DEVELOPING THE *GUIDELINES FOR RECLAMATION TO FOREST VEGETATION IN THE ATHABASCA OIL SANDS REGION*

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ABSTRACT

In 1996, the Oil Sands Vegetation Reclamation Committee was formed to prepare guidelines on the establishment of forest vegetation and ecosystems, with an emphasis on providing appropriate "starter vegetation" for use in reclaiming oil sands leases in northeastern Alberta. The outcome of this process, the first edition of the *Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region* (referred to as the Revegetation Manual), was released in 1998. The task of updating this manual currently resides with the Reclamation Working Group (RWG) of the Cumulative Environmental Management Association, a multi-stakeholder non-profit organization whose members include representatives from oil sands industry, government regulatory agencies, and local communities. At the end of 2009, RWG completed the 2nd edition of the Revegetation Manual, which was published by Alberta Environment in 2010. Use of this manual for reclamation of upland ecosystems by oil sands mining companies is mandated by their operating approvals under the *Alberta Environmental Protection and Enhancement Act.* Thus this manual and its successors will inform revegetation activities on over approximately 30,000 ha of current disturbed footprint, and eventually as much as ~200,000 ha of mine-related disturbance.

Key Words: CEMA, revegetation, ecosite, characteristic species, end land use, LFH

INTRODUCTION

Since its inception in 2001, the Cumulative Environmental Management Association (CEMA) has been addressing cumulative environmental effects of industrial development in the Athabasca Oil Sands Region (AOSR). CEMA's purpose is to develop and apply environmental management tools, thresholds, guidelines and objectives. CEMA has 46 members from provincial & federal governments, the oil and gas industry, the forestry industry, provincial conservation associations, local non-profit groups, a national park, Métis and First Nations.

The Reclamation Working Group (RWG) of CEMA produces and maintains guidance documents that provide recommendations and leading practices to support development of reclaimed landscapes in the AOSR that meet regulatory requirements, satisfy the needs and values of stakeholders, and are environmentally sustainable. RWG provides these guidance documents to the CEMA Board as recommendations to the Government of Alberta. RWG's work applies to surface mineable oil sands and other surface disturbances including in-situ extraction, and derives from the Regional Sustainable Development Strategy (RSDS, Alberta Environment 1999). The RSDS was created as a framework to address Alberta's commitment to sustainable resource and environmental management in light of increased oil sands mining activities. The RSDS identified 72 major issues of concern in 14 theme areas. RWG's scope of work is derived from the RSDS Theme 1 (sustainable ecosystems and land-use), which was divided into two separate objectives, one of which is being addressed by RWG:

> "To define the process and standards needed to return developed land to sustainable ecosystems with desired end land use values."

Prior to the establishment of CEMA, the first edition of the *Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region* (subsequently referred to as the Revegetation Manual) was prepared by the Oil Sands Vegetation Reclamation Committee and released in 1998. It was recognized that the Revegetation Manual would require periodic updates as new data became available to improve reclamation practices in the AOSR. In 1999, the Oil Sands Vegetation Reclamation Committee was reconvened, along with the Soils Working Group, to form the Soils and Vegetation Working Group. This group was subsequently integrated into CEMA as a subgroup of RWG in 2001-2002, and was re-named the Terrestrial Subgroup in 2009. The Terrestrial Subgroup (TSG) is currently responsible for the continued development of the Revegetation Manual, and completed the 2nd edition in December 2009. The CEMA Board recommended the 2nd edition to the Government of Alberta and in April 2010 it was officially published by Alberta Environment (AENV 2010).

The objectives of this paper are (1) to provide an overview of the structure of the 2nd edition of the Revegetation Manual; (2) to present the process used to develop the 2nd edition of the Revegetation Manual; (3) to describe the planning approaches for revegetation treatments; (4) to describe the planning guidance for overstory and understory species selection; and (5) to describe the methods for evaluating revegetation success.

STRUCTURE OF THE REVEGETATION MANUAL

The 2nd edition is comprised of six sections. Section 1 describes the historical development of the Revegetation Manual, the changes incorporated into the 2nd edition and the goals and objectives of the Revegetation Manual. Section 2 describes approaches to the use of the manual, and presents decision-flow structures in support of these approaches. Section 3 provides information on ecological classification applicable to the AOSR, and presents a table of regional characteristic species for these classes. Section 4 describes end land-use declaration and appropriate revegetation targets for the declared end land use. Section 5 describes indicators of revegetation success and methods to assess these indicators on reclaimed landscapes. Section 6 provides a glossary of terms relevant to reclamation in Alberta.

