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PPS Arctic Manual

Common protocols for field measurements and handling of collected material

Compiled and discussed at the 2nd annual meeting in Tromsø, March 2007

Completed and approved by the PPS Arctic group April 2008.

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PPS Arctic

Contents

Preface

These protocols are for selection of and measurements at study sites including: a) measurements on individuals of the tree species at each site and at all stages (size classes) in the tree life cycle: seeds, seedlings, saplings, and trees; b) soil measurements; and c) socioeconomic and cultural observations. Ideally, all measurements will be made; however, this is not likely to be possible for all sites. Researchers should gauge which of the common measurements can be made and complete at least those for one of the life stages.

Common “Level I” measurements at all PPS Arctic sites should be simple but useful and made to maximise the potential for syntheses across the network. These common measurements should not detract from the major research work by each research group or at each site; they should enhance the results. Further, some of the protocols and recommendations only apply to permanent study sites/plots. For example, not all PPS Arctic field teams will have the possibility to monitor snow disappearance, but as many as possible are encouraged to include this in their monitoring programme.

The general rationale for these common protocols is to make it possible to address the following questions:

- “What are the spatial patterns in measured variables across the PPS Arctic sites during the IPY years?”

- “What characterises the spatial variations in density and tree canopy cover at a range of scales: local to circumpolar?”

Refinement of these questions will involve examination and interpretation of patterns in the data along gradients, including oceanic to continental climates, and site moisture conditions.

Authorship of this document is indicated in each section. Any queries about the implementation of a protocol can be directed, in the first instance, to the person named as the ‘contact’ in each section.

Annika Hofgaard
for the PPS Arctic group

Trondheim, April 2008

Section I: Common protocols for site-level measurements

PPS Arctic site-level protocol, Tromsø, March 2007; revised St John's, April 2008.

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1.1 Recording location

Where it is necessary to record geographical location, the following datum and coordinate system must be used:

Datum:	WGS84
Coordinate system:	Latitude and longitude, decimal degrees.

Example: The coordinates of the Scott Polar Research Institute are 52.19832 N, 0.12622 E. A common convention is that positive values of the latitude denote values in the northern hemisphere, and that positive longitudes are east of the Greenwich meridian. Five decimal places are enough to specify the position to the nearest metre; GPS measurements are not usually this accurate.

Note that this is usually the 'default' setting for GPS receivers, and it is the convention adopted by, for example, *Google Earth*. Please check and confirm that your GPS receiver is correctly configured!

1.2 Characterising the forest-tundra ecotone at different spatial scales

Purpose: to characterise the variation in tree density and canopy cover at a range of spatial scales.

LEVEL I

Step 1: Establish Primary Transect

Define a transect that extends from well within the forest to well beyond it (i.e. including the tree species limit), oriented parallel to the main transitional gradient as much as possible (see A-B and green line in Figure 1.1, below). The length of this transect will depend on the nature of the treeline transition (e.g. if the forest-tundra transition occurs over several hundred metres then the transect will be at least this long). If possible, more than one main transect should be established at each site. If it is likely that topographic aspect is a significant factor in controlling the spatial distribution of trees (in hilly or mountainous regions for instance), then transects should be established in such a way as to capture this variation.

Step 2: Establish Secondary "Cross" Transects

Along each transect, select 2-5 points within each of the (i) forest, (ii) forest-tundra, and (iii) tundra zones (i.e. 6-15 points in total; see *red circles* in Figure 1.1). These points should be equally spaced unless there is another systematic means of determining their location (e.g., elevation, avoiding lakes). Each of these points acts as the centre of a shorter cross-transect line (see *red lines* in Figure 1.1) running perpendicular to the main transect. The cross-transect lines are chosen to capture as much of the spatial variability of tree density as possible within the respective regions. They should be at least 50 m long. The location of each point where the cross-transect intersects the primary transect (*red circles* in Figure 1.1) must be recorded. The GPS location should be recorded if possible, but it can be difficult to obtain a strong enough signal under a tree canopy. (If it is impossible to obtain a good GPS position, note the distance and compass bearing from a known location.) From this point, photographs (see section 1.3) should be taken in each of the four cardinal directions (north, east, south, west), with photo centre aligned with ground level at each end of the main transect and at each end of the cross-transect. (If the direction of the photograph is not suitable, a different orientation can be selected but should be noted).

Step 3: Measure Vegetation Composition along Cross-transects

The relative abundance and composition of the (i) tree, (ii) shrub, (iii) field, and (iv) ground vegetation layers is to be calculated for each cross-transect (refer to Section 2 for definitions of each. Examples of how these may be subdivided are given in Tables 1.1 and 1.2). Three possible methods for obtaining this data are suggested:

Table 1.1. In northern Norway variables for dominance and/or presence in the four vegetation layers is recorded as follows:

Tree layer	9 variables	*Pinus sylvestris, Picea abies, Betula pubescens, Alnus incana, Sorbus aucuparia, Populus tremula, Salix caprea, Salix sp.*
		only the dominating species is recorded for each line section (each 2 metre long)
Shrub layer	3 variables	*Betula nana, Juniperus communis, Salix sp.*
		only the dominating species is recorded for each line section (each 2 metre long)
Field layer	9 variables	tall herbs, low herbs, low herbs with dwarf shrubs, broad-leaved grass, thin-leaved grass, evergreen dwarf shrubs, deciduous dwarf shrubs, sedges, *Rubus chamaemorus*
		only the dominating category is recorded for each line section (each 2 metre long)
Bottom layer	9 variables	lichens, mosses, *Sphagnum*, litter, humic soil, mineral soil, boulders/stone/rock, stream, stagnant water
		only the dominating category is recorded for each line section (each 2 metre long)
Additional data	4 variables	exposed mineral soil, seedlings and saplings of pine, spruce and tree birch
		presence of the variables are recorded for each line section (each 2 metre long)

(i) The first method is to record the presence or absence of each of the four vegetation layers at regular intervals along each cross-transect. This is achieved by extending a tape

the length of the cross transect and recording data every 1 or 2 metres (optional). If the sampling point does not fall on or directly underneath one of the four layers, then that particular layer is recorded as absent at that specific location. If the sampling point does fall on or directly under one of the four layers, then the species (or closest taxonomic or functional group, as exemplified in Table 1.1) comprising that class should be recorded.

(ii) The second method is to, as in (i), record the presence or absence of each of the four vegetation layers at regular intervals along each cross-transect, but by using continuous sections. Use a tape as described above and divide the cross-transect into 2-metre sections (or 1-metre; optional) and record each component that occupies more than 50% of the line in each section (cf. Table 1.1 for examples). As you move along the measuring tape, imagine that you have a 2 m wide glass plate raised vertically along the line up to beyond the upper canopy. At every 2nd metre stop and record each component that "touches" the plate along more than 50% of the 2 m section. It is best to stand in the middle of the 2 m section to assess the cover.

(iii) The third method is a Level II protocol (see below) in which the cover for each layer is estimated visually in contiguous 1 × 1 m quadrats. This third method is the most time consuming, but gives the most detailed data.

Step 4: Measure stand structure and key individual variables

At each end of the cross-transect lines and at regular intervals along the line (the number of intervals is dependent on the length of the line; every 50th or 25th metre is recommended), make the following measurements (for all measurements, raw data, rather than derived measures (e.g., average densities), should be recorded wherever possible):

(i) Record location (see section 1.1).

(ii) Measure stand structure using one of these methods: (1) Use PCQ (point centre quarter plotless sampling) to record distance to nearest tree in each directional quadrant, stratified by species and height class (i.e. tree, sapling, seedling). Measure height (for trees, saplings and seedlings) and diameter at breast height (for trees) of each individual.

Table 1.2. In southwestern Yukon, membership of the four vegetation layers is recorded as follows:

Tree layer	• white spruce / black spruce / poplar / aspen •
Shrub layer	• willow / birch / alder / Potentilla / juniper (to species if possible) • height class is recorded as tall (>100cm), medium (50-100cm), or low (25-50cm)
Field layer	• deciduous dwarf shrub / graminoid / forb (to species if possible)
Ground layer	• lichen / moss / litter / soil / rock / water

Additional variables to record for each individual may also include diameter at root crown, number of upright stems >100 cm tall, presence or absence of cones/fruit, and other variables listed in Section II. An alternative method would be to (2) Measure stand density (relascope) combined with height measures of the tallest tree species individuals within a given circular or rectangular plot (e.g., 100 m^2). When in the tundra, the distance to nearest tree could be given as e.g., >10 m; >50 m; >100 m; >500 m.

(iii) Measure canopy cover, using a densiometer, LiCOR LAI2000 plant canopy analyzer or equivalent instrument, or by photographic (gap-fraction) analysis. For the photographic method, it is necessary to take a photograph with a 'fish-eye' lens, i.e. one that views a full hemisphere, pointing vertically upwards. The geometric properties of the lens must be calibrated. Digital photographs are most useful since the images can be analysed using freely available image processing software. The method of analysis can follow Miller (1967) or the more sophisticated approach of Chen et al (1997). If canopy cover is very low (very few cases where the foliage of different trees overlap), however, a better method of estimation is as follows. For each of the four trees measured in the PCQ analysis of density, also record the breadth of the canopy measured in the direction of maximum breadth and the direction perpendicular to this (if not already measured as detailed in Section II). If these two breadths are x and y, the canopy area of the tree can be calculated as $\pi xy/4$ (this formula assumes that the canopy is elliptical). The average canopy cover can then be calculated by multiplying the average canopy area by the stem density. For example, if the canopy cover measurements for 4 trees were 4.8 m^2, 9.2 m^2, 8.1m^2, and 13 m^2 (mean of 8.8 m^2), and stem density for the point-centred quarter was calculated as 41 trees ha^{-1}, the canopy cover value would be 360.8 m^2 ha^{-1}, or 3.61%.

