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An Investigation of Methods Used in Rare Plant Surveys Conducted for Impact Assessment

by

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ABSTRACT

Rare plant studies are often conducted to evaluate the potential effects of proposed development projects throughout a variety of jurisdictions in North America. In this research, existing rare plant study technical reports, government issued requests for proposals, and guidelines are reviewed to investigate impact assessment rare plant study methodologies. Focussing on three areas, (currently used methods, government regulatory requirements, and scientific requirements), seven study parameters are analysed, (investigator qualifications, literature review methods, target species selection, habitat prediction methods, survey timing, survey pattern, and documentation content). Based on this analysis, guidelines are developed for the conduct and documentation of these rare plant studies. The findings of this research are intended to provide guidance for those performing impact assessment rare plant studies, and also to act as a set of evaluation criteria for those charged with assessing the adequacy of these studies across a range of jurisdictions and geographic regions.

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GLOSSARY

COSEWIC	Committee on the Status of Endangered Wildlife in Canada
ESA	Endangered Species Act (US)
Floristic Study	A botanical study designed to identify all plant species in an area. Focuses on the entire range of plant species. [see also Vegetation Study]
Guideline Document	A document that describes a certain method or methods.
High Probability Habitat	Habitat with a high potential for the occurrence of rare plant species.
IC	Intuitive Controlled survey pattern.
Impact Assessment Study	An investigation performed to analyse an action's effect on selected environmental components.
IUCN	World Conservation Union
NEPA	National Environmental Policy Act (US)
Non-Apparent-Rarity	Refers to taxa which are rare and/or imperilled biologically, but are not recognised as such by government agencies or other listing organisations. [see also Pseudo-Rarity and True-Rarity]
Principal Investigator	The scientist under whose direction a study is performed.
Project Area	The area of potential direct project related impacts. [in most cases, the term 'Project Area' is equivalent to the term 'Study Area']
Pseudo-Rarity	Refers to taxa which are listed as rare or imperilled by government agencies or other organisations, but are, in reality, abundant and secure. [see also True-Rarity and Non-Apparent-Rarity]
Red List	IUCN's list of imperilled species throughout the world
Solicitation Document	A document that requests bids for performing a particular project.
SS	Selected Sites survey pattern.

Study Area	The area that is the focus of a particular impact assessment study. [In most cases, the term 'Study Area' is equivalent to the term 'Project Area']
Taxa	Plural of Taxon.
Taxon	A grouping of organisms with similar characteristics at or below the species level (*e.g.* species, subspecies, variety).
Technical Report Document	A document which reports on the methods and results of a study.
True-Rarity	Refers to taxa which are rare and/or imperilled biologically at a given scale, and are listed as such by government agencies or other organisations. [see also Pseudo-Rarity and Non-Apparent-Rarity]
Vegetation Study	A botanical study designed to describe the plant communities or associations of an area. Usually focuses on the dominant species. [see also Floristic Study]

CHAPTER 1: INTRODUCTION

1.1 IMPACT ASSESSMENT RARE PLANT STUDIES

Rare plant studies are conducted to meet a variety of objectives by government agencies, environmental consultants, and research organisations throughout North America. Many of these investigations are undertaken to determine the distribution of rare species within an area proposed for ground disturbing activities (*e.g.*, timber harvest or industrial development). Typically, the end objective of such studies is the prediction of potential project related impacts on the rare species in question. Once this impact assessment process has been completed, decision-makers can use the information to structure project planning and implementation decisions to meet desired environmental goals.

There are a variety of study methodologies which are applied to these impact assessment rare plant investigations across North America. However, currently, there is little agreement regarding the adequacy of these various methods. Regulatory requirements are unclear, and only a small amount of scientific research has been conducted regarding the validity of the methodologies. It is often difficult for regulators, judicial authorities, and even botanists to evaluate the adequacy of rare plant surveys which have been performed in support of development projects.

The present research is designed to address several questions regarding the methodologies used in these impact assessment rare plant studies. Through the analysis of collected references, this research attempts to determine and describe those methodologies in use, both historically and presently. Further analysis of collected scientific and regulatory literature is used to determine and describe the methods which are considered suitable by both the scientific community and the government regulatory agencies. Finally, this information is synthesised to produce rare plant survey guidelines which can be applied to impact assessment studies at a variety of levels.

1.1.1 Descriptions

Regulators, scientists, and project proponents all view impact assessment rare plant studies from different perspectives, and, therefore, often use different terms to describe the elements of the process. In addition, regional terminologies used to describe these studies vary. Further complicating the issue is the lack of standardisation in these investigations, which also leads to confusion regarding terms. It is therefore necessary, in any discussion of the subject, to carefully define the terms used. Presented below is a discussion of the relevant concepts which require clarification. These terms and definitions represent those which are commonly used in the literature, although it is important to note that significant variations exist from reference to reference.

1.1.1.1 Rarity

One of the most fundamental questions in any discussion of rare species pertains to the subject of rarity. What specifically is a 'rare' plant? The answer to this question varies based on the perspective of the person to whom it is posed. A botanist may determine the rarity of a species based solely on its abundance and/or range size, while a government regulator may determine the rarity of that species based on the threats to its survival. Reveal (1981) provides a widely accepted definition of rarity from the perspective of the biologist when he states, "…rarity is merely the current status of an extant organism which, by any combination of biological or physical factors, is restricted either in number or area to a level that is demonstrably less than the majority of other organisms of comparable taxonomic entities." This definition views the concept of rarity as a continuum. No specific cut-off points are given below which a taxon is considered 'rare'. Although this approach is useful for many scientific undertakings, other biologists, and especially government regulators, have found it necessary to break the continuum of rarity into discrete classes.

Gaston (1994) presents an excellent survey of the various definitions biologists have used over the years to separate out the class of organisms considered to be 'rare'. Although these vary widely, he settles on a definition which he believes is reasonable based on his research. He considers a species to be 'rare' if it has a frequency distribution, of either abundance or range size, in the lower 25% of all species in that group. In other words, the bottom quartile of all species in a particular group are considered to be 'rare', when ranked by either abundance or range size. This definition does provide a cut-off point, and allows for the categorisation of each species as 'rare' or not, (given the limitations of the population data gathered for all species in that group). Some practical considerations arise, however, when this definition is applied. Because this definition defines the rarity of a species in relation to others in a given group, it is possible that a particular species may fall in or out of the rare category even though it has not changed in either abundance or range size. This could result from changes in the abundance and/or range sizes of other species in the group, or it might result from a change in the composition of the species which make up that group. In addition, for certain assemblages, insufficient population data may be available to determine, with any certainty, which species fall below the 25% frequency distribution cut-off.

From a regulatory standpoint, as well as a conservation biology standpoint, simply knowing the relative abundance or relative range size of a particular taxon is of limited value. Because government regulators and conservation biologists place a high priority on species threatened with extinction, various classification systems which take into account threats to survival, as well as scarcity, have been developed. Perhaps the best known globally is the World Conservation Union's (IUCN) Red List classification scheme. This system places taxa in one of several categories ranging from Critically Endangered to Lower Risk (World Conservation Union 1997). Table 1-1 on page 4 presents the IUCN categories. Although abundance and range size are considered, Red List species are evaluated based primarily on their likelihood of extinction. It is important, therefore, to note that, although threat of extinction is often correlated with rarity, the two are not always related. Reveal (1981) notes that, "[r]arity alone does not imply endangerment or impending extinction."

In North America, numerous additional classification schemes are used to categorise rarity and threat. One of the most widespread is The Nature Conservancy's Conservation

Table 1-1: World Conservation Union (IUCN) Red List Categories
(Source: World Conservation Union 1997)

Category	*Criteria*
Critically Endangered	A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future...
Endangered	A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future...
Vulnerable	A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future...
Lower Risk	A taxon is Lower Risk when it has been evaluated, does not satisfy the criteria for any of the categories Critically Endangered, Endangered or Vulnerable.
Data Deficient	A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status.
Not Evaluated	A taxon is Not Evaluated when it is has not yet been assessed against the criteria.

Data Centre ranking system. Through its network of State and Provincial Conservation Data Centres and Natural Heritage Information Centres, The Nature Conservancy tracks element occurrence data on those species thought to be rare or threatened. As part of the tracking process, Nature Conservancy biologists have developed a classification system which ranks taxa based on rarity and imperilment. Separate rankings are generated for both the global and subnational, (state or province), scales (Idaho Conservation Data Center 1997a). Table 1-2 on page 5 presents The Nature Conservancy's ranking criteria.

In the United States, the Endangered Species Act (ESA) of 1973 defined a simple classification system based primarily on the threat of extinction (US Government 1973). Because the powerful US ESA applies broadly across many levels of government, and has the potential to impact numerous development projects throughout the US and

Table 1-2: The Nature Conservancy Conservation Data Centre Rankings

(Source: Idaho Conservation Data Center 1997a)

Rank	*Criteria*
1	Critically imperilled because of extreme rarity or because some factor of its biology makes it especially vulnerable to extinction (typically 5 or fewer populations).
2	Imperilled because of rarity or because other factors demonstrably make it very vulnerable to extinction (typically 6 to 20 populations).
3	Rare or uncommon but not imperilled (typically 21 to100 populations).
4	Not rare and apparently secure, but with cause for long-term concern (usually more than 100 populations).
5	Demonstrably widespread, abundant, and secure.

beyond, the classification system has considerable influence. Table 1-3 on page 6 presents the system based on the US ESA.

In Canada, although no comparable legislation to the US ESA has yet been enacted, efforts to protect rare species have been ongoing (Allen 1988, Argus and Pryer 1990, Wallis and Allen 1987). The classification systems developed by the IUCN and The Nature Conservancy's Conservation Data Centres are used in Canada. In addition, The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) evaluates and classifies species using a system similar to the US ESA (COSEWIC 1997). The COSEWIC categories are presented in Table 1-4 on page 7. Some provinces also have a separate classification system, such as the Red and Blue lists in British Columbia.

As can be seen from this cursory overview of the various classification systems, the determination of rarity is seldom clear-cut. Often, a species is classified as threatened under one system, and not threatened under another. To further complicate matters, rarity and threat are also functions of the geographic division considered. For example, the plant *Iris missouriensis* (western blue flag) is known in Canada from only a few populations in Southern Alberta. It is therefore classed by the provincial rare species data

Table 1-3: United States Fish and Wildlife Service Categories

(Sources: US Government 1973; US Government 1996)

Rank	*Criteria*
Endangered	...any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man.
Threatened	...any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.
Candidate	Taxa for which the US Fish and Wildlife Service has on file sufficient information on biological vulnerability and threats to support issuance of a proposed rule to list, but issuance of the proposed rule is precluded.

centre as S1S2, indicating that the species is highly imperilled in the province (ANHIC 1997). However, this rarity is a function of political boundaries, as western blue flag is common and widespread in the adjacent states to the south (Idaho Conservation Data Center 1997b, Montana Natural Heritage Program 1997, Washington Natural Heritage Program 1997). Had the Alberta border been drawn farther to the south, the species might be common in the province. Conversely, certain species are indeed rare and threatened over their entire range. *Stephanomeria malheurensis* (Malheur wire lettuce) occurs in one known population of less than 12 individuals in the desert area of Southeast Oregon (US Environmental Protection Agency 1997). From a global perspective Malheur wire lettuce and western blue flag are clearly at opposite ends of the rarity scale. But on the state/province level, both species appear extremely rare.

Most impact assessment rare plant studies performed in North America focus on species listed, at some level, in one or more of the four above-mentioned classification systems, (US Fish and Wildlife Service, IUCN, COSEWIC, and/or The Nature Conservancy's Conservation Data Centre). In addition, other species may be targeted, depending on the jurisdiction involved. The US Forest Service, US Bureau of Land Management, and

Table 1-4: COSEWIC Categories

(Source: COSEWIC 1997)

Category	*Criteria*
Extinct	A species that no longer exists.
Extirpated	A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered	A species facing imminent extirpation or extinction.
Threatened	A species likely to become endangered if limiting factors are not reversed.
Vulnerable	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Not at Risk	A species that has been evaluated and found to be not at risk.
Indeterminate	A species for which there is insufficient scientific information to support status designation.

many States and Provinces maintain separate lists of rare plant species of concern which often are considered in these studies.

Because the present research is intended to be applicable to real-world impact assessment studies, the term 'rare plant', as used throughout this paper, refers to any plant taxa deemed to be imperilled by the appropriate regulating agencies in the jurisdiction where the study is performed. This usage of the term focuses primarily on the administrative, rather than biological, definitions of rarity. But, considering the objectives of most impact assessment rare plant studies, this will be the most useful terminology in analysing these types of investigations. In addition, there is a close correlation between those species which are of concern to the regulatory agencies, and those species which truly are rare or imperilled.

For the purposes of analysing impact assessment rare plant studies, it is also helpful to define different types of rarity. The first type refers to those species which truly are rare and/or imperilled biologically at a particular geographic scale, (*e.g.*, provincially or globally), and are listed as such by government agencies or other organisations. This condition will be referred to as 'true-rarity' throughout this paper. This level of accuracy in the listing process is not always achieved, however, and certain listed species, in reality, are much more abundant and secure than their listed status would indicate. Gaston (1994) refers to this condition as 'pseudo-rarity'. The reasons that an abundant and secure species may continue to be listed as rare are many. Often, the range extent and/or abundance of a particular species may not be fully understood due to a lack of field work in the species' habitat (Dumond 1974). In other instances, taxonomic uncertainties may prevent botanists from identifying the species correctly (Gaston 1994). The listing process itself also contributes to cases of pseudo-rarity. Because the bureaucratic process through which species are listed tends to be slow, plants can often remain listed long after additional field work has shown that the species is more abundant or widespread than previously thought. Other factors, including usage of inappropriate sampling techniques, false assumptions regarding distribution, and insufficient data sharing can all lead to conclusions that a plant is more imperilled and/or rare than it actually is.

The converse can also occur. Gaston (1994) describes the situation where a species is actually rare and/or imperilled, but not listed as such by the agencies and listing organisations. This 'non-apparent rarity', as he calls it, probably occurs more often in the less-studied groups of species (*e.g.*, insects or lichens). For the most part, impact assessment rare plant studies do not address species which exhibit non-apparent rarity, focusing instead on the true-rare and pseudo-rare taxa.

1.1.1.2 Impact Assessment Studies

Impact assessment studies are performed to analyse an action's effect on selected environmental components. Often, these studies are performed as part of the permitting process to predict the impacts that a proposed project is likely to have on environmental resources in the vicinity. Once these potential impacts are known, project planners and regulators can make decisions regarding project construction and implementation. If potential impacts are severe enough, the project may be cancelled or significantly modified. In other cases, adequate mitigation measures can be designed to reduce the level of impact to acceptable levels. In still other instances, the impact assessment studies may indicate that potential effects will be minimal, and the project can proceed as planned. Impact assessment studies are known by different names throughout various jurisdictions. Environmental Impact Assessment, Environmental Assessment, Environmental Impact Statement, Biological Evaluation, and Biological Assessment are all terms used by different agencies and governments within North America to refer to various levels of the impact assessment process.

The classical experimental model is difficult or impossible to apply to these impact assessment studies. As Eberhardt (1976) points out, true replication is usually impossible to achieve in these studies due to the lack of identical treated and untreated (*i.e.*, control) sites. Typically, only one site is available for study, (the treated site). Occasionally, investigators can test assumptions by using similar nearby sites outside of the project area. However, due to variations in environmental factors, these sites are never truly identical to the treated site. Further limiting the experimental design, is the fact that many of these studies must be performed, and decisions must be reached, before the project is initiated on the ground. This removes the option of pre-construction—post-construction comparison, and forces the researcher to predict impacts based on modelling (Eberhardt 1976, Ward 1978). In most cases, the impact assessment studies that are being evaluated in this research are those where post-construction monitoring was not a factor in the predictive process.

1.1.1.3 Types of Plant Studies

Various types of botanical studies are used to satisfy differing experimental objectives. The present research, however, primarily focuses on the studies which are designed to describe the botanical resources of an area, and, subsequently, evaluate the potential impacts on those resources from a proposed development project. Two general study methods are typically employed for this purpose: vegetation studies and floristic studies.

The difference between the two is subtle, and often the subject of much confusion, even among botanists.

Vegetation surveys are designed to describe the plant communities of a particular area. Randall (1978), states, "Plants collectively are referred to as vegetation.", and, for the purposes of this research, this definition is helpful. Vegetation surveys are performed by analysing the plant species of a particular area, and grouping these into discrete plant communities or associations. This often involves the use of quadrat sampling to quantify the dominant species, (although it should be noted that with some vegetation survey methods, all species within a plot are recorded, not just the dominant ones). Typically, a series of transects will be laid out and sample points will be established along each line. At each sample point, a frame will be placed on the ground, and the plant species within the area bounded by that frame will be quantified. Quantification methods are numerous, but can involve such techniques as estimation of areal extent, presence-absence counting, and point intercept recording. These data are then analysed, again using one of a variety of methods, to provide a picture of the plant communities in the area. Many other vegetation survey techniques are used, and the methodologies have been, and continue to be, the subject of much scientific study, (see Myers and Shelton [1980], and Randall [1978] for good descriptions of the various methods).

Most vegetation survey methods, however, share a characteristic which limits their usefulness in rare plant work. These studies, by their nature, focus on the dominant (*i.e.* more common) species in an assemblage, and place less emphasis on the rare species (Lancaster 1997, Goff *et al.* 1982). Because the dominant species play a larger role in defining the differences between communities, vegetation surveys tend to focus more on these plants to the exclusion of the rare or accidental species.

Floristic studies, on the other hand, focus on the species level, and attempt to identify all taxa in a given area. Typically, the goal of a floristic survey is to locate and identify the entire complement of species in a study area. In addition, site information will often be recorded for selected species of interest. Floristic studies, by their nature, are usually less quantitative than vegetation studies, and tend to produce species lists, element occurrence data, and presence-absence information. During a typical floristic survey, the study area would be walked by botanists in a pattern designed to maximise the overall coverage of the area. The botanists would identify each plant encountered to the species level, (or below), if possible, and make collections of unknown specimens for later identification. The surveyors would attempt to cover the greatest diversity of habitat within the study area to ensure that all major plant communities were sampled. Data recorded might include a species list, locational information about a particular taxa of interest, or counts of species located per unit of time. Although the above methodology is commonly used for floristic surveys, many variations exist. Compared to vegetation surveys, however, very little research has been directed toward developing or analysing the various floristic survey methods.

