Rare and Endangered Plants

of the

[redacted]

Forest Management Agreement Area

Volume I - Status Report

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Preface

A review was done of the rare and endangered plants within the Forest Management Agreement (FMA) area belonging to [redacted]. This review was based solely on information currently available in the literature and related databases, as well as the data used to produce an ecosite classification of the FMA area.

This report lists the rare vascular and non-vascular plants and the habitats in which they are most likely found. It also discusses the most likely reasons why each species is considered rare in the vicinity of the FMA area. This information was applied to the ecosite classification to produce a model which predicts the probability that certain ecosites will contain rare plant species.

The original intent of this project was to map the rare plant resources using the Biodiversity Assessment Project (BAP) classification. However, the BAP method was developed to classify forested areas and the different age classes (seral stages) within forest habitats. As such, it does classify wetlands beyond the most basic level. The majority of rare and endangered plant species are found in wetlands, moist habitats and riparian zones. The ecosite map of the FMA area produced by Geographic Dynamics Corp. analyzes several different wetland environments within the three natural subregions of the FMA area. For this reason, the ecosite classification was more suitable for examining the spatial context of rare plant habitats.

This report also examines the basic impacts of forestry operations on rare plants, some of the landscape management strategies applicable to rare plant populations and a rare plant monitoring program for the FMA area.

Because this report was based mainly on information found in the literature, it cannot provide a completely accurate picture of the rare plants currently found within the FMA area. That information can only be gathered through a field survey program conducted by qualified pant taxonomists. This report provides some recommendations regarding a program to survey, assess and monitor the current rare plant populations.

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1.0 Introduction

As part of the process to produce a detailed forest management plan for their Forest Management Agreement (FMA) area, [redacted] contracted Geographic Dynamics Corp. to review the status of a number of natural resource features within its' FMA area. The purpose of this report is to present the results of one of these reviews: the rare and endangered plants of the [redacted] FMA area.

Rare plant surveys are one of the most difficult types of natural resource surveys, due not only to the effort required (in both time and manpower) but also to the scarce nature of the study subject itself. The first step in this survey process is an extensive background review of existing information about rare plants in the area and their habitat types.

The main objectives for this current project are as follows:

- to produce a list of the rare vascular and non-vascular plant species known, or believed, to be within the FMA area and the immediate surrounding area,
- to provide a detailed summary of which species are at risk,
- to describe the habitat preferences of the rare species,
- to perform ecosite modeling using the rare plant information,
- to assess the impacts of disturbances on rare plants,
- to define conservation and operations mitigation strategies for rare plants, and
- to devise a monitoring plan.

This report is the first comprehensive list of the rare and endangered plants, and their habitats, in the FMA area. However, this list was produced using only the published literature and other information sources; no field surveys were undertaken for this project.

Aside from a few unrelated biophysical inventories (Van Waas 1978, Bradley and Fairbarns 1984, Bentz et al. 1993, Bentz and Saxena 1994) and environmental impact assessment studies (Simons, H.A. Ltd. 1986, Nystrom, Lee, Kobayashi and Associates 1988) done in the region, there is not a great deal of natural resource information available for the FMA area. Bentz and Saxena (1994) found that there were significant information gaps with regards to the rare plants in the region of the FMA area. However, there are several known environmentally significant areas (ESA's) within the region which have a high potential for rare plant populations. These ESA's include the following (from Bilyk et al. 1996):

- Athabasca River (nationally significant: old growth forests, springs)
- McLeod River (provincially significant: highly diverse vegetation communities, wetlands)
- Sakwatamau River (regionally significant: old growth forests, wetlands)
- Baseline Lake (regionally significant: aquatic and wetland vegetation).

Overall, there is little existing information concerning the location, distribution or specific habitat requirements of the rare and endangered plants in the FMA area (Bentz and Saxena 1994).

Rare plants

A rare plant species is one which either occurs in a limited area or in small numbers over a large area. The practical application of this definition is based on a combination of geographic and demographic criteria, which can render a decision as to the rarity status of a species rather subjective (Harms et al. 1992). For rare vascular plants in Canada, information on population size is either unavailable or scarce, so the main criteria for acceptance as a rare taxon on a national scale is its occurrence in only a small geographic area (Argus and Pryer 1990). On a provincial basis, a rare species is one which has a small overall population or is highly restricted to specific habitats, and which is susceptible to human changes to the environment (Harms et al. 1992).

The rarity of a species is determined by three main factors: population abundance, species' range and habitat specificity (Drury 1974, Rabinowitz 1981).

Some species, which are at the extremes of their geographical range, are considered rare due to low population numbers in those areas. They are termed pseudo-rarities because they are often common in other parts of their range. They should still be considered important rare plants because they may be genetically distinct from conspecifics in other parts of the range due to the process of genetic drift (Lesica and Allendorf 1995).

There are a variety of reasons why a species is rare, either naturally or due to man-made interactions. Natural factors which contribute to the rarity of a species (taken from Scholfield 1998) include:

- plants can have very specific environmental site requirements, and these conditions are themselves uncommon or rare in the landscape,
- invasive species out-compete the native species,
- the plants suffer from reproductive inefficiency, or a low reproductive output (i.e. a rarity in the required seed dispersal agents such as insect pollinators; limited asexual reproduction),
- taxonomic expansion is limited due to environmental conditions (i.e. there is an inability to speciate),
- species which are naturally moving into an area lack the necessary adaptations to flourish in the new habitat, and
- climatic variations (such as climate change) affect the plants' population.

Man-made factors which can contribute to the rarity of a species (taken from Scholfield 1998) include:

- newly described plant species which have not yet been recognized in an area, some plants are overlooked due to either their small size or their presence in small, obscure habitats (for example, most species of bryophytes),
- habitat loss which has resulted in small, isolated populations of a species,
- ongoing habitat destruction,
- inadequate knowledge of the plant resources in an area,
- inadequate herbarium collections for an area, and
- field personnel with inadequate training in field botany and/or plant systematics.

The definition of a rare species in Alberta follows that developed by the Natural Heritage Information Center, and used by the Alberta Natural Heritage Information Center (ANHIC). This system is based primarily on the number of occurrences of a given 'element' (i.e. taxonomic rank, usually species) within the province, and to a lesser extent by factors which influence their ability to sustain the population, i.e. life history factors, responses to disturbances (see section 3.0).

Knowledge of rare plants

There are several reasons why knowledge about rare plant resources is important:

- many rare plants are quite site specific, and occur within a narrow range of habitat types and environmental characteristics. As such, they are useful as indicators of environmental conditions,
- rare plants can also be very sensitive to environmental quality. In this way they are good indicators of the physical and chemical characteristics of the landscape,
- changes in the population status of rare species can provide a strong indication of changes in environmental quality and conditions. Rare plants are often the first species to succumb to a changing environment, and
- rare plants are important constituents of landscape biodiversity.

Study area

The study area comprises [redacted] Forest Management Agreement area. The FMA area is made up of four separate blocks within two forest management units (FMU's) formerly known as [redacted], which are now all referred to as [redacted]. All four blocks are located in west-central Alberta, between the towns of [redacted] (see figure 1).

Forest Management Unit [redacted] All townships are west of the 5th meridian.

The total size of the FMA area is 299,437 ha (2994 sq. km).

The FMA is spread across two different natural regions, within each of which are two distinct subregions. These subregions are characterized by different climate regimes and dominant vegetation associations (Alberta Environmental Protection 1994).

(Note: even though there are four different natural subregions within the FMA area, the discussion of ecosites and rare plant models covers only three subregions. This is because the ecosites of the central mixedwood and dry mixedwood subregions are both considered part of the boreal mixedwood subregion in Beckingham and Archibald (1996)).

2.1 Foothills natural region

The Foothills Natural Region encompasses two subregions, the Lower Foothills and Upper Foothills Subregions. Due to the wide latitudinal coverage of the Foothills Natural Region, it has been divided into seven geographically distinct areas, one of which occurs within the FMA as a northern outlier of the Rocky Mountain foothills: the Swan Hills. Despite some geographical differences, the Foothills Subregions are similar to the Lower Boreal Cordilleran and Upper Boreal Cordilleran ecoregions of Strong and Leggat (1981) and Strong (1992).

2.1.1 Upper foothills subregion

This subregion is intermediate in elevation between the Lower Foothills Subregion and the Subalpine Subregion of the Rocky Mountain Natural Region. The Swan Hills are an outlier of the main foothills, and the topography of the hills varies from flat or undulating to gently rolling.

The landscape of the Upper Foothills is dominated by closed-canopied forests of lodgepole pine (*Pinus contorta*) with a high prevalence of ericaceous species in the understorey vegetation (Beckingham *et al*. 1996). White spruce (*Picea glauca*) is also common in the Upper Foothills as a component of mixedwood stands or in pure stands. Black spruce (*Picea mariana*) is common in wetlands and on upland sites mixed with lodgepole pine but is less prevalent in the southern portions of the Upper Foothills. The

Figure 1

lack of aspen (*Populus tremuloides*) distinguishes sites in the Upper Foothills from those of the Lower Foothills, with the exception of steep, south-facing slopes with coarse-textured soils where aspen may occur (Beckingham *et al.* 1996). Climax vegetation communities in the Upper Foothills will contain either white spruce or black spruce, depending on the nutrient status and moisture regime of the site (Beckingham *et al*. 1996). The range of vegetation sites in the Upper Foothills is similar to that of the Lower Foothills.

Ericaceous shrubs are a prominent component of Upper Foothills vegetation communities. Common shrub species include Labrador tea (*Ledum groenlandicum*), bog cranberry (*Vaccinium vitis-idaea*) and tall billberry (*Vaccinium membranaceum*), the latter of which is an indicator species for the Upper Foothills. Forb and grass strata are not as diverse here as in the Lower Foothills. Some common indicator forb species for the Upper Foothills are five-leaved bramble (*Rubus pedatus*) and heart-leaved arnica (*Arnica cordifolia*).

Surface drainage in the Swan Hills is characterized by an intricate dendritic pattern.

2.1.2 Lower foothills subregion

The Lower Foothills Subregion is the most arboreally diverse subregion in Alberta, with nine species of trees. This subregion has a generally rolling topography.

The Lower Foothills represents a transitional ecotone between boreal and cordilleran climates, and the boreal deciduous vegetation and cordilleran coniferous vegetation (Strong 1992). Typical vegetation within the Lower Foothills consists of mixed forests of lodgepole pine, aspen, and white spruce on moderately well-drained Gray Luvisolic soils, with the deciduous component dominant at lower elevations (Beckingham *et al*. 1996, Strong 1992). Sites in the Lower Foothills can range from lodgepole pine stands on shallow soils dominated by bearberry and lichen (*Cladina* spp.) (i.e., dry and nutrient poor areas) to sites with black spruce and lodgepole pine on gleysolic soils with Labrador tea and horsetail (*Equisetum*) species (i.e., wet areas with medium nutrient availability)(Beckingham *et al*. 1996). There is also an abundance of wetland types within the Lower Foothills, including meadows, bogs, fens and marshes (Beckingham *et al*. 1996).

White spruce is common due to its prominence in the secondary successional stage of forests but black spruce and balsam fir (*Abies balsamea*) are also present (Strong 1992).

