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Edmonton, Alberta

THE UNIVERSITY OF ALBERTA

FORAGE PRODUCTION AND UTILIZATION IN THE ASPEN PARKLAND OF ALBERTA FOLLOWING AERIAL APPLICATION OF 2,4-D AND 2,4,5-T

by

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

DEPARTMENT OF PLANT SCIENCE

EDMONTON , ALBERTA

FALL , 1970

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Forage Production and Utilization in the Aspen Parkland of Alberta Following Aerial Application of 2,4-D and 2,4,5-T," submitted by James E. Hilton in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

After aerial application of 2,4-D and 2,4,5-T to Alberta Aspen Parkland vegetation, there was approximately 5 to 7 times as much green herbage in the treated forests compared to the untreated forests. Cattle used the treated forest areas about three times as much as the untreated forest. The clipped plot data showed that the cattle consumed about 750 lb/acre of the total herbage in the treated forests compared to a use of only 100 lb/acre in the untreated forests.

Two applications of 2,4-D, spaced two years apart, ranged from concentrations of 1 to 4 lb/acre. The herbicide 2,4,5-T was included in the second application at a concentration of 8 oz/acre.

A relatively high use of grassland and forest herbage in the pasture which received only one application of 2,4-D was attributed to burning done in this area in 1967.

Festuca scabrella, Agropyron spp. and *Stipa spartea* var. *curtiseta* were the most heavily utilized species in the grassland community. In the forest community, *Agropyron subsecundum, Festuca scabrella* and *Poa* spp. supplied the largest amount of forage used in the small poplar type. *Agropyron subsecundum, Calamagrostis neglecta, Bromus ciliatus, Poa* spp. and *Carex* spp. accounted for the largest amount of forage utilized in the large poplar and poplar-willow types.

The forbs constituted about 12% of the total green herbage in the grassland and approximately 30% in the forest types. The most

common and productive forb species in the forest community were *Fragaria virginiana, Galium boreale, Aster hesparius, A. laevis, Anemone canadensis* and *Arenaria lateriflora.* The use of *Fragaria virginiana* was quite variable whereas the other above mentioned forbs showed substantial use by cattle.

Cattle used the forest community much more heavily than the grassland in 1969 compared to 1968. Lower precipitation and warmer temperatures in the 1969 growing season were believed responsible for early development of a mature grassland vegetation. This caused cattle to graze more intensely in the more palatable forest vegetation.

ACKNOWLEDGEMENTS

I would first like to thank Dr. A.W. Bailey for the valuable criticism and patience he has shown throughout the course of my research work and writing of this thesis. I am also indebted to Dr. R.T. Berg and Dr. Wm. G. Corns for their helpful suggestions and constructive criticism.

The congenial company and valuable assistance rendered by Mr. Tommy Peters in identification of the soil cores will always be remembered.

Messrs. Harlan Fulton and Gary Menshaw were most helpful during the summer work and in supplying grazing history information. I would also like to thank Mr. P.J. Martin of the Provincial Soil and Feed Testing Laboratory for analyzing a number of herbage samples.

The help of fellow graduate students in room 562 and the diligent work of the typists and students who helped with the plant sorting is also greatly appreciated.

The financial assistance for this project was made possible through a Canadian Department of Agriculture Grant to Dr. A.W. Bailey.

Last but certainly not least I would like to thank my wife Sandi for her help in typing and proof reading and above all her encouragement throughout my graduate career.

TABLE OF CONTENTS

Page

LIST OF TABLES

Table		Page

Table		Page

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

Effective removal and control of brush on rangelands has been and will likely continue to be an important aspect of rangeland management. Most woody species provide very little palatable forage for cattle and they compete with desirable understory species. The grassland chernozemic soils are being degraded to a less productive grey wooded type when invading trees are allowed to remain (34). The use of herbicides is an important rangeland tool in the control of undesirable plants and subsequent increase in desirable forages.

Little information is available on the kinds and amount of forage produced after application of herbicides to Alberta Aspen Parkland vegetation. In order to assess the economic feasibility of herbicide application, the increase in palatable and unpalatable understory species needs to be documented over an extended period of time.

Drayton et al (35) have estimated that by 1980 there will be an increase of 6.5 million cattle in Canada. The development of our present rangelands is one method of meeting the greater demand for forage that will be required to feed the increasing cattle population.

The objectives of this study were to:

i) compare the species composition and grazing use of herbaceous species in sprayed versus unsprayed areas;

ii) compare cattle grazing time in sprayed and unsprayed areas and

iii) investigate factors responsible for the different levels of forage use and grazing behaviour in the various vegetation types of treated versus untreated areas.

1. Location

The 150 acre study area was located on the University of Alberta Ranch, Kinsella, Alberta in S.E.¼ of Section 4, Township 47, Range 11, West of the 4th meridian. Kinsella is 95 miles southeast of Edmonton.

2. History of the Area

In September of 1960, the University of Alberta Ranch was established. Fifty-six hundred acres of land were acquired using a grant from the Horned Cattle Trust Fund (9). The main purpose of the Ranch was to carry out an extensive beef breeding project.

Extensive portions of the grasslands in the study area had been cultivated by homesteaders early in this century. Numerous piles of stones and ridges of soil well inside existing poplar clones indicated homesteader activity in the southwest corner and north central part of the study field . Parts of the grassland had been cultivated and sown to tame forage species or allowed to revert to a grass-weed stage of secondary succession. Young poplar trees had invaded some of the moister cultivated areas abandoned by the homesteaders.

Parts of the range showed evidence of excessive grazing when the ranch was purchased in 1960.[1]

3. Treatments prior to this study

A. Herbicide Application

In the summer of 1966, four 40-acre strips (each 330 ft. by 5,260 ft. and spaced 150 ft. apart) were selected to study the effect

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[1] Personal communication, Dr. R.T. Berg,Department of Animal Science, University of Alberta and H.W. Fulton, Manager of the University of Alberta Ranch, Kinsella, September, 1969.

of various concentrations of 2,4-D on parkland vegetation. On August 17, 1966, a fixed wing aircraft applied 4, 3, 2, and 1 lb/acre acid equivalent of 2,4-D butyl ester[1] to the selected strips. The herbicide was applied in diesel fuel at the rate of 1 gallon/acre total solution. Winds of 2 to 10 m.p.h. during application caused periodic drifting of the herbicide from the intended strips.[2]

Throughout the remainder of this thesis, the 40-acre strips receiving the 4, 3, 2, and 1 lb/acre of herbicide will be referred to as treatments A, B, C, and D respectively. On July 2, 1968, treatments A, C, and D received 4, 2, and 1 lb/acre respectively of 2,4-D butyl ester and 8 oz/acre of 2,4,5-T[3] in diesel fuel. The 2,4,5-T was included in the spray solution to control the 2,4-D resistant shrubs: *Rosa* spp., *Rubus* spp. and *Ribes* spp. The fixed wing aircraft applied 3 gallons/acre of total solution. Treatment B was not resprayed in 1968 so that the effects of a single application on the control of woody species could be studied in subsequent experiments.

B. Burning Trials

In October, 1967, approximately 60% of Treatment B was burned to observe the effect of fire on woody sucker regrowth.

4. Geology

The strata of the Kinsella area is of the Upper Cretaceous period (84). The main components of this strata are sandstone, shale and coal (46). In terms of physiography, the University Ranch is in

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[1] 2-4-dichlorophenoxy acetic acid

[2] Personal communication, A.W. Bailey, Department of Plant Science, University of Alberta, May, 1968.

[3] 2-4-5 trichlorophenoxy acetic acid

the "Eastern Alberta Plain".

Allen (2) states that the soil parent material of the area was probably affected by the Hudson's Bay Glaciation which moved across the area in a north-east to south-west direction. The glacial drift which made up most of the parent material was deposited as a mantle over the area. Portions of exposed bedrock also became parent material.

The Kinsella area is described as being in the third youngest of seven main geological types of the region. The rock formation in the Kinsella-Wainwright area is given the title of the "Pale Beds". The composition of these beds is sandstone; some thin coal seams; and freshwater fossils. Some areas, known as Variegated Beds, are underlain with darker colored green-yellow sandstone and shale. Much of the area is covered by glacial drift. Where the Pale Beds occur near the surface, however, the soils contain much material from the series of lower beds. Seventy-five percent of the Wainwright-Vermilion sheet has a mantle of unconsolidated glacial till. This till is in the form of either moraines or sorted glacial drift.

5. Soils

The area around Viking and Kinsella is classified under the general heading of the Viking Moraine (86). It lies almost completely within the Shallow Black Soil Zone; but does contain pockets of Dark Brown and Black-Grey Transition soils.

The soil in the area is mapped as unsorted glacial loam and has an average of 3 to 4 inches of black topsoil. Surface samples of the moraine average 53% sand, 41% silt and 6% clay; one-half of the

sand fraction is coarse sand. A lime horizon occurs at 15 to 24 inches.

About 40% of the area is classified as rolling land. Soils are variable in profile depth, depending upon their topographic position. They range from shallow on the knolls to relatively deep in the valleys. Stones are moderately abundant except in some sorted glacial basins.

6. Climate

Most of Alberta lies in the Cool Temperate Zone with some Polar Climate prevailing on certain mountain tops (46). Longley suggests the most important factors responsible in determining temperatures and precipitation in Alberta are height and width of the Rocky Mountains and the direction of the prevailing winds.

Parkland Climate

The term "long cool summer" can be applied to the Parkland because it is an area which has a mean temperature exceeding 50 degrees F for four months in the summer (46). Precipitation averages in the Kinsella area for 1931 to 1960 (84) were: annual, 14 to 16 inches; during the growing season (April to August), 10 to 11 inches; mean annual snowfall - 40 to 50 inches; mean annual number of days with precipitation - 100 to 110.

Temperature averages in the Kinsella area for the past 29 years were: January, 2 to 4° F; April, 38 to 40° F; July, 62 to 64° F; October, 38 to 40° F; warmest month - July, 75 to 80° F (average maximum); coldest month - January, -5 to -10° F (average minimum); last

spring frost - May 15 to 31; frost free period - 100 to 120 days; first fall frost - September 1 to 15.

7. Fauna

The animals of the Parkland are diversified and abundant. For the purposes of the study, only the abundant species which may have had some effect on the experiment will be mentioned. These are casual observations; no positive identification was made.

The most common small rodents in the grasslands are likely the white footed mouse (*Peromyscus maniculatus bairdii*) and voles (*Microtus pensylvanicus* and *M. ochrogaster*) (10). The thirteen striped ground squirrel (*Citellus tridecemlineatus*) and Richardson's ground squirrel (*Citellus richardsonii*) were abundant. Mounds of soil apparently left by the pocket gopher (*Thomomys talpoides*) were also evident.

Bird (10) described the varying hare or snowshoe rabbit (*Lepus americanus americanus*) as the dominant mammal in the forest. A large hare population was observed in the spring of 1969 throughout the study area. The three smaller mammals also observed in the forest were: the red-backed vole (*Clethrionomys gapperi loringi*), the chipmunk (*Eutamias minimus borealis*), and the Franklin ground squirrel (*Citellus franklinii*). Before cattle were turned into the study area, numerous white-tailed deer (*Odocoileus virginianus dacotensis*) were observed feeding in the forest and adjacent grassland communities.

8. Vegetation

The study area is located in typical parkland (Grovebelt) vegetation. Moss (63) describes the Alberta parkland as a mosaic of

prairie patches and aspen groves. The parkland of Saskatchewan is described by Coupland and Brayshaw (25) as an intermingling of grassland and forest communities with an ecotone occurring around each aspen grove. Wet, poorly drained depressions are often occupied by sedge (*Carex* spp.) meadows surrounded by belts of aspen (*Populus tremuloides*) and willow (*Salix* spp.) while shallower depressions are usually occupied only by aspen poplar.

Three major plant communities of the parkland are the dry grassland, forest and the wet meadows.

A. Grassland Community

The grassland can be further subdivided into two main types: i) Disturbed grassland and ii) Native grassland.

i) The disturbed areas in treatment A and B were dominated by native bearded wheatgrass (*Agropyron subsecundum*) which apparently invaded after the cultivated fields were abandoned. The old cultivated areas in the south end of treatment D and in the control area are dominated by introduced crested wheatgrass (*Agropyron desertorum* and *A. cristatum*) and native hair grass (*Agrostis scabra*).

ii) Native Grassland: This vegetation type can be subdivided on the basis of differences in microtopography. Coupland and Brayshaw (25) identified two communities: the *Stipa-Agropyron* faciation, occupying the south-facing slopes and the tops of knolls; and the *Festuca* community in the lower, moister areas. The area occupied by each community depends upon local topography as well as on location of the site within the major soil and vegetation zones of the province. More

hilly topography or a more southerly location will increase the size of the *Stipa* community at the expense of the *Festuca* community.

Ayyad and Dix (3) show three divisions of the grassland in the Dark Brown Soil Zone of Saskatchewan: a) *Festuca scabrella, Carex obtusata* and *Galium boreale* have their highest densities on the moist and cool lower portions of the north-facing slopes; b)*Koeleria cristata, Carex eleocharis, Stipa spartea* var. *curtiseta* and *Agropyron dasystachyum* occupy intermediate slopes; and c) *Phlox hoodii, Carex filifolia, Stipa comata* and *Artemisia frigida* dominate dry, upper south-facing slopes.

B. Forest Communities

The small poplar, large poplar and poplar-willow were considered as separate vegetation types in the study.

i) Small poplar (trees less than 3 inches DBH)

This type lies between the grassland and large poplar type and it has many major species of both types. Bird (10) describes the following as sparse in the inner portion of the clone in the large poplar type, but very dense on the forest margins: Rose (*Rosa* spp.), saskatoon berry (*Amelanchier alnifolia* Nutt.), snowberry (*Symphoricarpos occidentalis*), choke cherry (*Prunus virginiana* L.), and pin cherry (*Prunus pensylvanica* L.).

ii) Large poplar (trees greater than 3 inches DBH)

Moss (63) found the following five strata in the poplar association"(a) taller trees forming a nearly continuous canopy; (b) small trees and larger shrubs, an intermittent layer, usually poorly developed in the aspen consociation; (c) lower shrub layer, rich or

sparse, and more or less obscured in summer by the next stratum; (d) taller herbs, often an almost continuous stratum and quite prominent in the latter part of the growing season; (e) lower herbs, including mosses and lichens". Many of the characteristic genera mentioned in the aspen consociation were common in the stands of the study area; however, some species differed. Those species present were: the dominant tree, *Populus tremuloides*; the shrubs - *Symphoricarpos albus*, *S. occidentalis*, *Amelanchier alnifolia*, *Rosa woodsii*, *R. acicularis*, *Rubus strigosus* and *Salix* spp.; the herbs - *Rubus pubescens*, *Aster* spp., *Vicia americana*, *Lathyrus ochroleucus*, *Pyrola secunda*, *Fragaria virginiana*, *Galium boreale*, *Epilobium angustifolium*, *Viola adunca*, *Thalictrum venulosum*, *Calamagrostis canadensis*, *C. neglecta* and *Agropyron trachycaulum*.

iii) Poplar willow

Bird (10) describes willow communities which closely resemble the ones in the study site. He found basket willow (*Salix petiolaris*) the most abundant around margins of sloughs. The pussy willow (*Salix discolor*) was found on better drained areas upslope from the basket willow between it and the aspen forest or grassland. The herbaceous undergrowth was described as either sparse or a dense carpet of moss.

The study area understory differed from the willow communities described by Bird (10) because there were extensive areas of *Carex* spp. and water tolerant grasses. The major grasses found were *Poa* spp., *Calamagrostis inexpansa*, *C. neglecta* and *Beckmannia syzigachne*.

C. Wetlands

Moss (63) describes a marsh as "a grass-sedge-rush community, usually without mosses or much peat accumulation, and the floor

covered with water one or more months of the growing season". He defines a wet meadow as "a shallow marsh, having water only a small part of the growing season".

The term "marsh" could be applied to the wet areas in Treatment A because the water remained throughout the season. The main dominants in these areas were *Carex aquatilis, C. rostrata, C. diandra, C. lasiocarpa, C. vesicara, Glyceria* spp., *Calamagrostis inexpansa* and *C. canadensis*. Accompanying plants included *Poa* spp., *Hordeum jubatum, Beckmannia syzigachne, Galium trifidum, Sium suave,* and *Aster* spp.

The term "wet meadow" could be applied to the sloughs in the rest of the study area because they were covered with water for a part of the summer. Practically all species found in the marsh communities were also found in the wet meadows.

LITERATURE REVIEW

1. Brush Control

A. Use of Herbicides to Increase Forage Production in the U.S.A.

Many of the methods available for brush control are of limited usefulness because their high costs cannot be paid by the subsequent increase in forage production. Texas workers (67) have found that the cost of brush control can be reduced by combining more expensive mechanical methods with the less expensive herbicide and burning methods.

In California, Johnson et al (57) have demonstrated a five-fold increase in forage production following 2,4-D application to Blue Oak (*Quercus douglasii*) savanna. In a similar study in California, forage production under Blue Oak trees increased nearly eight-fold 18 months after treatment with 2,4-D (66). Cornelius and Graham (23) found a 155% increase in the basal area of Nevada bluegrass (*Poa nevadensis*) and a substantial increase in other desirable grasses 14 months after application of 2,4-D for control of big sage brush (*Artemisia tridentata*). The dry weight of the three main grasses was 625 lb/acre on the treated area compared to 285 lb/acre in the control. Aerial application of 2,4-D in Nevada increased the grazing capacity from 405 to 1920 sheep months as well as increasing availability of the herbaceous vegetation (58). In Wyoming, an area with a ground cover of 52% sagebrush, 28% grass produced 343 lb of forage per acre (55). Six years after treatment with 2,4-D, the ground cover was 13% sagebrush and 70% grass. The forage yield had increased by 233% to 1143 lb/acre.

After 2,4,5-T application to an oak woodland in the Arkansas Ozarks, Halls and Crawford (45) reported 660 lb/acre of forage on the treated area versus 75 lb/acre in the control. These authors suggested that respraying be done at less than 8 year intervals. In Southern Arizona, Cable and Tschirley (15) found nearly twice the production of the native perennial grasses for six growing seasons after the first application of 2,4,5-T. The production of seeded love-grass (*Eragrostis lehmanniana*) was three times as great on sprayed areas. On areas sprayed twice, an economic analysis showed that the increase in perennial grasses in the first three growing seasons was more than sufficient to cover costs of spraying and seeding. A substantial increase in forage production resulted from control of winged elm (*Ulmus alata*), oak (*Quercus* spp.) and hickory (*Carya* spp.) trees using 2,4,5-T in Oklahoma; but reseeding was suggested since the increase in forage was composed primarily of less desirable grasses and forbs (28).

Lyon and Mueggler (59) have shown that the use of 2,4-D and 2,4,5-T make certain northern Idaho browse species more available to wild ungulates. In the Ozark Woodlands, Halls and Crawford (45) also found an increase in desirable deer browse following herbicide application.

B. Use of Herbicides in the Canadian Parkland

i) Control of Woody Species

Much of the brush control research has been to determine the most effective herbicides, concentrations, and carriers (42). The brush species which pose the greatest control problems are poplars, (*Populus* spp.), snowberry (*Symphoricarpos* spp.), silverberry (*Elaeagnus*

commutata) and willows *(Salix* spp.).

Friesen et al (42) recommend using 3 lb/acre of 2,4-D in an emulsion of 1 gallon fuel oil and 3 gallons water for the control of poplar trees 20 to 25 feet high. For poplar trees over 25 feet, the concentration should be increased to 4 lb/acre in an emulsion of 2 gallons oil and 6 gallons water per acre. These applications will also control snowberry (42), willow (42) (6) and silverberry (42) (24). These last three species can readily be controlled with 2 lb/acre of 2,4-D when poplar is absent (42) (24).

Effective control is usually obtained by spraying in mid-June when there is adequate soil moisture, high relative humidity and temperatures of 70 to 75°F (42) (72). Respraying with lower concentrations than the initial application is usually necessary to control brush regrowth.

