Ecological Recovery Monitoring of Certified Reclaimed Wellsites in Alberta

Selection of Indicators and Indicator Field Data Collection Protocols

Version 2014-04-22

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SUMMARY

This report describes the process for selection of indicators for inclusion in the ecological recovery monitoring of certified wellsites in Alberta program and provides sampling protocols (methodology) for the selected indicators.

BACKGROUND

After upstream oil and gas facilities or other industrial developments have been decommissioned on specified lands[1], reclamation is directed through the Environmental Protection and Enhancement Act (EPEA) to return the land to "equivalent land capability" (ELC). ELC is defined in the EPEA's Conservation and Reclamation Regulation as "the ability of the land to support various land uses after conservation and reclamation is similar to the ability that existed prior to an activity being conducted on the land, but that the individual land uses will not necessarily be identical." After specified lands have been deemed to have met the legislated requirements, a reclamation certificate is issued. Recovery of ecological functions at certified wellsites, pipelines and other specified lands in Alberta may continue long after the reclamation certificate issue date. However, the rate of this ecological recovery is currently not documented or monitored. Knowledge of this rate of recovery is essential for accurate forecasting, land use planning, and cumulative effects management. One of the recommendations from the Alberta Environment Land Monitoring Program Inventory and Needs Analysis report (Alberta Environment, 2006) is the establishment of a long-term reclamation benchmark monitoring program in Alberta to determine if reclaimed and certified site conditions and trajectories perform in a manner that satisfies the legislated mandate of ELC.

The ecological recovery monitoring of certified sites program (formerly known as the long-term reclamation benchmark monitoring program) is intended to evaluate and report on soil and vegetation quality trajectories at reclaimed cultivated, grassland and forested lands in Alberta using appropriate and sensitive physical, chemical and biological indicators. The Alberta Wellsite Criteria Documents developed by the Reclamation Criteria Advisory Group, the Long-term Reclamation Benchmark Monitoring Program developed by EBA, and the ABMI's monitoring protocols have all been proposed as potential data collection protocol resources that could be useful for development of long-term monitoring of certified wellsites and other specified lands. A series of three workshops held between December 2012 and March 2013 with members of the Ecological Recovery Monitoring of Certified Sites in Alberta Advisory Group, evaluated these existing resources for their ability to monitor long-term ecological recovery of wellsites and building on them Advisory Group members identified a set of landscape- and site-level indicators that could be used to evaluate the ecological recovery of certified sites. This manual describes ecological recovery long-term monitoring protocols for certified sites in Alberta that measure these landscape- and site-level indicators that were selected by the Ecological Recovery Monitoring of Certified Sites in Alberta Advisory Group. Note that this first iteration of the integrated protocols is focused on sampling of wellsites. Future versions may also include sampling of linear oil and gas disturbances.

PROJECT OBJECTIVES

The purpose of this project was to develop an integrated, scientifically robust and financially sustainable monitoring program to enable the assessment of ecological recovery of physical, chemical, and biological indicators at certified reclaimed industrial sites across Alberta. Data will be generated from measurement of soil, vegetation, and landscape indicators at certified and reference sites. The objective of this document is to select the appropriate vegetation, soil, and habitat indicators for a long-term reclamation monitoring program in Alberta and then provide sampling protocols for the selected indicators. The

[1] land used for specified industrial disturbances – in this case oil and gas industrial disturbance

intention of this monitoring program is to track ecological recovery of reclaimed sites and not to assess whether current reclamation criteria are adequate. Furthermore the intent of the program is not to lay blame on previous reclamation criteria or practices. Thus, this program will not be used to cancel reclamation certificates on previously certified sites. The development of these integrated monitoring protocols is a first step towards the successful development of this long-term monitoring program to assess ecological recovery of certified sites in Alberta.

It should be noted that this is a preliminary version of the protocol to be implemented during a pilot study in 2013, and will be amended based on advice from experts as well as from results and data from the 2013 field season.

FUNDING SOURCES

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MONITORING PROTOCOLS FORMAT

This set of integrated monitoring protocols are documented in a set of chapters that first describes the selection of relevant indicators for measurement of ecological recovery, then describes the sampling layout for individual sites, followed by individual chapters with sampling protocols for each ecosystem component, and finally provides information related to management of personnel and data. In the current set of protocols the methodology related to selection of sites for inclusion in the long-term network of monitoring sites has not been included as this has not yet been developed, however there are plans to incorporate this information in the future. It is recommended that vegetation and downed woody debris (DWD) data are collected before the soil analyses in order to minimize effects of soil disturbance on the data recorded. Information related to analysis of the data collected in these protocols is beyond the scope of this document.

1. SELECTION OF INDICATORS

A wide range of vegetation, habitat, and soil parameters are potentially available for use as ecological recovery site condition indicators in a long-term reclamation benchmark monitoring program. We considered the following criteria as important when selecting appropriate indicators for inclusion in a long-term monitoring program to evaluate ecological recovery of reclaimed sites:

- the need for indicators that are relatively sensitive to land disturbances (i.e., relevant to evaluating ecological recovery of wellsites)
- indicators that can be measured precisely and consistently without too much variability, i.e., have low coefficient of variation (CV)
- ease of measurement and whether the indicator requires an expert to measure it,
- cost of measurement, sampling and analyses of the indicator,
- applicability of the indicator for measurement in cultivated, grassland and forested landscapes in Alberta,
- how destructive the indicator sampling would be in terms of its impacts on the ecosystem,
- whether methodology exists to effectively measure the indicator,
- ability to be collected over the growing season at a large number of sites.

Three workshops held between December 2012 and March 2013 with members of the Ecological Recovery Monitoring of Certified Sites in Alberta Advisory Group examined a suite of vegetation, soil, and habitat indicators that could potentially be used to monitor recovery in a long-term reclamation monitoring program. Indicators were assessed based on the criteria listed above and ranked to determine which indicators would be most useful for monitoring ecological recovery. Workshop participants decided that the most important criterion was relevance of the given indicator, as an indicator will need to be sensitive to change in order for it to provide insights into recovery of reclaimed sites over time. An indicator that is not expected to vary across a gradient of disturbance would be a poor indicator of ecological recovery and thus should be excluded from use as an indicator (although it may be valuable to measure during an initial site visit to provide additional useful information for that site - e.g., soil texture). The other criteria listed above were also considered, but relevance was by far the most important criterion for selection of indicators for inclusion in the monitoring program. In each section below the suite of potential indicators that were considered for inclusion are listed, and the indicators that were selected for inclusion in the monitoring protocols are described in additional detail.

A. Vegetation and Structure Indicator Selection

Potential vegetation and habitat indicators that can be used to evaluate reclamation recovery include percent ground cover by vegetation and non-vegetation group (trees, shrubs, grass, herbs, sedge/rush, moss, lichen, litter, DWD, rock, bare mineral, water), species composition based on percent cover by species within vegetation groups (trees, shrubs, grass, herbs, sedge/rush, moss, lichen), species composition based on percent cover by species within vegetation groups grouped by height strata, height and DBH of tree species (when trees are present), height and DBH of snags by species (when snags are present), biomass or volume of DWD when present, amount of litter, number of vegetation layers, foliar nitrogen, amount and distribution of undesirable plants and weeds. For agricultural lands additional potential indicators include plant growth stage, height, biomass, density and healthy by species, seed head length, weight and health by species. The advisory group members did not provide feedback specific to agricultural lands, so relevant indicators for monitoring of agricultural lands are not included in the current version of the monitoring protocols.

Based on the input from the vegetation sub-group comprised of Barry Adams, Cindy Craig, Donna Lawrence, Shauna Lee-Chai, Anne McIntosh, and Jim Schieck at the Reclamation Assessment and Monitoring Workshop 2, the following two indicators were selected for inclusion in the long-term monitoring program:

- Species Composition by Stratum (% cover by species)
- Structure

In order to structure the sampling design and obtain the right distribution of samples for a long-term monitoring program, the group recognized the need for information on ecological site classification (e.g., using soil, nutrient regime, hydrology), land use history, and relevant features in the surrounding landscape to assist in classifying a particular site. However, rather than considering all of this information only as indicators, the information will be used to guide which sites will be selected for monitoring (i.e., site selection screening). Protocols for identification of criteria for selection of certified sites that should be included in the long-term monitoring program are beyond the scope of this document, but should be included in a future version once criteria related to site selection have been developed and evaluated.

During the site visit, ecosites of the wellsite and the adjacent reference condition site should be classified using the data collected. This information will provide insights into the ecological recovery of the wellsite and the trajectory that its recovery is currently on. It is unlikely that the recovering wellsite will be at the same successional stage of development as the adjacent reference site, and thus ecosite classification can aid in evaluating the successional trajectory of the wellsite and whether it appears to be along the trajectory of the reference condition despite the two sites being at different ages or successional stages, or alternatively whether it is headed along a different recovery trajectory than the reference condition.

An understanding of the history of disturbance, reclamation, and other anthropogenic activities at a given site would greatly assist the analysis and interpretation of vegetation and soil indicators (Examples of other anthropogenic activities include the use of reclaimed areas by ATVs, grazing, etc.). Therefore, it is important to document this land-use history wherever possible in order to identify confounding factors that may be contributing to the pattern of recovery at a particular wellsite. However, it is recognized that it may be difficult to capture this information for a site – but to the level possible, land-use history should be documented. A sketch of disturbance observed on the site will be completed when the site is established, but additional research (remote sensing may be an appropriate analysis tool) will likely have to be done to identify historic disturbance events and their timing (e.g., date the wellsite was certified reclaimed).

Species composition by stratum

The importance of vegetation as an integral component of the ecological functioning and biodiversity of ecosystems is well known. For example, the forest understory community of non-tree plants growing beneath the canopy contains the majority of plant biodiversity in boreal forests, and can play an important role in determining canopy composition through its interactions with regenerating tree species (George and Bazzaz 2003). The plant community plays important roles in influencing both community and ecosystem properties above- and below-ground (Nilsson and Wardle 2005, Hart and Chen 2006). Understory vegetation may comprise less than 1% of the biomass of the temperate forest, yet can still comprise 90% or more of the plant species richness, and may supply up to 20% of the forest floor foliar litter, which is often of higher nutrient content than that of the tree foliar litter (Gilliam 2007). Persistent dense understories can be an important filter in determining the future successional trajectory of forests by reducing or delaying tree regeneration and growth (Lieffers et al. 1993, Royo and Carson 2006). The vegetation community also plays an important role in providing browse and habitat for a variety of other biota (e.g., Carey and Johnson 1995, Work et al. 2004). While plant community data are often collected based on percent cover by vegetation group – lumping estimates of vegetation cover at the level of forbs, grasses, and shrubs - a much more detailed understanding of the plant community can be obtained by measuring the percent cover of individual species (e.g., McIntosh 2012). Therefore, the vegetation and structure sub-group emphasized the need to measure species composition using percent cover estimates for individual vascular and non-vascular plants, as well as lichens, among the height strata/classes that are currently used by the Government of Alberta to ecologically classify lands and evaluate rangeland health in Alberta (ASRD 2003).

Structure

In addition to measuring the plant community composition, additional measures are needed to characterize a site to describe its ecological recovery. The forest canopy is an important driver of understory community composition and biodiversity, as well as below-ground processes (e.g., Légaré et al. 2002, Macdonald and Fenniak 2007), and it affects the nutrient and water availability of the stand (e.g., Prescott 2002). The forest canopy affects the availability of light, nutrients and moisture for use by the understory plant community, as well as soil pH and soil temperature (Prescott 2002, Hart and Chen 2006). The canopy also affects the understory plant community through its deposition of surficial litter, which can influence soil pH, and affects both the understory and the below-ground faunal and microbial communities (e.g., Hannam et al. 2006, reviewed by Barbier et al. 2008). Forest structural attributes such as basal area and stand height, independent of canopy species type, can also be associated with forest understory composition (e.g., Légaré et al. 2002). The height and diameter of trees can be used to measure site index and provide an estimate of productivity for forested lands. With disturbances associated with creation of wellsites, we would expect associated changes in structure to influence other ecosystem properties and processes, and measuring habitat structure can also help us to better understand what these changes are over time as the sites recover post disturbance.

The following sub-set of indicators was included to describe the vegetation structure indicator, recognizing the important values of these data to provide information, including their relevance to function as habitat for other species. Thus, under the descriptor of structure the following parameters were included:

- Estimates of percent cover of rock, bare mineral soil, and water
- When trees are present, height and DBH by species
- When snags are present, height and DBH by species
- When DWD is present estimates of biomass, including by size class distribution
- Depth of the LFH layer

Note that several of these parameters related to vegetation are described in the vegetation indicators protocols chapter, DWD is described in the woody material chapter, and LFH depth is described in the soil protocols chapter.

B. Soil Indicator Selection

A wide range of physical, chemical and biological soil parameters are potentially available for use as site condition indicators in a long-term reclamation benchmark monitoring program. A previous list of potential indicators was evaluated and provided to ESRD by EBA (2012) in a report titled “Reclaimed Benchmark Monitoring Protocol Design. Phase 1: Literature Review and Evaluation of Indicators”. These include, but are not limited to, soil bulk density, aggregate size distribution, penetration resistance (PR), soil moisture and available water capacity, soil texture, soil tilth, , topsoil depth, pH, electrical conductivity (EC), soil organic carbon (SOC) content, microbial biomass carbon, total nitrogen, total carbon, organic matter content, soil disturbed depth, soil porosity, and soil consistence.

Based on the input from the soils group comprised of Arnold Janz, Gordon Dinwoodie, Heather Jones and Bonnie Drozdowski at the Reclamation Assessment and Monitoring Workshop 2, five soil indicators were selected for the long-term reclamation monitoring program:

- soil pH
- EC
- bulk density
- SOC
- PR

Soil pH, EC, bulk density and SOC measurements and costs are different than PR since the former rely on data from laboratory analyses and the latter on data captured by field sensors.

Bulk Density
Bulk density was selected as one of the soil indicators for the long term reclamation benchmark monitoring program in Alberta because it may have considerable influence on the soil's capability for water partitioning, air exchange and plant growth as well it has low spatial and temporal variability (EBA 2012). Much of the spatial and temporal variability is dependent on the sampling method as the variability in sampling accuracy can be very high (Naeth et al. 1991). Therefore it is crucial to determine the appropriate sampling method for bulk density and use it consistently throughout the long term monitoring program.

Penetration Resistance
Penetration resistance (PR) was selected as an indicator for the long term reclamation benchmark monitoring program in Alberta because compacted soil and especially soil layers or abrupt textural/structural changes are hard to assess visually. Soil crusting (hardpan) and compaction are also two conditions that may severely inhibit vegetation establishment. Mechanical sensors such as a hand operated digital recording penetrometer can be used to estimate soil mechanical resistance which allows for an increase in the accuracy and efficiency of identifying soil compaction on reclaimed sites. Penetrometers work by measuring the force required to penetrate through the soil profile (Vazquez et al., 1991). Cone penetrometers are the most common type of device to measure penetration resistance of soils because they are relatively inexpensive, simple and easy to operate. One of the biggest advantages of doing soil PR measurements is that the penetrometer can be connected to a GPS receiver to generate a soil compaction map of the site which provides detailed site information at minimal cost. Some disadvantages of using mechanical sensors include the intrusiveness of the sensor as it penetrates the soil and since the penetration force depends strongly on the water content of the soil, the value of the penetration measurement would be more accurate if water content can be integrated into the measurement. There can potentially be large variability associated with PR measurements, especially in cultivated sites under the influence of tillage and impacts from equipment. PR can also be subject to operator error, depending on strength, weight or technique of the operator. Penetrometers may not be ideal for monitoring reclamation success in cultivated lands and may have more relevance in monitoring reclamation success in forested lands or pastures where ongoing soil disturbance is kept to the minimal.

PR has been correlated with various soil parameters such as bulk density, porosity, water content and soil texture (Busscher, 1990; Mapfumo and Chanasyk, 1998; Vazquez et al., 1991). If PR can be used as a surrogate for bulk density, considerable time and cost savings may be realized by capturing more PR measurements and fewer bulk density measurements. The soil committee suggests monitoring both bulk density and PR at the beginning of the long-term reclamation benchmark monitoring program to establish a clear relationship between the two methods.

Soil Organic Carbon

The most informative indicator of soil quality in the A horizon is soil organic carbon (SOC), as it is an important indicator of the soil's ability to sustain plant growth, rooting, water partitioning and air exchange (EBA, 2012). The total SOC content encompasses both the microbial carbon and stable organic carbon; it is a dynamic indicator that takes account of the newly photosynthesized C in the form of plant litter as well as the existing SOC that is being decomposed back to CO_2 by soil biota (Ellert et al., 2006). SOC can be well correlated with the other soil indicators such as bulk density, EC, pH as well other soil quality indicators such as water-stable aggregates, total nitrogen (Shukla et al., 2006). The management and environmental conditions of the site will determine the relative rates of organic matter inputs and decomposition which will affect the amount of carbon stored overtime. The CV for SOC at agricultural benchmark sites in Alberta can be high, it ranges from 29-104% in the A horizon to 55% to 96% in the B horizon (Cathcart et al., 2008). Slope position was a main factor for the large variation in SOC, therefore it is important to take that into consideration when selecting sampling locations on a site. A stratified sampling scheme may be employed to account for slope positions if the reclaimed or reference site is on a sloped area.

The measurement of SOC can also be used to quantify soil C "sinks" and expressed on a Mg C per hectare basis provided that bulk density measurements are also done at the same time as SOC measurements.

Soil Electrical Conductivity and pH

Soil electrical conductivity (EC) and pH are two useful indicators of soil quality and its capacity to support plant growth. EC in particular is a good indicator of salinity as well as admixing of the surface soil and sub-soil. Across five different soil groups in Alberta (Black Chernozem, Dark Brown Chernozem, Brown Chernozem, Gray Luvisol, and Brunisol), the range and CV of EC measurements can be high, 0.19 to 4.95 dS/m and 97.3%, respectively (Rowell and Florence, 1993). Soil pH on the other hand has a very low spatial and temporal variability (EBA, 2012). Based on the Alberta Environmentally Sustainable Agriculture Soil Quality Resource Monitoring Program, the CV for pH averaged around 11% across the province of Alberta (Cathcart et al., 2008).

Soil EC and pH can be measured on the bulk soil in a saturated paste extract or in water extracts at soil:water ratio of 1:1, 1:2 and 1:5 (Miller and Curtin, 2006). Saturated paste method requires more time and skill than the fixed soil:water ratios, therefore many commercial laboratories have been using fixed soil:water ratios, however that method can lead to overestimation of EC when samples contain high gypsum content or in the case with organic soil not enough extracts to do the measurement (Miller and Curtin, 2006). The saturated paste method relates more closely to the water holding capacity of the soil than do extracts at a fixed soil:water ratio. Most of the crop tolerance to salinity data has traditionally been collected from saturated paste extracts so we recommend that the soil EC and pH to be measured from saturated paste extracts.

2. SAMPLING DESIGN

In this chapter the sampling design and layout for individual sites are described, including providing detailed information on accessing and laying out individual sampling sites for future measurement.

~~This is the first version of the sampling design and protocols, and we expect to make refinements after they have been reviewed by the Ecological Recovery Monitoring of Certified Sites in Alberta Advisory Group and additional external reviewers and we have incorporated their feedback.~~ We recognize that there are multiple ways that the sampling design and monitoring protocols could be implemented and we have selected the protocols that we think will meet the criteria that are described in more detail in Chapter 1. The system that we have adopted samples two different areas within a single site: the wellsite, and a reference site (i.e., a paired comparison design). Both the on and off wellsite areas are sampled; the area is considered to be one unit that consists of two sites. The wellsite includes the disturbance footprint of the wellsite, and an adjacent reference condition site that does not have a footprint of human disturbance is the control/reference against which ecological recovery is assessed. In order to precisely measure the temporal change in the selected indicators, we need to minimize the spatial variability. This can be done by systematically selecting sampling points. The ease of use and the sampling efficiency makes it a better choice than random sampling for this monitoring program.

A. Plot Establishment - Setting up Access to Long-term Monitoring/Sampling Sites

Plot establishment is designed to facilitate field sampling by having a predetermined route to site center recorded on an access sheet (note: this may not always be possible depending on what information is available ahead of time and whether a crew has previously scouted the location). Crews will have an estimated timeframe for getting to the site and knowledge of potential access hazards.

Gaining access to terrestrial sites has multiple components:

1. Prior to the first site visit map/GIS and data reconnaissance work in the office that gathers as much data as possible about accessing the site and the site history[2] are needed to assist field crews in their first visit to the site. The wellsite center should be labeled and GPS coordinates from the map/GIS recorded for the wellsite center and four corners. **The need for surveying for ground disturbance needs to be established prior to the first visit to the site too**[3]**.** This involves setting up an account on Alberta OneCall (http://www.albertaonecall.com/) and submitting ground disturbance requests a minimum of 3 business days before sampling is going to be conducted. Companies with potential below-ground pipelines et al. will contact you to let you know whether or not there is a conflict and whether marking of lines will be required. In addition if you are working on private lands and/or public lands with grazing leases – you need to contact the landowner for permission to access their land. For agricultural lands you can get information by going to: **https://maps.srd.alberta.ca/RecAccess/default.aspx?Viewer=RecAccess.** There will be an icon for identify recreational access that will provide you with information on who has the grazing lease so you can contact them for permission to have access to their site (this is for grazing leases on public lands).

[2] These data could be collected using an approach similar to a Phase 1 Environmental Site Assessment – a lot of information can be obtained using Abadata (http://abadata.ca/) as well as the Environmental Site Assessment Repository website (http://environment.alberta.ca/01520.HTML) .

[3] There are ground disturbance issues with having some of our sampling of soils occur below 30 cm so ground disturbance approval needs to occur prior to site visit – field staff should take a ground disturbance training course to satisfy this requirement – e.g., . http://www.firstaidsafetytraining.ca/ground-disturbance-course.php

2. During the first visit to the site, the most efficient route is found, and potential hazards are described on Access Datasheets and supplied maps.
    - Ensure that compass declination is set appropriately for the location. Declination for the region is determined by checking on the GPS (see the GPS field manual for instructions) and recorded on the Access Sheet ~~and the front of the map folder~~. The accuracy of the GPS used during site establishment is also recorded on the Access Sheet.
    - Record the GPS locations of turnoffs, corners, significant landmarks, and parking locations. Include detailed direction and distance measures to aid staff in relocating all access points and site center (Appendix 1).
3. Finally, additional maps and descriptions are prepared if required for use to aid in locating the site, and access materials are compiled to facilitate data collection during future monitoring visits.

Field Equipment Needed:

- *Cellphone for communications*
- *2-way radios for communications among partners*
- *Datasheets and clipboard*
- *Site maps and wellsite information materials package*
- *Folding handsaw/"Swede-saw"*
- *GPS and compass*
- ~~*5 – 1.5 m orange steel or aluminum bars/site*~~
- *27 (3 per 10-m square plot (2 edges running along transect and centre) – permanent magnetic metal markers per site*
- *95 pigtails to mark the nested 5x5 m, 10x10 m, and 25x25 m plots, DWD transect start points, and wellsite center within the wellsite and reference sites.*
- *4- 50 m tapes, 4-100 m tapes and 4 – 30 m tapes.*
- *Multiple colors of flagging tape (e.g., brown = DWD, blue = 25x25m, pink = 10x10m, orange=5x5m)*
- *Fine tipped colored marker (to delineate polygons on human disturbance sketch)*
- *Plot layout 'cheatsheet'*

B. Laying out the plot for sampling

For level and near-level sites, the following sampling design is proposed (Fig. 1). On sites where there is significant across-slope curvature, it is important that all slope elements are represented. Hence the sampling squares should encompass all slope positions within the 1 ha site with one square in each convergent-divergent sequence across the slope and this should be noted on the site disturbance sketch.

Procedures:

- When the field crew arrive onsite, the first step is to identify the wellsite center, which will be the center point for the reclamation wellsite plot. It must be located as precisely as possible using a hand-held GPS with an accuracy of < 7 m (GPS coordinates will have been identified from the maps and GIS investigation prior to the site visit). If due to heavy forest cover or poor satellite coverage accuracy values from the GPS are > 7 m, this is noted on the site establishment datasheet.
- At wellsite center place a pigtail in the ground and flag it so that you can readily identify the wellsite center. A permanent metal marker will also be inserted at the wellsite center after the soil sampling is complete so that the location can be readily identified during future visits to the site. Note that these

permanent markers will also be used on private land, but approval for them should be obtained from the owner[4].

- The crew will need to lay out four sub-ordinal transects that are oriented to the four corners of the wellsite (e.g., if the wellsite is square in cardinal directions, then the bearings of the 4 transects would be northwest 315°, northeast 45°, southeast 135°, southwest 225° - if not cardinal then adapt the directions of the four transects to angles so they intersect the four corners of the wellsite). Each quadrant is assigned a letter code (wellsite = B, C, D, E; reference = F, G, H, I – see Fig. 1). **The plot layout cheatsheet is very helpful to use when laying out transects – especially for your first few sites of the year so definitely use it!** Start by establishing the first transect – it is most efficient to have both crew members establish each transect together. Carry an extra 100-m tape and 25-m tape and 23 pigtails (24 if you are doing a bryophyte/lichen plot) with you (if trees are absent and/or you are not doing a bryophyte/lichen plot, then you only need 15 pigtails. Using a 50-m tape attached to the wellsite centre, lay out your tape along the bearing of the sub-ordinal transect. When you have laid out 3.5 m of tape insert a pigtail (this will be the pigtail for the corner of the center 5x5 m plot). When [A1]you have laid out 6.7 m of tape insert a pigtail (this will be the pigtail for the near diagonal corner of your 25x25 m transect (note that if you are not doing a lichen/bryophyte plot in this quadrant and/or do not have trees > 25 cm dbh you don't have to insert this pigtail). When you have laid out 7.1 m of tape insert a pigtail (this will be the pigtail for the corner of the centre 10x10 m plot for soil sampling). When you have laid out 10 m of the tape, insert another pigtail – this will be the start point for the DWD transects (note that if you do not have DWD then you don't have to insert this pigtail). Continue laying out the tape measure until you reach 27.9 m from wellsite centre and insert a pigtail (this will be the near corner of your 10x10m plot), then continue out to 35 m from the wellsite centre and insert a pigtail (this is the center of your 10x10 m plot), and then continue to 42.1 m (this will be the far diagonal corner for the 10x10 m and 25x25 plots). Insert pigtails for the remaining sides of the 10-m square and 25-m square plots by measuring 10 m and 25 m (using the 30 m tape), N or S and E or W (depending on the quadrant of the wellsite you are setting up). For the quadrant where you are doing the bryophyte/lichen plot, mark the distance 15 m from the corner of the 25x25 m plot that is closest to the wellsite centre that is not part of the 10x10 m plot to create the fourth corner of the 25x15 m bryophyte/lichen plot. Add two additional pigtails for the remaining sides of the 5-m square plots by measuring 5 m, N or S and E or W (again will depend on the quadrant, using the 25 m tape). Finally you will need to mark the corners of the reference quadrant so continue You should flag the different plots with different colors of flagging to help identify them *(e.g., brown = DWD, blue = 25x25m, pink = 10x10m, green=5x5m). Hint: it is helpful to use 2 people and triangulate with a single tape to complete the final 2 corners for the 5x5 m, 10x10 m, and 25x25 m plots in areas where there aren't trees.*

[4] We need to determine whether it would be okay if we leave permanent metal markers for our long-term monitoring sites on private lands – as this will facilitate identification of plots and resampling during future visits to the sites.

