Habitat Associations of Pembina Valley Birds: Responses to Grazing

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A thesis 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

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Abstract

This study provided information on the species composition of the riparian bird community, evaluated the impact of grazing on avian species richness and abundance, and assessed avian habitat relationships relative to grazing in the Pembina Valley, Manitoba. Birds were censused using unlimited-radius counts at 27 grazed and 28 ungrazed point count stations through the month of June 1997. Fifteen habitat variables were measured in five 0.04 ha (11.3m radius) circular plots at 14 ungrazed and 15 grazed point count stations.

A total of 1028 individuals of 45 bird species were detected during point counts. The most abundant species on the study area were yellow warbler, cedar waxwing, red-eyed vireo, least flycatcher, brown-headed cowbird , house wren, and clay-colored sparrow Tree species composition and variables related to vegetation density, including shrub density, percent vertical cover, height of understory vegetation, percent canopy cover and percent ground cover, were most important to habitat associations of Pembina Valley birds. To some extent, livestock grazing was found to influence these variables and produce sites with comparatively lower vegetation densities. Bird species richness, abundance and diversity were similar on grazed and ungrazed treatments; however, bird species composition and representation of foraging and nesting guilds differed. Patchiness of vegetation on grazed sites continued to provide habitat for many bird species. Habitat associations suggested that veery, common yellowthroat, gray catbird and yellow-throated vireo are most sensitive to grazing in this area.

Managed grazing regimes and sustainable forest management may be viable means of improving habitat heterogeneity and sustaining regional bird species diversity while providing for the needs of habitat specialists. Land managers with avian habitat objectives in mind, must be wary of the influences of habitat patchiness on brood parasite and predator species and the resulting "ecological trap" this may pose for many bird species.

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And finally, to my dearest Mom and Dad, thanks for instilling in me the values that made me tackle a Masters degree in the first place: Your life's work should challenge you but make you happy; You can do anything you set your mind to; You should try to be a positive influence in the world; and It is your family and friends, not your source of income, that make life worth living.

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Chapter 1 Introduction

1.1 Background

Vegetative communities along rivers and streams have been referred to as the "aorta of an ecosystem" (Wilson 1979:82) due to their importance to water, fish, wildlife, rangeland and forest resources. Known as riparian zones, these productive habitats require a balance between often conflicting consumptive and non-consumptive uses (Krueper 1992). The need for multiple-use planning of riparian areas has been emphasized (Fitzhugh 1981; Heady and Child 1994) and requires that no one use damages the resources on which other uses depend (Sedgwick and Knopf 1987; Heady and Child 1994). Privately owned riparian lands pose a particular management challenge since land uses selected may not recognise public values, such as water quality or wildlife habitat (Fitzhugh 1981), but depend almost entirely on landowner's choice (Heady and Child 1994). Although economic factors are important determinants of landowner actions with respect to private lands, attitudes, misconceptions and lack of knowledge have been shown to have an even greater influence (Leitch and Danielson 1979; Fitzhugh 1981; O'Grady 1990). A fundamental first step to the preservation of all riparian resources is ensuring that landowners have access to sound information on the mutual effects of land use practices.

Riparian areas provide important habitat for numerous wildlife species (Thomas *et al.* 1979), and contain a critical source of diversity, particularly on the Great Plains (Sedgwick and Knopf 1987). Within these habitats, the local avifauna represents one of the most conspicuous and varied vertebrate groups (Stauffer and Best 1980). In the western United States, riparian vegetation provides habitat for more species of breeding birds than all other vegetation types combined (Knopf *et al.* 1988a). Studies of riparian communities have shown that bird species richness and abundance are greater in these habitats than in adjacent areas (Smith 1977; Emmerich and Vohs 1982; Gates and Giffen 1991), and this trend may be more pronounced in agricultural regions where the contrast in vegetation types is the most evident (Stauffer and Best 1980). In prairie agricultural landscapes, these gallery forests are particularly important to wildlife, in many cases representing the few remaining patches of habitat for forest-dwelling species (Emmerich and Vohs 1982; Faanes and Andrew 1983; Anderson *et al.* 1984; Meents *et al.* 1984).

Livestock grazing is often the most pervasive influence on riparian areas (Dobkin *et al.* 1998), and many grazing practices have had adverse impacts in western riparian systems (Krueper 1992). The provision of succulent forage, shade, and water makes these areas particularly attractive to livestock when upland areas become hot and dry (Platts 1991; Heady and Child 1994). Livestock grazing within riparian zones can dramatically alter vegetation structure, density, and cover (Bock and Webb 1984; Ammon and Stacey 1997) and plant community composition (Sedgwick and Knopf 1987). Riparian birds have been shown to respond to these vegetative changes (Taylor 1986; Sedgwick and Knopf 1987; Knopf *et al.* 1988b), but may be differentially affected (Schulz and Leininger 1991; Bock *et al.* 1992). Whereas aerial foragers and ground foragers that prefer less cover may be benefited by grazing (Bock *et al.* 1992), birds dependent upon the ground-shrub zone for nesting and foraging are typically negatively impacted (Sedgwick and Knopf 1987; Bock *et al.* 1992). Grazing may result in a reduction in the overall level of bird species diversity of a site (Taylor 1986), or a shift in species composition with diversity remaining constant

(Schulz and Leininger 1991). Recent research has shown grazing to impact avian nest success, through the physical removal of vegetation which increases predation rates (Ammon and Stacey 1997), through increases in Brown-headed cowbird abundance (Bock *et al.* 1992), and through nest trampling (Paine *et al.* 1996).

In south-central Manitoba, much of the Pembina Valley is privately owned and has been prone to land use conflicts (MES Environmental 1997). The Valley is notably rich in resources and has been recognised for its potential recreational value (Bintner 1971; Penner 1996), fish production (MES Environmental 1997), and game production (Chranowski 1985). Although little information is available on the avian diversity of the area, results from a North Dakota study (Faanes and Andrew 1983) suggest that there is potential for species-rich bird communities as well. Land use throughout the area has been identified as predominantly agricultural in nature, with livestock grazing occurring along 40% to 50% of the Pembina River (MES Environmental 1997). Whereas grazing has been associated with declines in water quality and severe limitations in fish production (MES Environmental 1997), its effect on the avian communities is not known. Given the potential importance of the Pembina Valley to avian production, further knowledge of the bird species inhabiting the area, their habitat associations, and their responses to grazing is required.

1.2 Issue Statement

Grazing has been identified as the dominant land use in the Pembina Valley and has been implicated in declines in water quality and fish production. However, the influence of this activity on avian populations is not known. Recognizing that a large portion of the Pembina Valley is private land under agricultural management, there is a need to recognize the impact of private land use practices, such as grazing, on other values and activities, including wildlife species dependent on the plant community. This study documented the bird community of a portion of the Pembina Valley, evaluated the impact of grazing on avian species richness and abundance within the valley, and assessed avian habitat relationships relative to grazing.

1.3 Objectives

The primary purpose of this study was to determine the influence of grazing on the avian communities of a portion of the Pembina Valley. Specific objectives include:

- To characterize the bird community in the Pembina Valley study area.
- To evaluate the associations between bird species and habitat features of selected grazed and ungrazed sites within the Pembina Valley.
- To compare the avian communities of selected grazed and ungrazed sites within the Pembina Valley.
- To recommend the range of habitat types and features required to sustain the quality of the Pembina Valley for Manitoba's bird species.

1.4 Limitations

This project was designed to include a single season of field data collection. Point counts to determine avian species richness and abundance were conducted during June 1997. Potential difficulties with this design are related to seasonal and yearly variation in the bird community. Point counts conducted during this interval are likely to detect the more vocal species on breeding territories at that time and may provide less information on species that breed earlier (e.g woodpecker species) or later (e.g. American goldfinches, Cedar waxwings) in the season, and on those migrating through the area. As well, sampling in a single year may not yield results that are representative of the overall pattern of habitat use, since the bird community may differ from year to year (Rice *et al.* 1983). However, whereas there can be considerable variation in the presence or absence of rare species from year to year, annual species composition of dominant species typically remains constant (Shugart *et al.* 1978).

Chapter 2 Review of Related Literature

2.1 The Notion of Diversity

Scientists have been observing diversity relationships for years, noting that tropical areas contain more species than temperate, and that faunal diversity is associated with certain characteristics of the floral community. More recently, "biological diversity" has become a universally sought after commodity and a frequent goal of wildlife management and conservation. Species diversity is a measure of community information expressed in terms of the number (richness) and/or equitability (relative abundance) of species comprising a community (Krebs 1989). Whittaker (1975) states that diversity can be measured at three scales: diversity at a single site is known as *alpha* diversity, diversity between communities or habitats as *beta* diversity, and diversity among communities over a geographical area as *gamma* diversity.

Numerous studies have demonstrated a linear relationship between habitat diversity and bird species diversity (Lack 1933; MacArthur and MacArthur 1961; MacArthur *et al.* 1962; Hilden 1965; Wiens 1969; Roth 1976; Anderson and Ohmart 1977; Cody 1985). Both the plant species composition and structural complexity are important in determining the number and kinds of birds a given habitat is capable of supporting. Habitat diversity likely translates into foraging sites, nesting sites, and protection from the elements and from predators (Cody 1985).

Structurally, habitat diversity can be achieved through both vertical and horizontal patterning of vegetation. MacArthur and MacArthur (1961) documented the relationship between foliage height diversity and bird species diversity, proposing that bird diversity could be predicted in terms of the height profile of foliage density. As well as this vertical complexity, vegetation structure may vary horizontally to produce patchy or heterogeneous habitats (Cody 1985). If the scale of this patchiness is small, as in the case of treefall gaps in forests, bird diversity may be enhanced. Roth (1976) found that a heterogeneity index calculated on several shrub and forest areas was positively correlated with bird species diversity. MacArthur *et al.* (1962) concluded that habitat patchiness was the principle factor affecting bird species diversity and may have a greater affect than that of additional vegetation layers.

Through a study conducted at the Hubbard Brook Experimental Forest, Sherry and Holmes (1985) determined that plant species composition was important in accounting for dispersion patterns of forest birds. Many bird species selected a certain tree species for foraging, and some birds were present in the forest only where a particular kind or combination of vegetation types was found. Plant species composition will likely be more important to habitat specialists, such as frugivorous and nectar-eating species, that rely on the presence of specific plants. Knopf and Samson (1994) noted that habitat structure is correlated with species composition of the plant community, and suggested that the association between vegetation structure and site diversity may be secondary to floristic composition at a site.

Wildlife species diversity is frequently used as a measure of habitat quality (Van Horne 1983) and maximizing this diversity is often the primary objective of habitat management and conservation. Maximizing habitat diversity is assumed to be the primary means of achieving maximum faunal diversity. Van Horne (1983) challenged this approach, suggesting that some species are not adapted to areas of high habitat diversity (e.g. forest interior and old growth forest specialists) and therefore achieving maximum diversity in the limited areas being managed may not maximize diversity at a larger scale. In fact, maximizing plant community diversity on a local scale has been found to select for generalist wildlife species common to disturbed habitats and ignore sensitive species (Van Horne 1983; Knopf and Samson 1994). Habitat diversity and wildlife species diversity will be positively correlated when the ratio of generalist to specialist wildlife species is high.

2.2 Riparian Areas as Centers of Avian Diversity

2.2.1 Description of western gallery forest communities

Vegetative diversity and productivity are typically high in gallery forests. Nutrient-rich soils resulting from periodic flooding support greater plant biomass and diversity and enable faster growth (Murray and Stauffer 1995). Disturbance plays an important role in the development of riparian ecosystems (Reily and Johnson 1982) and the flood regime is a major factor accounting for the distribution and composition of riparian plant communities.

Johnson *et al.* (1976) found that the structure and composition of a North Dakota gallery forest was strongly related to stand age, and horizontal and vertical position on the floodplain. Flood-tolerant cottonwood and willow are typically the most abundant species on low terraces, experiencing relatively frequent flooding. The soils of these young stands are sandy and low in organic matter. On the upper terraces, flooding occurs infrequently and stands reach a greater age. An ash (*Fraxinus* spp.), Manitoba maple (*Acer negundo*), American elm (*Ulmus americanus*), and oak (*Quercus* spp.) assemblage predominates, and the nutrient content and available water capacity are higher due to increased organic matter content and repeated inputs of nutrient-rich silt from past floods. Tree species diversity was found to increase as stands age, reach a maximum in stands with a mixture of pioneer and climax species, and decline slightly in the oldest stands. Similar patterning of vegetation in response to flood frequency is seen in southwestern Manitoba's riparian forests (CFS 1995).

Slope angle and aspect were found to be determinants of stand characteristics in North Dakota gallery forests (Wikum and Wali 1974; Killingbeck and Bares 1978; Killingbeck and Wali 1978). Killingbeck and Wali (1978) determined that aspect was the most important variable determining plant species distribution in northeastern North Dakota. On the east slope, the forest canopy was dominated by bur oak and basswood with a canopy closure of 96%, whereas the west slope community was dominated by bur oak (*Quercus* macrocarpa) and green ash (*Fraxinus pennsylvanica*) and had a canopy closure of 82%. Species diversity was found to be greatest in mid-slope plots.

2.2.2 Importance of western gallery forests to bird species

Over 60% of neotropical migratory birds use riparian zones in the western United States as stopover areas during migration or for breeding habitat (Krueper 1992). Although less than 1% of the western landscape of the United States is covered by riparian vegetation, this small amount provides habitats for more species of breeding birds than the surrounding uplands (Knopf *et al.* 1988a). Gori (1992) attributes a greater number of breeding individuals and species in riparian zones relative to non-riparian zones to three main factors. First, the availability of water, food and shelter attracts large numbers of both predator and prey species. Second, plant growth and vegetative biomass are very high, producing multi-layered vegetation and greater food production. Third, deciduous plant species characteristic of riparian zones invest in fewer chemical compounds to protect leaves from insect herbivores than coniferous species, allowing abundant insect prey for avian consumption (Gori 1992).

Riparian zones in the West are also important stopover areas for birds during the spring and fall migration. These forested areas have been shown to be extremely important for migratory species by providing cover, food, and water in many areas of the West which are surrounded by habitats deficient in these critical elements (Wauer 1977). Stevens *et al.* (1977) determined that western riparian areas contained up to 10 times the number of migrants per hectare than adjacent non-riparian habitats, with the greater number of birds using these areas being accounted for almost exclusively by the insectivorous bird foraging guild. Skagen *et al.* (in review) evaluated the relative importance of cottonwood-willow riparian corridors and isolated oases to landbirds migrating across southeastern Arizona based on patterns of species richness, relative abundance, densities, and body condition of birds. They concluded that all riparian patches in the area were important as stopover sites regardless of size and degree of isolation/connectivity, and recommended the protection of both small disjunct riparian patches and extensive riverine tracts in western landscapes.

2.2.3 Factors affecting birds of riparian habitats

Riparian systems are multi-use areas subject to a variety of activities, including livestock grazing, logging, and recreation (Rumble and Gobeille 1998). Activities that alter the plant community of an area will exert a corresponding influence on the bird community. In examining the actual and potential effects of vegetative changes on bird communities, it should be noted that bird species respond individualistically to alterations in their habitat. Every change that occurs will be beneficial to some bird species and detrimental to others.

Livestock Grazing

On upland sites, light grazing can increase the productivity of wild pastures by encouraging the vigour and growth of plants, but heavy grazing compacts the soil, accelerates soil deterioration and erosion, results in reduced photosynthetic capabilities and death of plants, and permits the expansion of unpalatable plant species (Goudie 1994). In riparian zones, grazing tends to be more destructive than in adjacent upland habitats, as cattle compact the soil by hoof action, remove plant materials, and indirectly reduce water infiltration (Holechek *et al.* 1989), but also eliminate riparian areas altogether through channel widening, channel aggrading, or lowering of the water table (Bock *et al.* 1992). Glinski (1977) determined that grazing by cattle reduced cottonwood establishment along an Arizona creek, and predicted that the future width of the riparian zone would be reduced by nearly 60%. Although the grass-herb-shrub layer of vegetation is directly affected by grazing, changes in overstory tree species composition, density, and demography may result from the long-term effects of grazing on seedling survival and regeneration (Sedgwick and Knopf 1987).

Bird species have been found to differ in their responses to changes in habitat as a result of livestock grazing. Of 43 songbird species studied in riparian woodlands, 8 responded positively, 17 were negatively affected, and 18 were unresponsive or showed mixed responses (Bock *et al.* 1992). Species responding positively to grazing included aerial foragers associated with open habitats, ground foragers preferring areas with relatively little cover, and the Brown-headed cowbird, a species directly attracted to livestock. Species negatively impacted by livestock grazing were those that nest and/or forage in heavy shrub or herbaceous ground cover, and/or that may be particularly vulnerable to cowbird parasitism.

The season of grazing may largely determine the extent of damage to plant communities, and this in turn determines the extent to which the avian community is impacted. Wiens (1973) suggests that timing is more important in this respect than intensity. Kauffman and Krueger (1984) found year-long and spring-summer grazing to be particularly detrimental to riparian ecosystems, whereas grazing during fall and winter has been shown to result in less damage to vegetation (Pond 1961). Kauffman *et al.* (1982) determined that fall-grazing had no effect on avian densities in a foothills riparian zone in Oregon. In their study of a plains cottonwood bottomland in Colorado, Sedgwick and Knopf (1987) concluded that short-duration fall-grazing had no impact on breeding densities of six migratory bird species. Along with reduced impacts on vegetation during the fall and winter, impacts on bird communities are minimized at this time because populations are at annual lows.

Forestry

Forestry practices have profound effects on structure and composition of vegetation of a site, and therefore have similarly large effects on bird communities. Clear-cutting produces evenaged stands and results in near complete removal of the previous stand and a complete turnover in breeding birds (Thompson *et al.* 1992). These harvesting methods will result in a greater representation of early successional stages and therefore create habitat for early successional bird species. The dense foliage characteristic of seedling-sapling trees planted following harvest can result in breeding bird densities, species richness and abundance that are often similar to or greater than those in mature stands. However, area-dependent and forest interior species, and those adapted to characteristics of older forests are most negatively affected by methods that produce evenaged stands. At a landscape level, avian diversity may be increased overall if a broad range of age classes, including old growth forests, is represented.

In selective logging, single trees or small groups of trees are periodically harvested (Thompson *et al.* 1992). This method produces unevenaged stands and results in far less change in vegetation structure and the local bird communities. Stands have a well-developed understory and sub-canopy due to frequent canopy gaps, resulting in higher within-stand bird species diversity than found in evenaged stands. Selective logging seems to create and maintain structural conditions that are suitable for species with a wide range of habitat requirements. Canopy gaps resulting from the harvest of single trees or groups of trees provide habitat for a variety of migrant birds associated with young second growth forests or gaps, while maintenance of the mature tree component provides habitat for canopy-dwellers. At a landscape level, these methods do not create the same mosaic of early- and later-successional stands as clear-cutting, and this may be more beneficial to forest interior and area-dependent species. Selective logging is a more appropriate method of harvesting intermediate shade-tolerant hardwood species found in riparian stands.

In an analysis of the effects of logging on riparian bird communities, Pashley and Barrow (1992) compared clearcuts, group selections, and individual tree selection. Clearcuts fail to provide habitat for forest-dwelling species. Group selections may better mimic the natural disturbance regime and appear to achieve good densities of a full range of forest migrants. Individual tree selection more closely mimics treefall disturbances, allowing increasing light intensity to reach the forest floor, and promoting the growth of denser foliage beneath the canopy than in the forest as a whole. There are several effects of single tree and group selection logging which may be of detriment to bird species (Thompson *et al.* 1992). Canopy gaps created by selective logging have been shown to provide access to nests by predators and cowbirds, resulting in reduced reproductive success. Removal of large trees from a stand may result in declines in numbers of bark forager, canopy-foliage gleaner and cavity-nester species. Tree species composition will change over time, single tree selection maintaining shade tolerant tree species, and group selection maintaining tolerant and intermediate tolerant species. Shifting dominance to shade tolerant trees may be detrimental to birds dependent on intolerant species for habitat requirements.

Water level alteration/stabilization

Flooding along riparian zones is one of the main factors determining the composition and diversity of the plant community. The woody vegetation of gallery forests is under strong influence of an environmental gradient associated with flooding frequency (Bell 1974). This arrangement is a function of the respective tolerances of plant species to conditions of low oxygen and high carbon dioxide levels of the rooting zone during flooding and saturated soil conditions (Pashley and Barrow 1992). Natural fluctuations between the high and low water levels generally produce high species-richness of plants and relatively dense vegetation in riparian environments (Wisheu and Keddy 1989).

Little research has examined the effect of moderating flood frequency and intensity on the riparian forest ecosystem. Johnson *et al.* (1976) suggested that the removal of periodic spring flooding by reservoirs in North Dakota resulted in a decline in the establishment of *Acer* and *Ulmus*, a decline in diameter growth rate for Manitoba maple, American elm, and green ash, and lack of seedling-sapling stands of trembling aspen (*Populus tremuloides*). Expected long term effects of water level stabilization included a decrease in the extent of the cottonwood/willow community, a decrease in diversity in transitional and climax stands due to declining reproduction of *Acer* and *Ulmus*, and increasing reproduction of *Fraxinus*. Reily and Johnson (1982) reached similar conclusions after examining the effects of the Garrison Dam on Missouri River plant communities. They added that floodplain trees at or near the edges of their geographical distributions may be particularly sensitive to changes in the hydrologic regime. Such changes in plant community structure and composition can be expected to impact the avifauna.

Habitat Fragmentation

Edge effects influence breeding bird populations in two main ways. Habitat patches with a high edge-to-area ratio have been shown to experience higher rates of nest predation. Wilcove (1985) examined rates of predation on artificial nests in forests of different sizes in Maryland and Tennessee, and determined that predation in small forest fragments was greater than that in large fragments. These habitats also experience high rates of brood parasitism. Brownheaded cowbirds have been found to be more common and active within 100 to 200m of the forest edge (Temple and Cary 1988). The forest interior normally provides a safe haven from brood parasitism, but in a small forest, most or all potential nesting habitat may be within 100m of the forest edge.

The combination of these two influences can result in significantly reduced nest success, and has been blamed for declines in several species of vireos, warblers, thrushes and flycatchers in the eastern United States (Askins 1995). Robinson *et al.* (1995) tested the hypothesis that reproductive success of nine forest bird species was related to regional patterns of forest fragmentation. They measured nest predation and brood parasitism in nine different midwestern landscapes, ranging from over 90% agricultural land to more than 90% forest. Both nest predation and cowbird parasitism increased with decreasing percent forest cover for all species. Parasitism levels of wood thrushes, tanagers, and hooded warblers, and predation rates on ovenbirds and Kentucky warblers were so high in the most fragmented forests that insufficient numbers of offspring were being produced to replace adult mortality.

Small forests are unfavourable for nesting due more to characteristics of the surrounding landscape than to habitat characteristics of the forest itself (Askins 1995). In regions with few nest predators and cowbirds, nest success has been found to be similar for large and small forests. In contrast, landscapes fragmented by agricultural fields experience levels of nest predation and brood parasitism so high that many populations of forest birds are not self-sustaining (Robinson *et al.* 1995). In particular, populations of cowbirds and many nest predators are higher in fragmented landscapes where there is a mixture of feeding habitats (agricultural and suburban) and breeding habitats (forests and grasslands). Riparian zones in agricultural areas can be expected to have high rates of brood parasitism and nest predation.

2.3 Methods: A Review of the Point Count Method

Point counts have become the most widely used method for sampling bird populations in recent years (Ralph *et al.* 1997). The point count method involves an observer recording all birds heard or seen at a single point for a specified time period. It is seen to represent the best compromise between economy of collection effort and precision and accuracy of the estimates of population trends or population indices (Verner 1985). In this method, a *count* refers to a single session of surveying at an individual point; a *point* is a single station from which a count is made; and a *site* is a location or tract that contains a series of points or stations (Buskirk and McDonald 1997).

Fixed radius point counts involve sampling birds in a circular plot of a specified size, usually 50-m or 70-m radius. Although sampling fewer individuals than unlimited radius counts, this method has several advantages. First, counts tend to be less affected by observer error due to weather, vegetation structure, "saturation" effects (inability of observer to accurately distinguish among individual birds due to their relatively high number within the area surveyed) and observer limitations (Petit *et al.* 1997). Observer error from these sources typically increases with plot size. Second, in studies in which patches of continuous habitat are required, 50-m or less fixed-radius circular plots can be used across patches that vary greatly in size and shape. For example, a 50-m plot requires a minimum area of only 100m X 100m (1 ha). Alternatively, an unlimited distance plot with an assumed radius of 150m (distance within which most birds are detected) requires a minimum area of 300m X 300m (9 ha) (Petit *et al.* 1997). Where habitat patches are small, it may be difficult if not impossible to use unlimited radius counts and ensure sampling is being conducted within the habitat type of interest. Third, fixed radius counts may provide a better means of examining habitat relationships, since they permit measurement of vegetation characteristics in physical proximity to locations of the birds. The main drawback of fixed-radius point counts is that fewer individuals are sampled, and because of this a larger number of stations may be needed to adequately sample rare species. As well, observers need training to estimate the distance to the perimeter of circular plots.

Unlimited distance point counts sample all birds detected at a given point. This method is the simplest, since observers do not have to estimate distance to either the plot edge or a singing individual (Wolf *et al.* 1997). The main advantage to using unlimited radius plots is that more individual birds are detected because of the larger effective areas surveyed compared to fixed radius plots (Thompson and Schwalbach 1997).

