A STRATEGY FOR LANDSCAPE PLANNING IN THE COUNTY OF PARKLAND, ALBERTA

by
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Master of Natural Resources Management

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A STRATEGY FOR LANDSCAPE PLANNING

IN THE COUNTY OF PARKLAND,

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BY

ANNE CAROL BASSO

A practicum submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF NATURAL RESOURCES MANAGEMENT

ABSTRACT

Private land management at the individual level strongly affects the sustainability of wildlife populations in the County of Parkland, Alberta. Landscape Ecology principles were used to develop a strategy for land management and planning, and, in doing so, facilitate maintenance of natural habitat for wildlife. Specific objectives included the identification of Landscape Ecology principles applicable to the County of Parkland; identification of existing habitat types and distribution patterns; assessment of habitat availability and suitability for indicator wildlife species; and, identification of goals and strategies for habitat management within Landscape Units in the County of Parkland.

Objectives were met using air photos from 1949 and 1987 to determine amount of land clearing in sample sections throughout the County. A Reconnaissance Vegetative Inventory within a GIS was also used to determine the available habitat and distribution pattern of coniferous forest, treed riparian areas, wetlands, shrub and deciduous areas, tall deciduous, and general upland vegetation.

The County is an agriculturally dominated landscape. Although the County has the capability of supporting vegetative habitat and associated wildlife species ranging form grasslands through coniferous forest, the vegetation available is fragmented and scattered throughout the County. Four main types of areas of conservation interest involve riparian areas, wetlands, remnant forested patches and fencerows. More deciduous dominated forest exists in the County than coniferous forest and generally these remnant forest patches are associated with wetlands or riparian areas. The establishment of additional upland cover associated with the two wetland areas in Glory Hills and Banksiana moraine, and of riparian buffer zones along stream, creek and river corridors would make more habitat available for a greater diversity of species. Retention and enhancement of the remnant coniferous patches of habitat located in the western half of the County is desirable, as is the maintenance of remnant patches of shrub and tall

deciduous habitat located north of Lake Wabamun, and along the Pembina and North Saskatchewan Rivers. Since most of the land in the County is under private ownership, landowner cooperation is necessary for habitat retention and enhancement. Individual habitat retention agreements should also be pursued by Fish and Wildlife Services along stream and creek corridor, and adjacent to wetland areas. A conservation program should be established in the County, along with a land stewardship program.

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CHAPTER 1
INTRODUCTION

1.1 Background

Land use planning often occurs at the local level in cooperation with provincial agencies and is based on political boundaries rather than ecological designation. Political boundaries tend to be drawn along lines that are convenient for people to identify and manage. However, the pattern of vegetation, and the associated wildlife, is determined by physical features of the landscape which may cross political boundaries. The result is a varied landscape within a political boundary beyond which landscape characteristics and wildlife still continue to exist.

The formulation of a set of sound conservation goals for a given area can assist in the formation of a comprehensive, ecologically based management plan. A new approach to land use planning, that consciously seeks sustainability, would be more beneficial to the management of transboundary environmental and ecological resources. The County of Parkland has indicated an interest in and sought advice on conservation management. Landscape Ecology is an accepted discipline which addresses concerns of sustainability, conservation and utilization of transboundary resources that are crucial to the management of ecosystems. Landscape Ecology can be used as a vehicle to move towards sustainable land use planning.

Although the principles of Landscape Ecology could be applied to both large and small scales, local-level county management may be justified for two reasons: 1) most actual land use impacts occur at this point and could conceivably be controlled or modified more readily at the local level, and 2) Counties in Alberta are responsible for land use planning within their jurisdictions. This study could be used by the County of Parkland to assist with future land use planning and management.

1.2 Study Area

The County of Parkland in the province of Alberta, extends from Edmonton west to the Pembina River, and is bordered on the south by the North Saskatchewan River (Figure 1). These boundaries encompass 2759.95 km^2, and contain a population of 22 500 people (1992 statistics; County of Parkland Office). The Town of Stony Plain and the City of Spruce Grove are the largest population centers. There are also two Indian Reserves wholly within the County: Stony Plain Indian Reserve (#135) which has an area of 51.9 km^2, and Wabamun Indian Reserve (#133A) with an area of 61.8 km^2 (Folinsbee, 1987).

The County of Parkland is covered by Wildlife Management Units (WMU) 248 (Edmonton) and 336 (Wabamun). A small provincial park, Wabamun Lake, is located on the northeast corner of Lake Wabamun. The County contains two large lakes: Isle Lake and Lake Wabamun, the latter of which is known for its whitefish *(Coregonus clupeaformis)* production. There are numerous small lakes throughout the County. There are three active open-pit coal mines in the County; Sundance, Keephills and Whitewood mines, which supply three power plants in the area. The Jackpine Provincial Grazing Reserve, located on provincial public lands within the County boundaries, covers 51.5 km^2 (Folinsbee, 1987).

The County of Parkland encompasses four ecoregions (Strong 1992c). Aspen Parkland covers Edmonton and part of the east side of the County. To the west is a band of Low Boreal Mixedwood then Mid Boreal Mixedwood. A small area of Lower Boreal Cordilleran is found in the southwest corner of the County. In general, land use within the County progresses from urban fringe through heavily agricultural with limited deciduous tree cover to less agricultural with a higher component of coniferous cover.

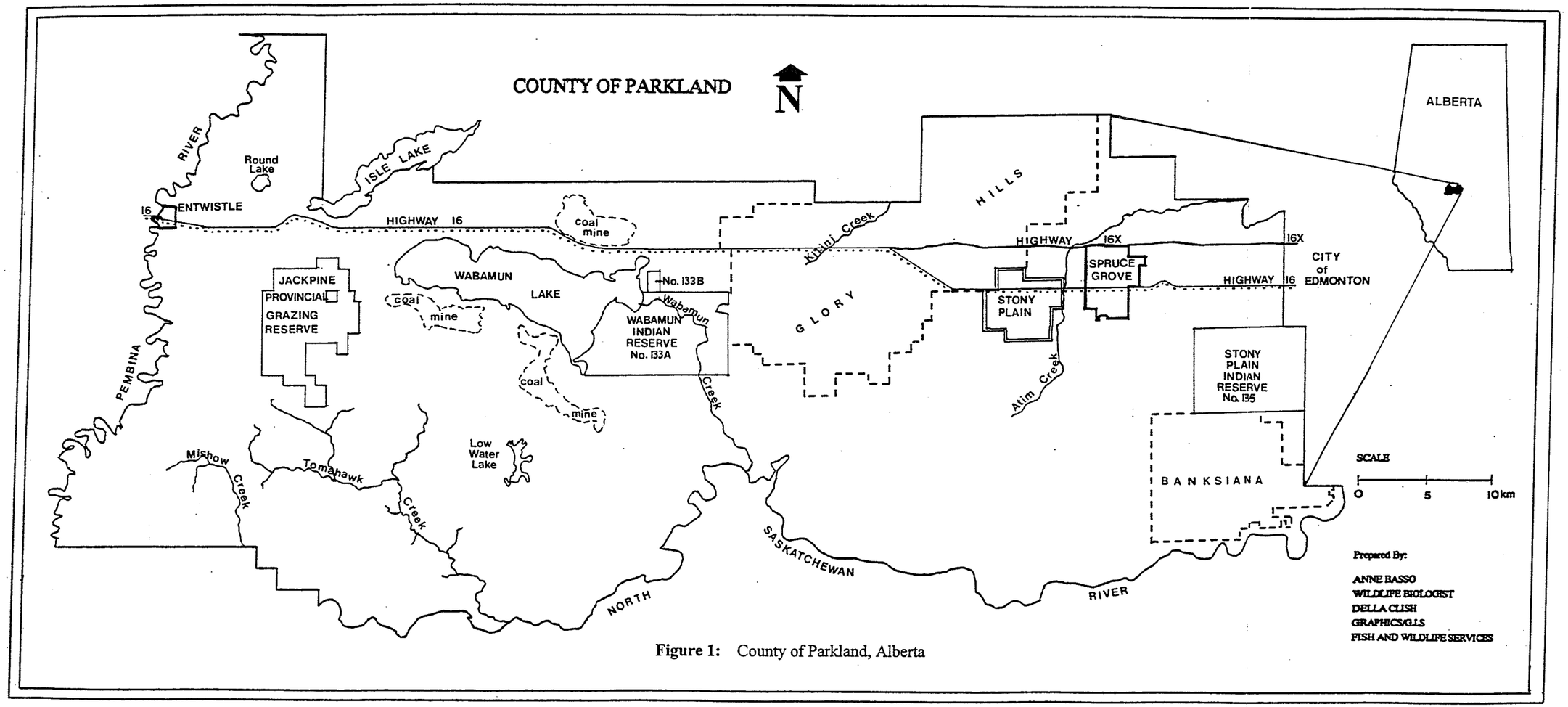


Figure 1: County of Parkland, Alberta

Most of the land, close to 90%, within Parkland County is privately owned (Kulak 1993; pers. comm.).

1.3 Issue

Although provincial and local government agencies have responsibilities for managing public resources, private land management at the individual level strongly affects sustainability of wildlife populations in the County of Parkland. One way to improve land management plans and to minimize conflicting interests could be through the application of Landscape Ecology principles. This landscape based approach has been applied to the County of Parkland in Alberta in this study.

1.4 Objectives

The primary objective of this study was to develop a strategy for habitat management for the County of Parkland in Alberta using ecologically-based principles for land management and planning.

Specific objectives were:

1. to identify principles of Landscape Ecology Theory which could be applied in the County of Parkland;
2. to identify existing habitat types, extent and distributional patterns in the County;
3. to assess habitat availability and sustainability for various indicator wildlife species within the County; and,
4. to identify possible goals and provide strategies for habitat management in the County.

1.5 Limitations

1. The study used existing data sources (no new field data collection or survey was undertaken for this study).

2. The classification system of the Reconnaissance Vegetation Inventory (RVI), and its scale of 1:100,000, influenced the indicator species that were chosen.

3. Habitat ratings for indicator species of good, fair and poor were established solely on the basis of vegetative cover. The size of the polygon was not considered in species habitat ratings.

4. The RVI had a number of characteristics that limited some aspects of this study. The minimum polygon size identified was $1cm^2$ at 1:100,000 (which is $1km^2$). Although this appeared relatively small on the map, habitat contained within that area may have been very diverse. Polygon descriptions were long and the habitat varied greatly within the polygon itself, making it difficult to select information for different habitat types. Percentages assigned to vegetation complexes were not broken down for each part of the complex, so they were not able to be separated into their component parts. As a result, the coding for the percentage may be in a complex with another vegetative cover type and thus may only exist as part of the percent given for it, e.g.: CA/NWL^5. If each of these is taken separately, the database will assign each one the value of 50%, even though together they make up 50% of the polygon at any ratio. Usually the first descriptor is the one that represents a higher percentage of the polygon, but it could also be 40%:10%, or 30%:20%, or 25%:25%. As a result, very few distinctions within the polygon descriptor could be made.

1.6 Assumptions

This study assumed that the species chosen as indicators will utilize similar habitat types and vegetative communities as those that will satisfy the habitat requirements of the associated species (Appendix G).

1.7 Justification

The County of Parkland has expressed an interest in retaining wildlife habitat. In order to incorporate habitat and wildlife values into the County landscape, Alberta Environmental Protection, Fish and Wildlife Services, has agreed to assist the County of Parkland to help them reach this goal.

Conservation objectives often contain specific wildlife goals which in turn have implications for managing vegetative communities. An integral part of land management planning are strategies for maintenance of soil and water of sufficient quality and quantity to maintain the standards presently enjoyed within the County of Parkland. Wildlife have been selected to serve as indicators of certain broad habitats and, therefore, representative of other wildlife species that use similar habitats. Since the RVI was used to identify the availability of broad habitat types at a County-wide scale, the RVI was appropriate for this study. The need for local, private land stewardship is vital in settled areas of Alberta. Management of wildlife habitats is an important consideration since the same areas and landscape qualities that satisfy human needs also satisfy wildlife needs. Strategies recommended in this proposal may be applicable in other counties in Alberta and elsewhere.

1.8 Glossary of Terms

corridor:	a narrow strip of land that differs from the matrix on either side. (Forman and Godron, 1986)
disturbance:	an event that causes a significant change from the normal pattern in an ecological system. (Forman and Godron, 1986)
ecology:	the scientific study of the relationships between organisms and their environment. (Forman and Godron, 1986)

ecosystem: all of the organisms in a given place in interaction with their nonliving environment. (Forman and Godron, 1986)

ecotone: a relatively narrow overlap zone between two communities. (Forman and Godron, 1986)

edge effect: a tendency for increased (organism) variety and density at community junctions. (Odum, 1971)

fragmentation: the disruption of continuity . (Lord and Norton, 1990)

habitat: a place or area where organisms or populations naturally live. (Saskatchewan's Round Table on Environment and Economy, 1992)

landscape: a heterogeneous land area composed of a cluster of interacting ecosystems that are repeated in similar form throughout. (Forman and Godron, 1986)

Landscape Ecology: a study of the structure, function, and change in a heterogeneous land area composed of interacting ecosystems. (Forman and Godron, 1986)

matrix: the most extensive and most connected landscape element type present, which plays the dominant role in landscape functioning. Also, a landscape element surrounding a patch. (Forman and Godron, 1986)

patch: a nonlinear surface area differing in appearance from its surroundings. (Forman and Godron, 1986)

patchiness: the density of patches, or the fineness of a mosaic. (Forman and Godron, 1986)

Sustainable Development: the ability to meet the needs of the present without compromising the ability of future generations to meet their own needs. (World Commission on the Environment and Development, 1987)

CHAPTER 2
REVIEW OF RELATED LITERATURE

2.1 Historical Overview of Landscape Ecology

The concept of landscape ecology deals with the interrelationship between human society and its living space (Naveh and Lieberman, 1984). The term was first used by German ecologist and geographer Carl Troll in 1939, to describe patterns in landscape use observed in aerial photographs (Zonneveld and Forman, 1990). The concept of landscape ecology evolved in Europe, primarily in Germany and Holland, through the interaction of geographers and ecologists/biologists and their understanding of the interconnectedness of man as a part of the environment. With these early beginnings, the European community established a foundation for landscape ecology within its academic and institutional hierarchy.

Egler (1942), a plant ecologist, coined the phrase 'total human ecosystem'. He was one of the first scientists in North America to articulate the idea of man and vegetation interacting to produce changes seen in the landscape (Naveh and Leiberman, 1984). Egler was followed by another North American in 1957, Pierre Dansereau, who used the holistic approach to ecology and landscape (Naveh and Leiberman, 1984). Although the concept underlying landscape ecology existed in North America, the development of landscape ecology in North America did not gain momentum until relatively recently. Hansen and di Castri (1992) wrote that the acceptance of landscape ecology as a concept began in the 1980s in North America with the realization that an ecological system may be heterogeneous. This important realization encouraged thought away from the stereotypical idea of only homogeneous areas functioning as ecosystems. Landscape ecology and ecosystem management are interrelated. Ecosystem management

builds upon developments made in the fields of landscape ecology and landscape planning.

2.2 Current Concepts of Landscape Ecology

In landscape ecology scale is the central issue, however, in planning it is often limited by political boundaries (Hall 1991). In heavily settled agricultural areas landscape planning, therefore, is the combination of landscape ecology and human ecology. Pesticide residues, topsoil erosion, ground water depletion and contamination are large problems on agricultural landscapes that can be addressed by landscape ecology. By focusing on interrelationships between the systems of the landscape and changing human values and expectations, landscape planning goals can be shaped by those who are affected by those goals.

The driving forces of landscape processes include patch dynamics (the concept of ecotones defining landscape patches) and the interaction of climate, disturbance and biotic factors (Hansen and di Castri, 1992). These forces serve to define different types of boundaries upon the landscape.

Boundaries between two different landscapes affect the export and import of energy and materials, and these in turn, influence the characteristics of the boundary itself (Ambrose and Bratton, 1990). Both biotic and abiotic factors may alter patch boundary locations through the creation of disturbances (Weins et al., 1985). Boundary dynamics is a more recent term used to describe ecotones of landscape features. This term treats boundaries as distinctly separate entities with differing biomass, soil characteristics, species composition, and abundance. The focus is on how boundaries influence ecological processes and vice versa (Gosz 1991). Human management of the landscape often creates or sharpens boundaries between managed and natural systems, and these boundaries often correspond to natural landscape features (Correll 1991).

Landscape ecology ..."is now being increasingly recognized as the scientific basis for land and landscape appraisal, planning, management, conservation, and reclamation, replacing consequently many fields of applied ecology and geography to which the rather vague prefix 'environmental' has been given," (Naveh and Leiberman, 1984, p. xi). Part of the increased interest in landscape ecology may be due to the increasing attempt to apply the large body of environmental knowledge to practical situations (Hansen and di Castri, 1992). Landscape ecology is based on applicability of its concepts. Richardson (1989) says that what is done with land is done to a portion of the ecosystem, and encourages the thinking that this land base is shared by the ecosystem and the economy and, as such, should be planned in the context of an ecosystem.

2.3 Structural Principles of Landscape Ecology

Landscape ecology specifically considers "...(1) the development and dynamics of spatial heterogeneity, (2) interactions and exchanges across heterogeneous landscapes, (3) the influences of spatial heterogeneity on biotic and abiotic processes, and (4) the management of spatial heterogeneity " (Turner and Gardner, 1991). There are also three main characteristics of the landscape that must be considered when making assessments or management decisions. They are: structure, function and change. The relation of these three components to space, time and scale must be considered (Turner and Gardner, 1991).

Realizing that there is inherent interconnectedness in ecosystems, the possibility always exists for a change in one factor to affect the whole ecosystem. Ecological processes operate at different time scales (Turner 1987). Changes in ecotones can be gradual or abrupt, and changes in the time that an ecotone develops can be gradual or sudden (Hansen and di Castri, 1992). Disturbance contributes to landscape pattern, and

heterogeneity may help or hinder the spread of disturbance (Turner 1987). It is important to note that disturbances are more likely to spread over areas spatially homogeneous than those that are heterogeneous. The extent of this is determined by factors such as boundary sharpness, scale, and the magnitude of disturbance (Wiens et al., 1985). There is a distinct edge community between two different habitats, in part due to natural disturbances such as fire and windfall, which create transition zones (Hansson, 1991). Thus, there are differences between landscape ecologies of original and altered areas. The different types of disturbances result in three basic landscape structures: patches, corridors, and matrices. Fragmentation, juxtaposition and the type of boundaries that exist in conjunction with these structures are important to the dynamics of the landscape.

Patches occur as one (or a combination) of five types: spot disturbance patch (caused by a small disturbance in one area of the surrounding matrix), remnant patch (caused by disturbance to the whole area surrounding the patch), environmental resource patch (present due to the normal heterogeneous distribution of resources in the environment), introduced patch (due to anthropogenic introduction of species), and an ephemeral patch (caused by normal short-lived variations in resource levels) (Forman and Godron, 1981; Godron and Forman, 1983).

Patch size, the amount of edge and the shape of the edge are important variables of patches in a landscape. Species diversity is strongly correlated with patch area , but it usually includes habitat diversity as well. Amount of edge available depends upon the shape of the patch, which has a large influence upon the suitability of habitat for various species. Wind, sun direction and degree of their penetration into and through the patch are all important determinants of the width of the edge of a patch. A narrow patch may only consist of edge, with no interior habitat present. This lack of interior habitat will

limit the number and type of species that inhabit the patch (Forman and Godron, 1981). Patch sizes are smaller and their edges are straightened with increasing agriculture or urbanization (Godron and Forman, 1983).

The juxtaposition of patches, and the presence and absence of corridors connecting them is important to the amount of interaction that occurs between patches. Four types of corridors exist: line corridors (narrow linear areas often containing edge species and/or allowing human movement), strip corridors (wider linear areas containing some interior habitat), stream corridors (varying width borders along watercourses), and networks (intersecting corridors that may contain loops and alter flows of nutrients, air and water across the landscape) (Forman and Godron, 1981; Godron and Forman, 1983). Line, strip, and network corridors increase with human disturbance of naturally vegetated landscapes, while stream corridors decrease with human disturbance because they are progressively divided into patches and can eventually be eliminated (Godron and Forman, 1983). Plant and animal species that inhabit line corridors are also generally found in patch edges. Continuous corridors are the most effective in the function of connecting patches, and the width of a strip corridor is critical for the movement of interior species. Networks are most evident in areas with high anthropogenic influence.

The presence, condition, and function of corridors are important to the health of the organisms within that landscape. Selman and Doar (1992) list 14 principles of landscape ecological planning with particular reference to species and the importance of corridors. The main thrust of their commentary is that corridors should be connected to woods and that there should be at least two options for the direction of movement in corridor networks.

Fragmentation of habitat resulting from disturbance, serves to spread ecotones throughout the landscape, ultimately resulting in either only linear elements or small

patches with no connections (Merriam and Wegner, 1992). Most landscapes consist of patches surrounded by a matrix, and therefore they are not like oceanic islands, because they do not stand alone. There is the potential for interaction and movement of species between the patch and the matrix. However, the degree of interaction will depend upon the individual species requirements for habitat and ability to adjust to different habitats.

Continuity of an organism's habitat depends upon the organism's perspective of its environment, so different organisms will view the same scale of fragmentation differently (Lord and Norton, 1990). Lord and Norton (1990) provide five general statements of the effect of scale on the impacts of spatial fragmentation: (a) ecosystem function is more likely to be disrupted when fragmented areas are small; (b) simpler systems will not be disrupted by fragmentation as much as complex systems; (c) smaller and smaller organisms are adversely affected the smaller the scale of fragmentation; (d) generalist species are less affected by small scale habitat fragmentation than specialist species; and (e) only very mobile organisms are likely to use coarser scales of fragmented habitat, and smaller scales of fragmented habitat will be used by a wider variety of organisms. The permeability of a boundary to a given organism will vary with organism size as well as with the density of the organisms within the bounded area (Wiens et al., 1985). To gain a full understanding of the consequences of habitat fragmentation the unchanging attributes of the system must be considered along with those attributes that do change (Robinson et al., 1992).

Biological diversity is threatened by man-made fragmentation of habitat, due to the effects of insularization and habitat loss (Wilcox and Murphy, 1985). This is the main cause of the large number of world wide extinctions presently occurring. Fragmentation causes a loss of potential sources of immigrants, a reduction and subdivision in amount of habitat, and conversion of natural habitat between fragments to

habitat with different characteristics from the original habitat. Insularization limits the maintenance of viable breeding populations to smaller areas of habitat.

The degree to which a patch is isolated from other patches of similar habitat, or fragmented, is important to the survival of a wild species population. Isolated patches can manifest population change in two ways: through recruitment within the patch, and immigration and emigration between patches (Fahrig and Merriam, 1985). The minimum patch size able to support species in an area will be linked to natural-historical populations within the area (McCoy 1983) as well as the biology of the species.

Immigration and emigration of organisms from patches varies with a number of factors, one of them being edge permeability. A boundary with a 'hard edge' i.e. fairly impenetrable such as the boundary between an oceanic island and the ocean, will be less permeable for most species than a 'soft edge' boundary as typified by the ability of some species to move between shelterbelts (Stamps et al., 1987). Stamps et al. (1987) found that in a patch with relatively hard edges, the permeability of the edge is the factor that determines emigration; but when the patch has relatively soft edges, the edge to size ratio is the more important determinant. This means in soft-edged insular patches of habitat, patch shape, and patch size may have important ecological effect on immigration and emigration rates. As wooded patches decrease in area, ecotonal area increases. Connections can be made between patches by linear landscape elements (wooded valleys, river valleys, hedgerows, etc.) acting as corridors (Merriam and Wegner, 1992). Forest edges increase as forest interiors decrease, and thus..."..gaps imbedded in a forest become increasingly forest embedded in gaps" (Sauer, 1992: p.28). These gaps are the matrix.

2.4 Methods Used in Landscape Ecology, Past and Present

Historically, the focus of methods used in landscape ecology tended to be upon the socioeconomic use pattern of resources that would best suit man's needs (Phillips et

al., 1978), rather than on retaining the inherent viability of the ecosystems. Emphasis was placed on the view that one use was a constraint on another use (Duinker 1988). This approach focused on production and not protection (Duinker 1988), and primarily economic concerns (Randall 1988) and failed to recognize the separate but interrelated use of the resource base, and the intrinsic worth of the resource base to and of itself.

Traditionally, ecological habitat mapping was done using false color infrared photographs and Landsat images which were incorporated by overlaying them onto topographic maps (Thompson 1978). Now Geographic Information System (GIS) technology can be incorporated readily into landscape ecology (Turner and Gardner, 1991). It can be used to manipulate data to take into account ecological principles and socioeconomic properties of particular units in order to outline a set of alternate land uses. These alternate land uses are decided by ecological capability and socioeconomic needs (Makhdoum 1992). Selman and Doar (1992) present a case study illustrating the advantage of a GIS's capacity to calculate different land use maps based on the percent of land allocated for a particular purpose.

Current GIS technology also allows land use and habitat cover to be overlain on a computer base map representing a geographical location. The system can then be programmed to model effects of management interventions to an ecosystem, in order to evaluate anticipated effects prior to implementation (Levinsohn and Brown, 1991).

2.5 Approaches Related to Landscape Ecology and Sustainable Development in Alberta

The World Conservation Strategy (Pollard and McKechnie, 1986) outlined three major objectives to govern management of living resources: (1) to maintain essential ecological processes and life support systems; (2) to preserve genetic diversity; and (3) to ensure sustainable utilization of species or ecosystems. To this list the Environmental

Council of Alberta has added; "(4) to provide for the recreational , spiritual, aesthetic and other non-material needs of Albertans; (5) to maintain and improve the quality of life in the urban environment; and (6) to use and manage non-renewable resources in the interests of developing a long-term sustainable economy for Albertans", (Swinnerton 1991: p.4).

A main objective in Alberta's Conservation Strategy is to identify interactions among economic resource sectors as a way to find generally acceptable solutions to resource management issues (Usher 1990). The need to look at federal and Provincial legislation pertaining to land use decisions within a given landscape is part of this approach. The conservation objectives for that ecosystem must be set and only then, will it be possible to decide the sustainable extraction capacity (Hamilton 1993). Currently, increasing emphasis is being placed on the concept of sustainable development. The Round Tables in Canada (Alberta, 1991; Manitoba, 1992; and Saskatchewan, 1992) were established to determine how sustainable development could be implemented.

Edmonton's Regional Planning Commission (1976) stated that planning boards at provincial, regional and local levels must collectively decide the best uses and allocation of the environment, especially in light of competing land uses. Suggestions were made that the provincial government develop guidelines for the Province to help municipalities make land use decisions. Although historical settlement patterns have resulted in the location of Calgary and Edmonton on some of the best agricultural land in Alberta (Rural Environmental Sub-Committee of the Public Advisory Committees to the Environment Council of Alberta, 1988) landscape planning could facilitate better decision making in the future.

Areas surrounding an urban center provide both recreational and additional subdivision space for future residents. This land use often entails large costs to the

surrounding rural areas (Swinnerton 1991). The City of Edmonton, which has over 500,000 residents, borders the eastern edge of the County of Parkland, so there is definite need for integrated planning between the City and the County to accommodate the distinctly different land use patterns in rural and urban life (UES, 1988). Swinnerton (1982) expresses concern for the long-term security of Alberta's agricultural land base, noting the impacts of other activities upon this land base, and the resulting decrease in productivity. Resource use does not occur in isolation but within the matrix of the landscape and its inhabitants. The inhabitants of the County utilize their land for crop production, grazing, residential use and a number of other uses. The degree of clearing for agricultural and settlement purposes allows predators greater access to prey species, and also increases the chance of domestic predator conflicts with wildlife (dogs and cats).

Jacobs (1991) makes the case that society should recognize that it cannot detach itself from the base of living resources necessary to sustain human settlements. Management of ecosystems depends upon the type and degree of support it gets from society as a whole and from individuals in that society. The ongoing maintenance of these resources depends on society's perceived need for the ecosystem's health and welfare. Society needs to act as the steward of the environment for the benefit of future generations.

Ecosystem management describes land management "...based on trying to understand and protect the processes that make an ecosystem function." (Sampson, 1992: p. 362). A concept similar to this is 'total resource management'. Inherent in these concepts is the protection of the integrity of the environment for its own sake. This does not necessarily mean returning to the way the land was prior to settlement, but it means using all of the knowledge currently available to increase cooperation between landowners and governments for the conservation of habitat. This will likely involve a

large initiative in the area of education of land managers, and the public, because agriculture and habitat conservation need not be considered mutually exclusive. Sound agricultural practices and land management facilitate wildlife habitat management. this is done by helping maintain habitat as well as environmental and social health and economic stability, through improved soil and water quality and conservation. This point is well illustrated by implementation of the North American Waterfowl Management Plan. Any decision regarding use of land, air or water will affect wildlife habitat because all land, air and water is habitat for wildlife.

2.6 Wildlife Habitat and Landscape Planning

> *"The lands and waters that produce virtually all human needs also harbor most of our wildlife. And their capacity to support fish, birds and mammals is a good indicator of their capacity to meet the basic needs of man."*
>
> (Wildlife Management Institute, 1985; as quoted in Wildlife Habitat Canada, 1991).

Managed habitats tend to evolve toward artificial homogeneity and habitat and movement patterns in these areas are affected by this evolution (Hansson 1992). Since wildlife serve as environmental barometers (Wildlife Habitat Canada, 1991), an analysis of current habitat conditions is an economical and more reliable way of ascertaining the well-being of the wildlife resource than population surveys over huge tracts of land (Klar and Stelfox, 1985). The present integrated resource planning approach supported by the Department of Environmental Protection will facilitate consideration of the broader perspective on wildlife and habitat management. If wildlife species are to survive and flourish in Alberta in the future, then habitat for them must be available now.