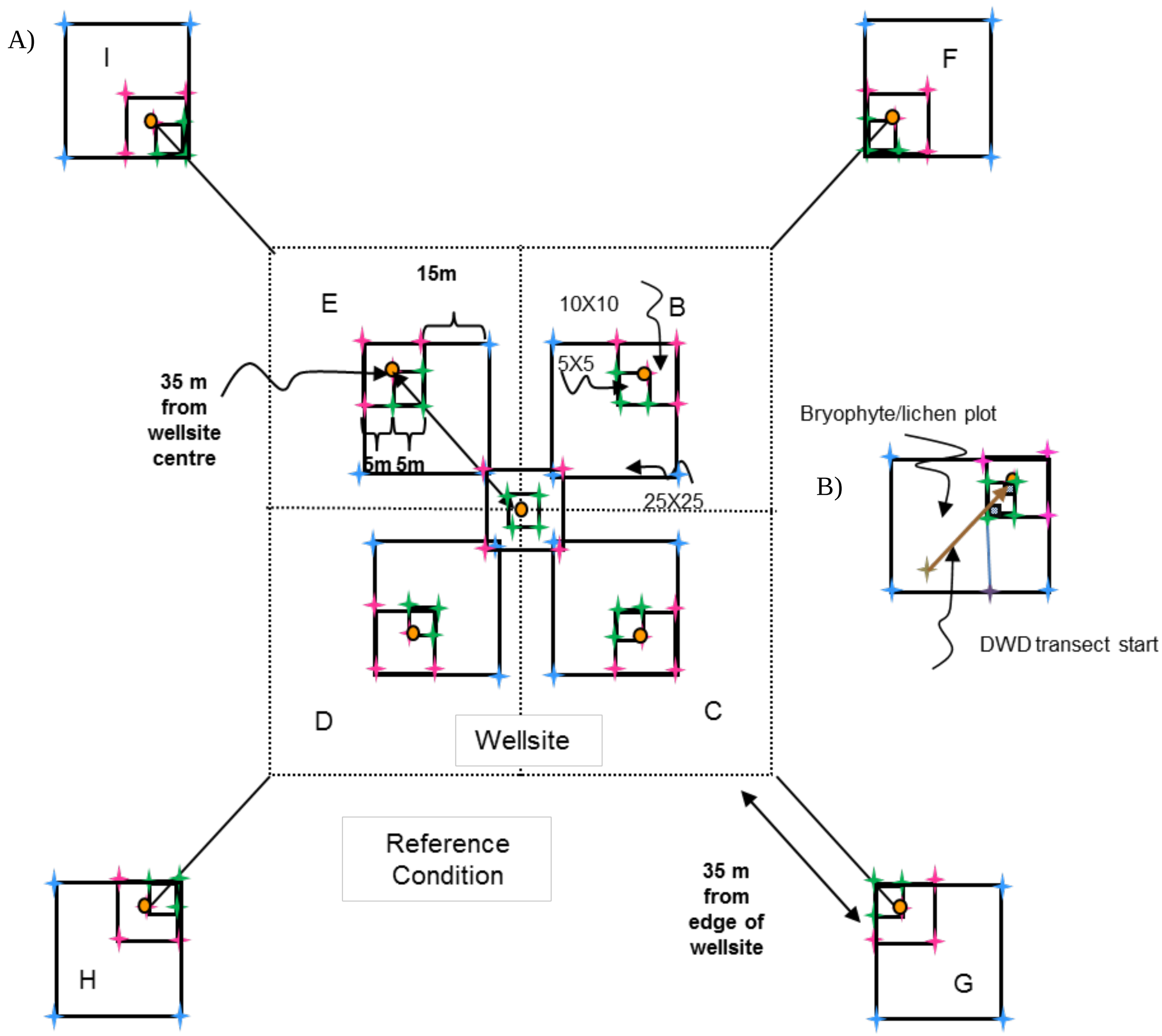


Fig. 1. A) Sampling layout of wellsites and adjacent reference sites, including identification of the nested square plots and pigtail placement for the 5x5 m (green), 10x10 m (pink), and 25x25 m (blue) plots, which are located within the four quadrants of the wellsite, wellsite centre (10x10 m plot), and the area surrounding each of the reference condition plots, which are also referred to as a quadrant. B) Pigtail placements for all plots including in the 25x25 m square plot that includes the DWD transect and the 25x15 m bryophyte plot are highlighted (in blue) – 12 pigtails are needed per wellsite quadrant and 12 pigtails are needed per reference site quadrant laid out if 25x25 m and 25x15 m plots are established. Note: plots are not drawn to exact scale.

- To establish the reference site plots (assuming the reference sites are contiguous with the wellsite), walk to the corner of the wellsite footprint and then roll out the 100-m tape and lay out the line transect at the same bearing as for the same sub-ordinal quadrant transect for a total distance of 63.3 m (this is only if there are trees > 25 cm dbh present and/or you are doing a bryophyte/lichen plot in this quadrant, otherwise you just layout the transect to 42.1 m) beyond the wellsite edge, inserting pigtails at 17.1 m from the wellsite edge (this will be the start of the DWD transect, if you have DWD) and 27.9 m, 35 m, and 42.1 m (These 3 pigtails will mark the two diagonal corners and plot center for the 10x10 m reference square plot), and at 63.3 m (this will be the far diagonal corner of the 25x25 m plot). Insert pigtails for the remaining sides of the 10-m square (and 25x25 m if trees > 25cm dbh are present and/or there is a bryophyte/lichen plot) plots by measuring 10 m (or 25 m for the 25x25 m plots), N or S and E or W (depending on the wellsite or reference site quadrant). For the quadrant where you are doing the bryophyte/lichen plot, mark the distance 15 m from the corner of the 25x25 m plot that is closest to the wellsite centre that is not part of the 10x10 m plot to create the fourth corner of the 25x15 m bryophyte/lichen plot. Add two additional pigtails for the remaining sides of the 5-m square plots by measuring 5 m, N or S and E or W (depending on the quadrant). See Fig. 1 for diagram of pigtail layout.

- For the remaining sub-ordinal transects that have not yet been established repeat the procedures described above.
- Note that 25x25 m plots are only required for the quadrants where bryophyte/lichen plots are being measured, and for remaining quadrants are not required in sites that have no trees > 25 cm DBH, and DWD transects are never required when there are no trees present.
- If you encounter a wellsite that is located in an area that does not have adjacent conditions that are suitable to be used as a reference condition, then the protocols for selection of reference conditions will differ and you should not extend the running of your lines beyond the edge of the wellsite and you will not establish the reference 10x10 m square plots directly adjacent to the wellsite. See description of special protocols described below to follow if this situation is encountered.
- All flagging and pigtails **must** be removed after each visit, but magnetic metal markers should be inserted along the transect at the two corners and plot centre of each 10x10 m plot so the plots can be re-identified in future visits to the site.
- Care should be taken to minimize impact on crops/livestock at private sites. Refer to Land Access datasheet for site-specific instructions (access, impact on land, etc.).

Special protocols when there is no adjacent reference condition:
When the reference condition is not located directly adjacent to the wellsite then there will have to be an alternative strategy to sample reference conditions. These will require an expert in the field identifying an area as close as possible to the wellsite that is undisturbed and representative of the natural conditions that were likely to be present on the wellsite prior to disturbance. A total reference area that is similar in size to the wellsite (1 ha) should be sampled – following modified protocols that adapt the protocols described throughout the document to the shape of the reference condition site. GPS points should be marked for the centers of the 10x10 m plots that are sampled in the reference condition sites.

C. Site Sketch – Human Disturbance

Procedure:

- Disturbances within the wellsite are hand drawn based on what is observed at the site.
- Use the data sheet provided to complete a map outlining all human disturbance evidence present at the site.
- Write the type of human disturbance in the polygons using the codes described under “Human Disturbance” included on the worksheets.
- Once mapping is completed, the diagram is reviewed to ensure that it accurately reflects the true size and shape of the human disturbances.
- When reviewing data after collection, all polygon boundaries and labels are traced with a fine-tipped color marker to ensure they are clearly visible.
- The field map is scanned, imported into GIS and if required aligned with the GIS image of the site.
- High-resolution imagery on which human disturbances visible on the ground can be mapped will also need to be obtained and assessed.

D. Site Photographs

This protocol is designed to provide permanent pictures of the site.

Field Equipment Needed:

- *Digital camera with extra batteries and charger if appropriate*

- *Calipers or backpack for scale*

Procedure:

- Use a digital camera with a 35 mm focal length and a quality setting of at least 3 Mega-pixels. Use “landscape” orientation.
- Take six photographs at each wellsite, and take six photographs at one of the reference site 10x10 m plots.
- Except for the canopy photo, include a back pack and/or DBH calipers approximately 5 m from the camera for scale.

For the wellsite:

1. Transect Photos – Standing at wellsite center, take a photograph at eye level in each of the four sub-ordinal directions (beginning with NE and moving clockwise).
2. Canopy Photo – Standing at wellsite center, directly over the pigtail, take a photograph of the canopy looking skyward.
3. Representative Site Photo – From anywhere within the 1 ha plot; take a single photograph that best represents the physical and vegetation characteristics, providing the location and direction of this photo on the site diagram.

For one of the 4 reference site plots that best represents the physical and vegetation characteristics:

1. Standing at the centre of the 10x10 m plot directly over the pigtail, take a photograph at eye level in each of the four sub-ordinal directions (beginning with NE and moving clockwise).
2. Canopy Photo – Standing at the centre of the 10x10 m plot, directly over the pigtail, take a photograph of the canopy looking skyward.
3. Representative Site Photo – From anywhere within the reference area; take a single photograph that best represents the physical and vegetation characteristics.

- Record the photo number on the data sheet.
- Check the resolution and quality of all photos at the site; re-take if any photos are blurry.
- Back-up and label photo files onto a laptop computer once back at your base camp. Transect photos are labeled ERCM_[year]_[site]_[quadrant].jpg (e.g., ERCM _2013_546wellsite_NW.jpg). Canopy and representative site are labeled with [canopy] and [site] at the end of the label name, respectively.
- All photos are copied to the field laptop or an external hard drive/flash key for backup, and at the end of each field shift or when visited by a field coordinator, site photos are transferred to a field coordinator.

3. VEGETATION SAMPLING

This chapter describes the vegetation sampling protocols. Vegetation sampling protocols will vary among the different upland vegetation types (see descriptions below, e.g., trees will only be measured when present and are generally absent in grasslands). The current set of protocols are designed for sampling in native grasslands and forested lands. The protocols will be updated in the future to include sampling of cultivated lands, as needed.

A. Classification of Upland Vegetation Types – (copied from Alberta Environment 2010)

Native Grasslands include lands that are permanently vegetated by native herbaceous species. Native grasslands commonly present a mixture of different native grass species, forbs (i.e., flowering/broad-leaved species), shrubs (i.e., woody species) and tree species, whereas tame grasslands (i.e., forage and tame pasture) produce agronomic seeded grass and legume species such as timothy and alfalfa. Grasslands occur primarily in the Grassland Natural Region, but they can also be found in other Natural Regions of Alberta, including the Parkland, Rocky Mountains and Foothills Natural Regions. Grasslands include range improvement areas, grazing dispositions on public lands (White Zone and Green Zone areas), native prairie and grassland areas, Special Areas, and the Eastern Irrigation District. Riparian areas may also occur in Grassland sites. Riparian areas are the moist habitats found along creeks and sloughs, that include wetland grasses, forbs, shrubs and trees. For grasslands that have been cultivated/seeded to agronomic species and the land use goal is to be managed as tame forage for hay or pasture, they shall be assessed under the Cultivated Land criteria.

Forested Lands includes any treed land, whether or not the forest vegetation is used for commercial purposes. Treed (bush) lands in the White Area (deedable land) that are to be maintained as 'treed' shall meet the forested criteria. Land in the White Area where a landuse has been changed to cultivation must meet the cultivated criteria. In the Green Area (crown land), native meadows or range improvement areas in grazing dispositions may be assessed using the grasslands or cultivated lands criteria.

Cultivated Lands include all agricultural lands managed under conventional, minimum, zero till or forage production practices. The Cultivated land use criteria will be used to assess perennial forage and grasslands that are seeded to agronomic species as well as to agroforestry tree farms. Cultivated lands include lands changed from peatland, forested land or grassland to cultivated land.

B. Shrubs and 2-Dimensional Cover

This protocol is designed to measure shrubs and vascular plant vegetation at the level of vegetation groups (e.g., shrubs, grasses, forbs).

Field Equipment Needed:

- *ABMI Ecological Site Classification Chart*
- *Plant Field Guide (one that is relevant to the area which you are studying*
- *"Cheat sheet" to estimate percent cover*

Procedure:

- 2-dimensional cover of the ground layer and shrub layer is measured at each 5 x 5 m plot within each of the five 10x10 m plots in the wellsite and four 10x10 plots in the reference condition site (n=10 5x5 m plots total, Fig. 2).

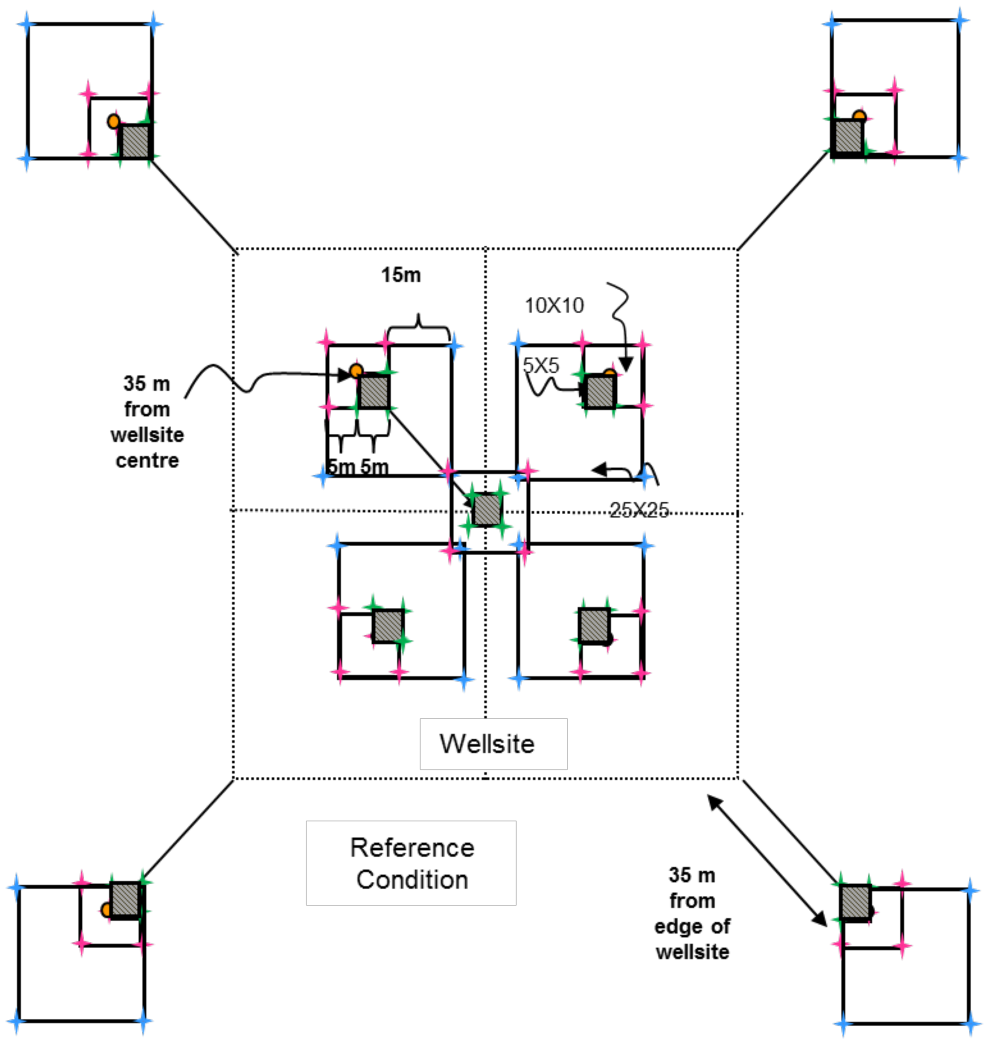


Fig. 2. More detailed scale of 5x5 m, 10x10m, and 25x25m plot sampling – shrub and 2-D cover are measured in the 5x5 m plots (shaded in grey) identified in the figure.

- Determine the ecological site type of each 5x5 m plot, using the ecosite classification chart (see Appendix 2).
- If the plot is disturbed (either by humans or naturally), indicate the cause of the disturbance and percent area affected based on disturbance categories from the site sketch protocols (See Chapter 2 Section C). If there is bare ground in the plot, the cause of bare ground must be included in the disturbance field.
- For the shrub layer estimate 2-dimensional cover (0, <1, and 5% increments) of shrubs and small trees.
    - Shrubs are defined as non-tree woody vascular plants that have woody stems.
    - Small trees are defined as trees <1.3 m in height and are included with shrubs in the estimates
    - Shrub/small tree cover is estimated for three height categories (0-0.5, 0.5-2 m, and 2-5 m high). Note: Each of these estimates cannot be greater than 100%.
    - The estimate for height class 0.5-2 m is recorded as if a photo was taken 2 m above the ground and foliage from all shrubs/trees <0.5 m was excluded.
    - The estimate for height class 2-5 m is recorded as if a photo was taken 5.0 m above the ground and foliage from all shrubs/trees <2 m was excluded.

- For the ground layer (<0.5 m), estimate 2-dimensional cover (0, <1, and 5% increments) as the percentage of the 5 x 5 m plot covered by shrubs/trees, grasses (including sedges/rushes), all "other" vascular plants combined (Herbs/forbs), mosses (includes all bryophytes), lichens, fungi, litter (dead vegetation material plus DWD <2 cm in diameter), wood (live and dead trees >1.3 m tall, plus DWD >2 cm diameter), water, bare ground, rock, and animal matter. These estimates are recorded as if a photo was taken 0.5 m above the ground. Values of all these independent categories must sum to 100%.
- Record percent cover for each individual shrub/tree species rooted within the plot, including which strata (see Table 1) it is located in.
- Percent cover is determined by ocular estimation (this requires practice before the start of the data collection to ensure the estimates are precise).

C. Plant and Lichen Cover by Species

This protocol is designed to monitor relative abundance of vascular, non-vascular, and lichen species by height strata.

Field Equipment Needed:

- *Plot frame (0.5 m x 0.5 m)*
- *Plant press*
- *Vascular plant field guide*

Procedure:

Ten plant and lichen cover quadrats (0.5x0.5 m = 0.25 m^2) are established in the wellsite, and eight plant and lichen cover quadrats are established in the reference condition site (Fig. 3). For both the wellsite and reference condition sites two 0.5x0.5 m cover quadrats are located in each of the 5x5 m plots at the two diagonal corners of the plot that intersect the sub-ordinal transects (see Fig. 3).

- Percent cover of individual vascular, non-vascular, and lichen species by strata are recorded within each 0.5x0.5 m quadrat. The strata are described in Table 1.
- Estimate percent cover (0, <1, and 5% increments) by strata (see Table 1) for each species in each of the 0.5x0.5 m quadrats (Fig. 3).
- In addition estimate percent cover for rock/bare mineral soil, litter, and water in the quadrat.
- Plants must be rooted within the quadrat to be included in the estimation.
- Due to overlapping of leaves at different heights, percent cover for each species, and all species combined can be greater than 100%.
- Collect voucher specimens of unknown or uncertain specimens from outside the 5x5 m plot if possible. Take the voucher specimens to camp for identification.

Table 1. Description of vegetation strata as described in the Ecological Land Site Description Manual (ESRD 2003)

Code	Strata	Definition
T1	Tree (main canopy)	Trees that make up the upper part of the height distribution population and form the general layer of the canopy or foliage
T2	Tree (understory)	Trees and/or shrubs whose crowns extend into the bottom of the general level of the canopy or are located below the main canopy. Trees and/or shrubs must exceed 5 m height
S1	Shrub (tall)	All woody plants between 2-5 m tall (includes regeneration of taller trees)
S2	Shrub (medium)	shrubs and regenerating trees between 0.5-2 m tall
S3	Shrub (low)	All woody plants up to 0.5 m tall
H	Herbs (forbs)	record all forb species regardless of height
G	Grass/graminoid	record graminoids (grasses, sedges, rushes)
M	Moss	record all bryophytes
L	lichen	lichen species growing on dominant substrate (usually mineral or organic soil) included
E	epiphytes	Lichens or mosses growing on other plants, usually trees or shrubs
F	fungi	Fungi (excluding lichen) growing on dominant substrate - mushrooms

- When collecting voucher specimens, record the reclamation site number and a unique reference code (UIS-Site Number-Specimen Number) and collector’s name on the field data sheet and on the sheet in the plant press (e.g., the fifth unidentified specimen from site 383 would be: UIS-383-05). Ensure that specimen numbers do not repeat those collected during the vascular plant search.
- For specimens that cannot be identified in the evening, remove them from the field press and place them in a different plant press for temporary storage. Ensure that the information (site number, reference code, date, collector’s name) on the data sheet matches the information included with the specimen in the plant press.
- Any plants that are identified at camp are discarded, the UIS line on the data sheet crossed out, the species code indicated beside the row, and a new row added for that species with all of the appropriate information added to the species record.
- At the end of the shift, take the press to the laboratory. These unknown specimens will be identified by experts (see Processing Vascular Plants in Chapter 7).

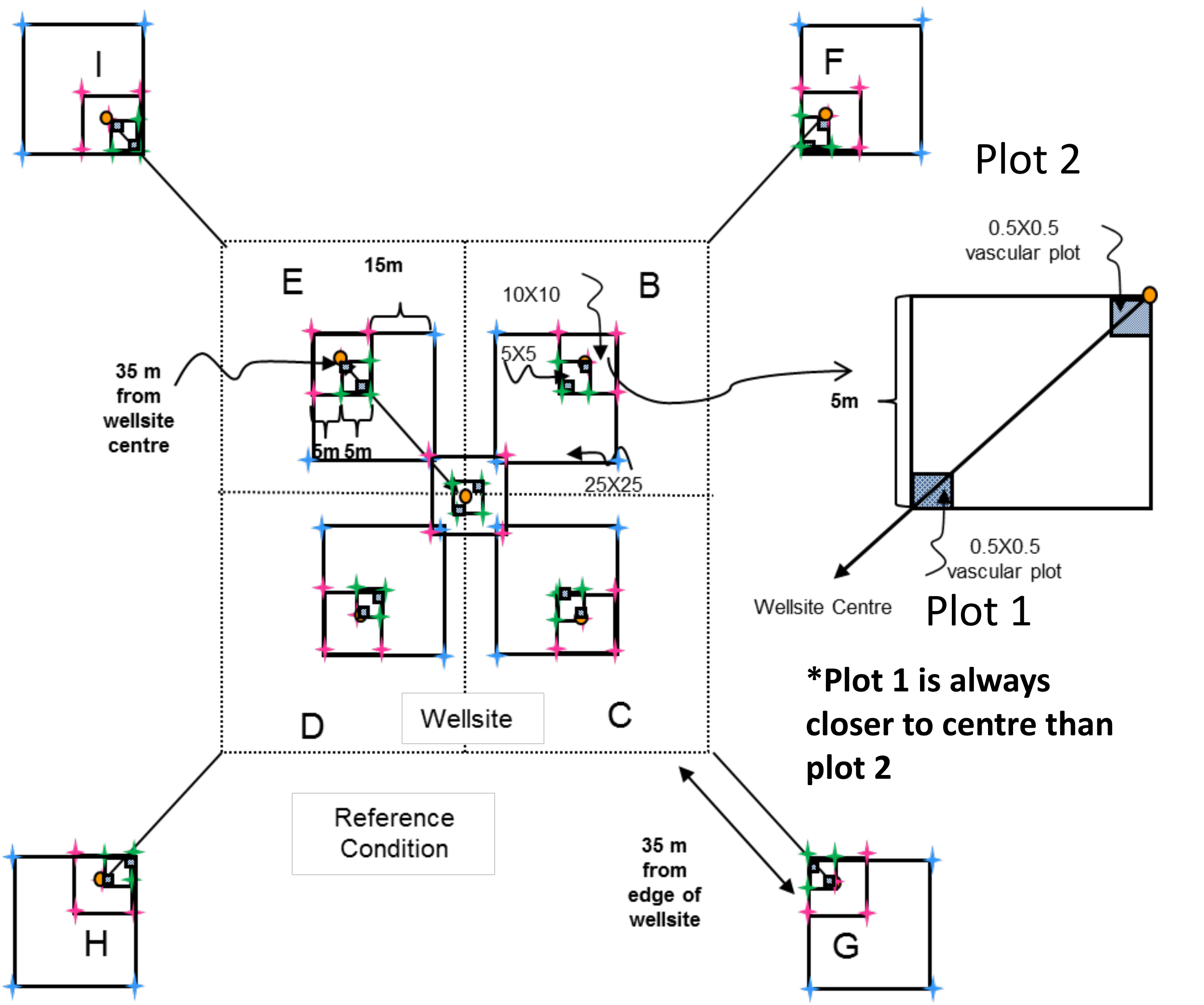


Fig. 3. Locations of the 0.5x0.5 m quadrats where vegetation are sampled at the species x height strata level. Note that for the wellsite centre 0.5x0.5 m plots, they are always in the B and D quadrants.

D. Vascular Plant Searches[5]

This protocol is designed to detect as many species of vascular plants as possible during a time constrained search within the wellsite area along with the adjacent reference condition site. To standardize sampling effort a single person completes all of the vascular plant surveys at a site, in the time specified.

Procedure:
Wellsite survey

- The crew member surveying vascular plants spends an initial 10 minutes populating a species list with the names of vascular plants seen at the wellsite. This initial listing of plant names is conducted so that the subsequent timed searches of the 50x50 m quadrants are spent mainly looking for species,

[5] Could modify the program of ABMI and allocate reduced amount of time perhaps - we should start out with this sampling effort level and then re-examine after pilot/retrospectivey study and likely can reduce to just doing 1 or 2 searches within the wellsite and reference site depending on how much change in species we have among the four quadrants and four reference sites.

with less time recording plant names/codes. During the initial 10 minutes when species are being recorded, locate the most diverse habitat types within the 1 ha site and spend time in these habitats recording species names.

- The technician then spends 20 minutes in each of the four quadrants (a total of 80 minutes) finding as many species of vascular plants as possible while walking a predetermined path (Fig. 4).
- To maintain consistency among observers, start at the 10x10 m plot center, and then begin heading toward site center, to within 5-10 m. Then head in a clockwise direction around the quadrant staying approximately 5-10 m from the quadrant edge. Stop every 4 or 5 steps to examine the plants in the immediate area (see Fig. 4).
- Ensure that all habitat types in the quadrant are searched for vascular plants.
- When a vascular plant species is detected in a quadrant, place a tick mark for that species in that quadrant.
- Always start the surveys in the NE quadrant and progress clockwise to the next quadrant (NE, SE, SW and NW).

