THE UNIVERSITY OF CALGARY

Monitoring Indicators of Ecosystem Integrity on the Ann and Sandy Cross Conservation Area

by

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Abstract

The purpose of this Masters Degree Project was to design and implement an ecological monitoring system that provides information which may be used to make informed management decisions regarding the maintenance and restoration of native wildlife habitat integrity and diversity on the Ann and Sandy Cross Conservation Area. The Guiding Principles of the Conservation Area provide direction towards a holistic approach to management of wildlife and habitat. This holistic approach can be most succinctly described as an ecosystem management approach towards the goal of protecting native ecosystem integrity.

A habitat monitoring system was designed to evaluate the status of ecological indicators at two scales. The ecosite scale evaluates ecological integrity on the Conservation Area as a whole unit. The ecoelement scale evaluates ecological integrity for individual habitat vegetation units within the Conservation Area. Indicators were chosen to represent the composition, structure, and function of the native aspen parkland ecosystem at both scales. Baseline indicator measurements were collected in the field. A database management system was designed to facilitate the storage, retrieval and analysis of indicator data. This management system utilized GIS and relational database computer software.

Design of an ecological monitoring system provides a tool that the Conservation Area can use to evaluate changes in key ecosystem components over time, and to guide management decisions. Key recommendations made by this project focus on management and modification of grazing practices on the Conservation Area that align the impacts of grazing with native ecosystem processes.

Key Words: ecosystem management, ecosystem monitoring, ecosystem integrity, ecological indicators, wildlife habitat management, Ann and Sandy Cross Conservation Area

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The world we have created today as a result of our thinking thus far,
has problems which cannot be solved
by thinking the way we thought
when we created them.

Albert Einstein

1.0 Project Background

1.1 Introduction

This Master's Degree Project (MDP) was completed as a client-based project for the Ann and Sandy Cross Conservation Area near Calgary, Alberta, Canada in 1997. The Ann and Sandy Cross Conservation Area has maintained a relationship with the Faculty of Environmental Design at the University of Calgary since the inception of the Conservation Area in 1987. The "Strategic Management Plan For The Ann and Sandy Cross Conservation Area" was developed by an EVDS 701 student project team (EVDS 701 1988). That initial document outlined issues and recommendations related to conservation, species diversity, education programs, built facilities, and monitoring programs. Several projects have followed that build on the foundations established by the Strategic Management Plan. The Wildlife Movement Patterns Study (Gilson and Pittaway 1996) was completed as a Directed Study by graduate students Neil Gilson and Lois Pittaway under the direction of Dr. Grant Ross. The project established the precedent for Conservation Area and community involvement in a planned system of wildlife movement corridors and protected spaces that protect the regional integrity of the Conservation Area as a home for wildlife. During the winter of 1997, an EVDS 707 team project proposed the required elements of an ecological monitoring system for the Conservation Area at both regional and ecosite scales (EVDS 707 1997).

Subsequently, the scope of this MDP was focused on the implementation of a monitoring system for the Conservation Area at the ecosite scale (i.e. the area within the administrative boundaries of the Conservation Area). Project work included the collection of baseline ecological data, and the establishment of a data monitoring and management system using Geographic Information Systems (GIS) computer technology. The results of this project include a system for the evaluation of native habitat integrity and detailed management recommendations for the maintenance of habitat and species diversity on the Conservation Area.

1.2 Purpose

The purpose of this project was to design and implement an ecological monitoring system that provides information which may be used to make management decisions regarding the maintenance and restoration of native wildlife habitat integrity and diversity on the Ann and Sandy Cross Conservation Area.

1.3 Objectives

1. To design a system for evaluating the compositional, structural and functional components of native habitat integrity on the Conservation Area.
2. To collect and organize existing and new biophysical data required for the evaluation of native habitat integrity.
3. To establish a GIS as an on-going data management and display tool for the monitoring system.
4. To recommend management strategies and priorities to maintain or restore integrity in compromised areas.

1.4 Biophysical History

The purpose of this section is to review the biological and physical features that have an underlying importance to the historical parkland ecosystem of the Conservation Area. Attempts to understand and manage ecosystems must consider the composition, as well as the structure, and function of natural systems (Noss 1990, Karr 1993, Woodley 1993). Consideration of the full range of significant ecosystem components will allow for management actions that are attuned most closely to the function of a natural system. Maintenance of natural ecosystem structure and function will also contribute to the preservation of native diversity and hopefully minimize intensive efforts to manage for the protection of specific species. A discussion of how important ecosystem components have been altered over time since European settlement concludes this section.

The Ann and Sandy Cross Conservation Area is located southwest of Calgary in the Foothills Parkland ecoregion. The native vegetation of this ecoregion is dominated by Aspen Parkland - a mixture of aspen *Populus tremuloides* forest and rough fescue *Festuca scabrella* grassland communities (Reid and Heseltine 1997). The climate of the area is primarily continental with 574.3 mm(22.6 in.) annual average precipitation. The winter season is moderated in temperature by drying Chinook winds from the adjacent Rocky Mountains. The topography of the area is rugged with a maximum variation in elevation of 217m (726 ft). The underlying geology of the area includes the shales of the Porcupine Hills Formation and the glacial till deposits of the Spy Hill Formation. The Conservation Area is found within the Thin Black Soil Zone of south-western Alberta and includes highly productive Chernozems as well as Luvisols and Gleysols (Reid and Heseltine, 1997). The headwaters of two main forks of Pine Creek are encompassed within the Conservation Area boundaries and a number of natural springs are found in the area. More detailed biophysical descriptions are found in the Strategic Management Plan (1988), and in the Vegetation And Soil Inventory of the Ann and Sandy Cross Conservation Area (Reid and Heseltine 1997).

Perhaps the most significant feature of the Conservation Area in terms of biophysical composition is the location. The Conservation Area is located within a narrow north to south extension of the Foothills Parkland ecoregion. This extension of the Parkland rarely exceeds 20 km in width and is sandwiched between the Lower Boreal ecoregion 7 km to the west and the Foothills Fescue ecoregion 10 km to the east. This locational feature, combined with the varied topography and subsequent microclimates found on the area, was recognized within the Strategic Management Plan as providing the Conservation Area with a rich diversity of plant and animal communities. The Strategic Planning team acknowledged that the maintenance of this diversity could prove to be a difficult management task. The diversity of the area is best documented in the work of volunteer biologist Olga Droppo (1997). Over forty plant species have been identified by Mrs. Droppo that occur on or beyond the outer limits of their known ranges in Alberta. The best description of the Conservation Area environment may be that of a transitional zone or ecotone, rather than that of a clearly defined ecoregion.

Ecosystem structure was historically maintained in prairie grasslands, including the Aspen Parkland regions, by the incidence of wildfire. Fire on the prairies was usually caused by lightning strikes or through intentional intervention by North American aboriginal peoples (Nelson and England 1971, Barrett 1980). The frequency of fire, in combination with climatic factors, was responsible for a shifting mosaic of grassland, shrub, and aspen forest across the prairie landscape through time (Reid and Heseltine 1997, Benn 1993). Due to effective fire suppression efforts since European settlement, most grasslands have existed without fire since the early part of the century (Nelson and England 1971). Mesic grasslands such as the rough fescue grasslands found on the Conservation Area are susceptible to invasion by shrubs and woody species and subsequent conversion to forest communities in the absence of periodic fire (Kerr, Morrison and Wilkenson 1993, Gerling, Bailey and Willms 1995).

While fire was a key disturbance process affecting the structure and distribution of native fescue grasslands, the grasslands themselves served an important ecological function - that of winter forage for bison and other grazers. Historical accounts refer to seasonal migration of bison *Bison bison* and elk *Cervus elaphus* from the open plains to the northern fescue grasslands in the late fall where they grazed for the duration of the winter (Trottier 1986, Nelson and England 1971). While the bison are now gone, the elk continue to gather on the Conservation Area in the winter, due in part at least, to the native forage.

Native grasslands on the Conservation Area, as elsewhere in the Province, are threatened with extinction through the invasion of introduced grasses, noxious weeds and aspen encroachment. There may be only five to ten percent of the native rough fescue grasslands remaining in Canada (Gerling et al. 1995, Trottier 1986, Allen 1997), and estimates of native grass cover on the

Conservation Area are in the range of two to three percent (Reid and Heseltine 1997). A number of factors likely have contributed to a decline in native grassland communities including land clearing and reseeding with non-native species (Romo and Grilz 1990, Romo 1997), suppression of wildfires (Gerling et al. 1994, Romo 1997), and changes in historical grazing patterns (Trottier 1987, Reid and Heseltine 1997, Campbell 1997, Romo 1997). The forage characteristics of the most prominent introduced grass species, smooth brome *Bromus inermis* and Kentucky bluegrass *Poa pratensis* do not replicate the function of native grasses. Neither grass cures well on the stem or is palatable or nutritious to wildlife in the winter (Tannas 1997). In addition, introduced grass communities support fewer wildlife species and represent a loss of native biological diversity (Romo and Grilz 1990).

The transitional nature of the Conservation Area creates a diverse habitat ideal for many wildlife species. The Conservation Area species list includes species typical of grasslands (Richardson's ground squirrel *Spermophilus richardsonii*, American badger *Taxidea taxus*), parklands (mule deer *Odocoileus hemionus*, white tailed deer *Odocoileus virginianus*, prairie long-tailed weasel *Mustela frenata*), forest (black bear *Ursus americanus*, red squirrel *Tamiasciuris hudsonicus*) and riparian areas (beaver *Castor canadensis*, muskrat *Ondatra zibethicus*). Despite this variety of wildlife, the net result of anthropogenic change has been a reduction in species diversity. Even though the Conservation Area remains a diverse community and supports many species, some native species have disappeared and others are threatened with local extirpation.

Species whose ranges encompassed the Conservation Area prior to European settlement and are no longer found include the grizzly bear *Ursus horribilis*, wolverine *Gulo gulo*, timber wolf *Canis lupus*, bison, and pronghorn antelope *Antipocapra americana*. While the loss of these species is due largely to changes taking place at a much larger scale than within the Conservation Area environment itself, many of the causes of species extirpation are not excluded from the history of the area. While these large species may be early warning indicators of ecosystem stress taking place at a larger scale, some of the effects may be felt currently by species whose range lies within the Conservation Area. Anecdotal observations by Conservation Area management indicate that species which may be currently affected by environmental change or stress include the badger, prairie long-tailed weasel and sharp-tailed grouse *Tympanuchus phasianellus*. While this discussion of threats to the Conservation Area ecosystem is hardly exhaustive, it does illustrate some of the primary changes that have been induced in the area by human activities in the past.

1.5 Administrative History

In this section the administrative history of the Ann and Sandy Cross Conservation Area is reviewed for the purpose of establishing the past effects and current focus of management efforts. A brief anecdotal history of the area prior to the designation as a Conservation Area precedes a review of management philosophy and land management efforts to date.

The Ann and Sandy Cross Conservation Area was donated to the Province of Alberta in 1987. Prior to the donation, the area had been managed as a working ranch known as Rothney Farm. Rothney was purchased piecemeal by Dr. Sandy Cross, beginning in the 1940's. Prior to Dr. Cross's acquisition of the land the area was ranched and farmed by a series of different people. It was during this era that most of the land was broken for introduced forage crops, a logging camp was established along Pine Creek, and clearing of some forested areas took place. For instance a prior owner has indicated that he cleared one of the highest points in the area of a stand of Douglas fir and converted it to pasture prior to Rothney Farm ownership (Rempel personal conversation. 1997). After Rothney Farm took over operation of the area, few changes were made other than occasional reseeding of alfalfa hayfields. The area was used for both summer and winter grazing of cattle and associated hay production.

The Cross family initially donated a 760 ha (1900 ac) parcel of land to the Province of Alberta in the fall of 1987. The land was managed under a lease by the Nature Conservancy of Canada and a local management board. In the fall of 1996 the Cross family donated another parcel of land, more than doubling the size of the Conservation Area to 1943 ha (4800 ac). At the same time the management of the area was turned over to the newly formed Sandy Cross Conservation Foundation. Currently, the Conservation Area is managed by the non-profit Foundation which is directed by a volunteer board. The Conservation Area is managed on a daily basis by two full time staff - the General Manager and the Education Coordinator. A part time volunteer coordinator and a part time grazing supervisor round out the staff support available. A considerable amount of support is given to the area by a group of volunteers. Projects and programs that volunteers have participated in, and even directed, include school education programs, Girl Guide and Boy Scout education programs, the planting and maintenance of native gardens, interpretive display design and construction, trail and fence maintenance, and wildlife tracking. Funding for the Conservation Area is provided through an endowment fund and the help of volunteers and grant money has been instrumental in the success of operations so far.

The efforts of the Foundation board and staff are directed by the Guiding Principles which were established with the initial donation of the Area.

Guiding Principles of the Ann and Sandy Cross Conservation Area

1. *To protect habitat and provide space for native species of wildlife.*
2. *To offer conservation education programs, particularly for young people, without jeopardizing wildlife and habitat.*
3. *To manage human use of the area through a system of entry by appointment only*

(SCCF 1998).

The first guiding principle is considered to be the most important of the three by the management board. This is reflected in the Board Vision Statement in the Area's Strategic Planning Matrix:

> *Our vision is to manage the Ann and Sandy Cross Conservation Area to reflect the guiding principles by managing for ecological integrity, while showing environmental leadership and serving as a model for conservation (SCCF 1998).*

Past management and research initiatives devoted to the achievement of the first guiding principle include:

- Interim Management Plan (Glasrud 1987) - this document provided guidance for the first year of operation of the Conservation Area
- Strategic Management Plan (EVDS 701 1988) - this has served as the long term management plan for the Ann and Sandy Cross Conservation Area
- Grasslands Inventory (Steeves 1993) - a detailed inventory limited to the original Conservation Area
- Forest Inventory (Broughton 1994) - an account of forest species in a variety of ecosites throughout the original Conservation Area
- Fire Control Plan (Gilson 1994) - this plan concentrates on policy for control of wildfires
- Proposed Grasslands Maintenance and Reclamation Plan (Gilson 1994) - identifies issues and prioritized objectives for the original Conservation Area
- Prospectus for Wildlife Research (Connolly 1995) - identified wildlife research priorities
- Wildlife Movement Patterns Study (Gilson and Pittaway 1996) - examined wildlife access to the Conservation Area from the surrounding region

- Vegetation and Soil Inventory of the Ann and Sandy Cross Conservation Area (Reid and Heseltin 1997) - the only vegetation or soil inventory to be completed on the expanded Conservation Area
- Control of Smooth Brome and Kentucky Bluegrass (Brown 1997) - a Master's thesis devoted to researching control measures for invasive grass species

Most of these past initiatives were completed for the original smaller Conservation Area. The physical expansion of the area brought with it a need to expand implementation of the Guiding Principles into the new area. Although aspects of past research projects and management plans remain relevant to the new area, a new habitat management plan, that integrates management of the entire expanded area into an effort to achieve the first guiding principle, is required.

1.6 An Ecosystem Management Approach

This section examines the basis for implementing an ecosystem management approach based on the Guiding Principles and Vision of the Conservation Area. Goals for habitat management are developed for the Conservation Area based on current concepts related to ecosystem management theory and ecological integrity. The implementation of ecosystem management and monitoring systems is discussed as a prelude to the next chapter, in which the approach taken to designing an ecosystem monitoring system for the Conservation Area is discussed.

1.6.1 A Basis for Ecosystem Management

The first guiding principle of the Conservation Area is "to protect habitat and provide space for native species of wildlife". In turn, the Strategic Management Plan defines "wildlife" as "all indigenous plants and animals including vertebrates and invertebrates" (EVDS 702 1988). If this definition of wildlife is accepted, it represents a departure from traditional wildlife habitat and resource management which focuses on the needs of selected valued species; usually high profile or economically valued vertebrates and plant species (Grumbine 1994, Roeper 1995). A broader definition of wildlife implies that a broader approach be taken to the management of protected spaces. It seems reasonable to combine these two statements to suggest that the mandate of the Conservation Area is to protect habitat for the full complement of native plant and animal species. In the current literature this type of approach is often referred to as an "ecosystem management" approach.

Ecosystem management as defined by Grumbine (1994) involves the integration of "scientific knowledge of ecological relationships within a complex socio/political and values framework toward the general goal of protecting native ecosystem integrity over the long term." The key elements of this definition are reflected in the Guiding Principles and the Vision Statement of the management board - the social values of public education and public access are integrated with current scientific knowledge of environment and conservation toward the goal of managing habitat for ecosystem integrity. The similarity between the definition and the mandate of the Conservation Area suggests that Ecosystem Management is a suitable and concise term for reflecting the management approach prescribed by the Guiding Principles and the Vision of the Board.

The current management framework of the Conservation Area is well adapted to the pursuit of an ecosystem management approach. Dominant themes of ecosystem management identified by Grumbine (1994) include consideration of a spatial and temporal scale appropriate to ecosystem functions, regardless of administrative or political boundaries; a science based management and feedback system; and initiatives to effect organizational change and interagency cooperation that deal with human values and use. Successful ecosystem management requires attention to this entire spectrum of concerns. The dominant themes of ecosystem management suggest that successful management does not depend on having an entire, intact, or pristine ecosystem to manage. Ecosystem management can take on a variety of forms and apply to a variety of spatial and temporal scales with success when these critical themes are included in management initiatives.

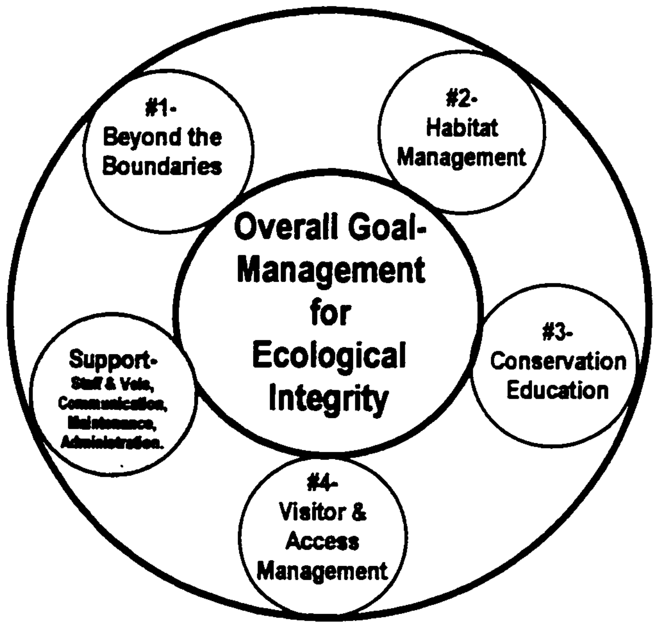
The Conservation Area Management Framework for Ecological Integrity (Figure 1) reflects all of the critical themes of ecosystem management as defined by Grumbine (1994). The goal of protecting ecological integrity depends on management initiatives that reflect and support these themes and principles. Each initiative takes place concurrently and in consideration of other initiatives. Ignoring or mismanaging any single initiative has the potential to compromise the integrity of the Conservation Area as an area for native species of wildlife. Each initiative contributes different overall goals to the management of ecosystem integrity. The elements of the Conservation Area management framework are reviewed briefly below (SCCF 1998).

1. *Beyond the Boundaries - to secure the ecological integrity of the Conservation Area within the surrounding natural and human communities.*
2. *Habitat Management - to protect native biodiversity, and the ecological patterns and processes that maintain that diversity within the administrative boundaries of the Conservation Area.*
3. *Conservation Education - to provide conservation education programs to enable people to better understand the natural world and the roles of biodiversity, humans, native plants and wildlife.*
4. *Access Management - to manage human use through a booking system and a series of regulations to control negative impacts on wildlife and vegetation.*

5. *Support- these functions are integral components of each of the previous initiatives. They include staffing and volunteers, administration and planning, maintenance of buildings and the land and communications both external and internal.*

Figure 1. Management Framework for Ecological Integrity

(SCCF 1998)



The "Beyond the Boundaries" and "Habitat Management" initiatives within the planning framework concentrate on the scientific and research aspects of managing for ecological integrity. An initiative to provide for corridors and buffer zones has already been instigated by the Conservation Area and the local Municipal District based on the work of the Wildlife Movement Patterns Study (Gilson and Pittaway 1996). This MDP is limited to the Habitat Management initiative and focuses on the protection of ecological integrity within the administrative boundaries of the Conservation Area while recognizing that the habitat management initiative is only part of an overall ecosystem approach.

The impacts of visitors to the Conservation Area ecosystem must also be considered in an overall ecosystem management approach. This would potentially include the impacts of registered visitors, school groups, research activities, special events, and motorized traffic within and around the Conservation Area. For the purposes of limiting the scope of this study, the impacts of visitors were not considered. Monitoring the impacts of visitors should be considered as a separate research initiative although there are most likely direct implications to habitat management and neither initiative can, or should be, isolated from the other.

1.6.2 Goals of Ecosystem Management

It is worthwhile to explore the concept of ecosystem management in more detail in order to define better the desired outcomes of such an approach. As pointed out by Munn (1993), the concepts of ecological integrity and ecosystem management are closely related. An understanding of the ecological integrity concept is required before ecosystem management can be planned or implemented. Before discussing the goals of managing for ecological integrity it is appropriate to briefly discuss the concept of ecological integrity. Several definitions of ecological integrity are outlined below that characterize current thinking on this concept:

Managing for ecological integrity is defined by Norton (1992) as:

> *...protecting total native diversity (species, populations, ecosystems) and the ecological patterns and processes that maintain that diversity.*

Karr and Dudley (1981) describe ecological integrity as:

> *...the capability of supporting and maintaining a balanced, integrative ,adaptive community of organisms having a species composition, diversity, and functional organization comparable to natural habitats of the region.*

Woodley (1993) defines ecological integrity for Canadian National Parks as:

> *...a state of ecosystem development that is optimized for it's geographical location, including energy input, available water, nutrients and colonization history. For National Parks this optimal state has been referred to by such terms as natural, naturally evolving, pristine and untouched. It implies that ecosystem structures and functions are unimpaired by human-caused stresses and that native species are present at viable population levels.*

Noss (1995) characterizes the concept of ecological integrity as being "complicated" and "slippery". Integrity is difficult to define in an operational or quantitative way.

> *The problem with characterizing integrity is particularly acute because ecosystems are not static; they change over time due to purely natural factors and their changes are often erratic (or chaotic) and unpredictable. Thus no single organizational state corresponds to integrity. Integrity, as its etymology implies, is an integrating and holistic concept; it pulls together many related ideas.*

Despite the difficulty in defining the concept of ecological integrity, a number of leading conservation agencies have adopted an ecosystem management approach based on protecting ecological integrity including Parks Canada (Woodley 1993, Henry, McCanny and Raillard 1995) the US Fish and Wildlife Service (Roeper 1995) and the World Wildlife Fund (Hackman and Hartsborn in Noss 1995). Parks Canada has formally defined the concepts of "Ecological Integrity" and "Maintenance of Ecological Integrity" within official parks policy (Henry, McCanny and Raillard 1995). Managing for ecological integrity may be better understood from an operational perspective in terms of defining goals for ecosystem management. Grumbine's (1994) review of ecosystem management literature identified five commonly cited goals:

1. *Maintain viable populations of all native species in situ.*
2. *Represent, within protected areas, all native ecosystem types across their natural range of variation.*
3. *Maintain evolutionary and ecological processes (i.e. disturbance regimes, hydrological processes, nutrient cycles, etc.)*
4. *Manage over periods of time long enough to maintain the evolutionary potential of species and ecosystems.*
5. *Accommodate human use and occupancy within these constraints.*

The US Fish and Wildlife Service defines their ecosystem management approach in terms of a series of goals that, in part, reflect Grumbine's five goals as well as their own agency perspective. Similarly, Parks Canada describes their ecosystem management approach in terms of a series of Guiding Principles.

Fitch (1997) summarizes an Alberta perspective on prairie ecosystem management in terms of four key principles:

1. *Maintains and restores native prairie.*
2. *Attempts to perpetuate and approximate natural factors and processes.*
3. *Applies ecological knowledge to prairie management, monitors the results and adapts.*
4. *Is multi-disciplinary and multi-jurisdictional.*

Regardless of the specific goals for ecosystem management outlined by various agencies and researchers there is a consensus in the scientific and popular literature that maintaining ecological integrity should take precedence over any other management goal (Grumbine 1994). An overall goal for habitat management on the Conservation Area was developed based on Norton's (1992) definition of management for ecological integrity. Objectives for the management of ecological integrity for the Conservation Area were based on three objectives for the maintenance of ecological integrity as outlined by Noss (1995). These objectives reflect the primary concerns in the literature and have been adapted and presented below as proposed objectives for the purpose of managing habitat on the Conservation Area.

Habitat Management Goal for the Ann and Sandy Cross Conservation Area

To protect native biological diversity and the ecological patterns and processes that maintain that diversity within the administrative boundaries of the Conservation Area while integrating with other initiatives that contribute to a holistic ecosystem management approach.

Habitat Management Objectives for the Ann and Sandy Cross Conservation Area

1. Sustain or approximate key geomorphological, hydrological, ecological, biological and evolutionary processes within normal ranges of variation.
2. Maintain or restore viable populations of all native species in natural patterns of abundance and distribution.
3. Accommodate human uses that are compatible with the maintenance of ecological integrity.

The mandate of the Conservation Area can be best described using the concept of ecosystem management. An ecosystem approach is supported by both the Guiding Principles and the Vision Statement. Managing for ecological integrity is the primary goal of ecosystem management and is also the primary goal of the habitat management initiative defined within the Conservation Area's Management Framework.

1.6.3 Implementation of Ecosystem Management

Literature related to the implementation of ecosystem management concentrates primarily on the establishment of monitoring systems based on the evaluation of ecological indicators (Noss 1990, Karr 1993, Keddy, Lee and Wisheu 1993, Munn 1993, Woodley 1993, Noss and Cooperrider 1994, Henry, McCanny and Raillard 1995). Once established, monitoring systems can be used to "understand long term changes in the ecosystem, identify baseline conditions, follow a response to a specific threat, or ensure specific conditions are maintained" (Woodley 1993). The information gained through monitoring is then incorporated into management plans and actions are taken in order to achieve ecosystem management goals. This approach to linking management with science-based monitoring is referred to as adaptive management (Holling 1978, Walters 1986, Noss and Cooperrider 1994). Adaptive management is included within the implementation strategies of a number of organizations whose goals are focused on the management of ecological integrity including the Canadian Parks Service (Canadian Parks Service 1992), the B.C. Ministry of Forests, Forest Practices Branch (Taylor 1996), and the U.S. Fish and Wildlife Service (Roeper 1995).

Noss and Cooperrider (1994) outline an approach to monitoring within the context of adaptive management that is tailored to management of biodiversity issues. This approach is divided into six overlapping steps intended to be applied at any spatial or biological scale. The six steps are described briefly below:

1. Scoping - identification of management issues and development of management goals and objectives
2. Inventory - gathering and organization of existing information in a format that contributes to management objectives

3. Experimental design and indicator selection - refining and narrowing of general management goals, the selection of indicators to measure the achievement of goals, and developing plans to collect and analyze data

4. Sampling - collection of indicator data from the field according to the experimental design

5. Validation of models - examining how well selected indicators correspond to the phenomenon of interest

6. Data analysis/ management adjustment - analysis and presentation of data in a manner that can be synthesized and used to make management decisions

A local example of how ecosystem management can be implemented is found in The Elkhorn Ranch Integrated Ranch Management Plan (Adams and Fitch 1997). While this plan does not explicitly state it's intention to utilize an adaptive management strategy, most of the six steps outlined by Noss are included in the implementation of the plan. Specific goals are developed, existing data on vegetation communities are mapped and interpreted, indicators for health of forests, rangelands, watersheds and wildlife are identified, and management recommendations are made based on data from field sampling. The Elkhorn Ranch provides an appropriate comparison to the Conservation Area in terms of size, landscape diversity, natural history, and human use. The Elkhorn plan is mentioned here to illustrate that ecosystem concepts can be employed to manage relatively small areas as well as regional scale ecosystems.

1.7 Chapter Summary

A mandate to manage for ecological integrity has been established for the Ann and Sandy Cross Conservation Area based on the Guiding Principles, Vision of the Board, and current concepts of ecosystem management. General goals and objectives have been proposed for the Conservation Area that are consistent with an ecosystem management approach. Implementation of ecosystem management can be achieved through the development of a monitoring program based on adaptive management philosophy. Ecosystem management is relevant to management of sites such as the Conservation Area as evidenced in the management plan developed for the Elkhorn Ranch. In the next chapter we will deal with the specific approach taken to the design of a monitoring system for the Ann and Sandy Cross Conservation Area.

2.0 Approach to the Project

2.1 Introduction

In the previous chapter, the basis for an ecosystem approach to habitat management on the Conservation Area was established. In this chapter, an approach to the implementation of ecosystem management and monitoring for the Conservation Area is developed, building on the information presented in the previous chapter. Noss and Cooperrider's (1994) six steps to implementing an adaptive management and monitoring system for biodiversity will be used to frame the discussion in this chapter. Reviewed here, the six steps are scoping, inventory, indicator selection, sampling, validation, and data analysis/management adjustment. The background issues and criteria associated with each step are discussed in relation to the Conservation Area.