Because floristic surveys focus on all plants, rather than just the dominant taxa in an area, it makes them especially suited to rare plant studies. In most cases, the rare plants that are being searched for are uncommon within the study area, and may occur at only a few locations, if at all. Vegetation surveys, with their focus on the dominant plants within a limited number of discrete plots, usually cover less area per unit of time, and are more likely to miss the rare species (Lancaster 1997). Both survey types have their uses in impact assessment, however, and can complement each other in a well designed study. Lancaster (1997) points out that it is often desirable to use vegetation studies to place rare plant populations within a community context. Conversely, presence-absence data from floristic studies can be used to extend the precision and accuracy of the plant community typing derived from vegetation studies.

In addition to floristic and vegetation studies, investigations which focus on individual taxa can be important to the impact assessment process. Population studies, critical habitat evaluations, and disturbance response investigations can all assist in refining the predictive capability of impact assessment studies (Bradshaw and Doody 1978). Typically, however, these more specific studies will be undertaken outside of the impact assessment process as part of basic academic research.

1.1.1.4 Impact Assessment Rare Plant Studies

As used in this research then, the term 'impact assessment rare plant studies' refers to those botanical studies carried out for the purpose of predicting the effects of a particular action on certain plant taxa deemed to be of concern to the appropriate regulating agencies. This definition refers to site-specific studies which typically are time-limited by a project deadline, (usually an administrative permitting schedule). These studies often must be completed prior to the initiation of the action being evaluated, and must therefore base their conclusions on predictive modelling and other indirect methods.

Impact assessment rare plant studies are often part of a larger evaluation which brings together similar studies on other environmental resources. The incentive for performing these analyses is most often regulatory. The project proponent will perform an impact assessment rare plant study to fulfil the requirements of environmental legislation. These studies are most often conducted by environmental consulting firms, government agencies, or, less often, by academic institutions.

1.1.2 Parameters of Impact Assessment Rare Plant Studies

No two impact assessment rare plant studies are the same. There are a wide array of variables which must be considered when analysing the appropriateness of the study methods used to complete these investigations. The parameters which make up each unique situation must be evaluated before the proper methodology can be selected. It is therefore necessary to define these variables to provide a common framework for the continued discussion of this topic. Table 1-5: Parameters for Impact Assessment Rare Plant Studies on page 13 provides a summary of the parameters used.

<u>Project Area Size</u>: The first, and most obvious, parameter that must be considered in these rare plant studies, is project area size. Obviously, the methods used for a survey of a proposed 30-by-30 metre wellhead site will be substantially different from those used for a survey of a 100,000 hectare timber sale area. In the first case, it would be entirely possible to visually inspect every square centimetre of ground, thus providing 100%

Table 1-5: Parameters for Impact Assessment Rare Plant Studies

Parameter	*Summary*
Project Area Size	Partially determines the intensity of the survey pattern to be used.
Project Area Shape	Partially determines the survey pattern to be used.
Physiography	Terrain partially determines the survey pattern to be used. Also affects the logistics of survey access.
Vegetation	Partially determines the width of the survey transects.
Target Species (Habitat)	Partially determines the habitats within the project area which need to be surveyed.
Target Species (Visibility)	Partially determines the intensity of the survey pattern, and the travel methods to be used.
Target Species (Abundance)	Partially determines the sampling method needed. Also influences the survey pattern used.
Target Species (Phenology)	Partially determines the timing of the surveys.
Administrative (Non-Environmental)	Partially determines the timing of the surveys, survey pattern used, type of travel within the project area, and access to project area sites.

coverage. In the case of the timber sale, this coverage level would not be an option, and some form of prioritised sampling method would have to be used.

Project Area Shape: Closely related to project area size is project area shape. The impact area of a project may be composed of a series of relatively small points, as in the case of a transmission line through non-forested habitats, where disturbance is limited primarily to the pole bases. Or the project area may be linear, as in the case of a pipeline. In still other situations, such as the timber sale described above, the project area may be a large, irregular polygon, or even a number of smaller polygons. Many projects are a combination of the above, having linear, point, and/or polygon components. In each case, the survey methods must be tailored to the project area shape.

Project Area Physiography: Physiographic and access factors also play a major role in determining the proper survey methodology. Walking a regular grid pattern may be an effective technique on level ground, but would be inefficient, or impossible, in mountainous terrain. Likewise, helicopters might be useful tools to access certain mountainous survey sites, but may not be cost effective on level ground where road access is good.

Project Area Vegetation: The vegetation of the project area partially determines the intensity of the survey method required. In dense forested habitats, visibility is limited, sometimes to a few metres. A tighter search pattern is needed in these habitats than in open grasslands, where sight distances are greater.

Target Species (Habitat): One of the most complex parameters of an impact assessment rare plant survey is the composition of the target species list. Typically, a list of several to many possible rare species will be identified as having potential for occurrence within the project area. If all these species happen to grow only in a specific habitat of limited extent within the study area, the surveys can focus only on that habitat. More often, however, a range of habitats must be searched. In many cases, all of the habitats within the project area have some potential for rare species, and must be surveyed.

Target Species (Visibility): The visibility of the target species is also important. The US federally threatened plant *Mirabilis macfarlanei* (MacFarlane's four o-clock) grows in open bunchgrass habitat in the canyons near the border of Oregon and Idaho (Mancuso 1996). The plant can attain heights of one metre, and the large flowers are bright rose-purple. Because of its high visibility, botanists have searched for this species from helicopters. *Botrychium crenulatum* (crenulate moonwort) is also a rare plant of federal concern in the US. However, this small green fern grows only 2-10 cms. high in dense grassy habitats (Brooks *et al.* 1991). It is extremely difficult to locate, and botanists usually search for it by crawling on their hands and knees in likely habitat.

Target Species (Abundance): The expected abundance of the target species also plays a role in determining which survey methods will be effective. It is not unusual for one or more of the target species to be common and abundant within the project area. This can occur if the project area happens to be located in an area of local abundance for a particular species, or can occur in the case of pseudo-rare species (see Section 1.1.1.1 above). Survey methodologies used for locally abundant species often, by necessity, differ from those used for locally rare species.

Target Species (Phenology): Phenology of the target species also plays a role in determining the timing of the surveys. Various species are identifiable in the field at different times of the year. It is often necessary to survey an area more than once to assure that all target species are identifiable. In addition, survey timing may have to be modified based on year-to-year variations in weather.

Administrative Factors: Lastly, administrative (*i.e.*, non-environmental) parameters must often be considered when designing impact assessment survey methodologies. Limitations on time, funding, site access, and data availability all have the potential to impact the methods chosen. Time limitations, in particular, are often a factor. Typically, certain longer-term methodologies are not an option due to regulatory and business requirements for expediency.

1.1.3 Current General Conditions

At the present time, there is little agreement, at either the regulatory or scientific level, regarding the requirements for impact assessment rare plant studies. Attempts have been made to produce standardised guidelines (see Lancaster 1997, Nelson 1985, Goff *et al.* 1982), but their acceptance within the regulatory structure has been limited. The investigators in each rare plant study, therefore, must develop a new methodology based on those which have proven effective, and been accepted by regulatory agencies, in the past. This lack of standardisation has made it difficult for regulatory authorities to assess the adequacy of these studies when submitted as part of the permitting process. In addition, project proponents find it difficult to plan and implement these rare plant studies, as they are unsure of the acceptable requirements. Even the botanists charged with carrying out these studies are often unsure of appropriate methodologies.

This situation is further exacerbated by the lack of co-ordination between the two major groups involved; the regulatory agencies on one hand, and the project proponents, (including their environmental consultants), on the other. Beanlands and Duinker (1983), writing about the Canadian environmental assessment process, state that the project proponents must, "...translate the terms of reference into a study programme but are seldom sure of the scientific standards which the [regulators] will finally adopt." They go on to state, "The result of this confusion over the appropriate scientific standards for impact assessment studies is a high level of dissatisfaction among those directly involved." The results of their work, which brought together a panel of regulators, project proponents, and environmental consultants, indicate that one of the main impediments to developing more effective, scientifically based impact assessments, is the lack of common standards for the component studies (Beanlands and Duinker 1983).

1.1.4 Need for Research

Clearly, there is a need for the regulatory agencies and project proponents/environmental consultants to agree on a greater level of standardisation in impact assessment rare plant studies. Unfortunately, major impediments to such agreement exist. Chief among these is the lack of co-ordination between regulators and project proponents (see Section 1.1.3 above). However, the state of knowledge regarding these studies is such that there is little of substance to agree on. Environmental consultants and regulators often have a feel for which methodologies are used in their region, but are unsure about the specifics of many of these studies. Additionally, many consultants have only a vague idea of how these studies are performed in other regions. As a start, a survey of the study methods used in various regions would be helpful in determining a common standard.

A set of guidelines, describing the appropriate rare plant study methods, would also be helpful in increasing co-ordination between regulators and project proponents. Although several attempts have been made to produce guidelines pertaining to rare plant surveys, these have tended to be very broadly focused, and provide only general guidance to consultants and regulators. These documents can, however, provide valuable input into the production of a more extensive set of guidelines which can be applied to a broad range of projects, yet still provide detailed direction for implementation and evaluation of these studies.

1.2 SCOPE OF THIS RESEARCH

The present research investigates several topics related to impact assessment rare plant investigations, primarily through an analysis of existing rare plant study reports and terms of reference. This information, along with an analysis of current relevant scientific literature, is used to produce a set of guidelines specifying rare plant survey methodologies, and the situations where each is applicable.

1.2.1 Objectives and Goals

The overall goal of this research is to increase the understanding of current practices in impact assessment rare plant studies, and provide a set of guidelines, based on this understanding, to be used in performing these studies. The following objectives are used in attaining this goal:

1. determine which methodologies and standards are required by Canadian and American regulatory agencies for impact assessment rare plant surveys at a variety of jurisdictional levels;

2. determine which methodologies and standards are generally accepted by the scientific community for these studies;

3. determine which methodologies are currently in use for these studies; and

4. develop guidelines, which can be used by regulatory agencies, project proponents, and environmental consultants to plan, implement, and assess the adequacy of these rare plant studies.

1.2.2 Limitations

This research is designed to address only those studies which are performed to determine the potential or actual effects of a particular development project on rare plant resources. Other types of botanical studies, such as those designed to determine the global distribution of a particular species, characterise vegetation communities, or investigate the population biology of a particular species are beyond the scope of this research.

Field tests to verify the accuracy of rare plant survey methodologies are not undertaken as part of this research. This would involve a number of largely uncontrollable variables which would significantly reduce the accuracy of the final conclusions. In addition, it is felt that the resources, in both time and money, are better focused on investigating the existing data, which are considered sufficient to adequately address the research objectives.

Although certain conservation biology concepts affect impact assessment rare plant studies, only those with direct bearing on methodological issues are addressed in the present research. For example, the political and bio-ethical choices surrounding the selection of particular species to receive legislated protection, while certainly important, are not addressed here. The process through which species are listed has little direct bearing on the methodologies used to search for such species. This research addresses those species which are typically targeted in these rare plant surveys, which, as it stands today, include species which may or may not be deserving of rare status designation. Additionally, the ongoing debate regarding the validity of basing conservation efforts around individual rare species is not addressed in this research. Presently, a significant proportion of conservation efforts are directed toward endangered species detection, monitoring, and recovery. Although many people have proposed a reordering of conservation priorities away from this focus, the current hierarchy has been slow to change. The focus on rare species appears likely to continue into the foreseeable future.

1.3 SIGNIFICANT PREVIOUS GENERAL RESEARCH

Floristic survey methodologies, (such as those used for rare plant studies), have not received the same level of attention in the literature as vegetation survey methodologies. A significant body of research literature exists regarding the appropriate methods to be used in vegetation studies and plant community classifications (see Brakenhielm and Qinghong 1995, Myers and Shelton 1980, Randall 1978, Benninghoff 1966, Cain 1938). However, with a few notable exceptions, scientists have been reluctant to pursue similar lines of inquiry regarding floristic surveys in general, and rare plant surveys in particular. The reasons for this are unknown, although it may be that, because vegetation surveys are inherently more quantitative in nature, they lend themselves more readily to scientific analysis. Additionally, because rare plant surveys are a relatively new undertaking compared to vegetation surveys, the science behind rare plant investigations may be less developed.

There have been a limited number of attempts over the years, however, to produce guidelines for impact assessment rare plant surveys. The most widely known of these is the work of Nelson (1985), who published a paper entitled, "Rare Plant Surveys: Techniques for Impact Assessment" in the Natural Areas Journal. This paper essentially consisted of a set of guidelines which are applicable to rare plant surveys throughout the US in general, and the state of California in particular. He recommends several field survey methods ranging from walking regular transects, to randomly meandering through the project area. These guidelines provide a good framework under which to conduct these impact assessment surveys, and the paper conveys some important basic concepts regarding sound floristic surveys. Most of the recommendations in these guidelines, however, are broadly worded and give only general guidance in specific project situations.

Several other general guidelines have been produced which are similar to Nelson's work. The year before Nelson's paper was published, the State of California (1984) published guidelines for impact assessment rare plant surveys on lands it administers. These were similar to Nelson's recommendations in both content and scope. In 1997, Lancaster edited rare plant survey guidelines for the Alberta Native Plant Council which were based heavily on the work of Nelson (Lancaster 1997). Lancaster provided some additional ideas, although the guidelines still retained the generalities of Nelson's work.

Another set of published guidelines recommends a slightly different approach to rare plant surveys than Nelson. Goff *et al.* (1982) propose a timed-meander method in which the investigator walks through the project area recording a species list of all plants encountered. On the species list, the investigator also notes the time at regular intervals. The total new species found per unit of time is plotted on a graph to produce a species-area curve. This graph is then analysed to determine when the study site has been surveyed sufficiently, (*i.e.*, when the curve has levelled off to a predetermined slope). These guidelines are much more prescriptive than Nelson's, and give specific guidance to investigators working at the project assessment level. However, the methodology has not been widely accepted, and does not appear to be in general use in North America. It is also doubtful that the methodology could be applied to rare plant surveys conducted in mountainous terrain. The guidelines contain the requirement that the investigator 'meander' in the direction of greatest floristic diversity, which would be difficult or impossible in steep terrain where routes are often determined by topography.

Other reports have dealt with specific parts of the survey process. These include recommendations regarding data sheet composition (Henifin *et al.* 1981), guidelines for prefield planning (McFarlane 1980, McFarlane and St. Clair 1978), and reports on methods for the prediction of likely rare plant habitat (Sperduto and Congalton 1996, Alverson 1990). These guidelines and reports provide useful information which can be used to refine the process.

Numerous guidelines have also been produced which are specific to a particular project. These are most often contained in Terms of Reference or Request for Proposals issued by various government agencies. These represent a good source of information about government requirements, and are summarised along with the technical reports later in this work.

CHAPTER 2: RESEARCH METHODS

2.1 REVIEW OF EXISTING DATA AND LITERATURE

The primary method for gathering information regarding impact assessment rare plant studies in this research was through the analysis of existing guidelines, solicitations, technical reports, and other relevant literature. Numerous documents from a variety of sources were collected and analysed to provide the answers to three basic questions:

1. what methods are required by government regulatory agencies for impact assessment rare plant studies;
2. what methods are considered sound by the scientific community for these studies; and
3. what methods are currently in use, and have been used in the past, for these studies?

2.1.1 Compilation Procedures

These documents were reviewed and summarised to extract the relevant information. To facilitate analysis, the information was compiled in a bibliographic database which was developed for this research. The Microsoft Access® application on the PC platform was chosen for database development because of its graphical presentation capabilities, and its close integration with other applications. A separate entry, containing four major field groups, was created for each document reviewed. The first field group contained bibliographic data, including such fields as Author, Title, Publisher, etc. This information was used in obtaining the document and, later, for creating the bibliography. The second field group contained procurement information, which was relevant during the acquisition phase of the work. In addition, the procurement section contained fields storing the current location of the document, in order to facilitate later retrieval if necessary. The third group consisted of fields which recorded the summary information derived from each reference. Detailed information obtained from the document that related to rare plant study methodologies was recorded in a memo field. This often included passages scanned verbatim from the document. In addition, binary fields in this group stored scanned images, (such as maps and graphs), from the documents. The summary group also included analysis fields for use in classifying the information contained in the references. These included fields such as Survey Type, Document Purpose, and Study Purpose. Finally, the fourth group, containing only one field, stored miscellaneous comments which had not been entered in any of the other fields. Table 2-1 on page 23 presents a complete list of the database fields used.

2.1.2 Document Type Classification

Each document was classified into one of four types based on the general function it was written to serve. In a few cases, a document was written for more than one purpose. In these instances, the document was classified into the type which most closely matched its dominant purpose. The four types are discussed below.

Guidelines: Documents were classified as guidelines when they contained a discussion of the methods which could be used in impact assessment studies. This group included papers which proposed a technique or procedure. Some were specific, prescriptive guidelines related directly to impact assessment rare plant studies, while others were general discussions of the methods used in related fields. In addition, documents which made recommendations regarding the overall impact assessment process were classified as guidelines.

Solicitations: Request for Proposals, Request for Quotes, and Terms of Reference were all classified as solicitations. These documents were usually requests to environmental consultants or academic institutions for bids on a specific project. Out of necessity, solicitations are typically prescriptive, and set out specific tasks which are to be performed. The methodologies to be used are often described in detail, making these documents especially helpful in analysing current practices and government

Table 2-1: Bibliographic Database Fields

Field Group	*Fields*
Bibliographic Information	Author(s); Title; Year; Journal Title; Month; Day; Volume; Number; In [which reference]; Pages; Type [book, journal article, etc.]; Publisher; City; Province/State; Country
Procurement Information	Status; Source(s); Date; Resides [currently]; Suggested [by which reference or individual]
Summary Information	Survey Type; Study Purpose; Document Purpose; Survey Timing; Investigator Qualifications; Literature Review Methods; Target Species ID Methods; Habitat Prediction Methods; Documentation Content; Summary; Binary Attachment 1; Binary Attachment 2; Binary Attachment 3
Miscellaneous Comments	Comments

requirements. Documents classified as solicitations were similar to guidelines in that they typically specify a method to be used for impact assessment studies.