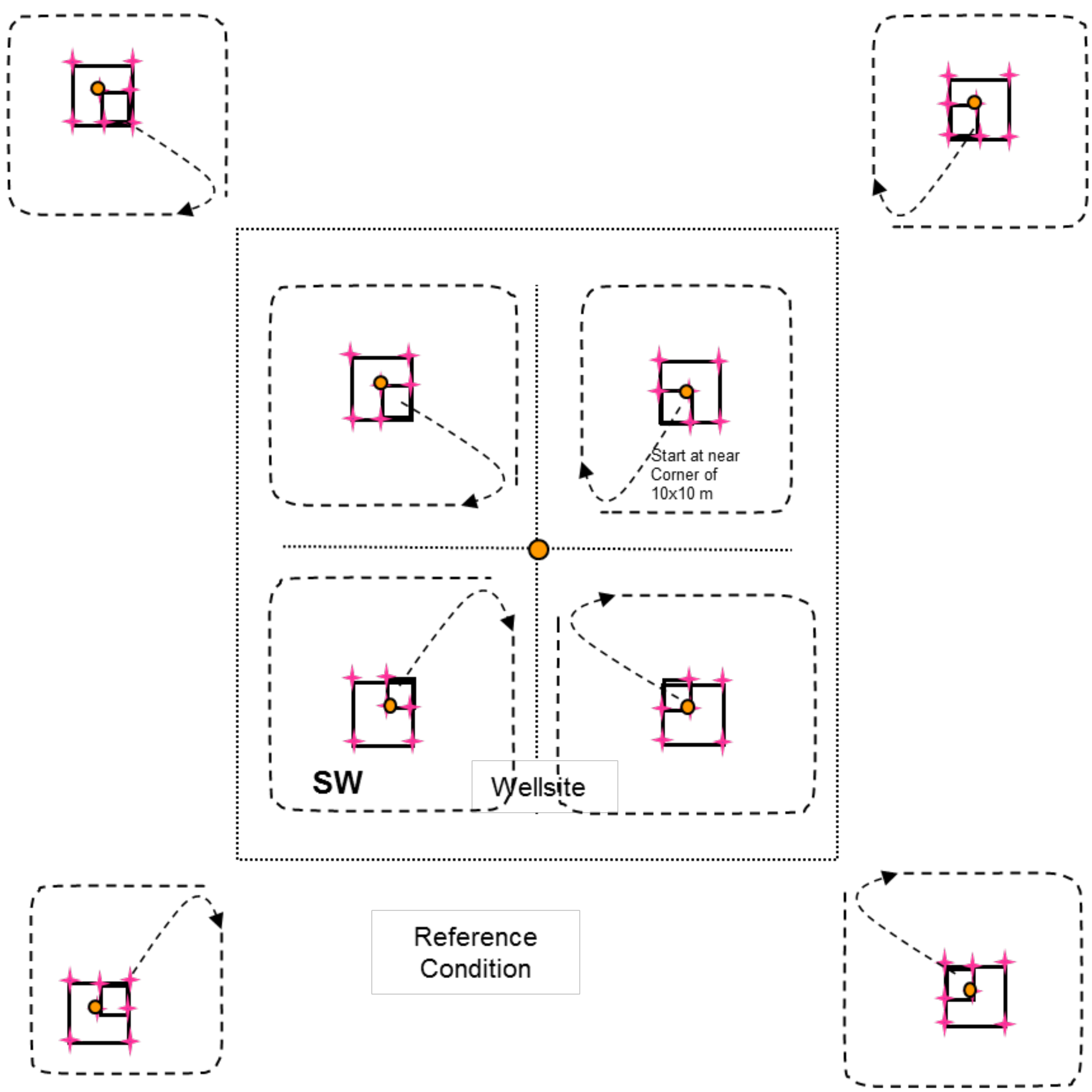


Fig. 4. Layout of survey to identify vascular plant richness within the wellsite and reference sites.

Reference Condition Site survey

- The crew member surveying vascular plants spends an initial 10 minutes populating a species list with the names of vascular plants seen at the reference condition site. This initial listing of plant names is conducted so that the subsequent timed searches of the equivalent area (50x50 m = 2500 m^2 – dimensions will vary depending on shape of reference condition polygon) of the reference sites are spent mainly looking for species, with less time recording plant names/codes. During the initial 10 minutes when species names are being recorded, locate the most diverse habitat types within the 1 ha equivalent area of the reference condition (2.5 minutes per reference 'quadrant') and spend time in these habitats recording species names.
- The technician then spends 20 minutes in each of the four 'quadrants' (a total of 80 minutes) finding as many species of vascular plants as possible while walking a predetermined path (Fig. 4).
- To maintain consistency among observers, start at the 10x10 m plot stake, and then begin heading toward the edge of the wellsite, to within 5-10 m. Then head in a clockwise direction around the 'quadrant' staying approximately 5-10 m from the quadrant edge. Stop every 4 or 5 steps to examine the plants in the immediate area (Fig. 4). Ensure that all habitat types in the quadrant are searched for vascular plants.
- When a vascular plant species is detected in a reference 'quadrant', place a tick mark for that species in that quadrant.
- Always start the surveys in the NE reference 'quadrant' and progress clockwise to the next quadrant (NE, SE, SW and NW).

For unidentified species:

- Unknown species can be quickly identified after the initial 10-minute search, but if the technician is unable to identify the species quickly, they will collect the specimen from a population of greater than 5 individuals, outside the plot if possible. These samples are assigned a unique specimen number and carried with the technician so as to avoid multiple collections in each quadrant if possible. Unidentified specimens are named UIS-Site Number-Specimen Number e.g. UIS-315-1.
- Field guides should not be used during the 20-minute search time. Collect voucher specimens of unknown or uncertain vascular plant species. After the 20-minute search in a quadrant is complete, attempt to quickly identify the species you have collected using field guides. Place labeled unknown specimens in a plant press and take them to camp for identification during the evening.
- The label on the specimen tag and in the plant press log will be written as UIS-SiteNumber-SpecimenNumber (e.g., the fifth unidentified specimen from site 383 would be: UIS-383-5). Ensure that specimen numbers are not repeated for the site. Be diligent when collecting specimens from the low vegetation and shrub cover plots that specimen numbers are not repeated within-site.
- For any vascular plant categorized as S1 or S2 by Alberta Natural Heritage Information Centre (ANHIC), collect a specimen so its identity can be confirmed by experts. Collect the specimen from a population of greater than 5 individuals, outside the plot if possible.
- Specimens that cannot be identified in the evening or for ANHIC S1 or S2 plants, place them in the camp press.
- Any plants that are identified at camp are discarded and the UIS number will be removed and replaced with the correct species code. Do not forget this step.
- Any species found after the vascular plant search is complete are to be recorded under incidental species.
- At the end of the field shift, plant presses are delivered to the Royal Alberta Museum. These unknown specimens will be identified by experts (see Processing Vascular Plants in Chapter 7).

D. Methods for Surveying Bryophytes & Lichens

Field Equipment Needed:

- *Mora knife*
- *Hand lens*
- *Toilet paper for fragile specimens*
- *Squares of paper for small specimens*
- *20 paper bags (Kraft #8) per site*
- *1 larger grocery sized paper bag per site*
- *Sharpie*
- *Water*
- *Watch*

Procedure:

- Select the quadrant with the most diversity of microhabitats (or if they all appear similar randomly select one) – only **one** of the four 25x15 m plots (0.0375 ha) on the wellsite and one of the four reference site 25x15 m plots to survey for bryophytes and lichens (Fig. 5).
- In each of the two plots record a visual estimate of the proportion of the area (as 0, <1% or in 5% increments) affected by human-caused disturbances.
- A single person spends up to 35 minute in each of the two plot quadrants (maximum total 70 minutes) collecting bryophytes. A second person independently completes the protocol for lichens.
- In each quadrant, surveys are divided into two periods:
  - **First**: the strata (microhabitat types) present are sampled in the 25x15 m plot.
    - **For bryophytes:** Search strata #1 logs/ stumps, strata #3 wetlands/peatlands and strata #4 rocks and cliffs (Table 2).
    - **For lichens:** Search the strata #1 logs/stumps, strata #2 trees/other structures and strata #4 rocks and cliffs (Table 2).
    - To help maximize the number of species detected, begin the timed search by surveying one example from each stratum that has the most diverse community of bryophytes/lichens. This must be completed within a maximum of 5-10 minutes. For example, large-diameter soft logs often have the highest diversity of both taxa, and when present in the plot, should be targeted early in the search.
    - Then search for the three primary strata by zig-zagging through the plot (Fig. 5).
    - Stop every 4 or 5 steps to examine the microhabitat types in the immediate area. When examples of the any of the primary strata are found, take samples as you encounter them.
    - Note that if there are no examples of the any of the primary strata in the plot, then the search can be terminated after 5 minutes. A minimum of 5 minutes **must** be spent searching for examples of the primary stratum in each plot as some microhabitats are small and dispersed in space (e.g., rocks).
    - If there are microhabitats (strata) found within the plot, then a minimum of 10 minutes must be spent searching if all examples have been searched (for example, if you are searching for lichens and there is a single tree, no logs, and no rocks/cliffs in the plot then sampling may be terminated after 10 minutes).
    - Plots which have all of the primary strata should take the full 25 minutes to search.

  - **Second:** the strata (i.e., the microhabitat types) that have less diverse communities are searched in a belt transect following the 2 long sides of the 25x15 m plot (Fig. 5). Walk along the 25x15 m plot boundary and sample within 1 m of either side of the transect. This results in two 25x2 m transects for one each of the wellsite and reference condition quadrants.

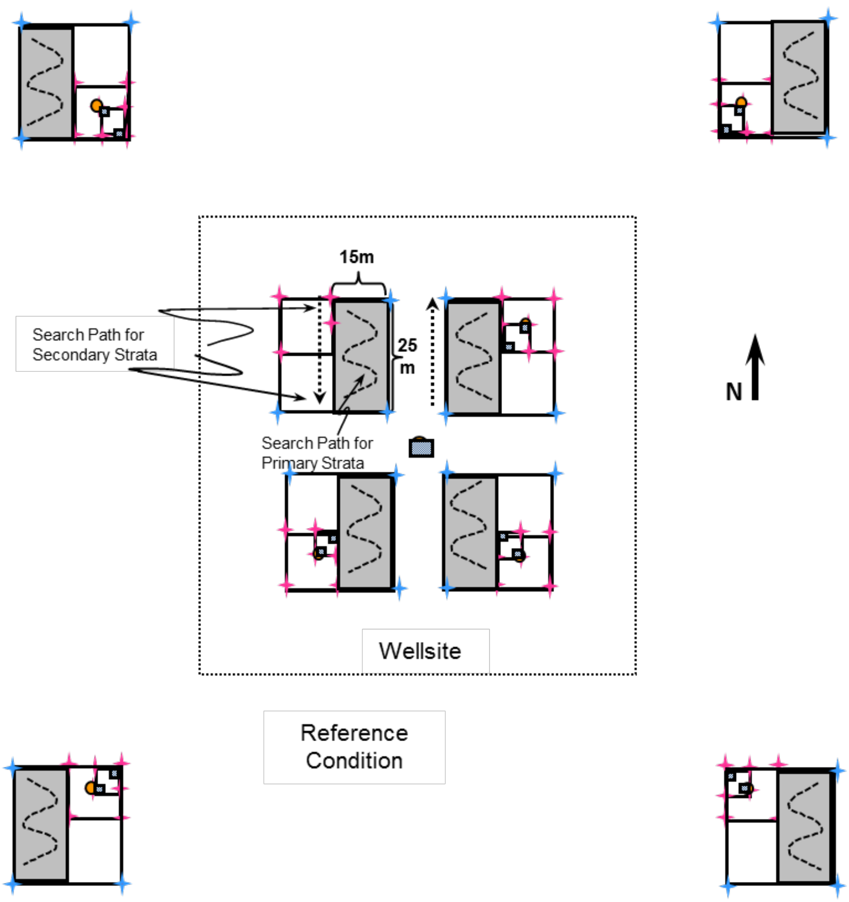


Fig. 5. Description of the plots where bryophytes and lichens are sampled (only 1 wellsite 25x15 m plot and 1 25x15 m reference site plot will be sampled).

- **For bryophytes:** Search the strata #2 trees/structures and strata #5 upland soils (Table 2).
- **For lichens:** Search the strata #3 wetlands/peatlands and strata #5 upland soils (Table 2).
- Ensure that examples of both secondary strata are searched if they occur in the transect.
- Search as many examples (or as much area) of the secondary strata as possible as you encounter them.
- If a variety of microhabitats are present in a stratum, then collect specimens from as many of these as possible (e.g., if many different tree species occur, then collect mosses from as many different tree species as possible).
- Use a time constrained search that is exactly 10 minutes long.

- In each stratum in each plot/transect collect examples of all the bryophytes/lichens that appear distinctive.
- When collecting specimens:
  - Select only a small sample (i.e., 4-6 cm^2) so that the vegetation community remains intact.
  - If the specimen is growing on mineral soil, wrap the sample gently with toilet paper so it does not break apart (disintegrate) once the soil dries.
  - If the specimen is growing on a large boulder/rock/cliff, wet it thoroughly to help detach it from the substrate. Place small/fragile specimens in paper packets so they don't get lost.

  - If the sample is very wet (e.g. a moss specimen from a wetland stratum) carefully squeeze out the sample before placing it in the bag. Be mindful to fluff the specimen back out after squeezing.
  - When in doubt about whether a specimen is unique or has been collected already, collect it again.
  - We do not sample crustose lichen; however, when in doubt about whether a specimen is crustose, collect it.
- For each taxon (bryophytes/lichens), all specimens collected from a stratum are placed as a composite sample in a single bag.
  - It may be easier to pre-label 20 paper bags with the site number and strata.
  - Be diligent to not collect the same species over and over again from a stratum as it takes considerable time to sort through duplicates in the lab.
- If no specimens are found in a stratum of a plot/transect, then indicate "None" on the empty paper bag and on the field data sheet. If no example of a stratum is found in a plot/transect (all microhabitats are absent), then indicate “VNA” on the bag for that stratum and on the field data sheet. Paper bags without either a “None” or a “VNA” are assumed to contain specimens.
- Once the surveys are completed, ensure there are 10 paper bags for bryophytes and 10 paper bags for lichens.
- Take the collections to camp, and dry them using the racks provided in trailers or any other well ventilated space. Place the bags on their side and fluff out the sample for optimal surface area. Be mindful to flip the bags daily and check the dryness of the samples. Most samples are dry within 3 days.
- Once dry, place all bryophyte sample bags into one large paper bag and label it with the site number and “Bryophyte”. Do the same for Lichens.
- At the end of each shift, fill a large cloth bag with all the bryophyte samples and one with all the lichen samples, and transfer these to the laboratory. Samples collected from the end of the shift will likely have not had time to dry completely. Mark these samples copiously as being wet and museum staff will attend to them at RAM.

Table 2. Strata and microhabitat types within strata used during searches for bryophytes and lichens.

Stratum #1: Logs and Stumps (samples in 1 bag)
LS: Soft stumps & logs (decay classes 3-5) - sample roots and all sides
LH: Hard stumps & logs (decay classes 1-2) - sample roots and all sides
Stratum #2: Trees, Shrubs and Other Vertical Structures (samples in 1 bag)
TD: Deciduous Trees - all sides of the roots, bases, trunks, and branches of both live and dead deciduous trees
TC: Coniferous Trees - all sides of the roots, bases, trunks, and branches of both live and dead coniferous trees
TS: Shrubs - all sides of the roots, bases, stems, and branches of live & dead shrubs
HB: Human Structures - vertical and horizontal parts of the structures (survey from the ground)
Stratum #3: Wetlands and Peatlands (samples in 1 bag)
WMF: Wetlands, marshes, & fens - within the wetland survey both under and away from trees
WSB: Shores/banks of wetlands, ponds, lakes, & streams - survey on organic or mineral soil adjacent water’s edge
WDS: Moist depressions/seasonal wetlands dry at time of survey - sample sides & bottom area influenced by water
WPW: Peatlands with or without standing water - survey both standing water and vegetation hummocks
Stratum #4: Rocks and Cliffs (samples in 1 bag)
BC: Boulders (>50 cm diam.) - survey all surfaces (top, sides, and base) from the soil upwards
RR: Rocks (<50 cm diam.) - survey all surfaces (top, sides, and base) from the soil upwards
CL: Cliffs (steep high rock face) - survey all of the faces, ledges, and crevices that can be accessed safely

Stratum #5: Upland Soils (samples in 1 bag)
UC: Humus soils under trees/shrubs (shaded by canopy) - survey as large a variety as possible
UO: Humus soils without trees/shrubs (open to sunlight) - survey as large a variety as possible
DC: Agriculturally cultivated soils
DM: Mineral soil in upland areas from any causes

E. Trees, Snags and Stumps

This protocol is designed to measure tree, snag, and stump densities and sizes and as such **will only be relevant when there are trees present.**

Field Equipment Needed:

- *5 m DBH tape*
- *10 m carpenters tape*
- *100 m measuring tape*
- *Vertex hypsometer w/transponder*
- *Clinometer*
- *Tree paint*

Procedure:
Data are collected in three nested plots for three different size categories. The smallest plot is 5x5 m (**Measure ALL trees, snags and stumps)** and is anchored at the center of the 10x10 m plot located at each quadrant center – with the 5x5 m plot in the quadrant of the 10-m square plot that is closest to the wellsite center (Fig. 6). The second plot is 10x10 m (**Measure ALL trees snags and stumps ≥7 cm DBH)**, and encompasses the entire 10x10 m plot (Fig. 6). The third plot is 25x25 m (**Measure ALL trees snags and stumps ≥25 cm DBH**) and encompasses both the first and second plots (Figs. 6 and 7).

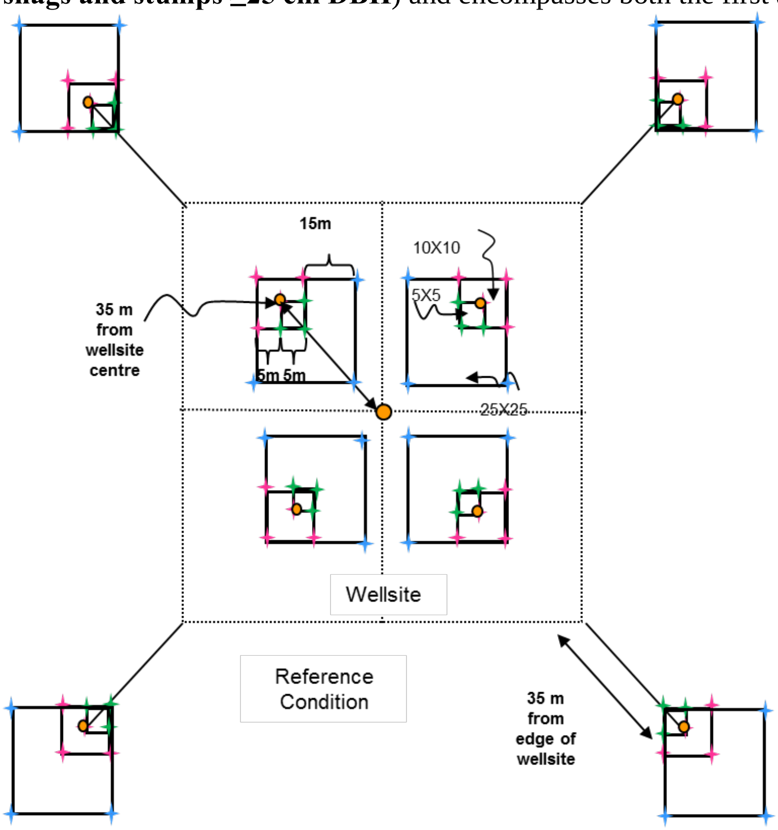


Fig. 6. Detailed scale of 5x5 m, 10x10m, and 25x25m tree, snag, and stump sampling.

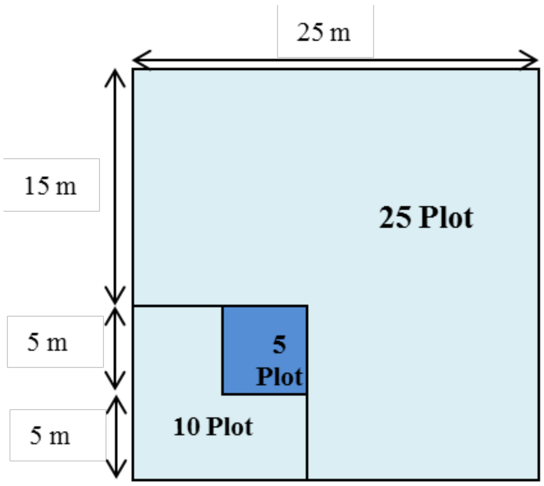


Fig. 7. Tree, snag, and stump plot layout of wellsites and adjacent reference sites delineating the 3 different plot types. The 5x5 m square plot is located in the quadrant of the 10x10m square plot that is closest to the wellsite plot center (see Fig. 6).

For accurate and consistent data collection treat the 5x5 m plot as a square, and the 10x10 m and 25x25 m plots as L-shaped (Figs. 6 and 7). Collect the information in the 5x5 m and then sequentially move to the 10x10 m and then 25x25 m plots.

For the purposes of this protocol:

- Trees are defined as any tree species with the exception of *Alnus* or *Salix* that is ≥1.3 m in height. Any trees <1.3 m in height are NOT measured.
- Snags are defined as DEAD trees ≥1.3 m in length, leaning ≤ 45°from vertical. Snags can be intact or broken below the canopy.
- Stumps are defined as DEAD trees broken below the canopy with a top height of <1.3 m, diameter is measured inside the bark, Height of all stumps is measured to the nearest 0.1 m.
- DBH is measured to the nearest 0.1 cm and is measured using a DBH tape.
- Top height and base height of trees and snags are measured to the nearest 0.1 m unless this value is estimated, in which case height is measured to the nearest 0.5 m. Tree height is measured using a vertex hypsometer, or in the case of small trees, can be measured using a carpenter's tape, or if a hypsometer is unavailable then a clinometer and tape can be used to estimate it.
- Measure trees and snags on the boundary of the plot only if greater than half of the bole is within the plot. Note that flagging tape may not be an accurate determination of plot boundary; if in doubt crews should lay out the measuring tape to confirm plot boundaries.
- Mark the sampled trees and snags with a small dot of tree paint to avoid re-sampling, mark it at breast height (i.e. point of measurement).
- Further details on the sampling within each of the 3-sized plots are described below (see Figs. 6 and 7 above for clarification of location of each plot).

5x5 m Square Plot (5)

- **Measure ALL trees snags and stumps.**
- For trees <7 cm DBH, record Plot Type[6], Species, Condition[7], and DBH.

[6] Plot where tree was measured: 5 = 5x5 m Plot; 10 = 10x10 m Plot; 25 = 25x25 m Plot
[7] Condition is recorded as A = Alive (live tree, >1.3 m); D = Dead (snag; dead tree >1.3 m); S = Stump (dead tree <1.3 m)

- For trees ≥ 7 cm DBH, record Plot Type, Species, Condition, DBH, and Tree Height for the 3 tallest trees.
- For snags <7 cm DBH, record the same categories as live trees, but including the appropriate decay stage (described in Table 3 and Fig. 8).
- For snags ≥7 cm DBH, record the same categories as live trees, but including the appropriate decay stage, and excluding Crown Class.
- For stumps, record Plot, Species, Condition, Decay Stage, Diameter Inside the Bark at Top height (recorded in the DBH field on datasheet), and Top Height.

10x10 m L-Shaped Plot (10)

- **Measure ALL trees snags and stumps ≥7 cm DBH.**
- For all trees, record Plot Type, Species, Condition, DBH, and Tree Height for the 3 tallest trees.
- For all snags, record the above categories, including the appropriate decay stage.
- For stumps, record Plot Type, Species, Condition, Decay Stage, 'DBH', and Top Height.

25x25 m L-Shaped Plot (25)

- **Measure ALL trees snags and stumps ≥25 cm DBH.(25)**
- For all trees and snags, record Plot Type, Species, Condition, Decay Stage, DBH, and Tree Height for the 3 tallest trees.
- For stumps, record Plot Type, Species, Condition, Decay Stage, 'DBH', and Top Height.

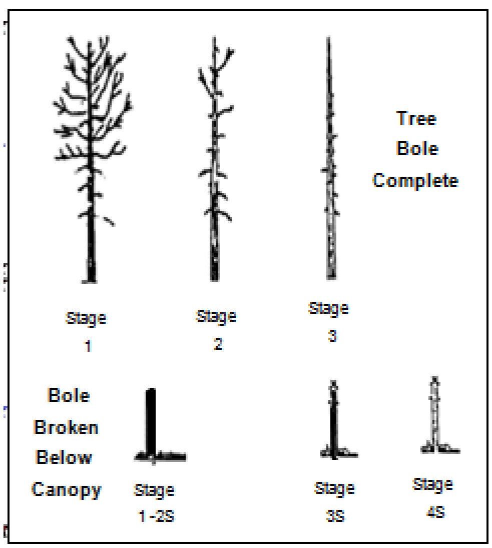


Fig. 8. Visual representation of decay stages for snags and stumps.

Table 3. Description of decay stages. Also refer to Fig. 8.

Decay Stage	**Description**
Trees not snapped	
1	Recently killed, all twigs/ branches present, wood hard, bark (normally) intact
2	Twigs and small branches missing (major branches remain), wood hard
3	No branches, bole mostly intact, wood starting to soften.
Tree snapped along bole: twigs and branches absent	
1-2S	Recently killed, wood hard, bark (normally) intact
3S	Wood starting to soften
4S	Wood soft throughout the snag

F. Tree Cores

This protocol is designed to measure age, and growth rate of trees (is only done when trees are present).

Field Equipment Needed:

- *16 inch (5.5 mm) increment borer*
- *Straws*
- *Ziploc bags*
- *Labels*
- *Vertex hypsometer*
- *Folding Saw*
- *DBH calipers and tape*

Procedure:

- Tree cores are obtained from a maximum of 9 trees at each wellsite and reference site.
- Trees are selected based on their relative abundance, height and age.

Wellsite

- Select the **largest** live DBH tree within the 1 ha wellsite area regardless of species. Obtain a tree core and record DBH, tree height, and significant tree damage for the tree.
- Select the largest live DBH tree from the **leading** species (species with the highest stem density of dominant and/or co-dominant canopy trees), within each 50x50 m quadrant (total of 4 trees per site), not including veteran or residual trees from a former stand. Obtain tree cores and record DBH, tree heights, and significant tree damage for the cored trees.
- Select the largest live DBH tree from the **second** species (species with the 2nd highest stem density of dominant and/or co-dominant canopy trees), if one occurs, within each 50x50 m quadrant (total of 4 trees), not including veteran or residual trees from a former stand. To be classified as the second species, the species must comprise >20% of the canopy stems in the quadrant. Obtain tree cores and record DBH, tree heights, and significant tree damage for the cored second species trees.

