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THE UNIVERSITY OF ALBERTA

A PROPOSED CLASSIFICATION, EVALUATION AND PRIORIZATION FRAMEWORK FOR THE CONSERVATION OF SPECIAL NATURAL FEATURES OF INTEREST IN ALBERTA, CANADA

BY

BRIAN R. BRAIDWOOD

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF SCIENCE

IN

WILDLAND RECREATION

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THE UNIVERSITY OF ALBERTA

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled A PROPOSED CLASSIFICATION, EVALUATION AND PRIORIZATION FRAMEWORK FOR THE CONSERVATION OF SPECIAL NATURAL FEATURES OF INTEREST IN ALBERTA, CANADA submitted by BRIAN R. BRAIDWOOD in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in WILDLAND RECREATION.

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ABSTRACT

This study outlined a framework for the classification, evaluation and priorization of species, natural community-types and abiotic phenomena in Alberta, Canada which are defined as "special." This framework serves as a general model to be used by land-use planners and resource managers to achieve a more comprehensive conservation strategy. It represents a rational means to allocate the scarce human resources of time, money and skills.

Seven forms of "specialness" are defined through a series of 24 interviews with professionals in a range of natural science disciplines. The seven forms of specialness are: few individuals/examples, endemic, peripheral, disjunct, unusual, diverse and sensitive.

A literature review of 31 studies developed a perspective into the most widely used approaches to conservation evaluation. Their inherent strengths and weaknesses were contrasted with general decision-making theory to reveal any methodological shortcomings. The three major components of the evaluations reviewed were: a system for feature categorization, a set of criteria to measure each feature and a means of aggregrating the measurements into at least one index.

The seven forms of specialness were used to develop a classification system for "Special Natural Features of Interest" (SFI). All SFIs, in all classification categories were valued equally, based on their intrinsic worth. SFIs were compared intracategorically by measuring threat levels and, to a lesser extent, feature desirability.

These abstract dimensions were measured using 17 criteria derived from the literature. Those SFIs which were assessed as being highly threatened and desirable will receive the highest aggregate scores and will therefore be assigned the highest priority for conservation.

The Simple Additive Weighting (SAW) Method was used in many studies to aggregate criteria measures. A review of the general SAW method was conducted with the Simple MultiAttribute Rating Techinque (SMART) version selected for use in this study. Unlike past studies, this thesis followed the method closely with each step explicitly stated. Using a population of Ferruginous Hawk <u>Buteo regalis</u>, a test application of the system was presented. The success of the test was discussed with recommendations made regarding system refinement and future conservation needs of SFIs.

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Abbreviations

AFW	Department of Alberta Fish and Wildlife
CUI	Conservation Utility Index
CWS	Canadian Wildlife Service
DM	Decision-maker
FAO	Food and Agriculture Organization
IBP	International Biological Program
IUCN	International Union for the Conservation of Nature
MAB	Man and the Biosphere Program
MCDM	Multiple-Criteria Decision Making Theory
NGO	Nongovernmental Organization
SAW	Simple Additive Weighting Method
SFI	Special Natural Feature of Interest
SMART	Simple MultiAttribute Weighting Technique
SPNC	Society for the Promotion of Nature Conservation
Unesco	United Nations Educational, Scientific, and Cultural Organization
WAM	Weighted Average Method
WNHP	Washington Natural Heritage Programme

Part I: Introduction

CHAPTER 1.0

INTRODUCTION

1.1 Context of Study

It is no longer mere conjecture that mankind's domination of nature is reflected in the excelerated loss of both species and entire natural communities throughout the world. This has resulted in an ongoing global debasement which may threaten our own survival (Udall, 1964; Commoner, 1971; Bell, 1973 and Orr, 1979). In response to this conclusion international organizations, countries and smaller jurisdictions have established official policies and programs for the purposes of conserving a wide range of existing natural ecosystems, natural phenomena and plant and animal species. The success of their total conservation effort can be determined, in part, by how systematically and comprehensively they have proceeded.

1.1.1 Conservation as Systematic Decision-Making

In the past, it has been the regional and local levels of government which, in an effort to set aside areas of biological or ecological significance, have suffered most from a wide range of problems. These problems have ranged from imprecise goals, impermanence of programs, duplication of effort and ad hoc methodology. The Society for the Promotion of Nature Conservation (SPNC) (1980) study of County

Trusts in Great Britain noted that actual acquisition of reserves depended on such transient and bias factors as political influence, the level of organization of the Trust, the energy and direction of certain individuals, funding ability and the degree of threat to the site.

The inability of smaller scale efforts to utilize the methodologies and resulting priority lists of sites and species of the international and national organizations only exacerbates the situation. These methodologies are applied at a relatively large scale and based on the most general characteristics of natural features (Holloway, 1979 and see for e.g., Udvardy, 1975; International Union for the Conservation of Nature (IUCN), 1978 and United Nations Educational, Scientific, and Cultural Organization (Unesco), 1983). Local level conservation efforts tend to be linked to the local sphere of interest, where little value is placed on protecting large representative ecosystems and species threatened on a worldwide basis (Margules, 1981). The sites selected are relatively small, at times comprising only a few hectares and are assessed using markedly different criteria (Margules, 1984, 1986 and Margules and Usher, 1984). Further confusing the issue are other related, but distinctly different, land conservation motives such as recreation, scenic preservation, cultural preservation and multiple-use natural resource management, which have become inextricably intertwined with this movement.

The result has been the limited success of each objective (Jenkins, 1982) and, in the public's mind, a lowered credibility of the agencies and organizations involved. The inability to outline a credible, structured and rational approach for the assessment of natural features and areas to the general public and special interest groups has proven to be a major stumbling block to regional and local conservation efforts (Catling, 1980 and Banff Centre School of Management, 1983).

1.1.2. Conservation as the Preservation of Natural Diversity

A second and perhaps more critical reason to develop a systematic methodology for the assessment of natural phenomena is that the problem of disappearing species and communities is becoming increasingly acute (Myers, 1979; Council on Environmental Quality, 1980 and Ehrlich and Ehrlich, 1981). Those biotic features with little or no economic value--"non-resources" (Ehrenfeld, 1976)--and/or low aesthetic value, are in the most vulnerable position in terms of their being candidates for protection (Wood, 1983). These features typically consist of non-game species, their critical habitats, "unrepresentative" community-types as well as unusual geological formations and processes. Bury <u>et al</u>. (1980) asserts that an inherent fault in using these terms is the relegation of these features to a "non-status," which by definition implies a low priority. This nonstatus implicitly denies the intrinsic worth of these features (particularly species), their right to exist, their potential worth to Man and to be considered as appropriate entities to manage and conserve. The notion that existence is the only criterion of value and that all living things should be valued equally has been termed the "Noah Principle" by Ehrenfeld (1976), after the first person to supposedly put it into practice.

In accepting this principle, and it's implication that [illegible] comprehensive conservation/management strategy is desirable; a dilemma arises. Given the limited resources of time, money and scientific skills, how may conservationists most effectively utilize these scarce resources to achieve maximum return in terms of numbers of species (and other natural features) protected? The most acceptable method is a "triage" strategy, first formally suggested by Lovejoy (1976) and later by Myers (1983). Couched in conservation terminology, it is a method which refers to the allocation of human resources to natural phenomena according to a system of priorities. The priorization system would be designed to maximize the number of phenomena saved from extinction or loss. It would evaluate and rank phenomena in a totally acceptable manner, by not comparing intrinsic qualities of features. It would thereby avoid the setting of one feature against another and creating an "apples and oranges" dilemma. Also, this strategy as proposed in this study, de-emphasizes economic considerations (either costs or benefits), as these are misplaced when used for non-game and smaller units of land (Frankel, 1981). Rather, it evaluates a feature on the requirements for its continued existence given a threat may be a factor in its survival. Since this strategy depends largely on the evaluation of threat levels for specific sites, its final form will undoubtedly resemble those developed for environmental impact assessments.

This system must be comprehensible and well structured if it is to survive public scrutiny and for decision-makers to allocate human resources in a consistent and justifiable manner. To this end, such an evaluation system must exist within a larger decision-making framework.

It is the objective of this present study to develop both the evaluation system and framework for the regional (i.e. provincial) and local conservation of special natural features in Alberta.

1.1.3 Systematic Decision-Making to Preserve Natural Diversity--the Alberta Perspective

The perceived need for such a comprehensive conservation/management strategy in Alberta is indicated by the growing interest throughout North America regarding nontraditional management concerns. These range from investigations into non-game responses to habitat alterations in Michigan (Beyer and Haufler, 1984), to the use of mines by bats in Kentucky and Tennessee (Barclay and Parsons, 1984), to the efforts to protect old growth forest in Eastern Canada (Edwards, 1976), to the identification of environmentally significant areas in the Yukon (Theberge et al., 1980).

Today, the major focus of wildland management in Alberta consists of the maintenance of game species populations and their habitats (Stelfox, 1984), the protection of a limited number of high-profile endangered species (Singleton, 1977 and Alberta Fish and Wildlife (AFW), 1985) and the identification and/or preservation of variously sized tracts of natural landscape represented by parks, natural areas and other protected areas (see for e.g., Landals, 1978; Taylor, 1978; Alberta Public Lands Division, 1981; Cottonwood Consultants, 1983; Alberta Energy and Natural Resources, 1984; Edmonton Metropolitan Regional Planning Commission, 1984 and Strong and MacCallum, 1984).

Non-game wildlife, non-commercial plant species and unrepresentative community-types have been seriously neglected within the management framework of the province. These features have been relegated to second place whenever they compete with other land uses (Ryder and Boag, 1984). Certainly no consistent and rational methodology has been applied for their collective evaluation and protection. In this regard, Alberta's pattern of bias conforms closely with that found in earlier wildland management strategies of agencies across North America (Crouse, 1974). That is, non-game receives either no protection or recognition (Alberta Wildlife Act, RSE, 1984), or in a few instances total protection, primarily because they are nationally endangered and have either little or no commercial or game value (see Alberta Regulation 312/77, 1977). Although legislation currently exists (see, Wilderness Areas, Ecological Reserves and Natural Areas Act; Forests Act; Wildlife Act; Parks Act and Historical Resources Act) which could theoretically protect any natural phenomena in the province, the impetus to do so appears to be lacking.

This indifference towards perceived nonresources may be understandable since wildlife and wildland management, both as a profession and as a government policy, developed for and as a result of hunters (Talbot, 1974). It has been hunters who, until the last twenty years, have been the most effective wildlife lobbyists. The result of this obvious inequity has been a bias in research funding toward game species (Clement, 1974), a disparity between the broader values we now assign to wildlife and wildlands and values we still manage them for (i.e. production of a shootable harvest and recreational sites) (Talbot,

1974) and the resulting deficiencies in training required by wildlife professionals to manage non-game species and wildland areas (Finley, 1980).

The identification of target (i.e. game) species has inevitably resulted in the extensive development of single-species management techniques and the notion of "good" and "bad" wildlife habitats (Bury, et al., 1980). Wagner (1977) has outlined several case histories where the emphasis on such management has proven disastrous, particularly for nontarget, highly specialized plant and animal species. Consequently, there is no such thing as "habitat improvement" from a community point of view since improvement for one species means less favorable conditions for other species in the community.

AFW has recently indicated an interest in non-consumptive wildlife pursuits as evidenced by the creation of a non-game section within the agency. To date, the focus has been on what are essentially nationally endangered species based on a province-wide status assessment (AFW, 1985). Literally dozens of species were listed but not evaluated due to a lack of data. No policy statements or programs have been forthcoming regarding a wide-ranging and anticipatory non-game strategy in Alberta.

The notion to set aside entire areas for preservation in Alberta has likewise focused on what are essentially representative natural community-types (Alberta Public Lands Division, 1981 and Alberta Energy and Natural Resources, 1984). While special and unusual communities have been identified as important to conserve at the international (Unesco/MAB, 1974; Ratcliffe, 1977 and Council on Environmental Quality, 1980), regional (Cottonwood Consultants, 1983) and local (Lamereux, et al., 1983) levels, the emphasis for their protection has been on the sc[illegible] or spectacular in parks and other recreational areas. Those efforts to protect wildland areas based on their more intrinsic values, such as in the cases of Wilderness Areas and certain Natural Areas, have not proceeded with an anticipatory planning process where the consequences of decisions are relatively predictable (Taschereau, 1985).

Brown's (1974, p. 14) summary of past federal attitudes towards Alberta's natural resources, seems equally applicable to the modern provincial regime;

> Non-agricultural lands were used, where possible, to enhance the value of agricultural lands, but, generally speaking, were of remote concern to the federal government and often served as pawns for political advantage.

With limited manpower, funding and time, the provincial government has had to focus on a few of the vast number of issues which make up the public's interest in nature as well as the areas in which scientific investigation has directed them to act. With a multitude of special interest groups and the resultant fragmentation of effort, an emphasis has developed on those areas which public and private pressures have been the greatest.

Although a legitimate desire seems to exist for a comprehensive approach (Landals, pers. comm., 1985; Erickson, pers. comm., 1985 and Lee, pers. comm., 1985), serious omissions still exist in the management strategy of the province regarding both its wildlife and wildland areas.

Among world leaders in nature conservation, the trend in resource management agencies has been towards viewing nature holistically and conserving as much of the earth's genetic diversity as possible (Oliver, 1979; Brookes, 1981; Tikhomirov, 1981 and Wells, 1981). In other parts of Canada methods have already been developed by which special and significant natural features are identified, classified, evaluated and protected (Beechey and Davidson, 1980, 1976; Reeves, 1980; Theberge, 1980; Keddy, 1984; Ontario Ministry of Natural Resources, 1984 and Smith, 1984).

By comparison, the protection of special natural features in Alberta may be seen as an effort in its infancy. Unfortunately, for many degraded landscapes and declining species in Alberta time is limited to respond pro-actively, but the losses can be minimized. Although some may object to a systemized approach to priorizing special natural features, particularly those which are endangered, in the interests of maximizing conservation efforts such an approach is desirable. The framework proposed in this study will contribute in this direction, toward the systems planning component of feature evaluation and selection.

1.2 Objectives of Study

The objective of this study is to develop a framework for the classification, evaluation and priorization of special natural features within Alberta. Once implemented, such a framework will allow for the identification of features which are highly threatened and desirable as well as indicate preliminary conservation initiatives for each feature assessed.

The sub-objectives include defining the term "special natural feature" and the identification, definition and application of evaluation criteria applicable to the assessment of special features.

1.3 Definition of Terms

Important terms used in this study are defined below.

1.3.1 Special Natural Feature of Interest

A Special Natural Feature of Interest (SFI) is defined in this study as:

a) an undomesticated, native, non-game invertebrate or vertebrate animal species, subspecies, or local population including its associated habitat,

b) an undomesticated, native, uncultivated vascular or nonvascular plant species, subspecies, or local population including its associated habitat,

c) a naturally occurring aquatic or terrestrial plant community, or

d) a naturally occurring geological or hydrological feature or process

which may be described by at least one of the following terms; few individuals/examples, endemic, peripheral, disjunct, unusual, diverse or sensitive. These terms are defined in detail as part of the classification system presented in Chapter 5. The terms "undomesticated" and "naturally occurring" refer to the relative lack of adaptation or modification to life or form in assocaition with, and to the use of, Man. "Non-game" refers to species which are not traditionally hunted in Alberta.

The term SFI can be applied to phenomena which are not restricted to a particular location, such as a highly mobile or migratory species. However, most SFIs will be either:

a) a site which comprises the entire FSI (e.g. a cave system); or

b) a feature and/or a site with components that constitute at least one aspect of the life-history requirements of the SFI (e.g. a small rocky out-cropping used as a hibernaculum for Heterodon nasicus).

SFIs will include such features as calving and denning areas, sites of unusual wildlife assemblages, areas containing rare plant and animal species and communities, and unique geological phenomena. In similar studies in Canada, the terms "environmentally significant area" (Reeves, 1979 and Smith, 1984), "environmentally sensitive area" (Eagles, 1981) and "natural site of significance" (Parks Canada, 1983) have been used to identify features similar to those recommended for protection in this study.

1.3.2 Threat

Several terms are commonly considered synonomous with threat. These include "impact" (Jain et al., 1985), "perturbation" (Loucks, 1975), "disturbance" (White and Pickett, 1980), "crisis" (Raup, 1980), "disaster" and "catastrophe" (Harper, 1977). Most authors appear to have their own particular definition and application of the term they have employed and may use one or several descriptors (e.g. distribution, frequency, magnitude and severity) to measure it.

Species survival and adaptation occur within a spatial and temporal framework as do the disturbances species must survive and adapt to. Over a broad area, a given type of disturbance may affect either many contiguous individuals, creating a few large areas of disturbance or many scattered individuals, creating several small disturbed patches (Runkle, 1985). The distribution of disturbance over time may occur on a spectrum of conditions, with low continuous levels of disturbance at one end, to discontinuous events of very high disturbance at the other.

Disturbances can generally be described as either relatively predictable and recurring, or stochastic events. Recurring disturbances which occur within the life cycles of successive generations conform to Harper's (1977) definition of "disaster" and Raup's (1980) definition of "threshold crisis," in that they are typically determinist The spruce budworm-balsam fir interaction (Morris, 1963 and Holling, 1973) and the periodic outbreak of naturally generated fires (Swain, 1973) in the boreal forest are examples of such indigenous disturbance. Random events, on the other hand, tend to appear without prelude and are not part of some familiar pattern of events. As such, they are likely to be unprecedented as selective forces in the evolution of adaptive traits by the species. Harper (1977) termed these "catastrophes" and Raup (1980) "point crises." These types of disturbances are usually associated with certain kinds of human activity and are the most likely to cause population or community extirpation. The distinction is somewhat arbitrary since, for example, what is a point crisis for an individual of a population may eventually prove to be a threshold crisis for the population as a whole.

Not all disturbances should be considered negative or threatening. Denslow (1985) points out that unstable communities, adapted to variable environmental conditions and high rates of mortality, are often the most resilient. Both fire and the budworm are mechanisms which result in a patchy mosaic in an otherwise monoculture community, thereby maintaining habitat for a variety of species. A successful attack by a predator is surely seen as a negative, unpredictable event with long-term consequences to the prey, but quite a normal non-crisis for the predator. In short, this author agrees with Foster (1980) in concluding that sites with a high rate of disturbance should not automatically be assessed as threatened.

The determination of threat levels for a site or feature requires an interpretation of the disturbance in relation to that which is being disturbed. Therefore, the notion of threat must encorporate Ratcliffe's (1977) two-fold definition: a) levels of "extrinsic disturbance" and b) degree of "intrinsic sensitivity." Intrinsic sensitivity refers to the extent an entity is vulnerable to a specific threat. Perhaps the greatest challenge in assessing threat is distinguishing between legitimately destructive events and natural patch dynamics or environmental fluctuations (see for e.g., Neilson and Wullstein, 1983). In the absence of specific threats, vulnerability may refer to more general life-history strategies, such as the species degree of specialization, reproductive rate and the extent to which its populations concentrate. Species which exhibit a high degree of vulnerability based on these and other characteristics are often referred to as "K selected" species (Myers, 1979 and Parry, 1981) and may be seen as "predisposed" to disturbance.

Based on the above discussion and for the purpose of this study, threat is defined as:

> the interaction between an existing disturbance occurring randomly as a relatively discreet event in time and the significant negative impact it has on an entity's structure, processes or viability including alterations to resource and substrate availability.

Such disturbances will almost always, but not exclusively, be human-induced in nature and will occur within a spatial and/or temporal framework. Types of disturbance will include environmental contaminants, habitat degradation, inappropriate land-uses and those which would interfere with the management of a feature. Intrinsic sensitivity must often be inferred by case histories involving specific threats or by assessing general life-history strategies.

1.4 Methodology and Delimitations of the Study

The methodology of this study was one of an extensive literature review coupled with a series of interviews with professionals in the areas of conservation, biology and resource management. This has been the approach taken by similar efforts in the past.

The study was designed to identify and evaluate special natural features and examine how the resulting model may be incorporated into the existing framework of natural areas protection in Alberta. It emphasizes the evaluation of species but with modifications to the criteria can apply equally well to other kinds of natural features. The results of this study will be only applicable to Alberta. The applicability of this framework to other regions of Canada or other countries will vary depending on the relevance of the classification system and criteria used to rank candidate SFIs, on the extent of existing natural areas protection programs and the prevailing attitudes of government agencies and the general public.

This framework may appear to promote a reactive (rather than preventive) management response, in that it directs action towards threatened sites and away from sites that are relatively pristine. While highly threatened features will generally be given high priority, this does not infer that relatively unthreatened features will be ignored. As will be outlined in this study, both kinds of features within the same SFI type may be protected. Also within the measurement scale of each threat criterion, the imminence of the threat will be taken into account. For some SFIs this will result in preventive action being initiated. Due to the inherent nature of special features and the philosophical problems associated with attempts at comparing their intrinsic qualities (see Chapter 1.1.2), a totally preventive approach based on intrinsic qualities is seen as unwarranted. A preventive approach also assumes that all features are in a relatively intact state and that there is no urgency in selecting features. This is certainly not the case for most developed regions of the world and is not the case for most of the southern two-thirds of Alberta.

Due to the most recent and accelerated man-made changes to natural landscapes, conservation evaluation has emerged as a developing field of study. In fact, this study represents the first attempt at such a comprehensive framework in Alberta. As such, its methods and basic assumptions require critical analysis, and logical refinements to the process should be encouraged where necessary. Since subjective valuation is the cornerstone of this framework, the results should be viewed as a set of guidelines to assist in decision-making and not a conclusive solution.

Finally, this study is not an attempt to develop an exhaustive list of SFIs in Alberta but to outline a method by which this may be effected. The actual implementation of this model and the generation of such a list is the next logical step in SFI protection.

Part II: Literature Review and Evaluation Design

CHAPTER 2

LITERATURE REVIEW

2.1 Nature Conservation--Justifications and Objectives

For conservation evaluation to have any value for society, nature conservation itself must first be seen as a worthwhile activity. To appreciate the relevance of nature conservation, it is important to briefly outline its basic tenets.

Conservation efforts have traditionally been aimed at what are known as natural "resources." Resources may be narrowly defined as reserves of commodities that possess some appreciable monetary value to Man, either directly or indirectly (Ehrenfeld, 1976). It was not until the 17th century that species and their associated habitats were of interest to Man for their intrinsic values as well. This early concern was based largely on the scientific interest of plant and animal species, primarily their identification, description and classification (Gilg, 1981). The modern conservation movement, which began in the latter half of the 19th century, witnessed a more widespread interest in nature. This was reflected in the growth of natural history societies and the transcendentalists' view of nature, attempts to prevent animal cruelty but perhaps most importantly, in the efforts to preserve large tracts of land as parks and save wild species from extinction (Margules, 1981). In 1863, John Gould implored the new settlers of Australia to:

> bestir themselves, ere it be too late, to establish laws for the preservation of the large Kangaroos, the Emu and other conspicuous animals (in Frith, 1973, p. 1).

The three main philosophical justifications which exist for nature conservation today are the "ethical/aesthetic," the "scientific/educational" and the "self-preservation/disaster" arguments which have been presented in various forms by several authors (see Braat, et al., 1979; Myers, 1979; Gilg, 1981 and Green, 1981). These have all be expressed, to varying degrees, in many cultures throughout recorded history (Hughes, 1975; Nash, 1982; Nature Conservancy Council, 1984). Also, within a single culture an environmental ideal may exist although not practised in reality (Tuan, 1970). As such, these justifications are interrelated and separation is to some extent artificial. They are more appropriately viewed as being situated along a continuum, such as that illustrated in Figure 1. The continuum ranges between a purely anthropocentric viewpoint and a purely biocentric viewpoint. Biocentric refers to natural objects which are theoretically free of all human-induced valuations.

It is the opposing ends of this continuum which represent the fundamental dichotomy in the rationale for conservation. As stated by Margules and Usher (1981, p. 80):

> Two types of justification for conservation can be recognized. The first assumes that there are identifiable or potentially identifiable benefits to be derived through conservation . . . The second justification is based on the assertion that organisms have a right to exist because they have already done so for a long time . . .

This duality has led to confusion in the public mind regarding the definition of conservation (Schneider, 1966). It has led to attempts to

Figure 1: Continuum of Justifications for Conservation

Ethical/ Aesthetic	Scientific/ Educational	Self- Preservation/ Disaster

biocentric/ <---> anthropocentric/

nature preservation   utilization reconcile the two by identifying monetary values for wildlife and wilderness (Helliwell, 1973; Langford and Cocheba, 1978). This has only proven to some, such as Ehrenfeld (1976, p. 654), the inherent futility in:

> the attempt to preserve non-resources ["useless" species or environments] by finding economic value for them.

Others have chosen to focus on one extreme or the other. Stone (1974), Kantor (1980) and Simonsen (1981) all present lucid, credible arguments for the intrinsic values and legal rights of natural objects. With equal lucidity, Linear (1973) and Livingstone (1981) conclude the exact opposite. Linear (1973, p. 11) states:

> . . . the use of the largest remaining wilderness areas for preservation of permanent stocks of wildlife is only justifiable and defensible if such areas can be made to produce.

Finally some individuals have resigned themselves to the undefinability of conservation and even to its fraudulence as a legitimate pursuit. Zurhorst (1970, pp. 3-4) merely labels conservation as:

> . . . a bit of nostalgia, and a wish for Utopia . . . primarily a political tool . . .

It should be evident that all justifications for conservation are a result of value judgments. As such, they share important similarities with the process of conservation evaluation and how individuals intuitively value natural features.

Arising from these general justifications are the more specific objectives of conservation. The British Government's submission to the United Nations Conference on the Human Environment held in Stockholm in 1972 continues to provide one of the most comprehensive listings to date. In no particular order they are:

1. as a contributory component of ecological stability
2. as a monitor of environmental pollution (and other Man-induced modifications)
3. for the maintenance of genetic variability
4. for the provision of a source of renewable biological resources
5. for the needs of scientific research
6. for its cultural and recreational value
7. as a component of the aesthetic quality of the landscape
8. for environmental education
9. for the economic value of its resource, scientific and recreational components
10. to provide future generations with a wide choice of biological capital; and
11. for moral and ethical reasons.

The conservation function has emerged in the last decade "as a major influence on policy concerning resource allocation and on current ethics of resource use" (Austin and Miller, 1978, p. 163). This widespread influence has been based largely on the acceptance of the justifications and objectives outlined above. However, as Strom (1973) and Ploeg and Vlijm (1978) point out, the "legitimacy" of conservation does not always translate to its "equality" with other land use functions and may be ignored when conflicts arise.

The major emphasis of this study is the preservational component of conservation. Specifically, the preservation of species, environments and other natural phenomena through the evaluation and designation of protected areas. The scientific, educational and recreational functions of conservation are given secondary importance. These are seen more as potential programs within the proposed system of protected areas. In this study, the economic valuations of nature have received minimal consideration, being recognized only as one of many criteria (i.e. cost of protection) in the evaluation process.

2.2 Conservation Evaluation and Related Assessments of Nature

It is important to clarify the difference between conservation evaluation and other related forms of environmental assessment. Van der Maarel (1975) and Van der Maarel and Dauvellier (1978) have outlined a range of functions (or benefits) of the natural environment which are outlined in Table 1. Ploeg and Vlijm (1978) state that ecological evaluations should concentrate on the "ecological" functions of information and regulation. Margules (1981, p. 8) perhaps more correctly suggests:

> Ecological values should be derived from the entire range of functions . . . Ecological evaluation requires the assessment of ecosystem productivity and the quality of products, the degree to which components of the natural environment regulate and stabilize products, the quality of physical properties such as soil, air and water, and the ability of both physical and biological components to deal with waste products, as well as factors such as biological diversity, rarity and natural ecosystem representation.

Conservation evaluation only assesses the latter group of diversity, rarity and representation and is therefore a subset of ecological evaluation. Ratcliffe (1977), Margules (1984) and Margules and Usher (1981) have identified these three factors as the major

Table 1: Functions of the Natural Environment

Production Functions		
	1. abiotic production	supply of cosmic energy supply of atmospheric matter supply of water production of surface minerals production of minerals at greater depth
	2. biotic production	biomass from aquatic environments biomass from terrestrial environments
	3. agricultural production	aquaculture agriculture, farming, ranching, forestry
Carrier Functions		
	1. urban/industrial activities	urban subsystem communication lines public services
	2. rural activities	water control structure and water retainment military bases/activities
	3. absorption of waste	solid waste liquid waste gaseous waste
	4. re-creation (restoration) activities	substrate related re-creation langscape re-creation
Information Functions		
	1. information use functions	orientation research education indicator
	2. information reservoir	abiotic biotic
Regulation Functions		
	1. purification functions	absorption of noise filtration of dust biological purification
	2. stabilizatin functions	protection against cosmic radiation climatic regulation water retention soil retention biotic retention

Source: Van der Maarel and Dauvellier (1978, pp. 141-142) criteria used to both intuitively and theoretically evaluate sites for strictly conservation purposes.

Many examples of true ecological evaluation can be cited (see for e.g., Anderson, 1977; Asherin et al., 1979; Short, 1982; Short and Burnham, 1982 and Stelfox, 1984). So too can those studies explicitly labeled as ecological but that have used conservation criteria exclusively to evaluate study areas (see fo~~r e.g.,~~ Tubbs and Blackwood, 1971; Gelbach, 1975; Goldsmith, 1975; Selman, 1982; Cottonwood Consultants, 1983 and Smith, 1984).

Another type of natural resource assessment--landscape evaluation--is related to, but distinctly different from, conservation evaluation. In the United Kingdom, where the majority of landscape evaluation has occurred, "landscape" denotes only the topographic form and surface elements of the environment (Laurie, 1970), or "scenery" (Lowenthal, 1979). Hence, its evaluation and management a[illegible] visual resource attempts to conserve areas that are assessed to be more visually attractive than others.

The major problem which has arisen in the majority of landscape evaluations is the lack of a theoretical basis with which to guide assessment criteria selection. Another is the inherent difficulty in deriving a finite number of criteria which can encompass all the gratifications we derive from landscapes. Furthermore, as Unwin (1975, p. 133) states:

> the frequency, order, timing and purpose of encounters with landscape alter its appearance for the individual.

Most recently, attempts at deriving universal standards of landscape aesthetics have been rejected (Jacques, 1980; Dearden, 1981 and Tips, 1984), the conclusion being that such appraisals are almost entirely subjective. It is recommended instead, that the identification of cultural groups and their tastes should commence, with the hopes of developing a degree of societal consensus.

Landscape evaluation differs from conservation evaluation in that it is narrower in scope, is solely an anthropocentric construct and has a limited theoretical basis. Furthermore, most conservation evaluations have evolved to compare sites with one another, in an attempt to select the most outstanding examples. Landscape evaluation tends to compare a site's assigned aesthetic value with the values of a wide spectrum of potential land uses. These other uses, measured largely in monetary terms, include resource extraction and facility development.

Outlining the distinctions between the various forms of nature evaluation may appear overly discriminatory. However, the misidentification of the type of evaluation being conducted leads to misconceptions regarding what a particular evaluation should and will accomplish. This is true for the actual assessment team as well as the decision-makers (DM) receiving the final summarized reports.

This study considers evaluation for conservation purposes only and mainly the evaluation of discrete, relatively small sites (containing a variety of features) and not whole regions. Both the classification system and criteria set used in this study have been developed accordingly.

2.3 Conservation Evaluation Models

2.3.1 Introduction

Models developed for conservation evaluation purposes have traditionally consisted of three basic components. These components are; (1) a classification system within which the features being evaluated are placed for organizational reasons; (2) a set of criteria by which the features are evaluated and (3) a method which aggregates the evaluations (or scores) into one composite index and determines a priority ranking and designation for each feature. These three components serve as headings to review the literature on conservation evaluation systems.

2.3.2 Classification Systems

Within the last two decades, several land-based classification schemes have been developed for use at the various levels of conservation effort.

At the international level, systems have been developed to assist in the identification and categorization of biogeographical provinces or regions of the world. They serve to categorize the living world into similar areas, based on their broadly defined physiognomy and structure. Systems such as these have been used by the IBP (Fosberg, 1967) and the Biosphere Reserve Program (Dasmann, 1972 and Udvardy, 1975).

On a smaller scale, Central American countries (Budowski, 1965), Australia (Laut et al., 1975), Canada (Wiken, 1980), Nordic countries (Nordic Council of Ministers, 1983), the province of Alberta (Cottonwood

Consultants, 1983), the Northwest Territories (Smith, 1984) and the Yukon (Theberge, 1980) have employed similar hierarchical classifications of ecological land units. This type of system allows for different levels of generality to be applied to different levels of decision-making. All levels of the hierarchy (from the largest Ecozone to the smallest Ecoelement) characterize land units based on multivariate analyses of combinations of climate, geology, physiography, pedology, hydrology, vegetation and fauna. However, it is not until landscapes are surveyed at the more detailed scales that the more unique and special qualities of the environment are uncovered.

A similar hierarchical method was proposed by Gelbach (1975) which allowed for small scale community-types to be more easily identified. He developed a simple dichotomous key which identified community-types based only on major physical media (i.e. trees, shrubs, grasses, etc.). Unfortunately, while the system was designed to facilitate the involvement of amateur naturalists its use was limited to the identification of representative physiognomic types and further, only those located in Texas, USA. If the key was to be used elsewhere, it would have to be completely altered except for the basic approach.

The Ontario Provincial Park System, in an attempt to classify kinds of nature reserves in Ontario, used for a more comprehensive approach. It used a two-fold sub-classification scheme which outlines nature reserve requirements for earth science (geological) and life science (biological) representation (Davidson and Tracey, 1976; and Maycock, 1976). Geological phenomena were identified based on the widest possible range of earth science disciplines including lithology, paleontology, stratigraphy, petrology and dendrology. Biological phenomena were identified solely on the description of plant communities found in each of the 13 "site regions" of the province (Beechey and Davidson, 1976). Unlike most of the systems mentioned previously, this system includes geological phenomena and its biological component includes open water communities. Although more generally applicable, it ignores both plant and animal species, is considered complex and difficult to understand (Beechey and Davidson, 1976 and Davidson, 1977).

The classification schemes used in four separate evaluation studies appear, to varying degrees, appropriate for a comprehensive regional/local conservation strategy. These were developed by Sargent and Brande (1976), Lamereux et al. (1983), Parks Canada (1983) and Washington Natural Heritage Programme (WNHP) (1983).

Lamereux et al. (1983) identified areas of environmental significance (ESAs) in the Calgary region and placed them into categories of biophysical, paleontological, archeological and historical significance. The category outlining types of biophysical significance is singularly relevant to this study. Within this category are seven major "themes" into which ESAs could be placed. These themes constitute the study's classification system and are reproduced in Table 2. While simple in design, the scheme lacks both general applicability and comprehensiveness for special features as defined for this present study. Categories two, three and four relate to habitats of specific game species and are of limited value to jurisdictions which do not contain these species or conservation efforts not involved with game

Table 2: Major Themes Used as the Classification System for Environmentally Significant Areas (Biological) in the Calgary Region

1. Significant Natural Landscapes
2. Key Areas for Bighorn Sheep and Mountain Goats
3. Key Areas for Elk and Moose
4. Key Areas for Mule Deer and White-tailed Deer
5. Key Areas for Birds
6. Key Areas for Fish
7. Actual and Proposed Parks, Natural Areas, Ecological Reserves and Wilderness Areas

Source: Lamereux _et al_. (1983, p. 31)

management. It is not explained why the term "significant" refers only to landscapes and not to other components of the environment. The term "landscape" does not receive a complete definition nor does the term "key areas," although the implication is that, except for endangered nesting birds, it applies almost exclusively to game species and sport fish.

Sargent and Brande (1976) designed an evaluation and planning system for "unique natural areas" in the New England States. Their system was comprised of a simple listing of categories as shown in Table 3. If a particular site could be placed within at least one category and sub-category, it was eligible for their evaluation process. For example, an unusual faunal community which exists in a sand-dune environment could be classed as IIF, VC. Although simple to use and comprehensive, it suffers from the same lack of consistent and general applicability as does that of Lammereux et al. (1983). Categories III, IV and V are appropriately described by generally stated sub-categories, used to compartmentalize all possible hydrologic and biologic phenomena. For reasons unexplained by the authors, in categories I and II they did not use general descriptors such as rare or unusual, but used geologic features found specifically in the New England area which are considered special. The implication is that those kinds of phenomena not specifically mentioned within the sub-categories are not suitable for consideration under a natural areas protection program. Also, the use of terms such as "mountains," "bluffs" and "waterfalls" in a classification scheme limit that scheme to areas where such features are

Table 3: Natural Science Categories Used for Unique Natural Areas in Wisconsin

I. Landforms

a. mountain peaks, notches, saddles and ridges
b. waterfalls and cascades
c. gorges, ravines and crevasses
d. deltas
e. peninsulas
f. islands

II. Geologic

a. cliffs, palisades, bluffs and rims
b. man-made rock outcrops
c. natural rock outcrops
d. volcanoes (geologic evidence)
e. glacial features (moraines, kames, eskers, drumlins and cirques)
f. natural sand beach, sand dunes
g. fossil evidence
h. caves
i. unusual rock formations

III. Hydrological

a. significant and unusual water-land interfaces (scenic stretches of shore, rivers or streams)
b. natural springs
c. marshes, bogs, swamps and wetlands
d. aquifer recharge areas
e. water areas supporting unusual or significant aquatic life
f. lakes or ponds of unusually low productivity (oligotrophic)
g. lakes or ponds of unusually high productivity (eutrophic)
h. unusual natural river, lake or pond physical shape

Table 3 (continued)

IV. Biological--flora
- a. rare, remnant or unique species of plant
- b. unique plant communities
- c. plant communities unusual to a geographic region
- d. individual specimens of unusual significance
- e. plant communities of unusual diversity or productivity
- f. plant communities representative of standard forest plant associations identified by the Society of American Foresters and American Geographical Society

V. Biological--fauna (classification is the same for fish, birds and terrestrial animals)
- a. habitat area of rare, endangered and unique species
- b. habitat area of unusual significance to a faunal community (feeding, breeding, wintering, resting)
- c. faunal communities unusual to a geographic area
- d. habitat areas supporting communities of unusual diversity or productivity

Source: Sargent and Brande (1976, p. 113) found. Reeves (1980), in developing a very similar scheme (for similar purposes) only several hundred miles away, found the categorization system of Sargent and Brande (1976) very inappropriate for his needs. Finally, while floristic components are mentioned in their scheme, faunal components are not. Only the habitats of rare and endangered and unique fauna are listed as sub-categories implying that, for their study, habitat retention (or loss) is the only means by which animal species may be protected (or threatened).

