North American Waterfowl
Management Plan

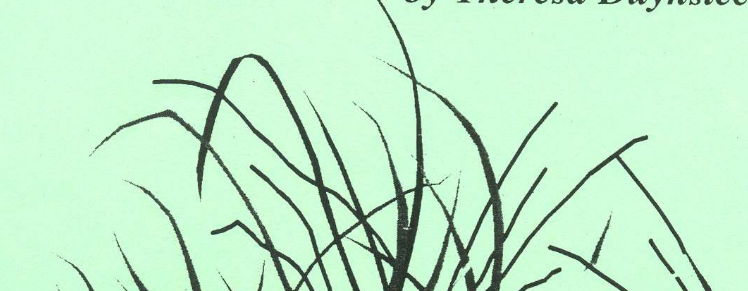
An Investigation into Field Grazing by Wigeon in Delta, British Columbia

1990-1991

A pilot study conducted by
the Greenfields Project

January 1992

by Theresa Duynstee



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Preface

"Formerly, the cultivated land of the Fraser Delta provided a relatively undisturbed wintering ground for many thousands of ducks. They fed upon the vegetation of the tidal marshes off the Delta Islands, and used the expanse of fields and pastures of the early farms. Crop damage was never considered serious since the waterfowl were distributed over a large feeding area. With the development of urban communities, the acreage of agricultural crops suitable as waterfowl food has been depleted. This condition has apparently forced large duck flocks to utilize remaining acreage so fully that serious local damage is not uncommon throughout the Fraser Delta District" (Baynes 1953).

Although written almost forty years ago, this statement sums up what is happening in Delta today. Continued urbanization has drastically reduced the habitat on which wildlife depends. This has resulted in more intensive utilization of remaining farmland making crop damage inevitable.

The main source of the problem in Delta is the American wigeon (Anas americana), a duck with a solid reputation for grazing agricultural grasses. The utilization of farmer's overwintering crops and forage fields, coupled with limited success using prevention techniques and no compensation for crop damage, continues to tip farmers attitude from tolerance to intolerance towards wildlife.

The Greenfields Project was initiated to promote widespread use of winter cover crops in an attempt to disperse waterfowl grazing. The goal was to lessen the impact of wigeon while still benefiting farmers through soil conservation. To facilitate an integrated approach to the problem also required improved communication between wildlife and agricultural sectors. This report provides information on wigeon usage of farmers fields in Delta, B.C. from November 1990 to March 1991. The status of knowledge of wigeon, and factors which contribute to crop losses are discussed. This information will be used to develop strategies to alleviate further conflict.

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Executive Summary

In the first year the Greenfields Project began to identify the extent to which wigeon use farmers' fields over the winter in Delta, B.C. Wigeon graze cover crops, such as winter wheat (Triticum aestivum), which are planted in the fall as a stewardship practice for soil conservation, and also perennial grass fields used for livestock forage.

Seventy five fields totaling 1600 acres were monitored for wigeon use from November 1990 to March 1991. Results showed that these migratory ducks utilized fields throughout Delta, from Westham Island to South Surrey. The wigeon began feeding on the farmers fields in mid-November. Intensive grazing continued through December until the snowfall, which restricted access to most crops. Mild temperatures in February brought on a resurgence of growth which was grazed again on many fields. Three quarters of these fields were more than 50% grazed by wigeon at least once during the study period. However, the intensity of use varied substantially. While some crops were only marginally grazed, others were repeatedly utilized leaving the soil without cover in the spring.

Grazing impact was measured by calculating the difference in biomass between grazed and ungrazed areas. Several fields did not regrow after the initial fall grazing, while many others grew back in February, giving an impression that biomass losses were minimal. The most dramatic differences occurred on fields which were repeatedly grazed in both the fall and spring. Calculations of the biomass difference ranged from 200-1500 lbs dry weight per acre (240-1800 kg dry weight per hectare) on fields used by the wigeon.

An accurate estimate of crop damage caused by wigeon is difficult to determine because of the number of variables that contribute to crop productivity and survival. The biomass differences measured represented not only what the wigeon ate but also the effects of climate and soil conditions in combination with waterfowl use. A preliminary investigation which looked at crop regrowth on grazed and clipped areas, (with and without soil disturbance) indicated that drained fields were better able to withstand the impact of wigeon grazing.

Rather than concentrating on damage assessment more emphasis should be placed on the most appropiate strategies to alleviate losses to farmers. Further research on wigeon behaviour and population demographics would confirm the overall importance of farmland habitat.

Chemical composition of the crops and surface water were investigated to determine what role they played in attracting wigeon to particular fields. High protein and low fiber content known to be preferred by grazing waterfowl did not emerge as a significant factor correlated to grazing. The wigeon's biological need for large quantities of biomass may be responsible for the reduced selectivity and for mature cover crops being utilized as well as the tender shoots of late planted crops.

Statistical analysis confirmed that surface water could account fot 24.4% of the variation of grazing in November. However the role of water is unclear, since several heavily impacted fields in this study had little or no surface water present. Other studies suggest the water is desirable because it reduces the risk of predation, rather than being a physiological necessity.

From observations over the winter, other factors such as disturbance and field characteristics, appear to play an important role in determining wigeon use of fields. Noise, field location and surroundings will be investigated further in 1991-92 to see whether they influence wigeon distribution and feeding behaviour.

To date investigations do not provide enough information to determine whether wigeon grazing could be dispersed by planting cover crops over large areas. Continual monitoring over the next two years will give an indication whether extensive planting can reduce crop damage. Observations from the first year suggest that wigeon are likely to extensively use a field once they discover a desirable food source. Dispersal may only be possible over time, in that a particular field may not be grazed every year.

There are no simple solutions to the waterfowl grazing problem. The wigeon will continue to utilize farmers fields as long as population levels remain, and alternate food supplys are unavailable. Only through cooperation and communication between the agricultural and wildlife sectors will appropiate strategies be identified which can resolve the issue.

Acknowledgements

A special thanks to Drs. Art Bomke and Wayne Temple from Soil Science, U.B.C. for taking the time and initiative to get the Greenfields Project off the ground. Other members of the steering committee provided invaluable support and guidence including Kathleen Fry, Lindsay Jones, Rick McKelvey and Steve Wetmore.

Much appreciation goes out to all the cooperating farmers of the Delta Farmers Institute for their participation, for without their faith, this project would not of been possible. In addition many farmers have enriched my education in agriculture in a way no textbook could.

Thanks to Celine Maurice for her commitment and preservence as supervisor of the Youth Corp crew which helped collect the data. The Youth Corp was sponsored by the Ministry of Environment.

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Most importantly, thanks goes out to the various agencies that provided financial support to this project: ARDCORP (B.C. Federation of Agriculture), Canadian Wildlife Service, Ducks Unlimited Canada, Department of Soil Science (U.B.C.), and Wildlife Habitat Canada.

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1. Introduction

1.1 Genesis of the Project

Cover crops are a valuable conservation practice. Planted in the fall these annual cereals, such as winter wheat, provide a lush green cover overwinter. As well as providing numerous benefits to the soil, cover cropping enhances habitat for migratory birds.

Drs. Art Bomke and Wayne Temple from the Department of Soil Science, U.B.C., have determined that winter wheat can be incorporated into current cropping systems in Delta, B.C. (Bomke et al. 1991). Planted after the main cash crop is harvested in the fall, winter wheat can be used as green manure, forage for livestock or grown to grain the following year.

In Delta, there was some relutance to plant cover crops because of heavy waterfowl grazing pressure experienced by some farmers. The U.B.C researchers approached the Canadian Wildlife Service of Environment Canada to see what could be done about this limitation. This branch of the federal government, responsible for the conservation of migratory birds, was aware of the conflict but did not know the extent of the impact on local farmers or the best way to alleviate the damage.

The mutual decision to investigate the issue of soil conservation and waterfowl grazing gave rise to the formation of the Greenfields Project. The goal was to promote cover crops in Delta to see whether grazing impact could be dispersed. Through support from the various agencies the Greenfields Project was able to initiate an integrated approach to the problem.

Not only was there a need to discover where and when the ducks were grazing, but it was also necessary to investigate factors which influenced wigeon use of farm fields. This information could provide a basis for a future strategy identifing ways to prevent grazing or reduce the impact, in hopes of finding ways to accomodate wildlife in the farm landscape.

On August 24, 1990 a letter was sent out to all members of the Delta Farmers Institute to inform them about the objectives of the Greenfields Project. Farmers were asked to plant a cover crop which could be monitored for waterfowl grazing. It was a cost sharing arrangement, where seed was supplied and farmers contributed the labour of planting the crop. The amount distributed and location of cover crops varied, depending on the availability of the fields.

1.2 Description of Greenfields

Cover Crops

The majority of the fields monitored overwinter for wigeon grazing were cover crops seeded between August and October to protect the soil overwinter. The fine textured soils in Delta especially benefit from a cover crop given the heavy winter rains. The beating and dispersing action of raindrops or suspended silt particles in ponded rain water form a compacted layer or surface crust. Previous studies (Keng 1983) indicated that mechanical impaction of raindrops densifies the surface 2.5 cm of the soil layer by 15%. This results in reduced water infiltration and evaporation which prevents early season field operations.

Vegetable producers benefit from cover crops used as a green manure in the spring. Organic matter is incorporated into the soil from both the fibrous root system and overall leaf production. In addition a fall planted crop can capture nitrogen which continues to be available through the nitrification process after the main cash crops are harvested. Instead of this valuable nutrient being lost through leaching over the winter, it can be incorporated back into the soil.

There are several types of cover crops used in Delta. Fall rye (Secale cereale) has traditionally been grown and is adaptable to a wide range of soils. Being extremely cold tolerant it will continue to grow during mild winter weather. Fall rye matures quickly and therefore must be worked into the soil early before it becomes unmanageable and difficult to till.

Winter wheat (Triticum aestivum) is becoming increasingly popular since it does not need to be plowed down in early spring, giving farmers more flexibility in their busy schedule. In addition this crop offers more harvesting options because of its potential as a forage or feed crop.

Spring cereals such as spring wheat (Triticum aestivum) and spring barley (Hordeum vulgare) do not require a cold period to mature from the tillering to elongation stage of growth. Therefore they are capable of vigorous growth in the fall producing large amounts of biomass when planted in late summer. Spring cereals are more susceptible to winterkill, and in cold temperatures will turn into a dead mulch rather than an overwinter crop.

Perennial Grasses

Perennial grass fields, commonly referred to as pasture, are used to feed livestock as green chop, grass silage or hay. Several farmers indicated that these fields were also desirable to wigeon, so they were included in the study.

Grass fields are generally comprised of several plant species to ensure nutritional quality and high yields. They are slow to establish, compared to annual crops, often not reaching peak yields until the second or third year. Perennial ryegrass (Lolium perenne) is often used because of its high quality and its ability to recover well from defoliation. Orchard grass (Dactylis glomerata) is another popular fodder with vigorous growth, although it prefers well drained soils. Tall fescues (Festuca arundinacea), and timothy (Phleum pratense) are commonly planted because of their tolerance to heavier, wetter soils. White clover (Trifolium repens) is easily established in a wide range of soils. Clovers are often included in seed mixtures because of their high digestibility and protein which is valuable for silage (Holmes 1989).

1.3 Wigeon

The wigeon (Anas americana) is a medium sized (average 700 grams) dabbling duck with a short bill, proportionately narrow wings, and a moderately long, wedge-shaped tail (Bellrose 1980). The white crown of a full plumaged wigeon is a distinctive mark which gives this bird its common name, baldpate. In flight a white rectangular shoulder patch on the drake and elliptical white belly on hens and immatures help with identification (Figure 1).

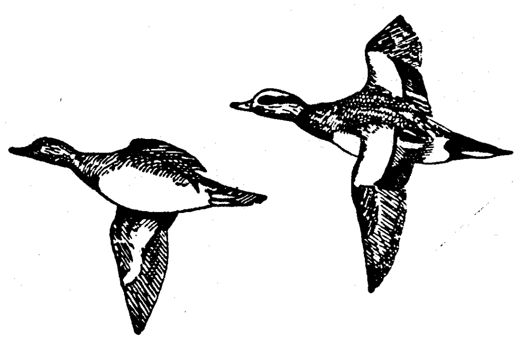

Figure 1: Female and male American wigeon (Bellrose 1980).

Figure 1: Female and male American wigeon (Bellrose 1980).

The gregarious nature and behaviour of wigeon allows them to be easily identified. They form large compact flocks, which in flight have a zig zag wheeling motion characterized by abrupt changes in direction. These ducks are more wary than most species, sometimes circling fields before landing. They are quick to take alarm, for if one or two are startled, the entire flock will take flight, rather than just the affected birds.

Wigeon are almost exclusively vegetarian. On estuaries, wigeon consume aquatic plants such as eelgrass (Zostera spp.) and algae (Enteromorpha spp.). Over the years, changes in availability of these marsh plants may have led to changes in wigeon feeding habits. Wigeon are now increasingly found on inland habitats. Inland pasture is now more important than either mudflats or saltmarshes for European Wigeon in Britain (Owen & Williams 1976). In the Fraser delta it appears that the agricultural areas provide a greater feeding opportunity for wigeon between October and January, than do the marshes (Burgess 1970).

In Delta observations of wigeon feeding on agricultural fields are infrequent because these ducks feed during the night when they are less likely to be disturbed. Local residents are aware of their presence because it is announced by a distinctive drake call, composed of three whistling, piping notes, the middle note higher than the others.

The American wigeon is the most abundant overwintering duck in the Fraser delta, with an average estimated population of 62,000 birds. (Butler & Campbell 1987). Banding studies have shown that the largest percentage of wigeon which overwinter on the Fraser delta come from Alaska, in areas such as the Yukon Flats, the Tanana River valley and the Yukon-Kuskokwim delta (McKelvey & Smith 1990). On the Pacific Flyway large populations of wigeon are also found in Puget Sound, Washington and in the valley of the Willamette and Columbia Rivers in Oregon. The principal wintering ground is in the Central Valley of California which sustains a population of about 700,000 wigeon (Bellrose 1980).

The first fall migrants may appear in early September. Numbers build up in October, with the peak movement into Delta occurring in November and December, when wintering populations become established. Spring migration may commence in late March, but most birds pass through in April. Few wigeon summer in the Fraser River delta (Butler & Campbell 1987).

1.4 The Study Area

The Greenfields Project was located within the municipality of Delta, which is less than an hours drive from the Greater Vancouver Metropolitan area, in south coastal British Columbia (Figure 2).

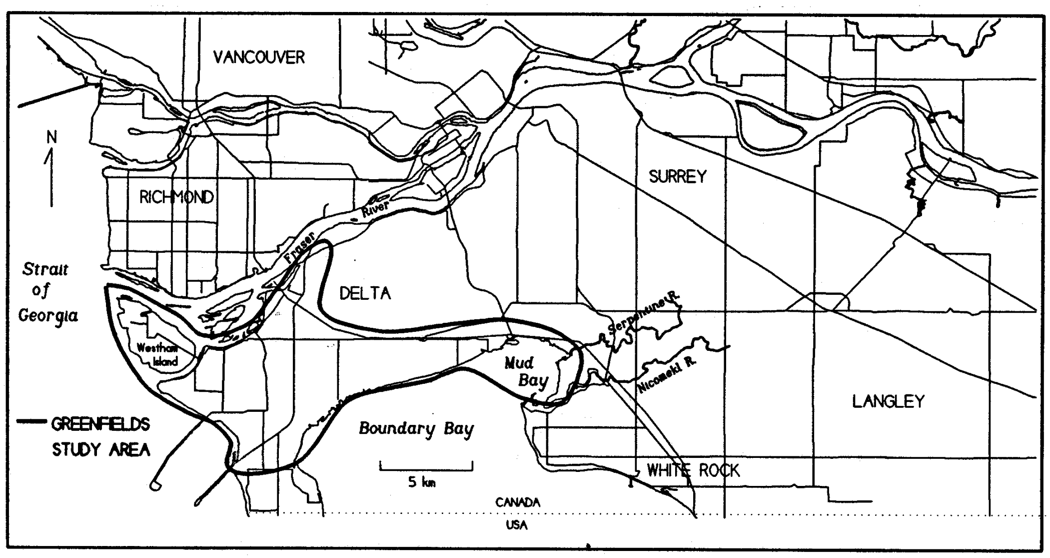

Figure 2: Location of the Greenfields study area.

