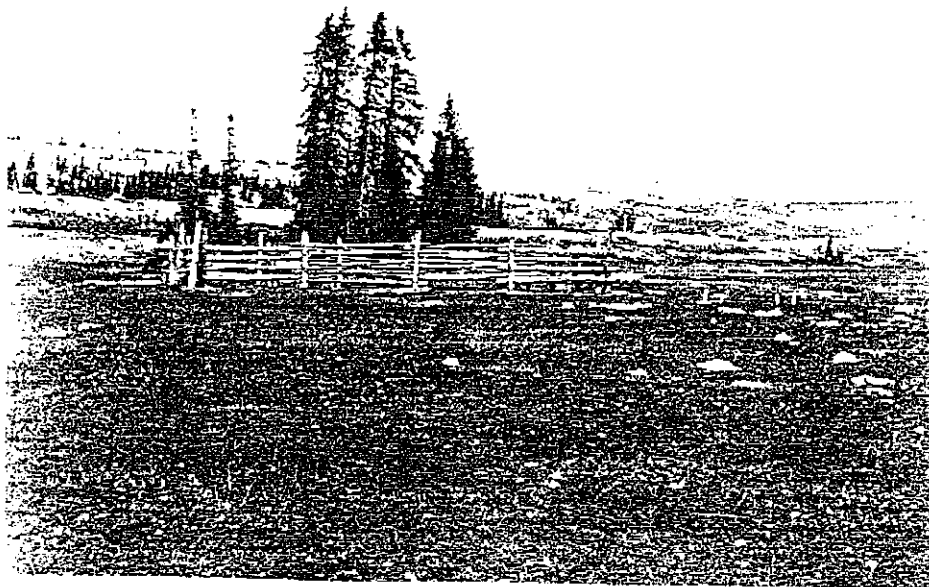
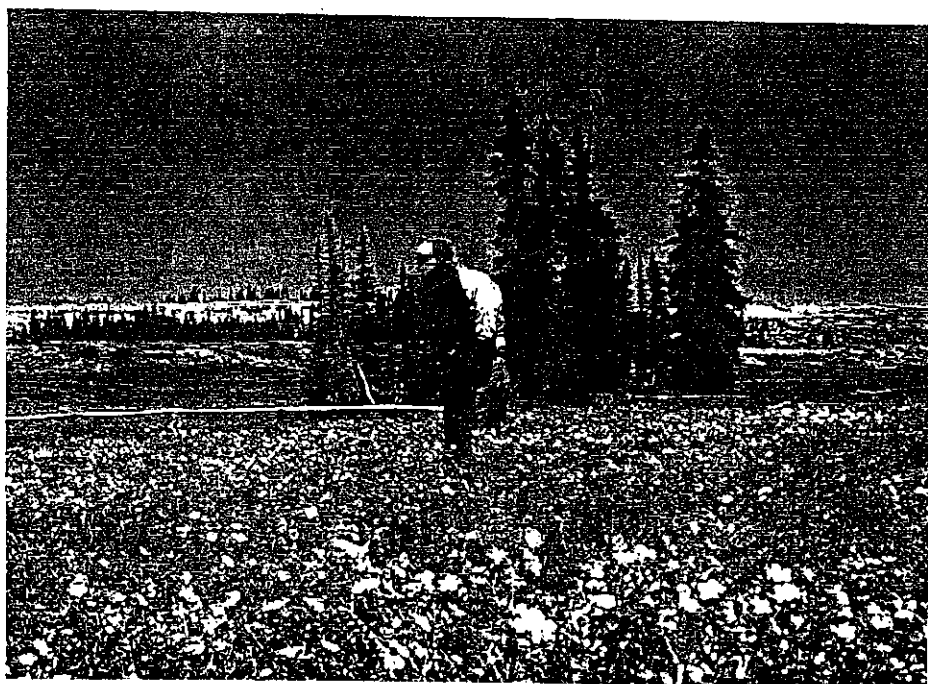


**SUCCESSIONAL CHANGES IN THE TALL FORB TYPE
WASATCH PLATEAU**



Upper Horseshoe - 1915



Upper Horseshoe - 1990

by Mont E. Lewis

ON THE COVER

Photographs on the cover page of this document provide a comparison of what the Upper Horseshoe area looked like in 1915 after a period of extremely heavy livestock grazing (upper photograph) compared to recovery that has occurred some 75 years later (lower photograph). Mont E. Lewis, the author, is shown in the lower photograph.

ABSTRACT

Historically high grazing pressure during the latter half of the last century and extending into the early portion of this century drastically changed the soil and vegetation conditions on the Wasatch Plateau. In general, vegetative ground cover was reduced and species composition was changed from an original Tall Forb dominated setting to lower statured forb, grass, and shrub species.