Reference site

- Select the **largest** live DBH tree within the reference area regardless of species. Obtain a tree core and record DBH, tree height, and significant tree damage for the tree.
- Select the largest live DBH tree from the **leading** species (species with the highest stem density of dominant and/or co-dominant canopy trees), within a 50x50 m area around each reference 10x10 m plot (total of 4 trees per reference site), not including veteran or residual trees from a former stand. Obtain tree cores and record DBH, tree heights, and significant tree damage for the cored trees.
- Select the largest live DBH tree from the **second** species (species with the 2nd highest stem density of dominant and/or co-dominant canopy trees), if one occurs, within each 50x50 m area around each reference 10x10 m plot (total of 4 trees), not including veteran or residual trees from a former stand. To be classified as the second species, the species must comprise >20% of the canopy stems in the quadrant. Obtain tree cores and record DBH, tree heights, and significant tree damage for the cored second species trees.
- Use a vertex hypsometer to determine tree height for each of the cored trees. Record height to the nearest 0.1 m.
- Use a DBH tape to record DBH to the nearest 0.1 cm.
- Significant tree damage is defined as any damage or condition that could affect the normal height or growth rate of the tree: broken tops, dead tops, forks, crooks, and/or abnormal scarring or other damage (e.g. mistletoe). Record significant damage as:
  - BT – Broken Top,
  - DT – Dead Top,
  - FC – Fork/Crook,
  - S – Scarring, and/or

  - O – Other (indicate damage from diseases, insects, wild and/or domestic animals, abiotic natural factors, and anthropogenic factors).
- Use the increment borer to obtain the cores. Bore the tree at 1.3 m (be accurate when determining the height of the core) and facing site center, if possible. If the tree is not round, obtain the core from the narrow width.
- If cores are rotten or break into more than 2 pieces while being extracted, recollect. If three attempts fail due to rot, collect a core from another similar tree. In some cases, a core will not be able to be obtained due to rot. In this case, record the DBH, height, and significant tree damage of the tree in question and indicate that a core was not collected and why (e.g. Other-with comments, rot).
- Preserve the core in a straw. Staple the straw ends (do not tape) to ensure the core can dry. In addition, puncture straw in many places to allow air flow and stop mold/rot.
- Label the core with the following information: site, quadrant, tree species, sample type (largest, leading, second), initials, and date.
- If all trees in the 50x50 m quadrant of **either** the leading or secondary species are <10 cm DBH, destructively sample a representative tree from **outside** of the quadrant by taking a cookie at a height of 1.3 m. This makes it possible to core a leading species and take a cookie from a secondary species, or vice versa.
- If all trees in 50x50 m quadrant (excluding veterans) are <10 cm DBH, only destructively sample the leading tree species from outside of the 1 ha area (i.e., total of 4 trees per site). Place the cookie in a paper bag. Cookies left in plastic bags will rot. Place a label in the bag or write on the outside with the same information as above. Note the secondary species, but do not take a second cookie from outside the quadrant.
- Place all cores in a protective case to transport from site to camp; be especially careful not to break the cores.
- When back at camp, dry the cores in a warm and dry environment to avoid rot.
- At the end of the shift, pack samples in a cardboard box and take them to the laboratory for processing (see Processing Tree Cores).

G. Canopy Cover

This protocol is designed to measure canopy cover within the site (and should only be recorded when there is vegetation that is taller than breast height (1.3 m).

Field Equipment Needed:

  - *Spherical (concave) densiometer*

Procedure:

- Take readings at the two diagonal corners of each 10x10 m plot (Fig. 9) along each sub-ordinal transect (a total of 8 readings per site).
- Hold the densiometer in the palm of your hand at elbow height (i.e., with your arm bent at right angles) and ensure that it is level.
- Stand facing site center at the corner that is closer to wellsite centre, and stand with your back to site center at the corner that is furthest from plot centre.
- Using your dominant eye, imagine four dots equally spaced in each of the 24 squares on the densiometer (4 equal quarters). Count the dots (quarters) that are in canopy openings (i.e. NOT covered) and record the number of open dots (quarters) on the data sheet.

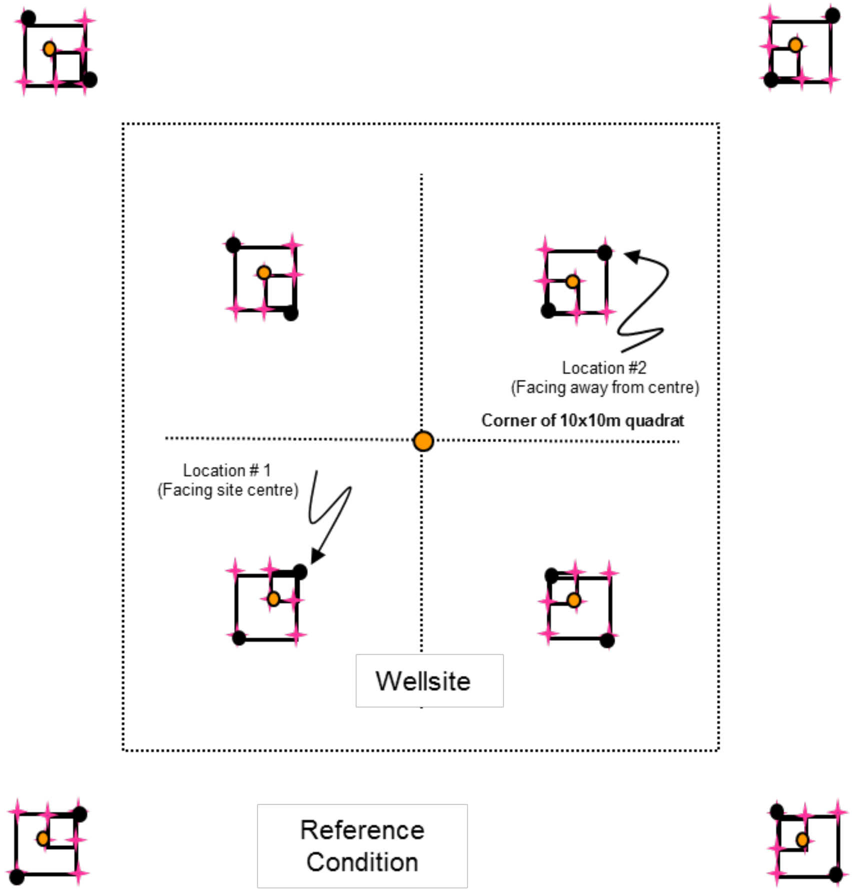


Fig. 9. Location of points where canopy cover is measured – illustrated with black circles on figure.

4. SOIL SAMPLING

This chapter describes the field-based protocols for sampling of soil indicators. Soil sampling should be conducted at 10x10 m plots only after all other sampling has been done (including DWD if appropriate) at the sites to minimize the effects of the destructive sampling on the other measured indicators. The lab analysis that will then be conducted on the samples is not described in these protocols.

A. Number of samples

In a systematic grid sampling design, one composite sample per depth made up of 5 cores from each of the 10m x 10m square is sufficient for each indicator analysis with the exception of bulk density and penetration resistance (Figs. 10 & 11). Compositing samples to reduce analysis cost is suggested for measuring SOC, soil EC and pH. One disadvantage of bulking the samples within the 10m x 10m square is that it does not allow for the calculation of the standard deviation or CV values. Carter and Lowe (1986) evaluated the precision of a variable measured by bulking forest floor samples. They compared the mean nutrient contents weighted by depth and bulk densities using 15 sampling points within a plot to the values obtained from analyzing a single composite sample from the 15 sampling points and the values from the composite samples were all within one standard deviation of the mean. Furthermore, they investigated the relationships between the weighted means and the composite sample values across six study plots and found that they were quite strong for most variables, suggesting that bulking samples can provide good estimates of the real population mean.

It is suggested that the bulking of samples should not be conducted in the field since it is unclear whether proper mixing is done. Preferably, samples should be stored separately and bulking should be done in the laboratory after they have been air-dried and ground to 2 mm.

For soil bulk density measurements, it was suggested on the first initial sampling interval to collect 5 core samples for the two depths (0-15 cm and 15-30 cm).The penetration resistance measurements will also be done adjacent to the five bulk density sampling points on each of the 10m x 10m squares. On a going forward basis, if the PR measurement correlates well with the bulk density measurements, then collect one bulk density core sample at the center of the 10m x 10m square. On the other hand, if PR does not correlate well with bulk density measurements, it will not be monitored for subsequent sampling events.

Depth of Sampling

The sample depth combinations were selected based on the indicator chosen. PR is measured at depth intervals of 2.5 cm. Two sample depths are recommended: 0-15 cm (0”-6”) and 15- 30 cm (6”-12”), for soil EC, pH SOC and bulk density. EC and pH will also be monitored at the 30-60 cm (12”-20”) and 60-100 cm (20”-40”) depths for the center sampling point in each of the 10m x10m square (Fig. 10). There may be merit in capturing bulk density and PR information at depths >30cm at the start of the program to establish the relationship between the two.

Sampling Frequency

It is recommended that the sampling frequency for the soil indicators be between 5 to 10 years depending on the indicator, budget and number of sites. The sampling frequency has not yet been determined and will be determined in a future version of the protocols. There are 10 different sets of sampling locations identified so that soils can be destructively sampled 10 times within each quadrat (Fig. 11). Each sampling point will be located a minimum of 1 m apart from the previous sampling location.

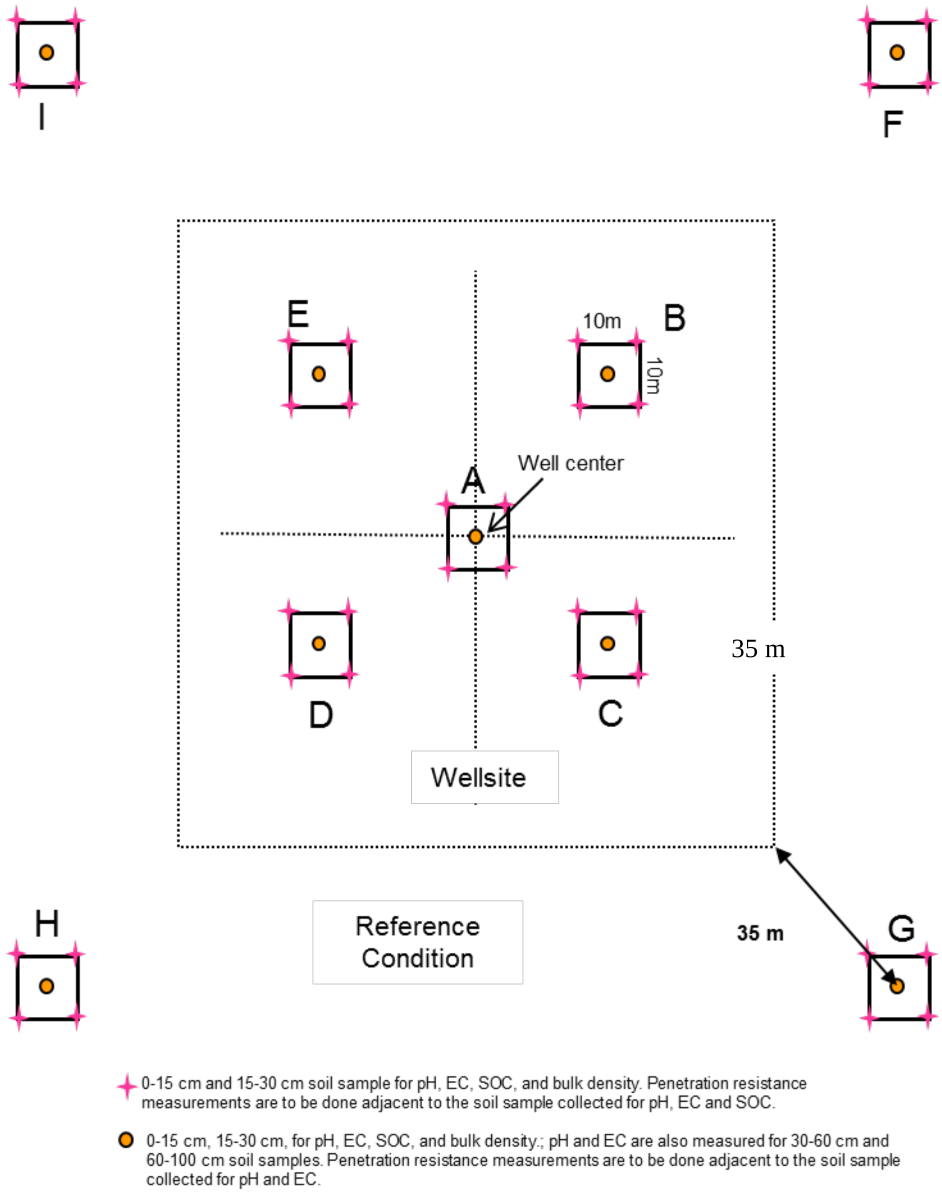


Fig. 10. The soils indicators are sampled within the 10x10 m plots identified in the diagram.

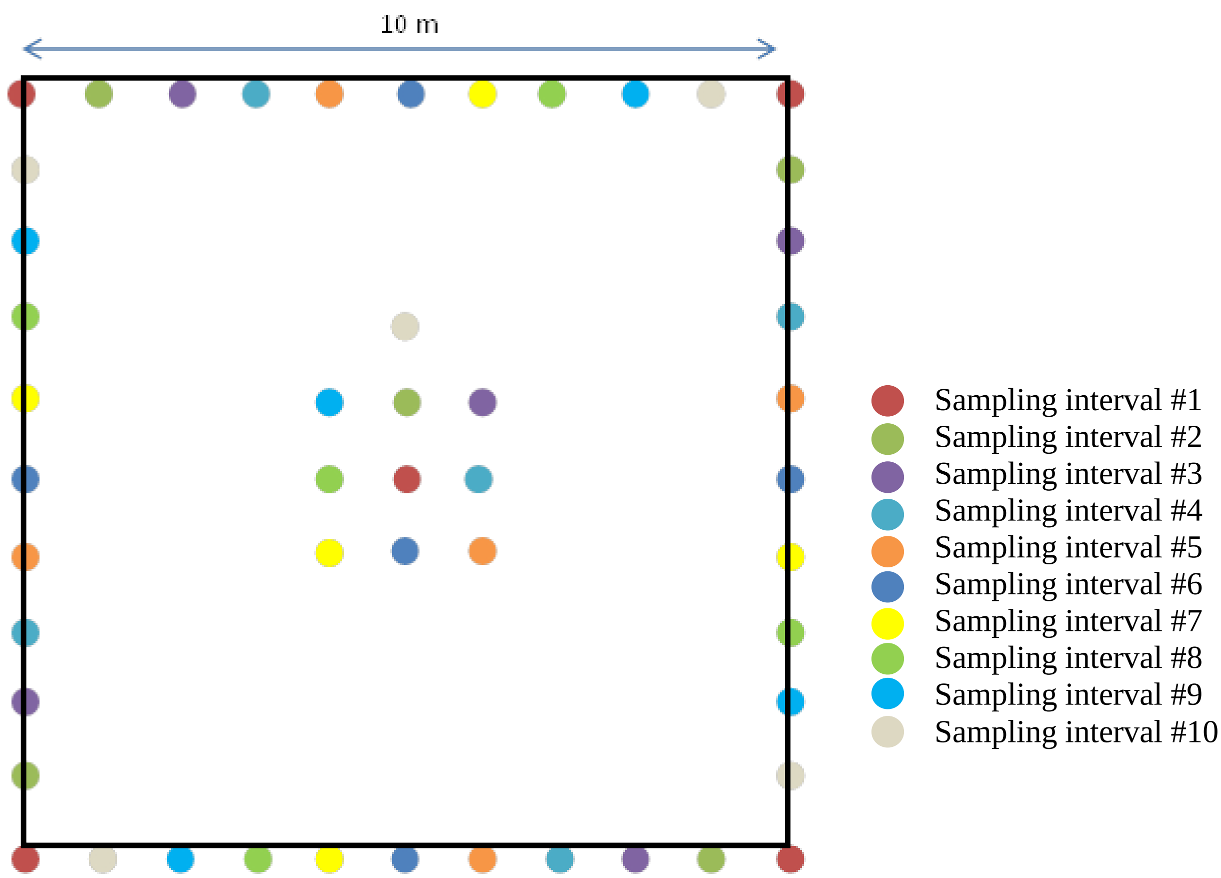


Fig. 11. Sampling layout within each 10x10 m plot on the wellsite and reference sites. Each color represents a different sampling interval, for a total of 10 sampling intervals.

B. Bulk density

There are a variety of soil sampling techniques to assess bulk density; the appropriate sampling method depends largely on the distribution of coarse fragments (particles with diameter > 2 mm) at the given site. The most common method is the core method, and should be used when coarse fragments occupy less than 25% by volume(Maynard, 2006). At forested sites on glacial till of the Precambrian Shield or other rocky soils with lots of coarse fragments and/or tree roots, the core method may be difficult to use and the excavation method is recommended.

Core Method

A double-cylinder, drop-hammer sampler with a liner core is designed to collect an undisturbed soil (Fig. 12). The sampler head contains an inner cylinder with a liner and is driven into the soil with blows from a drop hammer. The liner containing an undisturbed soil core can then be removed and trimmed to the end with a knife to yield a core whose volume can easily be calculated from its length and diameter. The weight of this soil core is then determined after drying in an oven at 105°C for 24 hours.

Field and Lab Equipment Needed:

- Double-cylinder core sampler. The most common core diameter range from 2” to 3” (5.1 cm to 7.6 cm).

- Clean, dry and uniform stainless steel liners with a known internal diameter and height for volume calculation
- End caps for the liners. Need two per liner.
- Trowel for excavation method
- Soil knife or metal spatula
- Analytical balance
- Drying oven capable of heating up to 105 °C
- Polyethylene plastic bags
- GPS for recording the location of the sample

Fig. 12. AMS Inc. double-cylinder, drop-hammer soil core sampler.

Procedure:

1. Label bags and liners and record the weight of the liners (this can be done in the laboratory before the samples are obtained).
2. Select a smooth and relatively undisturbed surface at the appropriate sampling point. Record the GPS location of the sampling point.
3. Drive or press the core sampler into the soil sufficiently to fill the inner liner without inducing compaction. In frictional or dense soils, lubricant may be required to prevent compaction of the soil and to facilitate emptying the collected core sample from the sampler. Research by Blaylock et al. (1995) found the use of WD-40, PAM cooking oil and Dove dishwashing liquid as lubricants will not affect soil test results other than the case of micronutrients iron, zinc, manganese and copper.
4. Carefully remove the undisturbed soil core and trim the ends flush with the edge of the cylinder. Resample adjacent to the original sampling point if large coarse fragments or roots protrude from the sample. Any deviation from the original sampling scheme will be recorded by the field staff.
5. Keep the sample inside the liner and store the sample in polyethylene bags. Store in a large durable plastic bag for transport.
6. Place the sample in an oven set to 105°C for 24 h. After drying, cool the sample in a desiccator and record the weight of the dry soil.

Excavation method

The excavation method according to Blake and Hartge (1986), Campbell and Henshall (2001), and Grossman and Reinsch (2002) involves digging a small hole, collecting a sample and then oven drying (at

105°C) and weighing the dried soil sample. The volume of the excavation is determined by lining the hole with plastic film and filling it completely with a measured volume of water (or sand, or silicon beads). Coarse fragments (diameter > 2 mm) are sieved out and bulk density is calculated as the mass of dry, coarse fragment-free soil per volume of the excavated soil, where volume is also calculated on a coarse fragment-free basis.

C. LFH Depth

Organic matter is defined as the LFH layer of the soil horizon. Determining the LFH horizon is usually straight forward in most soil conditions. The organic layer is typically dark in color, coarse and fibrous (containing rooting systems) whereas the mineral soil is typically lighter in color, finely particulate, and lacking most roots. LFH does **not** include live vegetation on the surface.

Field Equipment Needed:

- Trowel
- Ruler (measured to the scale of mm)

Procedure:

1. The thickness of the organic layer is measured at each of the five sampling points within each 10x10 m square plot where penetration resistance is recorded.
2. Gently insert the trowel into the organic layer and distinguish the transition between the organic layer and the underlying mineral soil.
3. After distinguishing the transition from LFH to mineral horizon, measure the LFH to the nearest 0.1 cm.

D. Penetration Resistance (PR)

Field Equipment Needed:

- Digital penetrometer (Spectrum Technologies FieldScout SC 900 Soil Compaction Meter)

The digital penetrometer (Spectrum Technologies FieldScout SC 900 Soil Compaction Meter) can be used to measure soil resistance (Fig. 13). The digital penetrometer measures soil resistance in kPa through 2.5 cm depth increments and has a cone diameter of 1.28 cm. For each of the 10m x 10m square on site, we recommend doing penetration resistance measurement in five distinct measurement points, adjacent to the area where the bulk density sample is collected. Since penetration resistance is measured on site, we recommend taking at least three measurements for each discrete measurement point with the digital penetrometer.

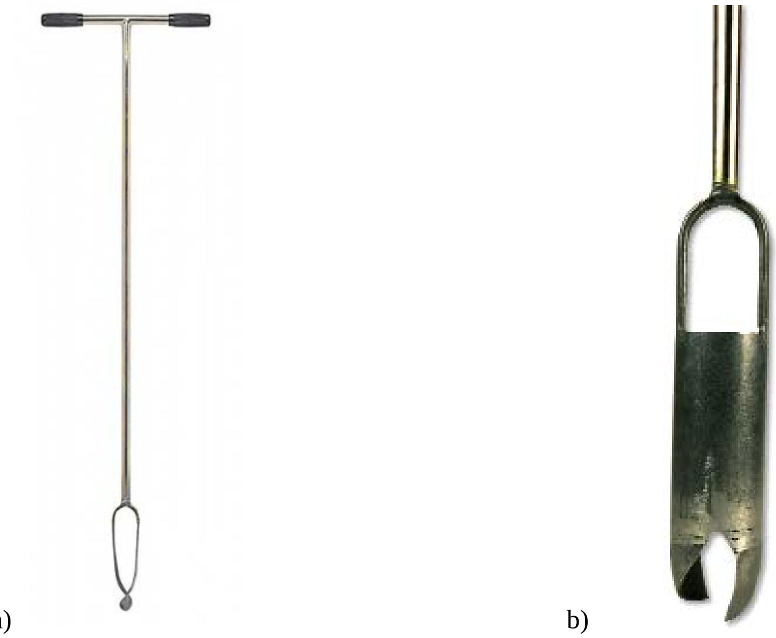
Fig. 13. Digital penetrometer (Spectrum Technologies FieldScout SC 900 Soil Compaction Meter).

E. Soil Organic Carbon, EC and pH

Soil organic carbon, EC and pH can be analyzed from the same composite sample. The section below describes the sampling protocol for collecting the core sample in the field as well as the sample handling, processing and compositing/bulking in the lab.

Equipment needed:

- Bucket auger (also known as barrel and core auger) shown in Fig. 14a for dry, coarse textured soil and Dutch auger shown in Fig. 14b for wet, finer textured soil.
- Heavy duty polyethylene bags
- Wire brush
- Soil knife
- Perforated drum grinder with 2 mm perforations
- GPS to measure soil sampling locations



a) b)

Fig.14. a) Dutch auger and b) Bucket auger

Procedure:

1. Before sampling, label bags with sample name, sampling date, location and soil depth.
2. In the field, at each sampling point, drill the auger tip into the ground by turning the handle in a clockwise rotation to the desired depth (0-15cm, 15-30 cm, 30-60 cm and 60-100 cm). The soil is forced into and retained in the auger. Be prepared to discard cores that are unrepresentative (e.g., excessively compacted during sampling, evidence of rodent activities and obstructed by rocks). Empty the soil into the labeled bag, avoid any loss of soil. Carefully place the auger in the same hole and repeat the process until the desired depth is reached. Store the sample in polyethylene bag in a large durable plastic bag for transport.
3. In the laboratory, remove soil from the polyethylene bags and air dry in lined trays at 37.5 °C. Avoid sample losses during processing and contamination by dust, plant material, and other C-rich contaminants.

4. Once the samples are air dry, crush and grind the samples to pass a 2 mm sieve and screen out any rocks that are > 2mm in diameter.
5. Thoroughly mix the 5 core samples after they have been coarsely ground to < 2mm and then subsample the soil for SOC, EC and pH analysis.

Soil sample handling and storage requirements are provided in Table 4.

Table 4. Soil sample handling and storage requirements for the selected soil indicators.

Indicator	Sample grinding	Moisture	Storage before analysis	Archival Storage Conditions
Soil Bulk Density	Avoided	Generally reported on an oven-dried basis	Indefinite if refrigerated, may change upon freezing	Indefinite if refrigerated, may change upon freezing
Soil EC & pH	Aggressive grinding acceptable to 2 mm	Generally reported on an oven-dried basis	Short term refrigerated, indefinite if dried	Indefinite if dried
Soil Organic Carbon	Aggressive grinding acceptable to 2 mm	Generally reported on an oven-dried basis	Short term refrigerated, indefinite if dried	Indefinite if dried

5. WOODY DEBRIS SAMPLING

In this chapter, sampling protocols for measuring woody debris are described. The protocols are only relevant for land types with woody debris, i.e., forested lands.

A. Downed Woody Debris (DWD) Sampling

Field Equipment Needed:

- *50 cm DBH calipers*
- *Go-No-Go Tool*
- *Mora Knife*
- *50-m Measuring Tape*

Procedure:

- DWD is measured on the four sub-ordinal (NE, SE, SW, NW) transects.
- Transects start 10 m from the wellsite center in each site quadrant and extend 25 m to the pigtail located at the middle of the 10x10 m square in each quadrant for the wellsite transects. For the reference sites, the plots run from the pigtail located 10 m from the edge of the wellsite out 25 m to the pigtail located in the middle of the 10x10 m square (see Figs. 15 and 16 for clarification).
- Dead wood must be on the forest floor or leaning >45° from vertical to be recorded as DWD, otherwise it is recorded as a snag.
- DWD is divided into Coarse Woody Debris (CWD; ≥7 cm), Small Woody Debris (SWD; 1-7 cm) and Fine Woody Debris (FWD; ≤1 cm). The "go-no-go" tool is used to determine which category each piece belongs to.
- Measure each piece of CWD >7.0 cm diameter (in 0.5 cm increments) where it intersects the transect along the entire 25 m of each DWD transect.
- For CWD (>7.0 cm diameter), record decay stage (Fig. 17), and diameter at point of intersection with the measuring tape. Measure diameter using DBH calipers in a plane perpendicular to the long-axis of the CWD.
- SWD is placed into 3 size classes (1.0-3.0, 3.1-5.0 and 5.1-7.0 cm). Tally the number of SWD 1.0-3.0 cm along the last 10 m (i.e., from the center of the wellsite 10x10 m plot to 10 m closer to the wellsite center) of each of the 4 DWD transects. SWD 3.1-5.0 cm and 5.1-7.0 cm are tallied along the entire 25 m transect. To be included as SWD, the piece must intersect the transect and be above the litter layer (i.e., <50% buried).
- Tally the number of pieces of FWD that intersect the transect above the litter layer, along the last 5 m (i.e., from the center of the wellsite 10x10 m plot to 10 m closer to the wellsite center) of each of the 4 DWD transects. Fine woody debris only includes twigs, stems, and branches and does not include cones, bark flakes, fragments of stems and branches < 10 cm long, or needles. These pieces of FWD often are short. Thus, it is necessary to have the tape measure within a few inches of the forest floor for the first 5 m to accurately determine whether or not the FWD piece crosses the transect.

When classifying the state of decay (1-5), careful attention should be given to all criteria listed (Table 5).

- Ensure that you look closely for logs with a decay class of 5, as some can be hidden by moss and litter covering the forest floor.
- Do your best to distinguish the edges of a class 5 log in order to obtain a diameter. If no clear log can be discerned, then it should be considered organic material and no longer woody debris.

