QUANTIFICATION OF CATTAIL (*Typha spp*.) WETLAND ATTRIBUTES IN THE PRAIRIE POTHOLE REGION OF NORTH DAKOTA

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Title

______Quantification of Cattail Wetland Attributes ______

_____ in the Prairie Pothole Region of North Dakota_____

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

__________MASTER OF SCIENCE__________

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ABSTRACT

Ralston, Scott Terrance, M.S., Department of Biological Sciences, College of Science and Mathematics, North Dakota State University, November 2004. Quantification of Cattail (*Typha spp*.) Wetland Attributes in the Prairie Pothole Region of North Dakota. Major Professor: Dr. William J. Bleier.

In 1992, at the USDA-NWRC Cattail Management Symposium in Fargo, ND, an official of the North Dakota Game and Fish Department spoke about concerns with the USDA cattail management program. The USDA reduces cattails in wetlands of the Prairie Pothole Region (PPR) of North Dakota and South Dakota in order to lessen damage to sunflower crops by blackbirds using cattail wetlands as roosting sites. The concern was that there was no empirical evidence on the amount of available cattail habitat or uses of cattail by non-target species. Since that time, research has been conducted on use of cattail by non-target species. This study quantifies the amount of cattail available in the PPR of North Dakota. The PPR was stratified based on biotic differences, and one hundred and twenty 10.4 km^2 sample plots were randomly selected within these strata. Aerial infrared photos were taken of each site in August and September 2002 and imported into a geographic information system. Wetlands with cattail were identified, and a supervised classification was used to delineate cattail area. Other wetland attributes were also identified, including basin size, classification, cattail density, and presence of water. Within the 95,172 km^2 of the PPR in North Dakota, approximately 2.3%±0.27% of this area was covered by cattail, with the highest densities in the Northeast Drift Plains and Southern Drift Plains. The amount of cattail reduced annually by the USDA cattail management program represented less than 1% of the total available cattail. The majority of cattail was found in semi-permanent wetlands. Cattail was found more often in areas with higher densities of wetlands and in wetlands with at least some standing water. Average cattail wetland size was 2.6 ha, with larger wetlands being found in the Missouri Coteau.

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DEDICATION

I extend a special thanks and dedication of my research to those who helped me get where I am today.

My father, Terry Ralston, whose passion for life, love of family, and respect for natural things inspired me to make the most of my life and to take the path of wildlife education. Terry passed away from cancer in 1994.

My mother, Donna Ralston, has provided me with an inordinate amount of support in the directions I have chosen to take. She became my example of courage to push forth in life as she was diagnosed with cancer in the midst of my time as a graduate student. She fought her battle with cancer and won, showing me that you really can accomplish anything if you want it enough.

My wife, Kathryn, has been patient and encouraging during my quest to complete my education. She has been a constant source of support and a true friend.

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INTRODUCTION

An aerial view of the Prairie Pothole Region (PPR) of North Dakota reveals two predominant landscape features, of which the first is agricultural cropland. In North Dakota, agriculture is an important part of the state's economy with 87% of the land area being used for farming or rangeland (NDASS 2004a). Sunflower (*Helianthus annuus*), one of the many crops grown in the region, can be profitable with prices per cwt. (45 kg or 100 lbs.) often reaching $15 to $20 for some varieties (NDASS 2004b). Production of sunflower in North Dakota has grown from a few thousand hectares in the 1960s to almost a half million in 2003 (Lilleboe 1979, NDASS 2004d). North Dakota is the nation's top producer of sunflower in most years (NDASS 2004c).

The second most prominent landscape feature of the PPR is the numerous wetlands that dot the landscape. Glaciers shaped the topography of the region during the Pleistocene Epoch. These glaciers formed uneven deposits of glacial till and large buried ice blocks that today make up the prairie potholes and sloughs (Colton et al. 1963). The abundant shallow wetlands provide excellent growing conditions for cattail (*Typha spp*.). Cattail is the dominant emergent vegetation in wetlands of the PPR. Animals, such as white-tailed deer (*Odocoileus virginianus*), ring-necked pheasants (*Phasianus colchicus*), marsh wrens (*Cistothorus platensis*), waterfowl (Anatidae), and blackbirds (Icteridae), use cattail as an important source of shelter (Kantrud 1992). The blackbirds that live in this habitat are abundant and constitute more than 9% of the avifauna in North Dakota (Igl and Johnson 1997).

Blackbirds present a conflict for sunflower producers. Blackbirds use the oil-rich sunflower crops as an energy resource during their fall migration through the Northern Great Plains. This migration occurs in late summer when the sunflowers are ripening and can cost sunflower producers millions of dollars in damage to their crops (Hothem et al. 1988, Lamey and Luecke 1991, Peer et al. 2003). During fall migration, blackbirds use stands of cattail as night roosts (Lutman 2000). If these roosts are large and are located near a sunflower field, that field may experience severe damage (Otis and Kilburn 1988). By fragmenting dense cattail stands near sunflower areas, managers may be able to reduce blackbird damage to crops (Linz et al. 1995b, 1996b). However, the reduction of cattail also raises concerns about organisms that benefit from cattail habitat. The purpose of this project is to provide managers with data to make informed decisions about cattail management. The objectives of this study were to 1) estimate areal coverage of emergent vegetation, especially cattail (*Typha spp.*), in randomly selected sample units in the Prairie Pothole Region of North Dakota and relate that to the amount of cattail being sprayed by the USDA through their cattail management program; 2) describe physical attributes of cattail wetlands within the sample units; and 3) develop methods for use in future cattail coverage monitoring programs, including GIS analysis and optimal sample size.

LITERATURE REVIEW

Study Area

The study area for this research includes parts of the Prairie Pothole Region (PPR). The topography of the PPR was formed during the Wisconsin stage glaciations of the Pleistocene Epoch ending around 12,000 years ago (Lemke et al. 1965). The PPR includes southern Alberta and Saskatchewan, southwest Manitoba, northeastern Montana, northern and east-central North Dakota, eastern South Dakota, and parts of western Minnesota and northwestern Iowa (Stewart and Kantrud 1971). The glaciers that moved through this area shaped the landscape. The land left behind was dotted with numerous undrained depressions, known as potholes or sloughs, formed by uneven deposits of glacial till, the scouring action of glaciers, and the melting of large buried ice blocks. Large moraines accumulated along the edges of the region, which formed low rolling hills such as those in the Missouri Coteau. Flat lake beds developed where glaciers dammed melt water as seen in the Agassiz Lake plain (Winter 1989).

The entire PPR covers over 712,000 km^2. The portion of the region that was used in this study includes about 95,100 km^2 within North Dakota. The PPR of North Dakota extends across the middle of the state from just east of the Missouri River to the western edge of the Lake Agassiz basin. This region lies at the center of the North American continent and is crossed by a continental divide, separating drainage systems of the Hudson Bay and the Gulf of Mexico (Stewart and Kantrud 1972). The boundaries of the PPR were defined by the Stewart and Kantrud (1972) stratification and include the following substrata: Missouri Coteau (MC), Northwest Drift Plains (NWDP), Northeast Drift Plains (NEDP) and Southern Drift Plains (SDP). The wetlands that make up this region's predominant land attribute are important ecological features. They produce at least one-half of North America's waterfowl, as well as a large portion of other prairie-dwelling, marsh, and aquatic birds. The wetlands differ greatly in their water chemistry, which varies from fresh to hyper-saline, as well as their ability to maintain surface water (Kantrud et al. 1989). Wetland water levels are mostly maintained by the spring snowmelt accumulation and the precipitation throughout the growing season.

Annual precipitation for the North Dakota PPR is approximately 38 to 48 cm with 77% of the precipitation falling from April to September (Bavendick 1959). The wetlands can change dramatically due to wet and dry cycles of abundant rainfall or drought that occur in this area (Diaz 1986). Temperatures in the summer season can reach over 38°C and fall to below -50°C in the winter. Mean annual temperature ranges from 2 to 6°C. Average growing season is about 121 days, with the average day of last freeze in the spring being May 19 and the day of first freeze in the fall being September 18 (Bavendick 1959).

Wetlands

Wetlands of the region can be classified by the Stewart and Kantrud (1971) or Cowardin et al. (1979) classification systems; however, only the Cowardin system has been used for a comprehensive wetland inventory (USFWS 2002). By definition, wetlands must periodically support hydrophytes, contain predominantly undrained hydric soil and be saturated or covered with water at some time during the growing season (Kantrud et al. 1989). The wetlands include riverine, lacustrine, and palustrine systems (Cowardin et al. 1979, USGS 1999). Water regimes are the main characteristic used in this study because of the importance of water depth and vegetation cover for birds that use wetlands (Austin 2002). The Cowardin freshwater, non-tidal water regimes include eight separate classes; however, in the PPR of North Dakota, only five classes are present and used. Each of these water regimes are defined as follows (Cowardin et al. 1979):

- Temporarily Flooded - Surface water is present for brief periods during the growing season, but the water table usually lies well below the soil surface. Plants that grow in both uplands and wetlands may be characteristic of this water regime.
- Seasonally Flooded - Surface water is present for extended periods, especially early in the growing season, but is absent by the end of the growing season in most years. The water table after flooding ceases is variable, extending from saturated to the surface to a water table well below the ground surface.
- Semi-permanently Flooded - Surface water persists throughout the growing season in most years. When surface water is absent, the water table is usually at, or very near, the land's surface.

- Intermittently Exposed - Surface water is present throughout the year except in years of extreme drought.
- Permanently Flooded - Water covers the land surface throughout the year in all years.

The Cowardin et al. (1979) classification system is used nationwide. On a local scale, the Stewart and Kantrud (1971) classification is more commonly used because it was designed for this region. The Cowardin classification was used for this study because of its national recognition and for its use in the National Wetlands Inventory (NWI) dataset which was integrated into this study. For comparison, the Stewart and Kantrud (1971) Class I – V definitions have been reviewed to convert between the two systems. The Cowardin temporarily flooded regime is comparable to the Stewart and Kantrud Class I ephemeral ponds and Class II temporary ponds. Definitions for the seasonally flooded regime are consistent with Class III seasonal ponds and lakes. Both the semi-permanently flooded and intermittently exposed Cowardin regimes fit well with that of the Class IV semi-permanent ponds and lakes. Cowardin et al. (1979) and Stewart and Kantrud (1971) both define the most permanent of wetlands with the permanently flooded regime and Class V permanent ponds and lakes classification, respectively. All of the wetland classifications are based on the long term mean of the wetland conditions because of the extreme variability in short term change of wetland water conditions.

The United States Fish and Wildlife Service (USFWS) has been using the Cowardin et al. (1979) wetland classification system to do a nationwide inventory of all wetlands (Kantrud et al. 1989). Specific goals for the NWI mapping project have been set.

> "The goal of the National Wetlands Inventory is to provide the citizens of the United States and its trust territories with current geospatially referenced information on the status, extent, characteristics and functions of wetland, riparian, deepwater and related aquatic habitats in priority areas to promote the understanding and conservation of these resources." (USFWS 2002)

The National Wetlands Inventory was established in 1974. The PPR of North Dakota was among the first areas to be mapped due to the importance of wetlands in the region. The average date of NWI data for this region is from 1979. Wetlands are mapped based on aerial photographs as well as from soil maps. NWI data do not provide accuracy on wetland size and shape because those polygons are drawn from aerial photos taken at one specific time which may change. NWI data can be used to identify approximate location and wetland classification of wetlands. Most of the data for the region are now available in digital format, but are in need of updating (USFWS 2002).

The wetlands, as well as the surrounding prairie, provide important ecological functions. The wetlands support a wide diversity of different biotic environments for phytoplankton, periphyton, metaphyton, macrophytes, and invertebrates. Prairie pothole wetlands also support communities of fish, especially fathead minnows (*Pimephales promelas*) and sticklebacks *(Culaea inconstans*) (Lawler et al. 1974), as well as 25 species of amphibians and reptiles, of which the most abundant are the tiger salamander (*Ambystoma tigrinum*), leopard frog (*Rana pipiens*), and chorus frog (*Pseudacris nigrita*) (Wheeler and Wheeler 1966). Approximately 23% of the PPR lies in North Dakota and provides habitat for about

50% of the duck breeding in an average year, as well as a significant portion of reproductive recruitment for other waterfowl and wetland birds (Smith et al. 1964, USGS 1999). For many birds that do not breed in North Dakota, the PPR provides important migratory staging areas (Kantrud 1986, Linz et al. 2004a). North Dakota wetlands are also habitat for semi-aquatic animals, such as the muskrat (*Ondatra zibethicus*), and provide water and shelter for terrestrial mammals, including white-tailed deer (*Odocoileus virginianus*) (Fritzell 1989; Kantrud et al. 1989).

Agriculture and Sunflower

The PPR of North Dakota provides important resources to humans as well. North Dakota is the nation’s leading producer of durum and spring wheat, barley, flax, dry edible beans, canola, and sunflower, and is a major producer of many other crops (NDASS 2004c). Agricultural production makes up about one quarter of North Dakota’s economic base and generates nearly $4 billion annually. The people of the state rely heavily on agriculture, with about 24% of the population employed in farm-related jobs (Johnson et al. 2003).

An important crop for North Dakota farmers is sunflower. Sunflower (*Helianthus annuus*) is native to North America and has been grown as a commercial crop in the Great Plains since the late 1960s (Linz and Hanzel 1997). Sunflower production peaked in the 1980s and 1990s, with almost one million hectares planted in North Dakota in some years. Although production has fallen because of lower prices offered for the achene, sunflower can still be a profitable crop. Two types of sunflower are produced; one type known as oil sunflowers produces high quantities of oil, while the other type produces confectionary seeds, which have lower oil content and are used primarily for human consumption. In 2002, the year of this study, over 771 million kg of sunflower seeds were produced within North Dakota. This amount represented over 68% of the total sunflower produced in the United States. At an average $0.27 per kg, this quantity generated over $205 million for North Dakota's economy in 2002 (NASS 2003).

Blackbirds

Because of the large economic value of sunflower to producers, damage to their crop can result in significant losses. In a 1997 survey of North Dakota sunflower growers, bird damage was listed as the number one production problem (23% of all production problems), and 46% of the producers reported yield losses of 5% or greater (Lamey et al. 1998). Blackbirds have been ranked as the avian pest that causes the most damage (95.7%) to sunflower crops (Linz and Hanzel 1997, Lamey et al. 1998).

Blackbird problems have become increasingly prevalent due to a recent rise in the numbers of blackbirds. Much of the 1990s had above-average annual precipitation. This excess water provided an increase in growth of suitable habitat for the blackbirds, thus producing higher reproductive success (NDASS 1999).

The three main blackbird species found in the PPR that contribute to crop damage are the red-winged blackbird (RWBL) (*Agelaius phoeniceus*), the yellow-headed blackbirds (YHBL) (*Xanthocephalus xanthocephalus*), and the common grackle (COGR)(*Quiscalus quiscula*) (Figure 1). Together these birds represent about 9% of the avifauna in North Dakota (Igl and Johnson 1997). Nelms et al. (1999) estimated the number of breeding pairs of blackbirds in North Dakota

Figure 1. Main species of blackbirds in the Prairie Pothole Region of North Dakota: Yellow-Headed Blackbird (*Xanthocephalus xanthocephalus*) (Left), Common Grackle (*Quiscalus quiscula*) (Top Right), and Red-winged Blackbird (*Agelaius phoeniceus*) (Bottom Right).

in 1991 as follows: RWBL 1,425,000 ± 43,000; YHBL 655,000 ± 52,000; and COGR at 698,000 ± 23,000; the total was 2,778,000 pairs of blackbirds. On a regional level, a more recent study estimated blackbird populations in the PPR including parts of North Dakota, South Dakota, Minnesota, Saskatchewan, and Manitoba, an area that covers about 472,000 km^2; Peer et al. (2003) estimated fall populations of birds in 1996-98 to be 39.3 ± 8.82 million RWBL, 19.0 ± 4.70 million COGR, and 16.8 ± 4.97 million YHBL.

The common grackle is a medium-sized blackbird. It has an iridescent black plumage with a long keel-shaped tail. Males and females are similar in appearance; the major differences are that the female is slightly smaller and less glossy. Common nesting habitat of these birds includes shrubs and tree groves. They are well adapted to urban areas and shelterbelts near agricultural fields (Peer and Bollinger 1997). The common grackle diet is about 79% insects, including beetles (Coleoptera), grasshoppers (Orthoptera), and caterpillars (Lepidoptera), during the breeding season, but the diet shifts to largely small grains (36%) and sunflower (48%) during the fall (Homan et al. 1994). Females have an average of one clutch per season, with an average size of 5 eggs. Annual adult survivorship is about 52% (Peer and Bollinger 1997).

Yellow-headed blackbirds are large bodied passerines (about 100g for males). They are sexually dimorphic, with the males having a mostly black body and a saffron yellow head. Males are about twice the size of females. The females are mottled brown with pale yellow on the breast and throat. Nesting habitat is primarily in prairie wetlands in cattail (*Typha* spp.), bulrush (*Scirpus* spp.) or reeds (*Phragmites* spp.) over deep water. The diet of the YHBL is primarily wetland-associated insects during the breeding season, but it shifts largely to seeds like sunflower and small grains during other times of the year. Mean clutch size is about 4 eggs. Annual adult survivorship is about 59% for males and 75% for females (Twedt and Crawford 1995).

Red-winged blackbirds are considered the most abundant and most commonly studied bird in North America. These birds are sexually dimorphic. Adult males are usually larger than females. In contrast to the female’s mottled brown color, males are mostly black except for the scarlet epaulets on their wing. Breeding habitat is mostly in shallow wetlands, but also includes tall grass prairies and meadows. During the breeding season, about half of their diet is made up of insects, and the other half is plant matter, such as seeds and grains (Yasukawa and Searcy 1995). During the non-breeding season, the diet turns to largely agricultural grains. In North Dakota, 91% to 98% of the RWBL diet before migration is sunflower (Linz et al. 1984). Typical clutch size and annual adult survivorship are about 3.3 and 42% to 62%, respectively (Dyer et al. 1977).

Depredation

All three blackbird species are migratory and form massive mixed-species flocks during their annual migration. During the night, these flocks congregate in areas called roosts. These roosts are largest shortly before and during migration and might contain a million or more birds (Lutman 2000). Roosts are most likely to be formed in areas with greater wetland densities, larger wetlands, and wetlands that have a greater coverage of emergent vegetation such as cattail (Leitch et al. 1997). The numerous birds staying in these roosts can cause problems such as nutrient loading in the wetland that can be equal to or greater than natural deposition rates (Hayes and Caslick 1984). An even greater problem caused by these roosts can be their proximity to sunflower fields and the concomitant depredation upon those fields (Dolbeer 1994).

The high oil content in sunflower seeds is a great resource for the birds as they prepare their energy reserves for fall migration through the Northern Great Plains. Migration coincides with the later development and ripening of sunflower before it can be harvested. Millions of blackbirds feeding on this resource can cause a significant negative impact to sunflower producers (Figure 2) (Hothem et al. 1988, Lamey and Luecke 1991, Peer et al. 2003).

Figure 2. Sunflower depredation by blackbirds. (Photo courtesy of NDSU Biological Sciences Blackbird Project.)

To assess the amount of damage caused by blackbirds to sunflower fields, surveys must be done. Superficial surveys of agriculture fields are often conducted near the edges where damage is often the greatest. Because of this technique, many surveys are biased and overestimate the overall damage of the field. Currently the USDA/APHIS is conducting annual sunflower damage surveys during the fall before harvest. These surveys have been designed to help reduce bias by using randomized transects and survey points throughout the field (Dolbeer 1994, Linz et al. 1996c).

Red-winged blackbirds and common grackles generate the most damage, with males of both species causing an estimated annual economic loss per bird of $0.09 and females costing $0.05 and $0.07, respectively. Yellow-headed blackbirds contribute a slightly lesser amount during their migration, with average loss per bird at $0.08 per male and $0.05 per female. Differences between sexes are attributed to size differentials between male and female blackbirds (Peer et al. 2003).

Red-winged blackbirds are most numerous in wetlands near agricultural fields; their relationship to crop damage has been studied extensively. A study in the late 1990s estimated annual damage losses from these birds at $2.8 million, which is close to 1% of the net income of seed harvested (USDA 2000, Peer et al. 2003). A 1% loss may be acceptable if spread evenly across all producers, but unfortunately the bird damage is disproportionate and devastating to fields in select locations (Hothem et al. 1988); sunflower damage is typically dependent on crop rotations and proximity of plantings to wetland roosts (Leitch et al. 1997). A survey of 276 fields in Stutsman County, North Dakota, conducted from 1994 to 1998 found 47 fields (17%) received damage of over 5% and 22 fields (8%) had damage exceeding 10% (NASS 1999). When sunflower production losses exceed 5% of the yield, economic impacts can be significant (KSU 2004). These production losses include factors such as insects, disease, weather, and harvest or cleaning inefficiencies; therefore, when bird damage is included, it often does not require much additional loss to reach negative profit margins (KSU 2004). The cost of repelling birds can be high, but it is often a price that must be paid in order to draw any profit from the crop. A survey of sunflower producers in 1997 suggested that the amount spent per producer on bird control was close to $1,000 plus 37 man-hours (Lamey et al. 1998). This cost may often be supplemented by the aid of state or federal agencies that can assist in bird management efforts.

Blackbird Management

Because of their migratory status, blackbirds fall under the protection of the Migratory Bird Treaty Act of 1918 which states; “Unless and except as permitted by regulations made hereinafter provided in this subchapter, it shall be unlawful at any time, by any means or in any manner to pursue, hunt, take, capture, kill….. any migratory bird …or part thereof….” (US Code 1918). Due to the extensive damage as a pest species, blackbirds were included in a depredation clause which now allows these birds to be more easily managed. The depredation order for blackbirds, cowbirds, grackles, crows, and magpies is as follows: “A Federal permit shall **not** be required to control yellow-headed, red-winged, rusty, and brewer’s blackbirds, grackles, …. When found committing or about to commit **depredation** upon ornamental or shade trees, agricultural crops, livestock, or wildlife, or when concentrated in such numbers and manner as to constitute a **health hazard** or other **nuisance**.” (US Code 1989)

The United States Fish and Wildlife Service (USFWS) is charged with upholding the laws regarding the management of these migratory birds. Wildlife Services, a division of the United Stated Department of Agriculture, Animal and Plant Health Inspection Services (USDA-APHIS-WS) is the leading agency for research and management of blackbird / human conflicts (USDA 1993). This agency works closely with a variety of groups including the United States Geological Service (USGS), North Dakota State University (NDSU), South Dakota State University (SDSU), the National Agricultural Statistics Service (NASS), the North Dakota and South Dakota Departments of Agriculture, the National Sunflower Association and several other government and private organizations.

Numerous management tools have been developed by these organizations to help reduce blackbird damage to crops. Among the oldest and simplest forms of bird damage control are modifying cultural practices. This method includes planting alternative crops in high-risk areas that do not attract blackbirds; e.g., potatoes, soybeans or hay. High-risk areas can be those that are within 8 km of a blackbird roost (Dolbeer 1994). Avoiding these areas can be difficult for producers due to the desire to plant a high-income crop like sunflower. With the high density of wetlands in the PPR, it is often difficult to avoid such areas. Damage can be more evenly distributed, and thus maintained at levels that are more acceptable, if farmers synchronize planting of multiple fields in a high-risk area. Sunflower should also be harvested as soon as possible after they reach maturity (Linz et al. 1996c). Another cultural practice used is early weed control, which reduces the attractiveness of the area as a food source. Lure or trap crops can be used; these crops are sacrificed in order to distract birds from the main crop (Dolbeer 1994). Access trails to the center of the field can also be left to aid in scaring birds from the interior of the field. Planting in north/south rows will reduce perching sites for the birds to use while foraging for the seeds due to the easterly orientation of ripe sunflowers (NDSU Extension Service 1995).

For many years, frightening or scare devices have been used as bird deterrents. Firearms, cracker shells, and other pyrotechnic devices can be used by producers, but these techniques require intensive and active management efforts. Propane exploders alone, or in conjunction with popup scarecrows, as well as electronic bird distress calls are used to try to frighten birds. These devices must be relocated frequently to avoid acclimation of birds to the deterrents. Airplane hazing has been used as an advanced scare tactic, but this technique is costly and must be combined with other methods (NDSU Extension Service 1995, Linz et al. 1996c).

Bird resistant plants have been developed. These sunflower plants have morphological characteristics that make it harder for birds to feed on the seeds. The main features of these plants are concave heads that are oriented horizontally once they are mature and longer head to stem distances, which reduce the perching platforms if planted in north/south rows (Linz et al. 1996c).

Chemical control of blackbird populations has been used. DRC-1339 (3-chloro-4-methylaniline), a slow acting avicide, has been applied using rice and corn baits. This method has had limited success and is not likely to be continued as a control method because of the sheer number of birds that must be treated to make a difference; there are also concerns for the impact on non-target species (Linz et al. 1995a, Linz and Bergman 1996, Linz et al. 2002). Avitrol® is a non-lethal chemical repellent that has been registered for control of blackbirds. Once ingested, this 4-aminopyridine compound affects a bird's nervous system, causing the bird to fly erratically and emit distress calls, which deter other birds from the area (Linz et al. 1996c). Another possible deterrent, Bird Shield™ (active ingredient: methyl anthranilate), is being used; it gives the crop a bad taste for birds but is safe for humans because the chemical is a constituent of Concord grapes (Bird Shield™ Repellent Corp. 2002).