If wildlife is not inhabiting an area of former range, it could be due to a lack of the required habitat. Habitat could be lacking for a number of reasons, both natural and anthropogenic. In order to provide the necessary range for wildlife, habitat may need to be enhanced. This may bring certain species back into an area formerly occupied. Sauer (1992) mentions that disturbed corridors for hydro lines and pipelines could be revegetated and function as flora and fauna corridors, since corridor management should re-establish links between remaining wild lands. the success of this will depend upon the matrix, the wildlife species and vegetative management of the corridor. However, Baskerville (1991) states that habitat management for wildlife is difficult due to the challenge of measuring population quality and size, as well as the general lack of population goals. He believes there is a need for a quantitative representation of the way wildlife populations relate functionally to their habitats, and this should be included in the beginning of a landscape plan, rather than at the end as is commonly done. When composition and structure of an ecosystem are maintained, wildlife habitat will be indirectly maintained, even if the relationships between the two are not totally understood (Rowe, 1991).

2.7 Administrative and Legal Considerations

Property ownership implies certain rights and with rights go responsibilities. In an area where almost all of the land is privately owned, it is private landowners who must be approached to aid in wildlife habitat protection. Responsible land stewardship is vital to the continuity of ecosystem processes. Where conservation of species of flora and fauna are concerned, private landowners are being asked to protect them for the public benefit but at a cost borne by the individual. The public is effectively imposing the cost of wildlife conservation on the private landowner (Appendix I) in areas that are highly settled (Sampson 1992).

To ensure that the citizens of a given jurisdiction retain the most control over land-use planning decisions in their area, integrated management approaches toward privately held resources need to be undertaken at the local level (Jennings and Reganold, 1991). Nudds and Clark (1992) state that the use of the landscape approach to achieve wildlife goals is more likely to succeed since it is treating the problem which is landscape degradation, and not just the symptoms, which are low wildlife population numbers (waterfowl in this case). This involves pro-active land use planning.

Barriers to effective land use planning include short-term socioeconomic goals; economic incentives that negate sound ecological planning; vested interests in profitable but non-sustainable enterprises; and a fragmented planning process (Richardson, 1989). Another major problem with county land use planning is the man-made nature of the county boundary which does not necessarily coincide with the natural boundaries that exist between vegetative and habitat zones (International Association for Landscape Ecology, 1992). Legal boundaries and ecological ones are not necessarily the same and, therefore, the proper importance must be attached to those ecological boundaries that lie within the legal one in question (Ambrose and Bratton, 1990). However, attitudes of the public and business sectors; political policy changes; alterations in economic theory and planning; and acceptance by administrative and institutional structures (Richardson, 1989) will determine when land use planning will be employed.

Laws and regulations in Alberta that control land use can be important to habitat options selected and the approach taken in a conservation strategy. Some of the pertinent regulations and legislation is discussed below.

The Alberta Legislation that deals with gifting land to the Crown includes: the Recreation, Parks and Wildlife Foundation Act; the Historical Resources Act; and the Federal Income Tax Act (Alberta Forestry, Lands and Wildlife, 1991). Since 1976 the

Park Ventures Fund of the Recreation, Parks and Wildlife Foundation has been authorized to receive land through donations, which can then be transferred to a suitable receiving agency. Section 5(1) of the Act states that the Foundation may acquire personal or real property through grant, lease, purchase, donation, bequest or otherwise. The Foundation operates at arms length from the government through a Board that is selected from across the province. The Historical Resources Act may also receive land that has significant heritage value under a similar section (37a) which states that the Foundation may receive land via donation or purchase. The example given is the land on which the Royal Tyrrell Museum of Paleontology was built. The Income Tax Act states that the person donating land to the Crown is entitled to claim all or a portion of the land gifted as a deduction, depending upon if the donation is conditional or unconditional.

Legal options for private are mentioned by Alberta Fish and Wildlife Division (1989). Fee simple options include: donating the land by transferring property ownership to a private or government agency devoted to conservation; gifting property to the government and receiving an official income tax receipt for it; gifting land to the Crown in a will. Gifts of less than fee simple, in which the landowner receives a tax benefit and is still able to use the land, include: restrictive covenants; easements; or a gift of foregone agricultural production (for which the landowner would receive a tax receipt). Each of these options has certain associated legal stipulations. Restrictive covenants require... "*two parcels of land, one constituting the servient tenement and one the dominant tenement. The dominant and servient tenements must be owned and occupied by different persons. As well, the restrictions placed on the servient tenement must be negative in nature and must benefit the dominant tenement.*" (Smith and Kwasniak, 1993).

Gaining the full-title to the land is the best way to ensure that the conserver can secure the land for the habitat purpose intended; a less than full-title interest in land is more commonly used in conjunction with protection. In an overview of habitat programs on private land, Scarth (1984) lists a number of considerations in the acquisition of full title of land for conservancy: 1) there is often public opposition if land is purchased on a large scale, 2) high cost of buying land limits the amount which can be purchased, 3) the time frame of effective negotiation can be lengthy, 4) as a result of 3, directly or indirectly, there may be a reduction in the budget for the next fiscal year, 5) funding for land acquisition programs must be indexed to the price of land.

Advantages in attaining lesser interests in a portion of land for conservation purposes include lower costs in relation to fee-simple interest in both maintenance and actual cost; and there is the advantage to the landowner of not having to make long term commitments (Scarth, 1984). The drawback lies in the additional enforcement costs and the potential for a landowner to withdraw from the agreement.

Scarth (1984) states that there is limited success with voluntary or persuasion methods, opposition is encountered with mandatory regulations (with which are associated enforcement costs and follow-up costs), and large sums of money are required for acquisition of full-title or interest less than title. Scarth (1984) concludes that in order to secure land for conservation, some form of financial incentives are required. However, the actual feasibility of managing the landscape for habitat will depend upon landowner willingness to lease or sell the land, and the cost of these endeavors (Nudds and Clark, 1992).

Part of the legislative structure within Alberta that has bearing upon the alteration of habitat include the following Acts: The Public Lands Act (1980); The Soil Conservation Act (1988); and The Water Resources Act (1982).

The lands which underlay permanent water bodies and watercourses are provincial Crown property. The Public Lands Act Section 3(1) states that the title to the beds and shores of (a) permanent and naturally occurring water bodies, and (b) naturally occurring rivers, streams, watercourses and lakes, is vested in the Crown in right of Alberta, unless the title has been specifically granted to a private land owner (prior to June 18, 1931). Section 3(3) states that if the water of a stream, river or watercourse is only diverted by human action, it would still be considered to naturally occur. Any use or alteration to public land requires Ministerial approval.

The Soil Conservation Act (Section 3 a, b) states that landholders shall take appropriate measures against soil loss or deterioration, and to stop these from continuing if they are occurring. This section is enforceable by the Agriculture Service Board Officer or a soil conservation officer under Section 4. If the landowner will not take action as defined in Section 3, then remedial measures can be carried out (Section 6) and payment covering expenses can be demanded of the landowner, or the costs will be added to the landowner's taxes. A fine for non-compliance can be up to $5,000.00. A permit is required to remove topsoil or burn stubble (Section 21(1)).

Under Section 2(1) of The Water Resources Act, the ownership of all the water in the province is vested in the Crown in right of Alberta. Thus, for all undertakings other than domestic purposes (Section 2(2,3)), a permit or license is required (Section 11(1)).

The Alberta Water Resources Commission (1993a) produced a policy document regarding wetland management titled "Wetland Management in the Settled Area of Albert: An Interim Policy", in which the goal is, *"... to sustain the social, economic, and environmental benefits that functioning wetlands provide, now and in the future."* The intent of this document is to set policy that (in order of importance) conserves; mitigates the degradation of ; and enhances, restores, or creates slough/marsh wetlands within the

settled area of Alberta. Alberta Environmental Protection will have the primary responsibility of coordinating wetland management, but no single agency has the responsibility for management of all aspects of wetlands in Alberta. Policy initiatives include topics of drainage, education, planning, incentives for wetland retention, legislation, coordination and cooperation (between government levels, industry, landowners, non-governmental organizations, and individuals). Points worth noting are: *"Provincial government policies and programs which directly or indirectly encourage wetland destruction or degradation will be amended to remove such incentives"(p.7)*; and, *"(L)egislative amendments to enable use of private conservation agreements to protect wetlands on private land will be considered"(p.9)*; and, *"(M)odification of private, federal and municipal programs, laws and policies to remove indirect incentives for wetland destruction will be encouraged"(p.10).*

Currently a discussion paper of the Alberta Water Resources Commission (1993b), called Beyond Prairie Potholes, is being considered for managing Alberta's peatlands and non-settled area wetlands. Once this document is finalized it will affect peat farming operations within the Province, as well as other industries.

CHAPTER 3
METHODS

3.1 Identifying Principles

Principles of Landscape Ecology Theory were identified through a review of literature dealing with these concepts. The literature was identified and obtained using key word indices and computer searches at the University of Manitoba, the University of Alberta, the University of Calgary and pertinent government libraries. Literature included textbooks, scientific papers, journal articles, and government documents.

Additional information on the topic of landscape ecology was acquired through personal communication with personnel at federal, provincial and municipal government organizations. Personnel from pertinent non-government agencies and people knowledgeable in the field of landscape ecology and / or responsible for wildlife habitat management were also contacted. These sources were contacted through meetings, telephone conversations and / or written communication.

3.2 Identifying Existing Habitat

3.2.1 County Overview

Identification of the types of habitat currently present in the County of Parkland was carried out through a review of the most recent data and resources available for that area. This involved Canada Land Inventory maps, the County map, the Ecoregions and Ecodistricts, air photos and a set of Reconnaissance Vegetation Inventory (RVI) maps. Habitat information was also obtained from various other sources. Ducks Unlimited Canada provided a set of false color infrared plots covering the County, and township summary information for wetlands within each section. These sources were supplemented with aerial photography (1: 40,000, and 1: 30,000), technical reports, limited ground inspections and aerial inspections. This yielded information on current

habitat type, and about the type of habitat that County of Parkland is capable of supporting.

3.2.2 Land Clearing (1949 - 1987)

By viewing black and white air photos available at the Air Photos Library, Maps Alberta in Edmonton, from the earliest date, 1949 (1:40,000), and the most recent date, 1987 (1:30,000), information was obtained for the County of Parkland, with respect to habitat loss and changes in land use. An overview of the amount of cleared versus non-cleared land within the County of Parkland was undertaken by choosing a set of sample sections (1 section = 259.008 hectares = 640 acres) within the County. Fifty-two sections were chosen (Appendix A) using a stratified random sampling procedure, out of a possible 936 full sections in the County, representing approximately 5.5% of the total area of the County. One section was chosen from each township that had 4 or more full sections within the County, yielding 38 sections; an additional section was chosen from each full township in the County of Parkland, yielding 14 sections.

Each section was classified into three categories: 'cleared' - consisting of areas cleared for anthropogenic purposes like roads, dwellings, agricultural crops; 'non-cleared' - consisting of treed or shrub areas, or areas appearing not to have been cleared for anthropogenic purposes; and , 'other' - consisting of areas that would/could not have been suitable for being cleared for cultivation or other anthropogenic purposes, such as bodies of water, marsh edges with emergent vegetation, alkali flats, and dry potholes. It was the proportion of cleared land that was the focus, regardless of whether the land could be cleared.

Aerial photographs of the 52 sample sections from 1949 (1:40,000) were overlain with a Modified Hectare Dot Grid with 9 dots per square centimeter (Forest Technology School, Hinton, Alberta). The number of dots of cleared, non-cleared and other areas in

each of the 52 sections were then counted. This was repeated to give a total of three trials for each section. The number of dots was then multiplied by a conversion factor of 1.7776 at the bottom of the Dot Grid to give the number of hectares represented by each dot. The resulting numbers of hectares were then averaged for the three trials. This same procedure was repeated for the same 52 sections on 1987 aerial photos with the following changes: the 1987 air photos were at a 1:30,000 scale and the resulting dot count was multiplied by a conversion factor of 1.0000 to obtain the number of hectares represented by each dot.

During analysis the categories of 'non-cleared' and 'other' were combined. A Paired t-Test (Zar, 1974, p.121), using the software package 'DataDesk' on a Macintosh PC, was performed on the number of hectares cleared and 'non-cleared' on the same section of land between 1949 and 1987. This was tested by examining the total proportion of land cleared on each section between the two years. The null hypothesis for this Paired t-Test was that no change was expected in the amount of clearing of land from 1949 to 1987. The results are graphically presented in Chapter 4, section 4.1. The Paired-t-Test is presented using Box-plots which compared the increase in the proportion of cleared land between 1949 and 1987 based on 52 sections. Frequency Histograms illustrate the proportion of cleared land in 1949 and 1987 as well as the change in proportion of clearing that took place within that period. A Scatter Plot compares the cleared areas in 1949 and 1987 to examine trends in clearing.

Alberta's Fish and Wildlife Services, Program Support Division (Planning and Technical Services Section) provided the technical assistance and support in cartographic services and GIS computer analysis.

3.3 Assessing Habitat Availability

3.3.1 General Overview

The scale and information available in the RVI were the defining criteria in the selection of the indicator wildlife species. The 1: 100,000 scale of the RVI and the vegetative cover identified in the individual polygon descriptors were such that habitat areas smaller than $1cm^2$ on the map were not distinguished as separate polygons, (unless they were pieces of polygons that were at the edges of the County of Parkland border). Based upon existing habitat survey information, and available habitat and forest cover mapping, a list of broad habitat types definable within the context of the RVI was made. From this list 6 broad habitat types were chosen: coniferous forest, treed riparian, wetland, deciduous forest, shrub and tall deciduous dominated forest, and general upland.

3.3.2 Species Selection

After determining six broad habitat types in the County of Parkland distinguishable from the RVI, species were selected as indicators of these habitat types. The possible list was compiled based on documented range pertinent to the County, information for certain habitat types, other studies using indicator species, and available aerial survey information. Consultation with wildlife biologists at Alberta Environmental Protection, Fish and Wildlife Services, along with cited references for each species, aided in selection of the six indicator species in Table 1.

Assessing habitat requirements for each indicator species was carried out using wildlife aerial survey information available from Fish and Wildlife Services, in addition to conversations with habitat and wildlife experts. Work done by Fish and Wildlife employee Keith Baker (unpublished) was also useful. John Martin (1993; pers. comm.) was consulted regarding mallard duck requirements.

Table 1: Indicator species and references

Habitat Type	Indicator Species	References
wetland	Mallard Duck (*Anas platyrhynchos*)	Semenchuk (1992), Jalkotzy et al.(1990), Nietfeld et al.(1985)
treed riparian	Mink (*Mustela vison*)	Quinlan et al. (1990), Smith, H.C. (1993), Novak et al. (1987)
coniferous forest	Marten (*Martes americana*)	Quinlan et al. (1990), Smith, H.C. (1993) , Nietfeld et al.(1985), Novak et al. (1987)
deciduous forest	Hairy Woodpecker (*Picoides villosus*)	Quinlan et al. (1990), Semenchuk (1992)
shrub & deciduous dominated forest	Moose (*Alces alces*)	Quinlan et al. (1990), Smith, H.C. (1993), Jalkotzy et al.(1990), Nietfeld et al.(1985)
general upland	White-Tailed Deer (*Odocoileus virginianus*)	Quinlan et al. (1990), Smith, H.C. (1993), Nietfeld et al.(1985)

After selection of indicator species, their habitat requirements were defined in terms of the RVI mapping legend. Habitat was placed in one of four categories: good, fair, poor, and inadequate. 'Good' habitat was defined as the quality of habitat utilized most predominantly by each species; 'Fair' habitat was similar to 'good' but either not as prevalent or of lesser quality. 'Poor' habitat was of marginal preference or quality; and all other areas within the RVI was designated as 'inadequate' for the particular species. The criteria for delineation of habitat types for each species is found in Appendix C, 'Habitat Rating Criteria'.

Species were chosen for the habitat that they could represent, thus although the maps say 'Habitat Rating for *'species'*, the habitat ratings of good, fair, poor, and

inadequate were given to polygons solely on the basis of the vegetative ground cover defined on the RVI maps.

3.3.3 Converting RVI to Digital Format

A GIS was used to analyze RVI information and prepare habitat maps for each indicator species. The RVI was completed by Sentar Consultants Ltd., through the interpretation of satellite images from the following LANDSAT TM color composite enlargements:

Quadrant	Date	Bands	Enhancement
44-23-02	1988/09/02	3,5,4	Boreal
43-23-08	1991/08/03	3,5,4	Custom
44-22-04	1988/09/02	3,5,4	Boreal

RVI information was converted to digital data using an IBM compatible 486 33MHZ PC configured for digitizing with dual screens and a digitizing table. Analysis was done using Microstation 4.03 PC which is an automated mapping software and ARC/INFO PC Geographic Information System analysis software.

The digital base maps (1:250,000) were obtained from Maps Alberta, Land Information Services, Alberta, Department of Environmental Protection. The hydrography was separated out and placed on a separate coverage.

In the digital conversion of the RVI, the polygons were cleaned (meaning spurious polygons, polygon slivers, and line overshoots were removed), converted to ARC/INFO format and numbered using Microstation. Hydrography was separated from the base maps, cleaned and converted to ARC/INFO format. Both vegetation and

hydrography were cleaned again in ARC/INFO. Topology was built into the vegetation cover. The hydrography was buffered at 200 meters.

A Simple Macro Language (SML) program was prepared to build a database for the County of Parkland. This program set out the database field names and their sizes. The database was filled using the polygon identifiers from the 1:100,000 RVI maps. Fields were added to house the species habitat ratings.

3.3.4 Categorization of Anthropogenic Cover

To determine the extent of anthropogenic influence present in the County of Parkland, a separate map of annual crop present in the RVI polygons was created. This was done by grouping percentages of annual crop into categories as follows for cover type 1A or 1B: 100-90%, 80-70%, 60-50%, 40%; for cover type 2A or 2B: 50%, 40-30%, 20-10%; for cover type 3A or 3B: 30%, 20-10%.

3.3.5 Categorization of Species Habitat Ratings

The database allowed for selection of RVI polygons which represented appropriate habitat types for each indicator species. These selected polygons were rated as Good, Fair, Poor and Inadequate as dictated by their polygon descriptions. One map per species was printed.

Due to the RVI and the nature of the information being categorized, two approaches to identify species habitat were taken. Two approaches were needed because there was difficulty with some of the species criteria when selecting criteria from the database for ranking. One approach was performed by selecting the 'good' polygons first and giving them a rating of '1' to effectively remove them from further ranking procedures. The same was done for fair (ranked 2); and poor (ranked 3). Thus all polygons left unranked would be 'inadequate'. The inadequate polygons were re-examined to ensure that they were ranked correctly. The other approach involved

selecting the inadequate polygons first. Then the good polygons were ranked as 1, and then the fair and poor polygons were distinguished from each other. Again, those polygons that were inadequate were reviewed to ensure no suitable habitat polygons were rated as inadequate.

All the species, except mallard duck, utilized a coverage map with full hydrography. Mallard duck habitat ratings were on a separate coverage map which only identified the hydrography of lakes and potholes within the County, the North Saskatchewan River and the Pembina River. No other watercourses were included. All species, except mallard and mink, had the areas within 200m of water buffered and given a rating of one category higher than the surrounding polygon area. This is because vegetation surrounding riparian areas and lakes and potholes generally have a higher moisture content and a greater diversity of accompanying vegetation. The mallard and mink maps only considered areas within this 200m buffer of water. The majority of waterfowl will remain within 200m of the wetland areas for nesting (John Martin, 1994, pres. comm.). Mink also are generally found within 200m of streams and lakes in forested areas (Quinlan et al., 1990).

Output was in the form of a paper map of areas suitable for each indicator species. The database allowed different maps to be created according to the species under consideration. These different species maps were listed in the GIS, and a report with habitat ratings for each polygon for each indicator species was created.

3.4 Delineation of County Landscape Units

Landscape Units, areas of the County with similar characteristics, were identified using a variety of information. This included a Quaternary geology map (Appendix D), Ecoregions, and Ecodistrict maps of Alberta (Strong, 1992c; 1992b), false color infrared

Landsat color photocopies indicator species habitat maps, and annual crop map created in this study.

It appears that there are two distinct landscapes within the County of Parkland. These can be identified with a line approximately bisecting the County running through Range 3 West of the 5th Meridian, approximately following Wabamun Creek through the Wabamun Indian Reserve and then north east along Kilini Creek. Aspen Parkland and Low Boreal Mixedwood occur east of this line. Mid Boreal Mixedwood and Lower Boreal Cordilleran occur west of this line. These four ecoregions have distinct characteristics, (Table 1 and Appendix E) (Strong, 1992a).

These four ecoregions can be further divided into eight ecodistricts (Strong, 1992b); characteristics of these ecodistricts are described in Table 2. Distinctive physiographic and/or geologic patterns are the bases for the division of ecoregions into ecodistricts (Strong, 1992a., p.5). Omitted from the ecodistricts map is the legend description for the district below Lake Wabamun, 11WP. The legend should read as stated in summary Table 2 (Ainsley, 1994; pers. comm.). The ecodistrict 9AV within the County of Parkland is described as being part of the McLeod River Valley. Although it possesses the same characteristic fluvial deposits, it is part of the Pembina River valley and may be referred to as such (Strong, 1994; pers. comm.). (Note that the temperature and precipitation values were averages taken from throughout the whole ecoregion within Alberta, and not just from stations within the county. These readings were taken over the period of January 1, 1979 to August 31, 1989.)

To translate the eight ecodistricts as identified by Strong (1992b) into landscape units, the following steps were performed (mapping was done by hand). First, a photocopy of the County of Parkland was underlain with an enlargement of the corresponding area from the Ecoregions map, and the lines defining the four ecoregions

were traced on a light table. This procedure was repeated with an enlargement of the appropriate area from the ecodistricts map. Using the ecodistrict boundaries as a guide, indicator species habitat maps were consulted to determine polygons that most closely followed ecodistrict boundaries, and also were consistent with boundaries defined by the quaternary geology map (Shetsen, 1990). The resulting Landscape Unit map for the County of Parkland was composed of eight Landscape Units closely following, but not identical to, the ecodistricts defined by Strong (1992b).

There are three main differences between the landscape unit and ecodistrict maps. One occurs where ecodstrict 8EP is divided into two units, the Glory Hills Unit and the Banksiana Unit. The second occurs where ecodistrict 8EP is separated from ecodistrict 11EU along the Kilini Creek polygon. The last occurs along the Pembina River where ecodistricts 9AV and 11AV were amalgamated to form the Pembina River Valley Unit.

Table 2: Climatic and Ecological Conditions for the Ecoregions within the County of Parkland; (values are median {50th percentile} and 25th/75th percentile values)

Climatic & Ecological Conditions	Aspen Parkland	Low Boreal Mixedwood	Mid Boreal Mixedwood	Lower Boreal Cordilleran
Mean summer temperature	14.4 degrees Celsius	13.8 degrees Celsius	13.5 degrees Celsius	12.8 degrees Celsius
Mean winter temperature	-8.7 degrees Celsius	-10.5 degrees Celsius	-13.2 degrees Celsius	-7.8 degrees Celsius
Median summer precipitation (Range)	259 mm 157/381mm	235 mm 136/356 mm	240 mm 155/345 mm	295 mm 182/444 mm
Median winter precipitation (Range)	53 mm 32/86 mm	61 mm 35/119 mm	64 mm 38/93 mm	60 mm 34/112 mm
Zone	Climatical and ecological transition zone between boreal forest and grassland environments	Transition zone between Aspen Parkland and Mid Boreal Ecoregion	Between boreal forest and Aspen Parkland; high wildlife diversity	Ecotone between boreal and cordilleran climatic conditions; also between deciduous boreal and coniferous cordilleran
Vegetation *(See associated environmental gradient for each Ecoregion)	3 distinct types: aspen, grassland, and willow	variable understory vegetation	variable understory vegetation; fires more frequent than Low Boreal Mixedwood	the most arboreally diverse in Alberta; species mixture highly dependent upon geographical location and site history
Present Use	One of the most productive agricultural zones in Alberta; native vegetation replaced with oats, barley, wheat, canola, and cattle grazing	Agriculture; but lower yields for harvest than the Aspen Parkland	Historically, not intensively used; white spruce and some jack pine logging; moose hunting; summer recreation; recent shift toward timber harvest	Eastern edge used for agriculture; grazing, forage production and growth of cool season crops;

(W.L. Strong Ecological Land Surveys Ltd. 1992. Adapted from "Ecoregions and Ecodistricts of Alberta; Volume 1", for Alberta Forestry, Lands and Wildlife; E

Table 3: Ecodistricts within the County of Parkland and Associated Quaternary Geology*

Ecoregion	Eco-district Unit	Physiographic Component	Landform /Parent Materials	% Slope	Soil Great Groups	Moisture Regime	Dominant Vegetation	*Quaternary Geology (Dominant first)
Aspen Parkland	4EP	Eastern Alberta Plain	Undulating morainal plain	3-5	Solodized Solonetz	Submesic	Cleared	2a, 1, 8
Low Boreal Mixedwood	8EP	Eastern Alberta Plain	Undulating morainal plain	3-9	Gray Luvisols	Mesic	Cleared	8 2a, 6a
Mid Boreal Mixedwood	11EU	Eastern Alberta Uplands	Hummocky moraine	6-15	Gray Luvisols	Mesic	Cleared and mixedwood forests	10b, 9, 16b, 10c, 6b, 12, 4, 0, 2a, 12a, 8
Mid Boreal Mixedwood	11WP	Western Alberta Plain	Rolling morainal plain	6-9	Gray Luvisols	Submesic	Cleared	6b 12a, 9, 0, 14a, 10b, 12, 15, 7a
Mid Boreal Mixedwood	11AV	Athabasca River Valley	Terraces and slopes of Pembina River Valley	3-5/ 31-45	Melanic Brunisols	Mesic	Cleared	3b
Mid Boreal Mixedwood	11NV	North Saskatchewan River Valley	Steep slopes and terraces of the North Saskatchewan River valley	3-5	Eutric Brunisols	Mesic	Mixedwood forests	3b, 4, 3a
Lower Boreal-Cordilleran	9AV	Athabasca River Valley	Terraces and steep slopes of the Pembina River valley	3-5/ 31-45	Eutric Brunisols	Mesic	Mixedwood forests	3b
Lower Boreal-Cordilleran	9WP	Western Alberta Plain	Undulating to hummocky morainal plain	6-9	Gray Luvisols	Mesic	Mixedwood forests	9, 14a, 2b, 10a

* See Appendix D for Quaternary Geology explanation

(W.L. Strong Ecological Land Surveys Ltd. 1992. Adapted from "Ecoregions and Ecodistricts of Alberta; Volume 1", for Alberta Forestry, Lands and Wildlife; Edmonton, Alberta. p.56-63.)

3.5 Habitat Rated as "Good" in Each Landscape Unit

A map depicting the polygons within the County of Parkland rated as 'good' habitat for each of the six indicator species was produced using the same technique and GIS equipment as listed in section 3.3.3.

A total area in square kilometers for each of the eight Landscape Units within the County of Parkland was obtained by first listing each whole polygon within each Landscape Unit, then adding up the land areas listed in the GIS report. The total area in square kilometers in each Landscape Unit for the habitat rated as "good" for each of the six indicator species was also calculated. This was done by adding each portion of a polygon area classified as good habitat that was listed in the cumulative species ratings for each of the six indicator species. Generally only a portion of any one polygon had a rating of 'good', and this would usually have been associated with water in the form of a river, stream, lake or pothole in the polygon. The reason that only a portion of the polygon would have a higher rating was due to the effect of having a buffer to 200m from the watercourses which would increase the habitat rating within that portion of the polygon. Without the buffer there are 396 polygons in the coverage, (note that there are no polygons numbered 277, 336, 385, and that polygons numbered 9083, 9146, and 9301 were added to the coverage once the edge matching stage of digitizing the RVI was completed). The 200m buffer on water creates 2088 polygon pieces on the RVI maps.

CHAPTER 4
RESULTS

4.1 Land Cleared for Anthropogenic Purposes

The mean percentage of cleared land in 1949 within the County of Parkland was 42.8%, however the range was extreme, covering from 1% to 88% cleared land. In 1987 the proportion of cleared land ranged from 12% to 94% (with outliers between 0% and 5%) with a mean percentage of cleared land at 55.5%. The mean of the difference across all sections shows 12.7% (55.5% - 42.8%) additional clearing in 1987 over 1949. Of the 52 sample sections, 39 sections had greater clearing in 1987 than 1949; 2 sections exhibited the same proportions of clearing; and 11 sections had a higher proportion of clearing in 1949 than in 1987. The increase in the proportion of cleared land between the years 1949 and 1987 was statistically significant (paired-t- test, $t = -4.843$, degrees of freedom = 51, $p < 0.0001$). This was confirmed using a non-parametric test (paired sign test, $p < 0.0001$).

The range of the data with the means of the amount of land cleared is illustrated in the Box-plot in Figure 2. The Box-plot summarizes the variation in the amount of 'clearing' between 1949 and 1987. In 1949 the amount of clearing ranged from approximately 0 to 90% of a section cleared, with a median of approximately 43%. The concentration of the middle 50% of cleared land was between 20 to 70% cleared. By contrast, the range of clearing in 1987 reached from approximately 15 to 95%, with a median of approximately 60%, and three outliers between 0% and 10% clearing. The concentration of the middle 50% of cleared land areas was in the 45 to 70% range. Note that some of the land left uncleared was land or water that was not able to be cleared for anthropogenic purposes.

