SUDBURY AREA RISK ASSESSMENT

VOLUME III: APPENDIX GE-4

PLANT COMMUNITY ASSESSMENT
LOE RANKING REPORT

Table of Contents

Page

Tables

Figures

Appendices

This page left blank intentionally

GE-4-1.0 INTRODUCTION

The Ecological Risk Assessment (ERA) in Sudbury will evaluate the risk from airborne particulate emissions of the chemicals of concern (COC), which are nickel, copper, cobalt, arsenic, lead, selenium and cadmium, resulting from past smelting operations on the Sudbury environment. One important component of the ERA is the estimation of the effects of the metals in the soils to plants.

Objective #1 of the ERA is to evaluate the extent to which the chemicals of concern (COC) are preventing the recovery of regionally representative, self-sustaining terrestrial plant communities. To fulfill this objective, multiple lines of evidence (LOE) were collected at 22 sites (18 test sites, three reference sites and one historically limed and re-greened site) across the study area, the results of which were assessed to contribute to an overall weight-of-evidence approach to assess risk to ecological receptors.

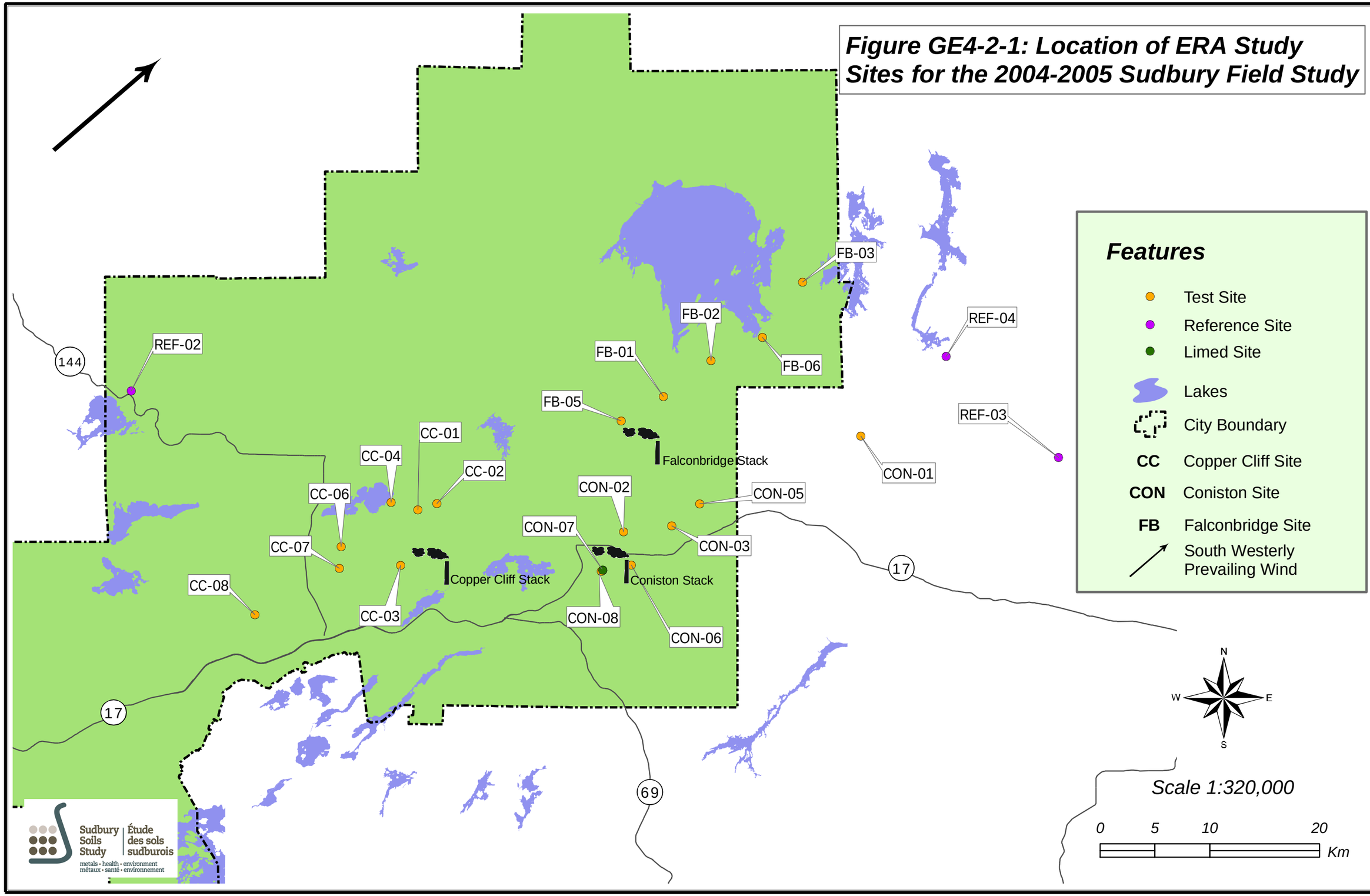
One of the lines of evidence was a detailed plant community assessment. The objective of this report is to provide an overview of the results of the plant community assessment, and the approach used to rank each of the test sites for this LOE.

GE-4-2.0 SITE LOCATIONS

In total, 22 sites were located, radiating from current and historical smelter sources. These consisted of: 18 test sites Copper Cliff (seven test sites), Falconbridge (five test sites) and Coniston (six test sites); 1 historically limed and re-greened site along the Coniston transect (CON-07) that is adjacent to an unlimed site (CON-08); and, 3 reference sites which had a variety of soil characteristics and plant communities but contained background metal concentrations. The locations of the test and reference sites are shown in Figure GE-4-2-1. The historically limed and re-greened site, CON-07, was not considered in the overall final ranking of the test sites but is included in the ranking report for the purposes of discussion. A comparison of the differences in the plant community at CON-07 and CON-08 is included in Chapter 3, Section 3.14.2.

This page left blank intentionally

Figure GE4-2-1: Location of ERA Study Sites for the 2004-2005 Sudbury Field Study



This page left blank intentionally

GE-4-3.0 OVERVIEW OF RANKING APPROACH

The plant community assessment provided a detailed snapshot of the vegetation community at each site during the summers of 2004 and 2005. At each site, observational data were collected as part of five major ecological components:

- A broad plant inventory,
- Percent cover assessment,
- Detailed tree and tall shrub assessment,
- Assessment of coarse woody debris, and
- An ecosite classification.

The field methodology protocol is presented in Appendix GB6 of Volume III. The raw data used in the evaluation and ranking of the sites are provided in Appendix GE2 of Volume III.

The raw data were interpreted and placed into one of four ecological criteria: site biodiversity, ecological integrity, long-term site productivity, and soil and water conservation. These criteria were composed of various indicators. For example, the degree of species dominance, which was calculated based on the data from the percent cover tally sheet, is an indicator of site biodiversity.

The approach used to evaluate the plant community assessment results and to determine an overall rank for each site is summarized in Figure GE-4-3-1, and the steps are outlined below.

The ranking of the sites was completed by a senior ecologist from the Sudbury area, and relied heavily on best professional judgement. Sites were ranked compared to reference site values for each indicator, as well as professional knowledge of typical values for healthy forest systems in the same ecodistrict.

The application of rankings followed a step-wise process:

1) The indicator results were calculated for each site and compared to the reference sites. Based on this comparison, a rank was assigned to each indicator at each site.

2) Based on the indicator ranks and using best professional judgement, a rank was given to each criterion for each site.

3) Once all criteria were ranked for each site, each test site was evaluated using best professional judgement. For the purposes of evaluating the results of the plant community assessment, each site was ranked according to the following categories:

G	Low to not impacted in comparison to the reference sites	The site was representative of a complete forest ecosystem in that ecodistrict of Ontario.
Y	Moderately impacted in comparison to the reference sites	The site was not representative of a complete forest ecosystem. It was an ecosystem in transition and was showing signs of recovery or decline.
R	Severely impacted in comparison to the reference sites	The site was not at all representative of a complete forest ecosystem, and showed very few signs of recovery.

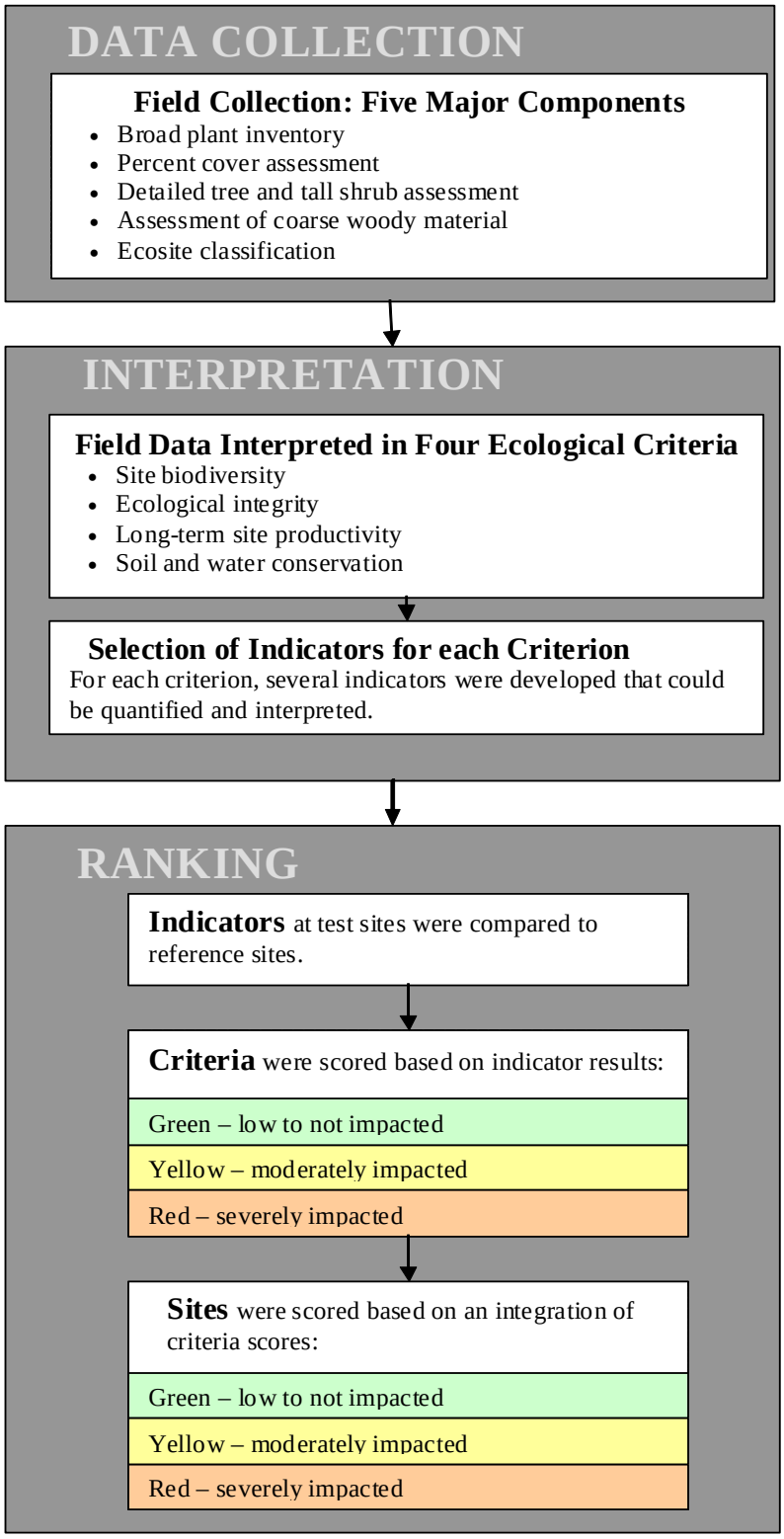


Figure GE-4-3-1 Procedure for the Collection of Data, Interpretation and Ranking of the Plant Community Line of Evidence (LOE)

GE-4-4.0 METHODS

GE-4-4.1 Ecological Criteria and Indicator Framework

The field data collected for the plant community assessment were interpreted in terms of four major ecological criteria:

- Site biodiversity;
- Ecological integrity;
- Long-term site productivity; and
- Soil and water conservation.

The selection of these criteria was based on the biological criteria defined by the Canadian Council of Forest Ministers to measure Canada's progress in the sustainable management of its forests (CCFM, 1995) and on the criteria used to assess biodiversity within Canada's biodiversity strategy, a framework adopted by national and provincial parks, and protected areas (Environment Canada, 2005).

A number of indicators were assigned to each of the four major criteria. The indicators were selected because they were considered to be good descriptors of the relative status of the community with respect to the criteria, they could be measured, they could be used for future monitoring of changes to communities and they were comprehensible to the informed public and policy makers.

The following section provides a description of each of the four major criteria and associated indicators that are summarized in Figure GE-4-4-1.

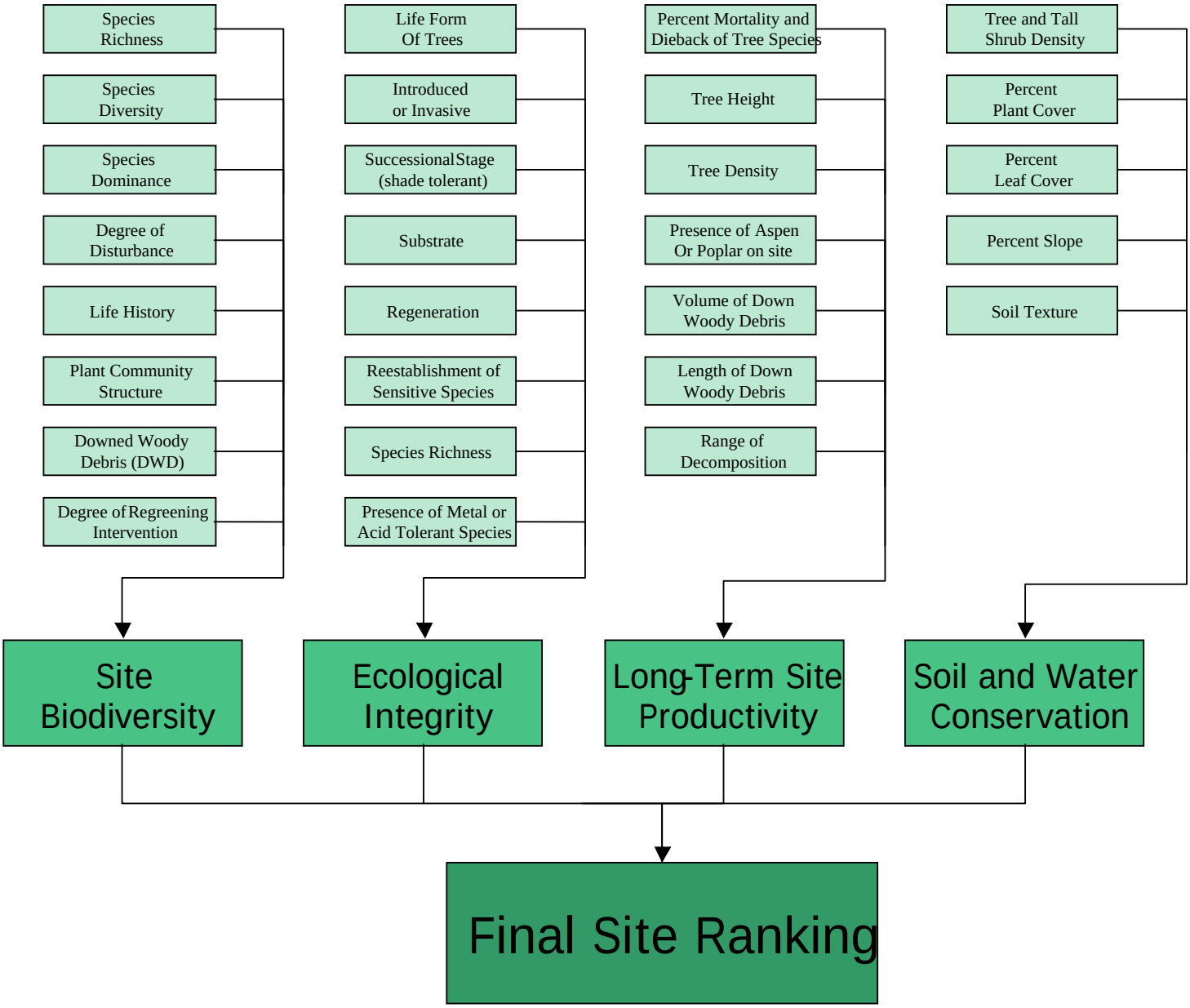


Figure GE-4-4-1 Plant Community Assessment Indicators and Criteria Used for Final Site Ranking

GE-4-1.1.1 Site Biodiversity

This criterion provides a snapshot of the number and distribution of species in the community. As such, it provides a biological index of the current overall status of the community. It does not provide any evaluation of the "quality" of the community in terms of the integrity of the species present or the presence/absence of all components in the community, nor does it provide a strong indication of the sustainability of the community over time. It can act as a rough estimation of the resilience of the community to stresses. In general terms, the greater the diversity, the greater the resilience of the community to external stresses, such as drought, insects and disease (which are often species or species group specific), or severe cold winters with late snowfalls. The maintenance of the variety and quality of plant communities is necessary for the preservation of both plant and wildlife species. Without this diversity, species become vulnerable. Table GE-4-4.1 summarizes the indicators for the site biodiversity criterion.