The understorey vegetation is similar to that of the Boreal Forest Natural Region (See sec. 2.2 below). Common shrubs include low-bush cranberry (*Viburnum edule*), prickly rose (*Rosa acicularis*), green alder (*Alnus crispa*) and Labrador tea. Wild sarsaparilla (*Aralia nudicaulis*), dewberry (*Rubus pubescens*), bunchberry (*Cornus canadensis*), fireweed (*Epilobium angustifolium*) marsh reed grass (*Calamagrostis canadensis*) and hairy wild rye (*Elymus innovatus*) are common forb and grass species. Drier sites tend to be dominated by lodgepole pine with a shrub understorey which may contain Canada buffalo-berry (*Shepherdia canadensis*), blueberry (*Vaccinium myrtilloides*), juniper (*Juniperus* spp.), white meadowsweet (*Spiraea betulifolia*) or bearberry (*Arctostaphylus uva-ursi*). Typical understorey plants of moist sites consist of Labrador tea, dwarf birch (*Betula glandulosa*), bog cranberry, and horsetail.

2.2. Boreal forest natural region

The Boreal Forest Natural Region consists of broad lowland plains and discontinuous but locally extensive hill systems (Achuff 1994).

Wetlands form a significant proportion of the land cover in the lowlands of the boreal forest. Bogs, fens and swamps are most common, while marshes are locally abundant. There is a great deal of topographic, biological and climatic diversity in this natural region. Six subregions have been identified, two of which occur within the FMA area: the Central Mixedwood and the Dry Mixedwood subregions.

2.2.1 Central mixedwood subregion

The surface expression of the Central Mixedwood Subregion is fairly diverse, with level to undulating topography between limited areas of greater relief.

There is a high diversity of vegetation communities in the Central Mixedwood Subregion. The climax community is white spruce and balsam fir. However, succession to balsam fir is very rare in the southern portions of the subregion (i.e., in the region of the FMA area) due to the high frequency of fire. In the more northern portions of the Central Mixedwood subregion, mixed forests of white spruce and aspen are more common. Protected sites, such as islands in large rivers, may have a greater proportion of balsam fir.

The most common vegetation community is the aspen-white spruce-white birch (*Betula papyrifera*) type, which generally occurs on moderately-well to well-drained Gray Luvisolic soils. Typical understorey vegetation includes low-bush cranberry, beaked hazelnut *(Corylus cornuta*), rose, red-osier dogwood (*Cornus stolonifera*), saskatoon (*Amelanchier alnifolia*), wild sarsaparilla, dewberry, common pink wintergreen (*Pyrola asarifolia*), palmate-leaved coltsfoot (*Petasites palmatus*), hairy wild rye and marsh reed grass.

Marshes are common in this subregion, occurring in depressional areas and along the borders of lakes. Other wetland features in the subregion include bogs and fens. Peatlands cover 31% of the subregion, and they occur as both large complexes along major drainage divides and as more localized features within poorly defined basins (Vitt *et al.* 1998).

Peatlands provide habitat for many rare species in the Central Mixedwood Subregion. Thirteen rare plants are known from this subregion, including seven bryophyte species and six vascular plant species (Vitt *et al.* 1998).

2.2.2 Dry mixedwood subregion

The Dry Mixedwood subregion represents a transition from the Central Parkland to the Central Mixedwood, with vegetation community types that are common to both of these subregions.

The vegetation in the Dry Mixedwood subregion is characterized by mixed forests of aspen, balsam poplar (*Populus balsamifera*), white spruce, black spruce and balsam fir. The subregion is differentiated from the Central Mixedwood by the relative proportions of tree species. For example, although paper birch is present in the Dry Mixedwood it makes up a greater proportion of the Central Mixedwood forests. Climax forests in the Dry Mixedwood are generally dominated by balsam fir. However, due to the high frequency of fires, this climax type rarely occurs. Deciduous forests are dominant throughout the portions of this subregion in the vicinity of the FMA area.

The vegetation type most characteristic of this subregion is the aspen-white spruce site, which generally occurs on moderately-well to well-drained Gray Luvisolic soils. The typical understorey vegetation includes low-bush cranberry, beaked hazelnut, prickly rose, red-osier dogwood, saskatoon, wild sarsaparilla, dewberry, common pink wintergreen, palmate-leaved coltsfoot, hairy wild rye and marsh reed grass.

3.0 Methods

Information used in this report was gathered from existing published and unpublished information sources. No field or herbarium surveys were done for this project. The following information sources were used.

ANHIC Database

The Alberta Natural Heritage Information Centre (ANHIC) maintains a database of rare plant species in the province. The first step in assembling a rare plant list was to access this database for any occurrences within the FMA area. A study area defined as the boundaries of the four sections of the FMA area plus a buffer zone of eight kilometers around each section was checked for records of rare species. Adding a buffer zone is standard procedure to ensure that species which have been recorded in the region, and which have a strong possibility of occurring within the FMA area, are also included. The following townships were reviewed for rare plant occurrences (all townships are West of the 5th Meridian):

Range	**Townships**
9	59, 60
10	57 – 60 inclusive
11	57, 58, 59
12	57 – 61 incl.
13	58 – 62 incl.
14	58 – 62 incl., 65, 66
15	58 – 62 incl., 65, 66
16	58 – 62 incl., 65, 66
17	58, 59

This database provided information on rare and endangered vascular and non-vascular plant species whose presence in the above-defined area has been confirmed. The most recent update of this database was in March, 1998.

Literature review

Other rare species which may be present in the FMA were determined by cross-referencing the ANHIC tracking list with information found in general references such as Moss (1983), Wallis (1987) and Argus and Pryer (1990). As well, other sources of biophysical information which may have had data on rare plants were checked. These included environmentally significant areas (ESA) assessments, vegetation surveys and environmental impact studies.

Levels of rarity

The level of rarity for vascular and non-vascular plants used in this project is the ranking system designed by The Nature Conservancy (The Nature Conservancy 1982). Each species has three levels of ranking based on different geographic scales:

G = global (status throughout its entire range)
N = national (status in Canada)
S = subnational (status in a province, i.e. Alberta)

The status of a species within each ranking (geographic range) is provided on a scale of one to five. This scale takes into account such factors as abundance, range, level of protection and threats. The Canadian ranks are based exclusively on the number of known occurrences, because other information is rarely available. The status codes are defined as follows:

1	Critically imperiled due to extreme rarity (5 or fewer occurrences)
2	Imperiled because of rarity (6 to 20 occurrences)
3	Rare or uncommon (21 to 100 occurrences)
4	Apparently secure, with many occurrences
5	Abundant and demonstrably secure, with many occurrences
Q	Questionable taxonomic rank
R	Reported but without persuasive documentation to either accept or reject the report
U	Uncertain status, possibly in peril; more information needed
?	No information available, or the number of occurrences is estimated.

Status for taxon ranks at the subspecies or variety level are designated as TX, where X is one of the status codes described above. For example, a taxon designated as G5T1 would be secure on a global scale, but the subspecies would be critically imperiled.

Taxonomy

The taxonomy used in this report comes primarily from Moss (1983) with addendums and revisions from Harms et al. (1992), Johnson et al. (1995) and Kershaw et al. (1998).

Subregions

For the purposes of this report, reference will be made to only three natural subregions, as opposed to the four described in section 2 (Study area). This is because the two subregions within the boreal forest natural region (central mixedwood and dry mixedwood) are so similar with regards to their ecosite classification (Beckingham and Archibald 1996) that they are both considered part of the boreal mixedwood natural subregion.

4.0 Rare and endangered plants

4.1 Rare vascular plants

There are eighty-six rare or endangered vascular plant species within the study area, as determined by a query of the ANHIC database, combined with additional information obtained from Moss (1983), Bradley and Fairbarns (1984), Packer and Bradley (1984) and Argus and Pryer (1990). A list of these species is found in Appendix I (see volume 2).

According to the ANHIC records, rare vascular plants in the southern blocks of the FMA area are widely scattered, with some concentrations along the Athabasca River and along some of the larger creek valleys (figure 2). The most concentrated area of rare vascular plants is found along the escarpment of the Swan Hills (in and adjacent to the Goose Mountain Ecological Reserve).

There are 507 vascular plant elements which are considered rare or endangered on a provincial basis (according to the ANHIC tracking list). The eighty-six rare species within the FMA area represents 16.9 percent of Alberta's rare flora. This figure is considerably less than the overall provincial flora, of which 28.9 percent is rare or endangered. (Note: these figures are approximate in that they include subspecies and varieties which are on the tracking list).

There are a total of approximately 440 vascular plants which should occur within, or immediately adjacent to, the FMA (Moss 1983), a figure which represents 25.1 percent of the provincial flora.

The 1755 vascular species present in Alberta (Moss 1983) represent 113 different families. The rare species present in the FMA represent 32 taxonomic families. These families, and the number of rare species in each found in the study area, is shown in table 1.

Graminoid species (grass and grass-like plants) are by far the most abundant of the rare vascular plants in the FMA area. Thirty-seven (44%) of the eighty-seven rare species belong to just three graminoid families: Cyperaceae, Poaceae and Juncaceae. The sedge family (Cyperaceae) is a very diverse group, with species occurring in a wide variety of habitats and in differing environmental conditions, although they do exhibit an affinity for moist to wet habitats (Kershaw et al. 1998). The rushes (Juncaceae) are found mainly in moist to wet areas while the grasses (Poaceae) prefer moist to dry habitats. The pondweeds (Potamogetonaceae), with six species, are completely aquatic plants. The remaining forty-three species are spread among twenty-eight different families.

The number of rare species in the Sedge family may be over-represented due to two factors. First, sedges are among the most difficult vascular plants to identify and most taxonomic keys require mature fruits for accurate identification. This, coupled with the fact that many sedges are inconspicuous and grow in association with other, similar sedge species, means that some sedge species may not be as rare as is currently believed.

Figure 2

Table 1. Number of rare vascular plant species according to family.