The 2nd edition includes ten appendices which provide information regarding acts and regulations; key concepts in monitoring; soil salinity; wildlife populations and habitat capability in the AOSR; revegetation considerations for traditional land use; plant species fact sheets; planting prescriptions on reclaimed landscapes receiving LFH amendments; seed zones, sources and regulations; list of species in the AOSR; and estimating ecosite based on species lists.

Goals and Objectives

The goal of the Revegetation Manual is to provide guidance on re-establishing the vegetation component of upland ecosystems on reclaimed landscapes, and on evaluating the success of this re-establishment. This goal is based on the following fundamental concepts:

1. That reclaimed plant communities should have species characteristic of native plant communities in the oil sands region.
2. That trends of vegetation community and structure development on reclaimed landscapes should be similar to native plant communities in the oil sands region.
3. That reclaimed ecosystems should have developmental trajectories that satisfy land-use objectives, and have characteristics that provide resilience against natural disturbance events.

The following objectives addressed in the Revegetation Manual contribute to the above goal and underlying concepts, and advance the 2nd edition beyond the 1st edition:

- Increase flexibility in revegetation treatments – the 2nd edition uses broader ecological classes as revegetation targets than the 1st edition, in recognition of the considerable species overlap between ecological classes found in Alberta's northeast boreal forest. This adjustment is intended to allow for greater flexibility in revegetation treatments, and acknowledge uncertainty in estimation of edatopic position on new reclaimed landscapes.
- Provide a more direct linkage to soil salvage and placement activities informed by a companion document (the *Land Capability Classification System* manual, or LCCS) and the revegetation activities informed by the Revegetation Manual. The LCCS (AENV 2006) is used to estimate soil moisture and nutrient regimes on reclaimed sites. This estimate is then used to identify target ecosites and corresponding appropriate species for revegetation of these sites.
- Provide guidance on overstory planting densities based on projected trends in tree growth and mortality over time, as guided by regional plot data. This guidance differs substantially from the uniform prescriptions presented in the 1st edition.
- Present a range of understory species appropriate to target ecosites, along with detailed fact sheets on these species, where available, in an appendix.
- Provide guidance on the use of surface soil (forest floor) materials as a propagule source – including guidance with respect to modification of overstory and understory planting densities.
- Provide methods and standards for evaluating the success of revegetation treatments based on indicators of ecosystem function. A number of indicators of revegetation success, and corresponding thresholds for evaluation of a sub-set of these indicators, are presented.
- Provide an explicit list of knowledge gaps encountered during the revision process, which can inform future work plans targeted for the next Revegetation Manual revision.

REVEGETATION MANUAL DEVELOPMENT PROCESS

There are two aspects of RWG's operation that are foundational to the successful development of the 2nd edition of the Revegetation Manual:

1. Multistakeholder participation, with consensus-based decision making – RWG and its subgroups are populated by representatives from interested member organizations, as well as by a limited number of technical staff from CEMA. Representatives are technical specialists who are charged with the duties to both actively contribute to the development, implementation, and completion of the technical work program; and to represent their organizations' interests during this process. Completion of the RWG work program is achieved through a variety of mechanisms, including out-sourced contracts, technical work by CEMA staff, and technical work and writing by member representatives. In the case of the Revegetation Manual, substantive background work and writing of the document were conducted by representatives and CEMA staff, which meant that the Working Group itself had significant ownership of and commitment to the document. Contributing to this commitment is that fact that all CEMA recommendations to the Alberta Government (i.e., new guidance manuals and manual revisions) must have consensus approval at multiple levels in the recommendation process. This consensus-based decision structure is at times unwieldy, but ultimately contributes to improved understanding of various member organizations' motivations and constraints, and can produce guidance documents that are informed and shaped by a variety of interests.
2. Support in the form of technical information from a broad network of research and monitoring programs – RWG's products are supported by research and monitoring results from a wide variety of programs. RWG itself conducts work targeted to address specific issues of uncertainty in reclamation (e.g., effects of native and residual hydrocarbons on soil biota and plants, effects of textural discontinuities in native and mine waste materials on soil water regimes), as well as maintaining a long-term network of monitoring plots on reclaimed sites and in non-mined reference ecosystems. In addition, RWG has access to information generated through individual and collaborative industry reclamation research programs across the AOSR (note that the majority of this work, both CEMA and external, is funded by the oil sands industry). Information from all applicable programs is discussed and synthesized at the Subgroup and Working Group level, and used to inform development of new guidance documents. Thus the revision of the Revegetation Manual was supported by 10 years of reclamation research and monitoring programs advancing knowledge on the establishment and development of vegetation communities on reclaimed oil sands sites, and on the materials and processes that influence this establishment and development.