Delta is within the Fraser River delta, an area which supports the highest winter densities of waterbirds, shorebirds and raptors in Canada. Being the largest estuary on the Pacific Coast, the area is key habitat on the Pacific Flyway, where peak numbers of birds in migration are estimated to be 1.4 million (Butler & Campbell 1987).

Due to the combination of mild climate and fertile soils, Delta is also one of the most productive farm districts in British Columbia. Locally grown cash crops include potatoes, beans, peas, corn, berries, greenhouse and nursery products. Further crop production of grain, hay and other fodder provide feed for the livestock and poultry industry (dairy, beef, eggs, broilers, sheep, goats and horses). This diverse agricultural industry also supports extensive value-added

1.5 Climate

The moderate climate provides an extended growing season which makes Delta valuable to both agriculture and wildlife. Winters are characteristically mild and wet, unlike other regions of the country which are usually frozen. Thirty year averages (Atmospheric Environment Service 1990) show that daily temperatures dip below freezing only in January and that December is traditionally the wettest month.

The weather during the winter of 1990 presented some anomalies (Appendix A). Heavy rains started in early November. By November 12 over 100 mm of rain had fallen in Delta (Nikkel 1991). Monthly total precipitation reached 215 mm, much higher than the 30 year average of 127 mm (Figure 3).

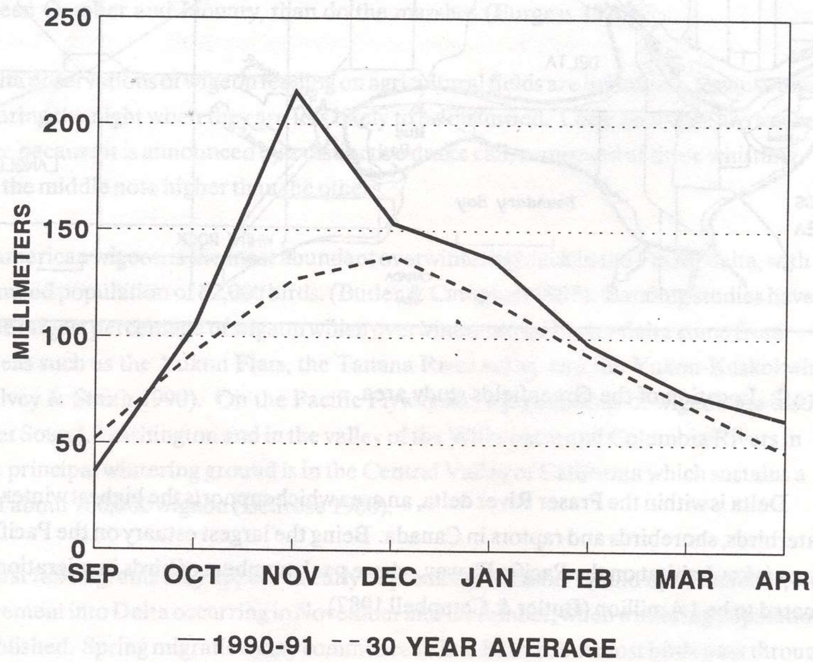

Figure 3: Winter precipitation at Delta, B.C.

Average monthly temperatures also revealed extremes when compared to previous years. December was unusually cool with overnight lows down to -14°C. Snow fell periodically starting December 17 and did not completely disappear until January 11. In contrast to these low temperatures February was an unusually warm month (Figure 4), averaging 5°C warmer than the previous three years (Appendix A).

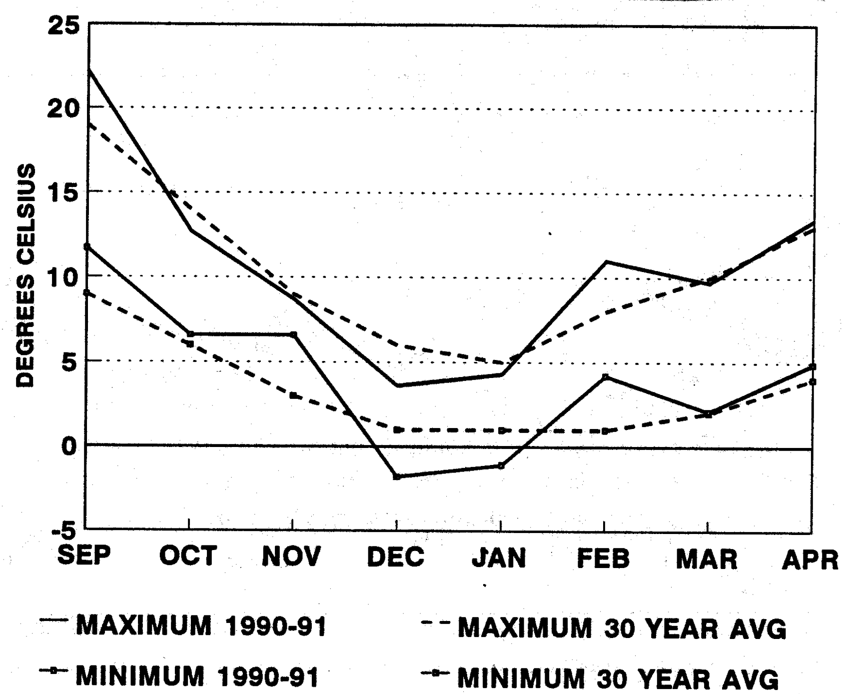

Figure 4: Winter temperatures at Delta, B.C.

2. Methods

2.1. Field Characteristics

A total of 75 fields were monitored from November 1990 to March 1991. Most of the fields were winter wheat (41). Other crops included fall rye (15), perennial grasses (8), spring wheat (7) clover (1), barley (1) and combinations of cereals (2). These fields were widely distributed throughout Delta (Figure 5).

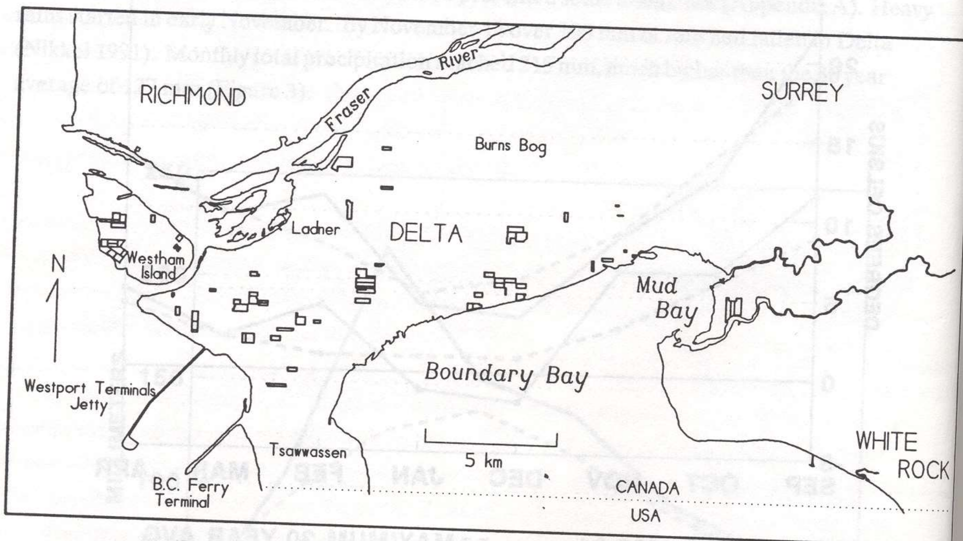

Figure 5: Location of cover crops and grass fields.

The total area in the survey was 1600 acres. The unit acre is consistently used throughout this report because it is still commonly used by the farming community.

A site description of each field (Appendix B) was provided by the farmer. Field size varied from 3 to 40 acres with most occurring in the 20-29 acre range (Figure 6). The method of planting was almost evenly split between broadcasting (usually accompanied with disking) and drilling. Half the fields were planted at a seeding rate of 100 lbs/acre, and the rest at a higher rate of 150 lbs/acre. Previous crops included corn, peas, potatoes and beans. Land improvements such as subsurface drains and levelling were also noted. All fields in the study were labelled according to the farmer who owned or leased the land, for example SR1 was farmed by Stan Reynolds.

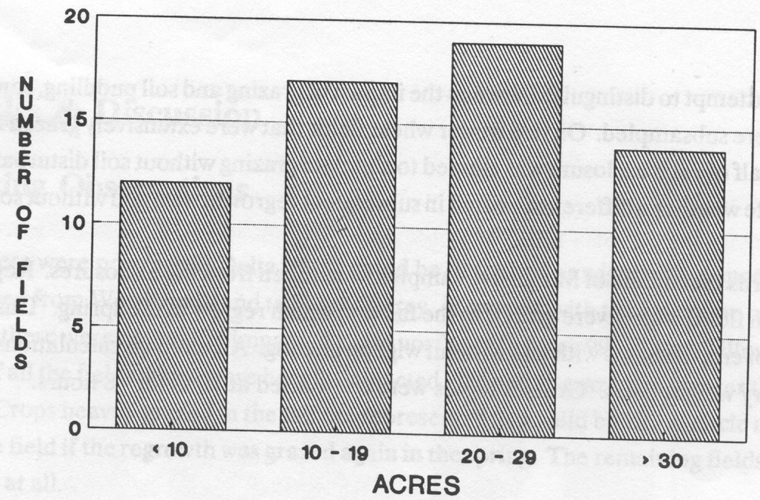

Figure 6: Distribution of field size.

2.2. Field Monitoring Program

Fields were visited every 15-20 days. The Greenfields crew walked fields to see whether grazing had occured. It was not necessary to actually observe wigeon grazing because the emphasis was on grazing impact, not general use, which can include roosting or loafing. Occasionally swans were observed grazing fields, but overall, wigeon were responsible for most of the crop use.

On each visit the condition of the field was noted. A sketch was drawn to show where crops were grazed and where the sheetwater was located. The level of grazing was assigned to 1 of 3 categories; (i) not grazed (ii) partly grazed (iii) fully grazed. On the initial visit two net exclosures (1.5 x 1.5 meters) were set in each field, except for those smaller than 5 acres, where only one was used. The exclosures, made out of fish netting and wooden stakes, were located near the centre of the field. They were used to obtain a grass sample in the spring representative of an ungrazed area.

Five 0.25 metre^2 samples were randomly taken in each field when the exclosures were set up. These grass samples were used to estimate biomass and the chemical composition or quality of the forage prior to grazing. Three grass heights were measured for each sample. Several winter wheat fields were sampled more frequently in order to determine changes in quantity and quality of cover crops throughout the study period.

In an attempt to distinguish between the impact of grazing and soil puddling, some exclosures were subsampled. On five winter wheat fields that were extensively grazed in November, half of each exclosure was clipped to simulate grazing without soil disturbance. This would indicate whether a difference existed in subsequent regrowth with and without soil surface disturbance.

Towards the middle of March five samples were taken from the exclosures. Regrowth was sampled from fields which were grazed in the fall and which regrew in the spring. This provided an estimate of crop biomass with and without wigeon grazing. All biomass calculations were made on a dry weight basis. Grass samples were oven dried at 70°C for 48 hours.

2.3 Chemical Analysis

All grass samples were dried and processed through a 1 mm mesh on a Wiley mill before being sent to the lab for chemical analysis. Grass samples collected throughout the winter were analyzed using the in vivo technique used to identify differences in chemical composition of forages. The alternative method is the in vitro technique which distinguishes differences in forage digestibility, particularly for ruminant animals (Raymond 1969).

The two most important indices of quality are percent fibre and percent protein. Modern techniques to determine digestibility separate dry matter into two fractions based on nutritional availability, the cell contents and the cell wall. The cell contents are comprised primarily of soluble matter such as carbohydrates (sugars & starches), lipids and protein. The plant cell wall consists of structural features such as pectic substances, polysaccharides, hemicellulose and cellulose, plus lignin.

The neutral detergent fibre (NDF) technique (Van Soest 1967) measures the cell wall content in forage. Since NDF includes hemicellulose, which can be a large and variable fraction, it provides a good estimate of the indigestible portion for mono- gastric animals such as wigeon. The acid detergent fibre (ADF) technique differs in that it represents the sum of cellulose and lignin, commonly a more useful indication of fibre for livestock (Raymond 1969). These methods of detergent analysis do not attempt to determine the nutritive value or digestibility of the various plant components, but only the chemical composition of what is available.

Dietary crude protein was detemined by the Kjeldahl procedure where nitrogen is converted to ammonium sulfate. Nitrogen times 6.25 provides a crude estimate of dietary protein content (Robbins 1983).

3. Results & Discussion

3.1 Grazing Observations

There were no areas in Delta which could be described as wigeon "hot spots", as fields were utilized from Westham Island to South Surrey. However, with the exception of one field in this study, there were no heavily impacted crops north of Highway 99. Figure 7 illustrates the location of all the fields which were heavily impacted, defined as grazed on greater than 50% of the field. Crops heavily grazed in the fall are represented as a solid block. A circle appears around the field if the regrowth was grazed again in the spring. The remaining fields had little or no grazing at all.

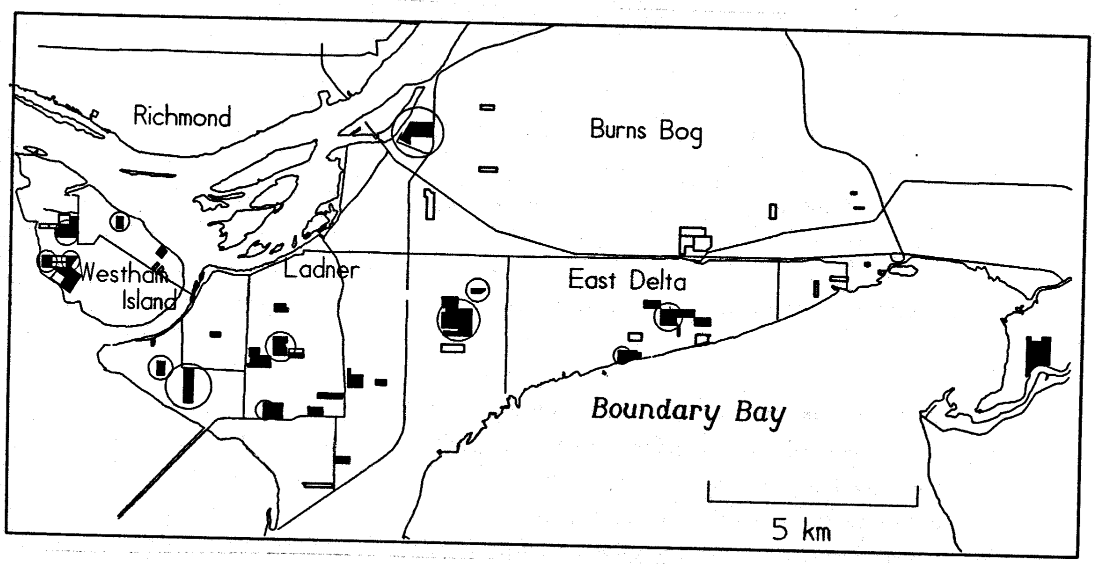

Figure 7: Location of heavily grazed fields.

A rating system was used to describe the extent of grazing in each field throughout the winter. From the field observations the percent of the field utilized was summarized for each month (Appendix C). Using this information the distribution of grazing can be presented.

The number of fields which were greater than 50% grazed are indicated by the solid bar in Figure 8. A total of 54 of the study fields were more than 50% grazed from November to January. Many of these grazed fields regrew in February, making them susceptible to repeated use. Only half (28) of the fall grazed fields were utilized again in the spring.