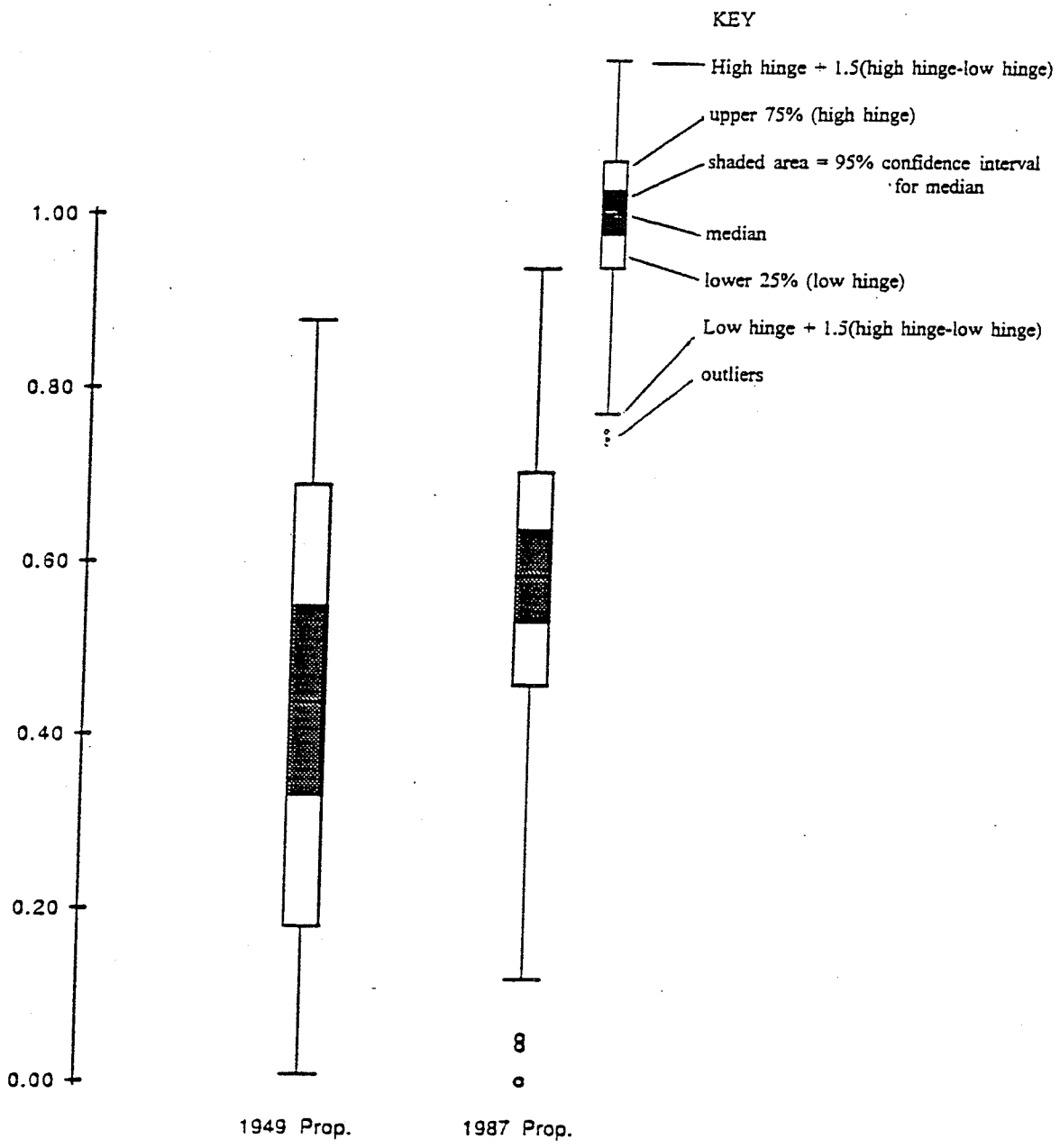


Figure 2: Box-plot summarizing the amount of clearing between 1949 and 1987.

The relationship between the amount of cleared land between 1949 and 1987 is illustrated in Figure 3. The data points are widely dispersed between 0.0 and 0.2 on the X-axis, corresponding to a range between 0.0 and 0.8 along the Y-axis. This indicates that many sections of land that had very little clearing on them in 1949 had a greater amount of clearing by 1987. The data points follow the line of no change more closely as they move toward the top right corner of Figure 3. There are fewer sections that have less cleared land on them in 1987 than they had in 1949.

The frequency histogram of the 1949 data (Figure 4a) shows 16/52 sections had 20% or less clearing; 12/52 had 20% to 50% clearing; 11/52 had 50% to 70% clearing; and 13/52 had between 70% and 90% clearing. There is an approximately equal distribution within Figure 4a, with a few more sections at the high and low ends of the distribution. Note that the higher amounts of clearing are at the low percentages (0-20%) and the higher percentages (50% -80%).

The frequency histogram of the 1987 data (Figure 4b) shows a single peaked curve with the peak being between 60% - 70% and a long tail of clearing between 30% and 60%. One section had between 90%-100% clearing. Only a relatively small proportion of sections, 7/52 of the sections, had 30% or less cleared area. Thus, a distinct peak in the frequencies exists, indicating a number of the areas have experienced more clearing. Therefore, the number of cleared areas has increased since 1949, and is statistically significant. Figure 4c illustrates the number of sections that have experienced increased clearing in 1987 as compared to cleared land in 1949. Note the highest proportion of land clearing involved between 0% and 10% of additional land cleared. The range of land clearing was concentrated between 0%-60%, with one section having between 70% -80% clearing. Of those sections having less clearing in 1987 than in 1949, most had 0-20% less clearing, and one section had between 20% and 30% less clearing.

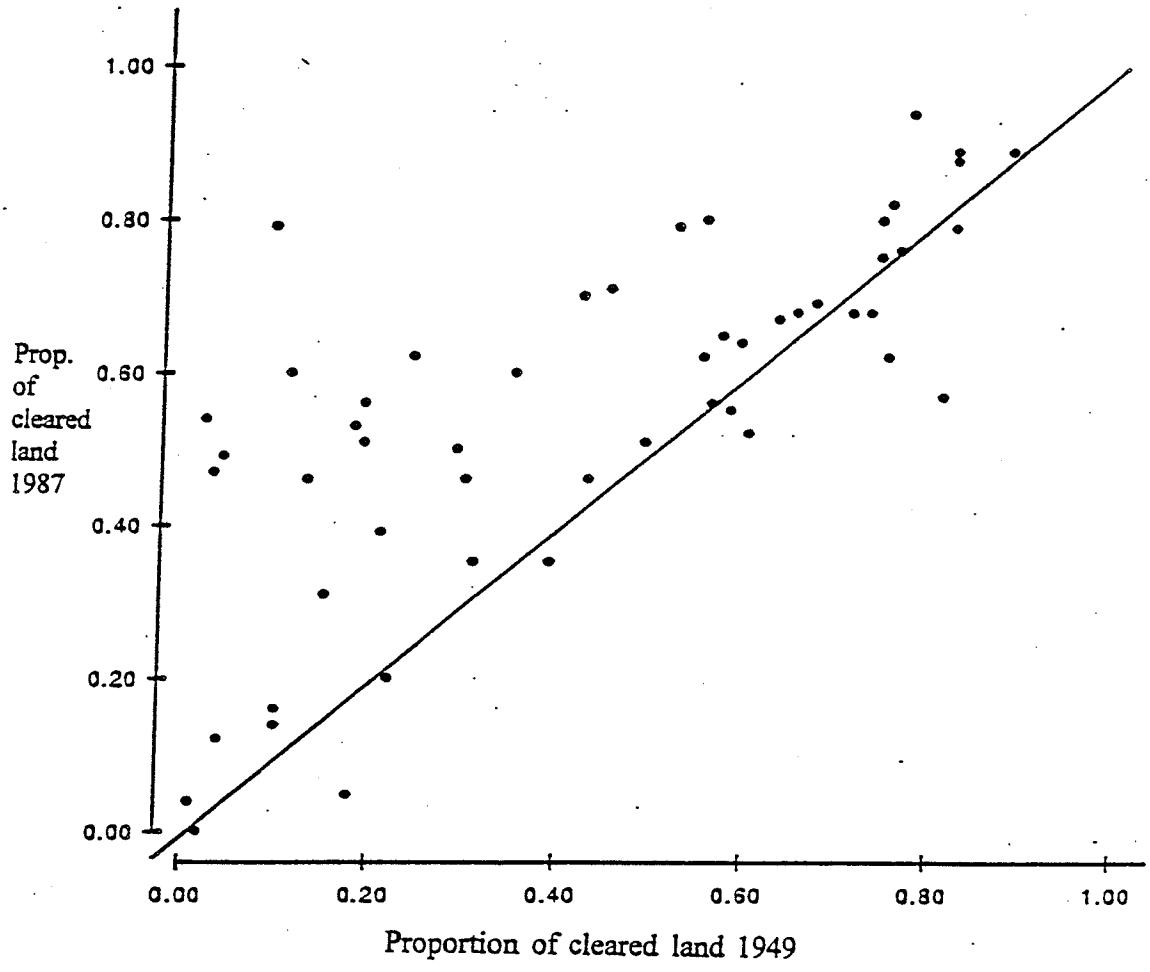
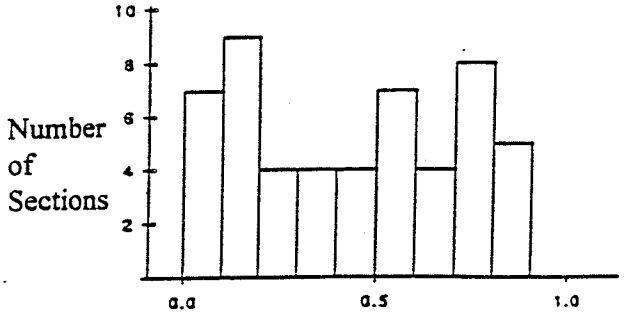
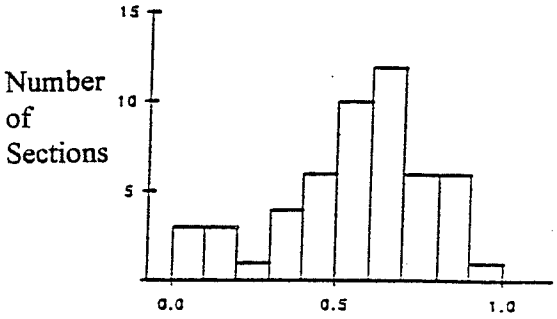


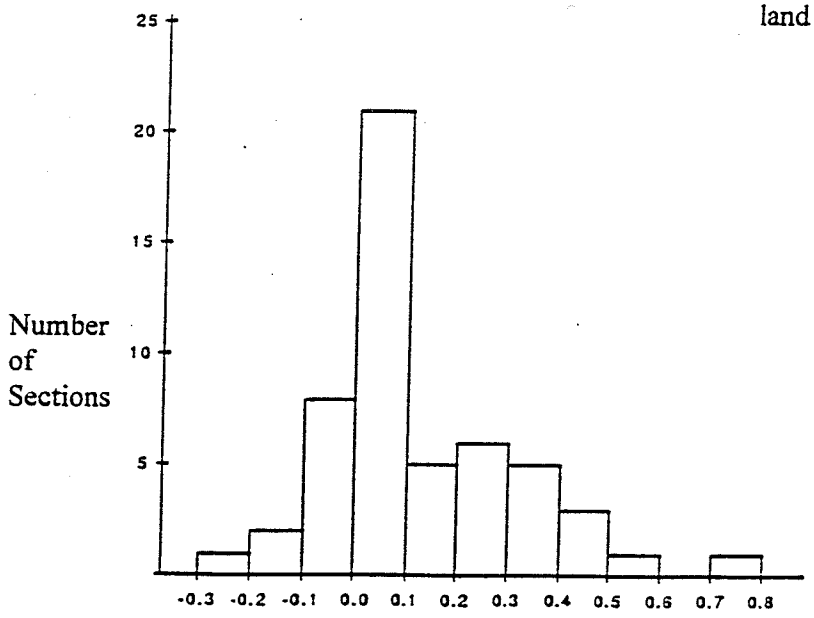
Figure 3: Scatter plot showing relatively few sample sections below the line of no change in land cleared between 1949 and 1987.



a) Proportion of cleared land 1949



b) Proportion of cleared land 1987



c) Proportion of cleared land 1987-1949

Figure 4: Frequency histograms of amount of clearing in (a)1949, and (b)1987, and (c) the change in proportion of cleared land between 1949 and 1987.

4.2 Habitat Availability Assessment

4.2.1 Annual Crop Map

The annual crop map (Figure 5) shows approximately 2/3 of the area within the County as having some amount of annual crop present. A very large portion of these polygons were rated as having between 50-80% annual crop using the percentages from the RVI map. The polygons with 90-100% and 10-40% cultivation are generally smaller and more widely dispersed over the County. There is a trend of decreasing annual cropland from east to west across the County. Generally areas south of Highway 16 have more annual cropland than north of Highway 16. There is less annual cropland within the two main moraine areas in the County; Glory Hills Moraine which runs through the center of the County, and Banksiana Moraine located in the southeast corner of the County. These two areas form the main pothole and wetland areas. Noting that close to 90% of the land is privately owned, it is not surprising that a large amount of annual crop exists in this County in the areas where the soil is suitable for agricultural use.

(Cover types referred to in Figure 5 are RVI categorizations of the different vegetation cover types within a polygon. e. g. : the description of polygon 196 is CA/CP^{6} - $NWL/SCD2/HE^{3}$ - $FCD2^{1}$. Cover type 1A = Annual Crop in complex with cover type 1B Perennial Forage Crop at 60% of the polygon. Cover type 2A = Lakes in complex with cover type 2B which is tall Closed Deciduous Shrub in complex with Herbaceous cover at 30%. Cover type 3A = tall Closed Deciduous Forest at 10%.)

4.2.2 Habitat Rated Using Indicator Species

Mallard Duck (*Anas platyrhynchos*) **for wetland**

The mallard duck map for wetlands used a separate coverage and buffered the inside and outside of lakes to 200m, leaving centers of some of the larger lakes outside

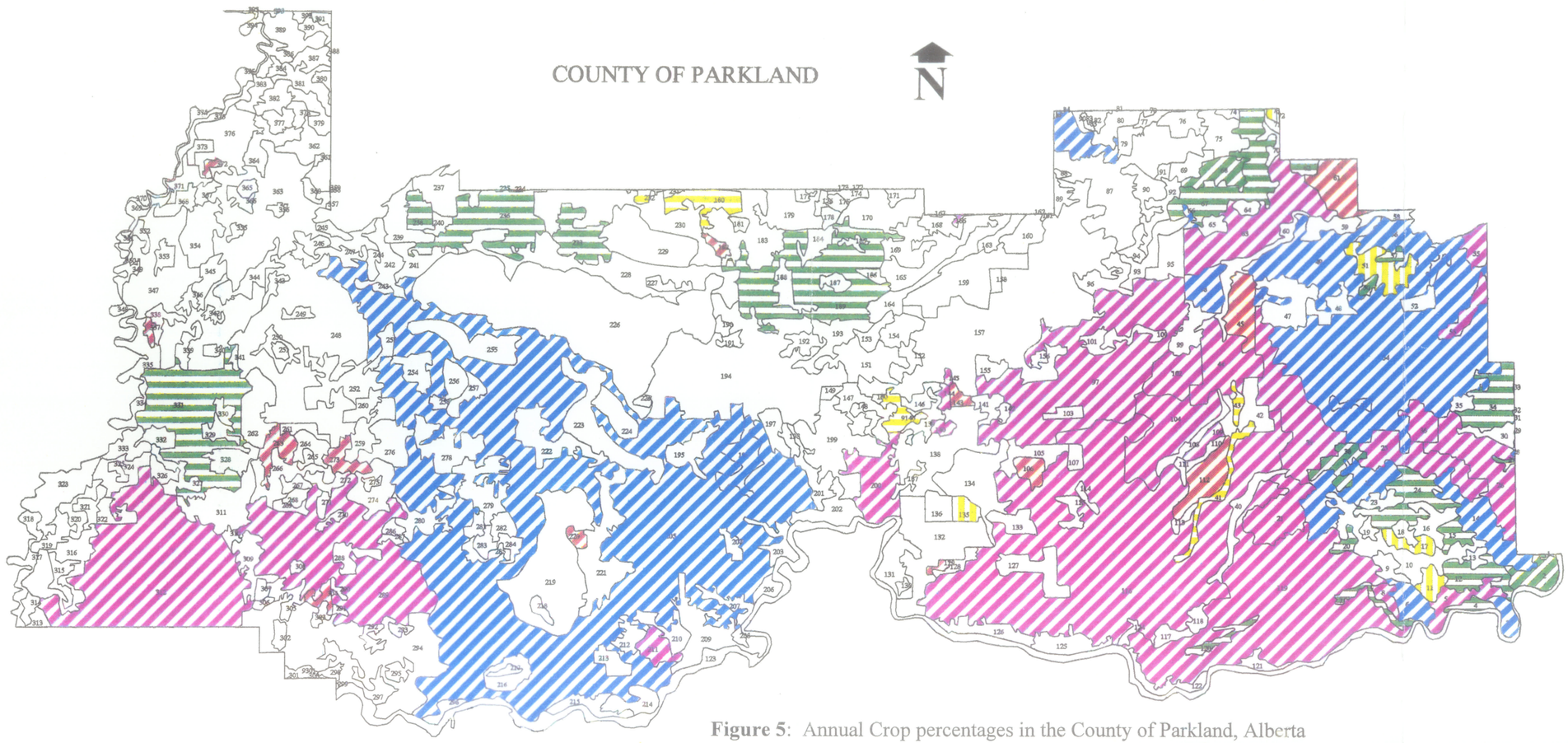


Figure 5: Annual Crop percentages in the County of Parkland, Alberta

of the buffer (see Figure 6). The buffer of 200m was used to incorporate the area surrounding potholes for consideration of nesting cover availability (Martin, 1993; pers. comm.). The wetland map depicts environmental resources patches, containing the water body and 200m of associated shore buffer, within a matrix of inadequate habitat. This map shows that most wetland habitats are located in the central and eastern half of the county, in the Banksiana and Glory Hills areas. Lake Wabamun is also rated as mallard habitat. Only the locations of the waterbodies, not the type of water, is depicted here. The differentiation of the landscape outside of the pothole depends on the ground cover and type of pasture.

Few lakes exist on the west side of the County, and only a portion of Isle Lake's shore bounds the County. In the Banksiana moraine area some lakes appear as good habitat but they are ringed with fair habitat because the surrounding soils are sandy and less suitable for the growth of dense nesting cover for mallards near the lake shore.

Mink (*Mustela vison*) **for treed riparian**

Figure 7 shows a large number of stream corridors, which are considered environmental resource corridors, and environmental resource patches of wetland, within a matrix of inadequate habitat. Much of the treed riparian habitat found is located along the North Saskatchewan and the Pembina Rivers. In actual fact there may be more treed riparian habitat present because small patches might not be shown at the RVI mapping scale (Figure 7). Many of the streams run through heavily developed annual cropland, so much of the riparian area is likely to be cultivated as close to water as possible. There are also numerous roads and highways that cut across the stream corridors in the County. For example, Kilini Creek and Atim Creek are divided by highway 16.

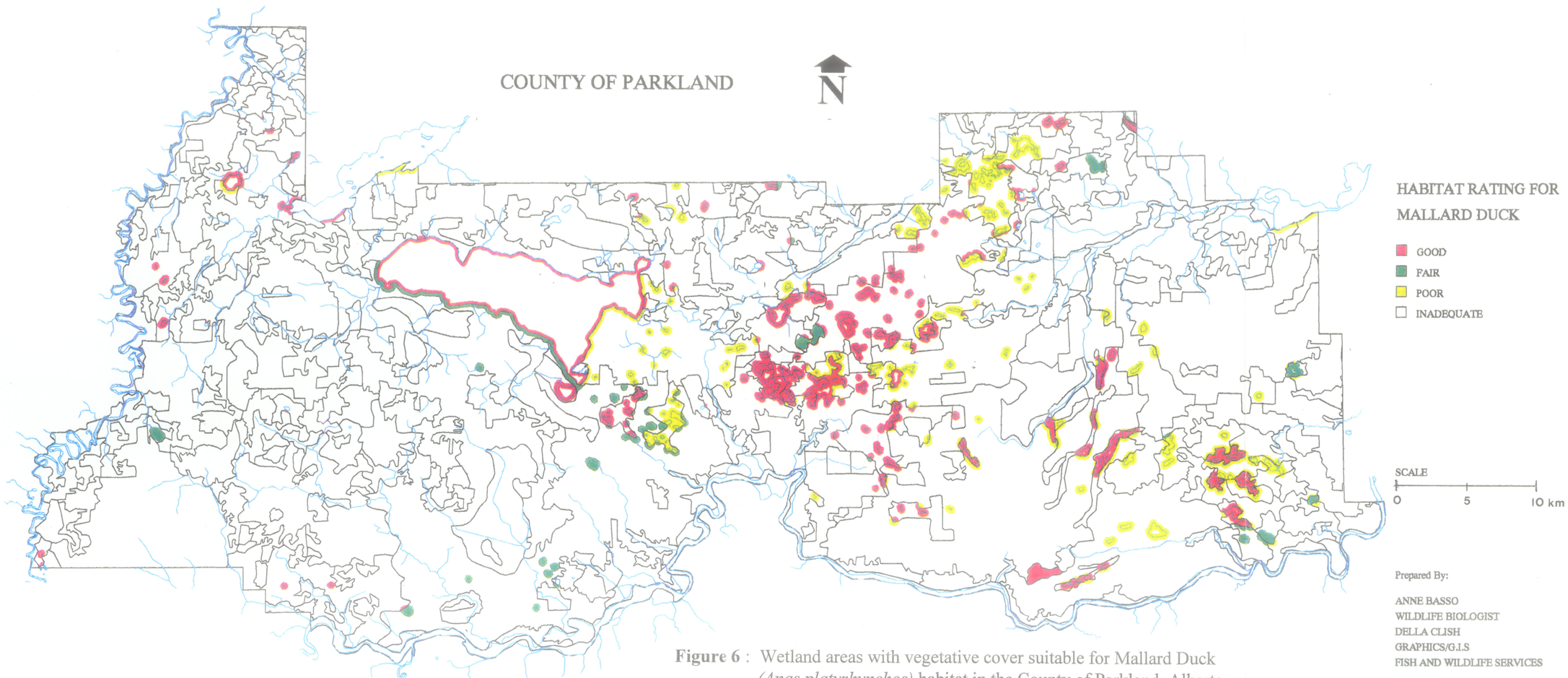


Figure 6 : Wetland areas with vegetative cover suitable for Mallard Duck *(Anas platyrhynchos)* habitat in the County of Parkland, Alberta

The 200m buffer not appearing around some waterbodies means that the majority of the County area shows up as not being treed riparian habitat, and many of the potholes and lakes within the County are rated as inadequate habitat for mink. The high amount of cultivation in the large polygon bordering the south side of Lake Wabamun indicated this shore was unsuitable as mink habitat, thus the outer 200m buffer is absent, while the inner 200m buffer is present. The presence of two coal strip mines and a coal fired electrical generating station south of the lake, has removed vegetation in the area and reduced potential habitat for mink. The north shore of Lake Wabamun has a high degree of anthropogenic influence in the form of cottages /cabins/ houses, railway tracks and a shoreline gravel road. Thus the vegetative cover that exists here would be suitable habitat for mink and other species, but it is fragmented.

Marten *(Martes americana)* **for coniferous forest**

Very few conifer dominated polygons exist in the County of Parkland (see Figure 8). Those remnant habitat patches that remain are often connected to other remnant patches with different habitat ratings. These aggregates of remnant patches are usually separated from each other, but a few are closely juxtaposed. The eastern half of the County contains very little coniferous forest, and what is present occurs mainly along rivers and streams (environmental resource corridors) or near lakes (environmental resource patches) within the Banksiana region. More coniferous habitat is present in the west side of the County, but in separate patches. The only area within the County that has significant semi-contiguous coniferous cover is the corridor along the Pembina River.

Although connections appear incomplete on 1986 false color infrared photography, it is possible there is more connectivity along watercourses than appears on the map. However these connections are only seen if the whole polygon has been rated good, fair, or poor.

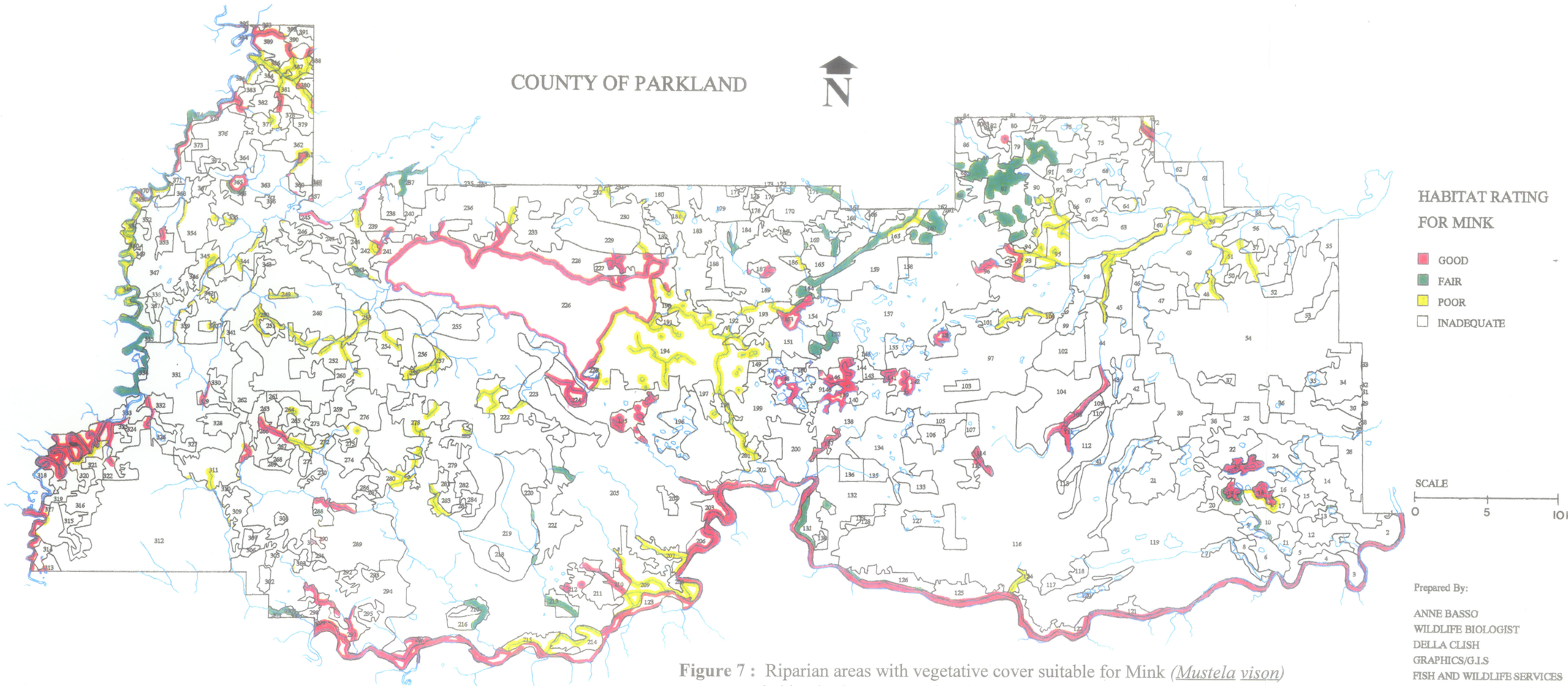


Figure 7 : Riparian areas with vegetative cover suitable for Mink *(Mustela vison)* habitat in the County of Parkland, Alberta

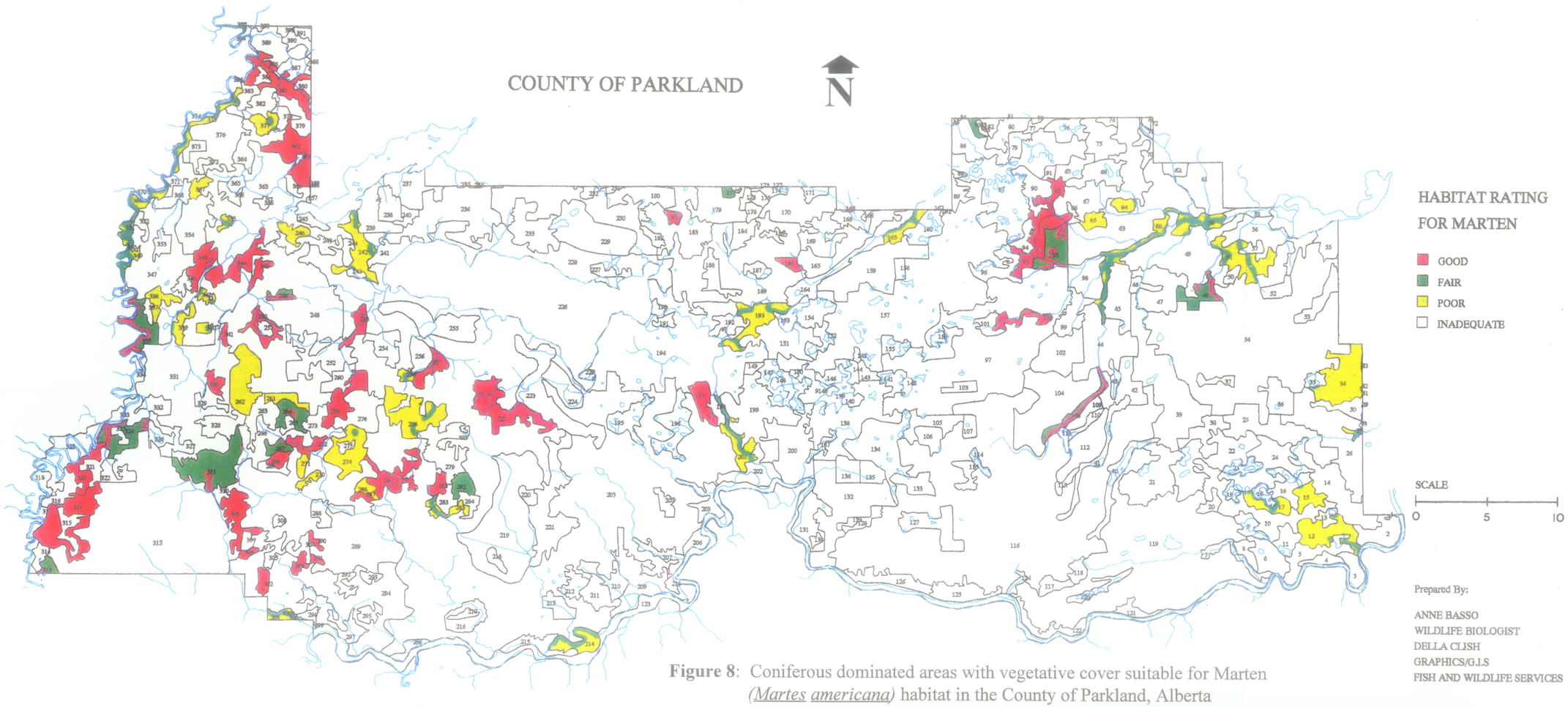


Figure 8: Coniferous dominated areas with vegetative cover suitable for Marten *(Martes americana)* habitat in the County of Parkland, Alberta

Hairy Woodpecker (*Picoides villosus*) **for deciduous forest**

There are larger numbers of blocks of tall deciduous than coniferous forest and they are spread throughout the County (see Figure 9). However, these remnant habitat patches are surrounded by a matrix of inadequate habitat. More of this habitat is found north of Highway 16, in the north portion of the Glory Hills moraine, north of Round Lake, and in strips along the North Saskatchewan River and the large area within the Wabamun Indian Reserve. (The Wabamun Indian Reserve may have a higher amount of cleared area in very recent years to make way for a golf course). More patches are rated as good deciduous forest habitat than were rated as good deciduous shrub habitat as indicated by the moose map (Figure 10).