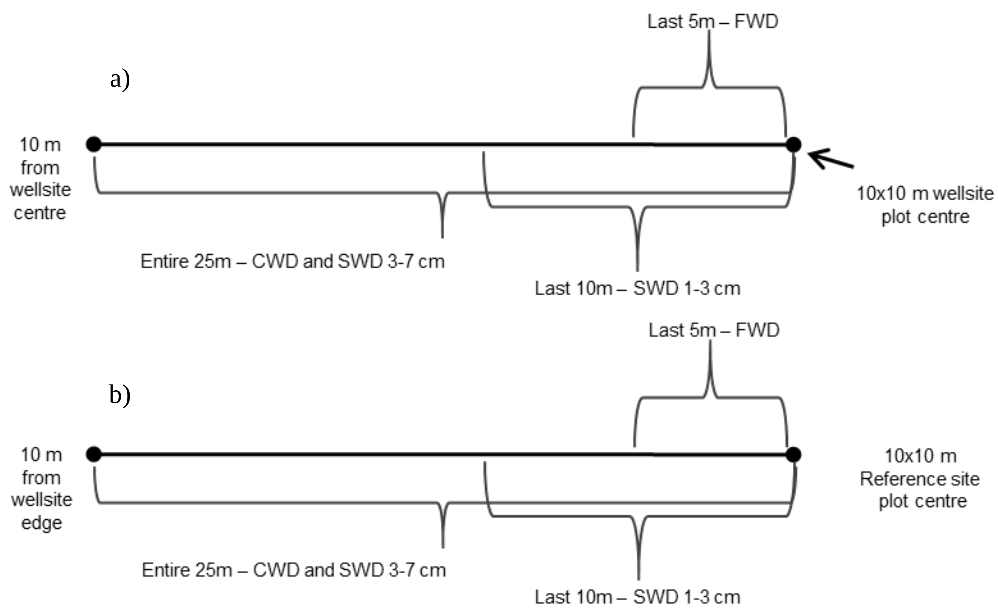


Fig. 15. Delineation of sampling of fine, small, and coarse woody debris along 25 m transects for a) wellsite transects and b) for reference site transects.

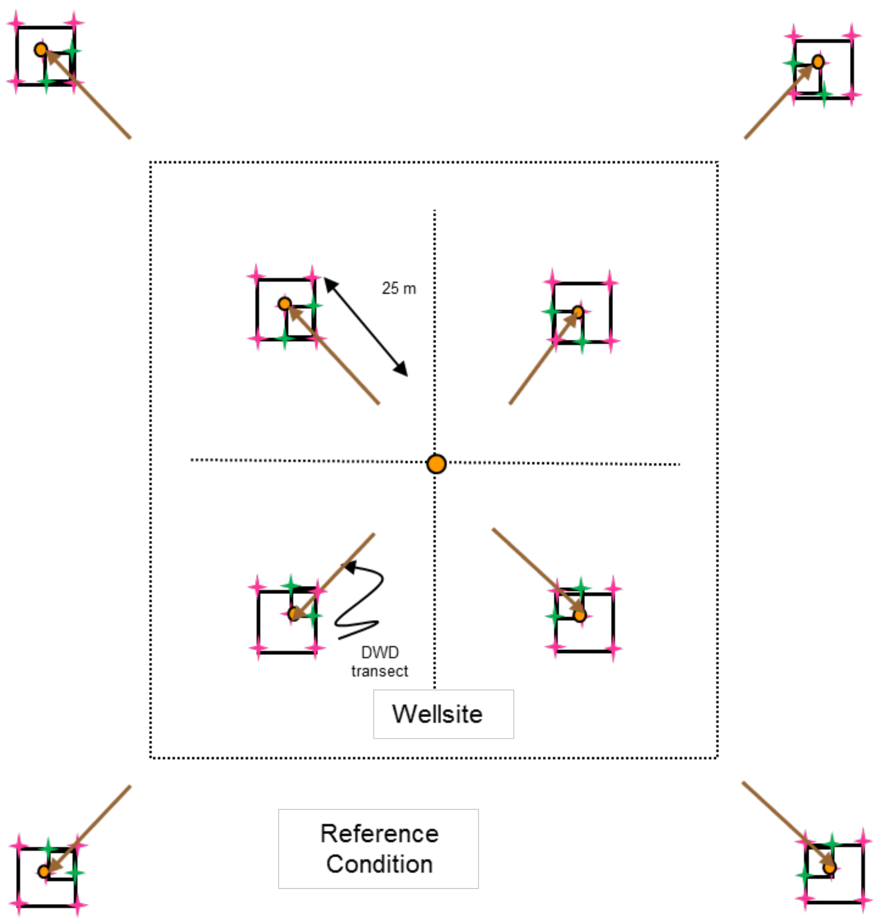


Fig. 16. Transect locations where DWD is sampled in the wellsite and reference sites – transects are highlighted in brown.

Table 5. Description of downed woody debris (DWD) decay classes.

DWD Class	Description
1	Recently Dead - Bark (normally) attached to the wood; little or no fungal mycelium developed under patches of loose bark. (*100-95 % of the initial dry density)*
2	Weakly Decayed - Loose bark (intact or partly missing); well developed fungal mycelium (normally) between bark and wood; rot extends <3 cm radially into the wood (as measured by pushing a knife into the wood). (*~ 95-75 % of the initial dry density)*
3	Moderately Decayed - Rot extends >3 cm into the wood (as measured by pushing a knife into the wood) but core still hard; log may be sagging or broken but still supported from forest floor by stones, humps, etc. *(~75-50 % of the initial dry density)*
4	Very Decayed - Rotten throughout (entire knife penetrates into wood); log shape conforms to forest floor; often elliptical in shape. *(~50-25 % of the initial dry density)*
5	Almost Decomposed - Log completely decomposed in sections; outline of log discernable but strongly fragmented and remaining parts often overgrown; wood disintegrates when lifted. *(25-5 % of the initial dry density)*

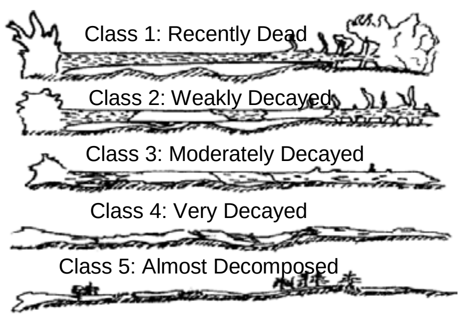


Fig. 17. Visual representation of decay stages for coarse woody debris

In some cases it may be difficult to determine what to measure. The following provides some details to help clarify sampling procedures:

1) Classified as Down Woody Debris:
   a. Twigs, stems, branches, and chunks of wood > 10 cm long with or without bark.
   b. DWD <u>above</u> the litter layer or soil; debris is considered no longer above when it is >50% buried beneath a layer of surface organic matter (forest floor) or mineral soil.
   c. Odd shaped pieces of wood; *estimate diameter at intersect as if it were round*
   d. Fallen or suspended (not self-supporting) dead tree boles and branches, with or without roots attached, that intersect the plane of the transect line and are leaning >45° from vertical. Stems and branches may be suspended on nearby live or dead trees, other coarse woody debris, stumps, or other terrain features
   e. Fallen trees/branches with green foliage that are no longer rooted in the ground (*decay stage 1)*
   f. Large fallen branches and broken tree tops that are horizontal or leaning and not connected to the tree bole
   g. Recently cut logs
   h. Uprooted (not self-supporting) stumps
   i. Exposed dead roots of snags/logs that have fallen and are crossing the transect
2) Things NOT classified as Down Woody Debris:
   a. Cones, bark flakes, needles, leaves and forbs.

b. Live or dead trees (still rooted) which are self-supporting and leaning <45° from the vertical
c. Dead branches still connected to standing trees
d. Exposed roots of self-supporting trees
e. Self-supporting stumps or their exposed roots
f. A piece is no longer considered debris when the wood is decomposed to the point where it could be described as forest floor humus (no discernible shape of log left).

3) **Accumulations** of large DWD (e.g., logging debris or slash piles): If a pile of CWD is encountered along the transect, and it is too time consuming to measure each piece individually, then a portion of the accumulation is measured and the total estimated from that partial measurement.
   a. For piles of DWD - If the pile is at an angle to the transect line, estimate perpendicular diameter at the point of intersect similar to what would be done for a log (note: do not measure pile width based on the intersect with the transect line). Estimate the horizontal perpendicular width of the pile, and the average vertical depth of the pile. Visually compress the pile to determine the actual cross sectional area of wood, not the space between the pieces. Based on length and width, estimate an approximate diameter of the accumulation as if it were round.
   b. Identify and record the most common species in the accumulation and the most common decay stage.
   c. Record an "A" under the accumulation column on the datasheet. Note that if no accumulations were present, VNA is recorded.
4) **Partial Tally** is used when many pieces of FWD and SWD cross the transect (e.g., wind throw and broken-off tree crowns containing many small branches). If a tree crown has fallen across the transect, a proportion of the branches/pieces are counted and the total number is estimated.
   a. Measure the entire horizontal length of the debris field crossing the line (i.e., debris field is 5m long).
   b. Choose a representative sub-sample (not just the first portion of transect) and tally the number of FWD and SWD pieces (i.e., 42 pieces of FWD and 25 pieces of SWD tallied within a 50 cm distance).
   c. To obtain an accurate estimate of DWD, the length of transect chosen for measurement must have at least 20 pieces for each type. Note that the length used for FWD may be different than the length used for SWD.
   d. Estimate the number of pieces in the total debris field (i.e., in the above scenario multiply by 10; 420 pieces FWD and 250 pieces of SWD).
   e. This is recorded in the partial tally section of the data sheet. Use VNA if you do not encounter a case which requires a partial tally.

6. ECOLOGICAL SITE CLASSIFICATION

This chapter describes the classification of the dominant vegetation community at sites. Ecological site types are named based on soil characteristics, soil nutrients, moisture status, and vegetation structural stage. It is likely most appropriate to complete identification of ecological site classification after you have completed the other protocols at the site and are more familiar with the plot characteristics.

A. Ecological Site Classifications

Field Equipment Needed:

- *ABMI Ecological Site Classification Chart* (provided in Appendix 2)

Procedure:
Ecosite categories in Table 6 are broadly based on vegetation communities described in ecosite field guides for Alberta (see Appendix 2 for details). Follow the list below to classify the site:

1. First, determine whether the area is upland or lowland.
2. Then determine the moisture/nutrient category based on the understory vegetation community that is present (if possible, depending on the age of the wellsite this may not be feasible).
3. After a moisture/nutrient category is assigned, determine the corresponding tree species modifier and structural stage (if trees are present).
4. The tree species modifiers listed in the table are the "most common" scenarios, and may not perfectly fit each scenario found in the field.
5. For wellsites, that have obviously been altered by human disturbance (e.g., well pad) it is important to determine ecosite type based on pre-disturbance conditions (historical). This will require looking at vegetation in adjacent areas to determine what "would have been present originally". This is recorded under Historical Ecosite type.
6. Add comments to your classification whenever the results appear odd.

Table 6. ABMI ecological site classification – upland and lowland vegetation communities.

Dominant Shrub/Herb/Ground Cover	**Nutr./ Moist. Code** [1]	**Tree Species Modifier**	**Tree Species Composition** [2] (In an area without human disturbance)	**Structural Stage** [3]
Upland Vegetation Communities				
Bearberry/Lichen Bog Cranberry common at some sites	1 - **PX**	1a **Pine**	Pj + Fd > 80%	<u>**A. Tree Dominated Ecosites**</u> *(Trees ≥10% cover)* – Add 4-letter code combining tree height, density, and arrangement. <u>Tree Height</u> **(TS) Short** – ≥50% of canopy cover <10 m tall. **(TT) Tall** – >50% of canopy cover ≥10 m tall. <u>Tree Density</u> **(D) Dense** – Trees ≥1.3 m tall are ≤2 m apart. **(S) Sparse** – Trees ≥1.3 m tall are >2 m apart. <u>Tree Arrangement</u> **(C) Complex (Spatially)** – Tallest trees ≥10 m apart, with smaller trees (~ ½ height) between that receive direct sunlight from above. **(N) Non-complex (Spatially)** – Tallest trees <10 m apart, with few or no smaller trees (~ ½ height) between, that receive direct light from above. <u>**B. Non-Tree Dominated Ecosites**</u> *(Trees <10% cover)* **Non-Vegetated** *(<10% Vegetation Cover)* – Add 2-letter code describing dominant substrate type. **(NR) –** Bedrock, cliff, talus, bolder **(NS) –** Sand bar in river/stream (cobble, gravel, sand) **(NB)** – Beach at edge of a lake or wetland **(NM) –** Mineral soil any other reason **(NO) –** Organic soil any other reason **Note:** If standing water is present, refer to Open Water Communities **Only Ground Vegetation Present** *(Shrubs <10%; Trees <10%; Other Vasc. >10%)* – Add 3-letter code combining dominant vegetation type and density <u>Vegetation Type</u> **(GB) Bryoid/Lichen** – Bryophyte and lichen **(GF) Forb** – Non-graminoid herbs and ferns
Labrador Tea / Feather Moss Bog Cranberry, Bilberry, Grouse-berry common at some sites	2 - **PM**	2a **Pine**	Pj + Pl > 50%	
		2b **Other**	Aw + Sw + Se +Fa +Pw > 50%	
		2c **Sb**	Sb > 50%	
Hairy Wild Rye Bearberry, Canada Buffalo-berry, Feather Moss common at some sites	3 - **MX**	3a **None**	No Trees	
		3b **Pine**	Pj + Pl > 50%	
		3c **AwMix**	Aw > 20%	
		3d **Spruce**	Sw + Se + Fa >50%	
Low-bush Cranberry / Canada Buffalo-berry Blueberry, Rose, Alder, Labrador Tea, Bearberry, Thimbleberry, Bog Cranberry, Feather Moss common at some sites	4 -**MM**	4a **Pine**	Pj + Pl + Fa >50%	
		4b **PjMix**	Aw + Bp + Sw >20%, AND Pj >20%	
		4c **Aw**	Aw > 50%	
		4d **AwMix**	Aw >20% AND Sw + Sb + Pl > 20%	
		4e **Spruce**	Sw > 50%	
Horsetail Dogwood, Rose, Willow, Feather Moss common at some sites	5 - **MG**	5a **Poplar**	Pb + Aw > 50%	
		5b **Spruce**	Sw + Se > 50%	
		5c **Sb**	Sb > 50%	
Dogwood / Fern / Feather Moss Rose, Alder, Bracted Honeysuckle, Devil's Club Fir common at some sites	6 - **RG**	6a **Pine**	Pl > 50%	
		6b **Poplar**	Pb + Aw > 50%	
		6c **Spruce**	Sw + Se + Fa > 50%	

<table>
<tr><td rowspan="6">**Not Treed**</td><td rowspan="6">7 - **NT**</td><td>7a **Alpine**</td><td>Elevation above tree line</td><td rowspan="7">**(GG) Graminoid** – grasses, sedges
(GR) Marsh – reeds, and rushes
Vegetation Density
(D) Dense – Cover >75%
(M) Moderate – Cover 25-75%
(S) Sparse – Cover <25%

Shrubs Present
(Shrubs >10%; Trees <10%) – Add 3 letter code combining shrub height and density.
Shrub Height
(SL) Low – Shrubby vegetation <2 m tall
(ST) Tall – Shrubby vegetation >2 m tall
Shrub Density
(D) Dense – Shrubs cover >75%
(M) Moderate – Shrubs cover 25-75%
(S) Sparse – Shrubs cover <25%</td></tr>
<tr><td>7b **Flood**</td><td>Site disturbed frequently by flooding</td></tr>
<tr><td>7c **Ice**</td><td>Site disturbed frequently by ice or snow</td></tr>
<tr><td>**7d Dry**</td><td>Site in prairies/parkland and receives little precipitation</td></tr>
<tr><td>7e **Geo**</td><td>Geological features not suitable for tree growth</td></tr>
<tr><td>7f **Human**[4]</td><td>Site disturbed recently by humans</td></tr>
<tr><td colspan="4">Aw - trembling aspen, Sw - white spruce, Fd – Douglas-fir,
Pb - balsam poplar, Sb - black spruce, Fb - balsam fir, and
Bp - paper birch, Se - Engelmann spruce, Lt – larch
Pl - lodgepole pine, Fa - subalpine fir, Pj - jack pine,</td></tr>
<tr><td>**Dominant Shrub/Herb/Ground Cover**</td><td>**Nutr./ Moist. Code** [1]</td><td>**Tree Species Modifier**</td><td>**Tree Species Composition** [2]
(In an area without human disturbance)</td><td>**Structural Stage** [3]</td></tr>
<tr><td colspan="4">**Lowland/Wetland Vegetation Communities**</td><td></td></tr>
<tr><td rowspan="2">**Bog - Labrador Tea / Peat Moss / Lichen**
Bog cranberry and cloudberry may also be present
(Soil saturated for part or all the year)</td><td rowspan="2">**8 - PD**</td><td>**8a SbLt**</td><td>≥10% tree cover (may only be in shrub/ground strata)
Sb + Lt > 50%</td><td rowspan="4">**C. Open Water Dominated Communities**
(Emergent Vegetation <10%) – Add 4-letter code combining dominant vegetation type, height and density
Vegetation Type
(OV) Vegetated – Floating or submerged plants ≥ 10% cover
(ON) Non-Vegetated – Floating or submerged plants < 10% cover (note that only a 2-letter code is used for this category → vegetation height and density are not added to the code)
Vegetation Height
(S) Short Submerged – ≥50% of vegetation extending 0.0 – <0.3 m above the substrate</td></tr>
<tr><td>**8b Shrub**</td><td><10% tree cover</td></tr>
<tr><td rowspan="2">**Poor Fen - Labrador Tea / Peat Moss / Sedge**
Bog cranberry, dwarf birch and river alder may also be present
(Soil saturated for part or all the year)</td><td rowspan="2">**9 - MD**</td><td>**9a SbLt**</td><td>≥10% tree cover (may only be in shrub/ground strata)
Sb + Lt > 50%</td></tr>
<tr><td>**9b Shrub**</td><td><10% tree cover</td></tr>
</table>

Rich Fen - Dwarf Birch / Willow / Sedge / Grass / Moss (Soil saturated for part or all the year; includes floating mats of vegetation)	**10-RD**	**10a SbLt**	≥10% tree cover (may only be in shrub/ground strata) Sb + Lt ≥ 50%	**(M) Medium Submerged** – ≥50% of vegetation extending 0.3 – 1.3 m above the substrate **(T) Tall Submerged** – ≥50% of vegetation extending >1.3 m above the substrate **(F) Floating** – ≥50% of vegetation with floating leaves on the water surface. Vegetation Density **(D) Dense** – Aquatic vegetation covering >75% of the substrate. **(M) Moderate** – Aquatic vegetation covering 25-75% of the substrate. **(S) Sparse** – Aquatic vegetation covering <25% of the substrate.
		10b Shrub	<10% tree cover AND ≥10% shrub cover	
		10c None	<10% tree cover AND <10% shrub cover	
Marsh – Cattail / Rush /Reed Conductivity < 15 mS/cm, sedge and grass may also be present (Water is above the rooting zone for most or all of the year)	**11-VD**	**11a None**	usually along a water body edge ≥10% emergent vegetation cover <10% tree cover	
Swamp Conductivity < 15 mS/cm, trees and shrubs present, (Water is above the rooting zone for some of the year)	12-**SD**	12a **Tree**	>10% tree cover	
		12b **Shrub**	<10% tree cover	
Alkali Conductivity > 15 mS/cm, white salt flats at water's edge, saltwater widgeon grass dominates (Water is above the rooting zone for most or all of the year)	13-**AD**	13a **None**	<10% shrub/tree cover	
Open Water	**14-OW**	**14a Lake**	In standing water <10% emergent vegetation cover	
		14b River	In flowing water <10% emergent vegetation cover	

Classifications are based on Dominant Shrub/Herb/Ground Cover before determining the Tree Species Modifier and Structural Stage. Tree species compositions in the tables are the "simplified categories" for the ABMI - these may not fit perfectly with what is seen at the site (see Appendix 2 for details).

1. Note that moisture nutrient category names are approximate and the category often also includes adjacent nutrient and moisture categories (Nutrient Status: P=Poor, M=Medium, R=Rich, V=Very Rich; Moisture Status: X=Xeric, M=Mesic, G=Hygric, D=Hydric, OW=Open Water. NT, SD, AD are exceptions)
2. Tree species composition is determined from both the dominant/co-dominant (canopy) and intermediate/suppressed (sub-canopy) trees, giving more weight to the dominant and co-dominant trees.
3. Determine the structural stage by first determining if the site is tree-dominated, non-tree dominated, or open-water dominated after ecological-site type is determined. Then choose the appropriate code combination paying careful attention to the descriptors.
4. Use category 7f (NT-Human) only when other ecosite classifications are not appropriate. Note that NT-Human CANNOT be used for historic conditions.
5. Record Ecological Site Classifications by separating each code part by slashes: Nutrient & moisture code /Tree species modifier/structural stage (e.g., RG/PbMix/TSDN; PD/SbLt/SLD; MM/None/GFD; OW/Lake/ONSS)

7. MANAGING PERSONNEL, DATA QUALITY AND INTEGRITY

This chapter provides background information related to the number of individuals needed to collect the data, the training field staff should receive prior to data collection, how datasheets should be completed in the field, including some metadata for the coding of data, ensuring data quality and completeness, procedures for storage and transfer of field-collected samples, and entry of data after it has been collected.

A. Personnel and Sampling

These data collection protocols are optimally designed to be implemented by a field crew of 2 personnel working together or, at times, semi-autonomously. At least one of the field crew members needs to have a strong background in identifying vascular plants and one should be familiar with reclamation and reclamation practices and regulations. The sampling should take place during the spring or summer when plants have leafed out and so estimates of plant cover will be representative of the maximum cover that will occur on a site and will make for more relevant comparisons among data from multiple sites sampled.

These protocols are designed to collect data on a variety of parameters, many of which require expert interpretation. As a result, these protocols include species-level identification of vascular plants in the field setting, and for other species, specimens are collected in the field and later identified by qualified personnel in a laboratory setting. Vascular plant searches are performed by a crew member that is capable of identifying all common species and >80% of all species encountered. This crew member must have at least one year experience surveying vascular plants and/or courses learning plant identification prior to conducting surveys. In addition, the crew member is required to spend a minimum of two days in the field brushing up on vascular plant identification prior to conducting the monitoring surveys. Due to the excessive time requirements for collecting and pressing vascular plant specimens, surveys for vascular plants must be conducted by field staff that are capable of identifying all common vascular plant species.

B. Crew Training Prior to Data Collection

All field staff are to receive proper and appropriate training so they can operate vehicles and equipment safely. In addition, staff are to receive extensive training (in the classroom and field) prior to the beginning of the field data collection. This protocol training includes learning what to do in the variety of field conditions that will be encountered, as well as conducting data collection at test sites. Crew members are first required to become familiar with the protocol documents, field manuals and general field procedures. Then they practice the data collection in the types of habitats where they will be sampling. Questions that arise during the training are discussed with the field supervisors. When possible, this training is provided by experts in the field (i.e. vascular plant identification, lichen and bryophyte identification, soil sampling and descriptions).

To ensure that data collection remains accurate throughout the field season and nothing is being missed, field crews are to review the protocols regularly.

C. Completing Data Sheets in the Field

Crews are responsible for filling information into the data sheets while conducting field protocols (in the future data may be collected using tablets in place of field datasheets, but for now datasheets (rite in the rain) are used). Data sheets must reflect exactly what was found / measured at the site. If options for the data field do not include an appropriate response, crews are instructed to record the most appropriate descriptors and make extensive notes on the data sheets. Technicians do not create new categories or descriptors. All fields on the data sheet must have information recorded – even if it is a “zero”, “not applicable", "did not collect" (see below for description of each). If data could not be collected for a specific element, then this must be noted on the data sheet and the crew supervisor advised as soon as possible (note that supervisors must be notified by the end of the day at the latest).

None or 0 – None or "0" is applied to any variable that ***was examined*** by field crews and found to be absent. "None" is used for text entries and "0" is used for numerical entries. For example, when field crews examine the canopy and find no "Veteran" trees in the canopy, this is to be recorded as "None". When there is no slope at the site, this should be recorded as "0". "0" can also be used as a code – for example, wind conditions can be recorded as "0".

Variable Not Applicable (VNA) – Some data are collected in a nested manner. For example, for the variable "Tree Species" a variety of nested conditions could be describing the variable (i.e., Condition, diameter breast height (DBH), Decay Stage, etc.). When a variable is recorded as "None", nested conditions do not apply and are recorded as "VNA". VNA is also used when the protocol calls for a modified sampling procedure based on site conditions (e.g., surface substrate protocol variant for hydric site conditions), or the data cannot be collected due to the site being in open water. The use of VNA indicates that the cell cannot have data present.

Did Not Collect (DNC) – Use "DNC" to describe variables that should have been collected but were not due to crew oversight, equipment failure, safety concerns, environmental conditions, or time constraints. The use of DNC highlights that the cell ordinarily would have contained data.

D. Checking Field Data and Storing Data Sheets Daily

Data sheets must be checked every evening for legibility and completeness. If data on a sheet cannot be corrected so they are legible, the data must be transcribed onto a new data sheet and both copies filed. Wet data sheets are allowed to dry, and then all data sheets are stored in a secured area if possible while in the field (e.g., in a folder in the trailer). Data sheets from one site cannot be taken to the field at another site. Crews must re-collect lost or missing data.

E. Transferring Field Data Sheets to a Secure Location

Data sheets are transferred in person to the crew supervisor when the supervisor visits, or at the end of a shift. The completeness (i.e. all data sheets present and all data fields filled in) of the data sheets is confirmed during the transfer. Missing fields or data sheets must be re-collected. Field supervisors take the data sheets to a secure office at the end of the shift, or sooner if possible. Data for each site are stored in a separate folder, with the folders organized by site number. Original data sheets are not allowed to leave the secure office.

F. Shipping Specimens and Samples

Specimens and samples are shipped by bus or courier from the field camps to the Royal Alberta Museum or commercial analytical labs, as appropriate. The timing required for this shipping, and the packaging required for each type of specimen and sample, are described in relevant protocols sections. All specimens and samples that are shipped must be accompanied by appropriate chain of custody form, a document containing a description of the items (type of sample, number of boxes/bags with specimens/samples, list of the sites where the samples were collected, number of samples and name(s) of person(s) that sent the samples).

G. Data Entry and Verification

Data are entered into an electronic database. If data are entered at a different location than they are stored the data sheets are photocopied or scanned and data entry occurs from the copies. Data entry is verified by comparing the electronic information against the information on the original data sheet. Electronic verification routines are performed on the database to ensure that data are consistent with the allowable codes and among sites.

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APPENDICES

Appendix 1: Example of an Access Data Sheet

Ecological Recovery Monitoring Program **Reclamation SITE: R24**

Access Description

Date:__May 14, 2013__________________ Crew:___JB/KB___________________

Maps Where Access Is Recorded

1:24,000 Map ______________________

1:62,500 Map ___X___________________

Direction & Distance to Nearest Town

_____Approx. 50KM_NE of Slave Lake_

Camp Location: Slave Lake (ATCO)___

Time From Camp to Site: 1 hour 15Mins

Location Of Site

		Township	**77**
Latitude[1]	**55.63xxx**	Range	**3**
Longitude[1]	**114.37xxx**	Section	**3**
		Meridian	**5**

1 – record decimal degrees (5 decimals)

Site Description Comments:

Site is wet in the NE quadrant, crews will need rubber boots.