Technical Reports: Documents were classified as technical reports when they described a specific botanical study. Primarily, these were impact assessment studies focused on a specific project, but general floristic and vegetation investigations were also included. In addition, reports which described the results of research relating to impact assessment were also classified as technical reports. These reports varied in the amount of detail presented, ranging from those which specified exact methods, to those which provided essentially no information about the methods used.

Miscellaneous Documents: Documents not classified into one of the other three categories were considered miscellaneous documents. These included documents which provided general information relevant to the botanical impact assessment process. In addition, documents which provided a historical or general overview of rare plant conditions were classed in the miscellaneous category.

2.1.3 Study Purpose Classification

In addition to classifying document type, it was also useful, when compiling the references, to categorise the purpose of the study referred to in the document. The study purpose was derived by examining the objectives of the investigation to determine its overall goal. In the case of guidelines, the study purpose was classified based on the goal of the investigation method recommended by the guidelines. Study purpose was broken down into three categories, as described below.

Impact Assessment: The majority of documents analysed in this research described studies or methods relating to impact assessment. Based on the definitions given in Chapter 1, the study purpose was classified as 'Impact Assessment' if the goal of the study was the prediction or assessment of the effects of an action on a particular resource. This included all of the technical reports which described the results of impact assessment rare plant surveys, as well as many of the guidelines and solicitations which set out the methods for these surveys.

Species Investigation: Studies whose primary purpose was the investigation of rare plant species for conservation goals other than impact assessment were classified as 'Species Investigations'. These included rare plant surveys conducted to determine global distribution, surveys which describe the rare plants in an area without predicting any effects, and studies which investigate a particular aspect of one rare species. In addition, several studies which report on methods for predicting the occurrence of a single species in a given area are included in this category.

Academic Research: Studies which examine broader issues of impact assessment, rarity, and botany were classified as 'Academic Research'. These studies are typically performed outside of the impact assessment process and explore larger, less site-specific issues than are addressed in impact assessment studies or species investigations. Studies regarding regional endangerment patterns, vegetation survey methods, and population assessment methods are also included in the 'Academic Research' category.

2.1.4 Document Summary

A total of 123 documents were reviewed to determine current and recommended procedures for impact assessment rare plant surveys. Table 2-2 on page 26 provides a summary of all the reviewed document types broken down by study purpose. As can be seen from the table, collection efforts focused on studies performed for impact assessment. Technical reports were the most numerous document type, making up more than half of those collected.

The documents were obtained from a variety of sources including various libraries and government agencies in both the US and Canada. The current location for all of the reviewed documents is stored in the bibliographic database. Because the goal of this work was to analyse these documents in groups, detailed summaries of individual documents are not presented in this paper. Sourcing information may be obtained from the author of this work for any of the reviewed documents.

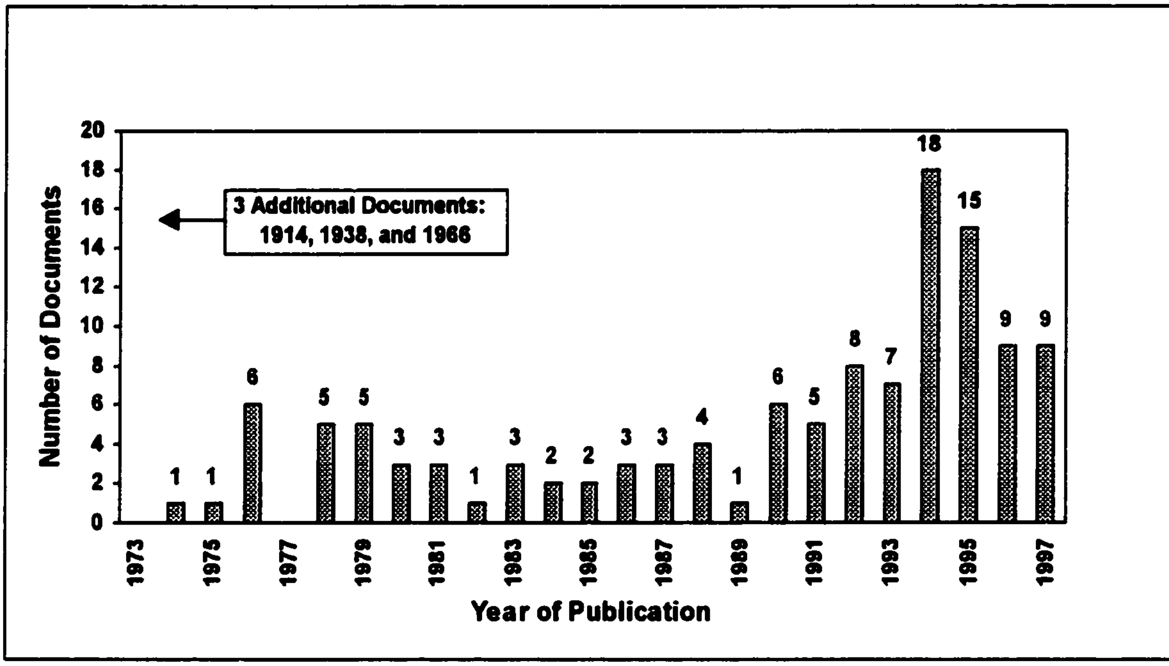
Figure 2-1 on page 27 shows a graph summarising the year of publication for all the reviewed documents. Most of the references, (77 documents or 63%), were published in the 1990s. It is interesting to note that no documents discussing rare plant species were located with a publication date prior to 1974, (the three pre-1974 documents which were reviewed discussed aspects of vegetation surveys). Although cataloguing and search methods biased the collection effort toward more recently published works, the seemingly sudden increase in rare species publications in 1974 may be due, in part, to the passage of the Endangered Species Act in the US in 1973. This legislation raised scientific and public awareness about the need for work on rare species, and spurred research into the topic.

Figure 2-2 on page 28 presents a chart showing the relevant country for the reviewed documents. Usually, this was the county of publication, however, for studies which focused on a specific country, but were published in another, the study was classified based on the country of focus. Most of the documents (93%) came from North America, (74% from the US and 19% from Canada). Although the focus on North American

Table 2-2: All Reviewed References

Document Type (broken down by study purpose)	*No. of Docs*	
Guidelines (documents which propose a method)		33
Impact Assessment	18	
Species Investigation	1	
Academic Research	14	
Solicitations (requests for proposals, requests for quotes, etc.)		21
Impact Assessment	21	
Species Investigation	0	
Academic Research	0	
Technical Reports (documents which report study results)		63
Impact Assessment	26	
Species Investigation	36	
Academic Research	1	
Miscellaneous (documents which don't fit into any of the above)		6
Impact Assessment	0	
Species Investigation	0	
Academic Research	6	
Total Documents Reviewed		123
Totals by Study Purpose		
Impact Assessment	65	
Species Investigation	37	
Academic Research	21	

Figure 2-1: Year of Publication (All Reviewed Documents)

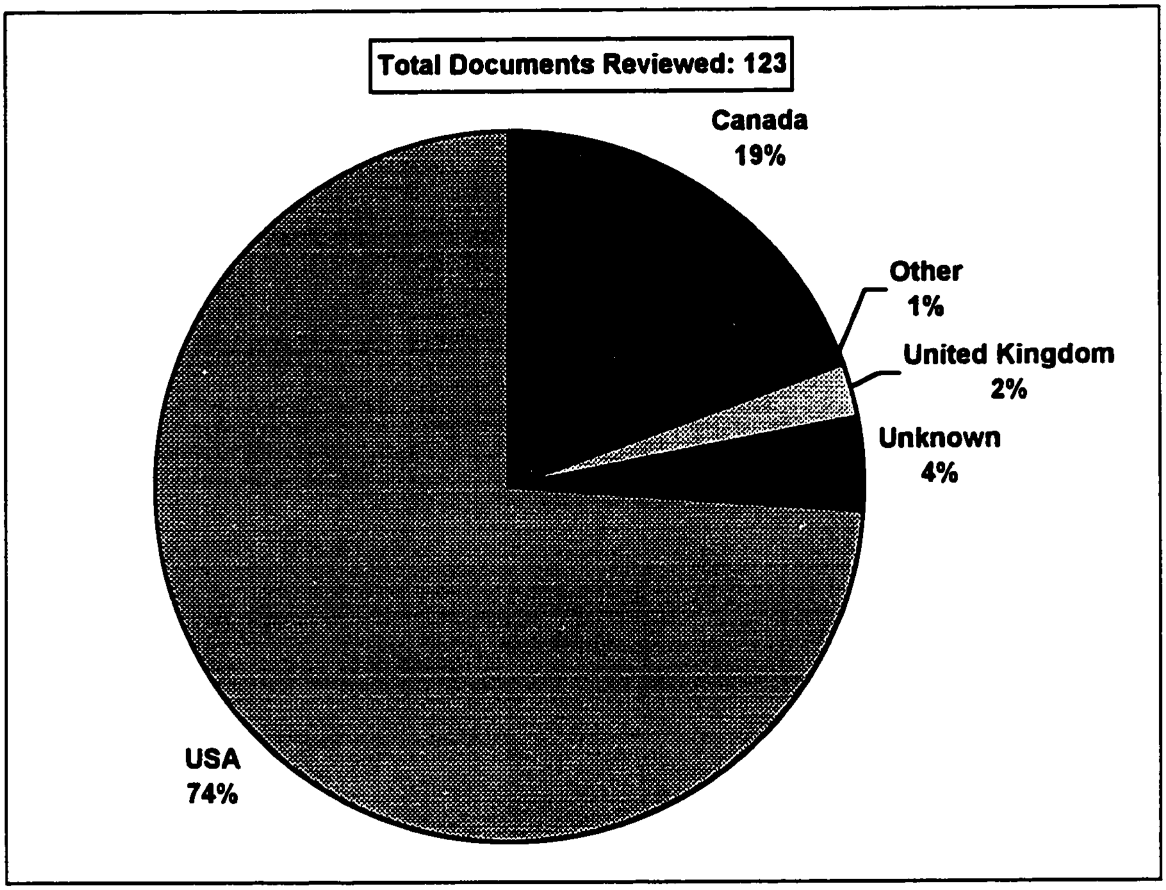


sources was intended, the preponderance of US documents was not. The fact that 74% of the documents found were from the US may simply be an indication of that country's larger population base compared to Canada. It also may be due, in part, to the stronger endangered species legislation in the US relative to Canada, which focuses a greater amount of survey and research effort on rare plants.

2.2 ANALYSIS METHODS

Following collection and compilation, the documents were analysed to determine the methods used, (or, in the case of solicitations and guidelines, the methods recommended for use). Additional data on report content, investigator qualifications, and other relevant factors were extracted where provided. Because some of the documents were deficient in their description of the procedures used, the methodologies could not be determined in all cases.

Figure 2-2: Country (All Reviewed Documents)



Regulatory Requirements: In determining the methods required by government regulatory agencies, the solicitations and government produced guidelines were the primary information sources used. In addition, those technical reports which were accepted as sufficient by regulatory agencies, were also used to determine the government required methodologies. Because rare species legislation typically does not address specific methodological issues, legislative documents were not used to determine government requirements for these studies.

Scientific Requirements: Academically produced guidelines, technical reports describing academic research, and other miscellaneous documents were used to determine the methods which are generally accepted by the scientific community. Because, very few refereed papers have been published relating to rare plant survey methods, this source alone was insufficient to determine scientific requirements. The additional documents were necessary to provide adequate information about general scientific requirements for these studies. Basic scientific principles, and simple probability analyses were also used to evaluate the methods' scientific soundness. For example, vegetation survey methods, (see Section 1.1.1.3 above), were considered inappropriate for rare plant surveys partially based on probability analysis. The chances of locating a population of an uncommon plant species using vegetation survey methods was calculated to be low, and this analysis, along with other published references, lead to the conclusion that the technique was inappropriate for rare plant studies (see Chapter 4 for details on the probability calculations).

Currently Used Methods: The determination regarding the methods currently in use for impact assessment rare plant surveys was made primarily through a review of the technical reports. Where provided, information was extracted from the reports on investigator qualifications, literature search methods, predictive habitat evaluation methods, survey timing, search pattern, and survey intensity. The content and structure of the reports was also analysed to determine the documentation procedures currently in use. In addition, solicitation documents were used to determine currently used methods.

2.3 GUIDELINE DEVELOPMENT METHODS

The guidelines developed in this research are intended for use on a variety of projects, by a broad range of public and private concerns. Due to the wide range of applicable situations, it was necessary to define the relevant parameters of each project (see Section 1.1.2 on page 12 for a description of the parameters). Once these parameters have been classified for a particular project, the appropriate methodology for the rare plant study can be chosen using the guidelines.

The guidelines specify a number of procedures and requirements for impact assessment rare plant studies. These include the following:

- Investigator Qualifications: specifying the level of training and expertise required by those performing these studies.
- Literature Review Methods: specifying the sources and content of the information to be collected during the prefield literature review.
- Target Species Selection Methods: specifying appropriate methods for determining target species.
- Potential Habitat Prediction Methods: specifying possible methods for determining likely habitat for rare species within the project area.
- Field Survey Timing: specifying the methods for determining when surveys need to take place.
- Field Search Patterns: specifying the appropriate search pattern(s) to be used for locating rare plant species.
- Documentation Requirements: specifying appropriate content and format for survey reports.

The guidelines were developed using information gathered in the analysis of government regulatory requirements, scientific standards, and current practices. In addition, industry requirements were also taken into account to ensure that the guidelines would be applicable in real-world situations.

The regulatory and scientific requirements were given the most weight in developing these guidelines. This was considered justifiable given that regulatory compliance is often the primary goal of these studies, (and there is, at least theoretically, a close correlation between regulatory and scientific requirements). Although current practices were also considered in the development of the guidelines, a currently used methodology was not necessarily incorporated into the guidelines simply because it had been used in existing studies. Currently used methods which were considered scientifically unsound, or were unacceptable from a regulatory standpoint, were not used in the production of the guidelines.

Industry requirements were also taken into account when developing these guidelines. The primary industry requirement in performing impact assessment rare plant studies is usually regulatory acceptance. This industry requirement is met by basing the guidelines on regulatory requirements, (and the closely related scientific requirements). The guidelines were developed, taking into account business realities, especially with respect to the timely completion of the studies. Where industry's requirement for expediency could be accommodated within the framework of regulatory acceptance, it was incorporated into the guidelines. In addition, industry's need for unambiguous guidelines which are applicable to a variety of project situations, influenced both the content and presentation style of the guidelines. Where two different methodologies would produce similar results, only one was chosen for recommendation in the guidelines to avoid confusion. Although this necessarily limits the latitude that a user of these guidelines has in employing alternate methods, this maintains the specificity of the recommendations.

CHAPTER 3: RESULTS

3.1 ORGANIZATION OF RESULTS

The results of the collected references analysis have been broken down into three sections corresponding to the objectives of the research: currently used methods, scientific requirements, and government regulatory requirements. In addition, a section analysing the survey patterns used in non-impact assessment botanical studies is included for comparison purposes. These results are presented in this chapter. The guidelines which were developed as a result of these analyses are presented in Chapter 5: Recommendations.

Each section contains a discussion and summary of the findings, arranged into seven content groups: investigator qualifications; literature review methods; target species selection; potential habitat prediction methods; survey timing; field search patterns; and documentation content. The content groups correspond to the procedures and requirements which are addressed in the rare plant survey guidelines developed in Chapter 5. These groups were chosen to encompass the major aspects of rare plant studies which are of importance to the impact assessment process.

3.2 CURRENTLY USED METHODS

3.2.1 Reference Summary

Forty-seven technical report and government solicitation documents described impact assessment studies, and were, therefore, used to determine currently used methods. Thirty-five described studies occurring, (or intended to occur), in the US, with the remaining 11 occurring in Canada. Table 3-1 starting on page 33 presents a summary of all references reviewed to determine currently used methods.

Many of the documents did not contain full information regarding all of the content groups analysed. For example, none of the technical reports which were examined

Table 3-1: References Used to Determine Currently Use Methods

Reference	*Project*	*Region*
Anonymous 1997a	Recreation Area	Alberta
Anonymous 1997b	Timber Harvest	Oregon
Anonymous 1992a	Airport Expansion	Minnesota
Anonymous 1991	Oil/Gas Development	Saskatchewan
Anonymous 1979	Reservoir Construction	Oregon
Duffy 1994	Various Forest Projects	Alaska
Environmental Man. Assoc. 1988	Reservoir Construction	Saskatchewan
Geographic Dynamics Corp. 1997	Ecological Reserve	Alberta
Griffiths *et al.* 1997	Recreation Area	Alberta
Hill 1996	Highway Project	Illinois
J. Williams Consulting 1995	Natural Gas Pipeline	Alberta
Mathews 1989	Various Forest Projects	Montana
Ode 1991	Unknown	South Dakota
Reichenbacher 1985	Indian Reservation	Arizona
Rhoads *et al.* 1979a	Military Test Range	Nevada
Rhoads *et al.* 1979b	Military Test Range	Nevada
Shaw and Laven 1993	Military Facility	Hawaii
Skinner 1991	Military Reservation	Missouri
Stone 1983	Univ. Research Centre	California
Taft 1994	Highway Project	Illinois
Tera Env. Consultants 1997	Natural Gas Pipeline	Alberta/BC
Tera Env. Consultants 1995	Natural Gas Pipeline	Sask./Man.