LEVEL II

The level I protocol described above can be extended to a level II measurement of spatial pattern as follows. Choose at least one cross-transect from each of the forest, forest tundra and tundra zones and extend it to at least 100 metres in length. In addition to the measurements already described, collect data using 100 *contiguous* (end-to-end, no space between quadrats) 1 × 1 m quadrats. In each quadrat record zenith tree cover (i.e. estimate what is vertically above the quadrat) by species, shrub cover (individuals >25 cm tall) and, if desired, field and ground cover (e.g., percentage cover of dwarf shrubs, mosses, lichens, graminoids etc and bare ground; see variables in Section 2). Recommended cover classes are: 0%, 1-25%, 26-50%, 51-75%, 76-100%.

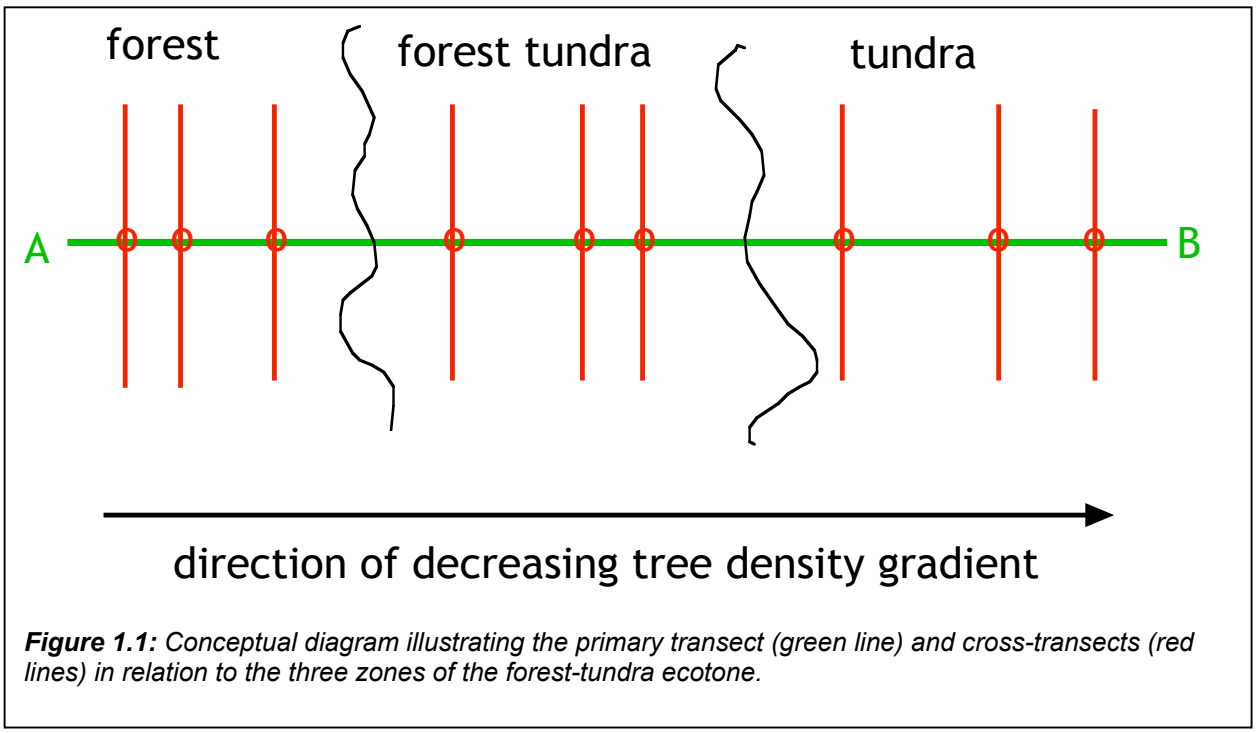

Figure 1.1: *Conceptual diagram illustrating the primary transect (green line) and cross-transects (red lines) in relation to the three zones of the forest-tundra ecotone.*

1.3 Imagery

LEVEL I: Ground level photographs.

Where ground level photographs are taken, it is important to record details and cross-reference them to an unambiguous identifier for the photograph. In (almost) all cases it is expected that photographs will be acquired digitally, in which case the resulting file will be given an automatically generated name. The image will also almost certainly have an embedded EXIF (exchangeable Image File Format) file containing information such as the date and time of the photograph (if these details are correctly set in the camera), make and model of the camera, and its settings. You should also note the location of the photograph (see section 1.1), direction of view, and a brief description of what the photograph shows (why you took it!)

LEVEL II

In addition to field-based measurements, imagery of various types has great potential to characterise the spatial configuration of the forest-tundra transition at a range of spatial scales, and to provide a link between site-level measurements and the circumarctic scale. This imagery might take the form of aerial photographs or high-resolution satellite images, and could be contemporaneous, near-contemporaneous or historical. If image data are acquired, suitable metadata, describing the essential characteristics of the image, should be logged. Examples are shown in table 1.3.

Table 1.3. Simple metadata table for airborne and spaceborne imagery collected for PPS Arctic. In addition, a lower-resolution jpeg 'quick-look' image should also be created if possible. Where possible, the coordinates of the image corners and centre should be given to 4 decimal places of degrees, equivalent to a precision of around 10 metres. Note that for processed images and derived data products such as classified images, considerably more information will need to be specified. Rather than try to construct a comprehensive metadata structure, it is suggested that the 'comments' field is used to provide a link to the originator of the data.

Raster image metadata

PPS Arctic acquisition number	1
Record edited date	20080401
Source ID	p180r013_7k19990902_z38
Image date	19990902
Type of image	satellite vertical
Instrument	Landsat 7 ETM+
pixel size (m)	28.5
spatial resolution (m)	30
Spectral type	multispectral
Centre lat	66.939
Centre lon	43.189
N lat	68.003
N lon	41.845
E lat	67.347
E lon	46.126
S lat	65.863
S lon	44.417
W lat	66.48
W lon	40.354
georeferenced	yes
orthoimage	yes
projection	UTM Z38
datum	WGS84
format	geotiff
data volume (MB)	773
quality	very good
physical location	SPRI
ownership	public
comments	

1.4 Snow and ice cover

LEVEL II

Note: much of this protocol is adapted from the ITEX protocol on snow and ice (Molau, 1993b), and further details can be obtained there if needed.

Some basic snow information in the form of long-term averages may be obtainable from general site characteristics. For example, in Europe it is possible to measure mean snow height with the use of the lichen, *Melanelia olivacea,* that grows on birch at the average snow height over the last 20-30 years (Sonesson et al. 1994). The height of branch skirting on spruce trees at North American and North European treelines can also be used in this regard. However, direct measurements are necessary for greater accuracy and these should be carried out annually in order to provide a measurement of temporal variability. To this end, two basic elements should be addressed when snow monitoring is undertaken at PPS Arctic study sites: (i) phenology of the snow cover, and (ii) physical properties of the snow pack.

1.4.1. Melt Phenology

Not all PPS Arctic field teams will have the possibility to monitor snow disappearance, but teams are encouraged to include this in their monitoring programme when possible. Snow disappearance can be measured in two different ways in the field, either by (1) monitoring the disappearance date in permanent plots or at predetermined points, or by (2) monitoring the progressive melt-off along a permanent transect, such as across the entire forest-tundra transition, along a north-facing slope, or perpendicular to a standardized snow fence. If applicable, a third related element, (3) monitoring of lake ice freeze-up and break-up, can also be implemented. Each of these is described in detail as follows:

(1) Snow disappearance date at specified points/plots: The recommended norm for recording the date when *stable* seasonal snow cover finally disappears in any given area or plot follows Foster (1989): “The date of snow cover disappearance is given as the day when 1 inch of snow (2.5 cm) can no longer be measured at the reporting station (plot) and hence only a trace of snow is observed”. Any 1×1 or 2×2 m (or other size) squares are suitable for this method. In cases where monitoring is carried out on permanently tagged individuals or branches instead of plots, use the surrounding square metre at each point as the snow monitoring plots. In order to find plots that are still snow-covered, mark the corners with sticks, irons, or plastic tubing long enough to be found in early spring. These markers should be white so as to reflect sunlight and avoid solar heating around the snow contact zone.

When monitoring of snow disappearance along a transect is not feasible (see below) the location of plots/points should be placed strategically to capture a range of variation in vegetation type and cover with adequate replication. In the context of PPS Arctic, this would include points in the forest, forest-tundra, and tundra zones.

There are at least two methods for automated detection of snow phenology at predetermined points currently in use at PPS Arctic sites. Some advanced weather stations have sonic rangers to detect snow depth (see Meteorology/Climate protocol, below). However, an inexpensive method is the use of data-logging thermistors placed at

ground level. Danby & Hik (2007) describe this method in detail. Periods when thermistors are under snow are associated with low variation in daily temperatures, since subnivean temperatures have a suppressed response to diurnal fluctuations.