The design of a point count monitoring system influences the ability of the technique to characterize the avifauna of interest, and needs to take into account tradeoffs between the quality of coverage from intensive sampling at single points and the statistical power of extensive sampling across many points (Buskirk and McDonald 1997). Greater coverage of an area can be achieved by increasing count duration, the number of point count stations, or the number of visits to each station.

The longer the count, the more likely the observer is to detect all individual birds at a point. Since it is not practical to use a count length of several hours, we must find the duration at which the number of individuals encountered is maximized. Several researchers have attempted to answer the question of optimal count length (Buskirk and McDonald 1997; Dawson *et al.* 1997; Thompson and Schwalbach 1997; Petit *et al.* 1997), and most recommend a duration of 3 to 10 minutes. Longer counts (≥ 10 minutes) permit surveying of fewer points per unit field time, and this results in a smaller sample size. The observer is also less likely to detect movements of birds into and out of the count area and this may bias results (Wolf *et al.* 1997). There are several advantages to using a longer counting period: observers with less experience or hearing acuity are more likely to detect birds (Dawson *et al.* 1997); bias resulting from variation in species detection probabilities is reduced; and the presence or absence of a given species is more accurately reflected for studies in which bird-habitat relationships are of interest (Petit *et al.* 1997; Savard and Hooper 1997).

Travel time between points influences optimal count duration. Where the goal is to maximize the amount of field time spent censusing, counts of ≤ 5 minutes are more efficient when travel time between points is ≤ 5 minutes. When travel time exceeds 10 or 15 minutes, counts of 10 minutes duration become a more efficient use of field time (Buskirk and McDonald 1997; Ralph *et al.* 1997).

Surveying a greater number of points increases the sample size and this is thought to be more important in detecting population trends than more thorough coverage of sampling units (Smith *et al.* 1997). However, count duration may need to be shortened to accommodate the time required to survey more points. Multiple visits to each point yield improved coverage and ensure more complete species counts, but >3 counts per season are unwarranted (Smith *et al.* 1997).

Chapter 3 Methods

3.1 Study Area

The study area is located in the Pembina Valley (99° 15' lat., 49° 15' long.) in southcentral Manitoba (Figure 3.1). The Pembina River flows for a total of 550 km from its headwaters in the Turtle Mountain area, through southern Manitoba, and into North Dakota where it empties into the Red River (MES Environmental 1997). The formation of the Pembina Valley was determined largely by the last continental glaciation (Bintner 1971). During this time drainage to the north was inhibited by the ice mass, and large volumes of water flowing eastward along the southern extremity of the glacier resulted in the formation of a deep channel. Since glacial retreat, tributaries of the Pembina have deposited sediments in the valley forming alluvial deltas which have served as natural dams and have formed the Pembina Valley lakes (Pelican, Lorne, Louise, Rock and Swan Lakes). As a result of this glacial history, the Pembina Valley forms a unique topographic feature in an otherwise flat landscape.

The area studied in this project begins at Louise Lake and follows the Pembina Valley eastward to the east end of Rock Lake (Figure 3.1). It also includes two sections of the Long River, a tributary of the Pembina River. The riparian community along this section of the valley ranges from approximately 100m to greater than 1km in width with surrounding land use being predominantly agricultural. Overstory tree species include bur oak (*Quercus macrocarpa*), green ash (*Fraxinus pennsylvanica*), trembling aspen (*Populus tremuloides*), western cottonwood (*Populus deltoides*), American elm (*Ulmus*

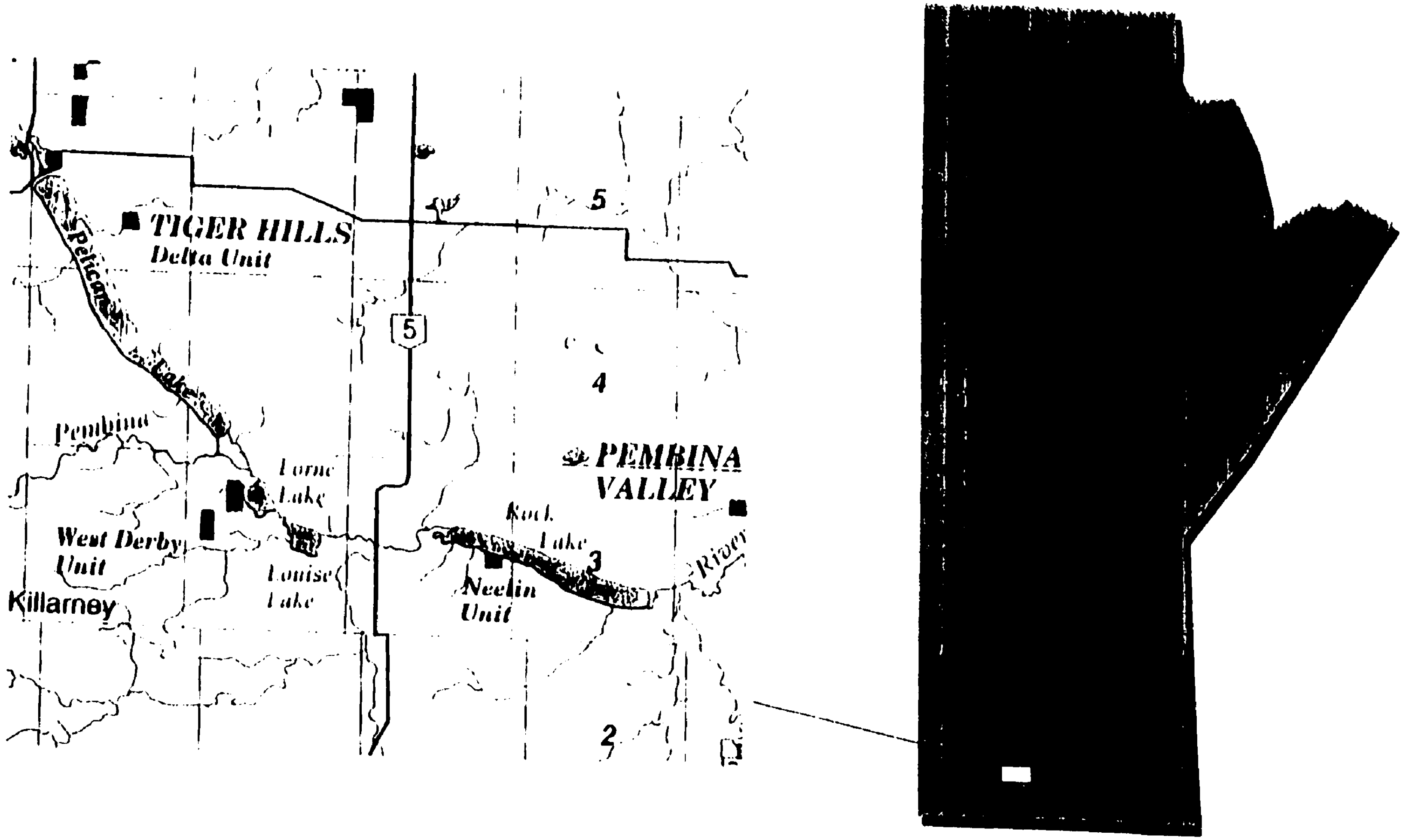


Figure 3.1. Geographic location of study area in south-central Manitoba.

americana), Manitoba maple (*Acer negundo*), balsam poplar (*Populus balsamifera*) and white birch (*Betula papyrifera*). Woody plants common in the understory include chokecherry (*Prunus virginiana*), pincherry (*Prunus pensylvanica*), beaked hazel (*Corylus cornuta*), red osier dogwood (*Cornus stolonifera*), Saskatoon (*Amelanchier alnifolia*), highbush cranberry (*Viburnum opulus*), and western snowberry (*Symphoricarpos occidentalis*) (Bird 1961). Wild sarsaparilla (*Aralia nudicaulis*), false lily-of-the-valley (*Maianthemum canadense*), northern bedstraw (*Galium boreale*), sweet-scented bedstraw (*Galium triflorum*), black snakeroot (*Sanicula marilandica*), dewberry (*Rubus pubescens*), wild strawberry (*Fragaria* sp.), meadow rue (*Thalictrum* sp.), and poison ivy (*Rhus radicans*) are common components of the herbaceous layer (Bird 1961).

3.2 Study Site Selection

Study sites were located along Rock Lake, Louise Lake, the Pembina River, and the Long River. A total of 12 sites (5 grazed, 7 ungrazed) were selected for sampling the avian and plant communities (Figure 3.2). The main criteria for site selection was location in riparian forest patches at least 200m wide, enabling the establishment of a transect running parallel to the shoreline, with 100m of forest cover on either side. Patches also needed to be at least 800m long to accommodate a minimum of three stations, each 200m apart. Slight differences in elevation, aspect, slope, soils and past human activity (e.g. cutting) resulted in some variation in plant community composition. Grazed sites varied in the intensity and duration of grazing. Details of site characteristics are shown in Table 3-1 and Table 3-2.

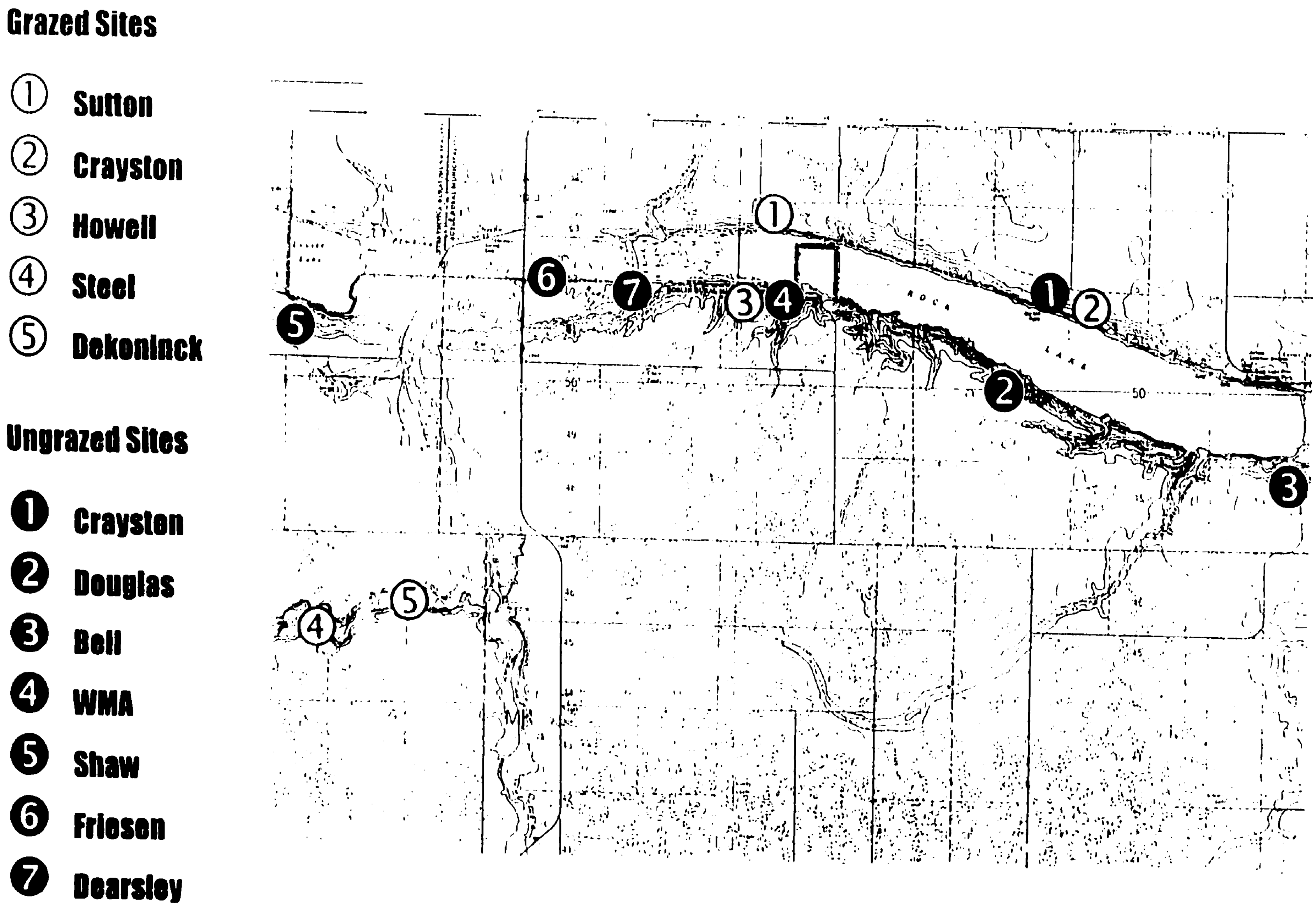


Figure 3.2. Location of grazed and ungrazed study sites, Pembina Valley, Manitoba.

Table 3-1. Characteristics of 5 grazed study sites located within the Pembina Valley, Manitoba.

Characteristics of Grazed Sites								
Landowner		Legal Description	Location	General Description	Aspect	Slope	Elevation	# point count stations
1	Sutton	23-3-14 E 24-3-14	Rock Lake	Heavily grazed site. Open canopy bur oak forest with short grass ground cover. Terrace.	S	40%	1375 ft	7
2	Crayston	16-3-13	Rock Lake	Lightly grazed site. Lush oak/elm community. Abundant arachnids. Predominantly grassy ground cover, some shrub patches forming limited understory. Terrace.	S	35%	1375 ft	5
3	Howell	E 15-3-14	Rock Lake	Heavily grazed site. Green ash community. Extremely short grass coupled with patches of Beaked hazel. Floodplain.	N	10%	1375 ft	5
4	Steel	27-2-15	Long River	Heavily grazed site. Aspen-oak forest. Several large-diameter elm snags. Floodplain.	E	5%	1425 ft	4
5	Dekoninck	36-2-15	Long River	Intermediate grazed site. Patches of Beaked hazel dispersed with short grass. Bur oak on terrace, Manitoba maple on floodplain.	N/S	20%	1450 ft	6

Table 3-2. Characteristics of 7 ungrazed study sites located within the Pembina Valley, Manitoba.

Characteristics of Ungrazed Sites								
Landowner		Legal Description	Location	General Description	Aspect	Slope	Elevation	# point count stations
6	Crayston	17-3-13	Rock Lake	Adjacent to grazed Crayston Oak-elm community with more well developed understory than grazed site. Abundant arachnids. Terrace.	S	25%	1375 t	3
7	Douglas, Bed ord	SW 17-3-13	Rock Lake	Oak-ash community. Well-developed understory. Terrace.	N	30%	1400 t	5
8	Bell	S11-3-13	Rock Lake	Green ash dominated site Well-developed understory. Terrace.	N	30%	1375 t	6
9	Pembina Valley W.M.A.	NW 14-3-14	Rock Lake	Ash-aspen dominated orest. Well-developed understory. Terrace.	N	25%	1400 t	3
10	Shaw	14-3-15	Louise Lake	Ash-aspen dominated orest Well-developed understory Terrace.	NE	30%	1375 t	4
11	Friesen	NW 17-3-14	Pembina River	Open site with numerous large-diameter elm snags. Well-developed understory dominated by erns, wood nettle, stinging nettle and willow spp. Some Manitoba maple becoming established. Floodplain.	S	5%	1350 t	3
12	Dearsley/Friesen	N 16-3-14 17-3-14	Pembina River	Ash-aspen dominated orest. Well-developed understory. Floodplain.	N	10%	1350 t	4

3.3 Sample Design

3.3.1 Avian Community Censusing

Unlimited-radius point counts were used to measure avian species richness and abundance. Transects were established within relatively homogeneous forest stands, 100m from the water's edge. Individual point count stations were located along these transects, the first station being 100m from the forest edge and all others 200m apart (Figure 3.3). Since it is assumed that only birds to a distance of 100m will be detected, this ensured that birds counted were located within the forest habitat being sampled and that individual birds were not counted at more than one station. Transects and stations were marked with flagging tape to facilitate relocation.

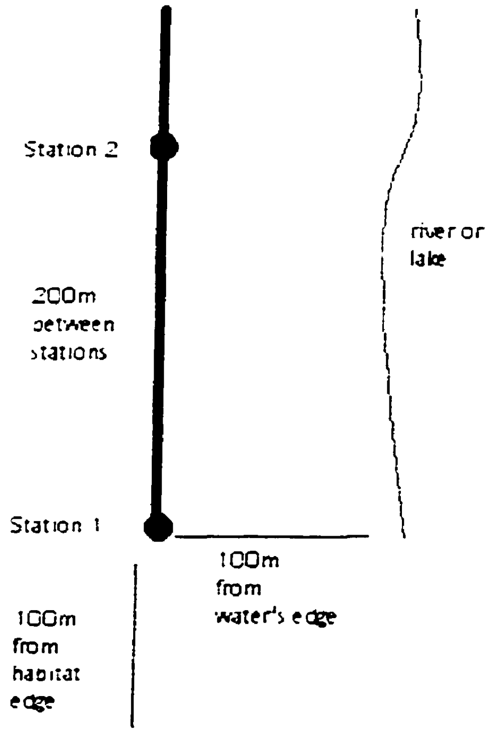


Figure 3.3. Location of point count stations in relation to watercourse, habitat edges, and one another.

Three to seven point count stations were established within each study site, for a total of 27 grazed stations and 28 ungrazed stations. The number of stations per site depended on the size of available habitat patches, and ease of access to and travel within the site (the observer must be able to conduct point counts at all stations at a site on a single day, including a 10 minute count, travel time between stations, and time to arrive at first station). Extremely dense brush on ungrazed sites prevented the establishment of more than 3 stations in a number of cases.

Point counts were conducted between June 8 and June 30, 1997. Following a 1-minute equilibration period, all birds heard or seen over a 10-minute interval were recorded. The approximate location of each individual was mapped on a data sheet (Appendix A). Recording the presence of birds in this manner and noting possible movements is suggested as the best way to minimize duplicate records (Welsh 1997). Birds suspected to be >50m from the point count station and birds flying over were recorded separately. Data were not limited to territorial or singing males, although these would comprise the majority of records. Censuses were conducted from approximately 30 minutes prior to sunrise until 0930 C.D.T., and did not occur on days with rain or high winds. One observer was used throughout the study. Two counts at each station yielded a total of 54 counts on grazed sites and 56 counts on ungrazed sites. Smith *et al.* (1997) suggest that, to compare bird abundance among different treatments, 50 counts per treatment should be sufficient to detect most biologically meaningful differences.

3.3.2 Vegetation Sampling

Vegetation measurements were taken throughout the month of July 1997 and generally followed the methodology of Wildlife Resource Consulting and Silvitech Consulting (1995). Due to time constraints, a subset of the avian point count stations were randomly selected and sampled, a minimum of 2 per site, for a total of 14 grazed and 15 ungrazed stations.

Habitat features were measured in five 0.04 ha (11.3m radius) circular plots clustered about the avian point count station (Figure 3.4). Four of these plots were located 50m from the centre of the point count station in the cardinal directions, and the fifth plot

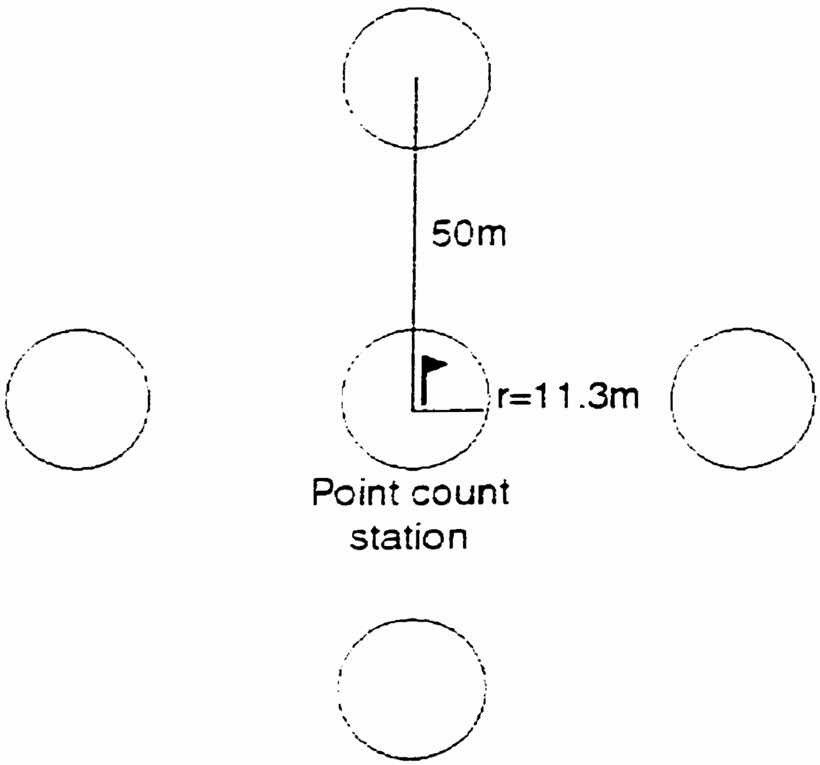


Figure 3.4. Design used to sample vegetation at a subset of point count stations.

utilized the station itself as its centre. Since the observer can detect birds to a distance of 100m and frequently only to within 50m or less, this ensured that much of the vegetation in which birds were detected was sampled. The sampled area was defined by two 22.6m ropes, intersecting at the plot center, and oriented in the cardinal directions. Within each 0.04 ha plot, the following measurements were taken (Wildlife Resource Consulting and Silvitech Consulting 1995):

1. Species and dbh of all live trees; dbh and decay class of all snags. Decay classes were based on the percentage of the original limbs still present (Decay Class 1 = least decayed, most smaller branches and all major branches present. Decay Class 2 = intermediate decay, most major branches present. Decay Class 3 = most decayed, trunk only).
2. Horizontal cover was estimated with the use of a density cloth divided into four height intervals: 0-0.3m, 0.3-1m, 1-2m, and 2-3m. The cloth was held up at the perimeter of the plot for each of the four cardinal directions, and the observer estimated the proportion obscured by vegetation for each of the four height intervals.
3. Shrub density was estimated using four $10m^2$ (1.78m radius) subplots located 10m away from the center of the 0.04ha plot in the cardinal directions. For each subplot the observer counted the number of woody stems <5cm dbh.
4. Overstory and understory canopy heights within the 0.04ha plots were measured with a clinometer.
5. Canopy cover and ground cover were estimated by sighting through an ocular tube. The observer walked along the 11.3m north and south axes sighting up to the canopy

and down to the ground. A total of 20 upward and downward readings were taken to indicate the presence or absence of vegetation at the intersection point of the ocular lense.

6. The five most dominant shrub and herb species in each 0.04 ha plot were ranked from 1 to 5 and recorded.

3.4 Data Treatment

Since two point counts were conducted at each station, the higher value for each bird species was used as a station estimate. Each bird detected, male or female, was counted as a single individual. It is frequently assumed that each singing male bird is paired with a female, so for every singing male detected two individuals are used in abundance calculations. There are two main reasons why this was not done in this study. First, the assumption that every singing male is paired with a female may not be accurate, since unpaired males also sing *to attract* mates. Following this assumption may therefore result in an overestimate of avian abundance. Second, in this case the bird community was sampled during the peak of the breeding season for neotropical migratory birds only. Since many resident species would have finished breeding by this time, it would be erroneous to assume that they were still paired with females. Again, making the assumption that all males are paired would overestimate abundance. All individual birds detected therefore received an abundance value of 1.0.

Flyovers and distant birds were dealt with on an individual basis. Flyovers such as Canada Geese, American white pelicans, and Franklin's gulls not part of the forest bird community were excluded, whereas American goldfinches and Cedar waxwings remained in the analyses, since there was evidence that these species were using the forest habitat at that time. Distant birds suspected or verified as being outside of the habitat being sampled were eliminated from the analyses. This included American crows recorded at >50m from the point count station, as well as Common Snipe, Redwinged blackbirds and Yellowheaded blackbirds.

To characterize the bird community of the Pembina Valley in general, point count data for all 12 sites (55 point count stations) were pooled. Avian abundance was determined for each species by summing all individuals of each species for all sites combined. It has been suggested that while riparian areas have diverse bird communities, many of the species inhabiting these areas are ecological generalists (Knopf 1986), and of lower conservation concern than species with specific habitat requirements and narrow ranges. For this reason, efforts to characterize the bird community of the Pembina Valley were geared in part toward identifying the relative conservation concern of species detected. Two measures of species vulnerability commonly used by the landbird conservation organization Partners in Flight were determined for species detected in the Pembina Valley: breadth of breeding distribution and provincial abundance rank. The proportion of the bird community represented by neotropical migrants was also calculated due to particular concern over this segment of the avifauna.

Correspondence Analysis and Canonical Correspondence Analysis were used to evaluate habitat associations of bird species censused. To prepare data for this analysis, a mean value for each environmental variable was determined for each of the 12 sites. Mean avian abundance was also determined for each of the 12 sites, and calculated for individual species, foraging guilds, and nesting guilds.

To assess differences in bird communities between grazed and ungrazed "treatment groups", values within each site were tallied and sites were used as replicates in analysis of grazed versus ungrazed. Avian abundance for a treatment was defined as the total number of individuals of each species occurring in that treatment. Each bird species censused was assigned to one of nine foraging guilds and one of six nesting guilds (Appendix B), to determine whether differences in abundance between treatments were related to specific habitat components. Abundance per guild per treatment was determined by summing individuals of all species representing a guild for each treatment.