Over the last decade, the State of Washington has employed a classification system for the components of natural diversity within the state as part of its Natural Heritage Programme. The program was initiated in large part by the Nature Conservancy of the United States and is similar to those found in several other states. The data which are inventoried and classified may be put to a variety of uses but, as Schwarz (1981, p. 10) states:

> The most critical of these uses allows us to concentrate our conservation efforts on those elements which are not only rare and diminishing, but are nowhere in the state represented . . .

The basic unit of this classification system is what is called an "element" (WNHP, 1983) and is analogous to what Dyrness et al. (1975) defined as a "cell." The major element types which comprise the system are listed in Table 4. Elements consist of those biological and geological entities, such as organisms, communities and geological features, that are desirable to protect. Organisms only receive explicit recognition as an element if they are considered rare or endangered or are of particular scientific significance. Otherwise, they are considered implicitly as part of a community or habitat type.

Table 4: Element Types Used as a Coarse Classification System for Components of Natural Diversity in Washington State

1. Special Plant Species

2. Special Animal Species

3. Special Ecosystems
    a. Terrestrial
    b. Aquatic

4. Unique Geolog[illegible]tures
    a. Unique a[illegible]rable Elements
    b. Prominent [illegible]ts of High Scientific and Educational Value

5. Marine Ecosystems

Source: Washington Natural Heritage Programme
(1983, p. 9-12)

This approach assures a comprehensive inventory of all natural features within the state or any jurisdiction which utilizes the approach. Its major innovation is that it avoids the stress on whole tracts of land within the classification system and focuses on the basic elements of the natural environment.

The only problem with the program is its lack of a clear statement regarding what should be included under each classification category. For example, within the element type "Special Plants," the only stipulation is that it must be a species native to Washington and does not include introduced, cultivated or ornamental species, sterile hybrids or minor floral variations. Under the element type "Special Animals," the plan is to include a:

> subset of those defined by the Game Code (RCW 77.12.175) which includes, "wildlife species including but not limited to songbirds, protected wildlife, rare and endangered wildlife, aquatic life, and specialized habitat types, both terrestrial and aquatic, as well as all unclassified marine fish, shellfish, and marine invertebrates . . ." (WNHP, 1983, p. 10).

Finally, the definition used for terrestrial and aquatic ecosystems and geological features implies that the former are to be protected with priority given to those which are rare, threatened or unprotected and the latter if they are easily destroyed. The emphasis of the system is placed on those elements which are rare or threatened or both.

In its attempt to identify Natural Sites of Canadian Significance, Parks Canada (1983) has perhaps come the closest to developing a comprehensive conservation classification system. It lists as "criteria" what this author identifies as "categories" within a classification system. However, the end result is the same in that both studies use these terms to identify and categorize natural features. The complete system is reproduced in Table 5. It is comprehensive, in that it lists all possible natural phenomena in major categories (i.e. botanical, wildlife, geological and ecosystem). It does not list specific kinds of features and has, therefore, general applicability. Unlike the State of Washington's system, Parks Canada employs a variety of sub-categories (including rare, superlative, endemic and benchmarks) many of which are suitable for SFI feature-type headings. It does not use any complex hierarchical structure or dichotomous keys; only a simple listing of sub-categories. Natural areas and features are identified using clearly defined characteristics and if seen as being significant are placed within the appropriate category and sub-category which best describes them. By clearly defining the terms used within the classification system Parks Canada has developed a totally comprehensive method of identifying natural features.

2.3.3 Criteria and Criteria Set

Many criteria have been used in the evaluation of natural features for conservation purposes. Only a limited number of studies have indicated exactly how their particular criteria set was arrived at. Only the earliest studies provide any theoretical basis for criteria selection (see for e.g., Ratcliffe, 1977 and Austin and Miller, 1978). Margules (1984, 1986) allowed criteria to be developed intuitively and independently amongst a group of assessors, while Sparrowe and Wight

Table 5: Identification Criteria Used for Natural Sites of Canadian Significance

- I. Botanical
  - a. rare species
    - a.1 concentrations of rare species
      - i) refugia
      - ii) remnants
      - iii) centers of evolution
    - a.2 individual species
  - b. rare environments
  - c. superlatives
  - d. exceptional representative sites
- II. Wildlife
  - a. habitat of species or populations of special interest
    - a.1 sites important for rate, threatened or endangered species;
    - a.2 sites important for other species or populations of special interest
      - i) endemic species
      - ii) relict species
      - iii) disjunct populations
  - b. sites of spectacular concentrations of wildlife
- III. Geological
  - a. geologic time
    - a.1 life history
    - a.2 earth history
  - b. geologic structures
  - c. geologic materials
    - c.1 rock types
    - c.2 mineral occurrence
    - c.3 soils
  - d. geomorphology
    - d.1 landforms
    - d.2 processes
  - e. hydrological phenomena
    - e.1 marine
    - e.2 freshwater
  - f. geographic benchmarks
- IV. Ecosystems
  - a. terrestrial ecosystems
  - b. aquatic ecosystems

Source: Parks Canada (1983)

(1975) and Fuller (1980) relied on a great deal of input from a variety of sources before deciding on their final versions.

One difficulty in using the literature and other professionals to establish a criteria set is that terms used for similar criteria vary from person to person and system to system. Margules and Usher (1981) examined nine studies and identified 18 classes of conservation criteria, which were then used to group the array of terms used in the various studies. Expanding on this approach, Smith (1984) reviewed 22 selected studies and identified 20 criteria classes. Both authors felt that this large number of criteria could be best comprehended and aggregated if they were placed into even smaller sub-groups which contained closely related criteria. Margules and Usher (1981) used the terms "scientific" and political" to distinguish between those sub-groups which are based on biological, ecological or biogeographic concepts and those which are oriented to planning and management considerations. Smith (1984) identified four sub-groupings--biotic, abiotic, cultural and planning and management--which pertain to either the measurement of site value to humans or to the measurement of endogenous characteristics of the site.

The existence of threat (the attribute of major concern in this study) was identified in both of the preceding studies. Margules (1981) recorded its use in six of the nine studies reviewed while Smith (1984) found it in only six of 22 studies. This disparity between the two studies likely reflects the differing priorities of extensively developed and densely populated areas (i.e. the majority of studies reviewed by Margules) and those which contain less degraded features (i.e. the majority of studies reviewed by Smith). None of the studies reviewed employed "threat" as the primary assessment criterion. Margules (1986) found that when it was used, it was applied most readily to small sites containing essentially special natural features. The result of this sporadic use of threat as an evaluation criterion is that either an incomplete listing of sub-attributes, which make up the criterion, is used or threat is described in only abstract terms. Defining any criterion in abstract terms allows the decision-maker to decide what constitutes a threat for each site being evaluated. However, intersite comparability suffers as does the understanding of the management implications for specific sites.

Many of the criteria classes developed by both Margules (1981) and Smith (1984) have been used in other studies to identify specific components of threat. For example, "rarity" (Sparrowe and Wight, 1975), "area" (Food and Agriculture Organization (FAO), 1982) and "buffer zone" (Wright, 1977) have all been identified as sub-attributes of threat which may jeopardize a feature's continued safety. "Naturalness" has been used by Tans (1974), Ratcliffe (1977) and the Island Nature Trust (1985) to imply freedom from human influence, though few if any natural sites are truly free from such influence. Some authors refer to natural settings as those being characterized by "minimum disturbance by Man" (Moir, 1972), "freedom of artificial human disturbance" (Jenkins and Bedford, 1973) and only "influenced by traditional or environmentally harmonious human uses" (Ray, 1975; Theberge, 1980). The difficulty with these terms is defining what is meant by "minimum," "artificial" and "harmonious" human influences. These terms are highly subjective and difficult to measure.

Other studies allude to the more intrinsic and ecological qualities of phenomena which make them prone to the adverse effects of disturbance. They mention such terms as "fragility" and "high elevation" (Sargent and Brande, 1976), "sensitivity" (Wright, 1977), "susceptible" (Ealey, 1981) and "vulnerability" (AFW, 1985) as attributes which are closely related to threat. These descriptors reflect the intent of Ratcliffe's (1977) phrase "intrinsic sensitivity" but have proven difficult to measure objectively. Cairns and Dickson (1980), in developing a method of estimating ecosystem vulnerability used several notions including "vulnerable to irreversible change," "ability to resist displacement or disequilibrium" and "degree of resilience from damage or repeated displacement."

The confusion surrounding which attributes comprise threat for conservation sites and features has hindered the protection of those in the greatest need. Table 6 lists selected criteria used in 31 studies conducted in various countries to measure a variety of conservation values. The complete list of studies and criteria used by each are listed in Appendix 1. The major purpose of many of these was not to evaluate levels of threat <u>per se</u> but to assess and protect a wide range of phenomena including ecologically representative sites. However, all the studies used criteria that, whether intentional or not, measured sites based on their susceptibility to threat and/or those which demonstrated high levels of vulnerability. The 26 criteria listed in Table 6 represent generalized classes of similar criteria used in these

Table 6: Classes of Evaluation Criteria Used in the Measurement of Threat Levels at Conservation Sites

Criteria Heading and Type	Number of Studies Utilizing each Criterion (n=31)
Eligibility Criteria	
Redundancy	5
Purpose or Objective of Site Nomination	1
Threat Criteria	
Population Status (rarity, abundance)	26
Size/Buffer Zone	25
Naturalness (habitat loss, degradation)	23
Vulnerability (fragility, recovery potential)	14
Patterns of Population Concentration	9
Access (includes human population densities)	9
Environmental Contaminants	5
Rate of Naturalness Loss	3
Rate of Extinction	2
Hybridization Potential	2
Security of Taxonomic Unit	1
Current Levels of Use	1
Population Concentration	1
Fecundity	1
Specialization	1
r and k Factors	1
Hunting/Trapping	1
Planning and Management Criteria	
Land Use Conflicts	13
Degree of Existing Protection	11
Assessment of Management	7
Landowner Cooperation	5
Cost of Protection	4
Level of Significance	4
Level of Information	1
General Threat and/or Management Considerations	2

various studies and considered by this author to reflect sub-attributes pertinent in the measurement of threat. While the frequency with which a criterion is used represents some measure of its value to conservation assessors, lower scoring criteria should not be automatically dismissed from consideration. The criteria were categorized into biotic and abiotic criteria which measured the degree of urgency and desirability for protective action required by a feature (i.e. threat criteria), those which measured the suitability of a feature from a planning perspective (i.e. planning and management criteria) and those used to assess the suitability of a feature prior to its actual assessment (i.e. eligibility criteria).

Eligibility criteria were used in only six evaluation studies (see, Ray, 1975; Rabe and Savage, 1979; Quebec Dept. of the Environment, 1981; Parks Canada, 1983; Game and Peterken, 1984 and Keddy, 1984). This is not surprising since in most of the studies it was the evaluation system itself which was meant to distinguish between high quality (eligible) sites, and poor quality (ineligible) sites. Other studies which did not formally sort sites did so in an intuitive manner. Eligibility criteria were concerned with redundancy of sites, degree of current degradation, land use conflicts and most importantly, whether the site was being considered for the conservation purposes and objectives intended by the program (see, "Conformity to the Act" in Quebec Dept. of the Environment, 1981).

Of the 15 threat criteria listed, "Population Status" was the most highly valued based on frequency of occurrence in the literature, appearing in 26 of the 31 studies reviewed. The term encompasses the attributes of rarity and abundance and thus could also apply to abiotic features as well. "Size/Buffer Zone was cited in 25 studies and involves the concepts of biogeographic theory. "Vulnerability," "Patterns of Population Concentration" and "Access" were also frequently used, being employed in 23, 14, 9 and 9 studies respectively. All remaining criteria were used in five or fewer studies and should subsequently be regarded as being of only minor value for use in the assessment of threat. It is of note that the rate of change for both population levels and habitat degradation was of less importance than the current state of these characteristics for any given feature.

Planning and management criteria were mentioned in as many as 13 studies but on the whole were considered less valuable in the evaluation of features for conservation purposes. This lack of emphasis on this class of criteria corresponds to the long held belief that conservation evaluation should depend more on ecological or on-site attributes than on non-ecological or off-site attributes (Unesco/MAB, 1974; Fenge, 1982 and Smith, 1984). "Land Use Conflicts" were used in 13 studies and pertain to the potential management problems of competing with other land uses. "Degree of Existing Protection," "Assessment of Management," "Landowner Cooperation," "Cost of Protection" and "Level of Significance" were valued moderately (11, 7, 5, 4, and 4 studies respectively) and relate to practical implications of site protection. Only two studies, Ranwell (1969) and the FAO (1982), mentioned threat or management considerations in general terms without specifying how these were to be measured. Only one study (Sparrowe and Wight, 1975) used

"Lack of Information" as a basis for assigning site priority. This condition was not used as a separate criterion but was used within the scale of measurement of each criterion in the criteria set. An example of this is provided in Table 7. The lack of knowledge of a site was the most highly valued condition for any given criterion. This factor was used to direct the decision-maker to provide the information required. If a site was threatened with imminent destruction, the authors recommended that action should be immediately taken to secure the site regardless of the need for information.

Although the criteria listed in Table 6 measure some aspect of threat or site vulnerability, redundancy in the criteria set of any evaluation must be avoided (see Chapter 2.4.4). For example, "Current Levels of Use" was used in only one study and could be considered a redundant criterion. This criterion is important only to the extent that access to the site is possible and should most likely be included under the criterion of "Access." Both could be easily subsumed ~~by the~~ overlapping and highly valued nonenvironmental criterion "Land Use Conflicts." "Fecundity" and "Specialization" could also be combined into the more general criterion of r and k selection factors of plant and animal species (Ricklefs, 1979 and Parry, 1981).

Once a set of criteria has been established, the type of measurement applied to each criterion must be decided upon and may take one of several forms. These forms may be generally classed as follows:

1. criteria used as guidelines only
2. criteria measured subjectively only

Table 7: Example of how the Factor of Limited Information may be Incorporated into the Measurement of a Criterion

Potential for Growth of Population (expressed as percent growth normally possible from one breeding season to the next under favorable conditions [10/25])

		Score
1.	High--growth rate greater than 100%	0
2.	High-Intermediate--growth rate 50 to 100%	2
3.	Intermediate--growth rate 25 to 50%	4
4.	Low-Intermediate--growth rate 10 to 25%	6
5.	Low--growth rate 5 to 10%	8
6.	Very Low--growth rate 0 to 5%	10
7.	Unknown Growth Rate	10

Source: Sparrowe and Wight (1975, p. 146)

3. criteria measured using a combination of subjective and quantitative criteria
4. criteria measured quantitatively only.

The form used depends in part on the quality and quantity of the available information, the objectives of the study and on the type of criteria being measured. The variation in form is reflected in the kind of measurement scale employed, which varies from nominal to continuous ratio.

A limited number of studies, such as Ratcliffe (1977) and Quebec Dept. of the Environment (1981) used criteria as functional guidelines, particularly those which involve public/government interactions (e.g. socio-economic pressure and ease of acquisition). The IBP terrestrial conservation section was the first attempt at a nationwide survey of natural ecosystems (see, Peterson, 1975 and La Roi, _et al._, 1979). Without a systematic approach for site comparison and criteria measurement, criteria served by necessity, as guidelines. Margules (1986), in examining the criteria selected intuitively by a team of experienced conservation assessors was not able to determine how each criterion was selected or measured. Consequently, he employed them as informal guidelines with site selection made by group consensus.

Most conservation systems do not use criteria as guidelines but rather attempt to provide some index of site value by applying numerical scores to each assessment criterion (i.e. classes two, three and four above). The degree of subjectivity of this approach depends largely on how reproducible and quantifiable the criteria are and if possible, systems are designed to measure the actual criteria using traditional scales (i.e. percent, numbers, ratio, etc.). For example, Fuller (1980) assessed the ornithological interest in sites for conservation purposes by measuring only three major attributes; population size, diversity and rarity. Extensive and detailed data on a site allowed for criteria to be quantifiably measured using ratio scales. Ploeg and Vlijm (1978) supplied mathematical formulations of surface area, diversity, rarity, reproducability and replaceability based on the methods used in ten studies in the Netherlands. Both studies stress the use of diversity and rarity as criteria. Not coincidentally, these have been extensively studied both in the field and in theory, and for which several accepted methodologies for their measurement exist.

It would be erroneous to assume that, in an attempt to be as objective as possible, only those criteria which are quantifiable should comprise the criteria set. Quantifiability assists in evaluation objectivity but is not synonomous with it. Reproducibility is the more reliable indicator of objectivity. All attributes which affect an entity (relative to the objectives of a study) must be used in the evaluation of that entity. In conservation evaluation, this will almost certainly include both qualitative and quantitative criteria unless subjective assumptions are made prior to the system's development. Fuller (1980) was required to make several primary and secondary assumptions prior to choosing his criteria. One stated assumption was that ornithological interest in sites could be classified into just three attributes and that these could be completely described through the measurement of only quantitative criteria.

Other studies, for example Helliwell (1969), Smart (1975), Austin and Miller (1978), Cottonwood Consultants (1983) and the Canadian Wildlife Service (CWS) (1984) used a combination of criteria in their systems. Parks Canada (1983) systematically evaluated such attributes as rarity, species diversity and community representativeness in their identification and selection of Natural Sites of Canadian Significance (NSCS). They also assessed more subjective attributes, such as special interest for wildlife and botanical superlatives in addition to using planning and management criteria as guidelines in negotiations with other government agencies (Parks Canada, 1982). In developing a system to priorize threatened wildlife in Alberta, the AFW (1985) likewise used a combination of criteria. Percentile and ratio measurements were used for most of the biological criteria but for life-history and extrajurisdictional factors, constructed ordinal scales were used with each level carefully defined. Smith (1984) incorrectly identified the approach of Rabe and Savage (1979) as being solely quantitative. Rabe and Savage's ~~system~~ assigned points to 24 physical and biological characteristics but also allowed for further site evaluation based on site ownership, alternate uses and threat. Furthermore, prior to the actual evaluation, a site was required to meet two basic criteria--"natural condition of site" and "no immediate use conflicts." Both criteria served as eligibility guidelines.

Most conservation evaluation systems measure the total subjective value of the criteria set by assigning different "scores" or "points" to levels of each criterion and aggregating the subtotals (see for e.g., Ranwell, 1979; Sparrowe and Wight, 1975; Reeves, 1980; FAO, 1982 and

Island Nature Trust, 1985). The low and high ends of the scale usually represent the realistic extremes of each attribute as shown in Table 8. Each level of the scale is defined and the definition may incorporate several aspects including the "imminence" or "probability of occurrence" of a criterion. For example, Tans (1974) assessed the physical characteristics of a site for the selection of Biotic Natural Areas in Wisconsin using both "size" and "buffer zone." The points assigned each level may increase by ones (i.e. 1, 2, 3, ...) as in Gelbach's (1975) system or by multiples (i.e. 0, 2, 4, ...) as in Sparrowe and Wight (1975). The use of even smaller units (i.e. fractions) is seen in the study by Reeves (1980). The type of gradation used may even vary within a single system (see for e.g., Sargent and Brande, 1976). While giving numerical value to a series of slightly changing definitions may make sense intuitively, such an allocation of points has little meaning. The assignment of points implies precise intervals between verbal descriptions yet such distances are unclear and may vary depending on the wording used at each level or the interpretation of the wording. The most obscure approach is exemplified by Wright's (1977) system, where the levels defined for each criterion are first scores as either 1, 2 or 3 and then directly transferred to high, medium and low ordinal rankings. As pointed out specifically by Smith (1984, p. 32) (and criticized generally by Kettle and Whitbread, 1973); "This is simply improper use of an ordinal scale" (see Chapter 2.4.5). Nevertheless, Wright (1977) compared his own system with those of Tans (1974) and Gelbach (1975) using ten sample sites. He found that while the final

Table 8 Example of how Points may be Assigned to Defined Levels of a Criterion

Level of Threat

Point Allocation	Points
Threat is imminent; main features currently being developed or destroyed	10
Threat is imminent to portion of main feature	8
Threat moderate; development probably in future	6
Disturbance encroaching upon area	4
Little threat; destruction unlikely	2

Source: Tans (1974, p. 38)

aggregate scores varied between the three studies, the priority rankings of the sites were the same. In Table 9, a list of the systems discussed are grouped to indicate the type of criteria used for each.

2.3.4 Methods of Criteria Aggregation

The condensing of pertinent information into one or a few indices has been considered essential in most decision-making problems (Keeney, 1982). Despite criticisms of this approach on either practical (Margules, 1981) or theoretical grounds (Ploeg and Vlijm, 1978), it continues to be the most accepted way to evaluate sites for conservation and wildland management purposes.

Only a limited number of studies have chosen not to combine sub-scores (Fuller, 1980 and Parks Canada, 1982) or to do so only ordinally (Ratcliffe, 1977). Most of the systems aggregate sub-scores using very unclear or informal processes involving addition or multiplication of scores. Systems using such processes have been developed by Tubbs and Blackwood (1971), Goldsmith (1975), Wright (1977), Sargent and Brande (1978), Reeves (1980), AFW (1985) and the Island Nature Trust (1985). This method consists of first assigning subjectively derived weights to each criterion then multiplying these weights by the associated scores received for each criterion. After the weighted scores are obtained they are usually added together to arrive at a final aggregate index for a site or feature. A variation in this approach is suggested by both Tans (1974) and Gelbach (1975). They recommend that instead of the addition of sub-scores they be multiplied together, as this accentuates the rank differences between sites. While this would undoubtedly prove

Table 9: Continuum of Categories for Conservation Evaluation Systems

Quantifiable Criteria Only	Combination of Quantitative and Subjective	Subjective Criteria Only	Criteria Used as Guidelines Only
Fuller (1980)	Helliwell (1969)	Tubbs and Blackwood (1971)	IBP*
Goldsmith (1975)	Everett (1978b)	Tans (1974)	Fisher et al. (1969)
Ploeg and Vlijm (1978)	CWS (1984)	Gelbach (1975)	Quebec Dept. of Environ. (1981)
	Austin and Miller (1978)	Ray (1975)	Ratcliffe (1977)
	Smart (1975)	FOA (1982)	Margules (1986)
	Parks Canada (1982, 1983)	Ranwell (1969)	
	Cottonwood Cons. (1983)	Wright (1977)	
	AFW (1985)	Game and Peterken (1984)	
	Ontario Ministry of Nat. Resources (1984)	Reeves (1980)	
	Rabe and Savage (1979)	Sargent and Brande (1976)	
	Keddy (1984)	Island Nature Trust (1985)	
		Sparrowe and Wight (1975)	

*Peterson, 1975 and La Roi et al., 1979

more convenient for the assessment team in separating groups of sites from one another, it has no justification based on the extensive theory on multiple criteria decision-making (see Chapter 4).

Tans (1974) did not explicitly weight his criteria but gave greater emphasis to some criteria by giving them higher maximum values. This resulted in a potential for these criteria to have a greater "impact" on the final score, since they could potentially contribute higher values than those allowed by the other criteria. Using this approach, comparability between sites would be highly variable and for this reason cannot be considered a sound method.

Another method has been used by Ploeg and Vlijm (1978) and Smith (1984). This method avoids the aggregation of attributes into a final score as well as the use of "non-ecological" criteria. As stated by Smith (1984, p. 38):

> In these systems the overall ranking is based on the highest rank each area has for any criterion. For example, the area with the most rare species would automatically occur in the highest ranking class as would the most diverse area.

The selection of a site based on its best attribute value while temporarily ignoring other potentially important attributes is definitive of the Maximax Multiple Criteria Decision-Making model (Hwang and Yoon, 1981). It tends to be ultra-optimistic in that it views entities only in terms of the best outcome for the strongest attribute. It is also inadequate for choices involving several criteria which are equivalent in importance. Furthermore, in the system proposed by Smith (1984), some sites are assessed using only one criterion, while others are assessed using several. Clearly, no valid comparisons can be made under these circumstances.

Based on the final scores, an entity may be assigned a position or rank within a group of status classes. WNHP (1983) lists three priority levels for ecosystems and species based on threat levels. AFW (1985) assigned four levels of threat (i.e. endangered, threatened, vulnerable and viable) to animal species based on their "status rating score," later combining the score with others to arrive at a "priority rating index." The range of status scores for the four levels of threat were established using hypothetical examples and species already listed under existing categories. Sparrowe and Wight (1975) use similar status classes for species in the United States.

Sargent and Brande (1976) assigned three priority levels to the combined total scores of areas. While the range of each level is indicated, how the divisions between levels was derived was not explained. Finally, Ratcliffe (1977) placed selected "key sites" in Great Britain into four classes based on a subjective assessment of their significance (i.e. international, national or regional).

2.3.5 Conclusion

This overview of conservation evaluation models has examined a broad range of approaches used in nature conservation. While most of the problems identified are evident in the earliest attempts, they continually re-appear in later efforts by other agencies in other pa[illegible] of the world. What is lacking is a critical analysis of the general evaluative/planning process as it applies to the field of nature conservation. This is particularly evident at the smaller political jurisdictions where a broad pool of expertise and/or experience may be absent. The greatest difficulty tends to be with measurement or score aggregation, rather than the establishment of a criteria set or classification system.

The emphasis in conservation efforts on classification systems based on plant communities is in part understandable and expected. Their relatively large size and lack of mobility are highly amenable characteristics to the biogeographic researcher. The rationale for this focus appears to be that by protecting a system of areas representing the major vegetation complexes, the associated flora and fauna will likewise be protected. Unfortunately, this assumption works best only when applied to large scale conservation practices or habitat assessments of widely distributed fish and game species. It omits from consideration the rare, unusual or otherwise special plant and animal species and associations identified at smaller scales. This kind of system does not allow for the identification of these types of natural features.

A classification system that deals only with one or a few aspects of the natural world or that deals in the large scale is rather inappropriate for broadly defined SFIs. The system required for SFIs needs to be more comprehensive in the scope of natural phenomena categorized, designed to identify smaller natural units including species and more generally applicable than those systems designed for a single jurisdiction or ecoregion. Furthermore, the system should be easy to utilize, since as Gelbach (1975, p. 80) points out:

> A survey organization cannot afford to devise such complex techniques of investigating and identifying natural areas that only professionals can use them.

This sentiment is clearly indicated in trend toward the use of subjectively assessed criteria. However, clear objectives, the outlining of how a criteria set was derived and how each criterion is measured represent the major problems associated with this segment of conservation methodologies.

Most models reviewed favored some final index of value for sites, derived by aggregating criteria scores. Virtually all lacked any explanation as to how or why this was done. Thus, both this component, as well as the resulting priority rankings of features, appear highly subjective and based on a priori judgements.

At the present time in Alberta, no comprehensive conservation strategy exists. Consequently, the agencies involved in resource conservation and management are subject to the same difficulties as those described in this review. It is therefore appropriate to review not only past conservation evaluation attempts but also the general theory behind the planning/evaluation and decision-making process. This review, coupled with the preceding one, will determine the direction of the conservation evaluation framework proposed in this study.

2.4 Concepts and General Components of the Evaluation Process

2.4.1 Introduction

Societal attitudes regarding nature conservation have been largely reactionary (Dasmann, 1968; Owen, 1980 and Margules, 1981). That is, they arose to proposed or real changes in land-use practices and other human-induced changes to the environment. Numerous examples exist which illustrate that "many reserves exist because they were under threat of some kind" (SPNC, 1980, p. 11). As stated by Margules (1981, p. 11), it was not until the 1970's that conservation became more pro-active:

> by shifting the stance of conservation from one of waiting to respond to threat to one of advocating land use change on its own behalf.

This attitude was initiated by Unesco/MAB (1974) outlining general guidelines for the selection of Biosphere Reserves. Rigorous discussions on the theoretical basis for criteria selection were provided by Ratcliffe (1977), Austin and Miller (1978), Everett (1978a) and Ploeg and Vlijm (1978). This gave land planning agencies a rational, strategic approach to site selection; one which would assist in defending choices against stiff opposition. It also gave planners a means of developing a list of priority sites and features.

A priorized list implies a comparison of alternatives, hopefully after a standardized evaluation of all alternatives is completed. Evaluation is part of the planning process which compares and chooses among alternatives based on some system of measurement. Margules (1981, p. 12) asserts that the development of some measure of conservation value would serve four useful purposes:

1. clarification of the goals of conservation policy
2. help judge the effectiveness of conservation programs
3. gauge the impact of proposed land-use changes; and
4. communicate trends in conservation effectiveness to officials of conservation organizations, decision-makers and the public.

It is important to appreciate the difference between "evaluation" and "decision-making" in the planning process. Although distinct in function, there is usually some overlap and they tend to be carried out by the same individuals (Edwards and Newman, 1982).

The function of evaluative research is to provide the best information possible regarding the consequences of specific actions, choices or alternative proposals. Kettle and Whitbread (1973, p. 96) suggest that one course of action being unanimously preferred solely on the basis of some evaluation is extremely unlikely since:

> Debates on the quality and interpretation of the evidence and its comprehensiveness, and on the fairness and justice of the proposals, as well as such considerations as the specific interests of the decision-makers themselves rule out [such a] proposal.

It is the responsibility of the DMs, therefore, to utilize the information provided by an evaluation to make decisions and justify their choices. They are most concerned with the socio-political aspects of the planning process, rather than the technical-analytical.

Definitions for, and conventional components of, the process of evaluative research have been outlined by several authors (Sochman, 1967; Robinson et al., 1976; Nijkamp and Van Delft, 1977; Ozernoi and Gaft, 1977; Cronbach et al., 1980; Edwards, 1980; Keeney, 1980; Zube, 1980 and Goicoechea et al., 1982). These authors' versions are very similar and have been incorporated into a single version as illustrated in Figure 2. It conforms to the generalized evaluation framework which has been used for many conservation evaluation systems, although most systems have not explicitly stated several components. Ideally, all of these components should be well developed and thoroughly understood by those involved in the evaluation. It is the lack of such development and understanding that has undermined the credibility of many past conservation efforts. Each component is briefly discussed below and in Chapter 4, the entire process will be related to the evaluative framework proposed in this current study.

2.4.2 Values, Goals and Objectives

Human values are varied, complex and change over time. Not everyone holds to the same set of values and if they do, they are not likely to place them in the same order of importance. This is due to the affects of the physical environment, past experiences, personal biases and various motivations on personal perceptions. This results in planners undertaking evaluations using the abstract--"good of the community"--justification, without assigning particular values to a truly identifiable group. Yet for any evaluation to occur, some value system must be in place.

Once "held" values have been broadly identified, examples arise where these values are not being satisfactorily "assigned" to objects in the real world.[1] This represents a value to be pursued--a goal (Young, 1975). Objectives represent directions of improvement or preference along individual or complexes of values (Zeleny, 1982). A goal can become a measurable objective when it is assigned a direction of either "minimization" or "maximization."

Objectives may combine to form a single higher level objective. Keeney and Raiffa (1976) present a good example of this hierarchy. To improve the well-being of residents of New York City, many subobjectives were identified and measured. They included "decrease adverse affects on health," "decrease adverse economic effects" and "achieve as desirable a political solution as possible." These were broken down into even lower-level sub-objectives which eventually were measurable using a set of criteria.

For the proposed evaluation system of this study, the conservation of nature is the paramount, indeed the exclusive, value considered. The identification and preservation of that portion of nature defined in this study or SFIs is the stated goal. Being a methodological study, specific objectives are not explicitly identified. It has been left up to the DM to determine if, when conservation values and goals are weighed against other values and goals, they are considered a priority.

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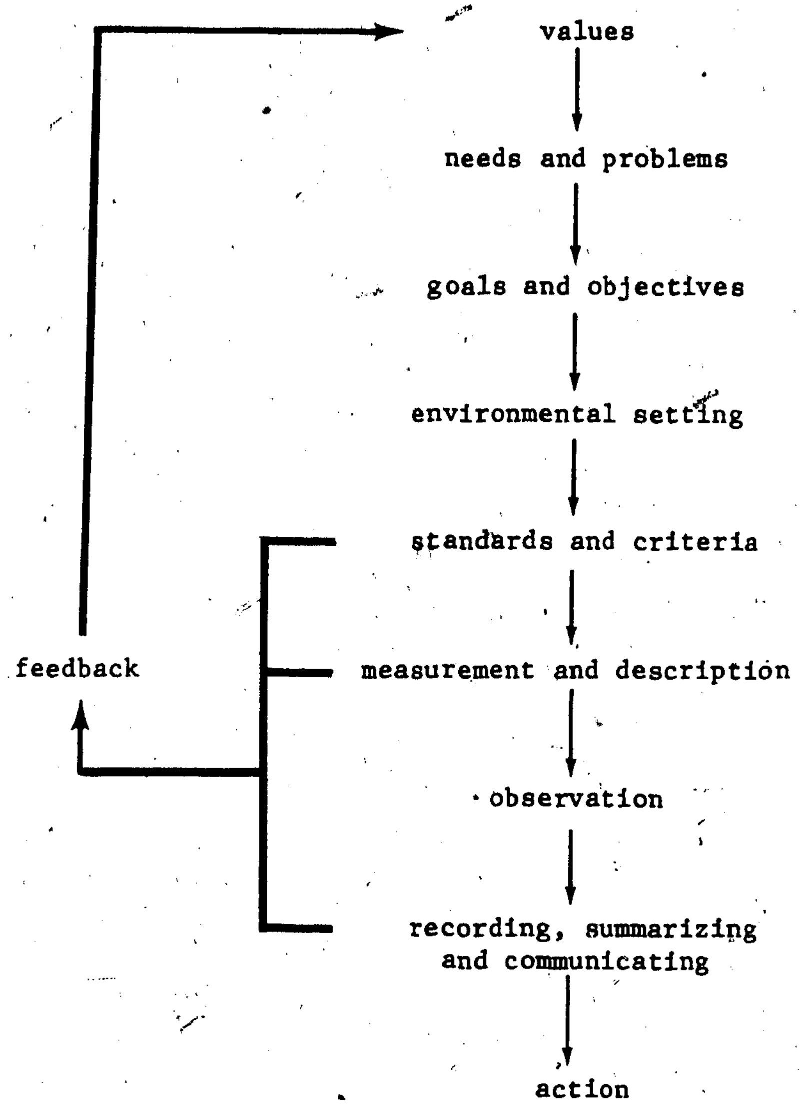
[1] See Brown, T. C. (1984) for a discussion on "held" and "assigned" values.

Figure 2: Generalized Evaluation Process



2.4.3 Environmental Setting

The listing of objectives allows for the environmental (i.e. physical) setting to be identified. The concept of environmental setting (i.e. environmental baseline information) serves to filter out unrelated features and impacts unrelated to specific features (Jain et al., 1981). The environmental setting is only that portion of the real world that the planning/evaluation process can alter by future courses of action (Faludi, 1970, & Gillingwater, 1975). For example, consider a university choosing between the construction of new housing or the renovation of existing facilities. The general domain being dealt with is university housing, while the particular setting could be on-campus, off-campus, etc. The domain for this present study is nature conservation requirements within the jurisdiction of Alberta. The needs are based largely on the assessments of threat and desirability of SFIs. The setting consists of those sites where such features occur.

2.4.4 Criteria

Criteria are the yardsticks by which the effectiveness of alternatives is measured (Hwang and Yoon, 1981). They result from both basic and evolved human needs and values. Few decision-making problems can be reduced to the evaluation of alternatives through the use of a single criterion. One exception is in the field of economics where value is measured by the unidimensional criterion of cost or profit.

Keeney and Raiffa (1976), in their seminal work on decision-making with multiple criteria, identified five attributes crucial to any set of criteria. These are: completeness, operationality, decomposability, nonredundancy and minimal size.

"Completeness" refers to the necessity that all important aspects of the alternatives are covered by the set of criteria. It includes the condition of "comprehensiveness" in that each criteria must encompass the full range of probable levels any alternative may obtain. "Measurability" is also important in that it must be possible to apply some reasonable scale to each criterion.

For the direct comparison of alternatives to be meaningful, a set of criteria is considered unacceptable if even one criterion is not relevant to all of the alternatives being compared (Ozernoi and Gaft, 1977). Since there is no formula to determine acceptability and completeness of a criteria set, the judgments of professionals is required.

"Operationality" implies that the criteria must be meaningful and acceptable to the DM so that they understand the implications of their decisions. This is particularly useful when the DM needs to communicate policies or advocate a position.

Keeney and Raiffa (1976) state that as the number of criteria increase, it becomes increasingly difficult to determine total aggregate value for all the criteria and to weight each relative to the other. This situation is alleviated if the criteria set is "decomposable" into smaller subsets of related criteria. For example, Sargeant and Brande (1976) evaluated unique natural areas using criteria divided into "natural science" and "planning" subsets, later combining the two to derive a total value for each site.

"Nonredundancy" refers to a reasonable non-overlap in meaning of criteria. If this occurs to any great degree, it places an unwarranted emphasis on what is essentially a single criterion divided in two. For example, McKean (1958) considered two criteria involved with the allocation of water resources. These were "increase in farm income" and "increase in livestock yield." These criteria are redundant since the latter is only important in so far as it directly affects the level of the former. This problem commonly occurs when the DM confuses the means (i.e. the criteria) of measurement with the desired end result (i.e. the objective).