Table GE-4-4.1 Site Biodiversity: Indicators and the Rationale for Their Use

Indicator	Field Parameter Collected	Interpretation	Rationale
Species Richness	Plant Species List	Number of plant species	In general, the greater the number of species that have successfully established at a site, the greater the resilience of the plant communities to stresses.
Species Diversity	Plant Species List	Shannon diversity index	In general, the greater the diversity of species that have successfully established at a site, the greater the resilience of the plant communities to stresses.
Degree of Species Dominance	Percent Cover Assessment	Identification of species dominating ground cover	If a single species dominates the site, the diversity of other species present is limited.
Life History	Plant Species List	Classifying species as perennials	The increased presence of perennial species is a good index of increased diversity of life cycles in the plant community. Perennials increase the diversity of habitat for wildlife species as compared to a community of largely annual pioneer species whose life histories tend to be less diverse.

Table GE-4-4.1 Site Biodiversity: Indicators and the Rationale for Their Use

Indicator	Field Parameter Collected	Interpretation	Rationale
Plant Community Structure	Plant Species List	Classifying species by strata	As stand structure complexity increases, the diversity of wildlife habitat increases. Increased representation of plants in different strata also reflects increasing diversity in the utilization of the site's resources and tends to increase the resilience of the communities to stresses (*e.g.* drought).
Downed Woody Debris (DWD) Count	Coarse Woody Material Assessment	Frequency of DWD	DWD provides suitable seedbeds for many native species. The material also returns organic matter into the ecosystem, which provides a niche for microflora and fauna, which are indicators of healthy ecosystems.
Degree of Disturbance	Remote Sensing Data	Proximity of site to mapped barren and semi-barren areas	Fire, wind and natural climatic events provide disturbances that increase local diversity in natural systems.
Degree of Re-greening Intervention	Remote Sensing Data	Proximity of site to known disturbed areas and re-greening activity in the region.	In barren and semi-barren areas where re-greening activities (liming, planting, seeding) have occurred, diversity increases as site conditions improve. The modifier for this parameter is that areas outside the barrens and semi-barrens are classified as "not needing intervention" and therefore scoring is not degraded for the absence of treatment at those sites.

GE-4-1.1.2 Ecological integrity

This criterion provides an index of not only the number of different species present in a community but the types of species and their growth habits. For example, ecological integrity takes into consideration the presence or absence of invasive species and the presence or absence of a skewed species distribution (for example, communities where most of the species are in the herbaceous layer and are pioneer species), thereby providing an indication of potentially unusual site conditions. This criterion measures the completeness of the community and the integration among the parts. Table GE-4-4.2 summarizes the indicators for the ecological integrity criterion.

Table GE-4-4.2 Ecological Integrity: Indicators and the Rationale for Their Use

Indicator	Field Parameter Collected	Interpretation	Rationale
Completeness/ Complexity of Ecosystems: Life Form of Trees	Detailed Tree and Tall Shrub Assessment	Percent cover of coniferous species	Evidence of a coniferous component in the community increases the diversity and quality of wildlife habitat. Conifers provide critical shelter in winter, and shade in summer. Conifers are indicators of pre-disturbance forest conditions on the shallow soiled sites of the Sudbury region.
Species Richness	Plant Species List	Number of plant species	In general, increased numbers of plant species suggest the establishment of natural communities. This is tempered by the reality that a variety of "weedy" species on bare soil can increase species richness, but can indicate very early recovery of sites that are unstable.
Completeness/ Complexity of Ecosystems: Introduced and Invasive species	Plant Species List	Number and percent cover of non-native species to Ontario, and cover of invasive species	A high number and/or cover of "weedy," often introduced species, indicates unstable sites with bare soil. Invasive species can displace natural species assemblages that have evolved with associated wildlife over time in a specific area.
Completeness/ Complexity of Ecosystems: Shade Tolerance	Plant Species List	Identification of plant species considered to be indicators of shade tolerance	A higher percentage of shade-tolerant woodland species reflects the degree of recovery of plant communities. Evidence of self-replacement of woodland species in the community indicates that the community will be resilient to natural stresses.
Reestablishment of Sensitive Species	Plant Species List	Identification of lichen and moss species considered to be indicators of good, intermediate, and poor site quality	Evidence of the reestablishment of sensitive lichen and moss species provides an index of recovery. These sensitive species will not survive at sites where air or soil conditions are toxic.
Presence of Acid and Metal Tolerant Species	Plant Species List	Identification of plant species considered to be indicators of acid and metal tolerance	Many young seedlings cannot survive and many plants cannot successfully germinate on sites with very low pH. This provides an indication of the degree to which the site is recovering. On re-greened sites, the maintenance of pH at post-treatment levels reflects the degree to which the site has moved towards a self-supporting system. Heavy metals limit root growth in many species. On very shallow-soiled sites, this limits the ability of these seedlings to survive mid-summer drought. In addition, the silt rich soils are susceptible to frost heave, which often "tosses" out young seedlings, resulting in seedling mortality.

Table GE-4-4.2 Ecological Integrity: Indicators and the Rationale for Their Use

Indicator	Field Parameter Collected	Interpretation	Rationale
Completeness/ Complexity of Ecosystems: Substrate	Percent Cover Assessment	Identification of substrate in plots	Natural communities have a component of downed woody debris in various stages of decomposition and generally support a continuous ground cover. Bare soil and rock surfaces devoid of a bryophyte or lichen cover usually indicate stressed or disturbed sites.
Completeness/ Complexity of Ecosystems: Regeneration	Percent Cover Assessment	Cover of tree seedlings and saplings, and cover of tree species in understory layer	The successful long-term establishment of woody species on a site is reflected in regeneration success (the presence of seedlings and saplings).

GE-4-1.1.3 Long-term productivity

Long-term productivity was selected as a criterion because it takes into consideration how well species are growing on a site and considers whether this growth is sustainable into the future. For example, indications of stresses, such as insects and disease, are considered. In addition, long-term productivity provides insight into the actual growing capacity of the site as reflected in a surrogate for biomass production (height of trees, density of trees and shrubs). It also provides an indication of the availability of organic debris in the community, which provides a slow release of organic-based nutrients. Table GE-4-4.3 summarizes the indicators for the long-term site productivity criterion.

Table GE-4-4.3 Long-Term Site Productivity: Indicators and the Rationale for Their Use

Indicator	Field Parameter Collected	Interpretation	Rationale
Percent Mortality and Dieback of Tree Species	Detailed Tree and Tall Shrub Assessment	Assessment of mortality and dieback in red maple, white birch and red oak	The degree to which white birch, red maple and red oak dieback reflects the stage of recovery. As sites move towards becoming self-sustaining communities, dieback is reduced. The degree of defoliation or dieback can be a result of the combination of insect outbreaks, shallow soils, COC levels or anthropogenic influences and drought. The factors that trigger dieback were not determined for this indicator, just the degree of dieback observed.
Tree Height	Detailed Tree and Tall Shrub Assessment	Average overstory tree height per plot for each species. Estimated height of each specimen of red maple, white birch and red oak.	The height of planted and natural pine, spruce and other trees on the site reflects the productivity of the site. The degree to which red maple, red oak and white birch have broken through the multi-stemmed stunted coppice growth form into tree forms with a single dominant stem also reflects improvements in site productivity.
Tree and Tall Shrub Density	Detailed Tree and Tall Shrub Assessment	Number of trees and tall shrubs per hectare	In general, the more productive the site, the greater the density of trees at the site.
Presence of Aspen or Poplar	Plant Species List	Identify plots where trembling aspen or poplar is present on the site	The presence of poplar or aspen at a site is correlated with more productive site conditions.
Volume of DWD	Coarse Woody Material Assessment	Average volume of DWD along two transects	DWD returns organic matter into the ecosystem, which provides a niche for microflora and fauna. The presence of DWD, unless excessive, is a good indicator of a healthy ecosystem and provides a slowly decomposing source of nutrients.
Range of Decomposition	Coarse Woody Material Assessment	Number of DWD decomposition classes represented on the site	A healthy site will have DWD material in all stages of decomposition.
Length of DWD	Coarse Woody Material Assessment	Lengths recorded for the DWD along two transects	The length of DWD provides an indication of the amount of DWD seedbed available for seedling germination and establishment. It also provides an indicator of the amount of DWD habitat.

GE-4-1.1.4 Soil and water conservation

Soil and water conservation was selected as a criterion because it reflects the integrity of the growing medium at the site. In addition, assessment of this criterion provides an indication of the degree to which water is held on the site to support growth. The properties of the soil define regeneration success potential and may promote or limit growth. These properties include mineral soil texture, soil toxicity and organic matter present at the site. The character of the soil is critical for sustaining the community over time. Water conservation was selected for two reasons: first, if the water is moving along the surface rather than filtering through the soil profile, surface soil loss through erosion degrades the growing medium over time by redistributing the more productive surface soils into valleys or water courses; second, if the water is draining through the profile, it may carry with it elements that might degrade the aquatic systems in the area. Table GE-4-4.4 summarizes the indicators for the soil and water conservation criterion.

Table GE-4-4.4 Soil and Water Conservation: Indicators and the Rationale for Their Use

Indicator	Field Parameter Collected	Interpretation	Rationale
Tree and Tall Shrub Density	Detailed Tree and Tall Shrub Assessment	Number of trees and tall shrubs (1 m high or taller) per hectare	The successful reestablishment of conifers and hardwoods is associated with reduced runoff from the site. In addition to binding the soil, this material contributes to the soil organic matter.
Percent Plant Cover	Percent Cover Assessment	Percentage of plot occupied by plant cover	The degree to which the surface soils are occupied by plant cover indicates reduced risks of soil loss from surface erosion from wind and rain. In addition, this plant material contributes to the soil organic matter through leaf litter fall and at mortality.
Percent Leaf Litter Cover	Percent Cover Assessment	Percentage of plot occupied by leaf litter cover	The degree of leaf litter provides a protective surface cover that reduces surface erosion. In addition, the leaf litter contributes to the organic content of the soil, thereby enriching it.
Soil Texture	Ecosite Classification	Soil texture, % silt, % clay of site soils	Finer-textured silt-rich soils are subject to frost heave in the absence of a vegetative cover. This reduces the success of early germination and establishment. These soils are also subject to surface soil erosion.

Table GE-4-4.4 Soil and Water Conservation: Indicators and the Rationale for Their Use

Indicator	Field Parameter Collected	Interpretation	Rationale
Percent Slope	Ecosite Classification	Estimated % slope at site	Steeper-sloped terrain increases the risk of surface soil erosion and surface water runoff. The loss of more productive surface soils reduces site productivity. Surface runoff reduces the quantity of rainfall that enters the soil.

GE-4-4.2 Data Analysis

The following section describes the approach used to analyse the numerical data collected in the field for each of the indicators. The indicators are arranged according to the ecological criterion that they support. The rationale by which the indicators were ranked is presented in Appendix GE-4-B. An explanation of how the indicator ranks were integrated to obtain the criterion ranks is provided in Section GE-4-4.2.

GE-4-4.2.1 Site Biodiversity

Species Richness

The data used to assess species richness was obtained from a master plant species list that consisted of presence/absence data. The actual tally sheets are provided in Appendix GE2. Data from Tally Sheet 1, containing presence and absence data for all plant strata along the four 50 m transects, were combined with species presence from Tally Sheets 2 and 3. Therefore, any plant species recorded in the percent cover or tree/tall shrub assessments that were not included in the broad plant inventory were also considered.

The number of different plant species was summed to give a total species richness for each species group (trees, tall shrubs, low shrubs, graminoids, herbs, pteridophytes, bryophytes, and lichens), and then to obtain overall species richness at each site. Any unknown species, or species identified only by genus, were counted as an additional species.

In addition, species richness excluding particular plant groups was also examined. For example, species richness without bryophytes or lichens was considered, as this is the most common approach in the literature and allows for the comparison of values with other studies. Also, species richness without the graminoids or lichen species groups was considered. High numbers of graminoid and lichen species are

often found at open, disturbed sites, and can increase overall species richness values to apparently healthy levels.

Species Diversity

For the purposes of analysis, species diversity was calculated for four different species assemblages:

1. All species;
2. All species except cryptogams (bryophytes and lichens);
3. Tree and shrub species (presence/absence data); and
4. Tree and shrub species (stem count data).

Data for the first two analyses were obtained from Tally Sheet 2, which records the percent cover of all plant species in twenty-five 1 x 1 m quadrats. The frequency of occurrence was calculated for each species by counting the number of 1 x 1 m quadrats in which each species was recorded.

A separate analysis was performed for tree and tall shrub species because the percent cover assessment was not designed for these plant forms. Data for the third analysis were obtained by combining presence/absence data from the tree and tall shrub plots (Tally Sheets 3a and 3b), where the frequency of occurrence was considered based on a total of four 10 x 10 m plots (two from Tally Sheet 3a, two from Tally Sheet 3b). For the fourth analysis, the data were obtained from Tally Sheet 3a, where the total number of specimens per species in both sampling plots was counted, and this frequency of occurrence was considered in terms of the overall number of specimens in the two 10 x 10 m plots.

Species diversity was calculated using the Shannon Weiner Diversity Index:

$$H' = -\sum_{i=1}^{S} p_i \operatorname{Log} p_i$$

where H' is the Shannon Index of diversity and p_i is the proportion of the sample represented by species i.

This version of the index was chosen because it is commonly used, and therefore comparisons could be made with other published literature on other ecosystems, if required at a later date. An assumption made for this analysis was that all species were considered equally important.

Some sites with high diversity indices may have under-representation of specific species groups (*e.g.*, few herbs, few shrubs) and overrepresentation of specific groups (primarily herb or lichen species). These communities may not be resilient to environmental stresses, as the entire plant group may respond in a similar fashion to environmental stresses. For example, the shallow rooting systems of many herbs may leave an herb-dominated site prone to rapid mortality from drought. Also, the sensitivity of many lichen species to the deterioration of site quality may lead to massive mortality of this layer. In addition, the value of lichen and bryophytes to the development of resilient natural forest communities, and to the support of a broad and diverse wildlife population may be limited, although it is poorly understood. These types of diverse sites may still be at risk in terms of their ability to develop into self-sustaining, complex natural communities.

Species Dominance

The data used to assess species dominance at each site were obtained from Tally Sheet 2, which contains the percent cover of all plant species in twenty-five 1 x 1 m quadrats. For each plant species, the total percent cover was calculated across all quadrats in the following manner:

- The percent cover from each quadrat was summed for each species;
- The average percent cover for each species was calculated; and
- The species with the highest average percent cover was noted.

Life History (Perennial Analysis)

All species from the master plant species list (described above in species richness) were categorized as perennial or non-perennial species (annuals, biennials, *etc*.) by a senior ecologist. The list of species and their classifications is found in Appendix GE-4-A of this report. Lichens and bryophytes were not included in the analysis. The percentage of perennial species found on all sites was then calculated using the following formula:

$$\text{Percent Perennial Species} = \frac{\text{Number Perennial Species}}{\text{Total Number of Species}} \times 100$$

Where possible, all species were assigned to a category (perennial or non-perennial). For instance, the literature was examined for species identified only to genus, and if all species within that genus had the same life history, the species was assigned to a category. Similarly, for some unknown species, assignment to a category was possible (*e.g.*, an unknown shrub could still be placed in the perennial

category). A conservative approach was taken with respect to remaining species that were unknown, incompletely identified, or where life history was not clear from the literature, by considering them as non-perennials.

Plant Community Structure (Strata Analysis)

The data utilized to evaluate community structure were obtained from the master plant species list (described above in species richness). The plants were categorized into the following strata:

- Trees;
- Tall Shrubs;
- Low Shrubs;
- Forbs (Herbs + Pteridophytes + Graminoids); and
- Cryptogams (Lichens + Bryophytes).

The list of species and their strata classifications is found in Appendix GE-4-A. The total number of strata represented at each site was counted. In addition, the number of species found in each stratum was considered during interpretation.

Downed Woody Debris Count

The data used to evaluate downed woody debris (DWD) at all sites were obtained from Tally Sheet 4, which assessed DWD along two transects at each site. The number of pieces of DWD located along the two transects was totalled.

Abundant downed woody debris (DWD) on the forest floor provides a variety of seedbed conditions for vascular plant germination and for the establishment of select mosses. It also increases the amount of organic matter present to support fungal, microflora and faunal populations that may rely on this medium.

Degree of Disturbance

Remote sensing data collected specifically for the Sudbury Soils Study were used for this analysis. Information included data provided by the City of Greater Sudbury, which were used to determine site proximity to previously mapped areas of significant disturbance. Parameters collected included the following:

- Whether or not each site was within 100 or 1,000 m of a known semi-barren area; and

- Whether or not each site was within 100 or 1,000 m of a known barren area (Copper Cliff, Coniston, or Falconbridge barren areas).

Degree of Re-greening Intervention

Remote sensing data collected specifically for the Sudbury Soils Study were used for this analysis. Data were provided by the City of Greater Sudbury and were used to determine site proximity to previously mapped areas of re-greening effort (up to the year 2003), including the following:

- Whether or not each site was within 100 or 1,000 m of a known area of tree planting;
- Whether or not each site was within 100 or 1,000 m of a known area of liming;
- Whether or not each site was within 100 or 1,000 m of a known area of tree planting and liming; and;
- Whether or not each site was within 100 or 1,000 m of a change in Normalized Difference Vegetation Index (positive or negative).

The Normalized Difference Vegetation Index (NDVI) is a spectral index method used to quantify vegetation change. The NDVI provides a means of inferring the presence of vegetation by utilizing a unique relationship between vegetation physiology and its reflectance property. The value of NDVI has no unit, has a range of -1 to 1 and standardizes the mapping of vegetated and non-vegetated surfaces.

GE-4-4.2.2 Ecological Integrity of Site

Completeness/Complexity of Ecosystems: Life Form of Trees (Conifer Cover Analysis)

The data used to evaluate the life form of trees were obtained from Tally Sheet 3a, which assessed tree and shrub communities at each site. The percent cover of all conifer species in both plots was totalled separately for the canopy and the understory to provide the overall percent cover of conifer at the site in each layer.