Cattail

Because of its importance as nesting and roosting habitat for blackbirds, manipulation of cattails has been studied extensively as a possible way to manage blackbirds. Common cattail (*Typha latifolia*) has broad leaves and is thought to be native to the continent, but it was first officially recorded in North America in 1836

(Kantrud 1992). A narrow leaf species of cattail (*Typha angustifolia*) was reported throughout most of North America by the late 19th century and was first noted in North Dakota by a federal waterfowl biologist in 1942 (Stevens 1963, Linz 1992). The status of *Typha angustifolia* as a native or introduced species to North America is unknown, but it is not thought to be native to North Dakota (Linz 1992). The narrow leaf cattail, however, has spread across the state and crossed with the broadleaf species to form a hybrid, *Typha glauca*, which is now the dominant emergent vegetation in the PPR (Stuckey and Salamon 1987). These three cattail species can be distinguished with a reasonable degree of accuracy using a variety of morphological measurements, but because of the overlap of certain characteristics, the only sure way to identify a particular species is through genetic analysis (Kuehn and White 1999). The abundance of wetlands, as well as the frequent disturbance by tillage, contributes to the success of cattail growth in the area. Cattails are resilient and can grow in a variety of conditions ranging from wet soil to water depths up to about 75 cm. They are highly reproductive and can spread by means of numerous seeds or by rhizomes. A single cattail plant can produce thousands of shoots in a single season (Linde et al. 1976).

The USDA implemented an active cattail management program in 1991; this program continues today. A study conducted from 1992 to 1994 suggested that cattail reduction near sunflower fields may reduce damage to those fields (Linz et al. 1995b, 1996c). Cattail stands can be burned, cut, plowed or sprayed with a herbicide. The primary method of cattail reduction used by the USDA cattail management program is a herbicide application with a fixed wing airplane or a helicopter. The herbicide used is a broad-spectrum aquatic herbicide that has been registered with the Environmental Protection Agency (EPA); the active ingredient is N-phosphonomethyl-glycine (glyphosate) (Ware 1989). Glyphosate translocates to all areas of the plant including the roots, and thus is effective at killing rhizomatous plants such as cattail (Cole 1985) (Figure 3). Solberg and Higgins (1993) proposed that glyphosate is up to 99% effective at reducing cattail one year after treatment, although plants may grow back in later years. Best results for a longer regeneration time are achieved when water levels remain at 30 cm or more after herbicide application (Linz et. al. 1995b).

Removing cattail has benefits to other wildlife, mainly wetland birds. Waterfowl generally prefer open water wetlands, and in a study comparing glyphosate treated wetlands to non-treated wetlands, densities of every species of ducks (Anatinae) surveyed were equal to or greater in the treated wetlands (Solberg and Higgins 1993, Linz et al. 1996a). Many birds, such as the American Coot (*Fulica americana*), Sora (*Porzana carolina*), shorebirds (Scolopacidae) and

Figure 3. Aerial application of glyphosate on a cattail-choked wetland by the USDA/APHIS/WS under the cattail management program. (Photo courtesy of USDA/APHIS Wildlife Services Bismarck, ND.)

the Black Tern (*Chlidonias niger*), also do well with open water; with the reduction of cattails, mud flats and floating mats of dead cattail are opened for nesting (Blixt 1993; Linz et al. 1994, 1997; Linz and Blixt 1997). Many invertebrates including corixids and chironomids also benefit from glyphosate-treated wetlands (Linz et al. 1999).

Cattail treatment does have some negative effects on wildlife, such as the reduction of nesting and roosting habitat for yellow-headed blackbirds and red-winged blackbirds (Linz et al. 1996b). This result is the desired effect for sunflower protection, but other non-target species can also lose habitat. White-tailed deer, furbearers and non-migratory birds such as ring-necked pheasants use the dense cattail stands as important winter habitat because of the vegetation's great thermal protection and cover (Weller and Fredrickson 1974, Kantrud et al. 1989, Stromstad 1992, Homan et al. 2000). Some invertebrates, especially chaoborids, are also negatively affected by glyphosate-treated wetlands (Linz et al. 1999).

Cattail management will continue to be used as a major tool in blackbird control. It is a simple and cost effective method at about $44 per ha for chemicals and about $52 per ha for application cost (Ryan Wimberly, USDA-APHIS-WS, personal communication; Linz et al. 2004b). In 2002, 2,380 ha of cattail-choked wetlands were enrolled in the USDA Wildlife Services cattail management program. Of the total enrolled hectares, managers target 70% of the cattail to be treated with an aerial application of 5.26 l / ha of glyphosate. The 70:30 proportion was shown to have the greatest cost:benefit ratio for reducing blackbird damage and application costs, as well as minimizing effects to other species (Linz et al. 1996b, 2004, Leitch et al. 1997). In 2002, Wildlife Services treated 1,652 ha (Phil Mastrangelo, USDA-APHIS-ND-SD WS State Director, personal communication). Because of this active cattail reduction, managers must have data on how much of the total available cattail they are manipulating. With this information, decisions can be made to determine if the program should be expanded or reduced in order to maximize blackbird damage control while minimizing non-target impacts. This study provides information about the cattail wetlands that may be helpful in managing with these wetland ecosystems.

Remote Sensing and GIS

With a large-scale study, the logistics of performing a ground vegetation survey with a large enough sample size would not be time or cost effective. For this reason, remote sensing and GIS analysis were used. Remote sensing is defined as the acquisition of information on an object or phenomenon by a recording device that is not in physical or in intimate contact with the object or phenomenon under study (Wilkie and Finn 1996). A Geographic Information System (GIS) is a system of hardware, software, data, people, organizations, and institutional arrangements for collecting, storing, analyzing, and disseminating information about areas of the earth (Dueker and Kjerne 1989). The beginning of GIS in resource management can be traced back to Ian McHarg (1969) in *Design with Nature* where he overlaid a series of transparent maps of land characteristics, such as geology, topology, soils, vegetation types, and others, to develop land use characteristics and planning.

GIS data can be represented in raster or vector format. In a raster, the data are represented as a grid with values for each grid cell, also known as a pixel. Most digital images are in a raster format, where each pixel represents the mean of all colors within the coverage area of that pixel. Vector data are used for high precision representation of features. These data use points, lines or polygons in which topological relationships, such as area and perimeter, are readily available (Koeln et al. 1994).

With the advent of computers for high speed and mass data processing and advances in remote sensing with satellite data, GIS has become increasingly popular. As early as 1982, Advanced Very-High-Resolution Radiometer (AVHRR) data from the National Oceanic and Atmospheric Administrations (NOAA) meteorological satellites were used to classify vegetation land cover (Tucker et al. 1985). Satellite imagery has been used extensively for large scale projects because of the size of the images produced as well as the frequent availability of images. For example, a Landsat image covers an area of 100 X 100 km, and a new image is available and stored in a database every 16 days; however, satellite imagery has limitations for projects that require high resolution for accuracy. Landsat images only have about a 30 X 30 m resolution (Wilkie and Finn 1996, Verbyla and Chang 1997). Cost can also be a consideration in image types; Landsat images often cost several thousand dollars per image (Wilkie and Finn 1996).

A popular alternative to satellite imagery is aerial photography. Aerial photography is versatile in its use because, unlike satellite imagery, photos can be taken at any time and with up to sub-meter resolution, depending on the altitude, lens and film chosen. Cost is relatively low (<$50/36 exposures), with the most expensive factor being aircraft rental and operation (Wilkie and Finn 1996).

With either aerial photography or satellite imagery, the choices of spectral bands are important for vegetation mapping. To distinguish vegetation types using remote sensing, in most cases infrared or near infrared parts of the electromagnetic spectrum are used. This part of the spectrum ranges from about 0.7 to 1.3 µm and is known as the color infrared region (Figure 4) (Lillesand and Kiefer 1987). Red and blue bands of light are absorbed by the chlorophyll of plant leaves, while the green bands are reflected, thus allowing the human eye to see leafy or chlorophyll-bearing parts of a plant as green. Color infrared wavebands are not absorbed by the chlorophyll, but are affected more by the plant structure and reflected around the intercellular spaces of the plant. Because plants differ more in structure than in chlorophyll content, it is easier to distinguish between

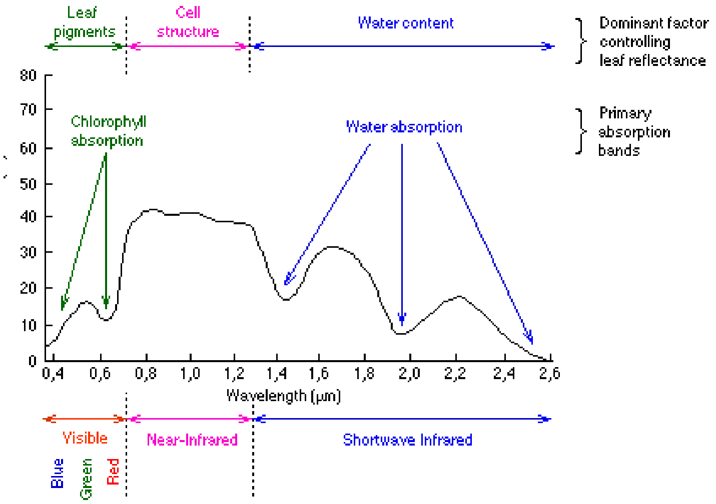


Figure 4. Light reflectance from leafy vegetation. (Adapted from Lillesand and Kiefer 1987.)

vegetation types using color infrared images (Lillesand and Kiefer 1987, Kumar 2002) (Figure 5).

Digital pixel classification for vegetation mapping has been used extensively for forest, wetland, and agricultural plant discrimination (Koeln et al. 1994, Sader et al. 1995, Kokaly et al. 2003, Schmidt and Skidmore 2003). Using computer GIS processing, images are classified based on the spectral signature of each individual pixel. All of the pixels that represent the spectral value for a desired plant type can be added, and the area represented by that vegetation can be determined by multiplying the summed pixels by the resolution size or pixel size (Wilkie and Finn 1996, Verbyla and Chang 1997, Chrisman 2002, Hirano et al. 2003). Supervised classification was found to be significantly more accurate in correctly classifying vegetation than unsupervised computer automated classification. Using GIS rule-based classification also improves the accuracy of

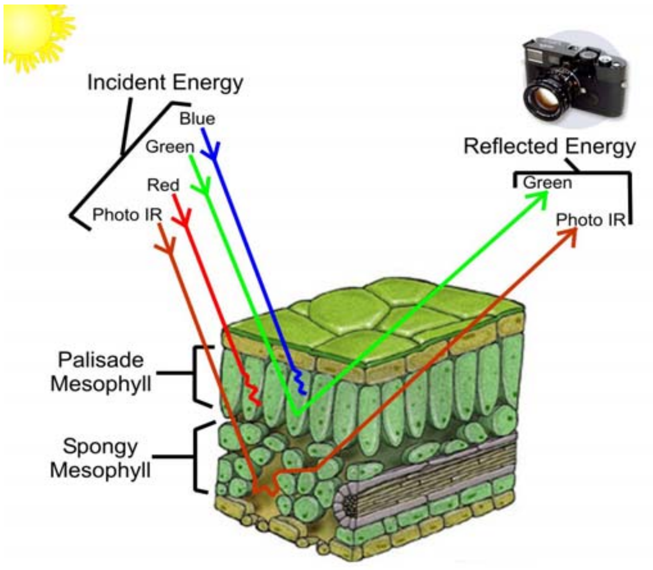


Figure 5. Color infrared light reflectance is affected by the structural aspects of the plant causing more variation than the green light wavelengths

image processing by using related GIS layers as guidelines for classification such as NWI, soils, Digital Elevation Models (DEM), and other layers (Koeln et al. 1994, Saderet al. 1995). The NWI dataset must be used with some caution, as there are many known errors in these data (Yi 1994, Johnson and Meysembourg 2002).

The Prairie Pothole Region of North Dakota provides many important ecological and anthropological functions. Because of the delicate balance between humans and their environment, managers must consider many aspects before manipulating the environment. GIS and remote sensing can be important tools in analyzing aspects of a large-scale landscape problem, such as quantification of cattail vegetation.

METHODS

Study Site Selection

A study by Johnson et al. (1999) suggested the best method for sampling wetlands in the Prairie Pothole Region (PPR) was to use 10.4km^2 stratified plots in order to reduce variance and bias. In this study, the PPR of North Dakota was stratified into four zones based on biotic differences described by Stewart and Kantrud (1972). The divisions include the Missouri Coteau (MC), Northwest Drift Plains (NWDP), Northeast Drift Plains (NEDP), and Southern Drift Plains (SDP) (Figure 6). Physiographic boundaries were drawn along the nearest township lines (ND D.O.T. 2002). Geopolitical divisions for land in North Dakota lend themselves well to sampling techniques by forming a grid. Boundaries follow a standard township, range, section format. Each section equals 2.6 km^2, or one square mile. Section lines are often easily defined visually by the presence of roads, fence lines, or sharp differences in vegetation types. For this reason, section or township boundaries were used to define the sample sites. The strata were divided into a grid using legal section lines, and the grid units were numbered. The sample sites were selected using a random number generator. Each of the four physiographic regions had a percentage of the samples allocated proportionate to its area (Table 1). The number of samples was chosen based on obtaining adequate sample sizes and cost limitations on aerial photography. A total of one hundred and twenty 10.4 km^2 sample plots were selected.

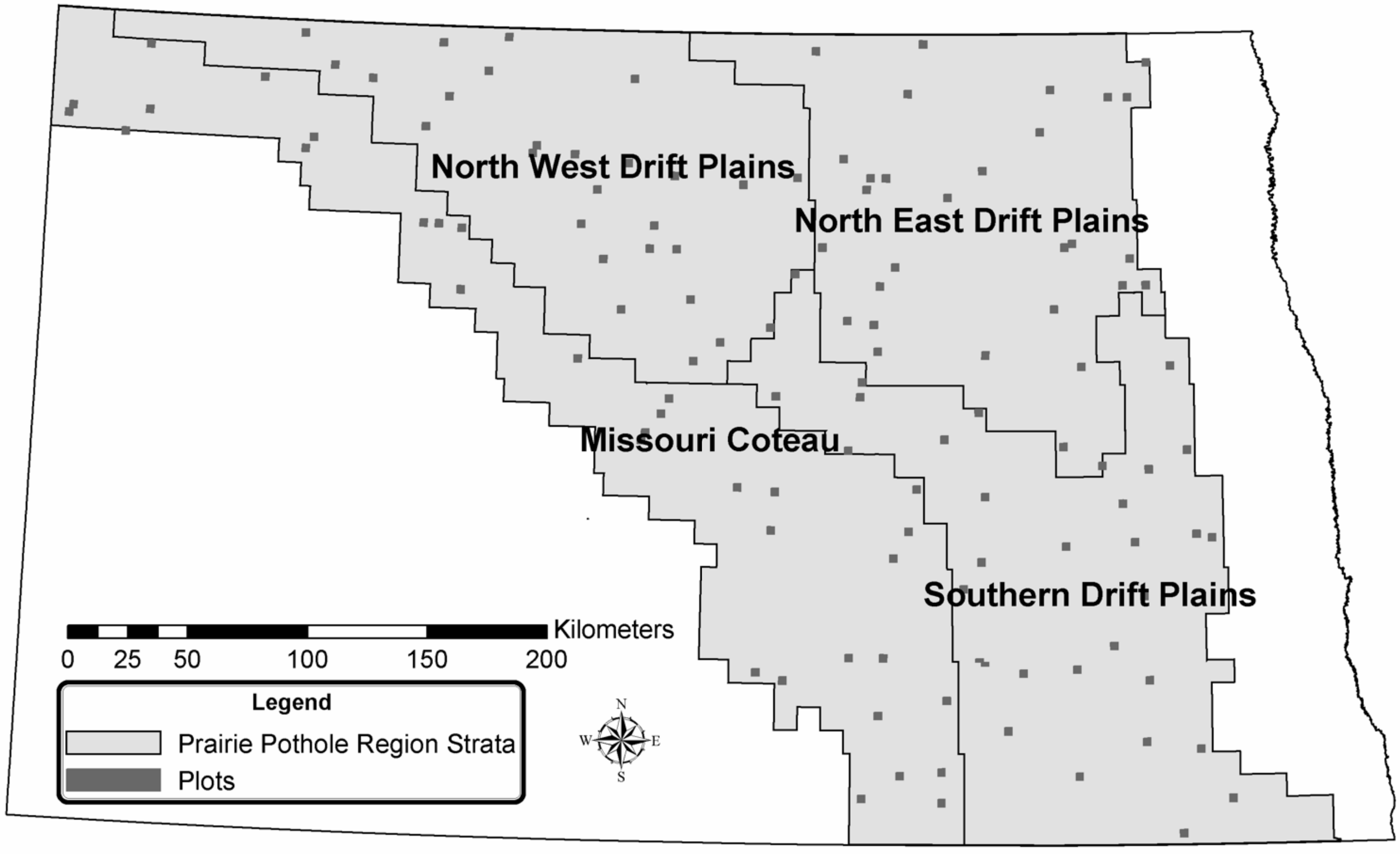


Figure 6. Stratified North Dakota Prairie Pothole Region with sample sites.

Table 1. Stratification of the Prairie Pothole Region of North Dakota and sample site allocation within each stratum.

Strata	Prairie Pothole Region of ND	Missouri Coteau	Northwest Drift Plains	Northeast Drift Plains	Southern Drift Plains
Area (km^2)	95,172	26,143	21,740	21,927	25,361
% of ND PPR	100%	27.5%	22.8%	23.0%	26.6%
Sample Plots	120	33	27	28	32
km^2 Sampled	1,243	342	280	290	332
% Strata Sampled	1.3%	1.3%	1.3%	1.3%	1.3%

Aerial Photography

Both satellite and aerial photos were considered as an image medium, but due to the need for high-resolution images, data were collected from each site by taking aerial photographs. Four photos were taken of each site, with one photo for each of the four legally defined sections. Each photo was taken with a large overlap to reduce the distortion caused by the curved outer edge of the camera lens. Kodak Aerochrome II infrared film 2443 was used with a 35mm Nikon F3 camera and a 35mm lens. A Tiffen #15 orange filter was also applied to reduce blue light. The camera was mounted on a fixed wing airplane flown at an altitude of about 3,100 meters above ground level. An onboard GPS unit was used in coordination with programmed locations of the sample sites to ensure accuracy of the location of the photo. Limitations were placed on the time of the flights (1100 to 1400 h) to reduce shadows caused by sun angles. Photos were taken from mid August to early September of 2002 during periods of clear skies. The dates were chosen because most agricultural crops were harvested or dried, while the cattails had not turned brown yet. These differences in vegetation provide good contrast in the color infrared photos.

Ground Surveys

Ground surveys were conducted on 60 (50%) of the sample sites distributed throughout the study area. Guidelines for ground truthing followed those used for the NWI surveys (USFWS 1995). Sites to ground truth were determined by the presence of problematic photo signatures. Other sites were chosen based on their proximity to a questionable site already determined to be visited. Ground surveys were done to gain knowledge of reading and interpreting aerial CIR images, as well as to serve as a later check for accuracy of image classification. Surveying was done in October and November of 2002. At each site, observations were made from a vehicle, an ATV, or on foot, depending on the condition of the site. Questionable features and cattail vegetation were recorded on a color copy of the photograph. GIS maps and GPS were used to locate the sites.

Photo Analysis in GIS

The photos were developed and printed on 30 cm X 22 cm color photo paper. Subsequently, these prints were digitized by scanning them with a flatbed scanner at 300 dpi into a TIFF format. Then images were cropped down to the legal section lines and imported into a Geographic Information Systems program for analysis. The GIS program used throughout this study is ESRI’s ArcInfo 8.x package.

The images were geo-referenced using at least four identifiable ground features in the image and referencing them with pre-referenced North Dakota Department of Transportation coverage layers. Once geo-referenced, the images were rectified to correct for pixel distortion caused by photo angles. Coordinate systems were defined for all of the files associated with sample sites. For the study area, the Universal Transverse Mercator, North American Datum 1983, Zone 14N projection was used. Each image was analyzed separately due to variations, such as contrast and light intensity, between each image.

When distinguishing cattail from other vegetation, CIR film is useful. Cattail, is large, tall, and has broad leaves that give a distinct red signature compared to most other plant species. Because of this difference, GIS works well to classify the image and separate land cover types based on pixel colors. To aid in cattail identification, land surface location of features are a good indicator for sites that were not ground truthed. To get a land surface image, United States Geological Survey (USGS) 7.5 minute Digital Elevation Models (DEM’s) were used. This elevation information enables viewing of the topological location of some land features and thus improves the probability of correctly identifying cattail stands. Before using the DEM’s, file conversions were needed. Using ArcToolbox, DEM’s are converted from their native format into three-dimensional TIN’s (Triangular Irregular Network). Because the DEM files are divided into quadrants, it is difficult to use these files for locations that are on the border of two files. The file size is also large for DEM/TIN files, which can slow computer processing. TIN models cannot be merged or cut by ArcInfo tools. This problem was solved by converting the TIN files into point coverages, which were then merged into one large file covering all available parts of the study region. The points for each of the study site locations were selected and saved into individual files for each of the study sites. Finally, each of the study site point coverages were converted into TIN files. DEM's were not available for all sample locations, but about two thirds of the sites were available.

USFWS National Wetlands Inventory data are also useful for cattail classification. This GIS data layer provides the location of wetlands and their water regime. The NWI data were converted from their native interchange file format into a usable coverage format. Because the original NWI data are provided in quadrants with hundreds of files for the entire state, much conversion took place to get them in a usable format. Files were then merged into an entire state file, and this file was spatially adjusted to better fit the location of wetlands in the photos. Attributes were dissolved and edited; in addition, quadrant division lines and unclassified land were removed. Errors were found in many of the attributes; most of these errors were typos in the water regime and its modifier categories. In most cases, the errors could be distinguished and were corrected. Individual coverages were cut out and saved for each of the 120 sample site locations. Using the DEM and NWI data, a manual rule-based classification was applied where questionable features in the aerial photo could be ruled out as cattail if they did not fit logical models. For example, possible cattail may be ruled out if the location was at the top of a hill in the DEM or away from any known wetland class in the NWI data.

To quantify cattail cover, a shapefile created for each photo in the sample site was imported into a GIS map document along with the photo, NWI and TIN layers. In order to reduce the variation in the image and lower the error produced by classifying pixels into the wrong class, a mask was used. To create this mask, the editor function was used on the shapefile to draw polygons around areas that contained cattail. Then, the shapefile was set as the mask for further processing of the image. The spatial analysis Reclass tool was used to classify the masked pixels. The image was classified into 10 to 30 groups based on the spectral signature and complexity of the pixels. Once classified, each class was visually evaluated and grouped into either cattail or non-cattail. If the class divisions did not satisfactorily define the image, the classification was rerun with more classes, class breaks were redefined, or the original mask was divided into smaller parts. This process was repeated for all four images in each site.

Up to this point, raster analysis was used due to its capability of extracting data from pixels and sorting them into groups. However, further editing of a raster in ArcInfo is not easily done without redefining the mask and rerunning the classifications. For finer detail editing, vector polygon analysis is much simpler. In addition to simpler editing processes, vector formats can readily give topographical information, such as area and perimeter of a polygon, and also more accurately represent natural shapes as a set of polygons rather than a grid.

After the cattail areas were defined with the raster method, the files were converted into geodatabase vector files. The four separate files pertaining to each of the four images within the plot were subsequently merged into one file to be used on the entire plot. Finally, this vector file was edited to add or remove polygons in misclassified locations. Misclassifications were common along the outer edge of the mask where a wetland abuts a broad-leafed agricultural crop such as beans or corn. Misclassifications were also found in open water portions of a wetland where floating vegetation such as duckweed (Lemnaceae) was found.

In situations where the photo-signature was difficult to interpret, ground truthed maps were used as a reference when available. For locations that were not surveyed on the ground, alternative methods of interpretation were used. Similar looking features on a ground truthed map were compared against the feature on the photo in question. National Wetlands Inventory data and USGS digital elevation models were also used to interpret questionable features where topography and proximity to known wetlands were used to form logical rule-based modifiers. When there were no questionable features in the photo, classified cattail was still compared against ground truthed photos when available, and also against NWI and DEM data to ensure the greatest possible accuracy.

Wetland Identification

For the purpose of this study, all locations with cattail were considered a wetland. Although undisputed wetlands exist that do not contain cattail, those wetlands were left out of this study. Personal geodatabase vector files were created for each of the sample plots. The geodatabase file for each plot was edited to define wetland boundaries. A polygon was created around each wetland using visual changes in vegetation or other land characteristics as defining boundaries. If two or more wetlands were adjoined by a small section, the boundary was drawn at the thinnest point of the adjoinment. If the wetlands appeared to be joined semi-permanently or permanently, the wetland was treated as one. Cattail in ditch or waterway situations had wetlands defined only to the extent of the cattail or visible water in the ditch and not along the entire length.

Once individual wetland boundaries were defined, each wetland was given a unique identification number to aid in later association with other wetland attributes. The cattail data layers created earlier represented plot totals. This layer could be broken down by individual polygons but would not relay information about cattail distribution or the wetland it was located within. In order to gather more useful information, the cattail layer was cut using the wetland layer so all cattail polygons could then be associated with their appropriate wetland using the unique wetland ID's. The cattail data could then be exported into a spreadsheet as plot totals or as wetland totals.

Wetland Classification

Wetland classification was simplified into a basin level classification. In the Stewart and Kantrud (1972) and Cowardin et al./NWI (1979) classification systems, wetlands are often classified in concentric rings emanating from the central, deepest portion of the wetland to the outermost low prairie zone. In landscape level studies, a single classification based on the wetland basin's most permanent classification can be used to simplify wetland categorization (Cowardin et al. 1979, Johnson and Higgins 1997). The wetland basin shapefiles that were created in the previous step were classified by their water system, water regime, wetland modifier and by the presence or absence of visible standing water.

Classification of the water system included riverine, Palustrine, and lacustrine systems designated by the NWI dataset (Cowardin et al. 1979). The water regime classification used the NWI designations of temporarily flooded, seasonally flooded, semi-permanently flooded, intermittently exposed or permanently flooded (Cowardin et al. 1979). National Wetland Inventory data layers were overlaid with the wetland basin shapefiles. When the wetland basins coincided with the location of a NWI identified wetland, the NWI classification was used. For those wetlands that did not coincide with NWI data, the aerial photos were used to visually compare the unidentified wetland to another similar looking wetland that was classified by the NWI. In some instances, the NWI classification was overridden if the classification did not fit the definition given for that class type. This situation most often occurred when a wetland basin was identified as a temporarily flooded regime but still had visible standing water. By definition, temporarily flooded regimes will not have standing water at the end of a growing season (Cowardin et al. 1979). In these cases, the classification was adjusted to the appropriate level.