While the criteria set should be as comprehensive as possible, several author suggest it is desirable to limit the total number of criteria used (Miller, 1956; Keeney and Raiffa, 1976; Edwards, 1977 and Nijkamp and Van Delft, 1977). The suggested upper limit for a criteria set is approximately twelve. (The set may be somewhat larger if it is broken down into subsets, as stated earlier.) Beyond this limit, the accuracy, consistency and reliability of assigning values or weights to criteria are greatly reduced. Furthermore, the greater the number of criteria used, the greater the averaging of the final value and subsequent masking of a high (or low) value for a given criteria. This can be partially remedied by a weighting system being placed on the criteria set. The function of weights is to numerically express the importance of each criteria relative to all others (Yu, 1985). How each criterion is measured is equally important in an evaluation system. Much care must be taken with the development of weights and measures of criteria as these are the most crucial means for choosing between alternatives. Most evaluations developed for conservation purposes do not outline the rationale or general approach by which criteria, their measurement or weighting is arrived at. The considerable variation in approaches suggests no standardized methodology. Criteria weighting is discussed in Chapter 4.2.6 and the concept of measurement is discussed below.

2.4.5 Measurement and Description

The ranking of sites for conservation management purposes is not possible without some form of measurement applied to the criteria. Measurement has been defined by Finklstein (1982, p. 6) as a:

> process of empirical, objective, assignment of numbers to properties of objects or events of the real world in such a way as to describe them.

Properties (i.e. attributes or criteria) of objects must be observable and measurable using some numerical relation. If the expression of a particular property in two objects (i.e. alternatives), once measured, are found to be equal, then the two property expressions are empirically indistinguishable. Conversely, inequality of measures implies empirical distinguishability. Although the above indicates that measurement is a process of property (not object) comparison, the implication is that there is an empirical relation which would allow the placing of the objects in the same order as the property, with respect to that property.

Measurement is an objective process, meaning that the assignment of numbers to a property by measurement must, within the limits of error, be independent of the observer. With regard to this present study, this infers that regardless of the assessor, features will be priorized in the same general order. This however, does not address specific problems inherent in the evaluation of natural features. Margules (1981, p. 13-14) states:

> Measurements taken in the field can be different in both magnitude and content depending on the time of year or, particularly, for many insects, the time of day. Different sample sizes make comparison extremely difficult, if not impossible. Some sites may be visited many times and some only once.

The values, attitudes and experience level of the assessor also create fundamental problems in measurement. This is most true for "constructed" scales (Keeney, 1980). Constructed scales lack common usage and interpretation. They are often developed for specific problems and each level of the scale must be clearly defined in words to convey its meaning. The lack of clear definitions is evident for criterion in many conservation evaluation systems.

Methodological or design errors may also exist in an evaluation system (Sydenham, 1982) which will consistently and erroneously rank certain kinds of alternatives higher than others. This is usually due to the inappropriate type and range of the scale used for each criterion in the criteria set (see for example, Tans, 1974).

There are four basic scales of measurement: nominal, ordinal, interval and ratio (Steele and Torrie, 1980).

The nominal scale is the weakest level of measurement and is used exclusively for the categorization of objects or events into a set of mutually exclusive subclasses (Batschelet, 1978). "Red," "blue," "green" and "yellow" are nominal labels of color, although one may argue that they actually grade into one another on the light spectrum. No ranking of classes is possible with a nominal scale and only the simplest of mathematical relations, such as mode and frequency, can be applied to it (Siegel, 1956).

The ordinal scale allows for the assignment of positions amongst categories, although the intervals between categories is not definable. Any appropriate symbolization may be assigned to the categories to convey this relationship. Moh's scale of hardness of minerals is often used as an example of an ordinal scale. Ten standard minerals are arranged in an ordered sequence so that preceding ones in the sequence can be scratched by succeeding ones and cannot scratch them. This scale assigns each standard a number from one to ten although any scale size is valid, including nonnumerical scales such as "high," "medium" and "low." If several items can be placed into a single rank, it is a "partial" ordinal scale and if each has its own unique rank relative the others it is a "complete" ordinal scale. The properties of this scale are not compatible with the arithmetic operations of addition and subtraction which require standard intervals between classes. Nevertheless, Siegel (1956) and Smith (1984) point out that arithmetic operations are still incorrectly applied to ordinal scales in much evaluative research.

An interval scale of measurement is achieved when the mapping of subclasses is so precise that we can assign a numerical distance between them. Both the unit of measurement and the zero point are arbitrary but once set, must be constant among all subclasses. Temperature and time are examples of measurement on an interval scale. For interval scales, the ratio of any two intervals is independent of the unit of measurement and the zero point. As in the case of temperatures, the ratio of differences between 30 and 10, and 10 and 0 on the Celsius scale is 30-10/10-0 = 2 and the comparable reading on the Fahrenheit scale is (86-50/50-32 =) 2 as well. All normal arithmetic operations can be applied to an interval scale.

The only distinction between interval and ratio scales [illegible] that the latter has a true zero point as its origin and th[illegible] its scale points (as opposed to its intervals) is indepe[illegible] the unit of measure. Weight, for example, [illegible]red on a ratio scale.

The only truly quantita[illegible]s, are the last two: interval and ratio. Objects measured on the[illegible]cales may be either "discrete," that [illegible] the assumable values are finite and isolated, or "continuous," where the range of values an object may assume is infinite (Steele and Torrie, 1980). However, some ordinal scales require an underlying continuum for the observed objects. For example, in ordering each exam mark in a set of marks as either a "pass" or a "fail," the assumption exists that there is in reality a continuum of possible marks (Seigel, 1956).

Regardless of the scale, the meaning of the numbers is not always stated clearly. "Representational" measurement implies a direct correspondence between the properties of that being measured and the numerical measurement system (Coxon, 1982). A value of 10 for a basket of 10 apples is an example of such a measurement. Conversely, an "index" measurement does not necessarily imply any such direct correspondence. An index value of 10 for the same apples may direct one to the tenth warehouse where they are stored.

Finally, the nomenclature of a measurement and what attributes make a measurement valuable is most appropriately reviewed in the proceeding section.

2.4.6 Observation

For the purposes of conservation evaluation, "observation" may be considered as the ability to observe and interpret natural history, identify plants and animals and understand natural processes. Designers of evaluation systems must enlist the help of individuals who possess these qualities. As most decisions involve a variety of concerns it is unlikely that one individual can serve as sole expert. Most evaluations require a team of professionals to contribute judgments in their field of expertise.

Four qualities which give an indication of assessment performance (of ~~both the~~ assessor and the system) are: discrimination, repeatability, reproducibility and accuracy (Sydenham, 1982). Discrimination refers to the ability to react to small changes in the attributes measured and repeatibility to the ability of an individual observer to continually give the same value to an unchanging attribute. Reproducibility refers to the consistency amongst evaluators and accuracy to the ability to give the "true" value of an attribute. It is evident that these qualities are interrelated. For example, the degree of discrimination of a measured attribute can affect how accurate an assessor can be. Also, the accuracy of a quantity depends entirely on the available facts, hence overtime, repeatability may not be a desirable or possible quality to retain. Even reproducibility may be difficult to obtain since observational abilities vary among assessors. Margules (1981) states that assessors may bias their evaluations due to a particular interest in a segment of the natural environment. The implication is that group decision-making, one that involves an exchange of information and ideas, is preferable to that which involves a single individual (Keeney and Raiffa, 1976). It is still unlikely that a group of unbiased and fully informed assessors will arrive at the identical valuations for all alternatives.

It would be incorrect to assume that evaluations could be made more accurate and reproducable, as well as provide the DM with more "hard" data, if only objective measures could be used exclusively (Campbell _et al._, 1976). This assumes objective and subjective measures are mutually exclusive. In reality, objective measures are not derived without subjective _a priori_ preconceptions and judgments (Aaron, 1978; Zube, 1980). Even the assumed impartiality of professionals is, at some level, influenced by attitude and cognitive style (Miller, 1983).

In summary, observation is an integral component of conservation evaluation. Since evaluations are performed by individuals of varying background, subjectivity is inescapable. Margules (1986) recently studied the evaluation of relatively well-known and well-defined sites by a small group of experienced conservation assessors. He found that the intuitive and personal means used to weight and integrate criteria for site evaluation were so disparate that no final index of conservation value could be derived from them. He did discover that not only were certain criteria continually used but that certain criteria were positively correlated with others. Edwards (1977) expressed similar sentiments, stating that decision-making disagreements usually revolve around the relative ordering of values and not the kind of values used.

2.4.7 Recording, Summarizing and Communicating

Margules (1981, p. 14) states:

> There are limits to the human ability to transpose emotional responses, which much conservation value is, into numerical or even verbal terms. There are even greater limits to devising statistical procedures to simulate human responses.

However, a well-planned evaluation system can be successful in guiding assessor responses by clearly outlining the range of acceptable values for each criterion.

Smith (1984) considers one of the main functions of conservation evaluation is to summarize the amount of information to be considered into one or a few indices. The problem is the lack of an acceptable formalized approach to aggregate the information. While most conservation evaluations have attempted such an aggregation, the extent to which this has been successful has been questioned. Margules and Usher (1981) state that while assessors intuitively combine criteria, a theoretical basis for doing so is lacking. This is largely due to evaluations dealing with the aggregation of incommensurable units (e.g. dollars vs. level of pollution) and dissimilar scales of measurement (Bell et al., 1977).

Some authors decry the dissection of attributes to only later sum them, as it belies the nature of ecosystems and other associations (Ploeg and Vlijm, 1978). While perhaps accurate, the majority of evaluations do just that and this "divide and conquer" orientation is virtually essential for addressing complex, interdisciplinary problems (Keeney, 1982). The only justification for this approach provided in this chapter is that of communication. Evaluative research is intended to provide reliable and useful information to the DM for the development of policy (Zube, 1980). The only value of measurement, including evaluative research, lies in the use to which it is put. The inability of a DM to understand how information has been derived, results in its ineffectual and inconsistent use. A DM virtually never makes decisions in isolation when public values and benefits are at issue. Therefore, the DM must be able to communicate to others not only the choices made, but the rationale behind them.

The paramount task for conservation evaluation is the development of a system which is theoretically sound yet allows for the greatest possible understanding and communication between the assessors, the DM and the individuals who will ultimately be affected by the choices made.

2.5 Multiple Criteria Decision-Making Theory

Operations Research or Management Science is a relatively new discipline that has attempted to develop more formalized approaches to addressing such problems as those mentioned above. Operations Research concerns itself with various modes of decision-making which involve the extracting of essential elements of real life problems, analyzing the relationships that determine the consequences of decision-making and developing solution techniques that result in optimal value (Moskowitz and Wright, 1979; Goicoechea et al., 1982 and Hobbs, et al., 1984). Decisions usually need to be justified to regulatory authorities, superiors, the general public or to oneself. The practical implications of this approach is that the DM is forced to think hard about his values and choices and that it provides a sound basis and systematic approach by which a range of decisions may be rationally developed.

The area of Operations Research which focuses on the development of models for problems involving multiple-criteria is known as Multiple-Criteria Decision-Making Theory (MCDM). Zeleny (1982, p. 23) has classified the four basic modes of MCDM as follows:

1. Clearly defined, certain alternatives, which are evaluated in terms of a single criterion
2. Poorly defined, uncertain alternatives, which are evaluated in terms of a single criterion
3. Clearly defined, certain alternatives, which are evaluated in terms of multiple criteria
4. Poorly defined, uncertain alternatives, which are evaluated in terms of multiple criteria.

Figure 3 characterizes the modes by the kind of analysis best suited to each.[2] Rarely are problems purely one mode or another, but rather an amalgam of two or more. To determine which approach best describes this

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[2] Christensen, K. S. (1985) developed a virtually identical matrix which she used to address uncertainty in the planning process based on goals and technology.

Figure 3: Modes of Decision-Making Based on Criteria of Choice and Information on Alternatives

		Criteria of Choice	
		Single	Multiple
Description of Alternatives	Certain	Computation	Compromise
	Uncertain	Judgment	Inspiration

Source: Zeleny (1982, p. 23).

current study, the alternatives and criteria used for the study must be reviewed in light of Figure 3.

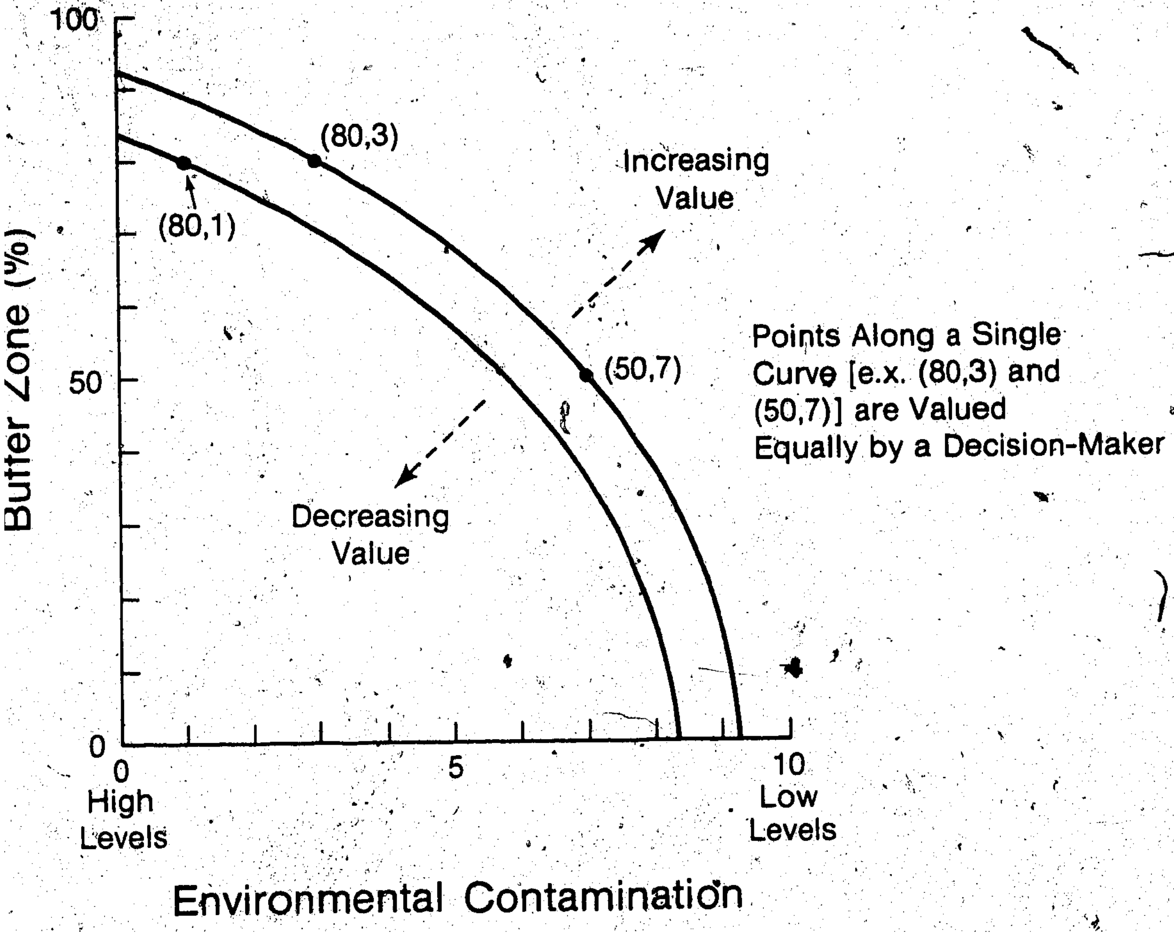
Most real life decisions involve a multitude of criteria and the evaluation of conservation sites is no exception. Natural settings are not usually identified by and valued for a single attribute, nor is adequate protection of a site or feature achieved through the control of a single factor. Also, there is a high level of certainty involving the alternatives (i.e. the candidate features) in that the DM has a very good idea that the alternatives chosen will meet the stated objectives. This is so because the criteria developed to meet the objectives were derived from the attributes of the alternatives (Hwang and Yoon, 1981).

Models may be further subdivided according to their ability to utilize hard and soft data (Nijkamp, 1983). This ability depends largely on the criteria chosen for evaluation. A criterion such as "Area of Site" may be measured in standardized units and result in relatively hard data. The more subjective criterion of "Degree of Existing Formal Protection" requires a constructed scale, which is a subjective endeavor and provides softer data. Poorly measurable or ill-defined criteria (i.e. the "fuzziness" of data [Seo, 1980]) are also considered a component of uncertainty for the DM (Keeney, 1982), in that these affect the degree of certainty of the alternatives. Since this study relies on a multitude of criteria resulting in both hard and soft data, the most appropriate mode of decision-making is one of compromise, using inspiration (i.e. professional judgment) whenever necessary and possible.

The compromise mode of MCDM consists of Compensatory Models (Moskowitz and Wright, 1979). These models consist of criteria which are considered nearly equivalent to each other, without one dominating the others. Scoring models (a category of compensatory models) use this equivalence to generate tradeoffs between the criteria in such a way that a measurable change in one criteria can be offset by an opposing change in any of the others (MacCrimmon and Wehrung, 1977; Keeney, 1980). A combination of criteria may have levels set in such a way as to be equal in value to another combination with levels set differently. To determine the most attractive alternative using a multi-dimensional space (i.e. many criteria), tradeoffs between the dimensions is a necessity. For example, consider only two criteria: "Extent of Buffer Zone" and "Degree of Environmental Contamination." The former is measured on a percentage scale (0-100) and the latter on a constructed scale (0-10). After suitable analysis it may be shown that scores of 80 and 3, respectively, are valued more than those of 80 and 1, but about the same as 50 and 7. Utilizing this information, a curve can be drawn, made up of combinations of the two criteria to which the DM is indifferent (i.e. the DM values each combination on the curve equally). The point (80,1) would exist on another curve below the first, indicating such a combination is not greatly valued. This concept is illustrated in Figure 4.

Roy (1977) emphasizes that certain pairs of alternatives may not always be comparable because the DM may not know how to or does not want to. Therefore, transitivity of combinations may not always exist in the

Figure 4: Example of an Indifference Curve Generated by the Valuation of Two Criteria by a Decision-Maker



real world. However, the assumption of MCDM is that indifference can always be ascertained by the DM.

Regardless, many researchers have employed a variety of procedures such as indifference curves to obtain criteria utility functions and weights. "Utiles" are the standardized units of measure of utility functions which can be used to measure all criteria. As Zeleny (1982, p. 141) states, most Compensatory Models assume:

> . . . the utility of a commodity bundle or multiattribute alternative is an aggregate of the utilities of its components.

From this, it can be reasoned that the alternative with the highest total utility or score will be the most preferred by the DM, the second highest will be the second most preferred and so on (Keeney, 1982). This decomposibility hypothesis, along with the assumptions of utility maximization and transitivity, represent the cornerstones of MCDM theory. All three are interdependent because if one is demonstrated to be unfulfilled, then the other assumptions might be violated.

The most informative and useful MCDM model for this study would be one that allowed alternative sites to be ranked with cardinal values. Cardinal values tell the DM that not only has site A been valued higher than site B but by how much. These values also allow for the categorization of ranked sites into groups with similar protection priorities. This can occur in much the same way that a range of final raw exam scores can be grouped into grades of A, B, C and D. For cardinal values to be the end product of an evaluation, it would be required that cardinal information be used as input. For many evaluations which use constructed scales the assignment of numbers to each level of the scale, with a later transformation to utiles, is all that is possible.

The best known and most commonly employed compensatory scoring model is the Weighted Average Method (WAM) (Goicoechea et al., 1982), also known as the Simple Additive Weighting Method (SAW) (Hwang and Yoon, 1981) and the Expected Value Method (Nijkamp and Van Delft, 1977). It allows for the use of multiple criteria, provides a ranking for each alternative and since criteria utilities result in cardinal values, a final cardinal value for each alternative. For these reasons it has been selected as the method by which to develop the evaluation scheme for this current study.

The most elaborate form of this method involves five basic steps, as stated by Keeney (1980) and Zeleny (1982):

1. introduction of terminology and ideas
2. determination of general preference structure
3. assessment of single-criteria utility functions
4. evaluation of scaling constants, and
5. testing for consistency.

The initial step involves introducing the DM to the terminology, concepts and procedures which are necessary for conducting meaningful assessment interviews. Interviews are conducted with the DM and are used to determine criteria utility functions and scaling constants. This allows the DM to provide more meaningful responses regarding this preferences and to understand how the evaluation component of the planning process utilizes his responses.

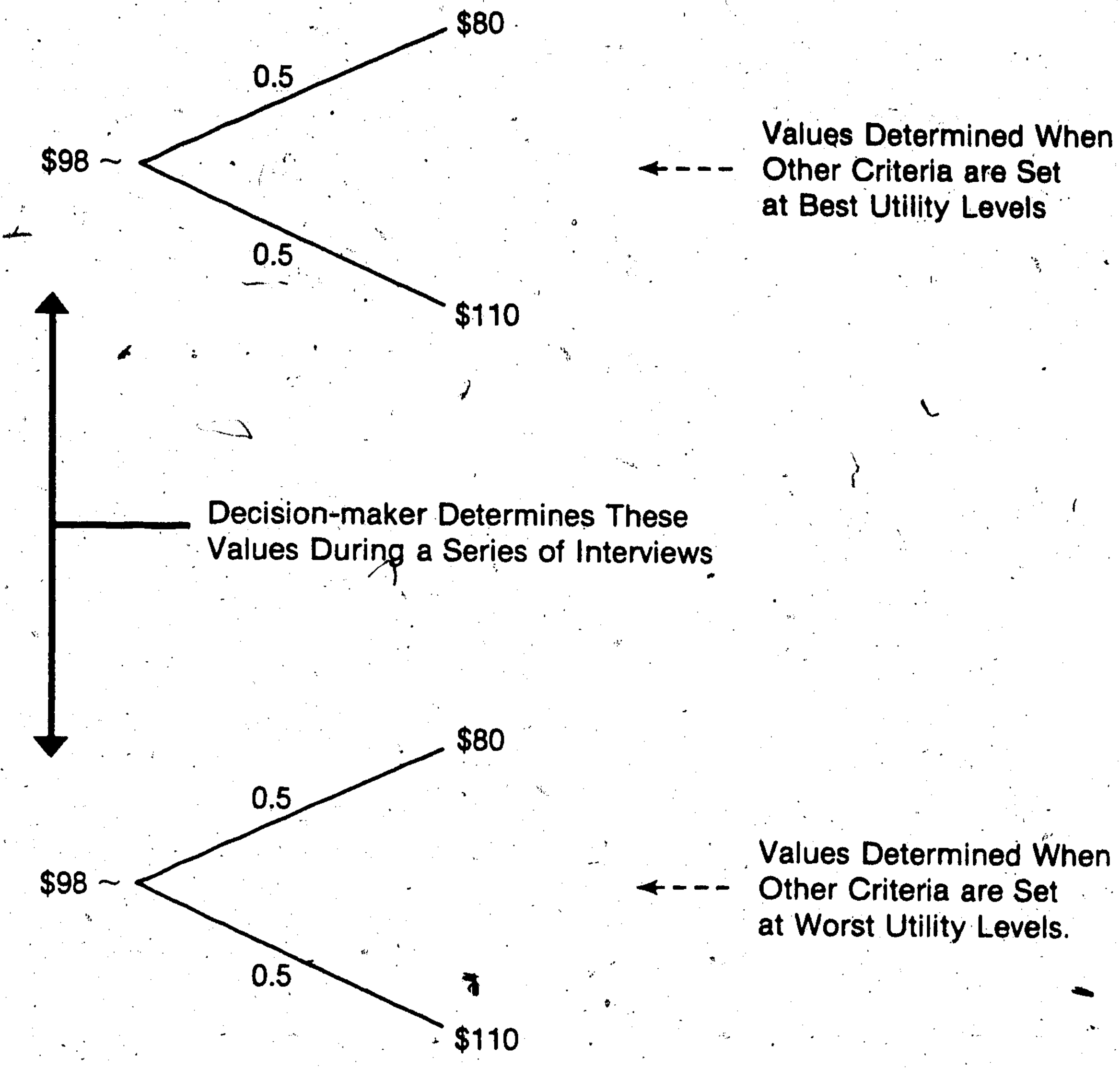
Before actually assessing utility functions, it is considered important in this most elaborate form to determine the form the functions should take (Keeney and Raiffa, 1976). This is accomplished by testing the level of "preferential independence" and "utility independence." Preferential independence concerns the DM's ordinal preferences among criteria, while utility independence concerns the DM's more precise cardinal preferences (Zeleny, 1982).

A pair of criteria are preferentially independent of criterion Z if the value tradeoff between X and Y remains unaffected by changing levels of Z. This means that regardless of whether Z is valued at any point through its worst to best levels, the indifference curve between X and Y will remain unchanged. This condition may apply to a set of criteria with three criteria, as in the example above, or any number of criteria.

Utility independence of criteria X is said to exist when conditional preferences for lotteries on X, given Y, do not depend on fixed levels of Y. A lottery is defined by specifying a set of consequences which may occur and the probability of each (Keeney, 1980). An actual example shown in Figure 5.

Figure 5 illustrates a lottery using the criterion of "project cost," where the remaining criteria in the set are fixed at any level. It depicts the best possible cost to be $80.00 (maximum utility of 1.0) and the worst cost to be $110.00 (minimum utility of zero). Using a series of questions, the DM is then asked what level of cost would be acceptable to him so that he would be indifferent between it occurring and a lottery where there was a 50-50 chance of obtaining either a cost level of $80.00 or a cost level of $100.00. A 50-50 chance means the

Figure 5: Example of a 50-50 Lottery used to Determine Utility Independence for the Criterion of Cost

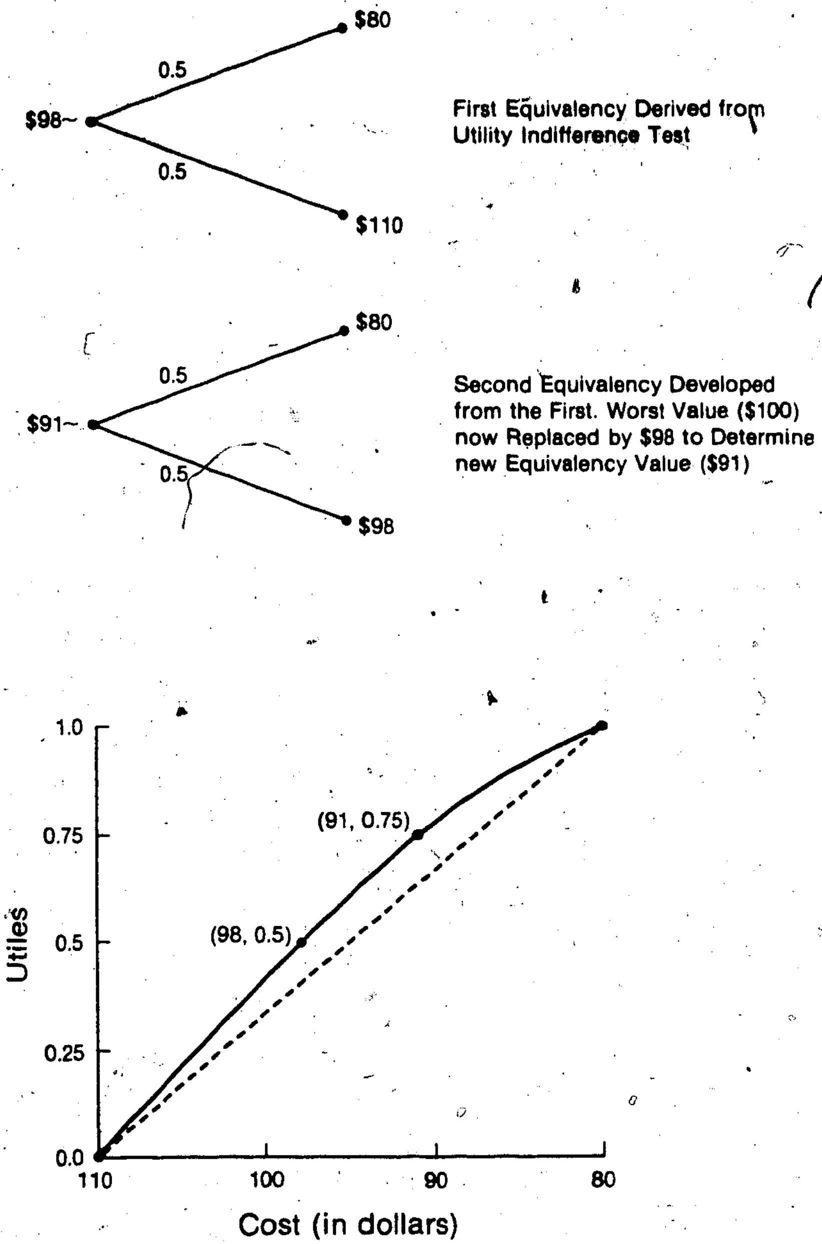


best and worst levels of cost are equally likely to occur. This value, referred to as the "certainty equivalent," has been elicted from the DM when the other criteria are set at both their worst and best levels. Since this value (in this case, $98.00) has been preferred under both conditions, the criterion of cost is said to be utility independent of the other criteria.

When both independence conditions are verified for all criteria, the utility function used to aggregate utilities may take either an additive and linear form or a multiplicative and nonlinear form. The choice between the two forms is based on the DM's attitude towards risk in decision-making which is discussed below.

By repeating the lottery process for a specific criterion, but replacing the worst consequence with a new one after each certainty equivalent has been identified, a utility curve (i.e. function) can be graphed for individual criteria (Figure 6). A concave utility curve indicates an aversion to risk by the DM and the multiplicative form is considered best suited to this condition. The criterion graphed in Figure 6 illustrates this case. The additive form is used when risk neutrality (i.e. a straight line) or risk propensity (i.e. a convex line) is indicated. The assumption is that diminishing marginal returns, as indicated by a concave line, are not very important to risk-takers. When multiple criteria are used, further questioning of the DM and a subjective assessment of all the curves is needed to determine the function's form. Again, a system of lotteries is involved.

Figure 6: Example of the Generation of a Utility Function from a Utility Independance Test for the Criterion of Cost



First Equivalency Derived from Utility Indifference Test

Second Equivalency Developed from the First. Worst Value ($100) now Replaced by $98 to Determine new Equivalency Value ($91)

After testing for both independence conditions and assessing criteria utility functions, the next step is the determination of the weight--or scaling constant--for each criterion. Scaling constants reflect the relative importance of each criterion and the sum of these weights is usually equal to 1.0:

This is a two-step procedure involving first, the ordinal ranking of criteria in order of general importance and seco[illegible] the quantification of the magnitude of each weight. Keeney (1980) suggests step one be accomplished by posing a series of questions to the DM. An example from Keeney (1980, p. 67) is as follows:

> Given that all n attributes are at their worst level, which would you most like to have at its best level, assuming that the n-1 attributes remain at their worst levels?

The answer to this question identifies the criteria whose weight value should be the largest.

Continuing this procedure with the other criteria would eventually result in the complete ranking of the criteria set. Note that some criteria may be considered of equal importance. Once this has been established, a series of indifference curves is generated. These curves compare the highest ranked criteria (e.g. "C6") with the remaining five. These indifference curves are used in step two of the weighting procedure.

The second step involves yet another lottery. The DM is required to determine a probability (p) such that there is indifference between the lottery and a certain outcome where all criteria are set at their worst levels except C6. At this stage, both the lottery and all criteria, except C6, have a utility of 0.0. If p was found to be 0.4, the utility of the certain consequence is the utility of C6. Therefore:

$$u(C_6) = p = 0.4$$

With the utility of C6 now known, the remaining scaling constants can be derived by using the value tradeoffs between C6 and the other criteria. These tradeoffs were identified in the indifference curves of step one.

The utility function, needed to determine the aggregate score and subsequent ranking of each alternative, is completely specified by the scaling constants and the individual criteria utility functions.

Any evaluation which involves the elicitation of values from professionals runs the risk of obtaining faulty or inconsistent information (Keeney, 1982). The time allotted to the study may be altered, objectives may change or the DM may simply not understand why the questions have been asked or the questions themselves. Consistency tests; the last step of this version of SAW; involve the reiteration of all or most of the component interviews in an attempt to reveal discrepancies in the DM's responses. If major differences are revealed, changes in the interview process may be required.

The procedures generally outlined above constitute perhaps the most technical and complex version of WAM used today. It was initially proposed by Raiffa (1968) and given its fullest theoretical treatment by Keeney and Raiffa (1976). Its very complexity makes it appear as a rigorous and highly desirable approach to decision-making. However, this approach has not been without its opponents who base their criticisms on both its theoretical and practical difficulties. A thorough discussion of these is not warranted here but a summary of the major points is as follows:

1. The WAM approach in general is rather rigid in approach and does not use the available information in a satisfactory manner (Nijkamp and van Delft, 1977).
2. The aggregation of criteria utility functions into an overall utility is only derived from a prescribed set of points connected by endpoints u(x) = 1.0 and u(x) = 0.0 of the evaluation space. These extreme value considerations occur when the analyst asks such questions as "if criterion X is set at its best level . . .," "if all criteria are set at their worst level but one which is set at its best level . . ." and so on. While this is necessary to keep the computational requirements at a manageable level, the U(x) is only affected by the situation defined by this line. Ideally, all possible decision outcomes should be addressed (Keeney and Sicherman, 1976; Moskowitz and Wright, 1979 and Zeleny, 1982).
3. Lotteries are chosen in an arbitrary, <u>ad hoc</u> manner and may therefore lead the DM to make preference choices which are not truly representative of his own (Zeleny, 1982).
4. Lotteries do not represent the actual conditions of the task at hand and therefore the DM's attitude towards risk is an artifact of the technique (Zeleny, 1982).
5. The extensive questioning which is conducted (see for an example, Keeney, 1980, pp. 282-317) is done in an intuitive manner. It

relies heavily on the abilities of the decision-analyst to elicit subjective numbers using hypothetical or idealized situations. It is not usable by a large number of individuals (Starr and Zeleny, 1977; Edwards, 1980; Zeleny, 1982).

6. Even when preferential judgments are "successfully" elicited, the assumptions made regarding the manner in which the DM has decided are in doubt (Goicoechea et al., 1982). It has been demonstrated in several studies that consistency in preferences is unreliable and even contradictory (Lichtenstein and Slovic, 1973; Fischoff, 1977 and Slovic et al., 1977).
7. Point (6) is largely due to the fact that DMs and people in general do not reach conclusions regarding preferences in the unfamiliar manner of lotteries (Zeleny, 1982).
8. The calculations involved in determining component utility functions and scaling constants is extremely tedious (Goicoechea et al., 1982).
9. The procedures are complex and difficult to teach, to understand and be used by busy DMs. The initial stage may cause the DM to reject the whole process outright or become disinterested in it at some point of the process (Edwards, 1977).
10. Even with a willing DM, there is a lack of immediate feedback to him regarding the implications of his preferences (Goicoechea et al., 1982).
11. There is no efficient way to update the DM's preferences if new information becomes available or to conduct consistency tests (Goicoechea et al., 1982 and Zeleny, 1982).

Even Keeney (1980) suggests that it is not always necessary to use such complicated procedures as described in this section. The nature of the problem, the client, the time available for the study and several other factors relate to and affect this decision. He maintains that such a rigorous version is still the only way to verify the qualitative assumptions made regarding the preference structure. However, perhaps the most compelling reason not to use this version, but a similar and yet more simple one, is that stated by Hwang and Yoon (1981, p. 103):

> . . . theory, simulation computation and experience all suggest that simple additive (linear) weighting method yields extremely close approximations to very much more complicated nonlinear forms, while remaining far easier to use and understand.

Other researchers agree (Einhorn and Hogarth, 1975 and Edwards, 1977), asserting that correlations in excess of .98 are typical. Daniel (pers. comm., 1986) suggests that nonlinear models which adhere to the economic law of "diminishing marginal utility" are most applicable in decision-making situations where the organization involved is near the end of its operating capital. Thus, the law is most meaningful when small differences in utility may have substantial consequences. This situation is not applicable to the practical consequences of the model outlined in this study. Furthermore, Keeney (pers. comm., 1986) suggests that for the purposes of this study (as outlined to him by this author) the necessity for a complicated model such as his is likely not indicated.

CHAPTER 3

EVALUATION DESIGN

The design of the evaluation framework involved the integration of decision-making theory with past approaches in nature conservation to meet the stated objectives.

The SAW approach, in general, has been widely used in the evaluation of alternatives ranging from nuclear plant siting to sociological problems. When used properly, it successfully deals with the recurring shortcomings of past conservation assessment systems. Based on the preceding literature review, it has been considered most prudent by this author to adopt a simpler version of SAW in developing the evaluative framework for this study. Edwards' (1971, 1977) Simple MultiAttribute Rating Technique (SMART) has been chosen due to its great advantage of being easily taught, its adaptability to a wide range of situations, its use of utility values to obtain cardinal numbers, its results closely resembling those of more complex models and finally, its requiring no judgments of preference or indifference among hypothetical entities. It also provides sufficient treatment of all of the components of the general evaluative framework presented in Chapter 2.4.1. The SMART method is outlined in Chapter 4, with this study, its objectives, environmental setting and criteria set, serving as a working example of the technique.