The data was further classified to illustrate the varying amounts of grazing which ocurred on the fields each month. The distribution illustrates that most fields in November were either heavily used (> 50%) or were lightly grazed (<25%). Towards March a greater number of fields were 25-50% grazed.

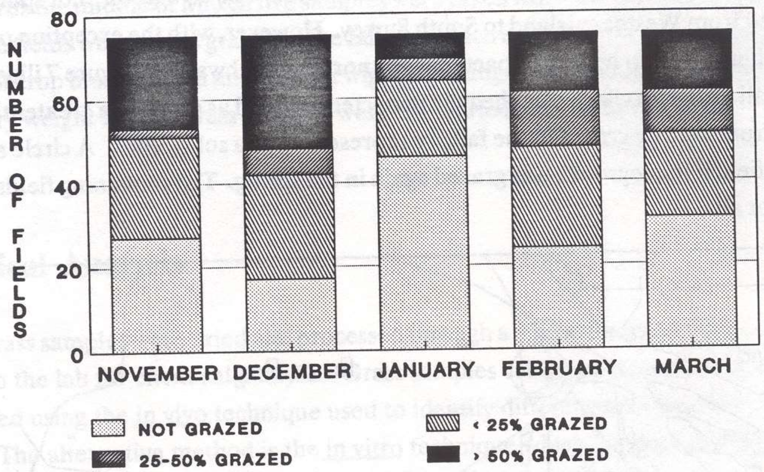

Figure 8: Relative monthly grazing pressure on fields.

Why cover crops were less utilized in the spring may be due to a preference for perennial grass fields. Several farmers had reported that many established grass fields, not in the study, were heavily grazed from February to April.

The proportion of each field grazed also varied substantially. During the first grazing period in November, wigeon were very efficient foragers, taking almost every blade of grass. Plants were not uprooted, just clipped, leaving at least 1 cm of stubble. The pattern of initial grazing was very distinctive in that the ducks started in one area and continued along as a group, rather than being dispersed over the field. Surrounding the more heavily grazed areas were areas partly grazed.

Crops were continually used, although not always on consecutive days, until the field was completely grazed, except for the field edges. The amount of crop left ungrazed depended on the location and characteristics of the field. Fields in proximity to buildings or well travelled roads, could have an ungrazed border of as much as 25 meters. Grazing was not always apparent unless the observer walked out to less disturbed areas.

When cold, snowy weather arrived in mid-December, grazing became patchy and often individual plants and fields were only partly eaten. At that time most of the young, tender crops were eaten or hidden below the snow. The only forage available was more mature and fibrous crops. In February, many fully grazed fields had regrown. This lush, new growth was again utilized by the wigeon in the same manner as the fall, except that a smaller percent of the field was grazed. Grazing impact may have been lower due to the availability of alternate food sources.

3.2. An Assessment of Grazing Impact

Cover Crops

In order to develop a strategy to reduce wigeon impact on farm fields it is necessary to understand the magnitude of losses. Assessing grazing impact was done by measuring the difference in crop production over the winter between an area of the field utilized by grazing wigeon and a protected portion within the exclosures. This quantity is not just what was grazed, but will include the effects of grazing in combination with climate, soil conditions and crop vigor. Therefore the amount of biomass measured would be an over estimate of the grass actually removed by the wigeon.

The difference in the amount of biomass between grazed and ungrazed areas varied substantially. While several fields were grazed repeatedly, leaving bare fields in March, others were only used by wigeon in the fall and regrew, appearing ungrazed.

In the following tables, calculations from the biomass data collected (Appendix D) illustrate the variation. Table 1 lists a few fields which were heavily used by wigeon in both the fall and spring. The amount of biomass lost on field SR1 was 3/4 of a ton dry matter per acre as illustrated in Figure 9. Field SR1 was the site of U.B.C.'s cover crop variety trials (visited on Greenfields Field Day November 2, 1990).

FIELD	CROP	BIOMASS DIFFERENCE LBS/ACRE DRY WT.
HR1	WINTER WHEAT	1006
JZ3	WINTER WHEAT	784
MG3	FALL RYE	1493
SR1	WINTER WHEAT	1337

Table 1: Biomass difference on heavily impacted fields grazed in the fall and spring measured in March 1991.

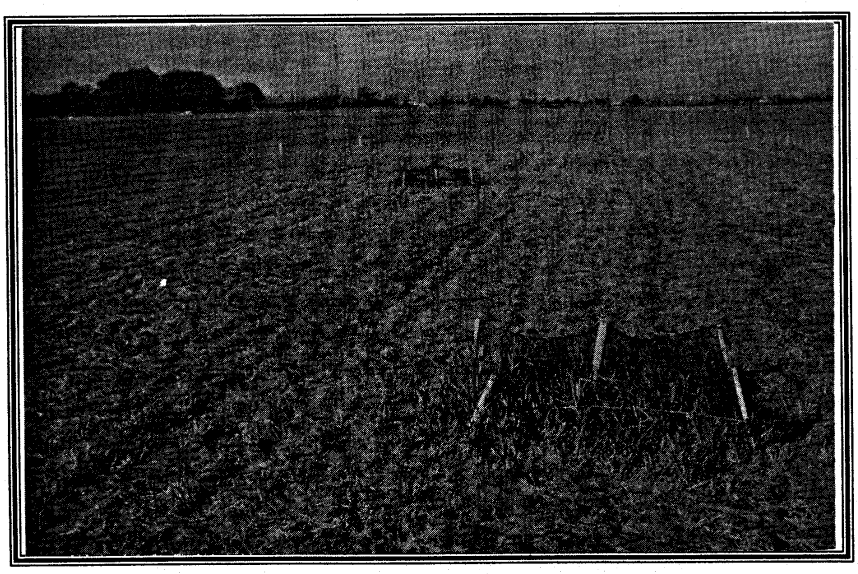

Figure 9: Picture of field SR1 taken in March 1991.

On fields heavily used only in the fall, the difference between an ungrazed exclosure and spring regrowth after fall grazing was also measured in March 1991. Again measurements of the difference in biomass range substantially, from one tenth to half a ton of dry matter per acre (Table 2).

FIELD	CROP	BIOMASS DIFFERENCE LBS/ACRE DRY WT.
AS4	FALL RYE	855
BL1	WINTER WHEAT	862
GE3	FALL RYE	453
HR4	WINTER WHEAT	627
KD2	WINTER WHEAT	560
LG2	FALL RYE	196
MG8	FALL RYE	1009
RH1	WINTER WHEAT	545
ROB1	WINTER WHEAT	274

Table 2: Biomass differences on fields grazed in the fall with spring regrowth measured in March 1991

There are several reasons why such variation in biomass occurs. The maturity of the crop at the time of grazing would be a significant factor for late planted crops. Newly sprouted plants do not have the root reserves to easily re-establish above ground growth, as do earlier plantings of cover crops.

The condition of the soil also appeared to have an influence on the impact of grazing. This can include both the soil structure and the amount of water present when the field was grazed. Evidence of this came from the preliminary clipping experiment, where half the exclosure was cut to simulate grazing without disturbance to the soil. The biomass produced on an undrained field in an area of regrowth and an ungrazed area, was compared to a similar field with subsurface drainage. Figure 10 illustrates the difference in biomass between clipped, regrown and ungrazed areas. Note that on the undrained field there was a greater impact on crop regrowth. The drained field showed greater biomass production, probably due to the better soil conditions.

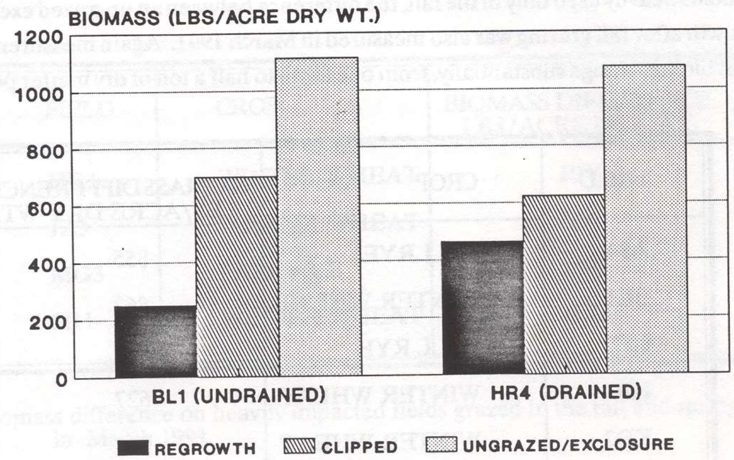

Figure 10: Ungrazed biomass, clipped biomass and amount of regrowth in an undrained and drained field.

A large number of studies have been undertaken in an attempt to assess the extent of waterfowl crop damage. Most of this research comes from Britain and the Netherlands, and pertains to geese. There are, however, some similarities with wigeon grazing.

Kear (1970) looked at the interaction of British agriculture and wild geese with particular reference to the problem of grazing damage to winter cereals. Through clipping experiments she concluded that grazing had little effect on crop yields. It was stated that possibly a very wet green cereal field could be damaged by large flocks of geese feeding for a long time, but that there was little evidence that this occurred, even with abnormal grazing densities.

Early crop depredation studies, such as Kear's, are no longer cited because they rarely combined adequate sample size and controls to determine both the statistical and biological significance of the effects of grazing on yield (Flegler et al. 1987). Except for Kahl & Samson (1984) few studies have documented the effect of grazing on the component parts of wheat yield. In their work they found that geese grazing in the fall, winter or spring had a marked effect on the height and relative density of winter wheat. Also there was evidence that trampling by geese may puddle and "cap" the soil surface, stunting growth and decreasing yield. It was concluded that variation in weather and soil type, particularly cold in winter, heavy fall or spring rains, and fine textured soil will influence the extent of damage.

Recent work indicates that goose grazing is associated with significant loss of yield, but there is great variability in the degree of loss suffered at a given level of grazing (Patterson 1991). The main problem encountered in most studies is great variability between samples, probably caused by variations in soil nutrients, soil moisture, weed density and other factors affecting growth and productivity.

Many have felt that there are some benefits to waterfowl grazing such as the addition of droppings. Jalil & Patterson (1989) found that goose droppings had no effect on total yield, since the amount of nutrients supplied was negligible when compared with fertilizer application.

Perennial Grasses

The difference in biomass on perennial grass fields was similar to the cover crop situation. Of the eight fields monitored, six were heavily impacted at least once during the winter.

Table 3 illustrates the difference in the amount of forage in grazed and ungrazed areas of three perennial grass fields. The volume of biomass (in tons per acre dry weight) may be difficult for non-farmers to envision, therefore calculations were converted to bales of hay, assuming a bale of hay to weigh 50 lbs and has a 25% moisture content. Grass at this stage of growth is not normally used for hay, so the conversion to bales is done for illustrative purposes only.

FIELD	BIOMASS DIFFERENCE LBS/ACRE DRY WT	BALES OF HAY PER ACRE
CD2	935	25
DS2	766	20
LG3	1042	28

Table 3: Biomass difference between ungrazed and grazed areas on perennial grass fields.

As with the cover crops, the difference in biomass averages a half a ton (1000 lbs or 454 kg) of dry weight per acre. However losses on perennial grass fields are more serious than cover crops because of the economic value of the forage crop.

Biomass removed by wigeon is at the expense of forage for livestock because producers need this feed in the spring, when overwinter reserves are low. Not only must farmers replace lost forage, but in some cases fields may need to be plowed and re-seeded. In those situations wigeon grazing may cost the farmer up to $365 per acre (DeBoer 1990).

On established fields the most significant damage reported in Europe refers to the structure of the grass sward or a delay in the first cut in the spring (Van Eeerden 1990). In the Netherlands research on improved grasslands (Lolium sp.) showed that wild geese grazing resulted in dry matter yield losses at first cut of 335-1100 kg/ha (298-980 lbs/acre). The losses varied depending on the grazing pressure, time of grazing and the productivity of the sward (Bruinderink 1989).

Patton & Frame (1981) also noted that while puddling by geese on grassland may not necessarily be severe overall, grassland heavily grazed in wet conditions could be damaged. Puddling can damage and destroy herbage growing points, leaves and roots. Sward production will be affected in the short-term because regrowth is reduced and in the long-term botanical deterioration can occur.

3.3 Limitations to Assessing Impact

This pilot study provides only rough estimates of the biomass removed by wigeon. The differences in biomass from grazed and ungrazed areas was measured, but it proved impossible to separate wigeon impacts from losses from winterkill, drowning and poor soil conditions. Also, the more time that passes between the moment of grazing and the time of harvest of a crop, the more difficult it is to estimate the effects of grazing alone (Van Eeerden 1990).

High variability within the fields, in both seeding density and amount grazed, also results in inaccurate estimates of biomass losses caused by grazing. This was particularly evident in the spring when individual fields contained areas that were fully, partly and ungrazed. To overcome such variability requires large sample sizes which is time-consuming, tedious and expensive (Patterson 1991).

Some important observations were made on the final visit to the fields in March. Through estimates of the percent of soil cover and ungrazed portions, a final condition rating was given to all the fields (Appendix E).

The final field condition rating compared to overall grazing (Figure 11) illustrates that grazing may not necessarily indicate a severe loss. Several fields which were only grazed in the fall, regrew in the spring, thus providing some benefit to the farmer, in spite of wigeon grazing. However, the cover crop, which protects the soil from winter rains was lost, so spring biomass should not be the sole criteron used to assess grazing.

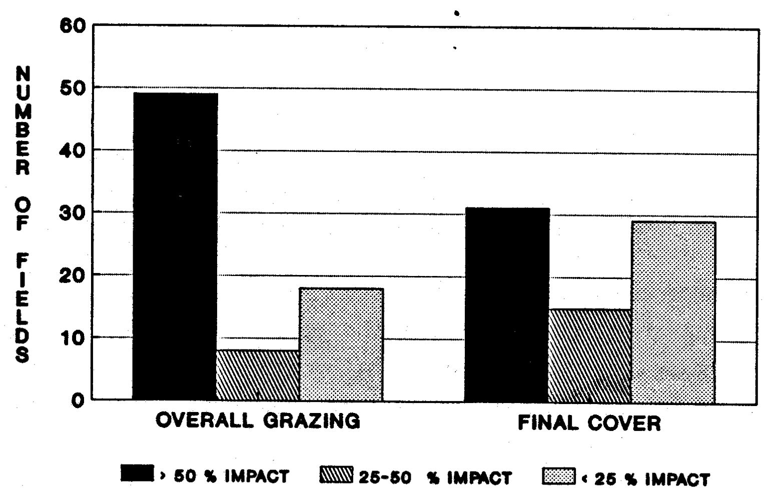

Figure 11: Comparison of overall grazing and final field conditions.

3.4 Chemical Composition of the Crops

The chemical composition of cover crops and grass fields was investigated in an attempt to determine the role forage quality played in relation to wigeon use of farmers fields. Owen (1973) suggested that food selection by wigeon can be partly explained by differences in the chemical composition of the forage, particularly newly seeded crops which are most digestible during their first flush of growth and tend to have higher protein levels.

In the early stage of plant growth, the soluble cell contents may account for at least two-thirds of forage dry matter, with protein being a major contributor (Figure 12). With advancing maturity, the concentration of cell wall constituents in grass increases, with lignin in particular. The increased spatial distribution of the cell wall has the most significant negative effect on the rate and extent of digestion of the forage.

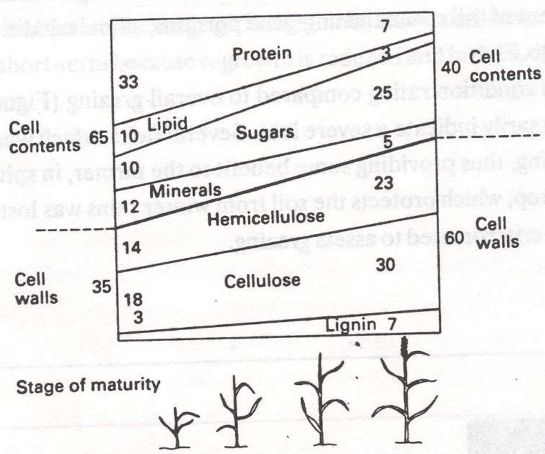

Figure 12: Schematic representation of the changes in the chemical composition of grasses which accompany advancing maturity (Holmes 1989).