REVEGETATION PLANNING APPROACH

The Revegetation Manual emphasizes the techniques and methodologies necessary to establish upland forest plant species and ecosystems appropriate to given site conditions and reclamation objectives. Two decision sequences are presented in the manual: one assumes that the starting point of revegetation design is a planned landform and corresponding soil cap for which revegetation treatments will be planned; the

other assumes the starting point is a desired end land-use objective or vegetation end conditions around which reclamation will be planned. Both approaches are based on similar principles, as described below.

The Edatopic Grid, Ecosites And Site Types

The Revegetation Manual relies on the Edatopic Grid to communicate information on the plant communities in both "natural" (non-mined) and reclaimed sites that are typically associated with the soil moisture regime (SMR) and soil nutrient regime (SNR) combinations represented in the grid (Figure 1). In Alberta, plant communities are classified according to their position on the edatopic grid (the ecosite), their overstory composition (the ecosite phase), and at the finest scale, the plant community type (based on their understory species composition) (Beckingham and Archibald, 1996). The grid also provides a basis for linking the LCCS estimate of the edatopic position of reclaimed sites to the Revegetation Manual. The estimated edatopic position is used as an input variable in the Revegetation Manual for planning revegetation strategies appropriate to a given set of soil and landscape conditions.

The Revegetation Manual uses site type, a broader vegetation classification unit, to acknowledge uncertainty in defining the edatopic position on young reclaimed sites, and to reflect the considerable species overlap among ecosites (see CEMA 2006a).

Site types are generally based on groups of ecosites with similarities in their ecological and tree productivity characteristics, such as an overlap in dominant and subdominant tree species; and similarity in soil moisture and nutrient regimes. It is expected that plant communities within each site type will respond to treatment or intervention in a similar manner. Site types used in the Revegetation Manual include:

- Dry site type (sharing characteristics of ecosites a and b);
- Moist Poor site type (characteristic of ecosite c);
- Moist Rich site type (sharing characteristics of ecosites d and e);
- Wet Poor site type (characteristic of ecosite g); and
- Wet Rich site type (sharing characteristics of ecosites f and h).

Characteristic Species

The Revegetation Manual utilizes the term "characteristic species" to identify those species typically found in the non-mined, native plant communities in the AOSR. These species are important because one of the fundamental concepts supporting revegetation activities on reclaimed landscapes is to re-establish communities of characteristic species and/or create conditions favourable to their natural re-establishment. Characteristic species are defined as those species that are either (Beckingham and Archibald, 1996):

a. Present in a minimum of 70% of the sample plots for a given vegetation class; or
b. Have a prominence value of 20 or greater, where prominence value = $\sqrt{\%\,\text{frequency} \times \%\,\text{cover}}$

Information on identification of characteristic species for the vegetation classes used in the Revegetation Manual, and relevant to the AOSR, is found in the Vegetation Data Synthesis (GDC and FORRx 2008).

REVEGETATION PLANNING GUIDANCE

The Revegetation Manual provides detailed guidance on declaration of end land-use and revegetation targets, and recommends actions to meet those targets. It is the intention of the Revegetation Manual that all revegetation planning will be guided by a "declaration" of revegetation intent. This declaration would include the target end land-use, ecosite/site type, and crown closure class.

End Land-use Determination

The Revegetation Manual considers in detail three primary end land-uses: (1) commercial forest; (2) wildlife habitat; and (3) traditional use. The latter two end land-uses can collectively be described as non-commercial forest. These primary end land-use options are included for two reasons:

1. Reclamation to commercial forest is limited by a number of factors, such as reclaimed soil conditions, overstory planting densities, and operability constraints. Thus, not all reclaimed upland areas will be capable of supporting commercial forest.
2. It is assumed that it will be desirable to create vegetation conditions for non-commercial forest that will make reclamation of commercially viable forest attributes unachievable. For instance, it may be desirable to create sparsely stocked stands for wildlife or traditional use – although these stands might be entirely successful forest reclamation, they might not be consistent with commercial yield requirements.