Part III: A Proposed Framework for the Classification, Evaluation and Priorization of Special Natural Features of Interest (SFIs)

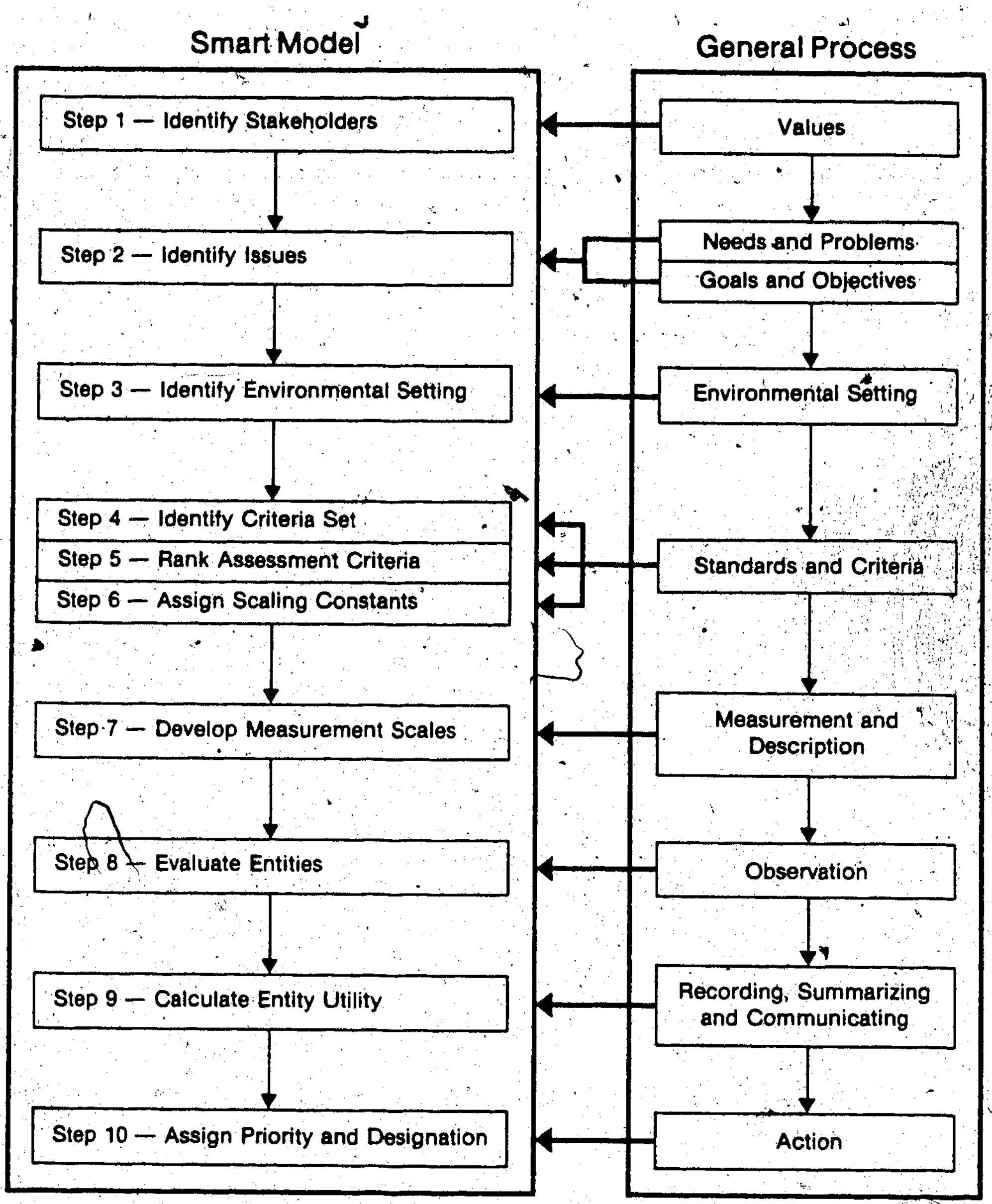
CHAPTER 4

A PROPOSED EVALUATIVE FRAMEWORK FOR SFIs

4.1 Introduction

The ten step SMART model, developed by Edwards (1977) and refined by Edwards and Newman (1982), was used as the framework for the proposed evaluation system for this study. It converts the values and objectives of stakeholders for a specific environmental setting into measurable criteria by which an array of alternatives is ranked. The rankings may then serve as a guideline for the initiation of conservation action. Each step is discussed in full but couched in the terminology of this current conservation study. The specific criteria, criteria weights and measurement scales discussed are those used for the test application in Chapter 7. How each step of the model represents each component of the generalized evaluative process of Chapter 2.4.2 is illustrated in Figure 7. The ten steps of SMART are discussed below. The two major components of the framework--the classification system and the criteria set--require a more detailed treatment, and are presented separately in Chapters 5 and 6 respectively.

Figure 7: Relationship Between the Generalized Evaluative Process and the Ten Step SMART Model



4.2 Steps in the SMART Model

4.2.1 Step 1 -- Identify Stakeholders

This model relies heavily on the subjective values (i.e. utilities) assigned to the features being assessed. The source of these values must come from those individuals or organizations which either make decisions regarding the assessed alternatives, or those who are affected by the decisions. These individuals are known as the "stakeholders" in the evaluation process; they are identified as having a stake in the outcome. Edwards and Newman (1982) state that values of the affected stakeholders enter less directly into the process since, it is presumed, their responses will be biased in their favor. Since DMs do not usually derive personal benefit from their professional decisions they are considered less biased. Also, evaluations intended to guide the internal workings of a program (as is the case [illegible] this study), require less input from outside stakeholders. DMs are viewed as being overly concerned with certain aspects of a program (e.g. the costs involved) and therefore, outside values are still required.

As is the case for most social programs, decisions are made at several different levels of government, involve several agencies within each level and affect many different public groups. Since utility judgements are made by individuals, those individuals must be carefully identified as actual spokespersons for the relevant stakeholder groups. The general public has often been identified as a loosely grouped stakeholder which decisions are meant to benefit. Because spokepersons for this group are not easily identifiable, value elicitation from them is often not done. The result is that public programs, of which conservation programs are but a few, often fail to adequately benefit the intended groups. Further confusing the issue is the fact that several arguments for conserving nature are based on "human-use free" values, such as the rights of all living things. Certain private citizens, highly knowledgeable in the area of concern, are invaluable in determining the values of the general public. It must be stressed that they are not intended to represent the opinions of the average citizen, but rather the informed opinion of a segment of the larger population. Additional input may be generated if independent academics are included as stakeholders (Edwards and Newman, 1982).

The study involved stakeholders from both the federal and provincial levels of government, from the general public (i.e. the spokesperson for an NGO) and from the academic world. The academic world was represented largely by the literature review in Chapter 2. The ranking and weighting of the assessment criteria as well as additional comments were obtained from the remaining stakeholders. The stakeholders were; Dr. Geoff Holroyd, CWS (Edmonton); Mr. Gary Erickson, AFW (Edmonton); Mr. Peter Lee, Public Lands Division, Alberta (Edmonton); Dr. Jim Butler, Department of Forest Science, University of Alberta (Edmonton) and Mr. David Dodge, Canadian Parks and Wilderness Society (Edmonton Chapter).

4.2.2 Step 2 -- Identify Issues

It is important to identify the issues for which the utilities being sought are relevant and state these issues clearly to the stakeholders. The issues will largely depend on the particulars of the evaluation, such as why is it done, the age of the program involved and if the process is to guide programatic choices or to assess the program itself. For this study, the conservation of nature is the issue. Specifically, the identification, evaluation and selection of those natural features in most urgent need of protection based on threat levels and desirability. Also relevant are secondary issues regarding planning and management considerations. Issues not dealt with in this study are the recreational opportunities a conservation feature or site may provide.

4.2.3 Step 3 -- Identify Environmental Setting

Step three involves the identification of those entities to be evaluated. This will depend on the purpose of the evaluation, but identification is generally enhanced if some means of defining or categorizing is in place prior to the actual evaluation. Both the general definition for SFIs, as well as the classification system outlined in Chapter 5 serve to define the environmental setting for this system.

To identify the major classification component--the feature-type headings--a series of interviews were conducted over a four month period. These were unstructured survey interviews consisting of two open-ended questions followed by repeated probing and clarification. The advantages and disadvantages of this technique are outlined in Stewart and Cash (1985) and are generally considered most effective in revealing what respondents think are important (Babbie, 1973). The personal interview was selected as the method of information gathering since methods such as the distribution of a questionnaire package have resulted in poor rates of response in other research and a high potential for response bias (Filion, 1974a, b). In a similar study, Lamoureux, et al. (1983) found that in most cases, persons had to be actively sought out to secure their cooperation and that when questionnaires were used, the completeness of responses varied greatly.

The initial open-ended question presented to each respondent was: "In your area of expertise and/or interest, what are those natural features in Alberta you consider to be 'special'?" Once a tentative list was elicited from each respondent, they were then asked: "What are the specific reasons you considered each feature listed 'special'?" By aggregating interview results into categories, a spectrum of special natural feature-types evolved. These were analysed for general importance in conservation in Alberta based on the frequency with which each occurred in the data.

The respondents selected for the survey collectively possessed a wide cross-section of expertise regarding the particular natural character of Alberta and conservation in general. Their expertise in a specific discipline or broader knowledge on an assortment of topics could have been gained either through professional, recreational or avocational activities. Individuals included local naturalists, members of environmental groups, government researchers and officials from agencies dealing with species or habitat management and university staff with expertise in disciplines including limnology, geology, botany, zoology, ecology and natural history. Their judgement and opinions were assumed to be representative of the larger professional group from which they were drawn.

Additional concerns involving the environmental setting are addressed by the eligibility criteria. These criteria are not part of actual site assessment but serve to screen-out irrelevant and redundant entities from further consideration.

✓ For each evaluation undertaken only one specific candidate SFI is dealt with, thus further specifying the setting. For example, the test application presented in Chapter 7 involves a "Biological--Faunal/Vertebrate/Bird" SFI. While the environmental setting for a particular SFI evaluation will change, the criteria set involved need not.

4.2.4 Step 4 -- Identify Criteria Set

Step 4 is accomplished in Chapter 6. This study departs from the approach taken by Edwards and Newman (1982) in that the set of criteria was not derived from the actual stakeholders but what may be referred to as stakeholder surrogates. These were the individual writers and researchers who are involved in nature conservation and conservation evaluation. This was appropriate due to the limited experience possessed by the author as a decision-analyst and the necessity of such experience to successfully attempt direct criteria elicitation. Secondly, the time and logistical problems of getting the stakeholders together was deemed too intrusive for an academically oriented study. Thirdly, it was felt that the literature on conservation and conservation evaluation fully represented the possible attitudes and values of those individuals involved in conservation, including those in Alberta.

When individuals are used to determine a criteria set, an extensive review is still essential for identifying redundant criteria, that is, attributes which are the same but worded differently and those which are not pertinent to the evaluation's objectives. The initial elicitation of criteria may be achieved using individual interviewing techniques or through group meetings, discussion and decision-making processes. In SMART, the Nominal Group Technique (Delbecq et al., 1974) is preferred over other forms[3] since it provides for an exchange of views and a common information base. The criteria set used in the test application of this study is presented as a dendritic hierarchy in Figure 8. It consists of four attribute categories (i.e. Disturbance/Sensitivity, Recovery Potential, Level of Significance and Planning and Management Considerations) within which 17 criteria are placed.

4.2.5 Step 5 -- Rank Assessment Criteria

Once the criteria set is finalized, the stakeholders are used to ordinally rank both the attribute categories, as well as the criteria

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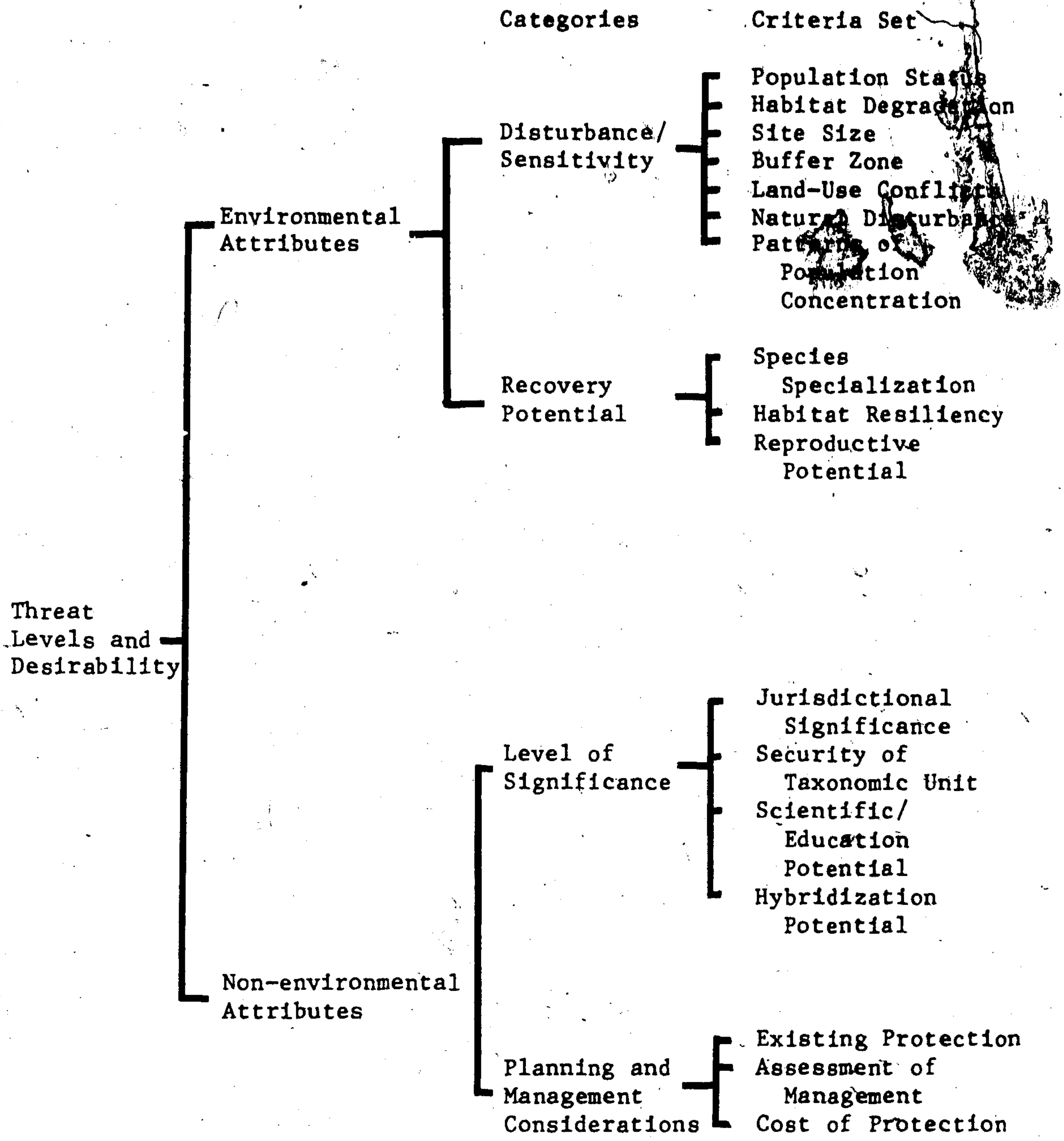
[3] See for e.g. the Delphi Technique in Moeller and Shafer (1983) and Bardecki (1984).

Figure 8: General Categories and Criteria Set Used in the Test Application of this Study



within each category, in order of importance. It is important that criteria be compared intracategorically only. If the values elicited are to be reliable it is necessary to explain fully to the stakeholders what the objectives of the evaluation are. Attributes will be valued differently depending on what is to be accomplished by the evaluation. It is also necessary to define to the stakeholders exactly what "importance" means as well the the terminology and general approach used to elicit their values. In past attempts at SMART, Edwards (1977, 1980) relied on the intuitive interpretations of "importance" by the stakeholders but has since concluded that this can be misleading. "Importance" measures the relative value of a criteria as well as the relative importance of change in a criterion value from its worst to its best levels along the scale of measurement. Stated simply, a criterion may change in value or weight, relative to other criteria, depending on the range of its measurement scale.

Measurement scales do not necessarily begin at zero and increase to the highest possible value. For example, in assessing the size of a natural area, no such area can be 0.0 square kilometers or likely to be 1000.00 square kilometers. Also, this study assumes linear utility functions represent criteria values but they do not always have to be expressed as monotonically increasing or decreasing. In other words, some functions may be bilinear. For example, a total inability to access an area hinders management's ability to monitor and manipulate the site to increase site viability. Too much accessibility exposes a site to actual or potentially high levels of human disturbance.

Therefore, optimal utility of access rests somewhere in between the lowest and highest plausible extremes.

When the rankings (and scaling constants) are elicited from the stakeholders, all that is required for them to know to complete the task is the end points of the ranges and the fact that all attributes will be eventually measured on a common utility scale (Edwards, 1980). For convenience, this scale usually ranges from 0 to 1.0, 10.0, or 100.0. Ranges are not possible for the four higher categories discussed in this study since these dimensions are abstract. Tradeoffs must still be made among these dimensions which are implicitly defined by the criteria contained within each. The form used to elicit category and criteria rankings and scaling constants used the the Test Application is reproduced in Appendix 2.

4.2.6 Step 6 -- Assign Scaling Constants

The application of scaling constants or weights to criteria is crucial for evaluation systems to reflect differences in criteria importance as perceived by the various stakeholders. Ordinal ranking indicates the value order of criteria; scaling constants describe the precise numerical differences between the criteria. Criteria are compared intracategorically (as are the rankings) only. Several methods exist by which differential scaling constants may be assessed. These include rank inverse, rank sum and rank reciprocal weighting methods. The ratio weighting method was used in this study as it tends to generate greater distinctions between the criteria.

To obtain scaling constants after ranking has occurred, the stakeholder first assigns a value of 10 to the least important criterion. Next, a numerical weight is assigned to the second least important criteria as to reflect how much more important it is relative to the least important criterion. If a value of 30 is assigned to the second criterion, this indicates the stakeholder perceives it as being three times as important as the lowest criterion. Moving up the list, the stakeholder assigns weights to successive criteria to reflect their importance relative to all the preceeding criteria. Stakeholders must be made aware that ties amongst criteria are permitted.

Once all the criteria have been assigned a number, these weights must be normalized to 1.0. This is done for convenience and to standardize weights between the categories. This is accomplished for each criteria by summing in a given category then dividing the total into the number of any given criteria in that category. The resulting value is the normalized weight for that criterion. For example, if the numbers assigned to three criteria are 10, 20 and 40 then their normalized weights would be .14, .29 and .57 respectively. The normalized weights for all the criteria used in the test application in Chapter 7 are shown in Figure 9. Also shown in Figure 8 are the final normalized weights.

To complete the final normalized weights for the criteria, their respective weights must be multiplied by the weight derived for the associated category. For example, if the weight of a criterion is .29 and the category it is in has a weighting of .50, then the final normalized weight for that criterion would be (.50 X .29 =) .145. Each

Figure 9: Normalized Weights and Final Normalized Weights of Criteria, Averaged from the Five Stakeholders

			Categories and Normalized Weights		Criteria and Normalized Weights	Final Normalized Weights
Threat Levels and Desirability	Environ. Attributes	.48	Disturbance/ Sensitivity	.28	Population Status	.13
				.24	Habitat Degradation	.12
				.12	Site Size	.06
				.08	Buffer Zone	.04
				.16	Land-Use Conflicts	.08
				.06	Natural Disturb.	.03
				.07	Patterns of Population Concentration	.03
		.10	Recovery Potential	.30	Species Specialization	.03
				.39	Habit. Resiliency	.04
				.31	Reprod. Potential	.03
	Nonenvir. Attributes	.31	Level of Signific.	.41	Jurisdic. Signific.	.13
				.33	Security of Taxonomic Unit	.10
				.11	Sci/Ed Potential	.03
				.15	Hybrid. Potential	.05
		.11	Planning and Management Considerations	.55	Existing Protec.	.05
				.30	Assessment of Management	.03
				.15	Cost of Protection	.02
Weight Totals		1.00				1.01

stakeholder must produce a normalized weight for each criterion. If there is more than one stakeholder, as is the case in this study, the weights are simply averaged. The normalized weights elicited from each of the five stakeholders as well as the standard deviations and resulting final means are listed in Appendix 3.

With the set of evaluation criteria established and the weights for each criterion finalized, all that remains before actual site assessment can proceed is the development of measurement scales for each criterion.

4.2.7 Step 7 — Assign Measurement Scales

Measurement scales need to be developed and assigned to each criterion. For any given criterion, more may be better than less, less may be better than more or some intermediate point preferred. Scales may be derived using existing units of measurement such as square feet, dollars, hours or simply numbers of entities. For attributes which must be subjectively assessed, or that for a variety of reasons must be stated in a very general way, no common measurement units exist. Instead, experts must use their professional judgement in assessing these kinds of attributes. Constructed scales need to be developed for such attributes with clearly defined endpoints and intermediate steps. These definitions assist the experts in making their decisions and limit individual interpretations.

The first step in assigning scales is determining which criteria are objectively measurable and which are subjectively measurable. For this current study, all of the criteria used are subjectively measured in that all use a constructed scale. However, several of these (including "Population Status", "Habitat Loss", "Site Size" and "Habitat Resiliency") may be measured quantitatively. These objectively measured attributes still must be placed on a constructed and generally stated scale since the criteria set is designed to apply to a very wide range of natural phenomena using, at times, low quality data. For example, scoring a site size of 25 square kilometers as "high" may be justifiable for a population of tiger beetle but wholly inappropriate for a herd of woodland caribou. The levels within each scale were assumed to represent the plausible ranges for the respective criteria.

Next, each level of each criterion scale must be defined with plausible end points established. It is not necessary at this point for every criterion scale to have the same number of levels since they will all be eventually converted to a common utility scale. It is important that each level is sufficiently distinct from the others so that the different levels reflect significant changes in an entity for a given criterion. Edwards and Newman (1982) clearly state that plausible minimum and maximum values should be used, not those values possible, conceivable or even actual. While creating these constructed scales it must be kept in mind whether each criterion is either monotonically decreasing or increasing, or bilinear. Measurement scales were generated for this study by first establishing plausible minimum and maximum values then working inward toward the mid-value.

After these scales are created they must be converted to a common scale. It assists in understanding this conversion if each is illustrated as a graph, with one axis being the constructed scale, the other axis being the utility scale. Each criterion used in this current study is illustrated in Figure 10 in this way. It must be understood that the desired affect in this type of evaluation is for the most desired alternatives (i.e. those that are most highly threatened and desirable) to score highly. Consequently, all the criterion must be oriented so that a high score indicates desirability.

To determine where each level of each scale falls on the utility scale, one of several linear functions must be applied. If the criterion value is linear and increasing, then the function used to determine utility value for any location on the normal scale is

$$U_L = 100\ (L_A - L_{min}) \,/\, (L_{max} - L_{min}) \qquad (1)$$

If the criterion value is linear and decreasing then the function is

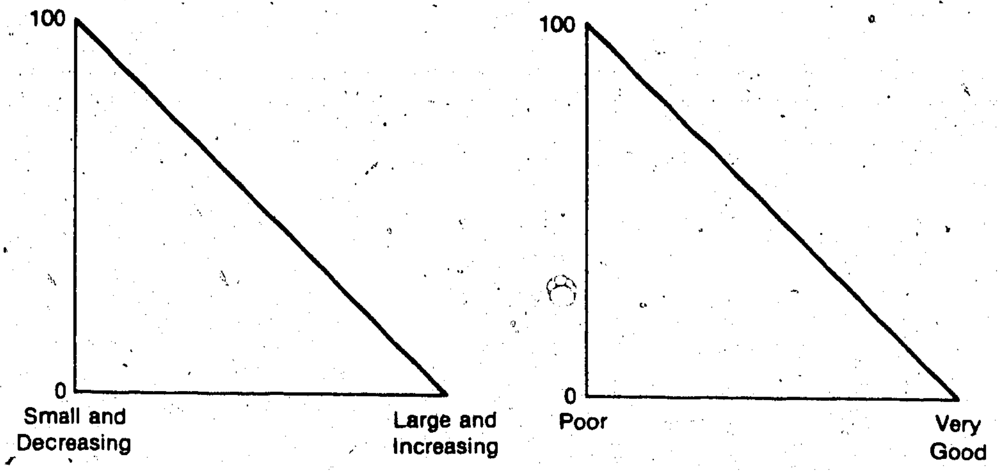
$$U_L = 100\ (L_{max} - L_A) \,/\, (L_{max} - L_{min}) \qquad (2)$$

where U_L is the location of the utility value, L_A is the location on the normal scale for the entity being measured, L_{min} is the minimum value of the normal scale and L_{max} is the maximum value of the normal scale. Equations (5) and (6) simply calculate the slope of the function and locate any point on the line. If the utility function is bilinear and the maximum value does not reach 0 utility, the equation is

$$U_L = U_{max} + (100 - U_{max}) \times (L_{max} - L_A) \,/\, (L_{max} - L_{min}) \qquad (3)$$

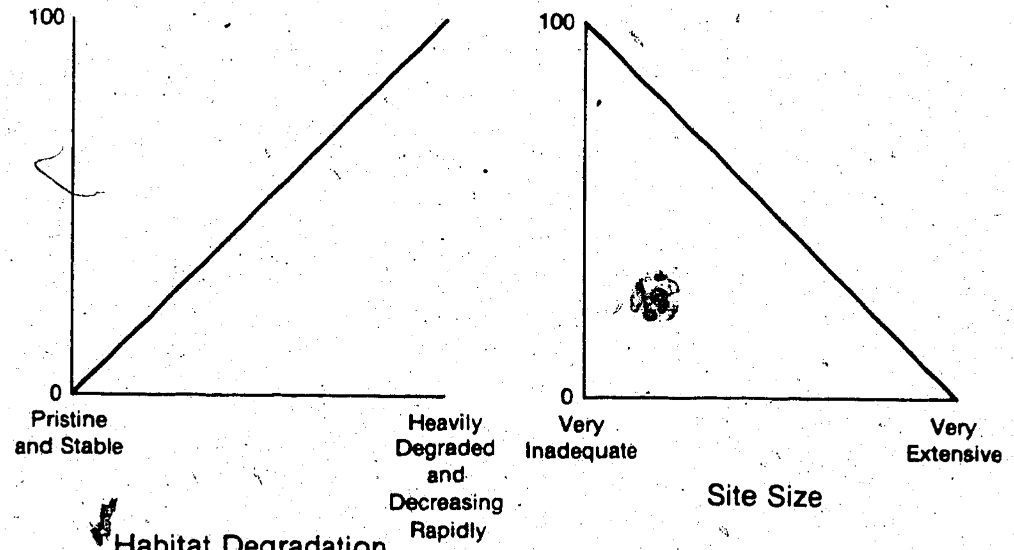
Where U_L is the utility of any given location, U_{max} is the utility associated with the maximum value of the normal scale, L_{min} is the

Figure 10: Utility Functions for Each Criterion Used in the Test Application of this Study



Population Trend

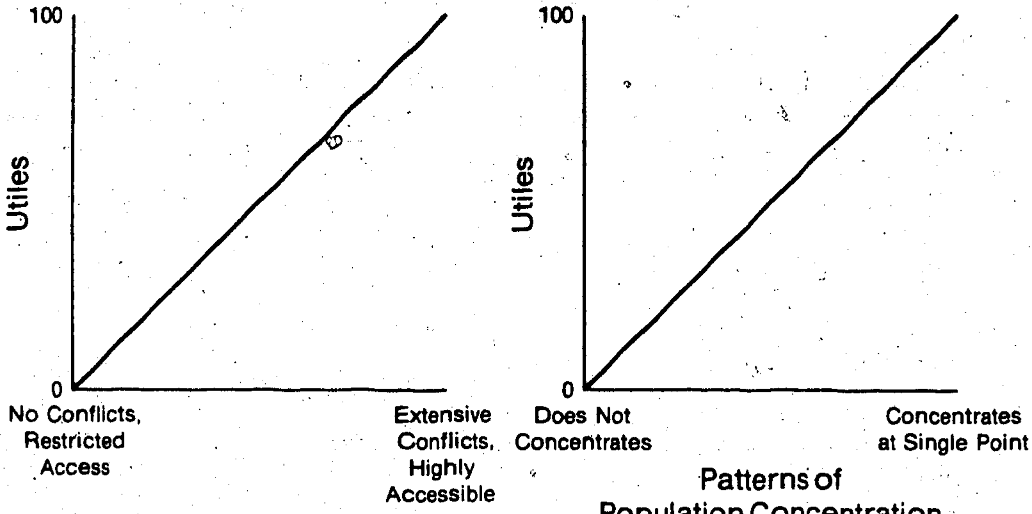
Buffer Zone



Habitat Degradation

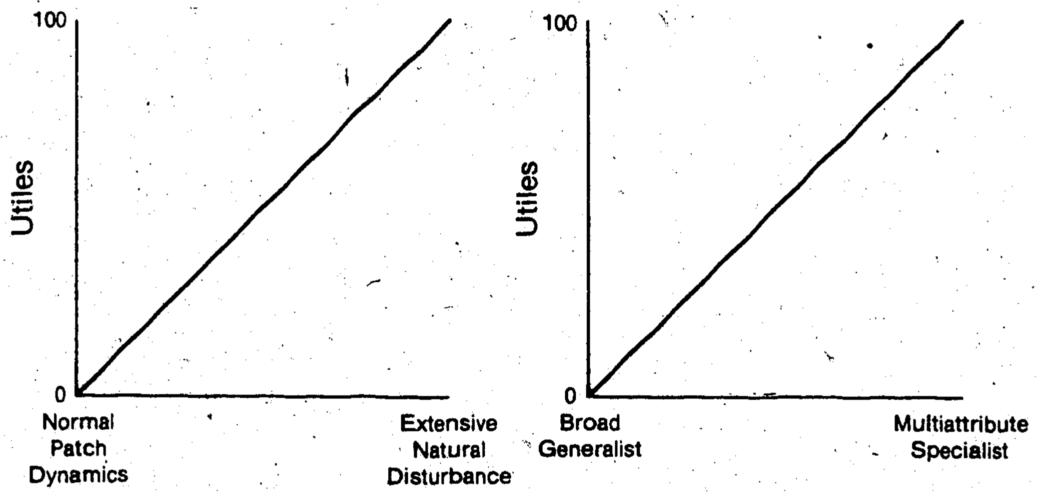
Site Size

Figure 10: (continued)



Land-Use Conflicts

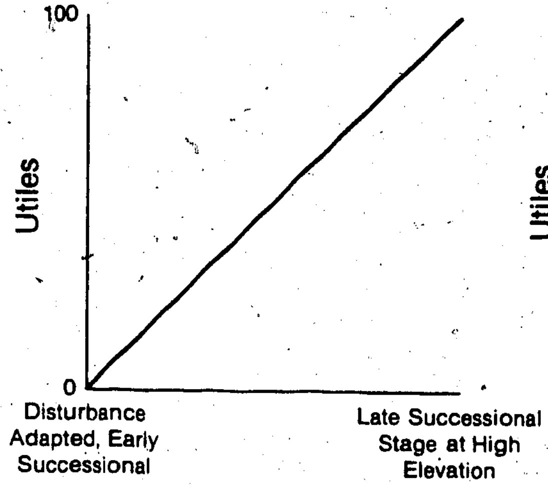
Patterns of Population Concentration



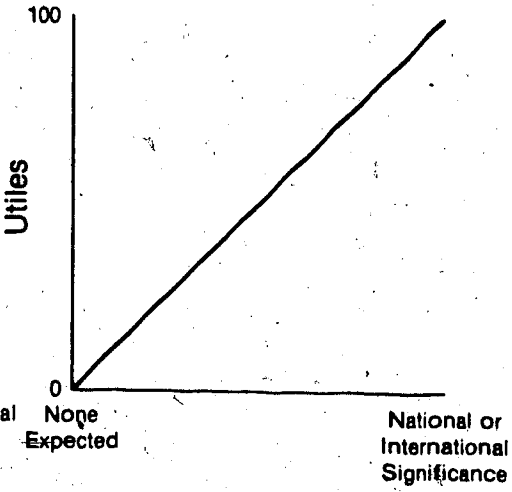
Natural Disturbance

Specialization

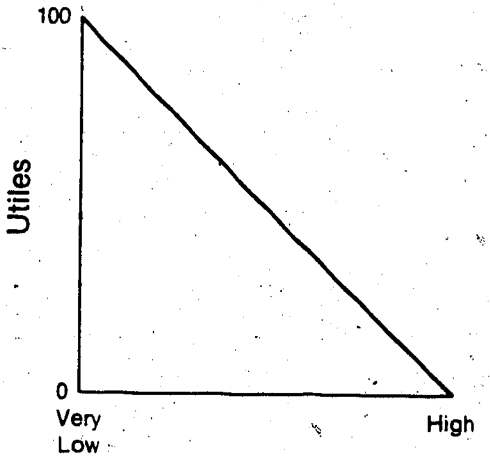
Figure 10: (continued)



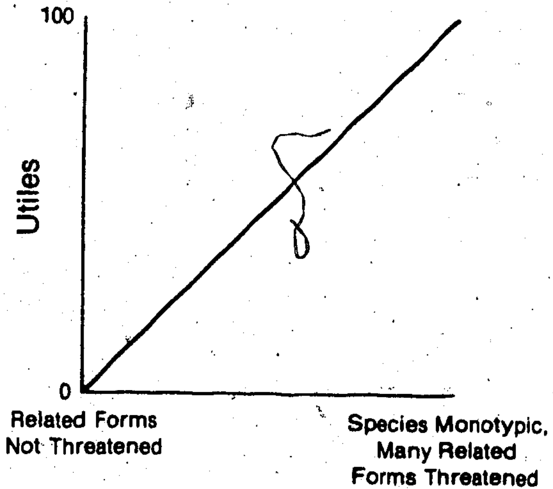
Habitat Resiliency



Jurisdictional Significance

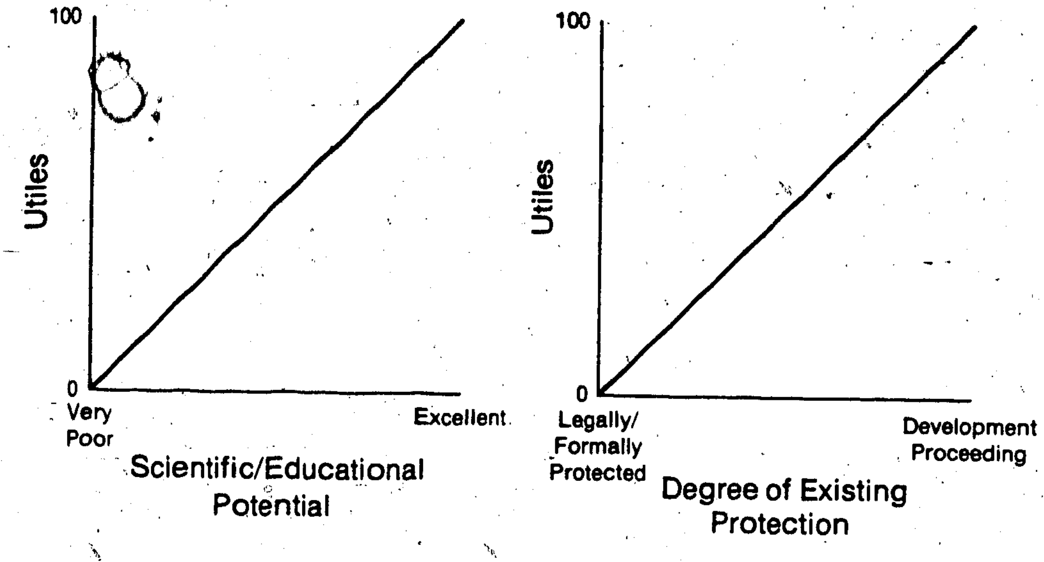


Reproductive Potential



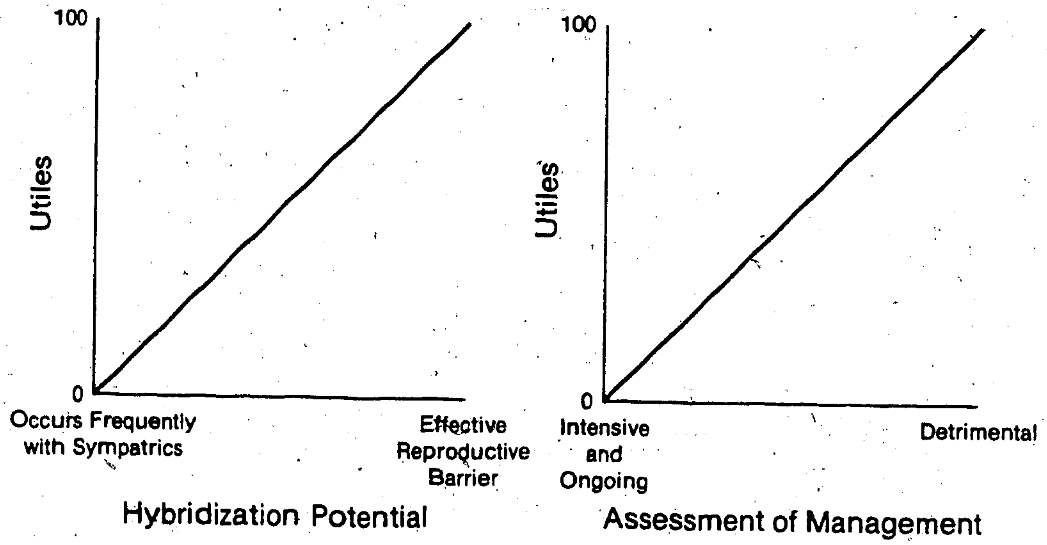
Security of Taxonomic Unit

Figure 10: (continued)



Scientific/Educational Potential

Degree of Existing Protection



Hybridization Potential

Assessment of Management

Figure 10: (continued)

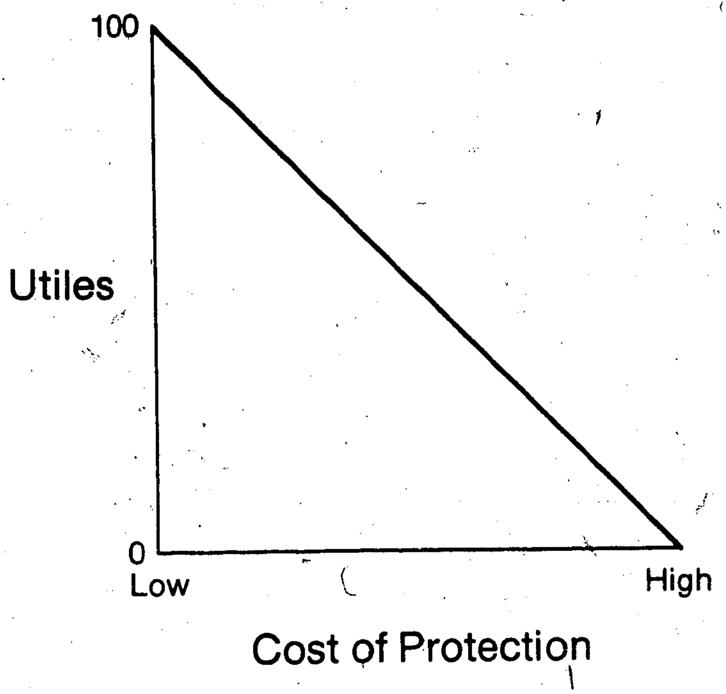
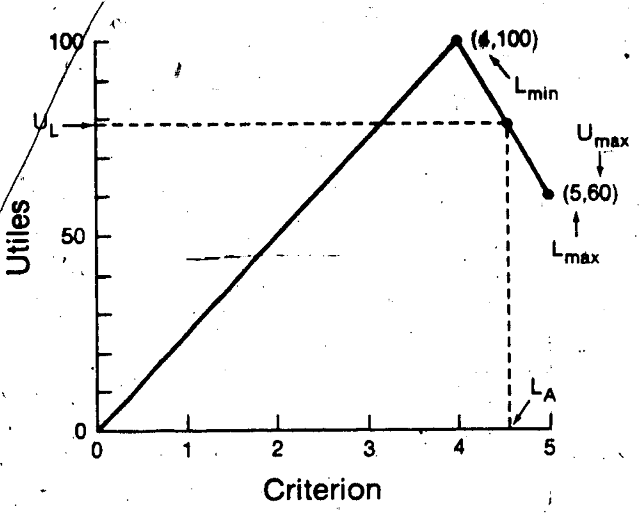
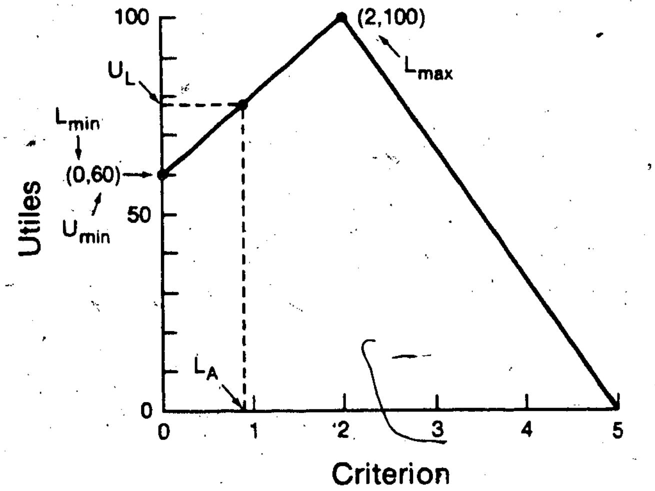


Figure 11: Illustration of the Symbols Used in Bilinear Functions (3) and (4)

Function 3: $U_L = U_{max} + (100-U_{max}) \times (L_{max}-L_A)/(L_{max}-L_{min})$



Function 4: $U_L = U_{min} + (100-U_{min}) \times (L_A-L_{min})/(L_{max}-L_{min})$



location of the function peak, L_{max} is the highest value on the normal scale and L_A is the location whose utility is being sought.