Fibre is an important indicator of quality because plant structure can affect digestibility. This is likely to be important to grazing waterfowl who apparently rely more on mechanical than chemical methods of breaking up ingested materials (Owen 1973). With fiber content increasing as the plant matures, a point will be reached where the animal is not able to process enough material to meet it's nutritional requirements.

Biomass samples collected in this study were analyzed for ADF (acid detergent fiber), NDF (neutral detergent fiber), and protein (Appendix G). The changes in chemical composition of winter wheat overwinter are presented in Figure 13. Fibre content remained stable until late winter when it peaked. The drop which occurred in March was most likely related to the resurgence of new growth. Protein levels continually decreased, even with the presence of new growth.

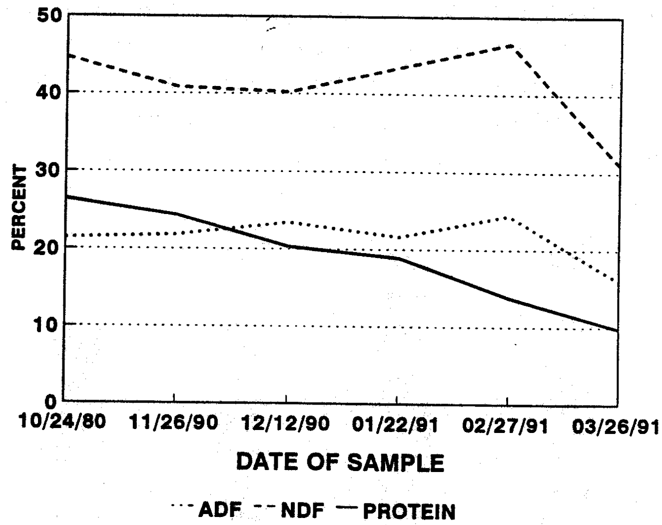

Figure 13: Overwinter chemical composition of winter wheat field RH1.

Differences in digestibility between forages cut on the same date are mainly attributed to different stages of physiological maturity. However, two winter wheat crops with nearly identical chemical composition (Figure 14) often experienced different grazing intensities. Field DS3 was heavily grazed by the wigeon while DS1 was only partly utilized. The only apparent difference was in height, field DS1 was an average of 4 cm taller. The preference for the shorter grass could have occurred because wigeon have short legs and may have difficulty moving through tall grass. Also they like to feed in open situations with a clear view on all sides (Owen 1973).

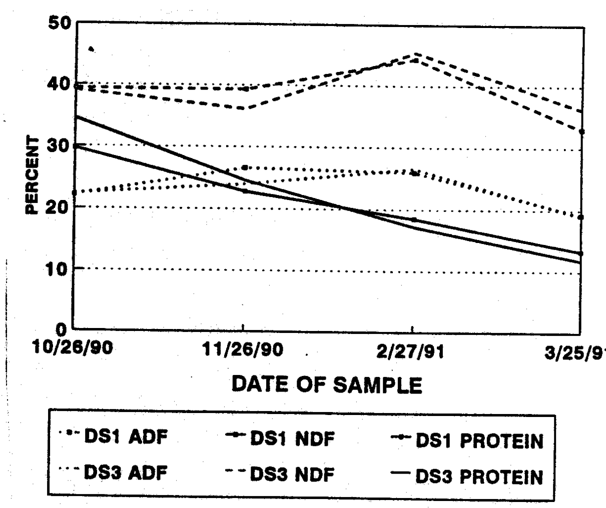

Figure 14: Chemical composition of fields DS3 & DS1. Differences were not significant.

Summaries of the chemical composition of each crop type for samples taken in the fall (October & November), winter (December & January) and spring (February & March) were calculated. The average values, range, and standard error for winter wheat, fall rye, spring wheat and perennial grass fields is listed in Appendix H.

Unlike cover crops, whose protein levels dropped almost a third between fall and spring, protein levels for perennial grasses were similar (Figure 15). The higher levels of protein in perennial grass fields may be responsible for the increased usage by wigeon in the spring.

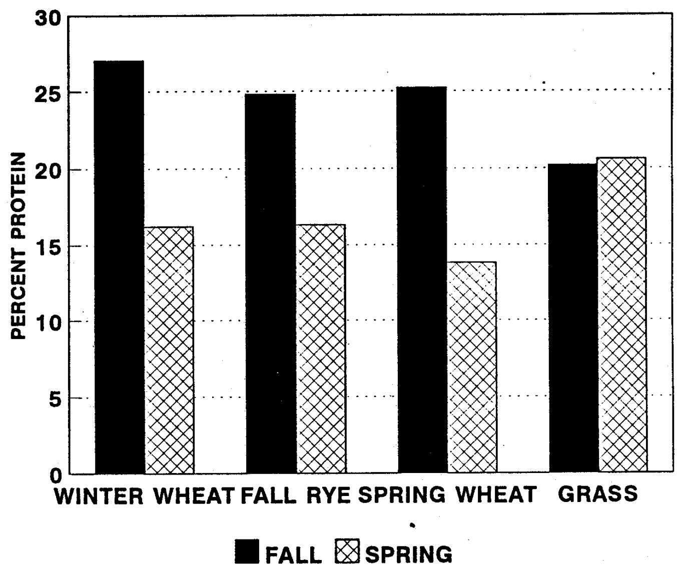

Figure 15: Average fall & spring protein levels for all cover crops and perennial grass fields.

Nitrogen is one of the main building blocks for protein and plant growth. It is also often a deficient soil nutrient. Plants absorb most of their nitrogen in the nitrate (NO3-) or ammonium (NH4+) forms. Nitrate tends to be the dominant source because it occurs in higher concentrations and moves through the soil by mass flow and diffusion and the uptake is favoured by low pH conditions. Ammonium however, is preferred because less energy is needed to convert it to protein, and it is less subject to losses from soil by leaching and denitrification (Tisdale et al. 1985).

By spring the amount of available nitrogen in the soil diminishes because soluble nitrates are leached out with the heavy winter rains. Therefore little nitrogen is available for cover crop regrowth in the spring. Little nitrogen can be generated through the nitrification process until the soil microbial activity picks up with warmer weather.

One of the benefits of cover crops is that they take up nitrogen in the fall. Cover crops use nitrates which otherwise would be leached away. The level of nitrogen uptake is dependent on nitrogen availability and on biomass produced. In this study up to 77 lbs of nitrogen per acre were taken up by the cover crops (Appendix I).

Perennial grass fields may have higher levels of protein in the spring due to nitrogen availability in their soils. Forage fields may obtain a greater portion of their nitrogen from the ammonification process if fields have larger reserves of organically bound nitrogen. Perennial grass fields contribute more to organic matter in the soil through their extensive root systems in comparison to annual crops which are regularly plowed. The addition of livestock manures also greatly contributes to soil organic matter.

3.5 Factors Affecting Field Use by Wigeon

Statistical analysis was undertaken in an attempt to identify and quantify field characteristics which may be related to wigeon use. Correlations are a frequently used method of analysis which help identify significant relationships between two variables. Table 4 lists variables which were tested using Pearson Correlation (n=54). The resulting r value indicates the strength of the relationships. Negative values mean that as one variable increases, the other decreases. All significant correlations (greater than .263, Zar 1984), are marked with a "*". Squaring the r value indicates the amount of variation explained by each of the factors. For example, in biomass quantity vs. November grazing, approximately 17% of the variation in the level of November grazing is explained by the quantity of biomass.

	November grazing	December grazing	Biomass quantity	Height	ADF (fiber)	NDF (fiber)	Protein	Maximum wate	Plant
November grazing	1.00								
December grazing	.143	1.00							
Biomass quantity	*.414	-.115	1.00						
Height	.248	-.099	*.749	1.00					
ADF (fiber)	-.036	.104	-.007	.049	1.00				
NDF (fiber)	.070	.004	-.161	-.089	*.404	1.00			
Protein	.071	-.085	-.066	-.038	*-562	-.037	1.00		
Maximum water	*.494	.252	*.294	.133	-.078	-.109	-.086	1.00	
Plant date	-.029	.221	*-.511	*-.593	.245	.109	-.194	.046	1.0

Table 4: Pearsons Correlation Matrix.

From this analysis we can see that chemical composition did not appear to be a major factor related to grazing pressure. The reason may be related to the biological needs of wigeon. Wigeon face three major problems in meeting their energetic requirements in winter. First, they feed solely on vegetation which is low in energy due to its high water content and high fibre content. Second, the wigeon lack the gut adaption necessary for microbial breakdown of cellulose, therefore only digest a relatively small fraction of their food intake. Mayhew (1988) found that the average digestive efficiency for wigeon was 28.8% indicating that a wigeon needs to ingest 91.6 grams of dry weight of grass each day. Finally, the wigeon's small body size means that its metabolic requirements are high relative to its food intake (Mayhew 1991). Briefy, metabolic rate increases to the 0.75 exponent of body mass, while gut size increases linearly with body mass. Thus larger herbivores generally will be in a more favourable energetic state compared to small species since more food can be gathered, transported and processed relative to energy requirements (Robbins 1983).

The results of these constraints is that wigeon appear to be hard pressed to meet their food requirements in winter and consequently are forced to employ feeding strategies which maximise their food intake. Probably the most important of these strategies is to spend a large part of the time feeding. Results from several studies show that wigeon spend an average of 13-15 hours out of 24 actively grazing (Mayhew 1991). Therefore quality of forage may be only one criteria explaining wigeon's preference for certain fields. The quantity of feed required may be important to consider.

Using Mayhews data, which is based on the digestive efficiency of perennial forages (Agrostis, Lolium, Poa, Ranunculus and Trifolium), Table 5 illustrates the acrege needed for different levels of wigeon use ("wigeon days" = population multiplied by number of days). This calculation assumes that each acre supplies 500 lbs (227 kg) of dry weight grass overwinter. It is important to note that this estimate does not account for food from other sources such as eelgrass from Boundary Bay.

WIGEON DAYS	1,000,000	3,000,000	5,000,000	10,000,000
ACREAGE NEEDED	404	1,212	2,020	4,040

Table 5: Estimated number of acres of forage needed for differing number of wigeon days, assuming food requirements of 91.6 grams grass (dry weight) per wigeon per day.

Baldwin & Lovvorn (1991) concluded that 57.4% of the food requirements for American wigeon is obtained from uplands, while the remaining 42.6% comes from tidal flats. Further estimates indicate 3,252,653 wigeon-use days for Boundary Bay. Using these figures, food requirements for approximately 4,400,000 wigeon days would be needed from the uplands, which includes farmland, wildlife sanctuaries and undeveloped areas.

If all the Greenfields listed as heavily used (greater than 50% grazed - see Appendix C) were completely grazed (most were at least 90%), then approximately 1000 acres were utilized by the wigeon in the fall and an additional 450 acres in the spring. Since the amount of grass removed from these fields varied substantially, estimating how much forage farmers' fields supplied is difficult. In any case these calculations illustrate that large acreages of farmland are needed to support overwintering wigeon populations.

Another factor known to affect the impact of grazing is climate (Temple 1979). During this study Delta had extreme temperatures and high precipitation. Local farmers mentioned that wigeon grazing occurred much earlier than in previous years possibly due to the extensive field flooding in November. Freezing temperatures and snow cover in mid-December to early January may also have forced wigeon to graze fields of lower preference because they were the only available food source. The mild temperatures in February brought on a resurgence of growth from crops grazed in the fall. Climate can neither be manipulated or predicted, yet it remains an important factor in predicting the level of use of farmland by wigeon.

3.6 The Role of Surface Water

Another factor believed to be important in determining wigeon use of fields is surface water. In the Fraser River delta, water accumulation on the soil surface is a common occurance due to heavy winter precipitation, high water tables and the limited capacity of drainage systems.

Controlling the water level through improvements such as ditching and subsurface drains is carried out by farmers to improve the productivity of the land. Not only are drained fields less susceptible to soil degradation (compaction, erosion) but they also maintain beneficial aerobic soil biota, reduce overwinter drowning of crops and allow earlier planting and later harvesting.

It was difficult to quantify water present on each field. The amount observed at each visit varied, depending on time since the last rainfall. Therefore a rating was given which represented the maximum water seen on each field at sometime throughout the winter (Appendix J).

The limitation of this method is that the estimation includes both pre and post wigeon use. Estimations of surface water may increase after grazing due to puddling effects. Figure 16 shows the number of fields and the range in amount of water coverage. Almost half of the fields (35) had 5-25% of the field covered in water at one time during the winter.

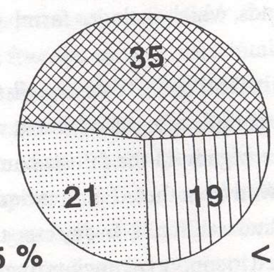

Figure 16: Maximum percent of water observed on 75 fields in Delta.

In Table 4, maximum water was signifcantly correlated with November grazing, explaining about 25% of the variation in the grazing level. Further analysis using multiple regressions identifies factors which are related to a dependent variable (ie. November/December grazing). Results showed that maximum water predicts 24.4% of the variation in grazing in November, and in combination with biomass, a total of 32.3 %. The "P" value shows the probability of this relationship occurring, where only values less than .05 are significant. (Table 6, indicated by a *). Water is close to significance in December, however the low r^2 values suggest that other factors may be increasingly important as the winter progresses.

DEPENDENT VARIABLE	INDEPENDENT VARIABLE	r^2	P
November Grazing	Water	.244 *	.001
	Biomass	.323 *	.018
December Grazing	Water	.064	.073
	Plantdate	.107	.120

Table 6: Regression analysis of grazing and maximum water coverage, biomass and planting dates.

Owen and Thomas (1979) stated that before refuges were created, fluctuations in European wigeon numbers were tied closely to levels of flooding; the creation of permanent water bodies increased dabbler usage and reduced fluctuations in numbers. Hirst and Easthope (1981) investigated the use of agricultural land by waterfowl in response to proposals to improve land drainage and flood protection in the Fraser Delta. Through waterfowl censuses conducted during the day from October-December 1976, they concluded that surface water influenced waterfowl occurrence in the lands more than any other factor. Eamer (1985) also asserted that the number of ducks inland is strongly tied to the area of flooding on the fields and to some degree affects seasonal duck numbers at individual coastal sites.

Why surface water is important is not clear. One researcher suggests water is needed for drinking and preening during the day. Rijnsdorp (1986) speculates that regular drinking bouts are needed to compensate for high water loss through regular defecation (wigeon produce about 20 droppings per hour while feeding). But this does not explain why his research also found that although there was a preference for wet pastures in autumn, this changed in early spring when dry pastures were more desirable.

According to the initial studies (Mayhew & Houston 1987) European wigeon feed close to water primarily as an anti-predator behaviour rather than a requirement for drinking and bathing. During his three year study at Caerlaverock, Scotland, anecdotal evidence showed that ducks would walk, run or fly back to water if any danger or disturbance was present, and they would stay on water till the danger had passed.

There is other evidence that indicates wigeon populations may be less dependent on the water regime. For example, at Englands' Ouse Washes reserve, research in 1972-73 showed there was very little flooding, but duck numbers remained high. In 1975-76 no flooding whatsoever occurred and still usage was high compared to 1968-69. It was concluded that the creation of this reserve in the early 70's reduced the need for water for safe roosting (Owen & Thomas 1979).

How much water wigeon need for foraging will have significant repercussions on land management. In terms of farm production in Delta, controlling the water level on fields is the single most important land improvement which can sustain soil productivity. Surface water flooding has several negative impacts on farmland such as increased compaction and ponding, ploughlayer cloddinesss, and less opportunity days to farm (DeVries 1983). Water does play a role in determining which fields are utilized by wigeon, but the reasons and necessity of surface water on fields should be more closely evaluated because the cost of surface water may be at the expense of farm viability.