Water regime modifiers did not follow modifier classes used in the NWI system. Definitions for the wetland basin modifiers used in this study are as follows: Ditch – Cattail wetlands found along a roadside right away and not extending beyond that right of way into the adjoining field or other land use category; Waterway – Any linear ditch, trench or water path in which water traveled without remaining stagnant for long periods of time and was not part of a roadside right of way; Roadside abutted – A cattail wetland that was at least partially abutted to a road and within the roadside right of way but extended past that right of way into the adjacent land use; Non-modified – Cattail wetland basins that were not part of a ditch or waterway modifier and did not encroach upon the a roadside right of way. These modifiers were created because of their biotic differences, as well as the importance of different management strategies that may be used to modify cattail in these various situations (Safratowich 2004).

Data gathered on wetland density, size and cattail components were broken down by proportions in each wetland classification and stratum. Measures of central tendency were calculated for each of the variables.

Related Biotic and Land-use Characteristics

Other biotic and land-use characteristics of the PPR and its strata were gathered in order to compare that information to the cattail and wetland basin information gathered. This information included U.S. Fish and Wildlife Service Breeding Bird Survey (BBS) data, NDSU Extension Service land-use crop data, North Dakota Agricultural Weather Network (NDAWN) precipitation data and NWI wetlands data.

The U.S. Fish and Wildlife Service conducts annual breeding bird surveys in which trained observers stop every 0.8 km along a 40-km route and record birds seen or heard. This information can be used as a population index. The routes are fixed through all years, but not all routes are surveyed every year. Using shapefile maps of the BBS routes and stratum boundaries created during initial sample site selection, GIS was used to determine BBS routes located within each stratum. The route was included if at least half was located within the stratum. For comparison against cattail and wetland data, bird counts for red-winged blackbirds, yellow-headed blackbirds, and common grackles were compiled for each route from 2001-2003. By gathering data from the year of this study and also the years before and after, more BBS routes were retained because there were some routes that did not have information available for 2002, but data were available in the other years. It is assumed in this study that wetland conditions did not change drastically enough within a span of one year to change blackbird's preference for an area due to the available habitat. Calculations were made for blackbird totals as well as for each of the three species. Route data were averaged for each route based on available years of data. All routes were then averaged to obtain the mean for each stratum.

The North Dakota State University Extension Service and North Dakota Agricultural Statistics Service use Landsat satellite imagery to create annual landcover classifications in North Dakota. They classify crop types and other land use categories. Landcover data for 2002 were obtained and imported into GIS. Raster imagery was converted into a vector format, which could then be cut by the strata boundary layer created for this project. Polygons representing land-use categories such as sunflower were extracted for each stratum and area of each category was calculated.

Data from NDAWN were used to collect precipitation values for North Dakota. NDAWN only reports precipitation from April to October. Data were not available for all stations in all years. Data for the year of the study were included because of their importance to current conditions. Data from the preceding year were also included because of the importance of water levels during the establishment of the vegetation. The use of multiple years also allowed retention of weather stations that were not available in 2002 but were available in 2001. Location of recording stations were created in GIS, and locations were cut into their appropriate strata. Data were averaged between years and then within the strata.

National Wetland Inventory data were used to compare against wetland basin data collected in this study. NWI data were simplified into their basins and cut into the appropriate strata. Wetland density information and wetland classification distribution were gathered for each stratum. Wetland size information was not used because the NWI does not claim accuracy on wetland size beyond the years closest to when the NWI data were collected for that region.

RESULTS

Total Cattail

Cattail coverage in the PPR represents about 2.3% of the land surface, or 221,509 ha. Greater amounts of cattail were found in the eastern strata with the Northeast Drift Plains having the most cattail, where over 4% of the land area was covered by cattail. The Northwest Drift Plains had the least amount of cattail, with a little over 1% of the land area covered by cattail (Table 2).

The number of wetlands containing cattail within all sample plots was 4,396. For measurements of cattail density, wetlands were divided into linear (i.e., Ditch and Waterway modifiers) and non-linear classes. The linear wetlands are not representative of natural wetland systems and, thus, may skew results of the more natural systems if included in calculations. Non-linear systems represented 88.6% of the total wetlands sampled. Mean area of cattail per wetland for the entire sample area was 0.70 ha, with the Northeast Drift Plains having the largest average cattail stands and the Northwest Drift Plains having the smallest average cattail stand per wetland. Cattail density per wetland followed the same distribution pattern among strata, with the average for the PPR suggesting that 36.4% of a typical wetland was covered with cattail (Table 3).

Cattail Distribution

Distribution of cattail among the various wetland classification levels was conducted for all strata. Results of wetland system classification distribution showed that the majority (95.7%) of the cattail in the PPR was found in palustrine systems. Dominance of cattail in palustrine systems was found across all strata,

Table 2. Mean (S.E.) cattail estimates for each stratum in the Prairie Pothole Region of North Dakota in 2002.

	Total Hectares of Cattail	% of Stratum Covered by Cattail
Missouri Coteau	33,891 ± 4,318	1.3% ± 0.17%
Northwest Drift Plains	25,590 ± 5,847	1.2% ± 0.27%
Northeast Drift Plains	92,010 ± 18,883	4.2% ± 0.86%
Southern Drift Plains	69,142 ± 11,532	2.7% ± 0.46%
Total Sample Area	221,509 ± 25,424	2.3% ± 0.27%

Table 3. Attributes of cattail in all wetlands sampled and those in more natural conditions which exclude ditch and waterway modifiers.

	Prairie Pothole Region	Missouri Coteau	Northwest Drift Plains	Northeast Drift Plains	Southern Drift Plains
Total Wetlands Sampled	4396	918	519	1707	1252
Mean (S.E.) Ha. of Cattail / Wetland	0.66 ± 0.03	0.48 ± 0.04	0.63 ± 0.07	0.71 ± 0.05	0.72 ± 0.06
Mean (S.E.) % Cattail Coverage / Wetland	36.6% ± 0.34%	22.8% ± 0.62%	31.2% ± 0.95%	43.2% ± 0.53%	49.0% ± 0.59%
Non-linear Wetlands Sampled	3894	868	435	1520	1071
Mean (S.E.) Ha. of Cattail / Non-linear Wetland	0.70 ± 0.03	0.50 ± 0.04	0.71 ± 0.09	0.77 ± 0.06	0.76 ± 0.07
Mean (S.E.) Cattail Density / Non-linear Wetland	36.4% ± 0.36%	22.2% ± 0.63%	30.6% ± 1.06%	43.6% ± 0.57%	40.0% ± 0.64%

with lacustrine systems a distant second, and riverine systems had the least cattail (Figure 7, Appendix I). Cattail distribution among water regime classifications showed dominance of cattail in the semi-permanently flooded regime in all strata except the NWDP, where more cattail was found in seasonally flooded wetlands (Figure 8, Appendix I). Wetland modifier classifications showed that the majority of cattail in all strata was located in non-linear systems, with non-modified wetlands being slightly more dominant than roadside abutted wetlands in all strata. The linear classes of ditch and waterway represented a small part (<10%) of the total cattail distribution, with inconsistent dominance between the two classes among strata (Figure 9, Appendix I). Comparisons between wetlands based on the presence of standing water at the end of the growing season showed that in all strata about three quarters of the total cattail was found in wetlands that did contain surface water (Figure 10, Appendix I).

Wetland Size

Wetland size for all wetlands that contained cattail was compiled from all sample sites and sorted by wetland classifications and by strata. The Missouri Coteau had significantly larger wetlands than all other strata in the PPR (Figure 11, Appendix I). Among wetland system classifications, lacustrine systems were significantly larger than palustrine systems (Figure 12, Appendix I). Only four instances of riverine systems were recorded within all sample sites, thus adequate data were not available to make inferences about this wetland system.

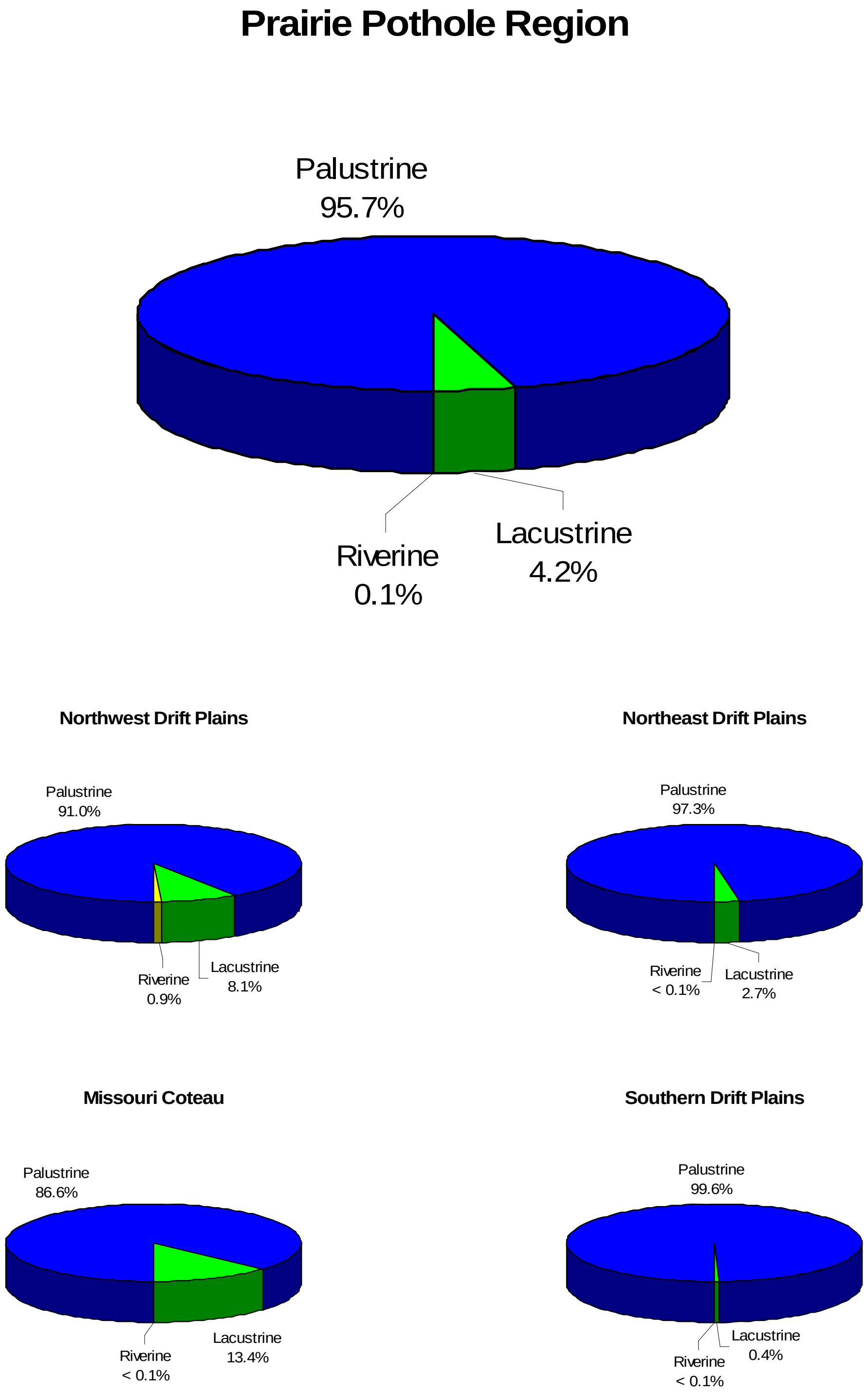
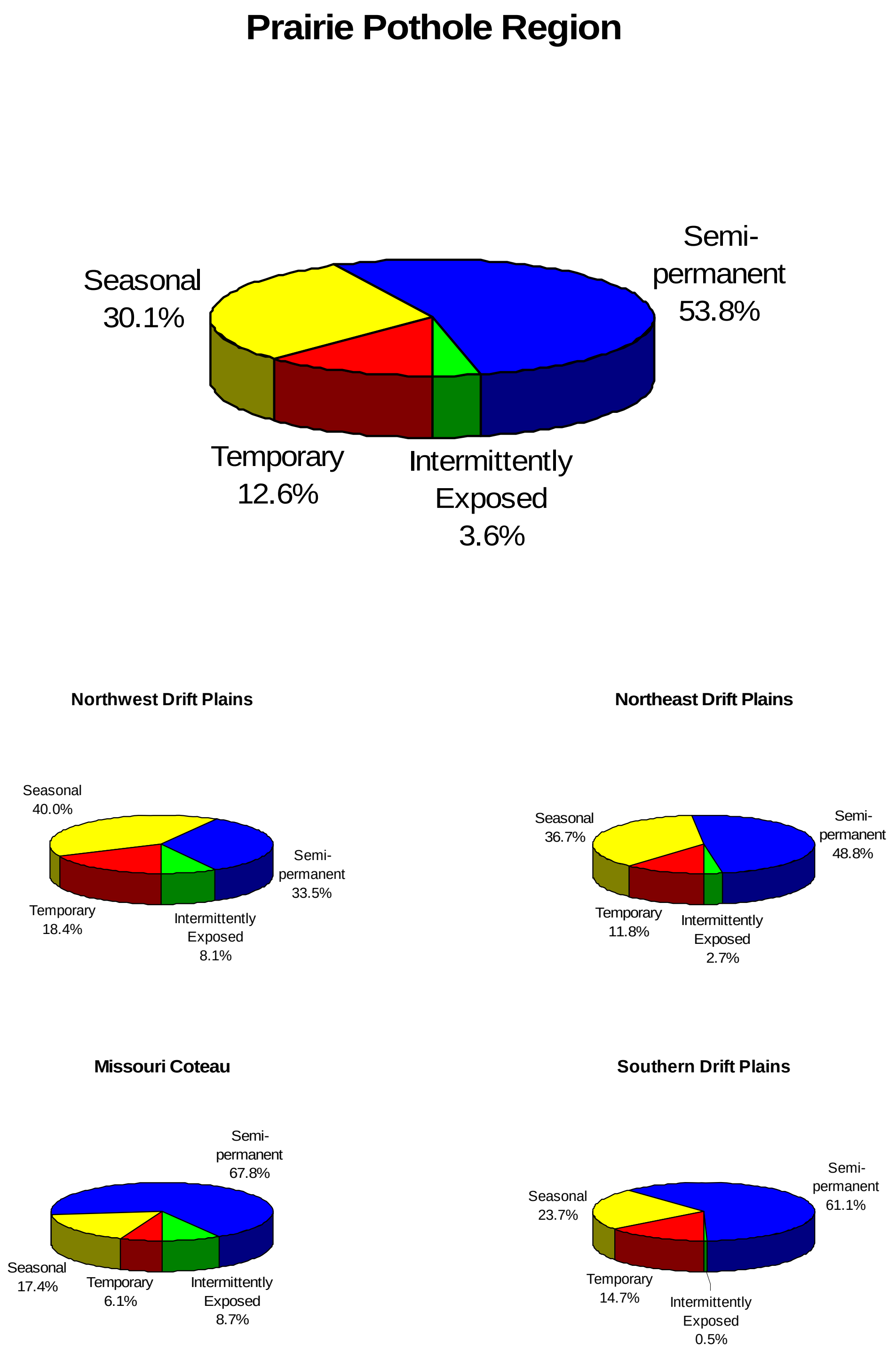


Figure 7. Cattail distribution among wetland system classifications in the Prairie Pothole Region of North Dakota in 2002.



Prairie Pothole Region

Northwest Drift Plains

Northeast Drift Plains

Missouri Coteau

Southern Drift Plains

Figure 8. Cattail distribution among wetland water regime classifications in the Prairie Pothole Region of North Dakota in 2002.

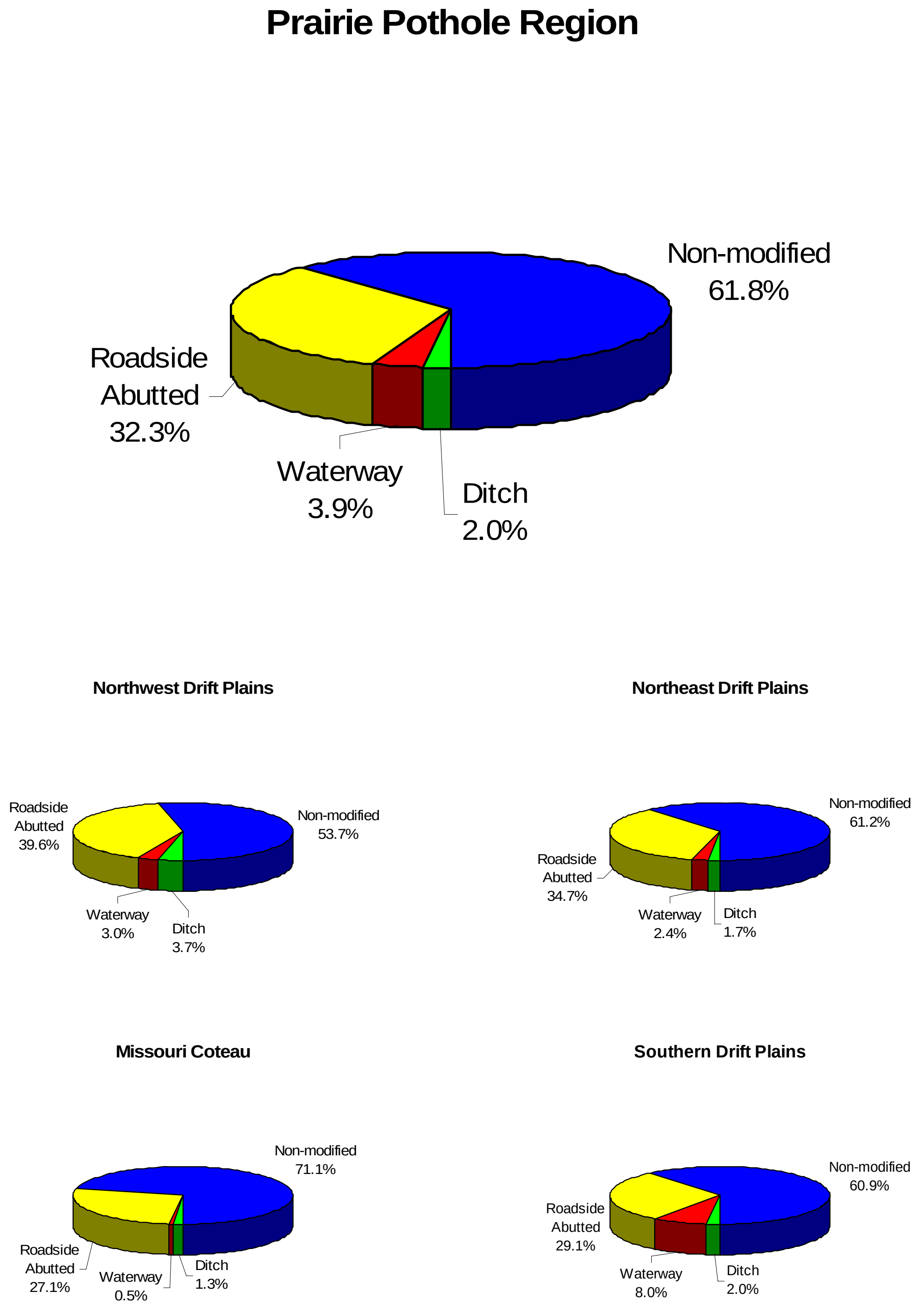


Figure 9. Cattail distribution among wetland modifier classifications in the Prairie Pothole Region of North Dakota in 2002.

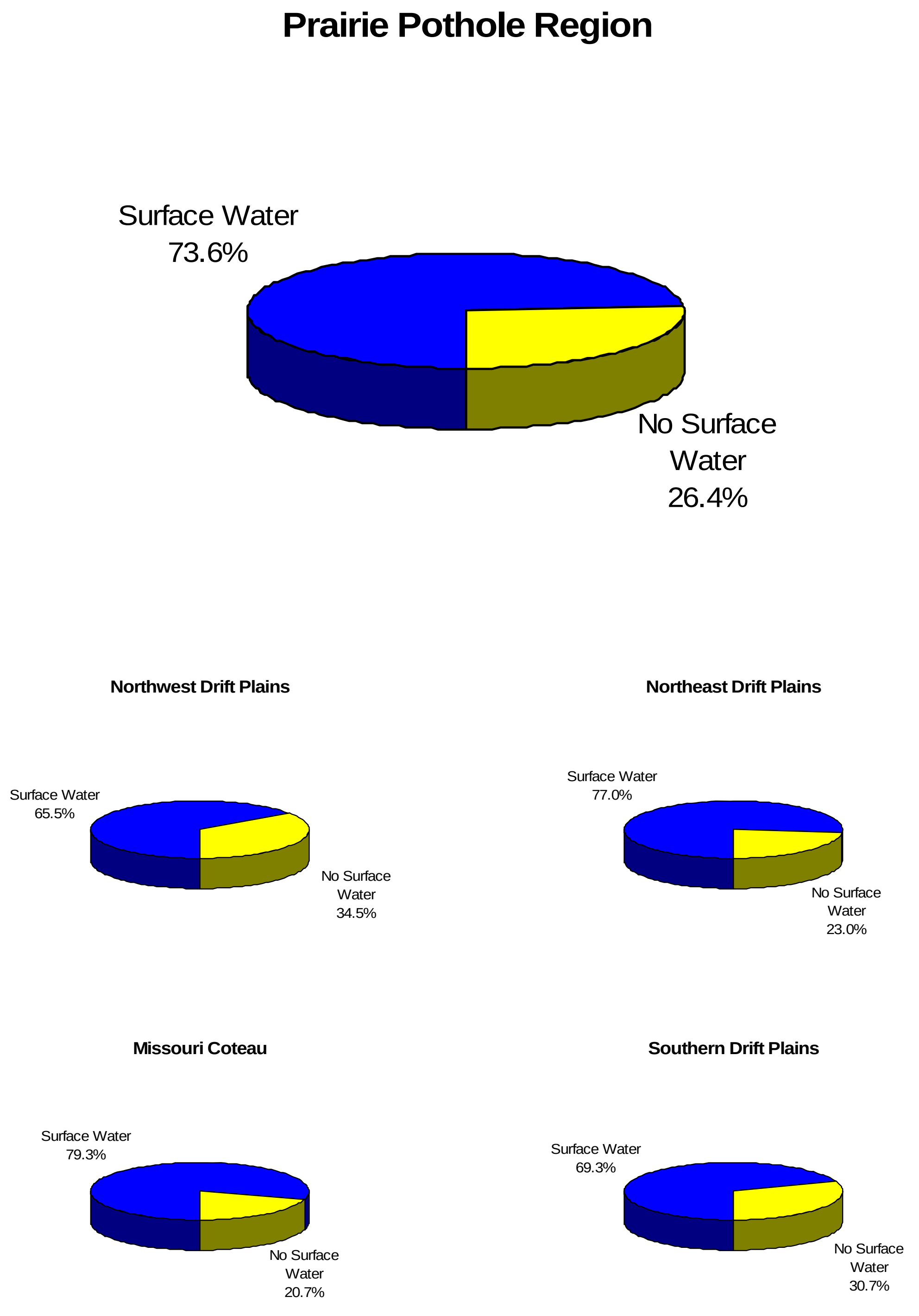


Figure 10. Cattail distribution among wetlands with or without standing water at the end of the growing season in the Prairie Pothole Region of North Dakota in 2002.

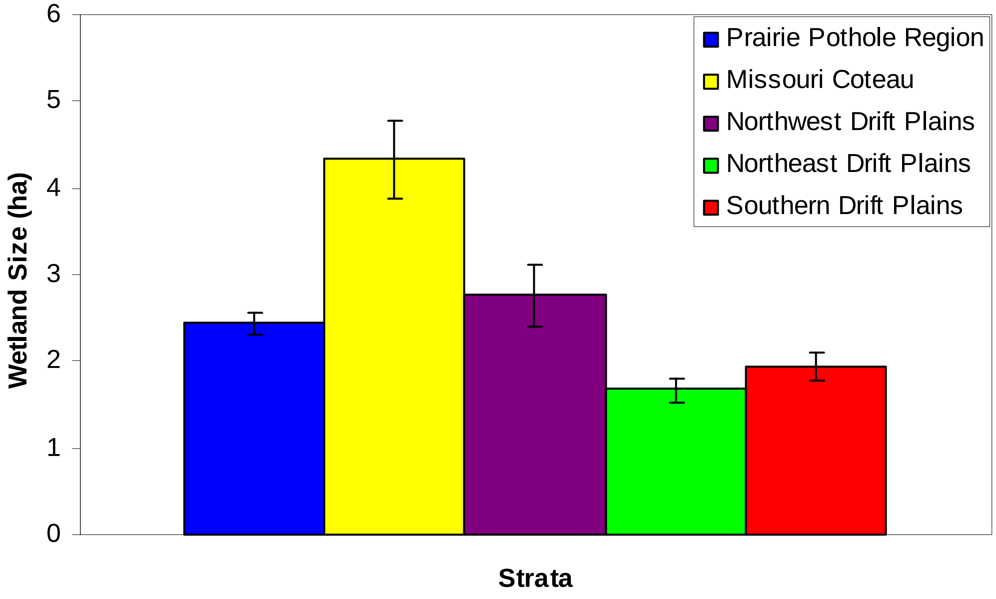


Figure 11. Mean (S.E.) size of sampled wetlands that contained cattail in the Prairie Pothole Region of North Dakota in 2002.