Many remnant patches are connected, and many more could be connected by corridors along streams and rivers. In areas of more intensive cultivation, blocks of deciduous cover are smaller and more widely separated. These smaller blocks are likely to be found in patches near water or wet depressions.

Moose (*Alces alces*) **for deciduous shrub and deciduous forest**

In general the moose map shows large patches of differently rated remnant habitat within a matrix of inadequate habitat (Figure 10). Areas within the Banksiana moraine, the northern portion of the Glory Hills moraine, the Wabamun Indian Reserve, the Stony Plain Indian Reserve, north of Round Lake, and the area north of Lake Wabamun were mainly rated as fair habitat with good habitat occurring along streams, lakes and potholes. Some semi-contiguous habitat also occurs along the North Saskatchewan and the Pembina Rivers. A large portion of the County is rated inadequate for moose, generally in the areas of high Annual Crop cultivation.

The area along the north shore of Lake Wabamun is rated as good moose habitat (Figure 10), however there are numerous cottages /cabins / houses in this polygon and the

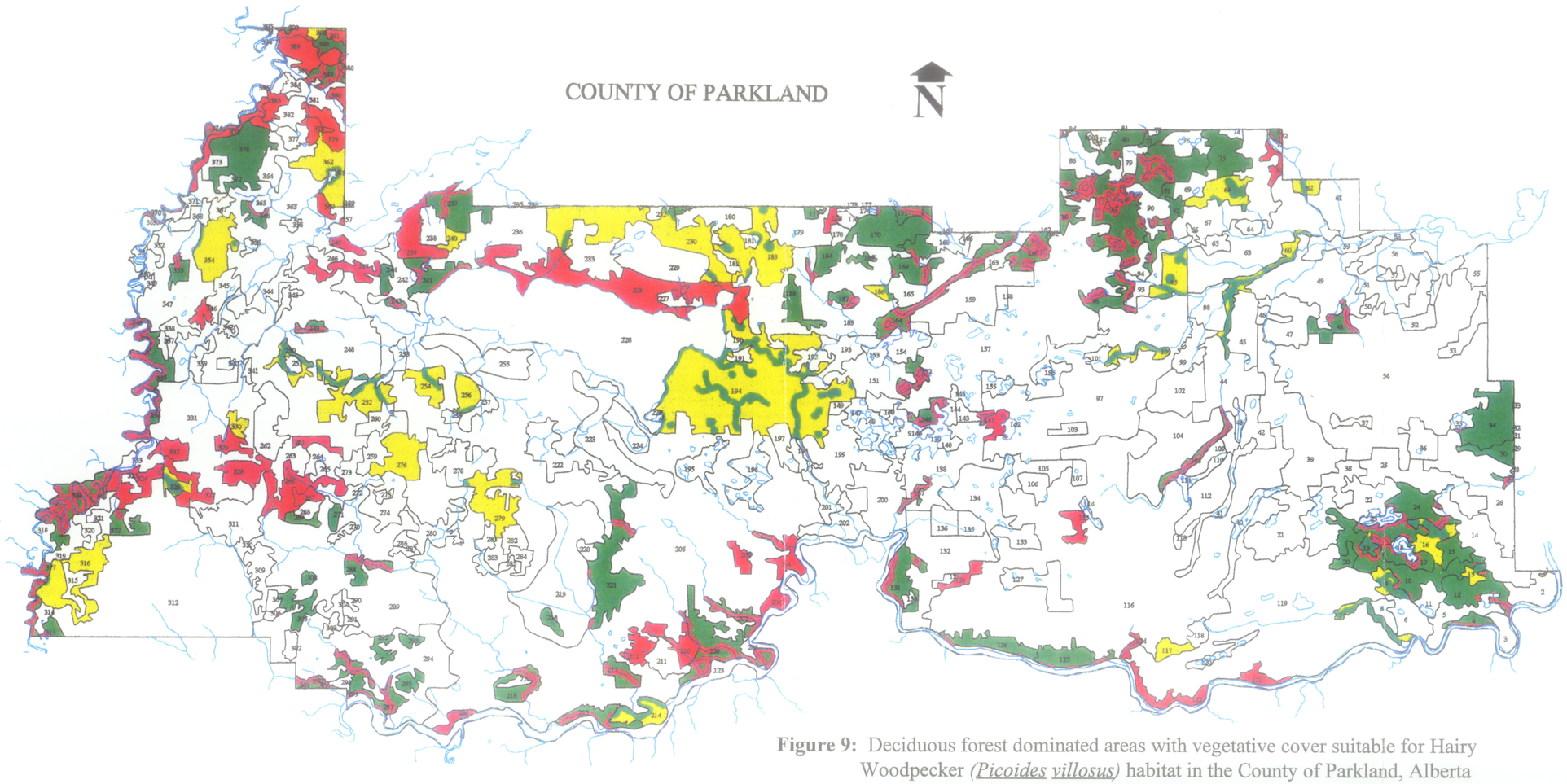


Figure 9: Deciduous forest dominated areas with vegetative cover suitable for Hairy Woodpecker *(Picoides villosus)* habitat in the County of Parkland, Alberta

railroad also runs along this shore. This is not taken into account in the polygon description, but it is likely that there are few moose in the area because of current land use. The area along the north shore was not differentiated as a separate polygon so its distinctive anthropogenic character does not appear in the RVI interpretation.

Riparian corridors are important for moose and other ungulates especially for overwintering and the vegetative cover available along the North Saskatchewan River and the Pembina River are essential corridors of habitat, travel and wintering areas.

White-Tailed Deer (*Odocoileus virginianus*) **for general upland habitat**

The map (Figure 11) for white-tailed deer contains the most habitat rated as adequate (rated good, fair or poor) for any of the six indicator species. The Banksiana area appears as a complex of fair and poor habitat with one inadequate patch of habitat in its center. The North Saskatchewan and Pembina River valleys are contiguous corridors of habitat, and have remnant blocks of variously rated habitat juxtaposed. The central and northern portion of the County are also matrices of habitat with patches of inadequate habitat interspersed, as is the area east of Lake Wabamun. There are two large areas located south of Lake Wabamun, and south and east of Stony Plain, that are composed of inadequate habitat matrices with remnant patches of habitat.

White-tailed deer is a very adaptable species that thrives in edge habitat. Within the County edges are plentiful due to the patchiness of the forest and shrub cover and the open cultivated spaces. Much of the County is white-tailed deer habitat particularly where cropland, pasture, and hayland exists for its food, juxtaposed with interspersed with treed patches for cover (Figure 11). The County is also traversed by many roads, power transmission and pipeline corridors, township grid lines, and other such features which create large amounts of edge. Only some of these edges may promote dispersal of white-tailed deer within the County.

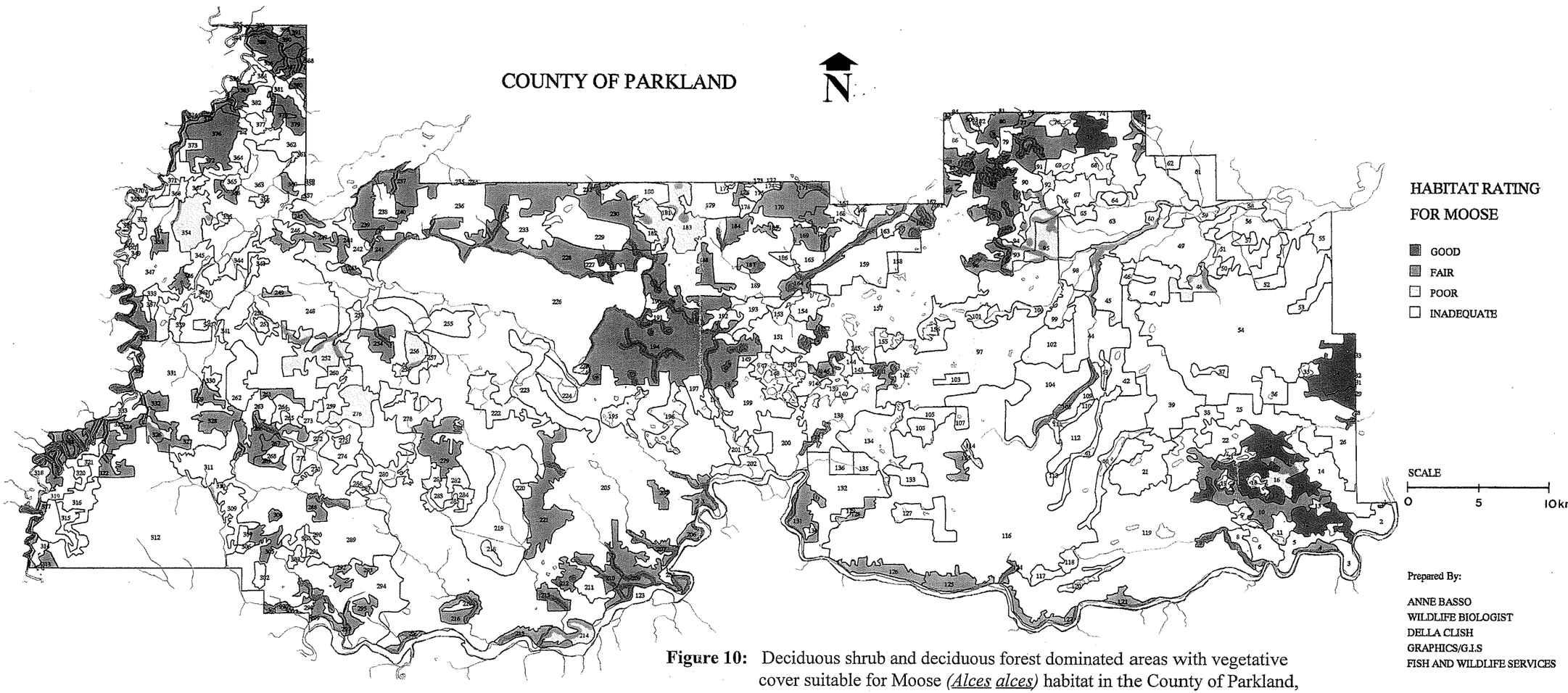


Figure 10: Deciduous shrub and deciduous forest dominated areas with vegetative cover suitable for Moose *(Alces alces)* habitat in the County of Parkland, Alberta

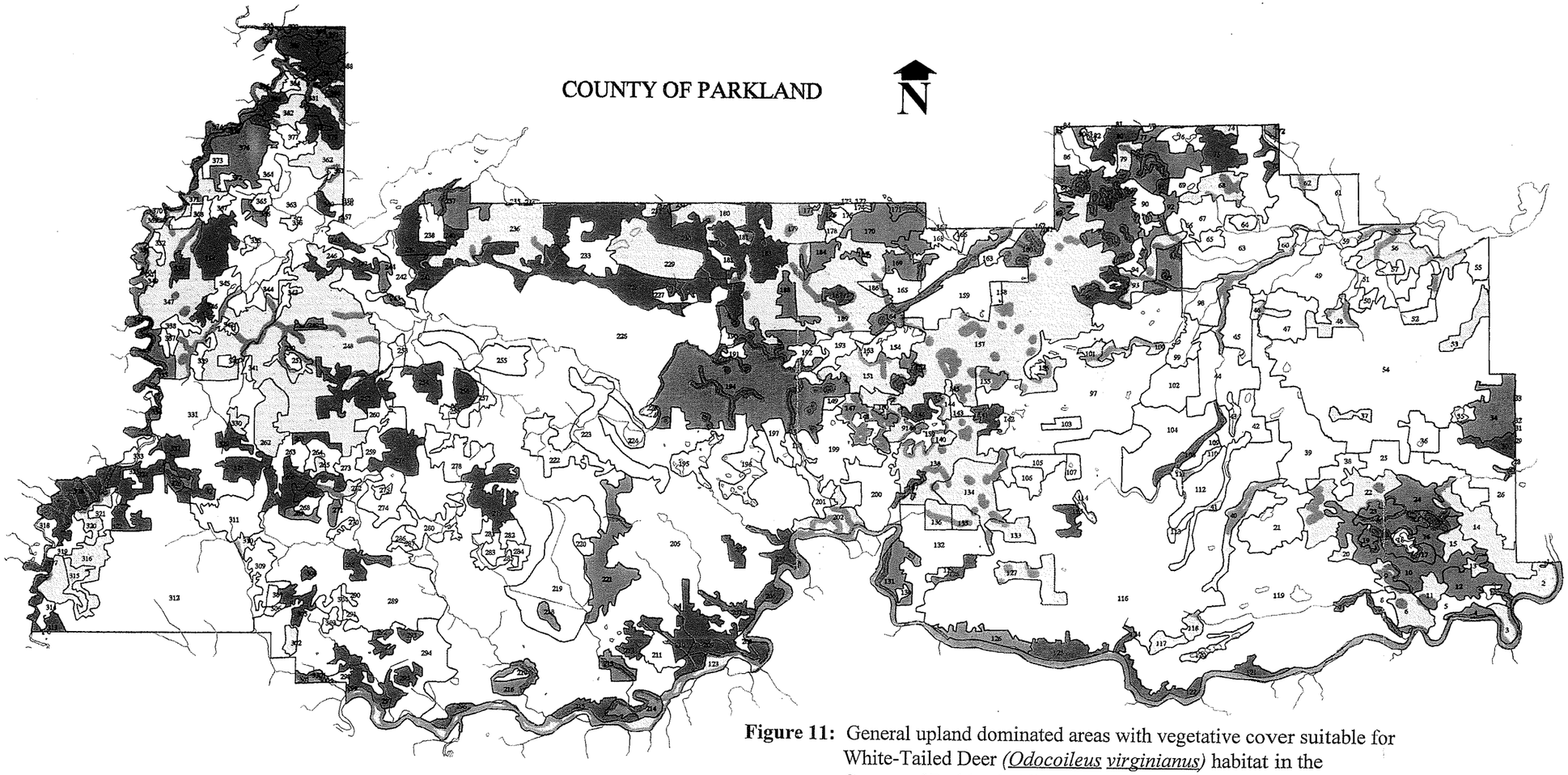


Figure 11: General upland dominated areas with vegetative cover suitable for White-Tailed Deer *(Odocoileus virginianus)* habitat in the County of Parkland, Alberta

4.2.3 Calculation of Species Habitat

The total area for the County of Parkland is 2759.95 km^2. Within this, the following areas were identified in each habitat rating category for each species (Table 4):

Table 4: Habitat areas in the County of Parkland for indicator species in each rating category.

Habitat	Indicator Species	Habitat GOOD (km^2)	Habitat FAIR (km^2)	Habitat POOR (km^2)	Total Habitat (km^2)	Inadequate Habitat (km^2)
CONIFEROUS	MARTEN	107.35	58.95	87.72	254.02	2505.93
DECIDUOUS	HAIRY WOODPECKER	196.57	247.27	148.37	592.21	2167.74
SHRUB DECIDUOUS	MOOSE	166.59	334.71	59.45	560.75	2199.20
GENERAL UPLAND	WHITE-TAILED DEER	353.01	329.16	394.24	1076.41	1683.54
RIPARIAN	*MINK	124.09	40.09	82.16	246.34	2513.61
WETLANDS	*MALLARD DUCK	86.35	19.19	65.87	171.41	2588.54

* Maps only considered areas both 200m outside and 200m within water; in the case of the Mallard Duck map, a separate GIS coverage was built and only lakes and potholes were considered.

Note that these numbers may not be added to calculate a total amount of habitat for the County because some areas are used by more than one species and/or are given a different habitat rating.

4.3 Landscape Units

The delineation of eight Landscape Units within the County of Parkland closely follows the ecodistricts identified by Strong (1992b). These Landscape Units, and the ecodistrict boundaries, are shown in Figure 12. The eight Landscape Units and the ecodistricts with which they are associated are:

Table 5: Landscape Units and their associated Ecodistricts.

Landscape Units	Total Area (km^2)	Associated Ecodistricts
North Saskatchewan River Valley	123.18	11NV
Stony Plain / Spruce Grove	541.75	4EP
Banksiana	188.92	8EP
Glory Hills	427.52	8EP
North of Lake Wabamun	484.86	11EU
South of Lake Wabamun	845.05	11WP
Mishow Creek	101.87	9WP
Pembina River Valley	46.11	9AV and 11AV

The amount of habitat in each Landscape Unit that was rated as 'good' habitat for any of the six indicator species is shown in Figure 13. The areal extent of this habitat for each indicator species in each of the eight Landscape Units is provided in Table 6. (The total area for LSU's in this calculation is 2759.26 km^2. The total area from the whole RVI is 2759.95 km^2. The discrepancy of 0.69 km^2 is due to very small polygon slivers that were less than 0.005 km^2 not registering when the values were rounded up to two decimal places.)

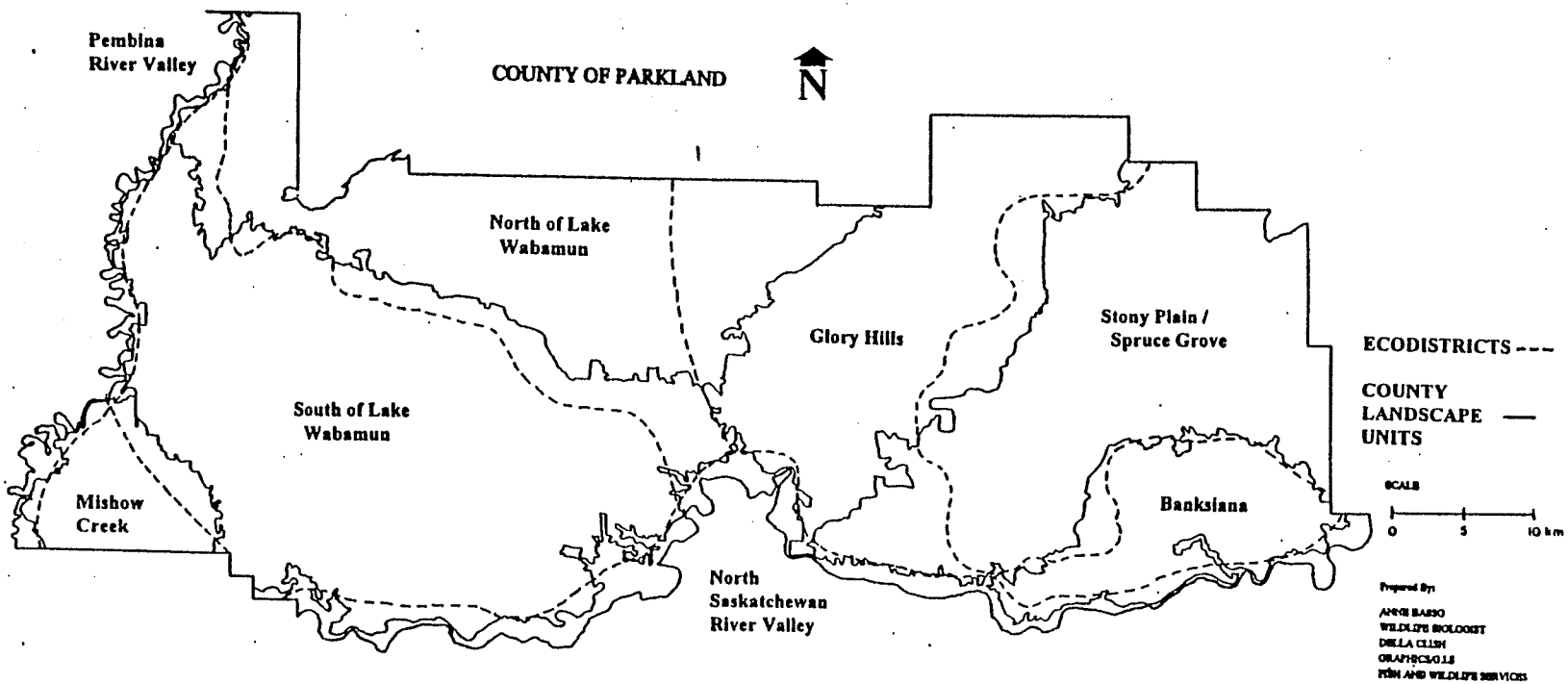


Figure 12: County of Parkland Landscape Units and their associated Ecodistricts

Table 6: Habitat rated "good" for each species in each Landscape Unit in the County of Parkland, both in square kilometers and in percentage of total area in the Landscape Unit.

County Landscape Units	Total Area (km^2)	White-tailed Deer	Moose	Mink	Marten	Hairy Woodpecker	Mallard
North Saskatchewan River Valley	123.18	52.17 km^2 42.35%	23.64 19.19%	49.29 40.02%	0 0%	30.87 25.06%	0 0%
Stony Plain / Spruce Grove	541.75	8.11km^2 1.50%	14.89 2.75%	3.94 0.73%	3.06 0.57%	5.53 1.02%	8.59 1.59%
Banksiana	188.92	7.89 km^2 4.18%	24.94 13.20%	4.68 2.48%	0 0%	6.17 3.27%	9.69 5.13%
Glory Hills	427.52	48.69 km^2 11.39%	33.30 7.79%	14.34 3.35%	13.10 3.06%	32.56 7.62%	44.15 10.33%
North of Lake Wabamun	484.86	118.85 km^2 24.51%	38.02 7.84%	27.82 5.74%	15.68 3.23%	61.34 12.65%	17.62 3.63%
South of Lake Wabamun	845.05	84.16 km^2 9.96%	9.39 1.11%	9.78 1.16%	58.11 6.88%	33.32 3.94%	6.11 0.72%
Mishow Creek	101.87	7.41 km^2 7.27%	1.63 1.60%	1.63 1.60%	14.67 14.40%	5.02 4.93%	0 0%
Pembina River Valley	46.11	25.73 km^2 55.80%	20.24 43.90%	12.40 26.89%	2.71 5.88%	21.76 47.19%	0.28 0.61%

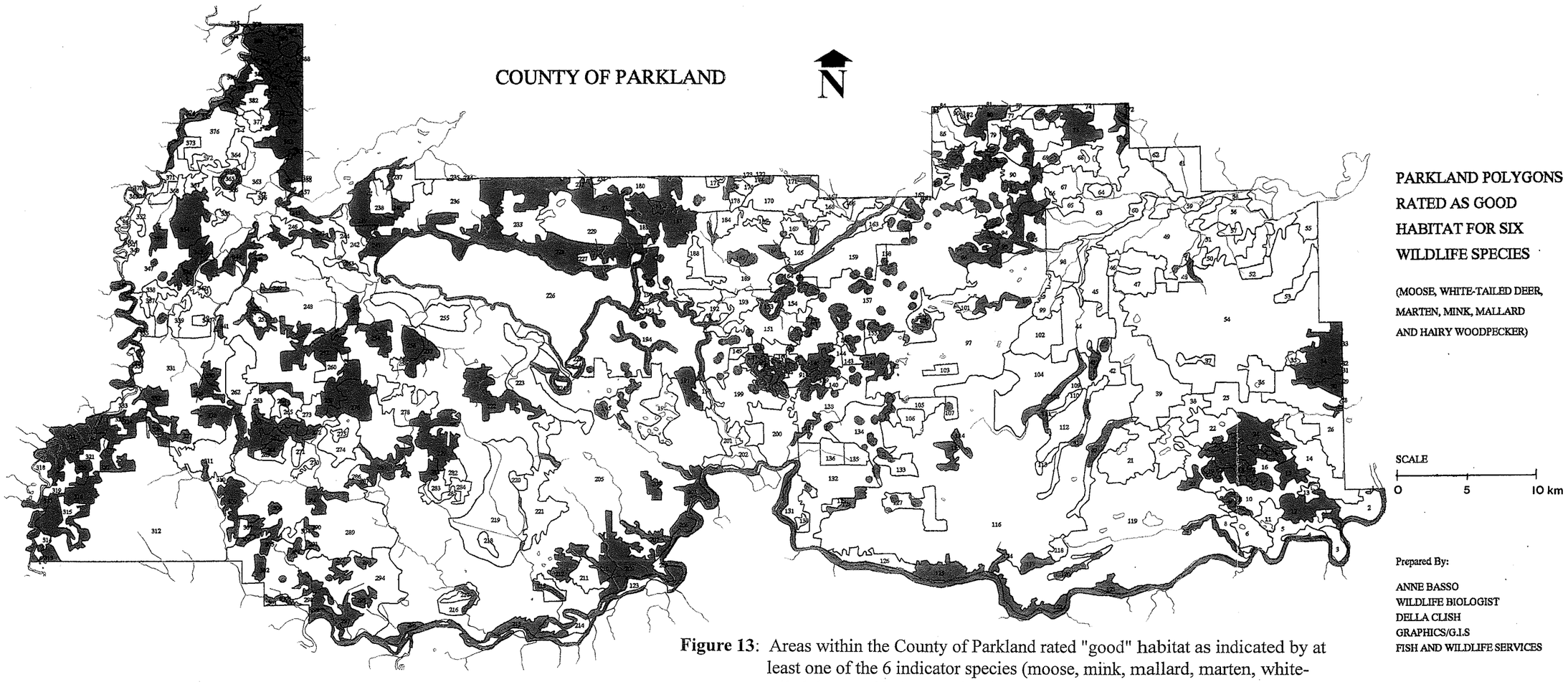


Figure 13: Areas within the County of Parkland rated "good" habitat as indicated by at least one of the 6 indicator species (moose, mink, mallard, marten, white-tailed deer, and hairy woodpecker)

4.4 Habitat Suitability within Landscape Units

Since landscapes are defined by spatial contiguity (Allen and Hoekstra, 1988), the County of Parkland was divided into eight County Landscape Units each with underlying ecological characteristics, based on Strong (1992a,b,c). These units are based upon ecological, topographical and geological conditions. These conditions, or similar ones within a given ecoregion, exist outside the County boundary, so there is no barrier to movement or establishment of wildlife flora or fauna from flowing outside the County along a natural vegetative, climatic and topographical continuum.

Within these County Landscape Units the broad vegetative habitat types identified by the indicator species were considered in terms of patches, corridors and matrices, and the fragmentation and juxtaposition of those. Habitat was the focal point in this endeavor, so it is important to note that the indicator species indicate habitat that has vegetative cover suitable for that species; no analysis was performed on the size or shape of the polygon (or portion thereof) with respect to the suitability for that species. For example, marten inhabit conifer dominated forests but they may require larger areas than are represented by some of the smaller coniferous dominated polygons.

North Saskatchewan River Landscape Unit

The North Saskatchewan River Landscape Unit (LSU) includes the terraced edges and steep sloped valley of the North Saskatchewan River. Stream and creek valleys enter the river at various points, and fragmented blocks of remnant mixed forest are spread along the banks of the river and river valley. The meandering west half of the river valley contains more forested habitat than the east half. Cultivation and acreages have pushed close to the edge of the river valley itself in places, effectively fragmenting naturally vegetated blocks. According to the County of Parkland's land use by-law 24-89 (1989)

map in schedule B, this LSU is designated as a Recreational District with permitted and discretionary uses.

Looking at the indicator species maps for the North Saskatchewan River LSU, the river valley and treed portions on islands are habitat for white-tailed deer and mink; and the remnant habitat patches connected with it would be adequate for hairy woodpecker, moose, and white-tailed deer. There were only two remnant patches that had a high enough coniferous component to be rated as poor habitat for marten. In many places 50-80% annual cropping is present to the river bank. There would be little mallard habitat within this LSU because there are extremely few potholes located within its bounds.