The herbicide 2,4,5-T is used to control rose and raspberry species. Both are resistant to 2,4-D. The usual procedure is to mix 2,4,5-T with 2,4-D in a ratio which will economically control both the 2,4-D and 2,4,5-T susceptible species.

ii) Increase in Herbage Production

In central Saskatchewan, Skoglund and Coupland (74) reported increased vigor of grass following 2,4-D treatment of snowberry. They found 66 and 85 wheatgrass culms/m^2 on the treated sites compared to 20 and 30 culms/m^2 on the control. At Lacombe, Alberta, Friesen (41) reported a strong recovery of grass following herbicide application to snowberry. At Kelliher, Saskatchewan, after two years application of 2,4-D to poplar, snowberry and silverberry, McIver (61) reported a production of 958 lb/acre of native grass on the treatment compared

to a production of 263 lb/acre on the check.

2. Animal Grazing Behavior

The many interrelated factors responsible for animal grazing behavior make analysis of the problem very difficult. Many attempts have been made to explain why animals choose certain plant species and plant communities over others. Some of the factors associated with animal preference are: (A) Palatability, (B) Topography, (C) Plant Communities and Soil Types, (D) Climate and (E) Breed of Animals.

A. Palatability

In 1955, Ivinis (56) defined palatability as "the sum of the factors which operate to determine whether, and to what degree the food is attractive to the animals." Early determinations of palatability were arrived at by (1) casual observations, (2) notations of amount of time spent in various plots, (3) visual observations of swards before and after grazing and (4) combinations of clipping techniques and observations.

Another approach to the study of palatability has been the investigation of physiological factors of the animal responsible for appetite control. Chemostatic regulation is one possible mechanism for controlling feed intake. The infusion of acetic, propionic and butyric acids into the rumen has resulted in a reduction of food intake by ruminants (4) (73). The rate of food passage through a ruminant is related to rates of digestion into major absorption products and into particles small enough to pass through the reticulo-

omasal orifice (8) (11).

McClymont (60) presents a model for appetite control which takes into account chemostatic regulation, rate of passage theory, and other aspects. He presents phagic behavior[1] as a balance between facilitory and inhibitory stimuli which are integrated by the central nervous system. Total energy demand, social facilitation and the questionable factor of high palatability are examples of facilitory stimuli. The inhibitory stimuli include energy intake, gastrointestinal or ruminal distention, fatigue, unpalatability, heat stress, nutritional stress, disease stress and social inhibition.

Grazing animals do show a definite preference for particular species in a sward. Bailey (7) reports a very different vegetative composition (disclimax) in a heavily grazed area between silverberry shrubs as compared to more lightly grazed near climax vegetation in the protection of the shrubs. Daubenmire (30) points out the drastic changes which occur in primary climax vegetation as a result of preferential species selection by grazing cattle and, even jackrabbits. In his review of palatability Heady (48) discusses the relationship between chemical composition and palatability. High positive correlations have been found between animal preference and (1) protein content, (2) sugars, (3) acetic, linolenic and butyric acids, and (4) ether extract. Lignin and crude fibre show a negative relationship to palatability.

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[1] "Phagic behavior", as used by McClymont, covers the total coordinated behavioral pattern of food seeking, selection and ingestion.

B. Topography

It is difficult to relate topography to utilization differences without considering the unique plant communities often associated with particular topographic positions. Hercus (51) found that utilization by sheep was concentrated on sunny slopes no matter what the quantity or quality of herbage was on adjoining shaded aspects. Cook (21), Glending (43), and Mueggler (65) have shown that steepness of slope and distance from water are also important in determining amount of utilization.

Similar preferences have been shown for wild ungulates. Crouch (27) and Miller (62) consider low elevation, low percent slope, southern aspect, convex slope form, high surface disturbance, favorable seasonal climate and plant community with associated soil types to be important factors in producing highly preferred forage species for black tailed deer (*Odocoileus hemionus columbianus*).

C. Plant Communities and Soil Types

In Britain, Hughes et al (54) demonstrated that domestic sheep preferred the more productive *Agrostis-Festuca* grassland to the less productive *Nardus stricta* area. The animals on the preferred area had a greater net gain per unit area even though crude protein, fibre, oil, total ash, nitrogen free extract and mineral element differences in the vegetation were small. Only calcium was higher in the more productive community. Davies et al (33) have shown that differences in calcium levels can be important. Forage from limed areas resulted in higher weight gains, higher digestibility and higher mineral retention in sheep.

Cook (20) found that cattle preferred forage from an upper,

less productive site over forage from a lower, more productive site. The plants in the upper plant community were more leafy and stems and leaves were smaller and less coarse. Protein and ash content were significantly higher in plants from the less productive site. The lower site plants, with their higher stem to leaf ratio, had higher cellulose content.

Oelberg (68) points out that soil phosphorus is most readily absorbed from soil with a pH between 6 and 7. Outside this range, more phosphorus is held in insoluble forms which are unavailable to plants. Soil in the preferred *Agrostis-Festuca* grassland referred to by Hughes et al (54) showed a pH of 6.5 as compared to 5.0 in the less preferred *Nardus stricta* grassland. The preferred soil showed a substantial increase in P_2O_5 and CaO. Soil types and climate together affect forage utilization; heavy clay soils are avoided in wet weather (48).

D. Climate

Climate can influence grazing behavior directly, by affecting the animal, or indirectly, by altering plant properties.

High temperatures coupled with high humidity reduce animal grazing time (39). Tayler (78) noticed that animal grazing time was delayed following a heavy rain. Miller (62) also showed direct environmental effects on grazing behavior of black-tailed deer. At temperatures above 60°F, deer became inactive; at low temperatures and with sudden drops in temperature, reduced activity also resulted.

Oelberg (68) discusses the effect of precipitation and light intensity on the nutritive value of plants. In general, precipitation tended to increase nitrogen, phosphorus and ether extract levels.

Some workers found that a decrease in precipitation resulted in a decrease in phosphorus and an increase in calcium (29) (82). There is, however, a discrepancy between findings concerning the effects of drought periods on levels of calcium. Some authors have found calcium to increase following drought periods (29) (82) while others, such as Ferguson (40), have found decreased calcium levels during such periods. Light intensity affects the nutritive status of plants. *Bromus inermis* grown in full sunlight had more carbohydrates and less protein than plants grown in the shade (82). The state of plant maturity, as affected by seasonal climatic changes, has also altered cattle grazing preference. In California, Van Dyne and Heady (79) found that as herbage availability decreased from 1490 to 420 pounds/acre, diets of cattle and sheep contained less crude protein and gross energy, but more silica and total ash. Reppert (71) also demonstrated that cattle showed a definite preference for different species at various seasons of the year.

E. Breed of Animal

In New Mexico, Herbel and Nelson (49) found that Hereford cattle spent less time walking, travelled less distance, and spent more time grazing than did Santa Gertrudis. They also reported that Santa Gertrudis cattle consumed more coarse grasses than the Herefords. The Herefords ate more Russian thistle (*Salsola kali* L.) and soaptree yucca (*Yucca elata* Engelm) (50).

METHODS

1. Forage Production and Utilization

A. 1968

In the spring of 1968, a barbed wire enclosure, containing approximately equal areas of treatments A, B, C, and D, was constructed across the central portion of the sprayed strips. The enclosure was extended to the west of treatment D to include a control area of approximately 30 acres.

Forage production and utilization was determined from plant unit weights taken before and after grazing (22). Plots, used to determine production, were clipped before cattle were placed into the enclosure; adjacent plots, used to calculate utilization, were clipped after the animals were removed. Use of this method was based on the assumption that in late August, plant growth in the two week grazing period between clippings, would not be an appreciable factor.

The 1966 herbicide application appeared to have caused high tree mortality in treatments A and B, but not in treatments C and D. Therefore, only treatments A, B and the control were sampled in 1968.

In the determinations of sample plot positions, five major vegetation types were considered: (1) grassland, (2) small aspen poplar, (3) large aspen poplar, (4) poplar-willow and (5) marsh and wet meadow. The forest vegetation types were identified on the basis of presence of dominant tree species. For example:

(1) the small poplar type consisted of poplar trees less than 3 inches in DBH[1].

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[1] Diameter at breast height.

(2) the large poplar type consisted of poplar trees greater than 3 inches DBH.

(3) the poplar-willow type consisted of willow trees alone or willow and poplar together.

Attempts were made to establish transect lines through stands of all five major vegetation types, however, some transects selected had at least one vegetation type absent. A cultivated fire guard surrounding treatment B and cultivated grasslands in the control interfered with the establishment of transect lines in some areas.

Transect lines were randomly located to extend from the upland grasslands through the poplar types to the centre of the low-lying wetlands. Nineteen transect lines were located in each treatment and the control (Figure 1).

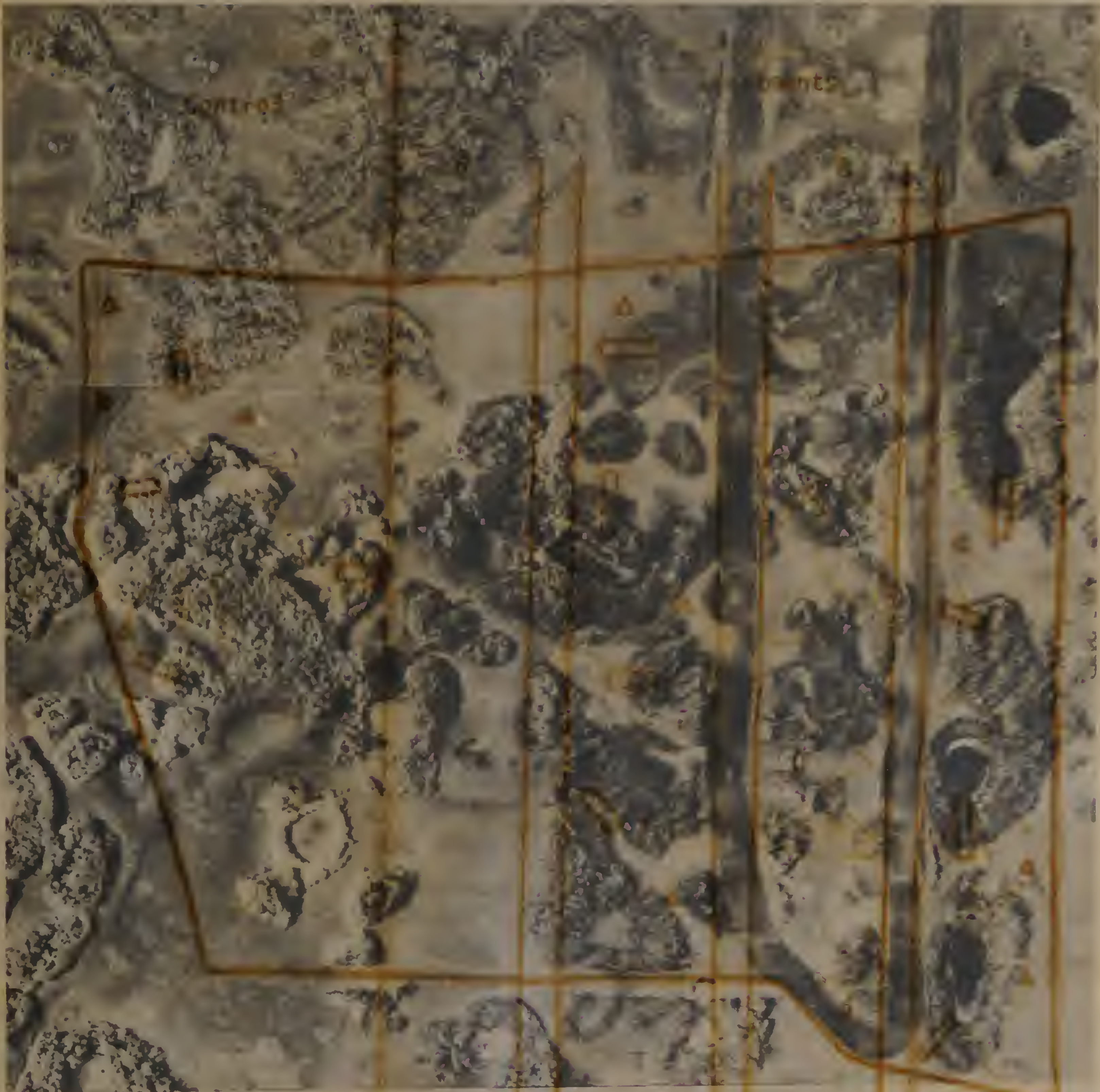
A one-foot squar production plot was randomly selected and located in each stand of the vegetation types occurring along the transect line. The location was rejected and another random selection made if more than one-half of the first plot contained animal droppings, large rocks or tree stems. Some transects did not intersect all five vegetation types so the number of plots in a treatment varied.

From August 12 to 16, all herbage in the production plots of treatments A, B and the control were clipped with handshears to estimate herbage production. All clipped vegetation, except shrubs, was placed in plastic bags and frozen.

On August 23, 1968, 30 head of cattle (cows and yearlings) and 21 four to six-month old calves were placed in the experimental field; included were Holstein, Hereford, Aberdeen Angus and crossbred beef cattle. The herd grazed in the study area for 21 days using 20

Figure II

LOCATION OF EXCLOSURES IN THE TREATMENTS AND CONTROL, [illegible]



animal unit months of forage. One-foot square utilization plots adjacent to the production plots were clipped September 16 to 20 after the cattle had been removed from the enclosure. A total of 224 production plots and 224 utilization plots were clipped in 1968.

Frozen vegetation from the two clippings was hand sorted to: (a) grass, (b) sedge, (c) forb and (d) litter categories. The first three categories were sorted to the genus and species level. The litter consisted of dead grass, sedge, forbs, twigs, mosses, lichens and tree leaves. Weights were recorded after air drying to a constant weight.

B. 1969 Production-Utilization samples inside enclosure

In 1969, the grazing period extended from June 26 to August 20. Because of probable changes in forage production during this period, exclosures were constructed inside the 137 acre study area. The herbage production was determined by plots inside the exclosure. The herbage utilization was determined by comparing the mean weight of the plots inside and outside the exclosures.

Heady (47) and Cowlishaw (26) have demonstrated that yields under cages were significantly greater than in adjacent grazed areas. Decreased wind velocity and increased humidity appeared to be causes for increases in yield. It was, therefore, essential that exclosures be constructed which minimized obstruction to wind movement, precipitation and insolation (30). The construction methods and locations of the barbed-wire exclosures are shown in Figures 3 and 4, and in Figure 2.

Four rectangular exclosures were constructed on selected locations in treatments A, C and the control. When the exclosures were located, an attempt was made to include 4 of the 5 vegetation

Figure 3. Triangular exclosure in treatment C.

Figure 4. Rectangular exclosure in treatment A grassland and forest

types sampled in 1968 (the wetlands being excluded); to minimize the difference between herbage production inside and outside the exclosure; to study areas of high forage production to obtain more information on potential productivity;and to choose similar topographic positions in treatments A and C and the control. Treatment C was sampled instead of treatment B in 1969 because the effectiveness of the 2 lbs/acre of herbicide in treatment C was more apparent than it had been the previous summer. Treatment B was excluded because it had been sprayed only once and had been burned. Each rectangular exclosure was about 16 feet wide by 75 to 120 feet long.

In each stand sampled, the rectangular exclosure extended from the poplar-willow type through the large and small poplar types and 20 feet into the grassland. In order to sample the drier grasslands which were not usually in the rectangular exclosures because they were farther from the forest edge, representative upland sites were chosen. The exclosures were located in the site by throwing a stake backwards over ones' shoulder. Three 30-square-foot triangular exclosures were constructed in the upper grasslands of treatments A and C. Because of a somewhat larger area and more diverse grassland in the control, 4 (30-square-foot) exclosures were constructed there.

On June 26, 23 cows, 17 calves and one bull were placed in the experimental area. The group consisted of Holstein, Jersey and crossbred cattle. Animals were added as the season progressed bringing the total to 30 cows, 20 calves and one bull by the end of the grazing period. The experimental area was subjected to about 47 animal unit months of grazing.

After the animals were removed, 35 one-foot-square plots were

clipped both inside and outside each rectangular exclosure. A transect line as long as the exclosure was randomly placed inside the exclosure parallel to its length. Two one-foot-square plots were then randomly located and clipped within each 10 foot interval on the transect line. Another transect line was then randomly located inside the exclosure and more plots were clipped at the randomly located positions on the line until the total number of plots clipped reached 35. The same procedure was used to randomly locate and clip plots outside the exclosure. The 35 plots inside and 35 outside were distributed among the vegetation types as follows: 5 plots in the grassland and 30 distributed among the young poplar, mature poplar and poplar-willow types. Three plots were clipped inside and three outside each triangular exclosure on the grassland. In the forest community of the control, only 10 plots were clipped inside and 10 plots clipped outside each rectangular exclosure. The number of plots chosen in the grassland and forest types was derived from 1968 data using a sample size formula of Guenther (44). The vegetation in the plots was clipped at ground level with hand shears, placed in plastic bags and frozen within 4 hours. The number of stems and average height of the shrub species in each one-foot-square plot was recorded. The amount of browsing on each shrub was measured after a method by Cooke et al (22). The clipped vegetation was hand sorted into grass, sedge, forb and litter categories. The percentage, by weight, of each species in the grass category was estimated. Throughout the estimations, 10 samples were sorted to species to check the accuracy of the estimation. No attempt was made to sort sedges to species due to a lack of fruiting heads. The forbs were sorted to the species level as in 1968. After sorting, the vegetation was air dried to a constant weight and weighed.

2. Animal Observations

A. 1968

For 11 days of the grazing period, the observer recorded location as well as feeding and resting activity of each animal every one-half hour during the 2-hour observation periods. The morning period was between 6 and 10 A.M. and the evening period between 3 and 7 P.M. If the positions of all the animals were recorded in less than one-half hour, the remainder of the interval was spent recording the time that smaller groups of animals spent in the various plant communities. Due to heavy brush cover, it was not always possible to locate all animals every one-half hour.

B. 1969

Observations of the grazing animals' location and activities were also recorded in the 1969 season. A major difference from the 1968 method was that location and activity of as many animals as possible were recorded every 15 minutes during each two hour observation period. The shorter observation interval was made possible by placement of bells on 11 cows, enabling more rapid location of the animal groups. Observations were made on 19 days of the 56 day grazing period.

3. Soil Description

On October 11, 1968, eighteen two inch soil cores were obtained from selected areas throughout the study area. The soil cores were identified and described by Mr. T.W. Peters[1]. Ten percent HCl was used during the identification procedure to determine the $CaCo_3$

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[1] Officer in charge. Research Branch (Soil Survey) Canada Department of Agriculture, Edmonton, Alberta.

level. As many soil cores as possible were taken adjacent to vegetation plots. This procedure was followed to relate the soil to characteristics of the vegetation.

4. Chemical Analysis of Selected Herbage Samples

Samples of selected important herbaceous species from grassland and forest communities were collected for chemical analyses. The species were selected from a number of different topographic positions throughout the grassland and forest communities of treatments A and C north of the study field. Within 24 hours of clipping, the selected species which had been kept in plastic bags were weighed and air dried. Eight weeks after clipping the samples were taken to the Soil and Feed Testing Laboratory, Alberta Department of Agriculture, where they were analyzed for protein, crude fibre, phosphorus and calcium.

5. Weather Data

Precipitation and temperature readings for the Kinsella area were obtained from a Department of Transport meteorological station which is located on the University of Alberta Ranch approximately 1 mile from the study area.

RESULTS AND DISCUSSION

1. Climate

The average growing season precipitation at Kinsella is approximately 11 inches but there is a great year to year variation. In 1969 the last half of May and all of June and August were much drier than equivalent 1968 periods (Figures 5 and 6). By June 30 there was 2.4 inches less precipitation than the same period a year earlier (Table 1). At the end of August in 1969 the accummulated precipitation was 3.5 inches lower than the same period in August of 1968.

In 1969 the mean monthly temperature was above average for the months of April, May, June and August (Table 2). In 1968 the temperature was above average during April and June.

Table 1. Cumulative monthly precipitation (inches), Kinsella.

	Months								
	April	May	June	July	August	September	October	November	December
1962-67[1]	2.03	3.56	6.80	9.98	12.97	14.15	14.60	15.56	16.17
1968	3.92	4.74	7.24	10.24	12.76	16.34	17.07	17.12	17.93
1969	2.92	4.38	4.80	8.68	9.31	12.35	12.61	13.38	14.81

[1] 2 to 6 year monthly averages because of incomplete data.