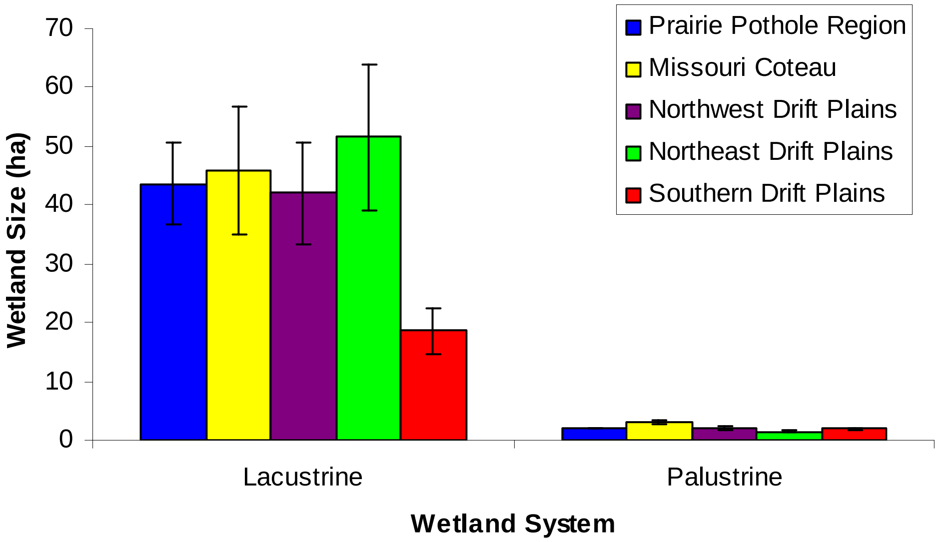


Figure 12. Mean (S.E.) size of sampled wetlands that contained cattail, separated by wetland system classifications, in the Prairie Pothole Region of North Dakota in 2002. Riverine systems were excluded due to only four instances of cattail within a riverine wetland in all samples.

A clear pattern was found with the water regime classifications, where more permanent wetland situations were larger than the less permanent wetlands (Figure 13, Appendix I). Classifications of wetland size based on wetland modifiers showed that non-linear wetlands were larger than linear wetlands. Within non-linear wetlands, the roadside abutted wetlands tended to be larger than non-modified wetlands. In linear wetland situations, ditch wetlands were normally smaller than waterway wetlands (Figure 14, Appendix I). Wetlands with surface water at the end of the growing season were significantly larger in all strata than wetlands without surface water (Figure 15, Appendix I).

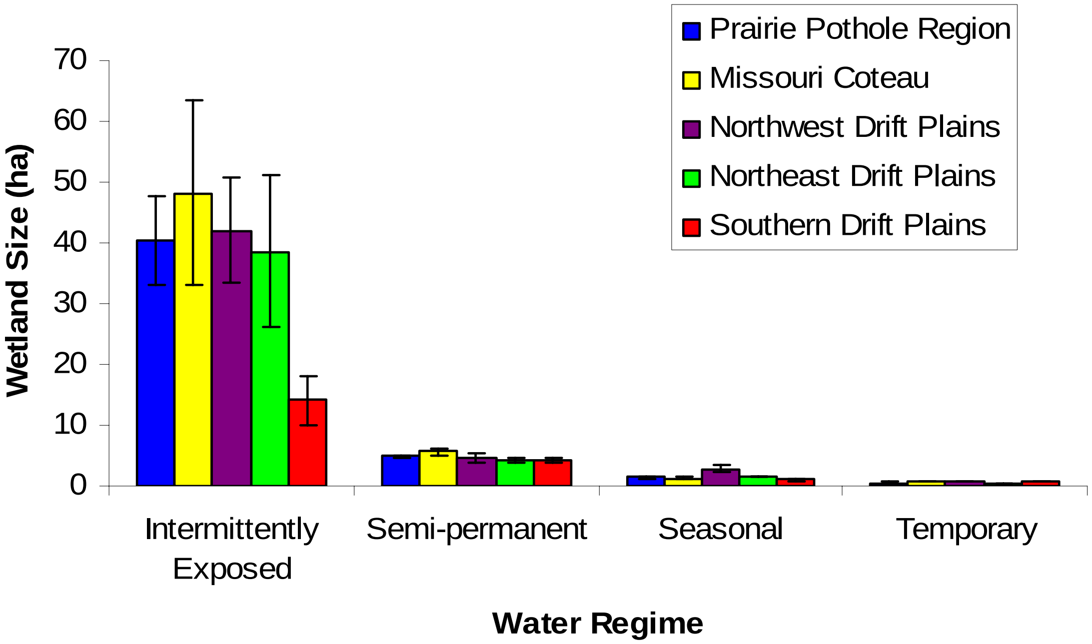


Figure 13. Mean (S.E.) size of sampled wetlands that contained cattail, separated by wetland water regime classifications, in the Prairie Pothole Region of North Dakota in 2002. The permanently flooded regime was excluded due to only one instance of cattail within a permanently flooded wetland in all samples.

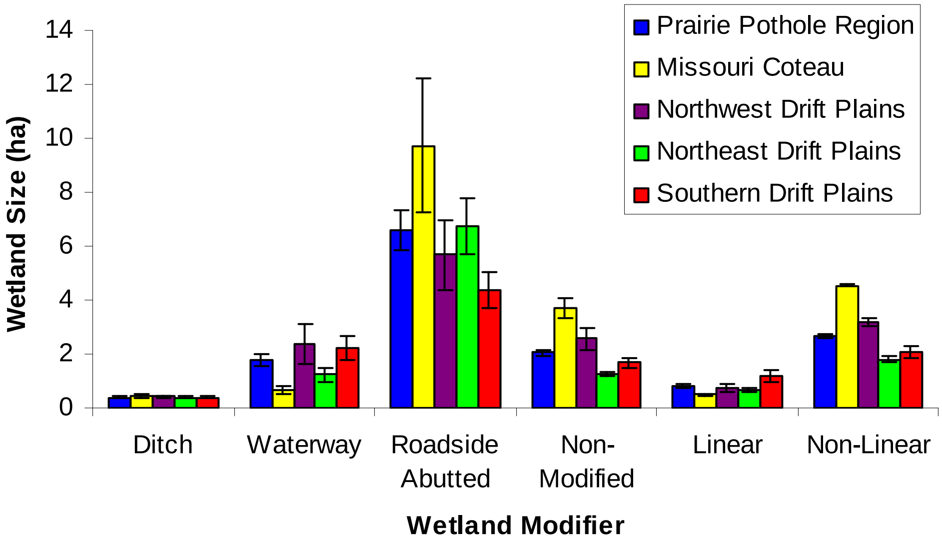


Figure 14. Mean (S.E.) size of sampled wetlands that contained cattail, separated by wetland modifier classifications, in the Prairie Pothole Region of North Dakota in 2002.

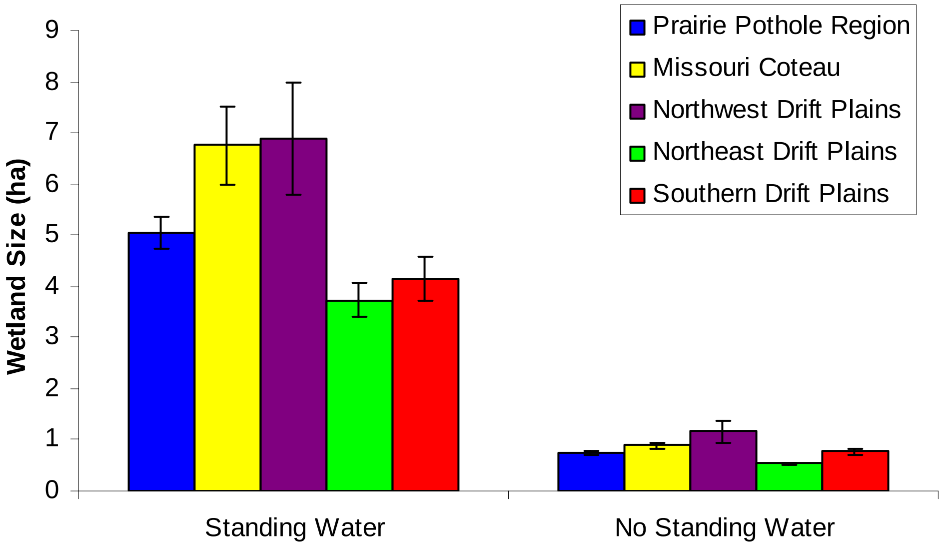


Figure 15. Mean (S.E.) size of sampled cattail wetlands based on the presence or absence of water at the end of the growing season in the Prairie Pothole Region of North Dakota in 2002.

Wetland Distribution

Density of wetlands was calculated for all wetlands sampled and compared against all wetlands identified by the NWI in the PPR. In both the sampled wetlands and NWI wetlands, the highest densities per km^2 were in the NEDP (Table 4). For comparison of cattail vs. total NWI wetland counts, linear wetlands were excluded because these wetland systems were not normally identified by the NWI. Estimates of non-linear wetlands that contained cattail represented about 47.6% of the total NWI wetlands identified.

Table 4. Wetland density for sampled wetlands containing cattail and total NWI classified wetlands.

	Total sampled wetland basins/km^2	Total sampled linear wetland basins/km^2	Total sampled non-linear wetland basins/km^2	Total NWI wetland basins/km^2
Missouri Coteau	2.69	0.15	2.54	4.40
Northwest Drift Plains	1.86	0.30	1.56	6.79
Northeast Drift Plains	5.88	0.64	5.24	8.19
Southern Drift Plains	3.78	0.55	3.23	7.21
Prairie Pothole Region	3.54	0.40	3.13	6.57
North Dakota	----	----	----	4.17

Distribution of the total number of wetlands sampled, based on wetland system classification, showed that in all strata, palustrine systems were the most numerous and lacustrine systems were second (Figure 16, Appendix I). Riverine systems with cattail were rare and only found in two of the four strata. Wetland identification by the NWI showed similar results to those wetlands sampled. Of all wetlands, the palustrine system was the most dominant in North Dakota, with lacustrine and riverine systems representing less than 2% of the total count (Figure 17).

Water regime distribution of wetlands showed that of wetlands which contained cattail, intermittently exposed wetlands were found the least often. Temporary, seasonal and semi-permanent regimes all represented a significant portion of the distribution, and the amount varied among strata. The NWDP and NEDP both had cattail most often found in temporarily flooded wetlands, with seasonal wetlands coming in second. The SDP had relatively equal distribution among temporary, seasonal, and semi-permanent regimes. Cattail was most often found in semi-permanent wetlands in the Missouri Coteau (Figure 18, Appendix I). Distribution of total NWI identified wetland regimes was different from those that contained cattail. In all strata, temporary wetlands were the most numerous (~75%), with semi-permanent wetlands second and seasonal wetlands third. Using the NWI data, some water regimes were identified that were rare or nonexistent in the sampled wetlands, and these regimes were lumped into the “other” category. The “other” category represented less than 0.1% of all wetlands (Figure 19).

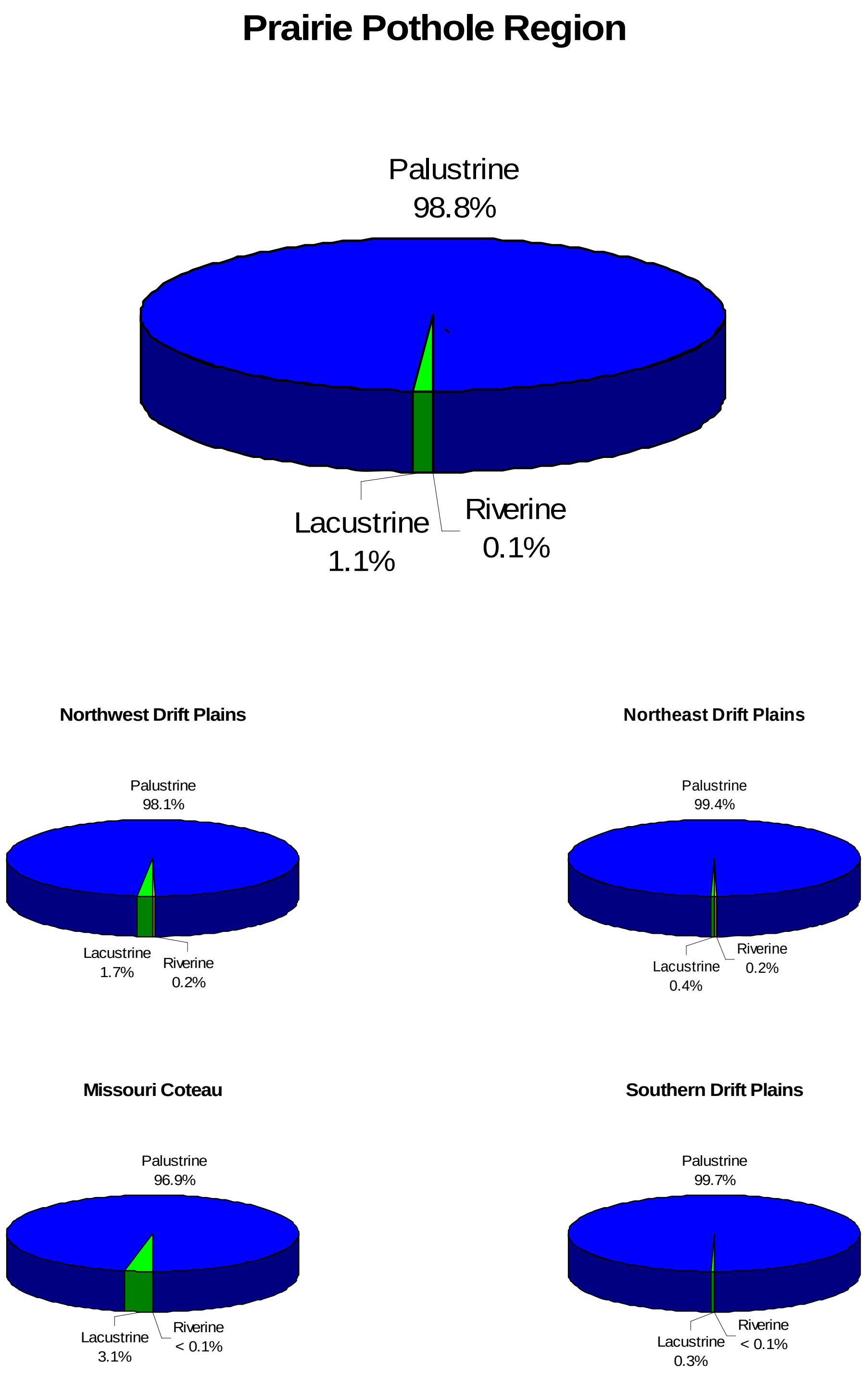


Figure 16. Distribution of sampled wetlands among wetland system classifications in the Prairie Pothole Region of North Dakota in 2002.

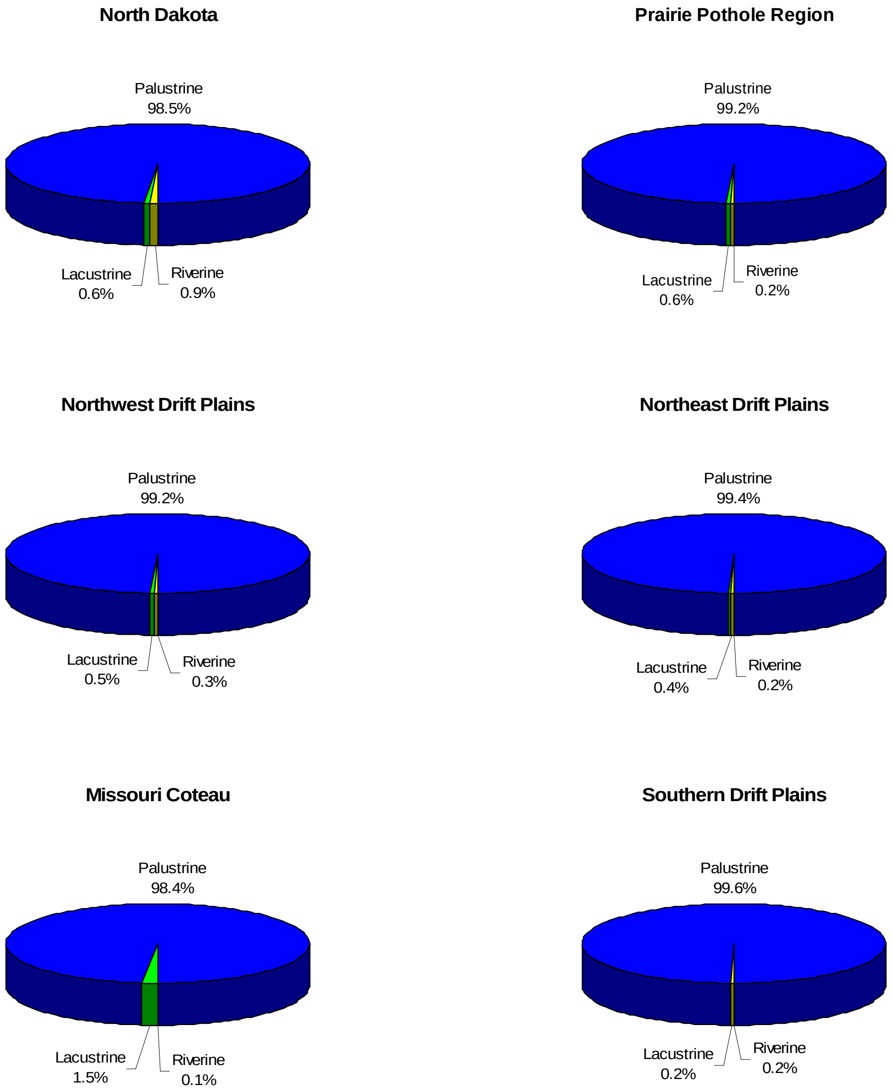


Figure 17. Distribution of all NWI classified wetlands among wetland system classifications in the Prairie Pothole Region of North Dakota.

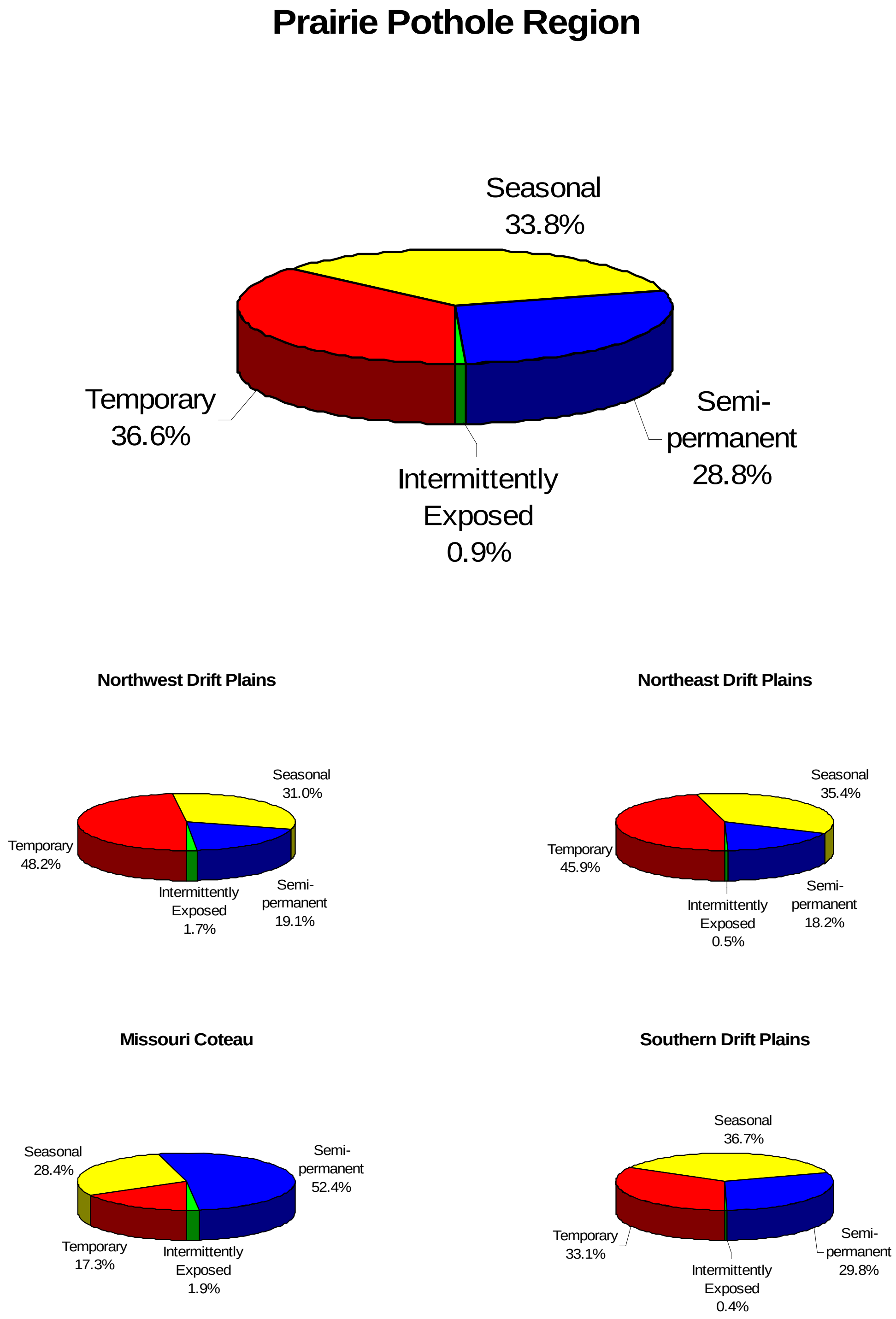


Figure 18. Distribution of sampled wetlands among wetland water regime classifications in the Prairie Pothole Region of North Dakota in 2002.

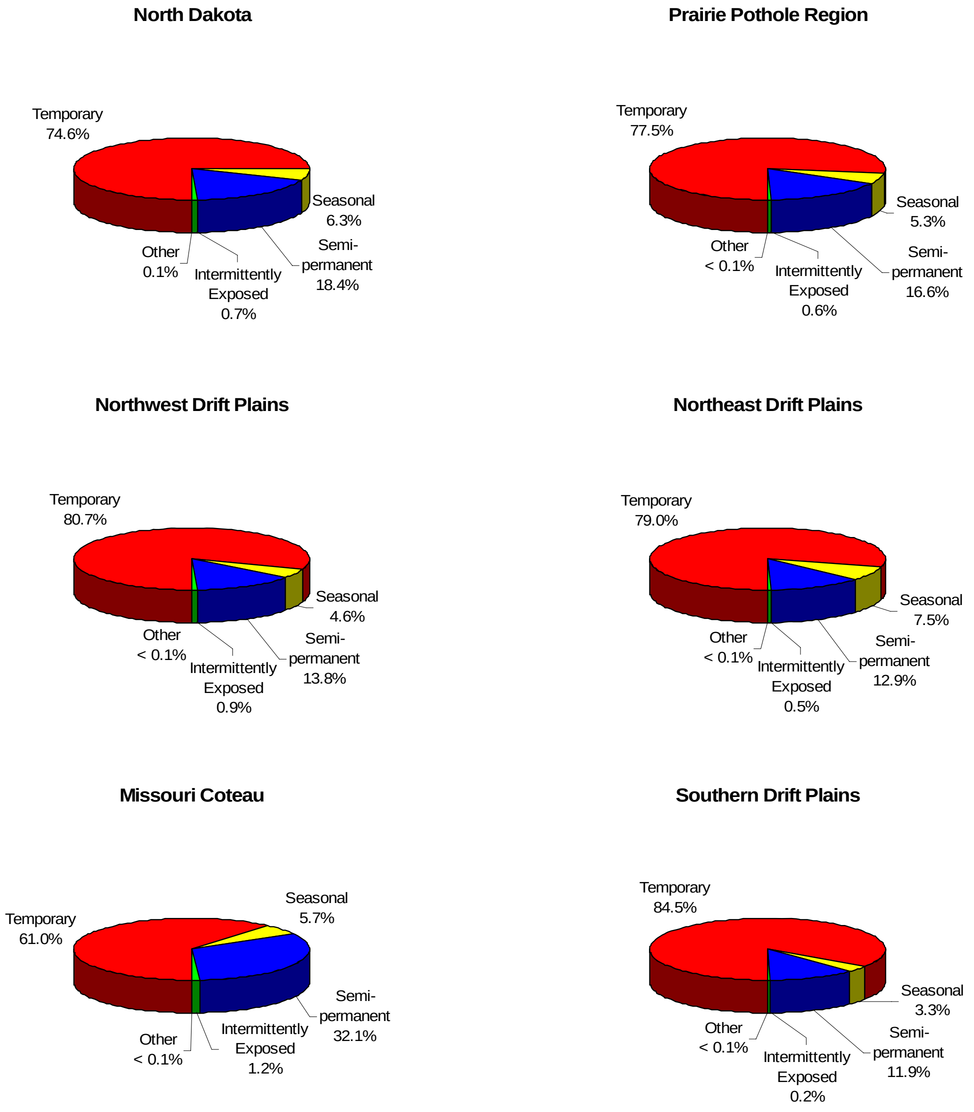


Figure 19. Distribution of NWI classified wetlands among wetland water regime classifications in the Prairie Pothole Region of North Dakota.

Wetland modifier classes differed in this study from those used by the NWI; therefore, comparisons between sampled wetlands and total NWI wetlands could not be made for modifier classifications. The number of wetlands represented by the non-modified class represented about 75% or more of all wetlands sampled in each of the strata. Roadside abutted wetlands were consistently the second most abundant, with ditch wetlands third and waterway wetlands last (Figure 20, Appendix I). Cattail wetlands that contained surface water at the end of the growing season were more numerous than dry wetlands in all strata except the Missouri Coteau (Figure 21, Appendix I).

Precipitation Data

NDAWN precipitation data for all available years and locations from 1991-2003 showed the regular cycle of low and high precipitation every 5 to 10 years. The mean growing season precipitation for all years and all locations was 37 cm for North Dakota and 36 cm within the PPR. Strata located on the east end of the PPR tended to have higher precipitation than the more western areas (Figure 22). Data for 2001-2002 showed precipitation amounts that might have had an influence on cattail growth conditions during the study period. The amount of precipitation in each stratum followed the same pattern as the amount of cattail found in those strata. The NEDP had the highest average precipitation (~36 cm per growing season), with the SDP second, MC third, and the NWDP had the least precipitation of all PPR strata (Table 5).