The Elkhorn Ranch Integrated Management Plan serves as a model for the approach taken in this project. The Elkhorn Ranch is an appropriate comparison to the Conservation Area in terms of size, landscape diversity, natural history and human use. At approximately 1600 ha (4000 acres), the Ranch is slightly smaller than the Conservation Area ; the Ranch encompasses a diverse natural environment including the Alpine, Montane and Subalpine subregions of the Rocky Mountains natural region and the Aspen Parkland natural region; the Ranch includes areas of native grassland, tame pastures, riparian and forest communities; lastly, the area has been managed as a cattle ranch for three generations and thus faces many of the same long term changes that have affected the Conservation Area. The Elkhorn Ranch also has management goals that are consistent with ecosystem management, similar to the Conservation Area. The Ranch has a mandate to manage for the "long-term health and sustained productivity" of the ranching operation and to "employ sustainable grazing and timber management practices that protect watershed and wildlife habitat" (Adams and Fitch 1997). The Conservation Area, in contrast, has no stated mandate to sustain a ranching operation. This is the fundamental difference between the two areas. In other respects the Elkhorn Ranch is similar enough to the Conservation Area to serve as a useful model for the design of an ecosystem management and monitoring system.

2.2 Scoping

The need to define integrity in an operational way is a prerequisite to choosing indicators for monitoring ecosystem integrity (Keddy, Lee and Wisheu 1993). As mentioned previously in Chapter One with regard to Parks Canada and the US Fish and Wildlife Service, the establishment of goals and objectives may be an effective way to define or describe integrity for specific situations. Explicit goals and objectives can provide clear direction to an ecosystem management and monitoring program even in the absence of readily defined and quantifiable variables of ecosystem integrity (Noss and Cooperrider 1994). Goals and objectives appropriate to a specific ecosystem monitoring project can be developed through scoping.

Scoping or problem definition refers to identifying and refining issues, determining data needs to address those issues, and ranking issues and data needs (Noss and Cooperrider 1994). Goals and objectives are then derived from scoping to fulfill management purposes. This type of approach to establishing a basis for ecological monitoring is supported by several authors. Woodley (1993) discusses a two-pronged approach to ecological monitoring for the Canadian National Parks that includes identification of threat-specific and general ecological integrity issues as the basis for indicator selection. Woodley's approach is consistent with hierarchical approaches to ecosystem monitoring recommended by Munn (1993) and Noss (1990, 1995). The approach taken in the Elkhorn Ranch Integrated Management Plan is consistent with that of the above authors and includes the identification of management issues prior to the establishment of goals and objectives for different habitat types across the Ranch area. For purposes of wildlife management on the

Elkhorn, scoping included consideration of the vegetation types and landforms present, important habitat structural components, and the distribution of habitat types across the landscape.

The process of defining clear ecosystem goals and objectives for the Conservation Area has already been initiated with the general goals identified in Chapter One for the habitat management initiative. Identification of threat-specific, and ecosystem management, issues for the Conservation Area was completed by drawing upon the existing base of staff knowledge, by referring to past work done for the area, and by literature review. Management issues were identified at an ecosystem level and for individual vegetation habitat types; management goals and objectives consistent with the general habitat management goals were identified; and monitoring goals and objectives were developed to support the achievement of management goals.

2.3 Inventory

Inventory refers to the gathering of existing data which may include baseline information on vegetation communities and wildlife species (Noss and Cooperrider 1994). In addition to existing data, it seems reasonable to include the acquisition of new data that may be required for the analysis of specific threats or ecosystem function, into the inventory stage. Information related to wildlife and wildlife habitat can be efficiently integrated into the initial planning and data gathering stages of an ecological land survey (Kansas 1991).

An ecological land survey (ELS) is an interdisciplinary approach to gathering and interpreting environmental data (Ironside 1991). An ELS simplifies and organizes a diverse body of environmental data including abiotic, biotic and cultural features in a way that allows resource managers to address complex day-to-day and long-term management issues. The land classification stage of an ELS is concerned with partitioning the study area into areas of similar environment and classifying the units based on physical and biological characteristics. Traditionally, this process has emphasized the mapping of soil, landform, and vegetation classifications. A focus on wildlife and wildlife habitat factors based on the selection of indicator species can be added to effectively relate wildlife species with physical and biological attributes of the land (Kansas 1991). The ecological land evaluation stage of an ELS converts the collected data into forms suitable for interpretation and analysis in support of specific information or decision-making requirements.

Data requirements for an ELS can be separated into diagnostic and supplemental land attributes. Diagnostic attributes are used in the actual delineation of map unit boundaries. These may be used as a form of ecological evaluation themselves (e.g. estimating the percentage cover of native grassland), or as a geographical basis for the evaluation of supplemental land attributes. Supplemental attributes provide additional information about the characteristics of diagnostic map units (e.g. measurements related to an indicator species within a particular vegetation type). The selection of land attributes to be included in an ELS depend on the objectives of the evaluation, the scale of mapping, and the wildlife species and indicators of concern (Kansas, 1991).

Wildlife management on the Elkhorn Ranch involves consideration of vegetation types, landforms, important structural components, and the distribution of habitat components across the landscape (Adams and Fitch 1997). The Elkhorn Management Plan used a breakdown of major vegetation types as the basic diagnostic unit for wildlife evaluation. Vegetation types included aspen, Douglas fir, lodgepole pine, and Engleman spruce forest types, and native grassland, riparian shrub, and tame pasture types. Evaluation of grazing information was based on fenced pasture units. Evaluation of water quality was based on identification of three watershed units. This same type of breakdown was used for the designation of diagnostic land units for the Conservation Area.

The Conservation Area was divided into major vegetation units for the evaluation of native plant and animal wildlife. These included native grassland, tame pasture, willow shrub and aspen forest vegetation units. Native grasslands, tame pastures and aspen forest units were further subdivided based on vegetation community associations. Two associations of native grassland (rough fescue and mixed grass) were identified by Reid and Heseltine (1997). Two types of tame pasture were also identified by Reid and Heseltine (brome/bluegrass pastures and alfalfa hayfields). Aspen forest communities on the Conservation Area were divided into mature and young units by Reid and Heseltine. The relation of aspen forest age structure to wildlife diversity is well documented in the literature. Generally, diversity is highest in young and old stands and lowest in even-aged, mature stands (Stelfox 1995, Wollis 1993). The composition, density and height of the vegetation canopy is also listed by Kansas (1991) as an influential habitat factor for many species. Based on the documented importance of forest structure to wildlife, the aspen forest on the Conservation Area was divided into young, mature, and old growth associations for the purpose of serving as surrogates of forest structure.

Similar to the Elkhorn Ranch, the Conservation Area was mapped into watersheds and hydrological features (streams, ponds, and springs) for the evaluation of riparian and aquatic habitats. Also following the design of the Elkhorn management plan, grazing effects on the Conservation Area were monitored on the basis of fenced pasture units.

The chosen diagnostic land units were mapped using Geographic Information Systems (GIS) computer software. Scott et al. (1991) identifies the "baseline assessment of biodiversity and subsequent updates as one of the primary applications of an ecological information system facilitated by GIS technology." The use of GIS technology and the selection of diagnostic land units allows for retrieval of information via "single or multiple descriptive characteristics which will make it extremely flexible for the ecological land evaluation" (Ironside 1991). The use of a GIS will provide a basis for the long-term monitoring of supplemental attributes or ecological indicators on the Conservation Area.

Monitoring trends is difficult when ecosystem components are dynamic in nature. Pasture units may change size and shape, vegetation patches may change in size, shape, and composition, stream channels may change location, and new ponds may be formed or dry up. A reliable, geographically static, diagnostic land unit is required for monitoring multiple attribute changes over time. The administrative boundary of the Conservation Area itself could be considered a diagnostic land unit. For example, by using the boundary as a diagnostic land unit, changes in vegetation composition can be monitored for the entire area. However, this does not provide any information on where changes are taking place within the Conservation Area. To accomplish this a diagnostic land unit with greater geographic resolution is required - in other words, a smaller unit. Ecosite management units, corresponding to a standard 1/4 section grid, were proposed for monitoring change over time across the Conservation Area. The use of these management units provides for the ability to monitor change over time for the Conservation Area, as well as the ability to identify the spatial patterns in changing ecological variables.

2.4 Indicator Selection

According to Noss (1995), the selection of indicators for ecological integrity must include consideration of ecosystem composition, structure, and function. Likewise, Karr (1993) recommends that in order to protect biotic integrity, monitoring systems must consider both the elements (species, assemblages, communities) and the processes (energy flow, nutrient dynamics) inherent in biological systems. A broadly based, multi-parameter approach to selecting indicators for monitoring systems appears to be well supported in the literature (Noss 1990, 1995, Noss and Cooperrider 1994, Karr 1981, 1993, Woodley 1993, Keddy, Lee and Wisheu 1993, Munn 1993). The idea behind a multi-parameter approach is that no single indicator is sufficient to evaluate ecological condition and complexity (Karr 1983, Noss 1995). A suite of indicators corresponding to the appropriate spatial scales of ecological organization and to the three types of ecological variables, composition, structure and function will allow for the most insightful ecological assessments.

2.4.1 Spatial Scale

Management for ecological integrity must consider a variety of spatial scales in order to address the full range of ecosystem functions (Noss, 1995). Ecosystem management theory suggests that successful management efforts will not be restricted to the political and administrative boundaries of protected areas (Grumbine 1994, Scott et al. 1991). A scale of evaluation that encompasses the ecosystem components that surround and affect the Conservation Area is as important as the evaluation of the land area directly managed by the CCA. The selection of ecological variables and indicators, and the level of detail that can be reasonably attained through data collection and analysis, is directly related to the scale of analysis being carried out. The integration of different scales in ecological evaluation is a significant issue that a GIS may be employed for (Scott et al. 1991).

Having pointed out that an evaluation of factors external to the Conservation Area boundaries is essential for managing for ecological integrity, it should be restated that the scope of the Conservation Area's habitat management initiative is limited to monitoring within the Conservation Area boundaries. Some monitoring of external factors such as wildlife movement and access is already being done by the Conservation Area. Other factors such as adjacent development proposals are monitored continually by management. The EVDS 707 project proposed a system for monitoring at a regional scale. The use of GIS in this project will allow for the integration of current and future ecological monitoring on a regional scale with the site scale monitoring system developed by this project.

The scale appropriate for the monitoring of Conservation Area habitat corresponds to the Community-Ecosystem and Species levels as described by Noss (1995) and the Ecosite and Ecoelement scales of the Canada Committee on Ecological Land Classification (Ironside 1991). Consideration of these spatial scales points to a set of indicators that evaluate the ecological integrity of the Conservation Area as a unit, as well as a set of indicators that evaluate individual components of the area, such as an individual vegetation patch.

2.4.2 Selection Guidelines and Criteria Overview

Noss (1995) outlines the criteria for narrowing the selection of ecological indicators to a workable set including " (1) a validated relationship of the indicator to the phenomenon of interest; (2) convenience and cost effectiveness of the indicator for repeated measurement; (3) ability of the indicator to provide an early warning of change or trouble ahead and (4) ability of an indicator to distinguish changes caused by human activity from 'natural' changes." Keddy, Lee and Wisheu (1993) identified similar indicator criteria including, a close relationship to maintenance of essential environmental processes and ecosystem functions, the reflection of changes in entire communities rather than selected species, sensitivity to stresses and perturbations, and ease of measurement.

Woodley's (1993) criteria for monitoring ecological integrity in the National Parks is in agreement with the above criteria and also includes the following (adapted slightly for presentation here) :

1. *Monitoring measures should have the capability to provide a continuous assessment from stressed to unstressed conditions.*
2. *Monitoring should not depend solely on a single criterion such as the presence, absence or condition of a single species.*
3. *Monitoring should reflect our knowledge of normal succession or expected sequential changes which occur in ecosystems.*

4. *Measures used for monitoring should have a defined mean and variance whenever possible or should be designed to establish them.*

5. *Monitoring should be designed to account for catastrophic changes that occur in ecosystems.*

6. *Monitoring should be based on the concept of ecosystems and not park boundaries.*

7. *Monitoring should be done in two ways - on the state of park ecosystems in general, as well as on specific threats known to exist.*

8. *Monitoring measures must be designed for specific ecosystems because the sensitivity of various elements of ecosystem structure and function vary between ecosystems.*

The Conservation Area is limited in terms of time and money available for monitoring projects. Many land management projects are currently done with the assistance of volunteers. This means that efficiency with time and with money will be important criteria for indicator selection. Also important will be the complexity of data collection and analysis procedures. These procedures will need to be easy to learn and replicate by trained volunteers in order to ensure that indicators will be monitored over time. Currently, the Conservation Area does not have a staff member with an ecosystem science background, and so the system must be easy for staff, board members, and volunteers to comprehend and interpret into management actions. Consideration of the indicator criteria in the literature and of the above limitations has resulted in a set of guidelines and criteria for indicator selection applicable to the Conservation Area.

2.4.3 Indicator Guidelines

1. Indicators selected for the Conservation Area should evaluate ecological integrity at the ecosite scale and at the ecoelement scale for individual vegetation communities.
2. The suite of chosen indicators should reflect elements of ecosystem composition, structure and function.
3. Indicator selection should support the goals of management and monitoring.

2.4.4 Indicator Criteria

1. Indicators should be cost effective and time efficient to measure.
2. Indicator measurements should be easy to learn and replicate by trained volunteers.
3. Indicators should distinguish human effects from natural changes.
4. Indicators should be related to perceived threats to natural processes.
5. Indicators should provide an early warning of change in the general state of the ecosystem.

The above guidelines and criteria were used for the selection of indicators for the Conservation Area. Previously established management issues and management goals were used as the basis for the development of monitoring goals. Indicators were then chosen on the basis of achieving the goals of monitoring.

2.5 Sampling

Sampling is the process of collecting field data on selected indicators according to the experimental design (Noss and Cooperrider 1994). Field sampling for the Conservation Area was done to ground-truth remote sensing data that was used to designate diagnostic land units, to stratify sampling sites for indicator measurements, to take baseline measurements of indicator data, and to gather new data for data gaps that existed in the current inventory.

Measurements that were completed in the field included, the gathering of grassland and riparian vegetation cover data utilizing current range assessment techniques, measurements of stream flow and stream habitat quality, assessments relating to forest structure and stand turnover through the estimation of tree age class, and both structured and unstructured wildlife observations designed to determine presence/absence level data or species richness.

Most field measurements were taken to support the baseline collection of data for selected indicators. Extra information on native grassland composition beyond that required for indicator measurements was collected since the current inventories available for the Conservation Area were lacking in grassland composition data, the techniques required to obtain the extra data were the same as those required to collect the indicator data and could be accomplished at the same time, and the information was seen to be important in terms of a baseline set of data that could be used in the future for indicator verification or for other statistical analysis.

2.6 Validation

Validation refers to examining how well the chosen indicators respond to the phenomenon of actual interest and is often done independently of the actual monitoring process (Noss and Cooperrider 1994). No validation studies were included within the scope of this MDP. However, the opportunity for future validation studies is facilitated by the choice of quantifiable indicators, and the selection of a group of indicators that may be compared against each other. The approach taken in this project assumes a pragmatic approach to implementation of a monitoring program as suggested by Keddy, Lee, and Wisheu (1993). Making preliminary decisions about indicators and their critical limits is an essential first step to the scientific process of using and refining them. This pragmatic approach is consistent with the assertion expressed in the monitoring literature that in the absence of suitable scientific models describing ecosystem relationships the researcher must still proceed on the basis of the best information available (Noss 1995, Keddy, Lee, and Wisheu 1993, Munn 1993). For instance Munn (1993) suggests that " a first generation model is by necessity simple but it provides a first set of indicators to be monitored. Then through successive iterations, both the model and the monitoring system gradually improve." Likewise, Noss and Cooperrider (1994) suggest that "the results of monitoring may provide insight about what models are suspect or need validation." Based on these assertions, the scope of the monitoring system designed for the Conservation Area in this project is limited to the implementation of an initial monitoring program and it is recommended that future validation studies take place independently of, and are based on, the results gained from the initial system.

2.7 Data Analysis/ Management Adjustment

Monitoring should be used as a tool to change management or to adjust human behavior (Noss and Cooperrider 1994). They further state that " monitoring for biodiversity should be issue-driven, and the issue is always to determine if specific human activities are compatible with or damaging biodiversity." A critical question with regard to monitoring systems is how to interpret the data that are monitored so that management practices can be adjusted as necessary. Woodley (1993) summarizes two potential approaches to data interpretation - the reference system approach and the trend analysis approach. In the reference system approach, the state of a test ecosystem is compared against a known or reference system. Woodley rejects this system for national parks since parks are large, unique, and often the least stressed ecosystems in the areas they represent. For the Conservation Area there may not be a good reference ecosystem for similar reasons. The Conservation Area is one of the largest roadless blocks of land left in the ecoregion it represents. Other large blocks of land have been managed as ranches in the area for similar periods of time. There is no other large undisturbed or protected area such as a national park in the same ecoregion. The least disturbed native sites on the Conservation Area may be as good a reference site as any other in the region.

Related to the idea of a reference system is the issue of identifying indicator thresholds that signal a need for management action in order to preserve ecological integrity. The idea of identifying indicator thresholds is well supported in the literature (Noss and Cooperrider 1994, Keddy, Lee and Wisheu 1993, Karr 1993). In the absence of a better reference site than the Conservation Area, the least disturbed native sites could be used to determine minimum threshold levels for some measurements. Alternatively, it may be possible to use general information and standards, such as those available in the range management literature on species composition, to define thresholds. Such an approach is suggested by Woodley (1993).

Woodley's recommendation for National Parks monitoring is the trend analysis approach. Monitoring indicators are chosen and analyzed to show trends that would be expected in stressed ecosystems. Noss (1995) suggests a somewhat broader approach through the identification of trends that illustrate states of integrity, disintegrity, or recovery towards integrity. Trends can be presented in many ways, including the use of indices and the use of graphical representations. Indices are valuable in that they synthesize a great deal of information. However a potential drawback is that no single numerical index can be expected to represent the status of a complex ecosystem (Woodley 1993). Despite the drawbacks, an interpretation of monitoring data using a simple index of change in ecological integrity has been suggested for the Prairie and Northern Region of Parks Canada (Henry, McCanny and Raillard 1995) and Karr's (1981, 1993) evaluation of biotic integrity for streams is composed of an index of twelve biological attributes of fish communities. Karr (1993) argues that stronger inferences of the state of biotic integrity can be made when a combination of measures are used and added together.

The approach to data interpretation in this project was to attempt to define management threshold levels, and at the same time provide for the long-term analysis of trends in indicator measurements. In the absence of a rigorous model to define ecosystem management thresholds, trend analysis may provide the Conservation Area with the best early-warning tool to identify changes negatively affecting ecological integrity. Management priorities and adjustments can then be made based on the degree of change occurring in a particular area over time and not just on a pre-defined threshold value. However it is also recommended that the Conservation Area pursue studies that may provide a better historical baseline from which management thresholds could be determined. Historical airphoto analysis and interviews with long-time residents may provide this type of information. This type of approach to identifying a historical baseline is currently being pursued by Barry Adams and Lorne Fitch (Quinn pers com 1998).

2.7.1 GIS and Database Tools

Several authors have referred to the suitability of geographic information systems (GIS) as a tool for ecological management. Scott et al. (1991) state that "a GIS-based biodiversity assessment can be one key component in an overall strategy of ecological management." Geographic Information Systems greatly increase the capability for display, overlay, and analysis of spatial data related to ecological land survey and wildlife management (Ironside 1991). Data required for ecological management should include the distribution of taxa, ecological features that characterize taxa habitats, and human activities that may affect habitats. These are inherently spatial attributes, and GIS is an appropriate tool for the storage, analysis, and display of these types of data (Scott et al. 1991).

The diagnostic land units previously identified in Section 2.3 (vegetation types, fenced pastures, watersheds and ecosite management units) were used as the basis for indicator evaluation. The indicator measurements taken from field sampling can be considered to be characteristic of the diagnostic land unit that they were collected in. Riparian indicators were evaluated on the basis of watershed units, native grasslands and Aspen forest were evaluated on the basis of vegetation units, and grazing effects were evaluated on the basis of pasture units. On a site scale the Conservation Area was evaluated based on the overall composition of vegetation units. Wildlife indicator data were mapped independently of diagnostic map unit boundaries and can be evaluated in relation to any diagnostic land unit.

Diagnostic land units were mapped using MapInfo GIS software. The maps were then joined to tables in a Microsoft Access database. A relational database structure was developed where thematic tables of data are linked by common key fields. The flexibility of the relational model makes it highly suitable for use with a GIS (Scott et al. 1991, Aronoff 1989). The database facilitates the storage, retrieval and analysis of data from indicator measurements. Processed data can then be displayed as tables, graphs, or maps by the GIS software. In this way, monitoring results can be directly related back to the diagnostic land unit where the measurements were taken. This provides the Conservation Area with a geographic basis for implementing management actions and a geographic comparison of areas for setting management priorities.

2.8 Chapter Summary

The approach to the implementation of an ecological monitoring system for the Conservation Area is summarized below in a series of stages. While presented as individual components, the process of implementing an adaptive management and monitoring system is not a linear process. It is more accurately depicted as a cyclical and incremental process for continually gaining insight into ecosystem function (Noss and Cooperrider 1994). The following summary describes the stages involved in this incremental, and somewhat iterative, process.

1. The general goals and objectives for habitat management presented in Chapter One formed the basis for a tiered set of management and monitoring sub-goals. Sub-goals were developed for the management of the whole Conservation Area at an ecosite scale, and at the ecoelement scale for native grassland, aspen forest, and riparian vegetation habitat types.
2. A suite of ecological indicators were selected for the purposes of monitoring the achievement of specified management goals. Indicators were chosen to represent the compositional, structural, and functional elements of the Conservation Area ecosystem.
3. Diagnostic land units were mapped using GIS computer software. Diagnostic units included watersheds, vegetation types, and pastures. The diagnostic units provided the geographic basis for indicator sampling in the field. Vegetation units were treated as diagnostic land units for the evaluation of indicators and were also analyzed as being characteristic of the Conservation Area at the ecosite scale.
4. Baseline indicator data was collected in the field. This included collecting information on native grassland composition, forest structure, weed distribution, stream flow characteristics and wildlife. Some additional information on grasslands composition was also collected at the same time to provide a more complete baseline inventory that may be used in the future for indicator verification. Indicator data was considered to be characteristic of the diagnostic land unit where the measurements took place and was analyzed on that basis.

5. Data analysis was designed to support two approaches - comparison with pre-defined management thresholds and to evaluate trends. Recommendations from this report are based only on the indicators where pre-defined management thresholds could be identified. A data analysis model based on the use of indices for identifying long term trends was proposed.
6. The proposed data management model was based on the use of GIS computer technology and facilitated by a relational database model. The model was developed to support both types of indicator analysis and to be flexible for future upgrades and changes to the monitoring system. The basic components of this system were established by the MDP including the mapping of diagnostic land units in MapInfo GIS software and the construction of the relational database structure in Microsoft Access.
7. Management priorities and recommendations were made based on the indicators that could be related to management thresholds. This included recommendations on specific management actions for specific management areas necessary to maintain or restore ecological integrity.

The organization of the project is graphically illustrated in Figure 2. The diagram includes the stages of monitoring system development completed by this MDP. The diagram also illustrates the future application and development of the monitoring system as provided through the completion of this MDP.

The following Chapters outline the monitoring system developed for the ecosite scale and for individual vegetation habitat types (native grasslands, riparian, and aspen forest). Each Chapter includes the specific details of indicator selection, data collection, data management and analysis, and management recommendations for that habitat type.

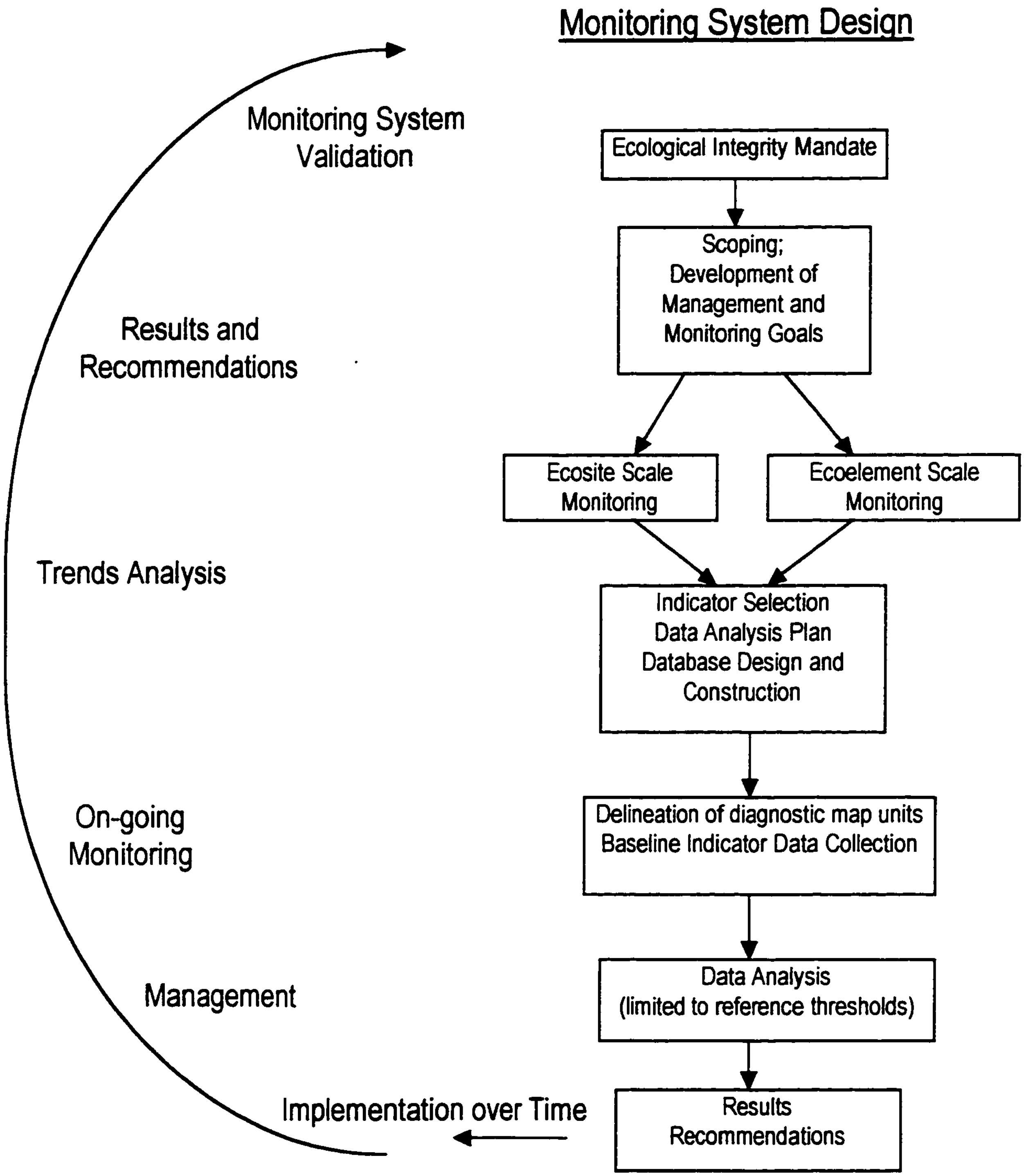


Figure 2. Project Schematic

The right hand column of boxes represents the development stages of the Conservation Area monitoring system completed within the scope of this project. The left hand arc represents the development and use of the monitoring system over time made possible through completion of the initial design.

3.0 Ecosite Scale Monitoring

Ecosite scale monitoring was focused on the evaluation of vegetation cover and composition, the presence or absence of wildlife indicator species, and the effects of cattle grazing on the Conservation Area. Within this chapter, a discussion of management issues and threats leads into the development of management and monitoring goals and the selection of indicators. Procedures for data collection, data management, and data analysis, are outlined. The results of the initial data collection and analysis are presented with specific management recommendations to conclude the Chapter.

3.1 Management Issues and Threats

Rough fescue grasslands are threatened by the invasion of highly competitive exotic grasses and weeds, and by the encroachment of aspen and other woody shrub species into grassland areas. In large part this can be explained by the suppression of fire and the change in grazing regime from that of wild bison herds to that of domestic cattle ranching. The expansion of aspen on the prairies in particular, can be best correlated to the extirpation of bison after 1870-1880 (Campbell, 1997). The combination of fire and bison grazing are thought to have prevented many aspen stands from reaching maturity, thereby preventing an increase in mature aspen cover, and sustaining native grassland cover.

While cattle ranching is often promoted as a surrogate for the disturbance regime eliminated in the wake of bison extirpation, it is equally true that indiscriminate cattle grazing on fescue prairies does not mimic the effects of bison and is detrimental to fescue survival (Adams, Willms, and Powell 1993, Adams and Fitch 1997). Fescue prairie evolved under a disturbance regime of fire and winter grazing by bison (Nelson and England 1971, Trottier 1986, Adams, Willms, and Powell 1993) and is readily damaged by spring and summer grazing (Adams and Fitch 1997). "The fescue prairie is better adapted to winter rather than summer grazing. When grazed in the summer, rough fescue is readily damaged with a single defoliation... after senescence, however, rough fescue tolerates grazing, is readily utilized by livestock, and provides forage with relatively superior quality." (Adams, Willms, and Powell 1993). Overgrazed grasslands are subject to invasion by exotic species, weeds, shrubs, and aspen.

Fire suppression has also directly affected the aspen communities. Historically, aspen stands on the prairies were typically young, and relatively even-aged, due to the frequency of fire and bison browsing (Campbell 1997, Benn 1994, Perala 1991). However, the aspen forest on the Conservation Area today is likely more structurally diverse than the historical forest. Diversity in stand age and structure has been related to wildlife diversity, with diversity being greatest in young and in old stands (Wollis 1991, Stelfox 1995). Province-wide, old growth aspen stands may be declining due to forestry management practices related to the relatively recent harvesting of aspen for pulp (Fuller 1991). At the same time the maturity of aspen stands on the Conservation Area is contributing to aspen encroachment into the grasslands. The ensuing management dilemma is somewhat obvious. Should aspen be managed for the historical, young, even-aged stand, or for stand diversity, taking into account the situation on a landscape scale? It seems reasonable to suggest that managing for stand diversity has the potential to meet the requirements of both the historical and the current situations. It is always possible to convert to a predominant even aged young forest in a short time span while it may take eighty years or more to develop an old growth aspen stand in the area (this estimate is based on an average age of 83 years for white spruce and of 65 years for aspen found in mature aspen stands on the Conservation Area as documented by Reid and Heseltine 1997).