Studies conducted in exclosures and in settings where livestock grazing has been considerably reduced indicate a gradual shift is taking place back to Tall Forb dominated communities. Rhizomatous, somewhat lower statured forb species, such as Penstemon rydbergii, Achillea millefolium and Artemisia ludoviciana are gradually being replaced by luxuriant, often taller species such as Geranium richarsonii, Polemonium foliosissimum, Aster foliaceus, Potentillia pulcherima, Erigeron speciosus, Valeriana edulis, Valeriana occidentalis, Osmorhiza occidentalis, Ligusticum porteri, and Heracleum lanatum. Areas where Stipa lettermanii and or Chrysothamnus viscidiflorus have become dominant due to previous grazing pressures, are returning to a dominance of these lush forb species along with modest amounts of larger statured grasses such as Stipa nelsonii, Bromus carinatus, and Elymus trachycaulus. Overall there appears to be successional changes from less luxuriant, rhizomatous forb species, through a dominance by Stipa lettermanii and / or Chrysothamnus viscidiflorus, in some settings, and on to the original Tall Forb dominants.

It appears that the Tall Forb Type in this portion of its range originally occurred on relatively deep, fertile soils with approximately 35 inches of annual precipitation. In order to maintain these areas as valuable, high elevation watersheds, it is advantageous to return them to, and maintain them in, the historical Tall Forb dominated Type.

SUCCESSIONAL CHANGES IN THE TALL FORB TYPE

WASATCH PLATEAU

by

MONT LEWIS

1993

ACKNOWLEDGEMENT

The author extends his thanks to the people and institutions that helped in the development of this three part study of the vegetation of the Wasatch Plateau.

Included in the study were:

1. A species list.
2. "Change In The Vegetation Of The Wasatch Plateau - 1912 To The Present".
3. Horseshoe study phase of the changes of vegetation cover under grazing and protection. This report represents coverage of part three of this study.

I would like to thank Dr. Alma Winward for his guidance and help. I would also like to thank the many people in the Range and Watershed Staff for all their diligent labor, especially Cindy Christensen who assisted with organization and typing of this report.

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INTRODUCTION

Horseshoe Studies

This study has been divided into three sections. Section one includes the vegetation cover changes between 1915 and 1960 as reviewed and presented by Johnson (1964). This information is summarized in Tables 1A, 1B, 2A, 2B, 3, and 4, plus the discussions. The data collected on these plots were determined by stem count of the forbs and basal area measurements for the grasses. Data from Major Plot 1 (Table 4) was collected by estimating specie cover. Major Plot 1 is discussed in both Section 1 and Section 2 because its' study period extends from 1915 to 1986.

Section 2 includes data collected between 1986 (generally) and 1991. These data came from estimates in four major plots. All but Major Plot 1 were new structures. Major Plot 1, 2, and 4 each had six, 100 square foot estimate plots that have been studied since 1936. Major Plot 2 also had four, 8' x 8' estimate plots, all of which have been protected by the Upper Horseshoe Exclosure. Only Major Plot 4, south of the exclosure, was open to grazing.

Section 3 includes changes that have taken place at the Lower Horseshoe Exclosure. Here there has been a change from a Chrysothamnus viscidiflorus - Stipa lettermanii community toward a forb dominated community.

HORSESHOE STUDIES

Location

The Horseshoe study plots are located in section 14, township 17 south, range 4 east in upper Becks Creek drainage. The Lower Horseshoe exclosure can be seen from the Ephraim - Orangeville Road, (about one mile below the Sky Line Drive). The Upper Horseshoe plots are about a half mile NNW from the Lower Horseshoe plots and about a 150 foot rise in elevation. The Lower Horseshoe plots occur at about 9,900 feet in elevation, the upper study is at about 10,000 feet (see Figure 1).

In his Thesis, Johnson (1964) made an important contribution in organizing raw data. To quote Johnson, "In 1960 an attempt was made to duplicate the methods used from previous studies in collecting these various types of records so as to establish a basis for comparing the present conditions with those of the past. Not all methods used in the past have been outlined clearly enough to ensure consistent examination techniques through the years" (Johnson 1964).

Johnson classified the study plots into three categories as follows:

1. Quadrats: Six meter square (M^2) quadrats were established first in 1915, followed by two more in 1932 (Figure 2). Of the first four, two were established within the exclosure (21 E. & 21 W.) and two outside the exclosure (22 E. & 22 W.). In addition to the range reconnaissance data for the period of 1912 to 1914, site studies were made between 1976 and 1986. Data were available from periodic studies of permanent plots over a period of 45 years (1915-1960).
2. Major plots, as here defined, are all square plots larger than one meter on a side. The smallest are 8 ft. x 8 ft. and the largest are 33 ft. x 33 ft. All representatives of this group have been inventoried by species cover estimates.
3. Permanent estimate plots are circular; each one has an area of 100 square feet. They are located at both study sites and were observed once in 1936 and again in 1960. The quantitative data collected on them for these years was in the form of species cover estimates based on the Square Foot Density Method (Stewart and Hutchings 1936).