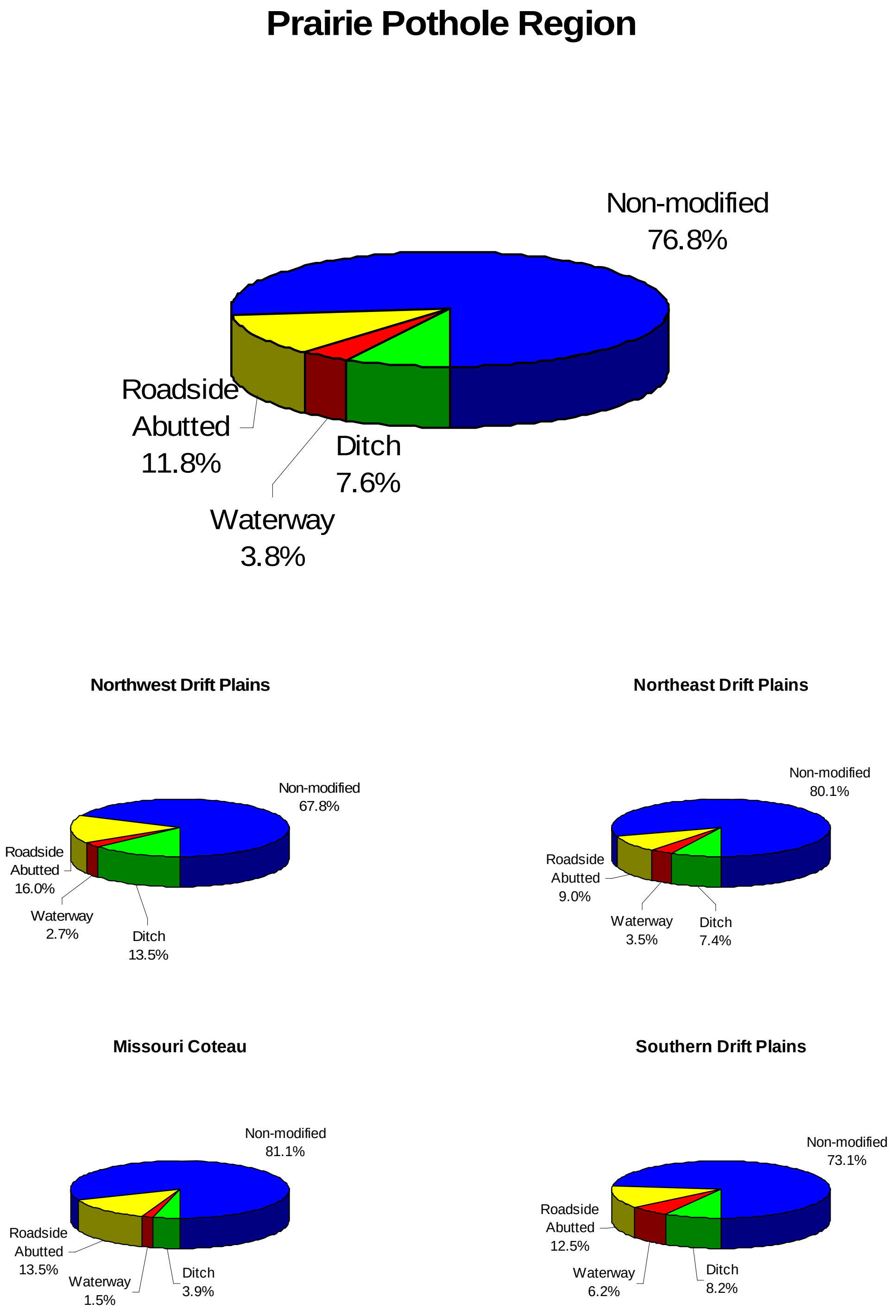


Figure 20. Distribution of sampled wetlands among wetland modifier classifications in the Prairie Pothole Region of North Dakota in 2002.

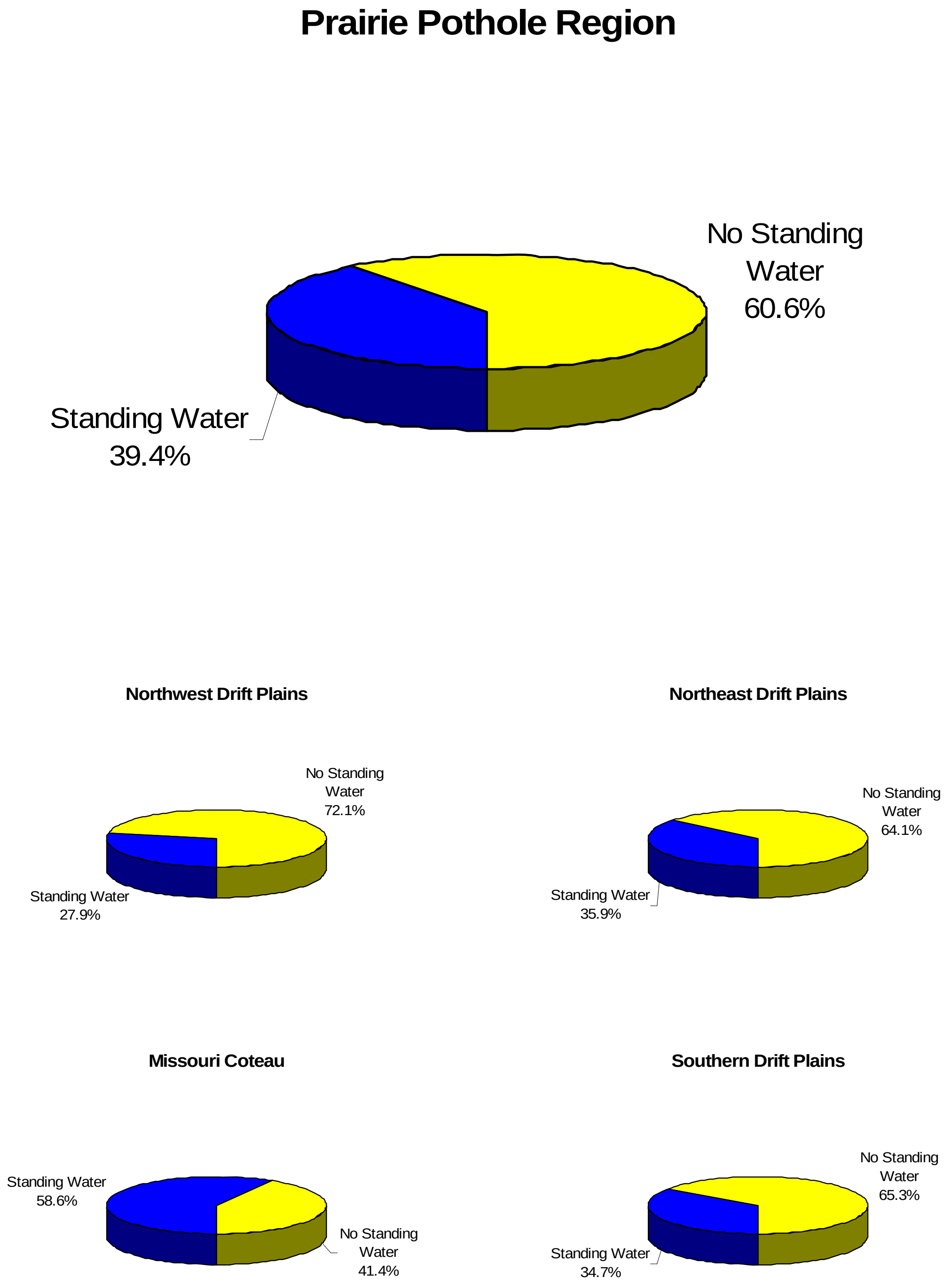


Figure 21. Distribution of sampled wetlands based on the presence or absence of water at the end of the growing season in the Prairie Pothole Region of North Dakota in 2002.

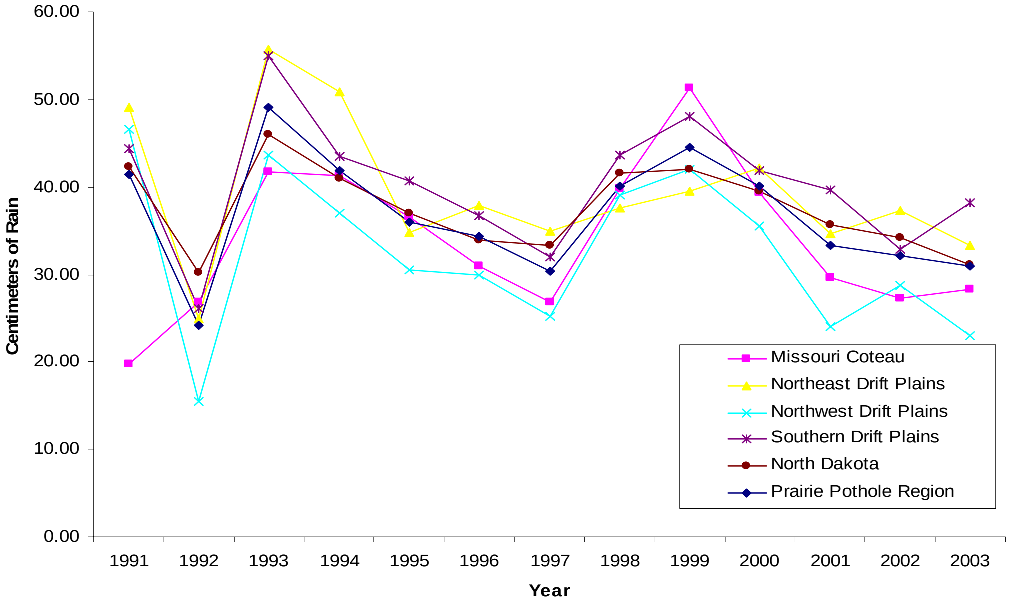


Figure 22. Mean growing season (April-October) precipitation from all available recording stations for each stratum in the Prairie Pothole Region of North Dakota from 1991-2003.

Table 5. Mean rainfall for 2001 and 2002 growing seasons (April-October) based on all available NDAWN recording stations.

Strata	Centimeters of Rainfall
Missouri Coteau	28.3
Northwest Drift Plains	27.0
Northeast Drift Plains	36.0
Southern Drift Plains	35.8
Prairie Pothole Region	32.3
North Dakota	34.8

Breeding Bird Survey Data

Analysis of BBS data from 2001-2003 revealed the most blackbirds per BBS route were found in the Missouri Coteau. When separated by species, red-winged blackbirds appeared to be most plentiful in the eastern part of the PPR, especially in the Southern Drift Plains where about 300 birds per route were found. Yellow-headed blackbirds were most abundant (268 birds/route) in the Missouri Coteau. Common grackles were also found most often in the Coteau (86 birds/route) but were the least abundant blackbird overall (Table 6).

Sunflower Production

In 2002, sunflower hectarage in the PPR represented over 63% of the total sunflower grown in the state. The highest amount of total sunflower crop was grown in the NWDP, where about 1,260 km^2 of sunflower were planted. The least amount of sunflower was grown in the Missouri Coteau, where only about 3.4% of the land area was planted to sunflower (Table 7).

Table 6. Mean (S.E.) birds/USFWS Breeding Bird Survey route in the Prairie Pothole Region of North Dakota averaged for all available 2001-2003 datasets.

	# of BBS Routes	Red-winged Blackbird	Yellow-headed Blackbird	Common Grackle	All Blackbirds
Missouri Coteau	6	254 ± 102	268 ± 71	86 ± 31	608 ± 178
Northwest Drift Plains	4	208 ± 127	114 ± 92	58 ± 29	379 ± 248
Northeast Drift Plains	6	287 ± 50	157 ± 49	55 ± 14	499 ± 178
Southern Drift Plains	5	299 ± 47	166 ± 54	62 ± 9	526 ± 97
Prairie Pothole Region	21	265 ± 39	183 ± 33	66 ± 11	514 ± 74

Table 7. Sunflower grown in North Dakota for 2002, derived from North Dakota Agricultural Extension Service land-use classification.

Strata	Km^2	% of Land Area
Missouri Coteau	887	3.4%
Northwest Drift Plains	1,260	5.8%
Northeast Drift Plains	971	4.4%
Southern Drift Plains	1,038	4.1%
Prairie Pothole Region	4,156	4.4%
North Dakota	6,572	3.6%

DISCUSSION

Sampling Methods

The use of 10.2 km^2 plots worked well for this study. As mentioned in the Methods chapter, a study by Johnson et al. (1999) suggested the optimal plot size for reducing bias and variance in wetland surveys was 10.2 km^2. Additionally, using legal section lines as the plot boundaries made sampling easier. Boundaries are professionally surveyed and are usually well delineated, making a convenient grid across the landscape. At most section boundaries, there is a visible marker such as a road, fence line, or sharp contrast between vegetation or land-use. Using four of the 2.6 km^2 sections per sample plot gave many visual cues which could be used to geo-reference the aerial photos. Error was reduced in geo-referencing when more reference points were used. For each legal section, at least four points could normally be seen. Without proper geo-referencing, subsequent area values could be skewed. The presence of roadways that often divided the section boundaries also provided convenient biotic divisions for dividing wetlands that would normally run into the adjacent section. When sampling wetland attributes such as size, roadway divisions reduced errors. The size of a wetland that was located on the edge of a sample plot was often underestimated because the boundary for the wetland was cut off at the edge of the sample plot. When a road divided a wetland, the wetland boundary was naturally divided, and the true area value was maintained.

Aerial color infrared photography worked well to identify cattail; however, in the future, hyperspectral imagery may be more beneficial because it provides greater spectral resolution and vegetation discrimination. Although the equipment was not available at the time of this study, any future aerial images should be scanned using a digital slide scanner. Using a flatbed scanner with photographic prints can cause imperfections in the image due to smudges on the print or on the surface of the scanner. Using four photographs per sample plot was beneficial in maintaining sub-meter resolution. During image reclassification, it was important to analyze each image separately because of differences in hue, contrast, brightness, and color balance between each image.

In this study, the wetlands sampled were only those wetlands that contained at least some cattail. Descriptions of wetland attributes of cattail wetlands may not be representative of all wetlands. In addition, cattail density per wetland may be lower than expected because boundaries used for wetland size were drawn based on visual cues of vegetation differences, which often extend into the low prairie zone. The inclusion of the low prairie zone typically includes a buffer strip around the wetland, outside of the range of the cattail, where there is a transition from wetland to upland vegetation.

GIS Analysis

The methods used to extract cattail and wetland information resulted in a high degree of confidence that areas identified as cattail were correct. The aerial CIR photos were relatively easy to interpret after some experience and training. Sub-meter resolution of the images aided in identifying ground features. If any cattail stands were missed, they were most likely too small or too sparse to give a distinct cattail signature and thus were presumably not biologically significant as cattail habitat for blackbirds. Other vegetation in and around the cattail wetlands could be discerned from cattail with reasonable accuracy. Giant reed grass (*Phragmites australis*) had a photo signature that was a dirty yellow color. Bulrush (*Scirpus spp.*) was lighter pink than cattail and had much less texture. Duckweed (Lemnaceae) was also light pink or white with a flat appearance. The vegetation with the most similar color signature to cattail was dock (*Rumex spp*.), which in some of the southern and central parts of the PPR was fairly abundant. The best method to distinguish between dock and cattail was to ground-truth those locations. Dock also had a flatter texture than cattail, and since cattail was usually a taller plant, it often had a small but visible shadow on the edge of the vegetation stand. Some crops such as corn also give off a similar color and texture signature to cattail; corn can be easily distinguished by location of visible wetland boundaries and the use of analysis masks for those areas.

A different aspect of this vegetation mapping project, compared to many other vegetation mapping methods, was the use of vector editing. Most methods for vegetation mapping encountered while designing this project used only raster methods. Currently there are some programs designed to work specifically with raster data, but the program readily available at the onset of this project was ESRI ArcInfo 8x. The ArcMap program within ArcInfo contained the spatial analysis extension, which was used for the initial raster image classification; however, once the raster layers were created, they were not easily edited without recreating the analysis mask and rerunning the image classification. By converting the classified raster layers into a vector format, data layers could easily be edited and worked with because ArcInfo was designed for manipulating vector layers. Polygons representing cattail areas were easily cut, reshaped, added to, merged or split. Area values could also be directly extracted from the attribute table or exported into a spreadsheet without additional calculations, which saved time. Vector layers also more accurately represent real world features because polygon shapes are not limited to square pixels.

Characterization of the Prairie Pothole Region and Its Strata

The PPR of North Dakota is a distinctive region as described by Stewart and Kantrud (1971). According to the NWI data, 81% of all wetlands in North Dakota are located in the PPR, with an average of 6.6 wetlands per km^2. Most of these wetlands (99.2%) are shallow depressions in the landscape and are not large enough or deep enough to constitute a lake, thus they are classified as palustrine systems. The majority (77.5%) of the wetlands in the PPR are classified as temporary, with semi-permanent making up the second largest group (16.6%). According to NDAWN weather data, precipitation that provides water for these wetlands is about 15% higher in the PPR than in the southwest portion of the state, and is 15% lower than in the Agassiz Lake Basin at the east end of the state. The water levels influence the growth of wetland vegetation. Cattail is a dominant wetland plant, and results from this study indicate that cattail covered over 2,200 km^2 or about 2.3% of the land surface in the PPR of North Dakota in 2002. Over half of all wetlands in the region contained cattail. The size of these cattail wetlands varied. The minimum wetland size measured was 0.02 ha, and the largest was 233.6 ha, the overall mean was 2.6 ha. Cattail typically covered about

36% of an average wetland. The abundance of blackbirds in this region may be due to the excellent nesting habitat that the cattail provides. Data from the BBS from 2001-2003 showed the average number of blackbirds recorded per 40 km survey route exceeded 500, over half of which were red-winged blackbirds. Over a third of the blackbirds recorded along the BBS routes were yellow-headed blackbirds, and the smallest proportion was represented by common grackles. Another reason, besides wetland habitat, that blackbirds are so abundant in the PPR may be due to the food resources that agricultural crops like sunflower provide. In 2002, 63% (4,156 km^2) of all sunflower in North Dakota was grown in the PPR.

The sub-strata of the PPR can be further broken down to reveal variation within the region. The Missouri Coteau stretches along the entire western edge of the PPR. The MC had the lowest density of NWI wetlands and was ranked third out of four strata for the highest density of cattail and cattail-containing wetlands. The MC had, by far, the largest average cattail wetland size at over 4.5 ha, exceeding by over 1 hectares the mean size for any other stratum. In addition, the MC had the highest percentage (1.5%) of lacustrine wetlands. Wetlands that contained cattail tended to be more permanent than in the other strata, with over 52% of the cattail wetlands classified as semi-permanently flooded. The MC was the only stratum where over half (58.6%) of the cattail wetlands still contained surface water at the end of the growing season. The third place rank for the amount of cattail may be due to the large wetlands. Water depth in many of the larger wetlands may have been too deep for cattail to grow. Incidentally, the MC also ranked third among the strata for the amount of average rainfall in 2001-2002 (28.3 cm). With less rain, the temporary and seasonal wetlands may be drier and, thus, support less cattail than in other strata that received more rain. Blackbird counts reflect some of the region's wetland attributes. Yellow-headed blackbird numbers are highest in the MC compared to the other strata. This difference is likely due to the YHBL's preference for nesting in cattail over open water, a habitat that is frequently encountered in the MC. The rolling hills, large wetlands, and lower precipitation of the region may also be a factor in agricultural production. In 2002, the MC had the lowest hectarage of sunflower (887 km^2) but the highest percentage (59%) of land in pasture, idle crop, and rangeland.

The Northwest Drift Plains ranked third of the four strata for the number of NWI wetlands per square kilometer (6.8) and last for wetlands that contain cattail (1.6/km^2). Distribution of NWI wetlands between system and water regime classifications was similar to the other parts of the drift plains, with the majority of wetlands classified as palustrine (99.2%) and temporary (80.7%), respectively. The cattail wetlands sampled were large (3.2 ha) compared to the other portions of the drift plains. Overall, the NWDP had the lowest amount of cattail in the PPR (25,600 ha, or 1.2% of land area). The NWDP was the only stratum where the highest percentage (40%) of the total cattail was found in seasonal wetlands, compared to dominance of cattail in semi-permanent wetlands of the other strata. The NWDP had the lowest (31%) cattail density per wetland of all regions of the drift plains. Precipitation during the growing season in the NWDP was the lowest of all strata (27.0 cm), which may account for the lower amount of cattail and probably contributed to the observation that only 28% of the cattail wetlands contained surface water at the end of the growing season. Low amounts of cattail habitat may be the reason for the low abundance of blackbirds (379 birds / route) in the stratum. The NWDP ranked last among all strata for blackbirds per BBS route in 2001-2003, with the exception of the common grackle's third place ranking out of the four strata. Low densities of blackbirds do provide an advantage for producers that grow crops such as sunflower, which is commonly depredated by blackbirds. Sunflower production in the NWDP was the highest for all parts of the state in 2002, with 1,260km^2 (5.8% of the land area) planted in sunflower.

The Northeast Drift Plains was a distinctive stratum for cattail. The estimate for cattail in the NEDP for 2002 was over 92,000 hectares or about 4.2% of the land area. A major factor that contributed to this abundance of cattail was the high density of wetlands. This stratum had more NWI wetlands (8.2/km^2) than any other part of the state, and about 72% of the wetlands contained cattail, giving this stratum the highest density of cattail wetlands (5.9/km^2). Within those wetlands, cattail density was also the highest among the strata, with over 43% of an average wetland covered in cattail. About half of the cattail was found in semi-permanent wetlands, and a large percentage (77%) of the cattail was found in wetlands that retained surface water at the end of the growing season. The size of cattail wetlands in the NEDP tended to be smaller than in the other strata. This small wetland size contributed to the distribution of the water regime classifications, where the majority of total NWI wetlands and the wetlands that contained cattail were temporary wetlands (79% and 46%, respectively). The reason for the large number of temporary wetlands with cattail growing in them may be due to the abundance of rain during the growing season. Of all strata, the NEDP received the highest average annual precipitation (36.0 cm) during the 2001 and 2002 growing seasons, which may have kept the temporary and seasonal wetlands moist enough to grow more cattail than in the other strata that received less precipitation. The profusion of cattail habitat was beneficial to blackbirds, especially red-winged blackbirds; the NEDP ranked second among PPR strata in the most birds per BBS route in 2001-2003. An abundance of cattail wetlands and an abundance of blackbirds in the NEDP did not deter producers from planting sunflower crops. In 2002, the amount of cattail and the amount of sunflower were nearly equal, and the NEDP ranked second out of the four strata in percent land area covered by sunflower (4.4%).

In terms of wetland attributes gathered in this study, the Southern Drift Plains was not at either extreme of most wetland measurements. Cattail amount was moderately high at 2.7% of the land area, which ranked second among the strata. Also ranking second was the density of cattail within wetlands (40% cattail). One distinctive attribute in the SDP was a less permanence of wetlands. The SDP had the lowest percentage of lacustrine wetlands (0.2%) and the highest percentage of temporary wetlands (84%) among all strata. Distribution of wetlands among water regime classes of temporary, seasonal and semi-permanent was relatively equal for wetlands that contained cattail, but over half (61%) of the total cattail was located in semi-permanent wetlands. The west-to-east gradient in the state of low to high precipitation held true for the SDP, with an average precipitation of 35.8 cm during the growing season for 2001-2002. The SDP ranked second among strata for the highest number of total blackbirds per BBS route. Although there was less cattail than in the NWDP, the number of red-winged blackbirds per BBS route (299) was slightly higher and ranked number one among strata. Rather than migrating further northward, these birds may have remained in the area because of the relatively high amount of cattail habitat and availability of food resources. Hectarage planted in sunflower in 2002 in the SDP ranked second among strata but third in percent of land area covered by sunflower (4.1%).

There were some general trends across the strata in relation to cattail abundance. Higher abundance of cattail was found in areas with higher densities of NWI wetlands, higher densities of wetlands that contain cattail, higher densities of cattail per wetland, greater precipitation during the growing season, a greater percentage of palustrine wetlands, and cattail wetlands that contain surface water at the end of the growing season.

Cattail and Precipitation Cycles

Wetland vegetation, such as cattail, is influenced by precipitation cycles (Larson 1995, Euliss et al. 1999). If a wetland is too dry, cattail will not have enough moisture to grow. On the other hand, if water depth is too great, the cattail will be flooded out (Kantrud 1990, Merendino and Smith 1991). Three hypotheses could be drawn regarding influences of precipitation on cattail abundance in wetlands. Cattail could increase during years of high precipitation. More temporary and seasonal wetlands would maintain sufficient moisture to support cattail growth, thus increasing the overall amount of cattail. Secondly, cattail could increase in periods of moderate to dry conditions. Although temporary and seasonal wetlands may become too dry to support cattail, most of the current cattail was found in semi-permanent wetlands, which are likely to maintain enough moisture in drier years to support cattail. Exposed mudflats in semi-permanent and intermittently exposed wetlands may support greater cattail seed germination and increase the amount of total cattail in those wetlands. Proliferation of cattail in the more permanent wetlands may outweigh the loss in the more temporary wetlands because more permanent wetlands tend to be much larger. A third idea is that the wet and dry conditions would counteract each other and the net cattail would be approximately the same. The distribution of cattail would shift in wet years to the less permanent wetlands and would reverse in dry years.

Given the data gathered from this study, the first of the three hypotheses would be the most probable. Analysis of Figure 22 indicates that the point where the data for this study were gathered (2002) is about in the middle of a typical decline from a wet cycle; therefore, it is unlikely that cattail vegetation would be at its highest or lowest levels. Over half (57%) of the total cattail wetland hectares and 54% of the total cattail hectares are in semi-permanent wetlands. An increase in water levels in the wetlands may decrease cattail in the interior, deepest portion of the semi-permanent wetlands, but the cattail on the perimeter of the wetland will most likely expand as cattail germinates on the moist soil of the periphery (Linz 1992, Linz et al. 1995b). The second largest percentage of total wetland and cattail hectares (20% and 30%, respectively) comes from seasonal wetlands, while the greatest percent of total wetlands are temporary wetlands (77.5%). With higher precipitation, seasonal wetlands would shift more to a semi-permanent configuration, and temporary wetlands would resemble more of a seasonal pattern; both of these conditions would increase the cattail. During dry periods, cattail that does grow in temporary or marginal seasonal wetlands is often plowed under when located among agricultural fields, which reduces the amount of cattail (Prochaska et al. 1998).