Habitat rated as 'good' for any one of the species (Figure 13) involves the forested remnant patches of the river polygon. The North Saskatchewan River LSU is primarily an environmental resource river corridor with connected remnant habitat patches, and associated stream corridors. This river valley area serves as a valuable overwintering area for ungulates and serves as habitat and a movement corridor for other species.

Pembina River Landscape Unit

The Pembina River Valley LSU includes the steep banked, winding river valley, and a relatively narrow buffer of mixedwood and coniferous forest. Most of the river valley is forested, although it is sparse in gradually sloping areas. Highway 16 crosses the Pembina River at Entwistle. Except for the village of Entwistle and its associated Expansion District, this LSU is designated as a Recreational District. (It should be noted here that this LSU not a continuous polygon but is formed from numerous small polygons which divide the river into pieces.)

The species maps for the Pembina River LSU show the most habitat for white-tailed deer within that map, which is shown to have contiguous habitat for almost the entire length of the LSU. The same is true for mink, although less contiguous. Moose,

hairy woodpecker, and marten maps also show large remnant patches of habitat along the river. There is no mallard habitat in this LSU.

Much of the length of this environmental resource corridor is 'good' habitat, but it is not totally continuous. The one place of discontinuity of good habitat is at Entwistle and its surrounding area, where Highway 16 crosses the river.

Glory Hills Landscape Unit

The Glory Hills LSU contains potholes in areas where the terrain is hummocky and forested. Cultivation occurs on undulating terrain. There are many acreages, and recreational areas in the hummocky areas surrounding the lakes. Forested areas are predominantly deciduous and mixedwood. Highway number 16 runs through the center of this LSU. This LSU is almost wholly designated as a Country Residential District. Small areas surrounding Gladu Lake, Hasse Lake, Lake Eden, Chickakoo Lake, and the area just north of the North Saskatchewan River near Keephills, are designated as Recreational Districts.

The majority of wetland habitat in the County of Parkland is found in the Glory Hills LSU. Although a 200m buffer was placed around lakes and potholes and appropriate cover was rated, the actual amount of habitat available within the 200m buffer zone may be less that is shown on the map due to human habitation and alteration of vegetation near water bodies. The habitat available will also vary with wet and dry years, with excess water covering some of the shoreline in wet years, and not enough moisture to provide food or cover in dry years. Variation in soil type and water quality will also determine the type of surrounding vegetation. However, no distinction was made between the different types of waterbodies in the RVI, so no differentiation could be made between saline, acidic, or other types of water.

Although this LSU is the best area in the County for ducks, there are also other species that utilize the habitat present within this LSU. The northern portion of the LSU has substantial remnant patches of fair habitat for hairy woodpecker and white-tailed deer as the matrix around lakes and potholes. Most of the remainder of the LSU is rated as poor for white-tailed deer. There is very little marten habitat, with the exception of one large remnant patch located west of Stony Plain. Fair mink and moose habitat is located along Kilini Creek, lakes and potholes in the northern portion of the LSU near Chickakoo Lake. Good mink, and good and fair moose habitat is located around Jackfish and Hasse Lakes. There is comparatively little annual crop in the LSU.

The habitat rated as good in Figure 13 in the Glory Hills LSU is concentrated around environmental resource wetland patches of lakes and potholes, including the environmental resource creek corridor of Kilini Creek. This Glory Hills area has been identified as the Stony Plain Landscape by North American Waterfowl Management Plan (NAWMP) for future habitat management work. There is a need to maintain cover near water bodies, especially shrub and rough pasture, and encourage sustainable land management practices. Initiatives such as Alberta Prairie CARE (APC) may aid in this effort.

Banksiana Landscape Unit

The Banksiana LSU is undulating terrain with sandy- silty soil. The western third of the LSU is between 70-80% annual cropland. The east two-thirds contains a significant density of lakes and potholes. The lakes area contains numerous subdivisions and acreages. The eastern half of this LSU is designated by County by-law as a Country Residential District, while the west half is designated as an Agricultural / Mixed Land Use district.

The species maps depict the eastern half of the Banksiana LSU as being habitat for white-tailed deer, hairy woodpecker, and one of the few places in the County that has good remnant patches for moose. There is some marten habitat within this aggregation of remnant patches. The lakes and potholes have adequate upland cover for mallard duck. The western half of the LSU is largely 70-80% annual crop. There is very little treed riparian habitat, as indicated by mink habitat in the LSU.

The 'good' habitat in the Banksiana LSU is mainly around the lakes and potholes and the habitat the connects them in the eastern half, although there are a few lakes and potholes in the western half of the LSU.

Stony Plain / Spruce Grove Landscape Unit

The Stony Plain / Spruce Grove LSU has annual crop coverage of between 50-80% over most of this unit. This LSU borders the Edmonton City boundary, and this proximity to Edmonton is convenient for the large number of acreage owners to commute to the city. The town of Stony Plain and the city of Spruce Grove are within this LSU, and Highway 16 runs from east to west through the northern portion of this Unit. Although few large blocks of forest appear on the RVI, there are smaller wooded areas as well as fencerows and shelterbelts that occur throughout the Landscape Unit, notably occurring within and along minor meltwater channels, streams, creeks, and lake borders. These forested areas are predominantly deciduous vegetation.

The bulk of this LSU is designated by the County of Parkland land use by-law (1989) schedule B map, as an Agricultural / Mixed Land Use District. The town of Stony Plain and the city of Spruce Grove are bridged by an Urban Expansion District. There are also 5 sections of land designated as Industrial / Commercial District, with 11 surrounding sections of land as 'reserved' for these same activities. These industrial / commercial designated areas are located north of the Stony Plain Indian Reserve, and

south of Highway 16X, and are bounded on the east by the Edmonton city boundary. Just over 2 sections are designated as Recreational Districts.

The species maps for this LSU show a few wetland patches along meltwater channels and creeks. There is also only a small amount of moose and hairy woodpecker habitat, some of which is located within the Stony Plain Indian Reserve, the rest of which is located along Atim Creek. Atim Creek is an important environmental resource corridor for all six indicator species. Marten habitat in the LSU is found in a few remnant patches, notably in Wagner Bog near Spruce Grove, and the Stony Plain Indian Reserve. Mink habitat occurs in fragmented pieces along Atim Creek and its associated streams. White-tailed deer habitat is the most prevalent, with some available near Big Lake, near the North Saskatchewan River, and within the Stony Plain Indian Reserve.

There is very little 'good' habitat in this LSU, with the three main exceptions being i) the environmental resource corridor of Atim Creek, ii) the Stony Plain Indian Reserve, and iii) lakes associated with the meltwater channels paralleling Atim Creek.

North of Lake Wabamun Landscape Unit

The North of Lake Wabamun Landscape Unit encompasses the area north of the lake itself and the area north of highway 16 to the west of the lake to the County border at the Pembina River north of Entwistle. A large component of forested land exists in this Unit, mainly consisting of mixedwood and deciduous trees and shrubs north of Lake Wabamun. The forested area in the northwest corner is mixedwood and conifer. Numerous cottages and small towns exist along the north and west shores of Lake Wabamun; while the east side of the lake is an Indian Reserve. A coal strip mine exists north of the highway. There is little annual crop in this Unit. This LSU includes Country Residential, Agricultural / Mixed Land Use, Resource Extraction, and some Recreational

Districts. Resource extraction is designated under the County of Parkland Land Use By-Law (1989).

Indicator species maps show that the largest amount of habitat available is suitable for moose (fair) and white-tailed deer (variable). Mallard habitat occurs along the shores of Lake Wabamun and Isle Lake, near Kilini Creek, and within the Wabamun Indian Reserve. Mink habitat in the LSU is located similarly, with additional habitat fragmented along portions of streams, and a network of streams north of Round Lake. Large remnant patches of hairy woodpecker habitat occur north of Lake Wabamun and the area between Isle Lake and Wabamun Lake; in Wabamun Indian Reserve and north of Round Lake. Almost the whole LSU is habitat for white-tailed deer. Small remnant patches north of Round Lake are the only places in the LSU that marten habitat is concentrated. There is comparatively little annual crop within this LSU.

Generally, the 'good' habitat in the North of Lake Wabamun LSU consists of juxtaposed remnant habitat patches adjacent to Lake Wabamun and north of Round Lake. Patches adjacent to Lake Wabamun are crossed by Highway 16, the railway line, numerous access roads to the lake. Cottage developments along the shores of the Lake and a coal mine north of the town of Wabamun also fragment the habitat.

South of Lake Wabamun Landscape Unit

South of Lake Wabamun LSU is the largest LSU in the County. The hummocky terrain and the varied soil types account for large areas of forested land, mainly mixedwood and coniferous dominated forests. This includes the Jackpine Provincial Grazing Reserve, and peat harvesting operations, two strip coal mines and their associated electrical power plants near the south shore of Lake Wabamun. The annual crop that occurs in the LSU is largely 50-60%, and occurs in the undulating terrain to the

south of Lake Wabamun. A band approximately two sections wide along the shore of Lake Wabamun is designated as a Resource Extraction District.

Annual cropland is the matrix of this LSU, at 50-60%, with some 70-80% further west in the LSU. The indicator species maps show that except for the south shore of Lake Wabamun, there is very little mallard habitat. There is some fragmented mink habitat along riparian stream corridors. This LSU has the largest amount of marten habitat, which are ranked as good, fair, and poor. Hairy woodpecker and white-tailed deer habitat occur in remnant patches in the middle of the matrix of annual crop, and also occur along the North Saskatchewan River in various places. White-tailed deer habitat occupies a large part of this LSU including the Jackpine Provincial Grazing Reserve, and an area east of Low Water Lake.

The 'good' habitat from the species maps is concentrated in aggregations of remnant forested patches in the middle of the agricultural matrix. Some of these blocks of habitat could be connected via enhancement of environmental resource stream corridors. The large amount of coniferous dominated patches is important in this LSU, since there is little in other areas of the County.

Mishow Creek Landscape Unit

The Mishow Creek LSU is largely cultivated with annual crop at 70-80% of the cultivation dominated areas. The Landscape Unit is bounded on the east by Mishow Creek, and the west by the Pembina River Valley. This whole LSU is designated as an Agricultural / Mixed Land Use District.

The species maps show that white-tailed deer habitat is the most prevalent, and is composed of connected remnant patches along the Pembina River LSU. Hairy woodpecker, moose, and marten habitat also occurs but to a lesser extent for moose, and

even less for marten. There is only a small, fragmented area of mink habitat located within the large 70-80% annual crop area.

The remnant patches that are connected with the Pembina River on the west side of this LSU are the 'good' habitat areas (Figure 13). They are contiguous, but they have patches of inadequate habitat within them. All the habitat along Mishow Creek, which forms the eastern border of the LSU, is rated inadequate for mink, due to the high level of cultivated land.

CHAPTER 5
DISCUSSION

5.1 Landscape Ecology Principles within the County of Parkland

Landscape ecology incorporates human as well as natural influences that operate on landscapes, which is why it is a viable framework for land use planning and management (Selman and Doar, 1992). Recognition that landscapes and their features are dynamic and will change through time is vital to land use planning. Selman and Doar (1992) also recognize that natural habitat loss is extensive over landscapes with large anthropogenic influence and that many initiatives to recreate landscape features are short-lived and fail to achieve the landscape goals sought. Often this short-term effort can be linked to changes in the political will that governs the area.

The County of Parkland is a landscape. Structure, function and change are the three main characteristics of a landscape to consider when making management decisions (Turner and Gardner, 1991). The actual structure of the County landscape is addressed through the location of broad habitat types in the maps for the six indicator species, and the annual crop map. The function of the landscape is identified by the ratings of the various habitats in the six species maps and the different percentages of annual crop in the annual crop map. The change within the County landscape is described by the increase in the amount of clearing between 1949 and 1987. The rejection of the null hypothesis, of no difference in the amount of cleared land between 1949 and 1987, confirms that there has been an increased amount of land cleared in the 52 selected sections. The Box-plot (Figure 2) supports the results of a higher percentage of sections on which there is more cleared land in 1987.

Following the line of no change to the right it is apparent that sections that had a lot of clearing in 1949 could not be cleared much further, thus the amount of cleared land

did not increase dramatically. Indeed, in a few areas where there was high clearing in 1949, less clearing was evident by 1987. There is the possibility of people planting shelter belts since 1949; allowing some cleared areas to be naturally reclaimed; and/or changing water levels affecting the amount of non-cleared area observed.

A comparison of the frequency histograms shows a shift of the amount of clearing to an increased amount of clearing in more sections in 1987. More of the eastern half of the County is cleared because those sections in the east half have soils more conducive to crop production than those in the western half of the County. The eastern half of the county lies closer to the city of Edmonton and would, likely, have been subject to earlier settlement and clearing. The eastern half of the County would has been subject to increased subdivision to accommodate for an increasing number of urban commuters who live on acreages outside the City of Edmonton. The large network of highways, secondary highways and other roads, rail lines, subdivisions and other disturbances have severely limited the areas suitable for native species of plants and animals. This is unlikely to change, so preservation and retention of natural vegetation presently within the County is vital to the maintenance of the biodiversity. Cooperation of the government with the landowner is vital to the conservation of habitat because private landowners are the ones who bear the brunt of wildlife habitat conservation and protection.

The main landscape structures present in the County were various sizes of patches, corridors and surrounding matrix. Associated with these are concepts of fragmentation, juxtaposition and the type of boundary that are found with these landscape structures. The County of Parkland is a highly managed system and the predominant patch types were remnant patches and environmental resource patches that surround lakes and potholes. The size of the patch and the diversity of habitat within the patch are

factors in the amount of species diversity within any given patch (Forman and Godron, 1981).

The corridors that are the main concern for this study in the County are environmental resource corridors along rivers, streams and creeks. The County's network of highways, roads and subdivisions have served to fragment these environmental resource corridors, with creek corridors being the most fragmented. Continuous corridors are desirable for connections between patches because this increases the potential for interaction and movement of species between patches (Selman and Doar, 1992).

The predominant matrix within the County is crop and pasture land, particularly in the eastern half of the County. Since human management sharpens borders between natural and managed systems (Correll 1991), the dominance of man within the County landscape is evident by the straight lines along many patch edges and transportation corridors.

The County of Parkland is located in a highly cultivated, anthropogenically influenced area of the province of Alberta. The soils are productive for agricultural purposes ranging from annual cropping to grazing. The County of Parkland has the capability to support vegetative habitat and associated wildlife species with habitat ranging from grassland to coniferous forest. The County is located at the north-western edge of the Aspen Parkland ecoregion; in the southern portion of the Low Boreal Mixedwood ecoregion; at the southern tip of the Mid Boreal Mixedwood; and at the eastern edge of the Lower Boreal Cordilleran ecoregion as delineated by Strong (1992a,c). However, the agricultural capability of the land combined with the proximity to the city of Edmonton has led to fragmented vegetative cover typified by patches of

natural vegetation amongst larger cleared areas. This is especially evident in the eastern half of the County.

Ecosystem suitability refers to the current state of an area; ecosystem capability refers to the optimal seral condition for each species (Demarchi 1992). The vegetative community plays an important role in ecosystem function. It is the most visible component, and it directly and indirectly indicates the quality of food and cover available for wildlife species (Klar and Stelfox, 1985). But man, as an animal, is increasing the importance of their role in ecosystem interactions (Lamotte 1983). Such is the case with ecosystem interactions in the County of Parkland.

5.2 Reasons for Habitat Retention, Enhancement and Development

On a County-wide basis there are a number of reasons identified in this study that indicate that habitat retention, enhancement and development are desirable goals within the County of Parkland. There has been an increase in the amount of cleared land between 1949 and 1987, as identified by air photo analysis; the dominant land use in the County is for crop and pasture; few remnant habitat patches of coniferous forest exist and those that remain are on the western side of the County; remnant deciduous patches of habitat, both tall and shrub, exist near flowing water and wetland areas, as well as in the northern portion of the County; only small remnant habitat patches remain along many of the riparian zones; general upland cover is found over a large portion of the County, usually where the annual crop cover is less than 50%; and habitat rated as good within the County is fragmented and generally occurs adjacent to water. Within this list of County areas are four main types of areas that are of concern to conservation of habitat for wildlife: riparian areas, wetlands, remnant forested patches, and fencerows.

Riparian Areas are Environmental Resource Corridors

Treed riparian areas, as identified on the Mink map are present throughout the County of Parkland, but most of this habitat occurs along the North Saskatchewan River Valley, the Pembina River Valley, and the shore of Lake Wabamun. These two environmental resource corridors are associated with remnant deciduous, coniferous, and mixedwood forest patches and connected to stream corridors. Agricultural development has led to clearing very close to the edges of most waterbodies. This, combined with ditching, draining, crossing, and filling of creeks and streams has fragmented many riparian corridors. This fragmentation and removal of riparian vegetation may lead to an increase in the nutrient loading to streams that drain agricultural land. For example, riparian areas serve as important wildlife corridors, retain some of the remaining natural vegetation, and influence soil and water movement. Effective management of any area will depend upon the treatment of other components of the ecosystem that are adjacent to, and interact with, the area in question through both time and space (Jennings and Reganold, 1991). Kratz et al., (1991) noted that movement of water was important in pattern variability across the landscape and that the spatial position of an ecosystem within the surrounding landscape influences the properties of that ecosystem, often governing the average conditions existing there. By permitting agricultural practices and other influences to change the patterns of water movement across the landscape, the suitability of the land to support certain vegetative and animal species will have been altered. Citing the ecological and economic values of riparian ecotones in their regulation and transformation of nutrients flowing from agricultural lands to streams, Correll (1991) views these as important reasons for conservation and enhancement of riparian vegetation. Stream corridors that remain in a natural vegetated state and link the streamside with upland habitat, allow greater ecological integrity of the landscape.

Riparian corridors often serve as travel corridors for animal species because of their higher moisture content and the diversity of accompanying vegetation. The larger riparian corridors associated with rivers also serve as important overwintering areas for ungulates such as moose (Wallis and Knapik, 1990). Many migrating and nesting birds also use riparian corridors (Wallis and Knapik, 1990). In a study of birds and riparian corridors in Pennsylvania, Croonquist and Brooks (1993) found that bird species abundance and richness generally decreased with increasing distance from streams in agricultural and residential areas. Limited bird species communities may exist in strips of vegetation < 10m along the watercourse, but sensitive species did not occur unless a width of >25m of undisturbed corridor occurred on either side of streams. This minimum of 25m allows both breeding opportunities and dispersal of avian species. Croonquist and Brooks (1993) advocate the protection of existing stream corridors and /or the restoration of native vegetation in riparian areas, and landowner education of the effect that small changes can have on avian communities. In Croonquist and Brooks' (1993) study management recommendations included: management of riparian areas for avian species that have become dependent upon patchy, native woody vegetation; streambank fencing and conservation easements along riparian corridors that would prevent livestock grazing.

Fish and fish habitat also benefit from the improvement in water quality to which a buffer contributes. Department of Fisheries and Oceans (DFO) (n.d.) advocate a minimum of 15m buffer along these river bank areas to protect water quality and provide landowner benefits using buffer zones along areas with steep banks or erodible soils. Croonquist and Brooks (1993) also suggest that the use of conservation easements would provide tax incentives to encourage retention of riparian corridors. Enforcement of

conservation regulations and sound land management practices for forestry and agriculture that occur near riparian zones would also help maintain these corridors.

To protect biodiversity in areas of high human influence, the main preservation focus should be on stream corridors and on large patches of habitat. Suggestions by Thorne and Huang (1991) for the preservation of habitat diversity within an agricultural and suburban matrix includes 100 m of upland habitat (the flood plain) and a 100m edge on one side of the stream corridor. Natural corridor links such as riparian areas provide good quality habitat as well as improving the connectivity of the landscape. The U.S. Forest Service and the U.S. National Parks Service have begun to recognize landscape ecological planning, especially with respect to river courses. The primary goal here is to connect the riparian areas using natural vegetation.

Establishing a vegetation buffer along all drainages would allow for natural vegetation to return over time and increase the amount of habitat along riparian corridors. Connectivity via corridors is beneficial in the following ways: a) populations survival at higher levels may be enhanced, b) population growth is supplemented by immigration and it may prevent some extinctions, and c) recolonization of depleted habitats is facilitated by dispersal (Selman and Doar, 1992). It should also be noted that corridors are also attributed with negative effects such as acting as barriers for certain smaller species, one problem being the edge to area ratio in the corridor. The corridor may be too wide for some smaller animals to cross.

Two suggestions for buffer strip establishment are found in the Buffalo Creek Study Site Management Plan, Report 3 (Natural Resources Institute Study Team, 1992) out of Manitoba. Outlined are a Voluntary Agreement Buffer Strip (VABS), and a Managed Buffer Strip (MBS) along riparian corridors for the protection of the stream or creek.

On leased or purchased lands, the conservation agency should protect or establish a MBS of native or natural vegetation of minimum 20m from high water mark on creeks; and for areas that are to serve as recreation areas or wildlife habitat, a recommendation of 100m minimum is made. An estimated cost of $200/acre ($494.22/hectare) for marginal land, to $1,200/acre ($2965.31/hectare) for Class I land, plus legal survey fees of $1,000/day; and if revegetation and restoration costs are involved then the cost could be over $2,000/acre ($4942.18/hectare) (Natural Resources Institute Study Team, 1992).

Due to the larger expense incurred with purchase or lease of land, and the unwillingness of some landowners to enter into long-term agreements, a VABS would be the better option to establish. Through the use of public education, either through information distributed to those landowners who have property along environmental resource corridors (focusing on soil and water quality and conservation principles), or public open houses and meetings, the concept of a VABS would be outlined. Landowners wishing to participate would enter into a signed but not legally binding agreement with the conservation agency to set aside a continuous strip of 10m from the typical high water mark of the creek (Natural Resources Institute Study Team, 1992). A sign would be erected acknowledging the landowner's contribution, and aspects of management such as weed control, fencing, controlled burns, or haying would be negotiated between the two parties. An estimated budget for this type of buffer strip is $200 for consultation, and $500 for promotional materials (Natural Resources Institute Study Team, 1992).

Wetlands are Environmental Resources Patches

The Glory Hills and Banksiana LSU's are the primary areas within the County for wetland habitat. The maintenance of the capacity of wetlands to act as filters for agricultural and other pollutants, as well as maintaining water levels of both ground and

surface water is crucial to the ecological processes in a landscape and maintenance of its vegetative cover. The maintenance of associated upland areas connected with wetlands are vital to waterfowl populations for nesting purposes. Clark and Nudds (1991) state that more information is needed to assist habitat managers in habitat restoration programs regarding duck nesting success in managed habitats, citing conflicting data regarding increased patch size and duck nesting success. An increase in habitat patch size available could be one factor in increased duck nesting success, but other investigations have suggested that the opposite may be true because increased habitat available may lead to increased predator abundance or higher nesting density (Clark and Nudds, 1991). Both habitat management and predator management need to be carefully considered in these areas. They also question the use of funds to establish small areas of cover, and say that funds should be redirected towards agricultural policy reform. Protection of wetlands can be accomplished by compensation, tax concessions, provincial regulation and municipal zoning (Canadian Wildlife Service, 1989).

An educational book from Maine, called The Lake Book (Moore, 1991), provides reasons for the maintenance of vegetation within a 100 ft. (30.48m) buffer zones of water of lakes and ponds. These buffers filter agricultural runoff, and maintain soil moisture. Maine's shoreland zoning law requires all municipalities to establish land use controls for all land areas within 250 ft. (76.20m) of ponds and wetlands that are larger than 10 acres (4.05 hectares).

In her Strathcona County Watershed Management Plan, Griffiths (1992), suggested that a minimum buffer of 50m be protected around potholes and 100m around lakeshores. Reasons given included the provision of nesting cover for waterfowl; food, cover and access to drinking water for upland species; breeding and hibernation habitat for amphibians; and provision for habitat for higher numbers of small mammals.

Remnant Forested Patches are Habitat

Coniferous dominated forest habitat, as identified on the Marten map occurs in small patches in the County, with most located in the South of Lake Wabamun Landscape Unit. This concurs with the information on capability identified in the ecoregion literature by Strong (1992a). There is little coniferous dominated habitat in the County (Table 6). To maintain biodiversity of the floral and faunal species that live in coniferous habitat, it is important to conserve existing coniferous dominated habitat.

Tall deciduous forest, as indicated by Hairy Woodpecker, is present in most of the same areas in the Landscape Units as shrub and deciduous dominated forest, which is indicated by Moose (Figures 9 and 10). The larger amount of deciduous cover is consistent with the capability of the ecoregions that make up the County, noting that most of these areas are associated with some type of water body. These large deciduous areas are also located in the Landscape Units North and South of Lake Wabamun. The areas South of Lake Wabamun are often found adjacent to coniferous areas due to the hummocky and variable terrain in this portion of the County. Although the vegetative cover is rated as good or fair in the Banksiana and Glory Hills Landscape Units, these areas are dominated by acreages and human activity. The Wabamun Indian Reserve was observed (August 12, 1993) to have more clearing than indicated by the RVI, and thus there is more fragmentation of habitat within these areas. Mishow Creek LSU also contains remnant mixedwood patches on the western side of the unit, adjacent to the Pembina River LSU.

Fencerows and Strip Corridors are Habitat

The LSU of Stony Plain / Spruce Grove possesses little forested habitat and a large amount of cultivated area compared to the other LSUs in the County. Moving from natural landscape through a continuum of increasing anthropogenic influence culminating

in urban landscape, there is an increase in the fragmentation of natural areas, and an accompanying decrease in biodiversity due to a lack of minimum suitable area for home range establishment (Thorne and Huang, 1991). The increase in fragmentation of the forested habitat areas in this LSU also means that breeding between individuals in separate patches is less likely to occur. Connectivity between these patches also decreases closer to urban areas. Farmers and landowners should be encouraged, through education and demonstrations, to allow fencerows to maintain an area of natural vegetation surrounding them. These structures, along with natural depressions containing trees and shrubs are vital links between environmental resource patches and corridors for wildlife.

General upland, as identified by White-tailed Deer (Figure 12) covers most of County Landscape Unit North of Lake Wabamun, and Glory Hills Landscape Unit. If this map (Figure 12) is compared to the Annual Crop map (Figure 6) they are close to being opposites for indication of wildlife habitat, with some overlap of the general upland on to areas with lower percentages of annual crop. This could lead to the conclusion that the upland habitat remaining is not likely suitable for agricultural use. Upland areas with suitable soil conditions are often already under a cultivation or domestic grazing regime.

5.3 Habitat Program Options

To conserve the habitat currently available in the County of Parkland three main options should be pursued to allow natural vegetation to reclaim areas, and to retain areas of existing vegetative habitat:

1. habitat retention / protection
2. habitat enhancement
3. habitat development

The actions taken to meet these goals should be undertaken by the County, with assistance from Fish and Wildlife Services, are:

i. Increased protection, maintenance and enhancement of riparian areas throughout the County.

ii. Increase connectivity between remnant habitat patches along stream corridors by allowing larger buffers along watercourses.

iii. Protect or retain existing coniferous habitat patches.

iv. Minimize further wetland drainage. Reduce incentives that encourage cultivation of marginal land to help prevent erosion, reduce pollution runoff, provide habitat for wildlife and retain natural vegetation.

v. Increase educational initiatives and informational sessions to facilitate the establishment of environmental stewardship and a sound land ethic.

To carry out these five specific actions may involve a number of different types of habitat management strategies and combinations of those strategies for any given area. Retention agreements could be pursued for areas of habitat that are already present in adequate condition. Modifications to improve habitat could include fencing habitat areas, creation of voluntary buffer zones, private woodlot management, alteration to bylaws along right of ways, or alteration to agricultural practices. Habitat development could include planting trees or shrubs along sparsely treed riparian areas, planting windbreaks or shelterbelts in open areas, converting marginal agricultural areas bordering wetlands to dense nesting cover, or restabilizing creek and river banks to prevent erosion.

There are areas throughout the County that should be retained for wildlife habitat. The County of Parkland has set aside 14 quarter sections dispersed throughout the County solely for habitat retention and enhancement. There is also the area within the Jack Pine Provincial Grazing reserve and other Provincial Crown land available for habitat use for wildlife species. Generally speaking, these lands would require retention and protection,

unless they are located along riparian corridors, in which case they may require some enhancement work like fencing.

Scarth (1984) lists the following five policy instruments available to private land habitat programs: 1) persuasion, including education and technical assistance programs; 2) economic incentives, including cost-sharing programs, tax incentives (credits or rebates), and paying fees for hunting on private land; 3) public investments through land acquisition, or limited use agreements; 4) mandated performance using zoning, or regulation; and 5) soil and water conservation programs, which include education, cost-sharing, and watershed planning.

The main problem with modern agriculture is the focus of short-term profit, which is perpetuated by government policies that continue to promote a maximization of cultivated acres, without consideration of the associated problems of declining soil organic content, soil erosion, and habitat loss (Pivnick et al., 1993). Thornton et al., (1993a) cites GRIP (Gross Revenue Insurance Policy), and the Canadian Wheat Board quota system (Thornton et al., 1993b) as focal points for policy reform regarding agricultural practices on the Canadian prairies. Suggested changes to GRIP involve ineligibility of newly broken native land, modification of the crop insurance policy so fragile soils do not qualify, and inclusion of forages, pastures and rangelands in the program (Thornton et al. ,1993a). Suggested changes to the CWB quota system involve: grain deliveries be changed from an acreage base to a volume base; or modification of the inclusion of summer fallow within the quota acreage formula; and alteration of the quota acreage formula to permit native pasture and uncultivated lands to be included up to a certain percentage of cultivated lands (Thornton et al., 1993b). An additional modification to the CWB quota system proposed by the Saskatchewan Wetland Conservation Corporation is reported by Thornton et al., (1993b). There is the option of

including marketable habitat quota acres that could be leased annually by conservation organizations. Initiatives such as these could contribute greatly to a more sustainable land ethic and increase natural habitat available in agriculturally dominated areas.