4. Conclusion

The Greenfields Project set out to gather more information on wigeon use of farmer's overwintering cover crops and grass fields through an intensive monitoring program. Documenting the time and location of fields which were utilized by the wigeon gave an overall view of the situation.. This information will become increasingly important as additional years of observations are added. For now results indicate that wigeon extensively use farmland in Delta and this is likely to continue due to the traditional habits of wintering waterfowl.

The assessment of grazing impact found that:

1) Farmer's fields from Westham Island to South Surrey were utilized by the wigeon. Only one field north of Highway 99 was heavily impacted.

2) Seventy five percent of the 75 fields monitored were more than 50% grazed from November to March. Thirty percent of these fields were heavily grazed in both the fall and spring.

3) The intensity of use varied substantially. The difference in biomass between grazed and ungrazed areas ranged from 200-1500 lbs forage dry weight per acre (240-1800 kg forage dry weight per hectare).

4) Crop damage is variable and dependent on many factors. Accurate assessments of damage are difficult and can only be documented through intensive trials, using detailed monitoring and large plots.

Factors related to grazing pressure are difficult to isolate:

1) Chemical composition *overall* did not determine wigeon use of a particular field even though there appeared to be a preference for late planted, newly sprouted crops.

2) Other studies suggest that large quantities of forage may be needed in order for current wigeon populations to meet their energetic requirements. Consequently wigeon are forced to employ feeding strategies to maximise their food intake.

3) Maximum surface water observed could explain only a quarter of the grazing which occurred in November. Clearly other factors are playing a major role in determining field use.

4) Disturbance, field characteristics and location need to be investigated further to identify how these factor influence wigeon behaviour.

Other Observations:

1) More data is needed to determine whether planting large acreages of cover crops will disperse wigeon impact. However, the behaviour of wigeon, particularly their gregarious nature, may make it difficult to reduce intensive use of a particular field.

2) Future objectives should focus on finding the most appropiate strategy to alleviate losses to farmers rather than damage assessment.

5. Future Strategy

This pilot study was able to provide some insight into wigeon behaviour and possible ways to reduce grazing impact. However more research needs to be done before decisive action to alleviate crop damage is taken.

In the next two years the Greenfields Project will continue to monitor the extent of wigeon grazing on farmers' fields. More information will be collected on fields to further elaborate on the relationship between wigeon impact and soil productivity. Methods of scaring wigeon which are cost effective and practical will be investigated on perennial grass fields.

How to resolve the crop damage conflict is difficult. Perhaps it would be best to recognize that any grazing, other than at a low level, is associated with losses, but that the extent of losses are variable and not predictable (Patterson 1991). Solutions should be directed towards what the farmers find acceptable, because grazing can be tolerated if the impact is reduced or compensated.

Communication and education will remain a priority with the project. Results of continued work will be presented in the Greenfields Newsletter which provides information on agriculture and wildlife in the Fraser River delta, and is published every two months. A better understanding of wildlife/farming interactions is a good start to resolving the waterfowl grazing issue.

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7. Glossary of Terms

Acre - A measurement of land equal to 43,560 square feet or .404 hectare.

Ammonification - The biochemical process whereby ammonia nitrogen $NH4+$ is released from nitrogen-containing organic compounds.

Agronomy - The branch of agriculture that deals with the theory and practice of field crop production and the scientific management of soil.

Available nutrient - The portion of any element or compound in the soil that can be readily absorbed and assimilated by growing plants.

Biomass - Total mass of living matter in a particular area, plant material used as a source of energy.

Clod - A compact, coherent mass of soil produced by digging or plowing. Clods usually slake easily with repeated wetting or drying.

Cover crop - A grass or broad leaf crop that covers or protect the soil from the erosive forces of wind or rain.

Cultivation - Tillage to prepare land for seeding or transplanting, and later to control weeds and loosen the soil.

Dabbling duck - A duck which feeds by dabbling or tipping rather than submerging.

Delta - A fan-shaped area at the mouth of a river formed by deposition of successive layers of sediments brought down from the land and spread out on the bottom of a basin.

Depredation - A plundering or despoiling.

Drake - A male duck.

Exclosure - An object which prevents use.

Flooding - Where the water table has risen above the soil surface because of inadequate drainage or ditch water elevation control.

Forage - Food suitable for horses, cattle or other domestic animals; fodder.

Green manure - A crop turned into the soil, whether originally intended or not, irrespective of its state of maturity, for the purpose of effecting some agronomic improvement.

Habitat - The natural environment of an organism.

In vitro digestible dry matter - Values relative to forage digested by ruminant animals which includes endogenous excretions from bacterial residues.

In vivo digestible dry matter - A chemical analysis of forage that does not include the bacterial component.

Lure crop - A field set aside to specifically provide a feeding area for ducks.

Mulch - Any material such as straw, sawdust, leaves, plastic film, or loose soil that is spread on the surface of the soil to protect the soil and the plant roots from the effects of raindrops, soil crusting, freezing and evaporation.

Nitrification - The biochemical oxidation of ammonium to nitrate (NO3).

Nightflight - A flight of ducks from the tidal marshes to inland fields typically in the twlight evening.

Palatibility - Plant characteristics determining relative animal preference.

Plow pan - A compacted subsurface layer in the soil.

Plumage - A birds entire covering of feathers.

Ponding - Free water is present on the soil surface, with the water table located below the soil surface, and with unsaturated soil present between the surface and the watertable.

Puddling - Change in orientation of disc-shaped clay particles from random in undisturbed soil to parallel in puddled soil.

Refuge - Shelter or protection from danger.

Roost - A temorary resting place.

Ruminants - A suborder of even toed, cud-chewing ungulates, as the antelope, bison, cow, deer, goat and sheep, having a stomach with four complete cavities; the rumen, reticulum, omasum, and abomasum.

Saline soil - A nonalkali soil that contains enough soluble salts to interfere with the growth of most crop plants.

Sanctuary - A place of refuge or protection.

Sheetwater - A thin or broad area of water on the soil surface.

Soil conservation - A combination of all methods of management and land use that safeguard the soil against depletion or deterioration by natural or man-induced factors.

Soil degradation - The changing of a soil to a lower quality; often a more highly leached and weathered state.

Soil improvement - The processes for, or the results of, making the soil more productive for growing plants, by drainage, irrigation, addition of fertilizers and soil amendations.

Soil organic matter - The fraction of the soil which includes plant and animal residues at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil populations.

Soil productivity - The capacity of a soil to produce a specified plant or sequence of plants under a specified system of management.

Surface crust - A compacted layer of parallel oriented soil particles at the soil surface.

Surface sealing - The orientation and packing of dispersed soil particles in the immediate surface layer of the soil to render the surface fairly impermeable to water.

Sward - Land thickly covered in grass or turf.

Tiller -A shoot from the base of the stem; sucker.

Tilth - The physical condition of soil as related to its ease of tillage, fitness as a seedbed, and impedance to seedling emergence and root penetration.

Ton - Short ton commonly used in the U.S.A and Canada equal to 2000 lbs.

Winterkill - Death of plants due to exposure to extreme cold or desication.

Appendices

A. CLIMATE DATA

MAXIMUM TEMPERATURE (°CELSIUS)

	YEAR	SEPT	OCT	NOV	DEC	JAN	FEB	MARCH	APRIL
	1987-88	19.9	16.3	10.5	5.6	5.6	8.2	10.3	13.1
	1988-89	18.7	13.7	9.3	7.2	5.9	5.3	8.9	15.2
	1989-90	20.5	13.6	8.8	7.0	6.0	5.9	11.0	13.7
	AVERAGE (1987-89)	19.7	14.5	9.5	6.6	5.8	6.5	10.1	14.0
***	30 YEAR AVERAGE	19.0	14.0	9.0	6.0	5.0	8.0	10.0	13.0
	1990-91	22.2	12.7	8.7	3.6	4.3	11.0	9.7	13.4

MINIMUM TEMPERATURE (°CELSIUS)

	YEAR	SEPT	OCT	NOV	DEC	JAN	FEB	MARCH	APRIL
	1987-88	8.3	3.6	4.9	0.1	-0.7	1.3	2.8	5.5
	1988-89	7.9	7.1	4.3	1.7	0.5	-3.3	2.4	5.0
	1989-90	7.0	5.9	3.6	2.0	1.0	-1.3	2.8	5.8
	AVERAGE (1987-89)	7.7	5.5	4.3	1.3	0.3	-1.1	2.7	5.4
***	30 YEAR AVERAGE	9.0	6.0	3.0	1.0	-1.0	1.0	2.0	4.0
	1990-91	11.7	6.6	3.2	-1.8	-1.1	4.2	2.1	4.9

PRECIPATION (mm)

	YEAR	SEPT	OCT	NOV	DEC	JAN	FEB	MARCH	APRIL
	1987-88	10.8	17.5	109.5	136.3	67.8	52.9	96.4	83.2
	1988-89	71.6	101.4	189.6	157.1	151.1	57.8	104.4	32.8
	1989-90	10.6	66.5	187.2	110.0	162.7	111.3	70.8	86.0
***	30 YEAR AVERAGE	52.0	93.0	127.0	138.0	118.0	92.0	69.0	47.0
	1990-91	36.4	105.2	215.3	153.3	137.2	97.0	74.4	62.0

DATA SUPPLIED BY:

BOUNDARY BAY CLIMATE STATION
SOILS & ENGINEERING BRANCH
MINISTRY OF AGRICULTURE, FISHERIES & FOOD

*** LADNER/SOUTH DELTA STATION
ENVIRONMENT CANADA

B. FIELD CHARACTERISTICS

FIELD	ACREAGE	PLANTDATE MM/DD/YR	SEEDRATE LBS/ACRE	PLANTING METHOD**	LAST CROP
WINTER WHEAT					
AS1	11	09/08/90	150	BR&DI	BEANS
AS2	37	09/25/90	90	BR&DI	POTATOES
BL1	40	09/25/90	120	DR&HA	PEAS
CD1	20	10/14/90	125	DRILL	CORN
CD4	5	10/14/90	30	DRILL	CORN
DG1	25	10/01/90	100		
DK1	8	09/10/90	100	DRILL	PEAS
DK2	25	09/10/90	100	DRILL	PEAS
DM1	15	09/18/90	120	DRILL	
DS1	20	09/01/90	100	BR&CU	BEANS
DS3	25	09/01/90	100	BR&CU	PEAS
GE1	8	09/05/90	100	DR&HA	POTATOES
GE2	8	09/08/90	100	DR&HA	PEAS
HM1	20	10/15/90	100	DR&DI	PEAS
HR1	12	09/12/90	150	DRILL	
HR4	15	09/07/90	100	DRILL	
JH1	5	10/06/90	150	BR&HA	CORN
JH2	7	10/06/90	150	BR&HA	CORN
JM1	20	09/03/90	100	DRILL	BEANS
JZ3	20	09/30/90	100	BR&DI	CORN
KD1	19	10/12/90	100	DRILL	PEAS
KD2	18	10/14/90	100	DRILL	PEAS
KD3	25	09/20/90	100	DRILL	PEAS
RB1	30	09/10/90	100	DRILL	BEANS
RH1	34	09/14/90	100	BR&DI	PEAS
RH2	36	09/14/90	100	BR&DI	BEANS
RH3	6	09/14/90	100	BR&DI	PEAS
RH4	10	09/14/90	100	BR&DI	PEAS
RH5	75	09/15/90	100	BR&DI	BEANS
RN1	8	10/11/90	180	DRILL	CORN
RN2	8	10/11/90	180	DRILL	CORN
ROB2	15	09/05/90	100	BR&DI	CORN
ROB3	15	09/05/90	100	BR&DI	CORN
ROB4	15	09/05/90	150	BR&DI	CORN
ROB5	15	08/15/90	100	BR&DI	
SC1	40	09/21/90	120	DRILL	CORN
SC2	40	09/21/90	120	DRILL	BEANS
SC3	40	09/08/90	120	DRILL	PEAS
SR1	25	09/03/90	100	BR&DI	POTATOES
TE1	10	09/28/90	120	DRILL	CORN
WN1	22	09/10/90	100	BR&DI	BEANS

**PLANTING METHOD
BROAD= Broadcast
BR&HA= Broadcast & Harrowed
BR&DI= Broadcast & Disked
DRILL= Seed Drill
DR&HA= Drilled & Harrowed
BR&CU= Broadcast & Culti-packed

FIELD		ACREAGE	PLANTDATE MM/DD/YR	SEEDRATE LBS/ACRE	PLANTING METHOD	LAST CROP
SPRING WHEAT						
BL2		20	09/25/90	120	DR&HA	PEAS
BL3		30	09/25/90	120	DR&HA	PEAS
DT1		24	10/11/90	130	DRILL	CORN
HR2		15	09/08/90	100	DRILL	
HR3		15	09/08/90	100	DRILL	
JZ2		25	09/27/90	100	BR&DI	CORN
BM1		3	09/29/90	160	BR&DI	OATS
FALL RYE						
AS3		11	09/01/90	100	DRILL	POTATOES
AS4		40	08/31/90	80	DRILL	
GE3		15	09/23/90	100	DRILL	CORN
JZ4		10	08/31/90	80	BR&DI	CORN
LG1		20	09/25/90	100	BR&DI	
LG2		20	09/15/90	100	BR&DI	
MG1		40	09/13/90	120	BR&DI	CORN
MG2		25	10/18/90	120	BROAD	POTATOES
MG3		12	08/30/90	120	DRILL	POTATOES
MG4		33	09/21/90	120	BR&DI	POTATOES
MG6		20	09/27/90	120	BR&DI	POTATOES
MG7		20	10/13/90	120	BR&DI	POTATOES
MG8		20	10/13/90	120	BR&DI	POTATOES
MG9		40	10/13/90	120	BR&DI	POTATOES
ROB1		20	09/25/90	100	BR&DI	BEANS
OTHERS						
JB1	MIX	15	10/05/90	100	BR&DI	PEAS
JB2	MIX	15	10/05/90	100	BR&DI	POTATOES
DS4	BARLEY	30	09/01/90	100	BR&CU	PEAS
DM2	CLOVER	25	06/18/90	30	BROAD	PEAS
PERENNIAL GRASS FIELDS						
CD2		21		30	DRILL	GRASS
CD3		25		30	DRILL	GRASS
CD5		25		30	DRILL	GRASS
CD6		16		30	DRILL	CORN
DS2		15		30	BR&CU	GRASS
JZ1		20		30	BR&DI	GRASS
LG3		30		30	BR&DI	
TE2		18		30	DRILL	POTATOES

C. GRAZING RATES

MONTHLY RATES (NOV90 - MARCH91)
1= > 50% GRAZED
2= 25-50% GRAZED
3= < 25% GRAZED
4= NOT GRAZED

OVERALL GRAZING RATES
1= HEAVY USE (> 50 % GRAZED IN EITHER FALL OR SPRING)
2= MODERATE USE (< 50% GRAZED THROUGHOUT WINTER)
3= LITTLE/NO USE (< 25% GRAZED THROUGHOUT THE WINTER)

FIELD	NOV90	DEC90	JAN91	FEB91	MAR91	OVERALL GRAZING
AS1	3	1	3	2	3	1
AS2	1	3	4	4	4	1
AS3	4	3	2	2	4	2
AS4	3	1	1	2	1	1
BL1	3	1	3	4	4	1
BL2	4	3	1	4	4	1
BL3	4	3	1	4	4	1
BM1	4	4	4	4	4	3
CD1	3	1	4	1	1	1
CD2	1	3	4	1	1	1
CD3	3	1	3	2	2	1
CD4	4	4	4	3	4	3
CD5	4	3	4	3	3	3
CD6	1	3	4	1	1	1
DG1	3	1	4	1	4	1
DK1	1	3	4	1	3	1
DK2	1	3	4	1	3	1
DM1	4	3	2	4	4	2
DM2	1	1	3	1	1	1
DS1	3	3	1	3	3	1
DS2	1	3	3	1	1	1
DS3	1	1	2	1	2	1
DS4	4	4	4	4	4	3
DT1	3	2	4	3	3	2
GE1	4	2	2	3	3	2
GE2	4	2	2	4	4	2
GE3	4	1	3	2	2	1
HM1	4	4	4	3	3	3
HR1	1	1	4	1	1	1
HR2	4	3	4	4	3	3
HR3	4	3	4	4	3	3
HR4	1	3	4	2	1	1
JB1	1	4	4	4	4	1
JB2	2	1	4	4	4	1
JH1	4	4	4	3	4	3
JH2	4	4	4	3	4	3
JM1	4	4	4	3	3	3
JZ1	4	3	3	2	2	2