Future Research

A landscape study such as this one opens the opportunity for other research to follow. Randomly chosen, stratified sample sites are available from this study. The aerial photographs and wetland conditions recorded from the sites serve as a reference from which future work could be compared. The cattail and wetland attributes gathered in this study are only a snapshot in time. Research should be done to test the hypotheses of cattail cycles presented above. Wetland dynamics could be analyzed by repeating the same study over multiple years as the region experiences different precipitation regimes. Wetland vegetation could possibly be predicted based on the available moisture. Now that variance estimates are available for cattail in different regions, future studies could use Neyman Allocation to more appropriately distribute sample sites (Cochran 1977). For example, if 100 sample plots were to be distributed throughout the strata of the PPR, based on cattail variance and stratum size, 4 samples would be taken in the Missouri Coteau, 24 in the Southern Drift Plains, 66 in the Northeast Drift Plains, and 6 in the Northwest Drift Plains.

Natural resource agencies are continually employing more GIS technology in their research. GIS is a powerful tool and can easily incorporate many different data sources. Much more work could be done with existing GIS data layers in conjunction with data gathered in this study. Using sub-strata, watershed layers or geopolitical boundaries, the cattail and wetland estimates could be broken down into smaller regions. Landsat satellite data have been used to run 30X30 m land-use classifications. The resolution is large in much of the satellite imagery, but it may be sufficient to relate general landscape characteristics to the cattail and wetland information gathered. National Wetlands Inventory data for the region are over 20 years old and should be updated; however, until this massive re-mapping project can be undertaken, error correction factors could be derived from the sample plots to estimate more current wetland sizes and densities. Cattail wetland basins have already been mapped and classified, thus researchers would only have to map and classify the remaining wetlands. Once the wetlands in the sample plots are all mapped, the NWI data could be compared against those plots to determine a correction factor for the NWI data for the current conditions. This correction factor could then be used until the NWI is updated. Similar work has been done in Ohio and Wisconsin to update their NWI maps (Yi et al. 1994, Johnston and Meysembourg 2002).

High resolution land-use characteristics, beyond cattail vegetation, could be gathered from the existing photographs for the sample plots, which could reduce the funding needed for such studies. General land use types, such as woodland, developed, roadway, rangeland, CRP and wetland basins, do not change greatly from year to year, thus archived photos may be sufficient. Although crop type often does change between years, typically the boundaries of the fields do not change; therefore, a broad category of agricultural crop could be applied to these situations. Once land-use types are classified, they could serve as descriptors of a region or they could be used to compare with animal surveys.

In the scope of the blackbird / sunflower management, it may be useful to conduct annual breeding bird surveys on all, or a subset, of the sample plots to learn landscape preference on a regional basis. In addition to blackbird surveys, sunflower damage surveys could also be conducted on sunflower fields within the sample plots. By learning more detail on what land-use characteristics cause birds to depredate crops in a certain area, producers and managers may be able to better predict high risk areas and avoid greater economic loss. Using data on blackbird populations, land-use and crop location, sunflower damage data, and the cattail information provided in this study, managers could improve the current blackbird management program to target resources in specific areas with greater risk.

Another major step in answering the concerns for the cattail management program is to experimentally determine the amount of cattail that can be safely removed from an area or region without causing significant negative effects on non-target species. Research has been done on a wetland basis to determine the amount of cattail that could be removed from a wetland to achieve desired results for blackbird control and still maintain habitat for animals such as ducks, pheasants, and deer (Linz et al. 1995b, 1996a and b, Kantrud et al. 1989). This research could involve a study that would measure how far non-target species, such as ring-necked pheasants and white-tailed deer, which rely on cattail cover, could disperse to reach an untreated area without significantly reducing survival or productivity (Homan et al. 2000, Linz et al. 1992). Conservation Reserve Program (CRP) land is known to be beneficial as wintering habitats of deer and pheasants (Linz 1992). Using GIS analysis, CRP locations could be associated with available cattail in an area to quantify alternative habitat if cattail were reduced.

Waterfowl is of great interest in North Dakota because of the income it generates by hunting in the state (Kantrud et al. 1989). Many water birds are tied to the wetlands and cattail. The information provided in this study may also be used to manage the waterfowl habitat in the PPR of North Dakota. As with the aforementioned blackbird surveys, waterfowl surveys could also be done on these sites and related to other land-use characteristics within the plot to track productivity of various regions and land-use types. Waterfowl populations are regularly surveyed by the USFWS, and data are available most years (Smith 1995). If a correlation between waterfowl populations and blackbird populations could be determined by counting both types of birds on the same sample plots, then future waterfowl surveys might serve as simple and cost effective indices of blackbird populations.

IMPLICATIONS AND MANAGEMENT

This research would not have been conducted without the questions that arose from active reduction of cattail by management agencies. Therefore, the most important implications of the results are those that could be applied to ongoing management programs. In 2002, the USDA Wildlife Services eliminated 1,728 ha of cattail in the PPR of North Dakota with glyphosate. Estimates show that the amount of cattail sprayed with glyphosate represents about 0.78% of the total cattail available (Table 8). Although cattail coverage is bound to fluctuate over time, if the assumption is made that the approximate amount of cattail estimated in 2002 remains the same through all years, a comparison can be made for the other years of the cattail management program. Under that assumption, only one year (1996) did cattail reduction exceed one percent (1.07%) of the total available cattail. The USDA only sprayed 70% of the hectares enrolled in the program for each wetland. Even if 100% of the cattail in the enrolled wetlands had been sprayed, most years still would have had less than 1% of the total cattail affected, and the highest percentage would have been 1.53% in 1996. No data are available on how much of the total cattail in the region could be removed without causing significant problems for non-target species, but it is unlikely that a 1% reduction would be harmful if it were geographically distributed somewhat evenly.

During recent review processes of blackbird management programs, there has been inquiry into expanding the cattail management program to reduce greater amounts of cattail (USDA 2004). Previous research has been conducted to determine optimal ratios of cattail to remove from wetlands in order to lower their

Table 8. Enrollment and management of cattail in the USDA-WS cattail management program in the PPR of North Dakota for all years of the program.

Estimated Cattail Hectares in the PPR of ND: 221,509.3 ha

Year	Cattail Reduced in ND (ha)	% of Estimated Total Cattail Reduced*	Total Enrolled Cattail (ha)	% of Estimated Total Cattail Enrolled*
1991	569.4	0.26%	813.4	0.37%
1992	1,421.3	0.64%	2,030.4	0.92%
1993	856.7	0.39%	1,223.9	0.55%
1994	714.3	0.32%	1,020.4	0.46%
1995	1,244.8	0.56%	1,778.3	0.80%
1996	2,367.0	1.07%	3,381.4	1.53%
1997	1,863.6	0.84%	2,662.2	1.20%
1998	1,793.5	0.81%	2,562.2	1.16%
1999	581.1	0.26%	830.2	0.37%
2000	1,146.5	0.52%	1,637.8	0.74%
2001	1,478.7	0.67%	2,112.5	0.95%
2002	1,727.6	0.78%	2,468.0	1.11%
2003	1,065.5	0.48%	1,522.2	0.69%
Mean for all Years	1,294.6	0.58%	1,849.5	0.83%

*All calculations involving estimated hectares of cattail are derived from the 2002 cattail estimate. Estimates for all years except the year of the study (2002-highlighted) are based on the assumption that the mean amount of cattail remains approximately the same as in the study year (2002).

appeal to blackbirds as a roost, as well as to increase the attractiveness to some waterfowl species (Linz et al. 1994, 1995b, 1996a and b). This thesis research estimated the abundance of cattail and density of wetlands in the PPR. Future research is needed to incorporate data gathered by past projects and information on cost vs. benefit of cattail management in order to determine how or if the cattail management program could be expanded. If the program is to be expanded, the management agency must determine if a higher percentage of cattail should be reduced in selected wetlands or if a greater radius of wetlands located around a sunflower field should be treated.

According to personnel at the USDA Wildlife Services office in Bismarck, ND, only wetlands that are two hectares or larger can be enrolled in the cattail management program. Enrolled wetlands must also meet other criteria including proximity to high sunflower production areas and areas of high blackbird damage to crops. Linear systems, such as ditch and waterway wetlands, are not normally eligible to be included in the program. Using these criteria, cattail wetlands sampled in this study were divided into two management categories: 1) Cattail wetlands that are less than two hectares or are in a linear type wetland are not eligible for enrollment into the cattail management program, but in many cases, could be managed by the individual producer, and 2) Cattail wetlands that are in non-linear systems and are two hectares or larger can be enrolled in the USDA cattail management program.

Categorizing the cattail wetlands and the total cattail in those wetlands revealed that about 20% of cattail wetlands and 70% of the total cattail in the PPR would be eligible for cattail management by the USDA. Incidentally, the areas with the greatest amount of total cattail had the least percentage of wetlands that fit into the manageable category (Figure 23). The producers in areas such as the NEDP and SDP that have a high percentage of non-eligible wetlands should be encouraged to reduce cattail via their own means on the smaller, more manageable wetlands, if they are concerned about blackbird damage. Important factors to consider when choosing areas to concentrate the USDA management efforts are areas with a high percentage of the total eligible wetlands and a high percentage of total eligible cattail as is seen in Figures 24 and 25. The Missouri Coteau had the largest proportion (36%) of manageable wetlands, but those wetlands only contained 16% of the total manageable cattail. The MC also produced the least amount of sunflower, so intensive management efforts may not be needed in this region. The NWDP produced a large amount of sunflower yet had the lowest percentage of total manageable wetlands, lowest total manageable cattail, and lowest density of blackbirds; therefore, USDA management efforts in the region could be minimal. USDA cattail control efforts could best be targeted in the NEDP and SDP because of their significant proportion of total manageable wetlands, high amount of total manageable cattail, high production of sunflower, and the presence of large numbers of red-winged blackbirds.

The data provided here on the distribution of cattail in the PPR could be used for non-blackbird research as well. Management agencies that deal with animals that use cattail habitat may benefit from the knowledge of where cattail is most abundant. The areas of high abundance may serve as winter refuge areas for

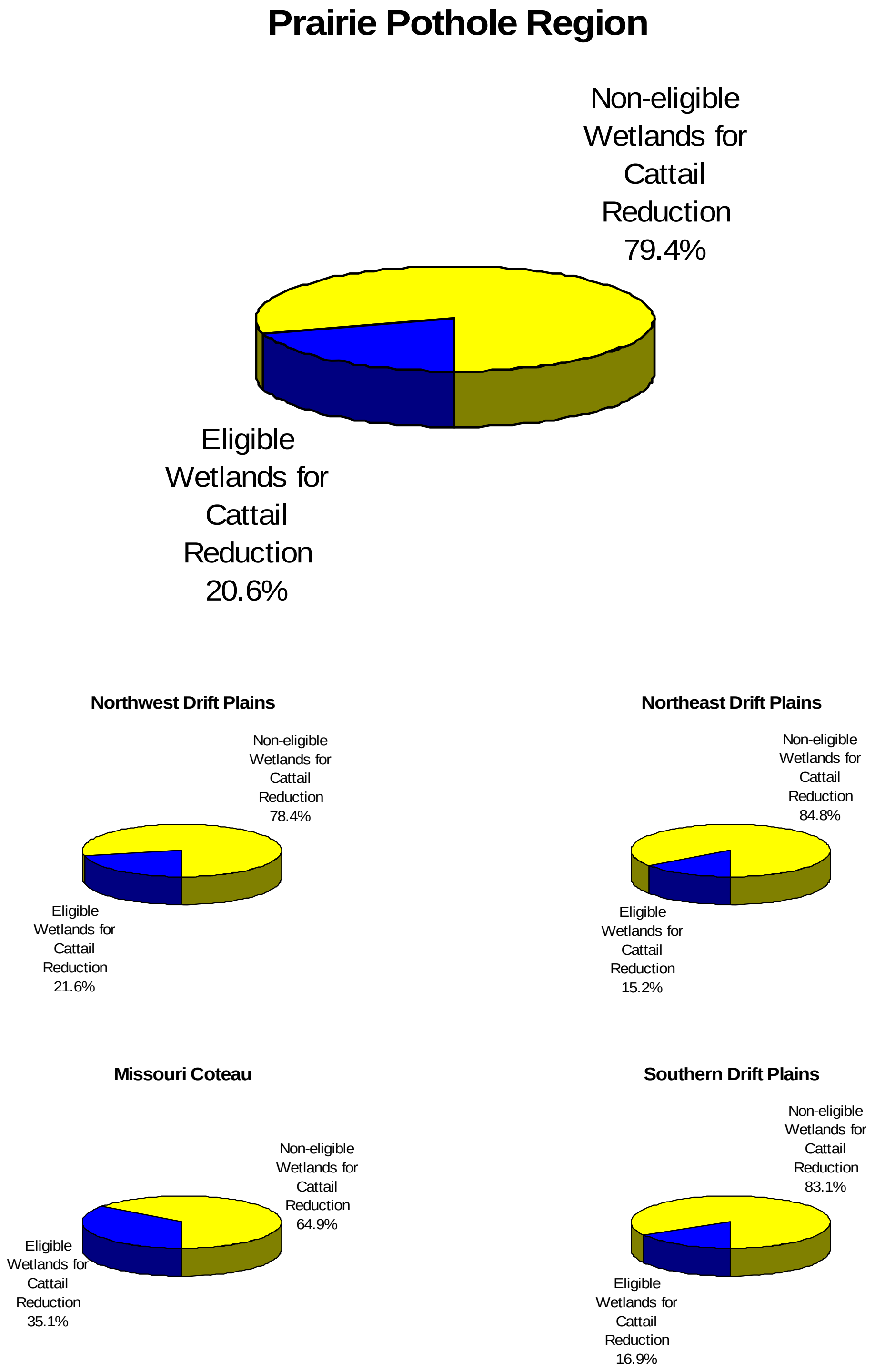


Figure 23. Percentage of wetland eligible for cattail management out of all wetlands sampled in each stratum.

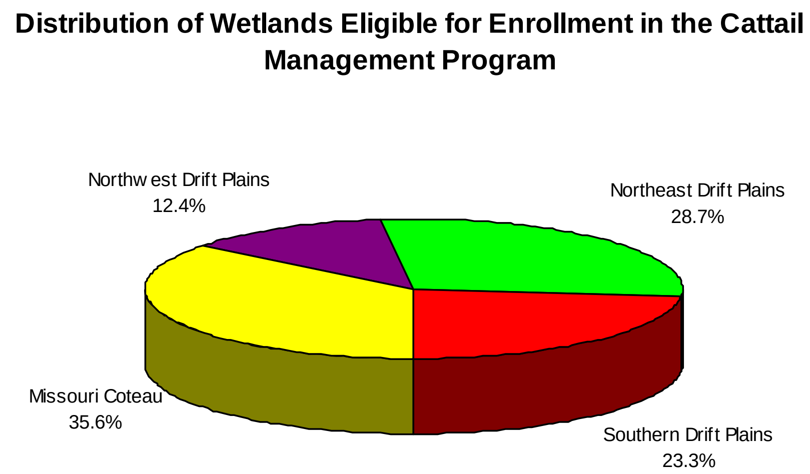


Figure 24. Distribution of all sampled wetlands in 2002 that were eligible for cattail management by the USDA among strata.

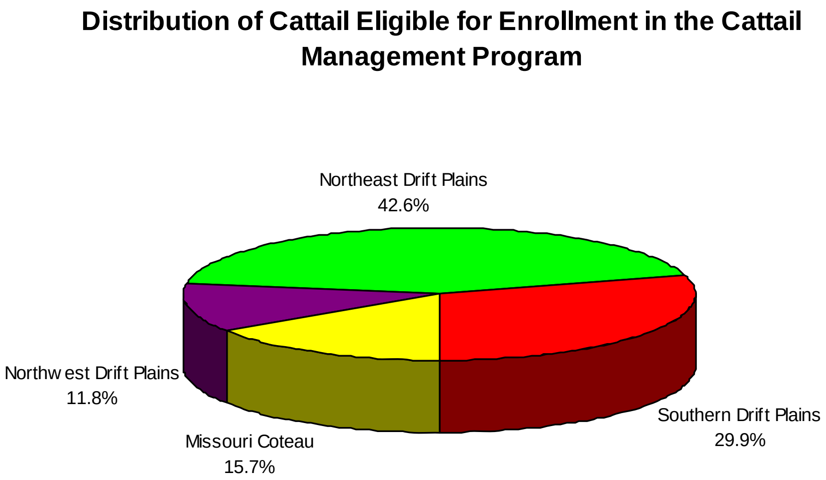


Figure 25. Distribution of all sampled cattail in 2002 that was eligible for cattail management by the USDA among strata.

species such as deer and pheasants that use cattail for its thermal protection in the cooler seasons (Kantrud et al. 1989, Homan et al. 2000). Populations of small mammals, such as the muskrat, may also be correlated to cattail abundance. Aside from the importance of cattail to animals, distribution information of this vegetation can be important in understanding sources and sinks of nutrients. Wetlands have been studied for their ability to store nutrients and elements such as nitrogen, phosphorus, and mercury (Hayes and Caslick 1984, Kantrud et al. 1989, USGS 1999). Some more recent interest in wetland vegetation involves carbon sequestration by cattail wetlands as a way to compensate for the increase of greenhouse gasses (USGS 2004).

Wetlands and cattail habitat provide many important ecological functions within the Prairie Pothole Region of North Dakota. Current information on wetland conditions and future monitoring programs can provide managers with empirical data to make research-driven decisions. Allocation of resources can be maximized, and a balance between natural and anthropogenic needs can be reached when proper data are provided.

LITERATURE CITED

Austin, J. E. 2002. Responses of dabbling ducks to wetland conditions in the Prairie Pothole Region. Waterbirds 25:465-473.

Bavendick, F. J. 1959. The Climate of North Dakota. Pages 811-812 *in* Climates of the States. Water Information Center, Incorporated, New York.

Bird Shield™ Repellent Corp. 2002. Bird Shield™ Repellent Information Pamphlet. www.birdshield.com.

Blixt, D. C. 1993. Effects of glyphosate-induced habitat alteration on birds. M.S. Thesis, North Dakota State University, Fargo, North Dakota.

Chrisman, N. 2002. Exploring Geographic Information Systems, Second Edition. John Wiley & Sons, Incorporated, New York, New York.

Cochran, W. G. 1977. Sampling Techniques, Third Edition. Wiley, New York.

Cole, D. J. 1985. Mode of action of glyphosate – a literature analysis. Pages 48-74 *in* E. Grossbard and D. Atkinson, editors. The Herbicide Glyphosate. Butterwoth, London.

Colton, R. B., R. W. Lemke, and R. M. Lindvall. 1963. Preliminary glacial map of North Dakota. U.S. Geological Survey, Geologic Investigation Map No. 1-331.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. United States Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Diaz, H. F. 1986. An analysis of twentieth century climate fluctuations in northern North America. Journal of Climate and Applied Meteorology 25:1625-1657.

Dolbeer, R. A. 1994. Blackbirds: Prevention and control of wildlife damage. United States Department of Agriculture - Animal Plant Health Inspection Service - Animal Damage Control Information Pamphlet.

Dueker, K. J., and D. Kjerne. 1989. Multipurpose cadastre: terms and definitions. American Society of Photogramy and Remote Sensing and American Congressional Survey Mapping, Falls Church, Virginia. 5:94-103.

Dyer, M. I., J. Pinowski, and B. Pinowska. 1977. Population Dynamics. Pages 53-105 *in* J. Pinowski and S. C. Kendeigh, editors. Granivorous birds in ecosystems. Cambridge University Press, Cambridge, U.K.

Euliss, N. H., D. M. Mushet, and D. A. Wrubleski. 1999. Wetlands of the Prairie Pothole Region: Invertebrate Species Composition, Ecology, and Management. Pages 471-514 *in* D. P. Batzer, R. B. Rader and S. A. Wissinger, editors. Invertebrates in freshwater wetlands of North America: Ecology and management. John Wiley & Sons, New York.

Fritzell, E. K. 1989. Mammals in prairie wetlands. Pages 268-301 *in* A. G. van der Valk, editor. Northern prairie wetlands. Iowa State University Press, Ames.

Hayes, J .P., and J. W. Caslick. 1984. Nutrient deposition in cattail stands by communally roosting blackbirds and starlings. American Midland Naturalist 112:320-331.

Hirano, A., M. Madden, and R. Welch. 2003. Hyperspectral image data for mapping wetland vegetation. Wetlands 23:436-448.

Homan, H .J., G. M. Linz, and W. J. Bleier. 1994. Effect of crop phenology and habitat on the diet of Common Grackles (*Quiscalus quiscula*). American Midland Naturalist 131:381-385.

__________, __________, and ____________. 2000. Winter habitat use and survival of female ring-necked pheasants (*Phasianus colchicus*) in southeastern North Dakota. American Midland Naturalist 143:463-480.

Hothem, R. L., R. W. DeHaven, and S. D. Fairaizl. 1988. Bird damage to sunflower in North Dakota, South Dakota, and Minnesota, 1979–1981. U. S. Fish and Wildlife Service Technical Report 15. U. S. Government Print Office, Washington, D. C.

Igl, L. D., and D. H. Johnson. 1997. Changes in breeding bird populations in North Dakota: 1967 to 1992-93. Auk 114:74-92.

Johnson, R., R. Carlson, and D. Hartwig. 2003. North Dakota Agriculture 2003. North Dakota Department of Agriculture, North Dakota Farmers Union and National Agricultural Statistics Service of North Dakota, Cooperative Report.

Johnson, R. R., and K. F. Higgins. 1997. Wetland resources of eastern South Dakota. Brookings: South Dakota State University.

____________, ____________, D. E. Naugle, and J. A. Jenks. 1999. A comparison of sampling techniques to estimate number of wetlands. Wildlife Society Bulletin 27:187-194.

Johnston, C. A., and P. Meysembourg. 2002. Comparison of the Wisconsin and National Wetlands Inventories. Wetlands 22:386-405.

Kansas State University. 2004. High plains sunflower production handbook. Kansas State University Information Handbook, Manhattan, Kansas.

Kantrud, H. A. 1986. Effects of vegetation manipulation on breeding waterfowl in prairie wetlands – a literature review. U. S. Fish and Wildlife Service, Technical Report 3.

___________ 1990. Effects of vegetation manipulation on breeding waterfowl in prairie wetlands – a literature review. Pages 93-123 *in* Can livestock be used as a tool to enhance wildlife habitat? U.S. Department of Agriculture, Forest Service General Technical Report RM-194.

___________ 1992. History of cattails on the prairies: wildlife impacts. *in* Proceedings of a Cattail Management Symposium (G.M. Linz, Ed.). U.S. Department of Agriculture, Denver Wildlife Research Center and the U.S. Fish and Wildlife Service, Fargo, North Dakota.

___________, G. L. Krapu, and G. A. Swanson. 1989. Prairie basin wetlands of the Dakotas: A community profile. Unites States Fish and Wildlife Service, Biological Report 85:1-111.

Koeln, G. T., L. M. Cowardin, and L. L. Strong. 1994. Geographic Information Systems. Pages 540-566 *in* T. A. Bookhout, editor. Research and management techniques for wildlife. Wildlife Society, Bethesda, Maryland

Kokaly, R. F., D. G. Despain, R. N. Clark, and K. E. Livo. 2003. Mapping vegetation in Yellowstone National Park using spectral feature analysis of AVIRIS data. Remote Sensing of Environment 84:437-456.

Kuehn, M. M., and B. N. White. 1999. Morphological analysis of genetically identified cattails *Typha latifolia, Typha angustifolia, and Typha glauca*. Canadian Journal of Botany 77:906-912.

Kumar, D. N. 2002. Energy Interactions with the Earth Surface. Civil Engineering Department, Indian Institute of Technology, Kharagpur, Unpublished Data.

Lamey, H. A., and J. L. Luecke. 1991. Preliminary results of the 1990 North Dakotas grower survey of pest problems and pesticide use. Pages 27-29 *in*. Proceedings in Sunflower Resource Workshop, Fargo, North Dakota, 10-11 January 1991.

___________, M. P. McMullen, P. A. Glogoza, R. K. Zollinger, J. L. Luecke, and D. R. Berglund. 1998. 1997 sunflower grower survey of pest problems and pesticide use in Kansas, Minnesota, North Dakota and South Dakota. North Dakota, State University Extension Service. Extension Report.

Larson, D. L. 1995. Effects of climate on numbers of northern prairie wetlands. Climatic Change 30:169-180.

Lawler, G. H., L. A. Sunde, and J. Whitaker. 1974. Trout production in prairie ponds. Journal of Fisheries Resources Board Canada 31:929-936.

Leitch, J. A., G. M. Linz, and J. F. Baltezore. 1997. Economics of cattail (*Typha* spp.) control to reduce blackbird damage to sunflower. Agriculture, Ecosystems and Environment 65:141–149.

Lemke, R. W., W. M. Laird, M. J. Tipton, and R. M. Lindvall. 1965. Quaternary Geology of Northern Great Plains. Pages 15-27 *in* H. E. Wright, Jr., and D.

G. Frey, editors. The Quaternary of the United States. Princeton University Press, Princeton, New Jersey.

Lilleboe, D. 1979. Crop reporting service, “Our goal is to provide facts for decision making.” Page 12 *in* The Sunflower. May/June

Lillesand, T. M., and R. W. Kiefer. 1987. Remote sensing and image interpretation. John Wiley & Sons, New York, New York.

Linde, A. F., T. Janisch, and D. Smith. 1976. Cattail: the significance of its growth, phenology and carbohydrate storage to its control and management. Wisconsin Department of Natural Resources Technical Bulletin 94:27.