While date of disappearance of continuous snow cover is the most important measure, even better resolution of the effects of climatic fluctuation/change will be obtained if you are also able to measure snow depth in the plots prior to final melt-off. In that case, a sub-sample of 10 random probings should be taken in each plot (or within a 2 m radius of the permanent measurement point) at regular intervals, preferably every third day. When monitoring snow depth or disappearance date, always note the time (hour) of the day when the measurements are taken.

(2) Melt monitoring along a transect: Monitoring of snow cover and disappearance in a systematic fashion across the forest-tundra transition yields more information than a small sample of localised plots or points. When possible, it is recommended that the monitoring of snow phenology occur along a transect that is set up in conjunction with the spatial configuration of transects used for characterising the forest-tundra vegetation transition (see previous section, and illustration in Figure 1.1). To this end, it is recommended that snow sample points or plots be established at regular intervals along each primary transect (green line in Figure 1.1). As a minimum, the points along the transect should coincide with the points at which the cross-transects cross the primary transect (red circles in Figure 1.1). Additional points can also be added at regular intervals between these. Record the location of each point (section 1.1) and make a detailed map of your transect, including orientation in degrees. Snow depth at each location should only be recorded every third day otherwise the snow cover will be too disturbed. Alternatively, each point along the transect could be marked with white PVC tubing or some other appropriate vertical gauge with metric gradations, high enough to be visible above the snow at any time of the year. In this fashion snow depth can be recorded more frequently by reading measurements with binoculars. The location of the snow edge should be recorded daily throughout the season.

(3) Ice freeze-up and break-up: If there is a suitable lake (recommended minimum size: 0.5 km^2 surface area, 5 m depth) close to the PPS Arctic site, it can be used to monitor ice freeze-up and break-up. Preferably, surface water temperature (uppermost 5 cm), break-up/freeze-up stage (see below), and ice cover should be recorded daily in addition to any manual weather observations taken at the standard 1900 hours local time. Ice cover of the lake surface is normally reported with an accuracy of 5–10 percent. For very large lakes, observations are made only for a particular area of the lake in question. Use the classification of lake ice stages shown in table 1.4 (modified from Palecki and Barry 1986). The dates of final break-up (B4) and freeze-up (F4) are most commonly used in comparisons.

Table 1.4. Classification of break-up and freeze-up of lakes

Break-up:	B0 - No sign of break-up	Freeze-up:	F0 - No ice formation
	B1 - Open water on shore		F1 - Ice formation on shore
	B2 - Open water offshore		F2 - Ice covers on bays
	B3 - Ice in movement		F3 - Ice within visible range
	B4 - Final break-up		F4 - Final freeze-up

1.4.2. Physical properties of snowpack

The second set of variables that may be measured pertains to the physical properties of the snow.

Include measurements of:

Depth
Density (e.g., using a corer)
Liquid water content (estimated by the 'snowball test', i.e. noting whether a snowball can be made from the snow and, if so, whether water can be squeezed out of it.)
Temperature profile (or at least basal temperature)
Conductivity (optional), and
pH (optional)

1.5 Meteorology/climate protocol

Note: much of this protocol is adapted from the ITEX protocol on climate stations (Molau 1993a), and is thus generally designed for permanent study sites. Further details can be obtained from the ITEX manual if needed.

If a field site is to be occupied for more than a few days, meteorological data should be collected from it if at all possible. (An alternative may be to collect data from a nearby weather station, field station, airport etc.) If a climate station is established, it should be located where surface measurements are representative for the site. Avoid unusual topographic settings, such as ridges or slopes. The station should be located within an area of uniform surroundings, and at least 30 m from larger buildings and rocks (as a rule, no closer than four times the height of the obstruction). Within the context of the forest-tundra ecotone, it is suggested that a station be located at (or just below) the treeline whenever possible.

LEVEL I

1.5.1. Measurements

In a Level I climate station the following variables are to be measured:

- Air temperature (protected from the sun, at 1.5–2 m above ground)
- Precipitation (0.5–1 m above ground)

Instrumentation for manual recording: mercury maximum and alcohol minimum thermometers, thermometer(s) for soil temperature, precipitation gauge. The air thermometer(s) must be screened in an enclosure (e.g. Stevenson screen) at a suitable recorded height (standard height is 2 m), while the precipitation gauge should be shielded. Two soil temperatures should also be measured, at depths of 10 cm and 50 cm (or as deep as possible if less than 50 cm). Note that some soil temperature probes may require weeks after installation to attain stable values, although thermistor probes generally will require only a few hours.

Manual measurements: Record the maximum and minimum temperatures daily at 07:00 and 19:00 local time. Record precipitation amount over the previous 24 h daily at 07:00, and note the type of precipitation.

Alternatively, and preferably, the data can be collected digitally using suitable sensors and a data logger (see Level II below). Cables should be protected against physical damage (e.g., by strong winds, rodents or reindeer, or clumsy scientists) with rubber tubing, or PVC or metal conduit.

Co-operation should be established with the permanent meteorological station located closest to the site. From there, extract daily means for all parameters common to both the site and the weather station for the time period the climate station has been operating, and run simple regressions (stratified by season) for all parameters. This procedure allows extrapolation of values for the site during periods when the climate station is not in operation.

1.5.2. Calculation of heat accumulation

Meteorological data may be needed in order to calculate the number of degree-days above some threshold temperature, e.g., 0 ˚C (for thawing) or 5 ˚C (for plant growth). If a continuous record of the temperature is not available, but daily maximum and minimum values are available, the number of degree-days contributed by each day can be estimated on the assumption that the temperature varies sinusoidally with time. If both the maximum and minimum temperatures are above the threshold, the number of degree-days contributed by the day is just the average of the two temperatures, while if both are below the threshold the contribution is zero. However if the minimum is below the threshold and the maximum is above it the calculation is more complicated. In such cases the following procedure, which has been adapted from the ITEX manual, may be used.

Note the daily minimum and maximum temperatures $T_{\min}$ and $T_{\max}$, measured in ˚C, and calculate

$$p = \frac{T_{\max} - K}{T_{\max} - T_{\min}}$$

where *K* is the threshold (0 ˚C or 5 ˚C as appropriate) for the degree-day calculation. If *p* is less than or equal to zero, the daily heat accumulation *H*=0. If *p* is greater than or equal to 1, *H* = $(T_{\max} + T_{\min})/2$. If *p* is between 0 and 1, *H* is given by the formula

$$\frac{\arccos(1-2p) + 2\sqrt{p(1-p)}}{2\pi}(T_{\max} - T_{\min})$$

It is necessary to take the inverse cosine (arccos) function in *radians*, not degrees.

A graph for simplifying this calculation is shown in figure 1.2.

LEVEL II

1.5.3 Measurements

In a Level II climate station the following additional variables are to be measured:

- Wind velocity (at 3.0 m above ground)

- Global solar radiation
- Relative humidity (at least during the vegetation period)

The Level II station requires a data logger. Configure it to store hourly means, and (if possible) also daily maximum and minimum records for all channels. If the station is entirely automatic you will need a heating device for the precipitation bucket recorder; most loggers are equipped with a feed-back output which can be programmed to be triggered by, e.g., temperatures below freezing. Power supply for logger operations can be a problem in remote field sites; use batteries (e.g., dry cell or vehicle battery) which can be recharged by a portable generator or continuously charged by solar cells and/or wind generators. If year-round operation is attempted, note that solar cells will be out of activity during winter in the Arctic. Install multiple climate stations if possible. If the site has significant variation in altitude, use multiple climate stations to investigate the local lapse rate.

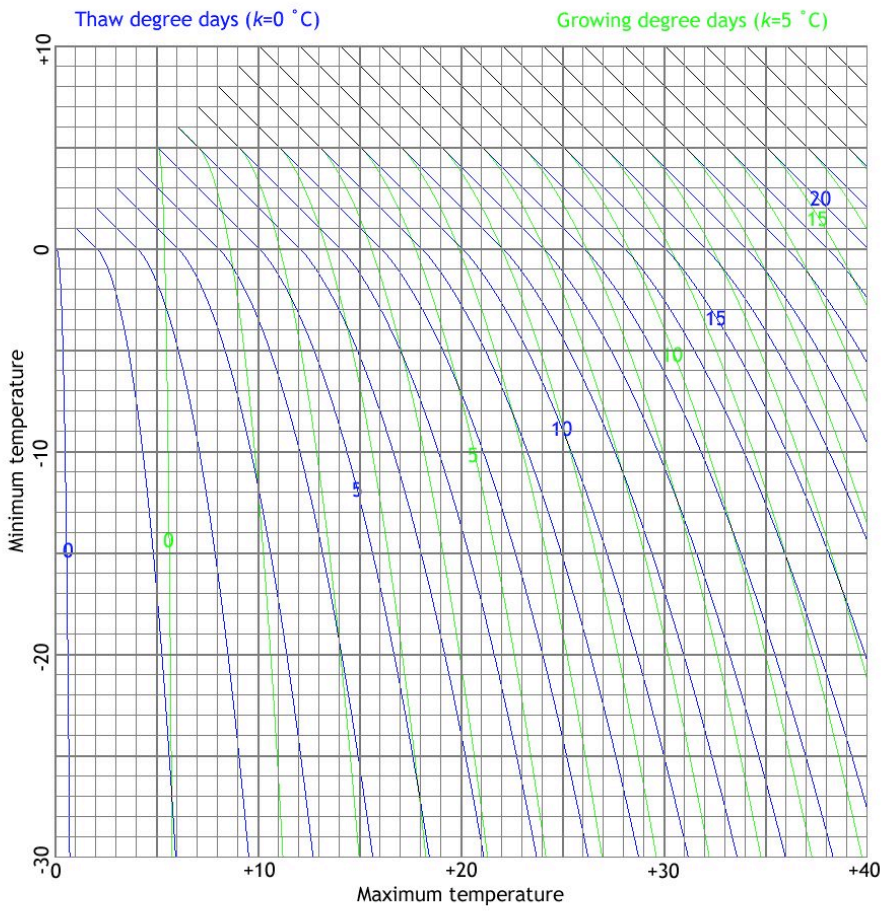

Figure 1.2. Graph for calculation of the daily heat accumulation. For example, if the day's maximum temperature is +7 ˚C and the minimum is –10 ˚C, the blue curves show that the number of thaw degree days is around 2.0 while the number of growing degree days is shown by the green curves as around 0.4.