Reference	*Project*	*Region*
Thomas and Carey 1996	Military Reservation	Washington
US Bureau of Land Management 1996	Bald Eagle Management	Oregon
US Bureau of Land Management 1995	Various Timber Projects	Oregon
US Bureau of Land Management 1994	Land Exchange	Oregon
US Forest Service 1997	Various Timber Projects	Oregon
US Forest Service 1996	Various Timber Projects	Oregon
US Forest Service 1995a	Various Timber Projects	Oregon
US Forest Service 1995b	Timber/Range Projects	Oregon
US Forest Service 1995c	Various Timber Projects	Oregon
US Forest Service 1995d	Various Timber Projects	Oregon
US Forest Service 1995e	Timber/Range Projects	Oregon
US Forest Service 1995f	Timber/Range Projects	Oregon
US Forest Service 1995g	Range Allotment	Oregon
US Forest Service 1995h	Aspen Restoration	Oregon
US Forest Service 1994a	Timber/Range Projects	Oregon
US Forest Service 1994b	Various Timber Projects	Oregon
US Forest Service 1994c	Various Forest Projects	South Carolina
US Forest Service 1993a	Timber/Range Projects	Oregon
US Forest Service 1993b	Timber Harvest	Oregon
US Forest Service 1992	Various Timber Projects	Oregon
Wallis and Wershler 1988	Agricultural Projects	Alberta
Webster and Richie 1997	Pipeline	NB
Wilkinson 1996	Pipeline	Alberta

Reference	*Project*	*Region*
Wilkinson and Bradley 1993	Pipeline	Alberta
Young *et al.* 1986	Dam and Reservoir	Alberta

described the qualifications of the investigator(s) who performed the study. And only nine of the twenty-one solicitation documents, (or 43%), provided investigator qualifications requirements. Conversely, 27 out of the 47 documents examined to determine current practices, (or 57%), contained some information regarding the methods used to determine the target species list. It should be noted that the omission of certain information in a document does not necessarily indicate a gap in the work performed. Often it simply indicates that the author chose not to explicitly address that aspect of the study in the report or solicitation. For example, although almost all rare plant studies involve some sort of prefield review before surveys begin, not all of the technical reports documented the methods used for this review.

3.2.2 Investigator Qualifications

One of the most important contributing factors to the successful completion of any impact assessment rare plant study is the expertise of the investigator(s) involved. Investigator qualifications can make the difference between a rare plant study that finds most, (or all), of the rare plant populations in the project area, and one which locates only a small percentage. In addition, a competent and experienced investigator can use knowledge gained from observing impacts on previous projects to predict potential impacts on the current project. Well qualified investigators also tend to facilitate the permitting process by providing regulators with adequate information on which to base their decisions, without supplying extraneous data which may confuse the issue.

As mentioned above, only nine of the forty-seven technical reports and solicitations reviewed (19%) provided any information about investigator qualifications. All of these were US Forest Service solicitations requesting bids for rare plant surveys. All but the one solicitation required that the study be under the direction of an individual with a Bachelor's degree in botany, or a related field. In addition, all nine solicitations required that the principal investigator have a certain degree of experience in performing botanical studies in the region. Experience requirements range from three months to two years. Botanical survey crew members were required by these solicitations to have minimum qualifications which usually included some sub-baccalaureate level of college botanical training, and three months to one year of experience performing botanical surveys in the region. Additional requirements for certain solicitations included demonstrated plant keying ability, proficiency in orienteering, and knowledge of the local flora.

3.2.3 Literature Review Methods

Most impact assessment rare plant studies begin with a prefield review. This first step is designed to gain information which will be relevant to the field surveys and impact predictions. One component of the prefield review is typically a literature search to uncover relevant existing information relating to the botanical resources in the project vicinity. In addition to written literature, sources may also include maps, digital databases, online resources, and interviews with botanists, regulators, and others who may have information on the project area.

Of the 47 documents reviewed for this assessment of currently used methodologies, 28, (or 60%), contained some information regarding literature review methods. Most often these were confined to a listing of the sources consulted, and, occasionally, the types of information obtained from these sources. The sources most commonly consulted are described below. The number in parenthesis indicates the number of reviewed documents, out of 47 total, which mentioned the particular source, (note that some documents mentioned more than one source):

- Aerial photographs (12): Aerial photographs were consulted to determine plant community types, terrain, and travel logistics within the project area.

- Topographic maps (11): Topographic maps were used to determine potential habitat locations, travel routes, and topography within the project area.

- Academic literature (10): Academic literature was consulted to determine species presence within the project area, clear up individual taxonomic questions, and determine global or regional distributions and listing status for particular taxa.

- Personal communications with botanists, regulators, and other knowledgeable individuals (9): Personal communications were used to gain information on a wide variety of factors, including species habitat preferences, taxonomic issues, regulatory approval, and project area access.

- Technical reports from previous studies in the area (6): These reports were consulted to gain information on various aspects of the project area, including common and rare species presence, habitat features presence, and other relevant information.

- Natural Heritage Program/Conservation Data Centre database queries (5): Searches of database records were used to gain information on known rare plant populations in the project vicinity, and derive target species lists for the project area. Database records were also used to gain information on species habitat preferences.

- Geologic maps (4): Geologic maps were used to determine potential rare plant habitats within the project area.

- Soil Maps (2): Soil maps were also used to determine potential rare plant habitats.

- Herbarium visits (2): Herbaria were visited to develop search images, and confirm identifications of suspected rare species.

3.2.4 Target Species Selection

A second component of the prefield review is the determination of which rare species will be addressed by the study. In a few cases the regulatory direction will be clear, and the target species will be limited to a well-defined, government-produced list. If a species is not on that list, it is not considered to be a target species for that study. In the majority of project situations, however, regulatory direction will be less prescriptive. Often, overlapping jurisdictions on a project mean that rare species from several lists must be considered. In other instances, regulatory prescriptions are vague, directing the proponent to consider all 'rare' species. In all cases, the consultant must determine which species will be of concern to the regulatory agencies at the time the project application is reviewed. This adds a temporal factor to the decision, often forcing the consultant to predict which species may be listed in the future.

Twenty-seven of the forty-seven documents reviewed for the currently used methods analysis, (57%), contained references to target species determination methods. Most often these were short descriptions, providing few details on the process. The methods are described in the list below. The number in parenthesis indicates the number of reviewed documents, out of 47 total, which mentioned that particular method:

- <u>Government Lists (19)</u>: In many cases, a specific government list, (*e.g.*, the COSEWIC List, the US Fish and Wildlife Service Endangered Species List, the US Forest Service Region Six Sensitive Species List), was used as the primary determinate for target species selection.

- <u>Natural Heritage Program/Conservation Data Centre Lists (5)</u>: The State and Provincial lists of rare species maintained by The Nature Conservancy's Natural Heritage Programs and Conservation Data Centres were also used in a number of cases to determine target species. In addition, queries of the various element occurrence databases, maintained by these organisations, were used to determine which of the target species had potential for occurrence within the project area.

- Consultations With Agencies (5): Informal consultations with agency officials, (both at the regulatory and technical levels), contributed to the determination of target species.

- Review of Previous Studies (3): Information from previous studies performed in the project vicinity was used to determine which rare species might be present in the project area.

- Herbarium Visits (2): Herbarium specimens were reviewed to determine the rare species which had documented historical occurrences in the project vicinity. These species were then considered to be target species for the study.

3.2.5 Potential Habitat Prediction

The final step in many prefield reviews is to remotely map potential rare plant habitats within the project area. Using information gathered during the literature review, the preferred habitats for each of the target species are determined, (to the extent possible given the existing data). Then, using a number of different techniques, the known habitats within the project area can be analysed to predict those areas which have the greatest potential for occurrence of rare species. Once this has been accomplished, a survey plan can be developed to guide the field work.

It should be noted that the accuracy of the potential habitat prediction process is highly variable from project to project, and even from species to species. Species habitat preferences, as well as existing habitat types within the project area must both be known to a substantial degree before accurate predictions can be made. For many rare species, there are few studied populations and, therefore, habitat preferences for these species are not known with any degree of certainty. Likewise, many projects are proposed for remote areas where existing data on habitat types is lacking or insufficient. However, in most cases, some general maps can be produced showing the areas of highest potential rare plant habitats.

Of the 47 documents reviewed for the analysis of currently used methods, 17, (or 36%), contained references to potential habitat prediction methods. Typically, description of these methods was not detailed, usually amounting to a listing of the resources used to make the predictions. The various resources reportedly used are presented below. The number in parenthesis indicates the number of reviewed documents, out of 47 total, which mentioned the particular resource:

- Topographic Maps (11): Maps delineating topographic features were used to predict the locations of suitable rare plant habitat. Factors such as slope, aspect, drainage patterns, and the location of wetlands and other unique features were all used for this purpose.

- Aerial Photos (11): Aerial photographs, including photomosaic maps, were used as frequently as topographic maps in predicting rare plant habitats. Plant communities and the locations of unique features can be discerned on these photos, making them especially helpful for habitat prediction.

- Existing Rare Plant Populations (2): The proximity to known rare plant populations was also a factor in determining potential habitats. Areas surrounding known rare plant sites, which contained similar habitats, were considered to be potential habitat.

- Geologic Maps (2): Geologic maps were used to predict potential habitat in a few cases. This method was helpful in predicting potential habitat for species which show a specific preference for certain substrates, (*e.g.*, limestone, serpentine soils, etc.).

- Cover Type Maps (1): Cover type, (*i.e.*, plant community or ecoclass), maps are one of the best resources to predict potential rare plant habitats. In most cases, however, accurate cover type maps are not available for a particular project area prior to the initiation of field studies.

- Previous Studies (1): Previously conducted studies which cover all or part of the project area were used to determine the habitat types and unique features present.

3.2.6 Survey Timing

Following the prefield review, typically, some sort of field survey will be undertaken to determine the presence and distribution of rare plant populations, (if any), within the project area. In a few cases, it will be determined during the prefield review that a field survey is not necessary. This is rare, however, and is usually confined to situations where the project area has already been extensively surveyed, or in cases where the project area contains no potential habitat for rare species.

One of the most important factors to consider in rare plant field work is the timing of the surveys. Given that different species are identifiable in the field at different times of the year, it is important that field surveys take place when the target species can be located. Usually, the phenologies of the various target species are different enough that more than one survey is required. For example, in the Wallowa Mountains of Northeastern Oregon, a typical target species list would include both *Ranunculus oresterus* (blue mountain buttercup), and *Botrychium crenulatum* (crenulate moonwort). *R. oresterus* emerges and blooms just after the snow recedes in late March and early April. By the end of April, the plants have withered and blown away, usually leaving no visible trace. Conversely, *B. crenulatum* does not emerge until July. In this area then, two surveys would be required to locate both species.

Of the 47 documents reviewed for this section, 30, (or 64%), appeared to use, (or recommend for use in the case of solicitations), a survey timing which was based on the phenology of the target species. Some of these 30 documents directly acknowledged that phenology was a factor in determining survey timing, and in others, this was inferred from the reported survey dates. The remaining 17 documents provided insufficient detail to determine the factors which were used to decide on survey timing.

3.2.7 Survey Patterns

The search pattern that the surveyor uses to locate new populations of rare plants is one of the most complex and confusing aspects of impact assessment rare plant studies. Numerous techniques are used to find populations, ranging from remote methods which employ offsite analysis, to complete-level intensive pedestrian transects of the entire project area. In most cases, the search pattern chosen will be somewhere between these two extremes in an attempt to balance the need for scientific accuracy, with the need for cost and time effectiveness.

Thirty-seven of the forty-seven documents reviewed for this section, (79%), contained information sufficient to determine the search pattern(s) used, (or recommended for use). The length of the search pattern descriptions contained in the documents ranged from one sentence to several pages. The remaining ten documents contained no information on search patterns. For this analysis, the search patterns were classified into several discrete types. Although there are variations within each type, this classification system is useful in determining the basic categories of surveys currently in use. Terms used in this document to describe each survey type are based on those commonly used in the literature. As mentioned in previous sections, there are often considerable differences in rare plant survey terminology from one document to the next. Survey patterns were classified based on the description of the methods used, rather than on the terms used to refer to the pattern in the document.

A description of the survey types is provided in the following paragraphs. As in previous sections, the number in parenthesis indicates the number of reviewed documents, out of 47 total, which referred to the particular survey pattern. It should be noted that some documents mentioned more than one pattern. Figure 3-1 on page 44 shows a graphic representation of the basic survey pattern categories.

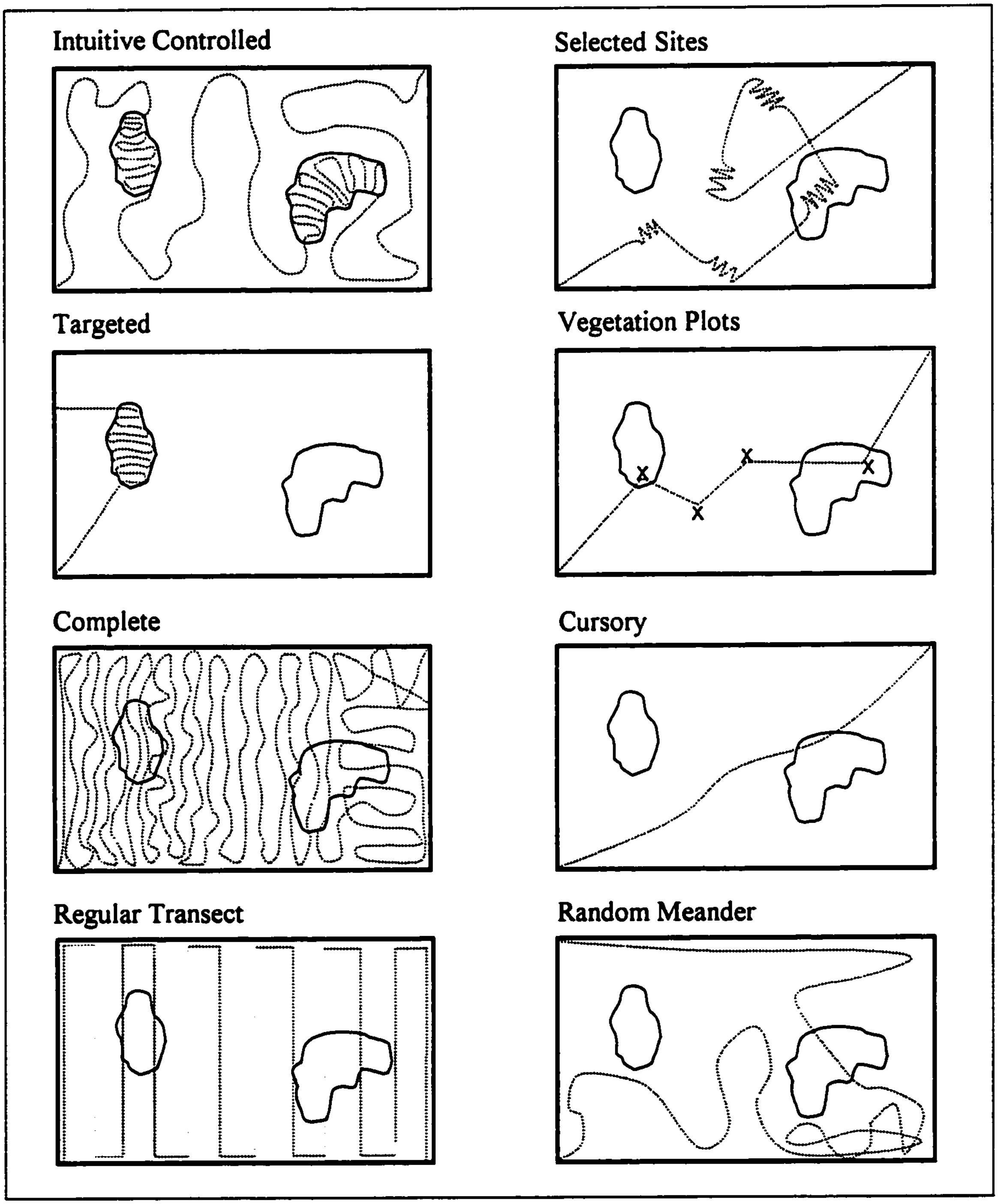
Intuitive Controlled (20): The Intuitive Controlled survey method relies on the knowledge and experience of the investigator to guide the search process. The surveyor walks through the project area taking care to locate and intensively search all high probability rare plant habitats and unique features. The investigator strives to cover the entire area in a systematic pattern that maximises the probability that all unique and high probability habitats will be located. In the process, a representative proportion of the low probability habitats are also surveyed. In dense cover, or in areas where the unique habitats are difficult to locate from a distance, the search pattern will be tighter than in open areas with evident unique habitats. The actual walking routes may be oriented in a grid pattern, especially in level terrain; or the routes may follow the contours of the project area, especially in the more mountainous terrain. For linear corridors, the survey route typically zigzags from one edge of the proposed right-of-way to the other.

The Intuitive Controlled survey type is a continuous search method, meaning that no plots are used. The key feature of this method is the varying coverage it provides depending on the likelihood of rare species occurrence. In sections with many high probability rare plant habitats, the surveyor moves slowly, carefully examining a large percentage of the ground. In sections with few high probability habitats, the surveyor moves more quickly, spacing the transects farther apart, (although still intensively searching any high probability habitats which are encountered). Usually, the surveyor will keep a running list of all plant species found. In addition, habitat types, unique features, and other information may be noted. When rare plant populations are found, they are extensively documented. In general, however, the data collection requirements of this type of survey are kept to a minimum, (except when rare plant populations are found), to maximise the amount of time spent actually searching the ground.

The Intuitive Controlled type was the survey pattern referred to by the most documents reviewed for this section, (although the terminologies varied). All of the 20 documents which mentioned this survey method were from the US.

Selected Sites (9): This method surveys particular sites within the project area, and ignores other areas. No attempt is made to cover the entire project area. Typically, the sites which are selected for survey are those that contain high probability rare plant habitat. In addition, lower probability sites are also surveyed to obtain a representative sample of these areas. The sites are often selected prior to the field work, during the

Figure 3-1: Survey Patterns



(Rectangles represent project area; Irregular polygons represent unique habitats)
Based on US Forest Service 1995d

prefield review. Survey intensity within these selected sites varies from a cursory walk-through, to an intensive, complete-level search.