Linz, G. M. 1992. Cattail management symposium. U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Animal Damage Control, Denver Wildlife Research Center, U.S. Department of Interior, Fish and Wildlife Service.

___________, and D. L. Bergman. 1996. DRC-1339 avicide fails to protect ripening sunflowers. Crop Protection 3:307-310.

___________, ___________, D. C. Blixt, and C. McMurl. 1997. Response of American Coots and Soras to herbicide-induced vegetation changes in wetlands. Journal of Field Ornithology 68:450-457.

___________, ___________, H. J. Homan, and W. J. Bleier. 1995b. Effects of herbicide-induced habitat alterations on blackbird damage to sunflower. Crop Protection 8:625-629.

___________, W. J. Bleier, J. D. Overland, and H. J. Homan. 1999. Response of invertebrates to glyphosate-induced habitat alterations in wetlands. Wetlands 19:220-227.

___________, and D. C. Blixt. 1997. Black terns benefit from cattail management in the Northern Great Plains. Colonial Waterbirds 20:617-621.

___________, ___________, L. Bergman, and W. J. Bleier. 1994. Response of black terns (*Chlidonias niger*) to glyphosate-induced habitat alterations on wetlands. Colonial Waterbirds 17:160-167.

___________, ___________, ___________, and _________. 1996a. Response of ducks to gyphosate-induced habitat alterations in wetlands. Wetlands 16:38-44.

___________, ___________, ___________, and _________. 1996b. Responses of red-winged blackbirds, yellow-headed blackbirds and marsh wrens to glyphosate-induced alterations in cattail density. Journal of Field Ornithology 67:167-176.

___________, R. A. Dolbeer, J. J. Hanzel, and L. E. Huffman. 1996c. Controlling blackbird damage to sunflower and grain crops in the northern Great Plains. United States Department of Agriculture, Animal and Plant Health Inspection Service, Agriculture Information Bulletin 679:1-15.

___________, and J. J. Hanzel. 1997. Birds and sunflower. Pages 381-394 *in* A. Schneider, editor. Sunflower science and technology. American Society of Agronomy, Madison, Wisconsin, USA.

___________, H. J. Homan, R. L. Wimberly, P. Mastrangelo, and W. J. Bleier. 2004b. Management of Cattail (*Typha spp*.) stands with glyphosate to disperse blackbirds. Pages 411-416 *in*. Proceedings of the 16th International Sunflower Conference, Fargo, North Dakota USA.

___________, M. J. Kenyon, H. J. Homan, and W. J. Bleier. 2002. Avian use of rice-baited corn stubble in east-central South Dakota. International Biodeterioration & Biodegradation 49:179-184.

___________, L. A. Mendoza, D. L. Bergman, and W. J. Bleier. 1995a. Preferences of three blackbird species for sunflower meats, cracked corn and brown rice. Crop Protection 14:375-378.

___________, D. A. Schaaf, P. Mastrangelo, H. J. Homan, L. B. Penry, and W. J. Bleier. 2004a. Wildlife conservation sunflower plots as a dual-purpose wildlife management strategy. 21st Vertebrate Pest Conference, March 1-4, 2004, Visalia, California.

___________, D. L. Vakoch, J. F. Cassel, and R. B. Carlson. 1984. Food of red-winged blackbird (*Agelaius phoeniceus*) in sunflower fields and corn fields. Canadian Field-Naturalist 93:38–44.

Lutman, M. W. 2000. Location and habitat characteristics of late summer blackbird roosts in the sunflower growing region of North Dakota. M.S. Thesis. North Dakota State University. Fargo, North Dakota.

McHarg, I. L. 1969. Design with Nature. Doubleday and Company, Garden City, New York.

Merendino, M. T. and L. M. Smith. 1991. Influence of drawdown data and reflood depth on wetland vegetation establishment. Wildlife Society Bulletin 19:143-150.

National Agricultural Statistical Service. 1999. National Agricultural Statistics Service, Agricultural Statistics Board, U. S. Department of Agriculture. Washington, D. C.

________________________________. 2003. North Dakota Farm Reporter. National Agriculture Statistics Service, U. S. Department of Agriculture Annual Crop Production Report. Fargo, North Dakota.

Nelms, C. O., D. L. Otis, G. M. Linz, and W. J. Bleier. 1999. Cluster sampling to estimate breeding blackbird populations in North Dakota. Wildlife Society Bulletin 27:931-937.

North Dakota Agricultural Statistics Service. 2004a. 2002 census of agriculture, A first look. U. S. Department of Agriculture – National Agricultural Statistics Service - North Dakota. News Report

____________________________________. 2004b. North Dakota Agricultural Prices – August 31, 2004. U. S. Department of Agriculture – National Agricultural Statistics Service - North Dakota. News Report.

____________________________________. 2004c. North Dakota's 2003 rank among states. U. S. Department of Agriculture – National Agricultural Statistics Service - North Dakota. News Report.

___________________________________. 2004d. Sunflower – August 2004. United States Department of Agriculture – National Agricultural Statistics Service - North Dakota. Production Report.

North Dakota Department of Transportation. 2002. North Dakota Minor Civil Divisions – Township Map. North Dakota Department of Transportation, Planning Division. Bismarck, North Dakota.

North Dakota State University Extension Service. 1995. Sunflower pest management (Birds) information bulletin. North Dakota Agriculture Experiment Station, North Dakota State University, Fargo, North Dakota.

Otis, D. L., and C. M. Kilburn. 1988. Influence of environmental factors on blackbird damage to sunflower. U.S. Fish and Wildlife Technical Report 16.

Peer B. D., and E. K. Bollinger. 1997. Common Grackle. Birds of North America 271:1-20

Peer, B. D., H. J. Homan, G. M. Linz, and W. J. Bleier. 2003. Impact of blackbird damage to sunflower: bioenergetics and economic models. Ecological Applications 13:248-256.

Prochaska, D. F., D. Lobpries, and D. Steinbach. 1998. Waterfowl management on agricultural land in southeast Texas. Texas Agricultural Extension Service Information Bulletin.

Sader, S. A., D. Ahl, and W. S. Liou. 1995. Accuracy of Landsat-TM and GIS rule-based methods for forest wetland classification in Maine. Remote Sensing of Environment 53:133-144.

Safratowich, B. D., G. L. Linz, and W. J. Bleier. 2004. Avian use of roadside habitat in the southern drift plains of North Dakota and implications for cattail (*Typha spp*.) management. Pages 423-427 *in* Proceedings of the 16th International Sunflower Conference, Fargo, North Dakota.

Schmidt, K. S., and A. K. Skidmore. 2003. Spectral discrimination of vegetation types in a coastal wetland. Remote Sensing of Environment 5814:1-17.

Smith, A. G., J. H. Stoudt, and J. B. Gollop. 1964. Prairie potholes and marshes. Pages 39-50 *in* La J-PLinduska, editor. Waterfowl Tomorrow. U. S. Fish and Wildlife Service, Washington, D.C.

Smith, G. W. 1995. A critical review of the aerial and ground surveys of breeding waterfowl in North America. Biological Science Report 5, National Biological Service, Washington, D.C.

Solberg, K. L., and K. F. Higgins. 1993. Effects of glyphosate herbicide on cattail, invertebrates, and waterfowl in South Dakota wetlands. Wildlife Society Bulletin 21:229-307.

Stevens, O. A. 1963. Handbook of North Dakota plants. North Dakota Institute for Regional Studies, Fargo, North Dakota.

Stewart, R. E., and H. A. Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. Resource Publication 92, Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, Washington, D.C.

___________, and ___________. 1972. Population estimates of breeding birds in North Dakota. The Auk 89:766-788.

Stromstad, R. 1992. Cattail management: The North Dakota Game and Fish Department Perspective. Pages 38-41 *in* G.M. Linz, editor. Proceedings Cattail Management Symposium. Fargo, North Dakota.

Stuckey, R. L., and D. P. Salamon. 1987. *Typha angustifolia* in North America: A foreigner masquerading as a native. Ohio Journal of Science, April Program Abstract 87:2.

Tucker, C. J., J. R. Townshend, and T. E. Goff. 1985. African land-cover classification using satellite data. Science 227:369-375.

Twedt, D. J., and R. D. Crawford. 1995. Yellow-headed Blackbird. The Birds of North America 192:1-27.

United States Code of Federal Regulations. 1918. Migratory Bird Treaty Act. Title 16, Chapter 7, Subchapter II, Section 703. U.S. Government Printing Office.

_____________________________________. 1989. Depredation Order for Blackbirds, Cowbirds, Grackles, Crows, and Magpies. Title 50, Chapter 1, Part 21, Subpart D, Section 21.43. U.S. Government Printing Office.

United States Department of Agriculture. 1993. Migratory bird damage control and depredation permits. Animal Damage Control Directive 2.301.

__________________________________. 2000. National Sunflower Association Sunstats 1999. http://www.sunflowernsa.com/producers/mark/sunstats_99.html.

__________________________________. 2004. Development and evaluation of management techniques for reducing blackbird damage to ripening sunflower crops and feedlots. Proceedings from Project Review, Bismarck, ND.

United States Fish and Wildlife Service. 1995. Photointerpretation conventions for National Wetlands Inventory. National Wetlands Inventory Group, St. Petersburg, Florida.

________________________________. 2002. National Wetlands Inventory: A strategy for the 21st century. U.S. Department of the Interior, U.S. Fish and Wildlife Service Report.

United States Geological Survey. 1999. National water summary on wetland resources. United States Geological Survey Water Supply Paper 2425.

___________________________. 2004. Prairie wetlands are important for carbon storage. Information Bulletin, Northern Prairie Research Center, Jamestown, North Dakota.

Verbyla, D. L., and K. T. Chang. 1997. Processing digital Images in GIS. OnWord Press, Santa Fe, New Mexico.

Ware, G. W. 1989. The pesticide book. Third edition. Thompson Publications, Fresno, California.

Weller, M. W., and L. H. Fredrickson. 1974. Avian ecology of a managed glacial marsh. Living Bird 12:269-291.

Wheeler, G. C., and J. Wheeler. 1966. The amphibians and reptiles of North Dakota. University of North Dakota Press, Grand Forks, North Dakota.

Wilkie, D. S., and J. T. Finn, 1996. Remote Sensing Imagery for Natural Resources Monitoring. Columbia University Press, New York.

Winter, T .C. 1989. Hydrologic studies of wetlands in the northern prairie. Pages 16-54 *in* A. G. van der Valk, editor. Northern prairie wetlands. Iowa State University Press, Ames.

Yasukawa, K., and W.A. Searcy. 1995. Red-winged blackbird. The Birds of North America 184:1-28.

Yi, G. C., D. Risley, M. Koneff, and C. Davis. 1994. Development of Ohio's GIS-based wetlands inventory. Journal of Soil and Water Conservation 49:23-28.

APPENDIX I. STRATA DATA TABLES

	Prairie Pothole Region Mean (S.E.)	Northwest Drift Plains Mean (S.E.)	Northeast Drift Plains Mean (S.E.)	Missouri Coteau Mean (S.E.)	Southern Drift Plains Mean (S.E.)
% of Land Covered by Cattail	2.33% (0.27%)	1.18% (0.27%)	4.20% (0.86%)	1.30% (0.17%)	2.73% (0.45%)
% of Land Covered by Cattail in Palustrine Systems	2.23% (0.27%)	1.07% (0.26%)	4.08% (0.85%)	1.12% (0.16%)	2.71% (0.46%)
% of Land Covered by Cattail in Lacustrine Systems	0.10% (0.03%)	0.10% (0.07%)	0.11% (0.06%)	0.17% (0.09%)	0.01% (0.01%)
% of Land Covered by Cattail in Riverine Systems	0.00% (0.00%)	0.01% (0.01%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)
% of Land Covered by Cattail in Temporary Regimes	0.29% (0.04%)	0.22% (0.05%)	0.49% (0.09%)	0.08% (0.02%)	0.40% (0.09%)
% of Land Covered by Cattail in Seasonal Regimes	0.70% (0.10%)	0.47% (0.14%)	1.54% (0.33%)	0.23% (0.05%)	0.65% (0.16%)
% of Land Covered by Cattail in Semi-permanent Regimes	1.25% (0.17%)	0.39% (0.12%)	2.05% (0.56%)	0.88% (0.13%)	1.66% (0.34%)
% of Land Covered by Cattail in Intermittently Exposed Regimes	0.08% (0.03%)	0.10% (0.07%)	0.11% (0.06%)	0.11% (0.08%)	0.01% (0.01%)
% of Land Covered by Cattail in Non-modified Wetlands	1.44% (0.16%)	0.63% (0.14%)	2.57% (0.53%)	0.92% (0.14%)	1.66% (0.27%)
% of Land Covered by Cattail in Roadside Abutted Wetlands	0.75% (0.13%)	0.47% (0.18%)	1.46% (0.42%)	0.35% (0.09%)	0.79% (0.20%)
% of Land Covered by Cattail in Waterway Wetlands	0.09% (0.02%)	0.04% (0.02%)	0.10% (0.04%)	0.01% (0.00%)	0.22% (0.07%)

% of Land Covered by Cattail in Ditch Wetlands	0.05% (0.01%)	0.04% (0.01%)	0.07% (0.02%)	0.02% (0.00%)	0.05% (0.01%)
% of Land Covered by Cattail in Wetlands with Surface Water	1.71% (0.23%)	0.77% (0.22%)	3.23% (0.77%)	1.03% (0.15%)	1.89% (0.37%)
% of Land Covered by Cattail in Wetlands without Surface Water	0.61% (0.23%)	0.41% (0.22%)	0.97% (0.77%)	0.27% (0.15%)	0.84% (0.37%)
Size (ha) of all Wetlands Sampled	2.44 (0.12)	2.77 (0.36)	1.68 (0.12)	4.33 (0.46)	1.94 (0.16)
Size (ha) of Lacustrine Cattail Wetlands	43.55 (6.96)	41.99 (8.62)	51.50 (12.44)	45.91 (11.00)	18.57 (3.98)
Size (ha) of Palustrine Cattail Wetlands	1.99 (0.08)	2.06 (0.24)	1.51 (0.09)	3.02 (0.21)	1.89 (0.16)
Size (ha) of Temporary Cattail Wetlands	0.57 (0.02)	0.70 (0.06)	0.41 (0.02)	0.68 (0.08)	0.75 (0.08)
Size (ha) of Seasonal Cattail Wetlands	1.42 (0.09)	2.74 (0.55)	1.48 (0.10)	1.23 (0.13)	0.98 (0.13)
Size (ha) of Semi-Permanent Cattail Wetlands	4.81 (0.29)	4.47 (0.80)	4.32 (0.42)	5.66 (0.56)	4.23 (0.48)
Size (ha) of Intermittently Exposed Cattail Wetlands	40.44 (7.42)	41.99 (8.62)	38.65 (12.40)	48.23 (15.19)	14.06 (4.05)
Size (ha) of Ditch Cattail Wetlands	0.40 (0.03)	0.41 (0.06)	0.39 (0.04)	0.42 (0.06)	0.39 (0.05)
Size (ha) of Waterway Cattail Wetlands	1.75 (0.23)	2.36 (0.72)	1.23 (0.24)	0.66 (0.14)	2.23 (0.42)
Size (ha) of Roadside Abutted Cattail Wetlands	6.57 (0.73)	5.70 (1.30)	6.73 (1.04)	9.73 (2.50)	4.39 (0.66)
Size (ha) of Non-modified Cattail Wetlands	2.04 (0.11)	2.56 (0.42)	1.25 (0.09)	3.69 (0.37)	1.67 (0.19)

Size (ha) of Linear Cattail Wetlands	0.84 (0.08)	0.74 (0.15)	0.66 (0.09)	0.49 (0.06)	1.18 (0.19)
Size (ha) of Non-linear Cattail Wetlands	2.64 (0.08)	3.16 (0.15)	1.80 (0.09)	4.55 (0.06)	2.07 (0.19)
Size (ha) of Cattail Wetlands with Standing Water	5.04 (0.30)	6.90 (1.10)	3.73 (0.32)	6.75 (0.76)	4.15 (0.44)
Size (ha) of Cattail Wetlands without Standing Water	0.75 (0.04)	1.16 (0.21)	0.53 (0.03)	0.90 (0.06)	0.77 (0.05)
Total Cattail Wetlands in Sample Plots	4396	519	1707	918	1252
Lacustrine Cattail Wetlands in Sample Plots	47	9	6	28	4
Palustrine Cattail Wetlands in Sample Plots	4345	509	1698	890	1248
Riverine Cattail Wetlands in Sample Plots	4	1	3	0	0
Temporary Cattail Wetlands in Sample Plots	1607	250	784	159	414
Seasonal Cattail Wetlands in Sample Plots	1485	161	604	261	459
Semi-permanent Cattail Wetlands in Sample Plots	1264	99	311	481	373
Intermittently Exposed Cattail Wetlands in Sample Plots	39	9	8	17	5
Permanent Cattail Wetlands in Sample Plots	1	0	0	0	1

Non-modified Cattail Wetlands in Sample Plots	3376	352	1366	744	914
Roadside Abutted Cattail Wetlands in Sample Plots	518	83	154	124	157
Waterway Cattail Wetlands in Sample Plots	166	14	60	14	78
Ditch Cattail Wetlands in Sample Plots	336	70	127	36	103
Cattail Wetlands with water in Sample Plots	1730	145	613	538	434
Cattail Wetlands without water in Sample Plots	2666	374	1094	380	818

APPENDIX II. LOCATION OF STUDY SITES

Plot #	County	Township	Range	Section	Strata	Date of Photo
1	Sargent	131	54	34	S Drift Plains	August 13, 2002
1	Sargent	131	54	35	S Drift Plains	August 13, 2002
1	Sargent	130	54	3	S Drift Plains	August 13, 2002
1	Sargent	130	54	2	S Drift Plains	August 13, 2002
2	Sargent	129	56	16	S Drift Plains	August 13, 2002
2	Sargent	129	56	15	S Drift Plains	August 13, 2002
2	Sargent	129	56	21	S Drift Plains	August 13, 2002
2	Sargent	129	56	22	S Drift Plains	August 13, 2002
3	Ransom	133	55	28	S Drift Plains	August 13, 2002
3	Ransom	133	55	27	S Drift Plains	August 13, 2002
3	Ransom	133	55	33	S Drift Plains	August 13, 2002
3	Ransom	133	55	34	S Drift Plains	August 13, 2002
4	Ransom	133	57	18	S Drift Plains	August 13, 2002
4	Ransom	133	57	17	S Drift Plains	August 13, 2002
4	Ransom	133	57	19	S Drift Plains	August 13, 2002
4	Ransom	133	57	20	S Drift Plains	August 13, 2002
5	Ransom	136	57	29	S Drift Plains	August 13, 2002
5	Ransom	136	57	28	S Drift Plains	August 13, 2002
5	Ransom	136	57	32	S Drift Plains	August 13, 2002
5	Ransom	136	57	33	S Drift Plains	August 13, 2002
6	Dickey	132	61	36	S Drift Plains	August 13, 2002
6	Dickey	132	60	31	S Drift Plains	August 13, 2002
6	Dickey	131	61	1	S Drift Plains	August 13, 2002
6	Dickey	131	60	6	S Drift Plains	August 13, 2002
7	McIntosh	132	67	25	Missouri Coteau	August 19, 2002

7	Dickey	132	66	30	Missouri Coteau	August 19, 2002
7	McIntosh	132	67	36	Missouri Coteau	August 19, 2002
7	Dickey	132	66	31	Missouri Coteau	August 19, 2002
8	McIntosh	130	67	1	Missouri Coteau	August 19, 2002
8	Dickey	130	66	6	Missouri Coteau	August 19, 2002
8	McIntosh	130	67	12	Missouri Coteau	August 19, 2002
8	Dickey	130	66	7	Missouri Coteau	August 19, 2002
9	McIntosh	132	68	31	Missouri Coteau	August 19, 2002
9	McIntosh	132	68	32	Missouri Coteau	August 19, 2002
9	McIntosh	131	68	6	Missouri Coteau	August 19, 2002
9	McIntosh	131	68	5	Missouri Coteau	August 19, 2002
10	McIntosh	131	70	33	Missouri Coteau	August 19, 2002
10	McIntosh	131	70	34	Missouri Coteau	August 19, 2002
10	McIntosh	130	70	4	Missouri Coteau	August 19, 2002
10	McIntosh	130	70	3	Missouri Coteau	August 19, 2002
11	Lamoure	136	60	7	S Drift Plains	August 13, 2002
11	Lamoure	136	60	8	S Drift Plains	August 13, 2002
11	Lamoure	136	60	18	S Drift Plains	August 13, 2002
11	Lamoure	136	60	17	S Drift Plains	August 13, 2002
12	Lamoure	136	63	14	S Drift Plains	August 13, 2002
12	Lamoure	136	63	13	S Drift Plains	August 13, 2002
12	Lamoure	136	63	23	S Drift Plains	August 13, 2002
12	Lamoure	136	63	24	S Drift Plains	August 13, 2002
13	Lamoure	134	63	31`	S Drift Plains	August 13, 2002
13	Lamoure	134	63	32	S Drift Plains	August 13, 2002
13	Lamoure	134	63	6	S Drift Plains	August 13, 2002
13	Lamoure	134	63	5	S Drift Plains	August 13, 2002
14	Lamoure	135	66	21	Missouri Coteau	August 13, 2002

14	Lamoure	135	66	22	Missouri Coteau	August 13, 2002
14	Lamoure	135	66	28	Missouri Coteau	August 13, 2002
14	Lamoure	135	66	27	Missouri Coteau	August 13, 2002
15	Stutsman	137	64	31	S Drift Plains	August 13, 2002
15	Stutsman	137	64	32	S Drift Plains	August 13, 2002
15	Lamoure	136	64	6	S Drift Plains	August 13, 2002
15	Lamoure	136	64	5	S Drift Plains	August 13, 2002
16	Logan	134	69	9	Missouri Coteau	August 13, 2002
16	Logan	134	69	10	Missouri Coteau	August 13, 2002
16	Logan	134	69	16	Missouri Coteau	August 13, 2002
16	Logan	134	69	15	Missouri Coteau	August 13, 2002
17	Logan	136	73	29	Missouri Coteau	August 19, 2002
17	Logan	136	73	28	Missouri Coteau	August 19, 2002
17	Logan	136	73	32	Missouri Coteau	August 19, 2002
17	Logan	136	73	33	Missouri Coteau	August 19, 2002
18	Emmons	136	74	18	Missouri Coteau	August 19, 2002
18	Emmons	136	74	17	Missouri Coteau	August 19, 2002
18	Emmons	136	74	19	Missouri Coteau	August 19, 2002
18	Emmons	136	74	20	Missouri Coteau	August 19, 2002
19	Cass	142	54	21	S Drift Plains	August 19, 2002
19	Cass	142	54	22	S Drift Plains	August 19, 2002
19	Cass	142	54	28	S Drift Plains	August 19, 2002
19	Cass	142	54	27	S Drift Plains	August 19, 2002
20	Cass	142	55	14	S Drift Plains	August 19, 2002
20	Cass	142	55	13	S Drift Plains	August 19, 2002
20	Cass	142	55	23	S Drift Plains	August 19, 2002
20	Cass	142	55	24	S Drift Plains	August 19, 2002
21	Barnes	142	57	30	S Drift Plains	August 19, 2002

21	Barnes	142	57	29	S Drift Plains	August 19, 2002
21	Barnes	142	57	31	S Drift Plains	August 19, 2002
21	Barnes	142	57	32	S Drift Plains	August 19, 2002
22	Barnes	142	60	31	S Drift Plains	August 19, 2002
22	Barnes	142	60	32	S Drift Plains	August 19, 2002
22	Barnes	141	60	6	S Drift Plains	August 19, 2002
22	Barnes	141	60	5	S Drift Plains	August 19, 2002
23	Barnes	143	58	3	S Drift Plains	August 19, 2002
23	Barnes	143	58	2	S Drift Plains	August 19, 2002
23	Barnes	143	58	10	S Drift Plains	August 19, 2002
23	Barnes	143	58	11	S Drift Plains	August 19, 2002
24	Barnes	137	59	12	S Drift Plains	August 13, 2002
24	Barnes	137	58	7	S Drift Plains	August 13, 2002
24	Barnes	137	59	13	S Drift Plains	August 13, 2002
24	Barnes	137	58	18	S Drift Plains	August 13, 2002
25	Barnes	139	57	5	S Drift Plains	August 19, 2002
25	Barnes	139	57	4	S Drift Plains	August 19, 2002
25	Barnes	139	57	8	S Drift Plains	August 19, 2002
25	Barnes	139	57	9	S Drift Plains	August 19, 2002
26	Stutsman	144	67	15	Missouri Coteau	August 19, 2002
26	Stutsman	144	67	14	Missouri Coteau	August 19, 2002
26	Stutsman	144	67	22	Missouri Coteau	August 19, 2002
26	Stutsman	144	67	23	Missouri Coteau	August 19, 2002
27	Stutsman	137	69	25	Missouri Coteau	August 19, 2002
27	Stutsman	137	68	30	Missouri Coteau	August 19, 2002
27	Stutsman	137	69	36	Missouri Coteau	August 19, 2002
27	Stutsman	137	68	31	Missouri Coteau	August 19, 2002
28	Stutsman	140	65	27	S Drift Plains	August 13, 2002