Section II: Common protocols for measurements of individuals and vegetation

PPS Arctic individual level protocol group, Tromsø, March 2007; revised St John's, April 2008.

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Introduction

These protocols are for measurements on individuals of the tree species and the vegetation at each site. The protocols are designed to include all stages (size classes) in the life cycle: seeds, seedlings, saplings, and trees. Ideally, all measurements at all stages will be made. Even if this may not be possible for all sites the measurements are considered to be Level I. Researchers should gauge which of the common measurements can be made and complete those for at least one of the life stages.

Site description measurements based on the structural layers are described in Section 1. These measurements will provide the basic, site-level descriptions of tree size, density, and vegetation cover. For measurements at individual level, the research question can be put as "What is the age structure, height, diameter growth and vegetation changes along forest-tundra gradients at circumpolar treeline sites?" Individual level data will allow examination of growing substrate and micro habitat, population age structure, and dynamics of diameter and height growth of woody treeline species. Methods for these measurements are described below.

Sampling Sites

Choice of sampling sites is based on criteria established in Section 1. However, some sites already have permanent plots for the measurements outlined below. Where possible, we recommend choosing sampling areas along local gradients (e.g. moisture, altitude, aspect). Locations of sampling points should be recorded by GPS, including coordinates and elevation as in Section 1.

Besides the basic information, researchers should take notes to describe other aspects of the sites and measurements that will help in the interpretation and potential re-measurement in the future. Photos of all individuals are very useful (see section 1.3).

Data forms

Data forms for the measurements are being developed and will be attached to this document and will be available on the web site. Data forms for the point frame method of vegetation description are found in the CANTTEX Manual (Bean and Henry 2003; www.eman-rese.ca/eman/ecotools/protocols/terrestrial/

2.1 Seeds: sampling and quality tests

Seeds should be collected from the important tree species and/or shrub species (to be decided by the researcher) within the study area. We recommend a minimum sample size of 10 trees/shrubs per site, composed of 10 cones or catkins per tree that are collected from at least five different branches to ensure that sampling is from all around the tree. Where possible, collect the same number of cones/catkins from each branch on the tree. When catkin- or cone-level estimates of viable seed (see below), is part of the study each catkin or cone should be placed in individual sample bags otherwise one bag per species and site can be used. The timing of seed collection will vary by species, but should be as close as possible to the natural time of seed maturation or dispersal. *Know the requirements for your species!* Seeds can be allowed to ripen in cones or catkins under cool, dry conditions. When collecting the seeds, do not leave them in plastic bags and ensure they are kept dry.

We recommend two types of seed collections and researchers are encouraged to participate in both:

1) Site level measures of viable seed production: Used to assess the potential for sexual reproduction across treeline ecotones. Ideally, germination tests should be done on a per cone or catkin basis. If this cannot be done, seeds from each tree can be mixed in a common, species-specific seed collection for the site. Ensure that species and sites are not mixed.
2) Contributions to national seed collections: Seeds should also be collected for National Tree Seed Centres in each of the PPS Arctic countries. For example, in Canada northern seed collections are solicited for the Legacy Arctic Seed Bank collection to be housed at the National Tree Seed Centre (CFS-Atlantic Forestry Centre, Fredericton, NB, Canada). The seed collections from each site (recommended minimum number would be ca 3,000 seeds per species and site) need to be labelled by individual tree (preferably) or at least by provenance.

After collection, seeds should be stored in cool and dry conditions, usually in a freezer or refrigerator. Seed extraction and testing are most conveniently done in the laboratory. Use a method appropriate for your species to extract seeds from cones or catkins. Before germination trials, seeds may be surface sterilized to reduce mould growth (Leadem et al. 1997). Conifer seeds should be pre-soaked for 24 hours and stratified at 4 ˚C in moist (not wet) sand or vermiculite before germination trials (Leadem et al. 1997). If space permits, it is easiest to stratify the seeds in the Petri dishes that will be used for the germination trials (described below). Some deciduous species do not need to be cold-stratified but *Salix* spp. in particular should be continually cold-stored under dry conditions until tested. Germination and optimal storage requirements will vary depending on species, so *know the requirements for your species!*

There are several possible methods for assessing seed viability. We recommend direct assessment of seed viability using germination trials. Germination studies should be conducted in a laboratory or greenhouse under relatively controlled conditions designed to simulate the late-spring or early summer conditions of your site. Day length should match the mean summer day length at the collection site. Germination trials should be carried out with replicated samples of seeds placed in Petri dishes. Form cotton batten or other sterile material into the base of a Petri dish (Figure 2.1). Moisten the cotton with water and pour any surplus water off. Sow a known number of seeds (e.g. 500 seeds, but the number

should be adjusted according to seed size and the size of Petri dishes) on the moist cotton or other material and cover with the top of the Petri dish. We recommend cotton batting as a substrate, rather than filter paper, because the paper tends to dry out more quickly. It is very important that the seeds are kept moist throughout the germination period. Covering the Petri dishes with a transparent plastic sheet or in loose plastic bags will help prevent moisture loss. Measurements of temperatures and light levels should be made as often as possible to document the germination conditions. The germination trials should last for at least 30 days for slow responding species such as *Picea*, but a considerably shorter period will be required for deciduous species such as *Populus*. The presence of germinants should be noted as often as possible (daily is optimal). Germination is apparent when the radicle or cotyledons are at least the same length as the seed. Remove germinated seeds from the dishes once they have been counted. At the end of the trial, non-germinated seeds may be dissected to determine if they were filled or empty (recommended for conifer seeds). When common species-specific site samples are used (cf. above) trials should be conducted on at least 3 replicate samples per site.

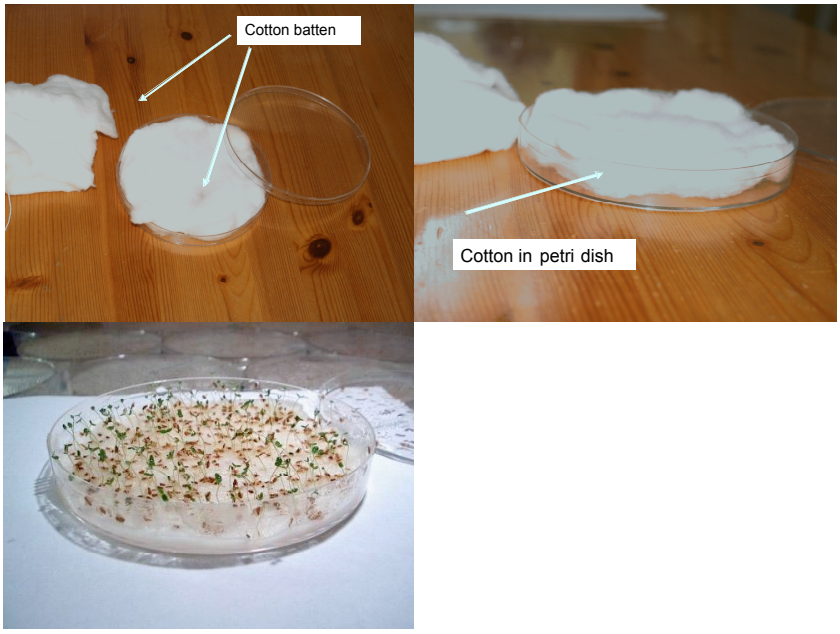

Figure 2.1: Cotton batten placed in Petri dish. Seeds to be placed on wetted cotton. Germinated seeds are counted and removed frequently during the germination period.

2.2 Measurements on individuals: Seedlings, Saplings, Trees

Individuals are categorised by height. Seedlings are up to 15 cm tall, saplings between 15 and 199 cm, and trees are 2 m or more.

The numbers of individuals of each species in each size class to be measured will be determined by each researcher. If sites are arranged through the forest-tundra as in Section 1, we recommend that plot size be chosen to include at least 30-50 mature trees for measurements at each of the sites along the main study transect (green A-B line in Figure 1.1 in Section 1). All individuals, irrespectively of size, within the plots (e.g. 50 m ×

50 m or larger) should be recorded and measured. Ideally, multiple plots ($n \geq 3$) should be used to sample spatial heterogeneity within each treeline zone. If necessary, smaller nested plots can be used for measurements of seedlings and saplings.