If the utility function is bilinear and the lower branch of the bilinear function does not equal 0 utility, then the equation is

$$U_L = U_{min} + (100 - U_{min}) \times (L_A - L_{min}) / (L_{max} - L_{min}) \qquad (4)$$

Where U_L is the utility of any given location, U_{min} is the utility associated with the minimum value of the normal scale for the entity being measured, but now L_{min} represents the value on the normal scale of the lowest possible measure and L_{max} is now the location of the function peak (i.e. highest utility value).

Figure 11 illustrates the symbols used in equations (3) and (4).

There exists bilinear functions where neither (3) or (4) are applicable. Equations (1) and (2) can be applied to the appropriate sections of these types of functions to successfully determine utility values.

4.2.8 Step 8 -- Evaluate Candidate Feature

Prior to site evaluation, a site is nominated using a nomination form and either accepted or rejected based on an eligibility assessment (see Chapter 6.2). Site nomination may be undertaken by a private citizen or group (e.g. NGO), private organization or government agency. Both private and public lands should be eligible for nomination. The actual evaluation of a candidate SFI involves obtaining its location measures for all criteria using an evaluation form. The evaluation system is so designed that the higher the final total score--termed the

Conservation Utility Index (CUI)--the more threatened and desirable the SFI is. High scores will also be received for those species about which we know very little. This unknown component of the CUI will be illustrated on the evaluation form. The recommendations for sites where little information is known will usually be directed towards providing the information required for proper assessment. Regardless of a site's CUI or general lack of information, any clear and sweeping threat to the continued viability of a SFI should result in immediate initiatives to halt the threat.

The forms used for SFI nomination, eligibility and evaluation are illustrated in the test application of Chapter 7.

4.2.9 Step 9 -- Calculate Feature Utility (CUI)

The CUI for a candidate SFI is obtained from the aggregation of the measurement values of all criteria. Since preferential and utility independence, and linearity are assumed for the entire criteria set (see discussion in Chapter 2.5), the additive form is used for utility aggregation, such that

$$CUI_{(x)} = \sum_{i=1}^{n} W_{i}U_{i_{x}} \qquad (5)$$

where W_i is the weight of the ith criteria, U_{ix} is the utility measurement for the Xth candidate site for the ith criteria and $CUI_{(x)}$ is the final utility index for X.

A single index frequently proves too condensed for use as an effective guideline to decision-making. Consequently, four subscores, derived from the aggregation of the criteria under each of the attribute categories are highlighted on the evaluation form. By indicating the maximum scores possible for each category as well as the actual subscores, DMs will be able to quickly see how well an SFI did in each category.

4.2.10 Step 10 -- Assign Priority and Designation

The CUI will be used as a ranking by which SFIs within the same classification category can be compared. The maximum CUI any one SFI can achieve is 100. The 100 points are arbitrarily divided into three levels of priority. "Priority One" is assigned to a SFI with a score between 66 and 100 points, "Priority Two" to a SFI with a score between 36 and 65 points and "Priority Three" to a SFI with a score between 0 and 35 points. Ongoing use of the system should indicate more appropriate ranges for the three priority levels. Low priority SFIs for which inadequate information existed for evaluation (a combination which will occur very infrequently) will not proceed further through the process. It will be set aside until the missing data are made available and a proper assessment can be made.

All other priorities (including Priority 3 when evaluated with sufficient data) will proceed to the next part regardless of information gaps. The next part of Step 10 involves deciding what to do with the array of prioritized SFIs. This task is not directly related to the evaluation team. Their role in the actual conservation of a feature is to contact the agency or institution best suited to manage the feature. This is referred to as the "Institutional Match." By the very nature of the evaluation system, all Priority 1 features in all the classification categories must be dealt with first (i.e. matched with an institution). These will represent those features in the greatest danger and desirability. However, all priority levels should be considered important and dealt with eventually. As stated by Nicholson (1968, p. 17).

> areas should be included whether or not they appear to be under immediate threat. Experience has shown that no reliance can be placed on the survival by good fortune even of very remote areas . . .

The direction a conservation action will take for a specific feature will depend largely on the subscore achieved in the planning and management category. For example, although a SFI may be priority 1 it may not be necessary for the agency involved in feature protection to take drastic action. Simply relating to the landowner the importance of the feature may be sufficient for action and management to commence. It will generally occur that those under the greatest threat will receive the greatest effort. The greatest effort is certainly expressed as the outright purchase of the site containing the SFI and adjacent buffer zone.

The three general approaches or designations for feature/site protection are outlined below.

A) Registration

This designation carries with it the lowest form of protection. As such, it is all that is required for those SFIs that are in no actual or imminent danger. All sites once identified and evaluated as an SFI will be automatically registered, although more protective action may be required for some. The registration procedure is a means to keep an ever-updated record of FSIs and to identify gaps and redundancies in the program.

The purpose of registration is voluntary protection in that inadvertant destruction of a feature may be averted simply by informing the landowner of its significance. While an access agreement may be reached with the landowner, the management of a site which is only registered remains the responsibility of the landowners. They have no obligation to be indefinite participants in the program. They are asked to inform the appropriate agency if they intend to alter the site, buffer zone or adjacent land-uses. This designation while providing the least protection also incurs the least costs to the agency. This form of protection has been used successfully in both England (i.e. Sites of Special Scientific Interest Program) and the United States (i.e. Nature Conservatory Programs).

B) Dedication

For sites which are at least moderately threatened it may be necessary or possible to dedicate a SFI. A dedication entails some form of legal encumbrance on the landowner and may take several forms. The form of the dedication may be voluntary or involuntary depending on the level of landowner cooperation and how urgently the site needs protection. Voluntary dedications include conservation easements, options to purchase, right of first refusal, joint management agreements, leasehold estates, restrictive and mutual covenants and right-of-way agreements.

Involuntary dedications include identifying the area as a Restricted Development Area, protecting it under the Historical Resources Act or zoning the land by municipalities and in official regional plans. These act as indirect forms of development control. These are also the least desirable methods since antagonisms are likely to develop between the landowner and the controlling agency. However, these should be pursued if significant legal and/or administrative commitment on the part of the landowner is not evident.

The advantages of dedication are that the cost of protection remains low but the site is formally and/or legally protected for a period of time.

C) Acquisition

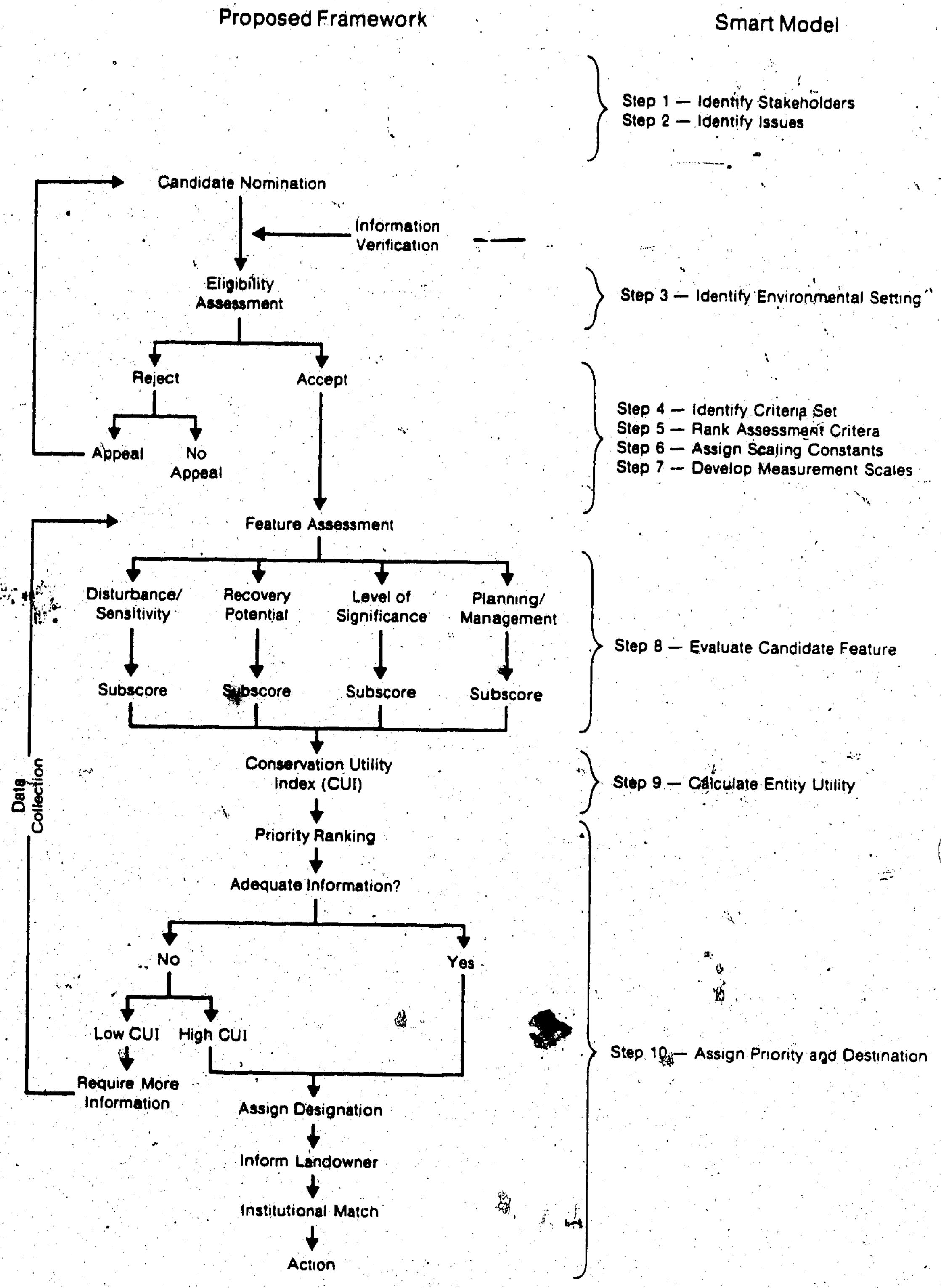
Some features will be so easily acquired or will prove so highly threatened that acquisition is the most reasonable protection alternative. To designate a site for acquisition provides optimal long-term security for an SFI but is also the most costly. The only means of acquiring land cheaply is through land donations which involve the transfer of rights by deed or will. Not only does this method assure the greatest tax benefits for the donor and assures that their land will be protected, but it also encourages public involvement in nature conservation. Additional means of either acquiring land or at least access to it include fee simple estate, life estate, purchase and lease back, option to purchase and bargain sale. All vary in terms of tax liabilities for the landowner and cost of acquisition for the agency involved.

For a more extensive review of the various options open to an agency for feature protection on private lands see Hees (1983), Brenneman and Bates (1984) and McClure (1984). Not all options reviewed are possible for every political jurisdiction. Some of these options listed are possible for the acquisition of government-owned or Crown land. Securing such lands will necessitate complex negotiations between the land-owning agency and the agency responsible for feature management. An example of such a (proposed) effort is found in Shandruk, et al. (1984).

After a site is evaluated and priorized the landowner and the institution best suited to manage the site are contacted. Both are appraised of the site's importance and proposed designation as an SFI and encouraged to begin protective initiatives. The extent to which this last step is pursued will ultimately depend on landowner and agency cooperation as well as the authority invested in the SFI program DMs.

The particulars of the entire evaluative framework of this study are presented in Figure 12 with the corresponding steps of SMART indicated.

Figure 12: Proposed Evaluative Framework for Special Natural Features Based on SMART Model



CHAPTER 5

A PROPOSED CLASSIFICATION SYSTEM FOR SFIs

5.1 Introduction

The definition developed for SFIs in Chapter 1.3.1 provides for an initial organization of special natural features. However, this stage does not provide the precise information or definitions required for the further organizational needs of an evaluation system. A clarification of how features and the terms used to describe them interrelate is required if a rational evaluation system is to be developed for each. This sorting process is most useful when in the form of a classification system which further defines and separates the entities of interest into similar groupings.

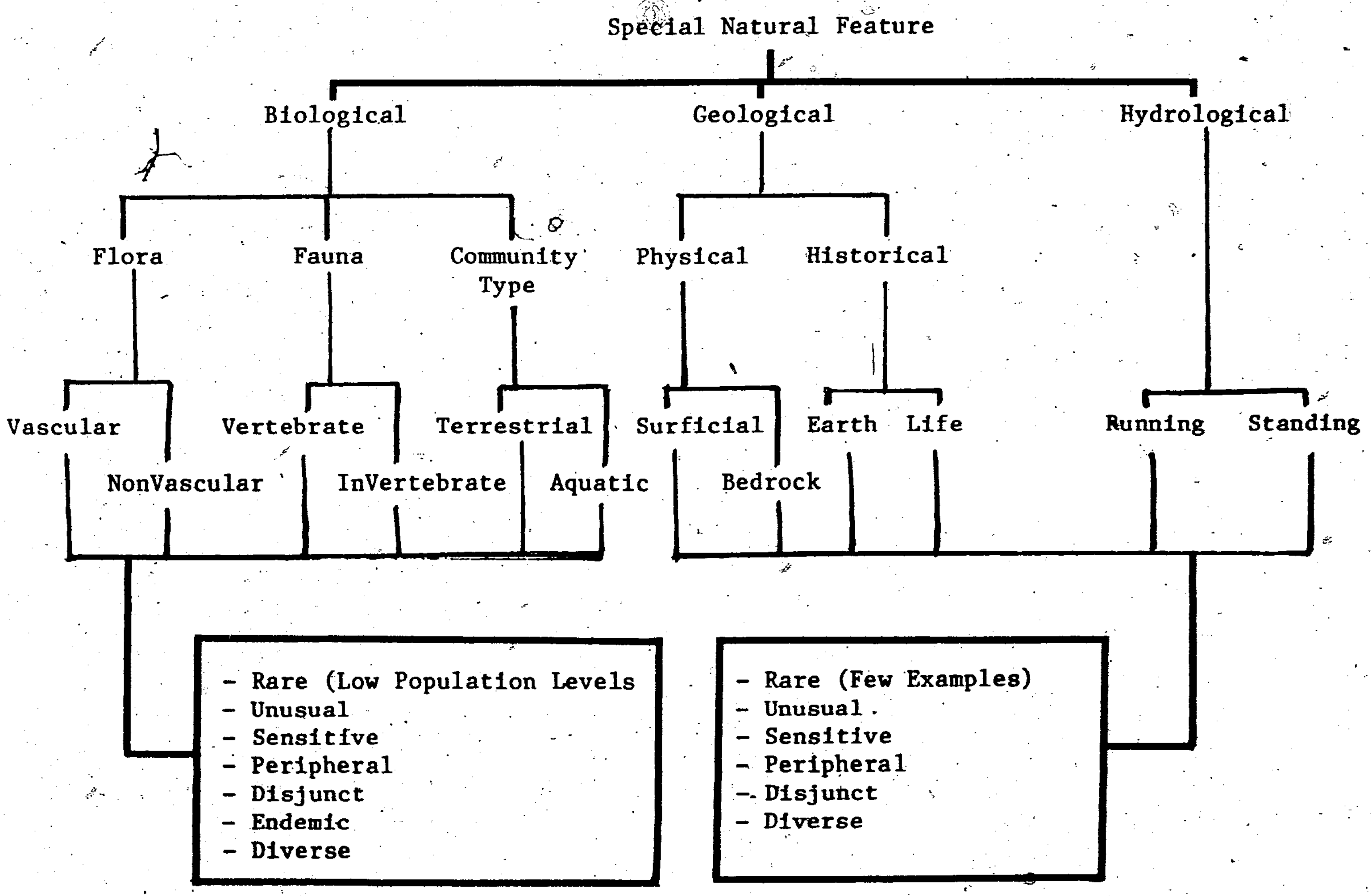
The development of a classification system for any discipline requiring an organization of information is desirable for the following reasons;

1. increased ability and ease to label entities
2. increased ability and ease to locate entities
3. increased ability and ease to locate information within the entities
4. increased ability and ease to identify gaps and redundancies within the overall inventory of entities
5. increased predictive value

The classification system proposed in this study is divided into two sections. The first section consists of the major categories of the system which draw extensively from those developed by Sargent and Brande (1976), the WNHP (1983) and Parks Canada (1983). The categories listed in these studies have been added to, deleted or modified to make the scheme more comprehensive and better suited to special natural features at the regional level. The categories were divided in a nonhierarchical manner and under each are listed the relevant Feature-type headings. These headings comprise the second section. The classification system is illustrated in Figure 13.

The discussion of the headings is divided into two parts. The first is the compilation and analysis of interviews conducted with professionals, as outlined in Chapter 4.2.3. The data from these are used to establish a tentative listing of those qualities of the natural world perceived as "special." The responses are summarized in this chapter with actual responses listed in Appendix 4. The interview summary was used to develop specific Feature-type headings. These represent an integral component of the classification system proposed in this study. They serve as the finest level of discrimination between SFIs and are simple non-hierarchical categorizations of natural features. Depending on the characteristics of a feature, it will be allocated to one or more of the categories. The more "nebulous" categories may have to be partially redefined over time in order to accommodate the particular characteristics of the entities dealt with. Clifford and Stephenson (1975, p. 26) state that for this reason the identification process:

Figure 13 Proposed Classification System for Special Natural Features



becomes an integral part of the classification process, rather than something quite separate.

It has been demonstrated by some government agencies and the general public that a lack of interest in, and adequate data on, certain kinds of natural phenomena results in these phenomena being largely ignored (Ratcliffe, 1977 and Everett, 1978b). The categorization of features serves as an organizational tool, ensuring that each receives sufficient treatment. In addition, categories are necessary since not all criteria pertinent to one group of features will be equally applicable to another. Sparrowe and Wight (1976, p153) concur with this approach when they suggest:

> . . . the difference between birds and mammals and fish is such that perhaps we should list them separately and then make our comparisons.

How fine or discriminating the classification system should be will depend largely on the agency using it. Some will wish to compare, for example, only birds with birds, while others, only raptors with raptors. The finest level of discrimination would be to compare sites containing populations of the same species, although this is somewhat unrealistic.

Ideally, a SFI should be placed into a single category and Feature-type heading. For example, a "Biological-endemic community-type" or "Geological-surficial disjunct." In reality, many SFIs will represent a number of significant special features resulting in their being classified as such, in much the same manner as that used by Sargent and Brande (1976) (see p. 32, this study). A SFI should be classified with the most dominant characteristic stated first, the second most dominant second. This would be subjectively determined by the assessment team and may include considering if a category is not sufficiently represented. A SFI may consist entirely of the actual feature being evaluated or, the support-base for the feature as well as the feature itself. Not all Feature-type headings apply to all categories.

An important component in system building should not be overlooked. That is a system must be viewed as valuable and acceptable, not only to the extent that it uses the pertinent properties of the entities with which it deals, but also that it succeeds in fulfilling the purpose for which it is required.

The purpose of most conservation efforts, including those of this study, are identification, description and protection. It is these qualities that should form the basis of site comparison and classification, and contribute in their appropriate management. The categories and headings of the proposed framework are briefly outlined below.

5.2 Categories

5.2.1 Biological

A) Flora

This is a major category which refers to features which are undomesticated, native, uncultivated nonvascular or vascular plant species, sub-species or local population, including associated habitat.

B) Fauna

This is a major category which refers to features which are undomesticated, non-game vertebrate or invertabrate species, sub-species or local populations, including habitat.

C) Community-Type

This is a major category which refers to features which represent an association of plants and/or animals that are spatially delimited and may be dominated by one or more prominent species at each or by a physical vegetative stratum characteristic such as hot-spring activity or a cave system. It includes both terrestrial and aquatic community systems.

5.2.2 Geological

A) Physical

This is a major category which refers to features that represent a surficial landscape feature (e.g. mineral occurrences, land forms, soils, glacial deposits), a bedrock feature (e.g. rock types) and/or the dynamic processes that affect both.

B) Historical

This is a major category which refers to features that represent examples of the geochronology of successive events in the making of the rock strata, continents, seas and landscapes, progress of extinct and living species and/or associated processes.

5.2.3 Hydrological

A) Running

This is a major category which refers to a phenomenon and/or process associated with a (partly or wholly) aquatic environment in which the water is flowing rather than standing for the majority of the year. This category includes rivers, creeks, streams, natural springs, waterfalls, flowing marshes, swamps and running-water/land interfaces.

B) Standing

This is a major category which refers to a phenomenon and/or process associated with a (partly or wholly) aquatic environment in which the water may circulate within the body of water, but is geographically static for all or most of the year. This category includes lakes, ponds, sink holes, stagnant sloughs, marshes and swamps and standing water/land interfaces.

5.3 Feature-type Headings

5.3.1 Interview Data

5.3.1.1 Introduction

SFIs were generally defined in Chapter 1.3.1. As outlined in Chapter 4.2.3 a more specific definition of specialness was developed through the compilation and analysis of 24 interviews with professionals. These have been incorporated into the classification system for SFIs proposed in this study and are outlined below. Actual responses of individuals are reproduced in Appendix 4.

5.3.1.2 Headings Derived from Interview Data

Table 10 lists heading categories, the number of occurrences of each category recorded in the compiled data (also listed as percentages) and the number of interviewees mentioning the heading at least once. The data give some indication of the value of each heading to the professionals interviewed.

Features described as "spectacular" or "unusual" were recorded most frequently, representing 23.6% of the data. This heading also relies most heavily on personal human perception for the identification of suitable examples. Such features as ecological anomalies, unusual assemblages of species, unique behaviors and outstanding examples were included under this heading.

"Rarity" was a term reserved for those features, usually species, which are dispersed throughout a portion of the province but that occur in low numbers. Used in this sense, rarity was the second most recorded heading, occurring 22.5% of the time. The heading included the crayfish in Beaver River, brine shrimp, the Cadomin Caves, the Ferruginous Hawk (Buteo regalis, Gray) as well as one pest species, the Arctic lamprey (Lampetra japonica, [Martens]).

"Sensitive" features were recorded 14.6% of the time and included such features as breeding sites of colonial nesters, snake hibernacula, fossil remains and sand-dune systems.

Features recorded under both "Peripherality" and "Disjunct/Outlier" headings occurred in 12.4% of the examples. Most

Table 10: Feature-type Headings and Frequency of Occurrence as Indicated in Interview Data

Feature-type Heading	Number of Occurrences of Heading in Interviews	Heading Frequency	Number of Interviews Listing Heading (N=24)
Spectacular/Unusual	21	23.6%	16
Rare	20	22.5%	14
Sensitive	13	14.6%	11
Peripheral	11	12.4%	7
Disjunct/Outlier	11	12.4%	6
Human Values	6	6.6%	5
Endemic	5	5.6%	5
Diverse	2	2.2%	2
High Quality	1	1.1%	1
Total	89	101.0%	

frequently mentioned as peripheral was the southern portion of the province where Pronghorn Antelope (*Antilocapra americana*, Ord), Eastern Short-horned Lizards (*Phrynosoma douglassi brevirostre*, Girard) and Soapweed (*Yucca glauca*, Nutt) occur. The Kakwa Falls area, Waterton Lakes National Park and the Kazan Upland region of the province were also recorded. Disjunct features included Rocky Mountain Bighorn Sheep (*Ovis canadensis*, Shaw), and the areas of Goose Mountain and Cypress Hills. The remaining four headings were each recorded in less than 10.0% of the data.

5.3.1.3 Summary of Interview Data

The heading classes developed from the interview data closely reflect the classification categories developed elsewhere by other researchers (see for e.g., Sargent and Brande, 1976; Wright, 1977; Parks Canada, 1983 and WNHP, 1983). The use of virtually all the headings developed in both the interview data and the literature reinforce and justify their use in this current study. "Endemicity" ranked low in the list of headings (5.6%) likely due to there being very few known examples of truly endemic features in the province. If all forms of rarity, of which endemicity is but one, are listed as one type of special feature then this heading clearly dominates all others. Their combined percentages equal 40.5% and represent the most important type of specialness for professionals in the field of wildland management and protection. Three headings -- "spectacular" "human values" and "high quality" -- were excluded from use in the proposed SFI system. High quality is usually derived from an evaluation and not identified beforehand. Also, the difficulties in labeling some special features as "better" than others has its philosophical difficulties, as outlined in Chapter 1.

The use of "human values" such as "spectacular" as a means to value or label conservation sites has been cautioned against by several authors (for e.g., Francis, 1985, pers. comm.). These terms are different in kind from the other headings in that the are strongly based on anthropocentric values. These aesthetic, recreational and educational values may bias site selection so that humans may benefit solely from the choices made. Such values are best viewed as potential on-going programs within a prote[illegible]e, the extent of which will depend on threat and fragility levels. The term "unusual" refers to features with qualities that are seldom seen or very uncommon. This term is not subsumed under the heading of "rare" since it does not refer to the number of individuals per species or the frequency of occurrence of a community-type, as is the usual biological meaning of the term "rare". Only scientific potential is included as an attribute value since the information derived from research may assist in the maintenance of special features.

The numbers of both columns two and four in Table 10 are very similar in their corresponding numerical values, in their general ordering and in the way the values decrease moving down the columns. This indicates that the classes were well distributed amongst the interviewees. If one interviewee had a strong interest in a particular form of specialness and listed many examples of this form; the result would be a much greater disparity between the two columns.

5.3.2 Proposed Feature-type Headings

5.3.2.1 Introduction

In keeping with the literature and interview data, the headings proposed in this classification scheme stress the various forms of rarity (i.e. low numbers, endemic, peripheral and disjunct), fragility, and diversity. All are seen as feature characteristics which create the need for protective action due to the percieved threat associated with them (Terborgh and Winter, 1980), or for the genetic materials they contain. It is expected that most species on a course to extinction will pass through a phase of low numbers of individuals. Species already occurring at low numbers are currently at this critical phase of the extinction process and may be lost in very short time if conditions become unfavorable.

Rarity is more specifically valued for a variety of reasons. There is high interest in the undoubtedly unusual ecological requirements of rare species and community-types, the research potential regarding the regulation of small populations and the factors limiting their geographic distribution. Usher (1980, p. 340) sees a:

> scientific challenge in devising systems of management that prevent the extinction of these rarities.

Ethical considerations also play an important part in their valuation, resulting in rare features possessing certain political leverage on occasion. These headings may be viewed as the initial attributes by which special features are identified. Feature-type headings are described below.

5.3.2.2. Few Individuals/Examples

This heading refers to the specific form of rarity involving features which are not necessarily threatened but occur in small numbers throughout a wide geographic range (Drury, 1980; Harper 1981; Rabinowitz, 1981). Within this range, their numbers may be small but their narrow habitat requirements often make them locally abundant.

Preston (1962) was one of the first to attempt a qualitative expression of commonness and rarity. He found that when a large number of individuals were sampled, their distribution among the species present was lognormal in fashion. The resulting bell-shaped curve indicates that only a few species have very few individuals (i.e. very rare), or very many individuals (i.e. very common). Most species fall somewhere between the two extremes (i.e. uncommon to common). While the data from some studies conform to this model, May (1976) argues that for any large, heterogeneous set of data a lognormal distribution is to be expected. Of importance to conservationists is the placement of "rare", "very rare" and "threatened" on this curve is highly subjective and does not take into account the spatial distribution of species abundance.

Argus and White (1982) used both the spatial and numerical components of rarity in a diagram reproduced in Figure 14. Rarity is represented by the shaded portion and the shaded portion relevant to this heading is that in the lower-right half. Rarity still remains a relative term, relying heavily on existing regional level information for a wide range of species. As such, some arbitrary decisions have been necessary in past efforts requiring a formal definition of rarity.

Straley *et al.* (1985) established four classes of rarity for vascular plants in British Columbia. Two classes (R1 and R2 in the study) were defined numerically (i.e. single, few, several) with no mention of distributions. Class R3 was defined by both range and numbers but only in very general terms. In compiling a list of rare valcular plants for Alberta, Argus and White (1978, p. 7) indicated that rare species "may occur over a wide area" but were flexible as to the meaning of "wide area" and by implication, what constituted sparsity. In an identical effort, Packer and Bradley (1984) included as rare only the species known from five or fewer localities without knowing population size or areal extent of the sites. This threshold has no scientific basis but was considered by the authors as the only operationally acceptable approach. In compiling a list of rare and endangered amphibians and reptiles of the U.S., Ashton (1976) suggested that for any State, "rare" should be defined as 25 or fewer specimens, with an indication of how many sites these represented. A rare species could therefore consist of a population of 25 individuals occupying one site to 25 sites with one individual each.

Hubbell and Foster's (1986, p. 210) tropical forest study defined a rare species as "having an average density of less than one individual per hectare or less than 50 individuals in the entire plot". Plot size was 50 hectares. Such small areas of homogeneous habitat make such figures easy to attain. Large, heterogeneous areas require greater outlays of time and money to inventory. Perring and Farrell (1977) used rarity as a criterion for admission into the British Red Data Book of Vascular Plants. They defined a rare species as occurring in 15 of fewer 100 km^2 areas. This, again, makes no references to population sizes within the areas or to area distribution in the country. Also, the standard is arbitrary but considered a useful and operational approach (Margules and Usher, [illegible] In comparison, Helliwell (1978) suggested "less common" species be defined as those occurring in fewer than 33% of the 10 x 10 kilometer squares of Great Britain. This translates to ((224,000 x .33) ÷ 100 =) 739 occurrences of a species being defined as "less common."

The inability to precisely estimate population size and geographical area results in using the number of locations a species is known to occur as the operational measure of rarity. The subjectivity of such an endeavor is obvious. One study mentioned above uses 5 or fewer locations for Alberta while another uses 15 or fewer for Great Britain, an area many times smaller. For the purposes of this study, plant and animal species will be placed under this heading if the number of known populations occurring in Alberta is 10 or fewer, and/or the total numbers for the province, if known, does not exceed 2,000 individuals.

For plant species, 2,000 individuals may prove more than required for species with high rates of vegetative growth or significant seed banks (Baskin and Baskin, 1978). However, this concern deals with species endangerment and not specifically with species scarcity.

Shaffer (1981) found that for dioecious or gonochoristic species (i.e. having separate male and female individuals), 50 individuals was the minimum viable population level. 2,000 individuals is considered for this study as the "safe" (i.e. rare), if not "minimum" (i.e. endangered), number to ensure species continuance. This number also corresponds with the numbers for species listed as rare and endangered by various wildlife management agencies.

To distinguish this heading from the heading "peripheral", the known range of the provincial population must exceed 10% of Alberta's area. This heading also refers to community-types and nonbiological features which may occur sporadically over a wide area when conditions or processes permit.

Examples of this heading include One-flowered Iron Plant (Haplopappus uniflorus, Hook) known in only four nonadjacent locations in Alberta (Plate 1) and the Rats Nest Cave System in Southwest Alberta (Plate 2).

5.3.2.3 Endemic

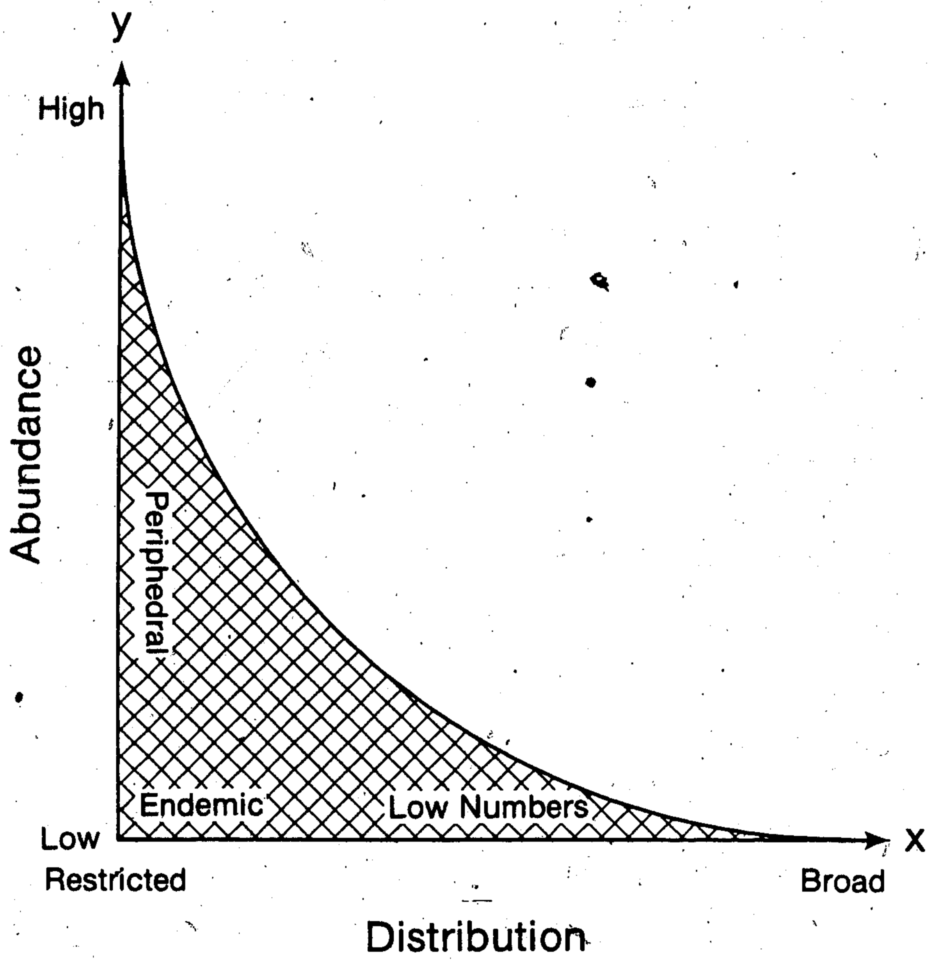
This heading refers to the specific form of rarity involving features which are native to, or restricted to, one or a very few localities within Alberta. These features are of interest since, within these sites, species may be undergoing evolutionary change at a greater rate than that in the surrounding area due to high habitat diversity or instability. It is important to specify the political boundaries when discussing endemicity since the only consideration of importance is that a feature occurs in only one place, the size of which is irrelevant

(Rapoport, 1982). It is unlikely that a species endemic to Alberta will at the same time be common in the province, as implied by the above statement. If so, endemics would occupy the portion of Figure 14 nearest the X and Y intercept. It is usually improper to refer to geologic and hydrologic phenomena as endemic or peripheral, with some exceptions being the occurence of exposed Canadian Shield and discontinuous permafrost in Alberta.

Examples of provincially endemic species include Kananaskis Whitlow Cress (Draba kananaskis, Mulligan), a mustard occurring only in the southwest, the Athabasca Rainbow Trout (Salmo gairdneri, Richardson), an endemic subspecies (Plate 3), and a species of snail (Physa johnsani, (Clench)) which only inhabits the hotsprings of Sulphur Mountain in Banff National Park.