Changes in the native aspen parkland also have the potential to affect animal wildlife species dependent on native habitat. Some species have particular habitat requirements that may be met within a particular vegetation community. Others may be associated with a undefinable group of plant species when evaluated at the community level (Hoekstra, Flather and Ironside 1991). This may be especially true in a diverse ecosystem such as the aspen parkland. Important considerations for evaluating wildlife habitat at the community level include species diversity, habitat diversity, and the spatial distribution of the wildlife and vegetation community. Considerations at the species or population level include animal characteristics, habitat characteristics and diversity, as well as the colonization and extinction rates of animals and habitat features such as vegetation composition, structure, and distribution (Hoekstra, Flather and Ironside 1991).

Ecosite level monitoring for wildlife habitat integrity on the Conservation Area will have to consider community and population level ecological variables. This will include consideration of the diversity and distribution of vegetation habitat types, and the diversity and distribution of animal wildlife species. Also important will be the evaluation of the threat imposed to the Conservation Area by the elimination or modification of historical disturbance processes. In particular, the grazing regime will need to be evaluated in terms of how well it mimics the processes necessary to maintain native rough fescue grasslands.

3.2 Ecosite Management and Monitoring Goals and Indicator Selection

The goals and indicators chosen for the ecosite scale were intended to reflect the patterns and distribution of vegetation and wildlife communities across the Conservation Area landscape. Vegetation community composition and structure, that are of importance to wildlife and wildlife habitat at the ecosite scale, were considered. Wildlife diversity and distribution were considered to be a reflection of overall habitat quality and ecosystem function. The impacts of current grazing management on ecosystem functions was also considered.

The goals for ecosite level management are summarized as follows:

1. Maintain and enhance the distribution of native grassland habitat on the Conservation Area
2. Maintain the diversity and distribution of vegetation communities on the Conservation Area such that the diversity of native animal wildlife habitat is supported
3. Maintain the diversity of the native animal wildlife community
4. Manage cattle grazing so as to mimic the effects of native disturbance processes

3.2.1 Ecosite Management Goal 1

Maintain or enhance the distribution of native grassland habitat on the Conservation Area.

Monitoring Goal

Detect changes in the area and distribution of native grassland communities across the Conservation Area.

Indicators:

- Native grassland percentage cover of total area (ha)
- Ratio of native to non native grassland cover
- Ratio of native grassland to forest/shrub cover

The ratio of native to non-native species is considered an important ecosystem level indicator by Noss (1995) and provides an indication of exotic species invasion for the Conservation Area grasslands. Comparison of native grass cover with forest/shrub cover gives an indication of the rate of woody species encroachment. The total area of native grass cover can be compared with a minimum area threshold value derived from the literature for conservation and protection. These calculations can be easily done with GIS technology and are easily understood for management decision purposes.

3.2.2 Ecosite Management Goal 2

Maintain the diversity and distribution of vegetation communities on the Conservation Area such that the diversity of native animal wildlife habitat is supported.

Monitoring Goal

Detect changes in the diversity and distribution of vegetation communities.

Indicators:

- Ratio of native to non native vegetation cover
- Percentage cover of young, mature and old Aspen stands
- Grassland indicators as discussed above

In combination with the grassland indicators as discussed above, this set of indicators provides for an analysis of vegetation composition and structure across the Conservation Area. The comparison of total native to non-native cover reflects the functional integrity of the area by serving as an indicator of exotic species invasion.

3.2.3 Ecosite Management Goal 3

Maintain the diversity of the native animal wildlife community.

Monitoring Goal

Detect changes to the diversity and distribution of native animal wildlife.

Indicators:

- Species Occurrences

Efforts to identify indicators for the Weldwood Hinton Forest Management Area and for the Elkhorn Ranch have focused on the selection of ecological indicator or "representative" species (Adams and Fitch 1997, Wollis 1991, Bonar et al. 1990). Noss (1990) identifies five categories of species that may warrant attention in monitoring systems (modified slightly here):

1. *Ecological indicators: species that signal the effects of perturbations on a number of other species with similar habitat requirements.*
2. *Keystones: pivotal species upon which the diversity of a large part of a community depends.*
3. *Umbrellas: species with large area requirements, which if given sufficient protected habitat area, will bring many other species under protection.*
4. *Flagships: popular, charismatic species that serve as symbols and rallying points for major conservation initiatives.*

5. *Vulnerable: species that are rare, persecuted, or otherwise prone to extinction in human-dominated landscapes.*

The Wildlife Movement Patterns Study (Gilson and Pittaway 1996) used a selection of umbrella species as indicators of the ability of wildlife to access and disperse from the Conservation Area as a way of evaluating the viability of Conservation Area wildlife habitat at the regional scale. Species monitored included mule deer, white-tailed deer, elk, cougar, and lynx. Although monitoring at the regional scale cannot be clearly separated from monitoring at the ecosite scale, for the purposes of limiting the scope of this project, it was decided to limit the consideration of wildlife indicators to those species whose habitat requirements are limited primarily to the ecosite scale.

Monitoring a single species as an indicator of ecological integrity is problematic due to variation in local populations and local extinctions that may have little to do with habitat quality (Noss 1990, Kansas 1991, Stelfox 1991, Karr 1993). Therefore, while the presence of a particular species may serve as a good indicator of an ecosystem with integrity, the absence of the same species may not be a good indication of a lack of integrity. For the purposes of monitoring wildlife on the Conservation Area, it was felt that a suite of indicator species would address the limitations of monitoring a single species, would provide the best overall indication of the state of ecosystem integrity, and would most effectively serve the goal of detecting changes to the diversity and distribution of native animal wildlife.

The suite of wildlife indicators for the Conservation Area should be chosen to match the goals of managing for ecological integrity and maintaining native species diversity. The indicators should show that the composition and structure of the native plant community supports native animal wildlife diversity and illustrate that wildlife diversity is being maintained through the composition and trophic structure of the wildlife community itself. Overall, the suite should indicate that ecosystem function, in terms of energy and nutrient cycling, has integrity, and that it is capable of supporting the most sensitive, and restricted, native wildlife species. This approach is not unlike the approach taken in Karr's (1981) Index of Biotic Integrity where trophic composition "metrics" or species are used to evaluate ecosystem function in terms of food chain conditions.

The scope of this project includes the initiation of research into wildlife indicators for the Conservation Area. Potential indicator species were identified, selecting from the existing wildlife species list for the Conservation Area. Species were selected that were representative of the main vegetation communities - native grassland, riparian, willow shrub/young aspen, and mature and old growth aspen forest. Species identified to be sensitive or vulnerable to habitat loss or alteration were preferred over other representative species. An effort was made to identify at least one umbrella species - usually a top carnivore - for each vegetation type. In addition, indicator species were identified at lower trophic levels, with a preference for species with a known relationship to the top carnivores. Indicators were chosen from birds, mammals, and amphibians on the premise that these species would be the easiest to identify and of the most interest to volunteer assistants.

The Conservation Area species list was compared to indicators selected for the Elkhorn Ranch (Adams and Fitch 1997), and to those species selected as indicators for the Weldwood Hinton Forest Management Agreement Area (Bonar et al. 1990) for the initial screening of indicators. Additional information on species ranges, species habitat requirements, and species vulnerability, as well as the identification of other potential wildlife indicators, was obtained by consulting mammal and bird literature (Bamfield 1974, Godfrey 1986), the Alberta Natural Heritage Information Centre (ANHIC 1997), and the North American Breeding Bird Survey (BBS 1997).

The research provides a list of potential indicator species based on existing information. The list provides a place to start monitoring wildlife with the intention of expanding the base of wildlife information, and ultimately refining the list of indicators to those best suited to the goals of the Conservation Area. For the short term, monitoring indicator species occurrences may contribute to the selection of indicators and may also identify potential problem areas that require more in-depth analysis. For instance, a lack of grassland species occurrence data may indicate that changes are needed in data collection procedures, or that grassland species do not occur in abundance, or perhaps the indicators are not appropriate for the Conservation Area. In any case management attention can be drawn to the issue through occurrence level data. Decisions can then be made accordingly.

A listing of potential indicator species is included below arranged by vegetation type association with brief descriptions of the primary reasons for their selection. This list is the result of the initial screening of potential indicators from the Conservation Area species list. Modifications to the list are recommended as a result of the review of existing wildlife data and the collection of new data over the course of the project. These recommendations are found in Section 3.5.3.

Native Grassland

- Badger (status uncertain in Alberta, top carnivore, sensitive to habitat alteration)
- Short-eared Owl *Asio Flammeus* (top carnivore, declining grassland species, strong native grassland habitat association)
- Sharp-tailed Grouse (declining grassland species, may have disappeared from Conservation Area)
- 13-lined Ground Squirrel *Spermophilus tridecemlineatus* (strong rough fescue association, central to food chain)
- Richardson's Ground Squirrel (overabundance or lack of abundance can indicate degraded grassland conditions)
- Sprague's Pipit *Anthus spagueii* (strong grassland habitat association)

Willow Shrub/Young Aspen

- Prairie Long-tailed Weasel (top carnivore, status uncertain)
- Warbling Vireo *Vireo gilvus* (habitat association)
- Snowshoe Hare *Lepus americanus* (central to food chain)

Mature Aspen

- Ruffed Grouse *Bonasa umbellus* (habitat association)
- Hairy Woodpecker *Picoides vilosus* and Downy Woodpecker *Picoides pubescens* (indicator for birds and animals requiring tree cavities)
- Red Squirrel (representative of aspen/spruce mixed wood associations)

Aspen Old Growth

- Pileated Woodpecker *Dryocopus pileatus*(keystone species for wildlife using large tree cavities)
- Black Bear (habitat association, large range, contributes to regional scale monitoring)

Riparian

- Great Blue Heron *Ardea herodias* (status uncertain, top carnivore)
- Northern Harrier *Circus cyaneus* (top carnivore)
- Mink *Mustela vison* (top carnivore)
- Wood Duck (threatened species in Alberta)
- Wood Frog *Rana sylvatica* and Boreal Chorus Frog *Pseudacris triseritat maculata* (sensitive to habitat degradation, contribute to global monitoring information)

Regional Indicator Species

The species that are currently monitored for the Conservation Area's on-going wildlife movement study are reviewed below for the reader's information. These species were not considered as indicators for the purposes of this project.

- Mule Deer and White-tailed Deer

- Elk
- Moose *Alces alces*
- Cougar
- Lynx *Lynx lynx*
- Coyote *Canis latrans*

Other Species of Interest

During the course of investigating potential indicators other species were identified that may serve as good indicators but are not currently found on the Conservation Area species list. These are included here for the purpose of illustrating the need for continued research into wildlife indicators and for expanded wildlife surveys before the best set of indicators can be selected.

- Great Grey Owl *Strix varia* (old forest interior habitat association, top carnivore, unconfirmed sightings on Conservation Area)
- Common Yellowthroat *Geothlypis trichas* (riparian habitat association used for the Elkhorn Ranch)
- Baird's Sparrow *Ammodramus bairdii* (strong native grassland habitat association, sensitive species, declining)
- Leopard Frog (very sensitive, globally threatened species)
- Piping Plover *Charadrius melodus* (threatened species, unconfirmed sightings on Conservation Area)
- Prairie Falcon *Falco mexicanus* (threatened species)

Although the above list of species seems like an extensive one to monitor, the Conservation Area has a large group of volunteers who are eager to assist with species monitoring. The chosen indicator species are relatively easy to identify and the level of detail required for occurrence level data collection is not extensive. Incidental observations are applicable to multiple species assessments and can confirm the presence or absence, and breeding status of selected species, as well as provide some basic information on trends in habitat use (Kansas 1991). Kansas also points out that data collection related to incidental observations needs to be well structured in order to be applied to habitat use assessments that can aid planners and managers with land use prescriptions. This approach seems appropriate for the Conservation Area at this stage in the evolution of the monitoring system.

3.2.4 Ecosite Management Goal 4

Manage cattle grazing so as to mimic the effects of native disturbance processes.

Monitoring Goal

Detect areas where grazing practices are compromising native habitat integrity.

Indicators:

- Carrying capacity (AUMs) compared to grazing pressure (AUMs used)
- Weed Density Distribution

Range carrying capacity is commonly used as the basis for setting cattle stocking rates that do not damage the long term health of the grassland being used. Range carrying capacity is used for cattle management for the Elkhorn Ranch (Adams and Fitch 1997) and is recommended for any cattle operation in Alberta (Adams et al. 1986). The carrying capacity can be used to set a maximum stocking rate. Pastures where actual use exceeds the stocking rate can be considered to be incompatible with historical patterns of range use and therefore considered a threat to range integrity. This management goal is consistent with recommendations for managing rangelands in any location as described by Noss and Cooperrider (1994); "Livestock grazing that mimics grazing patterns of native large herbivores is most likely to be sustainable."

An increase in invader plant species including weeds can be considered an indicator of degraded range condition (Adams et al. 1986). The tame pasture vegetation units on the Conservation Area are primarily composed of exotic grasses that have been planted to provide high quantities of summer forage such as smooth brome, timothy and Kentucky bluegrass. The prominence of these grasses does not make them a good indicator at a ecosite scale. Invader weeds such as Canada thistle could be expected to be found in areas where the condition of even tame pastures has been degraded, making weed cover a reasonable indicator.

Monitoring both of these indicators is not time consuming and does not require a great deal of technical expertise. Range carrying capacity can be derived, at least initially, from standard stocking rates based on Animal Unit Months (AUMs) for different range types. Keeping track of actual cattle use can be done easily by the Conservation Area cattle manager using standard provincial formats and figures. Weed density and distribution can be monitored by using the density distribution class values recommended by Robertson and Adams (1990) and is a suitable task for trained volunteers.

3.3 Data Collection

Data collection for ecosite scale monitoring included vegetation mapping, compilation and mapping of existing and new wildlife data, mapping of pasture units and tracking of grazing use.

3.3.1 Vegetation Mapping

Vegetation mapping of the Conservation Area was based on the analysis of black and white airphotos. Airphotos taken in 1996 at the scale of 1:30,000 were obtained from Foto Flight of Calgary (Foto Flight 1996). Although a larger scale set of airphotos could have been used to achieve greater resolution, Foto Flight flies this area each year for the City of Calgary. These airphotos are readily available, updated every year, and very inexpensive when compared to the price of a custom job. Updating the vegetation inventory every few years will be important for monitoring trends in vegetation cover. Using these existing airphoto sets was considered to be appropriate for the Conservation Area budget while still providing an appropriate level of resolution.

The airphotos were geocorrected to account for distortion due to changes in topography and elevation by Komex International Ltd. The resulting orthophoto is like a digital image map and distances measured on the airphoto can be converted to actual distance on the ground (Figure 3).

The vegetation inventory completed by AGRA Earth and Environmental Ltd. (Reid and Heseltine 1997) was used as the basis for the designation of vegetation units for the purposes of the monitoring system. The AGRA report identified two associations of native grassland within a brome/ rough fescue grasslands category. The location of rough fescue grasslands was identified through further airphoto interpretation and by using local knowledge of the Conservation Area staff. Locations were ground truthed in the field and subsequently mapped as either rough fescue or mixed grass native grasslands. Most of these grasslands are not pure stands of native species and contain invasive species as well. The designation of a grassland unit as native was based on a visual estimate of native species cover, particularly that of rough fescue, at the time of ground truthing. Rough fescue is easily discernible, even at cover values between one and two percent. Other grassland units designated as tame pasture units may have contained some native species cover; however, this was not readily discernible through visual observations in the field. Native grasslands designated for this project had a minimum 20 percent average cover of native grass species. The remainder of the grassland was designated as either a brome/ bluegrass association or as alfalfa as identified in the AGRA report.

Aspen forests in the AGRA report were divided into two age associations - young and mature. In light of the research regarding wildlife habitat associations with old growth forests as previously discussed, it was decided to separate old growth stands from mature stands. Initially, this was done through airphoto interpretation focused on the identification of canopy gaps. This information was then ground truthed in the field by a quantitative evaluation of tree height diversity (see Chapter 6), and a subjective evaluation of the prevalence of snags and downed woody material. The subsequent map designations involved the division of some forest units as designated by AGRA, and the combination of others. Mature forest patches are characterized by a closed canopy of primarily mature trees in the range of 2100 to 2700 stems/ha. Many suckers may appear each spring and then die off due to lack of light. In contrast, old growth stands are characterized by canopy breakup, and a subsequent variety of tree sizes and ages. Stem density in old growth stands varies greatly, from several hundred stems/ha and up, depending on the balance between stand decadence and regeneration (Perala 1991, Wollis 1991, Stelfox 1995).

Figure 3. Orthophoto Basemap of the Ann and Sandy Cross Conservation Area

Prepared by Komex international Ltd.
Source: Alberta Environmental Protection Digital Elevation Model
1:20,000 base map sheets for 82J/16
Original Aerial Photography by Foto Flight Ltd. 1995

Tree size, snags, and downed woody material are all important structural indicators for wildlife habitat evaluation (Stelfox 1995, Wollis 1991). All of these features can be quantified using standard forestry methods within forest study plots, or along transects. For the purposes of ecosite scale evaluation in this project, quantification of tree size was done primarily to separate mature from old growth stands, and to serve as a method of ground truthing for the airphoto analysis. A decision was made to not expend effort quantifying all structural features in all forest patches across the Conservation Area within the scope of this project. Grassland and riparian ecosystems were considered to be management priorities and most effort was concentrated in these areas. If forest management became a priority in the future, the evaluation and quantification of structural components across the Conservation Area would be important wildlife habitat indicators and important for monitoring trends in stand aging.

Willow shrub communities were not divided into smaller units than those designated by AGRA. Riparian and aquatic features were evaluated separately from other vegetation units. Riparian zones were not readily distinguishable from other vegetation units on the airphotos or even in the field, making accurate mapping of riparian area impossible without larger scale photography.

Vegetation units were further subdivided based on existing fencelines in order to define pragmatic field management units. A small number of vegetation units were subdivided based on radical changes in aspect (i.e. north to south over a ridge line) within the unit. It was felt that this aspect change could influence the results of monitoring as well as the potential results of management actions.

Vegetation units were drawn as polygons in an individual layer overlaid on the airphoto using the MapInfo GIS program. Polygons were labeled with a vegetation type and a community type designation to allow for the greatest range of query possibilities (Table 1).

Table 1. Vegetation Types and Communities

Vegetation Type	Community Type
Native Grassland	Rough Fescue Mixed Grass
Tame Pasture	Brome/Bluegrass Alfalfa
Aspen Forest	Young Mature Old
Willow Shrub	Mature

3.3.2 Wildlife Indicators Data Collection

Data on the selected wildlife indicators were compiled by reviewing existing Conservation Area records. This review included reports from the Area Stewards volunteer program for 1996 and 1997 and the reports of volunteer biologist Olga Droppo. Pre-1996 information was obtained from Mrs. Droppo and from Conservation Area staff input.

The results from the compilation of existing wildlife sightings were recorded as point data in a separate layer for each year in MapInfo. Information associated with each wildlife observation included the date, species common name, species Latin name, Latin family name, name of observer, observer type, observation type, and notes. Each observation was assigned either map coordinates or referenced to the quarter section in which it was observed, or both. Observations in the reports that could not be geographically referenced were not included in the data. Observations included actual animal sightings as well as confirmed sightings of tracks, scat, dens, foraging sites, nests, and bird calls.

Information on some of the indicator species was noticeably lacking in the existing data - in particular, observations of badger, wood duck, great blue heron and sharp-tailed grouse. Field surveys were conducted in an effort to improve the data available on badger, great blue heron, and wood duck. No effort was made to specifically survey for sharp-tailed grouse in the 1997 season. According to local information sharp-tailed grouse have not been observed for several years on the Conservation Area. Discussions have taken place between the Conservation Area and Provincial wildlife authorities regarding a sharp-tailed grouse habitat analysis and reintroduction program as a future management project. This being the case, it was decided not to expend effort to survey for this species as part of this project.

A survey for evidence of badger was conducted by staff and volunteers. Native grassland units were surveyed for any sign of badger activity including sightings, dens, and diggings. A search pattern was established that utilized groups of staff and volunteers to methodically search native grasslands for these signs. Participants spread out in a line approximately five metres apart and walked from one side of a vegetation patch to the other, shifted the line, and repeated until the entire area was covered. Locations of badger sign were recorded using a Geographic Positioning System (GPS) location device. Data were recorded in the same manner as other existing wildlife data.

Collection of data for great blue heron and wood duck was incorporated into a waterfowl and shorebird survey conducted for the evaluation of riparian zone integrity. Methods for this survey are discussed in Chapter Five.

3.3.3 Grazing Data Collection

Collection of grazing data was divided into calculations of carrying capacity and the tracking of actual cattle use in AUMs.

Carrying capacity was calculated in a manner similar to that of the Elkhorn Ranch (Adams and Fitch 1997). Pasture sizes were calculated using the GIS software. Each pasture was then assigned a stocking rate value (ha/AUM) based on the type of vegetation within that unit. Three stocking rates were used for the pastures on the Conservation Area:

1. Parkland (pastures that contained a mix of native vegetation including grasslands, willow, and aspen forest) 1.3 ha/AUM
2. Tame Pastures (pasture units consisting primarily of exotic pasture species including Smooth Brome, Timothy, Bluegrass and Alfalfa) 0.5 ha/AUM
3. Forest Pastures (consisting primarily of Aspen forest) 2.0 ha/AUM

For the purposes of this project, it was assumed that all pasture units were in good condition as defined in the range management literature. Stocking rates were based on Adams et al. (1986) and Adams and Fitch (1997). The total pasture area in hectares was then divided by the stocking rate to arrive at a total capacity in terms of animal units that could be grazed for one growing season on that pasture:

Pasture ha / ha per AUM = Total AUMs available

It should be noted that the carrying capacity estimates are average figures based on average growing conditions. Drought conditions would require a more conservative estimate of grazing capacity. A decline in range condition would also require a more conservative estimate of grazing capacity. Range condition field estimates by the Conservation Area cattle manager should be on-going and changes to the grazing capacity rates adjusted accordingly.

Actual grazing use was determined by multiplying the number of animal units in a pasture by the amount of time spent in the pasture expressed in months. The format for tracking actual cattle use is illustrated in Table 2.

Table 2. Stock Tracking Form

Pasture Unit	Class	Avg. Wt.	AUEs	Animal # s	Date in	Date Out	Actual Use	AUMs Used

Class: Cows, yearlings, bulls, cow-calf pairs, etc.

AUEs: Animal unit equivalents (e.g. Average weight in lb. / 1000 lb. = AUEs)

Actual use: Days in pasture divided by 30 = months (e.g. 25 days/30 = 0.83 month)

AUMs: AUE x # of animals x Actual use (e.g. 1.2 AUE x 20 animals x 0.83 mo. = 20 AUMs used)

An important aspect of tracking actual cattle use is the restriction of cattle to specified areas for a specific time period. If cattle are allowed to graze a pasture for a time and then later are allowed simultaneous access to another pasture by opening a gate, the ability to effectively estimate use for either pasture is lost. It becomes impossible to say which of the two pastures cattle are actually using, and what the intensity of use is. In effect, in terms of scientific analysis, the experimental control of variables has been lost. Estimating actual use requires tracking the number of animal units, tracking the time utilized for grazing, and controlling the area utilized. In some cases this may mean increased management by providing salt and water to pastures where none is currently available. However, if this is not done and cattle are allowed to wander freely over several pasture units, it becomes impossible to relate the impacts of actual cattle use on any given pasture to the estimated carrying capacity.

Table 3. Density Distribution Class Scale

Class	Description
1	Rare individual, a single occurrence
2	A few sporadically occurring individuals
3	A single patch or clump of a species
4	Several sporadically occurring individuals
5	A few patches or clumps of a species
6	Several well spaced patches or clumps
7	Continuous uniform occurrence of well spaced individuals
8	Continuous occurrence of a species with a few gaps in the distribution
9	Continuous dense occurrence of a species

Weed cover per pasture unit was estimated by utilizing the density distribution class scale as specified by Robertson and Adams (1990).The scale (Table 3) provides for an objective visual evaluation of weed cover that can be done quickly and inexpensively by Conservation Area staff or volunteers. Weed distribution evaluation was done in late summer when most weeds had reached maturity. Forest areas were not evaluated for weed distribution. The evaluation was restricted to the native grassland and tame pasture vegetation types based on staff knowledge of the type of weeds and their likely areas of occurrence on the Conservation Area (Rempel, Gilson 1997. Personal communication). For the purposes of this study weeds are considered to be restricted and noxious plant species as identified in the Province of Alberta Weed Control Act (Province of Alberta 1991).

3.4 Data Management and Evaluation

Data analysis focused on the evaluation of diagnostic map units and their associated indicator attributes, just as data collection was stratified based on diagnostic land units and their associated indicator attributes. Indicator data can be considered to be a characteristic feature of the diagnostic map unit where the data were collected. Information on mapped diagnostic land units, such as pasture units, and indicator data characteristic of the mapped land unit, such as the AUMs used, were associated with each other through the use of separate GIS and database software systems - termed a hybrid GIS system by Aronoff (1989). In the hybrid system designed for the Conservation Area, MapInfo software is used to manage the storage and analysis of spatial data, and Microsoft Access is used to store and access indicator data through a relational database model.

Relational database models have significant advantages over other database models for the management of spatial data. Relational databases are more flexible than other models and are based on sound mathematical theory. The organization of a relational database is relatively simple to understand, and there is less redundancy than with other database models. Relational database models are also easily modified and allow for maximum flexibility in terms of query possibilities (Aronoff 1989). Given the emphasis on adaptive management for ecological monitoring systems and the potential for future adjustment and modification, the relational model would appear to be the most adaptable to the needs of a continually evolving monitoring system. In the relational model designed for the Conservation Area, information on indicators is grouped into tables. Tables are then joined by common fields. The table designs minimize the repetition of records for any given field and conform to the requirements of fully normalized designs. "Normalization" ensures that table design conforms to the rules of relational models (Date 1981, Saunders 1992). "In fully normalized designs, each table represents entities of one type without redundancy, which makes for databases that are easier to understand, access, and maintain, and less prone to loss of integrity" (Pascal, 1993).

Every diagnostic land unit drawn in the GIS has a simple table associated with it which identifies the land unit and provides the link between the spatial information and the database information. Within the Microsoft Access database, information on diagnostic land units is arranged into a set of four Master database tables - Ecosite Management Units, Watershed Units, Pasture units and Vegetation units. The Master tables are essentially mirror tables of the land unit tables within the GIS. The Master tables are joined to two individual tables that contain the indicator information for the evaluation of pasture units and to a table that contains the information on wildlife observations.

The structure of the database allows the user to query the system for information on vegetation composition and structure indicators, grazing indicators, and wildlife indicators for one or more diagnostic land units. The structure also provides the ability to evaluate changes in vegetation composition and structure, and patterns in wildlife observations, over time for the Conservation Area as a whole, or for individual diagnostic land units. The results of queries on indicator data can then be displayed as maps, graphs or tables as appropriate in the MapInfo environment.

The analysis of indicator data at the ecosite scale can be divided into queries on vegetation composition and structure, grazing, and wildlife. In turn, the results of the queries can be used to evaluate the need for management action in order to attain the management goals related to each of these areas. The purpose of the following sections is not to document all possible query

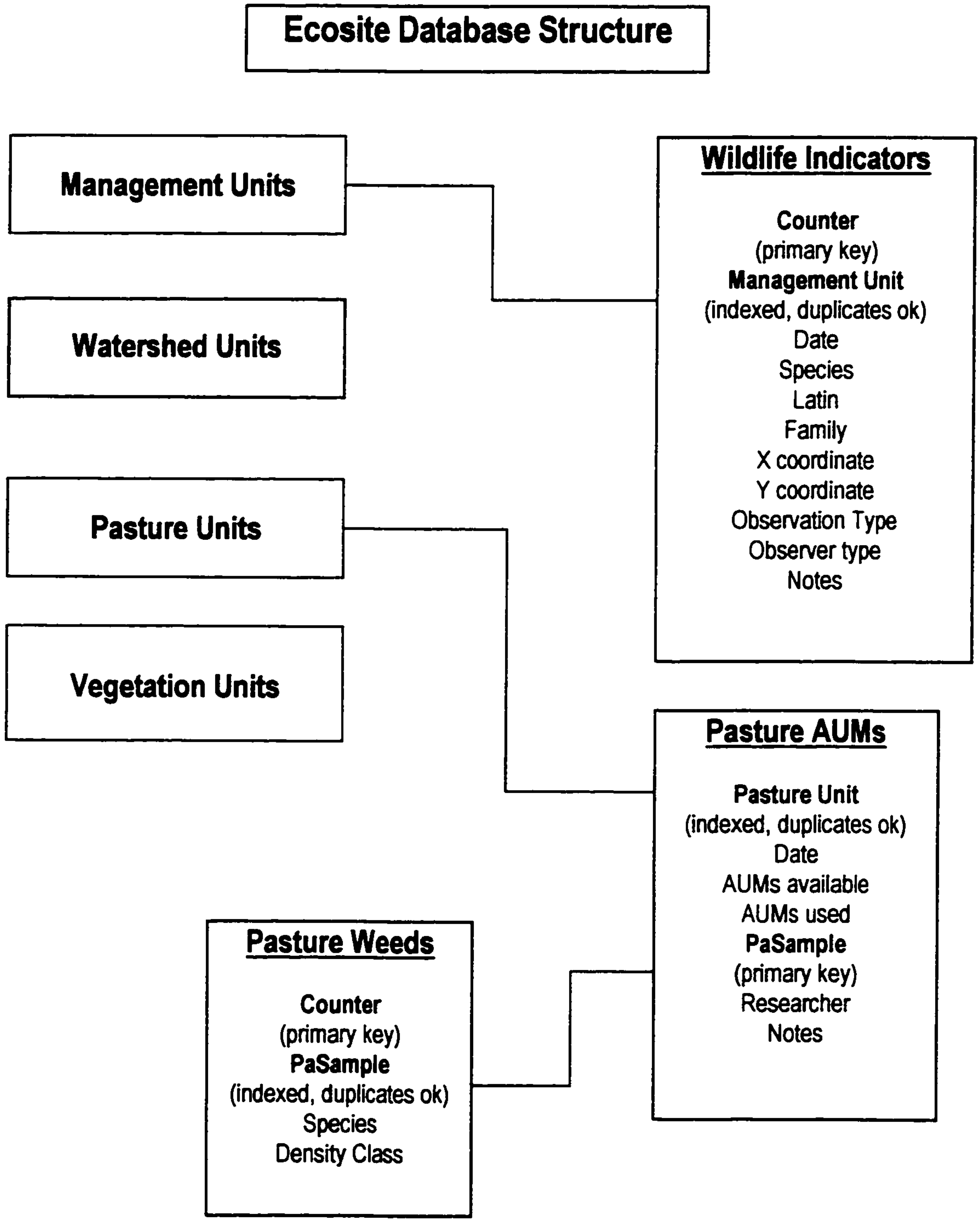


Figure 4. Ecosite Database Structure

The series of four tables in the upper left represent the spatial information associated with diagnostic land units which is stored and managed in the MapInfo GIS. The remaining tables represent the indicator data which is stored and managed within the relational database software. Indexed fields and keys are in bold type. Joins between tables are represented as lines connecting common fields in separate tables.

operations but to document those queries and display options considered to be basic to specifically addressing the monitoring goals associated with each management goal.