It is expected that the majority of reclaimed forest ecosystems will be capable of supporting multiple end land-uses simultaneously. For this reason, the foundation of revegetation planning in the Revegetation Manual is the ecosite/site type, as all reclaimed forest will be targeted towards and evaluated against vegetation characteristics of a given edatopic position(s).

Commercial Forest Operability Constraints

The potential to designate a stand as commercial forest is constrained by operability rules designed to safeguard ecosystems against degradation and to maintain and protect the range of values and services these ecosystems provide. The Revegetation Manual summarizes the characteristics necessary to achieve a commercial forest as a primary end land-use designation. Stands with merchantable timber that will not satisfy these requirements, as well as stands comprised of non-merchantable timber, must declare a primary end land-use other than commercial forest.

Declaration of Target Ecosite

One of the principles of the Revegetation Manual is that the user will provide a declaration of intent, and plan accordingly for, a selected ecosite, but be evaluated with reference to the associated site type. The rationale for this distinction is that it will be helpful to conduct planning based on a well-defined and well-understood ecological unit (the ecosite), but that the evaluation target should incorporate the uncertainty of early vegetation trajectories and estimation of SMR and SNR on reclaimed sites.

Declaration of target ecosite is based on anticipated soil characteristics of the designed or existing capping treatment, and the resulting position of the site to be reclaimed on the Edatopic Grid. In order to estimate edatopic position, the user requires an estimate of both SMR and SNR. This estimate is calculated by applying the LCCS to an existing or designed landform and soil cap for which revegetation is being planned. This process will generate an estimated SMR from xeric to hydric, and an estimated SNR from poor to rich – these estimates are then used on the Edatopic Grid in the Revegetation Manual to identify the associated ecosite and site type. For example, a mesic SMR and medium SNR would indicate a d ecosite – in this case the user would declare the site a d ecosite for revegetation planning purposes, and be evaluated with reference to the Moist Rich site type (Figure 1). Where estimated edatopic positions indicate multiple possible ecosites and site types, the user will declare which of the potential options is the target for revegetation planning, based on revegetation goals. For example, a submesic SMR and poor (B) nutrient regime could indicate either a c ecosite (Moist Poor site type), or a b ecosite (Dry site type) – in this case a decision would be made by the revegetation planner as to the actual target.

Declaration of Crown Closure Target

Crown closure refers to the percentage of area covered by a vertical projection of tree crowns onto the ground. In this respect, it can be considered as an index of the relative dominance of trees on site; stand density; and/or potential volume.

For the purposes of reclamation planning and revegetation declaration, four crown closure classes have been aggregated into two target classes at stand maturity: A/B (open stands, crown closure of 6-50% at maturity), and C/D (closed stands, crown closure of >50% at maturity). The user will declare a crown closure target of class A/B or C/D. Because commercial forests require fully stocked stands, identification of commercial forest as the primary end land-use precludes selection of the A/B class, and is constrained to class C/D. Selection of crown closure targets for non-commercial forest end land-uses is unconstrained. Open stands may be selected where reclamation objectives require a sparse overstory with higher understory light levels (e.g., production of understory species for wildlife habitat or traditional use).

Selecting Overstory Species and Establishment Densities

Guidance on overstory species selection and establishment densities organized by site type is presented in the Revegetation Manual. For each site type, the establishment densities are separated by target crown closure class (A/B versus C/D), and are stratified by stand type or desired overstory species. The

establishment densities were derived using site index data and Alberta Vegetation Inventory interpretive rules for mature, natural stands from 741 temporary sample plots in the AOSR. Mature mean densities +/- 20% were used to derive a range of mature stand densities. The forest growth-and-yield model GYPSY was used to determine densities at a stand age of 8 years that would produce the above target mature stand conditions. GYPSY model results were reviewed and adjusted based on professional opinion to increase applicability to forest regeneration on reclamation sites (e.g., high juvenile aspen densities produced by GYPSY were reduced to account for seed-origin – container-seedling – as opposed to sucker-origin stock). Minimum year-8 densities for the C/D crown closure class were set to approximately 1200 stems per hectare to allow achievement of an 80% stocking standard, consistent with current Alberta Regeneration Standards. Planting densities were determined using a standard assumed value of 10% mortality between planting and age 8 years.