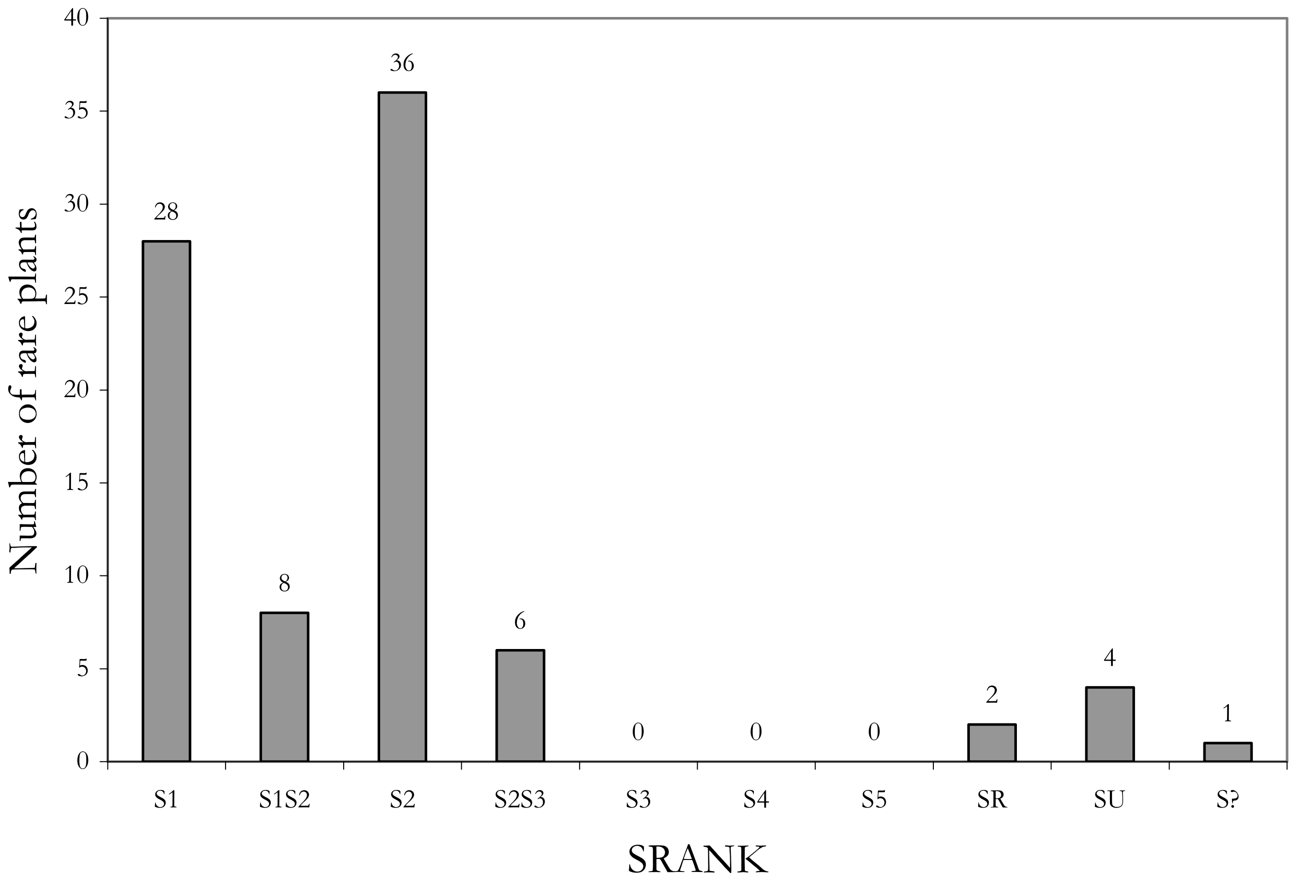
Taxonomic name	Common name	No. species
Cyperaceae	Sedge	24
Poaceae	Grass	7
Juncaceae	Rush	6
Potamogetonaceae	Pondweed	6
Cruciferae	Mustard	3
Ophioglossaceae	Adder’s-tongue	3
Polypodiaceae	Fern	3
Compositae	Composite	2
Liliaceae	Flowering-quillwort	2
Lycopodiaceae	Club-moss	2
Nymphaeaceae	Water-lily	2
Onagraceae	Evening Primrose	2
Orchidaceae	Orchid	2
Ranunculaceae	Crowfoot	2
Salicaceae	Willow	2
Alismataceae	Water-plantain	1
Araliaceae	Ginseng	1
Capparidaceae	Caper	1
Caryophyllaceae	Pink	1
Chenopodiaceae	Goosefoot	1
Droseraceae	Sundew	1
Geraniaceae	Geranium	1
Hydrocharitaceae	Waterweed	1
Hypericaceae	St John’s-wort	1
Isoetaceae	Quillwort	1
Monotropaceae	Indian-pipe	1
Najadaceae	Naiad	1
Parnassiaceae	Grass-of-Parnassus	1
Sarraceniaceae	Pitcher-plant	1
Scrophulariaceae	Figwort	1
Sparganiaceae	Bur-reed	1
Violaceae	Violet	1

Figure 3 shows the population status of the rare vascular plants. Twenty-eight species are listed as S1, meaning they are critically imperiled. Thirty-six species are considered imperiled (SRANK S2) and eight species are ranked as intermediaries between these two classes (i.e., as S1S2). Overall, seventy-three of the eighty-six rare species in the FMA area (83.9%) are considered to be, at the very least, imperiled due to the low frequency with which they have been recorded in Alberta. Six species are considered rare (SRANK S2S3) while the status of the remaining seven species is uncertain or unknown due to a lack of persuasive documentation.

The possible reasons why each of these species is considered rare is given in Appendix I. Of the seventy-three species ranked from S2 to S1 (figure 3), sixty-four are rare due to low population numbers in Alberta, while the remaining nine species owe their rare status to range extensions, mostly from the extreme northern or southern areas of the province (figure 4). The thirteen remaining vascular species represent range extensions from the Rocky Mountains and foothills to the west and southwest of the FMA area.

Information regarding the habitat preferences and taxonomy for the rare and endangered vascular species can be found in Appendix II.

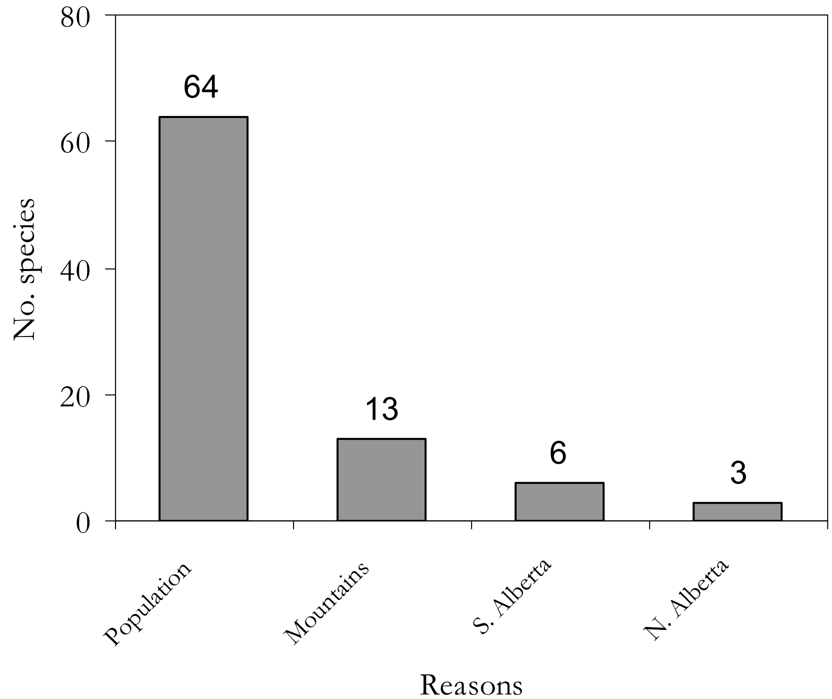
Figure 3. Frequency distribution of rare vascular species according to their level of provincial rarity (SRANK)



S1	Critically imperiled due to extreme rarity (5 or fewer occurrences)
S2	Imperiled because of rarity (6 to 20 occurrences)
S3	Rare or uncommon (21 to 100 occurrences)
S4	Apparently secure, with many occurrences
S5	Abundant and demonstrably secure, with many occurrences
SQ	Questionable taxonomic rank
SR	Reported but without persuasive documentation to either accept or reject the report
SU	Uncertain status, possibly in peril; more information is needed
S?	No information available, or the number of occurrences is an estimate

A combined SRANK (eg. S1S2) indicates that the species are an intermediary between the two rankings.

Figure 4. Reasons for rarity of provincially rare vascular species.



Population	- low population levels
Mountains	- disjunct species from the Rocky Mountains and foothills
S. Alberta	- disjunct species from extreme southern Alberta
N. Alberta	- disjunct species from extreme northern Alberta

4.2 Locally rare vascular plants

According to Bradley and Fairbarns (1984) and Moss (1983) there are thirty-six vascular species which are considered to be locally rare within the study area (Appendix III, volume 2). This number is based primarily on surveys done in the Swan Hills portion of the FMA area. These species are rare due to either their presence at the outer limits of their range in Alberta or they are disjunct species whose normal range is the foothills and subalpine regions to the west and southwest.

The locally rare vascular species represent fifteen different families (Table 2), seven of which are not represented by the rare or endangered species.

Table 2. Number of locally rare vascular plant species according to family

Taxonomic name	Common name	No. species
Cyperaceae	Sedge	10
Compositae	Composite	7
Gramineae	Grass	3
Juncaceae	Rush	2
Leguminosae	Pea	2
Saxifragaceae	Saxifrage	2
Scrophulariaceae	Figwort	2
Fumariaceae	Fumitory	1
Lemnaceae	Duckweed	1
Onagraceae	Evening Primrose	1
Ophioglossaceae	Adder's-tongue	1
Ranunculaceae	Crowfoot	1
Rosaceae	Rose	1
Salicaceae	Willow	1
Umbelliferae	Carrot	1

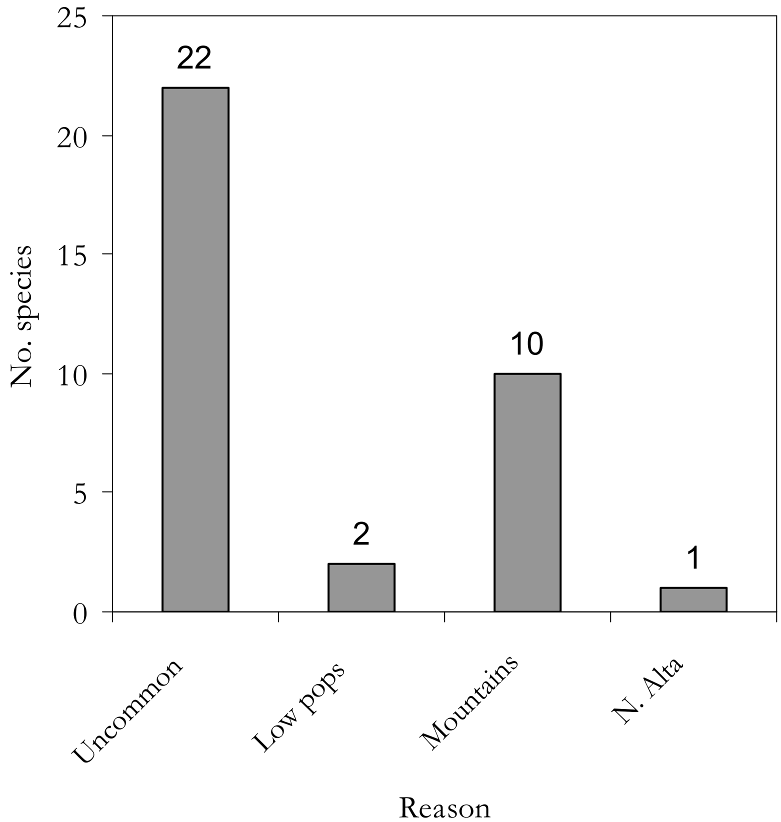
Of the thirty-six locally rare species, seventeen are found in just two families. The sedge family (Cyperaceae) is the most common one, as is also the case for the rare vascular species (see Table 1), while seven species are in the composite family (Compositae). The species found in both of these families exhibit a wide range of habitat affiliations. The remaining nineteen species are spread among thirteen different families.

Locally rare vascular species do not have a rarity status assigned by the ANHIC database since none of these species are considered rare on a provincial basis.

The reason why each of these species is considered rare on a local scale is given in appendix III (and illustrated in figure 5). Twenty-two of the species are uncommon in the region of the FMA area, but are considered common elsewhere in the province. Ten species are present in the FMA area as range extensions from the Rocky Mountains and foothills and one species as an extension from extreme northern Alberta. Two other species have small populations, but with numbers too high to warrant inclusion on the ANHIC tracking list. The specific reason for the local rarity of one species is unclear.

Information regarding the habitat preferences and taxonomy for the locally rare vascular species can be found in Appendix IV.

Figure 5 Reasons for rarity of locally rare vascular species.



Uncommon	- species which are uncommon in the region of the FMA area
Low pops	- low population levels (especially in this region of Alberta)
Mountains	- species whose range extends from the Rocky Mountains and foothills
N. Alta	- range extension from northern Alberta

4.3 Rare non-vascular plants

There are eighteen species of rare non-vascular plant species in the study area, according to the ANHIC database (Appendix V).

Table 3. Number of rare non-vascular plant species according to family.