2.2.1 Seedlings and Saplings

Sampling should be done at the level of individual stems. Where there is clonal growth, stems may be clustered into ramets. For each stem, record the following:

- Species
- Size class (seedling or sapling)
- Reproductive origin (sexual or clonal). In many cases, it will be necessary to excavate around the roots to look for evidence of clonal origin (layering or sprouting from roots or stumps).
- Height (measure from root collar to last bud scar)
- Basal diameter, at or near the root collar (measure widest point just above the swelling of the root bases)
- Crown diameter (measure the two longest perpendicular diameters at the same height, usually near the base of the live crown)
- Herbivory: note presence or absence of herbivory, such as browsing by mammals, insect or bird damage to stems or leaves, cut twigs lying on the ground, and piles of cone scales. Record the type of herbivory when it occurs.
- Damage to apical meristem (yes or no).
- Vitality class (dead, reduced, healthy). Stems classed as having reduced vitality should show clear signs of being stressed, such as frost cracks, fungal fruiting bodies, broken stem pieces, extensive leaf or needle death, discoloured foliage, branch dieback. Keep in mind that discolouration and death of the oldest needles on conifers is a normal late-summer/autumn process, and the same applies to all leaves of most deciduous species.
- Reproductive effort: note presence or absence of cones/catkins from the current year. If possible, assess abundance using a three point scale: <10, 10-50, >50 cones or catkins per plant.
- GPS position (see section 1.1) or plot coordinates of the individual.
- Microsite characteristics: recorded using the measured stem as the centre of a circular subplot. Measurements may be pooled for closely clumped stems.
    - Seed bed type: 20 cm subplot radius. Record the dominant ground layer functional group (Table 2.1) and moisture condition (dry, mesic, wet) and cm depth of the seed bed.
    - Vegetation composition (functional group; Table 2.1): 1 m subplot radius. List the dominant functional group (> 50% cover) for each of the major layers around the target plant: ground (bottom)-, field-, low shrub-, sapling/tall shrub-, and tree layer.
    - Microtopographic conditions: 1 m subplot radius. Record local slope position (top /convex, slope, or bottom/concave), and distance to major topographic features, such as a rock face, boulder, stream, etc.

Plot-based measurements for seedlings and saplings:

- In order to test for factors likely to affect seedling or sapling occurrence, microsite conditions measured around individuals (above) should be compared to a sample of subplots located at random points within the study plot. Points can be selected using a

random number table to determine coordinates within the plot or along transects. We recommend a random sample of at least 50 points per plot. Microsite measurements at random points should follow the same procedure as measurements around seedlings. Be sure to make record when a tree seedling is found within the random point subplot.

- Search for "true" seedlings using 10 cm × 10 cm quadrats along the vegetation structure transects. This will provide an estimate of the detection error for very small seedlings.
- Height growth of saplings, see section 2.5 below.

Table 2.1: *Functional groups for assessment of vegetation surrounding seedlings, saplings and trees*

BOTTOM- / GROUND LAYER:
- bare ground
- water
- litter
- dead peat moss (for peatland sites)
- *Sphagnum* mosses
- acrocarpous mosses
- pleurocarpous mosses
- lichen

FIELD LAYER (note to species level, if possible):
- ferns[0] or horsetails (*Equisetum* spp.)
- evergreen dwarf shrub (tall/short)*
- deciduous dwarf shrub (tall/short)
- graminoids (tall/short) (separate by group: e.g. sedges, rushes, grasses)
- forbs (tall/short)

SAPLING/TALL SHRUB LAYER:
- tree species individuals <2 m and deciduous and coniferous shrubs separated by genera or species: e.g. *Alnus, Betula, Salix, Juniperus* – canopy above the seedling/sapling in 1 m radius cylinder

TREE LAYER:
- trees (>2 m) by species – canopy above the seedling in 1 m radius cylinder

* *short = ≤15 cm; tall >15 cm*

2.2.2 Trees

- Species
- Stem diameter: basal (just above the swelling of the roots) and breast height (1.3 m)
- Crown diameter at base of live crown (measure the two longest perpendicular diameters)
- Height: living height; dead height (if dead top is taller than the living); height to the egression point of lowest living branches
- Height above ground to the top of abraded or defoliated zone to indicate long-term snow depth in forest tundra
- Herbivory: note presence or absence of herbivory, such as browsing by mammals, insect or bird damage to stems or leaves, cut twigs lying on the ground, and piles of cone scales. Record the type of herbivory when it occurs.

- Damage to apical meristem (yes or no). For tall trees, observe apices of branches within view.
- Vitality class (dead, reduced, healthy). Stems classed as having reduced vitality should show clear signs of being stressed, such as fungal fruiting bodies, broken stems, top dieback, extensive leaf or needle death, discoloured foliage, or branch dieback. Keep in mind that discolouration and death of the oldest needles on conifers is a normal late-summer/autumn process, and the same applies to all leaves of most deciduous species.
- Reproductive effort: note presence or absence of cones/catkins from the current year. If possible, use an abundance scale on trees where height was measured (10 or less, 10-50, more than 50). Binoculars are useful to assess cone abundance.
- GPS position (see section 1.1) or plot coordinates.
- Measure micro-site characteristics as for seedlings and saplings, including vegetation composition around the tree. This will provide the opportunity to compare changes in the abundance of vegetation functional groups associated with the three stages of tree development (seedling, sapling, and tree).

2.3 Age structure of tree species

The same plots should preferably be measured for age structure and the individual-based measurements described above in this section. If other individual sites are used, the sites should be chosen to ensure a relatively uniform density within the individual sites, i.e. not at a sharp boundary or strong density gradient. Record the location of the centre of the sample site by GPS (section 1.1) when circular plots are used and the corners for squared plots. Rectangular plots of 50 × 50 m are recommended, which can more easily be adjusted in size as required (see details below). Each assembled age structure should ideally consist of >150 tree, sapling and seedling individuals per tree species.

2.3.1. Trees

Take cores from all living trees within a plot large enough (or multiple plots) to contain a minimum of 50 trees. Sampling of dead individuals is optional. The recommended number only accounts for the forested part of the transition zone. At and beyond the treeline the number of trees will naturally be close to zero. Cores should be taken as low as possible (i.e. as close to the germination point as possible) and should reach beyond and include the pith. If good samples are not obtained from all trees, enlarge the plot as necessary. Record the diameter of the tree and height where the core is taken. Cores having heartrot should not be used for age estimation but the presence of heartrot should be noted. Handling of samples, preparation and ring counting for age determination should be done according to standard dendrochronological methods (e.g. Cook and Kairiukstis 1990).

2.3.2 Saplings and seedlings

Sample all saplings and seedlings within the same sample area as for trees, above. A randomly selected sub-section of the area can be used if the frequency of seedlings/saplings is high; area representation needs to be carefully noted. For each stem, note the reproductive origin (established clonally or from seed). Core/cut the sapling/seedling at the stem base. This gives a measure directly comparable with samples extracted from trees (cf. above). For recording of the “true” germination year excavating the base of seedling/sapling is needed. A stem section can thus be collected at the true root collar level. Note that these data are not directly comparable with data from cored

trees, but can provide helpful data on time required for development from the germination event to the height of tree coring position. It is also useful to measure the height of the sampled individuals (cf. 2.2.1), to look for age-height relationships.

2.4 Diameter growth of tree species

Sample trees should be chosen, as far as practicable, in areas with uniform density representing sections of the forest-tundra transition. Collating of trees representing different sections of the zone into joint chronologies should be avoided. Trees to select should have a straight upright growth form. Take two cores, perpendicular and from opposite directions, from each selected tree at the standard height of 1.3 m. If possible the cores should include the pith. We recommend that 20-30 trees are sampled per area/section of the transition zone. However, in the treeline section this might be difficult. Record the location of each sampled tree by GPS (section 1.1). Store your cores under dry conditions until bringing them back to the lab, or mount them on thin wooden moulding as soon as possible after coring (preferably the same day). Do not store the cores in plastic straws as they might rot. Label the tree data and cores in order to link them. Record other measurements related to the chosen individuals as described above. Handling of samples, preparation and ring measurement for diameter growth determination should be done according to standard dendrochronological methods (e.g. Cook and Kairiukstis 1990).

2.5 Height growth of tree species

Stem internode measurements (i.e. length between whorls of branches) on species with an apically dominant growth pattern. Randomly select approximately 30 saplings that show little or no evidence of disturbance, e.g. healthy saplings that have little evidence of browsing or wind damage. Note the species and which definition of internode length is being used. Measure internode lengths as far back along stem as possible. Without aging, this will give average extension per internode at the site level for comparison among PPS Arctic sites.

2.6 Additional measurements (Level II)

2.6.1 Vegetation measurements and analysis

In order to describe biodiversity changes through the treeline gradient, we require measurements of composition and abundance at the species level. Density and cover measurements of tree species and tall shrubs described above can be used for this purpose. For species composition and abundance of field- and bottom layers, more detailed analyses are needed. We suggest two different point frequency methods using analyses along lines and in plots/quadrats, respectively, nested in the tree/sapling/seedling plots (cf. 2.2). Note that both point methods are designed for vascular plant species and larger bryophyte and lichen species. The second suggested method is the most time consuming of the two.