Understory Species Selection

Appropriate understory species by target ecosite a through h are presented in the Revegetation Manual. The species presented are derived from characteristic species lists, with characteristic species defined as above. It is expected that these characteristic species may be established by a variety of means, including seedling planting, application of LFH amendment, and potentially through direct seeding. Selection of understory species should consider interspecific competitive relationships (e.g., excessive grass covers may inhibit tree establishment and growth). An appendix of the Revegetation Manual containing plant species fact sheets for a portion of these species provides further information on establishment methods.

Understory Species Establishment Densities

The 1st edition (OSVRC 1998) recommended a shrub planting density of 500 to 700 stems per hectare, based on conventional reclamation practice at that time. Empirical data from stands recovering from other (less severe) disturbances (logging, fire) indicate much higher early-seral understory densities (typical understory densities reported in a summary review of applicable literature range from 15,000-40,000 stems per hectare). However, currently there are no empirical data available that relate reclaimed understory planting densities to subsequent population growth and resilience. Thus, the 1998 recommendation is adopted in the 2nd edition as a minimum planting density for understory establishment based primarily on nursery seedling production and out-planting. Other reclamation methods (e.g., application of LFH amendments) that will increase the density and diversity of the understory to levels more typical of juvenile stands in the AOSR are also recommended. In addition to the above 500-700 stems-per-hectare guideline, understory planting-density prescriptions are recommended to be developed with reference to the characteristic species indicator to evaluate the minimum target numbers of characteristic species by site type.

Use of Upland Surface Soils/LFH Amendments Materials

Historically, establishment of woody plant species on reclaimed landscapes in the AOSR relied on out-planting of desired species with an expectation that additional species would establish through ingress. Research evidence collected over three years on micro- and meso-scale plots for ecosites a, b and d

suggests that utilizing the LFH layer and upper 10 to 30 cm of upland forest soils as a source of propagules (seeds and vegetative plant parts) enhances the abundance and diversity of woody plants on reclaimed landscapes, such that fewer trees and shrubs may be required for out-planting (MacKenzie 2009; MacKenzie and Naeth 2007; MacKenzie 2006).

A summary of research assessing the effects of the addition of LFH amendments on native plant establishment and diversity on various reclaimed landscapes in the AOSR indicates the following considerations for use of this material:

- Overstory species establishment – Woody stem densities on LFH amendment-treated plots range from approximately 4,000-100,000 stems per hectare one to three growing seasons after placement, compared to substantially lower values for non-treated plots.
- Understory species establishment – For most herbaceous plant species, those that are present at the upland donor site will establish successfully at the receiving site, provided similar SMR and SNR exist.
- Salvage – Depth of upland surface soil salvage (10-cm versus 25-cm salvage depths) has relatively little effect on resultant vegetation establishment, in comparison to stockpiling and application considerations.
- Stockpiling – Storage of LFH amendment in small stockpiles (typical windrows) has been shown to maintain propagule viability more effectively than storage in large (operational-sized) stockpiles. However, results indicate that the majority of propagules do not retain their viability when stored for durations greater than 12 months under any configuration.
- Application – Greatest regeneration results have been obtained using LFH amendments applied directly after salvage (not stockpiled), and placed in thicker layers (approximately 20 cm) on mineral (as opposed to peat/mineral) substrates. However, thinner placements (approximately 10 cm) have also demonstrated substantial regeneration after three growing seasons. Preliminary results indicate higher establishment densities in larger patches of LFH placement.

Based on the above, the Revegetation Manual provides a flow chart presenting guidance on the use of LFH amendments in different applications, and on potential corresponding reductions in planting density for woody species.

EVALUATION OF REVEGETATION SUCCESS

The Revegetation Manual provides information on indicators that are required to be used to evaluate revegetation success and on methods to assess these indicators. Within the context of reclamation the Revegetation Manual uses the following terminology: (1) Criterion represents a category of conditions or processes by which the success of a given set of reclamation practices is assessed (CCFM 1995); (2) Indicators constitute the elements of a criterion that will be used to assess the state of a reclaimed site and its progress over time, and to inform future decision making (Hickey and Innes 2005); and (3) Measures are those aspects of an indicator that can actually be quantified.