3.4.1 Vegetation Composition and Structure Queries

Queries and data analysis operations for vegetation composition and structure are primarily related to the calculation and display of the areas covered by different vegetation types. For the purposes of this report, vegetation area calculations were done based on evaluating the entire Conservation Area as a diagnostic land unit. In this section 'management unit' may refer to calculations for either the whole Conservation Area or a designated quarter section management unit.

Vegetation Query 1 - Vegetation Cover by Management Unit

This query concentrates on evaluating vegetation cover or within a management unit from a point-in-time perspective. The data analysis completed for this project and the subsequent management recommendations are based on this query.

Vegetation Query 1 - Description

Calculate the area of selected vegetation/community types within a selected management unit for a selected date.

Table 4. Vegetation Query 1 Sample Output

Mgt. Unit ID	Date	Veg Type	Comm Type	Area in Hectares	Area in Acres	% of Total Area

Vegetation Query 1 - Thematic Mapping Operations

Map displays offer the opportunity to visualize the pattern of vegetation across the Conservation Area or within a management unit.

- Map by vegetation type
- Map forest areas by vegetation and community type

Vegetation Query 1 - Graphing Displays

Pie charts offer an easy visual comparison of the total area of one vegetation type as compared to another.

- Display vegetation type by area as pie chart for selected dates
- Display native vegetation area by non-native vegetation area as pie graph for selected dates

Vegetation Query 2 - Vegetation Change Over Time

This query concentrates on identifying trends in vegetation cover within a management unit over time. The query requires at least two data sets from two different dates, and so is presented here as a basis for future evaluation purposes.

Vegetation Query 2 - Description

Calculate the percentage change in vegetation type/community area for selected dates for a selected management unit.

Table 5. Vegetation Query 2 Sample Output

Mgt Unit	Date	Veg Type	Comm Type	Area in Hectares	% Change

Vegetation Query 2 - Thematic Mapping Operations

- Map management units where native grassland vegetation is declining and tame pasture vegetation is increasing.
- Map management units where native grassland vegetation is declining and forest/shrub area is increasing.

Vegetation Query 2 - Graph Displays

- Display change in area cover for selected vegetation/community types for selected management units as a line or bar graph. This will provide a visual picture of the amount of change.
- Display the percentage change in area cover for selected vegetation/community types for selected management units as a line or bar graph. This will provide a visual picture of the rate of change.

3.4.2 Grazing Queries

Queries for evaluating grazing effects focus on the identification of pastures where AUMs used exceeds the carrying capacity and on the trends in weed distribution.

Grazing Query 1 - Description

Select pastures units where AUMs used exceeds the carrying capacity in AUMs and where the trend in weed cover is increasing.

Grazing Query 1 - Thematic Mapping Operations

Maps will identify the pasture units most at risk from grazing activities. AUMs used, weed density class, or both can be used to evaluate individual pastures.

- Map pasture units where AUMs used exceeds the carrying capacity in AUMs.
- Map pasture units by weed density distribution class for selected species.
- Map pasture units where AUMs used exceeds the carrying capacity in AUMs and where the trend in weed cover is increasing.

Grazing Query 1 - Graph Displays

Graph trend in weed density distribution class for selected pasture units for selected dates.

3.4.3 Wildlife Queries

Analysis of wildlife data is based on queries that display the presence or absence of the selected wildlife species and that provide an idea of their distribution.

Wildlife Query 1 - Description

Calculate the number of occurrences per species for a selected date.

Wildlife Query 1 - Thematic Mapping

- Map the occurrences for a selected species for a selected date.
- Map the distribution of selected species for a selected date by management unit.

Wildlife Query 1 - Graphing Displays

- Graph the number of occurrences for a selected species for selected dates.

3.5 Results and Recommendations

The analysis of results and subsequent management recommendations are arranged according to the management goals established previously in this chapter for the Ecosite scale.

3.5.1 Ecosite Management Goal 1

Management Goal - Maintain or enhance the distribution of native grassland habitat on the Conservation Area.

The vegetation communities of the Ann and Sandy Cross Conservation Area are shown in Figure 5. The area in hectares of the various vegetation communities types is summarized in Table 6. Native grassland vegetation compromises approximately 9.2% of the total land area and 16.8% of the grassland area. In contrast, tame pastures make up 45.5% of the total area and 83% of the grassland area. Aspen forest and willow shrublands combine to represent approximately 45% of the vegetation cover on the area. A comparison of vegetation cover type by area is graphically represented in Figure 6.

The results of this analysis suggest that management action is required to maintain and enhance native grasslands on the Conservation Area. Work by Noss and Cooperrider (1994) suggest that between 25% and 75% of any given area must be protected in order to meet integrity goals. These figures are presented by Noss and Cooperrider for the purposes of defining the appropriate size scale for regional conservation networks. If a minimum of 25% protection is required to protect integrity at a regional scale, it seems reasonable to suggest that protection of a minimum of 25% of native grasslands on the Conservation Area may serve as a starting threshold. Clearly the current levels of native grassland composition on the Conservation Area are not close to a 25% minimum threshold. The intention of using this threshold is not to suggest that 25% is enough to protect native grassland integrity on the Conservation Area, but rather, to illustrate that the amount of grassland that has been protected is considerably below even those thresholds suggested for regional protection. Minimal protection of native grassland integrity on the Conservation Area may well require a higher threshold, and protection or restoration of all of the original native prairie - a 100% threshold - offers the best protection of integrity.

Even more significant than size, is that the native grassland is fragmented into at least 15 distinct patches. It is well documented in the conservation biology literature that patch size is critical to the integrity of ecosystems and the preservation of species, and that habitat loss and fragmentation is the leading cause of species decline and extinction (Noss and Cooperrider 1994, Noss 1995, Woodley 1993, Primack 1993, Paquet et al. 1994). The extent of the fragmentation of native grasslands is easily seen in Figure 5. Maintenance of ecological integrity would be best served by one large patch rather than 15 small patches.

Fragmentation also creates a greater amount of edge which allows for infiltration of native grasslands by exotic grass species and for encroachment of woody species. The figure of 16.8% cover for native grasslands is somewhat deceiving because of this encroachment. Data collected for the evaluation of individual grassland patches (discussed in Chapter 4) suggests that only approximately half of any given native grassland patch could be considered to consist of a native grassland species composition. More realistic figures for native grassland composition would be in the order of 8.4% of the total grassland area and only 4.6 % of the total Conservation Area.

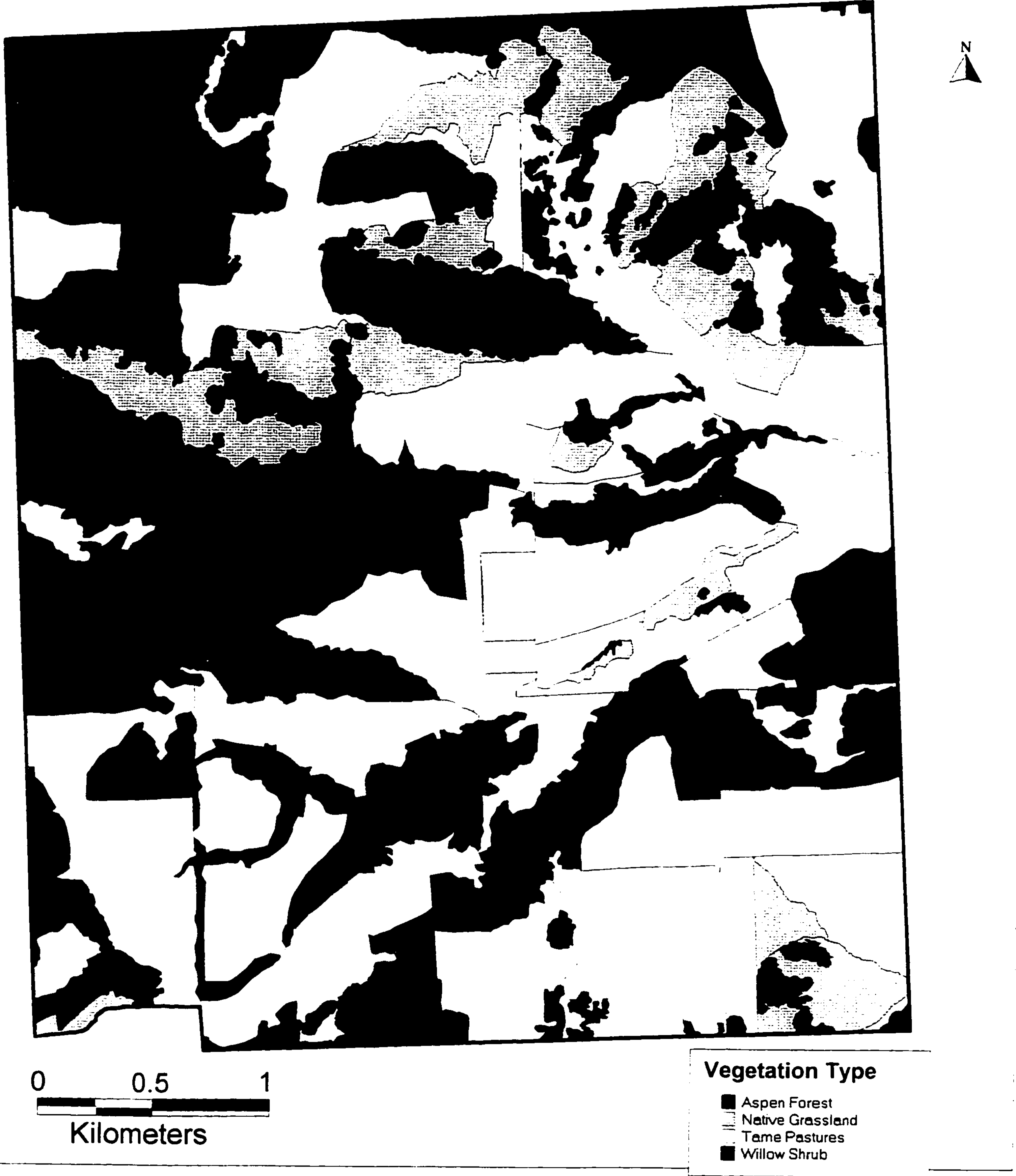


Figure 5. Vegetation Communities of the Ann and Sandy Cross Conservation Area

Table 6. Vegetation Communities by Area in Hectares

Vegetation Type	Community Type	Total Area in Hectares	% of Total Area
Aspen Forest	Young	208.3	10.5%
Aspen Forest	Mature	291.2	14.7%
Aspen Forest	Old Growth	312.4	15.9%
Native Grassland	Rough Fescue	148.1	7.5%
Native Grassland	Mixed Grass	34.5	1.7%
Tame Pasture	Brome/ Bluegrass	696.0	35.3%
Tame Pasture	Alfalfa	201.0	10.2%
Willow Shrub	Mature	79.2	4.0%
Total Aspen Forest	811.9	811.9	41.0%
Total Willow Shrub	79.2	79.2	4.0%
Total Native Grassland	182.6	182.6	9.2%
Total Tame Pasture	897.0	897.0	45.5%

The direct implications for ecological integrity on the Conservation Area are related to a lack of habitat for native grassland-dependent species and a lack of winter forage available for species such as elk and mule deer. The ecological structure and functions of native grasslands are not being maintained by the current distribution or composition of grasslands across the Conservation Area.

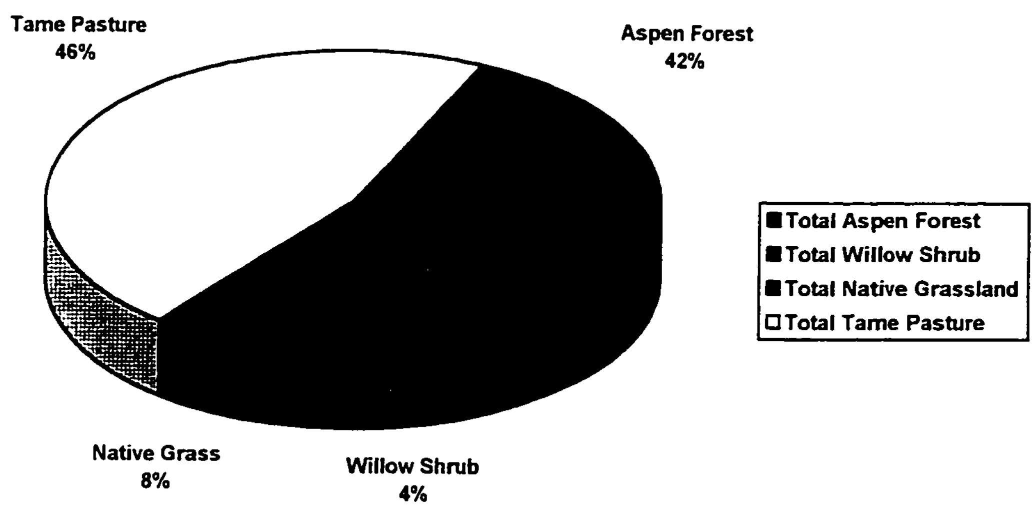


Figure 6. Vegetation Cover Type As a Percentage of the Total Area

The general recommendation for managing grasslands at the Ecosite scale is to enhance the native grasslands in terms of the quantity of habitat and the quantity of winter forage available to wildlife. Habitat quantity can be increased in the long term through restoration of native grassland patches. Restoration also increases the winter forage available to wildlife in the long term. Forage available to wildlife can be increased in the short term through the reseeding of selected pastures or hayfields with species that provide better winter forage.

Restoration sites for the Conservation Area were selected to enlarge the area of existing native grasslands and to increase the continuity of native grasslands across the Conservation Area by connecting adjacent native grasslands. Two patches of tame pasture of different size were selected for priority restoration so that either or both could be restored depending on the budget and manpower constraints of the Conservation Area (Figure 7).

While restoration of native prairie is a long term, labor intensive, and possibly expensive process, some Alfalfa hayfields on the Conservation Area are due to be cultivated and re-seeded to maintain their productivity. This situation presents an ideal opportunity to replace winter forage and increase native species distribution on the Conservation Area. Re-seeding is presented as an option to replace native winter forage relatively quickly and less expensively than through restoration. In this option tame pastures are re-seeded with native grass and forb species that are readily available as commercial or wild seed, establish quickly, can compete with aggressive exotic species, and cure on the stem to provide good winter forage. The resulting pastures would not be representative of native grasslands composition, but would fulfill the critical ecological function of providing winter forages. The approximate time frame required for a restoration project on a single pasture is optimistically in the range of five years. The re-seeding option could be accomplished within a single growing season. Re-seeded sites could also fulfill multiple functions and serve as hayfields and cattle pastures, in addition to providing winter wildlife forage.

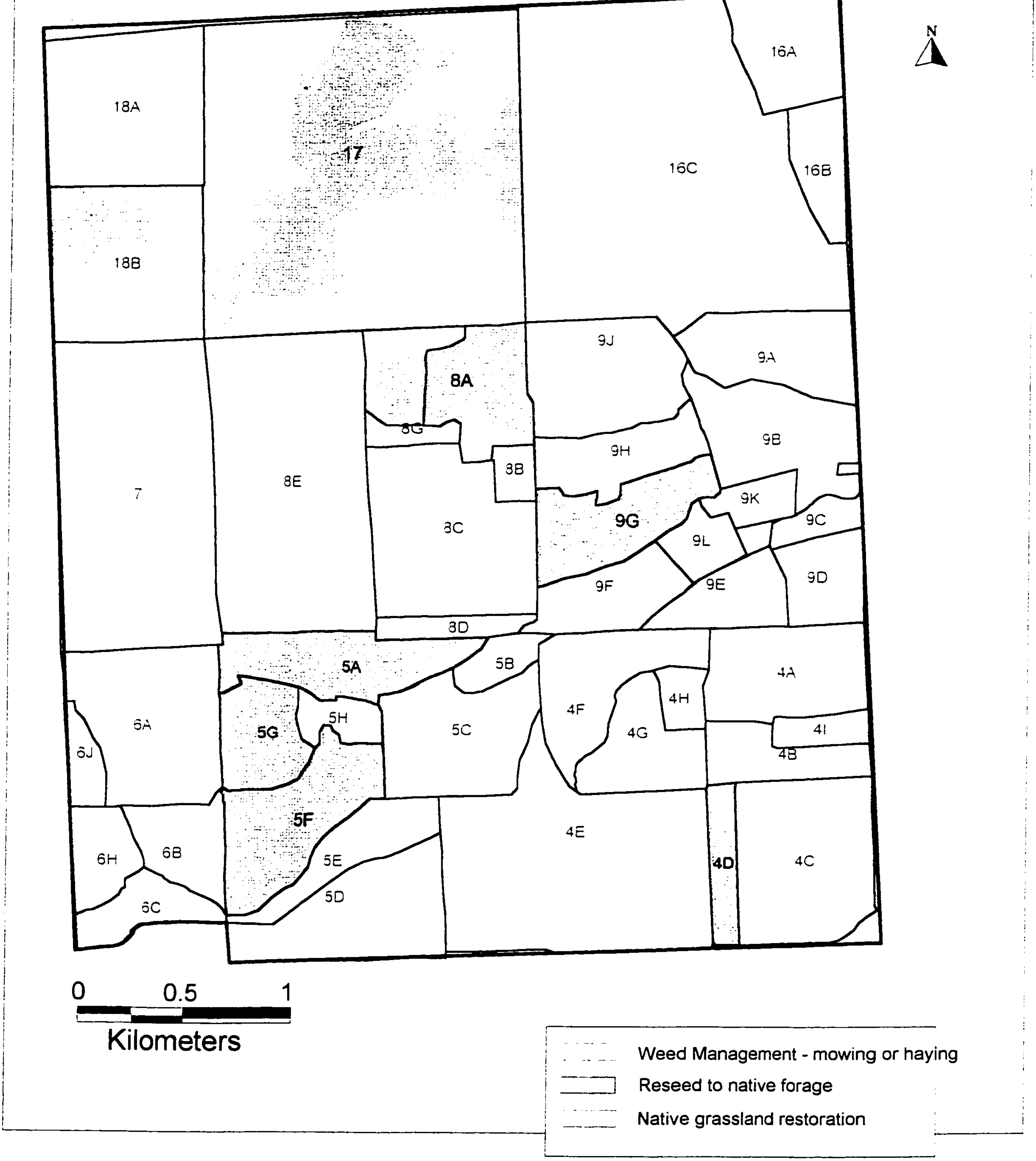


Figure 7. Grassland and Pasture Management Recommendations Map

Re-seeding sites for the Conservation Area were selected using criteria similar to those for selecting restoration sites. Hayfields that currently require re-seeding anyway were prioritized over pasture units that are not traditionally hayed and do not require re-seeding as long as other criteria were met. Re-seeding sites are also displayed in Figure 7.

3.5.2 Ecosite Management Goal 2

Management Goal - Maintain the diversity and distribution of vegetation communities on the Conservation Area such that the potential diversity of animal wildlife habitat is supported.

The age structure of the forest on the Conservation Area by area cover is shown in Figure 8. Young forest comprises approximately 10.5% of the area, mature forest 14.7%, and old growth 15.9%. As mentioned previously the historical parkland environment may have been dominated by young, even-aged aspen stands. These figures indicate a trend towards an aging forest. However the prominence of old growth forest may also contribute to the protection of these forest types on a regional scale. The diversity of forest structure on the Conservation Area provides habitat for more

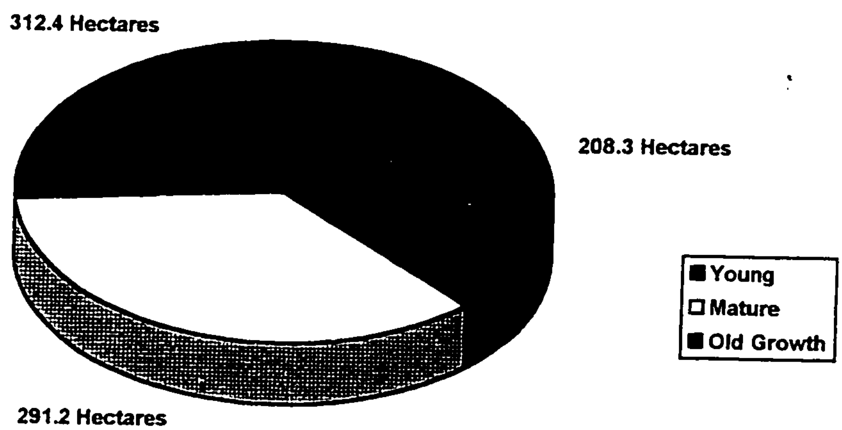


Figure 8. Aspen Forest Structure Type in Hectares

species than the historical forest structure. Maintenance of this structural diversity would appear to be a reasonable goal, given the decreasing amount of habitat available to wildlife due to increasing development pressure on a regional scale.

The recommendation of this study is to maintain forest age diversity and willow shrub cover at approximately the present ratio and pattern. Forest and shrub patches should not be allowed to encroach into native grassland patches. As the forest continues to age it would be appropriate to convert selected mature or old growth stands into young stands. This would emulate pre-European disturbance processes and conditions and was also recommended for managing aspen on the Elkhorn ranch (Adams and Fitch 1997). No areas have been selected for conversion at this time. This should be re-evaluated at the time of the next land survey.

3.5.3 Ecosite Management Goal 3

Management Goal - Maintain the diversity of the native animal wildlife community.

Most wildlife indicator data collected to date has been compiled by recording incidental observations of Conservation Area staff and volunteers. Access to the Conservation Area by volunteers has been restricted to the original, smaller area. Therefore, most of the wildlife data recorded are restricted to the geographic limits of the original Conservation Area. In terms of analyzing the data, this means that mapping of species distributions will be biased in favor of the original area. More data are required for the expanded area before distribution maps could be considered to give an accurate picture of wildlife distribution.

In general, it appears that occurrences of many indicator species are regularly recorded (Figure 9). In particular, ungulates, ruffed grouse, red squirrel, woodpeckers, black bear, and cougar, are all regularly sighted. All these species are easily identified and are likely to be recorded and reported by volunteers and staff. Species less easily observed, or less likely to be recorded without specific direction, such as warbling vireo, snowshoe hare, prairie long-tailed weasel, and Sprague's pipit show fewer sightings. Few actual sightings have been made of short-eared owls, badgers, lynx, mink, and great blue heron. In part, this may be due to the shyness of some species, such as mink and lynx. Trail locations on the area do not lend themselves to the observation of riparian species, such as mink and great blue heron. Relatively few observations have been made of either of the ground squirrel species except around the visitor centre - Belvedere House. This may be simply due to volunteers not considering these species to be important enough to record. There have been no actual sightings of badger, wood duck, or sharp-tailed grouse recorded in the data although these species appear on the Conservation Area species list. Badger signs such as digging sites were found during the volunteer badger hunts.

As a group, occurrence data appears to be sparse for the grassland species indicators. This may be due to some of the reasons noted above, but in light of the restricted availability of native grassland habitat, it also seems reasonable to suggest that it may be due to insufficient quantity or quality of habitat. The fragmentation and loss of native grasslands may not leave enough contiguous space to support a resident population of some of the carnivores such as badger. The encroachment of exotic grass species, and the lack of fire and native grazing disturbance, may be creating an environment unsuitable for ground squirrels within the native grass that is left. The lack of data on grassland species highlights the need to collect better data on the indicator species and to research and document their habitat requirements in more detail.

The lack of data on the wood duck and great blue heron bring into question the suitability of these species as indicators, especially in light of the results of the waterfowl and shorebird survey completed as part of the riparian evaluation. This is discussed further in Chapter Five.

Figure 9. Wildlife Indicator Observations 1997

Given the somewhat uneven coverage of the Conservation Area related to wildlife observations it would be premature to make judgments on the status of the indicator species at this stage. More observations are required and all of the Conservation Area needs to be included in the collection of data. This could be achieved by making wildlife indicator observations part of the Area Steward Patrol program. Below are recommendations for improving the collection of data for wildlife indicator species:

1. Expand Area Steward patrols to include the expanded Conservation Area
2. Train Area Stewards in the identification and habitat preferences of the selected indicator species
3. Plan and schedule Area Steward routes to include a variety of habitats - not just to follow existing ranch roads or trails
4. Provide Area Stewards with field observation cards and maps that can be used to accurately and consistently record wildlife data
5. Plan Area Steward patrols for early and late in the day to take advantage of the prime time for wildlife viewing

Implementation of the above recommendations would lead to more rigorous data collection which would provide for more accurate data analysis and for more analysis options in the future.

3.5.4 Ecosite Management Goal 4

Management Goal - Manage cattle grazing so as to mimic the effects of native disturbance processes.

The grazing carrying capacity for each pasture unit on the Conservation Area is presented in Table 7 as AUMs available. The figures for actual AUMs used were not available in time for the completion of this project. The recommendation presented here is that AUMs used in the future should not exceed that of the estimated carrying capacity. The carrying capacity figures should be used as a guide to the maximum stocking rates for an average growing season. During dry years the rate should be reduced. The Elkhorn Ranch recommendations reduced the carrying capacity to 75% of the average for dry years (Adams and Fitch, 1997). This same reduction is suggested as a recommendation for the Conservation Area by this project.

The present grazing practices on the Conservation Area could be described as a continuous grazing system. Cattle are put into a pasture and left until the available AUMs are used up. This type of practice can stress both grasslands and riparian areas. Long grazing periods result in poor animal distribution, impact vegetation during vulnerable periods, result in intensive grazing of preferred plants, and provide no opportunity for rest and regrowth (Adams and Fitch 1995).This type of grazing practice is not only inconsistent with managing rangelands for ecological integrity, but it is also inconsistent with current thinking regarding range management practices in general. Rotational grazing practices, including grazing deferral and rest rotation, are recommended for managing rangelands in most of Alberta outside the Dry Mixed Grass zone including the fescue prairie and Parklands regions (Robertson, Adams and Ehlert, 1991).

Table 7. Grazing Carrying Capacity

Pasture	Area (ha)	Ha/AUM	AUMs available	AUMs used	Surplus/Deficit
16C	223.2	1.3	171.69		
9A	32.88	0.5	65.76		
9B	40.11	0.5	80.22		
9J	44.51	0.5	89.02		
9K	9.26	1.3	7.12		
9L	10.22	1.3	7.86		
9F	23.53	1.3	18.10		
9E	19.05	0.5	38.10		
9D	18.26	1.3	14.05		
9G	33.16	0.5	66.32		
4A	38.28	1.3	29.45		
4F	34.67	1.3	26.67		
4G	25.74	0.5	51.48		
4B	19.06	0.5	38.12		
4H	7.76	1.3	5.97		
4D	11.58	0.5	23.16		
4C	56.82	1.3	43.71		
4E	117.1	0.5	234.20		
5B	8.92	1.3	6.86		
5C	42.87	1.3	32.98		
5A	34.9	0.5	69.80		
5G	22.47	0.5	44.94		
5H	9.24	1.7	5.44		
5F	41.37	0.5	82.74		
5E	21.4	0.5	42.80		
5D	43.83	1.3	33.72		
6A	55.65	0.5	111.30		
6J	8.09	1.7	4.76		
6B	19.78	0.5	39.56		
6C	16.14	1.3	12.42		
6H	15.05	1.3	11.58		
8F	16.28	1.3	12.52		
8A	29.87	0.5	59.74		
8B	6.05	0.5	12.10		
8C	65.1	0.5	130.20		
8D	8.54	1.3	6.57		
8E	129.55	1.7	76.21		
18A	64.77	1.7	38.10		
18B	64.77	1.3	49.82		
7A	129.55	1.7	76.21		
17A	259.1	1.3	199.31		
total	1878.48		2170.65		

Conservationists and range managers both suggest that sustainable livestock grazing should mimic the grazing patterns of native large herbivores (Noss and Cooperrider 1994, Adams, Willms and Powell 1993). The maintenance of native ecological processes is recommended by several authors as an economic, efficient, and perhaps the only way, to protect native plant species communities from aggressive exotic invaders (Adams and Fitch 1995, Adams, Willms, and Powell 1993. Noss and Cooperrider 1994, Hobbs and Huenneke 1992, Hobbs and Humphries 1995, Romo 1997). Devine (1993) argues that grazing should be managed to combat alien weeds and invader grass species and that grazing should be limited, or even stopped, based on the return of the native plant community species. The approach to maintaining native ecological processes as a method of managing native plant communities, is consistent with managing ecological integrity for the Conservation Area as well as being representative of the approach taken by some Alberta ranchers.