3.5 Data Analysis

Multivariate methods (Correspondence Analysis, Canonical Correspondence Analysis) were used to study habitat associations of the birds of the Pembina Valley. Habitat studies are typically characterized by numerous interdependent variables, and it is more efficient to use multivariate methods that take these interdependencies into account rather than separating and examining each variable individually (Morrison, Marcot and Mannan 1998). Correspondence Analysis (CA) was used to determine associations between tree species and study sites as well as between bird species or guilds and study sites. This method is suitable for use with non-linear data sets and permits a graphical representation of the relationships between individuals (sites) and variables (tree species or bird species/guilds). The analysis was run with basal area of tree species and with three avian data sets: abundance of individual species per station per site, abundance of foraging guilds per station per site, and abundance of nesting guilds per station per site. Canonical Correspondence Analysis is a method for quantifying the relationship between two sets of variables measured on a set of individuals and permitted us to assess the relationship between avian abundance data and habitat variables for each site (Ter Braak 1987). The analysis was run using abundance of individual species per station per site. Habitat variables derived from vegetation measurements and used in CCA are listed in Appendix C.

To test for significant differences in avian use of grazed and ungrazed treatments, environmental data for each treatment were pooled, and t-tests were conducted (α=0.05). Bird species diversity, herbaceous plant diversity and shrub species diversity on grazed and ungrazed sites was compared by calculating a Shannon-Weaver Diversity Index ($H=-\Sigma p_i \ln p_i$) using data on pooled grazed and ungrazed sites. Diversity indices express the number (richness) and equitability (relative abundance) of species comprising a biological community, and larger values indicate greater diversity. Values obtained were then converted to Effective Species Richness, a more interpretable index ($N=e^H$) (Krebs 1989). Differences in the number of individuals representing foraging and nesting guilds were tested using a X^2 test for homogeneity (α=0.05).

Chapter 4 Results

4.1 Vegetative characteristics of study sites

4.1.1 Tree species composition

Bur oak and green ash were the most abundant tree species on the study area, together representing 78.8% of all individual trees measured. Figure 4.1 shows the relative proportion of tree species present at each site based on basal area. Bur oak and green ash were each present at 11 of 12 sites, and sites were generally dominant in one of these two species. Trembling aspen and Manitoba maple were the next most abundant species. American elm was found almost exclusively on the adjacent grazed and ungrazed Crayston sites. Balsam poplar, Western cottonwood, and White birch were all sporadically distributed and uncommon on study sites. Shrub species reaching >5cm dbh are shown in Figure 4.2. Chokecherry reached this size class on all ungrazed sites, and on the grazed Dekoninck site. There was a very low occurrence of all other shrub species in this size class. Data on number, mean dbh and density of all tree species by site appear in Appendix D.

Correspondence Analysis was used to produce groupings of study sites by similarities in tree species composition based on the total basal area of each tree species (Appendix E). Figure 4.3 shows the relationship of tree species to one another and the placement of sites based on tree species composition. Sites appear to fall into one of two main groups, one located to the right of the figure (Steel, CraystonU, CraystonG, Douglas, Dekoninck, and Sutton) and one located to the left (Shaw, Dearsley, WMA, Bell, Howell, and Friesen). Most of the sites to the right are correlated with high basal area of Bur oak and/or

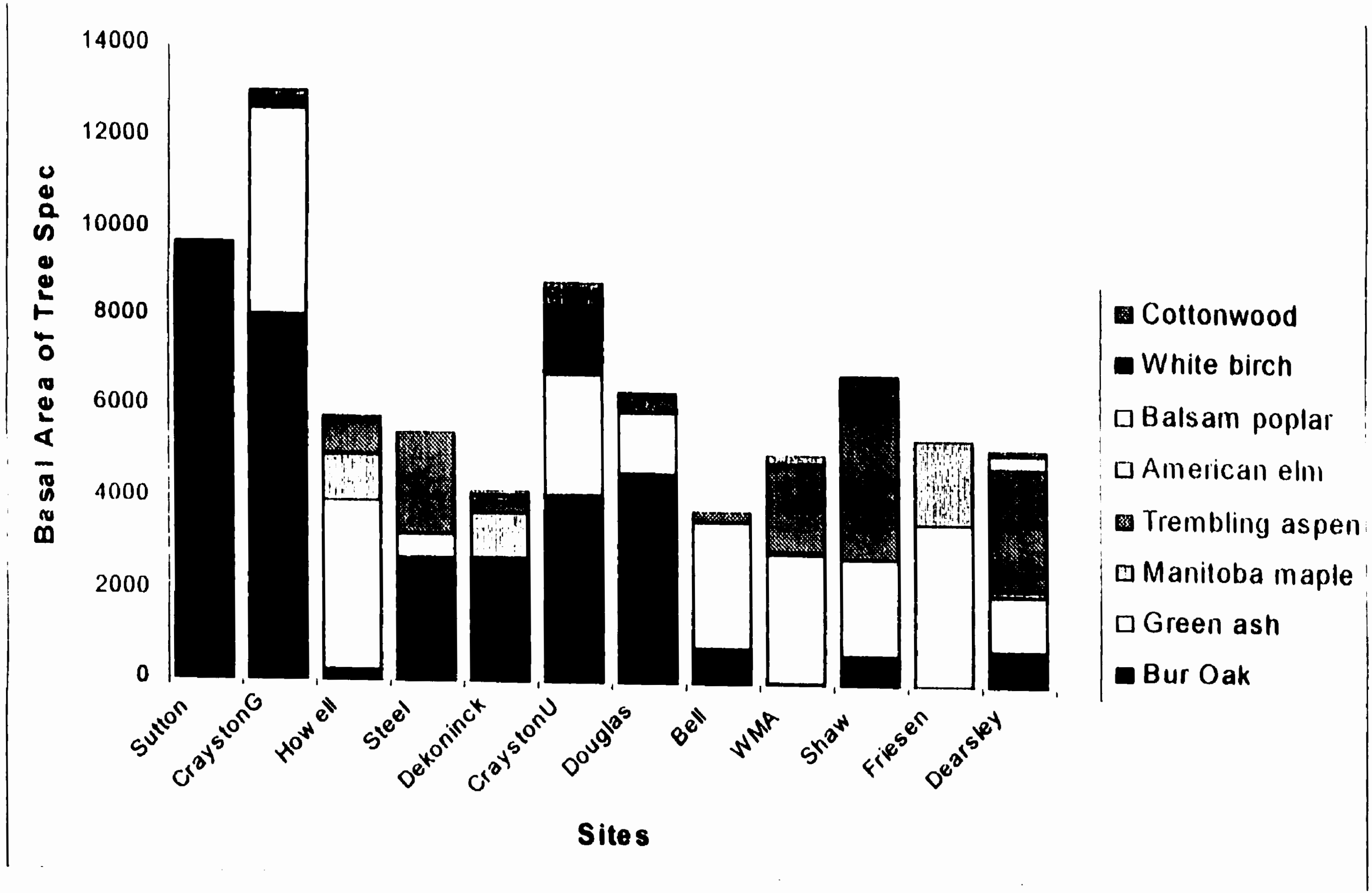


Figure 4.1. Basal area of tree species (in m^2) by study site.

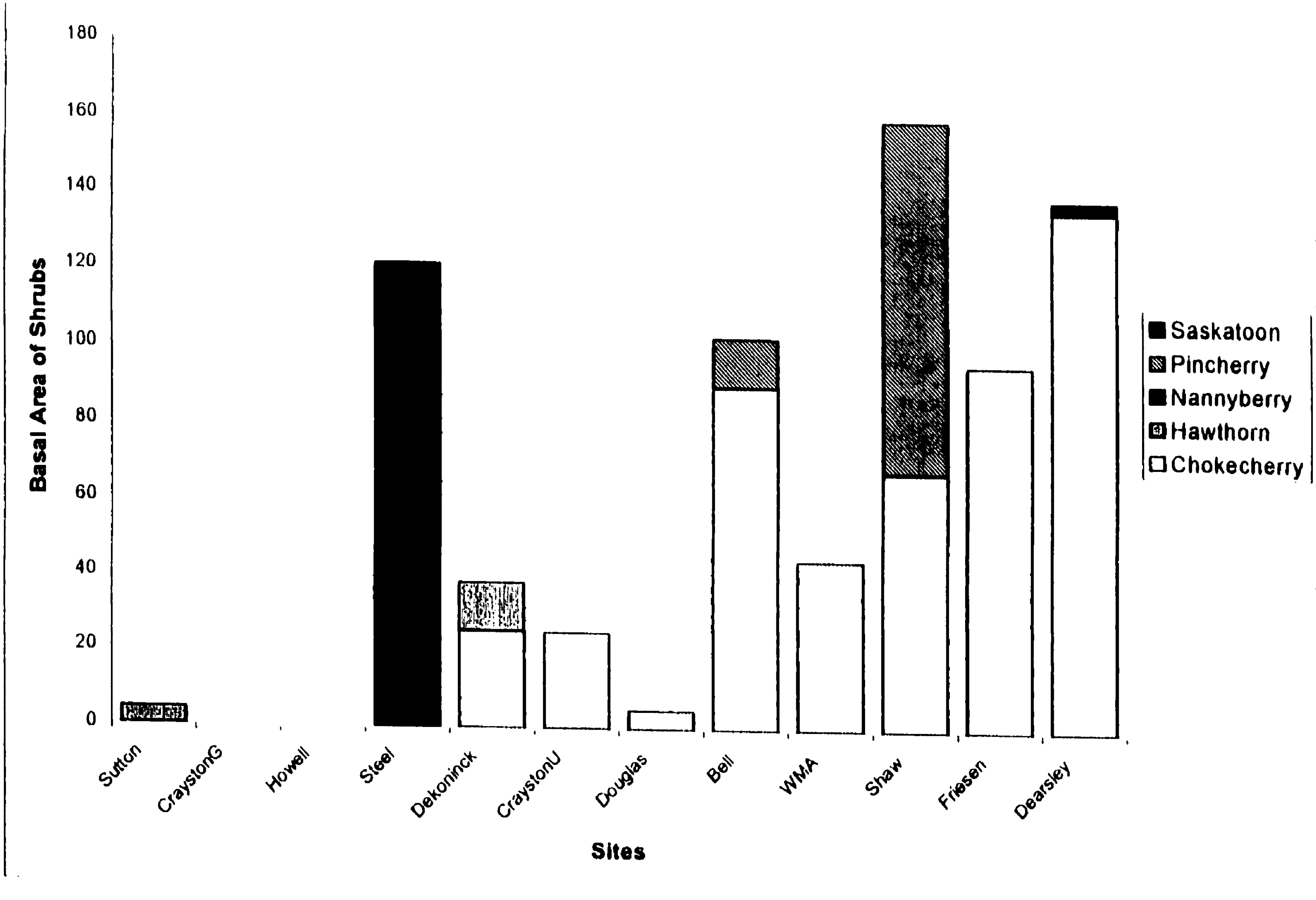
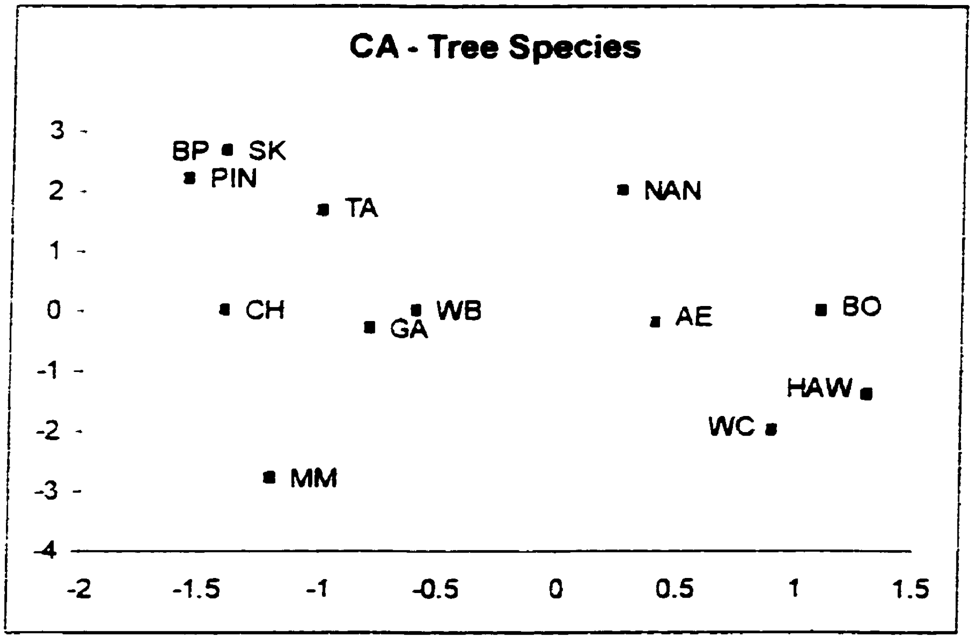


Figure 4.2. Basal area of tree-sized shrubs (in m^2) by study site.



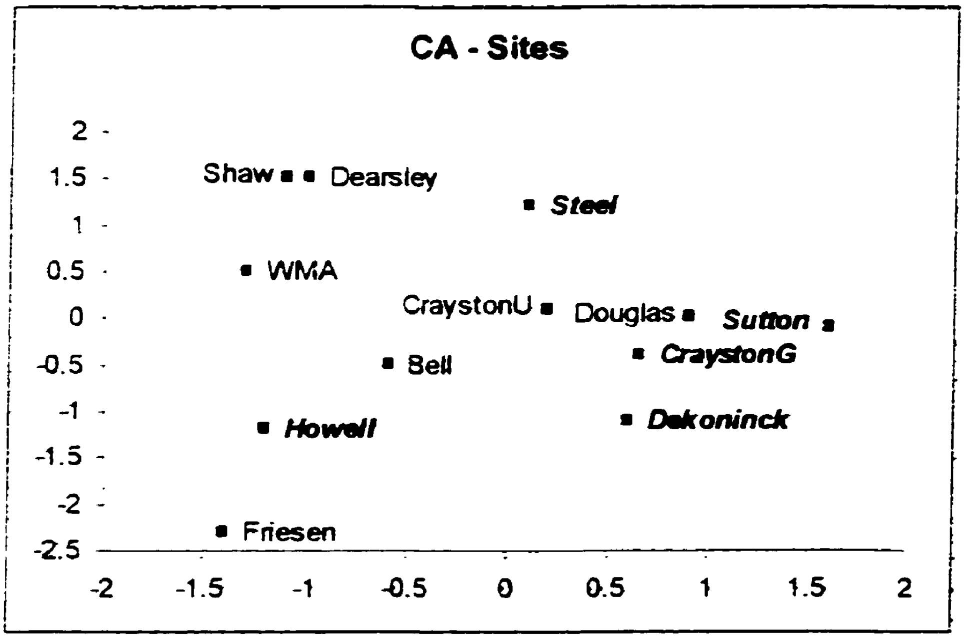


Figure 4.3. Results of CA conducted on basal area of tree species.
Cumulative percentage of eigenvalues: Axis 1 - 44.33, Axis 2 - 74.44. Tree Species Codes: AE=American elm, BO=Bur oak, BP=Balsam poplar, CH=Chokecherry, GA=Green ash, HAW=Hawthorn, MM=Manitoba Maple, NAN=Nannyberry, PIN=Pin cherry, SK=Saskatoon, TA=Trembling aspen, WB=White birch, WC=Western cottonwood. ***Grazed sites in bold italics.***

American elm. Sites high in Manitoba maple are situated in the bottom left corner of the figure, and included Friesen and to some extent, Howell. Sites in the top left corner (Dearsley, Shaw and WMA) are dominated by Trembling aspen. Green ash was widespread across sites and is therefore located centrally, although Bell and Howell were dominated by this species. Four of the five grazed sites were quite similar in tree species composition and this will have a bearing on other plant community characteristics. The influence of grazing on bird communities may be confounded by inherent differences in the vegetation of individual study sites.

4.1.2 Distribution of tree size classes

Grazing frequently causes a reduction in stand regeneration resulting in the prevalence of older trees. To determine whether this effect was felt in the Pembina Valley, individuals of the four most abundant tree species (Bur oak, Green ash, Trembling aspen, and Manitoba maple) were grouped into seven 10-cm dbh classes. For each of these species, a size class frequency distribution was developed for pooled grazed sites and pooled ungrazed sites (Figure 4.4). There were slightly fewer bur oak belonging to the 5-14.9cm size class on grazed sites, and more belonging to the 15-24.9cm and 25-34.9cm classes. Green ash were actively regenerating on ungrazed sites, as evidenced by the prevalence of young, 5-14.9cm trees, while there were fewer individuals in this size class on grazed sites. The distributions of Manitoba maple were similar between grazed and ungrazed sites, although there were slightly more 15-24.9cm individuals on grazed sites. There were large numbers of 5-14.9cm trembling aspen individuals on grazed sites, and fewer

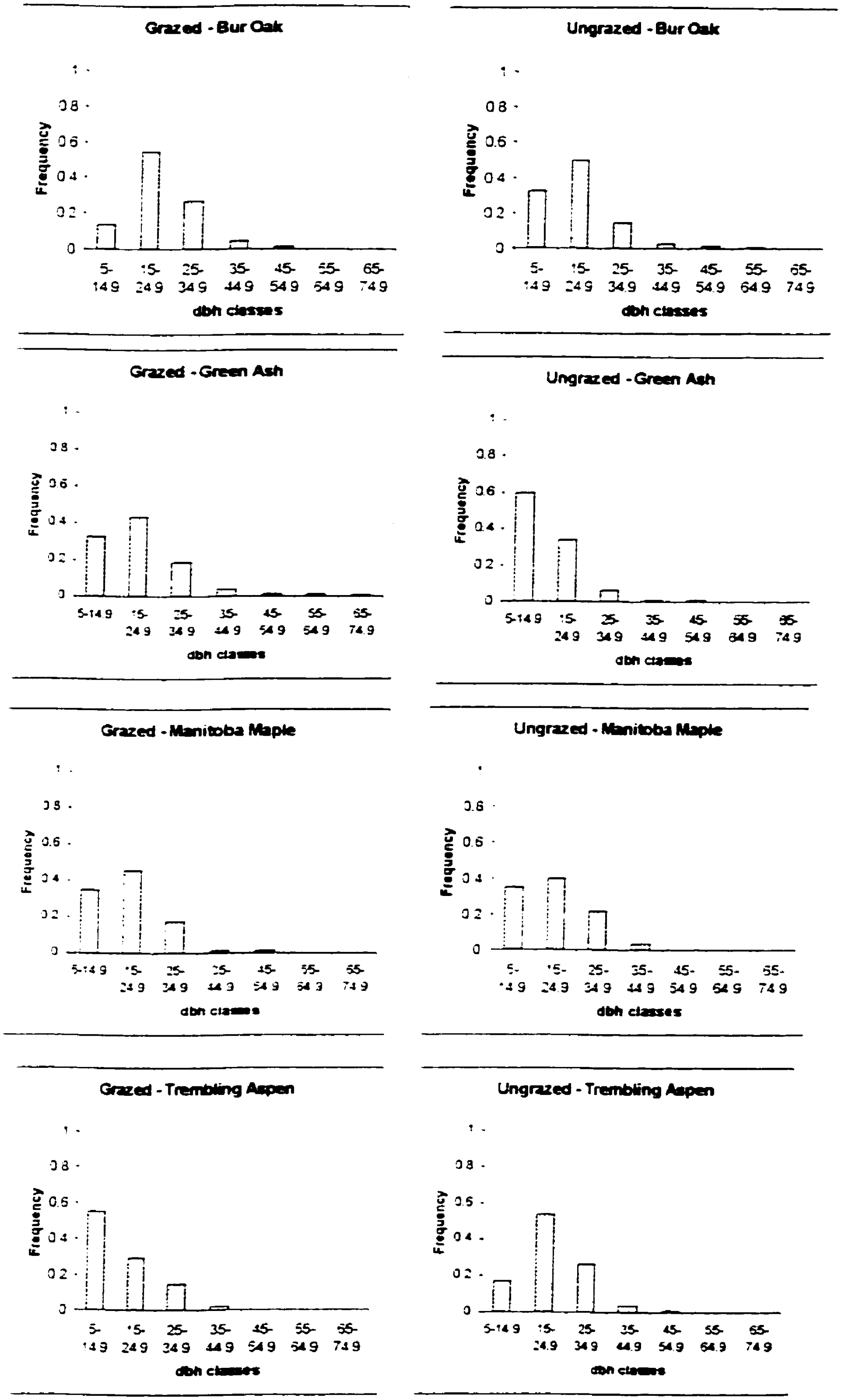


Figure 4.4. Distribution of dbh classes of the four most common tree species on the study area, for grazed and ungrazed treatments.

individuals in larger size classes. In contrast to this, there were very few small individuals on ungrazed sites, and comparatively more 15-24.9cm individuals.

4.1.3 Snags

In total, 355 Class 1 individuals (least decayed), 182 Class 2 individuals (moderately decayed), and 268 Class 3 individuals (most decayed) were measured on all study sites. Snag density was typically low with the highest density of all sites being 7.3 snags per plot (Sutton), and the lowest density 0.1 snags per plot (Howell) (Appendix F). Sutton had the most Class 1 snags largely due to high numbers of dead bur oak. Figure 4.5 shows the relative proportion of each decay class based on basal area occurring at each site. The first six sites (Sutton, Crayston, Howell, Steel, Dekoninck, Crayston) all appear to be dominated by class 1 snags, while the last six (Douglas, Bell, WMA, Shaw, Friesen and Dearsley) contain proportionally more class 3 snags. Dearsley is the only site with a significant proportion of class 2 snags.

4.1.4 Shrubs

Table 4-1 shows the mean number of shrub stems per subplot. Ungrazed sites WMA, Dearsley, Shaw and Bell contained among the highest shrub densities of all sites. Sutton also had a high shrub density value, and this was primarily due to the presence of numerous low-lying Western snowberry. Howell and Dekoninck had comparatively dense shrub cover, but this was accompanied by high patchiness of shrubs as indicated by the higher standard deviations obtained for these sites. Friesen, Steel, and grazed Crayston had the lowest shrub density.

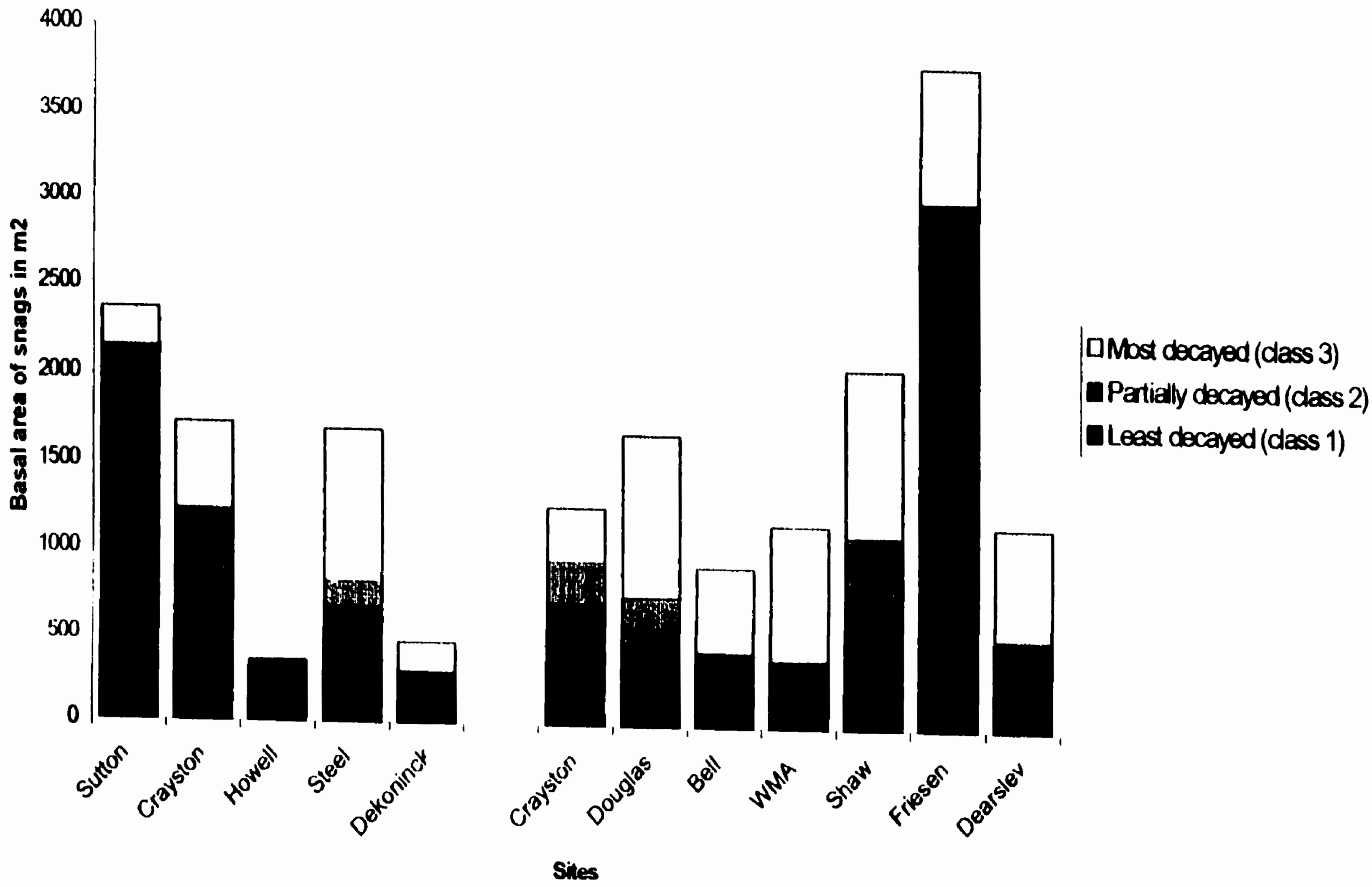


Figure 4.4. Basal area of snags (in m^2) by study site.