Taxonomic name	No. species
Dicranaceae	4
Polytrichaceae	3
Bryaceae	2
Fontinalaceae	2
Sphagnaceae	2
Brachytheciaceae	1
Encalyptaceae	1
Pottiaceae	1
Schistostegaceae	1
Splachnaceae	1

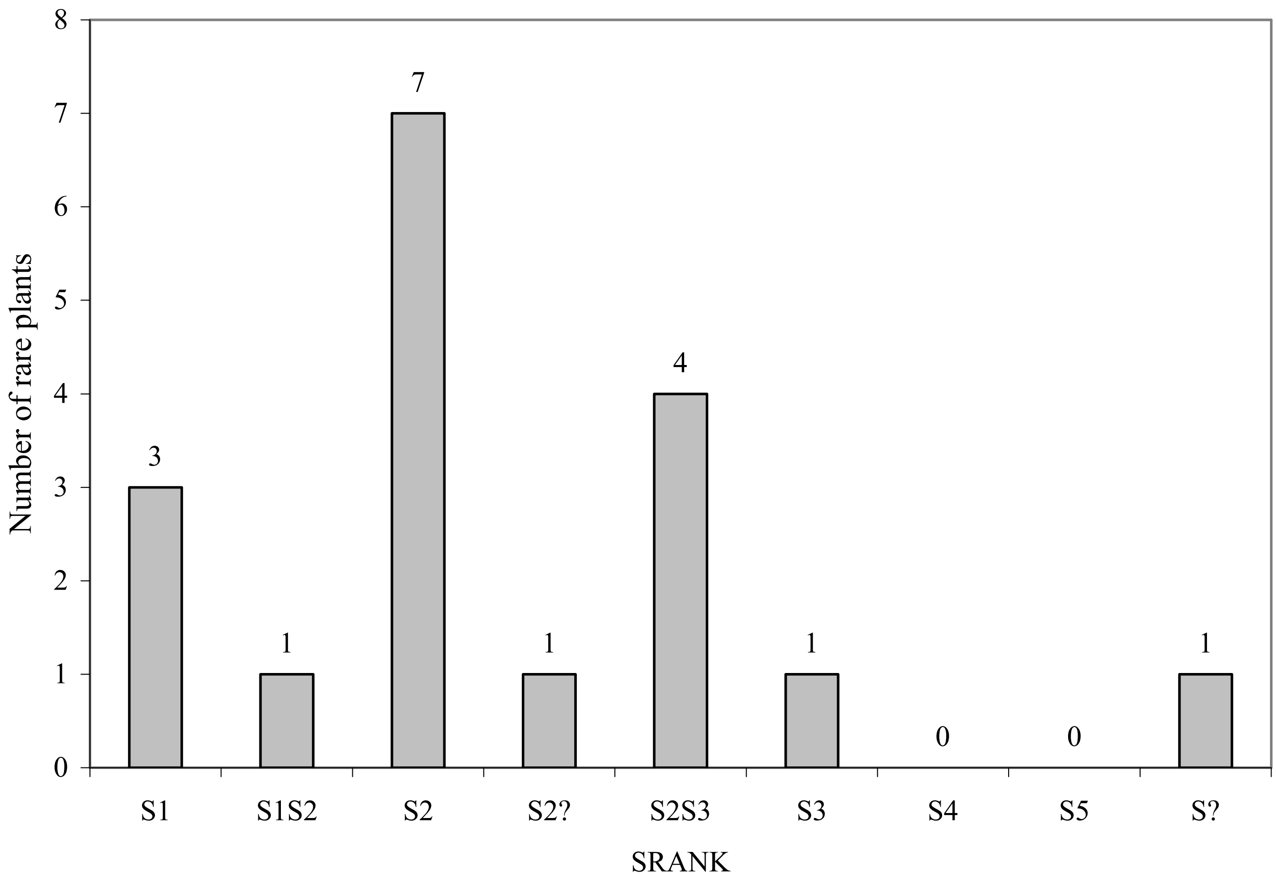
No single family is dominant among the rare non-vascular species as the eighteen species are spread fairly evenly between ten families (Table 3). All of the non-vascular species are mosses, as no rare lichens or liverworts have yet been recorded within the FMA area. Map 2 shows the known locations of rare non-vascular species in the FMA area.

Figure 6 shows the population status of the non-vascular plants. Eleven species are ranked from S1 to S2, thus, 61.1% of the species are at the very least, imperiled due to the low number of recorded occurrences in Alberta. Six other species are considered rare. The current status of one other species is unknown due to a lack of information.

The known locations of rare non-vascular plants are unevenly scattered over most of the FMA area. The only area where non-vascular plants are concentrated is along the escarpment and uplands of the Swan Hills (figure 2).

Information regarding the habitat preferences and taxonomy for the rare and endangered non-vascular species can be found in Appendix VI.

Figure 6. Frequency distribution of rare non-vascular species according to their level of provincial rarity (SRANK).



S1 Critically imperiled due to extreme rarity (5 or fewer occurrences)
S2 Imperiled because of rarity (6 to 20 occurrences)
S3 Rare or uncommon (21 to 100 occurrences)
S4 Apparently secure, with many occurrences
S5 Abundant and demonstrably secure, with many occurrences
SQ Questionable taxonomic rank
SR Reported but without persuasive documentation to either accept or reject the report
SU Uncertain status, possibly in peril; more information is needed
S? No information available, or the number of occurrences is an estimate

A combined SRANK (eg. S1S2) indicates that the species are an intermediary between the two rankings.

4.4 Habitat evaluations

The habitat preferences for vascular and non-vascular species was determined by a search through the relevant literature, predominantly regional floras and rare plant guides which have been published over the past several years. These references use habitat descriptions which are general standards used throughout the botanical literature. As such, several different sources could be cross-referenced for habitat information on the same species.

This habitat information is provided on a species-specific basis in Appendices II, IV and VI (see volume 2). An amalgamation of this information, which illustrates the most important habitats for the rare plant species of the FMA area, is presented in the following sections.

4.4.1 Rare vascular plants

The most important habitats for rare vascular plants in the FMA area are found in wetland environments (Table 4). Approximately forty percent of all rare plant occurrences are found in wetlands, with moist to wet bogs being the most common habitat. Moist meadows, marshes, fens and swamps also contain numerous rare species (26.5% of occurrences) while a few plants are specific to *Sphagnum* bogs.

The margins of wetlands also provide suitable habitat for rare plant occurrences (11.5%), as do riparian areas (9.3%) and moist habitats such as seepage areas (6.6%). In total, environments with a hygric to hydric moisture regime (which includes wetlands, wetland margins, moist areas and riparian zones) account for 66% of all rare vascular plant occurrences (figure 7).

Forests are also an important environment for rare species, particularly closed, mesic woods (8.8% of occurrences). Coniferous and open, subxeric woods also have several rare species though not to the same extent.

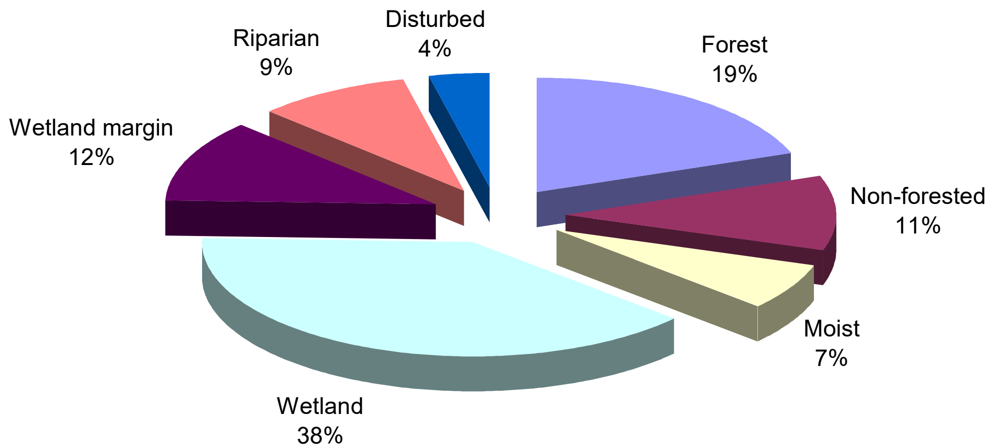
Non-forested areas account for approximately ten percent of rare species occurrences, predominantly in grasslands and dry, open slopes.

Table 4 Presence of rare vascular plants according to habitat type.
The number of rare vascular plant species which are, or likely would be, found in different habitat types. Species with more general habitat requirements would be listed in more than one habitat category.

Environment	Habitat	No. species	Total * occurrences	Percent occurrences
Forest	Closed woods (mesic to subhygric)	20		
	Open woods (subxeric)	10		
	Coniferous	11		
	Deciduous	0		
	Mixed	1		
	Woodland margin	3	44	19.8
Non-forested	Grasslands	4		
	Sandy areas	8		
	Stony areas, slopes	6		
	Dry hillsides	6	24	10.8
Moist habitats	Seepage areas	7		
	Alkaline areas	2		
	Calcareous areas	5		
	Mossy ledges	1	15	6.8
Wetlands	Meadows (moist)	18		
	Bogs	24		
	Sphagnum bogs	4		
	Fens	14		
	Swamps	9		
	Marshes	15	84	37.8
Wetland margin	Riverbanks, streambanks, lakeshores	26	26	11.7
Riparian habitats	Streams	5		
	Lakes, ponds	13		
	Acidic lakes or ponds	3	21	9.5
Disturbed areas	Forest clearings	5		
	Clearcuts, cutlines, roadsides	3	8	3.6
				100.0

* Total occurrences: number of occurrences of rare plants within a particular environment (eg., forest, wetlands)

Figure 7. Occurrences of rare vascular plants by habitat type.



4.4.2 Locally rare vascular plants

Wetlands are important habitats for the locally rare vascular species, although not to the same extent as is the case for the rare vascular plants. Twenty-six percent of all occurrences of locally rare vascular plants are found in wetland habitats, with moist meadows being the most common wetland habitat type (Table 5). Numerous species also occur in the moist habitats, wetland margins and riparian zones. In total, the hygric to hydric environments account for 54% of locally rare plant occurrences (Figure 8).

Locally rare vascular species are more often found in forest habitats than is the case for rare vascular plants. Twenty-nine percent of occurrences of locally rare species are in the forest environment, particularly the mesic, closed woods (13%) and the subxeric, open woods (11%). Thus, the locally rare species span a wide breadth of forest habitats.

Disturbed habitats (i.e., forest clearings, clearcuts, seismic lines, etc.) contain more species which are locally rare than species which are provincially rare (14.4% vs. 3.5%).

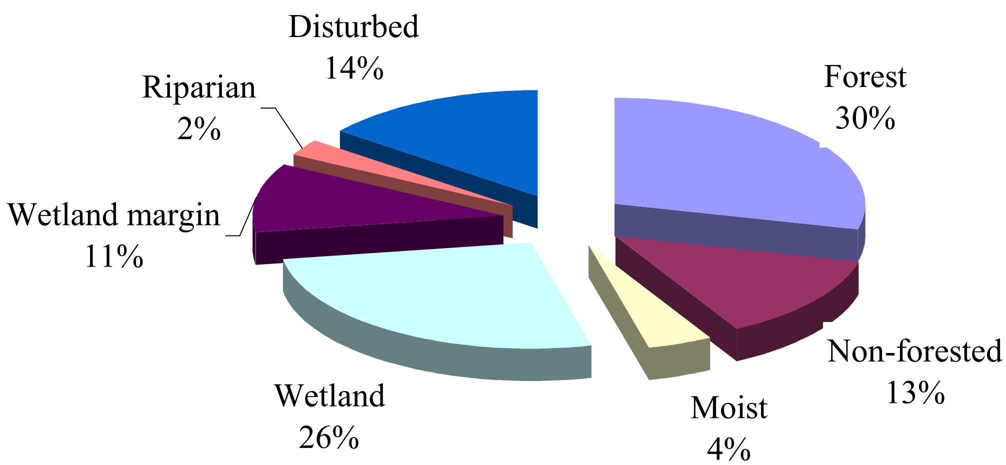
Table 5 Presence of locally rare vascular plants according to habitat type.