Species Richness

The same process used to assess the species richness in the ‘site biodiversity’ criterion was used; refer to the site biodiversity section above.

Completeness/Complexity of Ecosystems: Introduced and Invasive Species

Classifying all vascular plants as native or non-native to Ontario estimated the impact of introduced species on the ecological integrity of the sites. Lichens and bryophytes were excluded from this analysis.

Species identified only to genus were placed in an "unknown" category if there were both native and non-native species present in Ontario.

Two different approaches were used to assess the effect of introduced species on the ecological integrity of the site, the frequency and percent cover of each species, both of which were calculated as follows:

- Frequency: the data for this evaluation were obtained from the master plant list (described above in site biodiversity: species richness). The numbers of native, non-native, and unknown species were totaled at each site.
- Cover: the data for this evaluation were obtained from Tally Sheet 2. The percent ground cover for introduced, native and unknown species was totaled.

In addition, the percent cover of some native grasses was considered separately. Grass species that are native to Ontario, but considered by a senior ecologist to be invasive, were considered in the interpretation of this indicator. The list of species and their classifications is found in Appendix GE-4-A of this report.

Completeness/Complexity of Ecosystems: Shade Tolerance

Two senior ecologists from the Sudbury area selected a list of plant species considered to be good indicators of shade tolerance. The list of species and their classifications is found in Appendix GE-4-A. The number of indicator species found per site was then calculated using data from the master species list.

Reestablishment of Sensitive Species

Two senior ecologists from the Sudbury area selected a list of lichen and bryophyte species considered to be good indicators of different classes of site quality. These species were grouped according to their indications of good, intermediate, or poor conditions. The list of species and their classifications is found in Appendix GE-4-A. The presence/absence data in the master plant species list were then analyzed to identify the number of indicator species in each category at each site.

Presence of Acid and Metal Tolerant Species

Two senior ecologists from the Sudbury area selected a list of plant species considered to be good indicators of acid and metal tolerance. The list of species and their classifications is found in Appendix GE-4-A. The presence/absence data in the master plant species list were then analyzed to identify the number of indicator species at each site.

Completeness/Complexity of Ecosystems: Substrate Analysis

The data used for the substrate analysis were obtained from Tally Sheet 2. The average percent cover of bare rock and bare soil was calculated. Cover of bare rock and bare soil were summed to also give the total percent cover of mineral substrate. Although a rough assessment of these parameters was also made during the ecosite classification process, data from the ground cover assessment were considered more reliable.

Completeness/Complexity of Ecosystems: Regeneration Success

The regeneration success of woody species was evaluated two ways:

1. Mean percent ground cover of tree species (seedlings and saplings, all species combined) in the 1 x 1 m quadrats (Tally Sheet 2); and
2. Mean percent cover of tree species (all species combined) found in the understory of the first set of 10 x 10 m plots (Tally Sheet 3a).

GE-4-4.2.3 Long-term Site Productivity

Percent Mortality and Dieback of Tree Species

The data utilized to evaluate tree mortality were obtained from Tally Sheet 3b, which assessed tree and shrub mortality and dieback. Overall percent dieback was calculated individually for red maple, white birch and red oak. Percent dieback was calculated as follows:

$$\text{Percent Dieback} = \frac{\text{\# Dead Stems}}{\text{Total \# of Stems}}$$

Therefore, the percent dieback calculation per species included counts for the stems of that species only. For total percent dieback at the site, the stem counts for the three species were combined. In addition, the visual estimate of crown dieback for trees in the plots was considered, and snags (with species identification if possible) were enumerated.

Tree Height

Tree height was analyzed using two approaches. The first analysis calculated the mean height of white birch at each site, using data obtained from Tally Sheet 3a. The geometric mean height of all white birch trees in the canopy layer (and over 2 m in height) at each site was calculated. In the instance that no white

birch trees were present at a site, the most abundant tree species was used in the calculation. For the second analysis, the height range for all tree species was calculated using data from Tally Sheet 3b; the minimum and maximum tree height for each species was recorded. The maximum height reported for any tree species, obtained from Tally Sheet 3b, was the most used index for indicator ranking.

Tree and Tall Shrub Density

The data utilized in tree height evaluation were obtained from Tally Sheet 3a. The numbers of trees and tall shrub specimens present in both 10 x 10 m plots were totalled. This total was then converted to translate into the number of trees and tall shrubs present per hectare.

Presence of Aspen or Poplar

The data required for the evaluation of the presence of *Populus* species was obtained from the master plant list (described in Site Biodiversity: Species Richness Section) and Tally Sheets 3a and 3b. A list of sites where *Populus* species were present was first created. Where *Populus* species were present, their mean height (from Tally Sheet 3a) and/or height range (from Tally Sheet 3b) were determined. Availability of these measurements depended on whether or not the *Populus* species were recorded in either or both sets of 10 x 10 m plots.

The degree to which poplar (*Populus grandidentata, P. tremuloides or P.balsamifera*) grow on the site may provide an indicator of the degree of "calcium pumping" from deeper soil depths into plant material, which is later deposited to the soil surface in poplar foliage and, to a minor degree, from the deposition of bark material in downed woody debris.

Volume of Downed Woody Debris

Data for the calculation of the volume of downed woody debris (m^3/ha) were obtained from Tally Sheet 4 and used in the following equation from Van Wagner (1968):

$$V = \frac{\pi^2 \sum d^2}{8L}$$

Where V is the volume of DWD per unit area (m^3/ha), d is a diameter (cm) of a log recorded along the transect line, L is the length (m) of transect line, and the sum is taken over all logs recorded along the transect line. Volume was calculated separately for each decay class and for two species groups—deciduous and coniferous. If the species of the log was not available, the log was assigned to the same

group as the dominant species in the plot. For example, if the dominant species for the plot was white birch, then a log of unknown species was placed in a respective decay class of white birch.

No distinction was made between stumps and logs. All 'pieces' of DWD were treated as logs when applying the formula. Each transect line was treated as an independent replicate. The results for each plot were then averaged over two transect lines.

Range of Decomposition

The data required for the analysis of the range of decomposition of DWD at each site were obtained from Tally Sheet 4. The total number of decomposition classes represented at each site was determined from summing the classes present along both transects.

Length of Downed Woody Debris

For this analysis, DWD pieces were sorted into two categories: recent DWD (Class 1 + Class 2 decomposition classes), and well decomposed (Class 3 + Class 4 + Class 5). The lengths of all DWD pieces were averaged within these two categories, with the minimum and maximum lengths also taken into consideration. The average lengths calculated from each category were summed to provide an index of DWD length.

The length index of DWD provides an indication of the amount of habitat provided at this site for seedbed and the amount of nutritional medium for microflora and fauna. Both of these factors influence long-term site productivity. The range of species and decomposition classes provides a productive habitat for wildlife (small mammals, micro-organisms, fungi, invertebrates) and serves as favourable seedbed for many forest plant species, thereby contributing to the maintenance of site productivity. This material also contributes to the integrity of the nutrient cycling system in the forest, thereby contributing to the maintenance of the soil/vegetation system.

GE-4-4.2.4 Soil and Water Conservation

Tree and Tall Shrub Density

Data from Tally Sheet 3a were used to assess tree and tall shrub density. The numbers of tree and tall shrub specimens (1 m or more in height) in the two 10 x 10 m plots were summed, and then converted to number of specimens per hectare.

Percent Plant Cover

The data required for the percent plant cover evaluation were obtained from Tally Sheet 2. The average percent ground cover provided by trees, tall shrubs, low shrubs, herbs, graminoids, fern and fern allies, lichens and bryophytes was calculated to provide an estimate of ground plant cover for the site. In addition, the percent covers for bare soil and leaf litter were also taken into consideration during interpretation. The estimated percent bare soil was subtracted from 100% to provide an estimate of the total possible vegetated cover. The total percent cover of all plant groups was added to the percent cover of leaf litter to provide a sum of percent plant material cover. This information was used to create a Surface Soil Retention Index, which was the most conservative percent cover between 1) total possible vegetated cover, and 2) total estimated plant material cover.

The greater the surface plant cover, the greater the protection of the surface soils from surface water erosion. In addition, plants take up high volumes of near-surface soil water for growth and survival, thus reducing losses through the soil profile.

Percent Leaf Litter Cover

The data used for the percent leaf litter cover were obtained from Tally Sheet 2. The average percent ground cover from leaf litter was calculated from the data collected for the twenty-five 1 x 1 m quadrats.

Thick leaf litter can provide protection of surface soils from erosion, in addition to providing a source of organic matter that is integrated into the surface soils.

Soil Texture

The soil texture (as well as the percentage of sand, silt, and clay, individually by weight) was obtained from analysis by the Soil and Nutrient Lab at the University of Guelph. Analytical methods are found in Appendix GD2.

Percent Slope

The data used for this analysis were obtained from the ecosite classification (Tally Sheet 5). A visual estimate of the percent slope and a written description of the terrain were used during interpretation.

Surface soil erosion losses are lower in level terrain.

The percent silt and percent clay values were summed to provide an index for interpretation. Finer textured soils are more susceptible to surface soil erosion and soil loss through wind erosion.

GE-4-4.3 Data Ranking for Integration

Using the methods and approach outlined in the previous sections, each test site was evaluated to determine whether it was impacted or not. For the purposes of evaluating the plant community, each site was ranked. The following colour code was used for the different impact categories:

G	Low to not impacted in comparison to the reference sites	The site was representative of a complete forest ecosystem in that Ecodistrict of Ontario.
Y	Moderately impacted in comparison to the reference sites	The site was not representative of a complete forest ecosystem. It was an ecosystem in transition and was showing signs of recovery or decline.
R	Severely impacted in comparison to the reference sites	The site was not at all representative of a complete forest ecosystem, and showed very few signs of recovery.

The ranking of the sites was completed by a senior ecologist from the Sudbury area, and relied heavily on best professional judgement. Sites were ranked compared to reference site values for each indicator, as well as professional knowledge of typical values for healthy forest systems in the same ecodistrict.

Considerable effort was made to create strategies for ranking based on several methods for comparison purposes. These methods were meant for preliminary screening purposes and are presented in Appendix GE-4-B of this report, but it is important to note that expert opinion sometimes outweighed them.

The application of rankings followed a step-wise process:

1) Indicators were selected which represented four ecological criteria: site biodiversity; ecological integrity; long-term site productivity; and soil and water conservation.

2) The indicator results were calculated for each site and compared to the reference sites. A rank was assigned for each indicator at each site. A different process was used to rank each indicator. The details of the ranking process for each indicator are presented in Appendix GE-4-B.

3) Using best professional judgment, a rank was given to the criterion itself for the site, based on the indicator ranking results. Ecology experts considered the ranks given to the indicators, as well as their impression of the condition of the site to assign criteria ranks.

4) Once all criteria were ranked for each site, each test site was evaluated using best professional judgment to determine whether it was impacted or not. For the purposes of evaluating the results of the plant community assessment, each site was ranked:

Rank		Description
Green	Low to not impacted	The site was representative of a complete forest ecosystem in that Ecodistrict of Ontario.
Yellow	Moderately impacted	The site was not representative of a complete forest ecosystem. It was an ecosystem in transition and was showing signs of recovery or decline.
Red	Severely impacted	The site was not at all representative of a complete forest ecosystem, and showed very few signs of recovery.

Once all indicators were ranked for each site, a set of four separate word documents were set up for each site, containing one table for each criterion. For example, the site biodiversity table for CC-01 would be found in a separate document from the ecological integrity table for CC-01. This enabled the ecologist to concentrate on only the ranked indicators for one criterion, and one site at a time. Using best professional judgement, a ranking was given to the criterion itself for the site, based on the indicator ranking results. The process was undertaken on a criterion-by-criterion basis, instead of a site-by-site basis, to minimize any bias from previous criteria ranking results for that site.

Once all criteria were ranked for each site, another document was set up for each site. One table containing the four ranked criteria was contained in the document, to allow the ecologist to concentrate on one site at a time. Using best professional judgement, each site was given an overall ranking.

GE-4-5.0 REFERENCE SITE EVALUATION

The reference site evaluation assessed whether the ecological community at each of the reference sites could be considered "typical" of the Sudbury region, and self-sustaining. This determined whether the reference sites could be used as comparisons for the test sites. If the plant community at a reference site was considered natural of the region and self-sustaining, then the test sites could be reasonably compared to these conditions to determine whether the test site plant community was impacted.

Each reference site was evaluated in terms of the ecological criteria and indicators to determine whether they fell within the range of plant communities typifying the Ministry of Natural Resources Ecodistrict 5E4, in which Sudbury is situated.

The following section provides a general plant community description for each reference site, followed by a comparison to the four criteria. The three reference sites are discussed together to determine whether they are representative of typical natural plant communities found in northeastern Ontario. The results of the data analysis for all indicators for the reference sites are provided in Appendix GE-4-C of this report. Detailed descriptions of the reference sites are provided in Appendix GE-4-D of this report.

Following a discussion of the Reference sites, detailed descriptions are provided for each test site, along with site rankings.

GE-4-5.1 REF-02

Ecosite: White birch – balsam fir/ bracken fern deep loam community

Subdominant Community: N/A

Figure GE-4-5-1 Photograph of REF-02

General Community Description

This white birch – balsam fir/bracken fern forested community had a closed canopy on 95% of the site. Tree canopy was measured at a maximum of 14 m. Balsam fir (*Abies balsamea*) formed the understory, with some evidence of white birch (*Betula papyrifera*) regeneration. Low sweet blueberry (*Vaccinium angustifolium)* was present in the low shrub/forb layer, together with forest herbs, including bluebead lily (*Clintonia borealis)*. Eastern bracken fern (*Pteridium aquilinum*) was common at this site. The moss layer

was dominated by Shreber's moss (*Pleurozium schreberi)* with patches of common haircap moss (*Polytrichum commune)* growing in the openings. Monk's hood lichen (*Hypogymnia physodes*), a species commonly found on bark, was also present growing on the rock and among the moss of this mixed wood community.

The site was fully occupied with no bare mineral soil or bedrock. The site consisted of deep loam soils on undulating terrain (average slope 20%). The silt content of the soils was very high at 49%, with 8% clay.

GE-4-5.2 REF-03

Ecosite: Red pine/ fly honeysuckle shallow loam community

Subdominant Community: Poplar lowland community

Figure GE-4-5-2 Photograph of REF-03

General Community Description

This red pine (*Pinus resinosa*) forested community had a closed canopy on 95% of the site, with a tall shrub canopy dominated by red-berried elder (*Sambucus racemosa* ssp. *pubescens*). Canopy height was measured at 8 m. Minor components of white spruce (*Picea glauca*) and white birch (*Betula papyrifera*) occurred in the tree canopy. The low shrubs, bush honeysuckle (*Diervilla lonicera*) and flowering

raspberry (*Rubus odoratus*), were growing with drooping wood sedge (*Carex arctata*), and the forest herb, star-flower (*Trientalis borealis*), was abundant in the shade.

A subdominant lowland poplar community occurred on 40% of the site. Trembling aspen (*Populus tremuloides*) dominated the canopy of this community, with speckled alder (*Alnus incana* ssp. *rugosa*) and Canada fly honeysuckle (*Lonicera canadensis*) in the understory. The forb layer in this subdominant community was dominated by the sedges, pointed broom sedge (*Carex scoparia*) and fringed sedge (*C. crinita*), along with interrupted fern (*Osmunda claytonia*), and spinulose wood fern (*Dryopteris carthusiana*). Moss (*Brachythecium* sp.) grew on the woody debris at the site. Low sweet blueberry (*Vaccinium angustifolium*) was noticeably absent at this site.

The site was fully occupied with no bare mineral soil or bedrock. The site consisted of moderately deep (30–60 cm) loamy soils on level terrain (average slope 5%). The silt content of the soils was very high at 50%, with less than 10% clay.

GE-4-5.3 REF-04

Ecosite: Red pine/ blueberry – bracken fern moderately deep silt loam plain community

Subdominant Community: N/A

Figure GE-4-5-3 Photograph of REF-04

General Plant Community Description

This red pine (*Pinus resinosa*) community had a closed canopy on 85% of the site with a red maple (*Acer rubrum*), low sweet blueberry (*Vaccinium angustifolium*) and eastern bracken fern (*Pteridium aquilinum*) understory. Associated tree species included white pine (*Pinus strobus*) with minor components of white

birch (*Betula papyrifera*), balsam fir (*Abies balsamea*) and white spruce (*Picea glauca*). Forest understory species, including bunchberry (*Cornus canadensis*), wild lily-of-the-valley (*Maianthemum canadense*) and the moss *Dicranum polysetum* occurred at the site. The lichen *Cladina rangiferina* had established in the partial shade. Grasses were absent. Red pine achieved a maximum height of 14 m.

The site was fully occupied with no exposed mineral soil and only negligible occurrences of bare bedrock. The site consisted of silt loam soils on level terrain (average slope 5%). The soils were heterogeneously distributed across a range of very shallow to moderately deep depths. The silt content of the soil was extremely high at 70%, with an additional 25% clay content.

GE-4-5.4 Summary of Reference Site Results

Site biodiversity was rated high at all three reference sites, as reflected by high species diversity, high species richness, the absence of any dominance by a single species or small group of species, and the completeness in horizontal stand structure. A reasonable number of plant species were reported in each stratum, and there were no species that dominated any of the sites or created a risk in terms of excessive competition for the normal suite of woodland plant species for this ecodistrict. Fires and land clearing are known to occur in the area of all three sites, but there was no mapped or observed evidence of recent disturbances at any reference site.

Ecological integrity was also rated high at all three reference sites. A well-developed conifer component was present in each community, providing good summer and winter habitat to support diverse wildlife populations in this region, where openings and deciduous cover is abundant. There were only a few species tolerant to high metals, acidity, or poor site quality. There were a very high number of shade tolerant species at each site, indicating that the plant cover is well established on much of each of the sites. The regeneration of trees in the understory was not always high, but this is common in the dense shade of conifer forest communities.