5.3.2.4 Peripheral

This heading refers to the form of rarity involving features whose main range lies outside Alberta. The shaded area of Figure 14 closest to the Y axis represents peripheral features within a given jurisdiction. Peripherality does not involve the extent to which a peripheral population comprises a given political unit, only that it is part of the outer edge of the species range. In this sense, both Yucca glauca, Natt and the Badger (Taxidea taxus, Schreber) constitute peripheral species in Alberta, in that the northern-most extension of both species occurs there. However, the former is found in low numbers in less than one percent of the province while the latter ranges igure 14: Diagramatic Representation of the Forms of Rarity



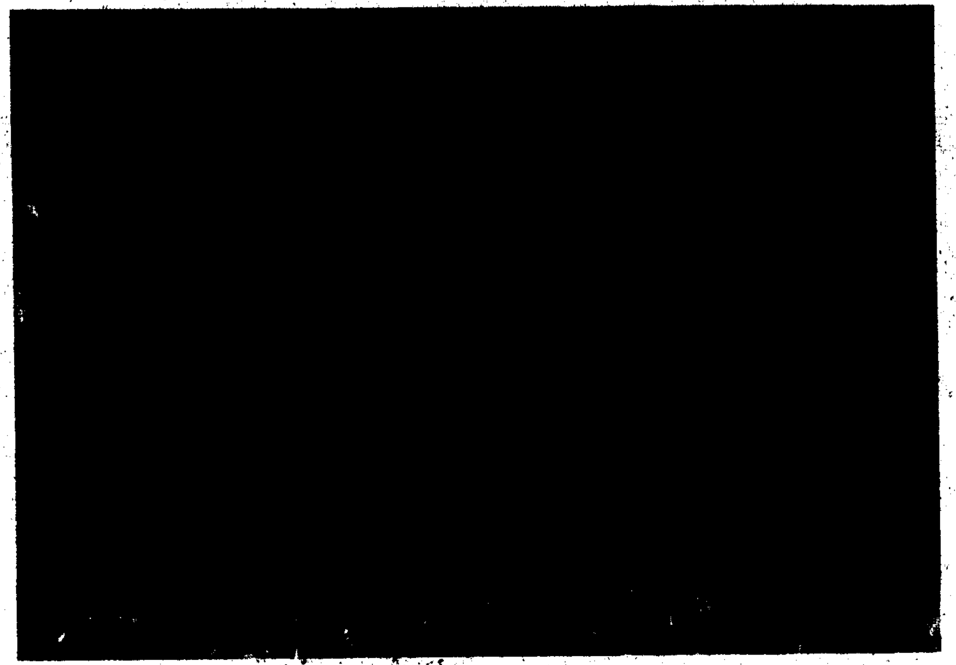


Plate 1. One-flowered Iron-Plant (<u>Haplopappus uniflorus</u>, Hook)--a rare plant species of Alberta. (photo by Cliff Wallace)

Plate 2. Rats Nest Cave, near Canmore, Alberta--an uncommon geologic phenomena in the province. (photo by Glen Hvenegaard)

Plate 3. Athabasca Rainbow Trout (Salmo gairdneri, Richardson)--an endemic subspecies of the Athabasca River drainage.

throughout 75 percent and is locally common. With regards to provincial conservation efforts, the Yucca constitutes a greater concern by far than does the Badger due to a higher probability of extirpation. To this end, some subjective guidelines must be established for the identification of peripheral populations in Alberta.

The carrying capacity of habitable sites tends to be the primary limiting factor for peripheral populations of a species rather than fecundity or predation(AFW, 1985). Consequently, these species often exhibit a high probability of local extinction and may also exhibit large population fluctuations (Soule, 1973; Kilpatrick, 1981). For these reasons this current study defines a peripheral population in Alberta as one which;

1) is reproductively contiguous with the greater population which lies outside of Alberta
2) has a permanent range edge in the province (i.e. relatively constant over at least a 50 year period)
3) has large population fluctations or consistently low numbers of individuals, and/or
4) does not comprise more than 10% of Alberta's total land area, or approximately 30,000 sq. km.

The area of peripherality in the extreme southeast portion of the province contains rare and peripheral plant species such as Soapweed (Yucca glauca, Nutt) (Plate 4), Six-weeks Fescue (Festuca octoflora, Walt), Wedgescale (Atriplex truncata, [Torr.] Gray) and Rabbit-Brush (Chrysothamnus nauseosus, Nutt).

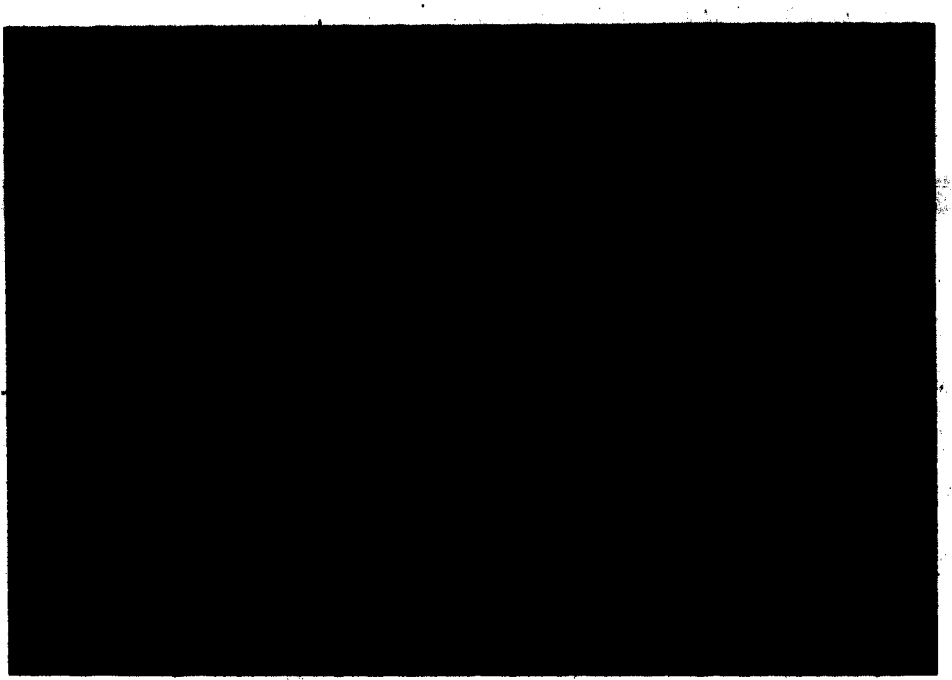


Plate 4. Soapweed (*Yucca glauca*, Nutt)--a species reaching its northern limit in Alberta. (photo by Cliff Wallace)

7.3.2.5 Disjunct/Outlier

This heading refers to features which are geographically separated from their more widespread area of distribution. Their genesis may be a result of human activity (i.e. a remnant feature) (Henderson, et al., 1985), glaciation (i.e. a relict feature) or other natural processes. Geographic isolation is widely believed to be a fundamental requirement for speciation (Endler, 1977). As a result, sites containing disjunct features considered genetically isolated are of considerable priority to conserve. Certain outliers may not be significant provincially but only regionally. Such features are seen as being "out of its expected context" (DuMond, 1973). An example is the unglaciated plateau of the Cypress Hills located in southeast Alberta. Surrounded by grassland, portions of it contain shrubland, stands of coniferous forest, rare species and underlying Tertiary conglomerate (unusual for the area).

There has been some speculation regarding the Great Plains Toad (Bufo cognatus, Say) (Plate 5) and the possible disjunct status of some populations. Agricultural drainage practices may have isolated certain viable groups from the rest of the greater population. The cactus Opuntia fragilis (Nutt) is an example of a disjunct plant species which occurs on warm, dry slopes in the Peace River region due to hypsithermal activity (Plate 6).

5.3.2.6 Unusual

This heading refers to a diverse range of features and is therefore the most difficult to define. It also is the least "biological" of the

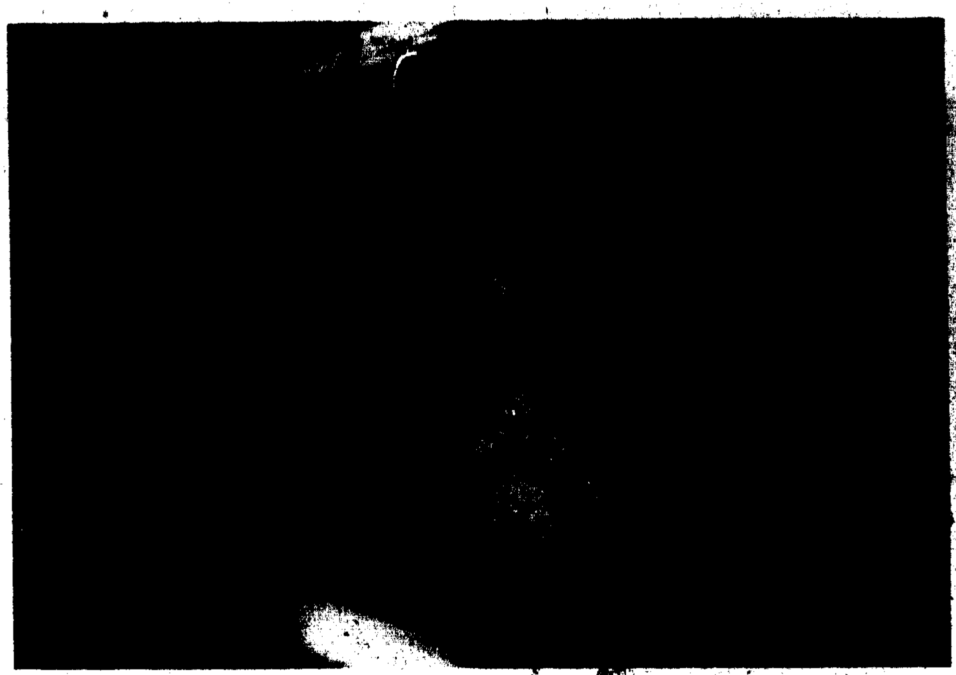


Plate 5. Great Plains Toad (Bufo cognatus, Say)--a species with possible disjunct populations in Alberta. (photo by Cliff Wallace)

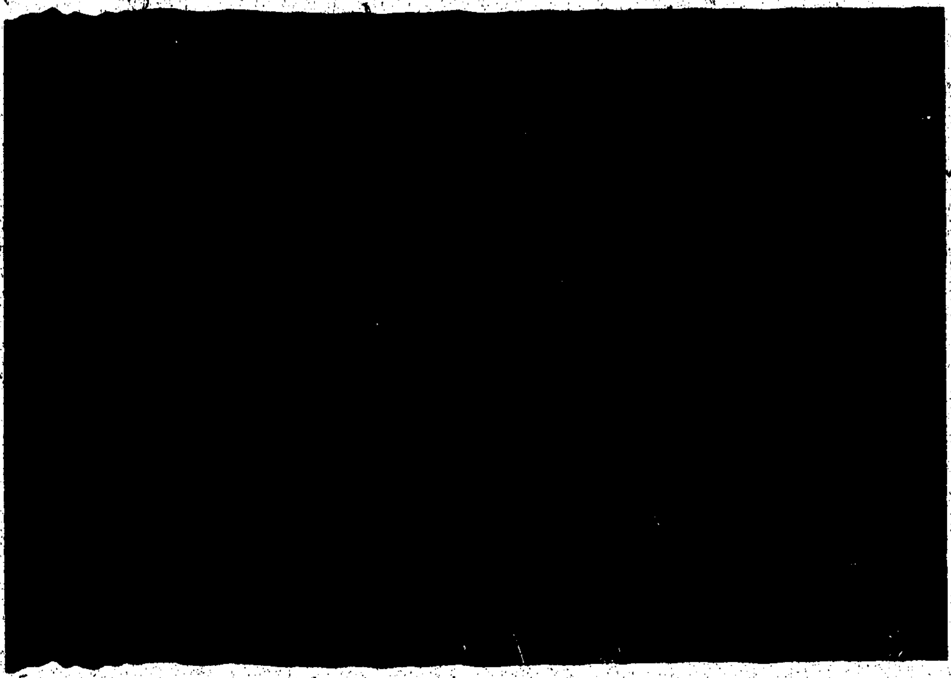


Plate 6, *Opuntia fragilis*, Nutt--a disjunct population of a common species of cactus, occurring in the Peace River region of Alberta. (photo by Julie Hrapko) headings but may provide interesting anomalies for research. The term "unusual" implies uncommon or seldom seen and co[illegible]s, a sense of rarity. However, it differs from Few Individuals [illegible]les in that it does not deal with the actual number of individuals comprising a species or feature. It does measure certain qualities of individuals of a species or feature. What qualities warrant placement under this heading depends greatly on what feature is being referred to. Concentrations of species existing at higher densities than normal or expected for a region could be considered under this heading. The concentrations of lepidopterans (i.e. butterflies and moths) occurring north of Willmore Wilderness Provincial Park serves as an example (Hilchie, 1985, pers. comm.).

Features representative of the oldest, largest or deepest of some phenomenon in addition to ecological anomolies would also fall under this heading. The pristine stands of 50 cm dbh poplar on Smoky Island in the Peace River region fall into this heading as do the old-growth forests of the province (Plate 7). Species and species/habitat associations uncommon in the province may be included under this heading. Two such examples exist in Alberta's north. The first occurs within the sink hole formations of the Karst topography of the Fort Hills (Plate 8). These sink holes are accessed by certain fish species via underground systems resulting in an unusual, possibly unique, assemblage of species (Nelson, 1985, pers. comm.). Secondly, the predator-prey relationship existing between the wolf and bison in Wood Buffalo National Park may currently be termed unusual, even though it was a common occurrence as little as 150 years ago.

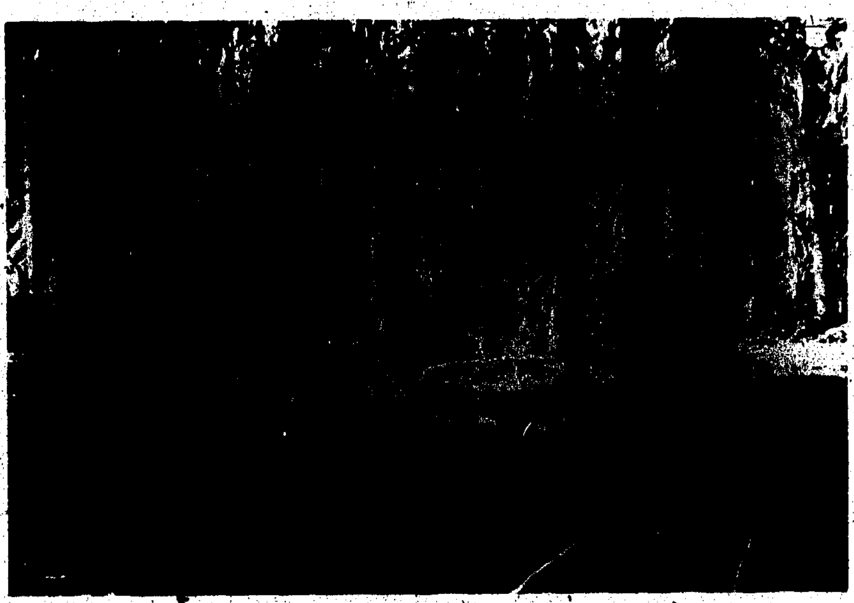


Plate 7. Old Growth forest -- an unusual community-type containing tree species of considerable age. Since such forests may contain specific assemblages, this example may also have been considered as a "rare" community-type. (photo by Peter Achuff)

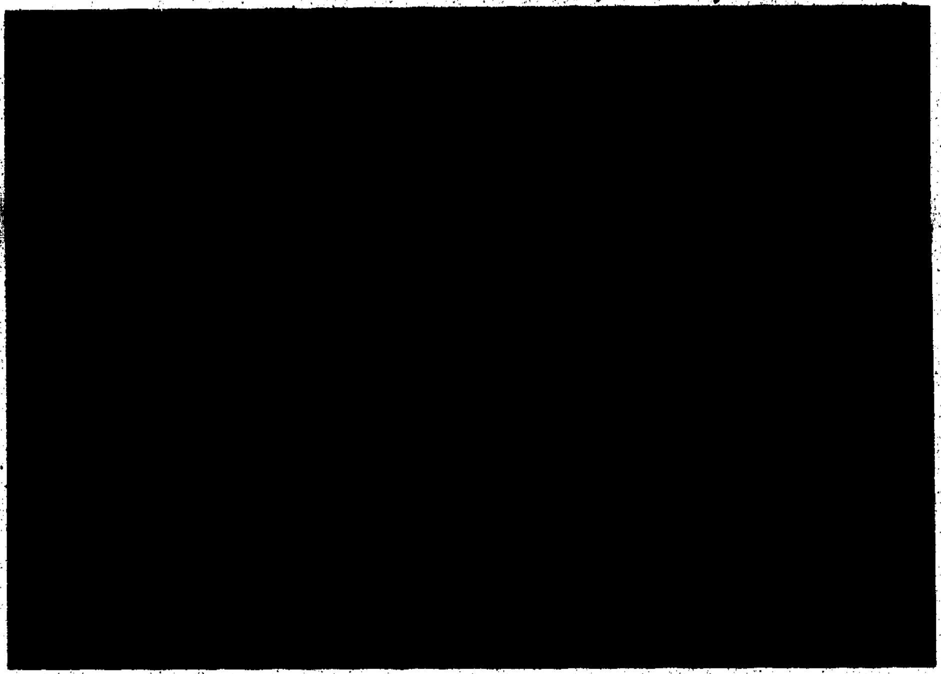


Plate 8. Sink Holes on the North side of Fort Hills, Alberta--an unusual geologic/hydrologic feature with an unusual assemblage of fish species. (photo by Peter Lee)

5.3.2.7 Diverse

This heading refers to sites containing a high diversity of communities, habitats or species, particularly those defined as S F I s. Site diversity is valued for the concentration of genetic materials and high levels of productivity inferred by the attribute. Community and habitat diversity can be measured using widely accepted vegetation classifications in conjunction with diversity indices. If more detailed classes are required to generate sufficient knowledge regarding a site, a new system may need to be developed. Species diversity refers to either the "species richness" (i.e. the number of species present) of a site, a function of the number of different species and their relative abundances or both (e.g. Shannon-Wiener Index). Relative abundance may be simply the numbers of individuals per species or some measure of importance, such as biomass (e.g. Simpson Index).

A site is considered diverse only relative to other sites in the immediate area. Maitland (1985) used diversity as one of several criteria to select important sites for freshwater fish in the British Isles. Since species richness varied greatly along a north to south gradient for these islands, sites in the north required fewer species present to be considered diverse than did sites in the south. Huston (1985) and Liddel et al. (1984) both found similar patterns of species diversity relative to coral reef depths.

Kempton (1979) has shown that standardized sample sizes are essential if inter-site comparisons of diversity are to be meaningful. The problems associated with small sample sizes have been outlined by

Peet (1974) and the problem of diversity being dependent on the successional stage of the site has been addressed by Usher (1979). Recent research has shown that contrary to biogeographic theory, one large site is not necessarily greater in diversity to several small sites (Jarvinen, 1982, Simberloff and Abele, 1982 and Boecklen and Gotelli, 1984). In fact, certain data indicate the opposite expected by the theory (Simberloff and Gotelli, 1984). Consequently, large sites should not automatically be seen as representing greater diversity than a group of smaller counterparts. The related notion that reserve shape may enhance the species richness within a reserve has also been questioned (Blouin and Connor, 1985). All of the above concerns must be addressed when identifying and evaluating features and sites under this heading. Examples of diversity in Alberta exist as a variety of sites which clearly demonstrate either a successional progression or the cutting across of many successional boundaries (Plate 9).

5.3.2.8 Sensitive

This heading refers to species, communities or abiotic phenomena which, due to certain characteristics of their life-histories, structure or composition, are easily disturbed or degraded. Such characteristics include 1) high erosion potential and 2) poor regeneration capabilities of certain terrain and 3) the seasonal concentration behaviors of wildlife species for reproductive, overwintering or migration purposes. The study by Sargent and Brande (1976) used elevation as a criterion measuring "area fragility" due to the greater growint time required by communities at higher elevations to reach equilibrium. For [illegible] purposes

Plate 9. Wagner Bog, near Edmonton--a site containing an interesting diversity of community types. (photo by Cliff Wallis)

of this study, all natural areas described as Alpine ecoregion in Alberta are considered as "fragile" due to the long period of recovery required after disturbance. This includes terrain above 2100 meters in the southern portions of its range, declining to approximately 1900 meters in the northern portions (Strong and Leggat, 1981). Terms such as "important" (Smith, 1984), "special importance" (Parks Canada, 1983), "critical" (Baysinger, 1980) and "key areas" (Lamereoux et al., 1983) have all been used for this attribute. Sensitive species are of greatest concern when concentrated at a single location. Therefore, both the species and the site are important to consider as nominees under this heading. Snake hibernacula are good examples of such a feature-type (Plate 10) as are the breeding sites of colonial nesting bird species such as the White pelican (Pelecanus erythrorhynchos, Gmelin) (Plate 11).

Plate 10. Snake Hibernaculum--an example of a sensitive overwintering area for snake species. (photo by Jim Butler)

Plate 11. Colony of White Pelicans (Pelecanus erythrorhynchos, Gmelin)--a breeding area sensitive to disturbance

CHAPTER 6

A PROPOSED CRITERIA SET FOR SFIs

6.1 Introduction

Prior to site evaluation, the identification and precise definition of each criterion used in the framework is required. The criteria set actually consists of two sections; "Eligibility Criteria" and "Assessment Criteria." The latter was further divided into "Environmental Criteria" and "Non-environmental Criteria."

Certainly the most important section of the set was the "Assessment Criteria." The basis for their selection was the ability of each to reflect some component of existing or imminent threat (and to a lesser extent, desirability) to a species, habitat, community type or other special natural feature. The "Eligibility Criteria" only serve to clarify the environmental setting. The criteria set used for this study was derived solely by a literature review and informally approved by the five stakeholders involved in criteria weighting.

At this juncture, there is no evaluative justification for obtaining a more formal consensus from the stakeholders regarding the criteria set. Individual criteria may be deleted, added or modified depending on which individuals comprise the assessment team. Therefore, since the group canvassed represents a transitory (although highly valued) opinion, the emphasis of this study must rest with the outlining of methodology and not the specific criteria used. It must be stressed that this author believes this criteria set to be relatively comprehensive, measurable and operational for the purpose described in the test application.

Efforts to include as many of the criteria listed in Table 6 of the literature review (see Chapter 2.3.3) was made. Remaining under the recommended maximum number of criteria suggested by several authors was also important as was the elimination of what were considered redundant criteria. Criteria listed and defined within "Assessment Criteria" are obviously not equally applicable to all SFIs. Some refer more to biotic than abiotic features, while some refer only to species. Consequently, separate evaluation forms need to be developed for the separate categories of species, community-types and geological and hydrological phenomena.

The criteria set used for the test application of this study is defined below.

6.2 Eligibility Criteria

The nomination of candidate features for protection under a SFI program may be received from a variety of sources including government agencies, conservation organizations and private citizens. Eligibility criteria serve as a screening mechanism by which features both desirable and possible to protect are separated from the remaining nominees.

Eligibility criteria must make it possible to judge only the relevance of a candidate feature to the goals and objectives of the SFI program and not specifically evaluate the feature itself. These criteria are not used for the final numerical valuation of a candidate SFI. The criteria are stated in broad terms only and not measured by some finely graduated scale of utility, as are the Assessment Criteria. To be eligible for the assessment process, a feature must rate highly in all four eligibility criteria used. At this initial sorting stage, all criteria are of equal importance although "Inclusion Within Classification System" most succinctly identifies the characteristics of that which is to be evaluated. The decision regarding candidate site eligibility should be made at the internal level only, with some statement made as to whether to proceed with the evaluation, to reject the site or to proceed but with a request for further information. In no particular order the criteria are as follows:

1. Geographic Location

   A candidate feature not situated partially or entirely within the province of Alberta will be excluded from further consideration. A multi-jurisdicational conservation site would no doubt require a cooperative approach to attain suitable protection, but should not be valued less as a candidate feature.

2. Degree of Permanence

   A candidate feature must be permanent, cyclical or relatively recurring to score highly for this criterion. The allocation of scarce human resources is not justifiable for transient occurrences or highly temporal features.

   In the largest possible perspective most things are impermanent; species become extinct and entire ecosystems are succeeded by new and different ones. The term permanent is meaningful only in relation to that which is being discussed. For example, the succession of a "dry" slough may occur in 25 years or less, while an aspen stand may take 125 years depending on a wide range of environmental factors. Furthermore, if a site is deemed special or significant, deliberate manipulations of the site may be performed to ensure its continued existence. For this study, "permanence" implies a consistency over time appropriate for measuring a particular feature. Example--an area containing several small bodies of water, with some utilized by waterfowl species one year and others utilized in other years, would be considered as permanent. Example--an area nominated for protection based on the existence of a single transient individual of a species not normally found in Alberta would not be considered as permanent. If additional surveys demonstrated that other individuals were present in the area or, in particular, that reproduction was occurring, this site would be considered permanent.

3. Inclusion Within Classification System

A candidate site must conform to at least one of the definitions as outlined in the Categories and Feature-type Headings of the classification system. The assumption is that the Feature-type Headings and Categories represent a comprehensive list of all phenomena which may be considered special in the province. In reality, these headings may be modified or added to over time if considered appropriate by an assessment team. This criterion also assists in identifying the purpose of feature selection while rejecting extraneous sites. Features not eligible for SFI evaluation and protection are those nominated for primarily historical, cultural or social reasons and those which are introduced, domesticated or artificial. There could conceivably be exceptions to these restrictions, such as the tropical fish fauna in Banff National Park (Nelson, 1983). Such exceptions should be dealt with on a case-by-case basis. Example--a natural area valued primarily because of its recreational qualities does not fall within any feature-type heading and would not be considered eligible. Example--a rare breed of domestic cattle would not be considered eligible.

4. Redundancy

A candidate feature will not be considered for evaluation if such features have been satisfactorily duplicated in previously established SFIs. Under certain circumstances it is desirable to create redundancy in that it ensures against loss of a special feature-type through fire, disease or similar occurrences. The number of SFIs required for a specific feature-type to be considered adequately protected will largely depend on the collective vulnerability and threat levels of these features. For example, if a feature traditionally occurs in the northern regions of the province or in high alpine environments, one or two sites may suffice in the short-term. In the more highly populated and accessible southern two-thirds of the province several sites may be required to protect a specific feature-type. The extent of acceptable redundancy should be left up to the professional judgement of the assessment team. Redundancy was not included as an assessment criterion as indicated in Table 6. If a feature was considered redundant it would be an illogical use of management resources to process it through the assessment stage at all. For this reason it is used in the screening section. Example--the protection of in excess of twenty snake hibernacula, protected throughout the province and including several for each of the rarer species, could hypothetically be considered an adequate level of protection for the SFI category of "Biological/Fauna/ Herptofauna (Sensitive)." Example--the protection of an endemic plant species may involve the only two sites where it is known to occur, resulting in the complete protection of the entire Alberta population.

6.3 Assessment Criteria

6.3.1 Environmental Criteria

Environmental criteria represent a comprehensive expression of the imminent or existing recovery potential, sensitivity and extrinsic disturbance levels of a feature. The criteria used in this section are divided into two natural groupings; "Disturbance/Sensitivity" and "Recovery Potential." They measure what are largely on-site attributes and require either actual on-site measurements, extensive survey work in the surrounding region or appropriate case histories for their assessment. The measurement scale for each criterion will be oriented so that SFIs which are highly threatened will score the highest and vice versa.

These criteria consist of both man-induced and natural disturbances with the emphasis on the former. Only those natural disturbances which are relatively random, such as flash floods or volcanic activity are considered in this system. Man-induced disturbances are measured by their affects on population numbers, site area, physiognomic structure and habitat loss. Two criteria in the set (Population Status and Patterns of Population Concentration) measure attributes which concern the species directly, while the remaining seven criteria assesses disturbance levels of the associated habitat, community, or features. Recovery potential criteria assess habitat sensitivity, species sensitivity as well as the species general ability to recover from disturbance once protective action has been initiated. Such resiliency implies the potential to realize a meaningful improvement in the overall status of the popul[illegible] This requires the measurement of both the capacity of a species to regenerate itself and the ability of the habitat to allow for this increase. This involves attributes which have traditionally been discussed as r and K selection factors. If the candidate SFI being evaluated is not currently threatened, recovery potential is obviously not an immediate concern. It is still important when considering the security of a species in general.

The criteria used in the Recovery Potential section are seen as additional measures of threat, in that the ability to recover from negative disturbance is essential for a feature to avoid eventual extinction or loss. The criteria listed here, from which the criteria set for any given category may be derived, are briefly outlined below.

6.3.1.1 Disturbance/Sensitivity

1. Population/Site Status

Features are considered at greater risk when their numbers (or size) are small and on the decline. Since actual numbers of individuals vary enormously between species, even within the same genus, measurement of this criteria must be assessed generally.

For living species of plants and animals the measurement scale needs to include a description of both abundance (relative to what occurs in areas of similar habitat) and the population trend (measured as a percent reduction over the last five to ten year period). Obviously, species life-history patterns, including cyclic patterns and stability, must be taken into account when assessing population trends. When specific information on numbers is sparse or lacking, stability is used in the sense of a system's or population's general ability to avoid displacement or loss during stress (Harrison, 1979). Knowledge of a community's system structure (i.e. mostly above ground, etc.) may assist in determining how a particular disturbance might alter a system (Pickett and White, 1985).

For rare and endangered species in the province direct enumeration of numbers is not only possible but already accomplished for some of the larger birds and mammals. Direct size estimates for species with high annual turnover rates (i.e. rodents, small birds, most amphibians and reptiles and insects) is not usually possible and therefore lacking. This is true provincially as well as for specific sites within the province. General population levels must be known for a region before any assessment can be made. This study considers species that are abundant or common to be equivalent to a ratio between 1.0 and 0.6 (numbers present/numbers expected, common to uncommon between 0.4 - 0.5 and very uncommon to rare as less than 0.4. Rates of decline may prove even more difficult to measure and require several years of data for any reliable assessment to be made. Specialists or amateur naturalists well acquainted with the site in question are essential in determining how to asses this attribute.

Communities and geophysical phenomena when considered as a candidate SFI may likewise be measured using this attribute. Pertinent components of the measurement scale will include the loss of area to date as well as the rate of loss. Those features which have suffered considerable reduction in numbers (or size) and are continuing to do so at a rapid rate will be considered the most threatened (i.e. will score the maximum of 100 points) based on this attribute.

2. Degree of Habitat Degradation

Populations require a certain quality and quantity of habitat to remain viable. Those species which face continued losses of habitat are seen to be more threatened (with at least extirpation) than those which have abundant habitat. Initially, the measuring of both population status and habitat degradation as components of threat may appear redundant since it can be argued that species will decline in numbers when habitat is lost. While true for the majority of endangered species, other factors may also be important. These include environmental contamination and overharvesting.

Environmental contamination includes introduced competitive exotics and predators and all forms of pollution. Since certain contaminants will benefit certain species or communities, contamination must refer to the direct or indirect effects on the candidate SFI. The principle of competitive exclusion states that two species cannot coexist on the same limiting resource (Davies and Krebbs, 1978). As com[illegible] recent introductions have yet to evolve, [illegible]ics are able to outcompete residents to the point of residen[illegible]tion within relatively few generations. Local species are lik[illegible] not capable of adjusting to intr[illegible]ed predatory species and may suffer similar high rates of loss.

Pollution which alters productivity, function, and availability of communities and habitats, and the physiology, reproductive ability, behavior or numbers of individual species is considered detrimental to candidate SFIs. This includes sporadic infusions of fertilizers which may appear to enhance the health or distribution of certain plant species but only to the detriment of total community integrity and stability. Also included are litter, noise, solid wastes, sewage, pesticides, waste heat, radioactive wastes and explosives. Exact data on the effects of pollutants on specific species and communities may not exist. When pollutants are known to exist or expected to exist within a site, past case histories will be used to evaluate the effects of the pollutants.

"Naturalness" is the term frequently used in the conservation literature as being related to habitat or community degradation (see for e.g., Tubbs and Blackwood, 1971; Ratcliffe, 1977 and Parks Canada, 1983). The term implies freedom from both the negative and positive influences of Man, although this is never wholly possible throughout much of the world. For many studies employing naturalness as a criterion, the lessening of this attribute implies a reduction in community structure, diversity and overall species richness. For species, a reduction in the naturalness may be interpreted as a reduction in the essential components of the community required for continued existence. Citing empirical data, Margules (1981) states that low levels of diversity and richness are not necessarily correlated to low levels of naturalness. He suggests the predominance of native species as a more acceptable and applicable attribute and this has been supported in other studies (Cottonwood Consultants, 1983).

While the occurrence of alien species as a measure of naturalness has been used as far back as Tansley (1935), it does not explain decreased naturalness for all situations. Many man-made disturbances, such as roadways, excessive or inappropriate land-use, overhunting, burning and selective harvesting, may not result in a change in the levels of non-native or introduced species. They may, however, alter community physiognomy, productivity, native species composition, moisture regime, erosion activity, soil profiles and fertility (Jain, et al., 1981). Interdisciplinary Systems Ltd. (1980) identified twelve activities which could affect the naturalness of any given area in different ways. The result is that the degree of naturalness of a community may remain constant (based on Tansley's definition) while the amount of habitat for any given species may vary. An example of this is the removal of deadfall and the subsequent loss of suitable nesting sites for cavity nesting bird species.

Ratcliffe (1977) evaluated naturalness differently for calcareous grasslands and peatlands. For grasslands, levels of naturalness were based on the lack of interference with physical structures and freedom of sheep-grazing. The naturalness of peatlands was assessed using the degree of intactness of morphological features and vegetation zones and a lack of disturbance of the hydrology. A retrogression or reverse succession may also be brought about by disturbances such as overgrazing. In these instances, Whittaker (1975) does recognize a reduction in the diversity and species richness as being characteristic of lowered levels of naturalness.

In assessing naturalness for species, the extent and rate of habitat loss is paramount. If a species habitat is homogeneously distributed throughout a site, the percentage of site loss may be considered equivalent to the percentage of habitat loss of a given species. If a species habitat is patchy within the site, then a more detailed inventory of the patches will be required. To assess the trend in habitat loss, (at least) some general knowledge of past conditions is necessary. This may be accomplished through existing data or verbal descriptions of individuals familiar with the site in conjunction with some deductive investigation. Habitat loss as defined in this study ranges from slight loss (0 to 10% over ten years) to extensive loss

(50% over ten years) with evidence of ongoing loss. In assessing this attribute for a community-type the loss of naturalness based on native/non-native species composition is most meaningful.

This study is designed to examine a variety of features, therefore the measurement of this attribute must be in general terms only. A community or habitat possessing a high degree of naturalness will be valued as a stable environment of high conservation value, as a desirable situation for fragile ecosystems and sensitive species and as a good source of baseline information. Within this proposed evaluative framework, naturalness or lack of degradation does not measure the spiritual, philosophical and emotional benefits to man.

3. Buffer Zone

A natural feature is considered less threatened if an adequate buffer zone exists. A buffer zone protects the site from direct and indirect activities of man and from adverse natural disturbances. The adequacy of such a zone depends primarily on the extent to which it encompasses the conservation site, but also on a number of other factors including vegetation type, the intrinsic characteristics of what is being protected, the depth of the zone relative to site area, adjacent land-use, topography and the nature of the site's boundary (i.e. road, river, fence, pasture, not defined, etc.) (Tans, 1974). Buffer zone quantity is simply the extent (in percent) that it surrounds the feature/site. The quality of the buffer zone contains too many variables to incorporate into a single measurement scale and by necessity, must be subjectively assessed.

The maximum score possible for this attribute is 100 points, which is achieved when the buffer zone quality is adequate or less and when it surrounds less than 25% of the SFI.

4. Site Size

The consideration of site size as a criterion in conservation efforts is based on the theory and discussion on equilibrium biogeography (MacArthur and Wilson, 1967; Wilson and Willis, 1975; Simberloff and Abel, 1982; Lynch and Whigham, 1984 and Margules et. al., 1982). It formerly states that for the species-area relationship, large areas of certain habitat usually contain more species than small areas of the same habitat. The number of species is expected to increase uniformly with area. Based on biogeographic theory and in an effort to maintain species and community diversity, some conservationists have argued for the protection of a few large reserves as opposed to many smaller ones (Terborgh, 1975 and Faaborg, 1979). The theory encompasses the argument that small reserves, existing in isolation from similar habitat, will lose species more rapidly and eventually a greater total number of species, than larger reserves. Furthermore, these smaller "islands" will reach equilibrium with a smaller number of species than larger sites. Recent literature in this area has argued against total or even partial acceptance of biogeographic theory. Researchers have claimed the theory is based on unsubstantiated assumptions (Margules, et al., 1982), faulty conclusions (Boecklen and Gotelli, 1984), unattainable management implications (Kushlan, 1979) and that empirical data on plant and animal species does not indicate the species-area relationship expected by the theory (Jarvinnen, 1982; McCoy, 1983; Game and Peterken, 1984 and Jefferson, 1984).

The use of biogeographic theory for conservation purposes revolves around the attempt to maintain species and genetic diversity. Diversity in this sense implies that the more species or communities conserved the greater the richness of life on the planet. The aims of this study are not exclusively to protect areas which may contain a diverse array of living species, but rather to focus protection efforts on specific special features which have been identified as threatened. While species or community diversity is applauded by this current study, it is not diversity within sites but a diversity of sites which is the focus. Consequently, given the aim of this study and the questions [illegible] from biogeographic theory, the acquisition, selection and design of nature reserves based solely on size (i.e. large size) is currently of limited value.

Criticisms aside, the theory does stimulate questions regarding what is the "minimum dynamic area" (Pickett and Thompson, 1978) for specific species and communities so that essential ecological, physiological and/or behavioral requirements will continue to be met. This is closely related to the concept of "minimum viable population" (Gilpin and Soule, 1986). If a site is smaller than the minimum dynamic area required by a population of a species to sustain itself above minimum viable population levels, the population with eventually be extirpated.

Problems arise as to how to determine both the minimum area and population levels. Ratcliffe (1977) outlines minimum or optimum areal size for various community-types. Based on theory, he concluded that a body of open water should not be smaller than 0.5 hectares; peatlands, 1.0 hectares; woodlands, 5.0 hectares and upland grassland/heath at least 50 hectares. Others discuss the "effective conservation unit" which includes not only size but shape, location and buffer zone (Toms, 1974 and Parks Canada, 1982).