The number of locally rare vascular plant species which are, or likely would be, found in different habitat types. Species with more general habitat requirements would be listed in more than one habitat category.

Environment	Habitat	No. species	Total * occurrences	Percent occurrences
Forest	Closed woods (mesic to subhygric)	13		
	Open woods (subxeric)	11		
	Coniferous	6		
	Deciduous	4		
	Mixed	0		
	Woodland margin	1	35	28.8
Non-forested	Grasslands	4		
	Sandy areas	3		
	Stony areas, slopes	7		
	Dry hillsides	2	16	13.2
Moist habitats	Seepage areas	5		
	Alkaline areas	0		
	Calcareous areas	0		
	Mossy ledges	0	5	4.1
Wetlands	Meadows (moist)	12		
	Bogs	4		
	Sphagnum bogs	2		
	Fens	6		
	Swamps	1		
	Marshes	7	32	26.3
Wetland margin	Riverbanks, streambanks, lakeshores	13	13	10.7
Riparian habitats	Streams	0		
	Lakes, ponds	3		
	Acidic lakes or ponds	0	3	2.5
Disturbed areas	Forest clearings	5		
	Clearcuts, cutlines, roadsides	12	17	14.4
				100.0

* Total occurrences: number of occurrences of rare plants within a particular environment (eg., forest, wetlands)

Figure 8. Occurrences of locally rare vascular plants by habitat type.



4.4.3 Rare non-vascular plants

Determining the habitat preferences for non-vascular plants is more difficult than for vascular plants due to a lack of basic information on the autecology of mosses and lichens, and to a scarcity of field surveyors with expertise in non-vascular plant identification. Thus, the information presented below is to be used with some caution as it presents only general results.

The most important environment for non-vascular plants is the non-forested environment. Twenty-nine percent of all non-vascular species occurrences are found in sandy areas and open slopes (Table 6, Figure 9).

The hygric and hydric habitats (wetlands, wetland margins, moist habitats and riparian zones) contain approximately 52% of rare non-vascular plant occurrences. Within these environments, fens have the greatest number of occurrences.

Forest habitats have very few rare non-vascular species, and those are generally found in coniferous woods.

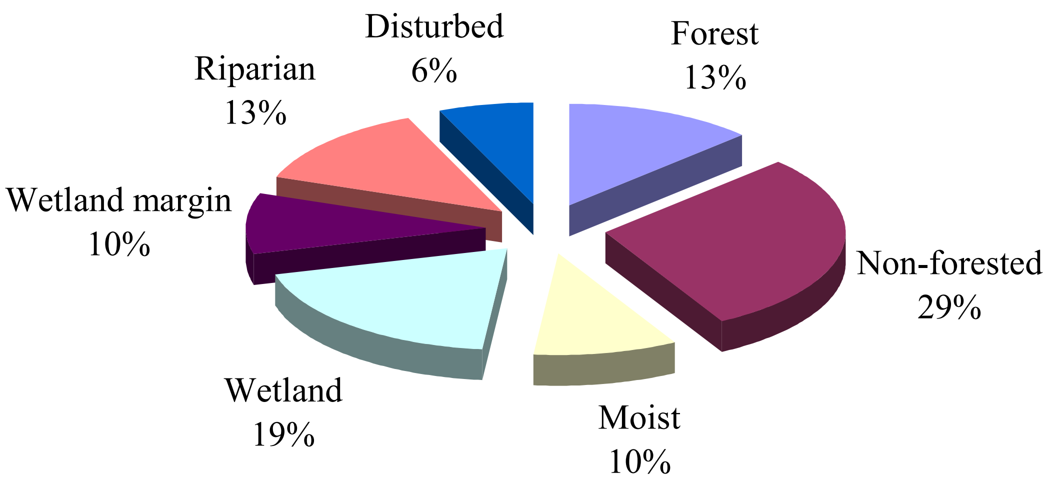
Table 6Presence of rare non-vascular plants according to habitat type.

The number of locally rare vascular plant species which are, or likely would be, found in different habitat types. Species with more general habitat requirements would be listed in more than one habitat category.

Environment	Habitat	No. species	Total * occurrences	Percent occurrences
Forest	Closed woods (mesic to subhygric)	0		
	Open woods (subxeric)	1		
	Coniferous	3		
	Deciduous	0		
	Mixed	0		
	Woodland margin	0	4	12.9
Non-forested	Grasslands	0		
	Sandy areas	6		
	Stony areas, slopes	3		
	Dry hillsides	0	9	28.9
Moist habitats	Seepage areas	0		
	Alkaline areas	0		
	Calcareous areas	1		
	Mossy ledges	2	3	9.7
Wetlands	Meadows (moist)	0		
	Bogs	1		
	Sphagnum bogs	0		
	Fens	5		
	Swamps	0		
	Marshes	0	6	19.4
Wetland margin	Riverbanks, streambanks, lakeshores	3	3	9.7
Riparian habitats	Streams	2		
	Lakes, ponds	2		
	Acidic lakes or ponds	0	4	12.9
Disturbed areas	Forest clearings	0		
	Clearcuts, cutlines, roadsides	2	2	6.5
				100.0

* Total occurrences: number of occurrences of rare plants within a particular environment (eg., forest, wetlands)

Figure 9. Occurrences of rare non-vascular plants by habitat type.



5.0 Rare plant model

In order to better understand how forestry operations will impact rare plant populations and their habitats, an ecological model describing the rare vascular plants was developed and applied to the ecosite map of the FMA area.

(Note: this model was applied only to the rare vascular plants, as there was not enough habitat information to analyze the non-vascular species)

The ecosite map was used for this model instead of the BAP habitat classification because the ecosite analysis was more amenable to the specialized habitat requirements of the rare plants. Whereas the BAP method is useful for classifying forested areas, it lacks the ability to distinguish between the wetland/moist habitats, where the majority of rare species are found. The ecosite method of landscape analysis is better suited to this type of use, where the entire spectrum of habitats are considered.

This model was designed to provide a direct association between the preferred habitats of each species and the ecosite map. This would provide a detailed picture of the current location and extent of the rare plant habitats within the FMA area (as accurately as can be accomplished using information from existing databases and the literature). There are several benefits to this approach:

- it would show resource managers the extent of critical rare plant habitats within the FMA area,
- it would allow resource managers to do a direct comparison between critical rare plant habitats and areas with high economic potential (i.e. those with merchantable timber), and
- it would be a first step towards implementing a rare plant monitoring program.

Objective of the model
The objective of the model was to illustrate the relative level of importance of each ecosite in terms of the rare vascular plants. In order to achieve this objective, the model took into account several factors:

- the species richness of rare vascular plants which would likely occur in the ecosite,
- the level of habitat specificity for each species (i.e. generalist vs. specialist), and
- the areal extent of each ecosite within the FMA area.

How the rare vascular plant model works
The following methods were used to produce the model, and it was done separately for each natural subregion since both the ecosite types and the number of rare vascular species differ between subregions.

- Determine the habitat requirements of each species. This information was gathered through a review of the literature and relevant databases.

- Determine the ecosites in which each species would likely be found. This was done by comparing the habitat requirements of each species to the ecosite descriptions found in Beckingham et al. (1996a, 1996b). This also permitted a more accurate determination of which species should be included in each natural subregion. (This information is presented in matrix form, in appendices 10, 11 and 12 of Rare and Endangered Plant Species - Volume 2).

- Assign each species a species-ecosite score (SES). This score is based on the number of ecosites in which a given species would be found relative to the total number of ecosites in that subregion.

  SES (x) = y/x n

Where

- SES (x)= species ecosite score for species x
- y = total number of ecosites
- n = total number of ecosites in which species x would be found

This score is given to all ecosites for that species. The result is a Species X Ecosite matrix, specific to each natural subregion.

- Determine an ecosite score (ECS). This is done by summing all species-ecosite scores for each ecosite.

  ECS (e) = (SES x + SES x + … SES x)

Where

- e = ecosite
- SES x = species-ecosite score for species x

- Determine the maximum species-ecosite score (SES max), i.e.:

  SES max = (Total no. species) (total no. ecosites)

- For a more meaningful comparison of ecosites across a subregion, determine the ecosite score as a percentage of the maximum possible ecosite score, i.e.

  ECS final = (ECS / SES max) x 100

The final value represents the relative importance of each ecosite (specific to that subregion). Within each subregion, the ecosite scores naturally divided themselves into distinct groupings, which were designated as having either a high, medium or low importance for rare vascular plants (see Table 7).

Figure 10 shows the spatial distribution of the ecosite categories. The most obvious feature of this map is that the different natural subregions are easily visible. The upper foothills is represented almost exclusively by the medium category and is thus, easily apparent compared to the lower foothills, which are mostly within the high ranked category. Even though just six of the thirteen upper foothills ecosites were rated as medium in importance, they represent approximately 88% of the area within this subregion (table 7).

A similar situation is found for the lower foothills, but in this case, it is the high category which dominates the subregion; eight of fourteen ecosites are rated as high, which represents 89% of the area of this subregion. In the boreal mixedwood, the four medium ecosites cover 67% of the subregion.

Overall, it appears that the lower foothills subregion is the most important of the three natural regions for rare vascular plant habitat since much of this subregion has a high potential for rare plant habitat. The greatest concentration of this highly rated habitat (i.e., ecosites) occurs in the extreme southeast portion of the FMA area and in the area just north of the Athabasca River.

Those ecosites ranked as having the lowest level of importance for rare plant habitat are small and widely scattered but are present in all parts of the FMA area. There are some areas where these ecosites are concentrated, most notably along the south side of the Athabasca River, where the Windfall and Whitecourt sand hill/peatland compexes are located. Sand dunes are notable for the presence of rare species but usually when they are stable and the vegetation is in an early successional stage (Robson 1997). These two dune fields are both well vegetated (Bentz and Saxena 1994).

The areal extent of each ecosite in this analysis is important, especially in the context of the relative contribution of each ecosite type to the overall FMA area. A variable for areal extent was not included in the rare plant model because doing so would have rendered a meaningful and accurate interpretation of the resulting ecosite scores quite difficult. Instead, a direct comparison between ecosite score and the relative contribution of each ecosite to the subregion can be made. Figure 11 illustrates the variation between the final score (ECS final) and areal extent of each ecosite within the boreal mixedwood subregion. The low-bush cranberry ecosite (ecosite d) is ranked within the medium category (ECS final: 8.4) however it covers 46% of the subregion, whereas the highest ranked ecosite (bog; ecosite i; ECS final: 12.2) covers only 3.2%.

In the lower foothills subregion, the low-bush cranberry ecosite (ecosite d; ECS final: 8.4) includes 64% of the subregion while the highest ranked ecosite (marsh; ecosite n; ECS final: 15.5) covers less than one percent. A similar situation is also found in the upper foothills, where the highest ranked ecosites (bog, poor fen, rich fen) account for a total of less than three percent of the subregion while the medium ranked ecosites (eg. Labrador tes-mesic, tall bilberry/arnica) cover 79% of the subregion.

Table 7. Ecosite scores, total area of each ecosite and the proportion of each ecosite within the three natural subregions.