CHAPTER 6
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

6.1 Summary

Species habitat preservation is the most important conservation goal that exists today (Watkins 1993), especially in the agricultural areas of the prairies. General principles of landscape ecological planning include the concept that areas of vegetation that contain a greater variety and amount of plant life will also support larger varieties of animal life, if the size of the area is adequate (Selman and Doar, 1992). The effect that the spatial arrangement of landscape features and their inherent characteristics of proximity and connectivity have on the ecological interactions is the crux of landscape ecology and are determining factors of the plant and animal species within a landscape.

The County of Parkland, Alberta is an agriculturally dominated landscape, with fragment patches of natural vegetation, varying in size and location. The County has the capability to support habitat ranging from coniferous forest to grassland, and the wildlife species associated with these habitats. For the purposes of wildlife habitat conservation the four main types of areas of concern in the County include riparian areas, wetlands, remnant forested patches, and fencerows. Low and/or wetland areas, such as those surrounding potholes, lakes, and riparian corridors, are generally associated with these remnant patches of natural vegetation. There is more deciduous dominated habitat than coniferous habitat, and both require sustainable land use practices to continue to be viable habitat for both floral and faunal species.

6.2 Conclusions

The objectives of this practicum were met by the following means:

1. Landscape Ecology Principles were identified through a literature search and incorporated into the study to describe various landscape structures. Major concepts

include: patches (both remnant and environmental resource); corridors (environmental stream and river corridors, and disturbance corridors); and matrix.

2. Availability of existing habitat types and patterns in the County of Parkland were identified mainly using the RVI map and GIS analysis. Within the County, wetland areas are concentrated in Glory Hills, Banksiana, and Lake Wabamun; coniferous forest is generally located on the western half ; treed riparian habitat is located primarily along the two river corridors, and fragmented patches of habitat are located along creeks; deciduous shrub is located in smaller remnant habitat patches throughout the County; tall deciduous forest is located along the river corridors and more predominantly in the northern half of the County; and general upland occupies the most area of the six broad habitat types, and occurs throughout the County, with main coverage in the northern half of the County.

3. Habitat suitability for indicator species was determined by setting criteria for the delineation of these habitat and indicator species within the GIS: mallard duck for wetland, mink for treed riparian, moose for shrub deciduous, marten for coniferous dominated, hairy woodpecker for tall deciduous, and white-tailed deer for general upland.

4. Habitat goals and program options for the County of Parkland were developed using Landscape Ecology principles and concepts, the most prevalent of which were maintenance and retention of environmental resource corridors and patches existing in the County through the establishment of buffer zones around wetlands and rivers and streams. Specific attention should be given to the Atim Creek environmental resource corridor, Kilini Creek corridor, the Banksiana moraine area, and the area north of Round Lake. Potholes and lakes within the Glory Hills Moraine, the remnant patches associated with the Pembina and the North Saskatchewan Rivers, and the large remnant wooded habitat patches south of Lake Wabamun all require habitat conservation efforts. The

connection of these landscape features could be accomplished by establishment of a VABS along the creeks and streams in the County of Parkland.

6.3 Recommendations by Landscape Unit

The following recommendations are made for the landscape of the County of Parkland, Alberta. Although the recommendations are directed to the County and should be put into action by Fish and Wildlife Services, private landowners will have a great deal of influence for land use in the area. Possible program options available to landowners for the meeting of the recommendations are listed in Appendix J. Other provincial initiatives could also affect land use within the County.

North Saskatchewan River Valley

Establishment of a Voluntary Agreement Buffer Strip, or if funds are available, a Managed Buffer Strip, would contribute to the maintenance of a 200m buffer of natural vegetative cover along the North Saskatchewan River Valley. Habitat within the river valley should also be retained, especially to prevent erosion of soil into the river. The County should consider passing by-laws restricting development within these 200m buffers. Encouragement of retention or enhancement of the buffered area for soil and water conservation would be desirable. Habitat retention agreements for the maintenance of a buffer 25m wide should be sought along creeks and streams entering the river. Program options should include habitat retention, private woodlot management, soil and water conservation, and conservation partnerships.

Stony Plain / Spruce Grove

This LSU is almost wholly agricultural in land use. Establishment and enhancement of habitat is a priority in this LSU. Habitat enhancement effort should be concentrated along Atim Creek and its associated streams, with the possibility of increasing connectivity of forested patches along its course with a buffer of 25m.

Conservation of the area surrounding Wagner Bog is desirable. Priority may be set along creeks and streams to use these corridors to connect remnant habitat patches. Program options should include habitat retention, private woodlot management, conservation partnerships, and soil and water conservation programs.

Banksiana

Maintenance of vegetative cover around the lakes and potholes on the eastern portion of the Landscape Unit is recommended. This area is a Country Residential district and is home to many landowners with small parcels of land. Voluntary habitat retention would be an option to pursue in this area. Education / information sessions should be held to encourage the maintenance of ephemeral potholes and buffers of at least 15m of upland habitat. Conservation Corridors Program would be beneficial for the establishment of more habitat in western portion of the LSU. Program options should include wetland education and maintenance, and conservation partnerships.

Glory Hills

Buffers of at least 25m on the outside of potholes are recommended. Even wider buffers would be better for waterfowl. Establishment of a corridor along Kilini Creek by seeking habitat retention agreements from landowners. This LSU is largely a Country Residential District, educational material and voluntary retention agreements should be pursued. Program options should concentrate on habitat retention, wetland education, private woodlot management, soil and water conservation programs, and conservation partnerships.

North of Lake Wabamun

Shoreline vegetation along Lake Wabamun and Isle Lake should be maintained. Adequate habitat patches surrounding the main transportation corridor should be retained. Remnant forested patches both north of Highway 16 and between Highway 16 and the

lake should be retained. Program options should include private woodlot management, conservation partnerships, and habitat retention.

South of Lake Wabamun

Most of the coniferous cover in the County is present in South of Lake Wabamun and the Pembina River Valley LSU's. Conservation of the areas of coniferous habitat in this LSU is important and Tomahawk Creek's riparian corridors could be maintained with a 25m buffer along the bank. A Voluntary Agreement Buffer Strip program could be initiated. The discussion paper of the Alberta Water Resources Commission (1993b), called Beyond Prairie Potholes, being considered for managing Alberta's peatlands and non-settled area wetlands will affect the peat farming area around Jackpine Provincial Grazing Reserve in the County of Parkland. Program options should include habitat retention, private woodlot management, conservation partnerships, and soil and water conservation programs.

Mishow Creek

Retention of the coniferous and mixedwood areas along the Pembina River is recommended. Habitat development will need to be undertaken along those areas bordering the creek that are highly cultivated. Program options should include habitat retention, private woodlot management, and conservation partnerships.

Pembina River Valley

As with the North Saskatchewan River Valley, a buffer of 200m would be beneficial but a buffer of 100m would be more realistic to pursue on this narrower river valley. VABS and MBS may be established, and the habitat within the river valley should be protected. Habitat retention agreements could be pursued in areas where there is agricultural clearing to the edge of the river bank. Program options should include conservation partnerships, private woodlot management, and habitat retention.

BIBLIOGRAPHY

Alberta Fish and Wildlife Division. 1989. A Summary of Habitat Conservation Options for Private Landowners in Alberta. Environmental Law Centre's Conservation Kit: A Legal Guide to Private Conservancy, and, Landowner Habitat Project (Northeast Region). St. Paul, Alberta.

Alberta Fish and Wildlife Division. 1990. Buck For Wildlife 1989. Alberta Forestry Lands, and Wildlife. Edmonton. Alberta.

Alberta Forestry, Lands and Wildlife. 1991. Gifts of Land to the Crown. Technical Services Section, Land administration Branch, Public Lands Division. Edmonton, Alberta.

Alberta Round Table on the Environment and the Economy, Report of, A.R.T.E.E. 1991. Alberta: Working for a Sustainable Future. Environment Council of Alberta.

Alberta Water Resources Commission, 1993a. Wetland Management in the Settled Area of Alberta: An Interim Policy. Edmonton, Alberta.

Alberta Water Resources Commission, 1993b. Beyond Prairie Potholes: A Draft Policy for Managing Alberta's Peatlands and Non-settled Wetlands. Edmonton, Alberta.

Allen, T. F. H., and T. W. Hoekstra. 1988. The Critical Role of Scaling in Land Modelling. Canada Committee on Ecological Land Classification; Newsletter #16, p. 9-10.

Ambrose, J. P., and S. P. Bratton. 1990. Trends in Landscape Heterogeneity Along the Borders of Great Smoky Mountains National Park. Conservation Biology. Vol. 4, No.2. p.135-143.

Baskerville, G. L. 1991. Designer Habitats: Edge, Carrying Capacity, Diversity, Etc.. Wildfor 91. WSI 3260 (bi.) ODC 15. p. E35-E40.

Clark, R. G., and T. D. Nudds. 1991. Habitat Patch Size and Duck Nesting Success: The Crucial Experiments Have Not Been Performed. Wildl. Soc. Bull. 19(4). p.534-543.

Correll, D. L. 1991. Human Impact on the Functioning of Landscape Boundaries. in M. M. Holland, P. G. Risser, and R. J. Naiman eds. Ecotones: The Role of Landscape Boundaries in the Management and Restoration of Changing Environments. Routledge, Chapman and Hall, Inc. pp. 142.

County of Parkland Municipal District, The. 1989. The County of Parkland No. 31 Land Use By-Law 24-89. The County of Parkland No. 31 Municipal Office, Stony Plain, Alberta.

Croonquist, M. J., and R. P. Brooks. 1993. Effects of habitat disturbance on bird communities in riparian corridors. Journal of Soil and Water Conservation. 48(1): 65-70.

Delta Waterfowl Foundation. n.d. Adopt a Pothole Program. Deerfield, Illinois.

Demarchi, D. A. 1992. Biophysical Habitat Classification in British Columbia: A Systemfor Mapping Mountainous Ecosystems. p. 39-46. in Ingram, G.B. and M.R. Moss, eds. Landscape Approaches to Wildlife and Ecosystem Management. Proceedings of the Second Symposium of the Canadian Society for Landscape Ecology and Management: University of British Columbia, May 1990. Polyscience Publications Inc., Morin Heights, Canada. 267 pp.

Department of Fisheries and Oceans. n.d. Protecting Your Shorelands. Minister of Supply and Services, Canada.

Ducks Unlimited. n.d. Alberta Prairie CARE. Ducks Unlimited, Canada. Edmonton, Alberta.

Duinker, P. N. 1988. Wildlife in Forest Management: From Constraint to Objective. in Ontario Forestry Research Committee Symposium Proceedings O-P-17. Forest Investment: A Critical Look. Forestry Canada. Ontario. p. 133-144.

Edmonton Regional Planning Commission. 1976. Parks, Outdoor Recreation and Open Space Policy. Position Paper No. 3. Edmonton Regional Planning Commission; Regional Plan Project.

Environment Canada. 1989. Wetlands. Canadian Wildlife Service, Ministry of Supply and Services. Ottawa.

Fahrig, L., and G. Merriam. 1985. Habitat Patch Connectivity and Population Survival. Ecology, 66(6) , p.1762-1768.

Folinsbee, J. 1987. County #31 Parkland: Summary from write up of W.M.U. 336 Wabamun revised to include part of W.M.U. 248 (Edmonton). Unpublished. Alberta Forestry, Lands and Wildlife; Fish and Wildlife Division.

Forman, R. T. T., and Michel Godron. 1986. Landscape Ecology. John Wiley and Sons, Inc., Toronto. 619 pp.

Forman, R. T. T., and Michel Godron. 1981. Patches and Structural Components For a Landscape Ecology. Bioscience. Vol 31, p.733-740.

Godron, M., and R.T.T. Forman. 1983. Landscape Modification and Changing Ecological Characteristics. Chapter 2.1 in H. A. Mooney and M. Godron eds. Disturbance and Ecosystems: Components of Response. Springer-Verlag Berlin, Heidelberg, Germany.

Gosz, J. R. 1991. Fundamental Ecological Characteristics of Landscape Boundaries. in M. M. Holland, P. G. Risser, and R. J. Naiman eds. Ecotones: The Role of Landscape Boundaries in the Management and Restoration of Changing Environments. Routledge, Chapman and Hall, Inc. pp. 142.

Griffiths, D. E. 1992. Strathcona County Southeast Watershed Ecosystem Assessment. Consultant Report for Lakes Management Plan.

Hall, D. L. 1991. Landscape planning; functionalism as a motivating concept from landscape ecology and human ecology. Landscape and Urban Planning, Vol. 21. p.13-19.

Hamilton, G. 1993. "Ecosystem Management: A Discussion Paper". Alberta Department of Forestry, Lands and Wildlife; Fish and Wildlife Division of the N.E. Region. p.1-8.

Hansen, A. J., and F. di Castri. eds. 1992. Landscape Boundaries: Consequences for Biotic Diversity and Ecological Flows. Ecological Studies Vol. 92. Springer-Verlag New York Inc., New York.

Hansson, L. 1992. Landscape Ecology of Boreal Forests. Trends in Ecology and Evolution. Vol. 7, No. 9. p. 299-302.

International Association for Landscape Ecology. 1992. Scanning the Mosaic. World Congress 1991. Ottawa, Canada.

Jacobs, P. 1992. Sustainable and Equitable Development A Goal for the 21st Century. Canadian Society of Environmental Biologists Newsletter. Vol. 48 (4). p. 9-15.

Jalkotzy, P.S., T.Van Egmond, T.R. Eccles, and R.Berger. 1990. Wildlife Habitat Evaluation, Assessment and Mapping for the OSLO Wildlife Study Area. The Delta Environmental Management Group, Ltd.. Calgary, Alberta.

Jennings, M. D., and J. P. Reganold. 1991. Hierarchy and subsidy-stress as a theoretical basis for managing environmentally sensitive areas. Landscape and Urban Planning. Vol. 21. p. 31-45.

Klar, A., and H. J. Stelfox. 1985. A Guide to Remote Sensing Interpretations for Reconnaissance Vegetation Cover Mapping and Wildlife Resource Assessment. Alberta Fish and Wildlife Division, Wildlife Inventory Unit. RSN 91-606-055.

Kràtz, T.K., B.J. Benson, E.R. Blood, G.L. Cuningham, R.A. Dahlgren. 1991. The Influence of Landscape Position on Temporal Variability in Four North American Ecosystems. The American Naturalist. Vol.138, No. 2. p.355-378.

Lamotte, M. 1983. Research on the Characteristics of Energy Flows within Natural and Man-Altered Ecosystems. Chapter 3.1 in H. A. Mooney and M. Godron eds., Disturbance and Ecosystems: Components of Response. Springer- Verlag Berlin, Heidelberg, Germany.

Levinsohn, A. G., and S. J. Brown. 1991. GIS and Sustainable Development in Natural Resource Management. A.G. Levinsohn Consulting Inc. Edmonton, Alberta. p.17-20.

Lord, J. M., and D. A. Norton. 1990. Scale and the Spatial Concept of Fragmentation. Conservation Biology. Vol. 4, No.2. p. 197-202.

Makhdoum, M.F. 1992. Environmental unit: an arbitrary ecosystem for land evaluation. Agriculture, Ecosystems and Environment. No.41. Vol.2. p. 209-214.

Manitoba Department of Natural Resources. n.d. Farm Woodlot Opportunities. Canada-Manitoba Partnership Agreement in Forestry.

Manitoba Habitat Heritage Corporation. n.d. Green Acres Program: A Land and Water Partnership. NAWMP. Manitoba.

Manitoba Round Table on Environment and Economy. 1992. Towards a Sustainable Development Strategy for Manitobans.

McCoy, E. D. 1983. The Application of Island-Biogeographic Theory to Patches of Habitat: How Much Land is Enough? Biological Conservation.Vol.25. p.53-61.

Merriam, G. and J. Wegner. 1992. Local Extinctions, Habitat Fragmentation, and Ecotones. p. 150-169, Chapter 7 in A J. Hansen and F. di Castri. eds. Landscape Boundaries: Consequences for Biotic Diversity and Ecological Flows. Ecological Studies Vol. 92. Springer-Verlag New York Inc., New York.

Moore, L. 1991. The Lake Book. Congress of Lake Associations. Yarmouth, Maine.

Moss, E. R. 1932. The Vegetation of Alberta: IV. The Poplar Association and Related Vegetation of Central Alberta. Journal of Ecology. Vol. 20. p.380 - 415.

Moss, M. R. ed. 1987. Landscape Ecology and Management. Proceedings of the First Symposium of the Canadian Society for Landscape Ecology and Management: University of Guelph, May, 1987. Polyscience Publications Inc., Montreal, Quebec.

Natural Resources Institute Study Team, 1992. Buffalo Creek Study Site Management Plan, Report 3. by Sherry Dangerfield, Pierre Johnstone, Calvin McLeod, John Sinclair. Natural Resources Institute, University of Manitoba, Winnipeg, Manitoba.

Naveh, Z., and A. S. Lieberman. 1984. Landscape Ecology: Theory and Application. Springer-Verlag New York Inc., New York.

Nietfeld, M., J.Wilk, K. Woolnough, and B. Hoskin. 1985. Wildlife Habitat Requirement Summaries for Selected Wildlife Species in Alberta. Wildlife Resource Inventory Unit; Alberta Energy and Natural Resources, Fish and Wildlife Division. Edmonton, Alberta.

Novak, M., J. A. Baker, M. Eobbard, and B. Malloch. eds. 1987. Wild Furbearer Management and Conservation in North America. The Ontario Trappers Association. Ontario.

Nudds, T. D., and R. G. Clark. 1992. Landscape Ecology, Adaptive Resource Management, and the North American Waterfowl Management Plan. pages 180-190 in G. L. Holroyd, H. Loney Dickson, M. Regnier, and H.C. Smith. Proc. of the Third Prairie Conservation and Endangered Species Workshop. Brandon University, Brandon, Manitoba. Published by Provincial Museum of Alberta, Edmonton.

Odum, E.P. 1971. Fundamentals of Ecology. 3rd ed. W.B. Saunders Company. Philadelphia, Pennsylvania. p.157.

Phillips, W., D.DePape, and L. Ewanyk. 1978. A Socioeconomic evaluation of the recreational use of fish and wildlife resources in Alberta, with particular reference to the AOSERP study area. Volume 1: Summary and Conclusions. Prep. for the Alberta Oil Sands Environmental Research Program by the University of Alberta, Department of Rural Economy. AOSERP Report 43. p.1-116.

Pivnick, K., F. Thornton, J. Bowman, and D. Struthers. 1993. Agricultural Policy: Its Effects on Nature, Agriculture and the Land In Saskatchewan. Blue Jay. 51(1) March. p.3-4.

Pollard, D. F. W., and R. McKechnie. 1986. World Conservation Strategy, Canada: A Report on Achievements in Conservation. Conservation and Protection, Environement Canada, Ottawa. p. 3.

Prairie Farm Rehabilitation Administration. n.d. Conservation Cover Program. PFRA. Brandon, Manitoba.

Public Lands Act, R.S.A. c. P-30, 1987. Queen's Printer. Edmonton, Alberta.

Quinlan, R. W., W. A. Hunt, K. Wilson, and J. Kerr. 1990. Habitat Requirements of Selected Wildlife Species in the Weldwood Forest Management Agreement Area. Habitat Branch, Fish and Wildlife Division; Forestry, Lands and Wildlife, Alberta. Edmonton, Alberta.

Randall, R. M. 1988. Economic Considerations in Wildlife and Fisheries: Multiple- Use Management. in Ontario Forestry Research Committee Symp. Proc. O-P-17. Forest Investment: A Critical Look. Forestry Canada. Ontario. p. 145-152.

Richardson, N. H. 1989. Landuse Planning and Sustainable Development in Canada. Canadian Environmental Advisory Council, Ottawa.

Robinson, G. R., R. D. Holt, M. S. Gaines, S. P. Hamburg, M. L. Johnson, H. S. Fitch, and E. A. Martinko. 1992. Diverse and Contrasting Effects of Habitat Fragmentation. Science. Vol.257. p.524-526.

Rowe, J. S. 1992. Saskatchewan's Endangered Spaces; The Essential Ecocentric Approach. Chapter 1 in Saskatchewan's Endangered Spaces: An Introduction. Jonker, Peter. ed. University of Saskatchewan, Extension Division. p.11-23.

Rowe, J. S. 1991. The Ecosystem Approach to Wildlife and Forestry. Wildfor 91. WSI 32254 (bi.) ODC 15. p.E7-E10.

Rural Environmental Sub-Committee of the Public Advisory Committees to the Environment Council of Alberta. 1988. Agricultural Considerations: For Today and Tomorrow. Environment Council of Alberta. p.1-35.

Sampson, N. 1992. Achieving public values on private land. Journal of Soil and Water Conservation. Vol. 47, No.5. p. 360-364.

Saskatchewan Round Table on Environment and Economy. 1992. Conservation Strategy for Sustainable Development in Saskatchewan. Government of Saskatchewan.

Sauer, L. 1992. "Bring Back the Forests: Making a Habitat of Reforestation; Saving the Eastern Deciduous Forest." Wildflower, Summer. p. 27-34.

Scarth, J. St.Clair. 1984. A Review of Private Land Habitat Programs. Master of Natural Resource Management Practicum. Natural Resources Institute, The University of Manitoba. Manitoba, Canada.

Selman, P., and N. Doar. 1992. An Investigation of the Potential for Landscape Ecology to Act as a Basis for Rural Land Use Plans. Journal of Environmental Management. Vol.35, No.4. p.281 - 299.

Semenchuk, G. P. ed, 1992. The Atlas of Breeding Birds of Alberta. The Federation of Alberta Naturalists. Edmonton, Alberta.

Shetsen, I. 1990. Quaternary Geology, Central Alberta: Map of Edmonton and surrounding area. Alberta Research Council, Natural Resources Division; Terrain Sciences Department. Alberta.

Smith, C., and A. Kwasniak. 1993. Protecting The Environment Though Private Conservancy Real Life Success. Alberta Naturalist Vol. 23, No. 1. p.16-18.

Smith, H. C. 1993. Alberta Mammals: An Atlas and Guide. with Contributions from Ross I. Hastings and James A. Burns. The Provincial Museaum of Alberta. Edmonton, Alberta.

Soil Conservation Act, R.S.A. c.S-19.1, 1988. Queen's Printer. Edmonton, Alberta.

Stamps, J.A., M. Buechner, and V.V. Krishnan. 1987. The Effects of Edge Permeability and Habitat Geometry on Emigration from Patches of Habitat. The American Naturalist, Vol.129, No. 4. p.533 - 552.

Strong, W.L. , Ecological Land Surveys Ltd. 1992a. Ecoregions and Ecodistricts of Alberta. Volume 1. for Alberta Forestry, Lands and Wildlife; Lands Information Services Division; Resource Information Branch. Edmonton Alberta.

_____, Ecological Land Surveys Ltd. 1992b. Dominant Biophysical Characteristics of Ecodistricts Map. for Alberta Forestry, Lands and Wildlife; Lands Information Services Division; Resource Information Branch. Edmonton Alberta.

_____ , Ecological Land Surveys Ltd. 1992c. Ecoregions of Alberta Map. for Alberta Forestry, Lands and Wildlife; Lands Information Services Division; Resource Information Branch. Edmonton Alberta.

Swinnerton, G.S. 1991. People, Parks and Preservation: Sustaining Opportunity. Environment Council of Alberta. p.1-69.

Swinnerton, G.S. 1982. Recreation on Agricultural Land in Alberta. ECA82-17/ IB27. Environment Council of Alberta, Edmonton. p.1 - 211.

Thesing, C. 1992. What is sustainable agriculture? The Land Stewardship Letter: Land Stewardship Project. Marine, Minnesota. Vol. 10, No. 4. p.13, 16.

Thompson, M.D., M.C. Wride, and M.E. Kirby. 1978. Ecological habitat mapping of the AOSERP study area: phase 1. Prep. for the Alberta Oil Sands Environmental Review Program by INTERA Environmental Consultants Ltd. AOSERP Report 31. p. 1-176.

Thorne, J. F., and Chang-Shan Huang. 1991. Toward a landscape ecological aesthetic: methodologies for designers and planners. Landscape and Urban Planning, Vol.21. p.61-79.

Thornton, F., J. Bowman, and D. Struthers. 1993a. Agricultural Policy Review Part 1: Gross Revenue Insurance Plan. Blue Jay. 51(1) March. p. 5-9.

Thornton, F., J. Bowman, and D. Struthers. 1993b. Agricultural Policy Review Part 2: Wheat Board Quota System. Blue Jay. 51(2) June. p.65-71.

Turner, M.G. 1987. ed. Landscape Heterogeneity and Disturbance. Ecological Studies Vol. 64. Springer-Verlag New York Inc., New York.

Turner, M.G., and R.H. Gardner. eds. 1991. Quantitative Methods in Landscape Ecology. Ecological Studies Vol. 82. Springer-Verlag New York Inc., New York.

Urban Environment Sub -Committee of the Public Advisory Committees to the Environment Council of Alberta. 1988. Environment by Design: The Urban Place in Alberta. Environment Council of Canada.

Usher, R. 1990. Alberta's Wetlands: Water in the Bank! A Discussion Paper Prepared for the Alberta Conservation Strategy Project. Environment Council of Alberta.

Van Tighem, K. 1992. The Land Ethic: The Problem With Planning. The Outdoor Edge. Vol.1, Issue 6. p.21-22.

Wallis, C., and L. Knapik. 1990. Environmentally Significant Areas of the County of Barrhead. County of Barrhead Agriculture Services Board. Barrhead , Alberta.

Water Resources Act, R.S.A. c.W-5, 1982. Queen's Printer. Edmonton, Alberta.

Watkins, T.H. 1993. The Lands of Life. Wilderness, Vol. 56, No.200. p. 8-9.

Western Producer. 1993. Reward Farmers for Preserving Wildlife, Say Conservationists. July 1. p.44.

Whitemud Conservtion District. n.d. Conservation Corridors Progrm Information Package. Board of the Whitemud Watershed Conservation District. Manitoba.

Wiens, J. A., C. S. Crawford and J. R. Gosz. 1985. Boundary dynamics: a conceptual framework for studying landscape ecosystems. OIKOS 45: 421-427.

Wilcox, B. A., and D. D. Murphy. 1985. Conservation Strategy: The Effects of Fragmentation on Extinction. The American Naturalist. Vol. 125, p. 879-887.

Wildlife Habitat Canada. 1991. The Status of Wildlife Habitat in Canada 1991. Judy Lord, ed. Ottawa. 102 pp.

World Commission on Environment and Development, The. 1987. Our Common Future. Oxford University Press. Toronto. p. 8.

Zar, J. H. 1974. Paired-Sample Hypotheses. p. 121-127 in Biostatistical Analysis. Prentice-Hall, Inc.. Englewood Cliffs, N.J..

Zonneveld, I.S., and R.T.T. Forman. 1990. eds. Changing Landscapes: An Ecological Perspective. Springer-Verlag New York Inc., New York.

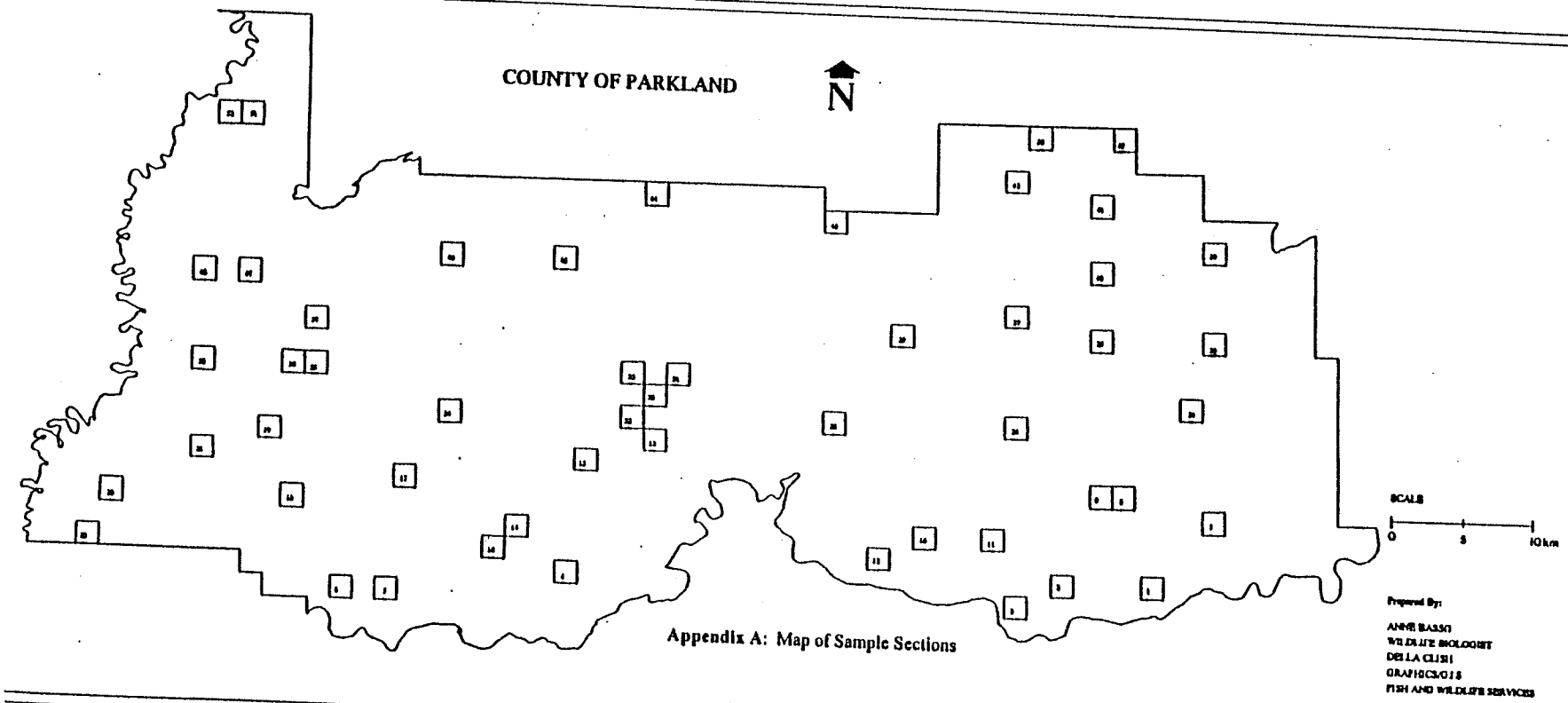
PERSONAL COMMUNICATION

Ainsley, K. 1994. Resource Analyst, Alberta Environmental Protection, Resource Information Branch. Edmonton, Alberta. February 1.