> *As a species we must adapt our management practices to the long-term needs of the earth, not only to our short term needs of survival. (Gardner 1992).*

Adams and Fitch (1995) recommend a grazing strategy that controls livestock distribution, provides easy access to water, controls grazing during times when plants are vulnerable to damage, adds more rest to the grazing cycle, controls grazing intensity, and excludes grazing from areas of high risk of permanent plant damage such as riparian areas. These steps should be implemented into a grazing system that defines recurring periods and patterns of grazing and rest for two or more pastures. While it is beyond the scope of this project to develop a rotational grazing system for the Conservation Area, the implementation of the following principles is essential for protecting native habitat and for implementing a sustainable grazing strategy:

1. The grazing rotation, timing of grazing, and stocking rates should be based on the type of plant community being grazed. This may require supplemental fencing to control cattle movements with greater precision.
2. Water and salt should be provided in the pasture unit being grazed. Cattle should be excluded from riparian areas, unless the riparian area is the specific unit being grazed. This may require a mobile water system or improved water development.
3. Grazing on native prairie pastures should mimic the grazing pattern established by bison. This would limit any grazing on native prairie until the fall and winter season. A winter's grazing would be followed by one or more years of rest.

Management also needs to address a weed problem on the Conservation Area. At their worst, weed distribution levels on the Conservation Area can be described by the density distribution class scale as the "continuous occurrence of a species with a few gaps in the distribution" (Robertson and Adams 1990). Weeds and other exotic species have been discussed previously as threats to ecological integrity and the control of weeds is also legislated by law.

The most common weeds found in the survey of the Conservation Area were Canada thistle *Cirsium arvense*, toadflax *Linaria vulgaris*, and leafy spurge *Euphorbia esula*. These are classified as noxious weeds under the Weed Control Act (Province of Alberta 1980). The Act, slightly revised here for brevity, states that:

> *An occupant of land shall as often as necessary, control in accordance with this Act and the regulations all noxious weeds located on the land to prevent the spread, growth, ripening or scattering of the noxious weeds.*

Cultural control measures for weeds are the most consistent with the goals of the Conservation Area. Briefly, a cultural control program would utilize haying, mowing, and weed pulling measures to starve the weed root systems and eventually kill off the weeds or reduce them to negligible amounts. This is in contrast to a chemical herbicide program which could have detrimental effects on native plant species and wildlife, or to biological control programs which can be very expensive and limited in scope.

The program recommended for control of leafy spurge and toadflax is to utilize volunteers to repeatedly hand pull the weeds. These weeds exist in small patches which makes this a viable option if implemented immediately. Canada thistle is the most widespread weed on the Conservation Area and hand control would be impractical. The control option recommended here is to convert the tame pastures with the worst thistle cover to hayfields that are harvested twice a season. Multiple harvests of hayfields has been shown to eventually eliminate Canada thistle cover (Moore 1975, Alberta Agriculture, Food and Rural Development 1994). Timing of the harvest is important and it must take place before seed heads form, and while root reserves are at a minimum in order to be effective.

Smaller areas of thistle cover can be mowed, hand pulled, and selectively treated with glysophate using a herbicide wicking device. This type of application applies herbicide only to the weed in question and does not affect surrounding vegetation as spraying applications do.

Pastures recommended for management by haying are also shown in Figure 7 (page 75).

3.6 Chapter Summary

Ecosite scale monitoring was divided into evaluating vegetation type cover and distribution, the occurrence of wildlife indicator species, and the effects of cattle grazing on the area. Management recommendations for achieving specific goals related to protecting ecological integrity included:

1. Restoring selected pastures to native prairie
2. Re-seeding selected pastures with native species that provide high quality winter forage for wildlife such as elk and deer
3. Expanding the Area Steward Patrol program to include planned surveys of the Conservation Area for wildlife indicator species
4. Implementation of a rotational grazing plan that mimics the patterns of native grazing animals
5. Conversion of selected tame pasture units to hayfields for the purpose of weed control
6. Cultural weed control for selected sites including hand-pulling and selective herbicide application.

It is also recommended that research be continued into the selection of wildlife indicators. The recording of occurrence data will provide a basis from which to start research and will identify areas of concern or priority. Research into indicators for native grasslands and riparian zones are recommended as the priority due to the limited amounts of wildlife data observed, and to the relatively small and fragmented areas that these habitats occupy on the Conservation Area.

Climatic effects influence many aspects of managing the Conservation Area. Although monitoring climate was not included as part of this project, temperature and precipitation in particular, will affect plant growth and have subsequent implications for management. Atmospheric pollution may become a concern as the adjacent City of Calgary grows closer. An additional recommendation of this project for ecosite scale monitoring is that the Conservation Area begin to consistently monitor climatic trends on the area. Although this could be considered part of regional scale monitoring, the influences could be quite specific to the ecosite scale. Environment Canada is currently searching for stable sites suitable for the establishment of remotely accessed weather stations (Tom Beck, personal conversation 1997). Remote stations would be ideal for the Conservation Area as specific data would be available for the area, it contributes to regional scale monitoring efforts, and would require no training or staff time except for occasionally acquiring data from Environment Canada. This information could be used to identify weather trends and to correlate them to indicator trends on the Conservation Area.

The results of ecosite scale monitoring point to additional concerns at the ecoelement level. Additional ecosystem monitoring was done based on specific threats perceived to native grassland, riparian, and old growth aspen forest communities and is reported on in the subsequent chapters. The intent of monitoring at a larger scale is to determine in more detail what specific elements are changing, and perhaps why. Management actions can then be adjusted to more precisely address these changes.

4.0 Native Grasslands Monitoring

4.1 Management Issues and Threats

The results of ecosite level monitoring show that the integrity of native grassland communities on the Conservation Area is being threatened. Indeed, anyone simply walking through a native grassland patch can observe the monoculture invasion of fingers and patches of smooth brome into the fescue grasslands. Less easily visible is the dominance of Kentucky bluegrass in the native prairie. Pre-settlement prairie was composed of native bluegrass elements in the range of two percent of the canopy cover - almost invisible to the casual glance. Now, Kentucky bluegrass is easily discernible as a co-dominant grass species along with smooth brome and rough fescue.

As native grasslands are perhaps the only threatened community on the Conservation Area their protection should be given top priority. Monitoring at the ecoelement scale 'zooms' in to obtain details on what changes are actually happening within a given vegetation patch. It may then be possible to discern the probable causes of change and to identify management actions that may be most effective at protecting and enhancing the native prairie habitat.

4.2 Management and Monitoring Goals and Indicator Selection

Three management goals were developed for the management of native grasslands on the Conservation Area. The scope of the goals overlap somewhat with each other, but also provide a management focus that does not overlook important aspects of grassland protection.

4.2.1 Native Grassland Management Goals

1. Maintain or enhance the quality of native grasslands in terms of the historical native species diversity and composition.
2. Prevent the invasion of native grasslands by aggressive exotic grass or weed species.
3. Maintain the ecological function of native natural disturbance processes by allowing natural processes to take place, or by implementing management practices that mimic the effects of natural processes.

4.2.2 Native Grassland Monitoring Goals

1. Identify changes in native grassland species composition and distribution.
2. Identify changes in the composition and distribution of exotic and native invasive plant species within native grassland patches.
3. Identify changes in ecological elements that are affected by natural disturbance processes or the lack thereof.

4.2.3 Native Grassland Indicators

An indicator serves as a surrogate for the integrity of an ecosystem, eliminating the necessity to monitor everything. This concept is discussed in Chapter 2. While range management concepts have been used traditionally to manage the health of grasslands, the use of these concepts may not be the best application for managing ecological integrity on the Conservation Area. Range management assessment requires staff with specialized knowledge and experience in range plant identification. Indicators chosen for monitoring the grasslands on the Conservation Area need to be simple enough for non-botanists to evaluate, while still reflecting the integrity of the native community. However, monitoring will also require the periodic assistance of trained ecosystem science personnel to validate the monitoring system, evaluate results, and make recommendations for changes.

A suite of indicators was selected for the evaluation of native rough fescue grasslands at the ecoelement scale. These indicators are used to evaluate native and non-native species composition as well as elements of native ecosystem processes. The indicators are; rough fescue composition; rough fescue plant vigor; total vegetation cover; native vs. non-native vegetation cover; amount of exposed soil; plant litter depth; and shrubby species composition. The justification for the selection of each indicator is discussed below.

Rough Fescue Composition and Plant Vigor

Rough fescue cover and plant vigor will serve as the primary indicators of grassland integrity. Rough fescue is a "decreaser" and like other decreasers is relatively easily reduced or eliminated through grazing practices insensitive to grazing intensity and timing (Adams and Fitch 1997, Trottier 1986, Willms et al. 1992, Tannas 1997). Rough fescue can also be expected to show a decrease in cover and plant vigor following growing season disturbances such as fire, grazing, or mowing, for a period of between one to ten growing seasons (Sinton and Bailey 1980, Bailey et al. 1980, Romo 1997). On the other hand, a lack of disturbance can result in plant litter buildup changing the microclimate at ground level resulting in a loss of cover and a loss in the palatability of fescue to cattle and wildlife (Sinton and Bailey 1980). Yet, being the historically dominant species of fescue grasslands, rough fescue must have been ideally adapted to the particular native disturbance regime. It would seem then, that by monitoring rough fescue, and consequently adjusting management practices to favor rough fescue, the historical vegetation composition and structure will be at least roughly approximated, and the role of native disturbance processes will be roughly duplicated. Rough fescue is also a good indicator for monitoring grassland integrity on the Conservation Area since it is easy to identify, making it suitable for volunteer monitoring.

Rough fescue cover was measured using standard range management techniques. Plant vigor was estimated by measuring the plant height. Forage production is dependent on both plant height and the number of tillers per unit area (Sinton and Bailey 1980). Although plant height is only one aspect of plant vigor, it is an easy measurement for volunteers to make and may be the most sensitive of the two to disturbance according to the results of Sinton and Bailey. As an indicator it may provide the best early warning of reduced rough fescue vigor. Plant cover and vigor measurements were taken as close as possible to the formation of seed heads on the plants - usually early to mid July on the Conservation Area.

Total Vegetation and Native/Non-native Vegetation Cover

Total vegetation cover can be expected to decrease under heavy grazing pressure (Willms, Adams and Domaar 1983, Adams et. al. 1986). As such, it is a good early indicator of excessive grazing and is simple to monitor. This indicator must be used with caution since it is conceivable that total vegetation cover could increase due to an increase in invasive grass species. It must be considered in combination with other indicators in order to serve as an indicator of integrity. Also, total vegetation cover would be expected to decrease in the wake of a disturbance event. These types of considerations need to be accounted for in evaluating this indicator.

The ratio of native to non-native plant species helps with the interpretation of total vegetation cover as an indicator of ecological integrity. If total vegetation cover is increasing and native plant cover is increasing relative to non-native cover, then the area could be moving towards a state of integrity. If total vegetation cover is increasing and native plant cover is decreasing relative to the non-native cover, ecological integrity may be compromised. The ratio of native to non-native species cover is an accepted indicator in itself for evaluating ecological integrity as has been discussed previously in Chapter 3.

Exposed Soil

Exposed soil could be considered another indicator of overgrazed pastures, being inversely related to total vegetation cover. Exposed soil is also a indicator of potential soil erosion and loss. Exposed soil would be expected at some stages of grassland succession, for example, immediately following a disturbance event. Exposed soil allows solar radiation to raise soil temperatures, creating a microclimate more favorable to the establishment of warm season grasses. While this is an expected short term effect of disturbance, long term increases in exposed soil can lead to erosion and loss of plant life (Adams et. Al. 1986). Overly frequent fire events may lead to replacement of the fescue community by a mixed grass type (Romo 1997) and fescue has been shown to respond slowly to recovery from fire events (Bailey and Anderson 1978). The slow recovery of fescue may be due in part to drier and warmer soil conditions caused by the removal of litter and increased exposure to the sun. Exposed soil is measured in precisely the same format as vegetation cover making it a simple indicator to incorporate into grassland evaluations.

Litter Cover and Depth

Litter cover and depth can be considered to be indicators of the need for a disturbance event. Excessive litter can choke out vegetation and change the ground-level microclimate making it less suitable to native species as discussed previously (Sinton and Bailey 1980). Again these are straightforward measurements that can be done at the same time as other indicator measurements.

Shrubby Species and Weed Composition

An increase in shrubby range species such as buckbrush *Symphoricarpos occidentalis*, shrubby cinquefoil *Potentilla fruticosa*, or aspen can be related to overgrazing of livestock (Adams et. al. 1986) and is not representative of the grasslands maintained by fire and bison grazing (Romo 1997, Campbell 1997). The cover of shrubby species can be estimated in the same manner as weed density distribution (see section 3.3.3) and can be accomplished at the same time as other grassland indicator measurements. The ecological impacts of weeds have already been discussed and weed monitoring is included in the monitoring of grazing at the ecosite level. The same figures obtained for grazing monitoring can be applied to the appropriate grassland vegetation unit or units that are contained within a pasture unit.

The selection of indicators for native grassland monitoring is designed to utilize many of the measurements commonly done as part of range assessments for the cattle industry. Most of these measurements use the same study quadrats and the same methods for estimating cover, making measurements in the field straightforward and efficient. These methods makes it suitable to involve trained volunteers in the monitoring process. The selection of indicators does not include the identification of a host of plant species that would have to be done by a range professional. Only plant species groups - native and non-native, as well as rough fescue need to be identified by the people in the field. Even this level of plant identification will require significant training and verification should be done by a trained professional at specified intervals.

4.3 Data Collection

Grassland indicator data were collected using standard methods and measurements from the MF5 range worksheet as provided by Alberta Forestry Lands and Wildlife (Robertson and Adams 1990). The MF5 form was recommended by Adams for the evaluation of the Conservation Area grassland environment (Jacquie Gilson in conversation with Barry Adams, 1993). Briefly outlined, the measurements involved establishing fixed transects through representative areas of each native grassland patch across the Conservation Area. Quadrats were spaced at regular intervals along the transects and indicator measurements were taken within the quadrats.

4.3.1. Transect Layout and Quadrat Placement

Transect locations were determined in the field based on the variations in slope position, aspect, vegetation, and size of a given native grassland patch. Every native grassland patch is on sloping ground. Transects were oriented to run parallel to the fall line. This orientation ensured that quadrats would fall in all slope positions and take into account possible variation in soil drainage characteristics. If the patch was characterized by a significant variation in aspect, transects were selected to represent each aspect. Transect lines were also chosen to run through the areas that appeared to represent best the variation in vegetation across the patch. Thus no transect was purposely placed to run through large areas of purely native or purely non-native vegetation. Transects were selected to run through areas where native and non-native vegetation was patchy and where quadrats on the transect would likely fall into either vegetation type. Finally, the number of transects was dependent on the field shape and size. Transects were chosen to represent the geographic variation in the patch and to include a minimum of eight quadrats in each patch. Transect location procedures correspond to guidelines established by Robertson and Adams (1990).

After some experimentation, quadrat locations were spaced at fifteen metre intervals along the transect, beginning five metres from the origin. This provided for a representative sample of the variation in vegetation along the length of a given transect. The minimum length for a transect was sixty metres. Transect locations were permanently marked with metal stakes. Ropes strung between stakes were flagged every 15m with the location for quadrats. Quadrats were placed moving downslope (or away) from transect origin, on the right hand side of the rope, with the upslope, left corner of the quadrat placed at the flag, and the left side of the quadrat placed along the line of the transect.

4.3.2 Quadrat Measurements

The quadrats used for indicator measurements were 20 cm x 50 cm frames, or 0.1 m^2. Foliar cover was estimated using the seven-class Daubenmire scale recommended on the MF5 vegetation inventory form (Table 8).

Table 8. Daubenmire Cover Class Scale

Cover Class Value	Range %	Mid-Point
1	0-1	0.5
2	1-5	2.5
3	5-25	15.0
4	25-50	37.5
5	50-75	62.5
6	75-95	85.0
7	97-100	97.5

Estimation of cover within each quadrat began by considering the total cover of all green vegetation. Next, native and non-native vegetation were estimated as distinct groups. Exposed soil and litter cover values were estimated next. Litter depth measurements were done by inserting a ruler into the litter at approximately the centre of the quadrat until it reached the soil. Measurements were taken to the nearest centimeter.

For this, the initial stage of monitoring, all grass species and noxious weeds were identified in each quadrat. This improved the baseline vegetation data available to the Conservation Area as well as providing baseline data for indicator verification in the future. A decision was made in the early stages of the project not to include cover estimates for forb species. This decision was made in order to simplify the future data collection for volunteers. In retrospect however, this level of data collection only needs to be done occasionally and should be done by professional personnel to give scientific validity to the results of the monitoring system. Including estimates of forb cover at this time would add little work for range professionals and is recommended for future detailed surveys. Species included in the estimates of vegetation cover for this initial stage of monitoring are presented in Table 9.

Foliar cover rather than canopy cover was used to estimate vegetation cover. Daubenmire (1968) describes foliar cover evaluation "... as the sum of shadows that would be cast by leaves and stems, taking each species separately, and expressing the result as a percentage of the land surface ... Many synecologists have used this approach.". As the Conservation Area has limited availability of labour (volunteers), and that labour is likely to be of limited experience, the most intuitive approach seemed to be that of using foliar coverage.

Table 9. Grassland Species

Species Short Form	Latin Name	Common Name	Category
Agrospp	*Agropyron spp*	Native Wheatgrasses	Native
Boutgra	*Bouteloua gracilis*	Blue Gramma Grass	Native
Calalon	*Calamoviffa longifolia*	Sand Reed grasses	Native
Calamon	*Calamogrostis montanensis*	Plains Reed Grass	Native
Carespp	*Carex spp*	Native Sedges	Native
Dantpar	*Danthonia parryi*	Parry's Oat Grass	Native
Festsca	*Festuca scabrella*	rough fescue	Native
Helihoo	*Helictotrichon hookeri*	Hooker's Oat Grass	Native
Koelmac	*Koelria macrantha*	June Grass	Native
Muhlcus	*Muhlenbergia cuspidata*	Prairie Muhly	Native
Stipcol	*Stipa columbiana*	Columbia Needle Grass	Native
Stipcur	*Stipa curtesefa*	Western Porcupine Grass	Native
Stipvir	*Stipa viridula*	Green Needle Grass	Native
Agropec	*Agropyron pectiforme*	Crested Wheat Grass	Non-native
Agrorep	*Agropyron repens*	Quack Grass	Non-native
Bromine	*Bromus inermis*	Smooth Brome	Non-native
Phalaru	*Phalaris arundinacae*	Reed canary Grass	Non-native
Phlepra	*Phleum pratensis*	Timothy	Non-native
Poaprat	*Poa pratense*	Kentucky Blue Grass	Non-native
Cirsarv	*Cirsium arvense*	Canada Thistle	Weeds
Erysche	*Erusimim cheiranthoides*	Wormseed Mustard	Weeds
Euphesu	*Euphorbia esula*	Leafy Spurge	Weeds
Lactspp	*Lactuca spp*	Lettuce	Weeds
Linavul	*Linaria vulgaris*	Toadflax	Weeds
Polyare	*Polygonum ??*	Common Knotweed	Weeds
Soncarv	*Sochus arvensis*	Perennial Sow Thistle	Weeds
Taraoff	*Taraxacum officinale*	Common Dandelion	Weeds
Thlaarv	*Thlaspi arvense*	Stinkweed	Weeds
Trifspp	*Trifolium repens*	Clover	Weeds

Fescue height or leaf length was measured by inserting a ruler as close to the centre of the tallest fescue plant in the quadrat as possible and measuring the maximum height to the nearest centimetre.

Shrubby species composition was estimated by using the Density Distribution Class Scale as provided on the MF5 form. This scale is reviewed in Chapter 3.0 for the purpose of estimating weed cover in pasture units. The scale provides a visual estimate of the distribution of shrubby species across the vegetation patch being monitored.

Quadrat measurements were recorded on standard MF5 forms - one form for each transect. In the future field forms should be based on forms generated specifically for the monitoring database by Microsoft Access. This will facilitate ease and accuracy of data entry.

4.4 Data Management and Analysis

Grassland data analysis can be viewed from a point-in-time or from a trend perspective. Data analysis can be focused on using individual indicator results to evaluate a grassland patch from a point-in-time perspective. This type of analysis is relevant to the results presented for this project at the initial stages of implementing the monitoring system. As more data are collected over time, trends in individual indicator measurements can be evaluated. For instance, the trend in compositional characteristics of rough fescue in a particular grassland patch can be monitored and graphed over time to see if the patch is moving toward or away from a state of integrity. Data analysis can also focus on evaluating trends using an index of multiple indicator measurements over time. This offers the possibility of increasing confidence in the results of monitoring by combining the trends in all indicators, and not just relying on one or a few indicators.

4.4.1 Database Structure

The grassland database structure is similar to the ecosite database structure in that all tables are joined back to a Master Table. The individual native grassland vegetation units in the Vegetation Units master table serve as the diagnostic land units for grassland analysis. The data base structure is shown in Figure 8.

The Sample field in the Grasslands Transects Information, Grassland Species Data, and Grasslands Transects Data tables represents a unique identification number that is assigned for every date that information was recorded for a particular transect. The sample field value is unique and is never repeated in the database. The sample field allows for queries that select and analyze all quadrat indicator data, for all transects, for a selected date or dates, for any individual vegetation unit or combination of units. This provides for considerable flexibility in the number of possible queries that could potentially be made. The database structure as a whole allows queries to be developed and modified on the basis of field results. Specialized queries can be developed based on the information required to support or make management decisions.

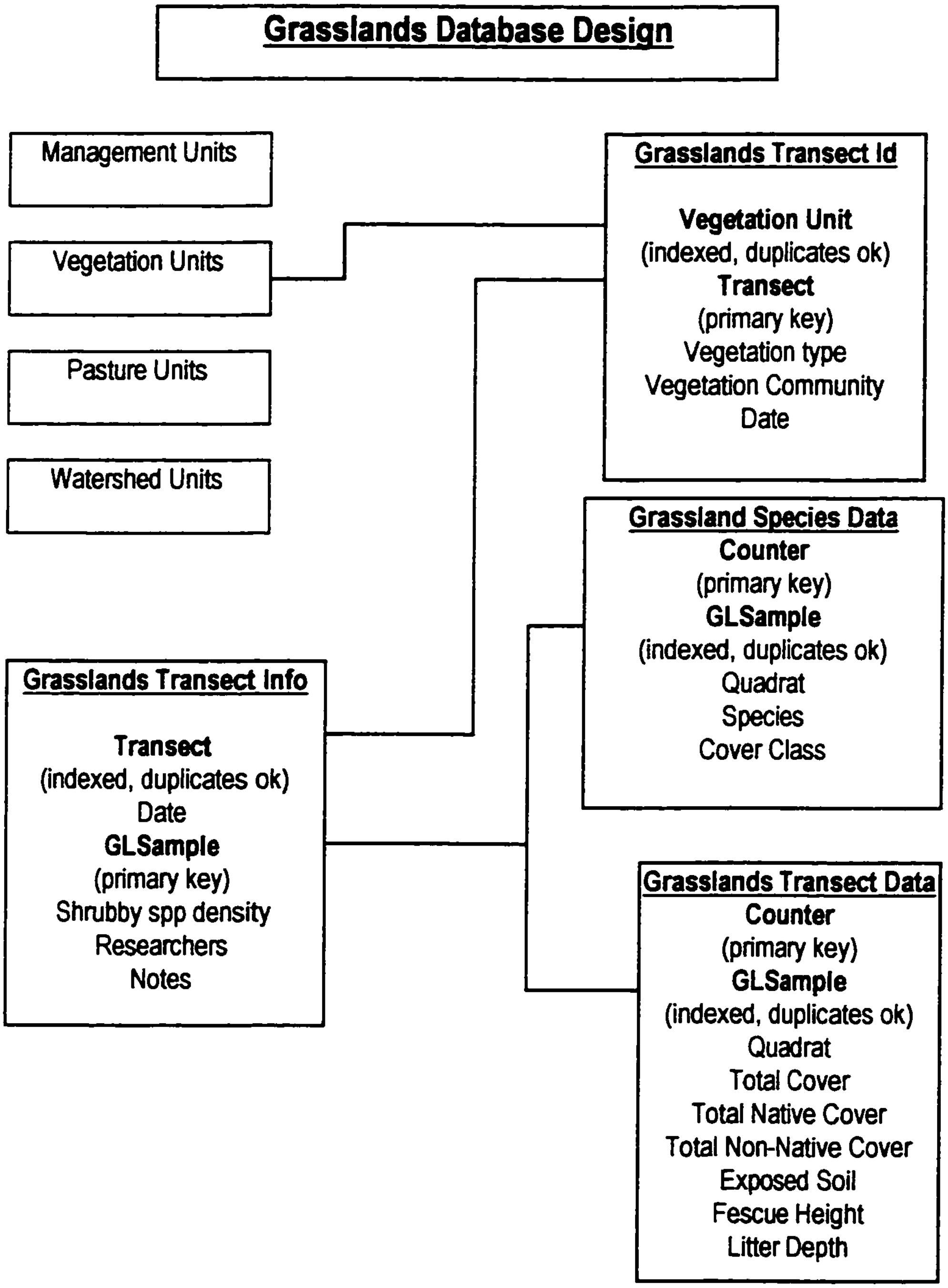


Figure 10. Grasslands Database Design

The primary diagnostic land unit for native grasslands monitoring is the vegetation unit. The vegetation unit master table is linked to a series of four tables in Microsoft Access. Indexed fields and keys are in bold type. Joins between tables are represented as lines connecting common fields in separate tables.

4.4.2 Grassland Database Analysis

Database queries outlined for this project are selected for the analysis of individual indicators or for the analysis of the group of grassland indicators through an index of grassland ecological integrity.

Grassland Query 1 - Grassland Species Composition

Grassland Query 1 - Description

Calculate composition statistics (average cover, percent composition, prominence value, percent prominence value) for selected species or species groups, for selected grassland vegetation units, for selected date(s).

Grassland vegetation cover can be analyzed in several standard ways which, when combined, culminate in a figure for percent prominence value (Robertson and Adams 1990).

Average Cover for a species or species group is calculated by totalling the midpoint values for each recorded cover class value (Table 8) and dividing by the total number of quadrats sampled along the transect or within the vegetation unit.

Percent Composition is calculated by totalling the number of quadrats in which a species occurred and dividing it by the total number of quadrats to arrive at the percentage of quadrats in which the species occurred.

Prominence Value is calculated by taking the square root of the percent composition value and multiplying it by the average cover value.

Percent Prominence Value is calculated by summation of the prominence values for all species. The prominence value of the species in question is divided by the total prominence value and then multiplied by 100.

Prominence value is a useful calculation as it essentially combines the average cover of a species with its frequency of occurrence. This takes into account the chance that a single species may occur with very high cover values in only a couple of quadrats. If only average cover was calculated the species would appear to cover more of the vegetation unit than it actually does. The average cover value is tempered by the frequency of occurrence as reflected in the percent composition values.

Percent prominence value is a more intuitively understandable number than prominence value that reflects the prominence of a species relative to the prominence of other species of interest measured in the quadrat. For this project, percent prominence values were calculated for native vs. non-native vegetation, and for all grass species in a grassland vegetation unit. It should be emphasized that percent prominence values for grass species are calculated only in relation to other grass species, not to other forb, weed, or shrub vegetation.

Grassland Query 1 - Table Displays

Table displays can be created to facilitate browsing of data for a single species in a grassland vegetation unit for a selected date(s) or for multiple species for a single date. A sample table format is displayed in Table 10.

Table 10. Grasslands Composition Query Table

Veg Unit ID #	Date	Species	Avg. Cover	% Comp	Prom Value	% Prom Value

Grassland Query 1 - Map and Graph Displays

Maps and/or graphs could be produced to display species actual values for a vegetation unit or to display data on the trends in one or more species values. Several basic mapping and graphing operations are outlined below. It should be noted that the display possibilities are not limited by this selection and other display options should be pursued on the basis of reviewing the results of newly acquired data.

- Map grassland units by percent prominence value of rough fescue
- Map or graph grassland units where percent prominence value of rough fescue is decreasing over time
- Map grassland units by percent prominence value of native or non-native species
- Map or graph grassland units where percent prominence value of native species is decreasing or percent prominence value of non-native species is increasing

Grasslands Query 2 - Grasslands Integrity Index

Several authors recommend combining indicator results into some type of ecological integrity index (Karr 1981, 1993, Woodley 1993, Henry, McCanny, and Raillard 1995). While some authors warn against redundancy in the design of indices, Karr argues that redundancy is desirable and reflects actual redundancy in ecosystem components and functions, thus taking into account the natural resiliency of ecosystems (Karr 1993). Such redundancy is built into the selection of grassland indicators for the Conservation Area and has been alluded to earlier in the discussion of indicators in this chapter.