There did not appear to be any evidence of risks to long-term site productivity at any of the reference sites. Each site supported a continuous plant cover and a dense tree and shrub layer that achieved good height growth. The communities were relatively young, with little evidence of major self-thinning and no evidence of dieback or mortality. Where the hardwood component was currently lacking at a reference site, evidence of past white birch and poplar on the site suggest that this reflects the current successional stage of the community. Periodic disturbances from wind, fire, or natural mortality with aging will lead to the re-establishment of deciduous species. Generally, the presence of downed woody debris in relatively

large quantities and at various stages of decomposition suggests that the nutrient cycling system was functioning well. In addition, the presence of this material on the forest floor provides a raised and moist seedbed for the reestablishment of tree seedlings, should any forest openings be created through natural disturbances. This woody material also added to the diversity of wildlife habitat, thereby contributing to sustaining overall site productivity.

In addition, each site was in good shape with respect to soil and water conservation. The erosion-prone silt-rich soils were protected by a continuous forest floor plant-and-litter cover and a well-established tree and shrub cover. Sufficient organic material was being added to the sites from the standing vegetation and its associated leaf litter to sustain soil quality.

All reference sites displayed many of the characteristics of a resilient plant community. Overall, the relative ecological status of all three communities was high.

GE-4-5.5 Comparisons among Reference Sites for the Four Criteria

The three reference sites were located in three very different plant communities growing on different terrain. One community was a mixed white birch/balsam fir community (REF-02) growing on deep loam-textured soils on undulating terrain (20% slope). The plant communities at the other two reference sites (REF-3 and REF-04) were red pine conifer communities growing on level terrain (<5% slopes). Even these two pine communities were quite different. REF-03 was a mosaic of red pine on 60% of the site, occupying the drier, shallower-soiled sections and poplar growing on 40% of the moister, deeper soiled areas. In contrast, REF-04 was an upland red pine/blueberry/bracken fern community growing on very shallow soils among bedrock outcrops. The silt-loam texture of the soils at REF-04 was different from the loam-textured soils of REF-02 and REF-03.

Site Biodiversity

With respect to species richness, REF-02 had the lowest value (64) overall and for vascular species only (47). REF-04 had the highest species richness score (90) overall but was intermediate for vascular species (53) compared to 63 for REF-03. The lichen community was extremely rich (22 species) in REF-04, suggesting that this reference site may be a good reference site for comparing to the shallow soil over bedrock test sites. In contrast, the other two sites were closed canopy forested communities.

REF-02 had the lowest overall species diversity indices. However, it had the highest score if only vascular species are considered. It also had the lowest score (0.94) if only trees and shrubs were considered.

Species richness values were far lower than at the other two sites (1.39, 1.45). REF-04 had highest overall site diversity, but it had the lowest index if only vascular species were considered.

All of the reference sites consisted of over 98% perennial species and had plants in all five vertical layers. REF-02 had the lowest percentage of plants in the tall shrub layer but was intermediate for numbers of species in other layers. REF-03 had the lowest percentage of trees, low shrubs and mosses/lichen.

DWD pieces (9, 9 and 10) were similar in all of the reference sites. As such, they provide a stable suite of plots for comparison of this parameter. One of the limitations of the sites was that the stands were relatively young and as such, do not display a wide range of debris in terms of sizes, species and degree of decomposition.

Bracken-fern was dominant in both REF-02 and REF-04 but varied from 15% cover in REF-02 to 6% in REF-04. Goldthread (*Coptis trifolia*) was dominant in REF-03 but occurred in patches.

Ecological Integrity

There were similarities among the reference sites for a few parameters. All of the plots had 89 to 96% conifer cover, although the species varied from balsam fir to red pine, which have very different ecological characteristics. The presence of non-native and invasive species was not an issue at any of the plots. One to three non-native species were reported at the reference sites, none of which were known invasive species. Grasses were present at each of the plots, but the cover was not extensive at any of the plots, consistent with what one would expect in forested communities. The number of shade tolerant plant species present at each site was fairly consistent, ranging from 11 species at REF-02 to 15 at REF-04. Each of the plots was also completely occupied by a ground cover.

In contrast, the reference sites displayed very different characteristics for a number of indicators. Understory tree regeneration was very different at REF-03, where it was less than 6%. In contrast, tree regeneration was very high at REF-02 and moderate at REF 04, ranging from 4% along the transects to 27% in the forest plot.

The reference sites also varied in terms of the presence of “good site” indicators (species that indicate relative health at a site, due to their sensitivity to poor growth conditions), with only 4% at REF-02 compared to 7% and 8% at the other two reference sites. REF-02 is not considered to be representative of an “undisturbed” community for this indicator. Similarly, the numbers of acid and metal tolerant plant species varied among the reference sites with a high of 10 species reported for REF-04 and eight at REF-

02 compared to only four at REF-03. Due to the high number of acid and metal tolerant species, REF-04 is not considered a strong reference site when looking at this indicator. The median value of the three reference sites was used as the index for this parameter.

Long-term Productivity

A high value of 27% dieback was reported at REF-02 compared to "no dieback" at the other two reference sites (which are largely conifer). REF-02 was not used as a good index for this indicator.

Tree heights ranged from a low of 8 m at REF-03 to 14 m at the other two reference sites. The 8 m height probably reflects a younger stand.

Tree density was very high at REF-02 (13,300 stems/ha) in contrast to moderate numbers at the other two reference sites (3,550 and 3,850).

The presence of poplar at the conifer-dominated reference sites suggests that the sites had relatively productive soil conditions.

The volume of DWD displayed a very wide range at the reference sites, with a value of 4 m^3/ha at REF-03 compared to a value of 187 m^3/ha at REF-04. REF-03 was not used for this indicator, the assumption being that the stand was very young and had not reached a self-thinning stage. An index for the length of DWD similarly displayed a wide range in numbers from a low of 363 cm at REF-04 to a high of 1171 cm at REF-02. The number of classes for decomposition also varied from a low of two at REF-03 to a high of four at REF-02. This may reflect natural variability and the limited sample size (up to four transects per site).

Soil and Water Conservation

REF-03 had the lowest density of trees per ha but was similar to REF-04. REF-03 had an exceptionally high density of trees per ha. As such, this may not have been the best reference site to use for this indicator. At all three reference sites, the surface soil retention index (incorporating both ground plant cover and leaf litter) was 100, indicating low potential soil loss.

REF-02 was located on undulating terrain in contrast to the other reference sites, which occurred on level terrain. When comparing the reference sites to the test sites, one needs to consider that many of the test sites occur on rolling terrain with much steeper slopes. Soil textures at the reference sites were similar to

those of the test sites and all displayed relatively high silt contents. Thus, the reference sites were reasonable for comparisons of soil texture.

Summary

Overall, the reference sites provided a reasonable basis for comparison for the majority of the indicator values for the test sites. However, different sites displayed values for selected criteria that were not representative of modal conditions, for example,

- REF-02 supported an extremely high density of stems/ha for trees and shrubs;
- REF-03 had extremely low volumes of downed woody debris;
- Tree height values were at times difficult to use as it was unknown if the trees had reached maturity or were still in the development stage; and
- Similarly, DWD values were so variable that not all plots provided what was thought to be reasonable values for "desirable" condition. The one young jack pine stand was not of an age to produce large amounts of DWD.

In addition, the plant communities varied between the reference sites, and not all test site conditions were represented. For example, in retrospect, it would have been useful to have a reference site in an upland white pine community growing on shallow to moderately deep undulating to rolling terrain.

Nevertheless, the reference sites provide satisfactory baseline conditions for the range of plant communities typifying the Ministry of Natural Resources Ecodistrict 5E4, in which Sudbury is situated. This ecodistrict is a transition vegetation zone where inclusions of boreal jack pine, balsam fir and spruce forest elements mix with Great Lakes St. Lawrence Forest hardwoods and mixed-forest elements. These reference sites do emphasize, however, that not every indicator has to be rated high for a plant community to be natural and self-sustaining.

GE-4-6.0 TEST SITES RESULTS

The results of the data analysis for all indicators for the test sites are provided in Appendix GE-4-C of this report. Detailed descriptions of the test sites are provided in Appendix GE-4-D of this report. Site descriptions and overall rankings are summarized below.

GE-4-6.1 CC-01

Ecosite: White birch – *Pohlia nutans* loam barrens community

Subdominant Community: N/A

Figure GE-4-6-1 Photograph of CC-01

General Community Description

This white birch – *Pohlia nutans* barren community was characterized by widely scattered, stunted white birch coppice clumps growing in a largely moss-dominated landscape. Tree cover accounted for

approximately 20% of the cover at the site. The relatively sparse tree cover, entirely composed of stunted white birch (*Betula papyrifera*), was largely present as multi-stemmed clumps reaching heights of less than 2 m; however, a few individual trees had reached a maximum height of 5 m. The lower shrub layer was comprised of scattered patches of low sweet blueberry (*Vaccinium angustifolium*) and clumps of sweetfern (*Comptonia peregrina*). The forb layer at the site was dominated by the potentially invasive common hairgrass (*Deschampsia flexuosa*), which occured at scattered locations in partial shade. The stress-tolerant moss, *Pohlia nutans*, which helps define the community, formed extensive mats across the site.

Approximately 14% of the ground at this site consisted of exposed mineral soil and bedrock based on the 1 x 1 m quadrat ground cover assessment. A visual estimate of percent bedrock on the overall site was 20%. The soils were predominantly moderately deep loams with no surface Ah layer. The terrain is level (average slope <5%). The silt content of the soils was high at 41%, with 8% clay.

Summary for the Four Criteria

CC-01 displayed many of the characteristics of a stressed plant community. Overall, the relative ecological status of this community was low. Biodiversity was low, reflected by moderately low species richness, low species diversity, and the low numbers of species present in several strata layers. The open conditions favoured the growth of low sweet blueberry, a species which is tolerant of open, acidic, nutrient poor conditions and can survive in areas where metals in the soil are higher than background levels. Its dominance on almost half of the site could limit the opportunity for other species to establish. In addition, the community was growing close to or within the semi-barren area of the Copper Cliff stacks, associated with the presence of a small number of species that are tolerant of the industrial conditions. Despite the proximity to tree planting and liming areas, changes in the vegetation cover at CC-01 were not detectable on the remote sensing analysis of plant cover for the Sudbury Region.

Ecological integrity was also scored low for this site. Coniferous species were completely absent in the community, which may also reflect a gap in wildlife species that rely on a conifer component to survive. A high number of species present are known indicators of metal and acid tolerance, which indicates that conditions give these metal and acid tolerant species a competitive advantage at this site and limit the establishment of many less tolerant species. There was a scarcity of sensitive cryptogam indicators, as well as shade tolerant species. The combination of low numbers of species present on the site and the moderate presence of bare mineral soil suggested that the site and soil conditions at CC-01 did not favour successful germination and establishment of a wide range of forest plant species.

There was abundant evidence of risks to long-term site productivity. The site supported only a moderate tree and shrub layer that was achieving poor height growth. The high crown dieback and high stem mortality in the white birch at this site was a strong indication of a stressed community. The low volume and small size of downed woody debris on the site further raised concerns that the rate of nutrient availability may not match the needs of a fully occupied site.

CC-01 was scored moderate with respect to soil and water conservation. The erosion-prone, silt-rich soils were exposed on portions of the site, and were only protected by a small amount of leaf litter. However, the terrain was relatively level, which reduced the chance of surface erosion. The silt content of the soil and open nature of the plant cover did pose some risk to losses of seedlings from frost heave. The moderate plant cover and density of tree and tall shrubs created a potential risk for loss through the soil profile and a moderate supply of organic matter for the soil pool.

Table GE-4-6.1 Overall LOE Ranking for CC-01

Criteria	Ranking
Site Biodiversity	Red
Ecological Integrity	Red
Long-Term Site Productivity	Red
Soil and Water Conservation	Yellow
OVERALL LOE RANKING	Red

GE-4-6.2 CC-02

Ecosite: White birch – Red maple bedrock (savannah) transition community

Subdominant Community: N/A

Figure GE-4-6-2 Photograph of CC-02

General Community Description

This white birch – red maple transition community consisted of barren terrain with scattered clumps of coppis white birch (*Betula papyrifera*), red maple (*Acer rubrum*), red oak (*Quercus rubra*), and trembling aspen (*Populus tremuloides*). Tree species occupied approximately 40% of the site, occurring as scattered vegetation clumps, with a pine component occurring primarily as planted seedlings. Tree cover in the tall

shrub and tree layers consisted of 70% white birch, 25% red maple, with minor amounts of trembling aspen and red oak. Many of the trees were less than 4 m in height, but maximum heights of 5 m were observed. Willow species (*Salix* sp.) occurred as scattered individuals in the tall shrub layer associated with patches of trees. Low sweet blueberry (*Vaccinium angustifolium*) formed patches in the low shrub layer. The forb layer at the site was intermittent at best, and was dominated by common hairgrass (*Deschampsia flexuosa*). The resilient moss, *Pohlia nutans,* formed extensive mats across the site among patches of bare mineral soil and bedrock.

The site had large areas of exposed mineral soil and bedrock, together comprising approximately 22% of the ground cover based on the 1 x 1 m quadrat ground cover assessment. A visual estimate of percent bedrock on the overall site was 30%. The site consisted of very shallow to moderately deep loamy coarse sands on rolling terrain (average slope 35%). The silt content of the soils was low at 22%, with 3% clay. Frost-fractured boulders, stones, gravel, and surface bedrock were visible at the surface throughout the site.

Summary for the Four Criteria

CC-02 displayed many of the characteristics of a stressed plant community. Biodiversity was very low, expressed as low species richness, low species diversity, and low numbers of plant species reported for many of the strata, with the absence of herb and fern species, and a depauperate tall shrub layer. In addition, the community was growing within 100 m of the semi-barren area of the Copper Cliff stacks, a disturbance that has historically been associated with a reduction in the successful establishment and survival of a number of common forest species.

Ecological integrity was low. Coniferous species were underrepresented in the canopy and virtually absent in the understory of this community. This gap reflected a parallel gap in wildlife species that rely on a conifer component for survival. A relatively high number of species are known indicators of metal and acid tolerance, which indicates that conditions gave these metal and acid tolerant species a competitive advantage at this site and limited the establishment of many less tolerant species. In addition, there was a scarcity in shade tolerant species and a complete absence of cryptogam indicators of improved site conditions. A large portion of the site was unproductive mineral substrate. Collectively, this suggested that the soil and site conditions at CC-02 did not favour successful germination and establishment of a wide range of forest plant species. The open conditions had favoured the growth of the moss, *Pohlia nutans,* which accounted for a relatively large portion of the ground cover. This species is

tolerant of open, acidic, nutrient poor conditions and can survive in areas where metals in the soil are higher than background levels.

There was abundant evidence of risks to long-term site productivity. The site supported only a moderate tree and shrub layer that achieved poor height growth, and a moderate tree and tall shrub density. The high crown dieback and high stem mortality in the white birch and red maple at this site was further evidence of a stressed community. The very small size and low volume of downed woody debris on the site further flagged concerns with the site that nutrient supply may not match the needs of a fully occupied site.

In addition, the site was at risk with respect to soil and water conservation. This site was susceptible to soil and water erosion because of the steep slopes and the presence of exposed mineral soil. In addition, the very low clay content reduced the moisture-holding capacity and the nutrient capital in the soil. In combination with low vegetation cover and low inputs from downed woody debris volume, the site remained at risk in terms of organic matter inputs to the site and nutrient cycling. Water (and associated soil solution) loss from the sandy-soiled system, in the absence of a well-established woody tree and shrub cover, was likely.

Table GE-4-6.2 Overall LOE Ranking for CC-02

Criteria	Ranking
Site Biodiversity	Red
Ecological Integrity	Red
Long-Term Site Productivity	Red
Soil and Water Conservation	Red
OVERALL LOE RANKING	Red

GE-4-6.3 CC-03

Ecosite: White birch- bedrock (savannah) transition community

Subdominant Community: N/A

Figure GE-4-6-3 Photograph of CC-03

General Community Description

This white birch – bedrock transition community consisted of a mosaic of grass and stunted coppice-origin white birch clumps growing on a very open landscape where bedrock outcrops and exposed mineral soil patches were common. Approximately 30% of the site supported a tree cover. The tree component consisted of 90% white birch (*Betula papyrifera*), with small percentage of red maple (*Acer rubrum*) and red oak (*Quercus rubra*). The canopy height was largely less than 2 m in height; however, a

few scattered individuals grew to a height of 6 m. Low sweet blueberry (*Vaccinium angustifolium*) and labrador-tea (*Ledum groenlandicum*) formed a patchy low shrub layer. The forb layer was intermittent, largely dominated by graminoids, including tufted hairgrass (*Deschampsia cespitosa*), tickle grass (*Agrostis scabra*), pointed broom sedge (*Carex scoparia*) and short-tailed rush (*Juncus brevicaudatus*). The cryptogam layer was dominated by the mosses *Polytrichum juniperinum* and *Pohlia nutans*, and the lichens *Cladonia deformis* and *Cladonia multiformis*.

The site had large areas of exposed mineral soil and bedrock, together comprising approximately 60% of the ground cover based on the 1 x 1 m quadrat ground cover assessment. A visual estimate of percent bedrock on the overall site was 25%. The site consisted of shallow to moderately deep silt loam on undulating terrain (average slope is 10%). The silt content of the soils was high at 57%, with 9% clay.