Natural subregion	Ecosite	Ecosite score	Ecosite score category	Total area (ha)	Proportion of the subregion
Boreal mixedwood	a	10.2	High	2.05	.00005
	b	4.5	Low	1759.83	.044
	c	7.6	Medium	2801.27	.071
	d	8.4	Medium	18411.27	.46
	e	6.6	Medium	3655.13	.092
	f	8.7	Medium	1819.51	.046
	g	4.9	Low	2080.29	.052
	h	5.5	Low	759.78	.019
	i	12.2	High	1274.80	.032
	J	10.7	High	6379.84	.16
	K	10.7	High	669.03	.017
	L	10.1	High	59.85	.002
Lower foothills	a	4.3	Medium	4.49	.00001
	b	5.05	Medium	804.63	.004
	c	5.65	Medium	1659.49	.008
	d	8.87	High	22459.60	.11
	e	9.58	High	130413.99	.63
	f	9.58	High	14008.29	.067
	g	7.98	High	891.32	.004
	h	1.02	Low	12057.05	.058
	i	1.02	Low	3610.75	.017
	j	1.02	Low	3719.94	.018
	k	11.66	High	4638.93	.022
	l	8.82	High	13349.60	.064
	m	8.68	High	705.26	.003
	n	15.45	High	24.25	.0001
Upper foothills	a	6.1	Medium	0	0
	b	4.6	Medium	0	0
	c	8.7	Medium	139.91	.004
	d	7.3	Medium	9174.47	.23
	e	9.5	Medium	22169.90	.56
	f	9.5	Medium	3345.05	.085
	g	10.6	High	24.07	.0006
	h	1.4	Low	2482.37	.063
	i	1.4	Low	541.32	.014
	j	2.1	Low	372.34	.009
	k	11.9	High	307.76	.008
	l	13.5	High	744.76	.019
	m	13.5	High	27.39	.0007

FIGURE 10

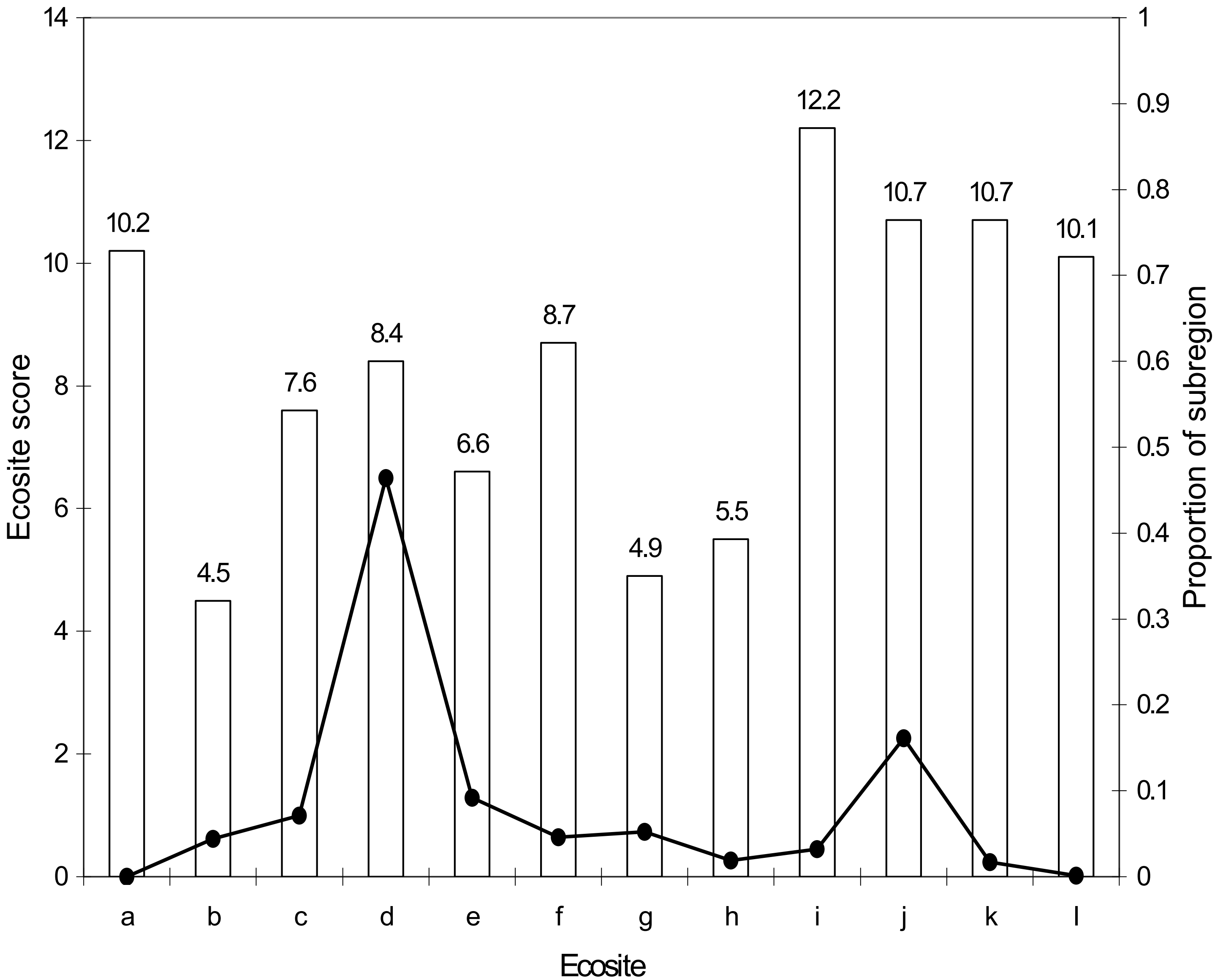


Figure 11. Boreal mixedwood ecosite scores and the proportion of this subregion represented by each ecosite.

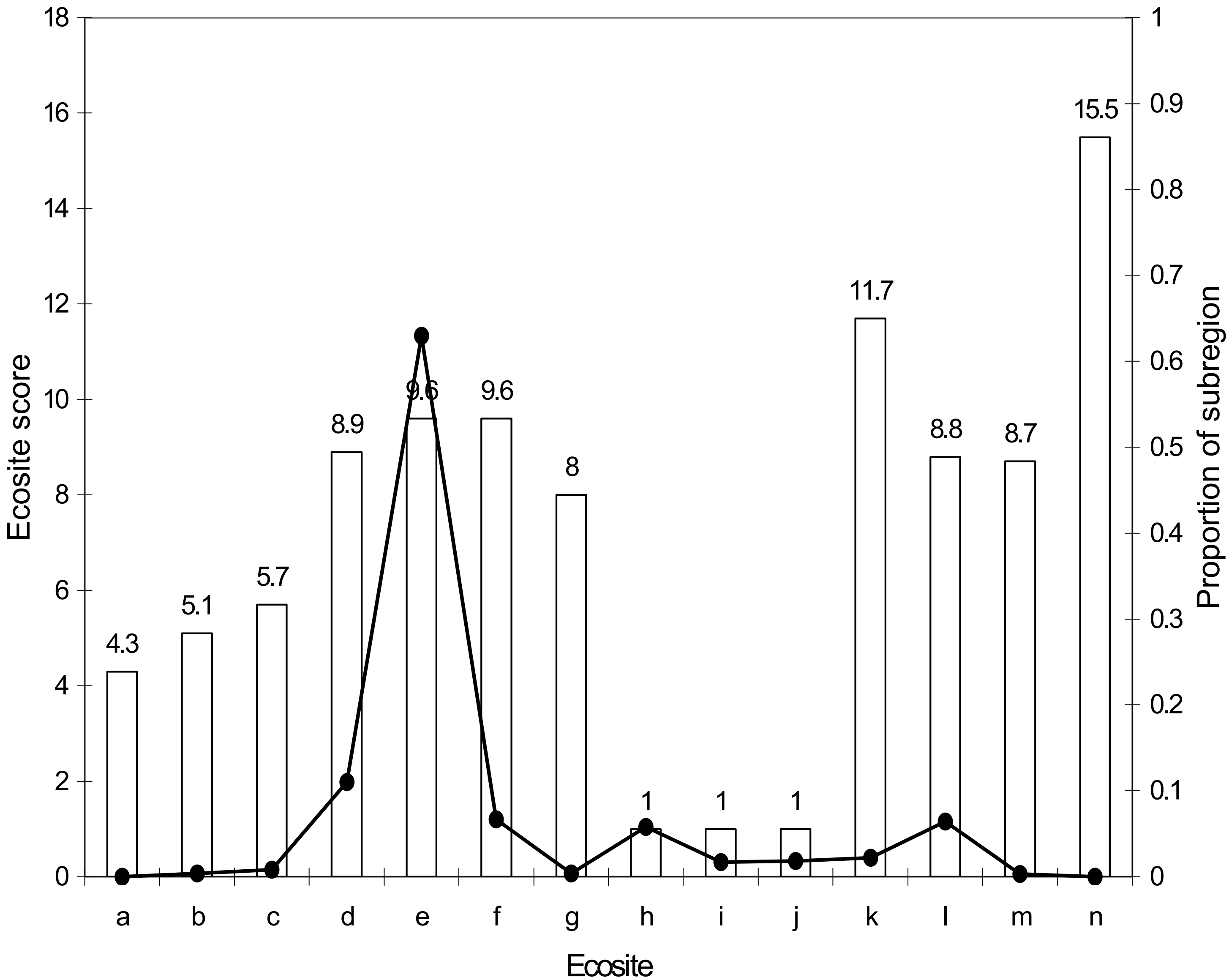


Figure 12. Lower foothills ecosite scores and the proportion of this subregion represented by each ecosite.

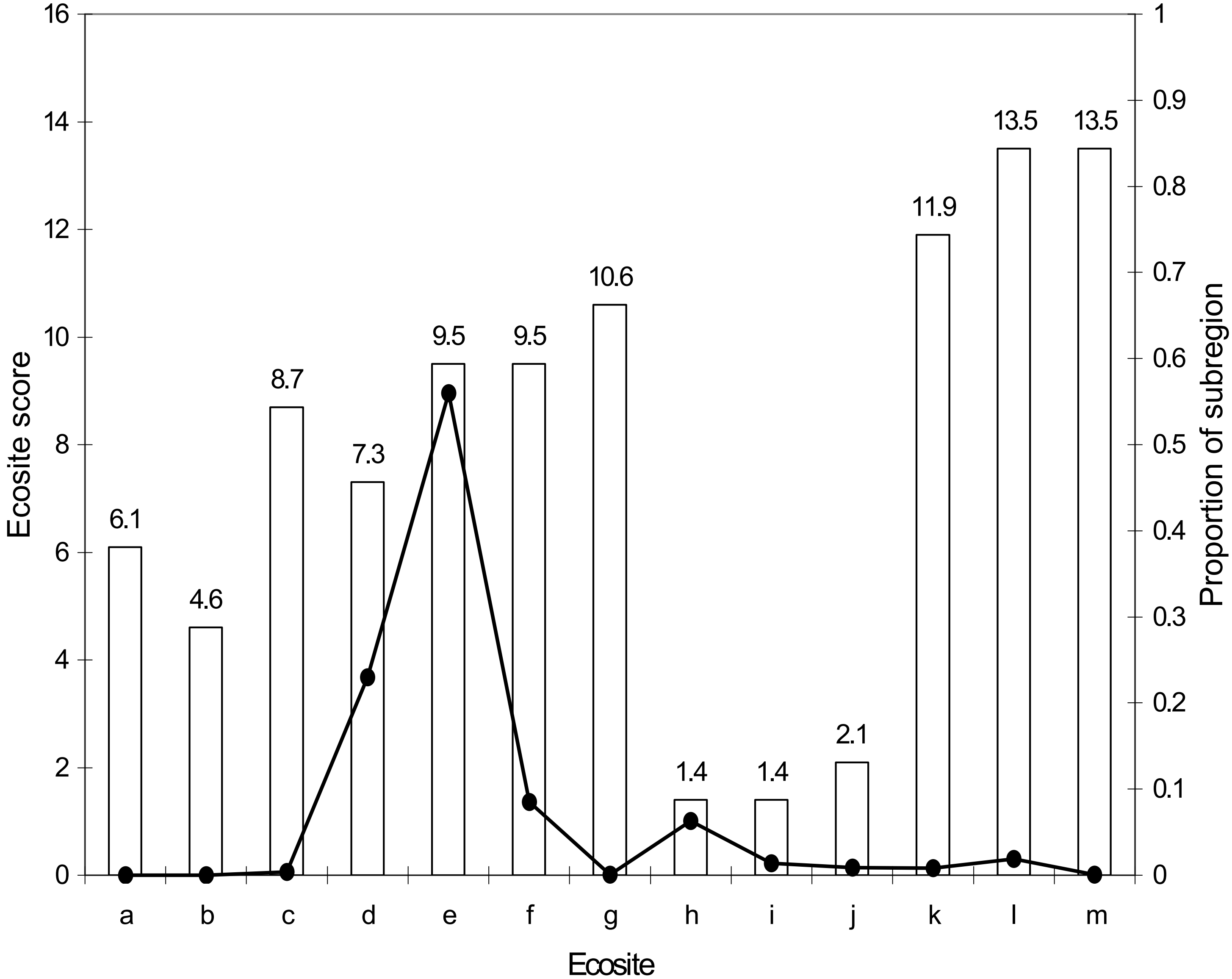


Figure 13. Upper foothills ecosite scores and the proportion of this subregion represented by each ecosite.