Ungrazed sites had more shrub stems per $10m^2$ subplot than grazed sites, but this difference was not significant (Figure 4.6).

Table 4-1. Mean number of shrub stems per $10m^2$ subplot for individual sites.

	Shrubs		
Grazed sites	*Mean*	*sd*	*n*
Sutton	88.1	30.5	80
Crayston	69.5	16.8	52
Howell	83.3	53.9	40
Steel	53.6	17.6	60
Dekoninck	75.0	40.0	60
Ungrazed sites			
Crayston	77.0	12.2	40
Douglas	73.2	16.9	36
Bell	96.4	21.2	40
WMA	154.9	18.6	60
Shaw	80.1	16.3	40
Friesen	32.9	19.5	40
Dearsley	104.6	32.8	40

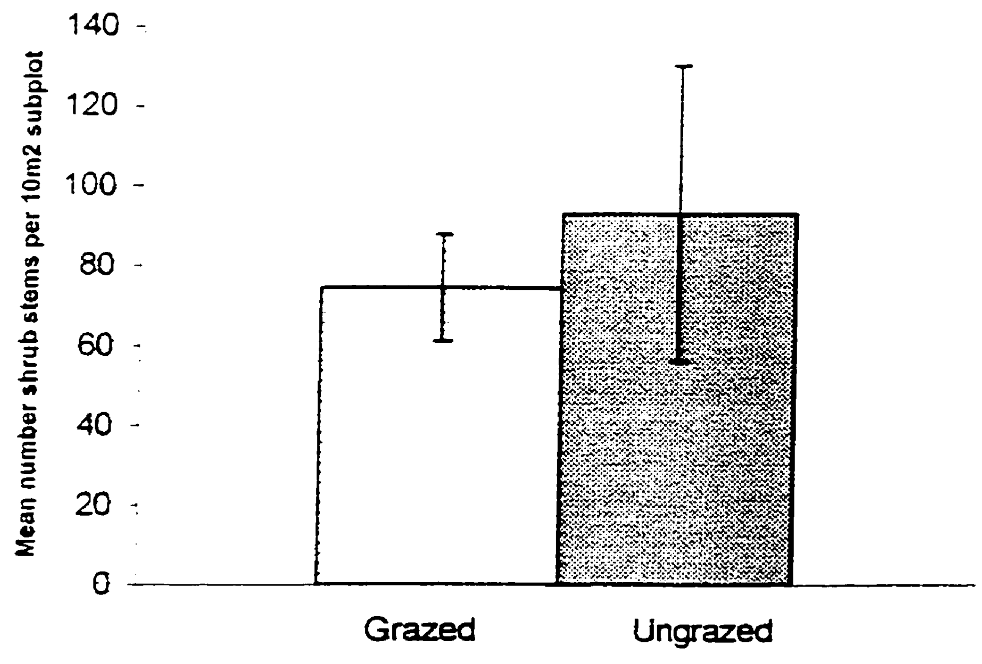


Figure 4.6. Comparison of shrub density between grazed and ungrazed treatments.

4.1.5 Vertical Cover

Table 4-2 shows percent cover values at four height classes for all individual sites. The same pattern was evident for grazed and ungrazed sites: percent cover was greatest for the 0 to 0.3m class, and declined through the 0.3 to 1m, 1 to 2m, and 2 to 3m classes. Higher percent cover values were obtained at all height classes on ungrazed sites. Based on vertical cover values, Bell, WMA, Shaw and Dearsley were the most densely vegetated sites. The least densely vegetated sites were Sutton, Dekoninck, Steel and grazed Crayston. Howell again had dense but variable cover, as indicated by the high standard deviations. Friesen had the lowest percent cover values of all ungrazed sites at the 0.3 to 1m, 1 to 2m, and 2 to 3m height classes, and this cover was variable at higher classes. Ungrazed sites had significantly greater percent cover values than grazed sites at 0 to 0.3m ($t=2.776$, $p<0.05$, $n=12$), 0.3 to 1m ($t=2.571$, $p<0.05$, $n=12$), 1 to 2m ($t=2.228$, $p<0.05$, $n=12$), and 2 to 3m ($t=2.262$, $p<0.05$, $n=12$) height intervals (Figure 4.7).

Table 4-2. Mean percent vertical cover in four cover classes for individual study sites.

	Cover class								
	0 to 0.3m		***0.3 to 1m***		***1 to 2m***		***2 to 3m***		***n***
Grazed sites	***Mean***	***sd***	***Mean***	***sd***	***Mean***	***sd***	***Mean***	***sd***	
Sutton	64.69	32.94	18.75	25.00	0.63	2.50	0.00	0.00	80
Crayston	87.02	21.86	49.71	35.55	14.33	24.01	5.87	20.60	52
Howell	72.00	42.50	71.38	42.64	64.13	42.83	56.88	45.43	40
Steel	75.00	30.53	43.17	35.32	16.92	29.86	15.75	32.47	60
Dekoninck	61.07	37.98	41.79	42.08	26.52	43.45	25.00	43.69	60
Ungrazed sites									
Crayston	100.00	0.00	90.00	17.72	62.13	42.00	40.88	39.02	40
Douglas	98.61	8.33	89.58	22.66	68.19	38.64	55.28	44.85	36
Bell	100.00	0.00	98.13	6.67	92.75	23.20	84.00	30.11	40
WMA	97.92	8.35	96.67	12.58	94.50	20.84	78.83	36.22	60
Shaw	100.00	0.00	97.22	13.06	95.83	18.42	91.67	22.36	40
Friesen	99.38	3.95	79.63	29.79	38.75	43.61	35.50	44.88	40
Dearsley	98.61	5.81	93.06	15.37	89.17	23.22	84.31	25.97	40

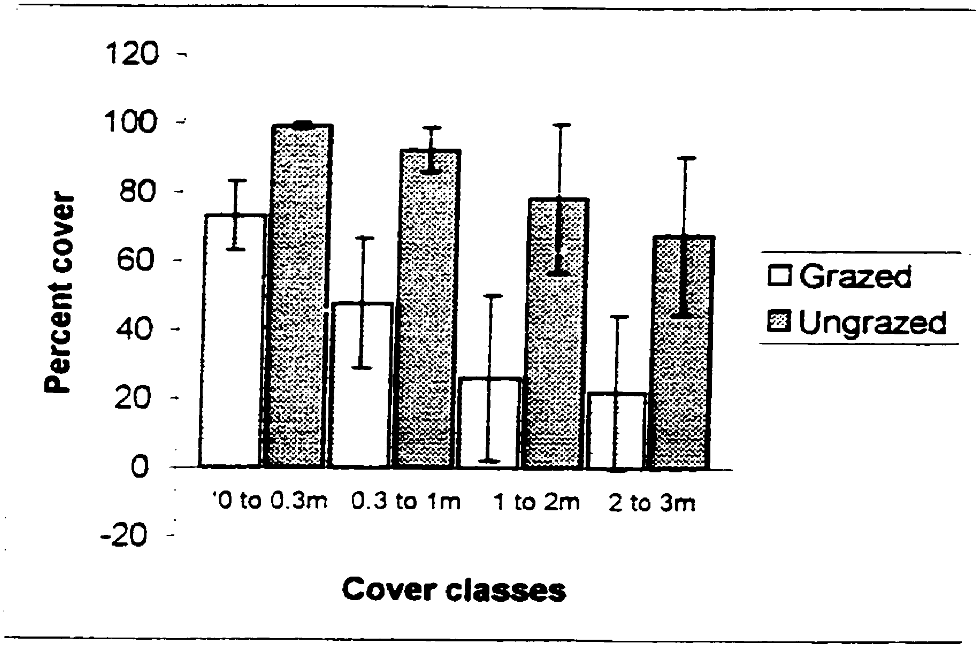


Figure 4.7. Comparison of percent cover in each of four height classes between grazed and ungrazed treatments.

4.1.6 Ground and Canopy Cover

Table 4-3 contains percent canopy cover and percent ground cover values for all individual sites. The highest canopy cover was reached at ungrazed sites Shaw, Douglas, and Dearsley and the lowest at Friesen, Steel, and Dekoninck. The highest ground cover was reached at Friesen, grazed Crayston, and Sutton, and the lowest at Shaw, WMA, and Dearsley. Howell was the most variable in canopy cover, but one of the least variable in ground cover. In general, percent canopy cover and percent ground cover were inversely related. Grazed sites tended to have higher ground cover and lower canopy cover, and ungrazed sites lower ground cover and higher canopy cover. Friesen was again the exception to the rule, having unusually low percent canopy cover and unusually high percent ground cover. Grazed sites had lower percent canopy cover and higher

Table 4-3. Mean percent canopy and ground cover at all study sites, Pembina Valley, Manitoba.

	Canopy cover		*Ground cover*		
Grazed sites	***mean***	***sd***	***mean***	***sd***	***n***
Sutton	56.00	19.84	80.50	12.23	20
Crayston	71.15	10.83	89.62	8.53	13
Howell	63.00	31.46	79.00	7.35	10
Steel	45.67	29.51	77.33	21.20	15
Dekoninck	49.00	29.47	69.00	16.39	15
Ungrazed sites					
Crayston	71.00	24.36	77.50	14.58	10
Douglas	79.44	11.02	77.22	7.12	9
Bell	69.00	14.87	70.00	20.14	10
WMA	63.00	18.01	55.67	19.44	15
Shaw	84.5	13.63	49.00	18.38	10
Friesen	40.50	27.43	92.00	7.89	10
Dearsley	72.00	20.17	56.50	11.32	10

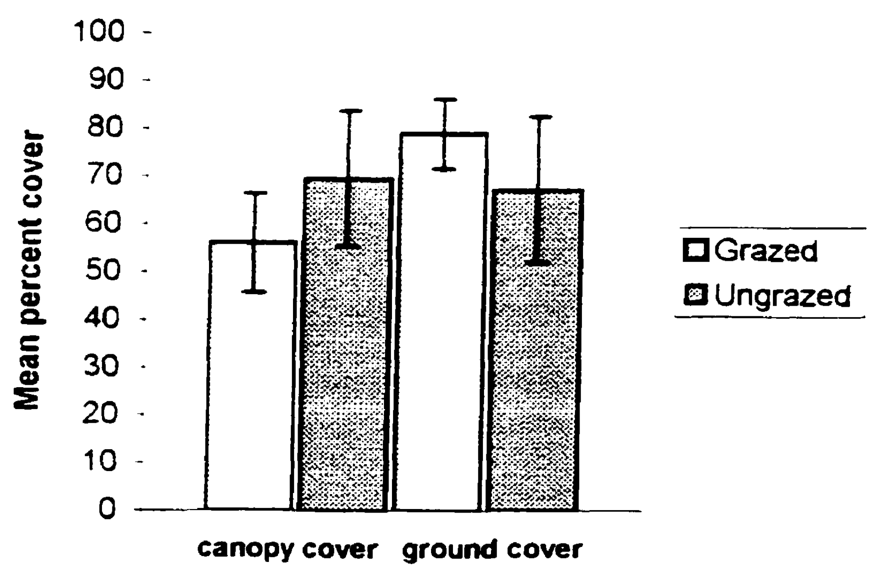


Figure 4.8. Comparison of percent canopy cover and percent ground cover between grazed and ungrazed treatments.

ground cover than ungrazed sites (Figure 4.8).

4.1.7 Understory and Overstory Height

Table 4-4 shows the average overstory and understory heights for all study sites. Mean overstory height generally varied little across sites, with a range of 9.29m (Dekoninck) to 15.3m (Crayston). WMA, Shaw, and Dearsley reached the greatest mean understory height, and the grazed Crayston and Dekoninck sites the lowest. Sutton was the only site that lacked an understory layer entirely. Ungrazed sites had a slightly greater mean overstory height than grazed sites, and a significantly greater understory height ($t=2.228$, $p<0.05$, $n=12$)(Figure 4.9).

Table 4-4. Mean overstory and understory height for all study sites, Pembina Valley, Manitoba.

	Overstory Height		*Understory Height*		
Grazed sites	***Mean***	***sd***	***Mean***	***sd***	***n***
Sutton	13.65	1.39	0.00	0.00	20
Crayston	15.27	3.48	0.12	0.42	13
Howell	12.20	1.75	2.45	1.42	10
Steel	11.60	6.21	2.37	2.36	15
Dekoninck	9.29	4.15	2.13	1.32	15
Ungrazed sites					
Crayston	15.30	2.87	2.65	0.71	10
Douglas	13.89	3.30	3.11	2.38	9
Bell	12.60	1.90	2.90	0.84	10
WMA	13.75	1.76	6.75	3.36	15
Shaw	13.70	2.71	4.30	2.18	10
Friesen	14.20	8.26	3.25	2.42	10
Dearsley	15.00	2.16	4.30	2.15	10

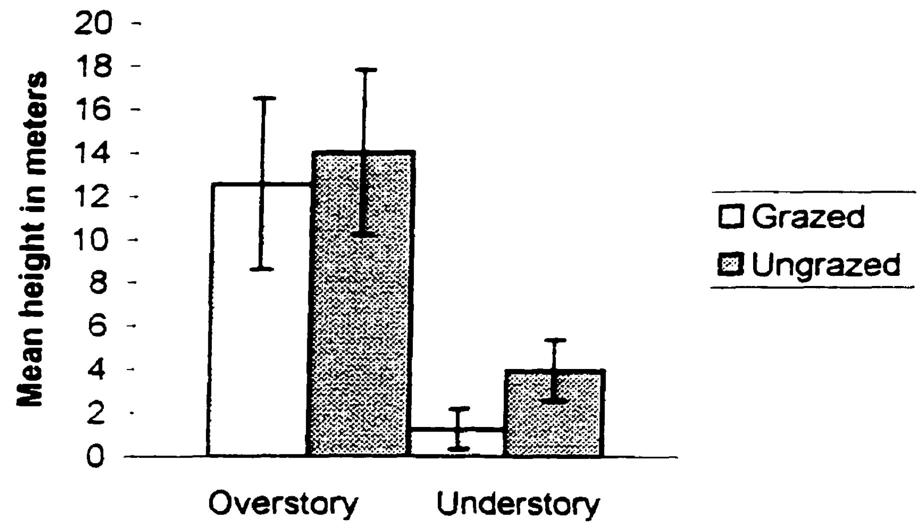


Figure 4.9. Comparison of average overstory and understory height between grazed and ungrazed treatments.

4.1.8 Herbs and Shrubs

Effective Species Richness and Percentage Similarity were calculated on herb and shrub data (Table 4-5). Herb diversity was similar on grazed and ungrazed plots, but species composition of the herbaceous community differed. Shrub diversity of grazed plots was slightly greater than ungrazed plots, and the two treatments held more shrub species in common.

Table 4-5. Effective Species Richness and Percentage Similarity calculated on herbaceous and shrub species of grazed and ungrazed sites.

	Grazed	Ungrazed
Herbs		
Effective Species Richness	14.1705	14.5036
Similarity	49.26%	
Shrubs		
Effective Species Richness	11.6965	10.4958
Similarity	68.26%	

Abundant species were defined as those ranked as one of the five most common species on a plot and dominant species were those ranked as the single most common species on a plot. Appendix G shows all herbaceous and shrub species ranked on grazed and ungrazed plots.

Grasses were dominant at grazed sites, accounting for 97.3% of all first ranked herbs. Abundant herb species included Northern bedstraw, Canada violet, Meadow rue, and Common dandelion. Dominance was shared by Wild sarsaparilla (45.9% of first rankings) and grass species (41.9% of first rankings). Other abundant herbaceous species on ungrazed plots included Northern bedstraw, Meadow rue, Poison ivy, Wild strawberry, and Sweet-scented bedstraw.

Western snowberry (60.3% of first rankings), Beaked hazelnut (16.4% of first rankings), and Chokecherry (11.0% of first rankings) shared dominance on grazed plots, comprising 87.7% of first rankings. Six other species made up the remaining 12.3%. Saskatoon, Wild rose, and Hawthorn were also abundant on grazed sites. Beaked hazelnut had the majority of first rankings (68.9%), with the next most dominant species, Chokecherry, having only 12.2% of first rankings. However, Chokecherry ranked in top 5 species in 86.5% of cases, and was therefore present on nearly all ungrazed plots. Saskatoon and Western snowberry were also quite common.

When tree seedlings are examined separately, American elm, bur oak, and trembling aspen were all common on >10% of grazed plots, and Manitoba maple followed closely behind this at 9.6% of plots. Green ash was ranked as abundant on only 3 plots. On ungrazed plots, oak seedlings were abundant at roughly twice as many plots, and Green ash seedlings at roughly four times as many plots. There was low representation of Trembling aspen (6.8%), Manitoba maple (4.1%), and American elm seedlings (2.7%).

4.2 Avian community

4.2.1 Characteristics of the Pembina Valley bird community

A total of 1028 individuals of 45 species were detected during point counts (Table 4-6). Incidental observations in the study area increased the total number of species to 73 (Appendix H). When results for all sites are combined, the most abundant species was Yellow warbler, with a total of 200 individuals representing roughly 20% of all observations. This was also the only species observed at all 55 point count stations. Other frequently observed species included Cedar waxwing (78 individuals), Red-eyed vireo (72 individuals), Least flycatcher (61 individuals), Brown-headed cowbird (51 individuals), House wren (50 individuals), and Clay-colored sparrow (50 individuals). These species were quite evenly distributed throughout the study area, all but the Clay-colored sparrow being observed at >60% of stations. Many species were uncommon on the study area (Figure 4.10), nineteen of the 45 species (42.2%) having fewer than 10 observations and seventeen species (37.7%) being observed at <10% of stations.

Table 4-6. Bird species censused during point counts at all sites, showing both the total number of individuals detected and number of point count stations at which each species was detected

Bird Species (in order of abundance)	Number of Individuals	Proportion	# stations observed (Total=55)	%
Yellow warbler	200	19.34%	55	100.0%
Cedar waxwing	78	7.54%	43	78.2%
Red-eyed vireo	72	6.96%	48	87.3%
Least flycatcher	61	5.90%	36	65.5%
Brown-headed cowbird	52	5.03%	34	61.8%
House wren	50	4.84%	33	60.0%
Clay-coloured sparrow	50	4.84%	25	45.5%
Great-crested flycatcher	39	3.77%	28	50.9%
American goldfinch	36	3.48%	28	50.9%
Song sparrow	34	3.29%	25	45.5%
Northern waterthrush	26	2.51%	21	38.2%
American crow	26	2.51%	17	30.9%
Warbling vireo	24	2.32%	20	36.4%
Chipping sparrow	24	2.32%	16	29.1%
Eastern wood peewee	22	2.13%	20	36.4%
White-breasted nuthatch	20	1.93%	16	29.1%
Northern oriole	20	1.93%	18	32.7%
Mourning dove	20	1.93%	14	25.5%
Veery	19	1.84%	13	23.6%
Rufous-sided towhee	19	1.84%	17	30.9%
Rose-breasted grosbeak	17	1.64%	17	30.9%
Black-and-white warbler	15	1.45%	14	25.5%
Gray catbird	12	1.16%	11	20.0%
Black-capped chickadee	12	1.16%	11	20.0%
American robin	12	1.16%	9	16.4%
Common yellowthroat	10	0.97%	8	14.5%
Yellow-throated vireo	9	0.87%	9	16.4%
American redstart	8	0.77%	6	10.9%
Belted kingfisher	6	0.58%	3	5.5%
Hairy woodpecker	5	0.48%	5	9.1%
Ruffed grouse	4	0.39%	4	7.3%
Red-tailed hawk	3	0.29%	2	3.6%
Orange-crowned warbler	3	0.29%	3	5.5%
Blue jay	3	0.29%	3	5.5%
Yellow-bellied sapsucker	2	0.19%	2	3.6%
Ruby-throated hummingbird	2	0.19%	2	3.6%
Eastern phoebe	2	0.19%	2	3.6%
Eastern kingbird	2	0.19%	2	3.6%
Downy woodpecker	2	0.19%	2	3.6%
Black-billed magpie	2	0.19%	2	3.6%
Wood duck	1	0.10%	1	1.8%
Ovenbird	1	0.10%	1	1.8%
Eastern bluebird	1	0.10%	1	1.8%
Connecticut warbler	1	0.10%	1	1.8%
Common flicker	1	0.10%	1	1.8%
45 species	**1028**			

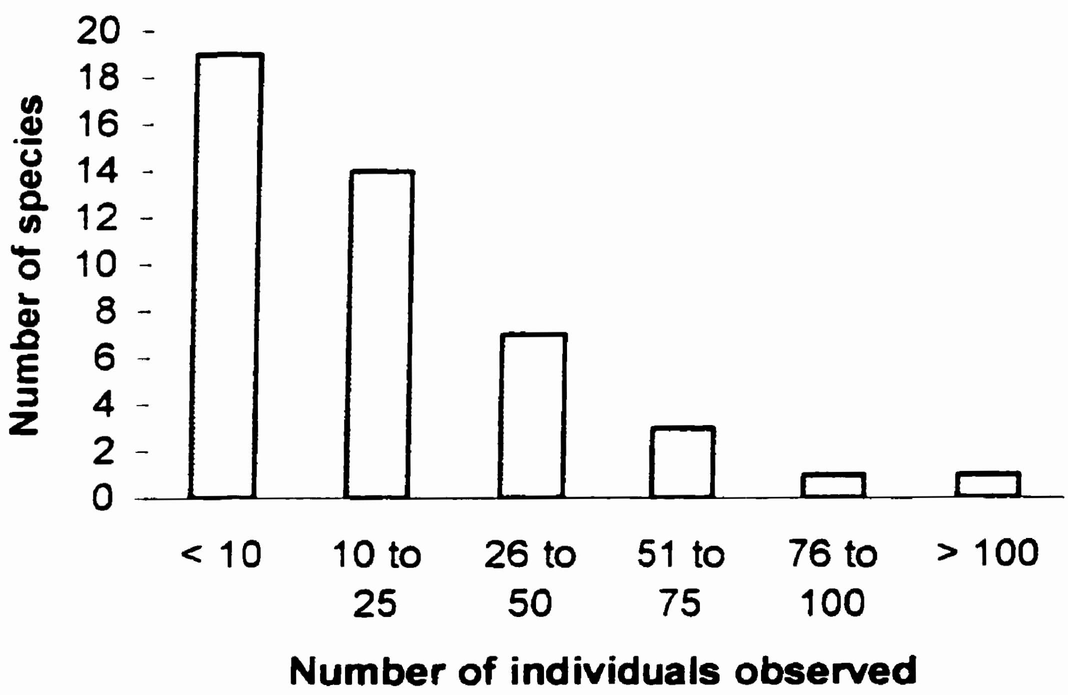


Figure 4.10. **Observation frequencies of all species detected on the Pembina Valley study area.**

Table 4-7. **Proportion of the bird community of the Pembina Valley study area represented by neotropical migratory birds: a) by species: b) by individuals.**

	# species	%	# individuals	%
Neotropical migrants	36	80	953	93
Residents/short distance migrants	9	20	75	7
Total	45	100	1028	100

The proportion of the community comprised of neotropical migrants, the distribution and the abundance rank of all species detected were determined to assess species' relative conservation concern. Eighty percent of species and 93% of individuals were neotropical migratory birds (Table 4-7). Roughly 53% of species censused had breeding distributions covering greater than 50% of North America (Figure 4.11). Three species (Clay-colored sparrow, Connecticut warbler and Wood duck) breed over 11-25% of the continent. None of the species detected fell into the most limited distribution size class. The majority of species detected (37 of 44) are ranked as abundant in Manitoba, while none are considered to be rare or uncommon (Figure 4.12). Individual species assignments for the above criteria are listed in Appendix I.

4.2.2 Habitat associations of Pembina Valley birds

Canonical Correspondence Analysis (CCA) relates bird species relative abundance data (Appendix J) to environmental variables (Appendix K). Based on bird species composition and environmental variables, the most similar sites are located closest to one another, and the most dissimilar are farthest apart. Several main groupings are evident (Figure 4.13):

- WMA, Shaw, and Dearsley form one group to the left of the figure.
- Bell, Douglas, and Howell form a second, more centrally-located group.
- Friesen is located at the top of the figure and is distant to most other sites.
- Grazed site Steel is situated closest Friesen.
- Dekoninck, Sutton, and the two Crayston sites form a group to the right-hand side.

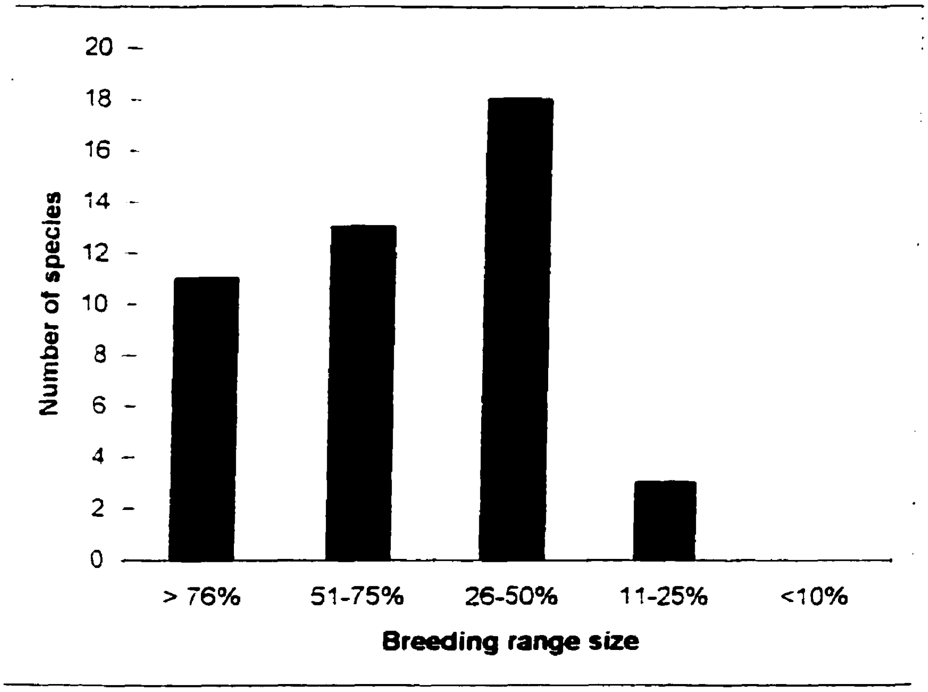


Figure 4.11. Size of breeding distributions for all species detected on Pembina Valley study area.

