quadrat frame
- Paper bags
- Trowel

- Clippers
- Ziplock and garbage bags
- Densiometer

Tree Coring:

- Quiver with straws
- Calipers
- Two increment borers
- Beeswax for lubricating borer

8. Appendices

Appendix 1: Decay classes for Snags and Coarse Woody Debris

Snags: Physical characteristics by deterioration stage (adapted from Table 2.3 in Maser et al. 1988)					
	Decay Stage				
Snag Characteristic:	I	II	III	IV	V
Limb & branches	All present	Few limbs, no fine branches	Only limb stubs	Few or no stubs	None
Top	Pointed	Broken	Broken	Broken	Broken
Bark remaining (%)	100	Varies	Varies	Varies	<20
Sapwood presence	Intact	Sloughs	Sloughs	Sloughs	Gone
Sapwood condition	Sound, incipient decay, hard, original color	Advanced decay, fibrous, firm to soft, light brown	Fibrous, soft, light to reddish brown	Cubical, soft, reddish to dark brown	
Heartwood condition	Sound, hard, original color	Sound at base, incipient decay in outer edge of upper stem, hard, light to reddish brown	Incipient decay at base, advance decay throughout upper stem, fibrous, hard to firm, reddish brown	Advanced decay at base, sloughing from upper stem, fibrous, or cubical soft, dark reddish brown	Sloughing, cubical, soft, dark brown or fibrous, very soft, dark reddish brown, encased in hardened shell

Appendix 2: Allometric equations for calculating total aboveground biomass for four genera of large shrubs that occur in the Kolyma River watershed (Berner, unpublished). The equations are in the form of $y = ax^b$, where *y* is the total plant aboveground dry weight (g), *a* and *b* are fitted coefficients, and *x* is the basal diameter (cm).

Genus	Weight Range (g)	A	b	r^2	p	df	RMSE
Alnus	0.05-9867	24.02	2.67	0.99	<0.001	2,20	108.78
Betula	0.04-522	23.51	3.21	0.95	<0.001	2,23	24.76
Pine	8.5-774.9	70.85	1.90	0.93	<0.001	2,12	57.58
Salix	0.08-3226	5.26	3.87	0.93	<0.001	2,38	148.15