6.0 Disturbance impacts

There is very little literature concerning the impacts of forestry on rare plants, as it deals mainly with effects on the overall vegetation. However, with the exception of some invader species who use clear-cut areas as short-term habitats, the impacts of forestry activities would be similar for both rare plants and the overall vegetation.

Harvesting
The most detrimental effect of logging activities on rare plants is their direct removal and/or destruction during harvesting operations. Species diversity and total cover decreases as a result of logging activities (Geographic Dynamics Corp . 1995). In the boreal mixedwood natural region, it was found that entire vegetative strata (in terms of foliar cover and species richness), including trees layers, tall shrubs and short shrubs, disappear when an area is clear-cut, and most of the forb layer also decreases significantly (Geographic Dynamics Corp . 1995).

Logging in forested areas within the FMA area would impact twenty percent of the rare vascular species, and an additional seven percent which are found in specific moist habitats within the forested areas (section 4.4). However, the clearings created by logging activities would provide the necessary habitat for about three percent of the rare vascular species, at least in the short term. Most of the rare vascular plants would not be directly impacted by logging since they occur in either wetlands (38%), wetland margins (12%) or riparian zones (9%). These areas and their plant species can be subjected to indirect disturbance effects through such things as altered water balances, changes in moisture regimes and accumulation of organic debris.

Most of the rare non-vascular plants are found in either wetlands (19%), wetland margins (10%), riparian zones (13%) and non-forested habitats (29%). Thus, a total of 72% of the rare non-vascular plant occurrences would not be directly impacted by logging. But, as is the case with rare vascular plants, indirect impacts are still possible.

The impact would be greatest on locally rare vascular plants, of which 29% are found in forested areas and 4% in moist habitats within forests. However, 14% of the species within this group can be found in disturbed areas.

Another important effect of logging is that of habitat simplification and fragmentation, with an accompanying loss of biodiversity due to the establishment of mono-culture tree stands (Geographic Dynamics Corp. 1997).

Disturbance impacts due to forestry operations may also have indirect impacts. Activities such as road building and accumulation of debris piles may alter surface drainage patterns, affecting wetland water regimes and thereby contributing to the decline or demise of some wetland rare plant populations (Snyder 1998).

Negative impacts, which reduce or eliminate the habitat, will also reduce the genetic variability within the population of a rare species, particularly when that population is an isolated colony, i.e. for disjunct populations (Drury 1974, Schaffer 1981).

A positive effect of logging for rare plant species is the potential creation of wetland areas. In some regions, removal of the tree layer reduces the transpiration rate and permits the water table to rise within the soil column, to the point where it effectively floods the clear cut area. This creates shallow wetlands, which may well, over the long-term, provide adequate habitat for several rare plant species.

Site preparation
The preparation of clear-cut areas after logging activities are complete has numerous effects on the soils and ground cover of an area, for both rare and common plant species.

Scarification of a logged area by mechanical means disturbs the humus layer and exposes the mineral soil, thereby increasing the ability of seeds to easily penetrate the seedbed (Corns and LaRoi 1976, McMinn and Hedin 1990). This same process also changes the microclimate of the soil (Bedford and McMinn 1990).

The displacement of soil by mechanical site preparation removes associated soil nutrients from the surface and represents a significant nutrient loss to growing plants (Morris et al. 1983).

This process of windrowing also changes surface drainage patterns and accelerates soil erosion (Morris et al. 1983).

The main effects of mechanical site preparation (following logging activities) on soils are (Enns 1994):

- Higher soil temperatures,
- Greater frost penetration,
- Inversion of LFH layers,
- An initial decrease in bulk density,
- Displacement of nutrients, and
- Changes in the physical properties of humus and debris layers.

The response of the natural vegetation community to mechanical site preparation will depend not only on the original vegetation and soils but also on the type of machinery used (Leblanc and Sutherland 1987). In general though, the main effects are a shift in species composition and a re-structuring of vegetation paterns (Enns 1994).

Species diversity immediately following site preparation was related to the intensity of the treatment (Jobidon 1990). However the initial differences in plant species diversity declined over time, to the point where, two years after site preparation, vegetation cover and biomass were similar to what had been present before site preparation (Conde et al. 1983).

According to Enns (1994) there is still a poor understanding of what vegetation communities and/or complexes develop following various mechanical site preparation techniques, how these habitats respond over time and whether some habitats recover adequately from the initial disturbance.

Table 8 provides a brief summary of the different types of forestry activities and their potential impacts on several habitat types which may harbour rare plants.

Table 8. The potential impacts of forestry activities on selected habitat types (Sources: Snyder 1998, GDC 1997)

Habitat Type	Forestry Activity			
	Harvesting	Site Preparation	Planting	Other (road building, landing sites *etc.)*
Riparian	- high impact - increases competition potential for invader species - intensive harvesting can alter/damage soil conditions thereby reducing available niches for rare plants	- low impact	- moderate impact - decreases habitat diversity and available niches for rare plants to establish	- moderate impact - increases competition potential for invader species - increases potential for disturbance or mortality by vertebrate activity (*i.e.* rare plants as food source) - intensive harvesting can alter/damage soil conditions thereby reducing available niches for rare plants
Wetland	- wetlands not generally harvested	- NA	- NA	- high impact - alters surface drainage patterns thereby changing site quality for rare plants - modifies wetland habitat structure, thus, reducing habitat availability for rare plants
Old-growth	- high impact - increases competition potential for invader species - increases potential for disturbance or mortality by vertebrate activity (*i.e.* rare plants as food source) - intensive harvesting can alter/damage soil conditions thereby reducing available niches for rare plants	- low impact - area already disturbed so limited effect of site prep machinery on presence of rare plants	- moderate impact - decreases habitat diversity and available niches for rare plants to become established	- moderate impact - increases competition potential for invader species - increases potential for disturbance or mortality by vertebrate activity (*i.e.* rare plants as food source) - intensive harvesting can alter/damage soil conditions thereby reducing available niches for rare plants
Other Stand Types	- high impact - increases competition potential for invader species - increases potential for disturbance or mortality by vertebrate activity (*i.e.* rare plants as food source) - intensive harvesting can alter/damage soil conditions thereby reducing available niches for rare plants	- low impact - area already disturbed so limited effect of site prep machinery on presence of rare plants	- moderate impact - decreases habitat diversity and available niches for rare plants to establish	- moderate impact - increases competition potential for invader species - increases potential for disturbance or mortality by vertebrate activity (*i.e.* rare plants as food source) - intensive harvesting can alter/damage soil conditions thereby reducing available niches for rare plants

Fire
Fire is the major natural disturbance which would impact rare plant populations, but it can have a double-edged impact. It will create open habitats which negatively affects those rare species which require closed and shaded habitats (Hurtt and Pacala 1995). However, the same fire event will also produce the habitat types required by different rare species (Bratton and White 1981).

Herbicides
Herbicides would have the obvious negative impact on rare plants by killing them, along with other species in the same area. This is especially true for broad-spectrum herbicides. In addition, persistent herbicides would become concentrated in surface run-off, thereby becoming concentrated in riparian zones and wetlands, two areas which provide habitat for a large percentage of rare plant species. Thus, herbicides can have a very negative effect on rare pants, both directly and indirectly.

Fertilization
It is not know what effects fertilizers would have on rare plants. But there are two main areas of concern:

- fertilizer chemicals would become concentrated in riparian and wetland areas, which are important habitats for rare plants, and
- fertilizers can alter species composition and overall plant biomass in some areas.

Both of these effects can be potentially damaging to rare plant populations although the extent of the effects is not known.

7.0 Rare plant monitoring program

In order to determine, with accuracy, all of the rare plant resources in the FMA area, and to maintain those resources over time, a monitoring program is required.

A well-designed monitoring program would have several objectives:

- it would quantitatively assess the location and areal extent of rare plant populations, both during the initial phase of the program and over the short-term and long-term periods,
- it would determine the conditions of rare plant populations over time,
- it would provide a framework through which ecological modeling of rare plant populations could be incorporated into ecosite modeling and landscape analysis,
- it would help assess the viability of resource management programs,
- it would permit resource managers to assess the effects of any disturbances (natural or man-made), and
- it would provide an indication of the success of any rare plant habitat protection programs.

The first basic steps of a monitoring program are (Wallis et al. 1986):

- assess which taxa are threatened,
- establish a permanent record of the locations of rare taxa, using the published literature and reviews of herbarium records, and
- implement a field survey to both verify old sites of rare taxa and to locate any new sites.

Even though basic inventories of rare plants and their habitats are required to establish conservation priorities, they do not provide enough information to manage the resource on a scientific basis (Davy and Jeffries 1981). For this, a permanent record of rare plant populations is required. This would involve (White and Bratton 1981):

- establishing permanent survey plots,
- mapping individual plants in those plots,
- establishing photographic records, and
- collecting demographic records.

The use of permanent survey plots is an integral component of any long-term monitoring program (Graber 1986). The key to permanent survey plots is to ensure that measurements are repeated (Wallis et al. 1986). Long-term use of permanent survey plots, which provide precise data, can be combined with rapid, large-scale surveys which would add information on a scale not possible using simple survey plots on an as-needed basis (Williams 1981).

In order for a monitoring program to effectively monitor the status and changes to plant populations it must be repeated over a period of several years. This will help account for the inherent variability in the yearly health and reproductive success of plant populations (Wallis et al. 1986). Three years is considered the minimal time needed to obtain an initial baseline of information (Camp 1986).

The types of data which need to be collected each time a plant population is surveyed includes the following (Ayensu 1981):

- number of individual plants in a population,
- vigor and status of individuals,

- area covered by the population and its distribution pattern,
- size and age classes,
- phenology of each age class,
- survivorship measures,
- types of reproduction found, i.e. seeds, vegetative, etc.,
- seedling establishment, i.e. microhabitat, localized conditions, individual plant morphology, etc.,
- mortality measures, and the causes of mortality at each life stage,
- presence of co-generic species or hybrids,
- evidence of disturbances such as herbivory, predation, diseases, pests,
- evidence of human disturbances, such as trampling, collecting, ATV damage,
- observed response to the disturbances, and
- evidence of threats to the habitat, i.e. logging, petroleum exploration. Define as to existing or potential threats.