28	Stutsman	140	65	28	S Drift Plains	August 13, 2002
28	Stutsman	140	65	33	S Drift Plains	August 13, 2002
28	Stutsman	140	65	34	S Drift Plains	August 13, 2002
29	Stutsman	141	64	21	S Drift Plains	August 19, 2002
29	Stutsman	141	64	22	S Drift Plains	August 19, 2002
29	Stutsman	141	64	28	S Drift Plains	August 19, 2002
29	Stutsman	141	64	27	S Drift Plains	August 19, 2002
30	Stutsman	141	68	15	Missouri Coteau	August 19, 2002
30	Stutsman	141	68	14	Missouri Coteau	August 19, 2002
30	Stutsman	141	68	22	Missouri Coteau	August 19, 2002
30	Stutsman	141	68	23	Missouri Coteau	August 19, 2002
31	Stutsman	142	67	8	Missouri Coteau	August 19, 2002
31	Stutsman	142	67	9	Missouri Coteau	August 19, 2002
31	Stutsman	142	67	17	Missouri Coteau	August 19, 2002
31	Stutsman	142	67	16	Missouri Coteau	August 19, 2002
32	Stutsman	144	64	27	S Drift Plains	August 19, 2002
32	Stutsman	144	64	26	S Drift Plains	August 19, 2002
32	Stutsman	144	64	34	S Drift Plains	August 19, 2002
32	Stutsman	144	64	35	S Drift Plains	August 19, 2002
33	Kidder	137	70	28	Missouri Coteau	August 19, 2002
33	Kidder	137	70	27	Missouri Coteau	August 19, 2002
33	Kidder	137	70	33	Missouri Coteau	August 19, 2002
33	Kidder	137	70	34	Missouri Coteau	August 19, 2002
34	Kidder	144	73	21	Missouri Coteau	August 19, 2002
34	Kidder	144	73	22	Missouri Coteau	August 19, 2002
34	Kidder	144	73	28	Missouri Coteau	August 19, 2002
34	Kidder	144	73	27	Missouri Coteau	August 19, 2002
35	Kidder	142	73	8	Missouri Coteau	August 19, 2002

35	Kidder	142	73	9	Missouri Coteau	August 19, 2002
35	Kidder	142	73	17	Missouri Coteau	August 19, 2002
35	Kidder	142	73	16	Missouri Coteau	August 19, 2002
36	Burleigh	144	75	14	Missouri Coteau	August 19, 2002
36	Burleigh	144	75	13	Missouri Coteau	August 19, 2002
36	Burleigh	144	75	23	Missouri Coteau	August 19, 2002
36	Burleigh	144	75	24	Missouri Coteau	August 19, 2002
37	Steele	146	55	27	S Drift Plains	August 19, 2002
37	Steele	146	55	26	S Drift Plains	August 19, 2002
37	Steele	146	55	34	S Drift Plains	August 19, 2002
37	Steele	146	55	35	S Drift Plains	August 19, 2002
38	Steele	145	57	24	S Drift Plains	August 19, 2002
38	Steele	145	56	19	S Drift Plains	August 19, 2002
38	Steele	145	57	25	S Drift Plains	August 19, 2002
38	Steele	145	56	30	S Drift Plains	August 19, 2002
39	Griggs	145	59	13	S Drift Plains	August 19, 2002
39	Griggs	145	58	18	S Drift Plains	August 19, 2002
39	Griggs	145	59	24	S Drift Plains	August 19, 2002
39	Griggs	145	58	19	S Drift Plains	August 19, 2002
40	Griggs	146	60	20	NE Drift Plains	August 19, 2002
40	Griggs	146	60	21	NE Drift Plains	August 19, 2002
40	Griggs	146	60	29	NE Drift Plains	August 19, 2002
40	Griggs	146	60	28	NE Drift Plains	August 19, 2002
41	Foster	146	65	7	S Drift Plains	August 19, 2002
41	Foster	146	65	8	S Drift Plains	August 19, 2002
41	Foster	146	65	18	S Drift Plains	August 19, 2002
41	Foster	146	65	17	S Drift Plains	August 19, 2002
42	Foster	147	64	3	S Drift Plains	August 19, 2002

42	Foster	147	64	2	S Drift Plains	August 19, 2002
42	Foster	147	64	10	S Drift Plains	August 19, 2002
42	Foster	147	64	11	S Drift Plains	August 19, 2002
43	Eddy	150	63	19	NE Drift Plains	August 24, 2002
43	Eddy	150	63	20	NE Drift Plains	August 24, 2002
43	Eddy	150	63	30	NE Drift Plains	August 24, 2002
43	Eddy	150	63	29	NE Drift Plains	August 24, 2002
44	Wells	146	70	25	S Drift Plains	August 19, 2002
44	Wells	146	69	30	S Drift Plains	August 19, 2002
44	Wells	146	70	36	S Drift Plains	August 19, 2002
44	Wells	146	69	31	S Drift Plains	August 19, 2002
45	Wells	148	69	16	S Drift Plains	August 19, 2002
45	Wells	148	69	15	S Drift Plains	August 19, 2002
45	Wells	148	69	21	S Drift Plains	August 19, 2002
45	Wells	148	69	22	S Drift Plains	August 19, 2002
46	Wells	149	69	26	S Drift Plains	August 19, 2002
46	Wells	149	69	25	S Drift Plains	August 19, 2002
46	Wells	149	69	35	S Drift Plains	August 19, 2002
46	Wells	149	69	36	S Drift Plains	August 19, 2002
47	Wells	150	68	16	NE Drift Plains	August 24, 2002
47	Wells	150	68	15	NE Drift Plains	August 24, 2002
47	Wells	150	68	21	NE Drift Plains	August 24, 2002
47	Wells	150	68	22	NE Drift Plains	August 24, 2002
48	Wells	148	73	14	S Drift Plains	August 19, 2002
48	Wells	148	73	13	S Drift Plains	August 19, 2002
48	Wells	148	73	23	S Drift Plains	August 19, 2002
48	Wells	148	73	24	S Drift Plains	August 19, 2002
49	Sheridan	150	75	3	NW Drift Plains	August 24, 2002

49	Sheridan	150	75	2	NW Drift Plains	August 24, 2002
49	Sheridan	150	75	10	NW Drift Plains	August 24, 2002
49	Sheridan	150	75	11	NW Drift Plains	August 24, 2002
50	Sheridan	146	78	6	Missouri Coteau	August 24, 2002
50	Sheridan	146	78	5	Missouri Coteau	August 24, 2002
50	Sheridan	146	78	7	Missouri Coteau	August 24, 2002
50	Sheridan	146	78	8	Missouri Coteau	August 24, 2002
51	Sheridan	147	78	11	Missouri Coteau	August 24, 2002
51	Sheridan	147	78	12	Missouri Coteau	August 24, 2002
51	Sheridan	147	78	14	Missouri Coteau	August 24, 2002
51	Sheridan	147	78	13	Missouri Coteau	August 24, 2002
52	Sheridan	148	77	19	Missouri Coteau	August 24, 2002
52	Sheridan	148	77	20	Missouri Coteau	August 24, 2002
52	Sheridan	148	77	30	Missouri Coteau	August 24, 2002
52	Sheridan	148	77	29	Missouri Coteau	August 24, 2002
53	Sheridan	150	76	33	NW Drift Plains	August 24, 2002
53	Sheridan	150	76	34	NW Drift Plains	August 24, 2002
53	Sheridan	149	76	4	NW Drift Plains	August 24, 2002
53	Sheridan	149	76	3	NW Drift Plains	August 24, 2002
54	Mclean	146	79	13	Missouri Coteau	August 24, 2002
54	Sheridan	146	78	18	Missouri Coteau	August 24, 2002
54	Mclean	146	79	24	Missouri Coteau	August 24, 2002
54	Sheridan	146	78	19	Missouri Coteau	August 24, 2002
55	Mclean	150	81	33	Missouri Coteau	August 24, 2002
55	Mclean	150	81	34	Missouri Coteau	August 24, 2002
55	Mclean	149	81	4	Missouri Coteau	August 24, 2002
55	Mclean	149	81	3	Missouri Coteau	August 24, 2002
56	Grand Forks	149	55	6	S Drift Plains	August 19, 2002

56	Grand Forks	149	55	5	S Drift Plains	August 19, 2002
56	Grand Forks	149	55	7	S Drift Plains	August 19, 2002
56	Grand Forks	149	55	8	S Drift Plains	August 19, 2002
57	Grand Forks	153	56	20	NE Drift Plains	September 3, 2002
57	Grand Forks	153	56	21	NE Drift Plains	September 3, 2002
57	Grand Forks	153	56	29	NE Drift Plains	September 3, 2002
57	Grand Forks	153	56	28	NE Drift Plains	September 3, 2002
58	Nelson	149	59	5	NE Drift Plains	August 19, 2002
58	Nelson	149	59	4	NE Drift Plains	August 19, 2002
58	Nelson	149	59	8	NE Drift Plains	August 19, 2002
58	Nelson	149	59	9	NE Drift Plains	August 19, 2002
59	Nelson	153	57	20	S Drift Plains	September 3, 2002
59	Nelson	153	57	21	S Drift Plains	September 3, 2002
59	Nelson	153	57	29	S Drift Plains	September 3, 2002
59	Nelson	153	57	28	S Drift Plains	September 3, 2002
60	Nelson	152	60	19	NE Drift Plains	September 3, 2002
60	Nelson	152	60	20	NE Drift Plains	September 3, 2002
60	Nelson	152	60	30	NE Drift Plains	September 3, 2002
60	Nelson	152	60	29	NE Drift Plains	September 3, 2002
61	Nelson	154	57	15	NE Drift Plains	September 3, 2002
61	Nelson	154	57	14	NE Drift Plains	September 3, 2002
61	Nelson	154	57	22	NE Drift Plains	September 3, 2002
61	Nelson	154	57	23	NE Drift Plains	September 3, 2002
62	Ramsey	155	60	35	NE Drift Plains	September 3, 2002
62	Ramsey	155	60	36	NE Drift Plains	September 3, 2002
62	Nelson	154	60	2	NE Drift Plains	September 3, 2002
62	Nelson	154	60	1	NE Drift Plains	September 3, 2002
63	Walsh	155	59	30	NE Drift Plains	September 3, 2002

63	Walsh	155	59	29	NE Drift Plains	September 3, 2002
63	Walsh	155	59	31	NE Drift Plains	September 3, 2002
63	Walsh	155	59	32	NE Drift Plains	September 3, 2002
64	Benson	154	67	28	NE Drift Plains	September 3, 2002
64	Benson	154	67	27	NE Drift Plains	September 3, 2002
64	Benson	154	67	33	NE Drift Plains	September 3, 2002
64	Benson	154	67	34	NE Drift Plains	September 3, 2002
65	Benson	153	68	23	NE Drift Plains	September 3, 2002
65	Benson	153	68	24	NE Drift Plains	September 3, 2002
65	Benson	153	68	26	NE Drift Plains	September 3, 2002
65	Benson	153	68	25	NE Drift Plains	September 3, 2002
66	Benson	151	68	8	NE Drift Plains	August 24, 2002
66	Benson	151	68	9	NE Drift Plains	August 24, 2002
66	Benson	151	68	17	NE Drift Plains	August 24, 2002
66	Benson	151	68	16	NE Drift Plains	August 24, 2002
67	Benson	151	69	6	NE Drift Plains	August 24, 2002
67	Benson	151	69	5	NE Drift Plains	August 24, 2002
67	Benson	151	69	7	NE Drift Plains	August 24, 2002
67	Benson	151	69	8	NE Drift Plains	August 24, 2002
68	Benson	153	71	6	S Drift Plains	September 3, 2002
68	Benson	153	71	5	S Drift Plains	September 3, 2002
68	Benson	153	71	7	S Drift Plains	September 3, 2002
68	Benson	153	71	8	S Drift Plains	September 3, 2002
69	Benson	155	70	32	NE Drift Plains	September 3, 2002
69	Benson	155	70	33	NE Drift Plains	September 3, 2002
69	Benson	154	70	5	NE Drift Plains	September 3, 2002
69	Benson	154	70	4	NE Drift Plains	September 3, 2002
70	Pierce	151	73	14	NW Drift Plains	August 24, 2002

70	Pierce	151	73	13	NW Drift Plains	August 24, 2002
70	Pierce	151	73	23	NW Drift Plains	August 24, 2002
70	Pierce	151	73	24	NW Drift Plains	August 24, 2002
71	Pierce	157	73	7	NW Drift Plains	August 24, 2002
71	Pierce	157	73	8	NW Drift Plains	August 24, 2002
71	Pierce	157	73	18	NW Drift Plains	August 24, 2002
71	Pierce	157	73	17	NW Drift Plains	August 24, 2002
72	Pierce	158	71	33	NW Drift Plains	August 24, 2002
72	Pierce	158	71	34	NW Drift Plains	August 24, 2002
72	Pierce	157	71	4	NW Drift Plains	August 24, 2002
72	Pierce	157	71	3	NW Drift Plains	August 24, 2002
73	Pierce	158	69	4	NE Drift Plains	August 24, 2002
73	Pierce	158	69	3	NE Drift Plains	August 24, 2002
73	Pierce	158	69	9	NE Drift Plains	August 24, 2002
73	Pierce	158	69	10	NE Drift Plains	August 24, 2002
74	Pembina	163	56	35	NE Drift Plains	September 3, 2002
74	Pembina	163	56	36	NE Drift Plains	September 3, 2002
74	Pembina	162	56	2	NE Drift Plains	September 3, 2002
74	Pembina	162	56	1	NE Drift Plains	September 3, 2002
75	Cavalier	161	57	13	NE Drift Plains	September 3, 2002
75	Pembina	161	56	18	NE Drift Plains	September 3, 2002
75	Cavalier	161	57	24	NE Drift Plains	September 3, 2002
75	Pembina	161	56	19	NE Drift Plains	September 3, 2002
76	Cavalier	161	57	18	NE Drift Plains	September 3, 2002
76	Cavalier	161	57	17	NE Drift Plains	September 3, 2002
76	Cavalier	161	57	19	NE Drift Plains	September 3, 2002
76	Cavalier	161	57	20	NE Drift Plains	September 3, 2002
77	Cavalier	161	60	3	NE Drift Plains	September 3, 2002

77	Cavalier	161	60	2	NE Drift Plains	September 3, 2002
77	Cavalier	161	60	10	NE Drift Plains	September 3, 2002
77	Cavalier	161	60	11	NE Drift Plains	September 3, 2002
78	Cavalier	160	61	36	NE Drift Plains	September 3, 2002
78	Cavalier	160	60	31	NE Drift Plains	September 3, 2002
78	Cavalier	159	61	1	NE Drift Plains	September 3, 2002
78	Cavalier	159	60	6	NE Drift Plains	September 3, 2002
79	Ramsey	158	63	21	NE Drift Plains	September 3, 2002
79	Ramsey	158	63	22	NE Drift Plains	September 3, 2002
79	Ramsey	158	63	28	NE Drift Plains	September 3, 2002
79	Ramsey	158	63	27	NE Drift Plains	September 3, 2002
80	Towner	157	65	25	NE Drift Plains	September 3, 2002
80	Ramsey	157	64	30	NE Drift Plains	September 3, 2002
80	Towner	157	65	36	NE Drift Plains	September 3, 2002
80	Ramsey	157	64	31	NE Drift Plains	September 3, 2002
81	Towner	157	68	16	NE Drift Plains	August 24, 2002
81	Towner	157	68	15	NE Drift Plains	August 24, 2002
81	Towner	157	68	21	NE Drift Plains	August 24, 2002
81	Towner	157	68	22	NE Drift Plains	August 24, 2002
82	Towner	158	67	32	NE Drift Plains	August 24, 2002
82	Towner	158	67	33	NE Drift Plains	August 24, 2002
82	Towner	157	67	5	NE Drift Plains	August 24, 2002
82	Towner	157	67	4	NE Drift Plains	August 24, 2002
83	Towner	158	68	34	NE Drift Plains	August 24, 2002
83	Towner	158	68	35	NE Drift Plains	August 24, 2002
83	Towner	157	68	3	NE Drift Plains	August 24, 2002
83	Towner	157	68	2	NE Drift Plains	August 24, 2002
84	Towner	161	66	9	NE Drift Plains	September 3, 2002

84	Towner	161	66	10	NE Drift Plains	September 3, 2002
84	Towner	161	66	16	NE Drift Plains	September 3, 2002
84	Towner	161	66	15	NE Drift Plains	September 3, 2002
85	Towner	163	65	6	NE Drift Plains	September 3, 2002
85	Towner	163	65	5	NE Drift Plains	September 3, 2002
85	Towner	163	65	7	NE Drift Plains	September 3, 2002
85	Towner	163	65	8	NE Drift Plains	September 3, 2002
86	Rolette	163	70	16	NE Drift Plains	September 3, 2002
86	Rolette	163	70	15	NE Drift Plains	September 3, 2002
86	Rolette	163	70	21	NE Drift Plains	September 3, 2002
86	Rolette	163	70	22	NE Drift Plains	September 3, 2002
87	McHenry	152	76	8	NW Drift Plains	September 3, 2002
87	McHenry	152	76	9	NW Drift Plains	September 3, 2002
87	McHenry	152	76	17	NW Drift Plains	September 3, 2002
87	McHenry	152	76	16	NW Drift Plains	September 3, 2002
88	McHenry	152	79	29	NW Drift Plains	September 3, 2002
88	McHenry	152	79	28	NW Drift Plains	September 3, 2002
88	McHenry	152	79	32	NW Drift Plains	September 3, 2002
88	McHenry	152	79	33	NW Drift Plains	September 3, 2002
89	McHenry	154	77	1	NW Drift Plains	September 3, 2002
89	McHenry	154	76	6	NW Drift Plains	September 3, 2002
89	McHenry	154	77	12	NW Drift Plains	September 3, 2002
89	McHenry	154	76	7	NW Drift Plains	September 3, 2002
90	McHenry	154	78	2	NW Drift Plains	September 3, 2002
90	McHenry	154	78	1	NW Drift Plains	September 3, 2002
90	McHenry	154	78	11	NW Drift Plains	September 3, 2002
90	McHenry	154	78	12	NW Drift Plains	September 3, 2002
91	McHenry	155	78	1	NW Drift Plains	September 3, 2002

91	McHenry	155	77	6	NW Drift Plains	September 3, 2002
91	McHenry	155	78	12	NW Drift Plains	September 3, 2002
91	McHenry	155	77	7	NW Drift Plains	September 3, 2002
92	McHenry	154	80	23	NW Drift Plains	September 3, 2002
92	McHenry	154	80	24	NW Drift Plains	September 3, 2002
92	McHenry	154	80	26	NW Drift Plains	September 3, 2002
92	McHenry	154	80	25	NW Drift Plains	September 3, 2002
93	McHenry	158	76	31	NW Drift Plains	August 24, 2002
93	McHenry	158	76	32	NW Drift Plains	August 24, 2002
93	McHenry	157	76	6	NW Drift Plains	August 24, 2002
93	McHenry	157	76	5	NW Drift Plains	August 24, 2002
94	McHenry	158	78	18	NW Drift Plains	August 24, 2002
94	McHenry	158	78	17	NW Drift Plains	August 24, 2002
94	McHenry	158	78	19	NW Drift Plains	August 24, 2002
94	McHenry	158	78	20	NW Drift Plains	August 24, 2002
95	McHenry	157	80	23	NW Drift Plains	September 3, 2002
95	McHenry	157	80	24	NW Drift Plains	September 3, 2002
95	McHenry	157	80	26	NW Drift Plains	September 3, 2002
95	McHenry	157	80	25	NW Drift Plains	September 3, 2002
96	Bottineau	162	78	27	NW Drift Plains	September 3, 2002
96	Bottineau	162	78	26	NW Drift Plains	September 3, 2002
96	Bottineau	162	78	34	NW Drift Plains	September 3, 2002
96	Bottineau	162	78	35	NW Drift Plains	September 3, 2002
97	Bottineau	163	83	6	NW Drift Plains	August 24, 2002
97	Bottineau	163	83	5	NW Drift Plains	August 24, 2002
97	Bottineau	163	83	7	NW Drift Plains	August 24, 2002
97	Bottineau	163	83	8	NW Drift Plains	August 24, 2002
98	Bottineau	159	82	30	NW Drift Plains	September 3, 2002

98	Bottineau	159	82	29	NW Drift Plains	September 3, 2002
98	Bottineau	159	82	31	NW Drift Plains	September 3, 2002
98	Bottineau	159	82	32	NW Drift Plains	September 3, 2002
99	Renville	158	81	2	NW Drift Plains	September 3, 2002
99	Renville	158	81	1	NW Drift Plains	September 3, 2002
99	Renville	158	81	11	NW Drift Plains	September 3, 2002
99	Renville	158	81	12	NW Drift Plains	September 3, 2002
100	Renville	158	83	1	NW Drift Plains	September 3, 2002
100	Renville	158	82	6	NW Drift Plains	September 3, 2002
100	Renville	158	83	12	NW Drift Plains	September 3, 2002
100	Renville	158	82	7	NW Drift Plains	September 3, 2002
101	Renville	162	84	20	NW Drift Plains	August 24, 2002
101	Renville	162	84	21	NW Drift Plains	August 24, 2002
101	Renville	162	84	29	NW Drift Plains	August 24, 2002
101	Renville	162	84	28	NW Drift Plains	August 24, 2002
102	Renville	163	86	17	NW Drift Plains	August 24, 2002
102	Renville	163	86	16	NW Drift Plains	August 24, 2002
102	Renville	163	86	20	NW Drift Plains	August 24, 2002
102	Renville	163	86	21	NW Drift Plains	August 24, 2002
103	Renville	161	86	27	NW Drift Plains	August 24, 2002
103	Renville	161	86	26	NW Drift Plains	August 24, 2002
103	Renville	161	86	34	NW Drift Plains	August 24, 2002
103	Renville	161	86	35	NW Drift Plains	August 24, 2002
104	Ward	159	87	5	NW Drift Plains	August 24, 2002
104	Ward	159	87	4	NW Drift Plains	August 24, 2002
104	Ward	159	87	8	NW Drift Plains	August 24, 2002
104	Ward	159	87	9	NW Drift Plains	August 24, 2002
105	Ward	155	81	2	NW Drift Plains	September 3, 2002

105	Ward	155	81	1	NW Drift Plains	September 3, 2002
105	Ward	155	81	11	NW Drift Plains	September 3, 2002
105	Ward	155	81	12	NW Drift Plains	September 3, 2002
106	Ward	152	86	5	Missouri Coteau	August 24, 2002
106	Ward	152	86	4	Missouri Coteau	August 24, 2002
106	Ward	152	86	8	Missouri Coteau	August 24, 2002
106	Ward	152	86	9	Missouri Coteau	August 24, 2002
107	Ward	155	86	15	Missouri Coteau	August 24, 2002
107	Ward	155	86	14	Missouri Coteau	August 24, 2002
107	Ward	155	86	22	Missouri Coteau	August 24, 2002
107	Ward	155	86	23	Missouri Coteau	August 24, 2002
108	Ward	155	87	10	Missouri Coteau	August 24, 2002
108	Ward	155	87	11	Missouri Coteau	August 24, 2002
108	Ward	155	87	15	Missouri Coteau	August 24, 2002
108	Ward	155	87	14	Missouri Coteau	August 24, 2002
109	Mountrail	155	88	12	Missouri Coteau	August 24, 2002
109	Ward	155	87	7	Missouri Coteau	August 24, 2002
109	Mountrail	155	88	13	Missouri Coteau	August 24, 2002
109	Ward	155	87	18	Missouri Coteau	August 24, 2002
110	Mountrail	158	92	7	Missouri Coteau	August 24, 2002
110	Mountrail	158	92	8	Missouri Coteau	August 24, 2002
110	Mountrail	158	92	18	Missouri Coteau	August 24, 2002
110	Mountrail	158	92	17	Missouri Coteau	August 24, 2002
111	Burke	159	92	28	Missouri Coteau	August 24, 2002
111	Burke	159	92	27	Missouri Coteau	August 24, 2002
111	Burke	159	92	33	Missouri Coteau	August 24, 2002
111	Burke	159	92	34	Missouri Coteau	August 24, 2002
112	Burke	161	89	5	NW Drift Plains	August 24, 2002

112	Burke	161	89	4	NW Drift Plains	August 24, 2002
112	Burke	161	89	8	NW Drift Plains	August 24, 2002
112	Burke	161	89	9	NW Drift Plains	August 24, 2002
113	Burke	162	91	22	NW Drift Plains	August 24, 2002
113	Burke	162	91	23	NW Drift Plains	August 24, 2002
113	Burke	162	91	27	NW Drift Plains	August 24, 2002
113	Burke	162	91	26	NW Drift Plains	August 24, 2002
114	Burke	163	92	8	NW Drift Plains	August 24, 2002
114	Burke	163	92	9	NW Drift Plains	August 24, 2002
114	Burke	163	92	17	NW Drift Plains	August 24, 2002
114	Burke	163	92	16	NW Drift Plains	August 24, 2002
115	Burke	161	94	10	Missouri Coteau	August 24, 2002
115	Burke	161	94	11	Missouri Coteau	August 24, 2002
115	Burke	161	94	15	Missouri Coteau	August 24, 2002
115	Burke	161	94	14	Missouri Coteau	August 24, 2002
116	Divide	162	99	3	Missouri Coteau	August 24, 2002
116	Divide	162	99	2	Missouri Coteau	August 24, 2002
116	Divide	162	99	10	Missouri Coteau	August 24, 2002
116	Divide	162	99	11	Missouri Coteau	August 24, 2002
117	Divide	160	99	32	Missouri Coteau	August 24, 2002
117	Divide	160	99	33	Missouri Coteau	August 24, 2002
117	Williams	159	99	5	Missouri Coteau	August 24, 2002
117	Williams	159	99	4	Missouri Coteau	August 24, 2002
118	Divide	160	103	36	Missouri Coteau	August 24, 2002
118	Divide	160	102	31	Missouri Coteau	August 24, 2002
118	Williams	159	103	1	Missouri Coteau	August 24, 2002
118	Williams	159	102	6	Missouri Coteau	August 24, 2002
119	Williams	159	103	11	Missouri Coteau	August 24, 2002

119	Williams	159	103	12	Missouri Coteau	August 24, 2002
119	Williams	159	103	14	Missouri Coteau	August 24, 2002
119	Williams	159	103	13	Missouri Coteau	August 24, 2002
120	Williams	159	100	32	Missouri Coteau	August 24, 2002
120	Williams	159	100	33	Missouri Coteau	August 24, 2002
120	Williams	158	100	5	Missouri Coteau	August 24, 2002
120	Williams	158	100	4	Missouri Coteau	August 24, 2002