The Selected Sites method differs from the Intuitive Controlled method in that the former surveys only discrete sections of the project area, while the latter attempts to cover the entire extent. With the Selected Sites method, some parts of the project area containing potential for rare plant species, are never entered and examined for rare plants. Typically, this unsurveyed habitat comprises greater than 50% of the total project area. It should be noted that with the Intuitive Controlled method, there may also be portions of the project area which are deliberately not surveyed; but, unlike the Selected Sites method, only in cases where the prefield review indicates that those portions have no potential for the occurrence of rare plant species.

The Selected Sites method was referred to by nine of the forty-seven documents examined for this section. Five of those documents related to Canadian studies, while the remaining four referred to US studies.

Targeted (5): The Targeted survey pattern, (sometimes referred to as the Limited Focus pattern), is designed to search certain habitats only. Typically, in this type of survey, the investigator will enter an area and proceed directly to the desired habitat block. This habitat will then be searched, and the investigator will either proceed to another similar habitat block, or will conclude the search and leave the area. The survey intensities of the individual habitat blocks can range from Complete to Cursory, (see definitions below), depending on the objectives of the investigation. No attempt is made to search all unique habitats within the area, and the ground between the targeted habitats is not surveyed. The Targeted survey pattern differs from the Selected Sites pattern in that the former attempts to survey only a few specific habitats, while the latter attempts to survey a sampling of many different habitats.

The Targeted survey pattern is often used for subsequent searches following an initial, more complete survey. The initial survey provides the location of habitat which requires survey at a different time of the year. A Targeted survey is then used to search those specific habitats, at the proper time of year, and ignores the remaining areas. In addition, Targeted surveys are used when the location of potential habitat is already well known, and the number of species being searched for is small.

Five documents reviewed for this section described methods which were classified as Targeted surveys. All five of these studies used Targeted surveys in conjunction with other survey types. Four were solicitation documents describing surveys on US Forest Service Land, and the fifth described a survey of a US military reservation.

Vegetation Plots (5): Although not designed for floristic surveys, vegetation methods are occasionally used for locating rare plants. This involves the systematic or random placement of plots within the project area. At each of these plots, the vegetation is analysed within a frame of constant size, (*e.g.*, 20 by 20 metres). When these plots are used for rare plant surveys, typically all of the species within the frame are listed. Other information is usually recorded including, cover measurements of the dominant species, slope, moisture regime, etc. For rare plant work, plots are usually located in a variety of habitats, although the unique habitats are usually over-represented. As opposed to the Selected Sites method, the vegetation plots are relatively small and intensively searched. All five of the documents which reported on the rare plant survey uses of Vegetation Plots were technical reports from studies which had taken place in Canada.

Complete (4): The Complete survey pattern strives to visually search every square centimetre of ground. Theoretically, every individual plant is identified. The actual pattern walked may be a series of closely-spaced transects, or it may be more random. Because this method is obviously time consuming, the Complete pattern is usually used for small areas. All four of the reviewed studies which used Complete survey patterns did so in conjunction with other, less intensive methods. Three of the studies took place in the US, and one took place in Canada.

Cursory (2): This search pattern consists of a quick walk through the project area. It is used most often to obtain a general idea of the habitat types present, or to confirm general assumptions about the project area. No attempt is made to visit all parts of the project area. Two reviewed documents described methods that could best be classified as Cursory. In both these studies, the Cursory pattern was used in conjunction with other, more intensive methods. Both the documents described studies from the US.

Regular Transect (1): This method uses a series of regularly spaced transects to survey the project area. Unlike the Complete pattern, not every square centimetre of ground is surveyed. This pattern is better suited to flat terrain with few obstacles to impede travel. The survey intensity, theoretically, remains constant across the entire project area. Only one of the documents reviewed for this section described a Regular Transect survey pattern. This study took place in flat, open desert habitat in the Southwestern US.

Random Meander (1): With the Random Meander pattern, the investigator is required to walk a 'random' route through the project area. No outside factors, such as topography, unique habitats, or obstacles, should be allowed to influence the route taken. In reality, this is impossible, but a certain level of randomness can be attained. The Random Meander pattern, through chance, surveys some parts of the project area more intensively than others. These more intensively surveyed parts may or may not be in unique habitats. Only one of the studies reviewed for this section used a Random Meander pattern. This was a Canadian study of a sand dune area, and the Random Meander method was used in conjunction with other survey patterns.

3.2.8 Documentation Content

The form and content of the documentation is also important in ensuring that impact assessment rare plant studies are completed effectively. In most cases the individuals who actually perform the work for the study, are not the same ones who make the final regulatory decision. It is therefore important that the information gained from the study, and the conclusions reached by the analysis, be communicated in a clear manner. This task is made more difficult because the impact assessment technical reports are often read by a variety of reviewers from different backgrounds. For example, the report may be read by a botanist to determine scientific adequacy, and also be read by a government regulator with little or no scientific training. Each reviewer must be able to derive sufficiently detailed information relevant to his or her analysis.

The documentation content of the references reviewed for this section varied greatly. Some provided almost no information regarding the methods used, or the results attained. Others described methods in details, but neglected to present the results in a coherent manner. Still others provided adequate detail on all counts. For the purposes of this analysis, the documentation content was broken down into several components. An annotated list of the components is presented below. As in previous sections, the number in parenthesis indicates the number of documents, out of 47 total, which presented that component:

- Narrative (43): Narrative descriptions of floristic conditions at the site can provide the reader with summary level information about the project area. Most of the documents reviewed for this section, (91%), contained some sort of narrative description of the site. These varied widely in extent from only a paragraph to several pages long.

- Plant Collection (31): Collection of specimens can be an important documentation procedure to ensure the accuracy of the study. Sixty-six percent of the studies reviewed for this section used specimen collection for the verification and documentation of species occurrence.

- Site Photos (27): Site photos serve to give a visual image of the project area, and can be important in the later analysis of aspects which might not have been considered at the time of the field work. Of the 47 documents reviewed for this section, 27, (or 57%), used photos to document the work.

- Botanical Survey Forms (26): The inclusion of botanical survey forms can provide the reader with raw data about the project area. Some type of botanical survey form was used by at least 26 of the 47 studies reviewed for this section, (55%).

- Aerial Photos (23): The use of aerial photos for marking significant locations provides a level of positional accuracy usually not possible with maps. This can assist in relocating specific sites. Forty-nine percent of the reviewed documents used aerial photos, (including photomosaic maps), to document significant locations.

- Survey Route Maps (21): The inclusion of maps showing the survey routes travelled by the investigators is helpful in determining the level of coverage achieved. Forty-five percent of the documents reviewed for the analysis of current methodologies contained maps showing survey routes.

- Plant Species List (16): A list of all plant species encountered within the project area is helpful in assessing the thoroughness of the survey. In addition, it provides raw data on the presence of species at the site. Sixteen out of the forty-seven documents reviewed for this section (34%) contained species lists for the project area.

3.3 GOVERNMENT REGULATORY REQUIREMENTS

3.3.1 Reference Summary

A total of 41 solicitations, guidelines, and government accepted technical reports were used to determine government regulatory requirements for impact assessment rare plant surveys. These documents were taken to represent the methods acceptable to government regulators in both Canada and the US at a variety of levels, ranging from the State/Provincial level to the federal level. Twenty-nine of the documents were from the US, while the remaining 12 were from Canada.

Many of the documents analysed for this section are the same ones employed for the analysis of currently used methods (see Section 3.2.1 above). All of the same solicitations are used here, and some of the technical reports, (those that were accepted by government agencies). Additionally, government produced guidelines were also analysed for this

Table 3-2: References Used to Determine Government Requirements

Reference	*Document Type*	*Region*
Anonymous 1997a	Solicitation	Oregon
Anonymous 1997b	Solicitation	Alberta
Anonymous 1992b	Guideline	California
Anonymous 1991	Technical Report	Saskatchewan
Duffy 1994	Technical Report	Alaska
Envir. Management Assocs. 1988	Technical Report	Saskatchewan
J. Williams Consulting 1995	Technical Report	Alberta
Lancaster 1997	Guideline	Alberta
Mathews 1989	Technical Report	Montana
NB Minister of Environment 1992a	Guideline	New Brunswick
NB Minister of Environment 1992b	Guideline	New Brunswick
NB Minister of Environment 1990a	Guideline	New Brunswick
NB Minister of Environment 1990b	Guideline	New Brunswick
Nelson 1987	Guideline	US
Nelson 1985	Guideline	US
Rhoads *et al.* 1979a	Technical Report	California
Rhoads *et al.* 1979b	Technical Report	California
Skinner 1991	Technical Report	Missouri
State of California 1984	Guideline	California
Tera Env. Consultants 1997	Technical Report	Alberta
US Bureau of Land Management 1996	Solicitation	Oregon
US Bureau of Land Management 1995	Solicitation	Oregon

Reference	*Document Type*	*Region*
US Bureau of Land Management 1994	Solicitation	Oregon
US Forest Service 1997	Solicitation	Oregon
US Forest Service 1996	Solicitation	Oregon
US Forest Service 1995a	Solicitation	Oregon
US Forest Service 1995b	Solicitation	Oregon
US Forest Service 1995c	Solicitation	Oregon
US Forest Service 1995d	Solicitation	Oregon
US Forest Service 1995e	Solicitation	Oregon
US Forest Service 1995f	Solicitation	Oregon
US Forest Service 1995g	Solicitation	Oregon
US Forest Service 1995h	Solicitation	Oregon
US Forest Service 1994a	Solicitation	Oregon
US Forest Service 1994b	Solicitation	Oregon
US Forest Service 1994c	Solicitation	South Carolina
US Forest Service 1993a	Solicitation	Oregon
US Forest Service 1993b	Solicitation	Oregon
US Forest Service 1992	Solicitation	Oregon
Wilkinson and Bradley 1993	Technical Report	Alberta
Young *et al.* 1986	Technical Report	Alberta

section. As is the case throughout this review, it was found that many of the documents did not contain complete information on all of the content groups analysed.

3.3.2 Investigator Qualifications

Twelve of the forty-one documents reviewed for this section, (29%), provided information on investigator qualifications. Most of these were government solicitations, which supplied specific contractor education and experience requirements. Three guideline documents, all produced in California, also provided lists of qualifications an investigator should possess in order to perform impact assessment rare plant surveys.

Most of the solicitations required that the principal investigator have a Bachelor's degree in botany, or a related field, and have a certain amount of experience performing botanical studies in the region, (ranging from three months to two years). The guidelines, in contrast, de-emphasised the academic component, instead focusing on field experience and knowledge of the local flora. Familiarity with the regulatory structure, writing ability, and enthusiasm for field work were also listed as desirable qualifications.

3.3.3 Literature Review Methods

Of the 41 documents reviewed for the analysis of government regulatory requirements, 20, (or 49%), contained some information regarding literature review methods. The sources most commonly mentioned were: topographic maps (11 documents); aerial photographs (10 documents); academic literature, including floral keys (7 documents); personal communications with agency and scientific experts (6 documents); previous studies in the area (5 documents); Natural Heritage Program/Conservation Data Centre databases (5 documents); geologic maps (3 documents); herbarium visits (3 documents); and soil maps (1 document).

3.3.4 Target Species Selection

Twenty-four of the forty-one documents reviewed for this section, (59%), contained references to target species determination methods. By far, the most prevalent was the use of specific government lists, occurring in 19 of the documents. Other sources of information included: Natural Heritage Program/Conservation Data Centre database queries (6 documents); consultation with agency officials (4 documents); review of previous studies (3 documents); and herbarium visits (3 documents).

3.3.5 Potential Habitat Prediction

Of the 41 documents reviewed for this section, 15, (or 37%), contained references to potential habitat prediction methods. The resources most used were: topographic maps (11 documents); aerial photos (7 documents); cover type maps (4 documents); proximity to existing rare plant populations (2 documents); and geologic maps (2 documents).

3.3.6 Survey Timing

Twenty-nine of the documents, (or 71%), contained information which was sufficient to determine the basis used for survey timing. In all of these cases, plant phenology, (*i.e.*, when the target species were identifiable), appeared to be the primary determining factor. The remaining 12 documents provided insufficient detail to determine the factors which were used to decide survey timing.

3.3.7 Survey Patterns

Thirty of the forty-one documents reviewed for this section, (73%), contained information on the search pattern(s) used, (or recommended for use). The remaining 11 documents contained no information on search patterns. The survey patterns are listed below. The number in parenthesis indicates the number of documents, out of 41 total, that contained reference to the particular survey pattern:

- Intuitive Controlled (22): This was, by far, the most often mentioned survey pattern among those reviewed for this section, (although the terminologies varied). Twenty-one of the documents were from the US. The remaining document is from Canada.

- Targeted (6): All documents reviewed for this section referring to the Targeted search pattern were from the US. This search pattern was used in conjunction with other patterns in all six cases.

- Selected Sites (4): Three of the documents referring to the Selected Sites pattern were from Canada, with one from the US. In only one case was this method used in conjunction with other patterns.

- Vegetation Plots (3): All three documents referring to the use of Vegetation Plots for locating rare plant species were from Canada.

- Complete (3): Two of these documents were from the US, and the remaining one from Canada. In all cases the Complete search pattern was used in conjunction with less intensive patterns.

- Regular Transect (2): Both references to Regular Transect methods were in guidelines produced in the US by the same author.

- Cursory (1): The sole document reviewed for this section which mentioned the Cursory survey pattern was a US Forest Service Solicitation. The Cursory method was to be used in conjunction with other, more intensive, patterns.

3.3.8 Documentation Content

The level of documentation varied greatly from reference to reference. However, it was still possible to identify some common components used in many of the reports, solicitations, and guidelines. Components used, (or recommended for use), in documenting rare plant surveys by the 41 references included: narrative descriptions (38 documents); plant collection (28 documents); site photos (25 documents); botanical survey forms (25 documents); aerial photos (23 documents); survey route maps (20 documents); and plant species lists (15 documents).

3.4 SCIENTIFIC REQUIREMENTS

Because few refereed scientific books and papers were available which specifically addressed impact assessment rare plant studies, it was necessary to also review other documents to determine the scientific requirements for these studies. Relevant information on rare plant studies was found in various papers and books relating to principals of impact assessment, species investigations, and population biology. A total of 21 documents were reviewed for this section. Table 3-3 on page 56 presents a listing of the documents used to determine scientific requirements.

3.4.1 Investigator Qualifications

Only three of the documents reviewed for this section contained any reference to investigator qualifications. These were guidelines produced in the US, designed to apply to a broad range of impact assessment rare plant studies. All three stressed that the field crew members should have some level of experience performing botanical studies in the region. No minimum levels of either experience or college coursework were set by any of the three guidelines.

3.4.2 Literature Review

Two of the guidelines, and a prefield review methods paper, were the only documents out of the 21 reviewed for this section which contained a discussion of literature review sources. All three recommended similar sources, including topographic maps, aerial photographs, previous technical reports on projects in the area, academic literature, personal communications with agency and scientific experts, herbarium visits, and Natural Heritage Program/Conservation Data Centre database queries.

Table 3-3: References Used to Determine Scientific Requirements

Reference	*Document Type*	*Subject*
Allen 1988	Other	Rare Plant Monitoring
Alverson 1990	Technical Report	Rare Plant Habitat Prediction
BC Environment 1992	Guideline	Env. Assessment
Beanlands and Duinker 1983	Guideline	Env. Assessment
Bradshaw and Doody 1978	Guideline	Population Biology
Goff *et al.* 1982	Guideline	Rare Plant Surveys
Henifin *et al.* 1981	Guideline	Rare Plant Surveys
Lancaster 1997	Guideline	Rare Plant Surveys
Lawrence 1993	Guideline	Env. Assessment
Mathews 1975	Guideline	Env. Assessment
McFarlane and St. Clair 1978	Guideline	Rare Plant Surveys
McFarlane 1980	Guideline	Rare Plant Surveys
Myatt 1987	Guideline	Rare Plant Surveys
Nelson 1985	Guideline	Rare Plant Surveys
Nelson 1987	Guideline	Rare Plant Surveys
Schemske *et al.* 1994	Miscellaneous	Plant Conservation
Sharma *et al.* 1976	Guideline	Impact Assessment
Shaw and Laven 1993	Technical Report	Rare Plant Surveys
Sperduto & Congalton 1996	Technical Report	Rare Plant Survey
Ward 1978	Guideline	Impact Assessment
Zar 1976	Guideline	Impact Assessment

3.4.3 Target Species Selection

Only four reviewed documents referred to methods for target species selection. These were two of the guidelines, and two papers on prefield review methods for potential habitat prediction. Resources recommended for consultation included government lists, Natural Heritage Program/Conservation Data Centre lists, consultations with agencies, past studies, and herbarium visits.

3.4.4 Potential Habitat Prediction

Six documents addressed methods of potential rare plant habitat prediction within the study area. These documents included two of the guidelines, and four documents specifically dealing with habitat prediction methods. Resources mentioned as being useful for potential habitat prediction included, topographic maps, aerial photos, geologic maps, soil maps, cover type maps, land use maps, and previous studies in the area. Geographic Information Systems were mentioned as being helpful in co-ordinating the various data, and in the predictive process.

3.4.5 Survey Timing

The five documents which addressed survey timing all stressed that field searches must be performed during the times of the year when the target species are identifiable. They noted that basing survey timing on plant phenology may require that more than one survey of the same area is needed to adequately address rare plant species.

3.4.6 Survey Patterns

The guidelines by Nelson (Nelson 1987, Nelson 1985), and the related Lancaster guidelines (Lancaster 1997), recommend what is essentially an Intuitive Controlled survey pattern, (although these guidelines do not refer to the pattern by this name). Nelson also recommends using Targeted and Regular Transect patterns in conjunction with the Intuitive Controlled method. Lancaster notes that for large project areas, a

Selected Sites pattern may be used. Where this method is chosen she cautions that the, "...searches should concentrate on as many likely habitats as is feasible while still sampling each plant community represented in the study area." (Lancaster 1997).

These three guidelines, as well as others reviewed for this section, specifically state that vegetation surveys, with their emphasis on the more common species, are not appropriate for rare plant studies. These documents stress that, floristic surveys, which attempt to identify all species in a given area, are the primary type suitable for rare plant studies.