The Revegetation Manual primarily addresses "hard" indicators, and an "intermediate" category of measures. Hard Indicators are required by the Revegetation Manual and were selected using the following principles:

- The indicator must be based on a well-developed knowledge, such that it contributes to a sound overall assessment of revegetation success.
- The indicator must have applicable and defensible thresholds such that success or failure with respect to relevant indicator measures can be assessed adequately.
- The indicator must be suitable for use on all assessment units (e.g., reclamation polygons). A more thorough discussion of indicators and monitoring, and use of a wider range of indicators, is provided in Proposed Criteria and Indicators of Ecosystem Function for Reclaimed Oil Sands Sites (CEMA 2006b).
- Based on the above three principles, the indicator must be applicable to assessments for Reclamation Certification.

The Intermediate Category applies to measures required by the Revegetation Manual on all assessment units (e.g., reclamation polygons), but which will be evaluated based on trends rather than thresholds, with no defined limits for success/failure.

During development of the Revegetation Manual, a wider suite of indicators was considered than those ultimately adopted as hard indicators and intermediate measures. Indicators were discarded if they were dealt with more appropriately in other guidance documents, or when the state of knowledge applicable to the indicator was insufficient to allow development of suitable thresholds or trends for evaluation.

The required indicators selected for inclusion in the Revegetation Manual are presented in Table 1, along with their corresponding criteria and a summary of the rationale for their selection. The criteria described in the following table are based on one of the fundamentals of reclamation – restoration of ecological function. Without restoration of ecological function within the soil and plant community, limitations related to successful reclamation are inherent.

Table 1 Criteria and their associated indicators that can be used to develop a monitoring program

Criterion	Indicator	Rationale
The structure and composition of vegetation will be restored to target levels	Plant Community Composition	Primary measure of success of revegetation programs in returning communities characteristic of the locally common boreal forest
Critical ecosystem processes will be restored to target levels	Ecosystem Net Primary Productivity	Known thresholds for acceptance as commercial forest
The physical, chemical and biological properties of the soil will be restored to target levels	Soil Salinity	Known thresholds for establishment of forest overstory species and for establishment of productive forest

This paper will discuss the Plant Community Composition and Soil Salinity indicators as examples of indicator development and evaluation in the Revegetation Manual.

Characteristic Species

At the time of assessment for Reclamation Certification, reclaimed sites should have enough characteristic species to be identifiable as a site type or sub-category (ecosite, ecosite phase, plant community type). The threshold used for the characteristic species indicator is the lower 95th% confidence interval of an estimate of central tendency and normal distribution derived from regional plot data per site type, where possible from juvenile stands (see GDC and FORRx 2008 and GDC 2009). Sites that do not meet this threshold have less than a 5% chance of being comparable to a "locally common boreal forest" population in terms of vegetation community composition.

Threshold numbers of species by site type are presented in the Revegetation Manual, along with mean values for this parameter and values from older stands (to provide an indication of progression in this parameter as stands mature). The thresholds and means were determined using data described in the Vegetation Data Synthesis (see GDC and FORRx 2008, Table 2.1, and GDC 2009). Values are based on 100 m^2 plots. Plot data for reclamation polygons are evaluated against all possible site types, and assigned to the site type or sub-category that they match most closely. Failure to meet threshold values for any site type indicates that remediation is required prior to a reclamation certification (following post-remediation assessment).

Restricted Weeds

Restricted weeds are non-native species that pose a serious threat because of their ability to spread rapidly and out-compete natural vegetation. Section 31(a) of the *Weed Control Act* states that "owners or occupants of land shall as often as necessary destroy all restricted weeds located on the land to prevent the spread, growth, ripening or scattering of the restricted weeds."

Evaluation of Restricted Weeds

The absence of restricted weeds on reclaimed sites is a requisite for certification, thus the threshold for this measure is zero. Presence of restricted weeds in any vegetation plots on a reclamation polygon undergoing assessment for certification indicates that the polygon is non-certifiable, and that remedial action will be required prior to re-assessment.

Selected Intermediate Measures

Evaluation of plant community composition includes the use of intermediate measures. Because these measures are trend-based, as opposed to threshold-based, their interpretation requires repeated data collection over time. These measures are included because they are central to the concept of demonstrating that reclaimed vegetation communities are on a trajectory towards communities more like those that existed prior to disturbance. However, these measures do not require dedicated data collection,

as they can be calculated from the same information used for the threshold-based indicators (e.g., from plot data providing species presence and abundance). Evaluation of the trend-based intermediate measures for plant community composition is based on the overall intent that developmental trajectories towards pre-disturbance vegetation conditions should be demonstrated, with an increase in characteristic species over time, and a corresponding decrease in alien species (including noxious and nuisance weeds).