(i) Point frequency measure adapted to line analyses. This method uses point-intercept observations along 10 m lines (or 5 m) to record species abundance. Use a measure tape for the lines. Multiple 10 m lines should be randomly distributed in the sample plot (at least 10 lines; if 5 m lines are used more lines are needed). Record only the first/uppermost hit

for each 10 cm mark on the tape along the lines (the width of tape markers used to be 1 mm which is the preferred dimension for the point intercept). Following this protocol a total of 100 field- and bottom layer recordings are recorded per line.
(ii) Plots/quadrat based measures following the ITEX / CANTTEX standardized point frame method for ground vegetation measurements (Molau and Mølgaard 1996; Bean and Henry 2003; Bean et al. 2003). This method uses a grid of point-intercept observations to record species abundance within 1×1 m plots. Quadrats should be located randomly within the larger tree plot (recommended at least 10 quadrats). Record all hits at the point in order from top to bottom. Example frames and data sheets are found in the CANTTEX Manual (Bean and Henry 2003). Because the point-frame quadrats cannot accommodate large-statured vegetation, sample points that land on a tree or large shrub cannot be sampled.
ITEX Manual available from: www.geog.ubc.ca/itex/library
CANTTEX Manual available from: www.eman-rese.ca/eman/ecotools/protocols/terrestrial/

2.6.2 Berry production and shrub cover

Protocols are being developed within the Canadian IPY Tundra Project (CiCAT) for transect measures of berry production by important shrub species and for shrub cover and density. Links will be made to these when available.

Section III: Common protocols for soil measurements

PPS Arctic soil protocol, Tromsø, March 2007; revised St John's, April 2008

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3.1 Soil sampling strategy

Transects are to be set up across the treeline as described in Section 1. Soil sampling will be conducted along this transect at representative locations within each zone, preferably in proximity to the vegetation points. Thus, soils will be sampled according to Level I protocols along or adjacent to this transect at 2 to 5 points in each of the three zones: forest, forest tundra, and tundra. Level II protocols will be applied to a subset of these points, with at least one point in each zone. The reference level for all depth measurements is the ground surface, defined as the surface of the soil sequence, below any above-ground plant parts or free litter.

At each sample site:

- Record date and time
- Record name of observer
- Record GPS location (cf. Section 1.1)
- Record elevation (metres above sea level) and indicate how determined (altimeter, GPS, extrapolation from topographic map) with estimate of probable error.
- Record aspect (azimuth bearing in degrees from true north OR direction on a 16 point scale)
- Describe general surface characteristics
    - vegetation community (e.g. dwarf-shrub heath) along with the total amount of ground covered by vegetation, rock, and bare soil). N.B. Most soil samples will be associated with a vegetation plot that will already have more detailed vegetation cover data recorded (cf. Section 2). In this case, it will be sufficient to give the name of the community type.)
    - moisture (dry, mesic, wet)
    - slope (level, slight, moderate, steep)
- Comment on recent weather: specifically when last rainfall occurred, and the amount.

At point of sampling:

Level I

Describe the surface cover – take digital photos, including one that includes the horizon and noting the direction of view (see section 1.3).

- Measure the organic layer depth at 10 points in a 5 m radius. Use a trowel or spade to expose the soil. In the case of deep organic soils, indicate e.g. "> 20 cm" or whatever the depth of exposure is.
- Measure Depth of thaw relative to soil surface (use a steel probe at 10 points in a 5 m radius)
- Soil pit: With a spade, dig a shallow (≤ 1 m) pit to expose the organic layer and at least the A layer (the A layer may not be visible in deep organic soils). Take digital photos of soil section showing horizons and roots. Include a scale in the field of view. Measure the depth of all available horizons, including the organic (LTH) layer. Indicate the criteria used to differentiate between the organic layer and mineral soil, as this is often problematic for organic-rich mineral layers. (E.g. use >30% organic content as the threshold, or a more qualitative threshold of mostly organic vs. mostly mineral, judged based on smearing the soil in your hand.)
- Assess the soil texture by hand (relative proportions of fine, intermediate, and coarse soils. For an appropriate qualitative scale and method, refer to BC Ministry of Forests (1998).
- Assess soil moisture. (Suggested categories: standing water [=super-saturated], free water [=water drains under gravity, leaves a wet mark on hand or water films clearly visible in soil], feels moist [between wilting point and field capacity], feels dry [crumbly texture, does not hold together in ribbons or balls]).
- Measure the soil pH of humus and mineral horizons. (1) *Fast field method* – Place a ca 50 gram soil sample in a plastic beaker and break it up using a clean wooden stirring stick. Make a slurry using an approximately equal weight of de-ionized or distilled water. Measure the pH of the slurry using either pH paper strips with 0.5 pH unit increments or a pocket pH meter with 0.1 unit accuracy (sources for both are standard laboratory suppliers, e.g. Fischer Scientific http://www.fishersci.ca/). Take a sample back to the laboratory for calibration with a pH meter. (2) *Precise water extraction method*. This requires a suitable work area in the field or laboratory. Collect a ca 50 gm soil sample from each horizon into plastic bags using a clean trowel. Prepare samples and measure their pH as described in the appendix to this section.

Level II

- Soil temperature is to be measured using miniature loggers or probes. (See Section 1, Snow and Meteorological Protocols, for probes and loggers to use.) Measure the temperature at 10 cm below the surface (as defined above). If possible measure at several depths (surface, 10, and 30 cm depth. Temperature should be recorded at least once every 4 hours, but preferably hourly. Time should be local standard time.
- Soil moisture
    - (a) bulk sample method (a sample is taken of the root zone soil (note depth), and sealed in plastic bags for later measurement of wet and dry weight).
    - (b) if available, soil moisture probes are planted at the start of the growing season and read periodically
- Laboratory analysis: Bulk samples (ca. 0.5 kg) of organic and mineral horizons should be taken for lab analysis to include: texture, grain size analysis (sand/silt/clay and loss

on ignition), total C and N. Samples should be kept cool if chemical analysis is to be done.

- Soil nutrients (major ions). The recommended method uses ion exchange membranes, such as Western Ag Innovations PRS™ probes (http://www.westernag.ca/innov/index.php) or equivalent. These are placed vertically in the soil for a period of at least three weeks during the growing season. Dates and times of installation and removal are to be recorded. Measure and record the 10 cm soil temperature at the start and end of the deployment. Probes are inserted directly below the live moss layer. Probes should be cleaned according to the instructions by Western Ag Innovations and analysed according to their specifications. Analysis may be done for the whole suite of nutrients, but at a minimum should include total nitrogen, nitrate and ammonium. A minimum of 20 soil mineralisation pairs per site should be used. This sampling size would typically allow you to detect differences of 25% or more in nutrient mineralisation. If you want to detect smaller differences you would have to increase the sampling size. If your sites are highly replicated (i.e. you have 10 closed forest, 10 open forest and 10 tundra sites) you may decrease the number of probes but you should maintain at least 20 probes per zone.

3.2 Litter bag protocols (all level II)

Litter bag experiments

Rationale

This protocol is designed to allow the detection of inter-site differences of 15% or more, based on experience of variability in forest environments. The experiment is described in such a way that the bigger motivation is visible, but could be difficult in practice to follow in detail. Anyone adapting the protocol to his/her sites should keep in mind the bigger pictures (and the details). We should try to follow the Fluxnet Canada protocol (http://www.fluxnet-canada.ca/) We should focus on upper soil processes, ignoring largely lower soil decomposition processes.

Hypotheses (not exclusive)

- Low soil nutrient mineralisation rates limit the existence of trees in the upper treeline ecotone
- Mineralisation rates are substrate-limited and different vegetation patches may have different mineralisation rates
- Decomposition rates are primarily temperature-limited and will change according to the soil microclimate and macroclimate.

Figure 3.1. Site patchiness

Site setup

Ideally there are three sites to set up (see Section 1):

- A tundra site (absence of trees) with no evidence of recent forest cover.
- A treeline site (intermingled trees and tundra patches)
- A forest site

Sampling should be concentrated on sites where other level I and level II protocols are implemented. We suggest a minimum of 8 litter bags per site. It may be practical to concentrate litter bag, soil temperature, and nutrient supply measurements all within a 1 metre radius to facilitate retrieval of material.

Ground vegetation is patchy and sampling should be stratified according to vegetation patches. The total area of patches should be estimated using a transect (cf. Section 1).

Tree stands should be stratified in terms of tree influence zone and non-influence zone. The crown influence zone is defined as twice the crown diameter. Rock and scree areas are excluded from the analysis but would have been written down for the area considered. (e.g. the calculated nutrient flux per hectare will be different if you think that 1/3 of your surface has little or no biotic cover). The types of ground cover will vary – especially in the tundra.

Litter bags:

Litter bags with black spruce litter should be used. Each bag should contain about 2 g of spruce litter. The bags will be placed under a moss/grass lichen layer into the first 2 cm of humus. Moss etc will be put again on the bags after insertion. The bags should be placed during early mid summer (target date 15th of June). The bags would have to be retrieved at the same time following year (target date 15th of June). .

Standard substrates are flat 'ice-cream' sticks of white birch material. The sticks are to be inserted with the litter bags (same position and time) at 45 degrees into the soil. The sticks are to be retrieved when the litter bags are retrieved and returned with them for analysis.

Setup:

There should be about 4 litter bags for each stratum at each site. Birch 'ice-cream' sticks will be replicated about 10 times per stratum per site. Sampling should be semi-systematic along a grid.

Litterbags should be dried at 65 ^{o}C for 24 hours prior to analysis. Litter weights are measured with and without the bags. The balance should be calibrated using standard known weights prior to analysis. Weights are recorded at least to the nearest mg.

Appendix A3.1 Measurement of Soil pH by Liquid Extraction

Figure 3.2. Measuring soil pH by liquid extraction.