Gilpin and Soule (1986) thoroughly outline the difficulties and complexities in determining minimum viable population levels. They conclude that while the factors which determine these levels are becoming clearer, it is to date only possible to loosely predict species' requirements based on taxonomic, ecological and body size categories. It has been suggested that the animal at the top of the food chain could be identified and its minimum area viability requirements be subsequently established. The setting aside of this area would theoretically ensure the area requirements (i.e. survival) of all the species within that food chain (Margules and Usher, 1981 and Shaffer, 1981). While such a strategy may make intuitive sense, if the major species of concern does not require such a large area, setting one aside would not be biologically justifiable. Also, the establishment of a series of these reserves would prove economically and politically unfeasible for regional and local political levels.

The lack of a definitive means for assessing site size requirements allows for little more than the qualitative impressions of conservation biologists as a means of scoring this attribute. In general, a site which serves as habitat for any species may be;

1. sufficiently extensive to allow for population increases through natural recruitment
2. insufficient to allow for population increases but large enough to maintain a moderate to large population
3. insufficient to naturally maintain a population at anything other than low levels, or
4. insufficient to maintain a population above its assumed minimum viable population level.

If viability is not an immediate concern, small areas can be effectively increased by man-made manipulations such as artificial feeding and nestbox construction.

For some species all of their life-history components are not pertinent to site size assessment, only those occurring at the site and/or within the province. For example, only the breeding grounds of migratory bird species are considered in relation to SFI size requirements. For other species, area needs will be more general and highly variable. They will range from large area needs of raptors, large mammals, predators and woodland communities, to small area needs of most rodents, land birds and most individual plant species (Adamus and Clough, 1978).

For highly mobile species, size requirements may be difficult to determine. It has been suggested by Wood (1983) that a series of small reserves be established along migratory pathways to resolve this difficulty. Such a strategy would likely prove equally useful when applied to formerly contiguous populations which have become fragmented. A cluster of small reserves may reduce population isolation and serve as havens for species existing in marginal habitat in the surrounding area (Wilcove, McLellan and Dobson, 1986). The proximity of the reserves will ultimately depend on such factors as species mobility (Higgs and Usher, 1980) and propagule dispersibility (Game, 1980). Grubb (1977) stresses the importance of required niches in the maintenance of species richness in plant communities. This implies that the entire range of age classes within a given community may be required for adequate protection of certain plant and animal assemblages.

5. Access/Land-Use Conflicts

Several studies consider high accessibility to conservation sites as desirable for the educational and recreational potential it implies (Smart, 1975; Everett, 1978 and Cottonwood Consultants, 1983). These values are not priority concerns for this current study. The lessening of negative disruptive events are of the greatest concern in the protection of SFIs and access should ideally be low and restricted. Low and restricted access may be the most beneficial for a feature if such access allows positive management and research activities to occur. Beyond this point it is assumed that the greater the ability of humans to access an area the greater the potential for significant land-use conflicts. The means by which an area is accessed (i.e. on foot or by vehicle) and what transpires thereafter (i.e. photography, stripmining, farming, hunting) is also pertinent, although the latter cannot be automatically inferred the former. Acquiring land for conservation purposes may also prove difficult if activities ranging from low-impact recreational use to high intensity resource extraction are already in place.

For any given region of the province extensive road systems are usually indicative of high human population densities. It will be expected for all candidate SFIs located within the Central Parkland, Grasslands and the Peace River Parkland Regions of the province, access will on average be greater and use heavier. For some species, road construction in itself may constitute incompatible land-use since it could contribute to habitat isolation and increased threat levels for some species (Mader, 1984). This must be considered for smaller, less mobile species or species highly adverse to human activities and structures when assessing the effects of human access. An assessment of specific existing or imminent conflicts relative to the specific SFI being assessed is necessary as some land-use/conservation interactions may not constitute significant conflict.

6. Natural Disturbance

Natural disturbance and patch dynamics occur on a wide variety of spatial and temporal scales. Those which occur over small areas with sufficient regularity to be a component of the selective forces exerted on a species, provide a measure of stability and continuity. These types of disturbances will not, in general, extirpate a population from a large area but will create smaller open spaces which the same species may eventually recolonize.

Natural disturbances which are of sufficient frequency, magnitude or intensity may be termed catastrophies. These forms of disturbance can eliminate the species or community from an entire area, limit resource availability for extended periods, but by and large occur much less frequently (Sousa, 1985). Extremes of drought, epidemics, climatic shifts or volcanic activity are examples of such diffuse, point crises (Delcourt, et al., 1983). This study identifies such natural disruptions as extensive, and if their affects envelope the SFI, will result in a maximum score of 100 points for this attribute. Tidal fluctuations, seasonal flooding and periodic low intensity fires are not examples of disturbances which threaten the continued existence of populations or communities within a relatively large area. Consequently, these are not considered events which will greatly threaten the existence of populations and may even be of benefit.

Due to the wide range of natural catastrophic events which may impinge on a SFI, the measurement scale of this attribute can only be assessed generally. The history of the site or at the very least a knowledge of the kinds of natural disturbances characteristic of the larger area are essential for scoring this attribute. The measurement scale for natural disturbances, as used in this study, range from no disturbance or normal patch dynamics through to the most severe natural disruptions. The latter include flash floods, volcanic activity and intensive and widespread fires.

7. Patterns of Population Concentration

Plant and animal species which occur across their range in localized concentrated groupings are considered in greater danger of losing a large proportion of their population through a single disturbance than those species more homogeneously dispersed. While disturbance may affect these groups directly, the fragmentation of the population, either naturally or through man's efforts, may have additional ultimate effects as well. These include low rates of colonization into suitable habitat, genetic drift, inbreeding and ultimately extinction (or extirpation). All of these factors can reduce genetic variability and species viability. If species do tend to occur in such concentrations, the greater the number of such groups the relatively less threatened a species tends to be by localized negative disruptions. Also, the less time spent in these concentrated groups the less vulnerable a population will be.

While evidence indicates some advantages to colonial nesting (Emlen, 1978), including predator defense and the locating of resources, the advantage is lost when they are hunted or disturbed in ways against which their behavior provides little defense. Therefore, species which concentrate for a portion of their life-history are not only valued as special (see Chapter 5.3.2.8), but are also considered more vulnerable to disturbance particularly when concentrations occur in a few large groupings.

6.3.1.2 Recovery Potential

1. Degree of Specialization

Species which are relatively more specialized in one or more life-history components are considered to be at greater risk than those species considered as generalists (Partridge, 1978). They are inherently less able to cope with abrupt changes in their environment and less able to recover once disturbed. Behavioral specializations, such as those of animal species that are "wilderness dependent" are also considered under this attribute.

Some studies have attempted to link specialization with rarity, and by extension with higher extinction rates. Hubbell and Foster (1986) found in tropical forests that rare species did show significantly greater degrees of specialization for both habitat (i.e. fixed microsite conditions) and regeneration (i.e. ephemeral microsite conditions) niches. Other studies support the "niche variation hypothesis" which suggest that generalist species may only be comprised of individual populations which have specialized in their habitat use (Van Valen, 1965 and Grant <u>et al</u>., 1976).

If it is advantageous for populations of a species existing in a relatively uniform environment to limit the range of its variability (Dobzhansky, <u>et al</u>., 1977), then genetic uniformity will prove disadvantageous when random and extensive alterations to the environment occur. These changes will significantly reduce the available space a highly specialized species may inhabit and thus potentially increase extinction rates. While rare generalists exist, the explanation for their rarity must be based on other intrinsic attributes and/or environmental conditions.

If it is legitimate to suggest a high degree of specialization increases, at least, potential threat for a species, the question of how to define a specialized species remains. Flessa <u>et al</u>. (1975) choose as a specialization "index" for aquatic free-living athropods the extent of morphological complexity as measured by the diversity of limbs. This method of inference appears to be necessary when data on actual habitat use is lacking. It is also an index with limited applications for other classes of species.

Even when information on habitat specialization is lacking, it is logical for a definition of species specialization to revolve around habitat usage. The concept of "guilds" has been used to categorize species based on their association with the structure of habitats. It can serve as a means of identifying guilds and species which have very specific habitat or niche requirements. Hubbell and Foster (1986) classified species as niche specialists if there was a positive association of individuals with the spatially delimited habitat area at a critical p value of 0.05. Short (1983) did not define specialization based on the degree of habitat affinity but on whether the disruption of a "layer" of habitat would deleteriously or adversely affect the species or guild in question. A deleterious affect occurs when a layer of habitat which serves as the only loci of breeding substrates or food sources for a guild is degraded or lost. An adverse effect occurs when a layer of habitat is degraded or lost that is one of the two or more loci of breeding substrates or food sources for a guild. Clearly, those species deleterious affected are relatively more specialized than those adversely affected, based on the niche requirements for breeding and food procurement.

Specialization so defined appears to better express the concerns conservationists must deal with in their attempts to preserve specialized species. It is therefore appropriate for use in this study. The measurement scale for this attribute ranges from a species which is considered a generalist, to a species which may be adversely affected in one or several niche attributes, through to one which may be deleteriously affected in several niche attributes. The degree of specialization as used in this study does not apply to communities, habitats or intercommunity species comparisons. It applies only to interspecific comparisons within the same class (or higher taxa) and only using those life-history components of breeding, food procurement and wilderness dependency.

It is recognized that for many plant and animal species, such data does not exist. If such is the case, scoring this attribute will require subjective professional judgement or stating that the degree of specialization is not known.

2. Habitat/Community Resilience

The resilience of a community is measured by the amount of time required to return to the composition and structure which existed prior to disturbance. This ability depends on two factors; the characteristics of the disturbance and the characteristics of the community. For those SFIs being assessed where specific kinds of disturbance can be identified, both factors should be included in the assessment. Knowledge of the systems' structure relative to a particular disturbance is required to specifically assess how the disturbance may affect resiliency. The structure of a community may be all above ground, all below ground, or some intermediate condition (Pickett and White, 1985). For those SFIs where specific disturbances are not readily identifiable or where unspecified threats may be imminent (i.e. not yet measurable), only the characteristics of the community can be used.

With regenerative abilities or resilience being measured as a function of time, later successional stage communities are viewed as less resilient than earlier successional stages or those adapted for patchy environments. Communities which typically occur at higher elevations are also considered to be less resilient for the same reasons. The measurement scale developed for this attribute will score 100 points (i.e. most threatened) for an SFI if it is a late successional stage for a particular ecoregion and occurs at elevations greater than 1900 meters.

While large or frequent fluctuations in population numbers may or may not indicate stability, Holling (1973) states that they most certainly imply resilient abilities in species when viewed in the long-term ecosystem perspective. Consequently, while at any point in time, a population's numbers may be declining, this need not imply low resilient abilities resulting in a high score for this attribute.

Continual negative disturbance may eventually affect the ability of a community to be resilient and should be considered during assessment (Denslow, 1985). However, due to the lack of information likely to exist on this issue, the expected affects of disruption on community resiliency can only be assessed generally if at all (May, 1974).

3. Reproductive Potential

The ability of a population or species to reproduce itself is a critical factor in assessing its potential to recover from threat or disruption. A species may possess several attributes which enhance or detract from this ability and these in turn are partly determined by environmental conditions. These include species size, maturation rate, brood size and frequency, level of parental care and life-span. Due to the vast differences amongst species in different taxa regarding these components of reproductive strategy, determining and comparing exact numbers would be meaningless if not impossible. An unwieldy scale would be required to compare even one attribute, for example fecundity, between a salmon and a carp let alone a [illegible] grizzly bear. Fortunately, Ricklefs (1978) in pointing out [illegible] all of th[illegible] attributes may be inherently correlated implies that they all may be subsumed into one, more manageable, criterion. Sparrowe and Wight (1975) suggest employing the "rate of average potential population growth" as measured by the general reproductive rate of the species and the expected survival rates of both young and adults. These can only be expressed generally, as in percent growth possible under near normal conditions, and would require mature professional judgement. Most insect species and many fish species produce many thousands of eggs annually per individual and would be considered as having high reproductive potential. Conversely, many vertebrate predators and most larger mammals would have a reproductive rate which is low to very low.

In many instances general life-history data on a species, or even related forms, will be required to extrapolate to the specific candidate SFI being assessed.

6.3.2 Non-environmental Criteria

Non-environmental criteria have traditionally been valued less highly for use in conservation evaluations. They represent additional off-site concerns which planning and management authorities must deal with to protect tracts of land for conservation purposes. They provide a useful means for distinguishing and choosing between two or more very similar sites within the same category and feature-type heading (Sargent and Brande, 1977 and Cottonwood Consultants, 1983). Measurement scales will be oriented such that those SFIs which provide the most desirable circumstances for protection will score the highest and vice versa.

The measurement of these attributes must be made largely by comparing similar case histories or by subjective estimates based on current knowledge. Non-environmental criteria are divided into two subsections; "Level of Significance" and "Planning and Management Considerations." The former involves additional considerations which may affect a feature's overall desirability for protection while the latter; the difficulties which may occur when actual attempts at site protection are initiated. Low "Planning and Management Considerations" scores may indicate potential threat, in the sense that such factors as high costs of protection and lack of landowner cooperation may inhibit or even prevent protective action from occurring. This could eventually lead to site loss through neglect. The criteria are briefly outlined below.

6.3.2.1 Level of Significance

1. Jurisdictional Significance

Both the public and governmental agencies have the responsibility for maintaining the biological diversity within their own political boundaries.

However, jurisdictions must not develop conservation strategies in total isolation from similar efforts. Sites which have been identified as increasingly more significant at scales larger than the local or regional are considered of higher protection importance in this study. Features listed as internationally significant are of importance at that level for reasons other than that which is primarily dealt with in this current study (i.e. regional threat levels). These include species with high public appeal and features with high educational value as well as those actually threatened on a worldwide basis. Features identified as important at the regional level will seldom also be identified as such internationally. A review of the literature combined with professional judgement should be used to assess this attribute.

2. Security of Taxonomic Unit

A species is considered of greater value if it is the last or one of the last representatives of a higher taxon (usually the genus or family level). This is important due to the emphasis in conservation on the maintenance of genetic diversity. An example in Canada of a species which would score highly for this criterion is the Virginia Opposum (Didelphis marsupialis, Linne), the only marsupial in Canada. The lack of taxonomic security may be the result of members within the taxa being severely threatened overall (perhaps due to a pervasive tendency to specialize) or simply that the species is monotypic. This study considers as most threatening to the security of a taxonomic unit the existence of a species which is monotypic and has many related subspecies threatened. This condition would score 100 points on the measurement scale constructed for this attribute.

For the purposes of this current study this criterion applies to all levels of significance and not just to the security of a taxon as it exists in Alberta.

3. Scientific/Educational Value

Scientific/Educational value refers to a candidate SFI's potential opportunities for research and learning. This value is enhanced when the benefits derived contribute directly towards conservation objectives. The measurement of this attribute will stress the scientific rather than the educational potential. The assessment of these values depends on several factors including the distance of the site from metropolitan areas, the number of people who may conceivably benefit from site use, the sensitivity of the site itself and the extent to which ongoing research is being conducted at the site. Unfortunately, these factors, which increase the scientific value of a site, are also those which invariably increase disturbance levels. Concerns regarding site protection must remain paramount for a conservation evaluation system which deals with rare and fragile features. Education, while recognized as an effective means to achieve long-term conservation objectives, must receive secondary consideration regarding on-site use. The measurement of this attribute is purely subjective and is scored on a percentage basis.

4. Hybridization Potential

For common species, the ability to hybridize is not seen as a threat to the security of a species or as detracting from it's ability to be successfully managed. If hybridization is occurring normally then the two species involved are insufficiently distinct (i.e. subspecies or clines) for concern to arise over gene pool contamination and managing against naturally occurring phenomena.

However, in attempting to identify threatened species and to conserve their distinct genetic materials, gene pool contamination is a legitimate concern. Beyond an optimum amount of genetic divergence, hybridization does not produce hybrid vigor, but rather outbreeding depression (Wallace, 1968 and Stuber, 1970). The occurrence of such depression in marginal species may result in their eventual loss. This can occur through the breakdown of reproductive isolating mechanisms of wild species or the introduction of genetically related domestic species. The efforts to retain the genotypic distinctions between Bison bison athabascae (Rhoads) (the Wood Bison) and Bison bison bison (Linne) (the Prairie Bison) by preventing further hybridization reflects these concerns by conservation biologists. Some researchers hold that conservation efforts should be directed at preserving unique evolutionary lineages and not the "currently-existing constellation of traits" we traditionally term a "species" (Templeton, 1986, p. 115). Certain studies lend credence to this when they conclude that inbreeding depression is rather temporary and can be rapidly eliminated by natural or artificial selection (Templeton and Read, 1983). Also, when the genes associated with the depression are selectively eliminated, superior gene complexes can arise.

Since little is known about this phenomena for most species, it seems prudent to define for this study -- the frequent occurrence of hybridization and/or ease of occurrence with sympatric forms -- the highest (i.e. 100 ponits) and most threatening scenario for a species.

The converse argument regarding this criterion should be noted. That is, those species which cannot interbreed are more threatened if their populations reach critical levels, since their gene pool cannot be "salvaged" by the intentional cross-breeding with related forms. This notion, that species or populations increase in value as the distance between them and related forms increases is implicitly dealt with under the criterion "Security of Taxonomic Unit."

6.3.2.2 Planning and Management Considerations

1. Degree of Existing Protection

A feature is considered to be more secure if it exists within a formally or legally protected area as opposed to an area held for speculation and development, or otherwise poorly protected. Legally protected sites include those with legislative mandates (e.g. National Parks, Provincial Parks, Wilderness Areas). Formally protected sites include those where written agreements are made (e.g. Cooperative Wildlife Management Areas, University Research Sites). Lands nominated as conservation areas often exist on private property or lands owned by other government agencies not directly involved in nature conservation. Both private citizens and government agencies may prove unreceptive to the setting aside of parcels of land solely for conservation purposes. The assessment of existing landowner attitudes and the potential for attitude change are required to determine the feasibility of initiating feature protection. Feature protection will prove more successful if conservation objectives are being initiated through formal or legal protection. Therefore, sites which are currently being developed, or where development is imminent score highest (i.e. 100 points) for this attribute. In the final analysis, such sites may prove impossible to save.

2. Assessment of Management

The existence of a candidate SFI within a formally protected area does not automatically insure that satisfactory management practices are in place and being consistently applied. The existence of ongoing management programs and policies influence the survival of plant and animal populations. For example, accurate monitoring of permanent reference points is one essential activity for rare and endangered species management to be successful (Bradshaw and Doody, 1978 and White and Bratton, 1981). The lack of management plans to deal with rare and sensitive natural features constitutes secondary threats to a site and indicates the extent to which such plans must be developed for site protection.

3. Cost of Protection

One result of setting aside lands for protection is the incurring of costs. These costs include the funds to acquire the land (if necessary), ongoing management costs and even legal fees. In extreme situations the expense involved in protecting and managing a conservation site may prove prohibitive even for those of top priority. In most cases, however, cost will only prove to be a suitable attribute for separating otherwise identically valued sites. The cost incurred in similar situations must be reviewed to subjectively estimate the initial and ongoing costs of protecting a SFI. The economic notion of "opportunity cost" which is the cost involved in not using the site for more profitable ventures is not considered under this criterion.

The scoring of this attribute must be done generally, with only subjective descriptions of the costs used (i.e. high, medium and low). Cost estimation on this scale will be relative to the budgetary constraints of the agency or group involved as well as what will be the "return" on the "investment." The "return" can be measured abstractly using the area of a site or number of species protected.

Part IV: A Test Application of the SFI Evaluation Framework

CHAPTER 7.0

A TEST APPLICATION--

"FERRUGINOUS HAWK POPULATION NEAR HANNA"

Introduction

It was important to conduct a test application of the proposed nework for several reasons. It was necessary to demonstrate the luation process and to determine if sufficient information could be hered on a specific feature for the system to be effectively lized. Finally, it was crucial to determine if the method of scoring ld result in a site priority that corresponded, at least broadly, to intuitive, pre-evaluation feature assessment by the professionals olved. A large discrepancy between the Conservation Utility Index I) (ie., the final score assign[illegible]to a feature) and the intuitive king by the professionals could indicate several problems. These lude that the system was not very accurate, that the criteria set was undant or incomplete, or that some or all of the criteria were roperly defined or calibrated. One alternative not considered is t the professionals themselves were inaccurate in their assessments.

The individuals involved in feature assessment were primarily ef. K. Schmutz and to a lesser extent, Alan R. Smith, both of katoon, Saskatchewan. Schmutz, a professor at the University of katoon, has spent the last 11 years studying and monitoring the site where the hawk population occurs. Smith, a habitat biologist for CWS has substantial knowledge of the site and the region in general. Ideally, a committee of several individuals should comprise the assessment team so that many points of view may be heard and a final concensus arrived at. It is desirable that some individuals remain as ongoing committee members to retain a continuity in site assessment. Time constraints made the organization of such a committee impractical. However, it is believed that the substantial discussion that went on between the two professionals and the author greatly reduced any confusion or bias on their part.

The candidate FSI chosen for the test application is a population of Ferruginous Hawks (*Buteo regalis*, Gray) located near Hanna, Alberta. Ferruginous Hawks have declined by approximately 50% in the province and are listed as "Threatened" on COSEWIC's status list. Schmutz and Schmutz (1980) attribute this decline to forest invasion of grassland habitat and increased human disturbance, primarily farming activities. The site itself exists in the Mixed Grass Prairie dominated by *Stipa-Bouteloua-Agropyron* grass community.

The test application is presented as a series of forms; the nomination form, the eligibility form and finally the evaluation form.

7.2 Feature Nomination

The nomination form serves to formally introduce the assessment team to the site. It should provide the information pertinent to assess site eligibility or at least indicate if further data collection is required. It should state site ownership, location, general site condition and the reason it is being nominated.

Nomination Form for Special Natural Features of Interest (SFI) Candidacy

1. Candidate Feature Name: ferruginous Hawk Concentrations

2. Nomination being made because site is itself, or contains, the special and/or significant:

(circle one or more)

A) plant species	B) habitat	C) community
D) animal species	E) geological phenomena	F) hydrological phenomena

3. Provide details regarding why the feature is special and/or significant (what exactly is on the site, how many, distribution on site, etc.).

Site contains population of Ferruginous Hawks which are listed threatened in Canada. Hawk population very large and increasing as of last year. Use shelterbelts for nesting. Site may contain viable population of Burrowing Owl, also threatened in Canada. Much of this type of habitat (i.e. short-grass prairie) has been lost.

4. General Area: Southeast of Hanna, Alberta

5. Specific Location: 51° 25' N Latitude (township, range and specific coordinates unavailable)

(geographical or township, range and section coordinates preferred) 111° 45' W Longitude

6. Site Size: 300 Square Kilometers

7. Legal Status: Provincial Crown Land; Special Area 2 Managed by Special Areas Board, Hanna, Alberta, T0J 1P0

8. Site Uses: leased as pasture land with less than 8% under cultivation

9. Provide general statement regarding site condition (is site being degraded, what kind of degradation, current land uses, is there a protective buffer zone, etc.).

- little true prairie grassland left due to grazing and cultivation, but population of major food source (ground squirrel) doing well.
- access may limit site tenacity, nesting success, etc.
- some poisoning of food source, buffer zone quite extensive.
- forest invasion of prairie habitat a small problem.

10. Additional Comments:

Extensive information on site. Information included with nomination form.

Contact Joe Schmutz for further data if required.

11. Feature Nominator (Group or Individual)

Name: Canadian Wildlife Service (Edmonton)

Address: Twin Atria Building, 2nd Floor
4999 - 98 Avenue
Edmonton, Alberta T6B 2X3

Phone: (403) 420-2525

Contact Person: Dr. Geoff Holroyd

Date of Nomination: January 5, 1987

7.3 Feature Eligibility

The eligibility form assists the assessment team in deciding if the feature should be accepted or rejected for further evaluation. If the feature is rejected no further action need occur except for an explanatory letter to the nominator. Some appeal process should be in place for the nominator. In some cases, a preliminary investigation may be required to find out if the site really exists as stated on the nomination form. If the site is assessed as eligible, information gathering should begin for actual site evaluation.

Eligibility Assessment of Candidate

Special Natural Feature of Interest (SFI)

1. Name of Candidate SFI: Ferruginous Hawk Concentrations

General Location: Southeast of Hanna, Alberta

2. Feature Nominator

Name: Canadian Wildlife Service (Edmonton)

Address: Twin Atria Building, 2nd Floor
4999 - 98 Avenue
Edmonton, Alberta T6B 2X3

Phone: (403) 420-2525

Contact Person: Dr. Geoff Holroyd

Date of Nomination: January 5, 1987

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circle either yes or no
for each question

3. Does candidate feature fall completely or partially within Alberta's jurisdiction? [✓ yes] no

4. Is candidate feature recorded as relatively permanent, cyclical or recurring to justify resource expenditures? [✓ yes] no

5. Does candidate feature fall within one classification Category AND Feature-type Heading? [✓ yes] no

List Category: Biological-Vertebrate/Bird (Raptor)

List Feature-type Heading: Rare

6. Is there currently insufficient representation within the program of this SFI, Feature-type Heading or Category to ensure continued feature viability in the province? [✓ yes] no

7. Based on questions 3 through 6 and Nomination Form, it is recommended that the candidate SFI be:

(circle one only)

[✓ A) accepted for evaluation] B) accepted with request for further information C) rejected for evaluation

8. Comments:

- Sufficient site documentation exists; verification of information not required.
- Evaluation should proceed.
- Contact Joe Schmutz at University of Saskatchewan (306) 966-4412 and Al Smith CWS, Saskatoon for consultation

Signatures of Administrative Board

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Date: January 28, 1987

7.4 Candidate Feature Evaluation and Priorisation

The evaluation form is the basis for deciding feature sta[illegible]d what actions should be undertaken for its protection. The final CUI, the priority ranking as well as the four category subscores serve only as guidelines in decision-making. The comments and recommendations section should discuss specific details about the feature, not just the scores, and should include the name of the agency best suited to manage it. To arrive at the final CUI, the final weighted scores are simply added together.

SFI Candidate Feature Summary Sheet

Category I -- Disturbance/ Sensitivity (n/49)		Category II -- Recovery Potential (n/10)		Category III -- Level of Significance (n/31)		Category IV -- Planning and Management (n/11)	
A.	2.6	H.	0.9	K.	13.0	O.	1.2
B.	3.0	I.	2.84	L.	5.0	P.	0.0
C.	1.16	J.	1.5	M.	2.4	Q.	2.0
D.	0.0			N.	0.0		
E.	4.8						
F.	2.25						
G.	0.0						

Category I Subscore 13.81 (add A→G)	+	Category II Subscore 5.24 (add H→J)	+	Category III Subscore 20.4 (add K→N)	+	Category IV Subscore 3.2 (add O→Q)

= CONSERVATION UTILITY INDEX (CUI) (add subscores I → IV) $\boxed{42.10}$

UNKNOWN COMPONENT (add all unknown scores) $\boxed{0}$

PRIORITY RANKING (circle one): P1 (CUI 66-100) [✓ P2 (CUI 36-65)] P3 (CUI 0-35)

Comments and Recommendations: feature not currently threatened though some potential exists. National/International significance with good scientific value and educational potential.

landowner cooperation good.

recommendations -- registration and designation of feature/site with legal agreement involving access for conservation managers/researchers and restrictions on further cultivation of native grassland.

-- erect and maintain nest boxes.

-- identify education potential.

-- contact Alberta Fish and Wildlife Division Nongame Section and Special Areas Board Hanna (Abner Grouer, Chairman, 854-4451)

Candidate Feature Assessment Form

Site Name: Southeast of Hanna Ref No.: 1 Size 300 sq. km.

Category: Biological/Vertebrate/Bird(Raptor) Feature Type: Rare

SFI Name: Ferruginous Hawk

1. Measurement descriptors for each criterion apply to current situation or imminence of occurrence.

2. Where applicable, utilities intermediate between any two stated utilities may be used for any criterion.

Assigned Utility
(Unknown component placed in boxes below)

I DISTURBANCE/SENSITIVITY
(49 possible points of 100 total)

A. Population Status (current abundance and trend for site) (13/49)
(Size = actual #/expected)
(Growth rate = % reduction over 10 year period)

0 - large and increasing	0	
1 - abundant (0.9-1.0) and stable	[✓ 20.0]	
2 - abundant and decreasing slightly (5-10%) or, small and stable	40.0	
3 - abundant to common (0.6-0.8) and decreasing moderately (10-25%)	60.0	
4 - common to uncommon (0.4-0.5) and decreasing rapidly (25-50%) or, small and decreasing slightly	80.0	
5 - small, rare, remnant or disjunct (0.4), and decreasing moderately to rapidly	100.0	1
- abundance and trend unknown		100.0
	20.0	☐ ·(x.13)=2.6

B. Habitat Degradation (current abundance and trend for site) (12/49) (% affected or lost over last 10 years)

		Assigned Utility (Unknown component placed in boxes below)	
0 -	habitat in pristine or near pristine condition	0	
1 -	slight reduction (0-10%) with no further loss evident	12.5	
2 -	slight reduction (0-10%) with slow rate of loss	[✓ 25.0]	
3 -	slight reduction (0-10%) with moderate rate of loss OR, natural recurring fluctuations in habitat quality and/or quantity	37.5	
4 -	moderate reduction (10-25%) with slow to moderate rate of loss	50.0	
5 -	significant reduction (25-50%) with slow rate of loss or, no further loss	62.5	
6 -	significant reduction (25-50%) with moderate of loss	75.0	
7 -	little remaining habitat (50+%) with no further decreases or, significant reduction with rapid rate of loss	87.5	
8 -	little remaining habitat (50+%) and decreasing at any rate	100.0	
-	abundance and trend of habitat degradation unknown	25.0	100.0 ☐ (x.12)=3.0

	Assigned Utility (Unknown component placed in boxes below)	
C. Buffer Zone (quality and quantity) (4/49)		
0 - completely surrounds site and of good quality	0	
1 - surrounds 75-90% of site and of good quality	14.0	
2 - surrounds 75-90% of site and is of adequate quality or, surrounds 55-70% of site and is of good quality	[✓ 29.0]	
3 - surrounds approximately 50% of site and is of good quality	43.0	
4 - surrounds approximately 50% of site and is of adequate to poor quality	57.0	
5 - surrounds 25-45% of site and is of good-adequate quality	71.0	
6 - surrounds 25-45% of site and is of poor quality or, surrounds less than 20% of site and is of good quality	86.0	
7 - surrounds less than 20% of site and is of adequate - poor quality	100.0	
- quality and quantity of buffer zone unknown		100.0
	29.0	☐ (x.04)=1.16

Assigned Utility
(Unknown component
placed in boxes below)

D. Site Size (based on general SFI size requirements and assuming adequate buffer zone) (6/49)

0 - size extensive, no restrictions	[✓ 0]	
1 - size moderately extensive no restrictions in short term	20.0	
2 - size adequate but population increases possible only with management assistance	40.0	
3 - size inadequate but can be adequate with assistance	60.0	
4 - size inadequate with migratation possible or occurring out of site	80.0	
5 - size inadequate with resultant loss in health and/or numbers, and/or no possibility of migration out of site	100.0	
- size unknown		100.0
	0	☐ (x.06) = 0

Assigned Utility
(Unknown component
placed in boxes below)

E. Land-Use Conflicts (relative to species and associated habitat only) (8/49)

0	- no land-use conflicts, none anticipated in near future. area not accessable or access restricted	0
1	- low-impact, non-consumptive conflicts of short duration or significant conflicts encroaching upon area. non-vehicular access	20.0
2	- land-use conflicts low and only temporarily displaces species without mortality	40.0
3	- land-use conflicts low to moderate, species mortality and/or species and habitat or habitat loss only. moderate vehicular access	[✓ 60.0]
4	- land-use conflicts moderate and significantly disrupts species and/or habitat or, increases habitat isolation. moderate/extensive vehicular access	80.0
5	- land-use conflicts extensive with significant to high loss of species and/or habitat. extensive vehicular access	100.0
	- land-use conflicts unknown	

60.0   100.0 ☐ (x.08)=4.8

	Assigned Utility (Unknown component placed in boxes below)		
F. Natural Disturbance (occurring within site and causing negative consequences for SFI) (3/49)			
0 - normal patch dynamics occurring at site or, no evidence of obvious detrimental natural disturbance occurring at site or in recent past (last 10 years)	0.0		
1 - minor natural disturbance occurring or occurred in recent past (some erosion, animal burrowing, low-moderate beaver activity)	33.0		
2 - moderate natural disturbance affecting site or occurred in recent past (brief-moderate climatic shifts, random low-level fires)	67.0	75.0	
3 - extensive natural disturbance (flash floods, volcanic activity, random and intense fires)	100.0		
- natural disturbance levels unknown	75.0	100.0 ☐	(x.03)=2.25

	Assigned Utility (Unknown component placed in boxes below)		
G. Patterns of Population Concentration (pattern of species in Alberta) (3/49)			
0 - species does not concentrate	[✓ 0]		
1 - species concentrates briefly (1 mo.) at many locations (10+)	20.0		
2 - species concentrates for portion of year (1-4 mo.) in many locations (10)	40.0		
3 - species concentrates for portion of year (1-4 mo.) in few locations (10)	60.0		
4 - species concentrates for portion of year (1-4 mo.) in one location or, species concentrates for most or all of year in few locations	80.0		
5 - species concentrates for most ~~or all~~ of year at single point	100.0		
- species concentration patterns unknown		100.0	
	0	☐	(3)=0

Assigned Utility
(Unknown component
placed in boxes below)

I Recovery Potential (13/100)

H. Specialization (3/10)
(in food, shelter, breeding,
space, requirements)

0 - broad generalist	0	
1 - species low to moderately specialized in one niche attribute	25.0	30.0
2 - species moderately specialized in more than one attribute	50.0	
3 - species moderately to highly specialized in one attribute	75.0	
4 - species moderately-highly specialized in more than one attribute	100.0	
- species level of specialization unknown	30.0	100 ☐ (x.03)=0.9

		Assigned Utility (Unknown component placed in boxes below)
I.	Habitat Resiliency (habitat of SFI species only) (4/10)	
0 -	earliest successional stage (i.e. highest level of resiliency)	0
1 -	early successional stage or, earliest stage with repeated human disturbance	14.0
2 -	early successional stage with repeated human disturbance or, mid-seral stage	29.0
3 -	mid-seral stage with single human disturbance	43.0
4 -	mid-seral stage with repeated human disturbance or, late late successional stage	57.0
5 -	late successional stage with single or repeated human disturbance	[✓ 71.0]
6 -	mid to late seral stage at high elevation (1900 meters).	86.0
7 -	late successional stage at high elevation (1900 meters). with single or repeated human disturbance	100.0
-	habitat resiliency unknown	

71.0 / 100.0 ☐ (x.04)=2.84

J.	Reproductive Potential (% growth normally possible from one breeding season to next under favorable conditions) (3/10)	
0 -	high (100+%)	0
1 -	high-intermediate (55-90%)	20.0
2 -	intermediate (35-50%)	40.0
3 -	low-intermediate (15-30%)	60.0
4 -	low (5-10%)	80.0
5 -	very low (5%)	100.0

50.0

50.0 / 100.0 ☐ (x.03)=1.5

		Assigned Utility (Unknown component placed in boxes below)
II Level of Significance (31/100)		
K. Jurisdictional Significance (formal or expected for site and/or feature) (13/31)		
0 - no expected significance	0	
1 - local significance	25.0	
2 - regional significance	50.0	
3 - provincial significance	75.0	
4 - national or international significance	[✓ 100.0]	
- significance unknown		100.0
	100.0	☐ (*.13)=13.0

	Assigned Utility (Unknown component placed in boxes below)	
L. Security of Taxonomic Unit (worldwide) (10/31)		
0 - species or genus polytypic, related forms not threatened	0	
1 - species or genus polytypic, some related form threatened	33.0	50.0
2 - species or genus polytypic with many related forms threatened or, monotypic with some related forms threatened	67.0	
3 - species monotypic with many related subspecies threatened	100.0	
- security unknown	50.0	100.0 ☐ (x.10)=5.0
M. Scientific/Educational Value or Potential (3/31)		
low (remote, no access, very limited research value)	0	
low-med	25.0	
medium	50.0	
med-high	[✓ 75.0]	
high (formalized access, existing or imminent educatinoal programs and research, near major centers)	100.0	
scientific/educational value or potential unknown	75.0	100.0 ☐ (x.03)=2.4

Assigned Utility
(Unknown component
placed in boxes below)

N. Hybridization Potential (5/31)

4 - hybridization does not occur due to effective reproductive barrier	[✓ 0]	
3 - hybridization not expected to occur with geographically isolated yet similar species	25.0	
2 - hybridization could possibly occur with geographically isolated yet similar species	50.0	
1 - hybridization occurs sporadically with sympatric forms	75.0	
0 - hybridization occurs frequently and/or easily with sympatric forms	100.0	
- hybridization potential unknown		100.0
	0.0	☐ (x.05)=0.0

V Planning and Management Considerations

O. Degree of Existing Protection (6/11)

	Assigned Utility (Unknown component placed in boxes below)	
0 - site protected within legislatively designated conservation area (national park, provincial park or wilderness area)	0	
1 - site protected within formally designated conservation area or, site protected through interest, cooperation or goodwill of landowner (cooperative wildlife management area, university research site)	[✓ 20.0]	
2 - site not formally or legally protected but conserved by landowner through benign neglect	40.0	
3 - site still intact but landowner not sympathetic to conservation aims	60.0	
4 - site currently being held for speculation and/or future development (recently rezoned land)	80.0	
5 - site currently being developed or development imminent	100.0	
- level of existing protection unknown		100.0
	20.0	☐ (x.06)=1.2

Assigned Utility
(Unknown component
placed in boxes below)

[illegible] Assessment of Management (3/11)

0 - site being actively and intensely managed, site manipulation, ongoing research, ongoing monitoring of site	[✓ 0]
1 - some ongoing efforts at management, systematic and on-going site monitoring	25.0
2 - incidental or sporadic site monitoring, no research, no management plan for site	50.0
3 - management unaware of sites' significance, access restrictions unlikely or not enforced	75.0
4 - management policies and/or programs for site detrimental for SFI's continued viability	100.0
- management unable to be assessed	

100.0
0.0 ☐(x.03)=0

Assigned Utility
(Unknown component
placed in boxes below)

Q. Cost of Protection (2/11)
(includes initial outlay and recurring annual management and administrative costs, in dollars)

5 - very high	0
4 - high	20.0
3 - moderate	40.0
2 - low-moderate	60.0
1 - low	80.0
0 - very low	[✓ 100.0]
- cost of protection unknown	

100.0
100.0 ☐ (x.02)=2.0

7.5 Summary of Test Application

Prior to formal site assessment, the evaluation team was asked to intuitively rate the feature in terms of threat levels, desirability and ultimately the need for site protection. It was clearly stated that neither the site itself nor the population of Ferruginous Hawks were in any immediate danger. Population levels actually increased the previous year. However, the site was considered important to protect since it contained a dense population of a species listed as threatened in Canada. It also contained a population of Burrowing Owls and a small lake which increased site value. They concluded that only a moderate effort was required to conserve the site and that short-term conservation efforts should be focused on other populations of Ferruginous Hawks that are more threatened.