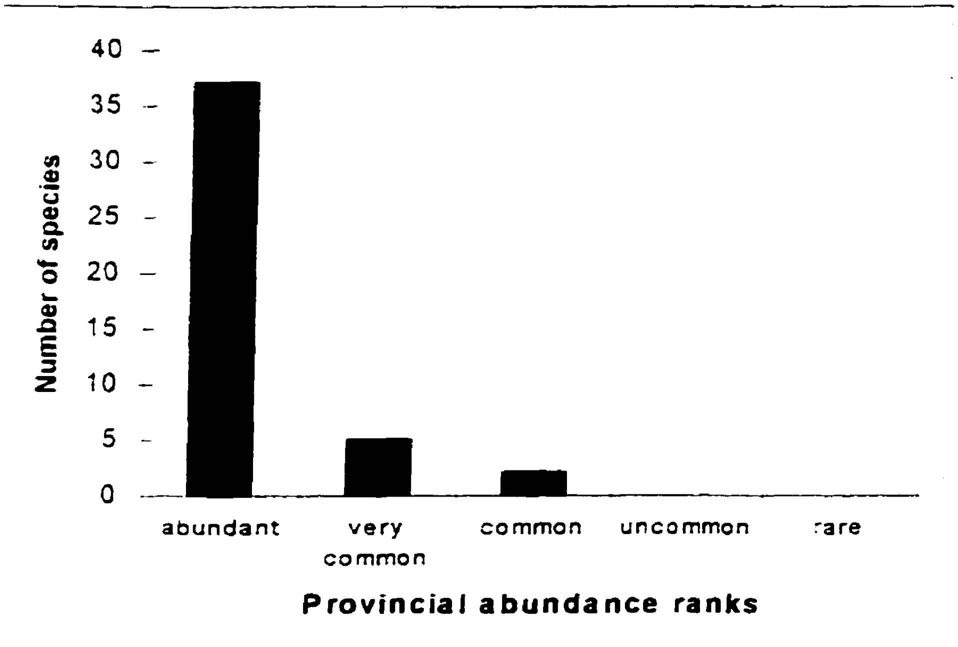


Figure 4.12. Distribution of birds censused according to provincial abundance rank. Rank assignments based on the Partners in Flight Landbirds Database.

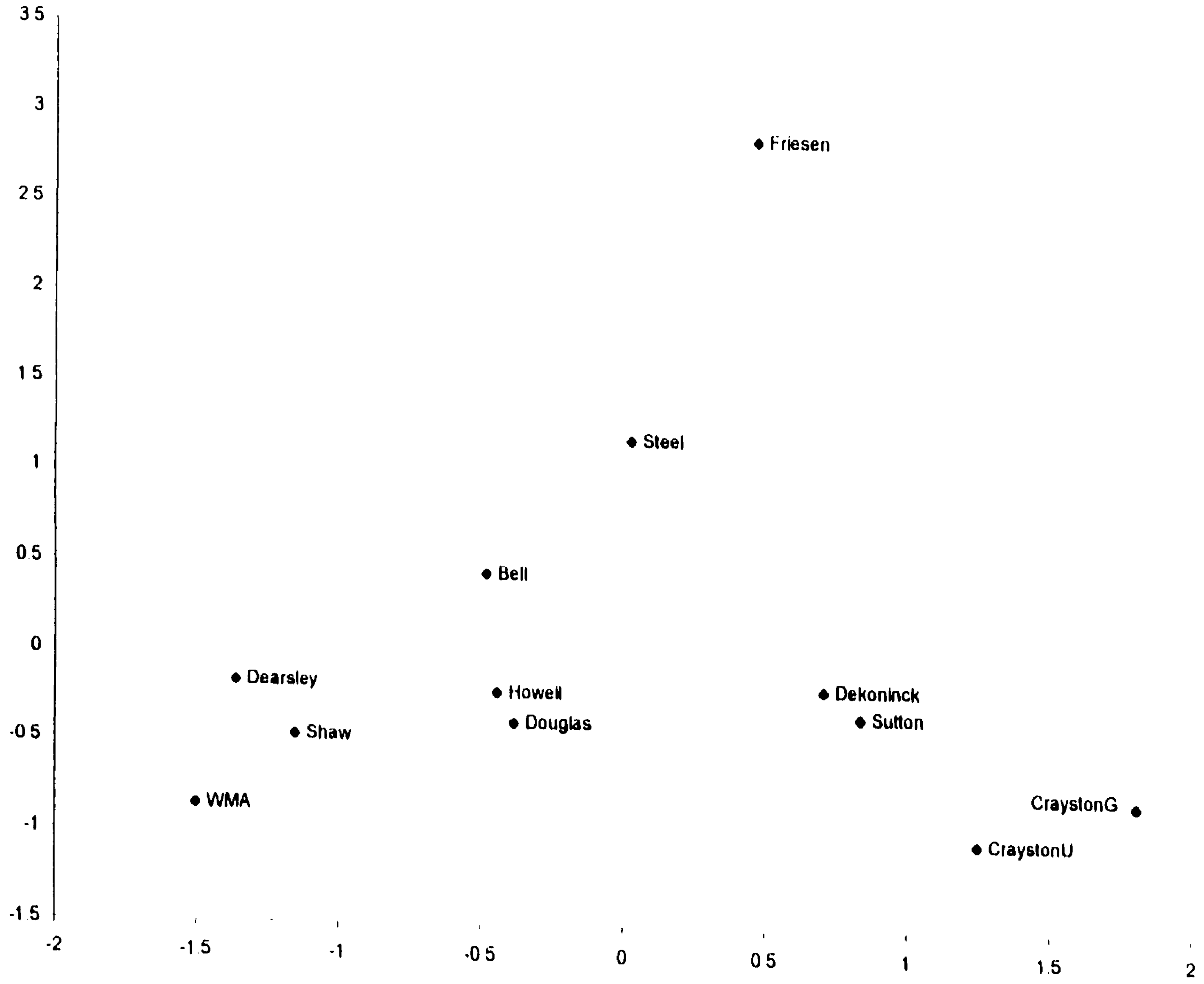


Figure 4.13. Placement of study sites resulting from CCA conducted on individual bird species and environmental variables.
Eigenvalues: Axis 1 – 0.189, Axis 2 – 0.158. Cumulative percentage variance of species-environment relation: Axis 1 – 24.1, Axis 2 – 44.3

There is a distinct concentration of sites along the bottom of the figure, only Friesen and to a lesser extent Steel occupying the top. There is also a right-left distinction: CraystonG, CraystonU, Sutton, Dekoninck, Friesen and Steel lying to the right: and WMA, Dearsley, Shaw, Bell, Howell, and Douglas lying to the left.

Figure 4.14 shows trends in the environmental data that emerged. Environmental variables associated with sites to the right included basal area of American elm and Bur oak and percent ground cover. Variables associated with sites to the left included basal area of Trembling aspen, height of understory vegetation, percent vertical cover, percent canopy cover and shrub density. High basal area of dead wood and Manitoba maple were associated with the top of the figure. Grazed sites are associated with vegetative characteristics including lower shrub density, lower percent canopy cover, lower percent vertical cover, and higher percent ground cover.

Figure 4.15 shows the resulting placement of bird species:

- Connecticut warbler, Chipping sparrow, Clay-colored sparrow, Eastern kingbird, Black-billed magpie, American crow, and Rufous-sided towhee are associated with sites to the right dominated by Bur oak, American elm, and high percent ground cover. These species are associated with grazed sites.
- Eastern phoebe, Veery, Ruby-throated hummingbird, Gray catbird, Rose-breasted grosbeak, Ruffed grouse, Northern oriole, and Yellow-throated vireo are associated with Dearsley, Shaw, and WMA characterized as having high basal area of trembling

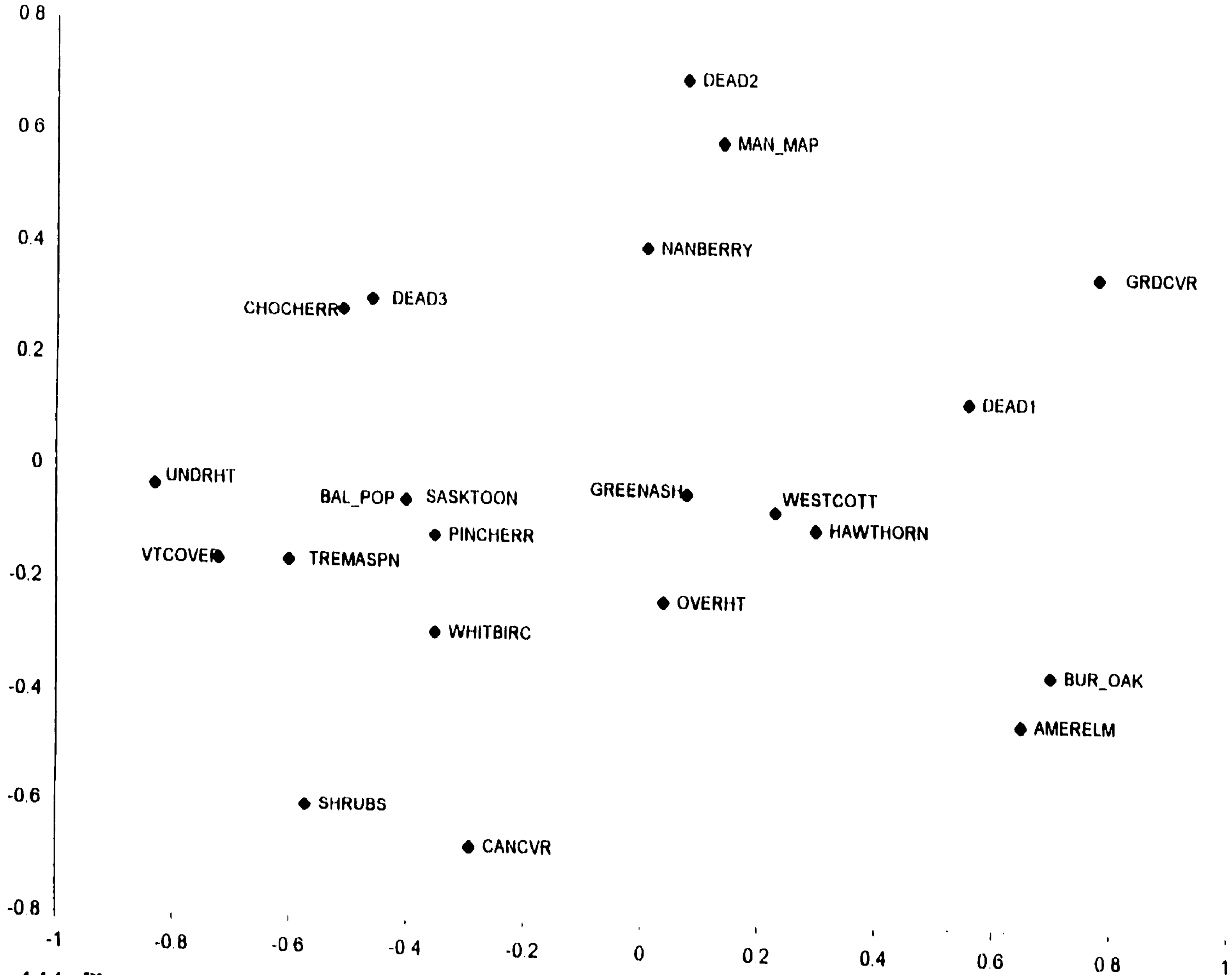


Figure 4.14. Placement of environmental variables resulting from CCA. Codes appear in Appendix K.

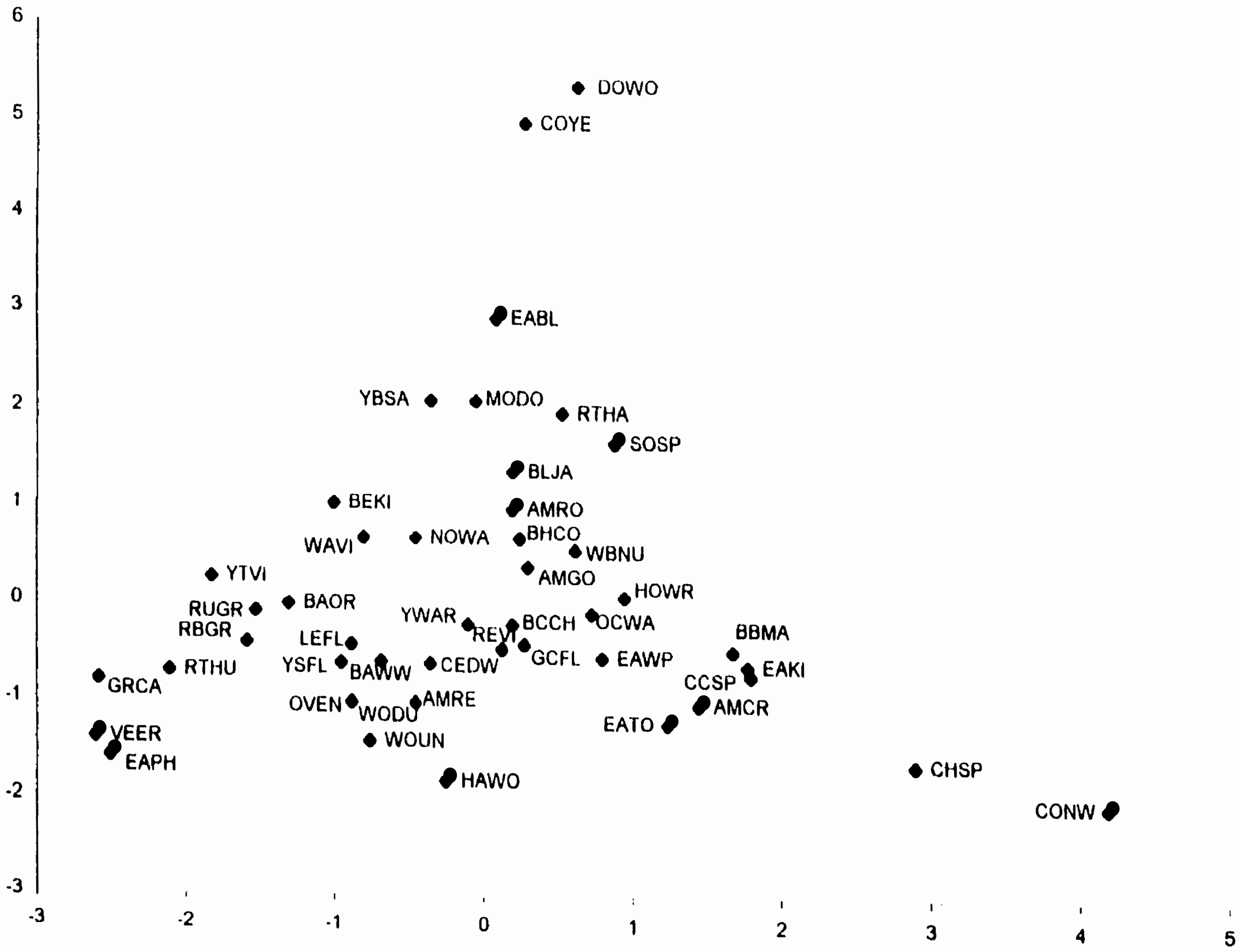


Figure 4.15. Placement of individual bird species based on CCA. Codes appear in Appendix I.

aspen, higher understory vegetation, and greater percent vertical cover and shrub density. These species are associated with ungrazed sites.

- Downy woodpecker, Common yellowthroat, Eastern bluebird, Mourning dove, Yellow-bellied sapsucker, Red-tailed hawk, and Song sparrow are associated with sites Friesen and Steel which had high basal area of snags (especially Class 2) and high basal area of Manitoba maple.
- There are several centrally-located species that were ubiquitous across sites and habitat variables. These included Yellow warbler, House wren, Brown-headed cowbird, Cedar waxwing, White-breasted nuthatch, and Red-eyed vireo.

4.2.3 Grazed and Ungrazed Bird Communities

A total of 520 individuals of 42 species were censused on grazed sites. The most abundant species were Yellow warbler (91 individuals), Clay-colored sparrow (41 individuals), Red-eyed vireo (35 individuals), Least flycatcher (34 individuals), Cedar waxwing (30 individuals), House wren (26 individuals), and Brown-headed cowbird (26 individuals). Together these species accounted for 54.1% of grazed site observations. Black-billed magpie, Yellow-shafted flicker, Connecticut warbler, Eastern bluebird, Eastern kingbird, and Red-tailed hawk were unique to grazed sites.

A total of 522 individuals of 39 species were censused on ungrazed sites. The most abundant species were Yellow warbler (109 individuals), Cedar waxwing (48 individuals), Red-eyed vireo (37 individuals), Least flycatcher (27 individuals), Brown-headed cowbird (26 individuals), House wren (24 individuals), and Great-crested flycatcher (20 individuals). Together these species accounted for 55.9% of all ungrazed site observations. Ruby-throated hummingbird, Ovenbird, Veery, and Wood duck were unique species to ungrazed sites.

When Effective Species Richness was calculated on avian abundance at individual study sites (Table 4-8), there was a much greater range in values for the ungrazed than grazed sites. Both the lowest and highest values were obtained on ungrazed sites. Lowest diversity was reached at Friesen, ungrazed Crayston, and WMA. Highest diversity was reached at Douglas, Steel, and Dekoninck.

Table 4-8. Effective Species Richness calculated using avian abundance data on all study sites, Pembina Valley, Manitoba.

Grazed Sites	
Sutton	14.3718
Crayston	14 3604
Howell	16.0614
Steel	24.2907
Dekoninck	20.1618
Ungrazed Sites	
Crayston	12.9419
Douglas	15.0532
Bell	18.7263
WMA	13.1825
Shaw	13.4647
Friesen	11.8764
Dearsley	17.7202

Diversity and similarity indices calculated on grazed and ungrazed treatments suggest that treatments were similar in diversity, but differed somewhat in bird species composition (Table 4-9).

Table 4-9. Effective Species Richness and Renkonen Index values for bird species on grazed and ungrazed sites.

	Grazed		Ungrazed
Effective Species Richness	22.2004		21.1461
Similarity		80%	

Table 4-10 shows individual species responses to grazing. Increaser species responded positively to grazing having a >50% difference in mean abundance in favour of grazed sites. Decreasers responded negatively to grazing with a >50% difference in mean abundance in favour of ungrazed sites. Species with few observations are included here, but due to their small numbers cannot be relied upon as conclusive evidence of a positive or negative response to grazing.

Fifteen species responded positively to grazing. There were nearly 8 times as many Clay-colored sparrows at grazed sites as ungrazed sites. This species was also seen at nearly 75% of grazed stations and at only 18% of ungrazed stations. Chipping sparrows were more abundant on grazed sites, with 7 times as many individuals as compared to ungrazed sites, and observed at >50% of grazed stations. There were 4 times as many American robins on grazed as ungrazed sites. Rufous-sided towhee, Eastern wood pewee and American crow also showed a preference for grazed sites with roughly twice as many individuals as at ungrazed sites.

Nine species responded negatively to grazing. Veeries were one of the most abundant species on ungrazed sites, but were observed at none of the grazed sites. There were 7

Table 4-10. Individual species responses to grazing based on 50% difference in mean abundance between grazed and ungrazed treatments.

Species	Mean number of individuals per grazed site	% of grazed stations observed	Mean number of individuals per ungrazed site	% of ungrazed stations observed
Decreasers				
Ovenbird	0.00	0.0%	0.14	3.6%
Ruby-throated hummingbird	0.00	0.0%	0.29	7.1%
Veery	0.00	0.0%	2.71	46.4%
Wood duck	0.00	0.0%	0.14	3.6%
Gray catbird	0.20	3.7%	1.57	35.7%
Common yellowthroat	0.40	7.4%	1.14	21.4%
Unknown woodpecker	0.60	11.1%	1.57	35.7%
Yellow-throated vireo	0.40	7.4%	1.00	21.4%
American redstart	0.40	3.7%	0.86	17.9%
Ruffed grouse	0.20	3.7%	0.43	10.7%
Neutrals				
Cedar waxwing	6.00	77.8%	6.86	78.6%
Hairy woodpecker	0.40	7.4%	0.43	10.7%
Rose-breasted grosbeak	1.40	25.9%	1.43	35.7%
Northern oriole	1.80	29.6%	1.57	35.7%
White-breasted nuthatch	1.80	25.9%	1.57	32.1%
Yellow warbler	18.20	100.0%	15.57	100.0%
Northern waterthrush	2.40	29.6%	2.00	46.4%
Black-and-white warbler	1.40	22.2%	1.14	28.6%
Red-eyed vireo	7.00	88.9%	5.29	85.7%
Great-crested flycatcher	3.80	48.1%	2.86	53.6%
Brown-headed cowbird	5.20	77.8%	3.71	46.4%
Song sparrow	3.40	55.6%	2.43	35.7%
Downy woodpecker	0.20	3.7%	0.14	3.6%
Eastern phoebe	0.20	3.7%	0.14	3.6%
Yellow-bellied sapsucker	0.20	3.7%	0.14	3.6%
House wren	5.20	63.0%	3.43	57.1%
Warbling vireo	2.60	40.7%	1.57	32.1%
Mourning dove	2.20	22.2%	1.29	28.6%
Least flycatcher	6.80	66.7%	3.86	64.3%
Black-capped chickadee	1.40	25.9%	0.71	14.3%
American goldfinch	4.20	55.6%	2.14	42.9%
Increasers				
Eastern wood pewee	2.60	44.4%	1.29	28.6%
Rufous-sided towhee	2.40	44.4%	1.00	21.4%
American crow	3.40	33.3%	1.29	28.6%
Belted kingfisher	0.80	7.4%	0.29	7.1%
Blue jay	0.40	7.4%	0.14	3.6%
Orange-crowned warbler	0.40	7.4%	0.14	3.6%
American robin	1.80	25.9%	0.43	7.1%
Clay-coloured sparrow	8.20	74.1%	1.29	17.9%
Chipping sparrow	4.00	51.9%	0.57	7.1%
Black-billed magpie	0.40	7.4%	0.00	0.0%
Common flicker	0.20	3.7%	0.00	0.0%
Connecticut warbler	0.20	3.7%	0.00	0.0%
Eastern bluebird	0.20	3.7%	0.00	0.0%
Eastern kingbird	0.40	7.4%	0.00	0.0%
Red-tailed hawk	0.60	7.4%	0.00	0.0%

times as many Gray catbirds at ungrazed as grazed sites. Common yellowthroat and Yellow-throated vireo were twice as abundant on ungrazed sites.

Twenty-one species differed little in abundance between grazed and ungrazed sites. Of these, six species showed just less than 50% difference in mean abundance (House wren, Warbling vireo, Mourning dove, Least flycatcher, Black-capped chickadee, and American goldfinch) and tended toward grazed sites.

Correspondence Analysis was run using relative abundance of nine foraging guilds (Appendix L), and resulted in a placement of sites similar to that produced using CCA, again with a strong right-left distinction (Figure 4.16).

- WMA, Shaw, Dearsley, Bell, Douglas, and Howell form a group to the left of the figure.
- Sutton, Dekoninck, the two Crayston sites, Steel and Friesen form a group to the right, with Friesen again being on the outskirts.

Grazed sites seemed to be associated with the right side of the figure, and ungrazed with the left. Guilds associated with sites to the left included ground-feeding insect eaters, trunk, branch and bark gleaners, foliage gleaners, and aerial flycatchers. Guilds associated with sites to the right included predators, ground-feeding seed eaters, and omnivores. Nectar-feeders (Ruby-throated hummingbirds) and aquatic specialists (Wood duck and Belted kingfisher) occurred on few sites and were therefore distal to other guilds.