This method (source: NASA Goddard Space Flight Center - http://soil.gsfc.nasa.gov/) involves the use of either pH paper or a PH meter, such as a portable pen-type. It employs de-ionized or distilled water to extract a solution of available ions from the soil. An equal weight of water is used per weight of soil. In addition to the pH paper or meter, an electronic or other sensitive balance is required. The procedure is as follows (see figure 3.2):

1. Soil samples are first prepared by drying and sieving. At least 40 g of sample is recommended for each analysis.

2. In a cup or beaker, measure the pH of the distilled water you will be using. Dip the pH paper or calibrated pen or meter, into the water and obtain a reading.

3. In another cup or beaker, mix 40 g of dried and sieved soil with 40 ml of de-ionized water (or other amount in a 1:1 soil to water ratio), using a spoon or other utensil to transfer the soil. Stir with a spoon or other stirrer until the soil and water are thoroughly mixed.

4. Stir the soil-water mixture for 30 seconds every 3 minutes for a total of five stirring/waiting cycles. Then, allow the mixture to settle until a supernatant (clearer liquid above the settled soil) forms (about 5 minutes).

5. Measure the pH of the supernatant using the pH paper, pen, or meter. Be sure to place the bottom of the pH pen or paper in the supernatant – that is, in t he clearer liquid above the settled soil.

6. Repeat the above steps for each sample from each soil horizon, and record your results.

Section IV: Common protocols for regional socioeconomic and cultural observations

PPS Arctic Social-cultural-ecological protocol, Tromsø, March 2007; revised St John's, April 2008

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4.1 Introduction

One of the four principal objectives of PPS Arctic is "to develop conceptual models of the long term relationship of environmental change and human health and well-being in the Arctic and Sub-Arctic. …". Research should therefore include the participation of Northern Peoples and address human-landscape interactions, documenting social-cultural-ecological patterns, and observations of political, economic and cultural factors related to health and well-being.

Snapshot level data collection should be completed wherever possible in consultation with local communities. Activities under Section IV are not intended to replace major social-cultural-ecological research at each site; rather these activities should enhance other more intensive research activities.

Common protocols for ethical human-landscape interaction research, for quantitative and qualitative social-cultural-ecological field observations, and for ethical handling of material collected with communities and individuals are described below. They reflect the 'respect model' mandated by the Canadian Government (see appendix A4.1).

4.2 Snapshot of regional socioeconomic and cultural observations

LEVEL I

At a minimum, you should try to obtain, where appropriate, qualitative data in response to the "snapshot". This Protocol is the initial survey of local conditions and concerns, as reported by local people, for all PPS Arctic Sites where contact occurs and local people wish to be included in the work of PPS Arctic. This Protocol includes a simple oral informed consent and unique identifier (the location, date and the researchers' name) to protect anonymity, and no personal information is to be collected in this connection. The initial survey consists of 10 very basic questions to be answered by self-reporting, on a single sheet of paper. The questionnaire can be prepared as a form, to be completed wherever possible in consultation with local communities by all PPS Arctic researchers.

4.2.1 Simple informed oral consent

Please read the following consent statement aloud to the person who is to be interviewed:

“If you agree, we would like to ask 10 questions concerning your experience and your well being so that we can understand the ways in which environmental changes and other changes may be affecting you. We will not record your name or any identifying information, and we will not disclose in anyway your identity, so that your anonymity is protected. We will include your answers in our research and in our reporting. We will not be giving a payment, but will provide a small gift to show our appreciation for your contribution. Do you agree to this arrangement, and that we may ask you these 10 questions?”

If the person says “yes”, then continue to the questions below. If the person says “no”, then the interview is ended at this time.

4.2.2 Questionnaire

Record location, date and name of the researcher.

1.What are main issues affecting the quality of life in the region where you are? Please list issues of concern to your quality of life (e.g., nature, economic, social, culture, governance…etc.).

2.What are the main driving forces contributing to the issues you listed in your answer to question 1 above?

3.What are the main consequences for quality of life of the issues that you listed in your answer to question 1 above?

4.What can be done to achieve a better quality of life and sustainability?

5. What are main indicators, or variables that we should observe to understand the trends for better and worse in the quality of life?

6. Is your environment healthy? (Yes or no, with invitation to add comments).

7. Is your life better than it was 5 years ago? (Yes or no, with invitation to add comments).

8. Is your personal health good? (Yes or no, with invitation to add comments).

9. Are you happier now than you were 5 years ago? (Yes or no, with invitation to add comments).

10. Are environmental changes that are taking place influencing your well-being? If yes, please add comments:

4.3 Human-landscape interaction

LEVEL II

It is necessary to document location, site and cultural landscape descriptions, and these should be completed for all sites, to the extent possible. Please note that the cultural landscape information includes local names, landscape features, governance, local facilities, and community organisations, as well as other features of political, cultural, economic and social life. Appropriate additional questions are provided in this section. These can again be prepared as data forms. Please note that in Canada, many jurisdictions require research licences and a list of contacts is provided (see appendix 4.2, below). If you are in a jurisdiction that requires a licence, you must be added to an existing licence or make an application well in advance of field work.

4.3.1 Site definition

1. Location (see section 1.1)

2. Elevation (in metres above sea level). Specify how this information has been obtained, e.g. from a map, or using GPS.

3. Site area (specify units, e.g. square metres, square kilometres)

4. Jurisdiction

5. Local language

6. Local name

4.3.2 Cultural landscape definition/description

1. Local name for location.

2. Name of local people

3. Primary landscape features (list, with coordinates, or mark on a map)

4. Governance arrangements (indicate all that apply)
   - Federal State
   - Province, Territory, State, Oblast, Other (please specify)
   - Hamlet, Village, Commune, Other (please specify)
   - Hunters' Association
   - Fishers' Association
   - Tourism-guiding organisation
   - Sewing centre or cooperative
   - Art centre or cooperative
   - Health centre or clinic
   - Justice centre or clinic
   - Indigenous peoples' association or organisation
   - Local educational opportunities (specify level, e.g. primary/elementary, secondary, college, technical school, university)

4.4 Human-landscape interactions and environmental and social change observations

LEVEL II

Recognising the need for in-depth information at selected sites, we provide a check list for a survey of environmental and social change observations. While it is not expected that this will be widely applied, we wish to attempt one such survey in each of regions where possible**.**

4.4.1 Environmental change

Indicate all that apply

1. Rising temperatures
2. Increasing river flows
3. Decreasing snow cover
4. Increasing precipitation
5. Thawing of permafrost
6. Diminishing lake and river ice
7. Melting glaciers
8. Retreating summer sea ice
9. Rising sea level
10. Wetland changes
11. Vegetation shifts
12. Increasing fires in nature
13. Increasing abundance of insects
14. New insect species
15. New mammal species
16. New plant species
17. New bird species
18. New fish species
19. Changes in fish
20. Changes in marine mammals
21. Changes affecting marine mammals
22. Changes in land animals
23. Changes affecting land animals
24. Changes in land use

4.4.2 Social change

Indicate all that apply

31. Loss of access to traditional foods
32. Loss of fishing
33. Loss of hunting
34. Loss of berries
35. Loss of herding
36. Loss of knowledge
37. Increased mining

38. Increased oil and gas activity
39. Increased accidents
40. Reduced travel on the land
41. Increased agriculture
42. Increased forestry
43. Increased commercial plant harvesting
44. Increased tourism
45. Increased drug and alcohol problems
46. Increased hunger
47. Increased poverty
48. Increased violence
49. Increased social assistance
50. Housing shortage
51. Increased housing availability
52. Other (please list)

4.4.3 Environmental and social observation system: local human population characteristics

1. Demography (vital statistics and demographic measures)
    Density of population (number per square kilometre)
    Net migration (in- and out-migration) (number per year)
    Structure of population (by: ethnic identity, gender, age, profession)
    Births (number per year)
    Deaths (number per year)
    Life expectancy (longevity in years, for women and men)
    Infant mortality (number of deaths in first year of life)
    Accidental death rates (number per year, for women and men)
    Health statistics as available: (e.g. physical and mental health, traditional food in diet, access to health care, quality of health care, birth weight, breast milk quality, cause of death – note findings on a separate sheet)

2. Livelihood and economic factors

    income generation and livelihood categories

    • formal sale from hunting (prohibited in some regions and thus may be unreportable)
    • formal sale of fish
    • informal sale
    • other subsistence activities (not on separate sheet)
    • dependency on single products (e.g. seals etc)

    social divisions in employment income distribution (wages), i.e. distribution of income, gender and ethnic differences in income

    salaries (annual: range and mean)

    poverty level (specify currency)

employment by sector (number per industry: infrastructure, conservation activities, reindeer herding etc: specify on separate sheet)

self-employment rate (number per local population, number per social division)

4.4.4. Economy (note: some indicators may be locally restricted)

1. Economic development (GRP per capita-living standards). (To document the gap in the living standards between Russia and the Nordic countries. Note: may be regionally reported)

2. Structure of economy (sectors and branches of economy, the structure of GRP. Specify on separate sheet.)

3. Domestic and foreign investment in the region.

4. Structure of foreign trade (e.g. timber). Specify.

5. Foreign trade of the region (specify).

4.4.5 Factors affecting quality of life – self-reported

What are limits to quality of life in your region (settlement)? Please mark all that apply.