These sentiments clearly correspond to the category subscores recorded on the evaluation summary sheets. Actual threat levels were low (13.81 of a possible 49.0 points). Neither "Recovery Potential" attributes (5.24 out of 10.0) nor "Planning and Management Considerations" (3.2 out of 11.0) were assessed as being only minor concerns. Only the "Level of Significance" attributes (20.4 out of 31.0), which reflect FSI desirability, received an overall high subscore. The bulk of the subscore was comprised of the measure for jurisdictional significance (i.e., the species was considered as being greater than national importance).

Based on the CUI, the candidate site received a priority 2 ranking. This corresponded to the pre-evaluation assessment by the evaluation team that site protection was not urgent. Such a correlation should not be expected for each candidate SFI assessed. Since a great deal of information was available for the site, no request for verification or further information was necessary. The recommendation to develop a management agreement with the landowner reflects the relatively high level of landowner cooperation. While the population remains healthy, significant mortality occurs through nest loss as a result of gusting winds (i.e. natural disturbance). The establishment of nest boxes would prove to be an inexpensive means of maintaining population size.

Part V: Conclusion

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1. Feature nomination by any interested government agency, NGO, private organization or other group
2. verification of information provided by nomination
3. eligibility assessment involving
    - acceptance or rejection of the feature
    - feature categorization in SFI classification system
4. evaluation of candidate SFI based on a set of weighted criteria
5. priorization of candidate SFI based on CUI of step 4
6. designation and registration of SFI in SFI Alberta Registry
7. inform landowner of feature significance
8. institutional match made to link feature with appropriate institutional and managerial arrangement
9. action plan for SFI conservation developed by institution, landowner and/or SFI Advisory Board

8.2 Recommendations

8.2.1 Toward System Refinement

The test application in Chapter 7 provided a single working example of the evaluation system. No definitive conclusions can be reached from one example that would be applicable to the wide range of features ideally dealt with by such a model. However, some recommendations can be made that, if implemented, would increase the accuracy and usefulness of the system. These are as follows:

1. A sensitivity analysis of the feature evaluation component of the framework should be conducted to determine its accuracy. This may be accomplished by:
    a. evaluating several features after removing weights from criteria
    b. evaluating several features after altering the scales of measurement of the most heavily weighted criteria
    c. evaluating several features after eliminating some criteria or,
    d. comparing CUI scores with intuitive assessments of several well known features.
2. To determine the system's general applicability to the wide range of abiotic and biotic features intended, it is necessary to process a variety of features through the system as it has been proposed and assess and deal with any problems that arise.
3. The emphasis in this study has been on species and community-types. To be useful to a broader range of planners, the geological and hydrological classifications and criteria set should be further delineated.
4. To make the system more useful to specific agencies and groups involved in nature conservation, the criteria set would require some revisions. For example, the cost of site protection may not be a concern to NGOs (as it is to government agencies) if they only perform an advocacy and lobbyist function.

5. If there proves to be too many features for which sufficient information is unavailable, the practice of assigning the maximum 100 points to "unknown" attributes may prove untenable. This would result in too many sites receiving top priority based on "unknown quantities." Although determining a safe minimum standard for each attribute is valid, it may be more reasonable to assign a score of 50 to attributes that are unknown. This will tend towards assigning features a priority of 2 and not retard the conservation process for features known to be deserving.
6. Prior to individuals weighting criteria, there should be group meetings (using for e.g., the Nominal Group Technique) used to reach a greater consensus among the stakeholders. This would reduce discrepancies between the individual weights and make the final mean weights more meaningful.
7. The range of points assigned to the three priority levels may need to be adjusted to correspond to actual natural breaks in the range of SFI scores. For this to be determined, many features will need to be evaluated.
8. This system stresses threat levels sites may be under. Such an emphasis may prove unwarranted in Alberta, as compared to, for example, Great Britain. If such is the case, this component should be deemphasized.

8.2.2 Toward the Conservation of SFIs

The following recommendations relate to both the inclusion of this model into existing governmental strategies and the overall success of FSI conservation. In no particular order they are as follows:

1. The government of Alberta in cooperation with provincial NGOs should codify within their mandate the fundamental premise that nature conservation and management should proceed holistically.
2. The relevant government agencies, specifically Forestry, Lands and Wildlife and Recreation and Parks, should expeditiously develop in its management and planning efforts the skills and policies necessary to adequately deal with nongame species, uncommon community-types and other natural phenomena not traditionally dealt with.
3. The Alberta government should put a moratorium on the cultivation and drainage of Crown lands in the White Zone of Alberta as well as existing programs which encourage habitat loss. In contrast, the government should provide incentives to private landowners to retain natural environments as has been successfully done in other countries.
4. In meeting the recommendations of 1) and 2) an SFI Advisory Board should be formally created to receive the mandate for developing FSI policy and programs, to evaluate candidate sites and to make recommendations for their preservation. To promote its acceptability and credibility, the Board should consist of a balance of government representatives (both provincial and

municipal), academics, private environmental consultants and designated representatives from several NGOs.

5. Pursuant to 3) sufficient time, money and skills should be allocated by the relevant agencies to the Board and its related functions. The Board must have ongoing access to data and other related documentation (collected and stored by the relevant agencies) which is deemed necessary to fulfill its mandate.

6. The implementation of an official policy regarding SFIs will require amendments to at least one existing Act. The relevant Acts include the Wilderness Areas, Ecological Reserves and Natural Areas Act, Historical Resources Act and Provincial Parks Act. In addition, ongoing efforts must be made to create reforms in donation, gift tax, income tax, capital gains, land transfers, municipal bylaws and other legislation favorable to conservation in general.

7. The development of an SFI program should commence and should encompass the following interrelated components:

   a. increased public education and involvement with the program through regional conservation centres, open houses, workshops and publications. The educational component should include instruction and information on aspects of private conservation, tax incentives, and land donations, as well as information on the importance of conservation in general.

   b. the development of an effective strategy for contacting and negotiating with landowners who own SFI sites but are not directly involved in nature conservation.

c. the initiation of long-term and rigorous baseline data collection and research on potential or proposed SFIs. Before conservation evaluations and management decisions can be made, a minimum level of sound information on species, ecosystems and disturbance regimes of individual areas is essential. If resources are limited, species identified as SFIs (essentially rare and endangered species) and those recognized as "indicator species" for specific habitats should receive priority. These include species at the top of food chains or mutualistic plant and animal species. Research initiatives should also commence on habitats where large information gaps exist. These include wetlands containing emphemeral or submergent vegetation, sand dune vegetation, and those found on solonetzic soil and fine glacio/acustrine deposits.

d. a computerized data base management system for the vast amount of information that will be generated in a range of disciplines. This system will serve as a storage and clearing-house which will allow research, inventory and administrative data to be effectively assessed, sorted and updated.

e. the development of an FSI Registry listing all established SFIs, their priority status, legal ownership and location. Locations should be plotted on small scale maps (< 1:250,000). These maps would be useful in identifying concentrations of special features and areas where boundary alterations to include additional features would prove beneficial.

f. the encouraging of provincial and municipal herbaria and zoological gardens to concentrate a portion of their efforts towards provincial species of interest, including species which are rare, endemic or declining in numbers. Such effort could benefit the SFI program by generating invaluable information regarding species tolerance limits, life histories, physiology and population dynamics.

8. A monitoring system must be developed to detect and measure changes in SFI status. This would require the establishment of permanent reference areas or plots to ensure that protected sites actually preserve FSIs.

8.3 Concluding Remarks

It is doubtless a maxim of planners that planning links knowledge with action. If this were unconditionally true, nature conservation would be a simple task of linking objective scientific data to resource management decisions. This is not the case. The meaning of any information that is used to make decisions must be evaluated in light of stated objectives and goals. Hence, evaluation is inescapably valuation, and valuation means value-laden subjectivity. Even the decision regarding which attributes are appropriate for use is, to some extent, a subjective matter.

Some attributes possessed by species, communities and abiotic features can be acceptably measured quantifiably, and if applicable to conservation aims, are useful in feature evaluation and protection. The concepts of rarity, endemicity, diversity and representativeness are examples of such attributes. But the inherent nature of conservation makes it only partly amenable to the rigorous analysis that is the scientific method. It is impossible to justify in purely scientific terms the preservation of a wild species simply because of its rarity or to empirically measure the natural beauty of a stretch of countryside. Yet these have always been extremely important considerations in wildland conservation. All that is realistically possible in conservation evaluation decision-making is for informed minds to make assessments based on concise objectives while adhering to the principles of decision-making theory.

This study has attempted to make a fundamental and precursory contribution to evaluating the relative significance of certain natural features. The proposed system provides a defensible, rational and practical method of evaluating and priorizing SFIs based on certain, largely extrinsic attributes. Attributes or values, either their number, type, ordering, weighting or aggregation will never be totally agreed upon by any group of individuals. This does not imply that inaction is the best alternative but rather that the information generated should serve as guidelines for action; but guidelines only. The CUIs, subscores and priorities which will be generated from this proposed framework are only a few of the many tools useful in wildland management decision-making. In conservation biology, as in other "crisis disciplines," it is at times "imperative to make an important tactical decision before one is confident in the sufficiency of the data. In other words the risks of non-action may be greater than the risks of inappropriate action" (Soule, 1986).

Whether this model, with its attendant philosophy, will be employed is another matter. In Alberta, political and economic realities appear to encourage the valuation of wildlife and wildlands in monetary terms. Evidence exists in the form of proposed game ranching, renewed grizzly bear hunts, the logging of old-growth forests and calls for provincial control over National Parks. To many nations around the world which have lost much of their own natural heritage, such an attitude is as antiquated as it is disturbing.

The extent to which the Government of Alberta can resist this approach will indicate the extent to which it has evolved away from dogmatic tradition and towards a greater challenge. Most importantly, it must reaffirm its commitment to the goals of conservation by developing a comprehensive, anticipatory system for dealing with its natural heritage. The result will be the emergence of nature conservation as a legitimate land use which can successfully compete with other more traditional land uses. This study and its recommendations serve in this direction.

This study has addressed the conservation of special natural features from a provincial perspective, from the Alberta experience. But jurisdictional frames of reference aside, I believe everyone working in the field of conservation biology and management wishes to pass on to preceeding generations, as much as we can for as long as we can.

Let's get on with it.

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Appendix 1

The criteria used in 31 evaluation systems for assessing natural areas and species are listed below. The author, year and region of the study as well as those terms used as criteria in the study are reproduced. Only those criteria which pertained to threat, disturbance or vulnerability as defined in this study were used to establish the category classes of Table 6. Where applicable, criteria were divided into subclasses and/or listed as primary and secondary criteria. Terms which were unclear received an additional explanation appearing in parentheses.

Fisher, et al., 1969 (International)

natural causes, hunting, introduced predators, non-predatory exotics, habitat modification.

Helliwell 1969 (Great Britain)

overall wildlife value (education, recreation, food, medical, aesthetics), cash value and cost as a resource, size, habitat diversity and integrity, access, species and habitat rarity.

Ranwell 1969 (Great Britain)

size and buffer zone, habitat diversity and physico-chemical features, species rarity and distribution, use value, naturalness, proximity to other sites, unknown factors.

Tubbs and Blackwood 1971 (Hampshire, England)

habitat rarity and diversity as reflected by ecological zone type primarily basis for comparison (zone type distinguished by degree of naturalness). Secondary criteria are outstanding scientific importance, value as [illegible]dlife reservoir, size.

Tans 1974 (Wisconsin)

quality, (naturalness), commonness (rarity), community diversity, size, buffer zone, use value, threat, availability.

Gelbach 1975 (Texas, U.S,)

heritage value (degree of naturalness), educational utility (size, buffer zone, accessability), species significance (rare, endangered species, level of significance, potential for hybridization), habitat diversity, level of existing protection, stress.

Goldsmith 1975 (Southeast, England)

size, rarity, species richness.

IBP Peterson 1975, La Roi et al., 1979 (International, Western Canada)

range of major . . . ecosystems (representativeness), rarity, interest, human-modified areas, documented research and scientific importance, size, diversity, fragility, educational value.

Ray 1975 (International)

Ecological: representative, unique, diversity, naturalness, size, buffer zone, importance to wildlife, criticalness, inclusiveness.

Practical: scientific value, other use values, fragility, feasibility, redundancy, level of significance.

Smart 1975 (North America)

level of species support (patterns of population concentration), species rarity, scientific and economic importance, representativeness, use value, physically and administratably capable of being conserved and managed, threat of major land-use impacts, environmental pollution.

Sparrowe and Wight 1975 (U.S.)

Current Status of Population: population size and trend

Vulnerability: habitat loss and rate of loss, population concentration, current reproductive rate, environmental contaminants.

Recovery Potential: habitat protection, successional stage, growth potential, recovery potential.

The Species: taxonomic unit, hybridization potential, endemicity, specialization, polytypic or monotypic species, security of taxonomic unit.

For each criterion, a site is valued most highly if there is insufficient knowledge regarding the site.

Sargent and Brande 1976 (Vermont, U.S.)

Natural Science: area, elevation, frequency of occurrence, (rarity), diversity, established significance (level of significance), fragility.

Planning: recreation uses, education/research uses, integrity, management status, planning status (jurisdictional authority and extent of formal plan), natural cycle protection.

Ratcliffe 1977 (Great Britain)

size, diversity, naturalness, rarity, fragility, typicalness, recorded history, position in ecological/geographical unit, potent value, intrinsic appeal.

Wright 1977 (Great Britain)

Scientific Appraisal: ecosystem representativeness, representativeness of geological region, diversity (community, habitat, plant species), species rarity landscape category (naturalness), sensitivity to disturbance (buffer zone and human activity), recorded history.

Management Appraisal: access, boundaries, availability, security of tenure, liabilities, manpower, cost, specialness (regards conservation "interest"), potential educational and amenity use.

Austin and Miller 1978 (New South Wales, Australia)

area, representativeness, degree of human disturbance, rarity.

Everett 1978 (North York Moors, England)

species richness, naturalness, accessibility, typicalness, previous studies, species or habitats which contribute to the character of an area, artistic or aesthetic value.

Ploeg and Vlijm 1978 (Netherlands)

area, diversity (plant and animal species, plant alliances and structural formations), rarity, vulnerability, replaceability.

Rabe and Savage 1979 (Idaho, U.S.)

Primary criteria: 24 physical and biological characteristics of aquatic and terrestrial components. Emphasis on diversity and uniqueness.

Secondary criteria: ownership, size, access, alternate uses, threat, type redundancy.

Naturalness and land use conflicts were used as screening criteria.

Fuller 1980 (Great Britain)

population size, species diversity and rarity, level of significance.

Reeves 1980 (Prince Edward Island, Canada)

site significance, site diversity, frequency of occurrence, species significance, natural stability, size, probability of destruction, existing buffer, status of natural feature (management assessment), mulitplicity of uses, potential value, site ownership, access.

Quebec Dept. of the Environment 1981 (Quebec, Canada)

Eligibility: conformity to the Act (regarding legislative restrictions), reserve, category, existing protection of this type (redundancy), value, land-use conflicts.

Assessment: representativeness (environment, ecological region, plant and animal species), quality of environment, diversity, rarity, state of preservation, urgency of protection, socio-economic pressure, fragility, location on public lands, ease of acquisition.

FAO 1982 (Indonesia)

Genetic values: size, diversity, rarity, endemism, rate of exhaustion, degree of protection.

Socio-economic: environmental benefits of protection, land use conflicts, priority, special value, use values, geological and ethnic etraxs, research investments.

Management feasability: size, shape, integrity, low boundary pressure, buffer zone.

Parks Canada 1982, 1983 (Canada)

uniqueness, rarity, best example of a natural theme (representativeness), minimum modification by man, recovery potential, scientific value and public interest, size, degree of protection, competing land uses, other existing protected areas (redundancy), international criteria (level of significance).

Cottonwood Consultants 1983 (Alberta, Canada)

Ecological: landscape representation, diversity (community and physiognamy), area, buffer zone, special features (rarity, outstanding, endangered species), degree of disturbance, extensive research, cultural and geologic extras.

Nonecological: distance from management, access, land use conflicts.

Section Priorities: human population density, degree of impact, degree of preservation (formal protection), number of extinction in last 100 years, rate of habitat destruction, number and exten of non-native species (environmental contaminants).

Canadian Wildlife Service 1984 (Canada)

Population: density (species and habitat), featured species (numbe and abundance), species concentration, rarity (species an habitat), seasonal importance of site, site importance to feature species, site interdependance to adjacent area, use by othe wildlife.

Threat: habitat (loss and disturbance), degree of disturbance imminence of threat, certainty of impact.

Cost: initial cost, recurring cost.

Availability: ease of protection, timing of availability, political suitability (land use conflicts, attitude of landowners).

Game and Peterken 1984 (Central Lincolnshire, England)

eligibility, species rarity, assessment of management, contaminants, vulnerability, attractive species, representation.

Keddy 1984 (Canada)

rarity, area, level of significance, redundancy, protection status, extent of human-caused modifications, degree of rarity (level of significance).

Ontario Ministry of Natural Resources 1984 (Ontario, Canada)

representation, diversity, quality (naturalness), size, rarity, species endangerment, remnant communities, integrity, concentrations of wildlife, linkage (connects or is connected to other significant natural areas), unusual landforms.

Alberta Fish and Wildlife 1985 (Alberta, Canada)

Biological: population trend (percent reduction over ten year period), vulnerability, abundance, distribution.

Life-History: r and k factors.

Extrajurisdictional: assessment of management potential for agency.

Island Nature Trust 1985 (Prince Edward Island, Canada)

community preservation, species rarity, vulnerability, education, recreation and research use, value, diversity (community and species), existing protection, size, access, historical value.

Margules 1986 (North Yorkshire, England)

Primary: diversity, rarity (species and habitat), representativeness, area, naturalness, threat, ecological fragility.

Secondary: wildlife reservoir potential, position in ecological/geographic unit, scientific value, other use value, management factors, recorded history.

Appendix 2

Prototype Form Used to Elicit Rankings and Weightings of the Categories and Criteria Used in the Test Application

Criteria Ranking and Weighting for Special Natural Features of Interest (SFI)

Introductory Information

- This form is part of an evaluation methodology which is being developed for nature conservation purposes. The features being assessed are "special" plant and animal species and their associated habitats.
- "Special" species include those that are rare, endemic, sensitive, peripheral, or even unusual in behavior, association, physiology, etc.
- The evaluation method is unique in that it evaluates specific aspects of the sites where these occur, as well as certain aspects of the species themselves.
- What is being evaluated are, once a list of species is considered special, which species and sites are in the most urgent need of protection. Urgency is measured primarily by the level of threat a species/site faces and secondarily, by how significant the species/site is to conserve.
- Listed within this form is a set of 4 categories. Each contains a list of criteria used to identify species and specific sites which are urgently in need of protection in Alberta.
- Each attribute is considered important in the measurement of the "urgent need" for protection. Some attributes are more important than others.

- Your task is to decide which criteria are more important than others and by how much. This will be done using your professional expertise in the areas of conservation, planning and related fields.
- The categories and criteria are presented in this form as a two-level hierarchy. Each branch of the hierarchy represents either a category or an criteria.
- To make your task more convenient, each level is presented separately within this form.
- The attributes are briefly defined separately in this form.

Your Task

- Using your professional judgement, write the weights you would assign to each category and criteria to reflect its relative importance in assessing how threatened a site and/or species is. It is also useful to think of each criteria and category in terms of how important it is in determining the desirability of a site and/or species for protection.
- "Importance" relates only partly to the relative differences in value between criteria. The range of measurement that any one criterion may exhibit is also critical to the notion of importance. For example, the importance of "Cost of Site Protection" will be substantially different if the range of cost considered is between $100.00 and [illegible],000.00 than if it is between $100,000.00 and $1,000,000.00
- For the purposes of your task, consider the ranges of all criteria within plausible minimum and maximum values, NOT possible, conceivable, or even actual ranges.
- Each criterion you are asked to assess has been briefly defined within this form. The categories are not explicitly defined as these are abstract dimensions. These are defined implicitly by the criteria included under them. Please ask for clarification if either the criteria or categories are not clear.

Ranking of Categories and Criteria is done by:

a. listing in order the criteria (or categories) from most important to least-important.

Weighting of Categories and Criteria is done by:

a. assigning a weight to 10 to the least important subcategory or attribute (lowest rank) as a common starting point. This has been done for you in each case.

b. Next, for the category or criterion with the next higher rank, assign it a weight to reflect its importance compared to the lowest one. For example, it may be half again as important to you as the lowest criterion. If so, it would receive a weight of 15. If it is twice as important, it would receive a weight of 20.

c. Then go to the next most important category or criterion and compare it to the one just completed and repeat the process.

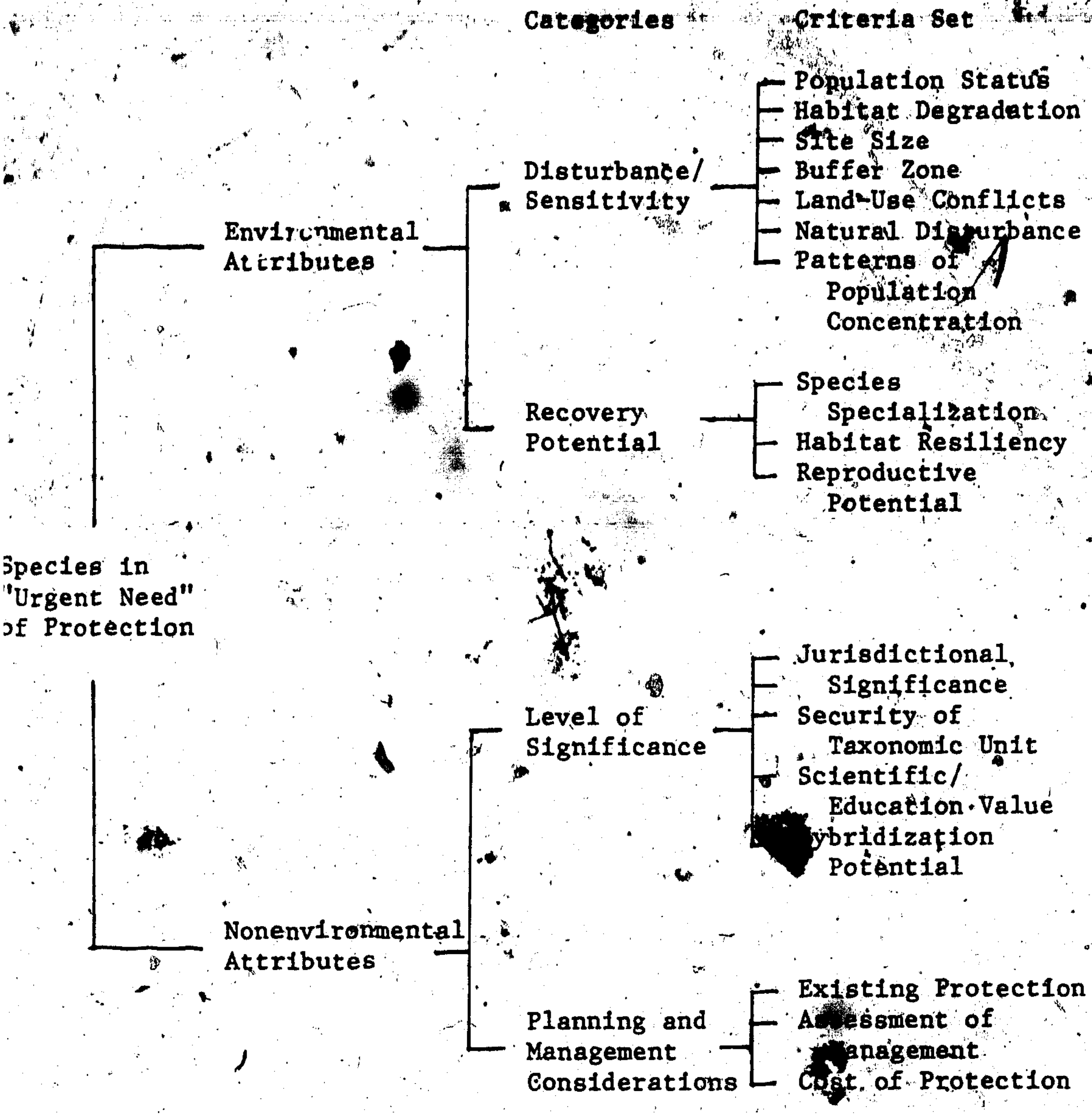
Please Note:

- There is no limit to the weight you may assign a category or criterion. When you finish, you will have weighted all the categories and criteria to reflect their relative importance to the objective of the evaluation as stated earlier.
- There are no right and wrong answer, we are interested in personal judgments based on your expertise in your field.
- Each category must be assessed by you and then ranked and weighted relative to the other categories only.

- Each criterion must be assessed by you and then ranked and weighted relative to the other criteria within a given category.

- Even though the criteria are measured on very different scales with very different ranges, all scales will eventually be converted to one common scale. This will allow for intracriteria comparisons to be made and for criteria measurements to be eventually combined.

The Dimension Hierarchy



THE CRITERIA USED TO IDENTIFY NATURAL FEATURES IN URGENT NEED OF PROTECTION IN ALBERTA

1. Population Status--measures the current levels of the population relative to what is expected at the site as well as the current rate of decline.
2. Degree of Habitat Degradation--measures the amount and rate of habitat loss in the site. Habitat are those factors a species require to live, such as cover, food, breeding locations, etc.
3. Size--measures the area of the site relative to species area requirements.
4. Buffer Zone--measures the quality and quantity of the buffer zone in relation to the general requirements of the species and external disturbances.
5. Land-Use Conflicts--measures on-site land-uses which may negatively disturb the species being evaluated. The type and extent of site accessibility is considered under this criterion.
6. Natural Disturbances--measures the existence of random destructive events caused naturally which may negatively disturb the species being evaluated. Such events are not considered to be part of the selective forces impinging on the species, as are recurring or cyclical natural disturbances such as annual flooding.
7. Patterns of Population Concentration--measures the tendency of the species in general to concentrate and how many sites it tends to concentrate at in the province.

8. Degree of Specialization--measures the tendency of the species in general to specialize in the aspects of its life-history. Important in determining how well the species will respond once protective action is initiated.

9. Habitat Resilience--measures the ability of the habitat to recover from disruption once protective action is initiated.

10. Reproductive Potential--measures the species ability to reproduce from one season to the next under favorable conditions. This includes the average litter size, the average number of litters per female, etc. in Alberta.

11. Jurisdictional Significance--this records the level of significance for this site and/or species. Significance means international, national, regional or local importance, or no importance.

12. Security of Taxonomic Unit--measures the level of safety that is currently present for related forms or within the same taxa as the species being evaluated. The more species within the taxonomic unit that are threatened the more desirable it is to conserve the species under assessment.

13. Scientific/Educational Value--measures the existing of potential use which can be derived from the species and/or site. The emphasis is on the scientific values.

14. Hybridization Potential--measures the extent to which the species is known to hybridize with sympatric forms. Species which do not hybridize are considered to contain more distinct genetic material and therefore are considered more valuable to protect. This does

not imply that subspecies or variants have no value and will be subsequently ignored.

15. Degree of Existing Protection--measures the extent to which both the site and species are protected.

16. Assessment of Management--measures the extent to which management policies and programs are allowing for the continued viability of the site and species.

17. Cost of Protection - measures the cost which will be incurred by specie[illegible]ite protection. Measurement includes both start-up costs and maintenance costs.

Ranking and Weighting--Categories

1. Rank the categories in the order of their general importance to you, based on the evaluation objectives.
2. Weight the categories as requested in the "YOUR TASK" section of this form.
3. Think HARD about your values and choices.
4. Remember, some categories may be equal in weight to other categories from your professional perspective.

Categories

1. Disturbance/Sensitivity
2. Recovery Potential
3. Level of Significance
4. Planning and Management Considerations

	Rank Order (place numbers of categories in blanks below)	Assign Weights
Rank A	________	________
Rank B	________	________
Rank C	________	________
Rank D	________	10

Ranking and Weighting--Criteria

1. Follow instructions for ranking and weighting of categories.

Disturbance/Sensitivity

1. Population Status
2. Degree of Habitat Degradation
3. Site Size
4. Buffer Zone
5. Land-Use Conflicts
6. Natural Disturbances
7. Patterns of Population Concentration

	Rank Order (place numbers of categories in blanks below)	Assign Weights
Rank A	________	________
Rank B	________	________
Rank C	________	________
Rank D	________	________
Rank E	________	________
Rank F	________	________
Rank G	________	10

Ranking and Weighting--Criteria

1. Follow instructions for ranking and weighting of categories.

Criteria--Recovery Potential

1. Degree of Specialization.
2. Habitat Resilience.
3. Reproductive Potential.

	Rank Order (place numbers of categories in blanks below)	Assign Weights
Rank A	______	______
Rank B	______	______
Rank C	______	10

Ranking and Weighting--Criteria

1. Follow instructions for ranking and weighting of categories.

Criteria--Level of Significance

1. Jurisdictional Significance.
2. Security of Taxonomic Unit.
3. Scientific/Educational Potential.
4. Hybridization Potential.

	Rank Order (place numbers of categories in blanks below)	Assign Weights
Rank A	______	______
Rank B	______	______
Rank C	______	______
Rank D	______	10

Ranking and Weighting--Criteria

1. Follow instructions for ranking and weighting of categories.

Criteria--Planning and Management Considerations

1. Degree of Existing Protection.

2. Assessment of Management.

3. Cost of Protection.

Rank Order (place numbers of categories in blanks below)		Assign Weights
Rank A	____	____
Rank B	____	____
Rank C	____	10

Appendix 3

Normalized Category and Criteria Weights Used in the Test Application, Averaged from the Weights of the Five Stakeholders

Stakeholders/ Dimension/	Holroyd	Erickson	Lee	Butler	Dodge	Mean	(standard deviation)
Categories							
Disturbance/Sensitivity	.40	.444	.522	.433	.606	.48	(.082976)
Recovery Potential	.04	.167	.130	.066	.091	.10	(.050544)
Level of Significance	.36	.278	.261	.40	.242	.29	(.068251)
Plan. and Managem.	.20	.111	.087	.10	.061	.11	(.052713)
Criteria							
Population Status	.299	.250	.224	.299	.308	.28	(.036953)
Habitat Degradation	.239	.200	.259	.269	.231	.24	(.026848)
Site Size	.105	.100	.141	.119	.123	.12	(.016180)
Buffer Zone	.149	.075	.059	.030	.092	.08	(.044345)
Land-Use Conflicts	.149	.150	.177	.179	.154	.16	(.014923)
Natural Disturbance	.030	.050	.118	.045	.031	.06	(.036383)
Patterns of Pop. Conc.	.030	.175	.023	.060	.062	.06	(.061233)
Specialization	.182	.571	.364	.10	.286	.30	(.181422)
Habitat Resiliency	.273	.143	.455	.50	.471	.39	(.154314)
Reproductive Potential	.545	.286	.182	.40	.143	.31	(.164444)
Jurisdictional Signif.	.645	.235	.476	.395	.464	.41	(.148241)
Security of Tax. Unit	.161	.471	.238	.372	.357	.33	(.121325)
Scientific/Ed. Potent.	.065	.118	.095	.186	.071	.11	(.048903)
Hybridization Potential	.129	.176	.91	.047	.107	.15	(.057567)
Degree of Exist. Protec.	.541	.571	.333	.652	.652	.55	(.130785)
Assessment of Mngmnt.	.403	.286	.222	.304	.261	.30	(.068457)
Cost of Protection	.054	.143	.444	.044	.087	.15	(.166440)

Appendix 4

The data collected from 24 interviews during 1984-1985 is listed below. The name of the interviewee, their agency or organization affiliation and pertinent comments made are presented. Pertinent information consists of the "type" of special feature mentioned and the example used to illustrate it.

name, affiliation	type	example
Cuthbert, Doug AFW, Nongame Section	fragile environment	cormorant habitat
	rare species	ferruginous hawk
	diversity of rare species	Brazeau Reservoir
	rare species	bluebird
Erickson, Gary AFW, Nongame Section	peripheral/rare	Short-grass Prairie Subregion
	rare/indicator species	Ord's Kangaroo Rat, Long-toed Salamander
La Roi, George University of Alberta, botany	rare/peripheral	Yucca Plant
	scientific interest	Wagner Bog
Karl, Leon AFW, ichthyology	vulnerable	Bull Trout
	endemic/unique genetic composition	Athabasca Rainbow
	rare species	Arctic Char

Hilchie, Gerry University of Alberta entomology	high concentrations of species	butterflies in west-central mountains
	rare/specialized habitat	tiger beetles in sandy habitats
Prepas, Ellie University of Alberta zoology, aquatic systems	ecological anomoly	hyper-eutrophic lake
Stepney, Philip Alberta Provincial Museum Asst. Director	rare/peripheral	southernmost portion of province
	vulnerable/migration path of raptors	Porcupine Hills area
	peripheral species	Trumpeter Swan
	rare species	White Pelican
	endemic species/, transitional zone	Waterton National Park Area
Evans, William University of Alberta entomology	unique argillotrophic lake	Fleeing Horse Lake
Gates Coryum CWS	rare species	White Pelican
	vulnerable habitats	Succeeding wetlands
	fragile	precambrian rock outcroppings
Wishart, William AFW, habitat management	sensitive area	snake hibernacula, pelican colony
	remnant/rare	Woodland Caribou
	peripheral	Pronged-horn Antelope
	disjunct/restricted range	Rocky Mountain Big Horn Sheep
	rare species	crayfish in Churchill River

Leach, Robin environmental consultant, entomology	disjunct species/community	south-facing slopes of Peace River
	peripheral species	horned lizard, black widow spider
	rare/restricted range	wolf spider in southern mountains
	unique behavior	burrowing spider
	temporally unique/unusual habitat	Agruilloblatta species
	disjunct	Cypress Hills
Koski, William environmental consultant, ornithology	peripheral/rare	Whooping Crane
	peripheral/sporadic distribution	Piping Plover
	aesthetic interest	Prairie falcon
	largest population in Canada	Trumpeter Swan at Saddle Hills
Samuel, William University of Alberta zoology, mammology and parisitology	sensitive	White Pelican
	unusual behavior	Pika
	very old aspen stand	5 Mile Island
	peripheral	Rufous Hummingbird
Showalter, Tim University of Alberta zoology	unique species	herptofauna in Tyrrel Lake
Stelk, Charles environmental consultant, geology	interesting geologic history/fragile	fossils in Badlands
	rare human/animal interaction	buffalo jump
	unusual geologic feature	lack of soil in Canadian Shield (Kazan Upland)

Paetz, Martin environmental consultant, ichthyology	rare, limited distribution	Mottled Sculpin
	rare, limited distribution	Log Perch
	large size	White fish in Buck Lake
	endemic	Athabasca Rainbow Trout
Van Ness, Jim University of Alberta zoology, entomology	rare/unique	Crayfish in Beaver River
	interesting physiological occurrence	larval tiger salamander
	large size	fairy shrimp species
	unique habitat/species	brine shrimp
	restricted range/disjunct	blind cave isopod species
Stubbs, Bruce AFW, habitat assessment	critical/sensitive	overwintering and reproductive sites
Fenna, Lois private environmental education	high educational value	Cooking Lake Moraine
Roberts, Wayne University of Alberta zoology	rare/restricted abundance	log perch
	declining population	Leopard Frog
	endemic/rare	Bull Trout
	aesthetic quality	Canada Geese
	interesting behaviors	sucker species

Nelson, Joe University of Alberta zoology, ichthyology	high scientific value	Kananaskis Country
	unique assemblage of species	sink-holes near Ft. Smith
	vulnerable/northernmost extension	White Pelican
	interesting physiological occurrence	Brook Stickleback which fail to develop pelvic skeleton
	endemic	Cutthroat Trout
	peripheral/rare	Milk River Area
	rare species	lamprey
	unique assemblage	tropical fish introduced in Banff hot-springs
Vitt, Dale University of Alberta, botany	unique assemblage/peripheral	Kakwa Falls
	unusual microclimatic feature	Kakwa Falls
	disjunct/refugium	Mountain Park
	outlier/disjunct	Goose Mountain
	rare community/species	Cadomin Mines/blind isopod
	unique geological feature	patterned mires at McLellan Lake
Wallace, Cliff environmental consultant	rare/fragile/outstanding	active dune system of Athabasca area
	outlier/diversity of species	moist site Cordilleran Mature *Abies* species of Swan Hills
	unique patterned ground/disjunct species/outlier	Plateau Mountain

	unique/disjunct community and interesting geologic features	Whale Back Ridge
	seasonally high concentrations	Beaverhill Lake
	area of peripherality	Milk River Area
	diversity and largest	wetlands of Peace-Athabasca Delta
	largest remaining	modal Aspen Parkland at Rumsey Area
Rutter, Nat University of Alberta, geology	quality area	fossils on the banks of the Red Deer River
	fragile	hoodoos in Dinosaur Provincial Park
	relict/interesting geologic history	Athabasca glacier, south of Jasper
	unusual/geologic process	volcanic lava boulders in Waterton National Park