One additional survey pattern deserves mention here. The Timed-Meander method described by Goff *et al.* (1982) may be useful in certain areas, and incorporates a rudimentary level of quantification into floristic surveys. For a description of this pattern, see Section 1.3 on page 19.

3.4.7 Documentation Content

Although little specific direction was found regarding documentation content in the references reviewed for this section, certain components were recommended. Several of the references recommended using some sort of field data survey form to document search efforts. In addition, narrative descriptions of rare plant sites and other botanical resources were recommended. Although species lists were mentioned, none of the documents reviewed recommended including a map showing survey routes. There was unanimous agreement throughout the references that rare plant sites needed to be copiously documented. Site forms, photos of both the rare plants and the surrounding habitat, and accurate locational maps, (including aerial photo marking), were all mentioned as useful site documentation methods. Several documents cautioned against indiscriminate collecting at rare plant sites, and recommended the collecting of rare plant specimens only in instances where the population was large enough to remain unaffected by the removal.

3.5 OTHER STUDIES

A number of other botanical studies and methodologies were reviewed to provide a means of comparison to impact assessment rare plant studies. These included vegetation characterisation studies, rare plant species investigations (non-impact assessment), and general floristic surveys not focussing on rare species. Table 3-4 on page 60 lists the documents reviewed for this section. A total of 42 references are included, with the majority being technical reports describing non impact assessment rare plant surveys or general botanical surveys.

The various survey patterns used in these studies was of primary interest to the present research. For many of these studies, the focus was on finding the most rare plants in a limited amount of time. This was often achieved by surveying only the highest probability rare plant habitats while ignoring the intervening ground. Conversely, impact assessment rare plant studies are more concerned with adequately covering the entire project area, with the goal of locating all rare plants present. This means that impact assessment surveys must also search medium and lower probability rare plant habitat.

Of the 42 documents reviewed for this section, 25 contained information sufficient to determine the survey pattern used. None of the studies appeared to use an Intuitive Controlled search pattern. However, 19, (or 76%), used a Targeted pattern, surveying only those areas with the best chance of containing rare plant populations. Three studies (12%) used a Selected Sites method, surveying a representative sampling of lower probability habitats also. The Random Meander pattern was used in two of the studies (8%), and one study (4%) used vegetation plots.

Table 3-4: References Used to Determine Other Study Methods

Reference	*Document Type*	*Subject*
Achuff & Shassberger 1992	Tech. Report	Botanical Survey
Andreas 1986	Tech. Report	Botanical Survey
Anonymous 1994	Tech. Report	Botanical Survey
Anonymous 1978	Tech. Report	Rare Plant Survey
Averett 1981	Guideline	Species Diversity Measurement
Benninghoff 1966	Guideline	Vegetation Surveys
Blewett 1986	Tech. Report	Veg. & Rare Plant Survey
Brakenhielm & Qinghong 1995	Guideline	Vegetation Surveys
Cain 1938	Guideline	Vegetation Survey
Gon & Chun 1992	Tech. Report	Rare Species Survey
Griggs 1914	Tech. Report	Botanical Survey
Gruber *et al.* 1979	Tech. Report	Rare Plant Survey
Heidel 1994a	Tech. Report	Rare Plant Survey
Heidel 1994b	Tech. Report	Rare Plant Survey
Heidel & Dueholm 1994	Tech. Report	Rare Plant Survey
Heidel & Marriott 1996	Tech. Report	Rare Plant Survey
Heidel & Vanderhorst 1996	Tech. Report	Rare Plant Survey
Johnson 1991	Tech. Report	Rare Plant Survey
Judziewicz 1983	Tech. Report	Rare Plant Survey
Lesica & Vanderhorst 1995	Tech. Report	Rare Plant Survey
MacDonald 1996	Tech. Report	Botanical Survey
Moseley & Bernatas 1991	Tech. Report	Botanical Survey

Reference	*Document Type*	*Subject*
Myers & Shelton 1980	Guideline	Ecosystem Surveys
Newbold *et al.* 1988	Tech. Report	Rare Plant & Botanical Survey
Ode 1990	Tech. Report	Rare Plant Survey
Poole & Heidel 1993	Tech. Report	Rare Plant Survey
Randall 1978	Guideline	Vegetation Surveys
Richardson 1979	Tech. Report	Veg. & Rare Plant Survey
Shassberger & Shelly 1990	Tech. Report	Rare Plant Survey
Smith & York 1984	Tech. Report	Rare Plant Survey
Spellenberg 1976	Tech. Report	Rare Plant Survey
Synge 1980	Guideline	Rare Plant Surveys
Vanderhorst 1997	Tech. Report	Rare Plant Survey
Vanderhorst 1995a	Tech. Report	Rare Plant Survey
Vanderhorst 1995b	Tech. Report	Rare Plant Survey
Vanderhorst 1994a	Tech. Report	Rare Plant Survey
Vanderhorst 1994b	Tech. Report	Rare Plant Survey
Vanderhorst 1994c	Tech. Report	Rare Plant Survey
Vanderhorst 1994d	Tech. Report	Rare Plant Survey
Vanderhorst 1993	Tech. Report	Rare Plant Survey
Vanderhorst & Lesica 1994	Tech. Report	Rare Plant Survey
Ward 1978	Guideline	Impact Studies

CHAPTER 4: DISCUSSION

4.1 ANALYSIS OF METHODS

4.1.1 Limitations

Certain limitations on the conclusions reached by this analysis must be acknowledged. Firstly, because much of the analysis is based on the review of technical reports, the accuracy of the conclusions reached necessarily depends on the completeness of the information contained in those reports. Regarding methods in particular, many of the reports were found to contain little descriptive information; and the information that was presented was often ambiguously worded and vague. Although every effort was made to extract accurate information from these reports, instances undoubtedly occurred where the methods which were perceived from a reading of the technical report, were not those that were actually used. However, these instances were kept to a minimum by attempting to choose only those report sections for inclusion in the analysis which provided clear statements on methods.

Lack of available documentation also hindered the evaluation of certain components. In particular, government regulatory requirements were difficult to determine owing to a lack of direct government regulatory guidance concerning impact assessment rare plant studies. The evaluation of government requirements was accomplished primarily through indirect methods, such as reviewing technical reports which had been accepted in the past. Although this evaluation method is less desirable than reviewing direct government guidelines, it would still reasonably be expected to produce credible results. Similarly, the limited amount of scientific research into rare plant survey methodologies meant that the scientific requirements analysis was necessarily restricted. The analysis of scientific requirements was enhanced, however, by employing some basic scientific principles, not directly related to impact assessment rare plant studies, in the evaluation (see following sections).

Care should also be taken when deriving recommended methods from an analysis of current methods and requirements. It does not necessarily follow that simply because a technique is in widespread use, and has been accepted by government agencies in the past, it should continue to be used in the future. The present research, in attempting to analyse methodologies from a scientific, as well as regulatory, viewpoint, strives to reduce this current methods bias in favour of a more critical approach. It must be remembered, however, that, as mentioned above, scientific requirements for these rare plant surveys are not always clear, and this may bias the conclusions toward an acceptance of current methods.

The large geographic and political scope of this analysis, while helpful in developing the widely applicable guidelines presented in Chapter 5, also limits the specificity of the conclusions which can be reached. Many political jurisdictions claim authority over rare species protection, and each has different procedures and processes. In some cases, due to the variety of different documents analysed, generalisations had to be made regarding the methods used. It should be remembered that correct survey methods must always be tailored to the particular jurisdiction, geographic region, and project site being evaluated. In certain instances, this may require a departure from the recommended methods presented in this research.

4.1.2 Investigator Qualifications

Investigator qualifications were difficult to determine for all three of the areas analysed, (currently used methods, government regulations, and scientific requirements). None of the reviewed technical reports provided any information about the qualifications of the surveyors who performed the studies. Investigator qualifications for the currently used methods section had to be determined solely on the basis of solicitation documents from the US. It is assumed that the work requested in the solicitation documents was carried out by investigators who possessed the qualifications specified in these documents, but that may not necessarily always be the case. It must be remembered that solicitation documents give an indirect indication of currently used methods only.

In general, it would appear that most impact assessment rare plant studies are currently being performed under the direction of individuals with at least a Bachelor's degree in botany or a related subject. In addition, these individuals possess a certain amount of experience performing botanical studies in the region. At the field crew level, surveyors usually possess some amount of college training in botany. In addition, field surveyors typically have some experience with botanical surveys in the region, although less than the principal investigator.

Government requirements for investigator qualifications in these studies are easier to determine. Solicitation documents and government produced guidelines provide specific requirements. For the principal investigator, some level of college botanical training is usually required/recommended. The minimum is typically a Bachelor's degree in botany or a related field, but the guidelines are less specific on this point. In addition, field experience performing botanical surveys in the region is required/recommended. The level of experience ranges from three months to two years. For the field survey crew members, typically some level of college botanical training is required/recommended, and from three months to one year's regional botanical survey experience.

Scientific requirements for investigator qualifications were based on only a few published guidelines. These qualifications were similar to those stated in the preceding paragraphs and typically involved a combination of college coursework and regional field experience. The scientific requirements, however, could be inferred to place a heavier emphasis on college based coursework.

In summary, then, there appears to be a close correlation between currently used methods, government requirements, and scientific requirements, with respect to investigator qualifications for rare plant surveys. This is not surprising given that the government requirements for these studies are often developed by scientists working within the agencies, who draw on their scientific training when specifying investigator qualifications. In turn, project proponents, whose ultimate goal is to gain regulatory approval, use consultants with the required qualifications. Although these qualifications would be expected to vary somewhat from jurisdiction to jurisdiction, their basic components likely remain similar.

4.1.3 Literature Review Methods

Literature review methods were also similar for the three sections analysed. Most of the information on literature review methods was presented as lists of references that had been consulted, (or were recommended for consultation). This provided for basic level comparisons between the three sections.

Aerial photographs and topographic maps were mentioned as sources most commonly across the range of documents reviewed. Academic literature (including floral keys), and personal communications with botanists, regulators, and other knowledgeable individuals were also frequently mentioned in many of the documents. Less frequently mentioned, but still common were technical reports from previous studies in the area, Natural Heritage Program/Conservation Data Centre database queries, soil maps, geologic maps, and herbarium visits. This similarity across all of the documents reviewed, suggests that currently used literature review methods are in line with government and scientific requirements.

The frequency with which these various resources are consulted should not be construed to reflect their value to the prefield review process. In many cases, it is more an indication of the availability of the particular resource, than it is an indication of the resource's usefulness. For example, topographic maps are available for most project areas, and therefore are used in the majority of literature reviews. Conversely, cover type maps, which arguably are of greater use to the prefield review process, are rarely used, because accurate cover type maps are seldom available. The various literature review resources identified from this research, then, should constitute simply an unweighted list of resources to be consulted where available.

In addition to those listed in the reviewed references, additional resources may be helpful during the literature review process. These include; satellite imagery of the project area, climate data for the project vicinity, land use maps, and any other information resources which help to characterise existing or past conditions in the project area. All available relevant resources should be consulted to ensure that a thorough prefield review has been performed.

4.1.4 Target Species Selection

For all three sections, (currently used methods, government requirements, and scientific requirements), the most frequent method by far of target species selection was to rely on government produced lists. This is not surprising, as the ultimate goal of most impact assessment rare plant studies is to gain government regulatory approval. It stands to reason that most studies, then, would rely on government lists for target species selection. In addition, several studies reported that the investigators clarified government lists by contacting agency officials directly, to inquire about specific concerns.

Many of the studies also used lists produced by the appropriate Natural Heritage Program/Conservation Data Centre. Because these lists are reviewed and revised every one to two years, they often reflect current conditions more accurately than government lists, which typically have a longer and more involved revision process. It should also be noted that some of the studies that were reviewed were conducted prior to the establishment of Natural Heritage Program/Conservation Data Centres in the State or Province that the study occurred in. For these studies, this resource would not have been an option, and other methods of target species selection would have been relied on.

Less commonly used, (or recommended), for target species selection were reviews of previous studies, and visits to herbaria. While not directly leading to a determination of which species have protected status, these resources served to assist in determining which listed species may be present in the project area.

As is indicated by these results, it is of primary importance to address those species on the appropriate government list(s). In many cases, it is also, equally important to address those species of concern to the agency or regulatory tribunal which will be determining the adequacy of the study. This is the case even if the species of concern are not formally listed.

4.1.5 Potential Habitat Prediction

The methods used, or recommended for use, to predict potential rare plant habitat within the project area primarily involve comparing known habitat preferences of the target species, to existing habitats within the project area. Species habitat preferences are usually determined, to the extent possible, based on information gained in the literature review. The resources used to remotely determine the habitat types within the project area, and their locations, are addressed in this section.

The most commonly used and recommended resources were topographic maps and aerial photos. Topographic maps can point out the locations of unique features, and preferred slope/aspect combinations. Aerial photos, when analysed by a skilled interpreter, can reveal unique features and plant community types. However, both these resources give only limited information about potential rare species habitat when compared to cover type maps. Cover type maps, if accurately produced, provide much of the habitat information needed to correlate species habitat preference with specific locations in the project area. These maps, however, are not available for most projects, and their infrequent use in impact assessment rare plant studies is likely a reflection of this fact. Additional resources either used, or recommended for use, include soil maps, geologic maps, and land use maps.

Other direct methods were also recommended, and occasionally used, to determine the location of potential rare plant habitat. Maps of existing rare plant populations within the project area can provide a strong indication of suitable habitat locations. Because similar habitat types are often found clustered together, as are rare plant populations, habitat in proximity to known populations will often be a good candidate for the discovery of additional populations. The fact that this method was used in only a few of the studies is likely not a reflection of its usefulness, but rather a function of the lack of known rare plant sites in most project areas.

As with the literature review methods, the use of a particular resource for potential habitat prediction is limited primarily by availability. Simply because aerial photos were consulted much more often than cover type maps, it should not be concluded that aerial photos provide more useful information. All available potential habitat prediction resources should be consulted where available.

4.1.6 Survey Timing

The analysis of all three sections, (currently used methods, government regulations, and scientific requirements), showed consistency with regards to survey timing. In all cases where survey timing was mentioned, it was stressed that surveys must be performed during the time(s) of the year when the target species are identifiable. While this may appear obvious, situations do arise where consultants are called upon to perform rare plant surveys during seasons when one or more of the target rare plant species are not identifiable. Surveys performed at these times may be useful for identifying potential rare plant habitat, and identifying sites for later survey, but the resultant technical report must explicitly acknowledge the limitations.

It is also important to note that the surveys must be performed when all of the target species are identifiable. As mentioned in previous sections, this may mean that certain areas must be surveyed more than once. Again, if surveys are only undertaken when a portion of the target species can be found, the technical report must explicitly acknowledge the limitations of the survey.

4.1.7 Survey Pattern

Currently Used Methods: The Intuitive Controlled survey pattern appears to be the primary search method in use currently for impact assessment studies. Because this method is a variable intensity pattern, meaning that the higher potential habitats are surveyed more intensively than the lower potential habitats, the method can be efficient at locating the majority of rare plant populations in a given area. Essentially, this pattern combines intensive coverage of the unique habitats, with more general coverage of the lower probability areas. The fact that this pattern strives to cover all habitats and the entire geographic scope of the project area at some level, makes it particularly suited to these studies.

The Intuitive Controlled pattern works well when combined with the Targeted pattern. The Intuitive Controlled pattern can be used for the first survey through the project area, while the Targeted pattern can be used for subsequent surveys, where only coverage of specific habitats is needed. The Targeted pattern was used for some of the studies reviewed for the current methods section. In each case, the Targeted pattern was used in conjunction with other survey patterns.

The Selected Sites pattern was also used in several cases. Typically, this method was used to survey project areas which were considered too large to warrant an Intuitive Controlled, or other full coverage survey pattern. Vegetation Plots were also used in several of the rare plant technical reports reviewed. This method, although similar in many aspects to the Selected Sites pattern, provides less complete coverage of the project area, due to the small size of the plots. In addition, extra time is often spent characterising vegetation within the plots, which reduces coverage even further.

The Complete and Cursory patterns represent opposite ends of the coverage spectrum. They were used, (or recommended for use), in several cases, but always in conjunction with other patterns. Likewise, the Random Meander and Regular Transect patterns were used, but only in a few of the reviewed documents.

Government Requirements: The Intuitive Controlled pattern, (often combined with subsequent Targeted searches), appears to be the primary method which satisfies government requirements, (at least in the US). Here, however, a distinction arises between US and Canadian requirements. Although there are exceptions, the Intuitive Controlled/Targeted pattern was primarily required for use in the US. In Canada other, sub-sampling methods, such as Selected Sites and Vegetation Plots, appeared to be accepted by government regulators. Six of the seven documents reviewed for government requirements which mentioned the Selected Sites or Vegetation Plots method were from

Canada, while 27 of the 28 documents which mentioned Intuitive Controlled or Targeted patterns were from the US.

Where government regulations in a jurisdiction require that the impact assessment address effects on all of the rare plant populations within the project area, the Selected Sites or Vegetation Plots methods would not appear to satisfy these requirements. Depending on the percentage of ground sampled, the Selected Sites method would not be expected to locate more than half of the populations within the project area; and the Vegetation Plots method would be expected to locate even less. However, in jurisdictions where only a general characterisation of rare plant conditions is required, the Selected Sites method could give a representative sampling of the rare plant populations present, provided that a significant portion of the project area is sampled. The Vegetation Plots method, however, would not appear to satisfy even this requirement. Because of the typically small plot size, and concentration of effort on dominant plant species, vegetation characterisation methods would not be expected to locate a representative portion of the rare plant populations, unless the plot size and density was increased to the point where it resembled the Selected Sites method.

It must be remembered, however, that in jurisdictions where a nearly complete picture of the rare plant populations is required, neither the Selected Sites or Vegetation Plots methods are sufficient. For these projects, a pattern which strives to search all high probability habitats, as well as a representative proportion of low probability habitats, would be the minimum requirement. The Intuitive Controlled pattern, (perhaps in conjunction with later Targeted surveys), the Complete pattern, or perhaps the Timed Meander pattern are the only methods that satisfy this requirement.