Kulak, D. 1993. County of Parkland Office. May 31.

Martin, J. 1993. District Biologist, Ducks Unlimited, Camrose, Alberta. July 28, and August 13.

Strong, W. L. 1994. W.L. Strong Ecological Land Surveys Ltd.. February 1.



Appendix A: Map of Sample Sections

Appendix B: Aerial Photo Cleared vs. Non-cleared Raw Data

Township	1949 Cleared	1949 Uncleared	1949 Total	1949 Prop.	1987 Cleared	1987 Uncleared	1987 Total	1987 Prop.
1	212.13	045.03	257.16	0.82	210.33	054.33	264.66	0.79
2	154.06	106.07	260.13	0.59	168.33	094.67	263.00	0.64
3	199.68	064.00	263.68	0.76	201.67	062.00	263.67	0.76
4	104.29	160.57	264.86	0.39	094.33	171.66	265.99	0.35
5	190.20	068.14	258.34	0.74	197.33	067.33	264.66	0.75
6	188.43	069.32	257.75	0.73	178.33	085.67	264.00	0.68
7	157.02	104.28	261.30	0.60	138.00	125.00	263.00	0.52
8	191.98	064.58	256.56	0.75	212.00	047.33	259.33	0.82
9	210.94	049.77	260.71	0.81	152.33	113.33	265.66	0.57
10	174.80	085.92	260.72	0.67	182.33	083.67	266.00	0.69
11	202.05	061.03	263.08	0.77	245.67	014.33	260.00	0.94
12	135.69	127.39	263.08	0.52	211.67	054.67	266.34	0.79
13	182.50	075.85	258.35	0.71	181.33	087.00	268.33	0.68
14	142.80	113.77	256.57	0.56	145.00	116.00	261.00	0.56
15	039.11	220.42	259.53	0.15	082.67	181.01	263.68	0.31
16	192.57	065.18	257.75	0.75	162.67	101.67	264.34	0.62
17	010.67	249.46	260.13	0.04	128.00	134.33	262.33	0.49
18	090.07	170.06	260.13	0.35	159.34	104.67	264.01	0.60
19	046.31	208.57	255.38	0.18	013.33	253.67	267.00	0.05
20	028.44	231.68	260.12	0.11	157.67	106.34	264.01	0.60
21	056.29	202.05	258.34	0.22	052.33	206.67	259.00	0.20
22	023.11	238.79	261.90	0.09	207.00	053.67	260.67	0.79
23	190.20	066.96	257.16	0.74	213.67	052.33	266.00	0.80
24	212.13	046.22	258.35	0.82	230.67	031.67	262.34	0.88
25	212.13	045.63	257.76	0.82	236.67	029.66	266.33	0.89
26	228.72	030.81	259.53	0.88	231.67	029.00	260.67	0.89
27	146.36	110.81	257.17	0.57	171.00	090.67	261.67	0.65
28	142.21	114.95	257.16	0.55	209.00	052.00	261.00	0.80
29	143.39	116.13	259.52	0.55	165.67	100.67	266.34	0.62
30	081.18	177.76	258.94	0.31	093.00	171.67	264.67	0.35
31	026.67	234.05	260.72	0.10	037.33	224.67	262.00	0.14
32	110.80	145.77	256.57	0.43	120.00	141.66	261.66	0.46
33	009.48	247.68	257.16	0.04	031.33	234.00	265.33	0.12
34	048.59	209.16	257.75	0.19	134.33	127.33	261.66	0.51
35	107.25	151.10	258.35	0.42	184.33	080.33	264.66	0.70
36	076.44	182.50	258.94	0.30	123.00	144.66	267.66	0.46
37	004.15	251.24	255.39	0.02	143.67	120.66	264.33	0.54
38	033.18	225.16	258.34	0.13	122.67	142.34	265.01	0.46
39	148.73	106.66	255.39	0.58	145.00	120.33	265.33	0.55
40	167.09	091.25	258.34	0.65	180.67	084.67	265.34	0.68
41	162.35	097.18	259.53	0.63	176.00	087.00	263.00	0.67
42	125.02	132.73	257.75	0.49	133.33	128.00	261.33	0.51
43	116.14	142.80	258.94	0.45	185.67	077.00	262.67	0.71
44	062.22	199.09	261.31	0.24	162.00	100.33	262.33	0.62
45	053.33	202.05	255.38	0.21	103.33	158.67	262.00	0.39
46	001.78	257.16	258.94	0.01	010.33	255.00	265.33	0.04
47	008.30	250.05	258.35	0.03	123.00	140.67	263.67	0.47
48	024.89	233.46	258.35	0.10	042.67	223.67	266.34	0.16
49	046.31	207.98	254.79	0.18	140.67	124.00	264.67	0.53
50	073.47	181.32	254.79	0.29	129.67	132.00	261.67	0.50
51	048.00	206.21	254.21	0.19	146.00	116.67	262.67	0.56
52	006.52	260.12	266.64	0.02	000.00	265.00	265.00	0.00

Prop = proportion cleared

APPENDIX C: HABITAT RATING CRITERIA AND RVI DESCRIPTION
HAIRY WOODPECKER (RVI)

GOOD:
- closed forest at 80-100% deciduous dominated or mixed leaves at over 6m
- up to 30 % closed conifer or needle at over 6m
- up to 30% cultivation
-10% non-vegetated polygon areas
- wet moisture regime permitted
- water allowed if associated with closed forest deciduous dominated or mixed over 6m.

FAIR:
- closed, open and partially open deciduous dominated and mixed forest at 50-70% over 6m tall.
(80% of above if there is too much cultivation for it to be rated as Good)
- no lakes if not associated with at least 30% of above deciduous criteria;
- pasture (including undefined perennial crop) and hayland up to and including 50% if assoc with deciduous dominated or mixed forest as stated above.
-non-vegetated cover type not to exceed 30%
- Annual crop up to and including 30%
- less than 50% closed coniferous and needle forest over 6m if associated with above deciduous criteria
- up to 50% herbs, grasses and forbs if associated with above forest criteria
- wet moisture regime permitted

POOR:
- closed, open and partly open deciduous dominated and mixed forest at least 30% of polygon area, and at least 6m tall
- up to 60% closed, open or partially open conifer or needle forest, at least 6m tall MUST be associated with the above deciduous forest criteria
- up to 100% rough pasture if in complex with tree cover as stated above
- up to 60% pasture (including undefined perennial crop) and hayland
- up to 40% annual crop
- up to 30% NAS
- wet moisture regime permitted

INAD:
- less than 30% closed, open or partially open deciduous dominated or mixed forest over 6m.
- over 40% annual crop
- 100% water

HAIRY WOODPECKER (Verbal)

GOOD: Upland and wetland closed deciduous dominated or mixed leaves forest at over medium or tall height, at a very high percentage; and up to 30 % closed conifer or needle at medium or tall height. Up to 30% cultivation, and up to 10% non vegetated polygon areas. Water is allowable except where it is 100%.

FAIR: Upland and wetland closed, open and partially open deciduous dominated and mixed medium to tall forest at 1/2 to under 4/5 area. Less than 1/2 closed coniferous and needle forest medium or tall; and /or up to 1/2 herbs, grasses and forbs if associated with above deciduous forest criteria. Up to 1/2 pasture and hayland if associated with deciduous dominated or mixed forest as stated above. Up to 1/3 annual crop; no lakes if not associated with at least 30% of above deciduous criteria; non-vegetated cover type not over 1/3 polygon area.

POOR: Upland and wetland closed, open and partly open deciduous dominated and mixed forest at least 1/3 of polygon area, and over medium height. Also up to 2/3 closed, open or partially open conifer or needle forest, at medium height or above, MUST be associated with the above deciduous forest criteria. Up to 100% rough pasture if associated in a complex with above forest cover; up to 2/3 pasture and hayland; up to 2/5 annual crop; and up to 1/3 NAS (NAS = surface mines, gravel pits, spoil piles, etc).

INAD: Less than 1/3 closed, open or partially open deciduous dominated or mixed medium or tall forest; over 40% annual crop; 100% water.

MALLARD (RVI)
(* ALL within 200m of lakes)

GOOD:
- within 200m of water (lakes)
- high percentage of low height shrub (over 30% deciduous shrub 2m or lower)
- greater than 30% hayland or pasture or perennial crop
- up to 30% annual crop
- no non-vegetated cover
- over 30% grasses, forbs, herbs
- max of 10% needle or conifer forest any height
- max of 20% tall (12m or over) deciduous dominant and mixed closed forest; and max of 30% of same at below 12m
- up to 30 % open deciduous forest

FAIR:
- below 40% deciduous shrub
- includes low amounts (any %)of pasture and hayland and perennial crop
- includes low amounts (any %)of grasses and herbs
- up to 50% annual crop
- up to 60% open and partially open deciduous dominant area
- max of 50% low (below 6m) deciduous dominant and mixed forest
- max of 20% conifer and needle closed forest any height
- up to 20% NAS
- max of 40% of decid. dom closed or open forest over 6m

POOR:
- over 50% Annual crop
- less than 50% closed forest conifer or needle any height
- less than 70% deciduous shrub
- greater than 60% open or partially open deciduous forest any height
- up to 30% NAS if satisfies all other criteria
- up to 80% low (less than 6m)closed forest deciduous dominated and mixed ; or up to 60% of same at 6m or over in height.

INAD:
- outside 200m of a lake OR greater than 200m into the interior of the lake
- high amounts of closed forest deciduous dominated: at up to 12m any area over 80% cover; at over 12m tall in any area over 60% cover of the polygon.
- over 50% of closed conifer or needle forest
- non-vegetated cover

MALLARD (Verbal)
(* ALL within 200m of lakes)

GOOD: Within 200m of water (lakes) with a high percentage of low height shrub and greater than1/3 hayland or pasture or grasses, forbs, or herbs; up to 1/3 annual crop. Very minimal needle or conifer forest any height, and up to 1/5 polygon area of tall deciduous dominant and mixed closed forest; and a maximum of 1/3 of deciduous dominant and mixed closed forest at low to medium heights. Up to 1/3 open deciduous forest; and no non vegetated cover.
(ADDED: #41, 43, 120, 180, 189, 236, 9146)

FAIR: Within 200m of lakes and having lower than 1/2 the area of deciduous shrub cover; also includes low amounts of pasture, hayland, perennial crop, grasses and herbs. Up to 1/2 the area can be annual crop; and 2/3 open and partially open deciduous dominated area. Maximum of 1/2 low deciduous dominated and mixed forest, and 2/5 of deciduous dominated closed or open forest of medium or tall height, with up to 1/5 conifer and needle closed forest any height. Up to 1/5 NAS.
(ADDED: # 6, 11, 68)

POOR: Within 200m of lakes and over 1/2 annual crop; or less than 1/2 closed forest conifer or needle any height; greater than 2/3 open or partially open deciduous forest any height; 2/3 or below deciduous shrub; up to 4/5 low closed forest deciduous dominated and mixed ; or up to2/3 of same at medium or taller in height. Up to 1/3 NAS if satisfies all other criteria.
(ADDED: #8, 12, 15, 17, 25, 34, 145, 183, 184, 276, 312, 392)

INAD: Outside 200m of a lake OR greater than 200m into the interior of the lake; high amounts of closed forest deciduous dominated: at up to 12m any area over 4/5; at over 12m any area over 1/3 of the polygon. Over 1/2 of the polygon closed conifer or needle forest; over 1/3 non-vegetated cover of NAS, or any other non-vegetated cover.

MARTEN (RVI)

GOOD: -Upland closed coniferous and needle leaved forest at least 6 m tall at 50-100% cover associated with natural vegetation types
- not wet
- cultivation or non-vegetated cover types up to 10% allowed

FAIR: -closed coniferous and needle leafed forest at least 12 m tall at 40-60% cover.
- closed coniferous and needle leafed forest between 6 and 12m from 70-100% cover.
- closed mixed forest over 12 m at 70-100% cover.
- not over 20% cultivation
- associated with up to and including 20% non-vegetated cover types
- closed coniferous less than 6m at 60% or greater cover
- wet moisture regime is allowed

POOR: -closed coniferous and needle leafed forest at least 6 m tall at greater than or equal to 30% cover.
- closed mixed forest over 12 m at over 50% cover; and between 6 and 12m at 70 % cover or over.
- can be wet moisture regime
- not over 30% cultivation
- up to and including 30% non-vegetated cover types

INAD:
- less than 30% conifer cover
- more than 30% cultivation or non-vegetated cover
- higher than 50% lake cover

MARTEN (Verbal)

GOOD: Upland closed coniferous and needle leafed forest medium or tall (at least 6m tall) at least half of the polygon area; associated with natural vegetation cover types. Very minimal areas of cultivation and non-vegetated cover.
(#280)

FAIR: Upland and wetland closed coniferous and needle leafed forest at least 6m tall, near half of polygon area, closed coniferous low height at 2/3 or greater of polygon area, as well as upland closed tall mixed forest at a very large area of the polygon. Can include small areas of cultivation and non-vegetated cover.
(# 267, 311, 313, 335, 9083)

POOR: Wetland and upland closed coniferous and needle leafed forest at least medium height greater than or equal to 40% polygon area, and closed tall mixed forest at over 1/2 cover and also medium tree height at over 2/3 polygon area. 1/3 of area can be cultivated or non vegetated cover types.
(# 12, 15, 17, 27, 34, 59, 271, 274, 278, 285, 286, 9301)

INAD: Less than 1/3 conifer cover; greater than 30% non vegetated cover; over 1/3 area of cultivation or non-vegetated cover types; higher than half lake cover.

** Polygons added to each category are listed at the bottom of the rating descriptions.

MINK (RVI)

GOOD:
- within 200m of water (lakes, rivers, streams)
- can be wet moisture regime
- closed deciduous dominated and mixed forest over 6m at 70-100% cover
- 10% non-vegetated cover allowed
- Rough pasture only at equal to or below 50% of cover
- 10% other pasture cultivation allowed (hayland, improved, and unidentified pasture)

FAIR:
- within 200m of water (lakes, rivers, streams)
- can be wet moisture regime
- closed deciduous dominated and mixed forest over 6m at 40-60% cover
- 20% non-vegetated cover allowed
- Rough pasture only at equal to or below 50% of cover
- 30% other pasture cultivation allowed (hayland, improved, and unidentified pasture)
- 10% annual crop allowed
- up to and including 50% shrub cover

POOR:
- within 200m of water (lakes, rivers, streams)
- can be wet moisture regime
- closed deciduous dominated and mixed forest, or conifer or needle at any height at 40% cover or over.(This will include those that did not make it into the Good and Fair categories)
- open and partially open forest up to 50% cover
- 30% non-vegetated cover allowed
- Rough pasture up to 100% of cover if associated with forest cover in the most dominant cover type
-hayland, improved, and unidentified pasture can be up to 50% of cover
- 20% annual crop allowed
- up to and including 50% shrub cover

INAD:
-outside 200m of water
- over 50% of pasture cultivation (except rough pasture)
- over 20% annual crop
- over 30% non-vegetated cover

MINK (Verbal)

GOOD: Within 200m of water (lakes, rivers, streams) with a tree cover of closed deciduous dominated and mixed forest at medium to tall height. Very minimal non vegetated or pasture cover types, but rough pasture can be up to 1/2 the polygon area.

FAIR: Within 200m of water (lakes, rivers, streams) with a tree cover of closed deciduous dominated and mixed forest over medium height. Non vegetated cover can be 2/5 the polygon area and pasture cultivation can be up to 1/3 of the polygon area. Rough pasture remains at up to 1/2 . Very minimal annual crop is allowed and up to 1/2 of the polygon area can be shrub cover.

POOR: Within 200m of water (lakes, rivers, streams) with closed deciduous dominated and mixed forest, or upland conifer tree cover at over 1/2 polygon area. Open and partially open forest up to 1/2 cover. Non-vegetated cover can be 1/3 the polygon area and pasture cultivation can be up to 1/2 of the polygon area. Rough pasture can be up to 100% of the polygon area if it is associated in a complex with the appropriate forest cover mentioned above. Up to 20% annual crop is allowed and up to 1/2 of the polygon area can be shrub cover.

INAD: Outside 200m of water; over half of area under cultivation (except rough pasture); over 30% non-vegetated cover; and over 20% annual crop.

MOOSE (RVI)

GOOD:
- not on wet land
- closed deciduous dominated and mixed forest 12m or below at 40-100% cover
- shrub of any height at over 50% but only if associated with the above specified deciduous dominated or mixed cover
- Up to and including 30% non vegetated cover
- Rough pasture only at equal to or below 50% of cover
- other pasture and hayland up to and including 30% cover
- up to 10% annual crop

FAIR:
- can be wetland moisture regime
- closed deciduous dominated and mixed forest over 40% cover, any height
- up to 50% closed, open and partially open forest with any leaf function, any height.
- lakes up to 50% cover; river any %
- Up to 30% non-vegetated cover
- Rough pasture up to 50% of cover
- other pasture and hayland up to 40% cover
- up to and including 20% annual crop
- up to and including 100% shrub cover
- 30% to 60% conifer or needle closed forest cover if associated with any deciduous, broadleaf or mixed forest.

POOR:
- can be a wetland moisture regime
- closed deciduous dominated and mixed forest, 40 % or over any height.
- upland needle or upland conifer at over 6m, at 70-90% cover when associated with any deciduous dominated or mixed closed forest at 70-90% cover. (This will include those polygons that did not make it into the Good and Fair categories)
- open and partially open forest up to 50% cover, any height.(can be wet)
- up to and including 30% non-vegetated cover
- Rough pasture can be up to 100% cover if associated with closed forest in the dominant descriptor.
- Improved pasture and hayland and unidentified pasture can be up to 50% of cover
- up to 30% annual crop.
- lakes up to 50% cover
- wet or upland herb and grasses up to 50% cover.

INAD:
- less than 40% forest cover
- over 30% non-vegetated cover

MOOSE (Verbal)

GOOD: Upland only and associated with closed deciduous dominated and mixed tall forest at 2/5 area or over of cover; shrub of any height at over 1/2 but only if associated with the above specified deciduous dominated or mixed cover. Rough pasture only at equal to or below 1/2 of cover and other pasture and hayland up to and including 1/3 cover; and very minimal annual crop. Up to and including 1/3 non-vegetated cover.

FAIR: Can be wetland or upland moisture regime and can have closed deciduous dominated and mixed forest over 2/5 cover, any height and up to 1/2 closed, open and partially open forest with any leaf function at any height. 1/3 to 2/3 conifer or needle closed forest cover if associated with any deciduous, broadleaf or mixed forest. Up to and including 100% shrub cover; lakes up to 1/2 cover; river any %. Rough pasture up to 1/2 of cover, and other pasture and hayland up to 2/5 cover, and up to and including 1/5 annual crop. Up to 1/3 non-vegetated cover permitted.

POOR: Can be a upland or wetland moisture regime associated with closed deciduous dominated and mixed forest, 2/5 of area or over any height; or upland medium or tall needle or conifer at very high area coverage when associated with any deciduous dominated or mixed closed forest at a very high area coverage.(This will include those polygons that did not make it into the Good and Fair categories). Open and partially open forest up to 1/2 cover, any height; and wet or upland herb and grasses up to 1/2 cover. Rough pasture can be up to 100% cover if associated with closed forest in the dominant descriptor; and other pasture and hayland can be up to 1/2 of cover. Up to 1/3 annual crop;
lakes up to 1/2 cover; and up to and including 1/3 non-vegetated cover.
(ADDED: # 13, 16, 48, 60, 91, 92, 95, 177, 183, 214, 218, 249, 252, 256, 271, 276, 300, 301, 310, 326, 354, 392).

INAD: Less than 2/5 forest cover; over 1/3 non-vegetated cover.

WHITE-TAILED DEER (RVI)

GOOD:
- can be a wet moisture regime
- closed, open or partially open deciduous dominated and mixed forest at any height at 70-100% cover.
- up to 30% closed, open or partially open forest of conifer and needle at any height (not wet)
- lakes and rivers up to 50% of cover.
- 30% or less pasture or deciduous shrub (incl. CPH, CPR, CPI, CP)
- 20% or less of annual crop
- non-vegetated cover allowed if other criteria is met

FAIR:
- can be a wet moisture regime
- closed, open or partially open deciduous dominated and mixed forest at any height at 40-60% cover.(Plus any polygon that does not fit into the Good category and meets the fair criteria)
- up to 40% conifer and needle any height (not wet); open, partially open and closed.
- lakes and rivers up to 60% of cover
- non-vegetated cover if it meets other criteria
- 60% or less pasture (rough, improved or hayland)
- 40% or less of annual crop; or deciduous dominated low shrub

POOR:
- can be a wetland moisture regime
- closed, open or partially open deciduous dominated and mixed forest at any height at 20% or over for cover.(Plus any polygon that does not fit into the Good or Fair category)
- up to 80% conifer and needle any height including closed, open and partially open forest cover.
- lakes up to 70% and rivers up to 90% cover
- non vegetated cover if it meets other criteria
- 80% or less defined pasture
- 60% or less of annual crop
- herbaceous graminoid or herb can be up to 100% cover if associated with some forest or shrub or cultivation as set above.
- deciduous shrub if 40% or over, either on its own, or associated with other forest

INAD:
- less than 20% deciduous dominated or mixed forest cover; or less than 40% shrub deciduous
- very high cultivation (90 or 100%)
- non-vegetated cover NAC, NMS, or NAS in 1A
- NWL at 80-100%
- 90-100% conifer or needle forest

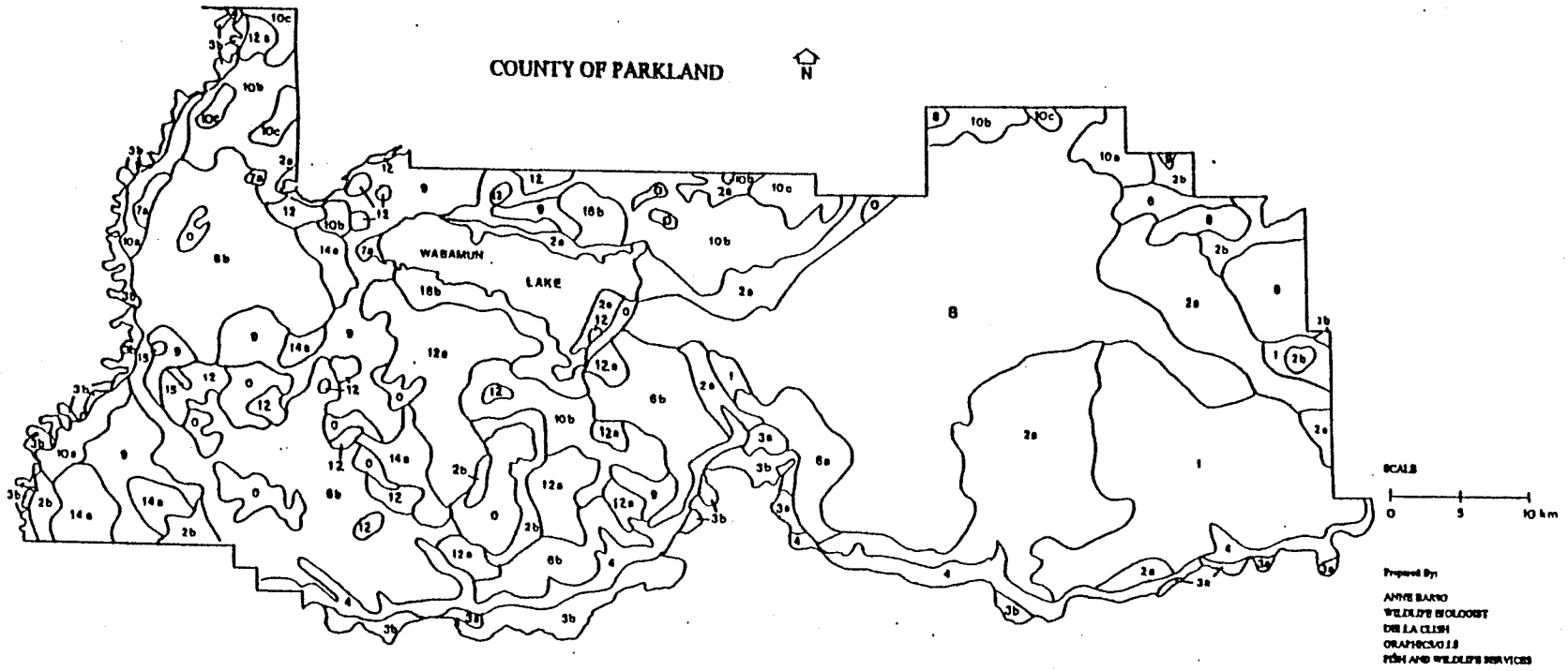
WHITE-TAILED DEER (Verbal)

GOOD: Can be upland or wetland of any deciduous dominated or mixedwood forest at any height with a large area; low amount of conifer at any height (not wet); and low amount of deciduous shrub, pasture or crop (30% or less). Lakes and rivers up to 1/2 of area; and non vegetated cover permitted if other criteria is satisfied.

FAIR: Can be upland or wetland of any deciduous dominated and mixed forest at any height at medium area of polygon cover; any conifer type or height below 1/2 of area (not wet). Low area of crop (2/5 or less); or deciduous mid height shrub; 1/2 or less pasture; lakes and rivers just over 1/2 of area; and non-vegetated cover if other criteria is met.

POOR: Can be wetland or upland of any deciduous dominated or mixedwood forest at any height, 20% or higher in area; low and medium amount (up to 4/5 area) of any conifer or needle forest , wetland or upland, at any height. Medium or low area (60% or less) of annual crop, or deciduous shrub; and grass and herbs up to 100% area with some forest, shrub or cultivation in association; and 4/5 or less pasture cover allowed. Lakes up to 70% and rivers up to 90% of cover. No high areas of non-vegetated cover, but non-vegetated cover is permitted as long as other criteria is satisfied.
(ADDED Polygon : #229)

INAD: Very low area of deciduous dominated forest (less than 20%); or a high amount of shrub; or high amount of cultivation. Medium and large areas of non vegetated cover (such as NAS { surface mines, gravel pits, spoil piles}, NAC {cities, towns, industrial developments, or NMS {sand, soil, alluvium, alkali flats}); and high lake area coverage.



Appendix D: Quaternary Geology map of the County of Parkland
(Adapted from Shetsen, I., 1990)

Appendix D: Key for the Quaternary Geology Map of the County of Parkland, Alberta (from Shetsen, 1990).