FIELD	NOV90	DEC90	JAN91	FEB91	MAR91	OVERALL GRAZING
JZ2	3	1	4	4	3	1
JZ3	1	3	4	2	2	1
JZ4	3	1	3	3	2	1
KD1	3	1	3	3	4	1
KD2	2	1	3	2	2	1
KD3	3	2	1	3	3	1
LG1	3	1	4	2	4	1
LG2	3	1	4	1	3	1
LG3	3	1	3	1	2	1
MG1	1	3	3	2	4	1
MG2	1	3	4	4	4	1
MG3	3	1	3	1	3	1
MG4	1	3	4	4	4	1
MG6	1	3	4	4	4	1
MG7	1	4	4	4	4	1
MG8	3	1	3	2	3	1
MG9	1	3	4	4	4	1
RB1	3	3	2	3	4	2
RH1	1	1	4	3	2	1
RH2	1	3	4	3	3	1
RH3	1	3	4	3	3	1
RH4	1	3	4	3	1	1
RH5	4	2	1	2	1	1
RN1	4	4	4	4	4	3
RN2	4	4	3	4	4	3
ROB1	3	1	4	3	3	1
ROB2	3	1	4	3	1	1
ROB3	3	1	4	3	1	1
ROB4	3	2	4	3	1	1
ROB5	3	2	4	3	2	2
SC1	4	4	4	4	4	3
SC2	4	4	4	3	4	3
SC3	4	4	4	4	4	3
SR1	3	1	2	1	2	1
TE1	4	4	3	3	3	3
TE2	4	4	3	4	4	3
WN1	4	4	4	4	4	3

TOTALS

RATE	NOV90	DEC90	JAN91	FEB91	MAR91	RATE	OVERALL GRAZING
1	22	26	6	14	13	1	49
2	2	7	7	13	11	2	8
3	24	25	17	24	20	3	18
4	27	17	45	24	31		

D. BIOMASS DATA

CROPS
- W= WINTER WHEAT
- R= FALL RYE
- SW= SPRING WHEAT
- P= PERENNIAL GRASS
- O= OTHERS (MIXED, BARLEY, CLOVER)

FIELD NAMES DERIVED FROM FARMERS INITIALS

CUT
- A= FIRST CUT
- B= SECOND CUT
- C= THIRD CUT
- D= FORTH CUT
- E= FIFTH CUT

- X= SAMPLE TAKEN FROM EXCLOSURE
- R= SAMPLE FFROM REGROWTH IN FIELD
- U= SAMPLES TAKEN FROM AN UNGRAZED AREA
- NA= NOT AVAILABLE

STATISTICAL MEASUREMENTS
- MEAN= GRAMS DRY WEIGHT PER QUARTER METER SQUARE
- SE= STANDARD ERROR
- STD= STANDARD DEVIATION
- VAR= VARIANCE

AH= AVERAGE HEIGHT
THREE MEASUREMENTS OF GRASS HEIGHT TAKEN AT TIME OF CUT

* * * * * *

CROP	FIELD	CUT	CUTDATE	# OF SAMPLES	MEAN	SE	STD	VAR	AH
W	AS1	A	10/24/90	5	5.3	0.4	1.0	0.9	17
W	AS1	B	01/14/91	5	34.6	2.9	6.4	40.6	18
W	AS1	C	02/20/91	5	31.0	1.8	4.1	16.7	21
W	AS1	DU	03/26/91	5	38.3	3.7	8.3	69.3	23
W	AS2	A	10/24/90	5	4.4	0.3	0.7	0.4	16
W	AS2	B	02/20/91	5	29.6	3.7	8.3	69.5	14
W	AS2	CU	03/19/91	5	44.7	2.5	5.6	31.7	25
R	AS3	A	10/24/90	5	22.2	3.9	8.7	75.7	36
R	AS3	B	01/14/91	5	30.1	4.0	8.9	78.3	27
R	AS3	C	02/20/91	5	46.7	3.3	7.3	53.7	27
R	AS3	DU	03/26/91	5	58.2	7.7	17.3	297.6	28
R	AS4	A	12/05/90	5	41.6	4.0	9.0	80.7	42
R	AS4	B	03/04/91	5	NA	NA	NA	NA	17
R	AS4	CR	03/25/91	5	7.4	1.5	3.5	12.0	12
R	AS4	CX	03/25/91	5	31.4	4.0	8.9	78.3	30
W	BL1	A	10/29/90	5	3.0	0.4	0.9	0.9	11
W	BL1	B	02/25/91	5	8.6	0.5	1.1	1.1	12
W	BL1	CC	03/27/91	4	19.6	2.5	5.1	25.8	17
W	BL1	CR	03/27/91	5	7.0	0.7	1.6	2.7	12
W	BL1	CX	03/27/91	4	31.2	1.7	3.4	11.7	24
SW	BL2	A	10/29/90	5	25.4	0.5	1.1	1.2	15

CROP	FIELD	CUT	CUTDATE	# OF SAMPLES	MEAN	SE	STD	VAR	AH
SW	BL2	B	02/25/91	5	6.8	0.7	1.6	2.4	18
SW	BL2	CX	03/27/91	5	14.7	1.0	2.3	11.7	24
SW	BL3	A	10/29/90	5	25.5	0.3	0.6	0.4	17
SW	BL3	B	02/25/91	5	6.8	1.1	2.6	6.5	17
SW	BL3	CX	03/27/91	5	10.9	1.0	2.2	4.8	21
O	BM1	A	01/16/91	5	24.5	8.5	18.9	358.2	14
O	BM1	BX	03/15/91	5	12.2	1.8	4.1	16.8	10
W	CD1	A	11/21/90	5	1.6	0.3	0.7	0.5	10
W	CD1	B	12/07/90	2	4.3	0.0	0.1	0.0	10
W	CD1	C	02/20/91	5	18.6	2.6	5.9	34.4	10
P	CD2	A	11/21/90	5	44.5	4.7	10.6	111.8	25
P	CD2	B	12/07/90	3	19.3	1.1	2.0	4.0	12
P	CD2	C	02/20/91	5	3.3	0.6	1.4	2.1	9
P	CD2	DX	03/18/91	6	26.2	3.1	7.7	59.4	14
P	CD3	A	11/21/90	5	22.2	1.1	2.6	6.5	20
P	CD3	B	02/20/91	5	27.2	3.7	8.4	70.3	17
P	CD3	CX	03/18/91	6	31.0	2.1	5.1	26.2	15
W	CD4	A	11/30/90	5	10.4	0.9	2.1	4.5	11
W	CD4	B	02/20/91	5	15.9	2.9	6.4	41.5	11
W	CD4	CX	04/08/91	5	24.3	4.8	10.7	115.2	22
P	CD5	A	11/28/90	5	10.6	1.1	2.5	6.2	25
P	CD5	B	02/20/91	5	17.3	3.6	8.1	65.0	12
P	CD5	CX	03/18/91	5	19.6	2.6	5.8	33.2	16
P	CD6	A	03/12/91	5	16.2	1.6	3.5	12.5	15
W	DG1	A	01/16/91	5	6.2	1.3	2.8	7.7	12
W	DG1	B	03/15/91	5	10.0	1.9	4.3	18.9	11
W	DK1	A	11/15/90	5	9.4	1.8	4.0	15.8	28
W	DK1	BX	03/15/91	5	8.6	0.6	1.2	2.7	13
W	DK2	A	11/15/90	5	5.2	0.7	1.6	2.7	13
W	DK2	BX	03/15/91	5	14.9	1.8	4.0	16.2	13
W	DM1	A	11/22/90	5	23.5	4.1	9.2	84.1	16
W	DM1	B	02/27/91	5	18.6	4.2	9.4	87.6	21
W	DM1	CX	03/15/91	5	44.5	4.9	10.9	117.7	24
O	DM2	A	11/22/90	5	30.1	2.9	6.4	41.5	21
O	DM2	B	03/15/91	5	11.3	2.3	5.2	27.0	10
W	DS1	A	10/26/90	5	22.6	3.5	7.8	61.0	28
W	DS1	B	11/26/90	3	51.8	8.1	14.1	198.3	29
W	DS1	C	02/27/91	5	43.4	5.6	12.4	154.3	25
W	DS1	DX	03/25/91	5	23.7	2.7	6.0	35.6	26
P	DS2	A	10/26/90	5	13.4	1.4	3.1	9.4	19
P	DS2	B	11/26/90	3	32.0	2.8	4.8	22.7	62
P	DS2	C	03/25/91	5	21.5	4.2	9.5	89.5	34
W	DS3	A	10/26/90	5	17.3	1.7	3.8	14.7	26
W	DS3	B	11/26/90	3	17.4	3.1	5.4	28.8	24
W	DS3	C	02/27/91	5	33.3	3.8	8.5	72.5	22
W	DS3	DX	03/25/91	5	33.4	2.0	4.4	19.6	24
O	DS4	A	02/27/91	5	40.0	6.5	14.5	211.3	51
SW	DT1	A	11/30/90	5	3.2	1.1	2.5	6.3	13
SW	DT1	B	02/28/91	5	3.6	0.3	0.6	0.4	11
SW	DT1	CU	03/21/91	5	3.4	0.8	1.9	3.6	9

CROP	FIELD	CUT	CUTDATE	# OF SAMPLES	MEAN	SE	STD	VAR	AH
R	GE1	A	11/13/90	3	58.2	11.3	19.5	382.0	28
R	GE1	B	02/28/91	5	40.1	4.3	9.6	91.4	25
R	GE1	CR	03/26/91	5	54.2	3.3	7.3	52.9	26
R	GE1	CX	03/26/91	2	34.3	0.0	0.0	0.0	29
W	GE2	A	11/13/90	3	39.5	5.3	9.2	83.2	30
W	GE2	BR	03/26/91	5	42.0	1.4	3.0	9.2	24
W	GE2	BX	03/26/91	3	43.3	1.9	3.2	10.3	25
R	GE3	A	11/27/90	5	39.7	5.3	11.9	140.9	22
R	GE3	B	02/28/91	5	13.7	1.9	4.2	17.8	13
R	GE3	CR	03/26/91	5	7.3	1.4	3.1	9.3	12
R	GE3	CX	03/26/91	5	20.0	4.0	9.0	81.1	17
P	GE4	A	02/28/91	5	20.4	2.5	5.5	30.6	9
W	HM1	A	12/07/90	5	56.1	3.9	8.8	76.6	30
W	HM1	B	02/20/91	5	31.3	1.0	2.3	5.3	23
W	HM1	CX	03/18/91	5	25.1	3.7	8.3	69.5	25
W	HR1	A	10/23/90	2	9.9	0.1	0.2	0.0	18
W	HR1	B	11/27/90	5	40.8	4.4	9.8	96.9	20
W	HR1	CX	12/04/90	5	22.2	1.3	2.9	8.4	21
W	HR1	D	03/04/91	5	18.8	2.6	5.8	33.9	20
W	HR1	EX	03/26/91	8	22.6	2.2	6.3	40.2	18
SW	HR2	A	10/23/90	2	23.1	6.6	9.3	87.1	30
SW	HR2	B	11/22/90	5	40.7	6.8	15.2	230.5	51
SW	HR2	CU	03/27/91	5	25.5	3.5	7.9	62.0	27
SW	HR3	A	10/23/90	2	30.2	0.5	0.6	0.4	29
SW	HR3	B	11/22/90	5	27.2	8.6	19.2	370.2	40
SW	HR3	CU	03/27/91	5	25.5	3.5	7.9	62.0	27
W	HR4	A	10/23/90	2	17.7	8.2	11.7	132.8	19
W	HR4	B	11/22/90	4	29.3	2.7	5.5	29.8	23
W	HR4	C	03/04/91	4	22.1	2.8	5.7	31.9	17
W	HR4	DC	03/26/91	3	17.5	1.7	2.9	8.5	16
W	HR4	DR	03/26/91	2	13.0	1.0	1.4	3.0	15
W	HR4	DU	03/26/91	5	30.2	11.0	24.5	6.0	25
O	JB1	A	10/29/90	5	1.6	0.2	0.4	0.2	14
O	JB1	B	03/19/91	5	12.8	1.4	3.1	9.7	16
O	JB2	A	10/29/90	5	1.5	0.1	0.3	0.1	12
O	JB2	B	11/27/90	3	14.1	0.3	0.5	0.2	20
W	JH1	A	11/06/90	5	1.2	0.3	0.7	0.5	8
W	JH1	B	02/20/91	5	4.9	0.5	1.2	1.4	11
W	JH1	CU	03/18/91	5	13.8	1.9	4.4	19.0	13
W	JH2	A	01/16/91	5	4.5	1.1	2.6	6.6	9
W	JH2	B	02/20/91	5	3.2	0.6	1.3	1.6	13
W	JH2	CX	03/18/91	5	10.5	0.7	1.5	2.2	14
W	JM1	A	11/13/90	5	47.5	5.9	13.2	173.9	37
W	JM1	B	03/05/91	5	NA	NA	NA	NA	NA
W	JM1	CX	03/21/91	5	26.0	1.9	4.3	18.7	24
P	JZ1	A	11/01/90	10	53.5	5.7	18.0	325.5	40
P	JZ1	B	03/15/91	5	42.9	5.8	12.9	167.5	27
SW	JZ2	A	11/01/90	5	20.2	2.0	4.5	20.2	32
SW	JZ2	B	03/15/91	5	18.1	1.1	2.5	6.0	23
W	JZ3	A	11/02/90	10	11.8	2.0	6.5	41.9	18