The integrity index designed for the Conservation Area is based on the direction of change in indicator measurements over time. A negative change in one or more indicators may be offset by a positive change in one or more other indicators. This situation may describe a state of relative ecological stability, although not necessarily, a state of integrity. A majority of indicators with negative trends would result in a negative index score, signifying movement of the ecosystem away from a state of ecological integrity. A majority of positive trends would result in a positive index score that signifies movement towards a state of ecological integrity. It should be emphasized that index scores in the neutral range do not necessarily reflect a state of integrity - only a state of relative stability in indicator measurements. The decision as to whether a particular vegetation unit has achieved a satisfactory state of ecological integrity is a value judgement that can be partially based on threshold values deemed to be acceptable by Conservation Area management. This type of index is consistent with recommendations by Noss (1995) to monitor indicator trends in terms of movement towards a state of integrity, towards a state of disintegrity, or on the basis of thresholds chosen to represent a state of integrity. Similar simple indexes are recommended by Woodley (1993) and by Henry, McCanny and Raillard (1995) for evaluating integrity of Canadian National Parks.

Some consideration should be given to weighting of the indicators in the index. There is potential for indicators to offset one another for reasons other than those which may affect integrity. For instance, in a wet year rough fescue vigour may increase, while native species cover declines due to encroachment. This would not indicate a state of integrity. In the long term it seems unlikely that fescue vigour would continually increase while being crowded out by aggressive non-natives. However, it would be appropriate to monitor the results of the index over time, to determine whether certain indicators need to be given more weight in order for the index to accurately reflect a trend in integrity, and whether the index is providing useful direction to management.

Table 11. Grasslands Integrity Index Values

Indicator	Trend	Value
Rough fescue % prominence	Increasing	+1
	Decreasing	-1
Rough fescue height	Increasing	+1
	Decreasing	-1
Native to non-native species	Increasing	+1
	Decreasing	-1
Exposed Soil	Increasing	-1
	Decreasing	+1
Litter Depth	Increasing	-1
	Decreasing	+1
Total Cover	Increasing	+1
	Decreasing	-1
Shrub Cover	Increasing	-1
	Decreasing	+1
Weed Cover	Increasing	-1
	Decreasing	+1

The grasslands integrity index can be used to evaluate trends in individual indicators over time for an individual grassland patch, or to prioritize different patches for management attention. For the evaluation of an individual patch, the change in individual indicator values can be monitored as a positive or negative percentage change over time. For making management decisions on which grassland patches most require management attention, it is necessary to compare one patch to another. For this purpose index values can be added to provide a relative comparison of the trend in integrity over time.

Henry, McCanny and Raillard (1995) propose an index of change for Parks Canada in which indicator measurements taken over time are expressed as a proportion of the value obtained during the first year of measurement. Ecological integrity is then estimated annually as the average of the proportions and provides a relative index of the performance of the ecosystem over time. This approach, which is similar to the index proposed for this project, could be used to refine the integrity index proposed for the Conservation Area and to provide more detail for decision makers.

Grasslands Query 2 - Description

Calculate the sum of indicator trend values based on the percentage change over two or more dates where a negative trend = -1, a neutral trend = 0, and a positive trend = +1.

Indicator trend index values are summarized in Table 11.

Grasslands Query 2 - Table Display

The index values can be displayed in a table format as seen below.

Table 12. Grasslands Integrity Index Query Sample Output

Veg Unit ID#	Date	Festuca % Prom	Fescue Avg Ht.	Avg Litter Depth	Weeds % Prom	Native % Prom	Non Native % Prom	Woody Species Density
		Actual value	Actual value	Actual value	Actual value	Actual value	Actual value	Actual value
		Actual value	Actual value	Actual value	Actual value	Actual value	Actual value	Actual value
		% change	% change	% change	% change	% change	% change	% change
		Index value	Index value	Index value	Index value	Index value	Index value	Index value

Grasslands Query 2 - Map and Graph Displays

The initial mapping operation associated with this query would be to map grassland vegetation units by the totalled index value. This would provide a visual reference to the grassland areas that are in the most need of management adjustment, or conversely, where management actions are resulting in a stable or improving level of integrity. Total index values for individual patches could also be graphed over time. This would be particularly useful if graphed against other trends that may be influencing the indicators, such as management activities or climatic conditions. This may provide the first step to identifying potential relationships that may need to be monitored and studied as the monitoring system evolves over time.

4.5 Native Grasslands Monitoring Results

The results from monitoring vegetation composition within native grassland units across the Conservation Area indicate that native to non-native species composition is approximately a 50/50 split. In most cases, total native species percent prominence is slightly greater than total non-native. This is due primarily to the forb and shrub components in the grassland. When the percent prominence values of individual grass species are compared it becomes apparent that non-native invasive species are dominating the native grasslands. Figure 11 shows pie charts comparing the native to non-native vegetation cover, and the percent prominence values of grass species, for the native grassland units on the Conservation Area with the best coverage of rough fescue.

Results show that Kentucky bluegrass is the single most dominant grass species throughout the Conservation Area ranging in prominence from a low of 27% to a high of 96%. Kentucky bluegrass is considered to be an invasive species in native grasslands under continuous summer grazing regimes. (Tannas 1997, Gerling et. al. 1996). The native origins of Kentucky bluegrass are questionable, although some native component seems to be generally accepted by the above authors and in other literature. However, the prominence of Kentucky Bluegrass on the Conservation Area is far beyond the cover suggested by Gerling et al. (1996) for mesic climax grasslands in the Foothills Parkland Subregion. Kentucky bluegrass in native historical grasslands should make up approximately 1% of the canopy cover. This canopy cover value could be converted to a rough prominence value of 1-2% when compared to the results obtained for species on the Conservation Area that make up approximately 1% of the foliar cover. Smooth brome, and to some extent Timothy and quack grass, are also invading the native grassland areas. In short, the results illustrate that the native grassland areas on the Conservation Area are not representative of the native rough fescue community and are possibly being impacted significantly by the current grazing regime as indicated by the dominance of invasive grass species.

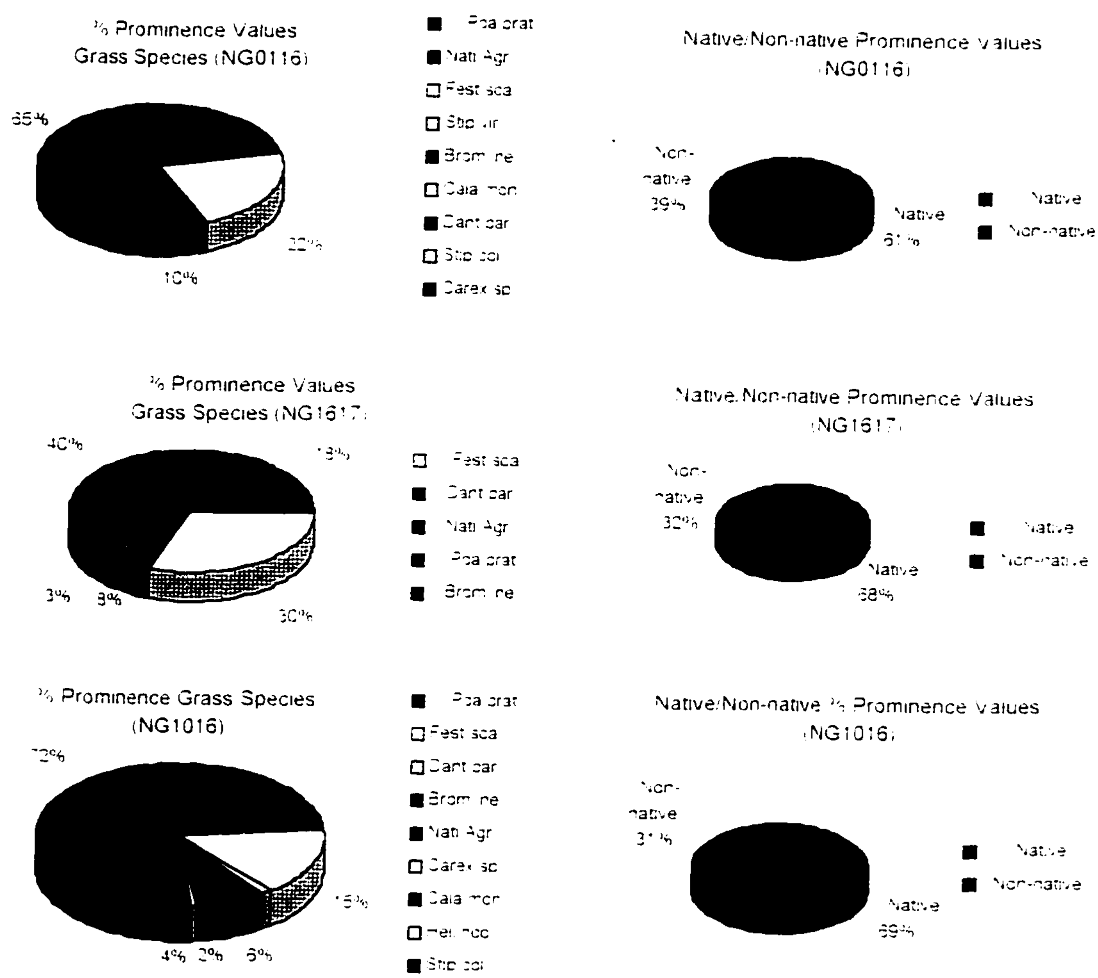


Figure 11. Native Grassland Percent Prominence Values

Pie charts comparing native to non-native species % prominence values, and grass species % prominence values for grassland units with the best Rough Fescue % prominence values. Native grassland units are identified with a character code e.g. NG1617.

The results do not show that native grasslands on the Conservation Area have been overgrazed. Litter cover and depth figures across the native grassland units are high, and shrubby species cover is moderate. The high percentage of invasive species do however, further support the contention that the current range management regime does not reflect the historical regime, particularly in terms of the timing and intensity of grazing.

Rangelands traditionally classified as being in 'excellent' condition are typified by a low percentage of invasive plant species (Adams et. al. 1986). The plant composition on the Conservation Area currently does not reflect these conditions. The location of the Conservation Area in the regional landscape does not make it a simple matter to estimate what the percent composition of native species should be in order to reflect 'native' conditions. Eighteen native grass species have been identified on the Conservation Area. Gerling et al. (1996) list only fourteen species for mesic sites in the Foothills Parkland Subregion and some of these have not been found on the Conservation Area. Some target for species composition is required in order to evaluate the state of native grassland integrity at any given time and for any given vegetation unit.

The work of Gerling et al. was reviewed in order to determine reasonable cover values for the grass species found throughout the Conservation Area. Ecological subregions surrounding the Conservation Area were prioritized as to which of the regions were the closest in physical proximity and in climatic description. Subregions were added to the list until all of the species found on the Conservation Area could be accounted for in the species lists for each subregion. The diversity of vegetation on the Conservation Area is apparent in that six subregions had to be included to account for the variety of grass species alone.

Cover values were then assigned to each grass species from the closest subregion in which the species occurred. Gerling et al. used canopy cover values for their species lists. These were converted to foliar cover values for use in the Conservation Area monitoring system. Foliar cover was estimated to be approximately one third of canopy cover measurements. Canopy cover values of one to two percent were considered to be realistically the same as the values that would be obtained for estimates of foliar cover and were not reduced by a third. This is a subjective estimate of the possible difference between evaluating canopy versus foliar cover. Actual differences estimated in the field would vary from species to species and even from one plant to another. The values do represent that in most cases foliar cover will be less than canopy cover and they do provide a meaningful reference for estimating native species composition for the Conservation Area.

The native grass species composition values are listed in Table 13. Values are provided for Mesic Rough Fescue Sites and for Dry Mixed Grass Sites. The average cover values for rough fescue in the same three sites as referenced in Figure 10 range between 6 and 12 %. In fact, these are the only sites where rough fescue cover is above three percent. Comparisons between these figures and the cover values recommended in Table 13 show clearly that rough fescue composition on the Conservation Area is, at very best, about half of what would be expected in a native climax grassland. More than half of the native grassland sites have rough fescue cover values under two percent.

Table 13. Native Grasslands Species Composition Values in Foliar Cover

Species	Composition Value Mesic Rough Fescue	Composition Value Mixed Grass	Ecoregion Reference
Rough fescue	20	-	Foothills Parkland
Parry's Oat Grass	17	16	Foothills Parkland
Fringed Brome	10	-	Foothills Parkland
Sedges	10	12	Foothills Parkland
Nodding Brome	3.5	-	Foothills Parkland
California Oat Grass	2	-	Foothills Parkland
Awned Wheat Grass	2	10	Foothills Parkland
Kentucky Blue Grass	1	1	Foothills Parkland
Northern Awnless Brome	1	-	Foothills Parkland
Green Needle Grass	3.5	3.5	Foothills Fescue Upper
Plains Reed Grass	3.5	3.5	Foothills Fescue Lower
June Grass	2	2	Foothills Fescue Lower
Northern Wheat Grass	1	1	Foothills Fescue Lower
Richardson's Needle Grass	4	4	Foothills Fescue Lower
Hooker's Oat Grass	2	2	Foothills Fescue Lower
Columbia Needle Grass	1	1	Subalpine T Valley W
Blue Gramma Grass	-	4.5	Mixed Grass Mesic
Western Porcupine Grass	3.5	3.5	Mixed Grass Mesic
Western Wheat Grass	3.5	3.5	Mixed Grass Mesic
Sand Reed Grass	-	7	Central Parkland Sandy Uplands

4.5.1 Recommendations

The following recommendations are designed to assist with efforts to manage native grasslands on the Conservation Area in ways that imitate the natural ecological rhythms and processes of the native aspen parkland and rough fescue grasslands. This management approach has been introduced in Chapter Three where recommendations were made for grazing management. These recommendations build on those of Chapter Three to apply specifically to maintaining and restoring the ecological integrity of native grassland vegetation.

The goals of native grassland management for the Conservation Area were to:

1. Maintain or enhance the quality of native grassland in terms of the historical native species diversity and composition.
2. Prevent the invasion of native grasslands by aggressive exotic grass or weed species.
3. Maintain the ecological function of native natural disturbance processes by allowing natural processes to take place, or by implementing management practices that mimic the effects of natural processes.

Management recommendations to achieve these goals are outlined below.

1. Plan a deferred rotation grazing system for native grassland areas. This will allow for one or more years of rest between grazing and best reflects the historical grazing regime of bison.
2. Restrict domestic grazing of native grasslands to the fall and winter seasons. This causes less damage to native grasses and again reflects historical grazing patterns.
3. Exclude cattle from native grasslands during the spring and summer periods. This will prevent damage to native grass and eliminate the importation of seed stock from invasive plants into native areas.

4. Develop a burn plan that includes controlled burns on a random five to ten year return time. Fires should be planned to include burning all native areas, at various times of year, and at various intensities. This will reflect the native fire regime.

5. Control smooth brome, Timothy and quack grass within native grasslands through a mowing and selective herbicide wicking program. Invasive grasslands immediately adjacent to native grasslands should be managed by mowing or grazing before seedheads form or ripen. This will reduce invasive plant vigor and reduce the invasion of native grasslands via spreading of seed and root systems.

6. Actively promote the expansion of native grasslands species within native grassland areas through reseeding and transplanting of native species. This type of labor intensive activity would be an ideal volunteer initiative.

7. Use the species composition list in Table 13 as a minimum threshold or target for managing native species composition in native grasslands on the Conservation Area. The composition of invasive species should be reduced to a minor component of the grasslands. The value of 1% cover given to Kentucky bluegrass may serve as the target for other invasive species as a group.

4.6 Chapter Summary

Monitoring native grasslands at the ecoelement scale 'zooms in' to evaluate the specifics of a given native grassland vegetation unit. Management goals were selected based on the maintenance of native grassland composition, structure, and function. Grassland indicators were chosen based on managing grasslands for ecological integrity as opposed to the traditional focus in rangelands management of managing forage for the production of beef cattle. Accepted range management measurements were used to gather data in the field and included the establishment of permanent transects and study quadrats. The grasslands database design uses the native grasslands vegetation unit as the diagnostic land unit for sampling and data analysis.

The results of native grasslands monitoring show that the current species composition within native grassland units does not reflect that of historical grasslands. Invasive and exotic grass species dominate the native grasslands in proportions well beyond those expected in purely native areas. While the results do not indicate that native grasslands on the Conservation Area are overgrazed, they do indicate that the past and current grazing regime is inappropriate for sustaining native grasslands and does not reflect historical patterns. Modifications are required in the way that native grassland areas are grazed and managed if native ecological integrity is to be maintained.

Recommendations for management of native grasslands include:

1. Development of a deferred grazing rotation
2. Restricting grazing to the fall and winter seasons
3. Excluding cattle in the spring and summer seasons
4. Development of a controlled burning cycle
5. Active control of exotic grass species such as smooth brome
6. Active promotion of native species through reseeding and transplanting

To sustain ecological integrity, native grasslands on the Conservation Area, as elsewhere, need to be managed so as to imitate the natural rhythms and processes of the native prairie. Implementation of the above recommendations will replace the effects of historical ecosystem processes to Conservation Area grasslands, which in turn, will result in the return of historical ecosystem structure and composition to native grassland units across the Conservation Area. A greater diversity of habitat for the support of native wildlife species will hopefully be the result.

The use of range exclosures should be implemented as a tool for comparison between grazed and ungrazed grasslands. At least one range exclosure should be included on each distinctly managed native pasture area. It may also be informative to set aside a relatively large exclosure of native grassland in the range of several hectares. Such an area would be excluded from cattle grazing but not from wildlife grazing or other native processes such as fire. A large exclosure may provide an important long-term benchmark for comparison of management techniques and as a control site for management experiments.

5.0 Riparian Habitat Monitoring

5.1 Riparian Management Issues and Threats

The geographic position of the Ann and Sandy Cross Conservation Area is unique, not only in terms of its proximity to several distinct ecoregions, but also in terms of its hydrological location. The Conservation Area encompasses a height of land that forms part of the apex or boundary of three distinct watersheds. The apex of the north and middle forks of the Pine Creek watershed are almost completely contained within the Conservation Area. The far northern sections of the Conservation Area drain into the Fish Creek watershed, while the southwest and southeast corners drain into the Pothole Creek watershed and the south fork of Pine Creek respectively. For water management purposes, the Conservation Area has the unique characteristic of not having upstream influences to consider. Management efforts can focus primarily on water quality and riparian integrity within the boundaries of the area. This may be one of few examples where the administrative boundaries of a protected area actually correspond relatively closely to ecological criteria.

Noss and Cooperrider (1994) outline a number of common threats to the integrity of aquatic ecosystems. Threats relevant to the Conservation Area include dams and water diversions, livestock grazing, and the invasion of exotic plants. The unique location of the Conservation Area effectively eliminates many other common threats to aquatic integrity, such as logging, stream channelization, and pollution effects. It should be kept in mind that the aquatic ecosystem on the Conservation Area is not isolated from downstream effects, such as restrictions on wildlife movement imposed by downstream developments. However, for the purposes of this project such influences are considered to be external to the Conservation Area and part of monitoring and managing for ecological integrity at a regional scale.

Dams and water diversions present a unique threat to riparian integrity by removing water from and impeding water flow within the riparian ecosystem (Noss and Cooperrider 1994). A number of dugouts have been constructed on the Conservation Area and a number of springs have been tapped to provide water sources for cattle. In some cases, dugouts have been constructed by damming watercourses, with the result that the dugout retains all water and the watercourse downstream dries up. The standing water bodies created by dugouts have some value to certain wildlife. Dugouts on the Conservation Area are used by waterfowl and aquatic mammals, such as muskrat and diving ducks. Dugouts provide a drinking water source for animals and can support a variety of riparian and aquatic vegetation. Management decisions to maintain or build dugouts may be justified in their value to certain wildlife, and in the light of the loss of prairie wetlands on a regional scale. However, dugouts are not natural and may have many adverse and unseen effects downstream, especially when water flow is completely blocked. Dugouts should be located, maintained and designed so that natural water flow is ensured within natural watercourses. Since dugouts exist on the Conservation Area and are needed for cattle grazing, the recommendation of this project is that dugouts be managed as any other natural riparian area in terms of providing habitat for native vegetation and wildlife.

The interrelatedness of the terrestrial, wetland, and aquatic realms is considered to be of central importance to many biologists (Noss and Cooperrider 1994). The riparian zone represents the link between terrestrial and aquatic ecosystems and provides a more holistic focus for management than just the aquatic ecosystem itself. Adams and Fitch (1995) promote riparian zone management as a means to benefit water quality, wildlife habitat, and sustainable ranching operations. Similarly, a focus on biological criteria for monitoring aquatic ecosystems developed by Karr (1981, 1993) includes consideration of riparian zone elements. The focus on management of aquatic ecosystems for the Conservation Area presented in this project is likewise based on monitoring the riparian zone, and is consistent with the approach taken by the Elkhorn Ranch (Adams and Fitch 1997).

5.2 Riparian Management and Monitoring Goals and Indicator Selection

5.2.1 Riparian Zone Management Goals

1. Manage so that stream flow and spring flow characteristics are unimpeded by human development or activity.
2. Maintain or enhance the quality of native riparian vegetation by preventing the invasion of exotic species and by mimicking natural disturbance processes.
3. Manage the riparian zone to maintain habitat for the full diversity of native animal wildlife.

5.2.2 Riparian Zone Monitoring Goals

1. Identify changes in stream flow characteristics that may be associated with cattle grazing activities and management.
2. Identify changes in the composition and distribution of exotic invasive plant species within riparian areas.
3. Identify changes in the diversity of wildlife using riparian zones on the Conservation Area.

5.2.3 Riparian Zone Indicators

Evaluation of streamflow characteristics is an important aspect of range management as evidenced by specific publications on riparian evaluation and management produced by the Alberta Riparian Habitat Management Project - commonly referred to as the "Cows and Fish" program. This program is sponsored by multiple agencies including the Alberta Cattle Commission, Trout Unlimited, and Alberta Environmental Protection. Evaluation checklists provided to ranchers by "Cows and Fish" focus on descriptive evaluations of stream channels, stream banks, streamside vegetation, and wildlife use (Adams and Fitch 1995, Moisey 1996).

As with native grasslands, monitoring the suite of indicators selected for riparian monitoring on the Conservation Area attempts to represent native species composition as well as structural and functional aspects of the riparian ecosystem. The indicators selected for riparian monitoring are; total vegetation cover; native vs. non-native vegetation cover; exposed soil; litter cover; weed cover; stream flow in cubic meters per second (cms); stream flow characteristics; and waterfowl and wading bird species diversity.

Vegetation Indicators

Since a system for vegetation monitoring had been established for native grasslands it seemed reasonable to incorporate aspects of the system into riparian vegetation monitoring. The indicators use the same field techniques and the same calculations as the native grassland indicators for simplicity and consistency in measurement and interpretation. An attempt was made to simplify vegetation monitoring in riparian areas as much as possible, and so no single vegetation species was selected out as an indicator for riparian monitoring. Total vegetation cover, native vs. non-native vegetation cover, exposed soil, litter cover, and weed cover were all selected as indicators using the same justifications as used in native grasslands monitoring.

Stream Flow Indicators

Descriptive evaluations are appropriate for evaluating stream flow characteristics on the Conservation Area, especially when important indicators may be difficult or time consuming to quantify. Indicators selected for descriptive evaluation from the "Cows and Fish" checklists include stream channel visibility, sedimentation, channel shape, and vegetation cover. Easily quantifiable measurements can also be made on stream flow characteristics. Stream channel width, depth and velocity can be converted into flow in cubic meters per second (cms). These figures can be then monitored over time and used to identify trends in stream flow (Moisey 1996). The entire suite of stream flow indicators provides the ability to describe and quantify changes in flow characteristics over the short and long term.

Waterfowl and Wading Bird Species Diversity

The great blue heron and the wood duck were selected as potential wildlife indicators for riparian habitat in Chapter 3. Since data on these species in the Conservation Area records were sparse, it was decided to attempt to improve the data by conducting field surveys. It seemed reasonable to include the survey of other waterfowl and wading bird species at the same time, in order to improve the information on species diversity in the wildlife database, to identify other potential indicator species, and to provide additional information that could be used to evaluate riparian habitat integrity. In this discussion, herons are included with the use of the terms "waterfowl" and "wading birds".

Waterfowl and wading birds use both the aquatic and terrestrial elements of riparian areas to fulfill life cycle requirements. Terrestrial areas are used primarily during the nesting season. The presence of waterfowl during these times could be seen to be an indication that the terrestrial riparian area fulfills the needs of riparian wildlife in general. Presence of waterfowl and wading birds later in the season is an indicator that feeding requirements are being met by the aquatic component of the riparian zone (Eng 1986). The presence of dabbling ducks may indicate that the vegetative components of the riparian food chain are in order, while the presence of diving ducks and many wading birds including sandpipers, herons, and plovers indicates that the animal food chain has integrity. Dabbling ducks feed primarily on riparian vegetation, while diving ducks feed primarily on aquatic animal wildlife (Godfrey 1986, Robbins, Bruun, and Zim 1983). The presence of waterfowl and wading bird species can be expected to shift throughout the season with changing water levels and to be impacted by changes in vegetative structure. For instance, species with deep water requirements such as the common goldeneye may be found early in the season, while herons and shorebirds appear later in the season as water levels drop (Fredrickson and Reid 1986).

Monitoring species diversity is considered to be an important indicator for the evaluation of ecological integrity (Noss 1995, Keddy, Lee, and Wisheu 1993, Woodley 1993, Karr 1981, 1983). Waterfowl and wading bird species diversity may indicate that both the terrestrial and aquatic elements of the riparian zone are fulfilling a variety of ecological functions, and that ecological processes such as natural water flow regimes are being maintained. Waterfowl and wading birds may also be good indicators for the Conservation Area because they are relatively easy to observe and identify for volunteers. Evaluation of riparian species diversity on the Conservation Area should also include the most sensitive aquatic species - amphibians, as well as other breeding birds and mammals. These species groups were not surveyed within the scope of this project. It was felt that surveys of waterfowl and wading birds, in combination with vegetation and stream flow evaluations, would provide the broadest assessment of riparian integrity with minimal effort at this stage in the monitoring system.

5.3 Data Collection

Vegetation, streamflow and waterfowl indicators each required different data collection procedures and the use of different study sites.

5.3.1 Riparian Vegetation Data Collection

The procedures employed for collecting data on riparian vegetation were very similar to those employed in the native grasslands. Due to the narrow and twisting nature of the streamside riparian areas in particular, it was not feasible to run a straight line linear transect. Instead of linear transects, 50m long riparian vegetation 'plots' were established that encompassed both sides of a stream section or ran along a representative side, or sides, of a pond. Study quadrats were then spaced at 10m intervals, beginning 5m along the stream or pond bank, and approximately 1m from the edge. Study plots were permanently marked and mapped so that they could be relocated for subsequent monitoring.

Riparian vegetation plots were selected to include both grassland and woodland riparian areas. Riparian vegetation monitoring plots were located only along permanent streams or ponds. The Fish Creek and Pothole Creek watersheds on the Conservation Area have no permanent water bodies and were excluded from riparian evaluation.

Quadrat measurements were taken in the same manner and using the same format as for native grasslands.

5.3.2 Streamflow Data Collection

Streamflow evaluations were done at two sites located at the downstream end of the North and Middle Forks of Pine Creek. These sites were chosen on the assumption that flow measurements taken at the farthest downstream points on the Conservation Area should reflect the overall conditions upstream. Flow measurements were only taken once for the scope of this project in early July.

Procedures for measuring flow were based on Moise (1996). A relatively straight 10m reach of stream was chosen. Width and depth were measured to the nearest centimeter at the upper, middle and bottom of the reach and then averaged. A cork was dropped into the stream at the top of the reach and timed until it reached the bottom. The cork was assisted as necessary to prevent it from being entrapped by emergent vegetation and debris. This was repeated three times, averaged and divided by ten to get speed in m/s. Stream flow was calculated using the following formula:

$$\text{Velocity} \times \text{Width} \times \text{Depth} \times \text{Bottom Factor}(0.9) = \text{Flow}\ (m^3/s)$$

Descriptive evaluations of stream flow characteristics were also done at these sites. The evaluation criteria for stream visibility, sedimentation, channel shape and vegetation are outlined in Table 14. In order to cover the most possible terrain for this initial stage of monitoring, the entire length of the two main streams on the Conservation Area were surveyed on foot. Researchers looked for areas where the descriptive characteristics indicated that riparian integrity was being compromised. This was done primarily to obtain an idea of the overall condition of the riparian areas and to identify potential trouble spots that would require more detailed monitoring. These areas were incorporated into the sites selected for riparian vegetation monitoring.

Table 14. Descriptive Stream Characteristics

Visibility	Sedimentation	Channel Shape	Vegetation
clear	slight	"U" shaped	bare ground/weeds
half way	moderate	wide/ shallow	upland species
no visibility	heavy	trampled	wetland species

The intention for the future is to monitor descriptive stream characteristics at the same sites as the vegetation monitoring. This was not done specifically for this project because the entire streams were surveyed prior to, and as part of, preliminary vegetation plot selection. Future monitoring efforts could be limited to the vegetation sites, could utilize additional sites, or could occasionally focus on re-surveying the entire stream length again as required.

5.3.3 Waterfowl and Wading Birds Data Collection

The survey for waterfowl and wading bird species utilized standard procedures as outlined by Eng (1986). Observation sites were selected from which an researcher could identify birds on one or more ponds or dugouts. Most ponds and dugouts on the Conservation Area that have water throughout the season were included in the survey. Researchers recorded all waterfowl or wading birds seen or heard in the vicinity of the observation site. While it is common procedure to limit the time spent at any one observation site, the time constraints suggested by Eng were found to be inadequate, given the level of experience of the researchers at bird identification. Instead of a time limit, researchers stayed at a site until all birds were identified. If no birds were observed within three minutes of the researcher's arrival at a site, the researcher moved on to the next site. Observations were avoided on cold, windy, overcast or rainy days, and most observations were made in the morning. Some observations were made in the late afternoon and evening, which proved to be productive survey times. The survey was done during the breeding season, continued after molting season and was halted before the main influx of fall migratory birds arrived. This allowed for an assessment of breeding birds, breeding success, and food productivity. Researchers recorded information on species, gender, broods, and any notable activity.