Table 2. Mean monthly temperatures, Kinsella (°F).

	Months					
	April	May	June	July	August	September
1962-67	35.6	50.2	54.1	63.3	61.8	51.8
1968	39.0	49.8	57.6	61.4	56.9	50.1
1969	43.7	50.4	57.0	61.2	62.9	50.6

Figure 5 Daily precipitation in 1968 at Kinsella

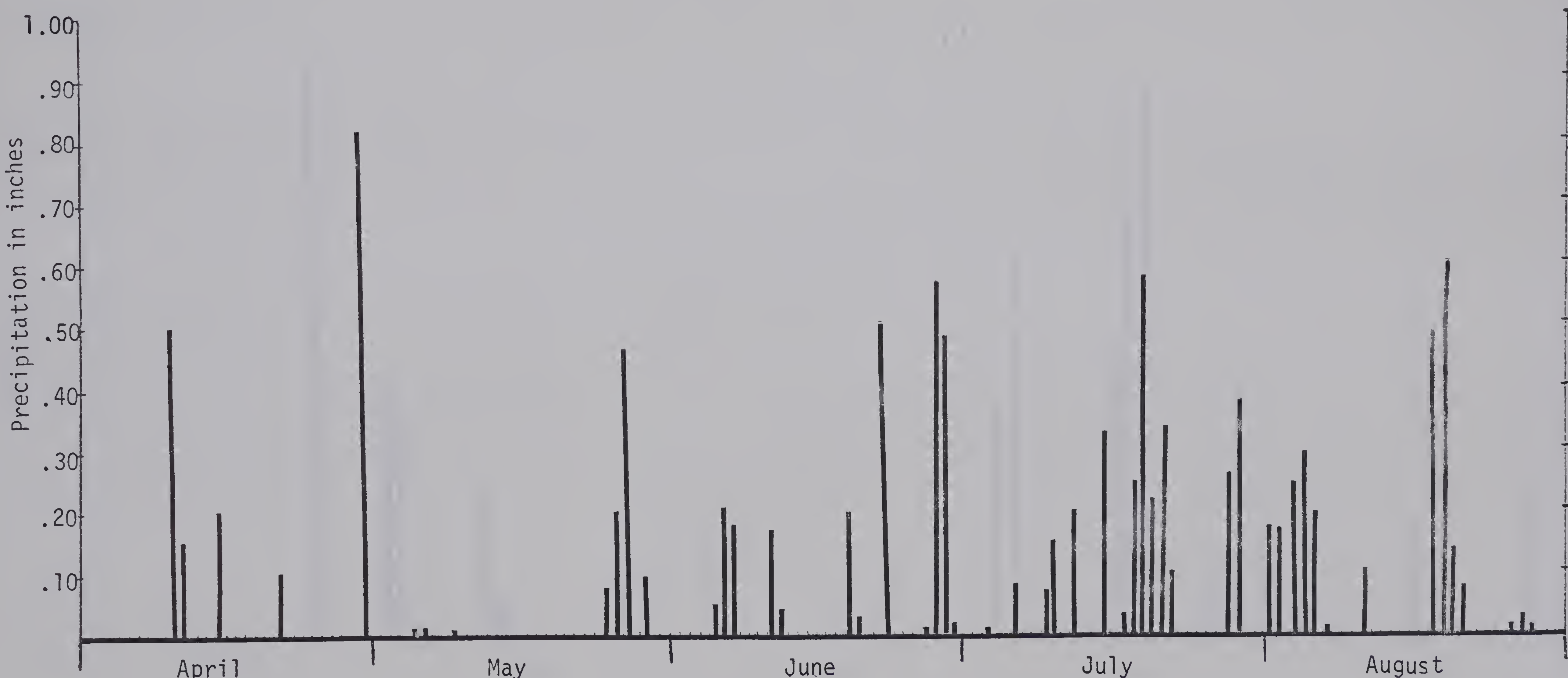
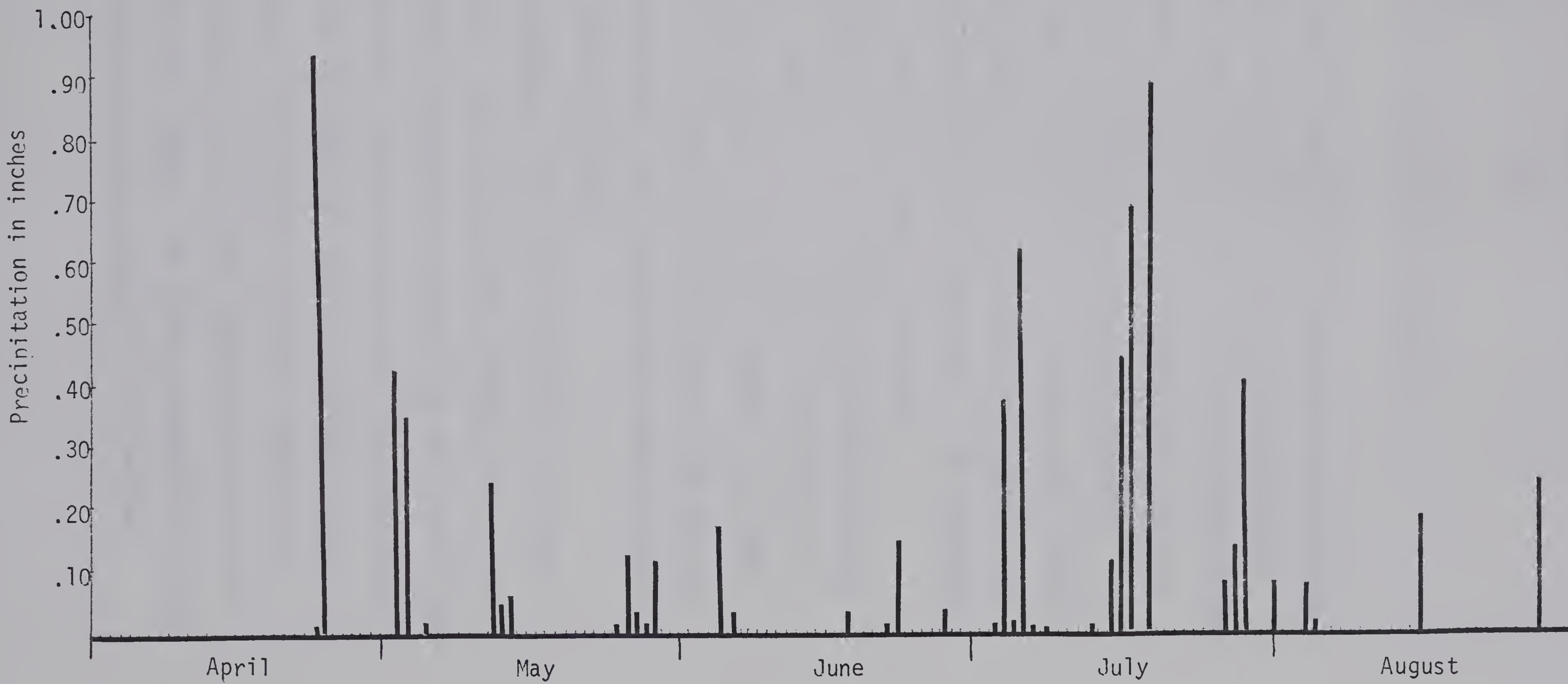


Figure 6 Daily precipitation in 1969 at Kinsella



2. Soil and Vegetation

A. Chernozemic soil and grassland vegetation.

i) Soil

The soil is well to imperfectly drained with a Chernozemic Ah horizon. The B and C horizons have a high base saturation with calcium as the dominant cation (13). These soils have developed under xerophyllic or mesophyllic grasses. The Chernozemic soil order can be further subdivided into the Dark Brown and Black Chernozems.

The Dark Brown soils are common on the upper, well-drained southerly facing slopes (Appendix 1). Black soils are common on the lower slopes and usually adjacent to the forest edge. The vegetation of these Black soils is frequently shaded by the trees.

The main subgroups of the Dark Brown Chernozems are Rego, Calcareous and Orthic. The Rego subgroup lacks a B horizon and is usually on the upper-most portion of the hill (Appendix 1). These soils are usually very well drained and well exposed to the sun and wind. The Calcareous and Orthic subgroups are more common on sites less exposed to the weathering elements.

The Orthic subgroup of the Black Chernozems is the most common with Regol cumulic, Thin and Calcareous (gleyed) also present. The Ah, Bm and Bk horizons are generally thicker than the same horizons in the Dark Brown Chernozems. The Ah horizon of the Black Chernozem is darker in color than the Dark Brown Ah horizon. The Thin subgroup occurs on the mid-slope of hills whereas the Orthic, Cumulic and Calcareous (gleyed) subgroups are on lower slopes receiving run-off and discharge from the upper slopes. The latter subgroups are similar to the Thin subgroup except for having thicker A and B horizons.

ii) Grassland Vegetation

The most frequently occurring and most productive grasses are *Festuca scabrella, Stipa spartea* var. *curtiseta* and *Agropyron* spp. (Appendix 2). *Carex* spp. are very common but their production is quite low (78 lb/acre) relative to their high frequency (100%). *Muhlenbergia cuspidata, Bouteloua gracilis* and *Koleria cristata* are also present but they account for very little of the total production.

The most common and productive forbs on the grassland are *Comandra pallida, Artemisia frigida, Thermopsis rhombifolia, Aster* spp; *Galium boreale* and *Achillea millefolium*. The last three species named are also common in the forest community. The forbs constitute a relatively small portion of the total grassland herbage production, 140 lb/acre compared to 800 lb/acre of the grass-sedge component.

The vegetation of the Dark Brown Chernozems is usually quite different than that of the Black Chernozems. *Stipa spartea* var. *curtiseta* and *Bouteloua gracilis* are indicative of a dry type of habitat and they form an important part of the herbage production of Dark Brown soils on upper slopes (Appendix 1). The lower, moister Black Chernozemic soils are dominated by *Festuca scabrella*.

The distribution of shrubs is sporadic; *Rosa arkansana, Symphoricarpos occidentalis* and *S. albus* have the highest frequency and density. (Appendix 3).

B. Grey Luvisolic soils and associated forest vegetation.

i) Soil

These soils are well to imperfectly drained and have developed under forest vegetation (13). The diagnostic features of the soil profile include an LH horizon composed mostly of leaf litter, and an eluviated A horizon underlain by a Bt horizon.

ii) Vegetation

The trees and shrubs are the most important components of the vegetation. The lower herbaceous vegetation consists of many plants found in the grassland community. This is especially true in the small poplar type which lies adjacent to the grassland. *Festuca scabrella, Agropyron* spp. and *Carex* spp. are the most common and productive grasses and grasslike species in the small poplar type (Appendix 2). The forb production (169 lb/acre) is much higher than the grass and grasslike production (93 lb/acre) in this forest type. The most common and productive forbs are *Galium boreale, Fragaria virginiana, Lathyrus venosus,* and *L. ochroleucus.* Herbaceous species in the large poplar type have a lower frequency and production than the small poplar type.

The herbaceous species frequency and production increase considerably in the poplar-willow type. The most common and productive grasses are *Poa* spp., *Calamagrostis neglecta* and *Bromus ciliatus*. *Carex* spp. are common in this forest type and produce about 90 lb/acre.

Forb production (151 lb/acre) is nearly equal to that of the grass-sedge components (183 lb/acre). *Fragaria virginiana, Arenaria lateriflora, Labiteae* spp., *Taraxacum officinale* and *Vicia americana* are the most common forb species.

The shrub species with the highest frequency and density are *Rosa woodsii, R. acicularis, Symphoricarpos occidentalis, S. albus* and *Rubus strigosus*.

C. Glysolic soils and associated wetland vegetation.

i) Soil

These soils have developed in depressions where a fluctuating water table has influenced profile development (13). Both the Humic

and Humic Eluviated great groups are present in the study area (Appendix 1). The distinguishing feature of these soils is the presence of strongly gleyed horizons.

ii) Vegetation

The most common vegetation associated with these soils is the poplar-willow and wet meadow types. *Carex aquatalis* and *C. vesicaria* are the herbaceous dominants in the wet meadow type (Appdendix 2). *Agropyron* and *Poa* spp., however, produce about 500 lb/acre in this type. Few forbs are present in the wet meadow type.

3. Forage production

A. Grassland type

i) 1968

Total herbage production ranged from 1674 lb/acre to 1843 lb/acre (Table 3). The amount of dead herbage ranged from 24% of the total herbage production in treatment B to 41% in the control. The small quantity of dead herbage in treatment B was apparently caused by the fall burn of 1967. The green grass and sedge category constituted 84% to 87% of the green herbage production.

The burning done in treatment B not only decreased its dead herbage production but could also be responsible for the greater total annual production in treatment B compared to treatment A and the control. Although the increase in the grass-sedge and forb categories of treatmentB was not significantly greater than the other treatment,A,or the control a number of authors found similar increases following burning. Vogl (80) reports a three fold increase in the forage production following burning trials in Wisconsin. Wahlenberg

Table 3. Herbage production (lb/acre) by year, tree sucker and shrub density[1] (stems/100 sq ft) in selected treatments of the grassland type.

	1968			1969		
	A	B	Control	A	C	Control
Herbage						
Total herbage	1677	1674	1843	1980	1954	1794
Dead herbage	606a[2/]	400b	754a	873f[3/]	894f	852f
Green herbage	1071	1274	1089	1107	1060	942
Green grass and sedge	956a	1064a	970a	964fg	1008f	799g
Green forbs	115a	210a	119a	143f	52g	143f
Woody sucker and shrub density				77	130	100

[1] Mean density inside and outside the exclosure

[2] Production values within each row in 1968 followed by a common letter between a and c do not differ statistically at the 0.05 level.

[3] Production values within each row in 1969 followed by a common letter between f and h do not differ statistically at the 0.05 level.

et al (81) and Ehrenreich (37) both report the retarding effects of litter on grassland plant growth. Ehrenreich and Aikman (38) report burning to be beneficial for some native grasses and detrimental to others. The effects of fire can be very complicated and as reported by Ahlgren (1) each case of increase or decrease in productivity must be considered individually. The lack of a second application of herbicide in treatment B in 1968 could also account for a greater forb production in treatment B than in treatment A.

ii) 1969

A range of 1794 lb/acre to 1980 lb/acre occurred in the total herbage production (Table 3). The amount of dead herbage was nearly equal in the treatments and control, ranging between 852 lb/acre and 894 lb/acre. A low grass-sedge production of 799 lb/acre occurred in the control compared to 1008 lb/acre in treatment C. There was a slightly rougher topography in the control relative to the treatment which would have resulted in a greater proportion of south facing slopes with associated dark brown soils.
The lower herbage production of the control could therefore be due to a greater number of plots occurring on the upper less productive sites of the dark brown soils in the control. The species composition of the treatments and control verifies the theory that the control had many grassland plots in the upper drier areas. (Table 4). For example the frequency and production of *Festuca scabrella* and *Agropyron subsecundum* was much lower in the control than in treatments A and C. These two species are characteristic of lower, moister grassland areas(14) (64). Conversely a grass like *Stipa spartea* var.*curtiseta* which is indicative of a dry grassland site has a higher production in the control than in the treatments.

Table 4. Frequency (%) and annual production of herbaceous species in the grassland type of treatments A, C and the control, 1969.

Species	Frequency A	Frequency C	Frequency Control	Annual production A	Annual production C	Annual production Control
Carex spp.	87	100	100	89a[1]	135a	78a
Grass						
Festuca scabrella	50	82	60	300ab	500a	273b
Agropyron subsecundum	43	29	3	307a	119bc	4c
Agropyron spp.	40	39	63	91a	127a	109a
Stipa spartea var. *curtiseta*	13	14	40	29a	49a	175b
Poa spp.	30	4	7	57a	2b	3b
Bouteloua gracilis	0	11	20	0	22	16
Other grasses				95a	56a	142a
Forbs						
Galium boreale	27	18	13	35a	11a	21a
Aster spp.	37	14	13	34a	8b	2b
Fragaria virginiana	17	4	7	19a	2b	.5b
Comandra pallida	17	7	40	7a	1a	26b
Artemisia frigida	0	0	17	0	0	32
Thermopsis rhombifolia	7	7	20	9a	6a	14a
Viola adunca	23	11	10	5a	7a	1a
Aster hesperius	3	0	10	15	0	26
Other forbs				20	18	20

[1] Production values within each row followed by a common letter between a and c do not differ statistically at the 0.05 level using the LSD test.

A greater production of the *Agropyron subsecundum* - *Poa* spp. component and lower production of *Festuca scabrella* in treatment A compared to treatment C was caused by a large amount of previous settler cultivation in the treatment A grassland. Cultivation could have also caused the increased production of *Fragaria virginiana* and *Aster* spp. in treatment A.

The reason for the relatively high forb production in the control was a greater abundance of *Artemisia frigida, Comandra pallida* and *Thermopsis rhombifolia*. These species are all indicative of drier, well drained sites (14) (64) indicating that the control had more of the *Stipa spartea* var. *curtiseta* grassland community.

The forb production in treatment C was significantly less than in the control. The lower production of *Galium boreale, Comandra pallida* and *Thermopsis rhombifolia* in treatment C compared to the control could be the result of the herbicide or differences in site. The high forb production in treatment A even after the herbicide application was likely due to an invasion of the cultivated areas of treatment A by a number of forbs prior to herbicide application. Use of 2,4-D at similar concentrations as in this study showed good control of *Artemisia frigida* but little effect on *Cerastium arvense, Anemone patens* and *Phlox hoodii* (75). Table 4 reveals that good control of *Artemisia frigida* was obtained in treatments A and C.

It is difficult to accurately determine the effect of herbicides on forb species without knowing the relative abundance of forbs in the treatment and control prior to herbicide application. The herbicide did not affect shrubs in the grassland, except *Elaeagnus commutata*. There does not seem to be any reasonable explanation for the relatively high amount of *Rosa arkansana, Symphoricarpos occidentalis*

and *S. albus* in treatment C compared to the control and treatment A (Table 5).

iii) 1968 and 1969

The most noticeable difference between the two years is the increase in the total herbage production of treatments A and C in 1969 over treatments A and B in 1968, while there is a decrease in the 1969 control production. The increase in 1969 is due to greater dead herbage production. Excluding the effect of fire on treatment B in 1968 the main cause for more dead herbage would be a lighter grazing pressure in 1968 season compared to 1967. The 1967 grazing pressure was approximately 0.38 A.U.M/acre[1] compared to 0.14 A.U.M/acre in the two week grazing period of 1968. Much of the grazing which took place in the 1967 season was in the late spring and early summer. This early grazing relative to 1968 would account for more litter being removed since less herbage would have been available at this time.

In 1969, total annual production of the control was 147 lb/acre less than the 1968 level. As mentioned in the methods section, triangular exclosures were used in 1969 to sample the grass areas farther from the forest border. This gave a more representative cross-section of the control grasslands resulting in a larger number of samples being taken from less productive upper slope communities. Fewer stands of less productive upper slope communities occurred in treatment A than in the control. Therefore, 1969 production of treatment A was not lowered by the placement of triangular exclosures away from the forest edge .

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[1] Personal communication H.W. Fulton, June 10, 1970

Table 5. Frequency (%), density (stems/100 sq ft) and height (inches) of shrubs in the grassland type.

	Frequency			A		C		Control	
	A	C	Control	Density	Height	Density	Height	Density	Height
Rosa arkansana	21[1]	42	19	36	5	90	4	35	4
Symphoricarpos spp.	21	16	23	39	7	71	12	42	13
Elaeagnus commutata								10	23

[1] Frequency, density and height of shrubs from plots inside the exclosure (ungrazed).

The ten samples which were sorted to the species level after the weight of each species was estimated showed the following results. The estimated weight was within ± 11% of the actual species weight when the production of the particular species was greater than 200 lb/acre . When the species weight was less than 200 lb/acre the estimate was only within ± 66% of the actual weight.