Code	Deposit Type	Sediment or Debris	Source	Topography
0	Organic	woody, fibrous and mucky peat; up to 7m thick	bog, fens swamps and marshes	generally flat
1	Eolian	fine and medium-grained sand and silt; up to 7m thick	longitudinal and parabolic dunes scoured by blowouts	undulating to rolling
2a	Lacustrine	Coarse sediment: sand and silt; up to 80m thick	deposited mainly in proglacial lakes, but includes also undifferentiated lake sediment	undulating surface in places modified by wind
2b	Lacustrine	Fine sediment: silt and clay; up to 80m thick	deposited mainly in proglacial lakes, but includes also undifferentiated lake sediment	flat to gently undulating surface
3a	Fluvial	Coarse sediment: gravel, gravel and sand, fine to coarse-grained sand, minor silt beds; up to 20m thick	present on floors and terraces of river valleys and meltwater channels, and in deltas	flat to undulating
3b	Fluvial	Fine sediment: fine sand, silt and clay, minor gravel beds; up to 20m thick	present on floors and terraces of river valleys and meltwater channels, and in deltas	flat to undulating
4	Stream and Slopewash Eroded	exposed till and bedrock, local slump material	slopes of river valleys and meltwater channels,	in places, badland type terrain
6a	Ice-Contact Lacustrine	Coarse sediment: sand and silt; up to 20m thick	deposited in supraglacial and ice-walled lakes or in proglacial lakes floored by ice	undulating to hummocky
6b	Ice-Contact Lacustrine	Fine sediment: silt and clay; up to 20m thick	deposited in supraglacial and ice-walled lakes or in proglacial lakes floored by ice	undulating to hummocky
7a	Ice-Contact Fluvial	Coarse sediment: gravel, gravel and sand, fine to coarse-grained sand; up to 25m thick	deposited in ice-walled and supraglacial streams, or in ice-front fans and deltas	undulating to hummocky

Code	Deposit Type	Sediment or Debris	Source	Topography
8	Ice-Contact Lacustrine and Fluvial; Undivided	gravel, sand , silt and clay, local till: up to 25m thick	deposited in intermittent supraglacial lakes and streams, or at margins of ice-floored proglacial lakes	undulating to hummocky terrain
9	Glacial; Draped Moraine	even thickness till, minor amounts water-sorted material and local bedrock exposures; up to 10m thick	includes local areas of undifferentiated subglacially molded deposit with streamlined features	flat to undulating surface reflecting topography of underlying bedrock and other deposits
10a	Glacial; Stagnation Moraine	till of uneven thickness, local water -sorted material;		undulating, with local relief generally less than 3m
10b	Glacial; Stagnation Moraine	till of uneven thickness, local water -sorted material;		hummocky, moderately to weakly developed, with irregularly shaped and poorly defined knobs and kettles; local relief 3 to 10m
10c	Glacial; Stagnation Moraine	till of uneven thickness, local water -sorted material;		hummocky,strongly developed, with generally round, well defined knobs, dimpled knobs, doughnut shaped hills and kettles; local relief 5 to 20m
12	Ice-Thrust Moraine	mixed and contorted bedrock, till and water-sorted material	translocated by ice as thrust blocks, slabs or folds; up to 100m thick	ridges, irregularly shaped hills and depressions
12a	Ice-Thrust & Stagnation Moraine; Undivided	bedrock, till, local water-sorted material; up to 50m		thick rolling to hummocky
14a	Bedrock and Glacial, Undivided	draped moraine on bedrock uplands and plains; till generally less than 3m thick	discontinuous till over bedrock surface slightly modified by ice and stream erosion	flat to undulating
15	Fluvial	gravel and sand, minor silt beds; up to 10m thick	found overlying bedrock in upland areas, but generally covered by till or water-sorted material and	exposed only along crests of erosional slopes
16b	Bedrock	sandstone, siltstone,mudstone, and shale, minor ironstone, limestone and coal beds;	includes slump material	bedrock exposed by erosion or human activity

APPENDIX E

TREE SPECIES IN THE COUNTY OF PARKLAND AND THEIR ABUNDANCE BY ECOREGION

Ecoregion	Aspen	Balsam Poplar	Black Spruce	White Spruce	Jack Pine	Lodgepole Pine	Tamarack	Paper Birch
Aspen Parkland	D	O	R	O	-	-	-	-
Lower Boreal Cordilleran	D	C	C	C	-	D	O	O
Low Boreal Mixedwood	D	O	C	C	C	-	O	O
Mid Boreal Mixedwood	D	C	C	C	C	-	O	O

D Dominant, a prominent species in terms of cover and influence on the environment.
C Common, an abundant species but secondary to dominant species.
O Occasional, a species that occurs infrequently.
R Rare, a species that occurs very infrequently.
- Does not occur.

(Adapted from "Ecoregions and Ecodistricts of Alberta; Volume 1", by W.L. Strong Ecological Land Surveys Ltd., for Alberta Forestry, Lands and Wildlife; Edmonton, Alberta. 1992. p.32.)

APPENDIX F

ECOREGION VEGETATIVE COMMUNITIES AND ENVIRONMENTAL GRADIENTS

Aspen Parkland

Aspen areas:

Aspen *(Populus tremuloides)*

associated understory

Saskatoon *(Amelanchier alnifolia)*
Prickly Rose *(Rosa acicularis)*
Veiny Medow Rue (*Thalictrum venulosum*)
Wild Strawberry *(Fragraria virginiana)*
Larkspurs *(Delphinium* spp.*)*
Violets *(Viola* spp.*)*
Fireweed *(Epilobium angustifolium)*

Grassland areas: (drier sites)

Rough Fescue *(Festuca scabrella)*
Bluebunch Fescue *(Festuca idahoensis)*
June Grass *(Koeleria macrantha)*
Needle grasses *(Stipa* spp.*)*
Old Man's Whiskers *(Geum triflorum)*
Sticky Purple Geranium *(Geranium viscosissimum)*
Northern Bedstraw *(Galium boreale)*

Shrubs: (found on northfacing slopes, and ravines, and in locations that accumulate snow during winter months in grassland dominated areas)
Saskatoon *(Amelanchier alnifolia)*
Prickly Rose *(Rosa acicularis)*
Buckbrush *(Symphoricarpos occidentalis)*
Snowberry *(Symphoricarpos albus)*
Silverberry *(Elaeagnus commutata)*

* Note: Since the County of Parkland is located at the north-western edge of this Ecoregion the extent of grassland areas is likely to be lower than that of the shrub or aspen areas.

(from "Ecoregions and Ecodistricts of Alberta; Volume 1", by W.L. Strong Ecological Land Surveys Ltd., for Alberta Forestry, Lands and Wildlife; Edmonton, Alberta. 1992. p.29.)

Aspen Parkland Ecoregion Environmental Gradient
(Adapted from Strong, 1992a; p.30)

Grassland Dominated Portion	**Aspen Dominated Portion**
DRY/WARM	**DRY/WARM**
Spear-Wheat Grass; Rough Fescue Well to moderately well drained Dark Brown and Black Chernozems I Saskatoon (shrubs) Moderately well drained Black Chernozems, Brunisols I Aspen **Imperfectly drained** Black Chernozems I Aspen - White Spruce - Willows Imperfectly to poorly drained Gleysols I Sedges Poorly drained Regosols, Gleysols	Spear-Wheat Grass; Rough Fescue Well to moderately well drained Dark Brown and Black Chernozems I Saskatoon (shrubs) Moderately well drained Black Chernozems, Brunisols I Aspen **Moderately well drained** Black and **Dark Gray** Chernozems I Aspen - White Spruce **Moderately well to imperfectly drained** **Dark Gray** Chernozems I Willows Imperfectly to poorly drained Gleysols I Sedges Poorly drained Regosols, Gleysols
WET/COOL	**WET/COOL**

"...there occurs between the poplar region and the prairie a broad transition belt, the parkland, consisting of groves of trees in depressions and on north-facing slopes, and patches of prairie vegetation on south-facing slopes and other dry situations. This transition belt contains within it thousands of narrow tension lines or ecotones, these occurring wherever poplar and prairie communities meet, ... aspen is probably the climax (species) *of the ...parkland." (Moss, 1932, p.414).*

Low Boreal Mixedwood

Cool, moist conditions beneath forest canopy:
Aspen *(Populus tremuloides)*
White Spruce *(Picea glauca)*

associated understory:
Bluejoint *(Calamagrostis canadensis)*
Cream-colored Vetchling *(Lathyrus ochroleucus)*
Prickly Rose *(Rosa acicularis)*
Bunchberry *(Cornus canadensis)*
Willows *(Salix* spp.*)*
Saskatoon *(Amelanchier alnifolia)*

Wetter sites:
Aspen *(Populus tremuloides)*
Balsam Poplar *(Populus balsamifera)*

Outwash and sand dunes:
Jack Pine *(Pinus banksiana)*

associated understory:
Ericaceous shrubs *(Vaccinium* spp.*)*
Bearberry *(Arctostaphylos uva-ursi)*
Lichens

Poorly drained soils:
Black Spruce *(Picea mariana)*

associated understory:
Common Labrador Tea *(Ledum groenlandicum)*
Bog Cranberry *(Vaccinium vitis-idaea)*
Mosses

(from "Ecoregions and Ecodistricts of Alberta; Volume 1", by W.L. Strong Ecological Land Surveys Ltd., for Alberta Forestry, Lands and Wildlife; Edmonton, Alberta. 1992. p.48-49.)

Low Boreal Mixedwood Environmental Gradient
(Adapted from Strong, 1992a; p.48)

DRY/WARM

Jack Pine
Rapidly to well drained
Eutric Brunisols
I
Aspen
Moderately well to well drained
Gray Luvisols and Eutric Brunisols
I
Aspen - Balsam Poplar
Imperfectly drained
Gray Luvisols and Gleysols
I
Black Spruce; Willows; Sedges
Poorly drained
Gleysols; Organics

WET/COOL

Mid Boreal Mixedwood
Aspen *(Populus tremuloides)*
Balsam Poplar *(Populus balsamifera)*

associated understory:
Bluejoint *(Calamagrostis canadensis)*
Wild Sarsaparilla *(Aralia nudicaulis)*
Prickly Rose *(Rosa acicularis)*
Fireweed *(Epilobium angustifolium)*
Bunchberry *(Cornus canadensis)*
Dewberry *(Rubus pubescens)*

also present, but to a lesser degree due to frequent fires:
White Spruce *(Picea glauca)*
Balsam Fir *(Abies balsamea)*

Subxeric sites:
Green Alder *(Alnus crispa)*
Pin Cherry *(Prunus pensylvanica)*
Prickly Rose *(Rosa acicularis)*

Xeric sites:
Jack Pine *(Pinus banksiana)*
Bearberry *(Arctostaphylos uva-ursi)*
Blueberries *(Vaccinium spp.)*

Poorly drained areas with moving water:
Willows *(Salix* spp.*)*
Sedge *(Carex* spp.*)*

Poorly drained soils:
Black Spruce *(Picea mariana)*

associated understory:
Common Labrador Tea *(Ledum groenlandicum)*
Bog Cranberry *(Vaccinium vitis-idaea)*
Mosses

(from "Ecoregions and Ecodistricts of Alberta; Volume 1", by W.L. Strong Ecological Land Surveys Ltd., for Alberta Forestry, Lands and Wildlife; Edmonton, Alberta. 1992. p.50.)

Mid Boreal Mixedwood Environmental Gradient
(Adapted from Strong, 1992a; p. 50)

DRY/WARM

Jack Pine
Rapidly to well drained
Eutric and Dystric Brunisols
I
Aspen
Well drained
Eutric Brunisols and Gray Luvisols
I
Aspen - Balsam Poplar - White Spruce
Well drained to imperfectly drained
Gray Luvisols to Eutric Brunisols
I
Black Spruce; Willows
Poorly drained
Gleysols, Organics
I
Sedges
Very poorly drained
Organics

WET/COOL

Lower Boreal Cordilleran

on medium textured, moderately well drained Gray Luvisolic soils:
Aspen *(Populus tremuloides)*
Balsam Poplar *(Populus balsamifera)*
Paper Birch *(Betula papyrifera)*
Lodgepole Pine *(Pinus contorta)*
White Spruce *(Picea glauca)*
Black Spruce *(Picea mariana)*
Balsam Fir *(Abies balsamea)*

associated understory vegetation:
Hairy Wild Rye *(Elymus innovatus)*
Fireweed *(Epilobium angustifolium)*
Wintergreen *(Pyrola* spp.*)*
Composite species (Compositae)
Common Labrador Tea *(Ledum groenlandicum)*

on rapidly to well drained sites:
Lodgepole Pine *(Pinus contorta)*
Common Bearberry *(Arctostaphylos uva-ursi)*
Junipers *(Juniperus communis* and *J. horizontalis)*
Canada Buffaloberry *(Shepherdia canadensis)*
scattered herbs

on imperfectly drained sites:
Lodgepole Pine *(Pinus contorta)*
White Spruce *(Picea glauca)*
Black Spruce *(Picea mariana)*

associated understory vegetation:
Mosses
Common Labrador Tea *(Ledum groenlandicum)*

on poorly drained depressions, with organic deposits on surface:
Black Spruce *(Picea mariana)*

(from "Ecoregions and Ecodistricts of Alberta; Volume 1", by W.L. Strong Ecological Land Surveys Ltd., for Alberta Forestry, Lands and Wildlife; Edmonton, Alberta. 1992. p.43.)

Lower Boreal Cordilleran Environmental Gradient
(Adapted from Strong, 1992a; p.43)

DRY/WARM

Open Lodgepole Pine
Well Drained
Brunisols
I
Aspen - Balsam Poplar - Lodgepole Pine
Moderately well to well drained
Gray Luvisols
I
Lodgepole Pine
Imperfectly drained
Gleysols
I
Black Spruce; Tamarack
Poorly to very poorly drained
Organic, Gleysols
I
Willows; Sedges
Very poorly drained
Organics, Gleysols

WET/COOL

APPENDIX G

CHARACTERISTIC ANIMAL SPECIES OF THE ECOREGIONS

Aspen Parkland

Red-necked Grebe *(Podiceps grisegena)*
Horned Grebe *(Podiceps auritus)*
Ruby-throated Hummingbird *(Archilochus colubris)*
Franklin's Gull *(Larus pipixcan)*
American Avocet *(Recurvirostra americana)*
White-tailed Deer *(Odocoileus virginianus)*
Franklin's Ground Squirrel *(Spermophilus franklinii)*
Prairie Vole *(Microtus ochrogaster)*
rare and threatened:
Piping Plover *(Charadrius melodus)*

(from "Ecoregions and Ecodistricts of Alberta; Volume 1", by W.L. Strong Ecological Land Surveys Ltd., for Alberta Forestry, Lands and Wildlife; Edmonton, Alberta. 1992. p.29, 31.)

Low Boreal Mixedwood

Beaver *(Castor canadensis)*
Moose *(Alces alces)*
White-throated Sparrow *(Zonotrichia albicollis)*
Red-eyed Vireo *(Vireo olivaceus)*
Common Loon *(Gavia immer)*
Eastern Phoebe *(Sayornis phoebe)*
Black Bear *(Ursus americanus)*

rapid conversion of forested lands to agriculture threatens larger wildlife species such as:
Moose *(Alces alces)*
Canada Lynx *(Lynx canadensis)*
Fisher *(Martes pennanti)*

*Note: the most species rich habitats are wetlands with tall shrubs, which are bordered by mature mixedwood forests; productive furbearer habitat and breeding bird habitat; vegetative diversity supports larger moose populations.

(from "Ecoregions and Ecodistricts of Alberta; Volume 1", by W.L. Strong Ecological Land Surveys Ltd., for Alberta Forestry, Lands and Wildlife; Edmonton, Alberta. 1992. p.49.)

Mid Boreal Mixedwood
Marten *(Martes americana)*
Black-and-white Warbler *(Mniotilta varia)*
Magnolia Warbler *(Dendroica magnolia)*
Ovenbird *(Seiurus aurocapillus)*

(also has many of the same species as Low Boreal Mixedwood)
* Note: riparian areas serve as travel corridors, and their forbs and shrubs are important food sources in both summer and winter.

(from "Ecoregions and Ecodistricts of Alberta; Volume 1", by W.L. Strong Ecological Land Surveys Ltd., for Alberta Forestry, Lands and Wildlife; Edmonton, Alberta. 1992. p.51.)

Lower Boreal Cordilleran
important winter habitat for:
Elk *(Cervus elaphus)*
Mule Deer *(Odocoileus hemionus)*

in aspen-dominated areas:
Moose *(Alces alces)*
Ruffed Grouse *(Bonasa umbellus)*
Common Snipe *(Gallinago gallinago)*
Northern Pygmy-owl *(Glaucidium gnoma)*
Yellow-bellied Sapsucker *(Sphyrapicus varius)*
Warbling Vireo *(Vireo gilvus)*

* fewer wetlands translates into lower overall wildlife diversity in this Ecoregion compared to Boreal Mixedwood Ecoregions;

(from "Ecoregions and Ecodistricts of Alberta; Volume 1", by W.L. Strong Ecological Land Surveys Ltd., for Alberta Forestry, Lands and Wildlife; Edmonton, Alberta. 1992. p.43 - 44.)

APPENDIX H

ASSOCIATED SPECIES FOR SIX BROAD HABITAT TYPES

Wetland (Indicator species = Mallard)
Beaver *(Castor canadensis)*
Muskrat *(Ondata zibethicus)*
Canadian Toad *(Bufo hemiophrys)*
Wood Frog *(Rana sylvatica)*
Striped Chorus Frog *(Pseudocris triseriata)*
Western Toad *(Bufo boreas)*
Common Loon *(Gavia immer)*
Eared Grebe *(Podiceps nigricollis)*
Western Grebe *(Aechmophorus occidentalis)*
Red-necked Grebe *(Podiceps grisegena)*
Common Goldeneye *(Bucephala clangula)*
Ring-necked Duck *(Aythya collaris)*
Yellow-headed Blackbird *(Xanthocephalus xanthocephalus)*
Marsh Wren *(Cistothorus palustris)*
Warbling Vireo *(Vireo gilvus)*

Treed Riparian (Indicator species = Mink)
Beaver *(Castor canadensis)*
Muskrat *(Ondata zibethicus)*
Black Bear *(Ursus americanus)*
Canadian Toad *(Bufo hemiophrys)*
Wood Frog *(Rana sylvatica)*
Striped Chorus Frog *(Pseudocris triseriata)*
Western Toad *(Bufo boreas)*
Red-sided Garter Snake *(Thamnophis sirtalis)*
Swamp Sparrow *(Melospiza georgiana)*
Pileated Woodpecker *(Dryocopus pileatus)*
Hoary Bat *(Lasiurus cinereus)*
Water Shrew *(Sorex palustrus)*
Common Yellowthroat *(Geothlypis trichas)*
Red-winged Blackbird *(Agelanius phoeniceus)*

Shrub Deciduous (Indicator species = Moose)
Mule Deer *(Odocoileus hemionus)*
Chipping Sparrow *(Spizella passerina)*
Gray Partridge *(Perdix perdix)*

Tall Deciduous (Indicator species = Hairy Woodpecker)
Ruffed Grouse *(Bonasa umbellus)*
Ovenbird *(Seiurus aurocapillus)*
Blue Jay *(Cyanocitta crisata)*
Silver-haired Bat *(Lasionycteris noctivagans)*
Little Brown Bat *(Myotis lucifugus)*
Big Brown Bat *(Eptesicus fuscus)*
Porcupine *(Erethizon dorsatum)*
Northern Saw-whet Owl *(Aegolius acadicus)*
Northern Oriole *(Icterus glabula)*
Woodchuck *(Marmota monax)*
Snowshoe Hare *(Lepus americanus)*

Coniferous (Indicator species = Marten)
Red Squirrel *(Tamiasciurus hudsonicus)*
Golden-crowned Kinglet *(Regulus satrapa)*
Red-backed Vole *(Clethrionomys gapperi)*
Three-toed Woodpecker *(Picoides tridactylus)*
Spruce Grouse *(Dendragapus canadensis)*
Pine Siskin *(Carduelis pinus)*
Boreal Chickadee *(Parus hudsonicus)*
Boreal Owl *(Aegolius funereus)*
Black-capped Chickadee *(Parus atricapillus)*
Gray Jay *(Perisoreus canadensis)*
Hoary Bat *(Lasiurus cinereus)*
Northern Long-eared Bat *(Myotis septentrionalis)*

General Upland (Indicator species = White-tailed Deer)
Savannah Sparrow *(Passerculus sandwichensis)*
Yellow-bellied Sapsucker *(Sphyrapicus varius)*
White-throated Sparrow *(Zonotrichia albicollis)*
Great Horned Owl *(Bubo virginianus)*
Red-tailed Hawk *(Buteo jamaicensis)*
Red-sided Garter Snake *(Thamnophis sirtalis)*
Woodchuck *(Marmota monax)*
Badger *(Taxidea taxus)*
Striped Skunk *(Mephitis mephitis)*
White-tailed Jack Rabbit *(Lepus townsendii)*
Red Fox *(Vulpes vulpes)*
Coyote *(Canis latrans)*
Least Chipmunk *(Tamias minimus)*
Franklin's Ground Squirrel *(Spermophilus franklinii)*

APPENDIX I

REWARD FARMERS FOR PRESERVING WILDLIFE

(From the Western Producer, Thursday, July 1, 1993. p. 44)

Reward farmers for preserving wildlife, say conservationists

LETHBRIDGE (Staff) — A conservation group says changes are needed in the way land is managed, to ensure room is made for wildlife in the future landscapes of Canada.

Caroline Caza of Wildlife Habitat Canada gave her organization's view of how to conserve landscapes so as to sustain wildlife at a recent sustainable land management workshop at the University of Lethbridge.

She says public opinion is on her side, citing a recent poll that indicated 46 percent of Canadians believe it is important to conserve wilderness outside of parks.

Wildlife Habitat of Canada is a non-profit national foundation dedicated to wildlife habitat conservation. Since 1984 it has worked with partners to invest millions of dollars to habitat preservation.

Wildlife Habitat uses what it calls the landscape approach to sustainable development of land in Canada. It is a three-tiered approach to sustainable development with a philosophical angle, practical suggestions for maintaining the landscape and goals for protection of the environment.

Governments have shied away from defining values and people's responsibility to the environment and preservation of biodiversity, she said. Rather, those in power seem to view sustainable development as a management strategy without really defining its goals towards sustainability.

A statement of goals is needed to define what conservation means to Canada and how it will be carried out.

It's frustrating work, said Caza.

"The bulk of our effort is ensuring compliance with and enforcement of minimum environmental standards to maintain the integrity of landscapes," she said.

But it's not enough, she says, because most standards ignore cumulative or other impacts on the landscape contributing to a declining environmental quality.

Wilderness plan

Canada has promised to set aside 12 percent of its land base as protected wilderness areas by the year 2000, according to a plan set up by the World Wildlife Fund.

However most of the wildlife which needs to be preserved lives outside the areas designated for protection, she said.

Since most wildlife is found on private lands, Caza recommends working with farmers to preserve wildlife. Farmers should be compensated for their work and those who practice sustainable agriculture should also be rewarded, she said. Besides recognition for wildlife conservation, they also need to be rewarded for promoting clean water and healthy soils.

Reforms to existing agriculture policy are needed to make room for conservation. "It appears these policies and the institutions of agriculture are the biggest obstacles in land management at present," she said.

Crop rotation, composting and using green manures integrated into natural areas will stimulate more healthy agricultural landscapes. It will encourage sustainable development and reduce farmers' dependence on management strategies that deplete natural resource capital.

"Techniques such as these, when integrated into landscapes with natural areas will sustain a much greater diversity of ecosystems within farmlands than currently is found in most parts of Canada," she said.

APPENDIX J
SPECIFIC HABITAT PROGRAM OPTIONS

ALBERTA PROGRAMS

ConservACTION Program

The ConservACTION Program in the County of Strathcona, Alberta operated as a partnership with Alberta Fish and Wildlife Services, Sherwood Park Fish and Game association, the County of Strathcona, and Environmental Partners Fund. Wetlands were prioritized over upland because they are harder to re-establish because of higher inherent biodiversity. Priorities also included uplands with specific criteria to mee to be eligible for the program. A one time recognition payment was on option given to landowners who agreed to this program.

An interesting option of private conservancy that was used in one instance was a restrictive covenant. In a restrictive covenant the landowner accepts restrictions on the use of a portion of land. In this particular case, the dominant tenement was the bed of a lake (owned by the Crown in the right of the Province), and the servient tenement on which the restriction of no development would apply, was a 40m buffer strip (17 acres) along the shore of this lake. The benefit received by the dominant tenement was the wildlife habitat in the buffer area, and the servient tenement was burdened by the covenant. The cost of this year long endeavor was $20,000.00, which included an income tax receipt from the Crown to the landowner, professional appraisal of the land, Fish and Wildlife staff time, partial cost of professional legal advice, and consultation with Revenue Canada (Smith and Kwasniak, 1993). This flexible alternative may incur a lower cost than would the acquisition of property, because the property still remains in the municipal tax base, and the landowner retains and manages the remainder of the property. However, this is a more costly option than having legislative amendments which would facilitate the achievement of longer term habitat goals. Suggestions for change to Alberta's legislation to facilitate the objectives of environmental conservancy by private landowners have been made by the Environmental Law Center (Smith and Kwasniak, 1993).

Landowner Habitat Program

A variety of methods that may be used to influence private land use decisions are included in Alberta Fish and Wildlife Division's (1989) Landowner Habitat Program. If the habitat the landowner wishes to maintain for wildlife meets criteria for size, location, quality, and land use, then an annual incentive payment based upon the value of the land and the length of the agreement will be paid. The incentive payment is based on approximately 80% of the average rental rate for a particular land use in a given district. Agreements can run from 5-30 years. To be eligible, landowners must have continuous blocks of cover that must be greater than or equal to 80 acres. Forty acre blocks may be accepted if they are within 0.80 km (half a mile) of a 0.32 km^2 (80 acre, or 32 hectare) block.

Options included: habitat retention (on areas that require no improvements); habitat enhancement and development (on lands that require improvement); land use change (for areas requiring a change to agricultural practices); habitat recognition (for smaller parcels of land); extension services (to provide information and technical assistance to landowners); and other options based on a case-by-case basis. Fish and Wildlife Services has also accepted also accept land donations or gifts of less than fee simple and provide official income tax receipts for them. (It is worth noting that all the current funding for this program is being used to pay existing agreements.)

Buck For Wildlife

Funded primarily through provincial hunting and fishing licenses, as well as tax deductible private donations, this program is administered by Alberta Environmental Protection, Fish and Wildlife Services (Alberta Fish and Wildlife Division, 1990). The focus is on improvement or protection of habitat for fish and wildlife in Alberta. The program involves individuals, groups and volunteer organizations to work toward habitat retention, improvement and development. (Most of the habitat retentionefforts carried out under the Landowner Habitat Program and other programs were funded in this manner.)

Alberta Prairie CARE

Alberta Prairie CARE, a major component of NAWMP's strategy in Alberta, offers a number of land use options for farmers and landowners in rural Alberta (DU, n.d.). Financial and technical assistance are available so landowners can adopt soil and water conservation practices that also improve wildlife habitat. Initiatives include intensive wildlife management, and modified agricultural management. Fair rental rates or fair incentives for modified agriculture uses are paid. A management plan specific to each piece of land can be developed. On-farm demonstrations of wildlife-friendly cropping systems have also been developed.

Prairie Farm Rehabilitation Administration (PFRA)

i) Farm Shelterbelt Program

This program is set up for the establishment of shelterbelts. Incentives and assistance include free seedlings, and the coverage of some planting and maintenance costs. Eligible areas must be over 40 acres.

ii) Conservation Cover Program

Within this program, encouragement is given to farmers to grow perennial forage where cultivation of highly erodible soils is causing severe soil deterioration. Parcels of minimum 40 acres are considered, and at least 50% of the cultivated areas within the parcel must be eligible lands, (generally CLI Class 4,5,6). The maximum acreage eligible for this is 640 acres (1 section) per landowner. A Land Use Contract may also be entered into in which the landowner receives a one-time payment of $20 per acre for a 10-year

agreement, or $50 per year for a 21-year contract. Technical assistance is also available (PFRA, n.d.).

Partners in Conservation Program

The County of Barrhead Agriculture Services Board offers a Partners in Conservation Program which attempts to educate landowners about habitat retention and involve them in habitat retention agreements. These agreements provide recognition payments (not the monetary value of the land) and the landowner receives a sign stating that he/she has signed this agreement. The County of Barrhead participated in the program and used a tax rebate system with program delivery by Fish and Wildlife. Interested landowners with eligible wooded land signed Habitat Conservation agreements for a 20 year period, which qualified them for a rebate in their municipal taxes on that habitat area. The same greater than 0.32 km^2 (80 acres) condition applied, but also with less than 25% of the similar type and size of habitat within a 3.22 km (2 mile) radius of the habitat lands.

MANITOBA PROGRAMS

Conservation Corridors Program

Manitoba's Conservation Districts within Agro-Manitoba, head this program (they are associated with Manitoba Department of Rural Development). Strips 99ft (30.18m) wide of Crown or public lands were set aside for road allowances when the prairies were settled, for use as transportation routes where required. This amounts to 12 acres per lineal mile. This program approaches Rural Municipal Councils in Manitoba to sign an agreement and pass a by-law whereby existing undeveloped road allowances are not to be developed without a permit from the Council. Signs are posted on such corridors and landowners within the area are informed of the change to their by-law. The funding for this effort is mainly from an annual grant from the Province of Manitoba, and municipal levies (Whitemud Conservation District, n.d.).

Green Acres Program

This Program is a NAWMP initiative that has the objective of securing, developing and managing wetlands and upland habitat that is marginal for grain production. The program coordinator is the Manitoba Habitat Heritage Corporation (MHHC, n.d.), and the other partners are: Manitoba Agriculture, Department of Natural Resources, Delta Waterfowl Foundation, Wildlife Habitat Canada, Agriculture Canada, Ducks Unlimited Canada, Environment Canada, as well as local groups. Financial incentives are available, as well as technical assistance with the construction of structures such as flatland dams, and nest structures. Activities including cover restoration and enhancement, special wildlife conservation projects, and other options are also eligible for financing.

Adopt a Pothole Program

Funded through the Delta Waterfowl Foundation, a division of the North American Wildlife Foundation, this program pays landowners not to drain potholes, or farm up to their edges (Delta Waterfowl Foundation, n.d.). It also leases the upland surrounding potholes and plants cover grasses. Where applicable, nesting structures are erected. This program targets only those potholes on private land which are being impacted by agricultural practices, and whose owners are willing to agree to a minimum 5 year contract. A landowner enters the program by making it known to the organization that he/she has potholes available for adoption. Payments range from $100 for a one acre pothole and associated upland habitat; to $500 for a complex of potholes. Farms are given forage seed and are paid for seeding, but must control the weeds themselves.

Manitoba Agro-Woodlot Program

The Manitoba Agro-Woodlot Program is delivered through funding from the Canada-Manitoba Partnership Agreement in Forestry, in conjunction with Forestry Canada, Manitoba Natural Resources, Wildlife Habitat Canada, Tree Plan Canada, PFRA, and Farming For Tomorrow (Manitoba Natural Resources, n.d.). The focus of this program is to promote active stewardship and sustainable development of private woodlots in the Agricultural areas of Manitoba. Their activities include tree planting, information, education, and wood product market development. Extension services include personnel evaluating each site and discussing the landowner's goals to help develop a tailored woodlot management plan. Within this plan is a list of activities, costs and incentives that may be available. Technical assistance may also be provided. Existing cost shared projects may pay up to 80% of some management activities, and 50% of approved planting stock.