CROP	FIELD	CUT	CUTDATE	# OF SAMPLES	MEAN	SE	STD	VAR	AH
W	JZ3	B	12/04/90	3	28.3	1.9	3.3	11.1	17
W	JZ3	C	02/28/91	5	49.6	2.9	6.5	42.0	20
W	JZ3	D	03/15/91	5	19.8	1.7	3.8	14.6	18
W	JZ3	EU	03/27/91	5	21.0	2.1	4.7	21.9	21
W	JZ3	EX	03/27/91	2	22.0	0.1	0.1	0.0	19
R	JZ4	A	11/23/90	5	47.1	2.4	5.4	29.1	35
R	JZ4	B	02/28/91	5	17.6	1.5	3.4	11.2	23
R	JZ4	CU	03/27/91	5	47.3	4.4	9.9	97.6	28
W	KD1	A	11/28/90	5	3.0	0.5	1.2	1.3	9
W	KD1	B	02/28/91	4	3.1	1.0	1.9	3.7	NA
W	KD1	CR	03/18/91	5	7.7	0.5	1.2	1.4	11
W	KD1	CX	03/18/91	6	12.5	1.8	4.5	19.8	19
W	KD2	A	11/30/90	4	12.3	1.1	2.1	4.6	14
W	KD2	B	03/05/91	5	NA	NA	NA	NA	NA
W	KD2	CR	03/21/91	5	12.5	1.1	2.6	6.5	12
W	KD2	CX	03/21/91	5	28.2	1.7	3.8	14.7	24
W	KD3	A	11/30/90	5	1.9	0.5	1.2	1.5	9
W	KD3	B	12/13/90	3	2.2	0.3	0.6	0.3	9
W	KD3	C	02/28/91	5	2.9	0.3	0.7	0.5	10
W	KD3	DR	03/21/91	5	4.7	0.5	1.1	1.3	11
W	KD3	DX	03/21/91	5	5.5	0.6	1.4	1.9	13
R	LG1	A	11/30/90	4	10.9	3.2	6.4	40.4	13
R	LG1	B	02/20/91	5	18.5	1.9	4.2	17.5	18
R	LG1	CR	03/25/91	5	10.5	2.2	4.9	24.0	15
R	LG1	CX	03/25/91	3	21.0	2.0	3.4	11.4	17
R	LG2	A	11/30/90	5	30.9	4.5	10.0	100.3	19
R	LG2	B	02/20/91	5	26.6	1.8	4.0	16.2	21
R	LG2	CR	03/25/91	5	5.2	0.9	2.1	4.5	12
R	LG2	CX	03/25/91	5	10.7	2.8	6.3	39.8	6
P	LG3	A	11/30/90	5	12.7	4.4	9.9	98.1	22
P	LG3	B	02/20/91	4	15.6	2.5	5.0	25.0	7
P	LG3	CU	03/25/91	5	29.2	3.3	7.4	55.4	12
P	LG3	CX	03/25/91	5	10.7	2.8	6.3	39.8	6
R	MG1	A	11/16/90	10	15.5	3.4	10.8	117.2	18
R	MG1	B	03/04/91	5	NA	NA	NA	NA	14
R	MG2	A	12/03/90	5	3.1	0.8	1.8	3.2	10
R	MG2	B	03/20/91	5	15.2	0.8	1.9	3.5	18
R	MG2	CX	03/27/91	5	16.2	1.5	3.4	11.3	16
R	MG3	A	12/06/90	5	54.3	3.8	8.4	70.3	31
R	MG3	B	03/04/91	5	NA	NA	NA	NA	22
R	MG3	CR	03/24/91	5	23.5	1.8	4.1	17.1	19
R	MG3	CX	03/24/91	5	41.9	1.5	3.4	11.6	32
R	MG4	A	12/03/90	4	3.0	0.8	1.6	2.6	11
R	MG4	B	03/20/91	5	13.4	0.7	1.5	2.2	14
R	MG6	A	12/03/90	5	7.3	2.0	4.4	19.5	16
R	MG6	B	03/20/91	5	6.9	0.8	1.7	2.9	12
R	MG7	A	12/03/90	5	4.8	1.6	3.7	13.5	14
R	MG7	B	03/20/91	5	11.5	0.6	1.3	1.7	15
R	MG8	A	12/03/90	5	16.2	1.1	2.5	6.2	13
R	MG8	B	03/04/91	5	NA	NA	NA	NA	11

CROP	FIELD	CUT	CUTDATE	# OF SAMPLES	MEAN	SE	STD	VAR	AH
R	MG8	CR	03/27/91	5	8.0	0.7	1.6	2.7	9
R	MG8	CX	03/27/91	5	36.3	4.0	9.0	80.5	22
R	MG9	A	12/03/90	5	4.3	0.7	1.5	2.3	15
R	MG9	BU	03/19/91	5	13.7	1.6	3.5	12.6	14
W	RB1	A	11/13/90	2	26.3	7.4	10.5	111.0	18
W	RB1	B	11/26/90	3	23.3	5.0	8.7	76.2	22
W	RB1	C	03/05/91	5	NA	NA	NA	NA	24
W	RB1	DX	03/26/91	5	42.1	1.9	4.2	17.6	28
W	RH1	A	10/24/90	10	4.2	0.4	1.4	1.9	17
W	RH1	B	11/26/90	3	7.3	1.3	2.3	7.9	12
W	RH1	C	12/12/90	3	25.4	8.7	15.1	228.4	26
W	RH1	D	01/22/91	3	21.2	1.1	1.9	3.7	18
W	RH1	E	02/27/91	5	25.9	2.4	5.5	29.7	19
W	RH1	FR	03/26/91	5	19.1	0.8	1.7	3.0	13
W	RH1	FU	03/26/91	3	31.5	4.4	7.7	58.8	20
W	RH1	FX	03/26/91	4	34.4	1.2	2.4	5.9	21
W	RH2	A	10/26/90	9	4.5	0.3	0.9	0.8	16
W	RH2	B	11/26/90	3	8.8	0.7	1.2	1.3	17
W	RH2	CX	03/26/91	5	42.7	6.5	14.5	209.7	17
W	RH3	A	10/26/90	5	8.5	1.6	3.6	13.0	23
W	RH3	B	11/26/90	3	32.8	2.1	3.6	13.0	33
W	RH3	C	12/12/90	3	43.7	8.1	14.1	198.3	36
W	RH3	D	01/22/91	3	21.5	2.0	3.5	12.0	12
W	RH3	EX	03/26/91	5	11.9	0.9	2.0	4.0	18
W	RH4	A	10/26/90	5	6.2	0.6	1.4	1.9	17
W	RH4	B	11/26/90	3	36.8	2.4	4.2	17.3	34
W	RH4	C	12/12/90	3	27.1	3.6	6.2	38.1	37
W	RH4	DX	03/26/91	4	54.0	2.1	4.3	18.2	29
W	RH5	A	12/05/90	5	33.2	1.6	3.6	13.2	43
W	RH5	B	01/17/91	3	31.4	4.6	8.0	63.3	34
W	RH5	C	03/05/91	5	NA	NA	NA	NA	25
W	RH5	DU	04/08/91	5	42.1	4.1	9.1	83.3	34
W	RN1	A	12/07/90	5	5.1	0.9	2.0	4.1	10
W	RN1	B	02/20/91	5	25.5	2.1	4.8	22.7	11
W	RN1	CX	03/18/91	5	11.1	0.2	0.5	0.3	14
W	RN2	A	12/07/90	5	8.4	0.9	2.0	3.8	10
W	RN2	B	02/20/91	5	29.0	1.1	2.6	6.5	9
W	RN2	CU	03/18/91	2	16.4	0.4	0.6	0.4	12
W	RN2	CX	03/18/91	2	6.7	0.8	1.1	1.3	12
R	ROB1	A	11/08/90	10	1.5	0.2	0.5	0.2	10
R	ROB1	B	12/03/90	3	3.6	0.6	1.1	1.2	14
R	ROB1	C	01/27/91	5	8.5	0.7	1.6	2.7	11
R	ROB1	DR	04/09/91	5	11.2	1.8	4.1	16.6	19
R	ROB1	DX	04/09/91	5	18.9	0.4	1.0	0.9	25
W	ROB2	A	12/10/90	5	17.5	2.8	6.3	39.6	22
W	ROB2	B	02/27/91	5	20.4	2.1	4.8	22.7	21
W	ROB2	CX	04/09/91	5	71.0	6.3	14.0	196.0	44
W	ROB3	A	12/10/90	5	11.9	4.9	10.9	118.2	17
W	ROB3	BX	04/10/91	5	27.6	3.6	8.0	63.6	27
W	ROB4	A	12/10/90	5	12.1	3.9	8.8	77.2	18

CROP	FIELD	CUT	CUTDATE	# OF SAMPLES	MEAN	SE	STD	VAR	AH
W	ROB4	BX	04/10/91	5	24.2	4.5	10.1	102.6	29
W	ROB5	A	12/10/90	5	57.0	3.9	8.7	76.6	36
W	ROB5	B	02/27/91	5	21.6	2.4	5.4	29.0	22
W	ROB5	CU	04/09/91	2	59.4	2.9	4.2	17.0	37
W	ROB5	CX	04/09/91	3	36.8	4.3	7.5	56.7	38
W	SC1	A	11/06/90	5	17.8	1.8	4.0	15.8	18
W	SC1	B	02/22/91	5	23.8	2.3	5.1	26.4	17
W	SC1	CX	03/20/91	5	25.0	2.9	6.4	40.8	20
W	SC2	A	11/06/90	5	6.6	0.5	1.1	1.2	13
W	SC2	BX	03/20/91	5	19.9	4.5	10.1	101.1	17
W	SC3	A	11/06/90	5	26.5	3.3	7.4	55.1	19
W	SC3	B	01/17/91	3	22.6	1.0	1.8	3.1	21
W	SC3	CX	03/20/91	5	25.0	2.9	6.4	40.8	20
W	SR22	AX	03/19/91	5	27.8	7.4	16.6	274.8	33
W	SR26	AX	03/19/91	5	37.5	0.9	2.1	4.4	36
W	TE1	A	11/06/90	5	2.0	0.8	1.9	3.5	11
W	TE1	B	02/27/91	5	10.8	1.2	2.7	7.0	16
W	TE1	CU	04/08/91	5	44.0	2.5	5.7	32.5	33
W	TE1	CX	04/08/91	5	30.7	1.8	4.0	15.8	30
P	TE2	A	11/06/90	10	22.5	2.3	7.2	51.7	33
P	TE2	BX	03/20/91	5	46.5	3.6	8.1	65.0	23
W	WN1	A	11/13/90	5	23.4	3.1	6.9	48.2	19
W	WN1	B	03/05/91	5	NA	NA	NA	NA	20
W	WN1	CX	03/21/91	5	51.3	3.7	8.2	66.9	30

NOTE: ROB= FORMERLY THE ROBERTSON FARM

E. FINAL IMPACT

OVERALL GRAZING

1= HEAVY USE (> 50% EITHER FALL OR SPRING GRAZED)
2= MODERATE USE (25-50% GRAZED THROUGHOUT WINTER)
3= LITTLE/NO USE (< 25% GRAZED THROUGHOUT WINTER)

MARCH FIELD CONDITIONS

COVER CROPS
1= < 25% COVER ON FIELD
2= 25-50% COVER ON FIELD
3= > 50% COVER ON FIELD

PERENNIAL GRASSES
1= < 25% OF FIELD UNGRAZED
2= 25-50% OF FIELD UNGRAZED
3= > 50% OF FIELD UNGRAZED

* * *

FIELD	CROP	OVERALL GRAZING	MARCH FIELD CONDITIONS
AS1	WINTER WHEAT	1	1
AS2	WINTER WHEAT	1	1
AS3	FALL RYE	2	2
AS4	FALL RYE	1	2
BL1	WINTER WHEAT	1	3
BL2	SPRING WHEAT	1	3
BL3	SPRING WHEAT	1	3
BM1	SPRING WHEAT/OAT	3	3
CD1	WINTER WHEAT	1	2
CD2	PERENNIAL GRASS	1	1
CD3	PERENNIAL GRASS	1	1
CD4	WINTER WHEAT	3	3
CD5	PERENNIAL GRASS	3	3
CD6	PERENNIAL GRASS	1	1
DG1	WINTER WHEAT	1	1
DK1	WINTER WHEAT	1	1
DK2	WINTER WHEAT	1	1
DM1	WINTER WHEAT	2	3
DM2	CLOVER	1	1
DS1	WINTER WHEAT	1	2
DS2	PERENNIAL GRASS	1	1
DS3	WINTER WHEAT	1	1
DS4	BARLEY	3	2
DT1	SPRING WHEAT	2	2
GE1	WINTER WHEAT	2	3
GE2	WINTER WHEAT	2	3
GE3	FALL RYE	1	3
HM1	WINTER WHEAT	3	3
HR1	WINTER WHEAT	1	1
HR2	SPRING WHEAT	3	2
HR3	SPRING WHEAT	3	2
HR4	WINTER WHEAT	1	1
JB1	MIX	1	1

FIELD	CROP	OVERALL GRAZING	MARCH FIELD CONDITIONS
JB2	MIX	1	1
JH1	WINTER WHEAT	3	3
JH2	WINTER WHEAT	3	3
JM1	WINTER WHEAT	3	3
JZ1	PERENNIAL GRASS	2	2
JZ2	SPRING WHEAT	1	1
JZ3	WINTER WHEAT	1	1
JZ4	FALL RYE	1	1
KD1	WINTER WHEAT	1	3
KD2	WINTER WHEAT	1	3
KD3	WINTER WHEAT	1	2
LG1	FALL RYE	1	1
LG2	FALL RYE	1	2
LG3	PERENNIAL GRASS	1	1
MG1	FALL RYE	1	1
MG2	FALL RYE	1	1
MG3	FALL RYE	1	2
MG4	FALL RYE	1	1
MG6	FALL RYE	1	1
MG7	FALL RYE	1	1
MG8	FALL RYE	1	2
MG9	FALL RYE	1	1
RB1	WINTER WHEAT	2	3
RH1	WINTER WHEAT	1	1
RH2	WINTER WHEAT	1	1
RH3	WINTER WHEAT	1	1
RH4	WINTER WHEAT	1	1
RH5	WINTER WHEAT	1	2
RN1	WINTER WHEAT	3	3
RN2	WINTER WHEAT	3	3
ROB1	FALL RYE	1	3
ROB2	WINTER WHEAT	1	2
ROB3	WINTER WHEAT	1	3
ROB4	WINTER WHEAT	1	3
ROB5	WINTER WHEAT	2	3
SC1	WINTER WHEAT	3	3
SC2	WINTER WHEAT	3	3
SC3	WINTER WHEAT	3	3
SR1	WINTER WHEAT	1	1
TE1	WINTER WHEAT	3	3
TE2	PERENNIAL GRASS	3	3
WN1	WINTER WHEAT	3	3

TOTALS		OVERALL GRAZING	FIELD CONDITION
	1	49	31
	2	8	15
	3	18	29

F. CHEMICAL ANALYSIS

FIELD	CUT	DATE	ADF %	NDF %	PROTEIN %	% N
AS1	A	10/24/90	22.4		30.8	4.9
AS2	A	10/24/90	33.0	46.2	22.7	3.6
AS3	B	01/14/91	34.8		20.0	3.2
AS4	A	12/05/90	23.8	38.7	23.4	3.8
AS4	B	03/04/91	22.6	37.6	18.8	3.0
AS4	C	03/25/91	21.2	39.0	17.0	2.7
BL1	A	10/29/90	23.6	48.9	31.1	5.0
BM1	A	01/16/91	39.4		13.2	2.1
CD1	A	11/21/90	23.0		30.1	4.8
CD1	B	12/07/90	37.2	46.5	19.2	3.1
CD2	A	11/21/90	35.8	49.0	19.9	3.2
CD2	B	12/07/90	26.8	42.3	23.5	3.8
CD2	C	02/20/91	30.8	52.2	28.9	4.6
CD2	D	03/18/91	27.8	52.4	21.2	3.4
CD3	A	11/21/90	27.8	40.4	20.6	3.3
CD3	B	02/20/91	36.4	60.2	19.6	3.1
CD3	C	03/18/91	26.2	43.1	15.7	2.5
CD4	A	11/30/90	22.6	46.8	23.6	3.8
CD4	B	02/20/91	34.8	50.1	16.0	2.6
CD4	C	04/08/91	19.0	34.8	11.4	1.8
CD5	A	11/28/90	35.8	48.6	14.1	2.3
CD5	B	02/20/91	38.3	55.5	18.5	3.0
CD5	C	03/18/91	29.0	47.6	16.2	2.6
CD6	A	03/12/91	33.8	50.3	20.2	3.2
DG1	A	01/16/91	40.2		12.3	2.0
DK1	A	11/15/90	29.4	43.1	21.5	3.4
DK1	B	03/15/91	25.0	42.7	15.0	2.4
DK2	A	11/15/90	21.8	50.2	23.8	3.8
DK2	B	03/15/91	25.8	46.4	14.9	2.4
DM1	A	11/22/90	20.8		29.6	4.7
DM1	B	02/27/91	21.2	40.5	25.4	4.1
DM1	C	03/15/91	20.4	36.7	16.6	2.7
DM2	A	11/22/90	27.0	35.6	23.1	3.7
DM2	B	03/15/91	27.2	39.8	24.9	4.0
DS1	A	10/26/90	22.2	39.4	29.7	4.8
DS1	B	11/26/90	26.6	39.3	22.8	3.7
DS1	C	02/27/91	26.0	44.3	18.5	3.0
DS1	D	03/25/91	19.2	33.0	13.3	2.1
DS2	A	10/26/90	24.0	43.0	17.5	2.8
DS2	B	11/26/90	31.2	47.0	17.3	2.8
DS2	C	03/25/91	22.0	36.7	21.5	3.4
DS3	A	10/26/90	22.4	39.1	34.5	5.5
DS3	B	11/26/90	24.0	36.1	24.6	3.9
DS3	C	02/27/91	26.6	45.4	17.2	2.8
DS3	D	03/25/91	19.0	36.2	11.8	1.9
DS4	A			41.8		
GE1	A	11/13/90	25.0	36.4	23.1	3.7
GE1	C	03/26/91	20.0	37.4	12.5	2.0