B. Small poplar type

i) 1968

The beneficial effect of the herbicide is shown by the much greater herbage production in the sprayed areas (Table 6). There was a low total herbage production of 348 lb/acre in the control compared to a low of 1400 lb/acre in the treated areas. The dead herbage constituted 8% to 24% of the total herbage production. As in the grassland type, the low dead herbage production in treatment B relative to treatment A would be caused by the 1967 fall burn. The low annual production in the control accounts for its low dead herbage production.

The green forb production ranged from 108 lb/acre to 545 lb/acre and constituted 20% to 40% of the green herbage production. This was much higher than the forb percentage in the grassland which ranged from 11% to 16% of the green herbage production.

The lack of herbicide and possibly the burning done in treatment B could account for its high relative forb production. For example the forb percentage in treatment B was 41% compared to 19% in treatment A which received two herbicide applications.

ii) 1969

As in 1968, the control of the woody overstory species

Table 6. Herbage production (lb/acre) by year, tree sucker and shrub density[1] (stems/100 sq ft) in selected treatments of the small poplar type.

	1968			1969		
	A	B	Control	A	C	Control
Herbage						
Total herbage	1400	1425	348	1887	1660	433
Dead herbage	340a[2/]	113ab	71b	865f[3/]	540g	173h
Green herbage	1060	1312	277	1022	1120	260
Green grass and sedge	849a	767a	169b	677f	762f	93g
Green forbs	211a	545b	108a	345f	358f	167f
Woody sucker and shrub density				231	194	354

[1] Mean density inside and outside the exclosure

[2] Production values within each row in 1968 followed by a common letter between a and c do not differ statistically at the 0.05 level.

[3] Production values within each row in 1969 followed by a common letter between f and h do not differ statistically at the 0.05 level.

resulted in a substantial increase in herbage production (Table 6). The total herbage production was 1887 lb/acre and 1660 lb/acre in treatments A and C, respectively, compared to only 433 lb/acre in the control. The dead herbage percentage ranged from 33% to 46% of the total herbage. The lower dead herbage production in treatment C relative to treatment A may have been due to a heavier grazing pressure in treatment C in 1968. It also may have been due to a lower 1967 and 1968 herbage production in treatment C because of poorer control of woody species by the August, 1966, spraying. Prior to the second herbicide application in 1968, the woody species in treatment C were not as well controlled as in treatment A. The control of woody species in treatment C appeared much more effective in the 1969 season after the second herbicide application. The nearly equal control in treatments A and C by 1969 was substantiated by the fact that the annual production of the two treatments was nearly equal.

The grass-sedge production ranged from a low 93 lb/acre in the control to 677 lb/acre and 762 lb/acre in treatments A and C, respectively. The sedge component was very common in this vegetation type although it contributed only 11% of the total grass-sedge production in treatments A and C and 40% in the control (Table 7).

Festuca scabrella and *Agropyron subsecundum* produced 333 lb/acre and 420 lb/acre, approximately 50% of the total grass-sedge production in treatments A and C, respectively. As suggested by the high frequency of these species in the control, this high production may be attributed to a high frequency prior to treatment. The greater abundance of *Agropyron subsecundum* and *Poa* spp. in treatment A compared to treatment C again indicated the effect of previous cultivation by

Table 7. Frequency (%) and annual production (lb/acre) of herbaceous species in the small poplar type of treatments A, C and the control, 1969.

	Frequency			Annual Production		
Species	A	C	Control	A	C	Control
Carex spp.	32	77	82	87	65	37
Grass						
Festuca scabrella	2	65	55	35a[1]	320	9a
Agropyron subsecundum	56	31	0	298	100	0
Agropyron spp.	10	31	36	26a	77a	33a
Calamagrostis neglecta	10	12	0	58	69	0
Poa spp.	46	23	9	147	31	0
Bromus spp.	10	15	18	21	50	1
Other grasses				2	52	13
Forbs						
Fragaria virginiana	85	69	27	140ab	155a	18b
Galium boreale	54	23	45	66a	13bc	31ac
Arenaria lateriflora	22	31	0	24	38	0
Aster spp.	10	15	9	60	5	7
Lathyrus spp.	7	19	27	1a	8a	80b
Other forbs				59	88	33

[1] Production values within each row followed by a common letter between a and c do not differ statistically at the 0.05 level using the LSD test.

homesteaders in treatment A.

The more than double increase in forb production of the treatments over the control was mostly due to an increase in the production of *Fragaria virginiana* (Table 7). *Galium boreale* may have been slightly more susceptible to the herbicide or less competitive than the *Fragaria virginiana* as indicated by its low production in the treatments and high frequency in the control. *Arenaria lateriflora* and *Aster* spp. also produced a substantial portion of the forb production. An unfortunate part of the herbicide application was the reduction of *Lathyrus venosus* and *L. ochroleucus*, two excellent forage species.

The effectiveness of the herbicides on woody plant control was shown by the reduction in the frequency and density of *Symphoricarpos occidentalis* and *S. albus*, *Rosa woodsii* and *R. acicularis* and *Rubus pubescens* and *R. strigosus* (Table 8).

The single application of 2,4,5-T did not appear to be very effective in reducing the density of the 2,4-D resistant *Rosa* spp.. *Symphoricarpos* spp. and *Rubus* spp. appeared to be more readily controlled by the herbicide. The abundance of shrubs in the treatments in addition to the presence of *Populus tremuloides* suckers exclusively in the treatments indicated there was a substantial regrowth of woody species.

(iii) 1968 and 1969

The only substantial difference in the 1968 and 1969 seasons was the greater total herbage production in 1969. As in the grassland , this increase was due to the greater amount of dead herbage in 1969, a result of a higher grazing intensity in 1967 relative to 1968.

Table 8. Frequency (%), density (stems/100 sq ft) and height (inches) of poplar suckers and shrubs in the small poplar type.

	Frequency			A		B		Control	
	A	C	Control	Density	Height	Density	Height	Density	Height
Symphoricarpos spp.	28[1]	42	73	64	11	104	14	218	13
Rosa spp.	26	31	36	56	13	69	16	82	16
Populus tremuloides	18	27	0	31	14	42	14	0	0
Rubus spp.	13	4	45	21	9	8	6	64	7
Ribes spp.	8	0	0	36	15	0	0	0	0

[1] Frequency, density and height of shrubs from plots inside the exclosure (ungrazed).

C. Large poplar type

i) 1968

Total herbage production was much less than in the small poplar type (Tables 6 and 9). Beneficial effects of the herbicide in controlling the competition of woody species was shown by the substantial increase in the total herbage production of treatments compared to the control.

Total herbage production ranged from a low of 101 lb/acre in the control to a high of 805 lb/acre in treatment B (Table 9).

The percentage of dead herbage in total herbage was low, ranging from 3% to 9%. The small amount of dead herbage in the treatments suggests that there was little herbage growth in this vegetation type during the 1967 season.

The nearly equal and low amount of dead herbage in the two treatments indicated that the burning done in treatment B had little effect on this vegetation type compared to the small poplar and grassland types. Bailey[1] reports very little burning occurred in the large poplar type during the 1967 burning.

As in the smaller poplar type, the percentage of forbs in the green herbage was lower in the treatments than in the control. This again demonstrated the selective nature of the herbicide against the forb component of the vegetation. Treatment B, sprayed only once, had a significantly greater forb production than the twice sprayed treatment A.

ii) 1969

The beneficial effect of the herbicide was shown by the

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[1]Personal communication, A.W.Bailey, July 14, 1970.

Table 9. Herbage production (lb/acre) by year, tree sucker and shrub density[1] (stems/100 sq ft) in selected treatments of the large poplar type.

	1968			1969		
	A	B	Control	A	C	Control
Herbage						
Total herbage	390	805	101	1624	1806	110
Dead herbage	34ab[2/]	39a	3b	622f[3/]	592f	16g
Green herbage	356	766	98	1002	1214	94
Green grass and sedge	247a	410a	25b	645f	1028g	29h
Green forbs	109a	356b	73a	357f	186gh	65h
Woody sucker and shrub density				268	215	275

1 Mean density inside and outside the exclosure

2 Production values within each row in 1968 followed by a common letter between a and c do not differ statistically at the 0.05 level.

3 Production values within each row in 1969 followed by a common letter between f and h do not differ statistically at the 0.05 level.

1624 lb/acre and 1806 lb/acre total herbage production in treatments A and B respectively compared to 110 lb/acre in the control. The dead herbage production in this large poplar type was much higher in 1969 compared to 1968. The production ranged from a high of 622 lb/acre in treatment A to a low of 16 lb/acre in the control. The much larger amount of litter in the treatments relative to the control was due to a carry-over from the high annual production in 1968.

The green herbage production ranged from a high of 1214 lb/acre in treatment C to a low of 94 lb/acre in the control. The green herbage production of treatment C was 212 lb/acre more than that of treatment A because of a higher production in the grass-sedge category. The greater production of treatment C was due to a greater production in *Carex* spp.,*Calamagrostis neglecta* and *Schizachne purpurascens* (Table 10).

The high forb production in treatment A was due to a greater production of *Fragaria virginiana*, *Arenaria lateriflora*, *Aster hesperius*, *A. laevis*, *Cerastium arvense* and *C. nutans*. The greater forb production in treatment A relative to treatment C helped to balance out the high grass-sedge production in the latter treatment.

The herbicides reduced the frequency of most shrubs and woody suckers with the exception of *Ribes* spp . and *Populus tremuloides* (Table 11). *Rosa woodsii* and *R. acicularis* in treatment C and *Rubus strigosus* and *R. pubescens* in treatment A had higher densities even though the frequencies were lower than the control. The frequency and density of *Ribes* spp. was still higher in Treatment A compared to treatment C and the control. As in the small poplar type, *Populus*

Table 10. Frequency (%) and annual production (lb/acre) of herbaceous species in the large poplar type of treatments A, C and the control, 1969.

Species	Frequency			Annual Production		
	A	C	Control	A	C	Control
Carex spp.	63	78	42	261a[1]	385b	17c
Grass						
Agropyron subsecundum	29	25	6	190a	121ab	3b
Agropyron spp.	4	11	12	3	45	2
Bromus spp.	16	18	9	31	57	4
Calamagrostis neglecta	18	32	0	69a	170b	0
Poa spp.	23	16	3	70	63	4
Schizachne purpurescens	0	20	3	0	134a	4b
Other grasses				21	54	0
Forbs						
Fragaria virginiana	64	50	36	96a	73a	10c
Galium boreale	27	46	27	35ab	38a	5b
Cerastium spp.	4	7	3	61	3	0.5
Arenaria lateriflora	41	29	36	38a	4bc	2c
Lathyrus spp.	11	17	21	2a	5a	16b
Anemone canadensis	14	16	3	19	20	0.5
Thalictrum venulosum	5	20	9	13	18	3
Labiatae spp.	4	11	3	33	3	0.5
Other forbs				73	25	33

[1] Production values within each row followed by a common letter between a and c do not differ statistically at the 0.05 level using the LSD test.

Table 11. Frequency (%), density (stems/100 sq ft) and height (inches) of poplar suckers and shrubs in the large poplar type.

	Frequency			A		C		Control	
	A	C	Control	Density	Height	Density	Height	Density	Height
Symphoricarpos spp.	35[1]	25	61	82	11	40	15	110	12
Rosa spp.	26	42	48	39	19	93	15	74	17
Rubus spp.	28	3	39	68	12	4	6	55	17
Ribes spp.	19	1	10	70	14	3	12	13	7
Populus tremuloides	4	29	0	4	21	46	13	0	0
Elaeagnus commutata	0	0	3	0	0	0	0	3	12
Amelanchier alnifolia	0	0	10	0	0	0	0	10	43

[1] Frequency, density and height of shrubs from plots inside the exclosure (ungrazed).

tremuloides suckers were only found in the treatments and their frequency and density was much lower in treatment A relative to treatment C.

D. Poplar - willow type

i) 1968

The total herbage production ranged from 356 lb/acre to 1360 lb/acre (Table 12). As in the large poplar type, the low amount of dead herbage in the treatments and control was due to a low 1967 herbage production.

Green herbage of the treatments ranged from 726 lb/acre to 1267 lb/acre and this was two to four times the production of the control. As in previous vegetation types, treatment B had a higher grass-sedge production than treatment A (911 lb/acre vs. 579 lb/acre). The green forb production was higher in treatment B than in treatment A because of the abscence of the second (1968) application of herbicide.

ii) 1969

In contrast to the large poplar type, this vegetation type had a larger total herbage production in treatment A relative to treatment C (2253 lb/acre vs. 1700 lb/acre). The greater herbage production in treatment A would account for the significantly greater dead herbage production in treatment A relative to treatment C. The greater green herbage production in treatment A was due to a higher grass-sedge and forb production. Most of the green grass-sedge production of treatment A was composed of *Carex* spp. and *Calamagrostis neglecta*, *Poa* spp. and *Bromus* spp. (Table 13). The grass-sedge production of treatment C was composed primarily of *Carex* spp.,

Table 12. Herbage production (lb/acre) by year, tree sucker and shrub density[1] (stems/100 sq ft) in selected treatments of the poplar-willow type.

	1968			1969	
	A	B	Control	A	C
Total herbage	780	1360	356	2253	1700
Dead herbage	54ab[2/]	93a	27b	678f[3/]	428g
Green herbage	726	1267	329	1575	1272
Green grass and sedge	579a	911a	179b	982f	853f
Green forbs	147a	356a	150a	593f	437f
Woody sucker and shrub density				183	239

[1] Mean density inside and outside the exclosure

[2] Production values within each row in 1968 followed by a common letter between a and c do not differ statistically at the 0.05 level.

[3] Production values within each row in 1969 followed by a common letter between f and h do not differ statistically at the 0.05 level.

Table 13. Frequency (%) and annual production (lb/acre) of herbaceous species in the poplar-willow type of treatments A and C, 1969.

Species	Frequency A	Frequency C	Annual Production A	Annual Production C
Carex spp.	64	71	144a[1]	396b
Grass				
Calamagrostis neglecta	40	10	237a	4b
Agropyron spp.	24	38	79	240
Poa spp.	32	19	258	46
Bromus spp.	56	19	215	17
Schizachne purpurascens	4	5	6a	83a
Other grasses			37	41
Forbs				
Fragaria virginiana	60	62	302a	188a
Anemone canadensis	36	5	86a	8b
Galium boreale	16	48	10a	66b
Arenaria lateriflora	48	33	19a	23a
Taraxacum officinale	28	0	22	0
Aster spp.	20	5	14	14
Other forbs			65	89

[1] Production values within each row followed by a common letter between a and c do not differ statistically at the 0.05 level.

Agropyron spp. and *Schizachne purpurascens*.

The higher green forb production in treatment A was due to a greater amount of *Fragaria virginiana* and *Anemone canadensis*. The most productive forbs in treatment C were *Fragaria virginiana* and *Galium boreale*.

Treatment C had a much higher shrub and tree sucker density than treatment A (261 vs. 129) which could help to explain the lower herbage production in treatment C (Table 14). The greater density was from *Rosa woodsii, R. acicularis, Symphoricarpos occidentalis, S. albus* and *Populus tremuloides*. *Ribes* spp., *Rubus strigosus and R. pubescens* had a higher density in treatment A. The higher concentration of 2,4-D in treatment A appeared more effective for the control of *Populus tremuloides* suckers as was demonstrated in the previous forest types.

No control data was shown for this vegetation type because of the much smaller number of clipped plots relative to the treatments. High water levels in the spring of 1969 restricted the construction of exclosures in the poplar-willow type of the control. This, coupled with the lower sampling intensity in the control resulted in an inadequate number of samples.

iii) 1968 and 1969

As in the large poplar community, the increased green herbage of treatment A in 1969 relative to 1968 was due to the placement of the 1969 exclosures in the more productive areas. Some of the increase could be due to an increased establishment of the herbage

Table 14. Frequency (%), density (stems/100 sq ft) and height (inches) of poplar suckers and shrubs in the poplar-willow type.

	Treatments					
	A	C	A		C	
	Freq.	Freq.	Density	Height	Density	Height
Ribes spp.	25[1]	10	54	13	35	11
Rosa spp.	17	50	25	11	111	13
Symphoricarpos occidentalis	8	20	25	8	55	12
Populus tremuloides	4	30	8	20	50	13
Rubus spp.	13	5	17	8	10	15
Total			129		261	

[1] Frequency, density and height of woody suckers and shrubs from plots inside exclosures (ungrazed).

but it is not possible to determine this because of different sampling methods used in the two years.

E. Wetland type

1968

There was a range in the total herbage production from 2211 lb/acre to 5051 lb/acre in treatments A and B respectively. The dead herbage ranged from 96 lb/acre to 148 lb/acre and constituted approximately 3 percent of the total herbage production. The low percentage of dead herbage could have been due to heavy use and trampling coupled with rapid decomposition because of a high water table. The forb component constituted a low 0.1% to 1.0% of the total green herbage production (Table 15).

The relatively low green herbage production of treatment A compared to treatment B and the control may have been caused by the occurrence of this vegetation type as a narrow band between the poplar-willow type and the permanent bodies of water. The higher water table and shading by the near-by trees may have caused the lower relative production. The water level in the majority of wetland types in treatment B and the control was not above ground level for the entire growing season as it was in treatment A. Therefore the wetland herbage production of treatment B and the control was greater than that of treatment A because of fewer growth restrictions. The herbicides did not appear to have any noticeable effect on the vegetation of the wetland type.

Table 15. Herbage production (lb/acre) for 1968 only, in the wetland type.

	Treatments		
	A	B	Control
Total herbage	2211	5051	3546
Dead herbage	146	148	96
Green herbage	2065	4893	3450
Green grass and sedge	2001	4887	3414
Green forbs	64	6	36

4. Forage utilization

A. Grassland

i) 1968

The total herbage was used between 33% and 49% (Table 16). Cattle grazed the green herbage at two to four times the rate of the dead herbage. The comparatively high use of the total herbage production in treatment B was likely due to the reduced amount of dead herbage. Dead herbage constituted 24% of the total herbage in treatment B compared to 41% in treatment A and 36% in the control. The removal of dead herbage by burning made the highly preferred green herbage more available to grazing cattle. Other workers have also shown that animals prefer burned rangelands over adjacent unburned areas (18) (19) (36) (52).

Contrary to the previous discussion, the total herbage in the control showed a higher level of use than in treatment A but a greater weight of dead material was available in the control. The higher use of the control relative to treatment A may have been due to a greater proportion of desirable herbaceous species such as *Festuca scabrella*.

The forb utilization was quite variable, ranging from 16% in the control to 91% in treatment A. The utilization of the grass-sedge component was not as variable as use of forbs; the range in use was from 41% to 60%.

ii) 1969

The use of the total herbage production varied from a low of 17% in the control to a high of about 45% in the two treatments (Table 16). The dead herbage showed a negative use in the

Table 16. Herbage production (P) and utilization (U) for selected treatments in the grassland type.

			1968 A	1968 B	1968 Control	1969 A	1969 C	1969 Control
Total herbage	P	(lb/ac)	1677	1674	1843	1980	1954	1794
	U	(%)	33	49	42	45	46	17
Dead herbage	P	(lb/ac)	606a[1]	400b	754a	873f[2]	894f	852f
	U	(%)	10	14	26*2[3]	23	22*1	-21
Green herbage	P	(lb/ac)	1071	1274	1089	1107	1060	942
	U	(%)	46	60	53	62	66	51
Green grass and sedge	P	(lb/ac)	956a	1064a	970a	964fg	1008f	799g
	U	(%)	41*3	60*3	58*4	61[4] -	68-	51-
Green forbs	P	(lb/ac)	115a	210a	119a	143f	52g	143f
	U	(%)	91*3	64*2	16	69*2	37	53*1

[1] Production values within each row in 1968 followed by a common letter between a and c do not differ statistically at the 0.05 level using the LSD test.

[2] Production values within each row in 1969 followed by a common letter between f and h do not differ statistically at the 0.05 level using the LSD test.

[3] *1, *2, *3 use was significant at 0.10, 0.05 and 0.01 probability levels, respectively.

[4] - 1969 utilization of green grass and sedge was not analyzed statistically.

control and about 22% use in the treatments. Bailey (7) reports approximately four times as much dead material underneath *Elaeagnus commutata* shrubs than between them. The negative use of the dead herbage in the control may have been due to a chance occurrence of more clip plots directly under shrubs than between shrubs on the grazed plots outside the exclosure. When the ungrazed plots were clipped inside the exclosure more plots may have been taken between shrubs than underneath them. The shrub density outside the control exclosures was 103 stems/100 sq.ft. compared to 87 stems/100 sq. ft. inside the exclosures (Table 17).