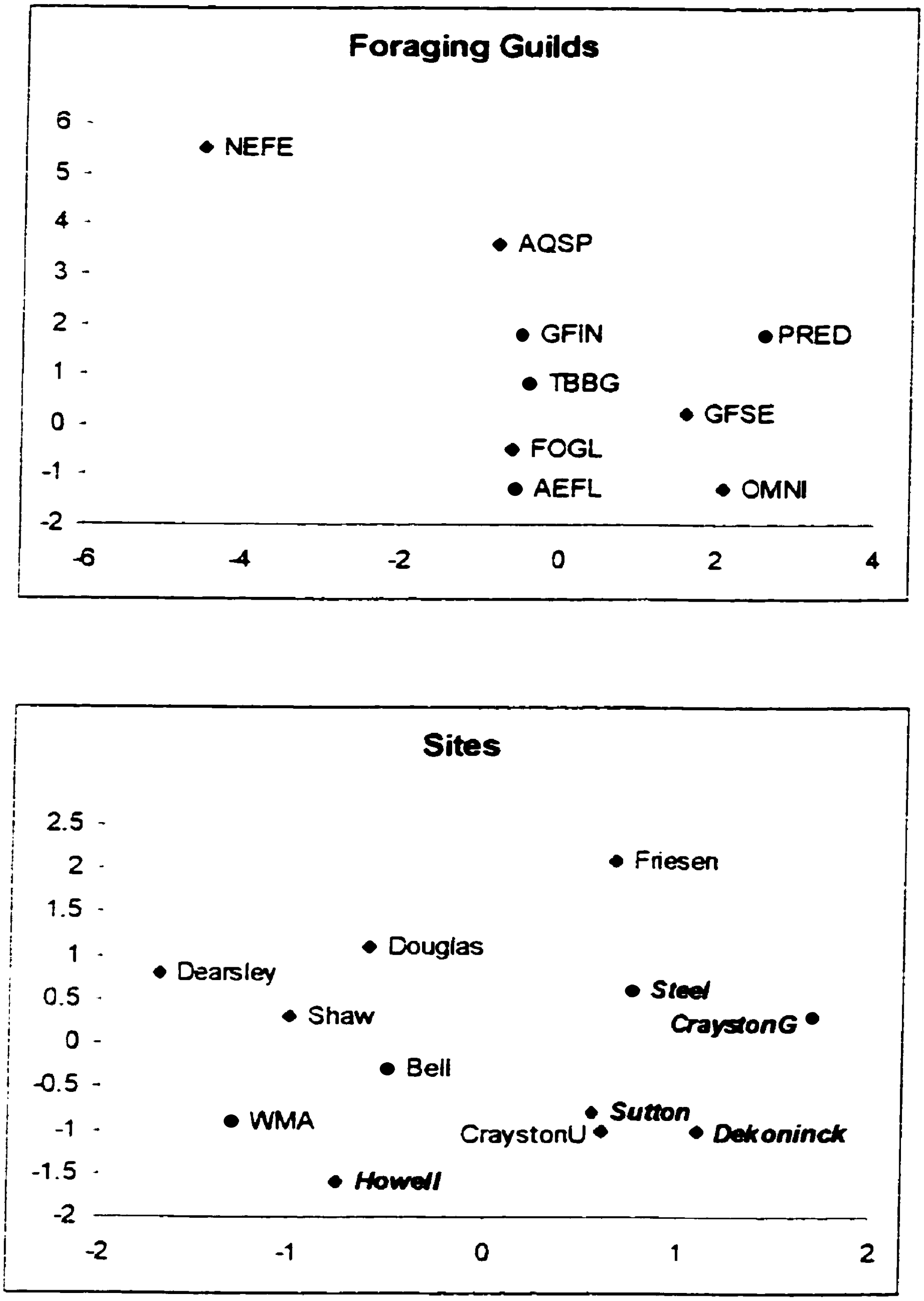
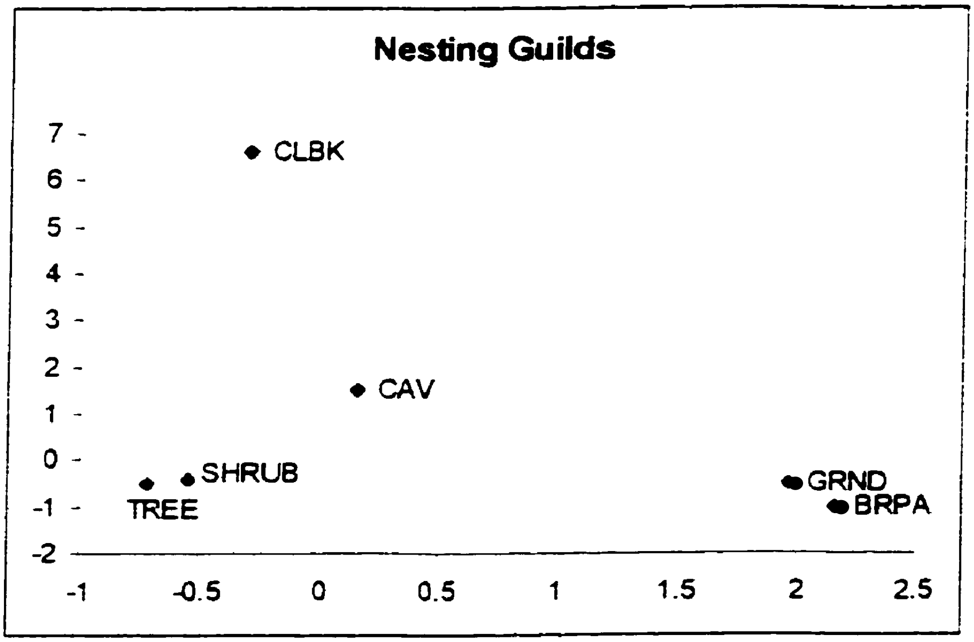


Figure 4.16. Results of CA conducted on foraging guilds.
Cumulative percentage of eigenvalues: Axis 1 – 42.98, Axis 2 – 63.05 Foraging guild codes: AEFL=aerial flycatcher, AQSP=aquatic specialist, FOGL=foliage gleaner, GFIN=ground-feeding insect eater, GFSE=ground-feeding seed eater, NEFE=nectar feeder, OMNI=omnivore, PRED=predator, TBBG=trunk, bark, branch gleaner. ***Grazed sites in bold italics.***

When analysis was performed using the six nesting guilds (Appendix L), the results obtained are very different from those produced using either CCA or foraging guilds (Figure 4.17). There is again a concentration of sites to one side of the figure, these sites being associated with tree-, shrub-, and cavity-nesters. Friesen was similarly the odd site, in this case associated with abundance of ground-nesters and brood parasites (Brown-headed cowbirds). Sutton, and the two Crayston sites remain proximate to one another as in the other analyses.

Relative abundance of members of nine foraging guilds and six nesting guilds on grazed and ungrazed sites are shown in Table 4-11. Members of the foliage gleaning guild were most abundant on grazed sites (191 individuals), followed closely by the seed-eating ground-feeders (149 individuals) and aerial flycatchers (70 individuals). On ungrazed sites, foliage gleaners were most abundant (240 individuals), followed by seed-eating (90 individuals) and invertebrate-eating ground-feeders (80 individuals). The tree-nesting, shrub-nesting and cavity-nesting species were most abundant on both grazed and ungrazed sites.

Significant differences in the number of individuals representing four foraging guilds and one nesting guild were evident on grazed and ungrazed sites (Table 4-11). There were significantly more omnivores ($p<0.05$) and seed-eating ground-feeders ($p<0.005$) on grazed sites and more invertebrate-eating ground-feeders ($p<0.025$), foliage gleaners ($p<0.025$), and ground-nesters ($p<0.05$) on ungrazed sites. There were also more aerial flycatchers on grazed sites, but this difference was not significant. Although the number



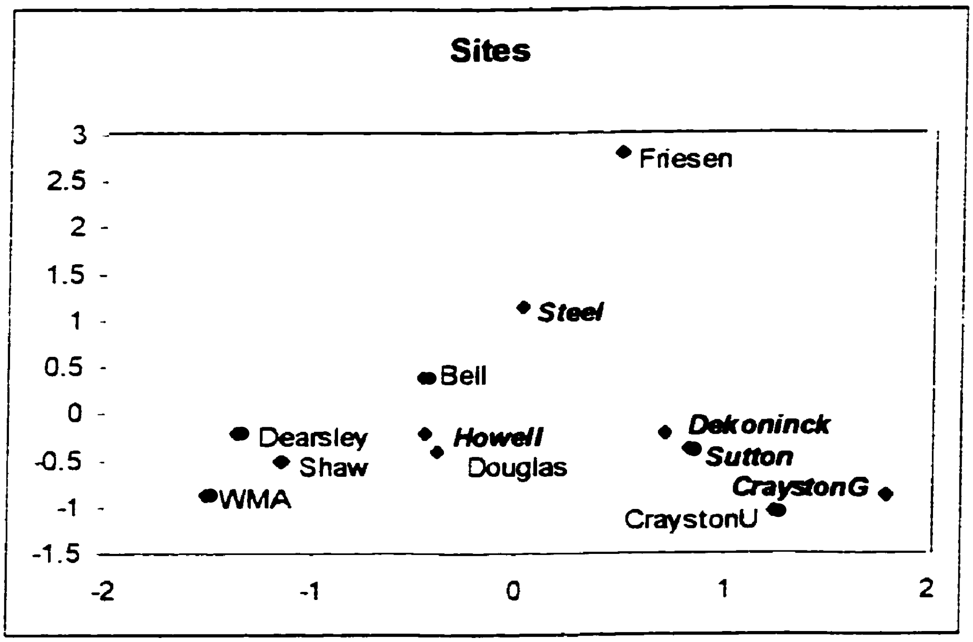


Figure 4.17. Results of CA conducted on nesting guilds.
Cumulative percentage of eigenvalues: Axis 1 – 41.70, Axis 2 – 69.23. Nesting guild codes: BRPA=brood parasite, CAV=cavity nester, CLBK=cliff/bank nester, GRND=ground nester, SHRUB=shrub nester, TREE=tree nester. ***Grazed sites in bold italics.***

Table 4-11. Number of species and number of individuals representing each of nine foraging guilds and six nesting guilds, for grazed and ungrazed treatments.

	Grazed n=27 stations		Ungrazed n=28 stations		
Foraging guild	**# spp**	**# inds**	**# spp**	**# inds**	
Omnivores	3	21	2	10	$p < 0.05$
Seed-eaters on ground	8	149	8	90	$p < 0.005$
Insect-eaters near ground	6	51	7	80	$p < 0.025$
Foliage gleaners	9	191	9	240	$p < 0.025$
Trunk/branch/bark gleaners	7	31	6	40	ns
Aerial flycatchers	6	70	4	57	ns
Aquatic specialists	1	4	2	3	ns
Nectar-feeders	0	0	1	2	ns
Predators	1	3	0	0	ns
Total	**41**	**520**	**39**	**522**	
Nesting guild					
On or near ground	8	54	9	78	$p < 0.05$
In shrub cover	4	154	4	144	ns
In trees	16	177	14	167	ns
Cavity-nesters	10	104	9	104	ns
Cliff, bank nesters	2	5	2	3	ns
Brood parasites	1	26	1	26	ns
Total	**41**	**520**	**39**	**522**	

of individuals in each guild differed notably between grazed and ungrazed sites, the number of species comprising each guild was similar.

Chapter 5 Discussion

5.1 Characterizing the Pembina Valley bird community

Forty-five species were observed during point count censuses in the Pembina Valley. This is somewhat lower than other studies of midwestern bird communities (Faanes and Andrew 1983; Rumble and Gobeille 1998). The focus of this study was avian use of the woodland community, and therefore species using other habitat types, such as agricultural fields and marshes, were excluded. Studies in which more bird species were detected sampled a greater range of habitat types potentially accommodating more bird species. Faanes and Andrew (1983) sampled the bird community in six distinct North Dakota habitat types. Their study area also contained the most northwestern tip of the eastern deciduous forest, which has its own assemblage of bird species. Differences in sampling intensity and timing of censuses may also result in detection of more species. In this study, the bird community was censused over a single breeding season (June 1997). Conducting censuses over multiple years may detect year-to-year variability in the bird community (Rice *et al.* 1983), and sampling earlier and later in the season may detect species migrating through the region. In both cases, the end result would be detection of more species.

The most abundant species on the Pembina Valley study area were yellow warbler, cedar waxwing, red-eyed vireo, least flycatcher, brown-headed cowbird, house wren and clay-colored sparrow. These species are characteristic of the upland deciduous forests of the Pembina Hills area of North Dakota (NPWRC 1998). Faanes and Andrew (1983) found yellow warbler to be dominant on their Pembina Hills study area. In South Dakota green ash woodlands, brown-headed cowbird, yellow warbler, and house wren were among the most abundant species (Rumble and Gobeille 1998). Interestingly, these seven species were also noted as abundant in the Pembina Valley at the turn of the century (Thompson 1891).

Most species on the study area were present in low numbers, with very few being present in high numbers. Such skewed distributions in abundance are commonly observed in biological communities (Putman 1994) and have been specifically noted in avian communities (Faanes and Andrew 1983; Knopf 1986; Mehlman 1994). One species (yellow warbler) comprised 20% of avian abundance, seven species accounted for 55% of abundance and 25 species accounted for 93% of abundance. Similarly, Faanes and Andrew (1983) found Yellow warbler to comprise roughly 20% of the Pembina Hills bird community, with five species making up 50% of the total avian abundance, and 20 species making up 90%.

Eighty percent of species and 93% of individuals on the Pembina Valley study area were neotropical migratory birds. The proportion of the community represented by resident and short-distance migrant ***species*** is likely fairly accurate, since only one individual of a species needs to be detected to be recorded. Faanes and Andrew (1983) report a similar percentage of migratory species in North Dakota. However, given that sampling took place at a time when many resident and short-distance migrant species would be less vocal, the number of ***individuals*** of these groups may be underrepresented. In their study of forest breeding birds in Arkansas, Ohio, Kentucky and Idaho, Petit *et al.* (1997)

suspected that the detection rate of migrants was higher than that of residents due to time of sampling. They concluded that this did not greatly influence differences observed in detection of migrants and residents across stations or visits, since most species sing or call at least once during any 8-minute period.

On the Pembina River study area, 24 of 45 species censused had breeding distributions covering >50% of North America, including five of the seven most abundant species. All are considered to be common or abundant within Manitoba (PIF Landbirds Database 1998). Ecological generalists tend to have broad distributions, since species more tolerant of environmental conditions are generally able to colonize a wider geographic area than those with less environmental tolerance (Mehlman 1994). This tolerance often permits generalist species to reach spectacular heights of abundance (e.g. American robin, house sparrow). Knopf (1986) observed that a large proportion of the riparian bird community in eastern Colorado was comprised of ecological generalists found across North America. He suggested that, although riparian areas support diverse bird communities, they contain few rare species. Data from the Pembina River study area suggest that it is dominated by ecological generalists.

5.2 Objective 2: Habitat associations of Pembina Valley birds

There is evidence that Pembina Valley birds select for specific habitat features. Environmental variables associated with vegetation density had the greatest bearing on the characteristics of the bird community. Ordinations resulting from Correspondence Analysis conducted on tree species, bird species and foraging guilds, as well as from

Canonical Correspondence Analysis, showed consistent site groupings. A clear right-left distinction in the placement of sites appeared to be attributed largely to the relative density of vegetation, and was reinforced by analyses of individual habitat variables. In general, Sutton, Dekoninck, CraystonG, CraystonU, Steel, and Friesen are characterized by less dense vegetation than Shaw, Dearsley, WMA, Bell, Howell, and Douglas. Habitat variables associated with vegetation density included decreased ground cover, and increased percent canopy cover, shrub density, understory height, and vertical cover. Density of vegetation at a site may be attributed to a number of factors including forest composition, grazing influences, topography, flooding, aspect, and disease, all of which may act together or in isolation.

In general, sites with high basal area of bur oak were most open and those with high basal area of trembling aspen were most dense. Faanes and Andrew (1983) found that bur oak forest was more open than other forest types in the Pembina Hills, ND, with an average canopy cover of 27%. Trembling aspen forest in the same region had a canopy cover of 48%. Tree species composition may in turn be tied to aspect and topography, bur oak tending to prefer warm, well-drained south-facing slopes and trembling aspen preferring the cooler north-facing slopes. The ordination of sites based on tree species produced similar *but not identical* groupings to those of other analyses, suggesting that tree species composition is not the sole factor determining the nature of a site and its bird community. It is important to note that four of five grazed sites were quite similar in tree species composition. Inherent similarities in sites may have confounded the influence of grazing on vegetative characteristics and avian responses.

Placement of sites in ordinations showed there to be a high but not perfect correlation between site openness and grazing. The ungrazed site Crayston was more open than other ungrazed sites, and may have been exposed to livestock in the past. Ungrazed Friesen was the most open site in the study due to Dutch Elm disease and flooding, rather than to grazing. Grazed site Howell contained dense hazelnut resulting in increased shrub density, vertical cover, and understory height, characteristics associated with ungrazed sites. The influence of grazing on vegetation is discussed in greater detail later in this chapter.

Disease and flooding played an important role in the habitat characteristics of Friesen. Openness of this floodplain site was due to the loss of all large canopy trees to Dutch elm disease and to the removal of herbaceous cover by seasonal flooding. Both of these factors have been shown to be important influences on understory vegetation (Sedgwick and Knopf 1991; Canterbury and Blockstein 1997). This site was distal to others in all multivariate analyses, and was unique in its vegetation and bird community.

Some generalizations can be made on bird species associations with site characteristics. Ten species in particular appeared to have an affinity for sites with more open vegetation (song sparrow, clay-colored sparrow, chipping sparrow, eastern towhee, eastern wood pewee, eastern kingbird, black-billed magpie, American crow, house wren and Connecticut warbler). Previous habitat association studies suggest that sparrows (Middleton 1998; Knapton 1994), flycatchers (McCarty 1996; Murphy 1996), and corvids (Andren 1992; Trost 1999) prefer open environments for foraging. Faanes and Andrew (1983) determined that house wrens reached their highest mean density in bur oak forest, the forest type with the lowest canopy cover and highest ground cover. Connecticut warblers inhabit open areas of wet deciduous forests, feeding on spiders and insects (Pitocchelli *et al.* 1997). This species' occurrence seemed associated with high spider populations on the site it was observed. Ground-feeding seed eaters, predators, and omnivores were associated with open sites. Faanes and Andrew (1983) found ground-feeding seed-eaters to be most abundant in bur oak forest. Red-tailed hawk was the only predatory species observed and prefers open agricultural areas for hunting small mammal prey (Preston and Beane 1993). Bird species diversity was intermediate at sites with open vegetation.

Friesen was a uniquely open site, deserving of individual attention in its interpretation. Bird species diversity was lowest at this site, support for the theory that structurally simplistic sites are capable of sustaining the fewest species (MacArthur and MacArthur 1961). Dominant species were common yellowthroat and song sparrow, species known to prefer open shrub-dominated areas (Sedgwick and Knopf 1987; Canterbury and Blockstein 1997). Both of these species reached their highest densities in willow shrub communities in North Dakota (Faanes and Andrew 1983). Stauffer and Best (1980) evaluated the effects of several habitat perturbations on riparian bird communities in Iowa and found that both of these species would benefit from partial removal of the woody canopy and a reduction of woody vegetation to narrow strips along streams. Song sparrow populations would increase further if all woody vegetation were removed, resulting in pastures or hayfields. In northern Minnesota, song sparrows were found to increase in numbers when disease, drought, and windstorms converted the closed canopy elm-birch-ash forest to a more open habitat dominated by basswood, ash, and standing snags with large areas of dense fern cover (Canterbury and Blockstein 1997).

Eight species were associated with densely vegetated sites (gray catbird, veery, eastern phoebe, ruby-throated hummingbird, yellow-throated vireo, ruffed grouse, rose-breasted grosbeak, and northern oriole). These species characteristically inhabit mature forest with a dense understory (Faanes and Andrew 1983; Moskoff 1994; Weeks, Jr. 1994; Rodewald and James 1996). Faanes and Andrew (1983) found gray catbird and veery to reach their highest densities in a willow shrub community in North Dakota. On the Pembina Valley study area, it seems that the high shrub density required of these species was met in the trembling aspen forest. Ruby-throated hummingbirds are not specifically associated with dense vegetation, but with woodland clearings and edges. This species will be found where floral nectar and small insects are available (Robinson *et al.* 1996).

Ground-feeding insectivore, trunk, branch and bark gleaner, foliage gleaner, and aerial flycatcher guilds were all associated with densely vegetated sites. Ground-feeding insectivores prefer areas with little ground vegetation and thick litter (Bock *et al.* 1992). Members of the flycatcher family typically prefer open environments that facilitate sallying for insect prey (McCarty 1996; Murphy 1996). However, the most abundant flycatcher on the study area, the least flycatcher, is associated with dense and closed canopy forests away from disturbances and openings (Briskie 1994). Faanes and Andrew (1983) found that the least flycatcher was the most numerous breeding bird species in North Dakota's trembling aspen forest. It is possible that when flycatchers were grouped as a guild for analysis, the preferences of the least flycatcher may have outweighed those of the other species. Greatest bird species diversity was reached at Douglas. In ordinations, this site was centrally located, being of moderate density, and may have been a heterogeneous mix of densely-vegetated and open areas. The high standard deviations associated with all height intervals of vertical cover support this notion.

Environmental variables associated with vegetation density had the greatest bearing on the characteristics of the bird community. Others, including basal area of green ash, western cottonwood, balsam poplar, nannyberry, hawthorn, chokecherry, Saskatoon, and pincherry, and height of overstory vegetation, appeared to be less influential. Snag density had surprisingly little effect on the presence of cavity-nesting birds. Downy woodpecker, eastern bluebird, and yellow-bellied sapsucker were positively associated with snag density, while white-breasted nuthatch, house wren, least flycatcher, great-crested flycatcher, wood duck, hairy woodpecker, yellow-shafted flicker and unknown woodpeckers had a negative or no association. Rumble and Gobeille (1998) found that snag density was not a good predictor of cavity-nesting birds in South Dakota prairie woodlands (Rumble and Gobeille 1998). On their study area, cavity-nesters made use of dead branches in otherwise living trees.

5.3 Objective 3: Effects of grazing on the bird community

Livestock grazing appears to have produced sites with more open vegetation in the Pembina Valley. In turn, differences in the composition and structure of the plant community between grazed and ungrazed sites can be expected to influence the nature of the Pembina Valley bird community. Again, it is important to note that inherent similarities in grazed sites may have been partially responsible for similarities in vegetative characteristics and bird communities.

5.3.1 Plant Community: Species composition

The effects of grazing on tree regeneration has been documented. Glinski (1977) found that excessive grazing pressure prevented the establishment of tree seedlings in Arizona, producing an even-aged non-reproducing vegetative community. Reproduction of many riparian tree species is often eliminated by grazing because young seedlings are preferred browse for cattle. As a result, the influence of livestock on the establishment and survival of tree seedlings may affect succession patterns of riparian woodlands (Sedgwick and Knopf 1987).

Grazing affected regeneration of the four most common tree species (bur oak, green ash, trembling aspen, Manitoba maple) on the study area and is therefore apt to affect the character of the plant community over time. All four species on grazed sites were regenerating to some degree, as evidenced by the presence of individuals in the lowest size class and by the presence of tree seedlings in shrub counts. There was greater regeneration of trembling aspen on grazed plots than on ungrazed plots. With roots capable of producing new shoots through suckering, regeneration in this species is encouraged by periodic or moderate levels of disturbance. Trembling aspen has been shown to decrease under heavy grazing pressure (ERDA n.d.). Green ash regeneration was lower on grazed sites. Rumble and Gobeille (1998) found that regeneration of this species decreased under grazing in South Dakota. Bur oak seedlings occurred on half as many grazed as ungrazed plots. Although the intensity of grazing on the Pembina Valley study area is permitting some degree of tree regeneration, it may alter tree species composition in the long term.

Herbaceous and shrub species diversity was similar on grazed and ungrazed sites. Other studies of the influence of grazing on plant species richness have found that grazing encourages diversity of herbaceous species (Dobson 1973; Hayes 1978; Kauffman and Krueger 1984), often by reducing vegetation density and creating more niches for opportunistic species to become established (Dobson 1973). Although similar in diversity, grazed and ungrazed sites were somewhat different in species composition.

Grasses were the dominant herbaceous species on the majority of grazed plots. Members of the grass family have their growing points located at ground level (Goudie 1994). Since this part is unlikely to be damaged by grazing, regrowth continues as leaf material is removed. Grazing slows growth of forbs as it removes growing points at the apex of their leaves, and gives grasses the competitive advantage. On ungrazed sites, Wild sarsaparilla was the dominant species. This is a common understory species of prairie woodlands and prefers shaded locations (Vance *et al.* 1999).

Western snowberry was the dominant shrub on grazed sites. This species prefers open habitats and has been found to increase under grazing, since it is unpalatable and overgrazing speeds root spread (ERDA n.d.). Hazelnut was dominant on ungrazed plots and is associated with moist but well-drained sites in thickets or woods (Johnson *et al.* 1995).

5.3.2 Plant Community: Structure

Grazing influenced the structure of the Pembina Valley plant community by reducing vertical cover, shrub density, understory height, and percent canopy cover, and by increasing percent ground cover. Alterations to the shrub layer as a result of livestock grazing are generally believed to have the greatest impact on bird species and have been well-documented (Marcuson 1977; Knopf and Cannon 1982; Taylor 1986; Schultz and Leininger 1991; Ammon and Stacey 1997; Rumble and Gobeille 1998). Grazing has been found to reduce the vertical diversity of woodlands (Ammon and Stacey 1997), to reduce shrub height, volume and cover (Knopf and Cannon 1982; Taylor 1986; Schultz and Leininger 1991), and to reduce shrub production (Marcuson 1977; Rumble and Gobeille 1998). Grazed sites Sutton, Dekoninck, Crayston, and Steel tended to have lower percent vertical cover, shrub density, understory height, percent canopy cover and highest percent ground cover.