5.4 Data Management and Analysis

Data management and analysis for the riparian zones on the Conservation Area was designed in a very similar format to that of the native grasslands. Data analysis is designed to be flexible and can focus on individual indicator results, on trends in individual indicator results over time, or on trends using an index of multiple indicator measurements.

5.4.1 Riparian Database Structure

As with the ecosite and native grassland databases each table in the riparian database is joined back to the Master Table. The Watershed Unit serves as the basic diagnostic land unit for riparian monitoring. The structure of the riparian database is illustrated in Figure 12. Watersheds and hydrological features of the Conservation Area are illustrated in Figure 13.

5.4.2 Riparian Database Analysis

Queries are outlined for the purposes of this project that provide basic information on vegetation composition, stream flow, and riparian wildlife. A riparian integrity index is outlined for the purpose of monitoring trends in the long term.

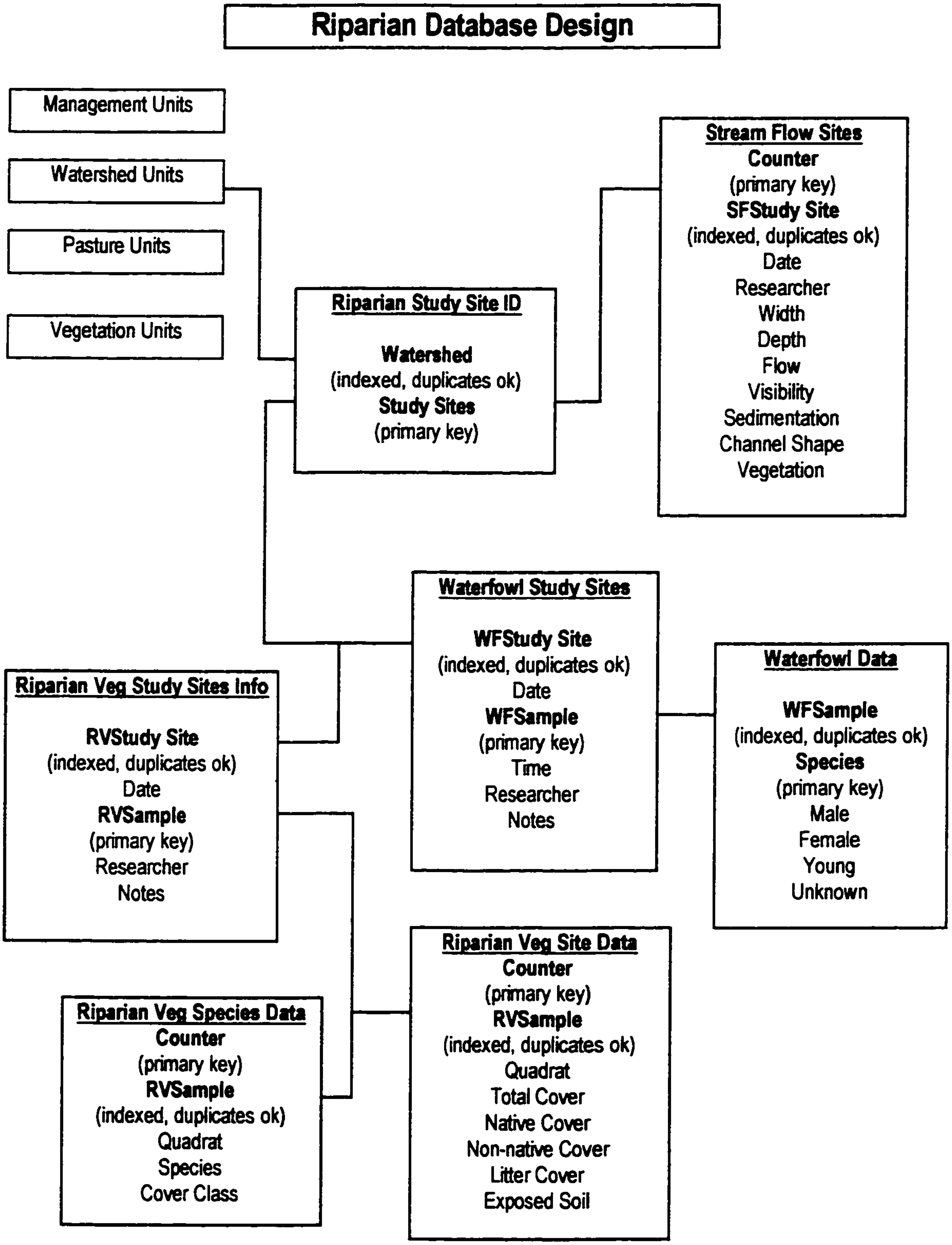


Figure 12. Riparian Database Design

The watershed unit is the primary diagnostic land unit for riparian monitoring. Indexed fields and keys are in bold type. Joins between tables are represented as lines between common fields.

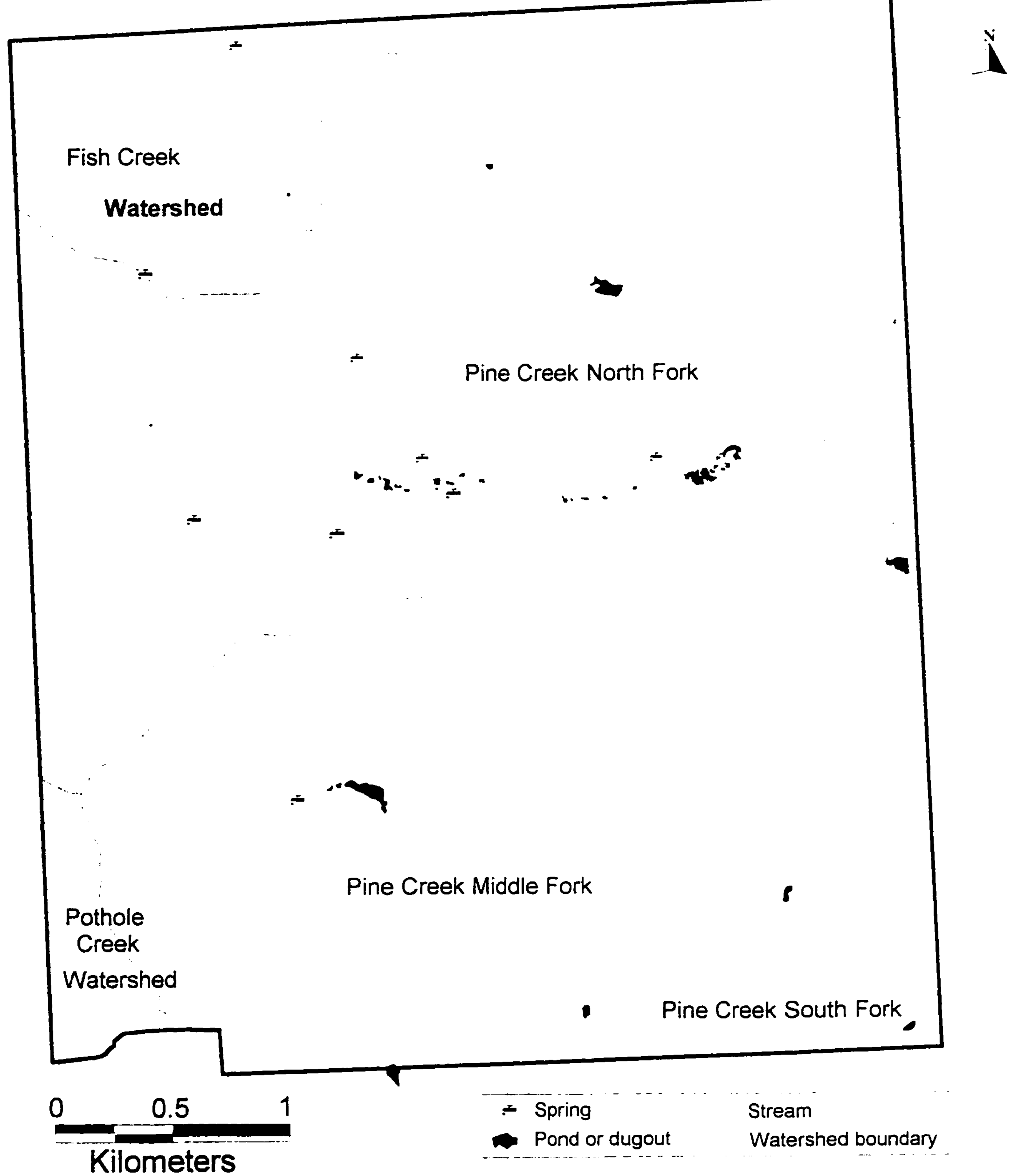


Figure 13. Watersheds and Hydrological Features of the Ann and Sandy Cross Conservation Area

Riparian Query 1- Riparian Vegetation Composition

Riparian Query 1 - Description

Calculate composition statistics for selected species or indicators, for selected watershed units for selected dates.

Riparian Query 1 - Table Displays

Table displays can be created to facilitate browsing of data for a single species or indicator in a watershed unit for a selected date(s), or for multiple species or indicators for a single date. Table 15 illustrates a sample format.

Table 15. Riparian Vegetation Composition Output Table

Watershed Unit	Date	Species/ Indicator	Avg. Cover	% Comp	Prom Value	% Prom Value

Riparian Query 1 - Map and Graph Displays

Thematic mapping operations available with MapInfo include the ability to display graphs in association with mapped land units. One of the simplest map displays would be to thematically map watershed units using pie graphs to display the % prominence of native to non-native vegetation.

Riparian Query 2 - Stream Flow

Display stream flow for selected watershed units for selected dates.

Riparian Query 2 - Table and Graph Displays

Stream flow measurements can be displayed simply as a table, or as a line or bar graph if displaying the trend over time. A map display is not necessary or appropriate for this type of information. Stream flow characteristics information could also be displayed in table form along with flow measurements. This would be useful for helping to interpret the results of flow measurements. A sample output is illustrated in Table 16.

Table 16. Stream Flow Characteristics Output Table

Watershed	Date	Flow/cms	Visibility	Sediment	Shape	Vegetation

Riparian Query 3 - Waterfowl and Wading Bird Diversity

Calculate waterfowl and wading bird species (or all riparian wildlife species in the future) richness by watershed unit.

Riparian Query 3 - Table Displays

A table display would be appropriate for listing all waterfowl and wading bird species observed in a selected watershed unit.

Riparian Query 3 - Map and Graph Displays

- Map waterfowl and wading bird species richness by watershed unit
- Graph the trend in waterfowl and wading bird species richness for a selected watershed unit for selected dates

Riparian Query 4 - Riparian Integrity Index

This index takes on the same form as the native grasslands integrity index. Trends in indicator measurements are assigned index values. Index values can then be added together to arrive at an integrity index value for the entire watershed which allows for a relative comparison of watersheds and enables management priorities to be set. The total index value indicates movement either away from or towards a state of integrity, or alternatively, the index value indicates a state of relative ecological stability.

Table 17. Riparian Integrity Index Trend Values

Indicator	Trend	Value
Native to non-native species	Increasing Decreasing	+1 -1
Exposed Soil	Increasing Decreasing	-1 +1
Litter Cover	Increasing Decreasing	+1 -1
Total Cover	Increasing Decreasing	+1 -1
Stream Flow	Increasing Decreasing	+1 -1
Visibility	Increasing Decreasing	+1 -1
Sedimentation	Increasing Decreasing	-1 +1
Waterfowl and Wading birds Species Richness	Increasing Decreasing	+1 -1

The indicators selected for the index are intended to represent the composition (native and non-native vegetation, waterfowl and wading bird species), structure (exposed soil, litter cover, total cover) and function (stream flow, visibility, sedimentation, waterfowl and wading birds) of the riparian ecosystem. The index in this form is only suitable for two of the five watershed units on the Conservation Area. The Pothole Creek watershed has no riparian areas, and there are no stream flow calculations for the Fish Creek or the South Fork of Pine Creek watersheds. For these watersheds it may be most expedient to evaluate indicators on an individual basis and not as an index.

5.5 Riparian Monitoring Results

5.5.1 Riparian Vegetation Results

The results of riparian vegetation monitoring indicate that native vegetation is dominant in most study sites. Native vegetation percent prominence values are generally in the order of 90% as compared to 0 to 5% for non-native vegetation. There are a couple study sites that serve as notable exceptions. These study sites are each located at man-made dugout locations. These sites are characterized by a higher prominence of non-native vegetation cover and exposed soil with very little litter cover. The worst sites have up to 97% exposed soil and less than 1% litter cover while the best sites are almost the opposite with 90% litter cover and less than 1% exposed soil.

While native vegetation is dominant at most riparian study sites, average total vegetation cover ranges from 67% in the middle fork of Pine Creek to only 14% in the south fork of Pine Creek. As with prominence values, dugout sites contribute the most to low total vegetation cover values. Exposed soil accounts for the majority of riparian ground cover in the north fork and south fork watersheds of Pine Creek. In general, stream sites are in good condition while dugout sites are in much poorer condition. Weed cover is low with cover values less than 1% except for a couple of sites where Canada Thistle cover reaches the range of 7% and broad-leaved plantain reaches 19% average cover. Riparian vegetation prominence values and the average cover of total vegetation, litter, and exposed soil are compared graphically in Figure 14. It may be worthwhile to separate the analysis of stream and dugout sites in the future to more accurately represent the impacts to riparian vegetation at individual sites.

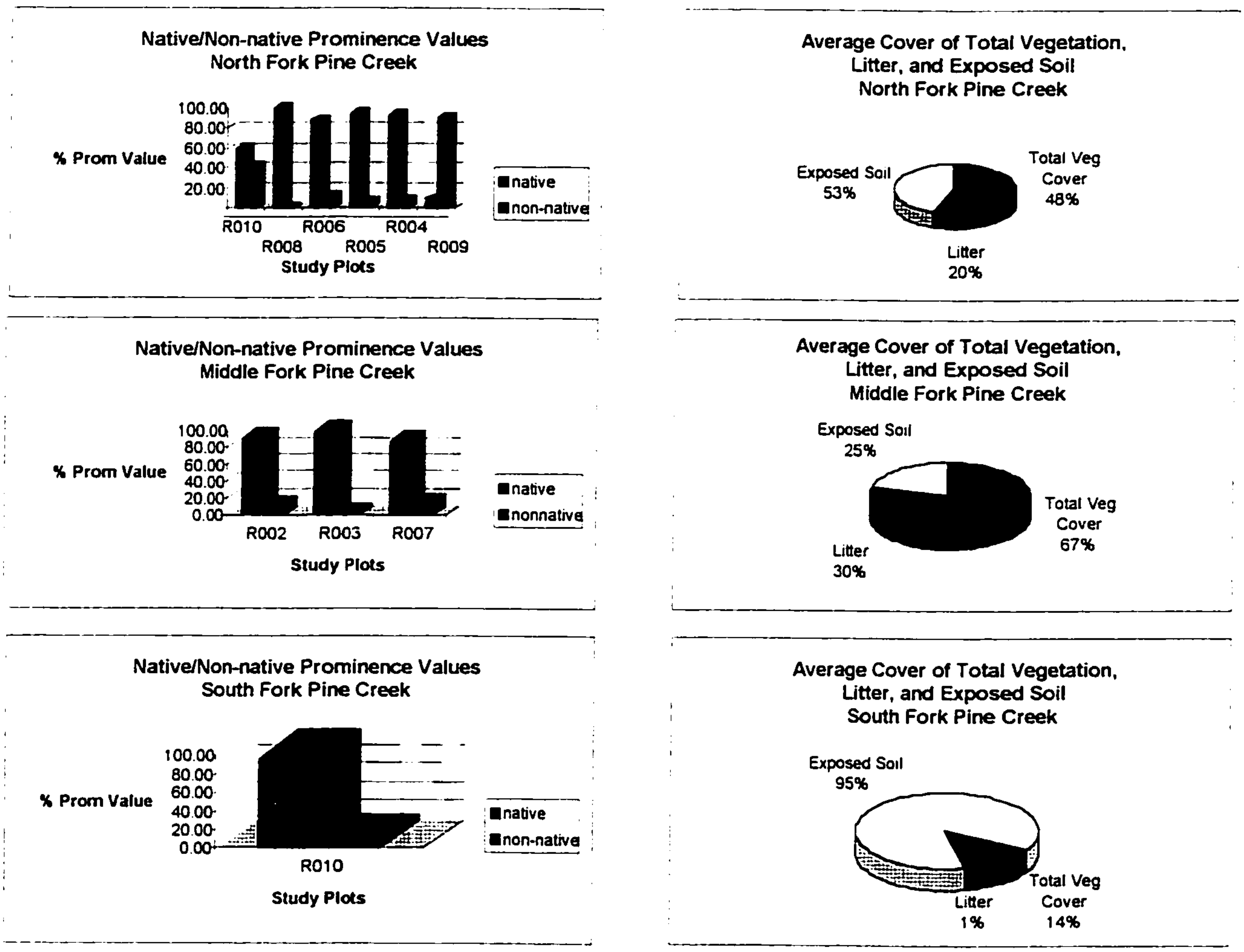


Figure 14. Riparian Vegetation Average Cover and Prominence Values

5.5.2 Stream Flow Results

The results of stream flow measurement presented in Table 18 indicate that stream flow at the downstream end of the Pine Creek watersheds was not being affected by upstream activities at the time of measurement. More information is needed to establish seasonal and annual trends before this type of information can serve as an effective indicator.

Table 18. Stream Flow Characteristics

Watershed	Flow in cms	Visibility	Sediment	Channel Shape	Vegetation
Pine Creek North Fork	.017	Clear	Moderate	U shaped	Wetland Species
Pine Creek Middle Fork	.018	Clear	Moderate	U shaped	Wetland Species

The recommendation of this study is to measure stream flow at least once a month through the spring, summer, and fall seasons. More frequent measurements will provide more information on seasonal trends and may pick up impacts of upstream activities that occur at different times of the season. For instance in the 1997 season no cattle were being grazed upstream on the north fork of Pine Creek until after the stream flow measurements were taken. Descriptive information should also be taken at more stream sites. Ideally, descriptive information would be gathered at the same sites that vegetation is being monitored at, but at the same time as stream flow measurements.

5.5.3 Waterfowl and Wading Birds Survey Results

The waterfowl survey identified twenty bird species including five species of diving duck, six species of dabbling duck, seven species of shorebird, one goose species, and one species of perching duck (Table 19). The survey identified birds of both gender, and broods of blue winged teal, mallard, and Barrow's goldeneye.

Table 19. Waterfowl, Wading Birds and Herons Species List

COMMON NAME	LATIN NAME	FAMILY
Kingfisher	*Ceryle alcylon*	*Alcedinidae*
American Widgeon	*Anas americana*	*Anatidae*
Barrow's Goldeneye	*Bucephala islandica*	*Anatidae*
Blue-winged Teal	*Anas discors*	*Anatidae*
Bufflehead	*Bucephala albeola*	*Anatidae*
Canada Goose	*Branta canadensis*	*Anatidae*
Common Goldeneye	*Bucephala clangula*	*Anatidae*
Gadwall	*Anas strepera*	*Anatidae*
Green-winged Teal	*Anas crecca*	*Anatidae*
Hooded Merganser	*Lophodytes cucullatus*	*Anatidae*
Lesser Scaup	*Aythya affinis*	*Anatidae*
Mallard	*Anas platyrhynchos*	*Anatidae*
Northern Shoveller	*Anas clypeata*	*Anatidae*
Wood Duck	*Aix sponsa*	*Anatidae*
Great Blue Heron	*Ardea herodias*	*Ardeidae*
Killdeer	*Charadrius vociferus*	*Charadriidae*
Piping Plover (unconfirmed)	*Charadrius melodus*	*Charadriidae*
Common Snipe	*Gallinago gallinago*	*Scolopacidae*
Solitary Sandpiper	*Tringa solitaria*	*Scolopacidae*
Spotted Sandpiper	*Actitis macularia*	*Scolopacidae*

As expected, the numbers of ducks declined throughout the season and the numbers of shorebirds increased. Some ducks continued to use ponds on the Conservation Area throughout the season, and some were identified with broods, notably blue winged teal, mallard and Barrow's goldeneye. This indicates that the riparian areas are suitable for nesting, breeding cover, and for feeding. Large ponds and dugouts were the most popular spots for waterfowl. Even the large dugout on section sixteen, with poor vegetation cover around it, featured considerable numbers of waterfowl. Canada geese were most likely passing migrants - they were observed both early and late in the season.

Wood duck and merganser were not observed during the waterfowl survey but appear in the species list based on past observations. It would seem reasonable to see these species on the Conservation Area, at least from time to time, as the Conservation Area is within the breeding range of both species. Godfrey (1986) specifically lists the Millarville and Turner Valley areas as the only breeding area for the wood duck in Alberta. However, the recommendation of this project is that these species not be considered as indicators in that they are likely only occasional visitors. Either Goldeneye species, or bufflehead, may be better indicators for cavity nesting species.

All recorded observations of great blue heron on-site have been of birds flying over the Conservation Area. If the heron is not breeding on-site, or at least feeding, it may also not be a good indicator species. More information on the activities of the great blue heron on the Conservation Area is needed before a decision can be made.

In general, it appears that riparian areas on the Conservation Area are presently supporting the habitat needs of a variety of waterfowl. Both breeding and feeding requirements are supported by riparian habitats. The information on waterfowl and wading bird species diversity will become more valuable as data is collected over time and trends become apparent.

5.6 Chapter Summary

The Conservation Area is in a unique situation in that there are no upstream influences to be concerned about in management and monitoring of riparian habitat. The main issues for riparian management centre around ensuring that water flow, riparian vegetation, and riparian wildlife are unimpeded by human developments and activities. Data were collected for indicators selected for the evaluation of riparian vegetation, stream flow characteristics, and waterfowl. Watersheds were used as the basic diagnostic land unit for riparian sampling and data analysis.

The results from the initial monitoring indicate that riparian vegetation has been impacted in some areas by both cattle and human activities. The location of some dugouts are in watercourses and seem to prevent any flow downstream of the dugout. Overall riparian integrity seems to be in a fairly good state. Streamflows are clear, ample waterfowl are supported in the area, and native vegetation dominates most riparian areas with a few exceptions around dugouts. The presence of mink, muskrat, beaver, and frog species further indicate that riparian areas are able to support a diverse native wildlife population.

The main recommendations for the management of riparian areas are similar to recommendations made previously for grazing management in Chapters 3 and 4.

1. Riparian areas should be fenced and grazed as separate land units, or not grazed at all.
2. Cattle should be excluded from riparian areas except when specifically grazing the area.
3. Water developments should not impede the natural flow of water from springs or stream channels. Existing dugouts should be examined to see if natural water flow is being maintained and if modifications can be made where necessary.

4. Existing dugouts should be treated as natural riparian areas and revegetated as appropriate with native upland grasses, riparian wetland vegetation, and emergent vegetation.
5. Streamflow evaluations should be done on a regular schedule at least once a month to establish seasonal trends.
6. Waterfowl observations should be expanded to include the dugouts in the south fork of Pine Creek watershed and the south fork itself.
7. Wildlife surveys should extend to amphibians, breeding birds, and riparian mammals such as mink, muskrat and beaver to gain information of species diversity and to continue research into the most appropriate wildlife indicators.

While riparian areas could be considered to be in generally good condition throughout the Conservation Area improved management does not require initiatives much beyond those required for improved management of grazing and native grasslands. Improved management of riparian areas will fulfill the Conservation Area mandate of protecting habitat for native species of wildlife. In some respects enhancement of riparian features is in conflict with improved grazing management. Water source development, although taken for granted as a good thing, could have significant impacts on riparian areas. This will have to be carefully considered when in the planning stages of grazing regimes and water development projects and may require expansion of the riparian monitoring program.

6.0 Aspen Forest Monitoring

6.1 Management Issues and Threats

The main issues affecting aspen management on the Conservation Area are related to modification of the native natural disturbance processes. Both Navratil (1991) and Perala (1991) document concerns that aspen stands may not regenerate naturally in the absence of periodic wildfire, and may require management intervention. Perala suggests that aspen stand decadence may happen so fast that the stand has no chance to regenerate and the forest area may revert to grassland. This may also be a concern for aspen stands on the Conservation Area. A relatively large percentage of the Conservation Area consists of old growth aspen stands. Reid and Heseltine (1997) identified widespread disease such as timber conk *Fomes tremulae,* and canker *Hypoxylon mammatum* within mature forest stands on the Conservation Area. Ample amounts of downed woody material and snags are also common in old growth stands across the Conservation Area. The amount of old growth stands, and the widespread presence of disease, snags, and downed woody material are all indications that the aspen stands on the Conservation Area have matured to the point that stand decadence and regeneration may have become an issue.

White (1997) points out that aspen is in decline in Canadian and American national parks and suggests that the decline is due to human caused changes in long-term ecological conditions. White points to fire suppression and the release of elk from additive predation from humans, wolves and other carnivores as the main reasons for aspen decline. Historical and archeological evidence presented by White suggests that historical elk numbers were low - about 7% of large wildlife. Today elk numbers are up to about 50% of large wildlife in the national parks. New aspen suckers are browsed off by elk before reaching 2m in height, and most mature trees exhibit bark ringing - bark stripped off of trees around the entire circumference by browsing elk. There is no sign of this type of heavy herbivory in the historical photographic record from the National Parks, indicating that the current population of elk is in excess of that which can be sustained by the historical population of aspen (White 1997).

Several questions arise from the above discussion pertaining to monitoring aspen on the Conservation Area:

- Are aspen stands regenerating on their own?
- Are aspen stands being heavily browsed by elk?
- Is aspen suckering sufficient to provide important winter browse for elk and other ungulates, and sufficient to sustain the regeneration of aspen stands beyond the impacts of browsing?

Management and monitoring goals and the selection of indicators should be oriented towards providing information that may help to address the issues posed by the above questions.

6.2 Management and Monitoring Goals and Indicator Selection

Goals proposed for aspen management and monitoring focus on adequate stand regeneration. It was anticipated that the management priorities for the Conservation Area would be related to grasslands management and not to forest management. Therefore a minimal set of goals were selected related to the concerns expressed in the previous Section. When combined with the ecosite level vegetation analysis, the proposed goals provide for a basic evaluation of threats to the aspen communities on the Conservation Area.

6.2.1 Aspen Management Goals

1. Ensure that aspen regeneration is adequate to replace decadent old growth stands.
2. Balance the availability of aspen browse with ungulate populations.

6.2.2 Aspen Monitoring Goals

1. Identify patterns in age structure diversity within old growth aspen stands.
2. Identify signs of overbrowsing.

6.2.3 Aspen Indicators

Given the assumption that forest management is not a priority for the Conservation Area (with the exception of encroachment into native grasslands), indicators were chosen that could be quickly and easily evaluated. Indicators chosen evaluate structural and functional elements of the aspen ecosystem. The indicators selected were age class of trees in stand, stems per ha, and the percentage of trees browsed.

Age Classes

The average and range of tree ages is listed as an important structural indicator at the community/ecosystem level by Noss (1994). However aspen can be difficult to age by coring, even though there is reliable methodology to accomplish this (Morgan 1991). Harper suggests that "predictions about the future of a (tree) population are best obtained by studying the size rather than the age distribution." (Harper 1977). Measuring tree diameter at breast height (dbh) is a common approach for relating tree age to tree size, however, there are significant difficulties with this approach (Harper 1977). For the purposes of this study it was decided to divide tree sizes into four nominal age categories based on relative tree size in height - suckers, saplings, sub-canopy, and canopy trees - rather than trying to age the trees accurately. It should be noted that these 'age classes' are really size classes and cannot be accurately correlated to actual tree age. However, age class is used for the purposes of this project because it is a more familiar term for describing the progression of tree growth over time. If old growth forest stands are regenerating adequately it would be expected that a selection of trees in various age classes would be found within the stands. This information can be gained by simply counting the number of trees in various age classes along a transect, making it very easy for volunteer labor to complete and replicate.

Stems per Hectare

The number of stems per hectare declines as a forest stand ages. Young aspen stands following a disturbance event may have as many as 260,000 stems/ha while old stands may have as few as several hundred stems/ha. Old stands can be expected to exhibit diversity in stems/ha due to canopy breakup and forest regeneration (Stelfox 1995). A consistent decline in stems/ha in an old growth patch would be a reasonable indicator that the stand is not adequately regenerating. Measuring this indicator in the field uses the exact same count as for the age class indicator.

Percentage of stems browsed

Monitoring the percentage of stems browsed also utilizes a count along a transect. The reasoning behind the selection of this indicator is that if aspen stands are not regenerating, or if ungulate numbers are increasing beyond the capacity of aspen browse available to them, the number of browsed stems will increase as a percentage of the total number of stems. Most ungulate forage is produced within 5 to 20 years of a disturbance when aspen is young (Timmerman 1991). Considerable signs of browsing on mature and old growth trees may indicate a lack of young aspen browse available to wildlife. This is the same type of observation made by White (1997) with regard to aspen regeneration and ungulate browsing in the national parks.

6.3 Aspen Forest Data Collection

Data collection procedures were designed so that information needed for the evaluation of all indicators could be collected at the same time. Briefly, one metre wide transects were established in forest patches and all trees within the transect were tallied, classified by age, and categorized as browsed or unbrowsed. Transects were chosen over forest plots because:

- It was felt that it was easier to cover more variety in terrain (for instance the top to bottom of slopes accounting for differences in moisture regime)
- Transects were quick to lay out and were consistent with the methods used for grassland survey making it easier for volunteers to assist
- Using transects allowed for edge to edge coverage in many patches which accounted for the natural, outward radiating, expansion of aspen clones

Preliminary location of transects was done through airphoto interpretation. Transect locations were further modified in the field to account for terrain features not identified in the airphotos. Transects were located only within old growth and mature forest patches because these are the areas of regeneration concern. There are no patches of very young forest in the sucker and small sapling stage that were considered to be threatened by excessive browsing. Not every forest patch was sampled, but an attempt was made to locate transects in old growth patches in representative locations across the Conservation Area. Transect locations were chosen to run more or less parallel to the fall line, to run through sections of open, mature forest canopy, and to cover the geographic variation within a forest patch. Transect locations were permanently marked and mapped for future reference.