Summary for the Four Criteria

CC-03 displayed many of the characteristics of a stressed plant community. Biodiversity was low, reflected by low species richness, low species diversity, and the low numbers of species present in each strata layer. In addition, the community was situated within 100 m of the Copper Cliff barrens, outside the mapped tree planting and liming areas. Although changes in the vegetation cover within 1,000 m of the site are detectable on the satellite analysis of plant cover for the Sudbury Region, no evidence of recovery occurs within 100 m of CC-03.

Ecological integrity was also scored low for this site. Coniferous species were completely absent in this community, which may also reflect a gap in wildlife species that rely on a conifer component to survive. A relatively high number of species present are known indicators of metal and acid tolerance. In addition, there was a complete absence of shade tolerant species and of cryptogam indicators of improved site conditions. The combination of the low numbers of species present, the almost complete absence of tree regeneration and the large portion of the site that was unproductive mineral substrate suggests that the site and soil conditions at CC-03 did not favour successful germination and establishment of a wide range of forest plant species.

There was abundant evidence of risks to long-term site productivity. The site supported a tree layer that had very low density and high dieback of both stems and crowns. The high volume of downed woody debris, but only in the well-decomposed categories, suggested that the reduction in tree cover on the site was relatively recent (within the past 80 years), and that changes in conditions had led to an environment where new material was not being added or processed at the site. The presence of a high number of metal

and acid tolerant plant species, the absence of shade tolerant indicators, the lack of species indicative of improving conditions, and the absence of tree seedling germination provided further evidence that the site was currently not favourable for plant establishment and growth.

CC-03 was scored very low with respect to soil and water conservation. The erosion-prone silt-rich soils were exposed on a large portion of the site, and were only protected by a small amount of leaf litter cover. However, the site was undulating with average slopes of 10%, which somewhat reduced the chance of severe surface erosion. The silt content of the soil and open nature of the plant cover did pose some risk to losses of seedlings from frost heaving. The low plant cover and very low tree density created a high risk for soil losses, both in solution through the soil profile and in surface losses. In addition, combined with historic evidence of much higher levels of tree growth on the site (as was evident in the very well decomposed DWD), the very low supplies of organic matter for the soil organic pool flagged this site as being in a degraded condition.

Table GE-4-6.3 Overall LOE Ranking for CC-03

Criteria	Ranking
Site Biodiversity	Red
Ecological Integrity	Red
Long-Term Site Productivity	Red
Soil and Water Conservation	Red
OVERALL LOE RANKING	Red

GE-4-6.4 CC-04

Ecosite: White birch - *Deschampsia flexuosa* bedrock (savannah) transition community

Subdominant Community: Poplar lowland silt loam community

Figure GE-4-6-4 Photograph of CC-04

General Community Description

This white birch–common hairgrass transition community supported a tree cover that occupied only 40% of the site, growing on deeper-soiled pockets among bedrock outcrops and moss- and low shrub-covered openings. The tree component consisted of 70% white birch (*Betula papyrifera*), 20% trembling aspen (*Populus tremuloides*), 10% red maple (*Acer rubrum*) and trace occurrences of balsam fir (*Abies balsamea*). The tree canopy was primarily less than 3 m in height with white birch occurring both in the

shrub and tree layers, however individuals had grown to a maximum height of 8 m. Low sweet blueberry (*Vaccinium angustifolium*) and bush honeysuckle (*Diervilla lonicera*) occurred in the low shrub layer. The forb layer at the site was comprised of scattered patches of wild lily-of-the-valley (*Maianthemum canadense*), eastern bracken-fern (*Pteridium aquilinum*), and common hairgrass (*Deschampsia flexuosa*). The cryptogam layer consisted of the mosses *Polytrichum juniperinum, P. commune* and *Pohlia nutans*, and the lichens *Cladonia multiformis* and *C. rei*. The lichen *Hypogymnia physodes* was evident on downed woody debris and the base of the white birch.

The site had no areas of exposed mineral soil and bedrock based on the 1 x 1 m quadrat ground cover assessment. A visual estimate of percent bedrock on the overall site was 30%. The site consisted of shallow silt loam soils on undulating terrain (average slope 30%). The silt content of the soils was high at 58%, with 12% clay.

Summary for the Four Criteria

CC-04 displayed many of the characteristics of a stressed plant community. Site biodiversity was moderate, reflected by a moderate scoring for the majority of indicators, including species richness, species diversity, species dominance, plant community structure and the moderately low diversity of DWD. The site lay within 100 m of the Copper Cliff semi-barrens, and there was no evidence of recovery within 1,000 m of this site.

The ecological integrity of the site was ranked low. Coniferous species were underrepresented in the canopy and virtually absent in the understory of this community. This gap reflected a parallel gap in wildlife species that rely on a conifer component for survival. A moderately high number of species present are known indicators of metal and acid tolerance, which indicates that conditions may give these metal and acid tolerant species a competitive advantage at this site and limit the establishment of many less tolerant species. In addition, there were very few cryptogam indicators of improved site conditions, a high cover of a potentially invasive grass species and a scarcity of shade tolerant indicator species.

There was abundant evidence of risks to long-term site productivity. The very low density and high dieback of woody material indicated the site was supporting a low level of production and placed the site at risk of further reductions in productive capacity with soils subject to losses through the profile. A low volume of downed woody debris further pointed to a site where productivity was limited and where the nutrient supply may not match the needs of a fully occupied site.

CC-04 was scored moderate with respect to soil and water conservation. A complete vegetation cover on the silt-rich soils reduced the risk of surface loss through erosion, although undulating slopes added the caution that areas were susceptible to soil loss with any surface disturbance. The low tree density created a high risk for losses both in soil solution through the soil profile and in surface losses.

Table GE-4-6.4 Overall LOE Ranking for CC-04

Criteria	Ranking
Site Biodiversity	Yellow
Ecological Integrity	Red
Long-Term Site Productivity	Red
Soil and Water Conservation	Yellow
OVERALL LOE RANKING	Red

GE-4-6.5 CC-06

Ecosite: White birch–*Deschampsia flexuosa* bedrock (savannah) transition community

Subdominant Community: Poplar lowland silt loam community

Figure GE-4-6-5 Photograph of CC-06

General Community Description

This site consisted of an upland white birch – *Deschampsia flexuosa* transition community and a lowland poplar community. The upland savannah-like community consisted of a grass-dominated landscape with patches of white birch (*Betula papyrifera*), occupying 25% of the dominant ecosite. The tree canopy was dominated by white birch growing as scattered, stunted clumps, or linear patches in deeper-soiled depressions in the bedrock. Individual trees grew to a maximum height of 3 m, although the majority of the birch were much shorter in stature. Shrub species at the site included scattered willow species (*Salix*

sp.) and patches of bush honeysuckle (*Diervilla lonicera*). Low sweet blueberry (*Vaccinium angustifolium*) formed a patchy low shrub layer among the birch. Common hairgrass (*Deschampsia flexuosa*) had expanded to form an almost continuous cover on 75% of the upland community, leaving little habitat for forest herbs.

A subdominant lowland poplar community occurred on 49% of the site. Trembling aspen (*Populus tremuloides*) formed an open but largely continuous canopy in this deeper-soiled, moist environment, contributing up to 65% overhead cover. Trees grew to a maximum height of 5 m, however crown mortality was high (90 to 95% crown mortality), likely due to insect defoliation. The understory consisted of a rich continuous tall shrub, low shrub, and grass cover. Bare soil and exposed bedrock was absent in this ecosite.

The site had very little exposed mineral soil and bedrock based on the 1 x 1 m quadrat ground cover assessment. A visual estimate of percent bedrock on the overall site was 10%. The upland white birch – *Deschampsia flexuosa* savannah-like community had developed on the very shallow to moderately deep silt loam upland sites. The silt content of the soils was high at 53%, with 9% clay. The terrain was rolling with average slopes of 30%.

Summary for the Four Criteria

CC-06 displayed many of the characteristics of a plant community in transition. Site biodiversity was moderate, as reflected by moderate species diversity. Although species richness was ranked high, and the site had good species representation throughout the vertical strata, the very low diversity of DWD and the absence of detectable vegetation recovery within 1,000 m of the site by satellite imagery indicated that the site was stressed. In addition, the presence of low sweet blueberry on almost 50% of the site provided a caution that this species dominated the site, reducing the area available for other species.

The ecological integrity of the site was also ranked moderate, despite the lack of bare mineral substrate and high species richness at the site. There were a moderate number of both shade tolerant species and species that are indicative of improved site conditions. Coniferous species were completely absent in the community, which may also reflect a gap in wildlife species that rely on a conifer component to survive. A high number of species were known indicators of metal and acid tolerance, which indicated that conditions give these metal and acid tolerant species a competitive advantage at this site and limit the establishment of many less tolerant species. No introduced species were reported at this site; however, there was a high cover of a potentially invasive grass, which may limit the opportunity for other species to

establish at the site. The abundance of the grass combined with the almost 50% cover by low sweet blueberry contributed to ranking the site as moderate in terms of ecological integrity.

This site was ranked low in terms of long-term productivity largely due to the virtual absence of downed woody material at the site. The low value suggested that tree cover had not been present at this site for some time, or that hot fires or manual labour had removed the material from the site. The density of woody material at this site, which was only 50% of that reported for the median site at the reference sites, indicated the site supported an intermediate level of production and placed the site at moderate risk of further reductions in productive capacity, with soils subject to losses through the profile. In addition, the tree and tall shrub layer achieved poor growth and very high dieback, a strong indication of a stressed community.

CC-06 was scored moderate with respect to soil and water conservation. A complete vegetation cover on the silt-rich soils reduced the risk of surface loss through erosion, although rolling terrain added the caution that areas are susceptible to soil loss with any surface disturbance. A very low tree and tall shrub density that was only 50% of that observed at the reference sites created a high risk for soil losses both in solution through the soil profile and in surface losses. The virtual absence of DWD indicated very low supplies of organic matter for the soil organic pool, flagging this site as being at moderate risk in terms of long-term carrying capacity.

Table GE-4-6.5 Overall LOE Ranking for CC-06

Criteria	Ranking
Site Biodiversity	Yellow
Ecological Integrity	Yellow
Long-Term Site Productivity	Red
Soil and Water Conservation	Yellow
OVERALL LOE RANKING	Yellow

GE-4-6.6 CC-07

Ecosite: White birch/Blueberry/Sweet fern/*Deschampsia flexuosa* bedrock (savannah) transition community

Subdominant Community: Sheep laurel lowland loam community

Figure GE-4-6-6 Photograph of CC-07

General Community Description

This open white birch savannah transition community had an estimated 40% tree cover, occurring as patches growing in the deeper-soiled depressions in the bedrock interspersed among a low shrub sheep laurel cover and patches of exposed bedrock. A few scattered willow (*Salix* sp.) and younger white birch (*Betula papyrifera*) clumps occupied the tall shrub layer. Canopy height was generally less than 2 m in

height, however some trees grew to a maximum 8 m. Red maple (*Acer rubrum*) and occasionally trembling aspen (*Populus tremuloides*) and large-tooth aspen (*Populus grandidentata*) were associates of the dominant white birch tree cover. The low shrub layer was dominated by an almost continuous cover of low sweet blueberry (*Vaccinium angustifolium*), with scattered patches of sweetfern (*Comptonia peregrina*) and sheep laurel (*Kalmia angustifolia*). Common hairgrass (*Deschampsia flexuosa*) was the dominant graminoid, growing alongside the clubmoss, *Diphasiastrum digitatum*. The cryptogam cover was primarily the mosses, *Polytrichum commune* and *P. juniperinum*. The resilient lichen, *Cladonia rei,* is present at the site. The lichen, *Hypogymnia physodes,* was also reported at this site growing on the downed woody debris and the base of white birch. Sheep laurel formed a lowland shrub community on 25% of the site.

The soils were loam in texture with 38% sand, 50% silts and 13% clay, rendering the site vulnerable to frost heave in areas where the vegetation cover was discontinuous. Exposed bedrock covered approximately 7% of the site based on the 1 x 1 m quadrat ground cover assessment. A visual estimate of percent bedrock on the overall site was 15%. The soils were variable in depth (very shallow to moderately deep) on this undulating terrain where the slope averaged 10%.

Summary for the Four Criteria

CC-07 displayed many of the characteristics of a stressed plant community. Site biodiversity was moderate, as reflected by moderate species richness. Species diversity was poor, and low sweet blueberry, a species which is tolerant of open, acidic, nutrient poor conditions and can survive in areas where metals in the soil are higher than background levels, dominated over half of the site, limiting the opportunity for other species to establish. In addition, there was a scarcity of DWD, and there was no evidence that tree planting or liming had occurred within 1,000 m the site to act as a trigger for continuous improvements in biodiversity.

The ecological integrity of the site was also ranked low. No conifer cover was present, and there was a scarcity of shade tolerant indicators and indicators of improved site conditions. In addition, there were a high number of indicators of metal and acid tolerance, which indicated that conditions gave these tolerant species a competitive advantage at this site and limited the establishment of many less tolerant species. Collectively these indicators suggested that site conditions remained favourable to more tolerant species, which continued to out-compete a suite of forest species common to this area.

This site was ranked low in terms of long-term productivity due to the virtual absence of downed woody material volume at the site, and to the low density of woody material growing on the site. In addition, there was a very high dieback of trees at the site. Collectively, this created a risk of further reductions in productive capacity with soils subject to soil solution losses through the profile. The very low DWD volume indicated very low supplies of organic matter for the soil organic pool, flagging this site as being at moderate risk in terms of long-term carrying capacity.

CC-07 was scored moderate with respect to soil and water conservation. An almost complete vegetation cover on the silt-rich soils and the low slopes reduced the risk of surface loss through erosion. However, low tree and tall shrub densities created a high risk for soil losses both in soil solution through the soil profile and surface losses during heavy rainfall events.

Table GE-4-6.6 Overall LOE Ranking for CC-07

Criteria	Ranking
Site Biodiversity	Yellow
Ecological Integrity	Red
Long-Term Site Productivity	Red
Soil and Water Conservation	Yellow
OVERALL LOE RANKING	Red

GE-4-6.7 CC-08

Ecosite: White birch/Blueberry/Sweetfern/*Deschampsia flexuosa – Lycopodium* bedrock (savannah) transition community

Subdominant Community: Poplar silt loam lowland community

Figure GE-4-6-7 Photograph of CC-08

General Community Description

This open white birch forested community had an estimated 70% tree cover at the site, growing among grass, low shrub and small scattered bedrock openings. Tree density varied throughout the community. White birch (*Betula papyrifera*) dominated the tree cover, ranging in height from less than 1 m to a maximum of 9 m. Minor components of red maple (*Acer rubrum*) were present, with traces of red oak (*Quercus rubra*) and balsam fir (*Abies balsamea*). The low shrub layer was dominated by scattered

patches of low sweet blueberry (*Vaccinium angustifolium*), bush honeysuckle (*Diervilla lonicera*) and sweetfern (*Comptonia peregrina*). Wild lily-of-the-valley (*Maianthemum canadense*) is representative of a remnant or re-establishing forest herb at the site. Patches of clubmosses (*Lycopodium dendroideum, Lycopodium clavatum* and *Diaphasiastrum digitatum*) were characteristic of this site. Common hairgrass (*Deschampsia flexuosa*) was the dominant graminoid forming a continuous and intermittent patchy cover throughout the community. The mosses *Polytrichum commune* and *P. juniperinum* formed the ground cover with several lichen species, including *Stereocaulon tomentosum*. In addition, the lichen *Hypogymnia physodes* was observed on woody substrates at the site.

A subdominant lowland poplar community, dominated by trembling aspen (*Populus tremuloides*), occurred on 49% of the site. This community occupied the moist, deeper-soiled sections of CC-08. The herb and shrub layer were continuous beneath the aspen canopy, forming a dense cover including willow (*Salix* sp.), sweetfern, grasses and compositae.

The ground cover consisted of 5% exposed mineral substrate based on the 1 x 1 m quadrat ground cover assessment. A visual estimate of percent bedrock on the overall site was 10%. Soil deposits were present at varying depths on this hilly terrain that had an average slope of 55%.

Summary for the Four Criteria

CC-08 displayed many of the characteristics of a stressed plant community. With respect to biodiversity, species richness was high when all species were considered, but scored slightly lower when the graminoid and lichen species were removed from the calculations. Species diversity was moderate, reflecting the lower diversity of tree and tall shrubs at this site. In addition, the presence of common hairgrass cover on over half of the site reduced the overall site biodiversity and reduced the seedbed available for the establishment of a variety of forest species. The distribution of species by stratum was moderately skewed, with high representation in the cryptogam and forb layers. Also, there was very little DWD on the site. There was no evidence that tree planting or liming had occurred on the site to act as a trigger for continuous improvements in biodiversity, but the site is located outside of the semi-barren and barren areas.

With respect to ecological integrity, there was a scarcity of shade tolerant indicator species, a moderate number of indicators of improved site conditions, and a very high count of indicator species of metal and acid tolerance. Collectively, these indicators suggested that site conditions remained favourable for tolerant species, which continued to out-compete a suite of forest species common to this area. In

addition, the presence of several non-native species and a very high cover of a potentially invasive grass species may limit the opportunity for other species to establish at the site. These negative aspects of CC-08 were offset by the high species richness and almost complete vegetation cover.

This site was ranked low in terms of long-term productivity due to the low volume of downed woody material at the site and the low density of woody material growing on the site. The low DWD value suggested that tree cover had not been present at this site for some time, or that hot fires or manual labour had removed the DWD from the site. The low tree and tall shrub density created a risk of further reductions in productive capacity with soils subject to soil solution losses through the profile. In addition, there was very high dieback in the trees and tall shrubs present at the site, and an absence of *Populus* species in the tree and tall shrub plots.

CC-08 was scored poor with respect to soil and water conservation. The silt-rich soils and the steep slopes increased the risk of surface loss through erosion. Low tree densities further increase the high risk for soil losses both in soil solution through the soil profile and surface losses during heavy rainfall events.