FIELDCUT		DATE	ADF %	NDF %	PROTEIN %	% N
GE2	A	11/13/90	23.0	35.5	31.2	5.0
GE3	A	11/27/90	30.8	38.6	20.0	3.2
GE3	B	02/28/91	26.6	38.9	10.9	1.7
GE3	C	03/26/91	20.8	42.6	11.1	1.8
GE4	A	02/28/91	25.8	49.7	27.8	4.4
HM1	A	12/07/90	29.2	44.7	21.1	3.4
HM1	B	02/20/91	30.2	48.0	20.1	3.2
HM1	C	03/18/91	18.6	36.8	13.3	2.1
HR	A	10/23/90	22.8		32.4	5.2
HR1	B	11/22/90	31.8	49.5	20.4	3.3
HR1	C	12/04/90	22.4	39.0	20.3	3.2
HR1	E	03/26/91	19.8	34.3	12.9	2.1
HR4	B	11/22/90	27.2	36.3	22.4	3.6
HR4	C	03/04/91	33.4	48.1	12.6	2.0
HR4	D	03/26/91	21.0	36.9	12.3	2.0
JB1	A	10/29/90	28.0		33.0	5.3
JB1	B	03/19/91	24.0	43.8	20.3	3.2
JB2	A	10/29/90	NA		25.5	4.1
JB2	B	11/27/90	32.2		28.9	4.6
JH1	A	11/06/90	27.4		24.3	3.9
JH2	A	01/16/91	48.0		11.9	1.9
JM1	A	11/13/90	27.6	40.2	20.6	3.3
JM1	C	03/25/91	25.0	47.3	16.6	2.7
JZ1	A	11/01/90	38.2	47.3	14.8	2.4
JZ1	B	03/15/91	36.4	55.8	16.4	2.6
JZ2	A	11/01/90	26.0		20.4	3.3
JZ3	A	11/02/90	23.8	36.6	22.5	3.6
JZ3	B	12/04/90	28.4	43.9	18.9	3.0
JZ3	C	02/28/91	25.2	40.8	21.0	3.4
JZ3	D	03/15/91	21.8	39.8	13.6	2.2
JZ3	E	03/27/91	18.6	39.3	11.8	1.9
JZ4	A	11/23/90	26.4	38.8	24.9	4.0
JZ4	B	02/28/91	22.0	39.4	21.6	3.5
JZ4	C	03/27/91	18.0	34.2	12.5	2.0
KD1	A	11/28/90	21.8	52.7	24.9	4.0
KD1	B	02/28/91	19.2	32.6	19.2	3.1
KD1	C	03/18/91	21.4	37.9	20.9	3.3
KD2	A	11/30/90	23.8	35.9	26.3	4.2
KD2	B	03/05/91	36.2	49.7	22.6	3.6
KD2	C	03/21/91	22.2	37.9	19.7	3.2
KD3	A	11/30/90	35.2	53.1	20.4	3.3
KD3	C	02/28/91	18.2	35.7	30.3	4.8
KD3	D	03/21/91	24.8	47.4	27.8	4.4
LG1	A	11/30/90	25.8	33.9	26.0	4.2
LG1	B	02/20/91	29.4	47.7	20.1	3.2
LG1	C	03/25/91	19.4	37.0	13.9	2.2
LG2	A	11/30/90	22.8	37.3	22.4	3.6
LG2	B	02/20/91	30.8	47.8	18.5	3.0
LG2	B	02/20/91	30.8	47.8	18.5	3.0
LG2	C	03/25/91	20.4	38.6	21.0	3.4

FIELD	CUT	DATE	ADF %	NDF %	PROTEIN %	% N
LG2	C	03/25/91	20.4	38.6	21.0	3.4
LG3	A	11/30/90	29.4	35.9	17.1	2.7
LG3	B	02/20/91	37.8	53.5	20.9	3.3
LG3	C	03/25/91	21.4	42.2	24.2	3.9
MG1	A	11/16/90	25.2	35.6	27.1	4.3
MG1	A	11/16/90	25.2	35.6	27.1	4.3
MG1	B	03/04/91	20.2	33.3	12.9	2.1
MG1	B	03/04/91	20.2	33.3	12.9	2.1
MG2	A	12/03/90	25.6	44.3	17.1	2.7
MG2	A	12/03/90	25.6	44.3	17.1	2.7
MG2	C	03/27/91	25.6	42.2	10.3	1.6
MG2	C	03/27/91	25.6	42.2	10.3	1.6
MG3	A	12/06/90	22.6	41.0	21.6	3.5
MG3	A	12/06/90	22.6	41.0	21.6	3.5
MG3	B	03/04/91	28.6	39.6	22.1	3.5
MG3	B	03/04/91	28.6	39.6	22.1	3.5
MG3	C	03/24/91	22.0	40.3	16.1	2.6
MG3	C	03/24/91	22.0	40.3	16.1	2.6
MG4	A	12/03/90	24.8	40.3	26.8	4.3
MG4	A	12/03/90	24.8	40.3	26.8	4.3
MG6	A	12/03/90	40.2	54.7	15.1	2.4
MG6	A	12/03/90	40.2	54.7	15.1	2.4
MG7	A	12/03/90	32.8	37.6	15.5	2.5
MG7	A	12/03/90	32.8	37.6	15.5	2.5
MG8	A	12/03/90	20.4	37.8	24.9	4.0
MG8	A	12/03/90	20.4	37.8	24.9	4.0
MG8	B	03/04/91	32.4	38.6	19.4	3.1
MG8	B	03/04/91	32.4	38.6	19.4	3.1
MG8	C	03/27/91	18.0	33.9	14.1	2.3
MG8	C	03/27/91	18.0	33.9	14.1	2.3
MG9	A	12/03/90	25.0	33.5	23.1	3.7
MG9	A	12/03/90	25.0	33.5	23.1	3.7
MG9	B	03/19/91	20.2	34.6	19.0	3.0
MG9	B	03/19/91	20.2	34.6	19.0	3.0
RB1	A	11/13/90	21.4	40.2	31.7	5.1
RB1	B	11/26/90	20.0	38.8	22.7	3.6
RB1	C	03/05/91	NA		NA	NA
RB1	D	03/26/91	19.2	36.7	12.9	2.1
RH1	A	10/24/90	21.4	44.6	26.4	4.2
RH1	B	11/26/90	21.8	40.8	24.3	3.9
RH1	C	12/12/90	23.4	40.2	20.3	3.3
RH1	D	01/22/91	21.6	43.4	18.9	3.0
RH1	E	02/27/91	24.4	46.5	13.8	2.2
RH1	F	03/26/91	16.0	31.0	9.8	1.6
RH2	A	10/26/90	23.0	42.8	33.3	5.3
RH2	B	11/26/90	23.8	41.0	24.8	4.0
RH2	C	03/26/91	22.4	35.3	9.8	1.6
RH3	A	10/26/90	22.0	44.4	36.8	5.9
RH3	B	11/26/90	27.2	40.8	24.0	3.8
RH3	C	12/12/90	28.2	43.2	16.5	2.6

FIELD	CUT	DATE	ADF %	NDF %	PROTEIN %	% N
RH3	D	01/22/91	31.8	55.4	19.0	3.0
RH3	E	03/26/91	22.0	37.0	11.6	1.9
RH4	A	10/26/90	23.2	42.5	33.3	5.3
RH4	B	11/26/90	27.2	39.3	23.1	3.7
RH4	C	12/12/90	26.2	42.6	19.8	3.2
RH4	D	03/26/91	20.4	33.6	12.9	2.1
RH5	A	12/05/90	26.8	42.9	25.2	4.0
RH5	B	01/17/91	32.4	51.5	19.7	3.2
RH5	C	03/05/91	30.2	46.0	16.1	2.6
RH5	D	04/08/91	20.0	36.3	10.4	1.7
RN1	A	12/07/90	30.8	38.2	19.4	3.1
RN1	B	02/20/91	28.4	40.7	19.5	3.1
RN1	C	03/18/91	21.0	34.7	14.1	2.3
RN2	A	12/07/90	32.4	39.9	16.4	2.6
ROB1	A	11/08/90	19.4	41.6	26.8	4.3
ROB1	C	01/27/91	22.8	36.0	18.3	2.9
ROB1	D	04/09/91	21.0	42.7	15.1	2.4
ROB2	A	12/10/90	23.2	43.3	25.5	4.1
ROB2	B	02/27/91	23.2	37.7	20.6	3.3
ROB2	C	04/09/91	24.2	40.8	10.6	1.7
ROB3	A	12/10/90	26.4	40.6	18.5	3.0
ROB3	B	04/10/91	19.8	34.8	9.6	1.5
ROB4	A	12/10/90	22.0	38.6	22.1	3.5
ROB4	B	04/10/91	23.0	36.3	9.9	1.6
ROB5	A	12/10/90	30.0	47.5	22.2	3.6
ROB5	B	02/27/91	29.8	47.8	20.4	3.3
ROB5	C	04/09/91	25.8	42.2	15.3	2.4
SC1	A	11/06/90	23.4	39.2	26.1	4.2
SC1	B	02/22/91	38.0	52.4	17.9	2.9
SC1	C	03/20/91	21.8	46.1	17.6	2.8
SC2	A	11/06/90	19.6	38.3	26.3	4.2
SC2	B	03/20/91	24.6	41.1	14.1	2.3
SC3	A	11/06/90	21.8	41.8	29.3	4.7
SC3	B	01/17/91	29.2	53.8	24.0	3.8
SC3	C	03/20/91	21.0	38.5	16.8	2.7
SR2	A	03/19/91	25.2	42.3	18.0	2.9
TE1	A	11/06/90	22.4	48.1	27.3	4.4
TE1	B	02/27/91	19.6	34.3	22.4	3.6
TE1	CU	04/08/91	24.1	40.8	27.4	4.4
TE1	CX	04/08/91	23.4	41.0	15.1	2.4
TE2	A	11/06/90	24.4	39.3	23.8	3.8
TE2	B	03/20/91	21.4	42.5	20.8	3.3
WN1	A	11/13/90	21.6	37.7	31.5	5.0
WN1	B	03/05/91	22.4	40.9	16.3	2.6
WN1	C	03/21/91	23.8	42.3	18.6	3.0

G. STATISTICS ON CHEMICAL ANALYSIS

ACID DETERGENT FIBER (% ADF)

	MEAN	SE	n	RANGE
FALL				
WW	23.8	0.52	42	19.6-35.2
FR	24.1	0.96	11	19.4-30.8
SW	30.4	3.47	6	23.0-48.2
PAS	30.0	1.51	10	24.0-38.2
WINTER				
WW	28.1	0.94	19	21.6-37.2
FR	27.3	1.93	10	20.4-40.2
SPRING				
WW	24.1	0.66	60	18.2-38.0
FR	23.4	0.87	21	18.0-32.4
SW	26.5	2.1	9	20.2-39.8
PAS	29.6	1.56	14	21.4-38.3

CROPS

WW= WINTER WHEAT
FR= FALL RYE
SW= SPRING WHEAT
PAS= PERENNIAL GRASSES

FALL= OCTOBER/NOVEMBER
WINTER= DECEMBER/JANUARY
SPRING= FEBRUARY/MARCH

MEAN= AVERAGE PERCENT
SE= STANDARD ERROR
n= NUMBER OF SAMPLES
RANGE= LOWEST & HIGHEST PERCENT

NEUTRAL DETERGENT FIBER (%NDF)

	MEAN	SE	n	RANGE
FALL				
WW	39.3	1.81	35	30.4-53.1
FR	36.5	0.97	9	32.4-41.6
SW	48.3	1.59	6	41.7-53.0
PAS	42.8	1.51	10	35.6-49.0
WINTER				
WW	44.3	1.1	19	38.2-55.4
FR	40.4	1.93	9	33.5-54.7
SPRING				
WW	40.8	0.74	60	31.0-60.5
FR	39.9	0.89	21	33.3-47.8
SW	42.3	1.23	9	36.0-47.1
PAS	48.6	1.78	14	42.2-60.2

PROTEIN (%)

	MEAN	SE	n	RANGE
FALL				
WW	27	0.66	42	20.4-36.8
FR	24.8	1.09	11	20.0-32.1
SW	25.2	3.31	6	12.6-34.4
PAS	19.2	1.06	10	14.1-23.8
WINTER				
WW	20.4	0.06	19	16.5-25.5
FR	20.6	1.2	10	15.1-26.8
SPRING				
WW	16.2	0.61	60	9.6-27.8
FR	16.3	0.79	21	10.3-22.1
SW	13.8	1.23	9	9.0-20.1
PAS	21.2	1.74	14	15.7-28.9

NITROGEN UPTAKE

FIELD	CROP	DATE SAMPLED	% PROTEIN	% N	BIOMASS LBS/A	N-UPTAKE LBS-N/A
AS1	W	10/24/90	30.8	4.9	188	9
AS2	W	10/24/90	22.7	3.6	156	6
AS4	R	12/05/90	23.4	3.8	1483	56
BL1	W	10/29/90	31.1	5.0	105	5
BL2	S	10/29/90	32.7	5.2	905	47
BL3	S	10/29/90	34.4	5.5	909	50
CD1	W	11/21/90	30.1	4.8	58	3
CD4	W	11/30/90	23.6	3.8	371	14
DK1	W	11/15/90	21.5	3.4	334	12
DK2	W	11/15/90	23.8	3.8	184	7
DM1	W	11/22/90	29.6	4.7	838	40
DS1	W	10/26/90	29.7	4.8	805	38
DS3	W	10/26/90	34.5	5.5	617	34
DT1	S	11/30/90	12.6	2.0	115	2
GE1	W	11/13/90	23.1	3.7	2074	77
GE2	W	11/13/90	31.2	5.0	1408	70
GE3	R	11/27/90	20.0	3.2	1415	45
HM1	W	12/07/90	21.1	3.4	1999	67
HR1	W	11/22/90	20.4	3.3	1454	47
HR2	S	11/22/90	23.4	3.7	1451	54
HR3	S	11/22/90	17.2	2.8	969	27
HR4	W	11/22/90	3.6	0.6	1044	6
JB1	O	10/29/90	33.0	5.3	58	3
JB2	O	10/29/90	25.5	4.1	53	2
JH1	W	11/06/90	24.3	3.9	42	2
JH2	W	01/16/91	11.9	1.9	159	3
JM1	W	11/13/90	20.6	3.3	1693	56
JZ2	S	11/01/90	23.4	3.7	719	27
JZ3	W	11/02/90	22.5	3.6	421	15
JZ4	R	11/23/90	24.9	4.0	1677	67
KD1	W	11/28/90	24.9	4.0	106	4
KD2	W	11/30/90	26.3	4.2	438	18
KD3	W	11/30/90	20.4	3.3	68	2
LG1	R	11/30/90	26.0	4.2	388	16
LG2	R	11/30/90	22.4	3.6	1101	39
MG1	R	11/16/90	27.1	4.3	552	24
MG2	R	12/03/90	17.1	2.7	112	3
MG3	R	12/06/90	21.6	3.5	1935	67
MG4	R	12/03/90	26.8	4.3	107	5
MG6	R	12/03/90	15.1	2.4	262	6
MG7	R	12/03/90	15.5	2.5	171	4
MG8	R	12/03/90	24.9	4.0	577	23
MG9	R	12/03/90	23.1	3.7	153	6
RB1	W	11/13/90	31.7	5.1	936	47
RH1	W	10/24/90	26.4	4.2	148	6
RH2	W	10/26/90	33.3	5.3	162	9
RH3	W	10/26/90	36.8	5.9	304	18
RH4	W	10/26/90	33.3	5.3	221	12