There are two types of regular monitoring programs (after Pavlick 1986):

1). Short-term, ecophysiology approach
This approach emphasizes precise data collection regarding ecophysiological characteristics such as plant growth, water status, gas exchange, etc. This would provide resource managers with information on how plant populations cope with habitat changes and environmental stresses, as well as possible explanations for mortality. This would also provide insights as to which limiting factors are acting on the population.

This approach is best suited for species near the limits of their geographical range or which are extremely sensitive to habitat changes.

2). Long-term, demographic approach
This approach examines the long-term trends in population dynamics. Repeated surveys over several years or decades would reveal information on survivorship, age structure, phenology, germination and seed dispersal. Annual surveys would have to be done to exclude phenological variations.

If the demographic type of survey is carried out frequently in the first years (i.e., every two weeks) then age-specific life tables can be constructed which would allow a more accurate determination of the status of each species (Bradshaw 1981). However, this type of study can be very labor intensive if all rare species are surveyed in this manner.

A detailed set of guidelines for conducting rare plant surveys was produced by the Alberta Native Plant Council and is provided in Appendix XIV.

An example (taken from Tannas nd.) of how detailed information on the life-history attributes of a species is required in order to manage it effectively is found with the Bog Adder's Mouth (*Malaxis paludosa*). This species, which occurs in the FMA area, is rare in both Canada and the United States, possibly due to its very specific habitat requirements: it grows best in mossy woodlands and obtains nutrients from a mycorrhizal fungus which infects its roots. In addition, the plant produces only a small amount of seed and there is subsequently a lack of cross-pollination between separated populations. Without this kind of information about its habitat requirements and physiological limitations, it would be very easy to design a forest/habitat management plan which would be counter-productive to the preservation of this species.

An example of how detailed habitat information is also important is found with regard to peatlands. Individual peatlands have a relatively restricted variability in water chemistry (Vitt et al. 1995). In order to preserve the landscape-level bryophyte diversity of fens, a number of fens in a particular region, representing a range of chemical variation, would need to be protected (Vitt et al. 1998). Also, because peatlands have a large number of microhabitats which contain site-specific species, all potential microhabitats need to be protected in order to maintain bryophyte diversity (Vitt et al. 1998).

Rare flora in Alberta's peatlands occurs as "hotspots" and these areas need to be protected in order to preserve peatland biodiversity (Vitt et al. 1998). However, the current state of knowledge regarding peatland biodiversity is still poor (Vitt et al. 1998).

8.0 Management recommendations for rare plant conservation

The following discussion presents several recommendations which would help ensure the preservation of rare and endangered plant populations within the FMA area.

Ecosystem management and preservation
The nature of rare plants is such that they are not only difficult to accurately identify in many cases, but they are also difficult to find. As such, any rare plant management program should preserve larger areas that are known or suspected of containing rare plant populations. This would help guarantee the conservation of a diversity of habitat types and, in turn, the rare plants within them. This coarse filter approach is preferable because it also has a greater probability of maintaining natural ecosystem functions.

The preservation of rare plants is more efficient if clusters of the plants are protected, and since these clusters occur in certain habitats and ecosystem types, conservation efforts should centre on whole ecosystems and not simply on individual species (Robson 1997). Directing conservation efforts to protect individual species does not compare favourably with the principles of landscape ecology because the species does not exist in isolation from the ecosystem around it (Forman and Godron 1986).

Robson (1977) found, in her research of rare grassland plant species, that certain ecosystems contained clusters of rare plants. Thus, she recommended that instead of reviewing the status of individual species, a better method would be to review the status of rare plant clusters using GIS systems. This method would determine which ecosystems contained clusters of rare plants and where these habitats were located. This would emphasize the protection of entire ecosystems which would not only protect known and unknown locations or rare plants, but would also conserve ecosystem integrity (Robson 1997).

Natural vs. human disturbances
Rare plants are vulnerable to both natural disturbances, which occur regardless of human activities, and human disturbances, which are the direct result of industrial activity. It should be recognized that both types of disturbances can have a significant impact on rare plants.

Organisms with smaller populations in a given area, which is often the case with rare species, are vulnerable to a variety of conditions which threatens their continued survival: environmental variation, demographic and genetic stochasticity, and natural catastrophes (Shaffer 1981). The principal threats to survival of populations of rare plants are natural catastrophes and environmental stochasticity (Menges 1991). By developing a database of detailed information regarding the status of rare plant populations, landscape managers can determine if changes to these populations are due to natural processes or to industrial activities.

There is very little information in the literature concerning the specific effects of disturbances on rare plants. For this reason, more data is required regarding the response of rare plant species to different types and levels of disturbances.

Habitat islands
The ability of a rare species to move into a new area or expand its range may be rendered impossible if the required habitat conditions are at too great a distance for the dispersal of propagules (Robson 1997). This situation also occurs if the population is surrounded by large tracts of unsuitable habitat, i.e. the population remains as an isolated island. For this reason, timber harvesting should be done in such a way that populations of rare plants are not isolated from other habitats they can readily colonize. Allowing populations the ability to colonize other habitats increases the long-term sustainability of the population.

Wetlands
Within the overall ecosystem of the FMA area, the most important habitats for rare vascular species are the wetlands, wetland margins and riparian zones. Together, they should account for 59% of the rare vascular plant occurrences in the FMA area. As such, they deserve some form of protection from non-natural disturbances. This protection should take the form of buffer zones and the designation of protected areas. And because these habitats are dependant on water movement, especially with regards to surface water, forestry activities in the vicinity of riparian zones upstream of wetlands should be closely monitored.

Since wetlands and wetland margins are potential habitat for many rare plants, drainage of wetlands should be prohibited (Robson 1997).

Non-forested areas
Non-forested areas would hold approximately one-third of the occurrences of rare non-vascular species. These areas, dominated by sandy and stony substrates, should be surveyed prior to disturbance and managed based on the results of these surveys. In some cases, they should be protected by buffer zones from such activities as road building or aggregate extraction.

Old growth ecosystems
Old growth systems are not only valuable in terms of timber resources but also in terms of rare species. Conserving representative areas of old growth would serve two purposes. Firstly, it would preserve rare plant assemblages which may occur nowhere else in the landscape. Secondly, these areas can serve as reference, or benchmark, areas for monitoring growth and changes in other habitat types.

Timber harvesting methods should stress the long-term conservation of the essential nature of these areas, i.e., using a selective cutting system to maintain the old growth characteristics of the area.

Data gaps
There are still significant gaps in the knowledge base about rare plants in the FMA area. Until these data gaps are rectified, the best management strategy would be to conserve a cross-section of undisturbed habitat types, thereby ensuring the preservation of the greatest level of rare plant diversity possible.

It would also be preferable to have larger areas of undisturbed habitat rather than smaller areas because the larger ones usually hold more viable populations, have a better buffering capacity against natural and human disturbances, and are less susceptible to edge-effects from nearby disturbances (D.A. Westworth & Associates 1990). And it would be beneficial to use timber harvesting methods that would support the strategy of long-term rare plant conservation, i.e., a progressive cut system.

Monitoring program
A well planned and executed monitoring program would help to reduce the impact of forestry activities. If resource managers had an accurate picture of the rare plant populations and their habitats, they could direct potentially destructive activities away from highly sensitive habitats or modify the impacts through such things as time scheduling, eg. road building in winter.

8.1 [redacted] rare plant management program

In addition to the recommendations outlined above, a detailed program to manage the rare plant resources would ensure that these resources are maintained within [redacted]' FMA area in perpetuity. An outline of this program is provided below.

Database
The first step would be to assemble a database of the rare plant resources within the FMA area. This would include collecting any necessary background information (which is essentially what this project has done) and designing the database to accommodate additional information types and regular updates.

Initial field survey
An initial field survey would be required to check all known locations of rare plants to verify either their continued presence or their disappearance.

Detailed field survey
Once the initial field surveys have been completed, and the resulting information added to the database of background information, a more detailed field survey program can be devised. This program would survey those habitats with the greatest probability of having rare species, in order to determine if any of these areas have additional rare species and, as a result, are in need of protection (see figure 10 and section 5.0, which outlines areas which have a high probability of containing rare species).

The resulting database should then be used to determine temporal changes in the distribution of rare species and their habitats. This would provide an indication of changes in the status of a species (i.e. increasing or decreasing rarity) due to various types of environmental impacts.

Field surveys
There should be a protocol for field surveyors to follow in the event that they discover new localities of rare plants. If a field surveyor has found a suspected rare species, then the protocol should be implemented to ensure that the plant and its habitat are properly surveyed so as to ensure its substantiation as a rare locality before any natural or man-made disturbance affects the plant. The following suggested steps are modified after Snyder (1998):

- the field location should be marked in such a way that it is recognizable as a rare plant locality,
- a detailed description of the plant should be recorded, including the date found and its flowering or fruiting stage (if applicable at the time),

- a photograph of the plant should be taken,
- a detailed map location should be recorded,
- record a detailed description of the surrounding habitat and associated vegetation community,
- collect a specimen of the plant. This should be undertaken only in specific circumstances and under the direction of a qualified botanist,
- confirmed identification of the species by a qualified botanist/taxonomist,
- transplant any rare plants to another, similar habitat if it is obvious that its current habitat is threatened by imminent destruction or alteration. This should be undertaken only as a last resort as most wild plants are highly sensitive to disturbance and will rarely survive transplantation to another location.

An example of a standard Native Rare Plant Survey form can be found in Appendix XII. It illustrates all the information required to officially record information on a rare plant discovery with the Alberta Natural History Information Center.

Gap analysis
The database could also be used to perform a gap analysis, wherein gaps in the knowledge base can be identified and flagged for future work. At the current time, there are still significant gaps in the knowledge base about rare plants in the FMA area. Until these data gaps are rectified, the best management strategy would be to conserve a cross-section of undisturbed habitat types, thereby ensuring the preservation of the greatest level of rare plant diversity possible.

Fact sheets
Once there is more detailed information gathered about the rare plants in the FMA area, facts sheets should be produced for each species. The purpose of these fact sheets would be to educate the reader about each species in an easy and efficient manner. The fact sheets would describe a variety of information for each species, such as its preferred habitats (specific to the FMA area), autecological characteristics, synecological relationships, phenology and other life history characteristics. The sheets could also be used in an education program to teach forestry workers not only about the importance of rare plants but also about the ones within their area of operations.

Training personnel
Personnel who are normally in the field for other purposes, i.e. timber cruising, block layout, regeneration surveys, etc., should undertake a training program designed to increase their ability to recognize the habitats which contain rare plants. These personnel could then serve as additional "eyes in the field", thereby contributing more information to qualified botanists in their search for rare plant populations.

A training program should cover basic plant identification (for both vascular and non-vascular plants), vegetation ecology and ecosystem classification. With additional knowledge about these three subjects, field personnel would be more capable of identifying habitats and specific sites which would have rare plants. They would also be able to identify some of the rare plants themselves, although many species of rare plants are quite difficult to correctly identify, and is a task best left to qualified plant taxonomists.

This training program would also help resource managers to incorporate appropriate mitigative strategies into their operations program, i.e., how to plan timber harvesting activities in a way that would minimize or eliminate the damage to rare plants and their environments.

Information sharing

In order to maintain as accurate a database as possible, there should be a sharing of information between [redacted] and the Alberta Natural Heritage Information Centre, to ensure that both parties have the most complete and up-to-date information regarding the rare plants in and around the FMA area.

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