In treatment A the shrub density inside and outside the exclosures was nearly equal and the dead herbage was used at 23%. The shrub density inside treatment C exclosures was nearly twice as dense as outside. This may indicate that the 22% use of dead herbage in this treatment was an overestimation or there may be little relationship between use of dead herbage and shrub density.

The difference in the amount of green material under the shrubs and between them is not as great as the difference in the amount of dead herbage (7). Therefore, the use of green herbage in the control should not be as severely affected by shrub density differences as the use of the dead herbage. The use of green herbage in the control was 51% while treatments A and C were grazed at greater than the 60% level. The low relative use of the green grass-sedge component in the control may be due to the greater shrub density outside the exclosure. The low relative use of the control could be due to less palatable herbage caused by a greater number of plots being on drier south-facing exposure.

Table 17. Tree sucker and shrub density (D) as stems/100 sq ft and % frequency (F) inside and outside grassland exclosures, 1969.

		Treatments					
		A		C		Control	
		Inside	Outside	Inside	Outside	Inside	Outside
Rosa arkansana	D	36	27	90	43	35	59
	F	21	19	42	23	19	28
Symphoricarpos spp.	D	39	38	71	10	42	34
	F	21	19	16	7	23	13
Elaeagnus commutata	D					10	10
	F					6	13
Ribes spp.	D			3	10		
	F			3	7		
Populus tremuloides	D		13		10		
	F		8		7		
Rubus spp.	D				3		
	F				3		
Amelanchier alnifolia	D				17		
					7		
Total sucker and shrub density		75	78	164	93	87	103

In the following discussion on utilization of individual herbaceous species, it is important to consider the relative frequency of species inside and outside the exclosure. Frequency and production are directly related. There is a correlation of 0.90 between the frequency and production of grass species in the grassland and a correlation of 0.57 between the frequency and production of forb species. If one assumes that grazing does not influence the frequency values, it should be possible to predict the original herbage production in a grazed area using the frequency data. The utilization value can therefore be adjusted upwards if the frequency value is higher in the grazed plots or downwards if the frequency is lower. However, before the extent of adjustments can be predicted, the exact relationship between frequency and production must be known for each species. Data was not available to make these determinations.

In treatment A, *Agropyron* spp. showed an 82% level of use and had a 15% lower frequency value outside the exclosure. In the same treatment, *Festuca scabrella* showed a 70% level of use and a 2% difference in frequency (Table 18). Because *Agropyron* spp. made up nearly one-half of the total grass production and it had a lower frequency outside the exclosure, the percentage use of *Agropyron* spp. should have been closer to the 64% use of the total grass production. The use of *Agropyron* spp. and *Festuca scabrella* in treatment C was also slightly overestimated because the frequency values were lower outside the exclosures.

The forbs constituted approximately 12% of the green herbaceous component in the treatments and control but some species showed fairly high levels of use. *Aster* spp., *Galium boreale* and *Fragaria*

Table 18. Frequency inside (I) and outside (O) exclosures, production (P) and utilization (U) of green herbaceous species in the grassland type, of treatments A, C and the control, 1969.

Grass and sedge		Frequency				Production and Utilization		
		A	C	Control		A	C	Control
Carex spp.	I (%)	87	100	100	P (lb/ac)[1]	89a[2]	135a	78a
	O (%)	84	93	100	U (%)	30	68*3[3]	21
Total grass	I (%)	100	96	100	P (lb/ac)	876	873	722
	O (%)	100	97	100	U (%)	64*3	68*3	54*3
Agropyron spp.	I (%)	87	75	67	P (lb/ac)	402	269	113
	O (%)	72	62	69	U (%)	82*3	71*3	60*1
Festuca scabrella	I (%)	50	82	60	P (lb/ac)	300ab	500a	273b
	O (%)	52	66	62	U (%)	70*2	75*3	50*2
Stipa spartea var. *curtiseta*	I (%)	13	14	40	P (lb/ac)	29a	49a	175b
	O (%)	20	21	31	U (%)	33	43	59*
Poa spp.	I (%)	33	4	7	P (lb/ac)	57	2	3
	O (%)	28	7	3	P (lb/ac)	-2	-100	82
Bromus spp.	I (%)	43	0	0	P (lb/ac)	43	0	0
	O (%)	23	0	3	U (%)	97*1		
Bouteloua gracilis	I (%)	0	11	20	P (lb/ac)	0	22	16
	O (%)	12	10	22	U (%)		81	20
Koeleria cristata	I (%)	10	7	10	P (lb/ac)	10a	3a	7a
	O (%)	32	14	13	U (%)	-27	-100	7
Muhlenbergia cuspidata	I (%)	7	7	17	P (lb/ac)	3a	3a	44a
	O (%)	24	17	13	U (%)	-223	-293	75
Other grasses		-[4]	-	-	P (lb/ac)	34	27	91

Table 18. (Continued).

Forbs		Frequency A	Frequency C	Frequency Control		Production and Utilization A	Production and Utilization C	Production and Utilization Control
Total forbs	I (%)	87	75	90	P (lb/ac)	143	51	143
	O (%)	88	66	91	U (%)	69	37	53
Galium boreale	I (%)	27	18	13	P (lb/ac)	35a	11a	21a
	O (%)	20	21	6	U (%)	78	56	87*1
Comandra pallida	I (%)	17	7	40	P	7a	.5a	26b
	O (%)	4	3	16	U	95*1	-33	82*2
Fragaria virginiana	I (%)	17	4	7	P	19a	2b	.5b
	O (%)	16	17	0	U	68	-405	0
Aster spp.	I (%)	40	14	20	P	49	8	28
	O (%)	40	17	25	U	77*1	57	65
Artemisia frigida	I (%)	0	0	17	P	0	0	32
	O (%)	0	0	16	U			64
Achillea millefolium	I (%)	37	25	27	P	5	9	6
	O (%)	52	21	19	U	-45	77	54
Thermopsis rhombifolia	I (%)	7	7	20	P	9	6	14
	O (%)	8	10	0	U	68	15	100*2
Viola adunca	I (%)	23	11	10	P (lb/ac)	5	7	1
	O (%)	20	17	16	U (%)	80	49	10
Other forbs	I (%)	-	-	-	P (lb/ac)	14	12	14
	O (%)	-	-	-	U (%)	-	-	-

[1] (lb/ac) is pounds per acre.

[2] Production values within each row followed by a common letter are not significantly different at the 0.05 level using the LSD test.

[3] *1, *2 and *3 indicates use was significant at 0.10, 0.05 and 0.01 probability levels respectively.

[4] - percent frequency and percent use of other grasses was not calculated.

virginiana were used extensively in treatment A but not in treatment C. Forb species supplying the bulk of the forb component that was used in the control were *Artemisia frigida, Aster* spp., *Comandra pallida* and *Galium boreale.*

Artemisia frigida showed a 64% use in the control but this species is an increaser (85). Although *Artemisia frigida* is described as an undesirable forb it possesses good nutritional value (16).

Aster spp. and *Galium boreale* appeared to be used consistently throughout the grassland community. Campbell, et al. (16) describe two asters (*Aster conspicuus* and *A. lindleyanus* T. & G.) as quite palatable but they are usually restricted to the woodlands. Research by Bailey (7) on a grassland site near the study area showed fairly high utilization values for a number of forbs. Forbs in the openings between the shrub *Elaeagnus commutata* received the following use: *Galium boreale* - 80%, *Achillea millefolium* - 71% and *Fragaria virginiana* - 37%. The three forbs showed a negative use when found underneath the shrubs.

The high use of *Festuca scabrella* in the grassland type agrees with results reported in the literature describing it as a very palatable grass (16) (85). *Agropyron subsecundum* was the most productive wheat grass and its high use also agrees with the literature (16) (85).

With the methods used to measure production and utilization it is difficult to accurately determine the utilization level of the low producing herbaceous species. The low producing *Bromus* spp. and *Bouteloua gracilis* are quite palatable and nutritious. *Bouteloua gracilis* is an increaser because of its low growth habit and consequent limited availability to grazing animals (16) (85). *Poa secunda*

is likely the most common bluegrass in the grassland and its low use agrees with the literature which describes it as unpalatable to livestock (16). The use of *Muhlenbergia cuspidata* may have been overestimated because of a low frequency value outside the exclosure.

The low growing shrub *Rosa arkansana* was the most readily used woody species in the treatments and control (Table 19). The lower height outside the exclosures in treatments A and C could have been due to heavy use by cattle. *Populus tremuloides* suckers showed moderate use in the treatments while *Symphoricarpos occidentalis* and *S. albus* were rarely used.

B. Small poplar type

i) 1968

The use of the total herbage production ranged between 22% and 63% (Table 20). The cattle used less than 16% of the dead herbage but consumed from 35% to 68% of the green herbage production. As in the grassland the higher relative use of treatment B would likely be due to burning. The total herbage of treatment B was used at 63% while treatment A and the control were only used at 29% and 22%, respectively. The high use of treatment B would likely be due to the low amount of dead herbage (8%) compared to 24% and 20% in treatment A and the control, respectively.

The green grass-sedge component of treatment A and the control was used at a low 26% and 23% respectively. The apparent high use of the forbs (63% to 53%) may be due to their greater susceptibility to weathering and trampling by cattle during the grazing period. Ratliff and Heady (70) working on California annual

Table 19. Tree sucker and shrub height (H) in inches and % utilization (U) inside and outside grassland exclosures, 1969.

		Treatments					
		A		B		Control	
		Inside	Outside	Inside	Outside	Inside	Outside
Rosa arkansana	H	5	1	4	1	4	4
	U		51		33		50
Populus tremuloides	H		2		10		
	U		25		33		
Rubus spp.	H				5		
	U				5		
Symphoricarpos spp.	H	7	7	12	5	13	10
	U		4				
Amelanchier alnifolia	H				9		
	U	3[1]					
Elaeagnus commutata	H					23	23
	U						

[1] Use inside the exclosure could have been due to deer browsing.

Table 20. Herbage production (P) and utilization (U) for selected categories in the small poplar type.

		1968 Treatments			1969 Treatments		
		A	B	Control	A	C	Control
Total herbage	P (lb/ac)	1400	1425	348	1887	1660	433
	U (%)	29	63	22	36	41	47
Dead herbage	P (lb/ac)	340a[1]	113ab	71b	865f[2]	540g	173h
	U (%)	15	-92	-18	32*1[3]	22	24
Green herbage	P (lb/ac)	1060	1312	277	1022	1120	260
	U (%)	33	68	35	41	49	63
Green grass and sedge	P (lb/ac)	849a	767a	169b	677f	762f	93g
	U (%)	26	72*1	23	44-[4]	50-	39-
Green forbs	P (lb/ac)	211a	545b	108a	345f	358f	167f
	U (%)	63*1	62*3	53*1	34	48*2	76

[1] Production values within each row in 1968 followed by a common letter between a and c do not differ statistically at the 0.05 level using the LSD test.

[2] Production values within each row in 1969 followed by a common letter between f and h do not differ statistically at the 0.05 level using the LSD test.

[3] *1, *2 and *3 use was significant at 0.10, 0.05 and 0.01 probability levels, respectively.

[4] - 1969 utilization of green grass and sedge was not analyzed statistically.

range report the dangers of mistaking a normal decline in herbage weight following maturity as a use by animals. The overestimation of use in this study may have occurred because of a weight loss following maturity, in the two week interval between clipping of the production and utilization plots.

ii) 1969

The utilization of total herbage production ranged from 47% use of 433 lb/acre in the control to 36% use of 1887 lb/acre in treatment A (Table 20). At these levels of use the cattle consumed an average of 678 lb/acre of the total herbage production from treatment A and C and 203 lb/acre from the control.

The use of the dead herbage was about 23% in treatment C and the control but it was 32% in treatment A. Unlike the grassland there was no relationship between level of dead herbage use and relative shrub density inside and outside the exclosures. For example the shrub density was higher in the grazed plots outside the exclosures of treatment A but the dead herbage was used at the highest rate (Table 21). The dead herbage may not be greater under the shrubs in this vegetation type because most of the herbage production in the treatments has developed in the past several years since herbicide treatment. This means that cattle have not yet been able to show the preference for areas between shrubs over those underneath shrubs and thereby change the dead herbage production beneath versus between shrubs.

Cattle removed 63% of the green herbage in the control compared to only a 41% use in treatment A. The high use of the control was due to a high level of forb use (Table 20), which may have

Table 21. Tree sucker and shrub density (D) as stems/100 sq ft and % frequency (F) inside and outside exclosures of the small poplar type, 1969.

		A		C		Control	
		Inside	Outside	Inside	Outside	Inside	Outside
Symphoricarpos spp.	D	64	70	104	63	218	243
	F	28	33	42	38	73	100
Rosa spp.	D	56	91	69	38	82	
	F	26	36	31	25	36	
Populus tremuloides	D	31	29	42	63		14
	F	18	15	27	29		14
Rubus spp.	D	21	48	8		64	14
	F	13	24	4		45	14
Ribes spp.	D	36	15				
	F	8	3				
Elaeagnus commutata	D						43
	F						14
Amelanchier alnifolia	D						29
	F						29
Total sucker and shrub density		208	253	233	164	364	343

been caused by a lower frequency of the forb category outside the exclosures compared to inside (Table 22). In particular, *Lathyrus* spp. and *Fragaria virginiana* had much lower frequency values outside the exclosures and both showed a very high use. Since the lower frequency would indicate a lower initial production, then the utilization percentage shown is an overestimation. It was overestimated because the production of these particular forbs was likely lower outside the exclosures before the cattle were placed in the study area.

Higher use of the green herbage in treatment C relative to treatment A may have been caused by the lower percent of dead herbage in the former treatment. The percentage of dead herbage in treatment C was 33% while it was 46% in treatment A. After consideration of the species frequency inside and outside the exclosures, the following were considered important herbaceous components: *Festuca scabrella* *Agropyron* spp. and *Poa* spp.. *Carex* spp. showed a low level of use in the treatments and control.

The forb species showing the greatest amount of use were: *Galium boreale, Aster* spp., *Arenaria lateriflora, Anemone canadensis* and *Cerastium* spp..

Fragaria virginiana showed a negative use in both herbicide treatments even though the production was around 150 lb/acre and the frequency was higher inside the exclosure (Table 22). One of the main reasons for this negative use may have been the particular growth form of the plant. *Fragaria virginiana* often formed dense, low-growing clumps. It appeared that this forb was not particularly available or desirable when it existed in this dense, low-growing

Table 22. Frequency inside (I) and outside (O) exclosures, production (P) and utilization (U) of green herbaceous species in the small poplar type, of treatments A, C and the control, 1969.

Species		Frequency A	Frequency C	Frequency Control		Production and utilization A	Production and utilization C	Production and utilization Control
Grass and Sedge								
Carex spp.	I (%)	32	77	82	P (lb/ac)[1]	87a[2]	65a	37a
	O (%)	50	92	50	U (%)	-1	-29	1
Total grass	I (%)	90	96	100	P (lb/ac)	591	697	57
	O (%)	72	92	100	U (%)	51*2[3]	57*3	63
Agropyron spp.	I (%)	63	62	36	P (lb/ac)	325	177	33
	O (%)	47	76	13	U (%)	46*1	-8	85
Festuca scabrella	I (%)	2	65	55	P (lb/ac)	35a	320b	9a
	O (%)	6	24	38	U (%)	64	93*3	-55
Poa spp.	I (%)	46	23	9	P (lb/ac)	149	31	1
	O (%)	31	40	0	U (%)	67*1	-81	100
Bromus spp.	I (%)	10	15	18	P (lb/ac)	22	50	1
	O (%)	22	24	0	U (%)	-59	57	100
Calamagrostis neglecta	I (%)	10	12	0	P (lb/ac)	58	69	0
	O (%)	9	0	0	U (%)	68	100	
Schizachne purpurascens	I (%)	0	8	0	P (lb/ac)	0	42	0
	O (%)	0	0	0	U (%)		100	
Other grasses	I (%)	-[4]	-	-	P (lb/ac)	2	10	12
	O (%)	-	-	-	U (%)	-	-	-

1 (lb/ac) is pounds per acre.

2 Production values within each row followed by a common letter are not significantly different at the 0.05 level using the LSD test.

Table 22. (Continued).

Species		Frequency A	Frequency C	Frequency Control		Production and utilization A	Production and utilization C	Production and utilization Control
Forbs								
Total forbs	I (%)	100	92	81	P (lb/ac)	345	358	167
	O (%)	97	88	63	U (%)	34	48	76
Fragaria virginiana	I (%)	85	69	27	P (lb/ac)	140ab	155a	18b
	O (%)	78	64	13	P (lb/ac)	-1	-5	95
Galium boreale	I (%)	54	23	45	P (lb/ac)	66a	13bc	31ac
	O (%)	38	28	63	U (%)	80*2	46	8
Aster spp.	I (%)	24	19	9	P (lb/ac)	65	61	7
	O (%)	22	8	0	U (%)	69	98*1	0
Arenaria lateriflora	I (%)	22	31	0	P (lb/ac)	24	38	0
	O (%)	25	8	0	U (%)	48	99*2	0
Anemone canadensis	I (%)	7	12	9	P (lb/ac)	11	28	6
	O (%)	6	8	0	U (%)	58	95	100
Cerastium spp.	I (%)	5	8	27	P (lb/ac)	11	24	5
	O (%)	6	20	13	U (%)	95	86	66
Lathyrus spp.	I (%)	7	19	27	P (lb/ac)	1a	8a	80b
	O (%)	25	0	13	U (%)	-200	79	92
Viola adunca	I (%)	22	15	18	P (lb/ac)	8	3	6
	O (%)	13	20	13	U (%)	66	-33	98
Other forbs	I (%)	-	-	-	P (lb/ac)	22.5	30.5	16
	O (%)	-	-	-	U (%)	-	-	-

[3] *1, *2 and *3 indicates use was significant at 0.10, 0.05 and 0.01 probability levels respectively.

[4] - percent frequency and percent use of other grasses was not calculated.

form but it showed high use when mixed in with other desirable vegetation.

As in the grassland, the shrubs *Rosa woodsii* and *R. acicularis* showed the highest level of browse use (Table 23). *Ribes* spp. and *Populus tremuloides* showed substantial use while *Symphoricarpos occidentalis* and *S. albus* were not readily used.

C. Large poplar type

i) 1968

Consumption of total herbage ranged from 40% to 44%(Table 24). The dead herbage showed zero use in the control and negative use in treatments A and B.

The green herbage also showed similar utilization throughout the treatments and control even though the treatments were three to seven times more productive.

The higher use of the grass-sedge production of treatment B relative to treatment A may have been due to the following:

a) mo e desirable species composition and greater availability because of high production (410 lb/acre vs. 247 lb/acre); and

b) attraction of the cattle to adjacent burned grassland and the small poplar type with their subsequent movement into the unburned large poplar type.

ii) 1969

Total herbage utilization ranged from a negative level in the control to a 48% level in treatments A and C (Table 24). This accounted for an average consumption of 823 lb/acre of total herbage in the treatments compared to non-use in the control.

Table 23. Tree sucker and shrub height (H) in inches and % utilization (U) inside and outside small poplar exclosures, 1969.

		Treatments					
		A		C		Control	
		Inside	Outside	Inside	Outside	Inside	Outside
Symphoricarpos spp.	H	11	10	14	12	13	11
	U		1		1		2.4
Rosa spp.	H	13	5	16	2	16	
	U		36		30		
Rubus spp.	H	9	6	6	0	7	2
	U		1				
Populus tremuloides	H	14	7	14	5		3
	U		8		28		
Ribes spp.	H	15	1				
	U		30				
Amelanchier alnifolia	H						35
	U						
Elaeagnus commutata	H						14
	U						

Table 24. Herbage production (P) and utilization (U) for selected treatments in the large poplar type.