Table GE-4-6.7 Overall LOE Ranking for CC-08

Criteria	Ranking
Site Biodiversity	Yellow
Ecological Integrity	Yellow
Long-Term Site Productivity	Red
Soil and Water Conservation	Red
OVERALL LOE RANKING	Red

GE-4-6.8 CON-01

Ecosite: Red oak – white birch / blueberry hilly fine sandy loam community

Subdominant Community: N/A

Figure GE-4-6-8 Photograph of CON-01

General Community Description

This red oak – white birch forest community had a continuous (95%) forest cover of red oak (*Quercus rubra*), red maple (*Acer rubrum*) and white birch (*Betula papyrifera*). Trembling aspen (*Populus tremuloides*) and large-tooth aspen (*Populus grandidentata*) were present in trace amounts. The trees in this community showed good height growth, with single stem growth forms in contrast to the stunted coppice forms more common in the shallow-soiled barren and semi-barren transition communities. Red oak and speckled alder (*Alnus incana* ssp. *rugosa*) occurred in the tall shrub layer, while low sweet

blueberry (*Vaccinium angustifolium*) and wintergreen (*Gaultheria procumbens*) were the most common species in the low shrub layer. Characteristic understory herbs and ferns included wild lily-of-the-valley (*Maianthemum canadense*), wild sarsaparilla (*Aralia nudicaulis*) and eastern bracken-fern (*Pteridium aquilinum*). The moss *Dicranum polysetum*, with minor occurrences of *Pohlia nutans* near the base of trees, contributed to the ground cover. The lichen *Hypogymnia physodes* was noticeable on the lower bark of red maple and red oak, but terricolous lichens were virtually absent at this site.

The site was a mosaic of shallow soil over bedrock hill-tops and deeper-soiled valleys. The fine sandy loam-textured soils consisted of 56% sand, 36% silt and 8% clay. Soil depth varied from 10 to 30 cm with no reports of exposed bedrock on this hilly terrain where average slopes of 40% created risks of soil erosion. A thin (3 cm) LFH layer had formed on these soils.

Summary for the Four Criteria

CON-01 displayed many of the characteristics of a plant community in transition. With respect to soil and water conservation, the criterion was ranked good, as very little impact was noted. The predominantly intermediate scores for the other criteria suggested that conditions on the site may either be improving or that productivity is inherently modest. It was unknown if the unimpacted soil and water conditions would sustain the community and enable it to recover.

Site biodiversity was ranked moderate for CON-01. This ranking was reflective of a moderate rank for species richness and a poor representation of species in several vertical habitat strata. The overall rank for this site was increased due to high scores for species diversity, degree of species dominance, a healthy diversity of DWD, and the general lack of observable disturbance.

With respect to ecological integrity, this site was ranked with an intermediate score, reflecting the contrasting results of several indicators. The virtual absence of conifer cover in this community equated to an absence of protective winter shelter for many wildlife species. There was also scarce representation of sensitive cryptogam indicators of improved site conditions. On a positive note, there was strong evidence of successful regeneration of red maple, white pine, red pine, large-tooth aspen and red oak. In addition, there was only 1 non-native species present, contributing negligible cover, and no exposed mineral soil or bedrock at this site.

This site was ranked intermediate in terms of site productivity due to high mortality and the absence of poplar to suggest a productive site. These poorly ranked indicators were balanced with a strong presence

of downed woody material of variable decomposition classes and sizes. In addition, the density of woody material at the site and the maximum tree heights achieved at the site were also very high.

The evidence collected suggested that soil and water conservation were not at risk at this site. High plant cover and leaf litter minimized the risk of soil loss due to erosion. Also, tree densities were very high, which contributed to retention of soil water and the reduction of surface losses during heavy rainfall events, in addition to providing an abundant on-site supply for the soil organic pool. In contrast, the moderate presence of silt in the fine sandy loam soils and the steep slopes in this hilly terrain increased potential risks of soil loss.

Table GE-4-6.8 Overall LOE Ranking for CON-01

Criteria	Ranking
Site Biodiversity	Yellow
Ecological Integrity	Yellow
Long-Term Site Productivity	Yellow
Soil and Water Conservation	Green
OVERALL LOE RANKING	Yellow

GE-4-6.9 CON-02

Ecosite: White birch / blueberry / *Pohlia nutans* silt loam transition forest community

Subdominant Community: N/A

Figure GE-4-6-9 Photograph of CON-02

General Community Description

This site supported a savannah-like community of scattered stunted white birch (*Betula papyrifera*) clumps with a 20% balsam poplar (*Populus balsamifera*) presence growing among moss-covered openings. The tree cover occupied approximately 30% of the site. Planted red pine (*Pinus resinosa*) seedlings and saplings were present at the site. Scattered individual willows (*Salix* sp.) were present in the tall shrub layer, growing among regenerating white birch. Patches of low sweet blueberry (*Vaccinium*

angustifolium) were representative of the low shrub layer. The herb, sheep sorrel (*Rumex acetosella*), grows as scattered individuals among a diverse graminoid cover, dominated by tufted hairgrass (*Deschampsia cespitosa)*, tickle grass (*Agrostis scabra)* and pointed broom sedge (*Carex scoparia*). The moss, *Pohlia nutans*, blankets several square meters of mineral soil, interspersed by an abundant and diverse lichen population that included *Cladonia multiformis*, *C. chlorophaea*, *C. rei*, *C. cristatella* and *C. coniocraea*.

The silt loam-textured soils consisted of 20% sand, 68% silt and 12% clay. They were present at varying depths on this level terrain where the slope averaged less than 5%. Approximately 3% of the surface consisted of bare mineral soils, with no reports of exposed bedrock at the site.

Summary for the Four Criteria

CON-02 displayed many of the characteristics of a stressed plant community. Site biodiversity for CON-02 was ranked poor, reflecting poor scores for the majority of indicators. Species richness was very low for all indices, as was species diversity. There was also particularly weak species representation in the tree, tall shrub and forb layers. In addition, there was a scarcity of DWD and strong evidence of disturbance at the site, as it lay within 100 m of the Coniston barrens.

With respect to ecological integrity, the scarcity of shade tolerant indicators and sensitive cryptogam indicators of improved site conditions, and the presence of a very high number of metal and acid tolerant indicators implied that site conditions were unfavourable for many common forest species. In addition, there was low species richness, and a virtual lack of conifer cover which equated to an absence of protective winter shelter for many wildlife species.

This site was ranked intermediate in terms of long-term productivity, reflecting an intermediate ranking for the majority of indicators. The moderate volume of DWD was present as well-decomposed large-diameter debris of indeterminate species originating from historic stands. The density of woody material at the site was also moderate, as was the tree height and the percentage of dieback in the tree population.

The evidence collected indicated that CON-02 was ranked high with respect to soil and water conservation. The silt-rich soils increased the risk of surface soil loss through erosion and plant establishment success through frost heave, should vegetation cover be absent. Similarly, low leaf litter cover at the site did not add to the protection of soils. However, the level terrain, moderate plant cover, and high density of trees and tall shrubs reduced the risk of realizing these losses by contributing to the retention of soil water and the reduction of surface losses during heavy rainfall events.

Table GE-4-6.9 Overall LOE Ranking for CON-02

Criteria	Ranking
Site Biodiversity	Red
Ecological Integrity	Red
Long-Term Site Productivity	Yellow
Soil and Water Conservation	Green
OVERALL LOE RANKING	Red

GE-4-6.10 CON-03

Ecosite: White birch/*Deschampsia flexuosa* shallow silt loam community

Subdominant Community: N/A

Figure GE-4-6-10 Photograph of CON-03

General Community Description

This was a young white birch forest that consisted of variable densities of tree cover that averaged 95% cover. Balsam poplar (*Populus balsamifera*) provided 5% of the total canopy cover, with white birch (*Betula papyrifera*) providing the rest of the canopy cover. The understory was very open, dominated by a continous grass cover dominated by *Deschampsia flexuosa* with some representation by pointed broom sedge (*Carex scoparia*), Canada bluegrass (*Poa compressa*) and drooping wood sedge (*Carex arctata*). The tall shrub layer was virtually absent. Patches of low sweet blueberry (*Vaccinium angustifolium*) were

present at scattered locations where the grass cover was lighter. The mosses, *Pohlia nutans* and *Ptilium crista-castrensis*, were present as a ground cover and at the base of the white birch trees, respectively. Terricolous lichen were largely absent, but the lichen, *Hypogymnia physodes*, was evident on the downed woody material and bark of the white birch at the site.

The site was a shallow-soiled level plain. The silt loam-textured soils consisted of highly erosion- and frost-prone silts (72%) and clays (21%) and very little sand (7%). Soil depth varied from 10 to 30 cm with no reports of exposed bedrock on this level terrain, where slopes averaged less than 5%.

Summary for the Four Criteria

CON-03 displayed many of the characteristics of a plant community in transition. Site biodiversity was ranked as moderate based on conflicting rankings between indicators. Species diversity was high, falling within the range found at the reference sites. In addition, there was a healthy species representation in all vertical strata layers. However, the cover of common hairgrass on over half of the site represented a serious concern, creating an impediment to the establishment of other species. In addition, this site was located within 100 m of the Coniston semi-barrens and as such it fell within the target treatment area, however, regreening activities had not occurred on-site.

With respect to ecological integrity, the absence of conifer cover in this community, the limited number of shade tolerant indicator species, the limited number of sensitive cryptogam indicators of improved site conditions, and the high number of acid and metal tolerant indicators contributed to a low score. In addition, there was little evidence of successful regeneration of tree species, and a very high cover of a potentially invasive grass species.

This site was ranked intermediate in terms of site productivity largely due to the extremely low volume of downed woody debris. In addition, the density of woody material at the site was also low. In contrast, tree height was comparable to reference sites, as was the absence of dieback at the site.

The evidence collected suggested that soil and water conservation were at only moderate risk, a reflection of conflicting rankings between indicators. The high percentage of silt in the silt loam soils, and the low density of trees at the site were of concern. In contrast, there was a high plant and leaf litter cover at the site and a level terrain, which collectively reduced the actual probability of surface soil loss through erosion.

Table GE-4-6.10 Overall LOE Ranking for CON-03

Criteria	Ranking
Site Biodiversity	Yellow
Ecological Integrity	Red
Long-Term Site Productivity	Yellow
Soil and Water Conservation	Yellow
OVERALL LOE RANKING	Yellow

GE-4-6.11 CON-05

Ecosite: Red pine/*Deschampsia flexuosa* – sweetfern silty clay loam savannah transition community

Subdominant: Trembling aspen/*Deschampsia flexuosa* lowland community

Figure GE-4-6-11 Photograph of CON-05

General Community Description

This community consisted of patches of red pine (*Pinus resinosa*), with minor components of white birch (*Betula papyrifera*) and white spruce (*Picea glauca*) growing in mosaic with a trembling aspen/*Deschampsia flexuosa* lowland community. The tree cover occupied 45% of the site. In the pine dominated community, scattered willow (*Salix* sp.), patches of sweetfern (*Comptonia peregrina*) and low sweet blueberry (*Vaccinium angustifolium*) form the understory. The forb layer in the trembling

aspen/*Deschampsia flexuosa* lowland community consisted of abundant asters (*Aster* sp.), growing among an almost continuous common hairgrass (*Deschampsia flexuosa)* cover. The mosses, *Polytrichum commune* and *P. juniperinum*, occupy more open upland sites along with patches of *Cladonia*, including the lichen, *Cladonia pleurota*. The trembling aspen (*Populus tremuloides*) – common hairgrass lowland subdominant community occupied 40% of the site.

The site was a moderately deep level plain. The silty clay loam-textured soils consisted of highly erosion- and frost-prone silts (57%), clays (36%) and very little sand (6%). Soil depth varied from 30 to 50 cm with no reports of exposed bedrock on this level terrain, where average slope did not exceed 5%.

Summary for the Four Criteria

CON-05 displayed many of the characteristics of a stressed plant community. Site biodiversity for CON-05 was ranked with an intermediate score, reflective of a high number of moderately ranked indicators. Species richness, species diversity, plant community structure and the degree of disturbance indicators all ranked intermediate for this site. In contrast, however, was the presence of a potentially invasive grass species covering almost half of the site, and a scarcity of DWD to provide forest floor material for wildlife cover and raised surfaces for seedling germination.

Ecological integrity at this site was poor, reflecting poor scores for the majority of indicators: conifer cover was very low; there was a scarcity of shade tolerant indicator species and cryptogam indicators of improved site conditions; and there were a high number of metal and acid tolerant plant species at CON-05. In addition, there was little evidence of successful regeneration.

This site was ranked intermediate in terms of site productivity due to the extremely low volume of downed woody debris that lacked a range of sizes and decomposition stages. In addition, there was a very low density of woody material at the site. In contrast, tree heights were comparable to reference sites, and no dieback was observed.

The evidence collected suggested that soil and water conservation was at risk. The high percentage of silt in the silt clay loam soils, the low density of trees and an extremely low cover of leaf litter, combined with the low volume of downed woody material, were of concern. In contrast, there was a continuous plant cover at the site and slopes are low, which collectively reduced the actual probability of surface soil loss through erosion.

Table GE-4-6.11 Overall LOE Ranking for CON-05

Criteria	Ranking
Site Biodiversity	Yellow
Ecological Integrity	Red
Long-Term Site Productivity	Yellow
Soil and Water Conservation	Red
OVERALL LOE RANKING	Red

GE-4-6.12 CON-06

Ecosite: White birch very shallow silt loam bedrock barrens community

Subdominant Community: N/A

Figure GE-4-6-12 Photograph of CON-06

General Community Description

This white birch barrens community was characterized by a very open landscape with scattered stunted white birch (*Betula papyrifera*) clumps providing a cover of only 20%. Tree heights rarely exceeded 2 m. Scattered young jack pine (*Pinus banksiana*) seedlings and saplings were also present on the site contributing to less than 10% of the tree cover. White birch was present in the understory among a low shrub cover of scattered patches of Labrador tea (*Ledum groenlandicum*), sedges, grasses and a variety of herbs. The herbs, bird's-foot trefoil (*Lotus corniculatus*) and field hawkweed (*Hieracium caespitosum*),

grew in the forb layer, along with tufted hairgrass (*Deschampsia cespitosa*), Canada bluegrass (*Poa compressa*), and red-top (*Agrostis gigantea*), with pointed broom sedge (*Carex scoparia*) in moist depressions. The moss, *Pohlia nutans,* provided a cover on the mineral soils with clumps of lichen including *Cladonia multiformis, C. cristatella and C. chlorophaea*.

The hilly site was characterized by 17% exposed bedrock in the ridge tops and a 5% cover of bare mineral soils based on the 1 x 1 m quadrat ground cover assessment. A visual estimate of percent bedrock on the overall site was 20%. Soil depth varied from 10 to 30 cm on this hilly terrain where slopes were commonly 45%. The silt loam-textured soils consisted of highly erosion- and frost-prone silts (76%) and clays (7%). There was high evidence of surface soil erosion and disruption by frost heave on these exposed mineral soils that lack a surface organic layer (LFH).

Summary for the Four Criteria

CON-06 displayed many of the characteristics of a stressed plant community. Site biodiversity for CON-06 was ranked moderate, reflecting an intermediate ranking for species richness, as well as an intermediate ranking for plant community structure. Downed woody debris values were very low and represented a major gap. In addition, this site showed strong evidence of disturbance, as it fell within 100 m of the Coniston barrens. These negative aspects of the analysis of CON-06 were offset by high species diversity and the lack of any one species dominating the site. However, in this case, the lack of species dominance may reflect overall poor growing conditions for any plant species.

Ecological integrity at this site was poor, reflecting poor scores for six of the eight indicators. There was a scarcity of both shade tolerant indicator species and sensitive cryptogam species. In addition, there was little evidence of successful regeneration and there were a very high number of metal and acid tolerant indicators reported at the site. There were also a high number of non-native species present at the site, and a large portion of the surface was exposed mineral soil.

This site was ranked poor in terms of site productivity due to the extremely low volume, size range and representation of decomposition classes of the downed woody debris at the site. In addition, tree height was very short, suggesting that productivity was low. However, the density of woody material at the site was high, although the vigour of individuals may be limited. No dieback or mortality was reported, although for some specimens there were limited observations of insect grazing.

The evidence collected suggested that soil and water conservation was also at risk. Although there was a high density of trees and tall shrubs over 1 m in height, there was a very high percentage of silt in the silt

loam soils, low plant and leaf litter cover, and a large portion of exposed mineral substrate at the site. In addition, the presence of steep slopes greatly increased the actual probability of surface soil loss through erosion.

Table GE-4-6.12 Overall LOE Ranking for CON-06

Criteria	Ranking
Site Biodiversity	Yellow
Ecological Integrity	Red
Long-Term Site Productivity	Red
Soil and Water Conservation	Red
OVERALL LOE RANKING	Red

GE-4-6.13 CON-07: Historically Limed and Re-greened Site.

Ecosite: Balsam poplar/*Lotus corniculatus*-graminoid silt loam transition community

Subdominant Community: N/A

Figure GE-4-6-13 Photograph of CON-07

General Community Description

This limed site was dominated by scattered, stunted poplar and a continuous cover of herbaceous species. The balsam poplar (*Populus balsamifera*) dominated the site representing 75% of the tree cover, growing with a minor component of jack pine (*Pinus banksiana*), white birch (*Betula papyrifera*) and incidental red pine (*Pinus resinosa*). Both balsam poplar and scattered willow (*Salix* sp.) were present in the tall shrub layer. Low shrubs were largely absent. The forb layer was dominated by bird's-foot trefoil (*Lotus corniculatus*), which carpeted the surface along with a variety of other herbs and the grasses, Canada

bluegrass (*Poa compressa*), timothy *(Phleum pratense*), red-top (*Agrostis gigantea*) and pointed broom sedge (*Carex scoparia*). The moss, *Pohlia nutans*, carpeted the mineral soil where the herbaceous species were unable to establish. Lichens were absent on the limed surfaces.