Truck Access to Site

GPS Label at Start Point with Latitude & Longitude	Road Name & Type	Direction and Dist. to Site Center or Next Waypoint
(Slave Atco) 55.78xxx/114.09xxx	Hwy 88 north - Paved	20 KM North (N) to marthillrd
(marthillrd) 55.79xxx/114.09xxx	Martin Hills RD – Good Gravel	42.3 KM East (E) to T721-2
(T721-2) 55.50xxx/114.16xxx	Meridian Tower RD – Good Gravel	16.4 KM Northwest (NW) to T721-3
(T721-3) 55.61xxx/114.30xxx	Unnamed – Gravel Road	1.6 KM North (N) to T721-4
(T721-4) 55.62xxx/114.30xxx	Unnamed – Gravel Road	4.1 KM West (W) to Q721-1 (Wellsite)

ATV Access to Site

GPS Label at Start Point with Latitude & Longitude	Trail Description	Direction and Dist. to Site Center or Next Waypoint
(Q721-1) 55.62xxx/114.37xxx	Cutline (Good Shape)	1.6 KM North (N) to W721-1

Walking Access to Site Center

GPS Label at Start Point with Latitude & Longitude	Trail Description	Direction and Dist. to Site Center or Next Waypoint
(W721-1) 55.63xxx/114.37xxx	Through Cutblock	200 M at 286 degrees to site center

Appendix 2: Ecological Site Classification Descriptions

Simplification of Upland Forest Ecosite Types To Be Used In The Ecological Recovery Monitoring. We have simplified the ecosite types from the "Field Guide to Ecosites of Northern Alberta" by Beckingham and Archibald (1996), "Field Guide to Ecosites of West-Central Alberta" by Beckingham *et al.* (1996), "Field Guide to Ecosites of Southwestern Alberta" by Archibald *et al.* (1996), "Range Plant Community Types and Carrying Capacity for the Upper Foothills Subregion of Alberta" by Willoughby (2005), "Range Plant Community Types for the Subalpine and Alpine Subregions" by Willoughby and Alexander (2006), "Range Plant Community Types and Carrying Capacity for the Montane Subregion of Alberta" by Willoughby *et al.* (2005), "Range Plant Community Types and Carrying Capacity for the Lower Foothills Region of Alberta" by Lawrence *et al.* (2005), "Guide to Range Plant Community Types and Carrying Capacity for the Dry and Central Mixedwood Subregions in Alberta" by Willoughby *et al.* (2006), and Range Plant Communities and Range Health Assessment Guidelines for the Foothills Fescue Natural Subregion of Alberta" by Adams *et al.* (2005).

Twelve broad categories of vegetation types were created from the above sources – these were labeled based on the common moisture/nutrient level. The categories were then subdivided based on composition of overstory trees. Note that the classifications of ecosites are based on vegetation communities and not soil information. The first letter in the moisture code indicates nutrient status (P=Poor, M=Medium, R=Rich, V=Very Rich), and the second letter indicates moisture conditions (X=Xeric, M=Mesic, G=Hygric, D=Hydric, OW=Open Water). Acronyms noted under the ecosite categories follow the literature that was summarized with the following additions: BM=Boreal Mixedwood, BH=Boreal Highlands, SB=Subarctic, CS=Canadian Shield, WC=Ecosites described for West-Central Alberta, SW= Ecosites described for Southwestern Alberta, LF=Lower Foothills, UF=Upper Foothills, MN=Montane, and SA=Subalpine.

Upland Vegetation Communities and Corresponding Ecosite Types

1. Bearberry/Lichen --- PX

The shrub/ground strata are usually dominated by bearberry and lichen, although bog cranberry and juniper sometimes are common at high elevations. This community is expected when soils are nutrient poor, and a moisture regime of xeric to subxeric.

1a) Pine –The shrub/ground strata is usually dominated by bearberry and lichen, although bog cranberry is common at some sites. The overstory is dominated by pine.
Ecosites Included:

- BM a1 (lichen Pj)
- BH a1 (bearberry Pj)
- SB a1 (bearberry Pl)
- SB a2 (bearberry PlAw)
- SB a3 (bearberry Aw)
- CS a1 (bearberry Pj)
- WC_LF b1 (bearberry/lichen Pl)
- SW_LF a1 (bearberry Pl)
- WC_UF b1 (bearberry lichen Pl)
- SW_UF a1 (bearberry Pl)
- SW_MN a1 (limber pine/juniper FdPf)
- SW_MN b1 (bearberry Pl)
- WC_SA b1 (bearberry/lichen Pl)

- SW_SA a1 (lichen Pl)

2. Labrador Tea/Feather Moss --- PM

The shrub/ground strata is usually dominated by Labrador tea and feather moss, although bog cranberry is common at some sites, and at upper elevations in the mountains bilberry and grouse-berry are common at some sites. This community is expected when soils are nutrient poor to medium, and moisture regime is submesic to hygric.

2a) Pine – The shrub/ground strata is usually dominated by Labrador tea and feather moss, although bog cranberry, and blueberry, are common at some sites, and at upper elevations in the mountains bilberry and grouse-berry are common at some sites. The overstory is dominated by pine.

Ecosites Included:

- BM c1 (Labrador tea – mesic PjSb)
- BH c1 (Labrador tea – mesic PjSb)
- SB c1 (Labrador tea – mesic PlSb)
- CS c1 (Labrador tea – mesic PjSb)
- WC_LF d1 (Labrador tea-mesic PlSb)
- SW_LF c1 (Labrador tea-mesic Pl)
- SW_LF f1 (Labrador tea-hygric Pl)
- WC_UF d1 (Labrador tea-mesic PlSb)
- WC_UF e1 (tall bilberry/arnica Pl)
- SW_UF c1 (tall bilberry/Labrador tea Pl)
- WC_SA d1 (rhododendron-mesic Pl)
- WC_SA f1 (rhododendron-subhygric Pl)
- SW_SA e1 (false azalea-grouseberry Pl)

2b) Other – The shrub/ground strata is usually dominated by Labrador tea and feather moss, although bog cranberry is common at some sites, and at upper elevations in the mountains bilberry, heather, and grouse-berry are common at some sites. The overstory is dominated by a variety of species including spruce, fir, and trembling aspen.

Ecosites Included:

- SW_LF c2 (Labrador tea-mesic AwSwPl)
- WC_UF e2 (tall bilberry/arnica AwSwPl)
- WC_UF e3 (tall bilberry/arnica Sw)
- WC_UF e4 (tall bilberry/arnica Fa)
- SW_UF c2 (tall bilberry/Labrador tea Sw)
- SW_UF c3 (tall bilberry/Labrador tea Fa)
- WC_SA d2 (rhododendron-mesic Se)
- WC_SA d3 (rhododendron-mesic Fa)
- WC_SA f2 (rhododendron-subhygric SeFa)
- SW_SA c1 (subalpine larch/heather LaFa)
- SW_SA d1 (spruce/heather Se)
- SW_SA e2 (false azalea-grouse-berry Pw)
- SW_SA e3 (false azalea-grouse-berry-Se)
- SW_SA e4 (false azalea-grouse-berry Fa)

2c) Sb – The shrub/ground strata is dominated by Labrador tea and feather moss, although bog cranberry is sometimes common. The overstory is dominated by black spruce.

Ecosites Included:

- BM g1 (Labrador tea – subhygric SbPj)
- BH g1 (Labrador tea – subhygric SbPj)
- SB e1 (Labrador tea – hygric SbPl)
- CS d1 (Labrador tea – subhygric SbPj)
- WC_LF h1 (Labrador tea subhygric SbPl)
- WC_UF h1 (Labrador tea subhygric SbPl)
- SW_UF c4 (tall bilberry/Labrador tea PlSb)
- SW_UF f1 (black spruce/Labrador tea SbPl)

3. Hairy Wild Rye --- MX

The shrub/ground stratum is usually dominated by hairy wild rye, although bearberry is sometimes common. This community is expected when soils have medium nutrient levels, and a moisture regime of subxeric to mesic. These soil conditions are mainly found on south facing slopes in mountains.

3a) None – The shrub/ground strata is usually dominated by hairy wild rye, other grasses and bearberry. No trees are present.

Ecosites included:

- WC_LF a1 (Shrubby grassland)
- WC_UF a1 (Shrubby grassland)
- WC_MN a1 (shrubby grassland)
- WC_MN a2 (graminoid grassland)
- WC_SA a1 (shrubby grassland)
- WC_SA a2 (graminoid grassland)

3b) Pine – The shrub/ground strata is usually dominated by hairy wild rye, although Canada buffalo-berry, bearberry, green alder and feather moss are common at some sites. The overstory is usually dominated by lodgepole pine or Douglas-fir.

Ecosites included:

- WC_LF c1 (hairy wild rye Pl)
- SW_LF b1 (bearberry/hairy wild rye Pl)
- WC_UF c1 (hairy wild rye Pl)
- SW_UF b1 (bearberry/hairy wild rye Pl)
- WC_MN b1 (bearberry Fd)
- WC_MN b2 (bearberry Pl)
- WC_MN c1 (hairy wild rye Fd)
- WC_MN c2 (hairy wild rye Pl)
- SW_MN c1 (Canada buffalo-berry/hairy wild rye Fd)
- SW_MN c2 (Canada buffalo-berry/hairy wild rye Pl)
- WC_SA c1 (hairy wild rye Pl)
- SW_SA b1 (bearberry/hairy wild rye Pl)

3c) AwMix – The shrub/ground strata is usually dominated by hairy wild rye, although Canada buffalo-berry and bearberry are common at some sites. The overstory is dominated by trembling aspen, with lesser amounts of lodgepole pine and white spruce.

Ecosites included:

- WC_LF c2 (hairy wild rye Aw)
- WC_LF c3 (hairy wild rye AwSwPl)

- SW_LF b2 (bearberry/hairy wild rye Aw)
- SW_LF b3 (bearberry/hairy wild rye AwSwPl)
- WC_UF c2 (hairy wild rye Aw)
- WC_UF c3 (hairy wild rye AwSwPl)
- SW_UF b2 (bearberry/hairy wild rye Aw)
- SW_UF b3 (bearberry/hairy wild rye AwSwPl)
- WC_MN b3 (bearberry Aw)
- WC_MN b4 (bearberry AwSwPl)
- WC_MN c3 (hairy wild rye Aw)
- WC_MN c4 (hairy wild rye AwSwPl)
- WC_MN b2 (bearberry Aw)
- WC_MN b3 (bearberry AwSwPl)
- SW_MN c3 (Canada buffalo-berry/hairy wild rye Aw)
- SW_MN c4 (Canada buffalo-berry/hairy wild rye AwSwPlFd)
- WC_SA c2 (hairy wild rye PlAw)

3d) Spruce – The shrub/ground strata is usually dominated by hairy wild rye, although Canada buffalo-berry, bearberry and feather moss are common at some sites. The overstory is dominated by spruce.
Ecosites included:

- WC_LF c4 (hairy wild rye Sw)
- WC_UF c4 (hairy wild rye Sw)
- SW_UF b4 (bearberry/hairy wild rye Sw)
- WC_MN b5 (bearberry Sw)
- WC_MN c5 (hairy wild rye Sw)
- WC_MN_SA c3 (hairy wild rye Se)

4. Low-bush Cranberry/Canada Buffalo-berry --- MM

The shrub/ground strata is often dominated by low-bush cranberry and Canada buffalo-berry, although the vegetation community is variable and blueberry, alder, rose, Saskatoon, Labrador tea, bearberry, thimbleberry, bog cranberry, willow, fir, and feather moss may be common. This community is expected when soils have medium to rich nutrient levels, and a moisture regime of submesic to mesic.

4a) PineMix – The shrub/ground strata is often dominated by low-bush cranberry and Canada buffalo-berry, although bog cranberry, green alder, feather moss, and a variety of other shrubs are common at some sites. The overstory is dominated by pine with lesser amounts of trembling aspen, balsam popular, paper birch, and spruce.
Ecosites Included:

- BM b1 (blueberry PjAw)
- BH b1 (blueberry PjAw(Bp))
- SB b1 (Canada buffalo-berry PlAw)
- CS b1 (Canada buffalo-berry green alder PjAwBw)
- WC_LF e1 (low-bush cranberry Pl)
- SW_LF d1 (low-bush cranberry/wild sarsaparilla Pl)
- SW_MN d1 (creeping mahonia-white meadowsweet Fd)
- SW_MN d2 (creeping mahonia-white meadowsweet Pl)
- SW_MN e1 (thimbleberry/pine grass Pl)

4b) Aw – The shrub/ground strata is often dominated by low-bush cranberry and Canada buffalo-berry, although alder, rose, bog cranberry, and a variety of other shrubs are common at some sites. The overstory is dominated by trembling aspen.
Ecosites Included:

- BM b2 (blueberry Aw(Bp))
- BM d1 (low-bush cranberry Aw)
- BH b2 (blueberry Aw)
- BH d1 (low-bush cranberry Aw)
- SB b1 (Canada buffalo-berry Aw)
- CS b2 (Canada buffalo-berry green alder Aw)
- WC_LF e2 (low-bush cranberry Aw)
- SW_LF d2 (low-bush cranberry/wild sarsaparilla Aw)
- SW_MN e2 (thimbleberry/pinegrass Aw)

4c) AwMix – The shrub/ground strata is often dominated by low-bush cranberry and Canada buffalo-berry, although alder, rose, feather moss, and a variety of other shrubs are common at some sites. The overstory is dominated by trembling aspen and a mix of spruce and pine.
Ecosites Included:

- BM b3 (blueberry AwSw)
- BM d2 (low-bush cranberry AwSw)
- BH d2 (low-bush cranberry AwSwSb)
- SB b1 (Canada buffalo-berry AwSwSb)
- CS b3 (Canada buffalo-berry green alder AwSwSb)
- WC_LF e3 (low-bush cranberry AwSwPl)
- SW_LF d3 (low-bush cranberry/wild sarsaparilla AwSwPl)

4d) Sw – The shrub/ground strata is sometimes dominated by low-bush cranberry and Canada buffalo-berry, although rose, fir, feather moss, and a variety of other shrubs are common at some sites. The overstory is usually dominated by spruce.
Ecosites Included:

- BM b4 (blueberry SwPj)
- BM d3 (low-bush cranberry Sw)
- BH b3 (blueberry SwPj)
- BH d3 (low-bush cranberry Sw)
- SB b1 (Canada buffaloberry Sw)
- WC_LF e4 (low-bush Cranberry Sw)
- SW_LF d4 (low-bush cranberry/wild sarsaparilla Sw)
- SW_UF d1 (silver-berry Sw)
- SW_MN e3 (thimbleberry/pinegrass Sw)

5. Horsetail --- MG

The shrub/ground strata contains horsetail, although dogwood, alder, rose, low-bush cranberry, Labrador tea, willow, and feather moss may be common at some sites. This community is expected when soils have medium to rich nutrient levels, and a hygric moisture regime.

5a) PbMix – The shrub/ground strata contains abundant horsetail, although alder, rose, low-bush cranberry, willow, and feather moss may be common at some sites. The overstory is

dominated by balsam popular and a mix of trembling aspen, paper birch, and white spruce.
Ecosites Included:

- BM f1 (horsetail PbAw)
- BM f2 (horsetail PbSw)
- SB d1 (horsetail PbBw)
- SB d2 (horsetail AwSw)
- CS e1 (willow/horsetail AwBpPb)
- WC_LF i1 (horsetail PbAw)
- WC_LF i2 (horsetail PbSw)
- WC_MN f1 (horsetail PbAw)

5b) Spruce – The shrub/ground strata contains abundant horsetail and feather moss, although Labrador tea and willow may be common at some sites. The overstory is dominated by white or Engelmann spruce.
Ecosites Included:

- BM f3 (horsetail Sw)
- BH f1 (horsetail Sw)
- SB d3 (horsetail Sw)
- CS e2 (willow/horsetail AwSwSb)
- WC_LFi3 (horsetail Sw)
- SW_LF h1 (white spruce/horsetail Sw)
- WC_UF j1 (horsetail Sw)
- SW_UF h1 (white spruce/horsetail Sw)
- WC_MN f2 (horsetail Sw)
- SW_MN g1 (horsetail SwPb)
- SW_MN g2 (horsetail Sw)
- WC_SA g1 (horsetail Se)
- SW_SA h1 (horsetail Se)

5c) Sb – The shrub/ground strata is dominated by Labrador tea and feather moss with horsetail present in lesser amounts. The overstory is usually dominated by black spruce.

- BM h1 (Labrador tea/horsetail SwSb)
- WC_LF j1 (Labrador tea/horsetail SbSw)
- SW_LF g1 (black spruce/ horsetail SwSb)
- SW_LF g2 (black spruce/horsetail Sb)
- WC_UF i1 (Labrador tea/horsetail SbSw)
- SW_UF g1 (black spruce/horsetail SbSw)

6. Dogwood/Fern/Feather Moss --- RG

The shrub/ground stratum usually contains dogwood, fern, and abundant feather moss, although rose, alder, bracted honeysuckle, devil's club, and fir are common at some sites. This community is expected when soils have rich nutrient levels, and a subhygric moisture regime.

6a) Pl – The shrub/ground strata usually contains dogwood, fern, and abundant feather moss, although bracted honeysuckle, alder, devil's club, and fir are sometimes common. The overstory is usually dominated by lodgepole pine.
Ecosites Included:

- WC_LF f1 (bracted honeysuckle Pl)

- SW_LF e1 (bracted honeysuckle fern Pl)
- WC_UF f1 (bracted honeysuckle Pl)
- SW_UF e1 (green alder/fern Pl)
- SW_SA f1 (thimbleberry Pl)

6b) PbMix – The shrub/ground strata usually contains dogwood, fern, and abundant feather moss, although rose, alder, bracted honeysuckle and devil's club are common at some sites. The overstory is dominated by deciduous trees (usually balsam popular, but sometimes trembling aspen and paper birch) although spruce and pine may be common.
Ecosites Included:

- BM e1 (dogwood PbAw)
- BM e2 (dogwood PbSw)
- WC_LF f2 (bracted honeysuckle AwPb)
- WC_LF f3 (bracted honeysuckle AwSwPl)
- SW_LF e2 (bracted honeysuckle fern AwPb)
- SW_LF e3 (bracted honeysuckle fern AwSwPl)
- WC_UF f2 (bracted honeysuckle Pb)
- WC_UF f3 (bracted honeysuckle PbSwPl)
- SW_UF e2 (green alder/fern Pb)
- WC_MN d1 (dogwood PbAw)
- WC_MN d2 (dogwood PbSw)
- SW_MN f1 (balsam poplar Pb)

6c) Spruce – The shrub/ground strata usually contains dogwood, fern, and abundant feather moss, although rose, alder, bracted honeysuckle, devil's club and fir are common at some sites. The overstory is dominated by spruce and fir.
Ecosites Included:

- BM e3 (dogwood Sw)
- BH e1 (fern Sw)
- WC_LF f4 (bracted honeysuckle Sw)
- SW_LF e4 (bracted honeysuckle fern Sw)
- WC_UF f4 (bracted honeysuckle Sw)
- WC_UF f5 (bracted honeysuckle Fa)
- SW_MN d3 (creeping mahonia-white meadowsweet Sw)
- SW_SA f2 (thimbleberry FaSe)

7. Not Treed --- NT

The shrub/ground stratum is either non-vegetated or dominated by shrubs, grasses, sedges and forbs. A very wide variety of nutrient levels and moisture regimes are present.

7a) Alpine – Sites occur at elevations above tree line. The shrub/ground stratum is either non-vegetated or dominated by heathers, grasses, sedges and forbs. Trees are absent due to climatic conditions.

7b) Flood – Sites are usually found at the edge of rivers, streams, lakes and wetlands where vegetation is disturbed frequently by flooding. The shrub/ground stratum is either non-vegetated or dominated by shrubs (often willow), grasses, sedges and forbs. Trees are absent due to the frequent flooding.

Ecosites Included:

- WC_LF g1 (shrubby meadow)
- WC_LF g2 (forb meadow)
- WC_UF f6 (bracted honeysuckle, willow)
- WC_UF g1 (shrubby meadow)
- WC_UF g2 (forb meadow)
- WC_MN e1 (meadow)
- WC_MN e2 (forb meadow)
- WC_SA e1 (shrubby meadow)
- WC_SA e2 (forb meadow)
- SW_SA g1 (dwarf birch/tufted hair grass)

7c) Ice – Sites are usually at higher elevations, where the vegetation is disturbed frequently be ice and snow. The shrub/ground stratum is either non-vegetated or dominated by shrubs, heathers, grasses, sedges and forbs. Trees are absent due to the action of ice and snow.

7d) Dry – Sites are usually in the grassland and parkland, where moisture stress limits establishment and growth of trees. The shrub/ground stratum is either non-vegetated or dominated by shrubs, grasses, sedges and forbs.

7e) Geo – Geological features (e.g., rocky outcrops, sand dunes, etc) limit tree establishment and growth. The shrub/ground stratum is either non-vegetated or dominated by heathers, grasses, sedges and forbs.

7f) Human – Human disturbance or activity limiting or preventing tree growth. The shrub/ground stratum is either non-vegetated or dominated by invasive species, grasses, sedges, or forbs.

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Appendix 3. Equipment needed for field data collection.

Sampling design and layout

- Cellphone for communications
- 2-way radios for communications among partners
- Datasheets and clipboard
- Site maps
- Laptop with card reader to download images onto
- Folding handsaw/"Swede-saw"
- GPS and compass
- 5 – 1.5 m orange steel or aluminum bars/site
- 27 (3 per 10-m square plot) permanent magnetic metal markers per site
- 93 pigtails to mark the nested 5x5 m, 10x10 m, and 25x25 m plots, DWM transect start points, and wellsite center within the wellsite and reference sites. (if you only do two transects at a time and remove the pigtails then you only need 45)
- 4 -100 m tapes, 4- 50 m tapes, and 4 – 30 m tapes.
- Multiple colors of flagging tape (e.g, brown, pink, blue, and green)
- Fine tipped colored marker (to delineate polygons on human disturbance sketch)
- *Plot layout 'cheatsheet'*

Field Photos:

- Digital camera and batteries (or adapter depending on camera needs)
- Calipers or backpack for scale

General Vegetation Sampling:

- ABMI Ecological Site Classification Chart
- Plant Field Guide (e.g. Common plants of the western rangelands - Volume 1 - grasses and grass-like species, Olds College and GOA - Kathy Tannas)
- Calipers for scale when taking photos
- Plot frame (0.5 m x 0.5 m)
- Plant press

Lichen and Bryophyte sampling:

- Vascular plant field guide
- Mora knife
- Hand lens
- Toilet paper for fragile specimens
- Squares of paper for small specimens
- 20 paper bags (Kraft #8) per site
- 1 larger grocery sized paper bag per site
- Sharpie
- Water
- Watch

Trees, Snags, and Stumps

- 5 m DBH tape
- 10 m carpenters tape
- 100 m measuring tape
- Vertex hypsometer w/transponder and/or clinometer
- Tree paint

Tree Cores:

- 16 inch (5.5 mm) increment borer
- Straws

- Ziploc bags
- Labels
- Vertex hypsometer
- Folding saw
- DBH calipers and tape

Canopy Cover:

- Spherical (concave) densiometer

Soil sampling core and excavation method:

Field equipment:

- Durable plastic bags to store the samples from each site in
- Double-cylinder core sampler. The most common core diameter range from 2" to 3" (5.1 cm to 7.6 cm). Note that it is good to have a minimum of 2 core samplers per field crew in case of breakage
- A couple of large crescent wrenches that can be used to adjust the double-cylinder core samples if needed
- Clean, dry and uniform stainless steel liners with a known internal diameter and height for volume calculation
- Trowel for excavation method
- Shovel (in case you have to dig out the double-cylinder core sampler if it is stuck)
- Soil knife or metal spatula
- Polyethylene plastic bags (2 - 7 pound bags per sample (we are currently using - 7 lb – 7" x 3" x 15" multipurpose clear plastic bags – Pur value brand which we order through U of Alberta Lab Stores) = 216 sample bags per site sampled)
- Labels on shipping tags that will be put in between the two 7 lb bags for each sample collected. – 108 labels on shipping tags per site sampled (we are currently using the following: https://www.officemaxcanada.com/en/product/013036_Avery_Manila_Shipping_Tags.aspx and https://www.officemaxcanada.com/en/product/5159_Avery_White_Mailing_Laser_Labels.aspx)
- Pam cooking spray to coat the stainless steel liners so they don't get stuck (1 bottle per site)
- 2 buckets with lids – it is useful to have a couple of buckets per field crew to help with storage of samples when they are being collected

Lab equipment:

- Analytical balance
- Drying oven capable of heating up to 105 °C

LFH sampling method:

- Trowel
- Ruler (measured to the scale of mm)

Penetration Resistance:

- Digital penetrometer (Spectrum Technologies FieldScout SC 900 Soil Compaction Meter)

Soil Organic Carbon, EC and pH:

- Bucket auger (also known as barrel and core auger) shown in Fig. 14b.
- Dutch auger shown in Fig. 14a.
- Heavy duty polyethylene bags (we are currently using - 7 lb – 7" x 3" x 15" multipurpose clear plastic bags – Pur value brand which we order through U of Alberta Lab Stores – the number needed per site are all included in the soil sampling list above)
- Wire brush
- Soil knife

Downed Woody Debris (DWD):

- 50 cm DBH calipers
- Go-No-Go Tool
- Mora Knife

- 50-m Measuring Tape

Ecological Site Classifications:

- ABMI Ecological Site Classification Chart (provided in Appendix 2)

Additional General Equipment Needs

First-aid kit

Rite in the rain paper

Wagon to help carry equipment

Datasheets

Emergency Contact Information

~~**Plot layout cheatsheet**~~

Pencils for recording data

- Laptop with card reader to download images onto[A2]

Appendix 4: Datasheets for Field Data Collection.

Ecological Recovery Monitoring of Certified Reclaimed Wellsites in Alberta

Field Data Sheets

Version 2014-04-30

April 2013

Prepared for:
Arnold Janz, Alberta Environment and Sustainable Resource Development

Prepared by:
Alberta Biodiversity Monitoring Institute & Alberta Innovates Technology Futures

Field DataSheets Table of Contents

1. Access Description

Date:___________________ **Crew Member(s):**__________________________

Maps Where Access Is Recorded:

1:24,000	
1,62,500	
Other	

Establishment and GPS Information:

Accuracy[2]	
Declination[3]	
Established[4]	

Location of Site Center:

Latitude[1]	
Longitude[1]	

Access Summary[5]:

Distance and Direction from Nearest Town:

____

____

Camp Location:

____

Time from Camp To Site:

____

Truck Access to Site

GPS Label at Start Point with Latitude & Longitude	Road Name & Type (Condition)	Distance and Direction to Site Centre or Next Waypoint

Quad Access to Site

GPS Label at Start Point with Latitude & Longitude	Trail Description	Distance and Direction to Site Centre or Next Waypoint

Walking Access to Site Centre and 4 Corners of the Wellsite

GPS Label at Start Point with Latitude & Longitude	Trail Description	Distance and Direction to Site Centre or Next Waypoint

1 – record decimal degrees (5 decimals) 2 – record GPS accuracy (in meters) 3 – record declination used to establish site 4 – check off when site is established or indicate in summary why site not established.5 – Describe in brief how to get to the site and any access challenges (boat required, river crossing, winch etc.)