		1968			1969		
		A	B	Control	A	C	Control
Total herbage	P (lb/ac)	390	805	101	1624	1806	110
	U (%)	41	40	44	48	48	-57
Dead herbage	P (lb/ac)	34ab[1]	39a	3b	622f[2]	592f	16g
	U (%)	-82	-26	0	33*1[3]	43*3	-94
Green herbage	P (lb/ac)	356	766	98	1002	1214	94
	U (%)	45	46	45	58	50	25
Green grass and sedge	P (lb/ac)	247a	410a	25b	645f	1028g	29h
	U (%)	38	49*2	49	58 - [4]	52 -	-7
Green forbs	P (lb/ac)	109a	356b	73a	357f	186f	65h
	U (%)	60*2	43*1	44*1	57*2	39*2	40*1

[1] Production values within each row in 1968 followed by a common letter between a and c do not differ statistically at the 0.05 level using the LSD test.

[2] Production values within each row in 1969 followed by a common letter between f and h do not differ statistically at the 0.05 level using the LSD test.

[3] *1, *2, and *3 use was significant at 0.10, 0.05 and 0.01 probability levels, respectively.

[4] - 1969 utilization of green grass and sedge was not analyzed statistically.

Although the level of use was the same in treatments A and C there was more total herbage consumed in treatment C because of higher use of dead herbage.

The use of green herbage in treatment A was 8% higher than in treatment C but the actual amount of green herbage consumed was about the same (600 lb/acre). The higher level of use in treatment A relative to treatment C was due to a higher level of use in both the green grass-sedge and green forb categories. The total sucker and shrub density was higher in treatment A than in treatment C (Table 25) and therefore would not be responsible for the higher use.

A difference in species composition between the two treatments would be the most logical explanation for the higher use of treatment A. *Carex* spp. showed approximately equal use in both treatments but the total grass production showed a 67% use in treatment A compared to a 55% use in treatment C (Table 26). The lower use of treatment C was due to lower relative use of *Agropyron* spp., *Calamagrostis neglecta* and *Bromus* spp.. One of the main reasons for the lower use may have been the presence of the unpalatable *Schizachne purpurascens* in treatment C. It had a low (37%) use even though the frequency was lower outside the exclosure. Campbell et al (16) describe this grass as unpalatable and it has a low protein and high fibre content during all stages of growth. The low use of this species and possible detrimental effects on grazing of other species growing with it may account for the lower percentage use of treatment C.

The green forb production and level of use was much higher

Table 25. Tree sucker and shrub density (D) as stems/100 sq ft and % frequency (F) inside and outside exclosures of the large poplar type, 1969.

		Treatments					
		A		C		Control	
		Inside	Outside	Inside	Outside	Inside	Outside
Symphoricarpos spp.	D	82	48	40	34	110	107
	F	35	25	25	19	61	59
Rosa spp.	D	39	79	93	110	74	96
	F	26	37	42	47	48	48
Rubus spp.	D	68	54	4	16	55	44
	F	28	31	3	6	39	30
Ribes spp.	D	70	77	3	10	13	4
	F	19	29	1	3	10	4
Populus tremuloides	D	4	13	46	73		
	F	4	12	29	40		
Amelanchier alnifolia	D		2			10	22
	F		2			10	19
Elaeagnus commutata	D					3	11
	F					3	4
Total sucker and shrub density		263	273	186	243	265	284

Table 26. Frequency inside (I) and outside (O) exclosures, production (P) and utilization (U) of green herbaceous species in the large poplar type, of treatments A, C and the control, 1969.

Species		Frequency A	Frequency C	Frequency Control		Production and utilization A	Production and utilization C	Production and utilization Control
Grass and sedge								
Carex spp.	I (%)	63	78	42	P (lb/ac)[1]	261a[2]	385b	17c
	O (%)	67	85	28	U (%)	45*2[3]	46*3	72*1
Total grass	I (%)	75	91		P (lb/ac)	384	643	13
	O (%)	64	74		U (%)	67*3	55*3	-107
Agropyron spp.	I (%)	32	36	18	P (lb/ac)	193	167	5
	O (%)	40	35	0	U (%)	61*1	44*1	100
Calamagrostis neglecta	I (%)	18	32	0	P (lb/ac)	69a	170b	0
	O (%)	4	17	0	U (%)	86*2	79*3	
Poa spp.	I (%)	23	16	3	P (lb/ac)	69	64	.5
	O (%)	22	13	0	U (%)	52	50	100
Bromus spp.	I (%)	16	18	9	P (lb/ac)	31	58	4
	O (%)	11	16	0	U (%)	70	33	100
Schizachne purpurascens	I (%)	0	20	3	P (lb/ac)	0	134a	4b
	O (%)	0	12	10	U (%)		37	75*2
Other grasses	I (%)	-[4]	-	-	P (lb/ac)	20	54	0
	O (%)	-	-	-	U (%)	-	-	-
Forbs								
Total forbs	I (%)	89	92	94	P (lb/ac)	357	187	65
	O (%)	91	98	79	U (%)	57	39	40
Fragaria virginiana	I (%)	64	50	36	P (lb/ac)	96a	73a	10c
	O (%)	65	56	21	U (%)	14	33	61
Galium boreale	I (%)	27	46	27	P (lb/ac)	35ab	38a	5b
	O (%)	31	47	17	U (%)	62*1	54*1	-100

Table 26. (Continued).

		Frequency				Production and utilization		
		A	C	Control		A	C	Control
Arenaria lateriflora	I (%)	41	29	36	P (lb/ac)	38a	4bc	2c
	O (%)	62	32	38	U (%)	43	-100	34
Anemone canadensis	I (%)	14	16	3	P (lb/ac)	19	20	.5
	O (%)	15	8	0	U (%)	78*	89*2	100
Aster spp.	I (%)	16	5	6	P (lb/ac)	24	5	1
	O (%)	16	8	3	U (%)	61	-.2	.02
Thalictrum venulosum	I (%)	5	20	9	P (lb/ac)	13	18	3
	O (%)	9	5	17	U (%)	83	99*2	-33
Lathyrus spp.	I (%)	11	17	21	P (lb/ac)	2a	5a	16b
	O (%)	24	26	31	U (%)	-.05	40	46
Cerastium spp.	I (%)	4	7	3	P (lb/ac)	61	3	.5
	O (%)	2	0	10	U (%)	98	100	-4
Other forbs	I (%)	-	-	-	P (lb/ac)	82	23	32
	O (%)	-	-	-	U (%)	-	-	-

1 (lb/ac) is pounds per acre.

2 Production values within each row followed by a common letter are not significantly different at the 0.05 level using the LSD test.

3 *1, *2 and *3 indicates use was significant at 0.10, 0.05 and 0.01 probability levels respectively.

4 - percent frequency and percent use of other grasses was not calculated.

in treatment A than in treatment C. In both treatments *Galium boreale, Anemone canadensis* and *Thalictrum venulosum* showed 50% to 99% levels of use. The greater production and hence greater availability of forbs in treatment A would account for high relative use.

As in the small poplar type, *Populus tremuloides, Ribes* spp., *Rosa woodsii* and *R. acicularis* were readily browsed by cattle (Table 27). Unlike the small poplar type, *Rubus strigosus* and *R. pubescens* also showed a heavy use by cattle in the large poplar type.

D. Poplar - willow type

i) 1968

The total herbage was used between 22% and 41% (Table 28). The 40% use of the total herbage in treatment B and the control was nearly identical to the level of use in the treatments and control of the large poplar type. The relatively low use in treatment A was caused by a negative use of the dead herbage. The green grass-sedge production of this poplar-willow type showed nearly identical use across treatments.

The green forbs showed a wide variation in use in this vegetation type. The high use in treatment B and the control was likely caused by a rapid loss of weight following maturity and by trampling rather than by grazing. It is unlikely that cattle would consume the forbs at such a high level when only about 28% of the grass-sedge component was grazed. The extreme variability in the forb use could be due to a differential species susceptibility to weight loss or trampling.

Table 27. Tree sucker and shrub height (H) in inches and % utilization (U) inside and outside large poplar exclosures, 1969.

		Treatments					
		A		C		Control	
		Inside	Outside	Inside	Outside	Inside	Outside
Rosa spp.	H	19	5	15	6	17	15
	U		47		30		17
Rubus spp.	H	12	6	6	6	17	10
	U		12		54		5
Populus tremuloides	H	21	6	13	6		
	U		43		3		
Ribes spp.	H	14	12	12	2	7	1
	U		10				
Symphoricarpos spp.	H	11	7	15	6	12	12
	U		2		1		2
Elaeagnus commutata	H					12	14
	U						
Amelanchier alnifolia	H					43	27
	U						1

Table 28. Herbage production (P) and utilization (U) for selected categories in the poplar-willow type.

	1968 Treatments			1969 Treatments	
	A	B	Control	A	C
Total herbage P (lb/ac)	780	1360	356	2253	1700
U (%)	22	40	41	28	53
Dead herbage P (lb/ac)	54ab[1]	93a	27b	678f[2]	428g
U (%)	-215	-29	-44	-44	29
Green herbage P (lb/ac)	726	1267	329	1575	1272
U (%)	32	45	47	46	61
Green grass and sedge P (lb/ac)	579a	911a	179 b	982f	835f
U (%)	29*2[3]	28	28	34	52*2
Green forbs P (lb/ac)	147a	356a	150a	593f	437f
U (%)	35	89	69	66*3	77*3

[1] Production values within each row in 1968 followed by a common letter between a and c do not differ statistically at the 0.05 level using LSD test.

[2] Production values within each row in 1969 followed by a common letter between f and h do not differ statistically at the 0.05 level using the LSD test.

[3] *1, *2, *3 use was significant at 0.10, 0.05 and 0.01 probability levels, respectively.

[4] -1969 utilization of green grass and sedge was not analyzed statistically.

ii) 1969

Use of the total herbage by cattle ranged from 28% in treatment A to 53% in treatment C (Table 28). This level of use accounted for an average total herbage consumption of 765 lb/acre from the treatments. A slightly greater shrub density outside the treatment A exclosures (236 vs. 216 stems/100 sq. ft.) and a greater quantity of dead herbage (30% vs. 25%) may account for the lower use level in treatment A compared to treatment C (Table 30).

The higher use of the grass-sedge component in treatment C relative to treatment A (52% vs. 34%) may have been due to a difference in the species composition of the two treatments. *Carex* spp. production was much higher in treatment C but the level of use was nearly the same (Table 29). The most productive grass in treatment C was *Agropyron* spp. and its 60% level of use may have been slightly underestimated because of a larger frequency value outside the exclosures. *Bromus ciliatus, Poa* spp. and *Calamagrostis neglecta* were the most productive grasses in treatment A. Consideration of the frequency ratio inside and outside the exclosures suggests that the relatively low use in treatment A may be attributed to the low use of the latter two species.

Fragaria virginiana was the most productive forb in both treatments and showed a high level of use in both cases. The 84% use of *Fragaria* in treatment C is likely an overestimation because it had a much lower frequency outside the exclosure. The high use of *Fragaria* in this type is in direct contrast to its negative use in the small poplar type. The *Fragaria virginiana* in the poplar-willow type occurred, not in patches, but evenly distributed throughout

Table 29. Frequency inside (I) and outside (O) exclosures, production (P) and utilization (U) of green herbaceous species in the poplar-willow type of treatments A and C, 1969.

Species		Frequency A	Frequency C		Production and Utilization A	Production and Utilization C
Carex spp.	I (%)	64	71	P (lb/ac)	145a[1/]	399b
	O (%)	50	64	U (%)	46	38*1[2/]
Total Grass	I (%)	88	71	P (lb/ac)	838	439
	O (%)	90	79	U (%)	32	56*1
Bromus spp.	I (%)	56	19	P (lb/ac)	215	17
	O (%)	37	21	U (%)	80*1	32
Agropyron spp.	I (%)	24	38	P (lb/ac)	79	239
	O (%)	33	52	U (%)	-2	60
Poa spp.	I (%)	32	19	P (lb/ac)	258	46
	O (%)	40	12	U (%)	13	80
Calamagrostis neglecta	I (%)	40	10	P (lb/ac)	237[a]	4[b]
	O (%)	20	9	U (%)	48	2
Schizachne purpurascens	I (%)	4	5	P (lb/ac)	6[a]	83[a]
	O (%)	0	18	U (%)	100	14
Other grasses	I (%)	[3/]	--	P (lb/ac)	37	41
	O (%)	--	--	U (%)	--	--

1 (lb/ac) is pounds per acre.

2 Production values within each row followed by a common letter are not significantly different at the 0.05 level using the LSD test.

3 *1, *2 and *3 indicates use was significant at 0.10, 0.05 and 0.01 probability levels respectively.

4 - percent frequency and percent use of other grasses was not calculated.

Table 29. (Continued)

Species		Frequency A	Frequency C		Production and Utilization A	Production and Utilization C
Total Forbs	I (%)	92	100	P (lb/ac)	593	437
	0 (%)	97	88	U (%)	66	77
Fragaria virginiana	I (%)	60	62	P (lb/ac)	302[a]	188[a]
	0 (%)	67	39	U (%)	75*[2]	84*[3]
Galium boreale	I (%)	16	48	P (lb/ac)	10[a]	66[b]
	0 (%)	13	33	U (%)	-.01	74*[2/]
Anemone canadensis	I (%)	36	5	P (lb/ac)	86[a]	8[b]
	0 (%)	17	3	U (%)	93*[2]	93
Arenaria latiflora	I (%)	48	33	P (lb/ac)	19[a]	23[a]
	0 (%)	40	39	U (%)	30	66
Cirsium spp.	I (%)	12	5	P (lb/ac)	35	0
	0 (%)	13	0	U (%)	89	100
Thalictrum venulosum	I (%)	0	29	P (lb/ac)	0	30
	0 (%)	0	12	U (%)	0	98*[3]
Taraxicum officinale	I (%)	0	29	P (lb/ac)	0	30
	0 (%)	0	12	U (%)	0	98*[3]
Pyrola secunda	I (%)	12	24	P (lb/ac)	5[a]	15[b]
	0 (%)	10	6	U (%)	51	98*[2]
Cerastium spp.	I (%)	20	5	P (lb/ac)	16[a]	10[a]
	0 (%)	20	0	U (%)	70	100
Lathyrous spp.	I (%)	20	24	P (lb/ac)	6[a]	9[a]
	0 (%)	33	3	U (%)	34	95*[2]
Other forbs	I (%)	--	--	P (lb/ac)	65	89
	0 (%)	--	--	U (%)	--	--

Table 30. Tree sucker and shrub density, D(stems/100 sq.ft.) and frequency, F(%) inside and outside exclosures of the poplar-willow type, 1969

		Treatments			
		A		C	
		Inside	Outside	Inside	Outside
Rosa spp.	D	25	41	111	91
	F	17	28	50	41
Symphoricarpos spp.	D	25	44	55	28
	F	8	25	20	19
Ribes spp.	D	54	125	35	9
	F	25	21	10	6
Populus tremuloides	D	8	13	50	88
	F	4	9	30	34
Rubus spp.	D	17	13	10	
	F	13	6	5	
Total sucker and shrub density		129	236	261	216

the stands. It would therefore have been difficult for cattle to consume the surrounding vegetation without also grazing the *Fragaria*. *Anemone canadensis* and *Cirsium* spp. also supplied a fairly large amount of green forb herbage (120 lb/acre) in treatment A. *Galium boreale*, *Thalictrum venulosum* and *Taraxacum officinale* supplied a substantial portion of the forbs eaten in treatment C. The *Populus tremuloides* suckers were used between 30% and 32%, while *Rosa* spp. (*R. woodsii* and *R. acicularis*) was used at 23% and 31% in treatments A and C respectively (Table 31).

Use of herbaceous species by cattle throughout the treated and untreated forest vegetation types varied a great deal. In the following discussion the species frequency inside and outside the exclosures is considered when relative levels of use are compared.

Fragaria virginiana showed a wide fluctuation in its level of use depending upon which vegetation type it was in. It had a negative utilization in the small poplar type even though the production was about 150 lb/acre. A low use was obtained in the large poplar type but a very high use (75%) occurred in treatment A of the poplar-willow type. *Fragaria virginiana* plants in the small poplar type differed in growth habit from those in the poplar-willow type. Most plants in the young poplar type were quite low growing and formed dense mats often excluding most other herbage. The plants in the poplar-willow type were more erect and well mixed in with the other vegetation making them much more accessible to the grazing animals.

Arenaria lateriflora and *Galium boreale* ranged from a negative use in the areas of low production to around 60% to 70%

Table 31. Tree sucker and shrub height (H) in inches and % utilization (U) inside and outside poplar-willow exclosures, 1969.

		Treatments			
		A		C	
		Inside	Outside	Inside	Outside
Populus tremuloides	H	20	3	13	3
	U		30		32
Ribes spp.	H	13	14	11	2
	U		1		2
Rosa spp.	H	11	5	13	18
	U		23		31
Rubus spp.	H	8	2	15	
	U				
Symphoricarpos spp.	H	8	7	12	11
	U				

use in areas where they had a higher production. The maximum production of *Anemone canadensis* was 86 lb/acre but the average was around 20 lb/acre. Even with this low production it showed a positive use in all treatments and controls of the forest types.

Aster hesperius and *A. laevis* showed their highest use in the small poplar type.

Three forb species which often showed uses in the 70% to 80% range were *Cerastium* spp.,*Thalictrum venulosum* and *Lathyrus venosus* and *L. ochroleucus*.

In general the results of this report agree with the limited literature available. Weatherill and Keith (83) compared the species composition of lightly grazed and heavily grazed aspen forest communities in central Alberta. Their results agree with this report in that they describe *Anemone* spp., *Fragaria* spp., *Lathyrus* spp. and *Thalictrum* spp. all as decreasers. They describe *Cerastium* spp. and *Taraxacum officinale* as being increasers but both of these species show relatively high grazing use in this thesis. It is difficult to compare an experiment of this type which determines the utilization percentage of a particular species to one which considers the competitive grazing advantage of a plant species. For example, even though a species such as *Taraxacum officinale* is described as an increaser, it is readily consumed by livestock (7) (16) (85).

After making the proper utilization adjustments for *Carex* spp. in the small poplar community, it appeared that *Carex* spp. was used around the 20 to 55% range depending on the level of production. The use of the *Agropyron* spp. in the forest community varied between a low of 20 to 30% and a high of 60 to 70%. The two main wheat -

grass species present were *Agropyron subsecundum* and *A. trachycaulum*. The use of these species was quite low in treatments A and C of the small poplar type in comparison to the other forest types.

As in the grassland, *Festuca scabrella* was quite productive and was used at a high level in the small poplar type. *Poa* spp. did not contribute much to the grass-sedge component of the forest vegetation types except in the poplar-willow type of treatment A. They generally showed a low to moderate use. *Bromus* spp. appeared to be of fairly good forage value while *Calamagrostis neglecta* and *Schizachne purpurascens* did not appear to be readily consumed, especially the latter species. Most of the literature shows comparable results. Paulsen (69) describes elk sedge (*Carex geyeri*) as not being heavily grazed by cattle although it was the most important component of the Aspen forest community because of the relatively large production. The most common *Carex* species believed to be in the forest types of the study area were *Carex foena, C. parryana, C.rostrata, C. vesicaria* and *C. atherodes*. The last three species were most common in the poplar-willow type which was next to the low wetland areas dominated by these species. *Carex rostrata* and *C. atherodes* are both described as palatable and readily consumed by cattle (16).

The growth form of *Agropyron* spp. seems to be the determining factor in its use. For example *Agropyron trachycaulum* is said to be fairly palatable and nutritious at all growth stages while *Agropyron subsecundum* has very palatable basal leafage but has a very unpalatable stem and seed head (16).

Poa compressa and *Poa scabrella* are believed to be the

most common bluegrass species present in the study area. *Poa compressa* is described as a palatable species but there is little information available on the palatability of *Poa scabrella*.

The main *Bromus* species was *Bromus ciliatus* and its relatively high use agrees with the literature which describes it as being quite palatable. It does not appear to be adversely affected. by grazing since it is referred to as an increaser by other authors (83).

The most abundant *Calamagrostis* species was believed to be *C. neglecta* but other *C. species* were also identified in the study area. The palatability of these species is quite variable. *C. canadensis* is not considered as a very palatable species but this depends on what area it is in (16). The basal leafage of *C. inexpansa* is considered quite palatable while the stem and head are not. *C. canadensis* is reported to be a strong decreaser by Weatherill and Keith (83) and, therefore, it must be used to a fairly great extent.