Seven percent of exposed bedrock characterized this level terrain based on the 1 x 1 m quadrat ground cover assessment. A visual estimate of percent bedrock on the overall site was 10%. Soil depth varied from 10 to 30 cm on this level terrain where slopes were less than 5%. The silt loam-textured soils consisted of highly erosion- and frost-prone silts (60%) and clays (17%). The soils supported a nearly continuous vegetation cover.

Summary for the Four Criteria

CON-07 displayed many of the characteristics of a plant community in transition. Site biodiversity was rated as intermediate, reflecting the moderate scoring for species richness, plant community structure, life history, and degree of regreening intervention. There was no DWD reported at the site, creating a major gap in diversity. In addition, the site showed strong evidence of disturbance, as it lay within 100 m of the Coniston barrens. However, species diversity at the site was comparable to, or higher than, reference site values for all indices. In addition, there were no species at the site that dominated the ground cover to an extent that would prevent other species from establishing.

The ecological integrity at this site was intermediate, reflecting moderate scores for species richness, numbers of shade tolerant species reported at the site and cover of bare mineral substrate. Conifer cover was virtually absent in the community, representing a gap in the ecological integrity of the site because conifer created no protective winter cover to ameliorate the site from high winds and cold temperatures. In addition, there were a very large number of non-native species, accounting for over half of the ground cover at this site, reflecting the history of liming and seeding on this site (since it was likely that this site was seeded with a non-native seed mixture). It was also likely that liming on these open sites had created favourable germination areas for wind-borne non-native species. There were also a high number of metal and acid tolerant species recorded at this site. However, there were a high number of cryptogam indicator species of improved site conditions, and good evidence of successful regeneration of white birch, jack pine, red pine, balsam poplar and trembling aspen in the understory.

This site was ranked intermediate in terms of long-term productivity, with some conflicting rankings between indicators for this criterion. There was only limited evidence of dieback at the site. The maximum tree heights at this site were low, and DWD was absent at this site. This represented a major gap in the system, suggesting that an inadequate supply of organic matter was seasonally added to the soil to sustain long-term site productivity. However, trembling aspen was abundant at the site, as was balsam poplar, suggesting that this was a relatively productive site. The high tree density values also supported this interpretation.

This site was ranked good in terms of the status of soil and water conservation. The silt loam-textured soils consisted of highly erosion- and frost-prone silts and clays. However, the level terrain, continuous plant cover and high density of trees greater than 1 m in height minimized the risk of rapid soil water/soil solution flow-through in the silt loam soils.

Table GE-4-6.13 Overall LOE Ranking for CON-07*

Criteria	Ranking
Site Biodiversity	Yellow
Ecological Integrity	Yellow
Long-Term Site Productivity	Yellow
Soil and Water Conservation	Green
OVERALL LOE RANKING	Yellow

* CON-07, the historically limed and re-greened site, was ranked at the LOE level, but was not given an overall site rank

GE-4-6.14 CON-08

Ecosite: *Deschampsia caespitosa/Pohlia nutans* mixed bedrock–silt loam soil barrens community

Subdominant Community: N/A

Figure GE-4-6-14 Photograph of CON-08

General Community Description

This grassy barren community had a very sparse cover of stunted coppice-origin white birch (*Betula papyrifera*) and patches of Labrador tea (*Ledum groenlandicum*) growing among a mossy and dry patchy grass-covered surface. Rock outcrops were common on this very shallow-soiled site. Heavily defoliated low sweet blueberry (*Vaccinium angustifolium)* formed scattered clumps in the low shrub layer in deeper-soiled pockets. The herbaceous community was characterized by scattered sheep sorrel (*Rumex*

acetosella) growing among an intermittent cover of tufted hairgrass (*Deschampsia cespitosa*). Pointed broom sedge (*Carex scoparia*) grew in the moist depressions. The cryptogam layer was dominated by the moss, *Pohlia nutans.* The lichen, *Cladonia multiformis*, was among the lichen reported at this site.

This undulating site was characterized by 16% exposed bedrock in the ridge tops based on the 1 x 1 m quadrat ground cover assessment. A visual estimate of percent bedrock on the overall site was 25%. Soil depth varied from 10 to 30 cm on the undulating terrain, with average slopes of 10%. The silt loam-textured soils consisted of highly erosion- and frost-prone silts (59%) and clays (17%). These erodible soils lacked a surface organic layer (LFH) and approximately 22% of soil lacked a vegetation cover, leaving the soils bare and vulnerable to erosion and frost action. The site displayed strong evidence of surface soil disturbances.

Summary for the Four Criteria

CON-08 displayed many of the characteristics of a stressed plant community. Site biodiversity at CON-08 was ranked low, reflecting low species richness and species diversity. Downed woody debris was completely absent, representing a major gap in the biodiversity of the site. The plant community structure at this site was characterized by few species within each layer and the complete absence of trees. In addition, this site occurred within 100 m of the Coniston barrens, providing strong evidence of disturbance for the area. Tree planting and liming had occurred within 100 m of the site, but there was no record of these management activities occurring on-site.

Ecological integrity at this site was poor, reflecting poor scores for seven of the eight indicators. Conifer cover was negligible, species richness was very low, and there was a scarcity of shade tolerant indicator species and cryptogam indicators of improved site conditions at this site. In addition, there were a high number of metal and acid tolerant indicators and very little evidence of regeneration. Of major concern was that over 20% of the surface was exposed, unproductive mineral substrate.

This site was ranked low in terms of site productivity due to the complete absence of DWD, the absence of trees, and the absence of trees and tall shrub specimens greater than 1 m tall. This left the site vulnerable to the loss of surface soils to erosion and to losses in soil quality due to the limited seasonal additions of organic matter.

The evidence collected suggested that soil and water conservation was also at risk. There was a very high percentage of silt in the silt loam soils, over 20% cover of exposed mineral substrate, and negligible leaf litter cover. The absence of downed woody material was a major concern. A risk of soil loss through surface erosion was high. In addition, seasonal additions of organic matter to the soil were negligible. Subsoil water retention would be limited due to the absence of a shrub and tree cover.

Table GE-4-6.14 Overall LOE Ranking for CON-08

Criteria	Ranking
Site Biodiversity	Red
Ecological Integrity	Red
Long-Term Site Productivity	Red
Soil and Water Conservation	Red
OVERALL LOE RANKING	Red

GE-4-6.15 FB-01

Ecosite: White birch – red oak / blueberry loam savannah transition community

Subdominant Community: N/A

Figure GE-4-6-15 Photograph of FB-01

General Community Description

This white birch – red oak savannah transition community consisted of clumps of stunted white birch (*Betula papyrifera*), red oak (*Quercus rubra*) and red maple (*Acer rubrum*), forming a 30% tree cover in a predominantly barren landscape. The average height of tree growth at the site was estimated at less than 3 m with only scattered remnant individuals displaying taller growth. White birch had been successful in establishing as scattered individuals on a surface that was characterized by decaying branch fragments and litter. Low sweet blueberry (*Vaccinium angustifolium*) was present in the sparse low shrub layer.

Eastern bracken-fern (*Ptilidium aquilinum*) and common hairgrass (*Deschampsia flexuosa*) formed scattered patches of sparse ground cover among a moss cover of *Pohlia nutans*. Scattered small patches of lichen were reported at the site, including observations of *Cladonia multiformis* and *C. rei.* The lichen, *Hypogymnia physodes*, was reported growing on woody substrates at the site.

The ground cover consisted of less than 1% exposed bedrock, and an estimated 3% of the surface is exposed mineral soil. The loam-textured soils consisted of 46% sand, 45% silt and 9% clay. The terrain was level with average slopes of less than 5%. Both the LFH and the Ah layers were absent. The surface soils consisted of a 5 to 10 cm Ae layer over 30 to 60 cm of parent material over bedrock.

Summary of the Four Criteria

FB-01 displayed many of the characteristics of a stressed plant community. Overall, the relative ecological status of this community was low. Biodiversity was low, reflected by low species richness, low species diversity, and the low numbers of species present in several strata layers. The open conditions had favoured the growth of low sweet blueberry, which is tolerant of open, acidic, nutrient poor conditions and can survive in areas where metals in the soil are higher than background levels. Its dominance on a moderately large portion of the site may have limited the opportunity for other species to establish. In addition, the community was growing within the semi-barren area of the Falconbridge stacks, a region associated with the presence of a small number of species that are tolerant of the industrial conditions. Despite the proximity to tree planting and liming areas, these management activities were not known to have occurred on-site.

Ecological integrity was also scored low for this site. Coniferous species were almost completely absent in the community, which may also reflect a gap in wildlife species that rely on a conifer component to survive. A moderately high number of species present are known indicators of metal and acid tolerance. There was a scarcity of sensitive cryptogam indicators, as well as shade tolerant species. The combination of low numbers of species present on the site and the low numbers of indicators of improving conditions suggested that the soil and site conditions at FB-01 did not favour successful germination and establishment of a wide range of forest plant species.

There was evidence of risks to long-term site productivity, with an overall moderate score. The site supported only a moderate tree and shrub layer that achieved poor height growth. The moderate crown dieback and high stem mortality in the white birch at this site was an indication of a stressed community.

The lack of poplar presence and small size of downed woody debris on the site further raised concerns that the rate of nutrient availability may not match the needs of a fully occupied site.

FB-01 was scored moderate with respect to soil and water conservation. The erosion-prone silt-rich soils, although only exposed on a small portion of the site, were only protected by a moderate amount of leaf litter cover. However, the site was relatively level, and had a high density of trees and tall shrubs, which reduced the chance of surface erosion. The silt content of the soil and moderate plant cover did pose some risk to losses of seedlings from frost heave, and for soil loss through the soil profile and provided a moderate supply of organic matter for the soil pool.

Table GE-4-6.15 Overall LOE Ranking for FB-01

Criteria	Ranking
Site Biodiversity	Red
Ecological Integrity	Red
Long-Term Site Productivity	Yellow
Soil and Water Conservation	Yellow
OVERALL LOE RANKING	Red

GE-4-6.16 FB-02

Ecosite: White birch / bracken fern – large-leaved aster silt loam community

Subdominant Community: Poplar lowland community

Figure GE-4-6-16 Photograph of FB-02

General Community Description

This forested community supported a tree cover of white birch (*Betula papyrifera*) and trembling aspen (*Populus tremuloides*), with a small component of balsam fir (*Abies balsamea*), red maple (*Acer rubrum*) and white spruce (*Picea glauca*). Canopy cover was estimated at 60%. The upland community consisted of a tall overstory of white birch shading an understory of red maple and low sweet blueberry (*Vaccinium angustifolium*). Scattered large-leaved aster (*Aster macrophyllus*) was common among the almost continuous eastern bracken-fern (*Ptilidium aquilinum*) understory. Growth of all plants was good with

tree heights commonly reaching up to 9 m. White-grained mountain-rice (*Oryzopsis asperifolia*) and bearded short-husk (*Brachyelytrum erectum*) represented the scattered grasses at the site. The cryptogam layer was dominated by the moss, *Dicranum polysetum*.

The low-lying area at the site supported a subdominant poplar community. Speckled alder (*Alnus incana* ssp. *rugosa*) and bracken-fern contributed to the majority of the cover in the dense understory.

The ground cover consisted of no exposed bedrock or mineral soil. The silt loam-textured soils consisted of 41% sand, 52% silt and 8% clay. Surface soil depth ranged from 10 to 30 cm over bedrock in this level terrain where the slope averaged less than 5%. A thin, 3 cm thick LFH soil layer was present.

Summary of the Four Criteria

FB-02 displayed many of the characteristics of a relatively stable plant community, with good scores for ecological integrity, long-term site productivity and soil and water conservation. The intermediate scores for site biodiversity may simply reflect the dense tree cover at this site, which provided continuous shade, thereby reducing the diversity of understory species.

With respect to biodiversity, species richness was moderate for all indices when compared to the reference sites. All five strata were present, and the number of species represented in each layer was reasonable, with good indices for species diversity. Downed woody material was present but limited to larger diameter well-decomposed material of indeterminate species. In addition, the presence of eastern bracken fern on a large portion of the site was not unlike many forested communities in this Ecodistrict. The absence of tree planting and liming within 1,000 m at this site was not significant, as the area lies beyond 1,000 m from the semi-barrens and, as such, was not identified as a site requiring treatment. Similarly, the lack of change in NDVI values over the past few decades on satellite imagery may just reflect relative stability in plant cover.

With respect to ecological integrity, a high number of shade tolerant indicators, a relatively high number of sensitive species with many additional intermediate species, and a low number of metal and acid tolerant indicators reflected good conditions for common forest species. There were no non-native plant species reported at this site and grass had not expanded in the understory. In addition, conifer cover was well represented, there was no exposed mineral substrate, and the presence of balsam fir, red maple, white birch, trembling aspen, eastern white cedar and striped maple regeneration on the site was promising, showing that the conditions were favourable for the germination of a variety of tree seedlings.

This site was ranked high in terms of long-term productivity. There was a high volume of downed woody material, but this was present as well-decomposed large-diameter debris of indeterminate material originating from historic stands. The density of trees and shrubs at the site was very high, there was no dieback exhibited by any tree species, and the tree heights were comparable to values observed at the reference sites.

The evidence collected indicated that FB-02 was secure with respect to soil and water conservation. The silt-rich soils rendered the soils susceptible to surface soil loss through erosion, but low slopes and continuous vegetation cover reduced the risk of realizing these losses. Tree and tall shrub densities were very high, contributing to soil stability and retention during heavy rainfall events. The low DWD volumes of recent material reduced the annual addition of organic matter to the soil, but the reasonable volume of well-decomposed debris of indeterminate (conifer) species at the site provided an on-site residual supply for the soil organic pool.

Table GE-4-6.16 Overall LOE Ranking for FB-02

Criteria	Ranking
Site Biodiversity	Yellow
Ecological Integrity	Green
Long-Term Site Productivity	Green
Soil and Water Conservation	Green
OVERALL LOE RANKING	Green

GE-4-6.17 FB-03

Ecosite: Jack pine – sheep laurel / *Polytrichum* very shallow silt loam plain community

Subdominant Community: N/A

Figure GE-4-6-17 Photograph of FB-03

General Community Description

The site supported a young jack pine stand consisting of dense jack pine (*Pinus banksiana*) with a low sweet blueberry (*Vaccinium angustifolium*) and sheep laurel (*Kalmia angustifolia*) understory growing on very shallow soils. The pine displayed 75% canopy closure and thin crowns. White birch represented less than 5% canopy cover. The common forest herbs, bunchberry (*Cornus canadensis*) and wild lily-of-the-valley (*Maianthmum canadense*), and eastern bracken-fern (*Ptilidium aquilinum*) occurred as scattered plants in the herbaceous layer. Common hairgrass (*Deschampsia flexuosa*) was present on the scattered

rock outcrop openings. *Polytrichum commune*, *P. juniperinum* and *Dicranum polysetum* were among the moss species reported at this site. A small patch of *Sphagnum girghensohnii* was found in a moist depression. Many species of *Cladonia* and several *Cladina* lichens also occupied the rocky openings.

The ground cover consisted of very little exposed bedrock based on the 1 x 1 m quadrat ground cover assessment. A visual estimate of percent bedrock on the overall site was 10%. The silt loam-textured soils consisted of 34% sand, 60% silt and 6% clay. The soil was less than 10 cm thick on this undulating terrain where the slope averaged 20%. A 3 cm thick LFH layer carpeted the very shallow soils.

Summary for the Four Criteria

FB-03 displayed many of the characteristics of a plant community in transition, with intermediate scores for site biodiversity, ecological integrity, long-term site productivity and soil and water conservation.

With respect to biodiversity, species richness was moderate when compared to values for the reference sites. Species diversity was low overall. All five strata were present, with a moderate number of species represented in several layers. In addition, downed woody debris habitat was modest. However, low sweet blueberry—which is tolerant of open, acidic, nutrient poor conditions and can survive in areas where metals in the soil are higher than background levels—occupied half of the site, reducing the establishment of other species in these areas. The absence of tree planting and liming within 1,000 m of this site did not reflect an absence of sustainable natural communities, because this site lay beyond 1,000 m of the Falconbridge barrens and semi-barrens and also showed little evidence of issues with community composition. The lack of change in NDVI values over the past few decades on satellite imagery may reflect a well-established tree cover and did not present a negative finding.

With respect to ecological integrity, the site was ranked as intermediate, reflecting conflicting rankings for the indicators of this criterion. Conifer cover was high and there were no non-native species or invasive species at the site. In addition, there were a high number of sensitive cryptogam indicator species, and no documented exposure of mineral soils. In contrast, there was a scarcity of shade tolerant indicators, a high number of metal and acid tolerant species and a lack of successful regeneration at the site. Collectively, these indicators suggested that tree cover was patchy or intermittent, and that site conditions remained less than favourable for common forest species.

Concerns with site productivity were related to the low volume and small size of downed woody material (largely conifer). In addition, the density of trees and shrubs growing at this site was less than half that

reported at the reference sites, and there was a lack of poplar at the site. However, this jack pine community showed moderate tree heights and several decomposition classes were represented.

The evidence collected ranked FB-03 as moderate with respect to soil and water conservation. The silt-rich soils rendered the soils susceptible to surface soil loss through erosion, but a high plant cover and moderate leaf litter cover reduced the risks. In contrast, moderately steep slopes and low densities of woody material increased the risk of surface soil erosion and soil loss during heavy rainfall events. The low DWD volumes and low density of woody material reduced the annual additions of organic matter to the soil and reduced the on-site supplies of residual organic matter.