At moderate levels, grazing may be desirable to open vegetation and increase diversity and patchiness (Ryder 1980). At higher intensities, this potentially positive affect is negated by the removal of vegetation and the frequent elimination of the entire shrub layer. On the Pembina Valley study area, two of the grazed sites (Howell and Dekoninck) were extremely patchy, as reflected in the high standard deviations in shrub density and vertical cover. Dense clumps of unpalatable hazelnut present on these sites were avoided by cattle, and as a result, a portion of the shrub layer remained despite grazing. Although grazing reduced vertical cover, shrub density, and understory height on sites overall, it may have also improved the structural diversity of those sites with abundant hazelnut.

5.3.3 Influence of grazing-related changes in vegetation on bird community

Numerous studies have documented the influences of livestock grazing on bird species diversity, species richness, and abundance (Kauffman 1982; Kauffman *et al.* 1982; Mosconi and Hutto 1982; Taylor 1986; Schultz and Leininger 1991), but have produced inconsistent results. In the Pembina Valley, avian abundance, species richness and diversity were comparable on grazed and ungrazed sites, suggesting that grazing had little effect on these variables. This is similar to the findings of Schultz and Leininger (1991) who determined that grazed areas and exclosures had similar bird species diversity and identical abundance on their Colorado study area. Mosconi and Hutto (1982) found no difference in bird density on lightly grazed and heavily grazed pastures in Montana. Other research suggests a negative influence of grazing on avian communities (Kauffman 1982; Kauffman *et al.* 1982; Taylor 1986), which once removed, results in increased bird abundance and species richness

Based on bird species composition, grazed and ungrazed treatments in the Pembina Valley were 80% similar. Although treatments were similar in abundance, species richness and diversity, the bird species comprising the grazed and ungrazed bird communities differed. In other studies, forage removal resulting from livestock grazing has been found to encourage some bird species, and discourage others (Kauffman *et al.* 1982; Bock *et al.*

1992), even where the number of individuals and number of species have been similar (Mosconi and Hutto 1982; Schultz and Leininger 1991).

Clay-colored sparrow, chipping sparrow, and American crow were associated with grazed sites, according to both ordinations and relative abundance. Clay-colored sparrow and chipping sparrow both forage in open shrubland, thickets along waterways, and forest edges and burns (Knapton 1996; Middleton 1998). Clay-colored sparrows are attracted to patchy shrub cover (Faanes and Andrew 1983), often created by grazing (Knopf *et al.* 1988b). Chipping sparrows have been found to respond negatively to grazing (Bock *et al.* 1992) and there are several reasons why this species may persist on grazed sites. It may be utilizing pastures for foraging sites while nesting elsewhere (Knopf and Samson 1994). Anderson *et al.* (1984) suggested that the interface between riparian and agricultural areas provides habitat for more species than either system alone, since elements of both systems are combined. Many passerines also exhibit site tenacity, returning to the same location for breeding even when reproductive success is poor (Van Horne 1983). American crow populations have increased in recent years as a result of human-induced changes in the landscape (Wilcove 1985). This species is commonly found along forest edges and in small forest fragments in agricultural landscapes (Wilcove 1985; Small and Hunter 1988).

Veery, common yellowthroat and gray catbird showed an affinity for ungrazed sites. Veeries prefer the dense understory of undisturbed forest (Moskoff 1995) and are discouraged by grazing (Bock *et al.* 1992). In northern Minnesota, this species decreased in abundance with increasing site openness (Canterbury and Blockstein 1997). Sedgwick and Knopf (1987) found common yellowthroats responded negatively to grazing on their northeastern Colorado study area. They suggested use of this species as an ecological indicator of habitat quality in lowland floodplains of the Great Plains. Gray catbirds typically inhabit dense shrubby areas, nesting in low dense growth at the edges of woods, fields, streams or lakes (Stokes 1979). Studies of the influence of grazing on this species have produced inconsistent results (Bock *et al.* 1992).

Some differences in the representation of foraging guilds were evident. Omnivores and ground-feeding seed-eaters were associated with grazed sites, whereas ground-feeding insect-eaters and foliage gleaners were associated with ungrazed sites. Members of the corvid family often forage in grazed and agricultural environments (Wilcove 1985) and ground foragers preferring areas with less cover have been shown to increase under grazing (Bock *et al.* 1992). Birds that feed predominantly on insects on the ground prefer the thick litter layer more commonly found on ungrazed sites (Bock *et al.* 1992). Mosconi and Hutto (1982) determined that ground-foraging and foliage-gleaning insectivores were most affected by grazing in Montana. In general, aerial, bark, and canopy insectivores appear to be less influenced than species feeding on nectar, insects or seeds in the understory or on the ground (Bock *et al.* 1992). Individuals in the guild nesting on or near the ground were more abundant on ungrazed sites. Species that nest in heavy shrub or herbaceous ground cover have been found to decrease under grazing (Bock *et al.* 1992).

Habitat heterogeneity is an important determinant of bird species richness, abundance and diversity at a site (McArthur and McArthur 1961; Roth 1976; Knopf et al 1988a; Knopf *et al.* 1988b). Woodlands tend to be naturally patchy due to openings in the canopy created by death of older trees and other small-scale disturbance (Smith 1996). These openings result in understory vegetation that differs in structure and composition from closed canopy areas, thereby increasing the overall habitat diversity of the woodland. In contrast, heavy grazing often simplifies a site in its structure and composition, converting woodland areas to contiguous expanses of short grass with some canopy cover.

Grazed sites in the Pembina Valley were fairly heterogeneous due largely to the clumping of shrub cover, and this apparent patchiness may be partially responsible for the similarities in bird species richness, abundance, and diversity of grazed and ungrazed treatments. Such variability in vegetation structure has been observed in other studies of grazing influences and may be attributed to a number of factors (Ryder 1980; Knopf *et al.* 1988b). Grazing at moderate levels often exerts a positive influence on vegetation and the bird community, by opening the canopy, encouraging structural diversity, and providing more habitats for birds (Ryder 1980). Topography may also encourage patchy vegetation, extreme slopes being avoided by cattle in favour of more gradual ones. The presence of unpalatable shrub species that are avoided by cattle may also result in large patches of vegetation being left intact. In particular, Howell and Dekoninck contained dense clumps of beaked hazelnut and were the most variable in characteristics related to vegetation density. Although patchy habitats may attract a greater diversity of bird species, they have also been found to permit greater accessibility to nest predators (Ammon and Stacey 1997) and to preclude use of grazed habitats by habitat specialists (Knopf *et al.* 1988b).

In the Pembina Valley, grazed sites and ungrazed sites are similar in bird species diversity at the within-habitat or site diversity level. Caution must be exercised when using diversity as the sole indicator of habitat quality. Based on this measure alone, grazed and ungrazed habitats may be interpreted as being of comparable quality (Van Horne 1983). However, site or alpha diversity can provide misleading views about the ecological value of a specific tract. First, it is often calculated to include information on the relative abundance of species; whereas generalist species tend to be the most common locally (Knopf and Samson 1994) and may dilute information on unique species. Second, simple abundance measures may also reflect past rather than current habitat quality, due to site tenacity in passerine birds (Hilden 1965; Rotenberry and Wiens 1978). Third, alpha diversity measures are insensitive to bird species composition (Knopf and Samson 1994), generalist and specialist species being counted equally. At the beta-diversity level, grazing may appear to exert an even more positive influence on bird communities. Since grazing provides habitat for a slightly different assemblage of species, it effectively improves between-habitat diversity. If used alone, within- and between-habitat diversity may produce erroneous conclusions on the influence of grazing on habitat quality.

Chapter 6 Summary and Recommendations

Variables related to vegetation density appear to be most important to habitat associations of Pembina Valley birds. To some extent, livestock grazing was found to influence these variables and produce comparatively more open sites that were preferred by some bird species and avoided by others. Although differences in bird species richness and abundance on grazed and ungrazed sites were negligible, individual bird species and guilds varied somewhat in their responses to grazing. Presently, only those species most sensitive to grazing are absent from grazed bird communities. This is attributed to remaining patches of shrub cover as a result of moderate grazing intensity, steep slopes and unpalatable shrub species in the Pembina Valley, that enabled shrub-dependent birds to persist on grazed sites.

6.1 Study Design Recommendations

Conduct sampling in riparian areas of various widths

The decision to limit study sites to woodland areas >200m wide had several drawbacks. First, it did not enable us to gain information on avian use of riparian habitats of narrower width, and these habitats are by far the most common in southwestern Manitoba. Second, so few areas of this width were available that obtaining a sufficient number of study sites required using all possible locations, some of which differed substantially in vegetation. This resulted in high variability in habitat characteristics. Third, being so restricted in possible study site locations, many grazed sites were coincidentally located on south-facing slopes and ungrazed on north-facing slopes. Aspect may therefore have confounded the influence of grazing on bird communities.

Sample the avian community using fixed-radius circular plots

To sample various widths of riparian habitat, a different sampling methodology may be required. The requirement for sites to be located in woodlands >200m wide was due to use of the unlimited radius point count method. This width ensures to a large degree that all birds detected are located within the habitat type being sampled. Fixed-radius circular plots require a smaller area of continuous habitat if the desire is to survey birds within the patch (Petit *et al.* 1997).

Sample the avian community outside of the breeding season

Any future work conducted on riparian bird communities in this part of Manitoba should perform sampling during winter, spring and fall. Many resident species are more active in spring, and a more accurate estimate of abundance and species richness is likely to be obtained at this time. During migration, the Pembina Valley may be an important corridor for forest birds travelling through a predominately agricultural landscape.

Measure distance to tributaries

On some sites, fairly distinct plant communities were associated with creeks, and these tributaries may permit a somewhat unique assemblage of bird species. American redstart and Northern waterthrush in particular have a high affinity for water (Eaton 1995; Sherry and Holmes 1997) and distributions of these species may be related to this variable. Forest moisture and distance to water have been found to be important determinants of avian habitat use (Svardson 1949; Smith 1977; Swift *et al.* 1984).

Assess reproductive success of Pembina Valley birds

Any notion of habitat quality should include a measure of offspring production and survival (Van Horne 1983). Livestock not only affects the availability of nesting and foraging substrates through changes in vegetation structure and composition, but may exert equal or greater effects by facilitating nest predation and parasitism (Ammon and Stacey 1997). Reduced reproductive success may be the result of increased detectability of nests and through changes in the predator community (Ammon and Stacey 1997). As well as determining rates of nest predation and parasitism, studies of the influence of livestock grazing on breeding birds should include examination of habitat variables involved in nest detection, composition and abundance of predators, and predator behaviour (Bock *et al.* 1992; Ammon and Stacey 1997). Assessment of the reproductive success of birds nesting in the Pembina Valley will provide more information than bird species diversity alone on the possible effects of grazing on habitat quality.

6.2 Management Recommendations

Habitat management should maximize regional diversity over within- and between-site diversity.

Heterogeneous habitats encourage a diverse assemblage of species, and management that increases heterogeneity will increase the number of bird species using a habitat (Schulz and Leininger 1991). Land uses that influence vegetation structure, such as livestock grazing and sustainable forest management, may improve habitat patchiness and increase within- and between-habitat diversity in the Pembina Valley. However, such management may reduce regional avian diversity since patchy habitats are avoided by some habitat specialists (Knopf *et al.* 1988b). Habitat management strategies should address the needs of species with narrow habitat requirements and generalist species more flexible in their requirements will follow (Taylor 1986; Sedgwick and Knopf 1987; Schulz and Leininger 1991; Knopf and Samson 1992). Species such as the veery, yellow-throated vireo, common yellowthroat and gray catbird are most likely to respond negatively to grazing, the first two preferring areas of mature forest and the latter preferring willow-shrub communities. Sustainable forest management and managed grazing regimes may be suitable tools to ensure these habitat types remain. With respect to avian habitat considerations, land managers must be particularly aware of potential ecological traps (Gates and Giffen 1991). Since patchy habitats have been shown to be attractive to nest predators and cowbirds (Thompson *et al.* 1992; Ammon and Stacey 1997), attracting species to breed and nest in these areas may be detrimental in the long term since declines in reproductive success may occur.

If grazing is used as a habitat management tool, cattle should be prevented from accessing shorelines directly.

The well-developed willow-shrub community used by gray catbird and common yellowthroat will be maintained by preventing cattle access to shorelines. This action has the added benefit of meeting objectives related to improved water quality, recreation opportunities, and fish habitat.

Encourage sustainable forest management as a means of maintaining forest cover on the landscape.

Due to the importance of the Pembina Valley to forest-dependent species, management that maintains forest cover on the landscape is critical. Use of these forests by generalist species suggests that they may serve as important temporary havens for birds of neighbouring areas that experience significant habitat loss or perturbation. Over time, livestock grazing will convert woodlands to open pasture through the continuous removal of tree seedlings (Sedgwick and Knopf 1987), and would result in a significant loss of forest-dependent birds (Stauffer and Best 1980). By providing a means for landowners to derive economic gains from their riparian woodlands, small-scale logging may provide an incentive to conserve forested areas and maintain this type of cover on the landscape.

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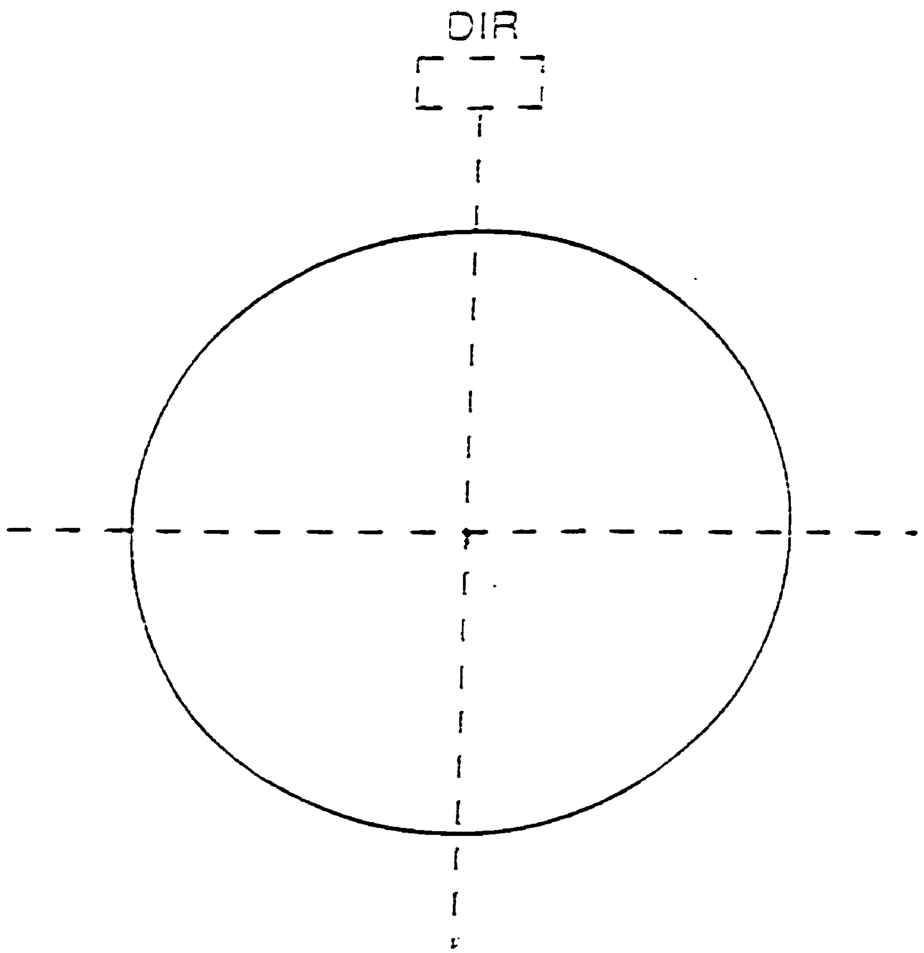
Appendices

Appendix A
Data sheet used to record location of birds during point counts

POINT COUNT LOCATION MAPPING

Station__________ Point__________ Date_________

Starting Time _____



MAPPING SYMBOLS

(AR) position of a singing male AMRO

AR position of a non-singing AMRO heard calling or seen

(AR)—| |—(AR) two counter singing AMROs

AR —| |— AR 2 different non-singing AMROs

—AR→ *Flyover AMRO*

black ink 0-3 minutes
red ink 3-5 minutes
pencil 5-10 minutes

(AR)—| |—AR two different AMROs one singing one not

(AR) ⟶ (AR) change of position of a singing AMRO

AR^2 two AMROs at the same place

MAPS-6a 4/92

Appendix B
Species assignments to foraging and nesting guilds

Foraging Guilds

Omnivores
American crow
Black-billed magpie
Blue jay

Seed-eaters on ground
American goldfinch
Brown-headed cowbird
Chipping sparrow
Clay-coloured sparrow
Mourning dove
Ruffed grouse
Eastern towhee
Song sparrow

Invertebrate-eaters on or near ground
American robin
Common yellowthroat
Connecticut warbler
Gray catbird
House wren
Northern waterthrush
Ovenbird
Veery

Foliage gleaners >1m
American redstart
Cedar waxwing
Northern oriole
Orange-crowned warbler
Red-eyed vireo
Rose-breasted grosbeak
Warbling vireo
Yellow-throated vireo
Yellow-warbler

Trunk/branch/bark gleaners
Black-and-white warbler
Black-capped chickadee
Common flicker
Downy woodpecker
Hairy woodpecker
Unknown woodpeckers
White-breasted nuthatch
Yellow-bellied sapsucker

Aerial flycatchers
Eastern bluebird
Eastern kingbird
Eastern phoebe
Eastern wood pewee
Great-crested flycatcher
Least flycatcher

Aquatic organisms
Belted kingfisher
Wood duck

Nectar-eaters
Ruby-throated hummingbird

Predators
Red-tailed hawk

References: Holmes 1979; Dobkin 1994; Eaton 1995; Murphy 1996; Robinson et al. 1996; Sherry and Holmes 1997

Nesting guilds

On or near ground
Black-and-white warbler
Common yellowthroat
Connecticut warbler
Northern waterthrush
Orange-crowned warbler
Ovenbird
Ruffed grouse
Eastern towhee
Song sparrow
Veery

In shrub cover
American goldfinch
Clay-coloured sparrow
Gray catbird
Yellow warbler

In trees
American crow
American redstart
American robin
Black-billed magpie
Blue jay
Cedar waxwing
Chipping sparrow
Eastern kingbird
Eastern wood peewee
Ruby-throated hummingbird
Mourning dove
Northern oriole
Red-eyed vireo
Red-tailed hawk
Rose-breasted grosbeak
Warbling vireo
Yellow-throated vireo

Cavity-nesters
Black-capped chickadee
Common flicker
Downy woodpecker
Eastern bluebird
Great-crested flycatcher
Hairy woodpecker
House wren
Least flycatcher
Unknown woodpeckers
White-breasted nuthatch
Wood duck
Yellow-bellied sapsucker

Cliffs, banks
Eastern phoebe
Belted kingfisher

Brood parasites
Brown-headed cowbird

References: Stokes 1979; Stokes and Stokes 1983; Stokes and Stokes 1989; Dobkin 1994; Degraaf and Rappole 1995

Appendix C
Environmental variables used in Canonical Correspondence Analysis.

Environmental Variable	*Description*
BUR_OAK	mean basal area per plot of all bur oak individuals >5cm dbh
GREENASH	mean basal area per plot of all green ash individuals >5cm dbh
MAN_MAP	mean basal area per plot of all Manitoba maple individuals >5cm dbh
TREMASPN	mean basal area per plot of all trembling aspen individuals >5cm dbh
AMERELM	mean basal area per plot of all American elm individuals >5cm dbh
BAL_POP	mean basal area per plot of all balsam poplar individuals >5cm dbh
WHITBIRC	mean basal area per plot of all white birch individuals >5cm dbh
WESTCOTT	mean basal area per plot of all western cottonwood individuals >5cm dbh
CHOCHERR	mean basal area per plot of all chokecherry individuals >5cm dbh
HAWTHORN	mean basal area per plot of all hawthorn individuals >5cm dbh
NANBERRY	mean basal area per plot of all nannyberry individuals >5cm dbh
PINCHERR	mean basal area per plot of all pincherry individuals >5cm dbh
SASKTOON	mean basal area per plot of all Saskatoon individuals >5cm dbh
DEAD1	mean basal area per plot of all snags in Decay Class 1 >5cm dbh
DEAD2	mean basal area per plot of all snags in Decay Class 2 >5cm dbh
DEAD3	mean basal area per plot of all snags in Decay Class 3 >5cm dbh
SHRUBS	mean number of shrub stems per $10m^2$ sub-plot <5cm dbh
GRDCVR	mean % ground cover per plot
CANCVR	mean % canopy cover per plot
VTCOVER*	mean % cover for all height classes combined
UNDRHT	mean height in meters per plot of understory vegetation
OVERHT	mean height in meters per plot of overstory vegetation

* Four height classes originally used were found to be redundant in preliminary analyses and were therefore combined into a single variable for CCA.

Appendix D
Number, mean dbh and density of all tree species recorded on Pembina Valley study area.

Sites	Bur Oak			Green Ash			Manitoba Maple			Trembling Aspen			American Elm			Balsam Poplar			White Birch			Cottonwood			#
	mean dbh	n	mean #/plot	mean dbh	n	mean #/plot	mean dbh	n	mean #/plot	mean dbh	n	mean #/plot	mean dbh	n	mean #/plot	mean dbh	n	mean #/plot	mean dbh	n	mean #/plot	mean dbh	n	mean #/plot	plots
Grazed sites																									
Sutton	22.0	461	23.1	23.4	91	4.6	20.1	4	0.2																20
Crayston	27.1	153	11.8	19.2	156	12.0							23.8	10	0.8										13
Howell	26.1	4	0.4	19.3	112	11.2	21.5	25	2.5	23.1	14	1.4	17.9	3	0.3										10
Steel	21.2	105	7.0	33.6	6	0.4				15.1	152	10.1													15
Dekoninck	22.5	92	6.1				18.7	46	3.1	20.7	9	0.6	7.2	1	0.1				26.8	3	0.2	31.5	2	0.1	15
																									73
Ungrazed sites																									
Crayston	26.5	63	6.3	16.5	106	10.6	9.4	1	0.1	29.0	22	2.2	22.9	10	1.0										10
Douglas	16.4	202	22.4	12.6	90	10.0				23.8	7	0.8							12.9	3	0.3				9
Bell	21.2	21	2.1	16.0	120	12.0				17.3	9	0.9													10
WMA	13.7	5	0.3	13.2	283	18.9	12.4	4	0.3	23.6	58	3.9							27.2	4	0.3				15
Shaw	20.5	17	1.7	12.0	160	16.0				21.6	106	10.6													10
Friesen				24.8	65	6.5	20.3	49	4.9																10
Dearsley	22.2	19	1.9	15.0	56	5.6	16.1	6	0.6	18.2	87	8.7				19.7	8	0.8	28.6	1	0.1				10
																									74

Sites	Chokecherry			Hawthorn			Nannyberry			Pincherry			Saskatoon		
	mean dbh	n	mean #/plot	mean dbh	n	mean #/plot	mean dbh	n	mean #/plot	mean dbh	n	mean #/plot	mean dbh	n	mean #/plot
Grazed sites															
Sutton															
Crayston															
Howell															
Steel							7.6	3	2.6						
Dekoninck	6.0	13	0.9	6.3	6	0.4									
Ungrazed sites															
Crayston	10.1	3	0.3												
Douglas	7.6	1	0.1												
Bell	6.8	24	2.4							8.9	2	0.2			
WMA	7.2	16	1.1												
Shaw	6.7	19	1.9							7.7	19	1.9			
Friesen	7.0	24	2.4												
Dearsley	6.9	35	3.5										6.0	1	0.1

Appendix E

Total cumulative basal area of tree species sampled on Pembina Valley study area and used in CA.