The low use of *Schizachne purpurascens* in this study does agree with all the literature which reports it to be an increaser because of high fibre and low protein content at all stages (16) (83).

The results agree with the high use of *Rosa* spp. and *Rubus* spp. (83) but do not agree with the statement that *Symphoricarpos occidentalis* is a decreaser.

E. Wetland type

i) 1968

This vegetation type was lightly grazed by cattle (Table 32). The high negative use of the dead herbage was likely due to trampling.

Table 32. Herbage production (P) and utilization (U) in the wetland vegetation type, 1968.

		Treatments		
		A	B	Control
Total herbage	P(lb/ac)	2211	5041	3546
	U(%)	22	25	25
Dead herbage	P(lb/ac)	146	148	96
	U(%)	-167*3	34	-205*3
Green herbage	P(lb/ac)	2065	4893	3450
	U(%)	28	25	29
Green grass and sedge	P(lb/ac)	2001	4887	3414
	U(%)	28	25*1	28
Green forbs	P(lb/ac)	64	6	36
	U(%)	43	75	50

Trampling causes current year's growth to look like dead herbage and, therefore, separating the current year's growth from the previous years' growth is very difficult in the grazed plots.

5. Grazing behaviour

A. Relative use of sprayed and unsprayed areas.

i) 1968

Table 33 shows that of the total instances of grazing in the grassland, 33% were in the control compared to the next highest of 18% in treatment B. The high use of the control grassland was due to a heavy grazing pressure in an old homestead area near the south end of the control. It appeared that old manure piles were in this area and they may have increased the palatability of the vegetation. Smoliak (76) reports that a single application of manure or straw increased forage production significantly as much as eight years after treatment. Utilization of fertilized ranges in Arizona was 3 to 5 times greater than that of unfertilized areas (53).

The higher use of treatment B relative to treatment A, using the observation method, agrees with the utilization data from the clipped plots. There was a 49% use of the total herbage in treatment B versus 33% use in treatment A (Table 16).

Treatment B also had the highest instance of grazing in the forest community. The greater number of grazing observations in treatment B agreed with the clipped plot data of the small poplar type where 63% of the total herbage was grazed versus 29% and 22% in treatment A and the control, respectively (Table 20). Treatment B did not show a higher use than treatment A

Table 33. Percentage of the total instances of grazing by treatment and plant community, 1968.

	1968 Treatments						
Plant community	A	B	C	CS[1]	D	Control	Total[2]
Grassland	8	18	13	10	14	33	96
Forest	22	51	11	2	6	10	102
Wetland	21	48	7	0	4	21	101

1. Control strip between treatments C and D.
2. Total may not be 100% due to rounding error.

or the control in the large poplar type but it did show a higher use than treatment A in the poplar-willow type.

Treatment B also had the highest proportion of the wetland grazing observations (48%) compared to 21% in treatment A and the control. The reduction of litter and possibly increased palatability because of burning in treatment B would be responsible for the much higher use in that treatment.

ii) 1969

The percentage of grazing observations in the grassland of the control was much lower in 1969 than 1968 but the grasslands of treatments A, B and C showed an increased use in 1969 (Table 34). The higher use of treatments over the control agreed with the clipped data where treatments A and C were used at the 62% and 66% level, respectively compared to a use of 51% in the control (Table 16). The burning done in treatment B grasslands appeared to have beneficially affected palatability two years afterwards, indicated by 30% of the total grazing observations occurring in treatment B.

The percent of grazing observations in the forest community was much higher in treatment A, B and C than in the control, control strip or treatment D (Table 34). There was very little defoliation in treatment D and it was approximately equivalent to the control in terms of understory herbage production. In the forest community, the grazing observations of the treatments versus the control compared closely with the clipped plot data.

Table 34. Percentage of the total instances of grazing by treatment and plant community, 1969

Plant Community	1969 Treatments						
	A	B	C	CS	D	Control	Total
Grassland	24	30	16	6	9	15	100
Forest	23	29	25	5	8	12	102
Wetland	19	7	33	1	12	26	98

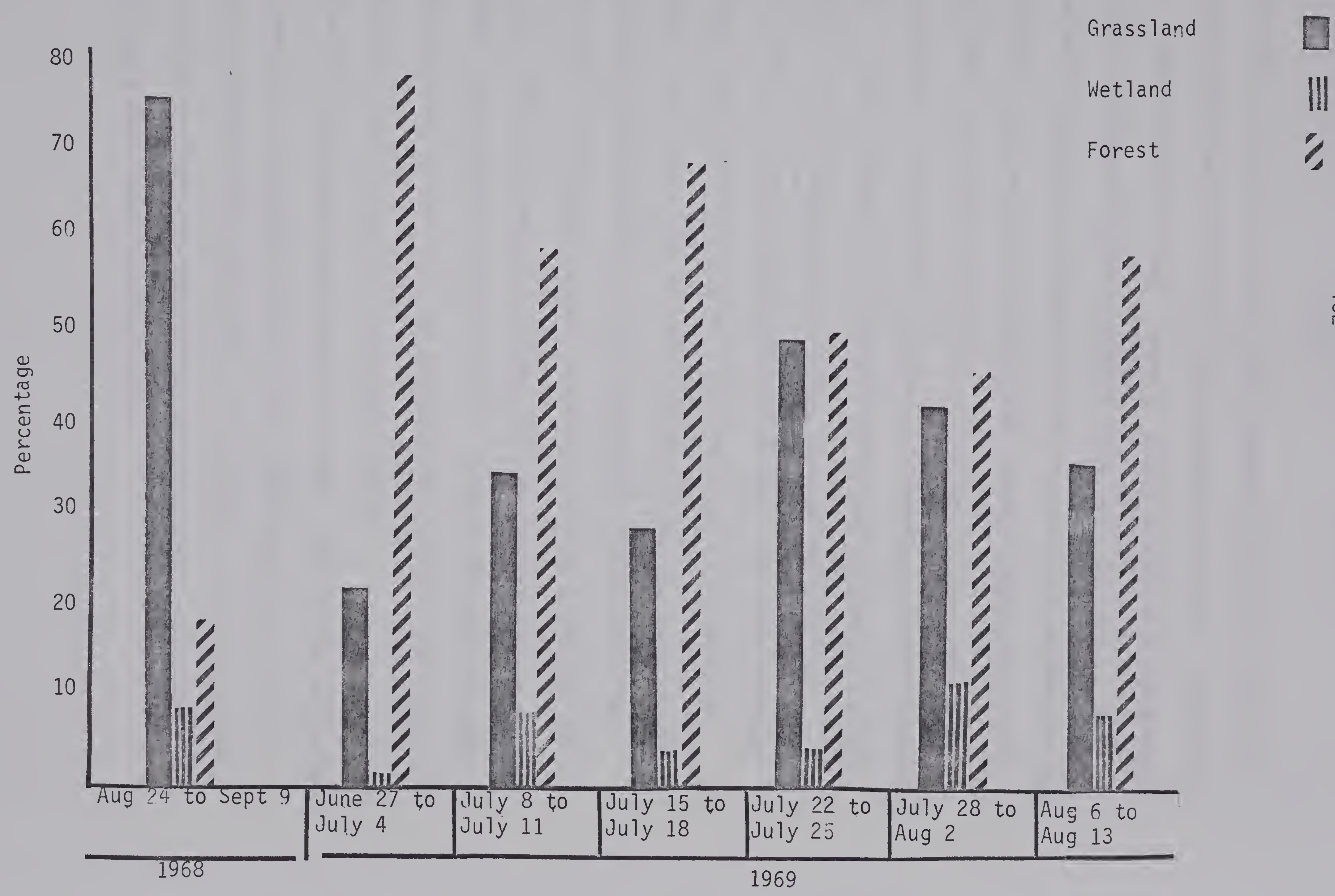
B. Relative use of the three main plant communities in 1968 and 1969.

Figure 7 shows that 75% of the 1968 grazing observations were in the grassland compared to 8% and 18% of the observations occurring in the wetland and forest communities, respectively. The high percentage of observations that occurred in the grassland substantiates the theory that part of the 1968 herbage use in the forest community could be due to trampling. Trampling of the vegetation by cattle during the two week grazing period in 1968 could have caused excessive leaf loss and increased susceptibility to weight loss because of weathering. If the forest species were more susceptible to the effects of trampling compared to the grassland species, then the use of the forest areas may have been overestimated in 1968.

During the first observation period in 1969, June 27 to July 4, the percentage of grazing observations on the grassland was only 22% compared to 77% in the forest community. By the fourth observation period, July 22 to 25, the percentage of grazing observations was nearly equal in the grassland and forest communities. In the last 1969 observation period, August 6 to 13, the percentage of the grazing observations was again higher in the forest community than in the grassland.

The low grazing use of the forest in 1968 was apparently caused by grazing obstruction from dead woody material and shrubs and the presence of readily available palatable forage in the grassland. The animals appeared to prefer the south-facing slopes and burned areas in the grasslands and avoided the highly productive *Festuca scabrella* areas near the forest border. These latter areas often had an abundance of dead herbage and shrubs.

Figure 7. Percentage of the total instances of grazing in three plant communities for 1968 and 1969.



In 1969, the cattle used the forest community much more than the grassland, particularly during the first observation period, June 27 to July 4. Cattle used the forest community almost exclusively and showed very little preference for the grassland sites well utilized in 1968.

The most noticeable difference in growing conditions between the two years was the lower precipitation and above average temperature in May and June, 1969. The 1969 season was an exceptionally good seed year for *Festuca scabrella* in contrast to virtually no heading and seed production in 1968. In 1969, because of low precipitation and apparently low soil moisture in the shallower grassland soils, most of the grassland vegetation was in a mature condition by late June. The lower moisture percentage of the grassland species (19%) relative to the moisture percentage of the forest species (41%) substantiates the observation of the relatively mature condition of the grasslands (Table 35). The culms and heads of the major grassland species, *Festuca scabrella* and *Stipa spartea* var. *curtiseta* had a lower moisture and protein percentage but a higher fibre content than the leaves. Many of the heads of these and other grassland species were not grazed by the cattle. The heads may have been an obstruction to the grazing cattle.

The wetlands were used quite heavily in 1969. Most of the vegetation in this community was grazed from its 2 to 4 foot height to a 4 to 12 inch stubble throughout the study field. The greater use of the wetland in 1969 relative to 1968 was probably caused by the drier grassland vegetation and a much longer grazing period.

Table 35. Chemical composition of selected grasses and sedges from grassland and forest.

	Percentage basis air-dry weight of sample				
	Moisture	Protein	Fiber	Calcium	Phosphorus
Grassland species					
Agropyron spp.	31	7.84	37.78	*[1]	.170
Stipa spartea var. *curtiseta*					
- culms and heads	7	4.37	33.65		.124
- leaves only	21	12.20	33.55		.222
- culms, heads and leaves	26	8.62	35.78		.156
Festuca scabrella					
- culms and heads	2	3.31	43.68		.150
- leaves only	22	8.18	39.35		.254
- culms, heads and leaves	21	7.47	43.18		.196
Boutoula gracilis	35	11.05	33.08		.239
Helictotrichon hookerii	9	7.06	40.49		.178
Koleria cristata	13	8.78	40.29		.187
Carex spp.	24	11.50	30.06		.190
Mean of all grassland spp.	19	8.22	37.80		.188

[1] * not available for grassland species

Table 35. (Continued).

	Percentage basis air-dry weight of sample				
	Moisture	Protein	Fiber	Calcium	Phosphorus
Forest species					
Agropyron subsecundum	46	8.5	45.7	.24	.21
Agropyron trachycalum	44	7.7	41.8	.26	.21
Calamagrostis inexpansa	42	6.7	46.9	.17	.16
Poa spp.	33	6.6	43.5	.25	.17
Bromus ciliatus	51	7.1	45.7	.22	.19
Stipa columbiana var. *nelsoni*	30	8.7	44.5	.19	.13
Carex spp.	43	10.2	32.7	.39	.21
Mean of all forest spp.	41	7.9	43.0	.25	.18

C. 1969 calf weight comparisons.

Table 36 shows calf weights of six different breeding groups during the 1969 season. The Holstein group was in the study area for the duration of the experiments while all other groups were on fertilized tame pastures. The weights show that male and female Holsteins were higher than all the other groups when they first went into the enclosure, June 27. The Holsteins were still superior when they were removed from the enclosure, August 20. The data reveal that the Holstein calves were able to maintain their superior weight gains while in the study field. It appears that the vegetation in the study area was as nutritious as that of the fertilized tame pastures.

Table 36. Average male and female calf weights (pounds) of six breeding groups at the University of Alberta Ranch, Kinsella, 1969. 1/

Date of weighing	Hereford	Hybrids	Charolais cross	Double muscle	Artificial insemination Charolais	Holstein
June 24/69	168	197	172	190	186	209
June 29/69	244	291	237	235	277	313
Aug. 20/69	287	346	288	316	332	363
Oct. 2/69	354	428	365	394	415	449
Oct. 7/69	339	411	349	378	395	429
Nov. 4/69	394	447	381	408	438	474

[1] Data courtesy of Dr. R.T. Berg, Department of Animal Science, University of Alberta.

SUMMARY AND CONCLUSIONS

A study was undertaken to determine the type and amount of forage production resulting from brush control with herbicides. The relative use of herbaceous species in treated versus control areas was also studied.

Three major plant communities and associated soil types were considered when studying the forage production and use in the study area:

A. grassland community and associated chernozemic soils

B. forest community and associated grey luvisolic soils

C. wetland community and associated glysolic soils.

The forest community was subdivided into i) the small poplar type, ii) the large poplar type and iii) the poplar-willow type.

In 1966, four spray strips in the study area received 4, 3, 2 and 1 lb/acre of 2,4-D. The three areas which had received 4, 2 and 1 lb/acre of 2,4-D in 1966 were resprayed in 1968 using the same concentrations. In 1968, 8 oz/acre of 2,4,5-T were also included in each of the spray concentrations.

Treatments receiving more than one lb/acre of 2,4-D in each herbicide application had a marked increase in herbage production in the three forest types. Two months after the second herbicide application to the small poplar type, the green herbage production ranged from 1000 to 1300 lb/acre compared to 260 lb/acre in the control. The following year, the green herbage production was nearly the same. Two months after the 1968 herbicide application, the green herbage production in the large poplar type ranged from 350 to 800 lb/acre while in the poplar-willow type, it ranged from 700 to 1300 lb/acre. In contrast, the unsprayed large poplar only produced 98 lb/acre of

green herbage and the unsprayed poplar-willow only produced 329 lb/acre. In 1969, the more productive areas in the forest types were studied and the green herbage production reached a level of 1200 and 1600 lb/acre in the large poplar and poplar-willow types, respectively.

The herbicides did not seem to have any effect on forage production of the grasslands. Cultivation by homesteaders in the grassland community of two treatments may have increased the forb production there and, therefore, complicated the study of herbicide effect on the vegetation.

Some of the grass species showing major increases in herbage production were *Festuca scabrella*, *Agropyron subsecundum*, *Calamagrostis neglecta*, *Poa* spp., *Bromus ciliatus* and *Schizachne purpurascens*. *Carex* spp. also showed a substantial production increase in the large poplar and poplar-willow types. Some of the most productive forbs were *Fragaria virginiana*, *Galium boreale*, *Arenaria lateriflora*, *Anemone canadensis*, *Aster hesperius* and *A. laevis*.

The shrubs with the highest frequency and density were *Symphoricarpos occidentalis* and *S. albus*, *Rosa woodsii*, *R. acicularis*, *Rubus strigosus* and *Ribes* spp. In some forest types, the total shrub density of the treated areas was only slightly lower than that of the control. This indicated some local ineffectiveness of the herbicides resulting from unsatisfactory herbicide coverage of the vegetation.

The treated forest was more heavily grazed than the untreated forest. Of the total grazing observations, 11% were in the control compared to an average of 27% in each of the treatments. The higher percentage of grazing observations in the treated forests also agreed with the clipped plot data. Cattle consumed approximately 750 lb/acre

of the total herbage in the treated small poplar and large poplar types compared to about 100 lb/acre in the same forest types of untreated areas.

The 1967 fall burn in the grassland and small poplar types of treatment B increased use of the 1968 herbage by 34%. With the exception of the small poplar type of treatment B, cattle grazed the forest communities less intensely than the grassland. From 33% to 42% of the total herbage was used in the grassland compared to 22% to 29% in the small poplar type. In the large poplar and poplar-willow, the apparent grazing use ranged from 22% to 44%, but these estimates were probably high because of forage loss from trampling and forage maturation during the two week grazing period.

The forest types in the treated areas were used much more extensively in 1969 than in 1968. In 1969, the grazing observations showed the cattle using the forest community nearly three times as much as the grassland during the first half of the grazing season. Precipitation and temperature data as well as chemical analysis of the forage indicated that the grassland was very dry and in a much more mature growth stage in 1969 compared to 1968. In 1968, the animals were observed using the grassland nearly four times as much as the forest.

Festuca scabrella, Agropyron spp. and *Stipa sparta* var. *curtiseta* supplied the greatest amount of grassland forage used. The grassland forbs formed a very small component of the total herbage production. *Agropyron subsecundum, Festuca scabrella* and *Poa* spp. supplied the most forage consumed by cattle in the small poplar type. *Agropyron subsecundum, Calamagrostis neglecta, Bromus ciliatus, Poa* spp. and *Carex* spp. accounted for the greatest amount of herbage utilized in the large poplar and poplar-willow types.

The highly variable use of the *Fragaria virginiana* was apparently related to its various growth forms. Other forb species showing consistent use throughout the forest areas were *Galium boreale*, *Aster hesperius, A. laevis, Anemone canadensis* and *Arenaria lateriflora.*

Most shrubs, with the exception of *Symphoricarpos occidentalis* and *S. albus*, were used by the cattle. *Rosa woodsii* and *R. acicularis* were the favorite browse species for cattle.

Herbicide application to forest areas caused a marked increase in desirable herbage production. However, there must be further research into the methods of control whereby sucker growth is more successfully reduced.

Cattle were readily able to use forage in the treated forests in spite of the obstructions caused by dead stems and branches of woody species. There was a marked change in preference of grassland versus forested areas depending upon the stage of maturity of the vegetation.

BIBLIOGRAPHY

1. Ahlgren, I.F. and C.E. Ahlgren. 1960. Ecological effects of forest fires. Bot. Rev. 26: 483 - 533.

2. Allan, John A. The relation of the geology to the soils in the Wainwright and Vermilion sheets. In: Wyatt, F.A., J.D. Newton, W.E. Bowser and W. Odynsky (ed). 1944. Soil survey of Wainwright and Vermilion sheets. Univ. of Alberta, Bull. No. 42.

3. Ayyad, M.A.G. and R.L. Dix. 1964. An analysis of a vegetation-micro-environmental complex on prairie slopes in Saskatchewan. Ecol. Monog. 34: 421 - 442.

4. Baile, C.A. and Jean Mayer. 1967. Intragastric injections of liquid diets, water and acetate and meal patterns in goats. Am. J. Physiol. 213 - 387.

5. Bailey, A.W. 1968. A comparison of the effect of 2,4-D on aspen poplar with and without added MSMA. Res. Rep. Can. Nat. Weed Comm. W. Sec., 258 - 261.

6. Bailey,A.W. 1969. Effect of 2,4-D ester and picloram on brush growing on subirrigated sand. Res. Rep. Can. Nat. Weed Comm. W. Sec., 295 - 296.

7. Bailey, A.W. 1970. Barrier effect of the shrub *Elaeagnus commutata* on grazing cattle and forage production in central Alberta. J. Range Manage. 23: 248 - 251.

8. Balch, C.C. and R.C. Campling. 1962. Regulation of voluntary food intake in ruminants. Nutr. Absr. Rev. 3: 669.

9. Berg, R.T. and L.W. McElroy. 1968. The University of Alberta beef breeding project. Report No. 5. The 47th Annual Feeders Day Report. Printed by University of Alberta Printing Department.