Limits to job opportunities
Low salaries
Poor access to transport
Poor access to drinking water of good quality
Poor access to traditional food
Hunger
Poor access to medical service
Bad food supply
Poor physical health
Poor mental health (alcoholism, suicide…)
Poor housing conditions
Pollution
Reindeer pasture degradation
Forest degradation
Tundra changing to shrubs
Water reservoirs shrinking
Climate change
Biodiversity change and ecosystem fragmentation
Traditional culture or indigenous language disappearing
Limited access to education
Limited access to information (e.g. internet, TV etc)
Traditional knowledge and practices disappearing
Inadequate laws
Insufficient local administration control
Insufficient federal government control
Other (please list)

4.4.6 Food access

1. Hunters' and trappers' association – collect harvest data (species, amount and geographical location of harvest), collect number of full-time and part-time hunters, ask for an estimation of country food use among general community members).

2. Hamlet office – ask for the number of community feasts per year and the species most often consumed.

3. Social assistance – obtain estimates of social assistance and costs of living, determine if there is a community food bank and if there is, what types of food are commonly held in the bank.

4. Northern and co-op stores – collect inventory of the type of food that is purchased on a weekly basis.

Appendix A4.1 Ethical Requirements for Research Involving Indigenous and Local Peoples

There are many international standards for guiding research conduct in relation to indigenous peoples and their knowledge, both nationally and internationally. In Canada, all research is governed by the Tri-council Policy Statement (http://www.pre.ethics.gc.ca/english/pdf/TCPS%20October%202005_E.pdf). As well some jurisdictions such as Nunavut, Yukon and Northwest Territories in Canada, have licensing bodies for research, and all researchers must apply and be approved to obtain a research licence.

The "guiding ethical principles" of the Tri-council Policy Statement are:

- Respect for Human Dignity
- Respect for Free and Informed Consent
- Respect for Vulnerable Persons
- Respect for Privacy and Confidentiality
- Respect for Justice and Inclusiveness
- Respect for Balancing Harms and Benefits
- Respect for Maximizing Benefit

In addition, other bodies, including the Inuit Circumpolar Council (formerly known as the "Inuit Circumpolar Conference") and the Inuit Tapiriit Kanatami (formerly known as Inuit Tapirisat of Canada), have developed extensive policy documents related to rights of Indigenous Peoples and to the conduct of research involving Indigenous Peoples, as have UNESCO, WTO and other international bodies.

While not all circumpolar jurisdictions have such requirements, in Canada we are legally bound to follow the highest Canadian standards in this regard. In jurisdictions where research licenses are not required, we note the need for voluntary observation of fundamental ethical principles. To facilitate this, we set out three key sections of the Tri-Council Policy Statement:

1. A moral imperative: respect for human dignity.

An ethic of research involving human subjects should include two essential components: (1) the selection and achievement of morally acceptable ends and (2) the morally acceptable means to those ends." (See also Principle "Respect for Human Dignity" below.)

2. Guiding ethical principles.

The approach taken in this framework is to guide and evoke thoughtful actions based on principles. The principles that follow are based on the guidelines of the Agencies over the last decades, on more recent statements by other Canadian agencies, and on statements from the international community. The principles have been widely adopted by diverse research disciplines. As such, they express common standards, values and aspirations of the research community.

Respect for Human Dignity: The cardinal principle of modern research ethics, as discussed above, is respect for human dignity. This principle aspires to protect the multiple and interdependent interests of the person—from bodily to psychological to cultural integrity. This principle forms the basis of the ethical obligations in research that are listed below.

In certain situations, conflicts may arise from application of these principles in isolation from one other. Researchers and REBs must carefully weigh all the principles and circumstances involved to reach a reasoned and defensible conclusion.

Respect for Free and Informed Consent: Individuals are generally presumed to have the capacity and right to make free and informed decisions. Respect for persons thus means respecting the exercise of individual consent. In practical terms within the ethics review process, the principle of respect for persons translates into the dialogue, process, rights, duties and requirements for free and informed consent by the research subject.

Respect for Vulnerable Persons: Respect for human dignity entails high ethical obligations toward vulnerable persons—to those whose diminished competence and/or decision making capacity make them vulnerable. Children, institutionalized persons or others who are vulnerable are entitled, on grounds of human dignity, caring, solidarity and fairness, to special protection against abuse, exploitation or discrimination. Ethical obligations to vulnerable individuals in the research enterprise will often translate into special procedures to protect their interests.

Respect for Privacy and Confidentiality: Respect for human dignity also implies the principles of respect for privacy and confidentiality. In many cultures, privacy and confidentiality are considered fundamental to human dignity. Thus, standards of privacy and confidentiality protect the access, control and dissemination of personal information. In doing so, such standards help to protect mental or psychological integrity. They are thus consonant with values underlying respect for privacy, confidentiality and anonymity.

Respect for Justice and Inclusiveness: Justice connotes fairness and equity. Procedural justice requires that the ethics review process have fair methods, standards and procedures for reviewing research protocols, and that the process be effectively independent. Justice also concerns the distribution of benefits and burdens of research. On the one hand, distributive justice means that no segment of the population should be

unfairly burdened with the harms of research. It thus imposes particular obligations toward individuals who are vulnerable and unable to protect their own interests to ensure that they are not exploited for the advancement of knowledge. History has many chapters of such exploitation. On the other hand, distributive justice also imposes duties to neither neglect nor discriminate against individuals and groups who may benefit from advances in research.

3. Putting principles in practice

Beyond a keen appreciation for context, effective guiding principles also depend on procedures and policies for their implementation. Indeed, modern research ethics are premised on a dynamic relation between ethical principles and procedures. This relationship is implemented through a mechanism that has emerged in many countries over the last decades and which consists of the articulation of national norms that are applied through prospective ethics review of research projects. Typically, the review is undertaken in local research institutions by independent, multidisciplinary ethics committees that apply substantive and procedural norms. This Policy is consistent with this model.

Balancing Harms and Benefits: The analysis, balance and distribution of harms and benefits are critical to the ethics of human research. Modern research ethics, for instance, require a favourable harms-benefits balance—that is, that the foreseeable harms should not outweigh anticipated benefits. Harms-benefits analysis thus affects the welfare and rights of research subjects, the informed assumption of harms and benefits, and the ethical justifications for competing research paths. Because research involves advancing the frontiers of knowledge, its undertaking often involves uncertainty about the precise magnitude and kind of benefits or harms that attend proposed research. These realities, as well as the principle of respect for human dignity, impose ethical obligations on the prerequisites, scientific validity, design and conduct of research. These concerns are particularly evident in biomedical and health research; in research they need to be tempered in areas such as political science, economics or modern history (including biographies), areas in which research may ethically result in the harming of the reputations of organizations or individuals in public life.

Minimising Harm: A principle directly related to harms-benefits analysis is non-maleficence, or the duty to avoid, prevent or minimize harms to others. Research subjects must not be subjected to unnecessary risks of harm, and their participation in research must be essential to achieving scientifically and societally important aims that cannot be realized without the participation of human subjects. In addition, it should be kept in mind that the principle of minimizing harm requires that the research involve the smallest number of human subjects and the smallest number of tests on these subjects that will ensure scientifically valid data.

Maximizing Benefit: Another principle related to the harms and benefits of research is beneficence. The principle of beneficence imposes a duty to benefit others and, in research ethics, a duty to maximize net benefits. The principle has particular relevance for researchers in professions such as social work, education, health care and applied psychology. As noted earlier, human research is intended to produce benefits for subjects themselves, for other individuals or society as a whole, or for the advancement of knowledge. In most research, the primary benefits produced are for society and for the advancement of knowledge."

Appendix A4.2 IPY Northern Canadian Coordination Offices

(Source: http://www.ipy-api.gc.ca/ipcn/index_e.html)

Northern offices, or " IPY Northern Coordination Offices", will be hosted by a regionally based organization in several regions of Canada's North. These offices will coordinate IPY activities on a regional and community level, and will support and encourage northern communities and organizations to become more engaged in IPY activities.

At this time, IPY Northern Coordination Offices coordinators have been hired on an interim basis to serve as a regional point of contact and to facilitate the involvement of northerners in IPY. IPY Northern Coordination Offices will be established on a longer term basis following further consultation with regional and national stakeholders.

The interim IPY Northern Coordination Offices coordinators are:

Nunavut: hosted by Nunavut Research Institute
Coordinator: Jamal Shirley, tel: 867-979-7290; fax: 867-979-7109;
email: jshirley@nac.nu.ca

Yukon: hosted by Council of Yukon First Nations
Coordinator: Bob Van Dijken, tel: (867) 393-9237; fax: (867) 668-6577;
email: bvandijken@cyfn.net

Nunavik and Labrador: hosted by the Nunavik Research Centre
Coordinator: Barrie Ford, tel: 819-964-2951; fax: 819-964-2230;
email: b_ford@makivik.org

Northwest Territories: hosted by the Aurora Research Institute
Coordinator: Alana Mero
tel: (867) 777-3298 ext. 30; fax: (867) 777-4264;
email: amero@auroracollege.nt.ca

Canadian Northern Research Licensing Agencies

For an excellent but slightly dated discussion of licensing requirements across Canada, see:
http://www.ipy-api.ca/english/documents/ipy_reslic_updated_0705_e.pdf

To apply (for research in Canadian jurisdictions where licensing is mandatory) see the following:

Nunavut
http://www.nri.nu.ca/researchlic.html

Northern Quebec, Nunavik and Labrador – no requirement in N. Quebec, please contact communities in advance to seek their agreement, as a courtesy.

Northwest Territories
http://www.nwtresearch.com/Apply.aspx

Yukon
http://www.tc.gov.yk.ca/pdf/scientists_explorers_permit.pdf

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