<u>Scientific Requirements</u>: As noted previously, scientific requirements were difficult to determine. The few scientific papers that did address impact assessment rare plant surveys stressed that the surveys had to be floristic in nature rather than vegetative. That would preclude the use of vegetation plots for rare plant surveys, a practice that appears to be rarely used in the US, but more common in Canada. Using simple probability analysis, the inadequacy of vegetation plots for rare plant surveys can be shown.

Assuming a project area size of 1,000 hectares, and the random placement of 100 twenty-by-twenty metre vegetation plots, approximately 0.4% of the ground surface is surveyed. Further, assuming that a particular rare plant species is represented within the 1,000 hectare project area by one 100-by-100 metre population, then one plot would have a 0.2% chance of intersecting that population. All 100 plots would have only an 18% chance of locating that population. Even though plot placement which over-represents unique habitats may increase this probability slightly, it is still clear that vegetation surveys will typically not locate most of the rare plant populations within a project area, unless the number of plots used is extremely large.

The Selected Sites pattern has similar limitations because it typically ignores certain areas with potential for rare plants. However, in situations where the project area is large, and government regulations do not require an analysis which takes into account all, or even most, of the rare plant populations within the project area, the Selected Sites method is more desirable than the Vegetation Plots method. Because the Selected Sites method covers a larger area of ground per unit of time than the Vegetation Plots method, the chances for locating a particular rare plant population are increased. However, where the Selected Sites method is used, it is important that the technical report specifically note the limitations.

It should also be remembered that none of the survey methods described here ensures that all the rare plant populations will be located. Even the most complete survey has the potential to overlook some species. A thorough rare plant survey can only confirm the presence of rare species within a project area, and reduce, to a low level, the probability that undetected rare plant populations exist (Lancaster 1997).

<u>Comparison to Other Study Types</u>: When comparing the survey patterns most used, (and recommended), for impact assessment rare plant studies with other types of botanical studies, significant differences become apparent. The Intuitive Controlled survey pattern, which is so prevalently used for impact assessment rare plant surveys, is rarely used for other types of botanical studies. This is likely a reflection of the differing goals that impact assessment studies have in relation to other types of botanical studies. The goal of

most impact assessment rare plant surveys is to locate all of the rare plant populations within a given project area. The Intuitive Controlled method is uniquely suited to this task, (although, as noted earlier, no method can provide 100% assurance that all populations have been located). Conversely, non-impact assessment rare plant surveys are typically more concerned with locating the most number of rare plant populations in the shortest amount of time. Full coverage of a particular area is not necessarily a goal. For these types of surveys, the Targeted method, with its focus on only the high probability habitats, produces better results. Vegetation studies, which focus on characterising the plant communities in a given area are best served by the Vegetation Plots method.

4.1.8 Documentation Content

The level of documentation in the technical reports reviewed varied widely, especially with regard to methods. Some of the reports provided copious detail on the methods used, while others supplied little information. In some cases, no description of methods was presented. Generally, methods descriptions for most of the reports appeared to be insufficient to allow reviewers to assess the adequacy of the study. The documents typically provided more detail regarding the results of the studies, but this factor too, varied greatly from report to report.

From a government regulatory perspective, the documentation needs to provide sufficient detail to allow regulators to both determine the adequacy of the study, and determine the likely impacts that the project will have on rare plant resources. Simply knowing the results of a study is not sufficient unless the accuracy of those results is also known. In addition, from a regulatory perspective, the data has to be in a format that allows scientists and non-scientists alike easy access to the information. This may require stating certain passages twice, in both scientific and non-scientific terms.

From a scientific perspective, copious documentation of both methods and results is important. In addition, providing the raw data, perhaps in appendices, can make the evaluation process for scientific reviewers much easier. In addition, providing raw data (*e.g.*, species lists, survey routes, survey dates, etc.), allows for later analysis in ways not originally conceived. This can be important if the regulatory or project conditions under which the study was originally conducted change, (*e.g.*, change in the listing status of a particular species, change in the proposed placement of a certain project facility, etc.).

4.2 OTHER FACTORS

4.2.1 Differences Between US and Canadian Methods

As mentioned above, differences exist between the impact assessment rare plant survey methods used in the US, and those used in Canada. Methods which sample only portions of the project area, such as the Selected Sites method and the Vegetation Plots method, are used and accepted in Canada. In contrast, US methods tend to cover a larger percentage of the project area at a higher level of intensity, such as with the Intuitive Controlled method. There are several possible reasons for this difference. The first lies in the differences between the rare species protective legislation in the two countries. The US has had, what is regarded as the world's strongest endangered species legislation since 1973 (Flather *et al.* 1994). Canada has no comparable legislation at either the federal or provincial levels. Although Canadian legislation does provide for the consideration of rare plant effects in the impact assessment process, the impetus for detailed, (and costly), rare plant surveys of a proposed project area is generally not as strong as in the US. This factor would explain at least some of the discrepancy between US and Canadian methods.

Another factor may be the difference in the total number of studies performed under each jurisdiction. Because the US has had more projects which require impact assessment rare plant surveys, the process of settling on a standardised methodology for these studies may be farther along in the US than it is in Canada. This, however, would imply that Canadian methodologies will eventually converge to resemble those used in the US. This may not be the case, though, due to the differing regulatory structures in the two counties.

Finally, the size of the Canadian projects for which rare plant studies are performed is typically larger than those in the US. In addition to Canada's larger geographic extent, the country's environmental legislation only requires rare plant studies for relatively large projects. Because larger project areas are more difficult, and costly, to survey completely, Canadian methods may have naturally evolved toward more use of selective sampling techniques than the US.

4.2.2 Regulatory Considerations on Rarity

As noted in Chapter 1, rarity is a function of scale. Any species may appear to be rare if viewed within a sufficiently limited geographic scope. However, it is important for regulatory agencies, and consultants to put these different levels of rarity into perspective. Globally rare species, (*i.e.*, species which have low abundances when viewed on a global scale), should be treated more carefully than locally rare species, (*i.e.*, species which have low abundances when viewed on a more limited scale, such as provincially, but are common when viewed globally). In some jurisdictions, this difference is not stressed, with the result that all rare species are given the same weighting in the regulatory process.

This, however, should not be taken to imply that the protection of locally rare species is unimportant in maintaining biodiversity. For example, disjunct populations often contain genotypes which vary significantly from those found in populations closer to the main central range of the species. In these cases, the disjunct populations may be undergoing the first stages of speciation due to reproductive isolation. From this standpoint, it is important to preserve representative portions of the disjunct populations, in order to preserve the genetic range of the species. The need for preservation is less clear in cases where a few populations, (or individuals), have been cut off from the central contiguous range of the species by a political boundary, (as is the case with *Iris missouriensis* described in Chapter 1). In these situations, the reduction or extirpation of that species from the particular political jurisdiction, such as a province or state, would not likely result in a significant impact to the species globally. However, it would, most likely reduce the biodiversity in the area of the reduction or extirpation, which might reduce the functioning of the ecosystem. In global terms though, this is less of an impact than the extinction of a species across its entire range, as might be the case with impacts to globally rare species.

CHAPTER 5: RECOMMENDATIONS

5.1 PROPOSED GUIDELINES

The following guidelines are based on the analyses presented earlier in this work. They are intended to be applicable throughout North America, across a variety of jurisdictions and geographic regions. Rare plant studies performed to the specifications set out in these guidelines would be expected to meet the requirements of both the scientific community and government regulatory agencies. Although specifically designed for impact assessment rare plant studies, portions of these guidelines may also apply to other types of studies, (*e.g.*, noxious weed surveys). The guidelines contain certain descriptions and figures which are similar to others in previous chapters of this work. This was necessary to ensure that the guidelines could be understood on their own, without the need for extensive background reading.

It should be noted that each project situation is unique, and methods should be determined on a case-by-case basis. There may be instances where it is necessary to deviate from the specifications presented in these guidelines. For example, highly competent investigators are occasionally found who do not possess the minimum qualifications as set out in these guidelines, (especially with regard to college training). In these cases, it would be reasonable to allow such individuals to perform work on rare plant studies in spite of their non-conformance to the qualification requirements.

5.1.1 Investigator Qualifications

Impact assessment rare plant studies should be under the direction of a principal investigator who guides the prefield review, field survey, and documentation phases of the study. The principal investigator should possess, at a minimum, the following qualifications:

1. A bachelor's degree in botany or a related natural science subject. Coursework should include plant taxonomy, and, at a minimum, classes in two of the three

following subjects; biogeography, field ecology, and/or geographic information systems.

2. One year of field experience in the project area region performing impact assessment rare plant surveys, or general floristic surveys.

3. Demonstrated skills writing technical reports and compliance documentation at the appropriate regulatory level.

Field survey crew members should possess the following minimum requirements:

1. Two years of college level botanical training including a course in plant taxonomy. Additional coursework should include one of the following three subjects; biogeography, field ecology, and/or field study methods.

2. Six months of field experience in the project area region performing impact assessment rare plant studies, or general floristic surveys.

3. Demonstrated skills in map reading and orienteering.

4. Demonstrated physical capability to perform field work in remote areas.

5.1.2 Literature Review Methods

It is important that all available relevant literature review sources be investigated thoroughly, prior to commencing field work. This includes unpublished works, personal communications with agency and scientific experts, and Internet resources, in addition to traditionally published sources. The following resources, when available, should be consulted. Note that this list is not exhaustive, and any additional relevant resources not listed here should also be reviewed where possible:

- Aerial photographs: used to determine plant community types, terrain, and travel logistics within the project area.

- Topographic maps: used to determine potential habitat locations, travel routes, and topography within the project area.
- Academic literature (including floral keys): used to determine species presence within the project area, answer individual taxonomic questions, and determine global or regional distributions and listing status for particular taxa.
- Personal communications with botanists, regulators, and other knowledgeable individuals: used to gain information on a wide variety of factors, including species habitat preferences, taxonomic issues, regulatory approval, and project area access.
- Technical reports from previous studies in the area: used to gain information on various aspects of the project area, including common and rare species presence, habitat features presence, and other relevant information.
- Natural Heritage Program/Conservation Data Centre database queries: used to determine information on known rare plant populations in the project vicinity, and derive target species lists for the project area. Database records are also used to gain information on species habitat preferences.
- Geologic maps: used to determine potential rare plant habitats within the project area.
- Soil maps: also used to determine potential rare plant habitats.
- Herbarium visits: used to develop search images, and confirm identifications of suspected rare species.
- Satellite imagery: used to determine access routes, locations of large scale unique features, and gross plant community types (*e.g.*, forested vs. non-forested types).
- Climate data: used to predict habitat parameters and species preferences.

- Land-use maps: used to locate potential rare plant habitats.
- Cover type maps: also used to locate potential rare plant habitats.

5.1.3 Target Species Selection

In most cases, the target species for a given study should be based on the government rare plant lists from the appropriate jurisdictions which are regulating the project. It is important to incorporate all lists which apply to the project area. These may include, but are not limited to, federal lists, state or provincial lists, and agency lists (US Forest Service, US Bureau of Land Management, etc.). Questions about which rare species lists apply to a given project should be resolved through personal communications with regulatory personnel if possible.

Once a preliminary target species list has been compiled from the appropriate government list(s), additional species should be added, if necessary. Target species should include all taxa of concern to the regulating agency, whether the species is listed or not. Personal communications with regulatory personnel, potential intervenors, and stakeholders can help to identify unlisted species which may be of concern.

The Natural Heritage Programs and Conservation Data Centres are also useful resources for target species selection. The lists produced by these organisations can help determine the degree of rarity and threat for the species of concern.

5.1.4 Potential Habitat Prediction

Once all prefield information has been gathered and reviewed, a list of rare plant species with potential for occurrence within the project area should be produced. This list should include a description of the preferred habitats for each species, and the times they are typically identifiable in the field.

The information from this list, in conjunction with project maps, should then be used to tentatively identify the location of habitats within the project area which contain potential for occurrence of each species. Cover type maps, soil maps, aerial photos, topographic maps, and other resources should be used, when available, to assist in identifying potential habitat locations. These areas of potential habitat should be mapped onto project maps for use during the field work.

In addition, the location of known rare plant populations, if any, should be transferred onto this potential habitat map. The areas surrounding these known locations should also be considered potential habitat, and should be searched intensively during the field survey. It must be remembered that prefield potential habitat prediction methods have their limitations. It is likely that additional potential habitat will be located once the field work begins.

5.1.5 Survey Timing

All field surveys should take place at the time(s) of the year when the target species are identifiable. In many cases, this will require more than one survey of a particular area. At the beginning of any field work, the general phenology of the flora in the project area should be assessed to ensure that survey timing is adequate. Year-to-year variations must also be taken into account, as the identification time period of certain plants can vary considerably from one year to the next.

Immediately prior to the systematic search of the project area, known rare plant populations, (if any), in the project vicinity should be visited. This serves to confirm assumptions made about the phenologic stage of these particular species. In addition, it helps the investigator(s) to develop a search image for these species, reducing the chances that target species within the project area will be overlooked during the survey.

5.1.6 Survey Patterns

Floristic surveys, (*i.e.*, those surveys which strive to locate and identify all species in a given area), should be used for impact assessment rare plant studies. Vegetation surveys, which focus on characterising plant communities, are not appropriate for these studies.

The survey pattern to be used depends on the parameters of the proposed project. In the majority of cases, the Intuitive Controlled pattern is the most appropriate, and should be used unless compelling reasons can be found to employ an alternate pattern. When there is doubt about which survey pattern is appropriate, the Intuitive Controlled pattern should be used as a default.

For an Intuitive Controlled survey, the investigator walks the project area following a route designed to locate all high probability rare plant habitats present. The exact pattern is determined by the surveyor, usually in the field, and can range from evenly spaced transects, to irregular meanders following the contours of the land. The surveyor must take care to ensure that the route travelled covers all parts of the project area, (except for cultivated fields and developed land with no potential for rare plants), at a level of intensity sufficient to locate all high probability habitats. For areas with dense vegetation which limits sight distance, the survey pattern will be necessarily tighter than in open vegetation where the view is less obstructed. When high probability habitats, (which include all unique features), are encountered, the habitats are searched intensively at nearly the Complete level. This may entail walking a tight grid of transects across the habitat, or more random methods may be used. However, the pattern must ensure, (to the extent possible), that any rare plant populations in that habitat will be located. Once the intensive search of that habitat is complete, the surveyor continues on through the project area, until additional high probability habitat is encountered. In this way, all high probability habitats are intensively searched, and, in locating these areas, a representative portion of the lower probability habitats are also surveyed.

The investigator is constantly searching for rare plant species in all habitats with this method. A species list of all plants encountered within the project area should be kept. The investigator should also mark the survey routes on detailed project area maps, or aerial photos. In addition, the locations of high probability habitats and unique features should be recorded on the maps or photos. Depending on the objectives of the study, information may also be recorded on general vegetation types, topography, current weather, and any other parameters relevant to the analysis. However, the amount of information recorded in the field should only be that which is necessary to achieve the goals of the study. It must be remembered that time spent recording data in the field reduces the time spent actually searching the area for rare plants. However, at a minimum, a comprehensive species list should be kept, the survey routes and high probability habitats/unique features should be mapped, and copious documentation should be recorded for any rare plant populations found (see Section 5.1.7 below for rare plant site documentation methods).

For subsequent surveys of a study area following an Intuitive Controlled search, the Targeted search pattern may be used. Because the first survey presumably maps the locations of all rare plant habitat within the project area, subsequent searches can focus directly on those potential habitats. The Targeted pattern is specifically designed to intensively search particular selected habitats, while ignoring other areas. The surveyor enters the project area, and proceeds directly to the targeted habitat, (not necessarily searching for rare plants on the way there). The targeted habitat is searched intensively in a similar manner to that described for the intensive search portion of the Intuitive Controlled pattern. When the habitat has been surveyed sufficiently, the investigator moves on to other targeted habitats. A comprehensive species list should be kept, and the survey routes should be mapped. In addition, any rare plant populations found should be documented as outlined below in Section 5.1.7 below.

As mentioned previously, the Intuitive Controlled method, (possibly coupled with the Targeted method for subsequent searches), should be used in the majority of project situations. This method is appropriate for all project area shapes and sizes, although other patterns may be used as an alternative to Intuitive Controlled for extremely small or extremely large project areas.

For extremely small project areas, (*i.e.*, polygon areas less than one hectare, or linear areas less than one kilometre), the Complete pattern may be used. This pattern involves searching the entire project area at the 100% coverage level. Theoretically, every square centimetre of ground should be searched, and every plant should be identified.

For extremely large project areas, (*i.e.*, polygon areas greater than 10,000 hectares, or linear areas longer than 200 kilometres), where regulatory agencies do not require that the impact assessment address all of the rare plant populations within the project area, the Selected Sites method may be used. The Selected Sites method surveys only particular portions of the project area and ignores others. During the prefield review, a survey plan is drawn up which specifies the areas to be surveyed. These surveyed sections should include all habitat types found within the project area, although high potential rare plant habitat should be over-represented. The investigator surveys only those sections identified in the prefield review, at an intensity level designed to find all rare plants present in that section. Other areas with potential for rare plant species are ignored. A comprehensive species list should be kept, survey routes and high probability habitats should be mapped, and rare plant populations should be documented to the standards set out in Section 5.1.7 below. It must be stressed that the Selected Sites method is only appropriate where regulatory agencies do not require that all rare plant populations within the project area be considered in the impact assessment. This method will typically not find more than 75% of the rare plant populations present.

Table 5-1 presents a matrix which should be used in the selection of an appropriate survey pattern. Additionally, Table 5-2 on page 84 summarises several project area parameters which modify aspects of the survey pattern. Figure 5-1 on page 84 shows a graphic representation of the four survey patterns described in these guidelines.