Transect origins and endpoints were permanently marked with metal stakes. From the transect origin, researchers followed a compass bearing towards the endpoint marking the route with flagging tape placed on trees. The counting procedure worked well with two people. One person would hold a metre wide stick directly in front of themselves while proceeding along the transect in a straight line. Any aspen tree touched by, or passed over by, the stick would be counted as falling within the transect. The second person ensured that the first person stayed on route and recorded the information. The number of trees in each age class was recorded by a tally as the researchers proceeded along a transect. Each tree was also categorized as browsed or unbrowsed. Age class descriptions were as follows:

- Suckers < 1m
- Saplings > 1m < 3m
- Subcanopy > 3m but below forest canopy
- Canopy - the tallest trees in the stand

Transect information was recorded on a standard field form designed specifically for this purpose.

6.4 Aspen Forest Data Management and Analysis

6.4.1 Database Structure

Vegetation Units were used as the primary diagnostic land units for sampling and analysis of aspen forest indicator data. Since not all forest units were monitored, it would also be useful to evaluate forest data based on the results summarized for individual management units, or for the entire Conservation Area. This type of evaluation would be done within the GIS program based on using management units as a supplementary diagnostic feature. The database structure is shown in Figure 15.

6.4.2 Aspen Forest Database Analysis

Aspen forest database analysis focuses on the visual display of summarized data results for both point-in-time and trend.evaluations. It is difficult, if not impossible, to relate the results to a reference value. As pointed out by Stelfox, (1995) the number of stems/ha in old growth forest stands is dependent on canopy breakup and regeneration. The approach taken by this project is to present quantifiable data on tree age diversity and ungulate browsing in visual or graphic terms so that it can be interpreted qualitatively. Data are not interpreted against a pre-established, measurable threshold.

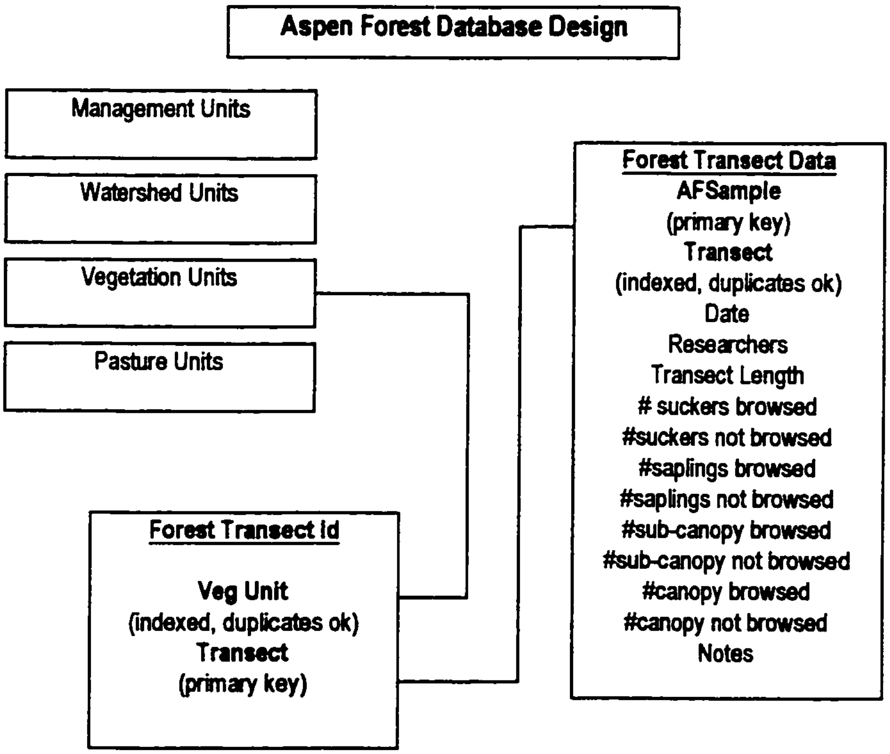


Figure 15. Aspen Forest Database Design

Indexed fields and keys are in bold type. Joins between tables are represented as lines connecting common fields in separate tables.

Visual or graphic approaches to data analysis are supported by Noss and Cooperrider (1994) and Woodley (1993). Woodley in fact, states that "no single numerical index can be expected to represent the status of a complex ecosystem...therefore interpretation might be best performed by that great integrator, the human brain." As data are accumulated over time it may be possible to identify management thresholds that newly acquired data may be compared to. Graphic representation of data however, provides a starting point for interpretation while more quantitative data are being collected over time.

Queries for the evaluation of aspen forest indicator data are based on simply summarizing and displaying indicator data results.

Aspen Forest Query 1 - Stems/ha

This query calculates the total stems/ha for a forest unit and the total stems/ha for any age class in a selected vegetation unit.

The query is completed by totaling the stem numbers in each age category and over all categories. The total stems are divided by the transect area in square metres to arrive at stems/m^2. This number is subsequently multiplied by 10,000m^2/ha to arrive at stems/ha.

total stems / transect area x 10,000 = stems/ha

Aspen Forest Query 1 - Table Displays

Results can be effectively reviewed in table format for one or more aspen forest vegetation units or alternatively, for ecosite management units.

Table 20. Aspen Forest Stems/ha

Veg Unit	Date	Suckers	Saplings	Sub-canopy	Canopy	Total

Aspen Forest Query 1 - Map and Graph Displays

Results can be easily graphed for individual vegetation or management units. These can be presented as individual graphs or can be thematically mapped in association with the selected diagnostic land unit.

Aspen Forest Query 2 - Percentage of Stems/ha Browsed

Query 2 expresses stems/ha browsed for individual age classes as a percentage of the total stems/ha for the age class, or as a percentage of the total stems/ha for a selected vegetation or management unit. The total stems/ha browsed in each age category are divided by the total stems/ha and multiplied by 100.

Aspen Forest Query 2 - Table Displays

The results of the query can be displayed and browsed effectively in table format.

Table 21. Aspen Forest % Stems/ha browsed

Veg Unit	Date	Suckers	Saplings	Sub-canopy	Canopy	Total

Aspen Forest Query 2 - Map and Graph Displays

Results of Query 2 can also be presented as individual graphs or be thematically mapped in association with selected diagnostic land units.

6.5 Aspen Forest Monitoring Results

Results were compiled into two individual tables. One table displays stems/ha by age category, while the other displays stems/ha browsed expressed as a percentage of the total stems/ha in each age category. Results are arranged by individual vegetation units sampled in 1997. The results are presented in Tables 22 and 23.

Table 22. Aspen Forest Stems/ha by Age Category 1997

Veg Unit	Suckers	Saplings	Sub-canopy	Canopy	Total Stems/ha
AF0702	1250	2941	813	1188	6192
AF0802	1583	1250	83	667	3583
AF0804	1111	889	667	333	3000
AF0901	1389	1778	194	667	4028
AF0902	2000	0	167	333	2500
AF1703	1405	1000	446	987	3838
AF1704	539	2115	1173	981	4808

Table 23. Aspen Forest % Stems/ha browsed 1997

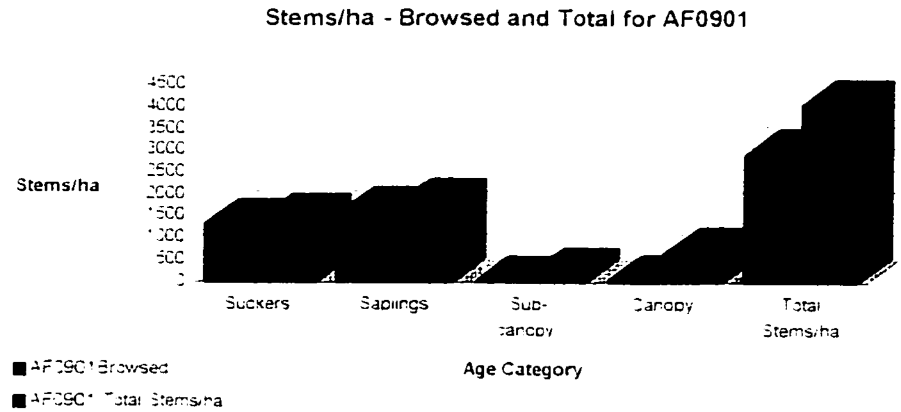
Veg Unit	% Suckers browsed	% Saplings browsed	% Sub-canopy browsed	% Canopy browsed	% Total stems browsed
AF0702	100	98	23	63	81
AF0802	47	100	0	12	58
AF0804	80	100	100	17	83
AF0901	94	88	0	4	71
AF0902	96	0	50	75	92
AF1703	70	93	27	29	60
AF1704	57	75	52	31	58

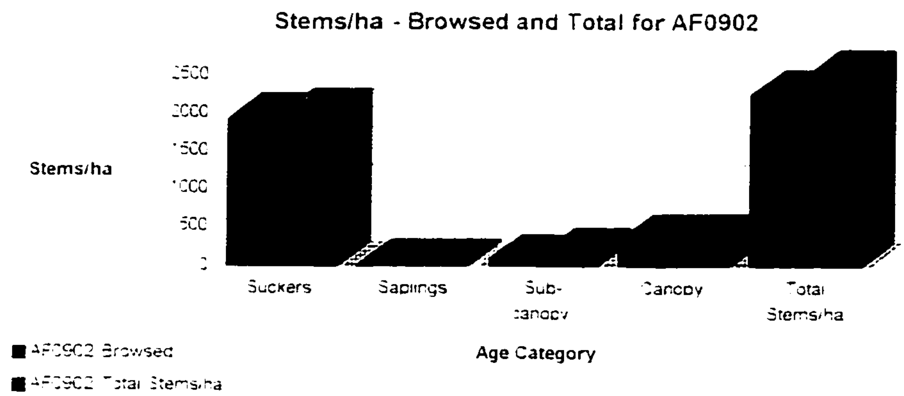
In Figure 16 forest monitoring data results for three selected forest units on the Conservation Area are graphically represented. AF0901 and AF1704 are classed as old growth forest units while AF0902 is a mature forest unit.

Natural regeneration of aspen forest stands appears to be taking place in all forest units as evidenced by the number of suckers found in each stand, and by the mix of non-canopy trees in the stands. Within old growth forest units, considerable numbers of suckers have progressed to the sapling stage. The mature forest unit appears to have a higher rate of sucker mortality - few trees have progressed to the sapling stage. This trend is characteristic of a mature forest unit. Many suckers emerge, but the lack of light due to canopy closure causes considerable sucker mortality (Perala 1991). The reason for the results in AF0902 may simply be timing. Suckers may not have had time to progress to the sapling stage. The results may also be due to excessive browsing. Ninety six percent of the suckers exhibit signs of browsing and this may be preventing suckers from maturing to the sapling stage.

Browsing pressure appears to be substantial on suckers and saplings in all three forest units. However, it is unclear at this stage if browsing pressure is inhibiting the progression of forest succession. The results for AF1704 suggest that forest succession may be taking place while the results for AF0901 suggest that succession may be suppressed by one or more factors. If forest regeneration is taking place an increase in the number of subcanopy trees would be expected over time. Caution is required when evaluating forest progression over time since some mortality of young trees is to be expected as aspen forests naturally thin themselves.

In general it appears that aspen forests on the Conservation Area have been successful at regenerating naturally to this point. Whether this will continue is not clear from the results of one set of data. The primary recommendation of this study is to continue to monitor aspen forests at regular intervals, especially in light of the high percentage of browsed trees in the sucker and sapling stages. An increase in browsing pressure on canopy and subcanopy trees and depressed numbers of suckers and saplings would be a good indication that browsing ungulates are affecting aspen regeneration and that management intervention may be required.





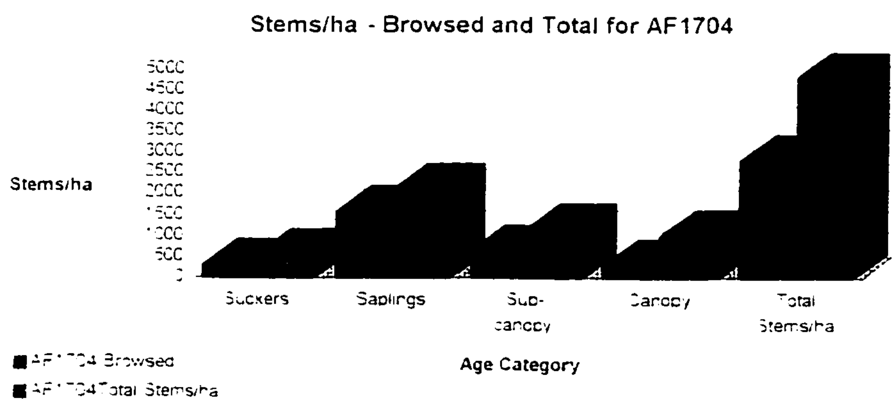


Figure 16. Aspen Stems/ha in Selected Forest Units

Stems/ha browsed and total stems/ha for selected aspen forest vegetation units on the Ann and Sandy Cross Conservation Area - 1997.

6.6 Chapter Summary

Aspen forest monitoring was not seen as a high priority for the Conservation Area in light of the threats imposed on native grasslands. Nonetheless, indicators were chosen based on threats to the regeneration of aspen forests as documented for other locations in Alberta. Data collection for the basic indicators chosen - tree age class, stems/ha, and percentage of stems browsed - can be collected all at the same time by simply counting trees in various age classes as browsed or unbrowsed along established forest transects. Data analysis is designed to graphically illustrate the results of summarized data based on vegetation or ecosite management units.

In general, data results indicate that aspen forests on the Conservation Area have been naturally regenerating to this point in time. Data collection and analysis could be refined to include a more detailed quantifiable evaluation of canopy closure, tree size and age, snags, and downed woody material. The establishment of permanent forest plots may be a more suitable method of quantitatively evaluating this information over time. Such an evaluation would provide considerably more detail for the evaluation of individual aspen forest patches and for the evaluation of aspen forest at the ecosite scale.

The validity of pursuing a more detailed survey of aspen forest indicators is questionable at this stage of monitoring, as the threats to native grassland and riparian habitat on the Conservation Area are of a higher priority. A more detailed survey would involve considerably more time and resources that might be better spent on implementing management strategies for the grassland and riparian areas. In addition, Alberta Fish and Wildlife is actively reducing the elk population in the area through a relocation program. This will reduce browsing pressure and should alleviate threats to aspen on the Conservation Area.

7.0 Project Summary and Recommendations

In this chapter management recommendations from Chapters Three through Six are summarized and presented as habitat management priorities for the Conservation Area. Implementation of the monitoring system is outlined by reviewing the steps required to finish the construction of the GIS and database, and by providing a monitoring schedule that acts as a guide for planning future monitoring activities. Additional recommendations for further study or management action, apart from those discussed throughout the document, are reviewed. A section on closing remarks concludes this chapter and the overall document.

7.1 Management Priorities

The most pernicious threat to the integrity of the Conservation Area as habitat for native species of wildlife is the relatively small amount of remaining native grassland. The gradual loss of this grassland habitat reduces the number of species that can effectively utilize the Conservation Area as habitat, and impacts the ability of the area to support an important historical ecological function - that of providing winter forage for a host of range species including bison, elk and deer. Management priorities for the Conservation Area should be oriented towards protection and enhancement of native grassland habitat.

Management Priority #1 - Top habitat management priority should be placed on the protection and enhancement of existing native grasslands. Management actions to include:

1. Development of a deferred grazing rotation
2. Restricting grazing to the fall and winter seasons
3. Excluding cattle in the spring and summer seasons
4. Development of a controlled burning cycle
5. Active control of exotic grass and weed species such as smooth brome and Canada thistle
6. Active promotion of native species through reseeding and transplanting

Details on these recommendations are in Section 4.5.

Management Priority #2 - Priority should be given to weed control in tame pastures. Canada thistle densities are high in some pastures. Toadflax and leafy spurge are found in isolated patches. There are ecological, aesthetic, social and legal implications to not controlling these weeds. Management actions to include:

1. Mowing or haying selected pastures twice a season. This will help to eliminate Canada thistle or reduce densities to acceptable levels. Candidate pastures for this type of management are reviewed in Figure 7 in Chapter 3.
2. Repeated defoliation of Toadflax and leafy spurge patches which will reduce root reserves
3. Selected herbicide application as deemed appropriate

Details on these recommendations are found in Section 3.5.

Management Priority #3 - Priority should be given to the replacement of native forage production throughout the Conservation Area. A long term approach could include native grassland restoration. A short term approach could include the reseeding of selected pastures or hayfields to native grass and forb crops that cure on the stem. Restoration will provide more native habitat for dependent species and reseeding will help to fulfill the ecological function of providing winter forage to grazing animals. Management actions to include:

1. Weed control measures and cultivation as preparation to seeding for native grassland restoration
2. Weed control measures, cultivation, and reclamation of tame pastures to native forages

Candidate pastures and vegetation units for both of these management actions are reviewed in Figure 7 in Chapter 3. Details on reclamation and restoration recommendations are in Section 3.5.

Management Priority #4 - Protect and enhance riparian areas through development of a water management plan. Management recommendations include:

1. Fencing and grazing of riparian areas as separate land units
2. Exclusion of cattle from riparian areas except when specifically grazing the area
3. Development of mobile water systems to reduce the impact of cattle on all riparian sites including dugouts and "improved" springs
4. Control of weeds such as Canada thistle through bi-yearly clipping and removal
5. Examination of existing dugouts to see if natural water flow is being maintained and if modifications can be made where necessary

6. Revegetation of existing dugouts as appropriate with native upland grasses, riparian wetland vegetation, and emergent vegetation

Details on riparian zone management are in Section 5.6.

7.2 Implementation of the Monitoring System

7.2.1 GIS and Database Design and Construction

The scope of this MDP addressed the design and construction of the basic elements of the GIS and database management and monitoring system. However, an operational system has not been fully established by this MDP. The full implementation of the system requires that a series of steps, primarily related to the construction of the computer elements, continue to take place. The steps required to complete the construction of the monitoring system are:

1. Design and creation of data input forms in Access
2. Enter existing data into Microsoft Access tables
3. Database and GIS documentation
4. Design and programming of query operations
5. Design and programming of user interface and application program
6. System testing
7. System revision as required

The monitoring system will be designed to be user friendly for Conservation Area staff and volunteers. However, the design and construction stages will have to continue with the assistance of GIS and database professionals. Maintenance and updates of the system may also require the timely assistance of professional consultants.

7.2.2 Monitoring Schedule

Most of the indicators selected for the monitoring system will not need to be evaluated every year. For example, management actions applied to rough fescue grasslands may suppress rough fescue for several seasons before recovery takes place and the long-term effects of management are known. Monitoring annually may give the best results but may be prohibitive for the Conservation Area budget and available human resources. On the other hand, some information needs to be collected on an annual or seasonal basis to provide consistency in results. Wildlife observations fall into this category. The proposed monitoring schedule for the various groups of indicators selected for the Conservation Area monitoring system follows below.

Indicator Group	Timing	Date of next observation
Wildlife	annually	Jan 1998
Waterfowl	annually	April 1998
Stream Flow	monthly	April 1998
Native Grasslands Vegetation	every 3 years	July 2000
Riparian Vegetation	every 3 years	July 2001 to stagger with native grasslands
Forest Structure	every 5 years	June 2002
Ecosite Vegetation Analysis	every 5 years	June 2002
Grazing use AUMs	annually	ongoing
Grazing carrying capacity	every 5 years	June 2002 coordinated with ecosite vegetation analysis
Weed Density	annually	July 1998

7.3 Additional Recommendations

The purpose of this section is to discuss briefly additional observations made during the course of this project that did not seem to fit within any of the main Chapters of the document. Suggestions are proposed with regard to weather and climate observations, sharp-tailed grouse reintroduction, grasslands wildlife, bison grazing and scientific research.

7.3.1 Weather and Climate Observations

As noted in the summary of Chapter 3, weather and climatic factors have considerable influence on wildlife. Weather in the region of the Conservation Area is highly variable on a spatial and temporal basis. Consistent and accurate meteorological observations made specifically on the Conservation Area, would contribute to regional data as well as having considerable application to the evaluation of indicators of ecological integrity on the Conservation Area. Being an area of relative stability in terms of regional development, the Conservation Area may be a prime candidate for an automated weather station sponsored by Environment Canada.

7.3.2 Sharp-tailed Grouse Reintroduction

Discussions have taken place between the Conservation Area management and Provincial authorities with regard to reintroduction of sharp-tailed grouse to the Conservation Area. While this seems like a worthwhile endeavor, there are issues arising from the results of this project that should be considered prior to reintroduction attempts. The most obvious question to arise is why are sharp-tailed grouse gone in the first place. Sharp-tailed grouse rely on high quality native habitat and the results of this project indicate that native grassland habitat has been compromised across the Conservation Area in terms of quantity and quality. A specific habitat evaluation should be completed prior to the release of any birds, and other potential impacts on birds should be identified and mitigated as part of this type of endeavor. In light of the uncertainty as to their disappearance, it would be expedient to radio tag any birds that are released in order to track their locations and monitor their fate.

7.3.3 Wildlife

Initial observations of grassland wildlife indicators would suggest that grassland wildlife species are not found in abundance across the Conservation Area. Improvements made to the Area Steward patrols may result in a more accurate estimate of grassland species distribution on the Conservation Area. However, it would be reasonable to suggest that initiatives to specifically survey or study grassland wildlife on the Conservation Area should be supported if the opportunity is presented. Other wildlife research is also important to the identification of indicators and to estimates of species diversity on the Conservation Area. Recommendations for wildlife research include becoming involved with the North American Breeding Bird Survey, and a survey of amphibians and riparian mammal populations. When more detailed species information is available, the selection of wildlife indicators, and the subsequent data collection and analysis, should be refined and incorporated into the monitoring system. Soliciting University or College projects may be an inexpensive means of gaining more information on the status of wildlife species on the Conservation Area.

7.3.4 Bison Grazing

Through the course of researching and writing this MDP, it has become apparent that there are a number of compelling reasons to consider bison grazing as an alternative or replacement to cattle grazing on the Conservation Area. Aside from aesthetic and nostalgic reasons to have bison on the Conservation Area, there are potential benefits to both the maintenance of native habitat, and to the management effort required to maintain native habitat. Potential benefits are summarized as follows:

- Bison are large grazers native to North America not domesticated animals of Middle Eastern origin such as cattle.
- Bison are hardy and naturally adapted to the climate, vegetation, and water supply of the prairies.
- Bison readily graze in more xeric areas and graze a wider variety of vegetation than cattle.

- Bison tend not to loiter in riparian areas - less fencing and less water development, water hauling, or water management may be required.
- Because bison are more mobile than cattle, less fencing and control of movement is required.
- Bison maintain different nutrient cycling characteristics than cattle.
- Bison are naturally intensive grazers, and it may be easier to mimic native grazing patterns simply by replacing cattle with bison.

Bison are not likely a cure-all for ecosystem management on the Conservation Area. Specific management and protection of fescue grasslands will still be required. Bison typically require sturdier fencing than cattle, which is expensive and may inhibit other wildlife movement. There are genetic and disease related issues in the management of bison as with any aspect of game ranching. There are visitor safety issues that would have to be addressed. However, there are compelling reasons to at least consider the return of bison to the Conservation Area. There may be many unknown benefits to replacing one of the key elements in historical prairie ecosystems. The return of bison is certainly consistent with the mandate of the Conservation Area. A feasibility study is recommended as a first step to replacing bison on the Conservation Area.

7.3.5 Scientific Research

The monitoring system designed as the main focus of this project should be viewed as a first step to the implementation of an adaptive, ecosystem, approach to management of the Conservation Area. One of the intentions of the project was to provide a monitoring system simple enough in terms of commitment to time and money, and in terms of analysis, to encourage its use in the future. Research and monitoring should not end with the completion of this project. Modifications, additions, and deletions should be made to the monitoring system as results come in and new information becomes known. New, and more detailed research initiatives should be entertained by the Conservation Area, if they contribute to monitoring and management and are consistent with the goal of having a 'do-able' monitoring system. Verification studies in particular, should be pursued by the Conservation Area and may be appropriate projects for University or College involvement. A list of possible research initiatives includes:

- Surveys of grassland wildlife, breeding birds, amphibians, riparian mammals
- Refining the selection and analysis of wildlife indicators
- Research to define a historical baseline for vegetation analysis on the Conservation Area
- Research into monitoring visitor impacts and incorporation into the monitoring system
- Expansion of regional scale monitoring and coordination with ecosite scale monitoring
- A feasibility study for the inclusion of bison grazing
- Incorporation of climatic data into the monitoring system

7.4 Closing Remarks

> *At the same time that we are earnest to explore and learn all things, we require that all things be mysterious and unexplorable, that land and sea be infinitely wild, unsurveyed and unfathomed by us because unfathomable.*
>
> Henry David Thoreau (1854)

The greatest challenge to the completion of this project was to simplify an overwhelmingly complex, and poorly understood, body of information into a monitoring system that could be easily understood, applied, and maintained over time within the operational constraints of the Conservation Area. As results and observations came in from the field it became clear that not all was well with Conservation Area habitat. It also became clear that more information needed to be collected over time in order to produce results that could be considered to be statistically valid or to describe scientifically valid relationships. It was clear that we did not know enough about the ecosystem, and yet it was clear that something had to be done to protect habitat while learning more about the system.

It also became clear through the course of completing this project that the complexity of ecosystems makes it very difficult to know how to even start to manage them with any degree of efficiency. While we cannot manage ecosystems, we can manage our own human activities. The monitoring system and the management recommendations presented in this MDP are intended to ensure that natural ecosystem components, structure, and processes are not impeded by human activities. Nature can then take its course.

My sincere hope as author, is that this system can be applied effectively by the Conservation Area to align human activities with ecosystems, and that the model presented here can be adapted to other situations, locations, and organizations with similar goals.

> *Human management, even the most intelligent and enlightened, is not as effective at facilitating species preservation at multiple trophic levels and maintaining sustained levels of productivity as are the mechanisms produced by 50 million years of evolution, including coevolution, of grasses, the herbivores that feed on them, and other members of natural grassland trophic webs.*
>
> S.J. McNaughton (1993)

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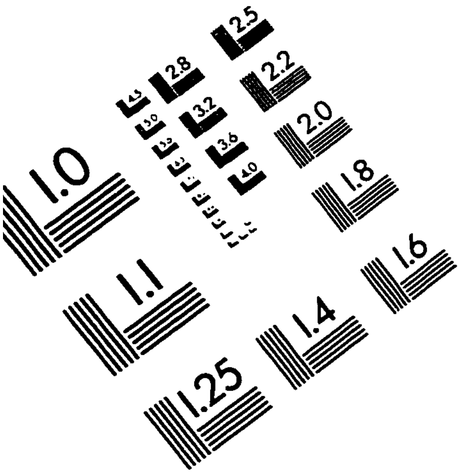
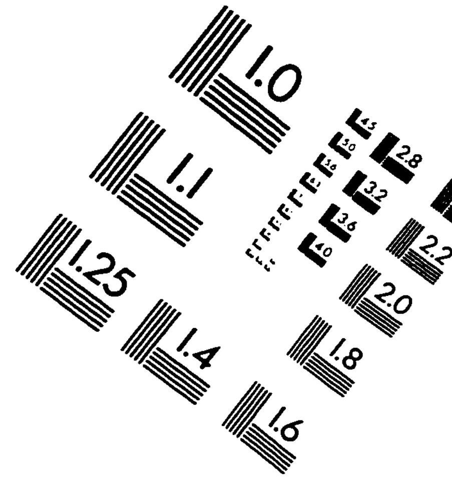
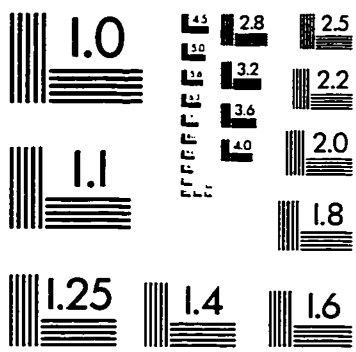
IMAGE EVALUATION TEST TARGET (QA-3)



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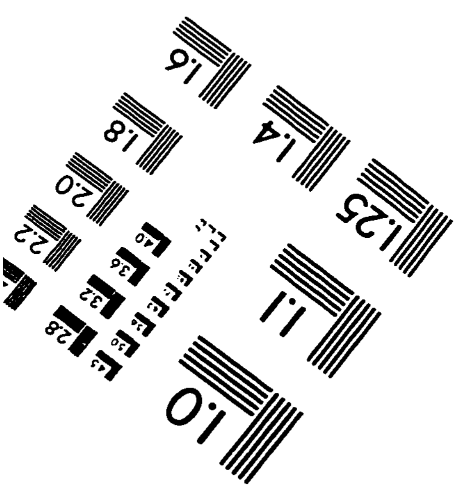
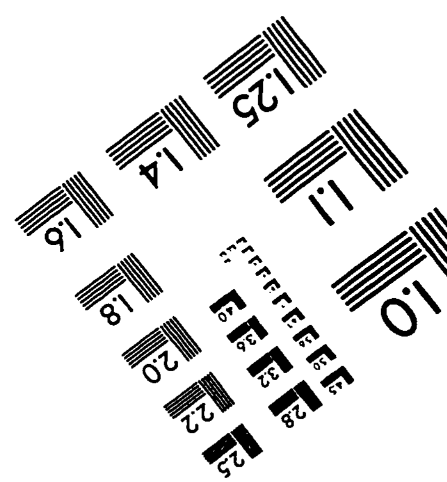

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