Table GE-4-6.17 Overall LOE Ranking for FB-03

Criteria	Ranking
Site Biodiversity	Yellow
Ecological Integrity	Yellow
Long-Term Site Productivity	Yellow
Soil and Water Conservation	Yellow
OVERALL LOE RANKING	Yellow

GE-4-6.18 FB-05

Ecosite: Mixed white birch / red pine fine sandy loam plain community

Subdominant Community: N/A

Figure GE-4-6-18 Photograph of FB-05

General Community Description

This mixed white birch/red pine community supported a 50% tree cover and achieved moderate heights of up to 7 m. The average canopy height was commonly less than 4 m. The tree cover was mixed in composition dominated by red pine (*Pinus resinosa*) and white birch (*Betula papyrifera*) but with scattered jack pine (*Pinus banksiana*) seedlings, saplings and trees, multi-stemmed red maple (*Acer rubrum*) and a 15% balsam poplar (*Populus balsamifera*) component. Young white birch dominated the

understory, with low sweet blueberry (*Vaccinium angustifolia*) and bush honeysuckle (*Diervilla lonicera*) present in the shrub layer. An understory of eastern bracken-fern (*Ptilidium aquilinum*) and a variety of scattered forest herbs including round-leaved pyrola (*Pyrola americana*) had established under the tree canopy. The clubmoss, *Diphasiastrum digitatum*, was noticeable at the site. Canada bluegrass (*Poa compressa*), common hairgrass (*Deschampsia flexuosa*) and incidental occurrences of tickle grass (*Agrostis scabra*) were found throughout the community. *Polytrichum commune* and *P. juniperinum* formed a moss cover on the deep soils in the openings and partial shade. A variety of *Cladonia* lichens including *Cladonia multiformis* occupied the rocky openings. The lichen, *Hypogymnia physodes*, was present on the woody debris.

This deep-soiled site consisted of 3% exposed mineral soil with no reports of exposed bedrock. A 1 cm LFH layer had formed on most of the site. The fine sandy loam-textured soils consisted of 73% sand, 22% silt and 5% clay. The terrain was level with average slopes less than 5%.

Summary of the Four Criteria

FB-05 displayed many of the characteristics of a plant community in transition, with very low scores for biodiversity, intermediate scores for ecological integrity and long-term site productivity and good scores for soil and water conservation.

Site biodiversity for this site was rated as "poor," reflected by low species richness and poor representation of species in several vertical strata. In addition, the site showed signs of disturbance, as it lay within 100 m of the Falconbridge barrens, and there was an absence of any management activities that could trigger movement towards a more sustainable natural community.

With respect to ecological integrity, the site was ranked as intermediate due to conflicting results of the indicator analyses. There was a high coniferous component in this community, thereby providing protective winter shelter for many wildlife species. In addition, there was negligible cover of introduced species, and a very small amount of exposed mineral soil at the site. In contrast, the site had poor species richness, a scarcity of shade tolerant indicators and a complete absence of sensitive cryptogam indicators of improved site conditions.

Concerns with long-term site productivity were intermediate. The major concern at the site was the high percentage of dieback at the site despite good scores for several other indicators. The volume of downed woody material on the forest floor was high, but the volume was entirely hardwood in origin. The density of trees and shrubs growing at this site was also high.

The evidence collected at FB-05 ranked the site high with respect to soil and water conservation. The soil texture was ranked good, as is the low average slope, together reducing the susceptibility of the soils to surface soil loss through erosion and seedling mortality through frost heave. A high density of woody species the site further reduced the risk of surface erosion and soil loss during heavy rainfall events. The relatively high downed woody material volumes in combination with the moderate plant cover suggested that annual additions of organic matter to the soil and to on-site supplies of residual organic matter were reasonable, and that continuous improvement at this site would occur.

Table GE-4-6.18 Overall LOE Ranking for FB-05

Criteria	Ranking
Site Biodiversity	Red
Ecological Integrity	Yellow
Long-Term Site Productivity	Yellow
Soil and Water Conservation	Green
OVERALL LOE RANKING	Yellow

GE-4-6.19 FB-06

Ecosite: White birch/ red maple/ blueberry shallow loam plain community

Subdominant Community: N/A

Figure GE-4-6-19 Photograph of FB-06

General Community Description

This white birch forest community consisted of an overstory of 60% white birch (*Betula papyrifera*), 15% red maple (*Acer rubrum*), 10% red oak (*Quercus rubra*) with traces of white spruce (*Picea glauca*), white pine (*Pinus strobus*) and red pine (*Pinus resinosa*). Tree cover displayed 75% canopy closure at the site and good height growth up to 8 m. A tall shrub layer of red maple grew over a low shrub layer dominated by low sweet blueberry (*Vaccinium angustifolium*). The forb layer consisted of forest herbs including

wild lily-of-the-valley (*Maianthemum canadense*), eastern bracken-fern (*Ptilidium aquilinum*) and white-grained mountain-rice (*Oryzopsis asperifolia*). The cryptogam layer included the forest moss, *Dicranum polysetum*. Terricolous lichens were largely absent, but *Hypogymnia physodes* was reported on the bark of the red maple and red oak.

The ground cover consisted of 2% exposed bedrock based on the 1 x 1 m quadrat ground cover assessment. A visual estimate of percent bedrock on the overall site was 0%. The loam-textured soils consisted of 42% sand, 48% silt and 10% clay. Soil depths were shallow (10 to 30 cm) on this undulating terrain where the slope averaged 10%.

Summary of the Four Criteria

FB-06 displayed many of the characteristics of a plant community in transition, with intermediate scores for biodiversity, ecological integrity, and long-term site productivity and good scores for soil and water conservation.

Site biodiversity for this site was rated as intermediate. Species richness and species dominance were both found to be intermediate, and a moderate number of DWD pieces were recorded at the site. All five strata were present, but the number of species in several layers was very low. In contrast, there was no threat to the biodiversity of the site in terms of dominant species, and FB-06 lay beyond 1,000 m of the Falconbridge barren and semi-barren areas. The absence of tree planting and liming at this site only reflected the absence of any need for enhancing the vegetation cover at this site. There was no detectable change in NDVI values over the past few decades based on satellite imagery, which may only indicate that the natural cover had remained relatively stable in terms of conifer/hardwood species.

With respect to ecological integrity, the site was ranked as intermediate. There were no introduced species reported at this site and no indications of invasive species. In addition, there were a high number of cryptogam indicators of improved site conditions, very little exposure of bedrock, and good evidence of successful regeneration of balsam fir, white birch and red oak in the understory. However, there was only moderate conifer representation in the community, moderate species richness, a moderate number of shade tolerant species, and a moderate number of metal and acid tolerant species in this community, resulting in an overall moderate score.

Concerns with site productivity were moderate. The major concerns at this site were the high percentage of dieback and low volume of downed woody material. In contrast, the density of trees and shrubs was high, as were the tree heights and the number of decomposition classes represented at this site.

The evidence collected ranked FB-06 high with respect to soil and water conservation. The loam soils had a high percentage of highly erosion and frost-prone silts and clays. However, the risk of erosion was minimized by a high percentage of leaf litter cover, a high percentage plant cover, and a high density of trees and tall shrubs. This woody growth both provided a source of organic matter to the soil and dampened the rate of through-flow of soil solution through the profile. Risks of surface soil loss increased somewhat after high rainfall events or after disruption of the plant cover, as the site had moderate slopes.

Table GE-4-6.19 Overall LOE Ranking for FB-06

Criteria	Ranking
Site Biodiversity	Yellow
Ecological Integrity	Yellow
Long-Term Site Productivity	Yellow
Soil and Water Conservation	Green
OVERALL LOE RANKING	Yellow

GE-4-7.0 TEST SITE RANKING SUMMARY

Table GE-4-7.1 provides the overall LOE rankings for all the test sites. These results are also illustrated spatially in Figure GE-4-7.1.

Table GE-4-7.1 Overall Plant Community Assessment LOE Ranking for Test Sites

Site	Overall LOE Ranking
CC-01	Red
CC-02	Red
CC-03	Red
CC-04	Red
CC-06	Yellow
CC-07	Red
CC-08	Red
CON-01	Yellow
CON-02	Red
CON-03	Yellow
CON-05	Red
CON-06	Red
CON-07*	Yellow
CON-08	Red
FB-01	Red
FB-02	Green
FB-03	Yellow
FB-05	Yellow
FB-06	Yellow

*CON-07, the historically limed and re-greened site was ranked at the LOE level, but was not given an overall site rank.

Figure GE4-7-1: Final Site Rankings for the Plant Community Assessment (LOE)

FB-03
FB-02
FB-05
FB-06
FB-01
CON-01
CON-05
CON-02
CON-07
CON-03
CON-08
CON-06
CC-04
CC-02
CC-06
CC-01
CC-08
CC-07
CC-03
144
17
69
Falconbridge Stack
Copper Cliff Stack
Coniston Stack

Features

Vegetation Community Ranking

- Severely Impacted
- Moderately Impacted
- Slightly Impacted to No Impact
- Test Site
- Limed Site
- Lakes
- City Boundary
- **CC** Copper Cliff
- **CON** Coniston
- **FB** Falconbridge
- South Westerly Prevailing Wind

N
W
E
S

Scale 1:300,000

0 5 10 20 *Km*

Sudbury Soils Study | Étude des sols sudburois
metals • health • environment
métaux • santé • environnement

This page left blank intentionally

GE-4-8.0 UNCERTAINTIES

For the Plant Community LOE, uncertainty existed in each of the field survey, data analysis and results. The associated uncertainties are discussed below.

GE-4-8.1 Field Survey

In general, most field surveys were limited to a sample of the total population or area under survey; thus, there was a potential for over or underestimation of the true population. This potential contributed to the uncertainty for all data and conclusions based on the field survey. The extent of this uncertainty was limited by using a sampling program that generated data with adequate statistical power. Appropriate data analysis and interpretation also limited this risk.

GE-4-8.1.1 Broad Plant Inventory

The data quality for the broad plant inventory was relatively high; therefore the uncertainty can be classified as low. There was a risk of missed observations of plant species, and misidentification of plant species, but these were minimized through the following measures:

- The sampling protocols included three opportunities to identify and list species. The formal broad plant inventory consisted of a qualitative survey of four 10 m x 50 m transects. Subsequent to this, 25 1 m x 1 m plots were also surveyed as part of the percent cover assessment, and two 10 m x 10 m were surveyed as part of the detailed tree and tall shrub assessment. The species lists from these three sets of observations were compared and combined. Any inconsistencies between the three lists were investigated to ensure that that final list was accurate.

- Teams of two conducted sampling, so that identification was confirmed by a second, educated opinion in the field. Field-team members were provided with training at the beginning of the field season, and used good quality plant keys for species identification.

- A set of voucher samples was collected in the field, and photographs were taken of all plant species. These were compared to known samples at the Laurentian University herbarium to confirm species identification. Expert plant biologists (Dr. Beckett and M. Kershaw) provided continuous quality assurance and quality control. This took the form of spot checks in the field, review of tally sheets, and verification of any unusual or uncommon plant species listed.

The above precautions were also applied to the species identification components of the percent cover, and detailed tree and tall shrub assessments.

GE-4-8.1.2 Percent Cover Assessment

There is low uncertainty in the assessment of percent cover by herbs and low shrubs. A standard method, using 1 m x 1 m quadrats, was adopted. The risk of not fully capturing the variability in percent cover across the site was minimized through a series of precautions. Twenty-five quadrats were used per site to capture some of the natural variability in percent cover across the site.

Field teams were provided with training in estimating percentage cover at the beginning of the field season. Total percentage cover was calculated first to get the best estimate, and individual cover classes were calculated later.

Again, quality assurance and quality control were provided by expert plant biologists (Dr. P. Beckett and M. Kershaw).

GE-4-8.1.3 Detailed Tree and Tall Shrub Assessment

There was moderate uncertainty associated with the detailed tree and tall shrub assessment. The risks of over or underestimation of cover, inaccuracy of height data, and error in height estimation were minimized through a series of precautions:

- Sampling was conducted in teams of two, so that identification was confirmed by a second, educated opinion in the field. Furthermore, a second team repeated the assessment later in the season. Quality assurance and quality control were provided by expert plant biologists (Dr. P. Beckett and M. Kershaw). Unusual values were questioned and investigated.

- Field teams were provided with training at the beginning of the field season. Less complex parameters were selected for measurement (*i.e.*, single stems instead of multiple stems). Tree height measurements were made with a clinometer and measuring stick, as well as ocular estimates. In addition, photographs were taken along the transects for later verification of assigned cover values.

GE-4-8.1.4 Percent Mortality and Dieback of Tree Species

There was moderate uncertainty associated with the assessment of mortality and dieback of tree species. The risks of over or underestimation of percentage mortality, and of miscounting were minimized by using the standard ecological plot size for this type of assessment (10 m x 10 m). Also, field teams of two or more were used to obtain two estimates and reduce the risk of double counting. Quality assurance and quality control were provided by expert plant biologists (Dr. P. Beckett and M. Kershaw).

GE-4-8.1.5 Coarse Woody Debris Assessment

There was high uncertainty associated with the coarse woody debris assessment. There are a number of reasons for this uncertainty:

- Coarse woody debris was potentially underestimated as only above ground debris was assessed;
- The degree of decomposition was hard to standardize as a subjective scale was used;
- As sampling as done along a transect, the assessment could only be an estimate of the total for the site.

Risks were minimized by providing training to the field teams at the beginning of the field season, using teams of at least two, surveying two plots, and using a standard forestry sampling method. Quality assurance and quality control were provided by expert plant biologists (Dr. P. Beckett and M. Kershaw).

GE-4-8.1.6 Ecosite Classification

There was low uncertainty associated with the ecosite classification. The risk posed by the lack of a standard classification scheme for disturbed plant communities was minimized by using a standard approach to naming ecosites in Central Ontario, but not forcing sites into existing classifications that were based on undisturbed communities. The classification was limited to overstory species and dominant understory species for simplicity. Two assessments, performed by two different teams were conducted to confirm the classification.

GE-4-8.2 Data Analysis and Results

Errors in data recording, transcription and calculation are sources of uncertainty in the data analysis and results. These were minimized by checking the data and calculations at least three times. Different people conducted these checks, and if inconsistencies were found, the steps of the calculation were retraced back to the originally tally sheets until the source of the inconsistency was identified and corrected.

GE-4-9.0 CONCLUSIONS

An evaluation of the Plant Community Assessment LOE revealed the following:

- All reference sites displayed many of the characteristics of a resilient plant community. The site biodiversity and ecological integrity of all reference sites was rated high. There was no evidence of risks to long-term site productivity at any of the reference sites. All of the reference sites provided good conditions with respect to soil and water conservation. The relative ecological status of the three communities was good, establishing them as providing adequate baseline conditions for comparison with the test sites.

- The test sites contained a diversity of plant communities. A method was established to compare these communities to the reference sites. Each site was given an overall ranking that ranged from low to no impact to severely impacted.

This LOE will be evaluated as part of the weight-of-evidence approach for Objective #1 of the ERA.

GE-4-10.0 REFERENCES

Amiro, B.D., and Courtin, G.M . 1981. Patterns of vegetation in the vicinity of an industrially disturbed ecosystem, Sudbury, Ontario. Can. J. Bot. 59(9): 1623-1639.

Brodo. I., Sharnoff, S.D., Sharnoff S. 2001. Lichens of North America. Yale Univ. Press. New Haven, USA. 795 p.

Brower J. E., Zar, J.H., von Ende, C. N. 1997. Field and Laboratory Methods for General Ecology, 4th edition. WCB McGraw Hill, Boston, USA. 273 p.

CCFM. 1995. Defining Sustainable Management: A Canadian Approach to Criteria and Indicators. Canadian Council of Forest Ministers. Available: CCFM: Defining Sustainable Forest Management: A Canadian Approach to Criteria and Indicators

Chambers, B., Naylot, B., Nieppola, J., Merchant, B., and Uhlig, P. 1997. Field guide to forest ecosystems of central Ontario. SCSS Field Guide FG-01. Queen's Printer, Bracebridge, ON. 200 p.

Cody and Britton 1989. Ferns and fern allies of Canada. Res. Br. Agr. Canada. Ottawa, ON. 430 p.

Crum, H. 1976. Mosses of the Great Lakes Forest. Univ. Herbarium. Univ. of Michigan. Ann Arbor, Michigan. 404 p.

Dore, W.G., and McNeill, J. 1980. Grasses of Ontario. Monograph 26. Min. of Supply and Services Canada. Hull, Quebec. Canada. 566 p.

Environment Canada. 2005. Canadian Biodiversity Strategy. Available: http://www.cbin.ec.gc.ca/cbs/default.cfm

Gleason, and Cronquist, 1991. Manual of vascular plants of northeastern United States and adjacent Canada. New York Botanical Garden. New York, USA. 910 p.

James, T., and Courtin, G. 1985. Stand structure and growth form of the birch transition community in an industrially damaged ecosystem, Sudbury, ON. Can. J. Forest Res. 15:809-817.

Krebs, C.J. 1989. Ecological methodology, Wiley and Sons Inc.

SCSS Field Guide FG-01 1997. The field guide to forest ecosystems of Central Ontario

Sinclair, A. 1996. Floristics, structure and dynamics of plant communities on acid, metal-contaminated soils. M.Sc. Thesis, Laurentian University, Sudbury, ON.

Sollins, P. 1982. Input and decay of coarse woody debris in coniferous stands in western Oregon and Washington. Can. J. For. Res. 12:18-28

Soper, J. H., and Heimburger, M.L. 1990. (3rd printing), Shrubs of Ontario. Royal Ontario Museum. Toronto, ON. 495 p.

Van Wagner, C.E. 1968. The line intersect method on forest fuel sampling. Forest Science 14(1):20-26.