2. Site Coordinate Establishment – GPS Coordinates[A3]

Site:___________________________

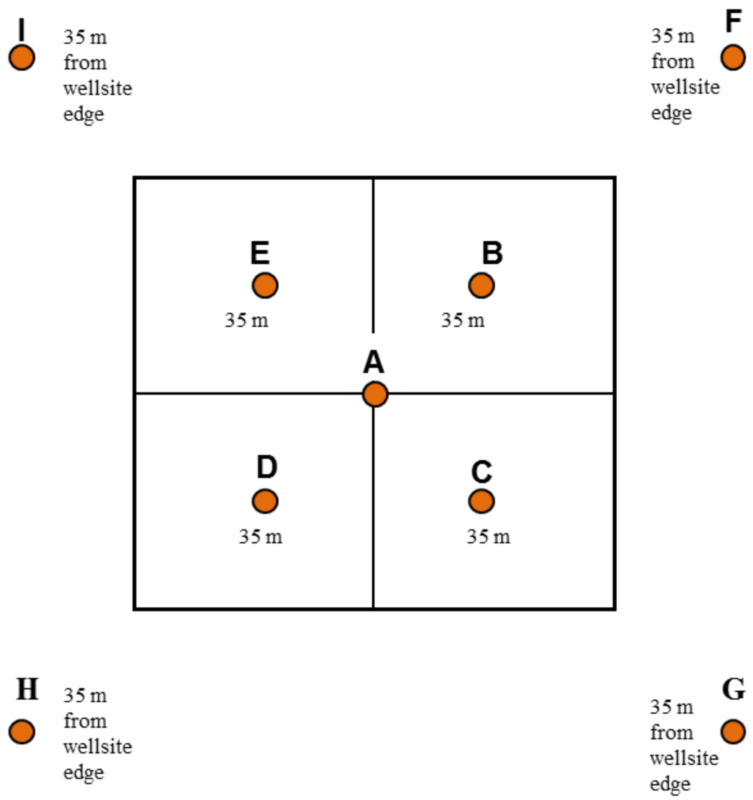
Date: ____________________

Data collected by_______________________

Description of weather (e.g., overcast, sunny, raining):

Location	UTM coordinates[1]		Bearing [2] (0-359 degrees)	Comments
	Easting[2]	Northing[2]		
Wellsite Center - A			n/a	
B - Center of B 10x10 m plot				
C - Center of C 10x10 m plot				
D - Center of D 10x10 m plot				
E- Center of E 10x10 m plot				
F - Center of F 10x10 m plot			n/a	
G- Center of G 10x10 m plot			n/a	
H - Center of H 10x10 m plot			n/a	
I - Center of I 10x10 m plot			n/a	

1 –Record coordinates when measuring out the site on the ground. Mark a waypoint and record the UTMS for each of the 9 plot centres listed.
2. – Record the bearing on your compass standing at wellsite centre of each of the four corners of the wellsite and record those bearings. Those will be the bearings for the 4 transects running from the wellsite centre to the wellsite corners.



Ecological Recovery Monitoring of Reclaimed Wellsites

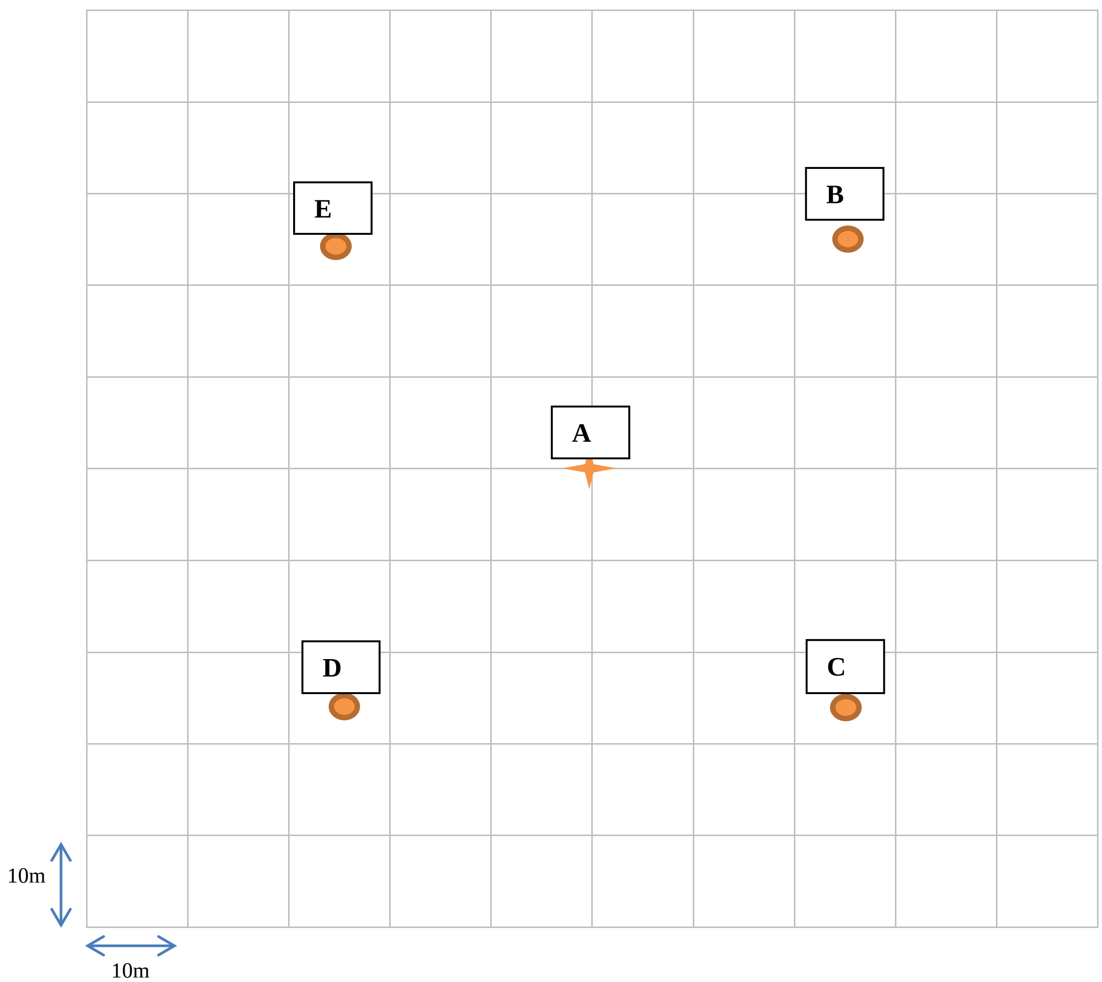
3A. Site Level Human Disturbance (Within the 1 Ha): Wellsite

Site:___________________________

Date:___________________ **Data collected by:**________________________

Place arrow point north on sheet to indicate direction of North

North?



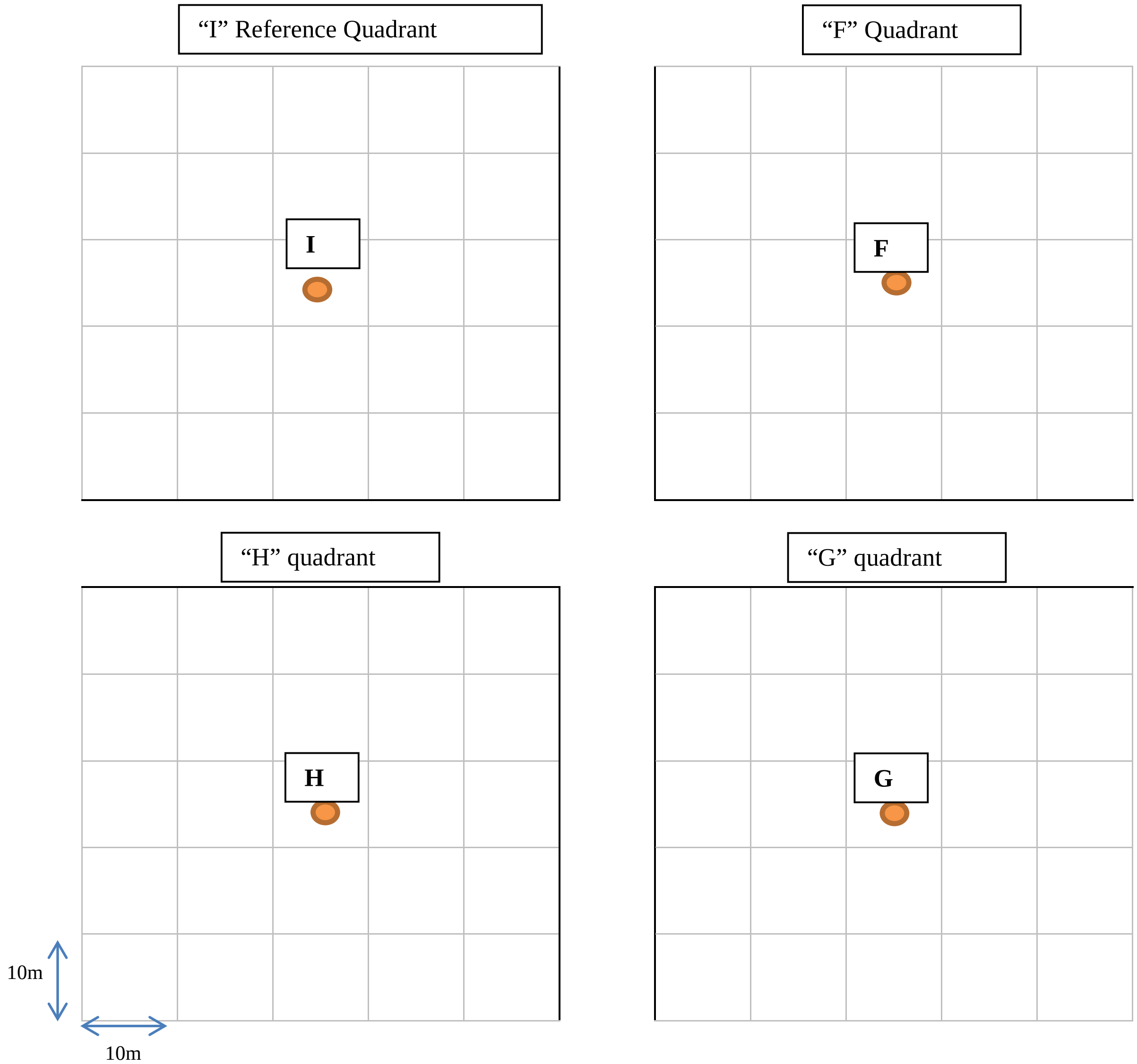
Human Disturbance Codes:

Well pad **(WELL)** – Any type of area cleared for oil/gas/CBM pump jacks or well heads
None **(NONE) –** No human caused disturbance
Harvest **(HARV)** – Any type of forest harvesting (clear-cut, partial cut, understory retention, etc.) <30 years old
Linear-pipeline **(PIPE)**
Linear-powerline **(POWER)**
Linear-seismic **(SEIS) –** Any type of cutline or seismic line
Railway **(RAIL)**
Road-paved **(ROADP)** – Any type of road with paved surface
Road-unpaved **(ROADG) –** Any type of road with an unpaved but improved surface (i.e. gravel)
Trail **(TRAIL)** – Any type of truck or ATV trail with an unimproved surface
Cultivated crop/field **(CULT) –** Any type of cultivated field that is used to grow agriculture crops
Pasture **(PAST)** – Any type of pasture (tame or native), grazing reserve, etc.
Residential **(RES)** – Any type of human dwelling, farm building, or farm yard in a rural or acreage setting
Urban **(URB) –** Any type of human dwelling, associated building, or yard/driveway/road in an urban setting
Industrial **(IND) –** Any type of building, roadway, yard, etc. associated with industrial development
Bare ground- undetermined cause **(BARE)** – Human caused bare ground for which the cause cannot be determined
Other **(OTHER) –** Specify other disturbance type

3B. Site Level Human Disturbance (Within the 1 Ha): Reference

Site:___________________________

Date:___________________ **Data collected by:**________________________



* Each quadrant represents one of the reference sites – recognizing they are not contiguous in the field

Human Disturbance Codes:

Well pad **(WELL)** – Any type of area cleared for oil/gas/CBM pump jacks or well heads
None **(NONE) –** No human caused disturbance
Harvest **(HARV)** – Any type of forest harvesting (clear-cut, partial cut, understory retention, etc.) <30 years old
Linear-pipeline **(PIPE)**
Linear-powerline **(POWER)**
Linear-seismic **(SEIS) –** Any type of cutline or seismic line
Railway **(RAIL)**
Road-paved **(ROADP)** – Any type of road with paved surface
Road-unpaved **(ROADG) –** Any type of road with an unpaved but improved surface (i.e. gravel)
Trail **(TRAIL)** – Any type of truck or ATV trail with an unimproved surface
Cultivated crop/field **(CULT) –** Any type of cultivated field that is used to grow agriculture crops
Pasture **(PAST)** – Any type of pasture (tame or native), grazing reserve, etc.
Residential **(RES)** – Any type of human dwelling, farm building, or farm yard in a rural or acreage setting
Urban **(URB) –** Any type of human dwelling, associated building, or yard/driveway/road in an urban setting
Industrial **(IND) –** Any type of building, roadway, yard, etc. associated with industrial development
Bare ground- undetermined cause **(BARE)** – Human caused bare ground for which the cause cannot be determined
Other **(OTHER) –** Specify other disturbance type

Ecological Recovery Monitoring of Reclaimed Wellsites

4. Site Photos

Site:_____________________________
Date:_____________________________
Data collected by:__________________

	Location (10x10 m plot centre)			
Site Photographs [1]	**B**	**C**	**D**	**E**
Wellsite Quadrant Photographs (Record Photo #)				
Wellsite Representative Photograph (Record Photo #)				
Wellsite Canopy Photograph (Record Photo #)				
	F	**G**	**H**	**I**
Reference Site Quadrant Photographs (Record Photo #)				
Reference Site Representative Photograph (Record Photo #)				
Reference Site Canopy Photograph (Record Photo #)				
Comments				

1 – Standing at the wellsite centre - one photo is taken in each of the sub-ordinal directions (total of 4 photographs), one representative site photo is taken from anywhere in the 1 ha wellsite area, and one canopy photo is taken from site centre looking directly up at the sky. For the reference site quadrant photos, stand on the near edge of the wellsite quadrant and take the picture facing into each of the wellsite quadrants (F-I, total of 4 photographs). All photos are taken at eye level using a lens with a 35 mm focal length. Check the quality and focus of each photo and re-take if necessary.

5. 2-Dimensional Cover (5x5 m plot)

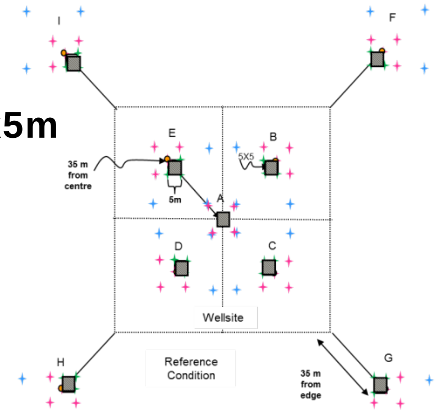
Site:___________________________
Date:___________________________
Data collected by:________________

Shrub Cover	A	B	C	D	E	F	G	H	I
Ecological Site Classification (Primary) [1]									
Percentage of 5x5 Area [2]									
Slope and Aspect[3]		/	/	/	/	/	/	/	/
Disturbance type (human or natural) [4]									
% area disturbed[4]									
Total Shrub Cover 0.5-2m (%) [5]									
Total Shrub Cover >2m (%) [6]									
2-Dimensional Cover [7]									
Forbs/Herbs: Other Vascular Cover (%)									
Shrub Cover (<0.5 m) (%)									
Grass Cover (includes sedge/rush) (%)									
Moss Cover (%)									
Lichen Cover (%)									
Fungi Cover (%)									
Wood Cover (%) [8]									
Litter Cover (%)									
Water Cover (%)									
Bare Mineral Ground Cover (%)									
Rock (%)									
Animal Matter (%)									
Comments									

1 – Record Nutrient/Moisture code (based on Veg.)/Tree sp. Modifier/Structural Stage for the predominant ecosite type within 5x5 m plot; refer to Ecosite chart
2 – Record the percentage of the 5x5 m plot occupied by the primary ecosite type if more than 1 ecosite type present.
3 – Record Slope (degree of slope) as: C= crest, T= toe, D= depression, L= level (0-2°), S1= 2-5°, S2= 6-10°, S3= 11-30°, S4= >30°. Record Aspect in degrees (direction water would flow)
4 – Record type of disturbance present (human or natural) and % of area disturbed (0%, <1%, 5% increments). Human Disturbance Codes: None (NONE), Harvest (HARV), Linear-pipeline (PIPE), Linear-powerline (POWER), Linear-seismic (SEIS), Railway (RAIL), Well pad (WELL), Road-paved (ROADP), Road-unpaved (ROADG), Trail (TRAIL), Cultivated crop/field (CULT), Pasture (PAST), Residential (RES), Urban (URB), Industrial (IND), Bare ground- undetermined cause (BARE), Other (OTHER). Natural Disturbance Codes: Beaver, Fire, Wind, Erosion, Flood, Ice, Insect, Disease, Other, Unknown. List all disturbance types starting with the one that affected the largest area.
5 – Cover estimates that would be obtained if a photograph had been taken from a height of 2 m, with shrubs <0.5 m removed. 0%, <1%, 5% increments.
6 – Cover estimates that would be obtained if a photograph had been taken above all shrubs, with shrubs <2 m removed. 0%, <1%, 5% increments.
7 – Cover estimates (0, <1%, and 5% increments) obtained if a photograph had been taken from a height of 0.5 m; estimates must sum to 100%
8 – Includes DWD >2 cm plus the bases of live trees

Ecological Recovery Monitoring of Reclaimed Wellsites

6. Shrub and 2-D Cover: Shrub Species Cover 5x5m



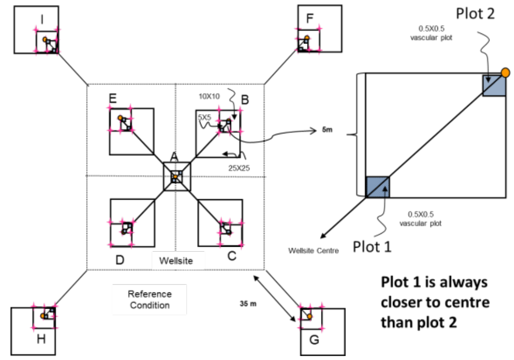
Site:____________________________
Date:____________________________
Data collected by:__________________

Shrub Species [1,2]	A	St[3]	B	St	C	St	D	St	E	St	F	St	G	St	H	St	I	St

1 – List all shrub species (7-letter code) rooted within each of the 5 x 5 m plots. If a species cannot be identified then collect the specimen and preserve it in a plant press. Unknown specimens are given a unique ID (UIS-Site#-Specimen#). Collect specimens from populations with more than 5 individuals, and collect from outside the 5x5 m plot if possible. Use caution to not repeat specimen numbers within a site.
2 – Record the percent cover estimates (0, <1, or 5% increments) of each shrub species present within each plot; Due to overlapping of leaves at different heights, percent cover for all species combined can be greater than 100%.
3- Follow Strata Codes provided below.

Code	Strata	Definition
T1	Tree (main canopy)	Trees that make up the upper part of the height distribution population and form the general layer of the canopy or foliage
T2	Tree (understory)	Trees and/or shrubs whose crowns extend into the bottom of the general level of the canopy or are located below the main canopy. Trees and/or shrubs must exceed 5 m height
S1	Shrub (tall)	All woody plants between 2-5 m tall (includes regeneration of taller trees)
S2	Shrub (medium)	shrubs and regenerating trees between 0.5-2 m tall
S3	Shrub (low)	All woody plants up to 0.5 m tall

7A. Plant and Lichen Cover by Species: Wellsite



($0.25\ m^2$ plot)
Site:____________________________
Date:____________________________
Data collected by:__________________

Comments:

Species [1]	A-1	St[2]	A-2	St[2]	B-1	St	B-2	St	C-1	St	C-2	St	D-1	St	D-2	St	E-1	St	E-2	St
Rock																				
Mineral soil																				
Litter																				
Water																				

Begin survey at the wellsite centre. The wellsite plot A-1 is located in the “B” quadrant of the 5x5 m wellsite centre plot, and plot A-2 is located in the “D” quadrant .

1– List the vascular plants (seven letter species code) that are present within the 0.5m x 0.5m plot and estimate percent cover (0, <1, or 5% increments) in each plot the species occurs. If a species cannot be identified then collect the specimen and preserve it in a plant press. Unknown specimens are given a unique ID (UIS-Site#-PlotLetter-Specimen#). Collect specimens from populations with more than 5 individuals, and collect from outside the 5x5 m plot if possible. Use caution to not repeat specimen numbers within a site. Note that Plot 1 for a given quadrant is always the closer plot and Plot 2 is always the plot furthest from wellsite centre.

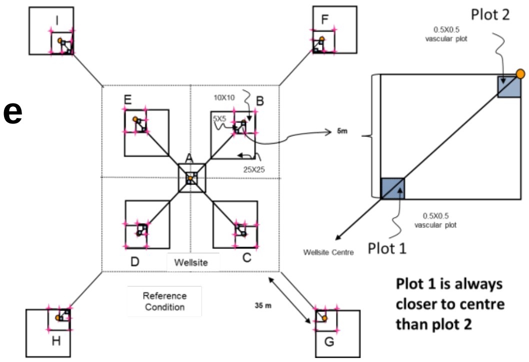
In addition estimate percent cover for rock/bare mineral soil, litter, and water in the quadrat. Plants must be rooted within the quadrat to be included in the estimation.

2- Follow Strata Codes provided below.

Code	Strata	Definition
T1	Tree (main canopy)	Trees that make up the upper part of the height distribution population and form the general layer of the canopy or foliage
T2	Tree (understory)	Trees and/or shrubs whose crowns extend into the bottom of the general level of the canopy or are located below the main canopy. Trees and/or shrubs must exceed 5 m height
S1	Shrub (tall)	All woody plants between 2-5 m tall (includes regeneration of taller trees)
S2	Shrub (medium)	shrubs and regenerating trees between 0.5-2 m tall
S3	Shrub (low)	All woody plants up to 0.5 m tall
H	Herbs (forbs)	record all forb species regardless of height
G	Grass/graminoid	record graminoids (grasses, sedges, rushes)
M	Moss	record all bryophytes
L	lichen	lichen species growing on dominant substrate (usually mineral or organic soil) included
E	epiphytes	Lichens or mosses growing on other plants, usually trees or shrubs
F	fungi	Fungi (excluding lichen) growing on dominant substrate - mushrooms

Ecological Recovery Monitoring of Reclaimed Wellsites

7B. Plant and Lichen Cover by Species: Reference



(0.25 m^2 plot)

Site:____________________________

Date:____________________________

Data collected by:_________________

Comments:

Species [1]	F-1	St[2]	F-2	St[2]	G-1	St	G-2	St	H-1	St	H-2	St	I-1	St	I-2	St
Rock																
Mineral soil																
Litter																
Water																

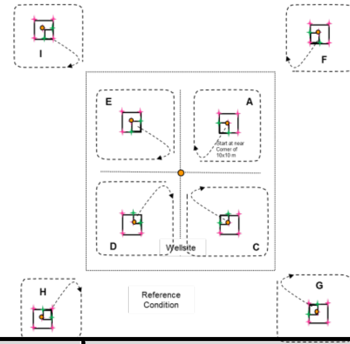
1– List the vascular plants (seven letter species code) that are present within the 0.5m x 0.5m plot and estimate percent cover (0, <1, or 5% increments) in each plot the species occurs. If a species cannot be identified then collect the specimen and preserve it in a plant press. Unknown specimens are given a unique ID (UIS-Site#-Plot Letter-Specimen#). Collect specimens from populations with more than 5 individuals, and collect from outside the 5x5 m plot if possible. Use caution to not repeat specimen numbers within a site. Note that Plot 1 for a given quadrant is always the closer plot and Plot 2 is always the plot furthest from wellsite centre.
In addition estimate percent cover for rock/bare mineral soil, litter, and water in the quadrat. Plants must be rooted within the quadrat to be included in the estimation.

2- Follow Strata Codes provided below.

Code	Strata	Definition
T1	Tree (main canopy)	Trees that make up the upper part of the height distribution population and form the general layer of the canopy or foliage
T2	Tree (understory)	Trees and/or shrubs whose crowns extend into the bottom of the general level of the canopy or are located below the main canopy. Trees and/or shrubs must exceed 5 m height
S1	Shrub (tall)	All woody plants between 2-5 m tall (includes regeneration of taller trees)
S2	Shrub (medium)	shrubs and regenerating trees between 0.5-2 m tall
S3	Shrub (low)	All woody plants up to 0.5 m tall
H	Herbs (forbs)	record all forb species regardless of height
G	Grass/graminoid	record graminoids (grasses, sedges, rushes)
M	Moss	record all bryophytes
L	lichen	lichen species growing on dominant substrate (usually mineral or organic soil) included
E	epiphytes	Lichens or mosses growing on other plants, usually trees or shrubs
F	fungi	Fungi (excluding lichen) growing on dominant substrate - mushrooms

Ecological Recovery Monitoring of Reclaimed Wellsites

8. Vascular Plant Search



Sheet _____of_____

Site:___________________________

Date:___________________________

Data collected by:________________

	Wellsite			
Species [1]	**B**	**C**	**D**	**E**

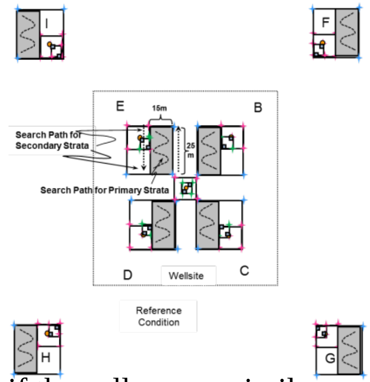
	Reference Condition			
Species [1]	**F**	**G**	**H**	**I**

Begin surveys in the B quadrant and move in a clockwise direction through quadrants. Start at the centre of each quadrant, working your way toward site centre, then walk through each quadrant in a clockwise direction, approximately 10 m from the edges, stopping every 4-5 steps to survey the immediate surroundings.

1 – List the vascular plants (seven letter species code) that are present within the central 1 ha area and place a tick mark in each quadrant that the species occur in (1st column); if a species cannot be identified then collect the specimen and preserve it in a plant press. Unknown specimens are given a unique ID (UIS-Site#-Specimen#). Collect specimens from populations with more than 5 individuals, and collect from outside the 1-ha if possible.

Ecological Recovery Monitoring of Reclaimed Wellsites

9A. Bryophyte Collection - Detailed



Detailed Survey 1: 25X15 m Plot

Site:___________________________

Date:___________________________

Data collected by:________________

Wellsite quadrant sampled(B,C,D,E):______

Reference condition quadrant (F-I) sampled:_____

Method: For the quadrant with the most diversity of microhabitats (or if they all appear similar randomly select one) - survey the 25x15 m plot starting at the most diverse microhabitat you can find in the plot. Continue the survey by covering the entire plot in a "W" path (see figure). Stop every 4 or 5 steps to examine microhabitats and collect walnut-sized plugs of unique species.