10. Bird, R.D. 1961. Ecology of the aspen parkland of western Canada. C.D.A. Pub. 1066. Ottawa, Queen's Printer. 153 pp.

11. Blaxter, K.L. and R.S. Wilson. 1962. The voluntary intake of roughages by steers. Animal Prod. 4: 351 - 358.

12. Bowes, G. 1968. Effect of water volumes on the control of aspen poplar with 2,4-D. Res. Rep. Can. Nat. Weed Comm. W. Sec. 261 - 262.

13. Bowser, W.E., A.A. Kjearsgaard, T.W. Peters, and R.E. Wells. 1962. Soil survey of Edmonton sheet. Univ. of Alberta Bull. No. SS-4. Alberta Soil Survey Report No. 21.

14. Budd, Archibald, C. and Keith F. Best. 1964. Wild plants of the Canadian prairies. Res. Branch C.D.A. Pub. 983 Ottawa, Queen's Printer. pp. 519.

15. Cable, D.R. and Fred H. Tschirley. 1961. Responses of native and introduced grasses following aerial spraying of velvet mesquite in southern Arizona. J. Range. Manage 14: 155- 159.

16. Campbell, J.B., Keith F. Best, Archibald C. Budd. 1956. 99 Range forage plants of the Canadian prairies. C.D.A Pub. No. 964, Ottawa, Queen's Printer, pp. 99.

17. Campbell, J.B., R.W. Lodge, A. Johnston and S. Smoliak. 1962. Range management of grasslands and adjacent parklands in the prairie provinces. C.D.A. Pub. 1133, Ottawa, Queen's Printer. pp. 32.

18. Campbell, R.S. and John T. Cassady. 1951. Grazing values for cattle on pine forest ranges in Louisiana. La. Agr. Expt. Sta. Bull. 452, pp. 31.

19. Campbell, R.S., E.A. Epps, Jr., C.C. Moreland et al. 1954. Nutritive values of native plants on forest range in central Louisiana. La. Agr. Expt. Sta. Bul. 488. pp. 18.

20. Cook, C.W. 1959. The effect of site on palatability and nutritive content of seeded wheatgrass. J. Range Manage. 12: 289 - 292.

21. Cook, C. Wayne. 1966. Factors affecting utilization of mountain slopes by cattle. Jour. Range Manage. 19: 200 - 204.

22. Cook, C. Wayne, Harold H. Biswell and R.T. Clark, et al. 1962. Basic problems and techniques in range research. Nat. Acad. Sci., Nat. Res. Counc. Publ. No. 890. Washington, D.C. pp.341.

23. Cornelius, Donald R. and Charlies A. Graham. 1951. Selective herbicides for improving California forest ranges. J. Range Manage. 4: 95 - 100.

24. Corns, Wm.G. and R.K. Gupta. 1967. Mist blower, low-volume, low dosage herbicides treatments including adjuvant Atplus 210, of *Elaeagnus commutata* and *Populus tremuloides*. Res. Rep. Can. Nat. Weed Comm. W. Sec. 265.

25. Coupland, Robert T. and T. Christopher Brayshaw. 1953. The fescue grassland in Saskatchewan. Ecology 34: 386 - 405.

26. Cowlishaw, S.J. 1951. The effects of sampling cages on yields of herbage. Brit. Grassland Soc. Jour. 6(3): 179 - 184.

27. Crouch, Glenn L. Forage production and utilization in relation to deer browsing of douglas - fir seedlings in the Tillamook burn, Oregon. Ph.D. thesis. Corvallis, Oregon State University, 1964. 162 numb. leaves.

28. Dalrymple R.L., Don D. Dwyer and P.W. Santelmann. 1964. Vegetational responses following winged elm and oak control in Oklahoma. J. Range Manage. 17: 249 - 253.

29. Daniel, H.A. and H.J. Harper. 1934. The relationship between total calcium and phosphorus in mature prairie grass and available plant food in the soil. J. Amer. Soc. Agron. 26(12); 986 - 992.

30. Daubenmire, R.F. 1940. Exclosure technique in ecology. Ecol. 24(4): 514 - 515.

31. Daubenmire, Rexford. 1968. Plant communities. A textbook of plant synecology. New York, Harper and Row, 300 pp.

32. Davies, A.M. 1967. Range development through brush control in Arkansas Ozarks. Agr. Expt. Station Div. of Agric. University of Arkansas, Fayetteville Bull. 726. 47 pp.

33. Davies, R.O., D.T.H. Johnes and W.E. Milton. 1959. Factors, influencing the composition and value of herbage from fescue and molina areas. J. Agric. Sci. 53, 268 - 285.

34. Dormaar, J.F. and L.E. Lutwick, 1966. A biosequence of soils of the rough fescue prairie - poplar transition in south-western Alberta. Canadian Journal of Earth Science 3: 467 - 471.

35. Drayton, L.E., J.M. Fitzpatrick, V. Gilchrist, C. Haase, C.I. Johnston, et al. 1964. Demand for beef in 1980 and related land requirements. Economic Annalist 34:(4) 77 - 85.

36. Duval, V.L. and L.B. Whitaker, 1964. Rotation burning. A forage management system for longleaf pine-bluestem range. J. Range Manage. 17: 322 - 326.

37. Ehrenreich, John H. 1959. Effect of burning and clipping on growth of native prairie in Iowa. J. Range Manage. 12: 133 - 137.

38. Ehrenreich, John H. and John M. Aikem. 1963. An ecological study of certain management practices on native prairie in Iowa. Ecol. Manage. 33: 113 - 130.

39. Ehrenreich, J.H. and A.J. Bjugstad. 1966. Cattle grazing time is related to temperature and humidity. J. Range. Manage. 19: 144 - 142.

40. Ferguson, W.S. 1931. The seasonal variation in the mineral content of pasture with particular reference to drought. Jour. Agri. Sci. 21(2): 233 - 240.

41. Friesen, H.A. 1966. Herbicides applied in 1964 to control *Symphoricarpos occidentalis* assessed in 1966. Res. Rep. Can. Nat. Weed Comm. W. Sec. 269.

42. Friesen, H.A., M. Aaston, Wm. G. Corns, J.L. Dobb. 1965. Brush control in western Canada. C.D.A. Pub. 1240. Ottawa, Queen's Printer.

43. Glending, G.E. 1944. Some factors affecting cattle use of northern Arizona pine bunch-grass range. S.W. For. Range Exp. Sta. Res. Rep. 6.

44. Guenther,W.C. 1965. Concepts of statistical inference. New York, McGraw Hill.

45. Halls, I.K. and H.S. Crawford. 1965. Vegetation response to an Ozark woodland spraying. J. Range Manage. 18: 338 - 340.

46. Hardy, W.G. 1967. (Ed.) Alberta - A natural history. Pub: by the Patrons. Distributed by M.G. Hurtig Publishers, Edmonton, Alberta.

47. Heady, H.F. 1957. Effect of cages on yield and composition in the California annual type. J. Range Manage. 10: 175-179.

48. Heady, H.F. 1964. Palatability of herbage and animal preference. J. Range Manage. 17: 76 - 82.

49. Herbel, C.H. and A.B. Nelson. 1966. Activities of Hereford Santa Gertrudes cattle on a southern New Mexico range. J. Range Manage. 19: 173 - 176.

50. Herbel, C.H. and A.B. Nelson. 1966. Species preference of Hereford and Santa Gertrudes cattle on a southern New Mexico range. J. Range Manage. 19: 177 - 181.

51. Hercus, J.M. 1961. What do sheep eat on tussock grassland? N.Z.J. Agric: 103, 73 - 76.

52. Hilman, J.B. and R.H. Hughes. 1965. Fire and forage in wire-grass type. J. Range Manage. 18: 251 - 254.

53. Holt, Gary A. and David G. Wilson. 1961. The effect of commercial fertilizers on forage production and utilization on a desert grassland site. J. Range Manage. 14: 252, 256.

54. Hughes, R.F., C. Milner and J. Dale. 1964. Selectivity in grazing. Crisp, D.J. Ed. Grazing in terrestrial and marine environments. Blackwell Oxford. 189 - 202.

55. Hyatt, S. Wesley. 1966. Sagebrush control -- costs, results and benifits to the Rancher. J. Range Manage. 19: 42 - 43.

56. Ivinis, J.D. 1955. The palatability of herbage. Herbage Abstracts 25: 75 - 79.

57. Johnson, W., C.M. McKell, R.A. Evens and L.J. Berry. 1959. Yield and quality of annual range forage following 2,4-D application on blue oak trees. J. Range Manage 12: 18 - 20.

58. Lord, Philip, B. and William H. Sanderson. 1962. An eastside Sierra Nevada aerial spraying project. J. Range Manage. 15: 200 - 201.

59. Lyon, J.L. and W.F. Mueggler. 1968. Herbicide treatment of north Idaho browse evaluated six years later. J. Wildlife Manage. 32: 538 - 541.

60. McClymont, G.L. 1967. Selectivity and intake in the grazing ruminant. Handbook of Physiology, Sec. 6, 1:, 129 - 137.

61. McIver, R.N. 1963. Brush control on native pastures. Res. Rep. Can. Nat. Weed Comm. W. Sec., 194 - 195.

62. Miller, F.L. 1966. Distribution patterns of black-tailed deer *odocoileus columbianus* in relation to environment. Oregon State Univ. M.S. thesis. 90 p.

63. Moss, E.H. 1955. The vegetation of Alberta. The Botanical Review 21:(9) 493 - 567.

64. Moss, E.H. 1967. Flora of Alberta. University of Toronto press. 546 p.

65. Mueggler, W.F. 1965. Cattle distribution on steep slopes. J. Range. Manage. 18: 255 - 257.

66. Murphy, Alfred H. and Beecher Crampton. 1964. Quality and yield of forage as affected by chemical removal of blue oak *(Quereus douglasii)*. J. Range Manage. 17: 142 - 144.

67. Newell, Joseph C., Willie L. Ulich and Joseph L. Schuster. 1968. Development of equipment for chemical and mechanical Mesquite control. In: Brush Control Research Progress Report, Texas Technological College, Lubback Texas. Special Report #15, 52 - 53.

68. Oelberg, K. 1956. Factors affecting the nutritive value of range forage. J. Range Manage. 9: 220 - 224.

69. Paulsen, Harold A. Jr.. 1969. Forage values on a mountain grassland - aspen range in western Colorado. J. Range Manage. 22: 102 - 107.

70. Ratcliff, Raymond D. and Harold F. Heady. 1962. Seasonal changes in herbage weight in an annual grass community, 15: 146 - 149.

71. Reppert, Jack N. 1960. Forage preference and grazing habits of cattle at eastern Colorado range station. J. Range Manage. 13: 58 - 65.

72. Sharma, M.P. and W.H. Vanden Born. 1970. Foliar penetration of picloram and 2,4,-D in aspen and balsam poplar. Weed Sci. 18: 57 - 63.

73. Simkins, K.L. Jr., J.W. Suttie, and B.R. Baumgardt. 1965. Effect of glucose and volatile fatty acids on feed intake in ruminants. J. Dairy Sci. 48: 799.

74. Skoglund, N.A. and R.T. Coupland 1966. Effect of 2,4-D on *Symphoricarpos occidentalis*. Res. Rep. Can. Nat. Weed Comm. W. Sec. 275 - 276.

75. Skoglund, N.A. and R.T. Coupland. 1967. Control of forbs on native grassland by various herbicides. Res. Rep. Nat. Weed Comm. W. Sec. 271 - 272.

76. Smoliak, S. 1965. Effects of manure, straw and inorganic fertilizers on northern great plains ranges. J. Range Manage. 18: 11 - 15.

77. Steel, G.D. and James H. Torrie. 1960. Principles and procedures of statistics. New York, McGraw - Hill. 481 pp.

78. Taylor, J.C. 1953. Grazing behaviour of bullocks under two methods of Management. Brit. Jour. of Anim. Behaviour 1: 72 - 77.

79. Van Dyne, G.M. and Harold F. Heady. 1965. Dietary chemical composition of cattle and sheep grazing in common on a dry annual range. J. Range Manage. 18: 78 - 86.

80. Vogl, Richard J. 1965. Effects of spring burning on yields of brush prairie savana. J. Range Manage. 18: 200 - 205.

81. Wahlenberg, W.G., S.W. Greene and H.R. Reed. 1939. Effects of fire and cattle grazing on longleaf pine lands as studied at McNeill, Missippi. U.S. Dept. Agr. Tech. Bul. 683, 52 p..

82. Watkins, J.M. 1940. The growth habits and chemical composition of Brome grass *Bromus inermis* as affected by different environmental conditions. J. Amer. Soc. Agron. 32(7), 527 - 538.

83. Weatherill, Ronald G. and Lloyd B. Keith. 1969. The effect of livestock grazing on an aspen forest community. Alberta Dept. of Lands and Forests. Bull. 1, 31 pp.

84. Wonders, William C. 1969. (Chairman of Executive Committee.) Atlas of Alberta Pub. University of Alberta Press in association with University of Toronto Press. 158.

85. Wroe, R.A., S. Smoliak, J. Johnston et al. 1970. Range, its nature and use. Pub. No. 146 Edmonton, Queen's Printers. 39pp.

86. Wyatt, E.A., J.D. Newton, W.E. Bowser and W. Odynsky. 1944. Soil survey of Wainwright and Vermilion sheets. Univ. of Alberta, Bull. No. 42.

Appendix 1. Main subgroups of the major soil orders and associated herbage species production.

Subgroup	Dark Brown Chernozem					Black Chernozem						Grey Luvisol	Glysol		
	Rego	Rego	Rego thin	Calcareous	Orthic thin	Regol cumulic	Thin	Orthic	Calcareous (gleyed)	Orthic thin	Orthic	Dark	Humic elluviated	Humic elluviated	Humic
Horizon thickness (inches)	Ah 14 Cca 18	Ah 7 Cca 16	Ah 4 Cca 24 Ck +[1]	Ah 6 Bm 2 Bk 5 Cca 12	Ah 5 Bm 2 Cca 36 Ck +	Ah 12 B I 14 Ah II 3 B II 2 Ah III 3 B III 14 Cca 26	Ah 4 Bm 10 Cca 14	LH 1 Ah 7 Bm 5 Cca +	Ah 10 Bm 7 Bk 7 Cca 29 Ck 10	Ah 5 AB 7 Bm 5 Cca 17 Ck +	Ah 8 Bm 12 Cca +	LH 1 Ahe 4 Bt 7 BC 5 Cca 17	LH 2 Agh 5 Aeg 2 Btg 8 Bkg 6 Ccag	LH 2 Ahq 8 Ae 1 Btg 8 Cg 14 II Cg 28	LH 2 Ahg 5 ABg 4 Bg 9 BCg 7 Ccag 4
Position on slope	Upper	Top of hill	Upper	Top of hill	Flat	Lower	Mid	Flat	Low spot	Mid	Flat	Mid	Low spot	Low spot	Low spot
Drainage	Well	Well	Well	Well	Well	Moderate	Moderate	Moderate	Poor	Moderate	Moderate	Moderate	Poor	Poor	Poor
Aspect	South	South	South	South	North-east	West	South	Shaded	Flat	Shaded	N.-facing	Shaded	Flat	Shaded	Flat
Plant community	Grassland	Grassland	Grassland	Grassland	Grassland	Grassland	Grassland	Grassland	Poplar forest	Grassland	Grassland	Forest	Poplar willow	Poplar willow	Wetland
Location	Control	Control	Treatment B	Control	Treatment A	Treatment A	Treatment C	Control	Fireguard	Treatment B	Control	Treatment B	Fireguard	Control	Control
<u>Grass and Sedge (lb/ac)</u>															
Bouteloua gracilis	154	29													
Stipa spartea var. *curtiseta*	188	456		162				204							
Carex spp.	109	114	324	123	69	39		90				127			3354
Festuca scabrella	143	373		408	374	1048		1002							
Agropyron spp.	20		77	126		160		172			909				
Poa spp.				84		60					20			244	
Total production	614	972	401	804	443	1305	N.D.[2]	1468	N.D.	N.D.	929	127	N.D.	244	
<u>Forbs (lb/ac)</u>															
Artemisia frigida	642										7				
Cerastium spp.	54													22	
Comandra pallida				99											
Campanula rotundifolia				29											
Galium boreale			292			200						68			
Aster spp.			47	221							44				
Viola adunca			20												
Vicia americana			20					1				1			
Lathyrus spp.			47									10			
Fragaria virginiana						21									
Achillea millefolium			13					36			2				
Artemisia ludoviciana											32				
Taraxacum officinale														2	
Smilicina stellata												37			
Thalictrum venulosum												12			
Potentilla spp.														14	
Other forbs								6				21			
Total production	705	0	453	350	0	221	N.D.	43	N.D.	N.D.	84	148	N.D.	65	
Litter	604	909	13	1021	653	333	N.D.	1702	N.D.	N.D.	376	0		181	338
Grand total	1923	1881	867	2175	1096	1859	N.D.	3231	N.D.	N.D.	1389	275	N.D.	490	3692

[1] Horizon was encountered but depth was not determined.

[2] N.D. no vegetation plot was taken near the soil core.

Appendix 2. Frequency (%), and production (lb/ac) of main herbaceous species in five vegetation types of the control.

Year	1969		1969		1969		1968		1968	
	Grassland		Small poplar		Large poplar		Poplar willow		Wetland	
	Freq.	Prod.	Freq.	Prod.	Freq.	Prod.	Freq.	Prod.	Freq.	Prod.
Species										
Grass and Sedge										
Stipa spartea var. *curtiseta*	40	175								
Boutela gracilis	20	16								
Koleria cristata	10	7								
Muhlenbergia cuspidata	17	44	9	12						
Festuca scabrella	60	273	55	9						
Agropyron spp.	64	113	36	33	18	5	20	6	8	313
Carex spp.	100	78	82	37	42	17	73	91	92	2905
Poa spp.	7	3	9	1	3	5	27	28	15	185
Bromus spp.			18	1	9	4	13	21	8	1
Schizachne purpurescens					3	4				
Calamagrostis neglecta							33	27	15	9
Other grasses	13	91					13	12		
Total=Grass and sedge		800		93		31		185		3413
Forbs										
Artemisia frigida	17	32								
Comadra pallida	40	26								
Thermopsis rhombifolia	20	14								
Campanula rotundifolia	17	3								
Aster spp.		28	9	7						

Appendix 2. (Continued)

Year	1969		1969		1969		1968		1968	
	Grassland		Small poplar		Large poplar		Poplar willow		Wetland	
	Freq.	Prod.	Freq.	Prod.	Freq.	Prod.	Freq.	Prod.	Freq.	Prod.
Galium boreale	13	21	45	31	27	5			8	23
Achillea millefolium	27	6	18	7			7	.1		
Arenaria lateriflora	7	6			36	2	27	3	8	1
Viola adunca	10	1	18	6	21	7	7	3		
Fragaria virginiana			27	18	36	10	60	10	8	2
Lathyrus spp.			27	80	21	16	13	15	8	3
Artemisia ludoviciana			18	7			7	2		
Cerastium spp.			27	5						
Anemone canadensis			9	7			7	.1	8	2
Pyrola secunda					12	6	7	1		
Epilogium angustifolium					3	6				
Thalictrum venulosum					9	3	13	7		
Solidago spp.					6	3	7	52		
Smilacina stellata					12	3				
Taraxacum officinale							20	21	8	.2
Labiteae spp.							27	9		
Vicia americana							20	8		
Galium spp.								3		
Cirsium spp.									8	2
Potentilla spp.									8	3
Unknown forbs		5		2		9	27	9	8	.2
Total forbs		142		169		70		151		36.4
Litter							87	28	77	96

Appendix 3. Frequency (%) and density (plants/100 sq ft) of shrubs and woody suckers in three plant communities of the control.

Year	1969		1969		1969		1968		1968	
	Grassland		Small poplar		Large poplar		Poplar willow		Wetland	
	Freq.	Den.	Freq.	Den.	Freq.	Den.	Freq.	Den.	Freq.	Den.
Species										
Rosa arkansana	19	35								
Rosa spp.			36	82	47	73	ND[1]		ND[1]	
Symphoricarpos spp.	23	42	73	218	58	112	ND		ND	
Elaeagnus commutata	6	10			3	3	ND		ND	
Rubus spp.			45	64			ND		ND	
Ribes spp.					9	12	ND		ND	
Amelanchier alnifolia					9	9	ND		ND	

[1] ND = no data