Soil Salinity

Some reclaimed upland landscapes will likely be prone to salinity through the oxidation of shallow shales in saline-sodic overburden dumps or as a result of accumulated salts associated with process-affected waters in tailings landforms (Macyk et al., 2007). The Revegetation Manual provides thresholds and guidance for reclaimed environments affected by salinity. Where electrical conductivity (EC) levels in topsoil layers (0-20 cm) are anticipated to be < 2 dS/m, revegetation activities are unconstrained. Where topsoil EC values are anticipate to be between 2 and 4 dS/m, sites can be reclaimed with characteristic species appropriate for the estimated edatopic position, but salinity values preclude declaration of a commercial forest end land use, due to expected reductions in overstory productivity. Where topsoil EC values are anticipated to be > 4 dS/m, saline conditions preclude the establishment of forested ecosystems, and revegetation planning should be based on non-forest vegetation communities specifically adapted to these conditions. Specific guidance is provided in the Revegetation Manual for appropriate species selection for these sites.

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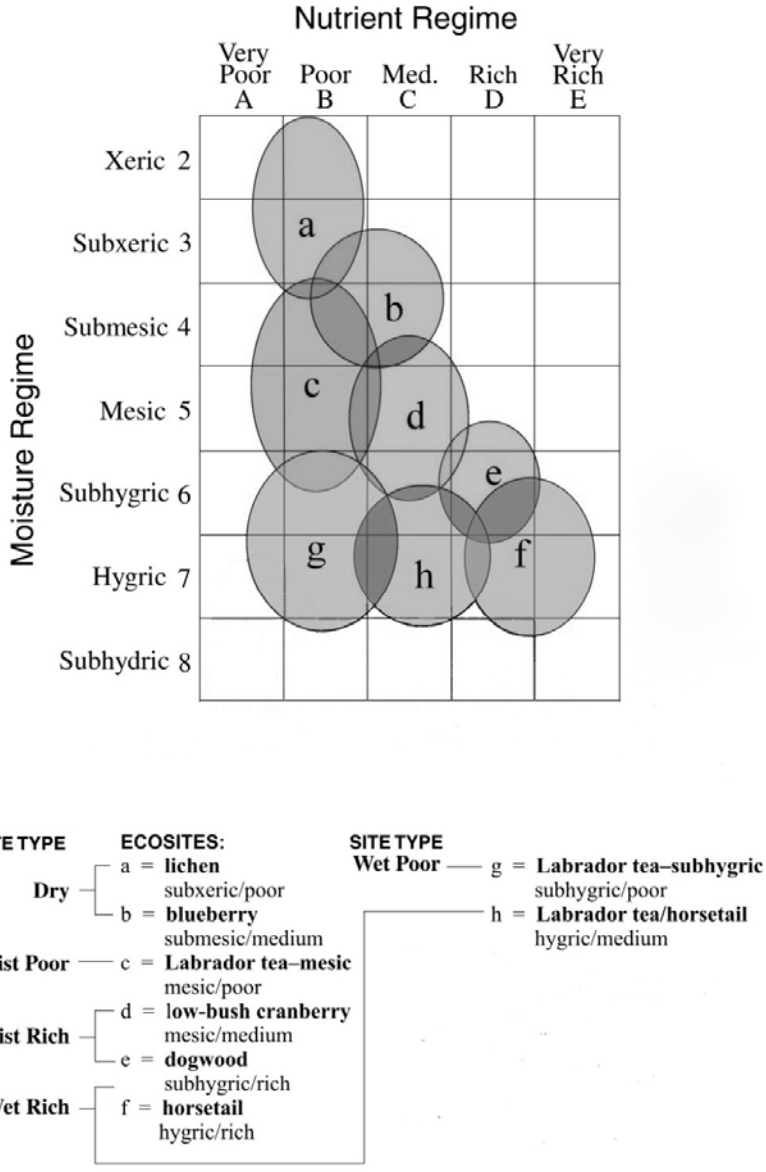

Figure 1. Five site types characteristic of the boreal mixedwood region (dry, moist poor, moist rich, wet rich, wet poor), their associated ecosites, and positions on the Edatopic Grid (modified from CEMA 2006A)