Time searched:

Minimum 5 min → No Microhabitats found → Terminate search

→ Microhabitats found → Minimum 10 min

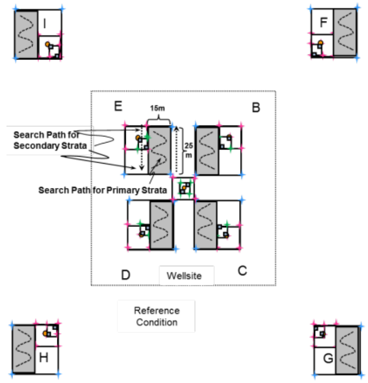
Continue searching until all examples of microhabitats are searched up to 25 min maximum (Most sites need 25 min)

Data entry: Mark the cells of the table as follows
C: microhabitat present and specimens collected
None: microhabitat present but no specimens found
VNA: microhabitats absent

	Time Searched	Time Searched
	Wellsite	**Reference**
Logs and Stumps (samples in 1 bag)		
LS: Soft stumps & logs (decay classes 3-5) sample roots and all sides		
LH: Hard stumps & logs (decay classes 1-2) sample roots and all sides		
Wetlands and Peatlands (samples in 1 bag)		
WMF: Wetlands, marshes, & fens - within the wetland survey both under and away from trees		
WSB: Shores/banks of wetlands, ponds, lakes, & streams survey on organic or mineral soil adjacent the water's edge		
WDS: Moist depressions/seasonal wetlands dry at time of survey sample sides and bottom in the area influenced by water		
WPW: Peatlands with or without standing water survey both standing water and vegetation hummocks		
Rocks and Cliffs (samples in 1 bag)		
BC: Boulders (>50 cm diam.) survey all surfaces (top, sides, and base) from the soil upwards		
RR: Rocks (<50 cm diam.) survey all surfaces (top, sides, and base) from the soil upwards		
CL: Cliffs (steep high rock face) - survey all of the faces, ledges, and crevices that can be accessed safely		

Ecological Recovery Monitoring of Reclaimed Wellsites

9B. Bryophyte Collection - Belt



Belt Transect Survey: 2x25 m Belt Transect

Site:_________________________

Date:_________________________

Data collected by:_______________

Wellsite quadrant sampled(B,C,D,E):_______

Reference condition quadrant (F-I) sampled:_____

Method: Move in a clockwise direction along east and west plot Boundary for the 15x25 m plot that you sampled. Stop every 4 or 5 steps to examine microhabitats and collect within 1 m of either side of perimeter.

Time searched:

Exactly <u>10 min</u>

Data entry: Mark the cells of the table as follows

C: microhabitat present and specimens collected

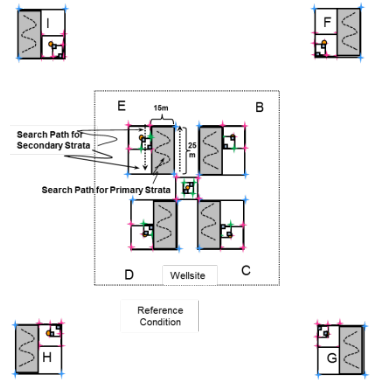
None: microhabitat present but no specimens found

VNA: microhabitats absent

	Time Searched	Time Searched
	Wellsite	**Reference**
Trees and Other Vertical Structures (samples in 1 bag)		
TD: Deciduous Trees - all sides of the roots, bases, trunks, and branches of both live and dead deciduous trees		
TC: Coniferous Trees - all sides of the roots, bases, trunks, and branches of both live and dead coniferous trees		
TS: Shrubs - all sides of the roots, bases, stems, and branches of live & dead shrubs		
HB: Human Structures - vertical and horizontal parts of the structures (survey from the ground)		
Upland Soils (samples in 1 bag)		
UC: Humus soils under trees/shrubs (shaded by canopy) survey as large a variety as possible		
UO: Humus soils without trees/shrubs (open to sunlight) survey as large a variety as possible		
DC: Agriculturally cultivated soils		
DM: Mineral soil in upland areas from any causes		

Ecological Recovery Monitoring of Reclaimed Wellsites

10A. Lichen Collection - Detailed



Survey 1: 25 x 15 m Plots

Site:_______________________

Date:_______________________

Data collected by:_____________

Wellsite quadrant sampled(B,C,D,E):_______

Reference condition quadrant (F-I) sampled:_____

Method: For the quadrant with the most diversity of microhabitats (or if they all appear similar randomly select one) survey the 25x15 m plot starting at the most diverse microhabitat you can find in the plot. Continue the survey by covering the entire plot in a “W” path (see figure). Stop every 4 or 5 steps to examine microhabitats and collect walnut-sized plugs of unique species.

Time searched:

Minimum 5 min → No Microhabitats found → Terminate search

Minimum 5 min → Microhabitats found → Minimum 10 min

Continue searching until all examples of microhabitats searched up to 25 min maximum (Most sites need 25 min)

Data entry: Mark the cells of the table as follows
C: microhabitat present and specimens collected
None: microhabitat present but no specimens found
VNA: microhabitats absent

	Time Searched	Time Searched
	Wellsite	**Reference**
Logs and Stumps (samples in 1 bag)		
LS: Soft stumps & logs (decay classes 3-5) sample roots and all sides		
LH: Hard stumps & logs (decay classes 1-2) sample roots and all sides		
Trees and Other Vertical Structures (samples in 1 bag)		
TD: Deciduous Trees - all sides of the roots, bases, trunks, and branches of both live and dead deciduous trees		
TC: Coniferous Trees - all sides of the roots, bases, trunks, and branches of both live and dead coniferous trees		
TS: Shrubs - all sides of the roots, bases, stems, and branches of live & dead shrubs		
HB: Human Structures - vertical and horizontal parts of the structures: (e.g., posts, buildings) survey from the ground		
Rocks and Cliffs (samples in 1 bag)		
BC: Boulders (>50 cm diam.) survey all surfaces (top, sides, and base) from the soil upwards		
RR: Rocks (<50 cm diam.) survey all surfaces (top, sides, and base) from the soil upwards		
CL: Cliffs (steep high rock face) - survey all of the faces, ledges, and crevices that can be accessed safely		

Ecological Recovery Monitoring of Reclaimed Wellsites

10B. Lichen Collection – Belt

Survey 2: 2x25 m Belt Transects

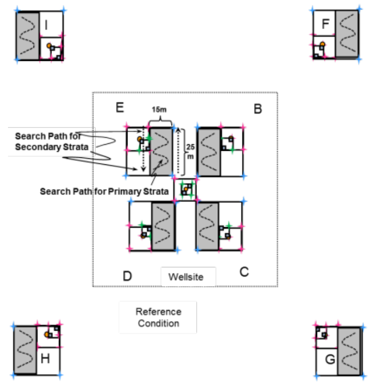
Site:____________________________

Date:____________________________

Data collected by:________________

Wellsite quadrant sampled(B,C,D,E):_______

Reference condition quadrant (F-I) sampled:_____



Method: Move in a clockwise direction along east and west plot boundary of the 15x25 m plot that you sampled for lichens. Stop every 4 or 5 steps to examine microhabitats and collect within 1 m of either side of perimeter.

Time searched:
Exactly 10 min

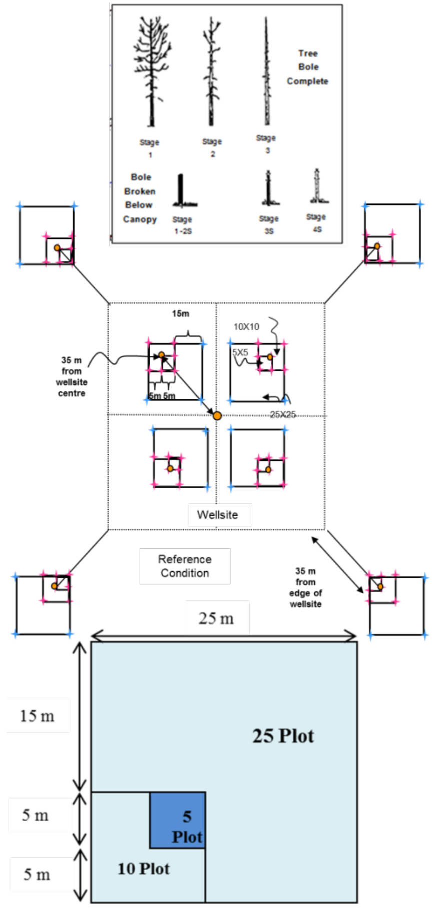
Data entry: Mark the cells of the table as follows
C: microhabitat present and specimens collected
None: microhabitat present but no specimens found
VNA: microhabitats absent

	Time Searched	Time Searched
	Wellsite	**Reference**
Wetlands and Peatlands (samples in 1 bag)		
WMF: Wetlands, marshes, & fens - within the wetland survey both under and away from trees		
WSB: Shores/banks of wetlands, ponds, lakes, & streams survey on organic or mineral soil adjacent the water's edge		
WDS: Moist depressions/seasonal wetlands dry at time of survey sample sides and bottom in the area influenced by water		
WPW: Peatlands with or without standing water survey both standing water and vegetation hummocks		
Upland Soils (samples in 1 bag)		
UC: Humus soils under trees/shrubs (shaded by canopy) survey as large a variety as possible		
UO: Humus soils without trees/shrubs (open to sunlight) survey as large a variety as possible		
DC: Agriculturally cultivated soils		
DM: Mineral soil in upland areas from any causes		

Ecological Recovery Monitoring of Reclaimed Wellsites

11. Trees, Snags and Stumps

Sheet _____of_____
Site:__________________________
Date:__________________________
Data collected by**:**______________



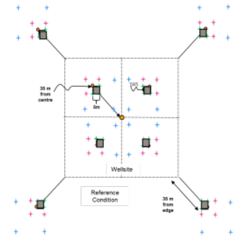
Quad [1] all trees	Plot [2] all trees	Spp. [3] all trees	Cond. [4] all trees	DBH [5] all trees	Decay Stage [6] (cond= S or D)	Top Ht. [7] pick top 3 trees in each plot	M/E [7] pick top 3 trees in each plot

1 – Location of plot - use the coding W=wellsites R=reference along with the quadrant direction (NE, SE, SW, NW) – e.g., WNE or RSW.
2 – Plot where tree was measured: 5 = 5X5 Meter Plot; 10 = 10X10 Meter Plot; 25 = 25X25 Meter Plot
3 – Aw - trembling aspen, Pb - balsam poplar, Bp - paper birch, Ba - Alaska birch, Pl - lodgepole pine, Pj - jack pine, Sw - white spruce, Sb - black spruce, Se - engelmann spruce, Fa - subalpine fir, Fd - Douglas fir, Fb - balsam fir, and Lt - tamarack; if snags cannot be determined record as CON - unknown conifer, DEC - unknown deciduous, and/or UNKN - unknown species.
4 – Condition: A = Alive (live tree, >1.3 m); D = Dead (snag; dead tree >1.3 m); S = Stump (dead tree <1.3 m)
5 – Diameter at Breast Height. Taken at 1.3 m high (to nearest 0.1 cm or 0.5 cm for <7 cm and ≥7 cm DBH trees, respectively). For oval shaped trees record the average of the long and short axes. For stumps, DBH is recorded as the inside diameter (not including bark) at top height.
6 – Based on the 6 categories in the figure. If the bole of the tree is not snapped decay is classified as: 1 = Recently killed, all twigs/ branches present, wood hard, bark (normally) intact; 2 = Twigs and small branches missing (major branches remain), wood hard; 3 = No branches, bole mostly intact, wood starting to soften. If the tree is snapped along the bole so that the presence of twigs and branches cannot be evaluated, then decay is classified based on the stump condition as: 1-2S = recently killed, wood hard, bark (normally) intact; 3S = wood starting to soften; 4S = wood soft throughout the snag. Note; since the presence and condition of branches, wood, and bark may not always co-vary exactly as outlined, all characteristics should be used to evaluate a snag.
7 – Measured using vertex hypsometer or estimated using 10 m carpenters tape with clinometer. Top Ht. =Height to top of stem; See protocol for details. To nearest 0.1m if measured, 0,5m if estimated. M = Measured; E = Estimated

Ecological Recovery Monitoring of Reclaimed Wellsites

12.Tree Cores

Site:____________________________
Date:____________________________
Data collected by:________________

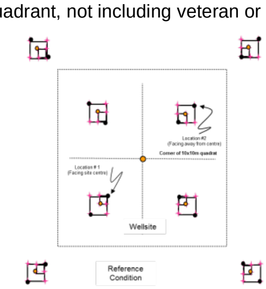


Tree Cores [1]	Wellsite 1 ha				WNE				WSE				WSW				WNW			
	Spp.	Ht.(m)	DBH	STD [2]	Spp.	Ht.(m)	DBH	STD [2]	Spp.	Ht.(m)	DBH	STD [2]	Spp.	Ht.(m)	DBH	STD [2]	Spp.	Ht.(m)	DBH	STD [2]
Largest DBH Tree [3]																				
Leading Species [4]																				
Second Species [5]																				
Comments																				

Tree Cores [1]	Reference 1 ha				RNE				RSE				RSW				RNW			
	Spp.	Ht.(m)	DBH	STD [2]	Spp.	Ht.(m)	DBH	STD [2]	Spp.	Ht.(m)	DBH	STD [2]	Spp.	Ht.(m)	DBH	STD [2]	Spp.	Ht.(m)	DBH	STD [2]
Largest DBH Tree [3]																				
Leading Species [4]																				
Second Species [5]																				
Comments																				

1 – All trees must be dominant or co-dominant in status (except largest). Bore the tree at 1.3m and facing site centre, if possible. If the tree is not round, obtain the core from the narrow width. If trees are <10 cm DBH, destructively sample a representative tree from outside of the quadrant by taking a cookie. If all trees are <10 cm DBH, only destructively sample leading tree species from outside of the 1 ha area (i.e., total of 4 trees per site).
2 – Significant tree damage is anything that can affect tree growth in categories: BT=Broken Top, DT=Dead Top, FC=Fork/Crook, S=Scarring, M=Mistletoe, and/or O=Other (indicate in comments).
3 – Select the largest live DBH tree within the 1 ha area regardless of species. Record tree species code, height (using vertex), DBH, and significant tree damage (if any).
4 – Select the largest live DBH tree from the Leading species present in the composition of canopy trees, within each quadrant, not including veteran or residual trees from a former stand.
5 - Select the largest live DBH tree from the Second species present in the composition of canopy trees (if they occur), within each quadrant, not including veteran or residual trees from a former stand. Second species must comprise more than 20% of the stems in the quadrant.

13. Canopy Cover



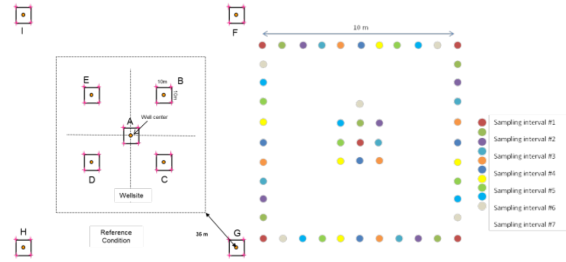
Date:____________________________
Data collected by:________________
Site:____________________________

	WNE	WSE	WSW	WNW	RNE	RSE	RSW	RNW
Location #1 (27.9 m)								
Location #2 (42.1 m)								
Comments:								

Record number of open dots (out of 96); i.e. the dots NOT covered by leaves, branches or other objects.
At 27.9 m face toward site center. At 42.1 m face away from site center (These are the diagonal corners of the 10x10 m plot).

Ecological Recovery Monitoring of Reclaimed Wellsites

14A. Soil Bulk Density, EC, pH, SOC samples

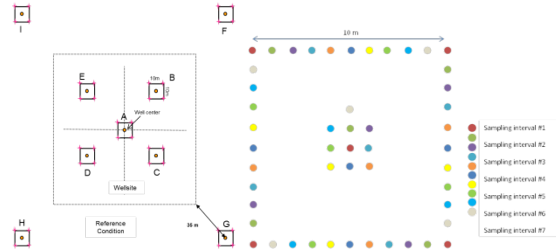


Site:______________________________
Date:________________**Data collected by:**_________________________
Sheet ___1__**of**__3___

Sample ID	GPS	% elevation	Profile Depth (cm)		Comments/photo#'s
			Start	Finish	
W-A-1-0					
W-A-1-15					
W-A-1-30					
W-A-1-60					
W-A-2-0					
W-A-2-15					
W-A-3-0					
W-A-3-15					
W-A-4-0					
W-A-4-15					
W-A-5-0					
W-A-5-15					
W-B-1-0					
W-B-1-15					
W-B-1-30					
W-B-1-60					
W-B-2-0					
W-B-2-15					
W-B-3-0					
W-B-3-15					
W-B-4-0					
W-B-4-15					
W-B-5-0					
W-B-5-15					
W-C-1-0					
W-C-1-15					
W-C-1-30					
W-C-1-60					
W-C-2-0					
W-C-2-15					
W-C-3-0					
W-C-3-15					
W-C-4-0					
W-C-4-15					
W-C-5-0					
W-C-5-15					
W-D-1-0					
W-D-1-15					
W-D-1-30					
W-D-1-60					
W-D-2-0					
W-D-2-15					

Ecological Recovery Monitoring of Reclaimed Wellsites

14A. Continued



Site:_______________________________

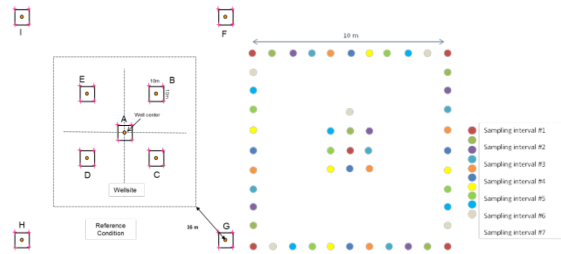
Date:________________**Data collected by:**_________________________

Sheet __2___**of**__3___

		Profile Depth (cm)			
Sample ID	GPS	Start	Finish	% Elevation	Comments/photo#'s
W-D-3-0					
W-D-3-15					
W-D-4-0					
W-D-4-15					
W-D-5-0					
W-D-5-15					
W-E-1-0					
W-E-1-15					
W-E-1-30					
W-E-1-60					
W-E-2-0					
W-E-2-15					
W-E-3-0					
W-E-3-15					
W-E-4-0					
W-E-4-15					
W-E-5-0					
W-E-5-15					
R-F-1-0					
R-F-1-15					
R-F-1-30					
R-F-1-60					
R-F-2-0					
R-F-2-15					
R-F-3-0					
R-F-3-15					
R-F-4-0					
R-F-4-15					
R-F-5-0					
R-F-5-15					
R-G-1-0					
R-G-1-15					
R-G-1-30					
R-G-1-60					
R-G-2-0					
R-G-2-15					

Ecological Recovery Monitoring of Reclaimed Wellsites

14A. Continued



Site:______________________________

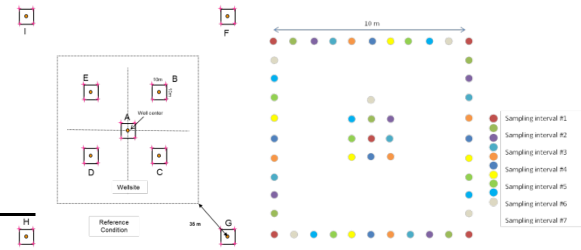
Date:________________**Data collected by:**________________________

Sheet __3___**of**__3___

		Profile Depth (cm)			
Sample ID	GPS	Start	Finish	% Elevation	Comments/photo#'s
R-G-3-0					
R-G-3-15					
R-G-4-0					
R-G-4-15					
R-G-5-0					
R-G-5-15					
R-H-1-0					
R-H-1-15					
R-H-1-30					
R-H-1-60					
R-H-2-0					
R-H-2-15					
R-H-3-0					
R-H-3-15					
R-H-4-0					
R-H-4-15					
R-H-5-0					
R-H-5-15					
R-I-1-0					
R-I-1-15					
R-I-1-30					
R-I-1-60					
R-I-2-0					
R-I-2-15					
R-I-3-0					
R-I-3-15					
R-I-4-0					
R-I-4-15					
R-I-5-0					
R-I-5-15					

Ecological Recovery Monitoring of Reclaimed Wellsites

14C. Penetration Resistance and LFH



Site:______________________________

Date:________________**Data collected by:**_________________________

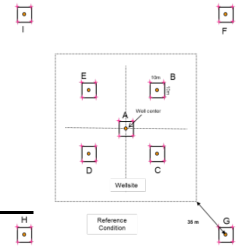
Sheet ______**of**______

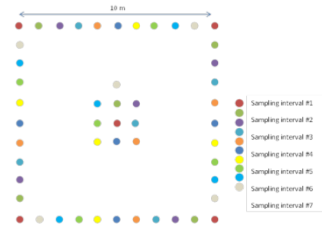
Wind condition:____

					Depth of measurement		
Sample I.D	Plot ID	N (# of readings)	GPS	LFH (mm)	Start	Finish	Comments/photo#'s

Ecological Recovery Monitoring of Reclaimed Wellsites

14C. Penetration Resistance and LFH





Site:____________________________

Date:______________**Data collected by:**______________________

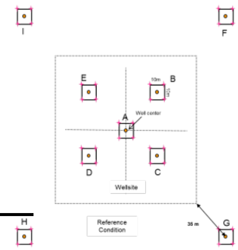
Sheet _____**of**_____

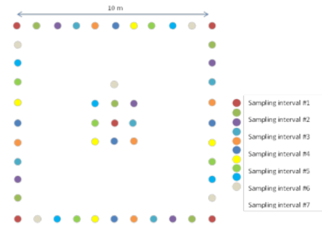
Wind condition:____

					Depth of measurement		
Sample I.D	Plot ID	N (# of readings)	GPS	LFH (mm)	Start	Finish	Comments/photo#'s

Ecological Recovery Monitoring of Reclaimed Wellsites

14C. Penetration Resistance and LFH





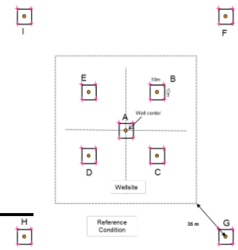
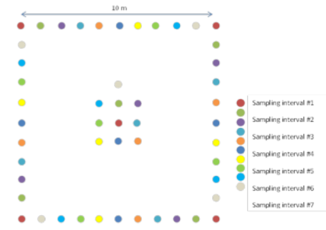
Site:________________________________

Date:________________ **Data collected by:**__________________________

Sheet ______**of**______

Wind condition:____

					Depth of measurement		
Sample I.D	Plot ID	N (# of readings)	GPS	LFH (mm)	Start	Finish	Comments/photo#'s

Ecological Recovery Monitoring of Reclaimed Wellsites

14C. Penetration Resistance and LFH

Site:______________________________

Date:_______________**Data collected by:**_________________________

Sheet ______**of**______

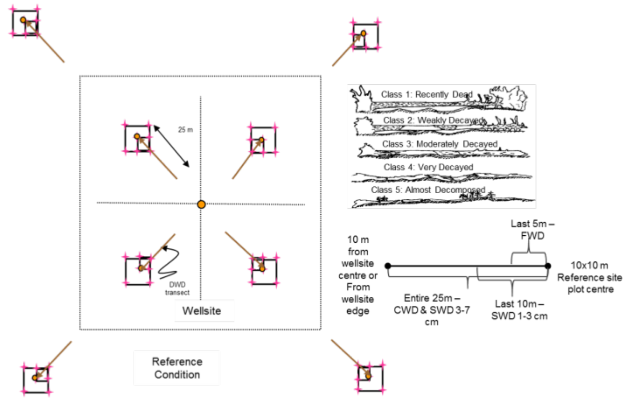
Wind condition:____

					Depth of measurement		
Sample I.D	Plot ID	N (# of readings)	GPS	LFH (mm)	Start	Finish	Comments/photo#'s

Ecological Recovery Monitoring of Reclaimed Wellsites

15. Downed Woody Debris

Site:____________________________
Date:____________________________
Data collected by:__________________



Coarse Woody Debris (CWD) >7 cm
(entire 25 m)

Quad.[1]	Diam. (cm)	Decay Class [2]	Ac. [3]

Quad.[1]	Diam. (cm)	Decay Class [2]	Ac. [3]

Quad.[1]	Diam. (cm)	Decay Class [2]	Ac. [3]	Quad.[1]	Diam. (cm)	Decay Class [2]	Ac. [3]

1 – Location of plot - use the coding W=wellsites R=reference along with the quadrant direction (NE, SE, SW, NW) – e.g., WNE or RSW.
2 – Decay Class at Transect Intercept: 1 = Bark (normally) attached to wood, hardly any fungus mycelium developed under patches of loose bark; 2 = Loose bark (intact or partly missing), well developed fungus mycelium (normally) between bark and wood, rot extends <3 cm radially into the wood (measured with a knife pushed into wood); 3 = Rot extends >3 cm radially into wood but core still hard, log may be sagging or broken but still supported from forest floor by stones, humps, etc.; 4 = Rotten throughout (entire knife penetrates wood), log shape conforms to forest floor, often elliptical in shape; 5 = Log completely decomposed in sections, outline of log discernable but strongly fragmented and remaining parts often overgrown, wood disintegrates when lifted.
3 – If an accumulation estimate was made indicate A = Accumulation.

Fine (FWD) & Small Woody Debris (SWD) * FWD and SWD must intersect transect and be above the litter layer

		Last 5 m		Last 10 m		Entire 25 m		Entire 25 m	
		FWD (<1.0 cm) [4]	**Total**	**SWD (1.0-3.0 cm) [5]**	**Total**	**(3.1-5.0 cm) [6]**	**Total**	**(5.1-7.0 cm) [6]**	**Total**
WNE	**Tally**								
	Partial[7]								
WSE	**Tally**								
	Partial[7]								
WSW	**Tally**								
	Partial[7]								
WNW	**Tally**								
	Partial[7]								
RNE	**Tally**								
	Partial[7]								
RSE	**Tally**								
	Partial[7]								
RSW	**Tally**								
	Partial[7]								
RNW	**Tally**								
	Partial[7]								

4 – Tally all pieces of FWD along the last 5 m of each transect. FWD only includes twigs, stems, and branches and does not include cones, bark flakes, fragments of stems and branches, or needles; If >20 pieces are encountered per 50 cm section, partial sample. 5 – Tally all pieces of SWD 1.0-3.0 cm along the last 10 m of each transect. If needed, estimate SWD by partial sampling. 6 – Tally all pieces of SWD 3.1-5.0 cm and 5.1-7.0 cm along the entire 25 m of each transect.
7 – Record the length of partial transect and number of pieces - example 0.35m (50)

15. Additional Data Entry for CWD >7cm

Quad.[1]	Diam. (cm)	Decay Class [2]	Ac. [3]	Quad.	Diam. (cm)	Decay Class [2]	Ac. [3]	Quad.	Diam. (cm)	Decay Class [2]	Ac. [3]

1 – Location of plot - use the coding W=wellsites R=reference along with the quadrant direction (NE, SE, SW, NW) – e.g., WNE or RSW.

2 – Decay Class at Transect Intercept: 1 = Bark (normally) attached to wood, hardly any fungus mycelium developed under patches of loose bark; 2 = Loose bark (intact or partly missing), well developed fungus mycelium (normally) between bark and wood, rot extends <3cm radially into the wood (measured with a knife pushed into wood); 3 = Rot extends >3cm radially into wood but core still hard, log may be sagging or broken but still supported from forest floor by stones, humps, etc.; 4 = Rotten throughout (entire knife penetrates wood), log shape conforms to forest floor, often elliptical in shape; 5 = Log completely decomposed in sections, outline of log discernable but strongly fragmented and remaining parts often overgrown, wood disintegrates when lifted (See Appendix 4 for examples).

3 – If an accumulation estimate was made indicate A = Accumulation.