	BUR_OAK	GREENASH	MAN_MAP	TREMASPN	AMERELM	BAL_POP	WHITBIRC	WESTCOTT	CHOCHERR	HAWTHORN	NANNBERR	PINCHERR	SASKTOON	Total # species	n
Grazed sites															
Sutton	9626.92	21.68	39.55	0	0	0	0	0	0	4.31	0	0	0	**4**	20
Crayston	8027.51	4617.79	0	0	374.54	0	0	0	0	0	0	0	0	**3**	13
Howell	222.41	3755.44	1026.09	739.98	80.50	0	0	0	0	0	0	0	0	**5**	10
Steel	2752.27	474.72	0	2242.17	0	0	0	0	0	0	121.18	0	0	**4**	15
Dekoninck	2750.49	0	983.19	249.25	2.69	0	144.33	107.62	25.02	12.80	0	0	0	**8**	15
															73
Ungrazed sites															
Crayston	4181.59	2606.71	6.93	1498.05	502.12	0	0	0	24.61	0	0	0	0	**6**	10
Douglas	4662.82	1294.37	0	378.41	0	0	42.46	0	4.58	0	0	0	0	**5**	9
Bell	840.41	2730.13	0	254.19	0	0	0	0	89.81	0	0	12.67	0	**5**	10
WMA	53.23	2875.42	33.80	1948.33	0	0	175.72	0	44.18	0	0	0	0	**6**	15
Shaw	655.78	2168.79	0	4020.98	0	0	0	0	67.93	0	0	91.92	0	**5**	10
Friesen	0	3587.18	1842.59	0	0	0	0	0	95.82	0	0	0	0	**3**	10
Dearsley	826.52	1204.78	132.95	2674.66	0	313.23	64.46	0	136	0	0	0	2.87	**8**	10
															74

Appendix F

Number, mean dbh and density of snags by site.
Decay Class 1=all branches and some smaller twigs remain
Decay Class 2 =most branches remaining
Decay Class 3=trunk only remaining

Sites	Decay Class 1			Decay Class 2			Decay Class 3			
	mean dbh	n	mean/ plot	mean dbh	n	mean/ plot	mean dbh	n	mean/ plot	# plots
Grazed sites										
Sutton	16.71	145	7.3	12.97	47	2.4	11.48	37	1.9	20
Crayston	18.37	36	2.8	20.27	11	0.8	19.93	18	1.4	13
Howell	15.44	5	0.5	24.31	4	0.4	7.32	1	0.1	10
Steel	15.92	41	2.7	12.50	15	1	24.18	27	1.8	15
Dekoninck	18.96	10	0.7	14.16	3	0.2	19.16	8	0.5	15
										73
Ungrazed sites										
Crayston	17.44	25	2.5	16.29	8	0.8	20.39	7	0.7	10
Douglas	12.83	22	2.2	11.60	23	2.3	16.42	36	3.6	9
Bell	10.74	8	0.8	14.56	16	1.6	19.23	16	1.6	10
WMA	13.26	12	0.8	18.21	12	0.8	21.32	29	1.9	15
Shaw	14.81	25	2.5	19.57	16	1.6	15.67	46	4.6	10
Friesen	28.41	10	1	39.05	15	1.5	25.88	12	1.2	10
Dearsley	15.13	16	1.6	13.45	12	1.2	15.43	31	3.1	10
										74

Appendix G
Herbaceous and shrub species ranked as abundant (1 of 5 most common species on a plot) and dominant (most common species on a plot) on grazed and ungrazed sites

Grazed Herbs

Common Name	Scientific Name	Abundant	%	Dominant	%
Grasses	*Graminaceae*	73	100.0%	71	97.3%
Northern bedstraw	*Galium boreale*	51	69.9%	0	0
Canada violet	*Viola canadensis*	45	61.6%	0	0
Meadow rue	*Thalictrum sp.*	38	52.1%	0	0
Common dandelion	*Taraxacum officinale*	27	37.0%	0	0
Yellow wood sorrel	*Oxalis stricta*	19	26.0%	0	0
Vetch	*Vicia sp.*	17	23.3%	0	0
Wild strawberry	*Fragaria sp.*	11	15.1%	0	0
Wild sarsaparilla	*Aralia nudicaulis*	9	12.3%	2	2.7%
White clover	*Trifolium repens*	8	11.0%	0	0
Wild mint	*Mentha sp.*	7	9.6%	0	0
Sweet-scented bedstraw	*Galium triflorum*	7	9.6%	0	0
Common plantain	*Plantago major*	6	8.2%	0	0
Black snakeroot	*Sanicula marilandica*	6	8.2%	0	0
Wild bergamot	*Monarda fistulosa*	5	6.8%	0	0
Yellow sweet clover	*Melilotus officinalis*	5	6.8%	0	0
Canada thistle	*Cirsium arvense*	3	4.1%	0	0
False Solomon's Seal	*Smilacina racemosa*	2	2.7%	0	0
Wild cucumber	*Echinocystis lobata*	2	2.7%	0	0
Harebell	*Campanula rotundifolia*	2	2.7%	0	0
Bluebur		3	4.1%	0	0
Sweet cicily	*Osmorhiza claytoni*	2	2.7%	0	0
Two-leaved Solomon's Seal	*Maianthemum canadense*	1	1.4%	0	0
Common burdock	*Arctium minus*	1	1.4%	0	0
Columbine	*Aquilegia canadensis*	1	1.4%	0	0
Pussytoes	*Antennaria neglecta*	1	1.4%	0	0
Dewberry	*Rubus pubescens*	1	1.4%	0	0
Black medick	*Medicago lupulina*	1	1.4%	0	0
Milkweed	*Asclepias syriaca*	1	1.4%	0	0
Wild licorice	*Glycccyrrhiza lepidota*	1	1.4%	0	0
Silverweed	*Potentilla arvense*	1	1.4%	0	0
Leafy spurge	*Euphorbia esula*	1	1.4%	0	0
				73	

Ungrazed Herbs

Common Name	Scientific Name	Abundant	%	Dominant	%
Wild sarsaparilla	*Aralia nudicaulis*	59	79.7%	34	45.9%
Grass	*Graminoid sp.*	58	78.4%	31	41.9%
Northern bedstraw	*Galium boreale*	41	55.4%	1	1.4%
Meadow rue	*Thalictrum sp.*	32	43.2%	0	0
Poison ivy	*Rhus radicans*	24	32.4%	0	0
Wild strawberry	*Fragaria sp.*	20	27.0%	0	0
Sweet-scented bedstraw	*Galium triflorum*	20	27.0%	0	0
Two-leaved SS	*Maianthemum canadense*	17	23.0%	0	0
Black snakeroot	*Sanicula marilandica*	16	21.6%	0	0
Dewberry	*Rubus pubescens*	14	18.9%	0	0
Goldenrod	*Solidago sp.*	11	14.9%	1	1.4%
Canada thistle	*Cirsium arvense*	8	10.8%	0	0
Kidney-leaved violet	*Viola primulifolia*	8	10.8%	0	0
Wood nettle	*Laportea canadensis*	8	10.8%	6	8.1%
Columbine	*Aquilegia canadensis*	6	8.1%	0	0
Baneberry	*Actaea pachypoda*	5	6.8%	0	0
Stinging nettle	*Urtica dioica*	5	6.8%	1	1.4%
Bunchberry	*Cornus canadensis*	3	4.1%	0	0
Sweet cicily	*Osmorhiza claytoni*	3	4.1%	0	0
Vetch	*Vicia sp.*	2	2.7%	0	0
False Solomon's Seal	*Smilacina racemosa*	2	2.7%	0	0
Yellow wood sorrel	*Oxalis stricta*	1	1.4%	0	0
White clover	*Trifolium repense*	1	1.4%	0	0
Common burdock	*Arctium minus*	1	1.4%	0	0
				74	

Grazed and Ungrazed Shrubs

Grazed Shrubs					
Common Name	*Scientific Name*	***Abundant***	***%***	***Dominant***	***%***
Western Snowberry	*Symphoricarpos occidentalis*	69	94.5%	44	60.3%
Saskatoon	*Amelanchier alnifolia*	59	80.8%	1	1.4%
Chokecherry	*Prunus virginiana*	30	41.1%	8	11.0%
Wild rose	*Rosa sp.*	22	30.1%	0	0.0%
Beaked hazelnut	*Corylus cornuta*	22	30.1%	12	16.4%
Hawthorn	*Crataegus chrysocarpa*	20	27.4%	1	1.4%
Oak seedlings	*Quercus macrocarpa*	20	27.4%	0	0.0%
Elm seedlings	*Ulmus americana*	19	26.0%	0	0.0%
Trembling aspen seedlings	*Populus tremuloides*	13	17.8%	1	1.4%
Manitoba maple seedlings	*Acer negundo*	11	15.1%	1	1.4%
Mountain ash	*Sorbus americana*	5	6.8%	4	5.5%
Red osier dogwood	*Cornus stolonifera*	5	6.8%	1	1.4%
Green ash seedlings	*Fraxinus pennsylvanica*	5	6.8%	0	0.0%
Red currant	*Ribes triste*	3	4.1%	0	0.0%
Nannyberry	*Viburnum lentago*	3	4.1%	0	0.0%
Silverberry	*Elaeagnus commutata*	3	4.1%	0	0.0%
Skunk currant	*Ribes glandulosum*	2	2.7%	0	0.0%
Soapberry	*Shepherdia canadensis*	1	1.4%	0	0.0%
Pincherry	*Prunus pensylvanica*	1	1.4%	0	0.0%
Highbush cranberry	*Viburnum opulus*	1	1.4%	0	0.0%
Raspberry	*Rubus strigosus*	1	1.4%	0	0.0%
		315		73	

Ungrazed Shrubs					
Common Name	*Scientific Name*	Abundant	%	Dominant	%
Chokecherry	*Prunus virginiana*	64	86.5%	9	12.2%
Beaked hazelnut	*Corylus cornuta*	59	79.7%	51	68.9%
Saskatoon	*Amelanchier alnifolia*	59	79.7%	1	1.4%
Snowberry	*Symphoricarpos occidentalis*	58	78.4%	4	5.4%
Oak seedlings	*Quercus macrocarpa*	32	43.2%	0	0.0%
Green ash seedlings	*Fraxinus pennsylvanica*	25	33.8%	0	0.0%
Red osier dogwood	*Cornus stolonifera*	19	25.7%	0	0.0%
Elm seedlings	*Ulmus americana*	9	12.2%	0	0.0%
Manitoba maple seedlings	*Acer negundo*	9	12.2%	1	1.4%
Trembling aspen seedlings	*Populus tremuloides*	8	10.8%	0	0.0%
Wild rose	*Rosa sp.*	8	10.8%	0	0.0%
Ostrich fern	*Matteuccia struthiopteris*	7	9.5%	6	8.1%
Highbush cranberry	*Viburnum opulus*	5	6.8%	0	0.0%
Raspberry	*Rubus strigosus*	4	5.4%	1	1.4%
Caragana	*Caragana arborescens*	2	2.7%	1	1.4%
Pincherry	*Prunus pensylvanica*	2	2.7%	0	0.0%
Red currant	*Ribes triste*	2	2.7%	0	0.0%
Buffaloberry	*Shepherdia argentea*	1	1.4%	0	0.0%
		373		74	

Appendix H
Alphabetical list of all birds observed on Pembina Valley study area

Common name	Scientific Name
American crow	*Corvus brachyrhynchos*
American goldfinch	*Carduelis tristis*
American redstart	*Setophaga ruticula*
American robin	*Turdus migratorius*
American white pelican	*Pelecanus erythrorhynchos*
Bank swallow	*Riparia riparia*
Barn swallow	*Hirundo rustica*
Belted kingfisher	*Ceryle alcyon*
Black tern	*Chlidonias niger*
Black-and-white warbler	*Mniotilta varia*
Black-billed magpie	*Pica pica*
Black-capped chickadee	*Poecile atricapillus*
Black-throated green warbler	*Dendroica virens*
Blue jay	*Cyanocitta cristata*
Broad-winged hawk	*Buteo platypterus*
Brown thrasher	*Toxostoma rufum*
Brown-headed cowbird	*Molothrus ater*
Canada goose	*Branta canadensis*
Cedar waxwing	*Bombycilla cedrorum*
Chipping sparrow	*Spizella passerina*
Clay-coloured sparrow	*Spizella pallida*
Cliff swallow	*Hirundo pyrrhonota*
Common flicker	*Collaptes auratus*
Common grackle	*Quiscalus quiscula*
Common loon	*Gavia immer*
Common snipe	*Gallinago gallinago*
Common tern	*Sterna hirundo*
Common yellowthroat	*Geothlypis trichas*
Connecticut warbler	*Oporornis agilis*
Double-crested cormorant	*Phalacrocorax auritus*
Downy woodpecker	*Picoides pubescens*
Eastern bluebird	*Sialia sialis*
Eastern kingbird	*Tyrannus tyrranus*
Eastern phoebe	*Sayornis phoebe*
Eastern wood peewee	*Contopus virens*
Franklin's gull	*Larus pipixcan*
Gray catbird	*Dumetella carolinensis*
Great blue heron	*Ardea herodias*
Great-crested flycatcher	*Miarchus crinitus*
Hairy woodpecker	*Picoides villosus*
House wren	*Troglodytes aedon*
Killdeer	*Charadrius vociferus*
Least flycatcher	*Empidonax minimus*
Long-eared owl	*Asia otus*
Mallard	*Anas platyrhynchos*
Mourning dove	*Zenaida macroura*

Northern oriole	*Icterus galbula*
Northern waterthrush	*Seiurus noveboracensis*
Orange-crowned warbler	*Vermivora celata*
Ovenbird	*Seiurus aurocapillus*
Pileated woodpecker	*Dryocopus pileatus*
Red-eyed vireo	*Vireo olivaceus*
Red-tailed hawk	*Buteo jamaicensis*
Red-winged blackbird	*Agelaius phoeniceus*
Ring-billed gull	*Larus delawarensis*
Rock dove	*Columba livia*
Rose-breasted grosbeak	*Pheucticus ludovicianus*
Ruby-throated hummingbird	*Archilochus colubris*
Ruffed grouse	*Bonasa umbellus*
Rufous-sided towhee	*Pipilo erythrophthalmus*
Sharp-shinned hawk	*Accipiter striatus*
Song sparrow	*Melospiza melodia*
Sora	*Porzana carolina*
Tree swallow	*Tachycineta bicolor*
Veery	*Catharus fuscescens*
Warbling vireo	*Vireo gilvus*
Western grebe	*Aechmophorus occidentalis*
White-breasted nuthatch	*Sitta carolinensis*
Wood duck	*Aix sponsa*
Yellow warbler	*Dendroica petechia*
Yellow-bellied sapsucker	*Sphyrapicus varius*
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*
Yellow-rumped warbler	*Dendroica coronata*
Yellow-throated vireo	*Vireo flavifrons*

Appendix I

Species assignments for migratory status, distribution size and provincial abundance for birds detected during point count censuses

Common name	Code	Migrant?[a]	BR_size[b]	Provincial Abund. Rank[c]
American crow	AMCR	R/SD	1	1
American goldfinch	AMGO	N	3	1
American redstart	AMRE	N	2	1
American robin	AMRO	N	1	1
Belted kingfisher	BEKI	N	2	1
Black-and-white warbler	BAWW	N	2	1
Black-billed magpie	BBMA	R/SD	3	1
Black-capped chickadee	BCCH	R/SD	2	1
Blue jay	BLJA	R/SD	2	1
Brown-headed cowbird	BHCO	N	3	1
Cedar waxwing	CEDW	N	3	1
Chipping sparrow	CHSP	N	1	1
Clay-coloured sparrow	CCSP	N	4	1
Common flicker	YSFL	R/SD	1	1
Common yellowthroat	COYE	N	1	1
Connecticut warbler	CONW	N	4	2
Downy woodpecker	DOWO	R/SD	1	1
Eastern bluebird	EABL	N	3	2
Eastern kingbird	EAKI	N	2	1
Eastern phoebe	EAPH	N	3	1
Eastern wood peewee	EAWP	N	3	2
Gray catbird	GRCA	N	2	1
Great-crested flycatcher	GCFL	N	3	2
Hairy woodpecker	HAWO	R/SD	1	1
House wren	HOWR	N	1	1
Least flycatcher	LEFL	N	2	1
Mourning dove	MODO	N	2	1
Northern oriole	BAOR	N	3	1
Northern waterthrush	NOWA	N	2	1
Orange-crowned warbler	OCWA	N	3	1
Ovenbird	OVEN	N	3	1
Red-eyed vireo	REVI	N	2	1
Red-tailed hawk	RTHA	N	1	1
Rose-breasted grosbeak	RBGR	N	3	1
Ruby-throated hummingbird	RTHU	N	2	2
Ruffed grouse	RUGR	R/SD	3	1
Rufous-sided towhee	EATO	N	3	3
Song sparrow	SOSP	N	2	1
Veery	VEER	N	3	1
Warbling vireo	WAVI	N	1	1
White-breasted nuthatch	WBNU	R/SD	3	1
Wood duck	WODU	N	4	N/A
Yellow warbler	YWAR	N	1	1
Yellow-bellied sapsucker	YBSA	N	3	1
Yellow-throated vireo	YTVI	N	3	3

a Migratory status: N = neotropical migrant; R/SD = resident or short-distance migrant
b Distribution size as percentage of North America: 1 = >76%; 2 = 51-75%; 3 = 26-50%; 4 = 11-25%; 5 = <10%
c Provincial abundance rank: 1 = abundant; 2 = very common; 3 = common; 4 = uncommon; 5 = rare

Appendix J. Mean avian abundance values used in Correspondence Analysis and Canonical Correspondence Analysis calculated as the number of individuals of a species/station/site.

	Sutton	Crayston	Howell	Steel	Dekoninck	Crayston	Douglas	Bell	WMA	Shaw	Friesen	Dearsley
American crow	0.29	1.6	0.2	0.25	0.83	0.67	0.4	0.33	0	0.5	0	0.25
American goldfinch	0.71	0.8	0.6	1	0.83	0.33	0.4	0.83	0.33	0.75	0.67	0.25
American redstart	0.00	0	0	0	0.33	0.33	0.2	0.17	0	0.75	0	0
American robin	0.29	0.2	0.4	0.5	0.33	0	0	0	0	0	0.33	0.5
Belted kingfisher	0.00	0	0.4	0.5	0	0	0	0.17	0	0	0	0.25
Black-and-white warbler	0.00	0	0.4	0.25	0.67	0.33	0.2	0.33	0.33	0.25	0	0.5
Black-billed magpie	0.00	0	0	0	0.33	0	0	0	0	0	0	0
Black-capped chickadee	0.29	0.2	0.4	0.25	0.17	0	0.6	0.33	0	0	0	0
Blue jay	0.00	0	0	0.25	0.17	0	0	0.17	0	0	0	0
Brown-headed cowbird	0.71	0.8	0.8	1.25	1.33	0.67	1.4	1.17	1	0.25	1.67	0.25
Cedar waxwing	1.00	1	0.6	1.25	1.67	2	2.2	1.5	2.67	2.25	0.67	0.75
Chipping sparrow	1.14	1.6	0	0	0.67	1.33	0	0	0	0	0	0
Clay-coloured sparrow	2.00	1.6	0.4	1.75	1.67	2.33	0	0.17	0.33	0	0	0
Common flicker	0.00	0	0.2	0	0	0	0	0	0	0	0	0
Common yellowthroat	0.00	0	0	0.5	0	0	0	0.33	0	0	1.67	0.25
Connecticut warbler	0.00	0.2	0	0	0	0	0	0	0	0	0	0
Downy woodpecker	0.00	0	0	0.25	0	0	0	0	0	0	0.33	0
Eastern bluebird	0.00	0	0	0.25	0	0	0	0	0	0	0	0
Eastern kingbird	0.14	0	0	0	0.17	0	0	0	0	0	0	0
Eastern phoebe	0.00	0	0.2	0	0	0	0	0	0.33	0	0	0
Eastern wood pewee	0.43	0.2	0.4	0.5	0.83	1	0	0.67	0	0.5	0	0
Gray catbird	0.00	0	0	0.25	0	0	0	0.5	1.33	0.5	0	0.5
Great crested flycatcher	0.29	1	1.4	0.5	0.5	1.67	0.6	0.33	0.33	0.25	0.67	1.5
Hairy woodpecker	0.00	0.4	0	0	0	0	0.2	0	0.33	0.25	0	0
House wren	0.71	2	0.6	1	0.67	1.33	1.4	0.83	0.33	0.25	1.33	0.5
Least flycatcher	2.00	0	1.6	1.75	0.83	0.33	0.8	0.83	1.67	1.5	0	1.5
Mourning dove	0.00	0	0	1.25	1	0	0	0.5	0.33	0	1	0.5
Northern oriole	0.29	0	0.8	0.75	0	0	0.2	0.83	0.67	0.25	0	0.5
Northern waterthrush	0.43	0.2	0.4	0.75	0.5	0	0.4	0.67	0.33	1	0.67	0.25
Orange-crowned warbler	0.00	0	0	0	0.33	0	0	0.17	0	0	0	0
Ovenbird	0.00	0	0	0	0	0	0.2	0	0	0	0	0
Red-eyed vireo	1.29	1	1	1.25	1.83	2	2	1.33	1.67	0.25	0.67	1.25
Red-tailed hawk	0.14	0	0	0.5	0	0	0	0	0	0	0	0
Rose-breasted grosbeak	0.00	0	1	0	0.33	0	0	0.67	0	0.5	0	1
Ruby-throated hummingbird	0.00	0	0	0	0	0	0.2	0	0	0	0	0.25
Ruffed grouse	0.00	0	0	0.25	0	0	0.2	0.17	0.33	0	0	0
Rufous-sided towhee	0.14	0.6	0.6	0.5	0.5	1.33	0.4	0	0.33	0	0	0
Song sparrow	0.71	0.8	0.2	1	0.5	0.33	1	0.67	0	0.25	2	0
Veery	0.00	0	0	0	0	0	1.2	0	1.67	0.75	0	1.25
Warbling vireo	0.29	0	0.4	1.25	0.67	0	0	0.5	0.33	0.75	0.33	0.75
White-breasted nuthatch	0.71	0.4	0	0.5	0	0.67	0.4	0.33	0	0	0.67	0.75
Wood duck	0.00	0	0	0	0	0	0.2	0	0	0	0	0
Unknown woodpecker	0.14	0.2	0	0	0.17	0.67	0.4	0.17	0.67	0	0	1
Yellow warbler	4.14	2.8	4	2.75	2.83	4	3.6	4.67	4	4.5	3.33	2.75
Yellow-bellied sapsucker	0.00	0	0	0.25	0	0	0	0.17	0	0	0	0
Yellow-throated vireo	0.00	0	0	0.5	0	0	0	0.33	0	0.75	0	0.5

Appendix K
Environmental data used in Canonical Correspondence Analysis

	Sutton	Crayston	Howell	Steel	Dekoninck	Crayston	Douglas	Bell	WMA	Shaw	Friesen	Dearsley
Bur Oak	9626.92	8027.51	222.41	2752.27	2750.49	4181.59	4662.82	840.41	53.23	655.78	0	826.52
Green Ash	21.68	4617.79	3755.44	474.72	0	2606.71	1294.37	2730.13	2875.42	2168.79	3587.18	1204.78
Manitoba Maple	39.55	0	1026.09	0	983.19	6.93	0	0	33.8	0	1842.59	132.95
Trembling aspen	0	0	739.98	2242.17	249.25	1498.05	378.41	254.19	1948.33	4020.98	0	2674.66
American elm	0	374.54	80.5	0	2.69	502.12	0	0	0	0	0	0
Balsam poplar	0	0	0	0	0	0	0	0	0	0	0	313.23
White birch	0	0	0	0	144.33	0	42.46	0	175.72	0	0	64.46
Cottonwood	0	0	0	0	107.62	0	0	0	0	0	0	0
Chokecherry	0	0	0	0	25.02	24.61	4.58	89.81	44.18	67.93	95.82	136
Hawthorn	4.31	0	0	0	12.8	0	0	0	0	0	0	0
Nannyberry	0	0	0	121.18	0	0	0	0	0	0	0	0
Pincherry	0	0	0	0	0	0	0	12.67	0	91.92	0	0
Saskatoon	0	0	0	0	0	0	0	0	0	0	0	2.87
Decay Class 1 Snags	1802.22	849.5	133.48	664	243.62	704.62	336.05	81.55	138.76	513.35	951.42	327.23
Decay Class 2 Snags	349.44	370.02	212.11	153.7	49.12	247.44	340.33	347.03	248.76	600.66	2074.19	197.53
Decay Class 3 Snags	212.18	501.8	4.21	869.54	168.78	305.72	838.25	492.02	783.47	952.92	781.74	645.58
Shrub density	88.05	69.48077	83.3	53.63333	75	76.975	73.19444	96.4	154.85	80.05	32.925	104.625
Ground cover	0.81	0.9	0.79	0.77	0.69	0.78	0.77	0.7	0.56	0.49	0.92	0.57
Canopy cover	0.56	0.71	0.63	0.46	0.49	0.71	0.79	0.69	0.63	0.85	0.41	0.72
Horizontal cover	21.02	39.23	66.09	37.71	38.59	73.25	77.92	93.72	91.98	96.18	63.31	91.28
Understory height	0	0	2.9	2.37	2.13	2.65	3.11	2.9	6.75	4.3	3.25	4.3
Overstory height	13.65	15.27	12.2	11.6	9.29	15.3	13.89	12.6	13.75	13.7	14.2	15

Appendix L
Mean avian abundance values calculated as the number of individuals within each guild per station per site

	Sutton	Crayston	Howell	Steel	Dekoninck	Crayston	Douglas	Bell	WMA	Shaw	Friesen	Dearsley
Foraging Guilds												
Omnivores	0.29	1.6	0.2	0.5	1.33	0.67	0.4	0.5	0	0.5	0	0.25
Seed-eaters, ground	5.43	6.2	2.6	7	6.5	6.32	3.4	3.51	2.65	1.25	5.34	1
Insect-eaters, ground	1.43	2.6	1.4	3	1.5	1.33	3.2	2.33	3.66	2.5	4	3.25
Foliage gleaners	7	4.8	7.8	7.75	7.99	8.33	8.2	10.17	9.34	10	5	7.5
Trunk/branch/bark gleaners	1.14	1.2	1	1.5	1.01	1.67	1.8	1.33	1.33	0.5	1	2.25
Aerial flycatchers	2.86	1.2	3.6	3	2.33	3	1.4	1.83	2.33	2.25	0.67	3
Aquatic specialists	0	0	0	0.5	0	0	0.2	0.17	0	0	0	0.25
Nectar-feeders	0	0	0	0	0	0	0.2	0	0	0	0	0.25
Predators	0.14	0	0	0.5	0	0	0	0	0	0	0	0
Nesting Guilds												
Ground	1.29	1.6	1.6	3.25	2.5	1.99	3.6	2.34	2.99	2.25	4.34	2.25
Shrub	6.86	5.2	5	5.75	5.33	6.66	4	6.17	5.99	6.5	4	3.5
Tree	5.29	5.6	4.8	8.25	9.16	7.33	5.2	7	5.67	7.5	3	6.25
Cavity	4.14	4.2	4.2	4.75	2.34	4.67	4.6	2.99	3.33	2.25	3	5.25
Cliff, bank	0	0	0.6	0.5	0	0	0	0.17	0.33	0	0	0.25
Brood parasite	0.71	0.8	0.8	1.25	1.33	0.67	1.4	1.17	1	0.25	1.67	0.25