Table 5-1: Survey Pattern Selection Matrix

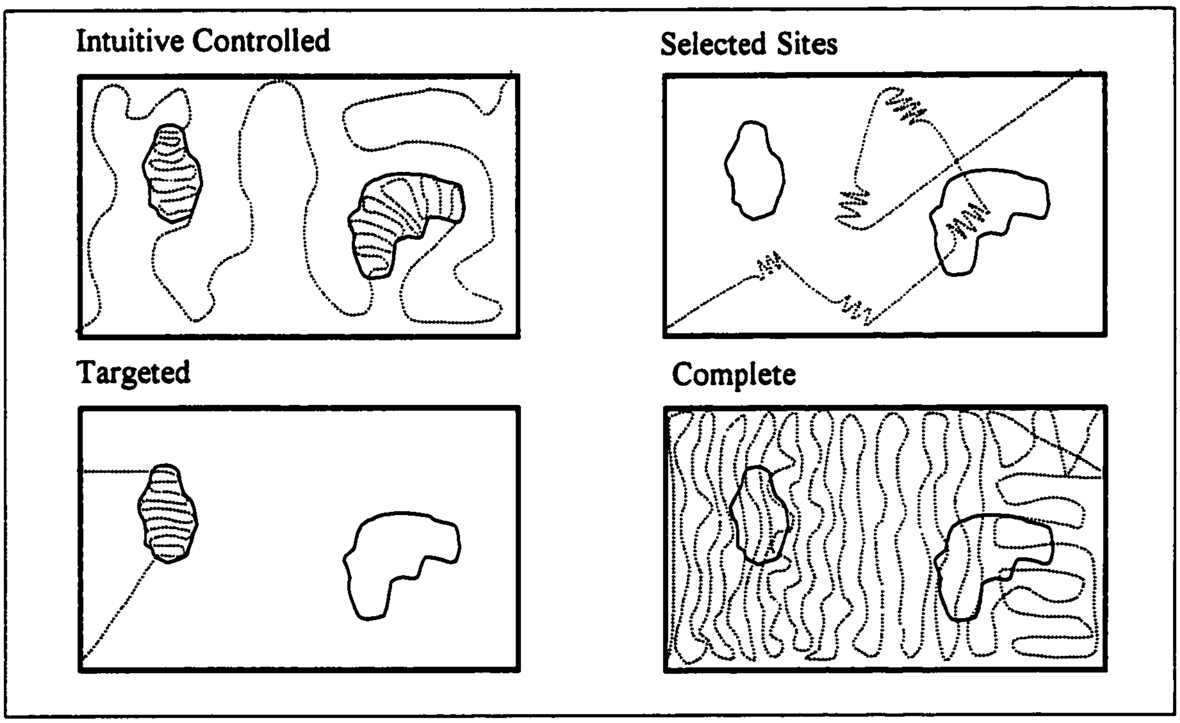
Project Area Size/Shape→ ↓	*Linear*	*Polygon*	*Series of Points*
Small (<1 ha, or 1 km)	IC or Complete	IC or Complete	IC or Complete
Medium	IC	IC	IC or Complete
Large (>10K ha, or 200 km)	IC or SS	IC or SS	N/A

IC = Intuitive Controlled (w/Targeted for subsequent searches); SS = Selected Sites

Table 5-2: Survey Pattern Modifiers

Modifier	*Effect*
Physiography	Regularly spaced transects can be used on relatively level, flat terrain. Conversely, in mountainous or dissected terrain, transect routes typically must follow contours.
Project Area Vegetation	Dense vegetation necessitates a tighter search pattern. Open vegetation allows for greater spacing between passes.
Target Species Visibility	Inconspicuous target species necessitate a tighter search pattern. Highly visible target species allow for greater spacing between passes.

Figure 5-1: Survey Patterns



(Rectangles represent project area; Irregular polygons represent unique habitats)
Based on US Forest Service 1995d

5.1.7 Documentation Content

When rare plant populations are found, they should be documented as follows:

- The appropriate Natural Heritage Program/Conservation Data Centre element occurrence data form should be filled out. In addition to complete population and habitat information, this should include detailed directions which would enable relocation of the population.

- The location of the population should be mapped on a map or aerial photograph at the most detailed scale available.

- The longitude and latitude, or UTM co-ordinates of the population should be determined using a GPS unit. This information should be recorded on the element occurrence data form.

- A permanent metal tag with an identifying number should be affixed to a metal stake or length of rebar driven into the ground within or near the population. Alternately, the tag may be affixed to a nearby tree. The relocation directions should describe the position of the metal tag also.

- At least four photos should be taken of the population. Two photos should be taken of the individual rare plants, and two of the surrounding habitat.

- If additional assistance is needed to relocate the site, the perimeter of the population may be flagged with surveyors tape.

- Voucher rare plant specimens should not be collected in the majority of cases. If collection is necessary for verification, the smallest amount of plant material that will confirm identification should be taken, and then, only if the collected amount represents no more than five percent of the total population. Under no circumstances should any collection take place from populations numbering less than 20 individuals.

Rare plant study technical reports should contain the following elements:

- Title Page: The title page should include the name of the project, the consultant's company name, the author(s)' name, and the client company name. If exact rare plant locations are provided in the report, the title page should clearly state that the information contained in the report is confidential and not for public distribution.

- Table of Contents; Table of Figures; List of Tables; and List of Appendices: These should be listed with page numbers for easy reference.

- Glossary: The glossary should define all technical terms, project specific terms, and acronyms.

- Executive Summary: The executive summary should be written so that the important points of the document can be gained without reading the entire report.

- Introduction Section: This section should contain a description of the steps which led to the need for the impact assessment rare plant study. The introduction section should also contain the following subheadings: **Project Description** (a detailed description of the proposed project, the type of impacts expected, their duration, and other relevant project features); **Location** (a precise description of the project area location, using both descriptive text and maps); **Physiography and Substrate** (a description of the terrain, geology, and soils generally present in the project vicinity); **Climate** (a description of the general climate of the project vicinity); **General Vegetation** (a description of the general vegetation in the project area); and **Land Use** (a description of local land use patterns in the project area).

- Methods Section: This section should contain a detailed and complete description of all techniques and procedures used to conduct the study. The methods section should be detailed enough to allow the reader to assess the adequacy and completeness of the study. The following two subsections should be contained:

Prefield Review (a description of the sources consulted for the literature review, the methods used to determine target species, and the techniques employed to predict potential habitat within the project area); and **Field Survey** (describing exactly what survey techniques were used, the routes the surveyors walked, how many investigators took part in the surveys, when they were out in the field, how they travelled, what species they searched for, what data was recorded, and any other information that allows the reader to evaluate the survey methods).

- Results Section: The results should be presented in a variety of formats ranging from raw data included in the appendices, to summary tables presented throughout the results section. In addition, detailed narrative descriptions should be used to present the results. The following two subsections should be included: **Prefield Review** (describing the results of the literature review, the list of target species selected, and the results of the potential habitat prediction work); and **Field Survey** (describing the rare plant populations and potential habitats that were found, and the general vegetation types found). For each rare plant population located within the project area, a description should be included of the population's location, associated habitat, abundance, relation to project facilities, condition, and any other relevant factors.

- Discussion Section: This section should contain a discussion of the various factors relevant to the impact assessment process. The following subsections should be included: **Limitations** (discussing the reasons the study may not have located all rare plant populations, what gaps exist in the knowledge necessary to predict impacts, etc.); **Potential Project Impacts** (discussing all possible impacts to rare plant species as a result of the proposed project, the potential cumulative impacts, impacts to individual populations, and the significance of these impacts); and **Recommended Mitigation** (discussing the specifics of possible actions to reduce or eliminate potential rare plant impacts, and the chances these actions have of succeeding). In addition, other subsections can be included to discuss information that is relevant to the analysis and would be of help in the decision making process regarding the project.

- References: This section should contain a listing, in citation format, of all documents, personal communications, publications, and Internet resources referred to in the report.

- Appendices: The appendices should contain all supporting information for the report. This should include, at a minimum: a comprehensive species list, maps showing survey routes, resumes of the principal investigator and field crew members, and data forms for all rare plant populations located. Other appendices may also include: unit survey data sheets, vegetation maps for the project area, maps showing the location of unique habitats and features, and any other information relevant to the analysis.

5.2 IMPLEMENTATION OF GUIDELINES

The guidelines developed in this research are designed to apply at a variety of regional and jurisdictional levels. In addition, they are intended, not only to serve as a guide for those performing impact assessment rare plant studies, but also to act as a set of evaluation criteria for those charged with assessing the adequacy of these studies. To this end, the guidelines can be used as a checklist of requirements that each rare plant study should meet.

The guidelines should be supplied by the regulatory agency to the project proponent, with the explicit understanding that studies performed to these specifications will be accepted for impact assessment purposes. It is important to make the guidelines available to the project proponent early in the process, to allow for adequate preparation time. Because rare plant surveys must be performed only during certain seasons, early planning is necessary to ensure field surveys are undertaken at the proper time.

It is also important for regulators, project proponents, and consultants alike to allow for some degree of flexibility in the application of these guidelines. Each project situation is unique, and there will be times when it is either not possible or not prudent to follow the guideline specifications exactly. In these instances, the project proponent/consultant should detail, in the technical report, the areas where alternate methods were used, and the justifications for each.

5.3 CASE STUDIES

In order to relate the recommendations to real-world situations, the following examples of two of the reviewed documents are presented. These studies were selected from the many reviewed for this research because they illustrate the basic elements of successful, as well as unsuccessful, rare plant investigations. The first case study is presented here as an example of an inadequately performed investigation. The second study presented is a solicitation which, based on the recommendations contained herein, would constitute a basically sound investigation, (although not all elements of the recommended guidelines are explicitly specified in the solicitation).

5.3.1 Pohakuloa Training Area Range Complex Project

The following information comes from a case study paper published by Shaw and Laven (1993). They describe a US Army Multipurpose Range Complex (MPRC) training facility proposed for construction in the mountains of Hawaii at the Pahakuloa Training Area. The MPRC design called for access roads, manoeuvre trails, railed targets, and operations buildings spread out over a 500 hectare area. The US National Environmental Policy Act (NEPA) of 1969 requires all federal agencies to evaluate the environmental effects of their major projects (US Department of Energy 1994). In compliance with the Act, the Army contracted with a consultant to prepare an Environmental Assessment of the proposed project area. As part of that assessment, a rare plant study was undertaken which involved both field surveys and literature searches. At the time of the field surveys, the exact placement of project facilities had not been determined, so a general rare plant survey was conducted over the entire area. A total of seven days were spent surveying the area. Only selected sites were visited. No federally listed rare plant species were found during this survey, but one taxon, *Tetramolopium consanguineum* var. *leptophyllum*, was a candidate for listing at the time. This rare plant study, combined with studies of other environmental resources on the site, was used to produce the Environmental Assessment. The Army used this assessment to conclude that the proposed facility would not have any significant impacts on the environmental resources in the vicinity. The Army issued a Finding of No Significant Impact, waited the required time for public comment (which was minimal), and then proceeded with construction on the project. Construction began in November of 1988.

Then, in December of 1989, a suit was filed by a member of the public to halt the project. The plaintiff contended that the analysis of environmental effects had been insufficient because, among other reasons, the rare plant surveys had been performed inadequately. Eventually, after appeal, the government settled out of court and agreed to prepare a full-scale Environmental Impact Statement on the project, (while still continuing with construction). The additional field work included approximately 150 person-days of botanical surveys which identified 140 species of vascular plants, (nearly twice as many as were found during the original survey). The surveyors located over 100 populations of 12 rare plant taxa, (one listed endangered species, seven candidate taxa, three possibly undescribed taxa, and one species formerly thought to be extirpated from the island). Because of the large number of rare plants on the site, Shaw and Leven maintain that the army will be forced to limit its use of the facility, and a multi-million dollar investment will be jeopardised.

Obviously, this case is an example of an initially inadequate impact assessment rare plant survey. The duration and extent of the original survey was insufficient to provide an accurate picture of the rare plant resources on the site. The subsequent, more comprehensive, survey discovered a number of significant rare plant populations which, under US law, should have been considered in the original analysis. Using the Selected Sites method for this particular survey was not prudent, as US regulations required an assessment of impacts to all rare plant populations within the study area. In addition, the initial survey occurred during one season only, (April 3-11), likely missing species which bloomed outside of that time period.

5.3.2 Request for Quotes No. 16-95-86 (US Forest Service)

An example of a rare plant study whose specifications more closely approximate those recommended by this research can be found in one of the solicitation documents reviewed for the analysis. This solicitation (RFQ 16-95-86) is a Request for Quotes put out by the US Forest Service Wallowa-Whitman National Forest for impact assessment rare plant surveys in support of various timber and range projects (US Forest Service 1995f). Although not all aspects of the recommended guidelines are specified in RFQ 16-95-86, many of the important elements are included. It is important to note that this document is a call for bids only, and may not necessarily represent the methods used during the final implementation of the study.

Regarding the prefield review phase, the RFQ specifies the following: "The Contractor shall determine the probability of habitats that may support Sensitive Plants. A Pre-field Review form...shall be completed for each project area, and accepted by the Government prior to field surveys. The Contractor shall review Forest Service records of known sites in the project area, and record them on the Pre-field Review Form. The Contractor shall provide a survey design, and a Work Plan and Schedule......" (US Forest Service 1995f). While lists of resources are not given, the solicitation does stress the importance of determining the locations of high probability habitats for later survey.

The target species are listed in exhibits attached to the solicitation. In addition, the RFQ states that, "[t]he Wallowa-Whitman Sensitive Plant List (Exhibit A) is not necessarily all inclusive; other species with Oregon status on the Region Six Sensitive Plant List may be found, and will require the same documentation as the plants on the Wallowa-Whitman Sensitive Plant List." (US Forest Service 1995f).

The solicitation is specific about the timing of surveys. It states that, "[t]he contractor shall begin surveys when plant conditions indicate. The surveys shall be conducted during the time of year when potentially occurring sensitive species are identifiable. Some areas may require more than one visit in order to fulfill this requirement." (US Forest Service 1995f).

Although the solicitation does not use the term 'Intuitive Controlled', the search pattern it specifies is essentially that. The RFQ states: "[f]loristic surveys shall be performed in sufficient depth and in a manner that conforms to the standards of the professional botanical community. Surveys shall include the search for, and verification of Plant Species of Interest at known, reported, or suspected locations; including all suitable habitat within the contract area. All vascular plant species encountered shall be identified to species, and a list of all species encountered in each sub-watershed of the project area shall be kept by each field crew member. Units shall be surveyed by walking routes which cover a representative cross-section of all major topographic features and plant associations within the unit. Each unit shall be surveyed intensively enough to locate any unique habitats and high probability areas for Sensitive Plants. A representative portion of moderate and low probability habitats must also be surveyed for each unit. Generally, at least 40% of the ground shall be physically covered by the surveyor. There shall be no unsurveyed voids greater than ten acres within any given unit surveyed. All proposed roads, trails, fence lines, areas of high ground level disturbance (landings, mining projects, stream improvements, and water developments) and 'unique habitats' (creeks, bogs, seeps, springs, meadows, scabs, ridge lines, and rock outcrops) shall be surveyed at the complete 100% level." (US Forest Service 1995f).

Finally, the documentation specifications set out in the solicitation contain similar elements to those recommended in the guidelines. A comprehensive species list is to be kept by each member of the survey team for each sub-watershed in the project area; a botanical survey data sheet form is to be filled out; and survey routes and unique habitats are to be marked on topographic maps. When rare plant populations are encountered, extensive documentation is required, including: completing a Region Six Threatened, Endangered, and Sensitive Plant Sighting Form; marking the population on aerial photos, topographic maps, and sketch maps; marking the boundary of the population with flagging; tagging a nearby reference tree with paint; and collecting a voucher specimen if the population is large enough.

5.4 FUTURE RESEARCH

As mentioned previously, little research has been conducted into rare plant and floristic survey methodologies. The currently used methods have been developed primarily through trial-and-error, and are based on those methods which have proven effective in past studies. Although these techniques are presumed accurate, experiments which directly test the effectiveness of different survey methods would help to confirm assumptions held by the scientific community about these studies. Several areas of research can be envisioned which could advance the state of knowledge into these topics.

The first group of studies which would be helpful are direct comparative investigations into the effectiveness of different field survey patterns. Test 'project areas' could be set up containing a known number of rare plant populations, (or a known number of flagged locations representing rare plant populations). Subject investigators would then search the 'project areas', each using a different survey pattern. Following a number of trials, the results attained by the subject investigators could be compared to the actual numbers to evaluate the effectiveness of each pattern. Although this research would be helpful, it would be exceeding difficult to accomplish with an acceptable level of statistical confidence. The high number of largely uncontrollable variables from site-to-site and from surveyor-to-surveyor could erode the confidence level in the results. In addition, there is a limited pool of qualified rare plant surveyors from which to draw subjects for these type of studies.

The second area of research which is needed into impact assessment rare plant studies are investigations into the disturbance response of various rare species. Without knowing the effects that an impact will have on a rare plant population, it is impossible for the investigator to predict the significance of these impacts. For most species, the investigator must rely on untested predictions and perceived responses in order to forecast potential project impacts. Although disturbance response experiments have been performed for some species, significant additional work remains to be done. One impediment to further research in this area, is the relative vulnerability of rare plant species due to low abundance. Experimentally disturbing a significant percentage of the known individuals of a species in order to obtain data on disturbance response is not acceptable if it jeopardises the continued existence of that species. Other methods must often be found to test responses, such as analysing the results of non-experimental disturbance, (*e.g.*, wildfire, accidental chemical spraying, etc.).

A third area of future study which would be helpful to the impact assessment process, is research into the effectiveness of particular mitigation measures. Often, consultants propose mitigations for which there is little data demonstrating the effectiveness of the method. Once the project is built, and the mitigation measures are put in place, there are often no follow-up studies to determine the effectiveness of the actions. Although some research into this area has taken place, more work is needed. The impact assessment documents can serve to provide the baseline pre-project conditions at the site, with only post-construction monitoring of the treated areas needed to assess the effectiveness of the mitigation measures.

The three areas of research mentioned above would all be useful in refining the impact assessment process as it relates to rare plants. However, the current state of knowledge regarding these rare plant study methodologies is sufficiently advanced to allow these surveys to be performed in an acceptably effective manner. The need for additional research into these areas should not be taken as an indictment of the currently used methods, and impact assessment rare plant studies should continue to be performed whenever necessary.

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IMAGE EVALUATION
TEST TARGET (QA-3)

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