Data from the latter were taken from a thesis by Johnson (1964). He summarized information for the Great Basin Experiment Station plot records in 1958 and then made final measurements and estimates in 1960. Johnson's data and results are discussed in the Upper Horseshoe Plot Studies.

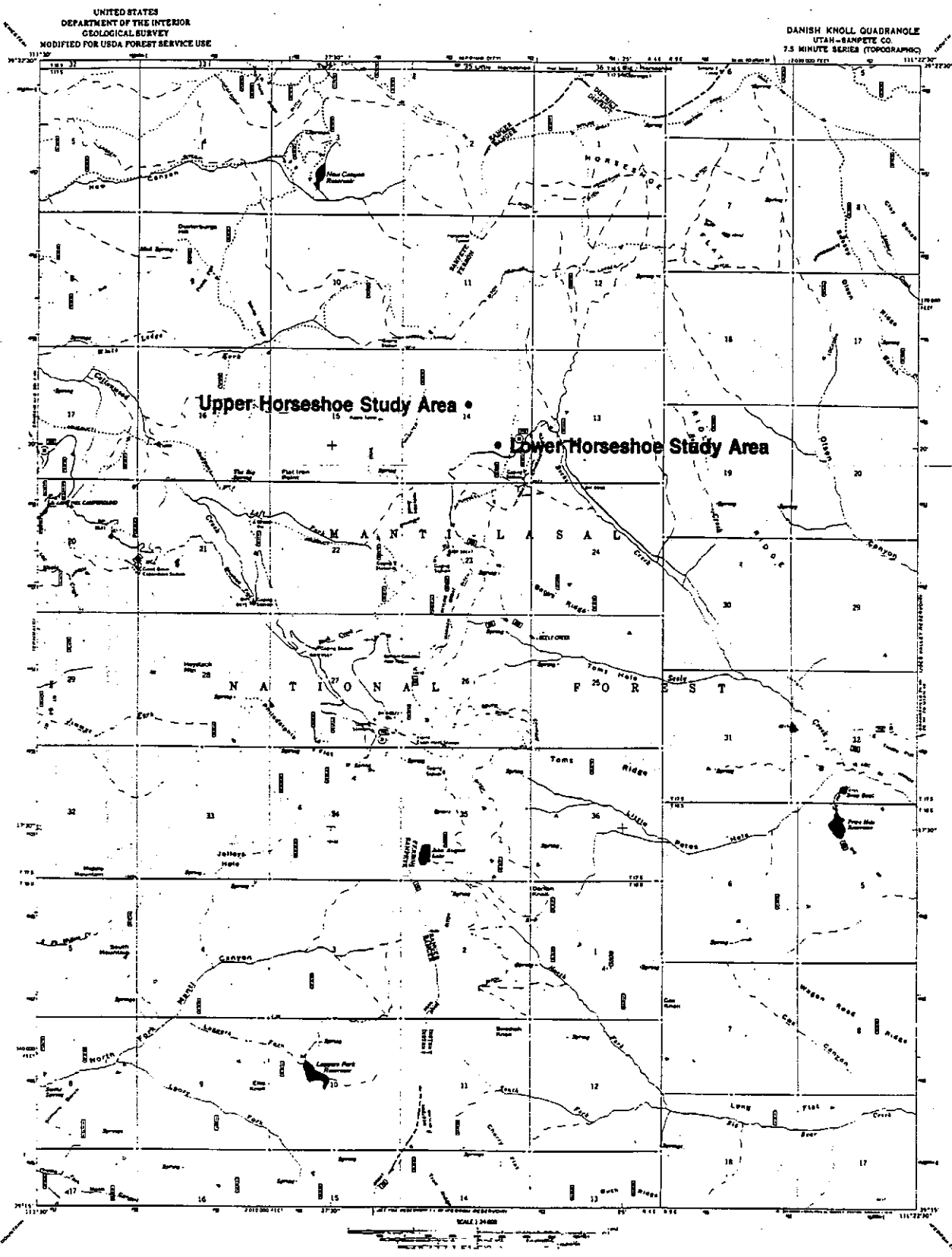
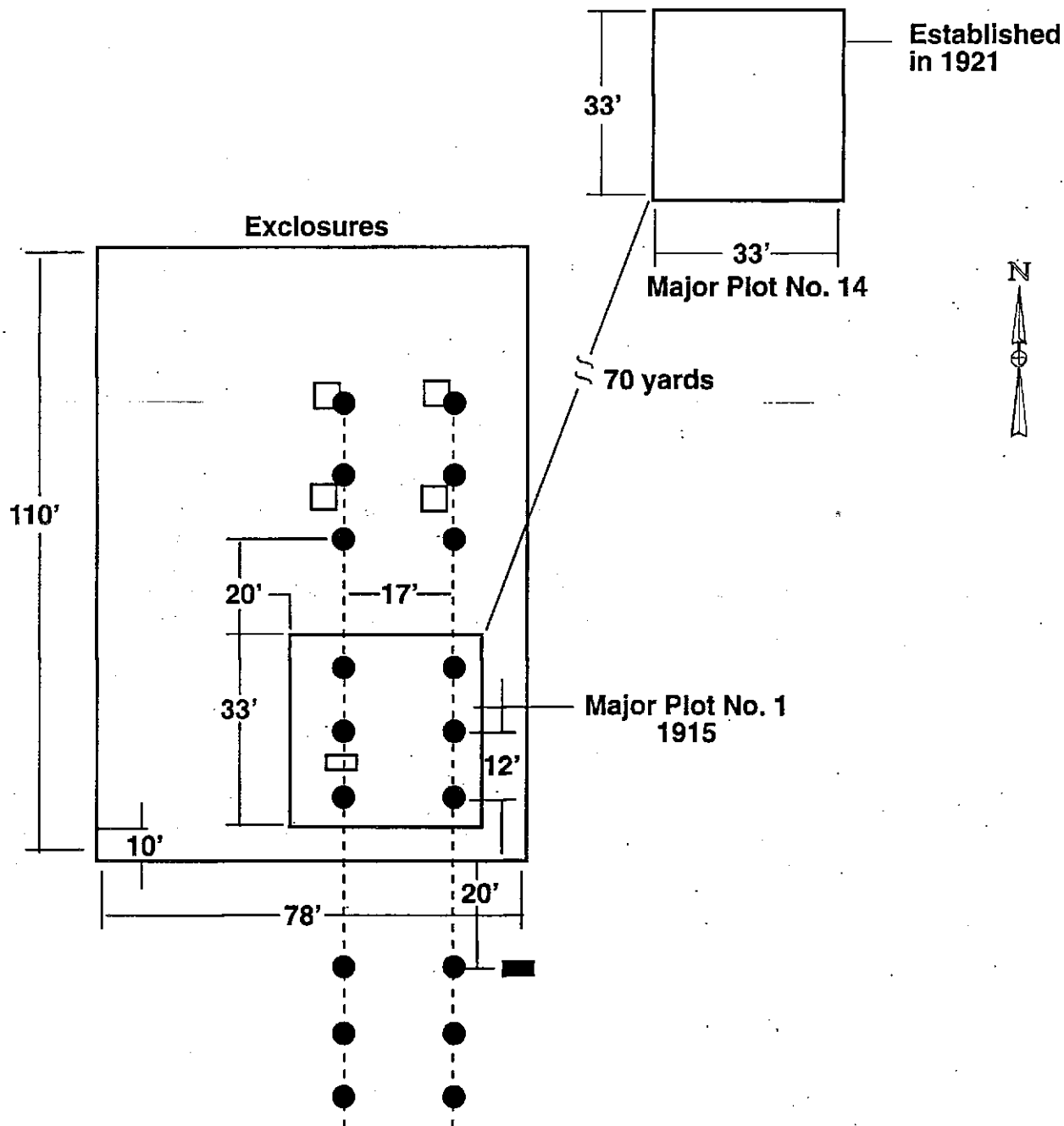


Figure 1. Map of the Upper and Lower Horseshoe study area located on the Manti-LaSal National Forest.

Figure 2 UPPER HORSESHOE STUDY PLOTS



- Hub of 100 sq. ft. Circular Plots, Established in 1936
- 8ft x 8ft Major Plots, Established in 1932
- Meter Square Quadrat 22E 22W
- Meter Square Quadrat 21E 21W

Scale 1 in = 30 ft

Soils

The soils of the Upper and Lower Horseshoe study plots are very similar. Both fall into the clay loam textural class and vary in depth between 20 and 30 inches. Both are located on relatively level terrain which has protected them from heavy erosion. The soils lie on Flagstaff Limestone but are slightly acidic at the surface and slightly basic at lower levels.

Major Plot 14, located about 70 yards north of the Upper Horseshoe Quadrats, is located on relatively poor, rocky soils.

Physical Features

The physical features on Horseshoe Flat were altered by glacial action. Glacial movement was in a south easterly direction. The resistant Flagstaff Limestone has an average slope of about 10 percent. The present slope is not uniform, but uneven with a series of steps resulting from glacial quarrying (Johnson 1964; Spieker 1940).

The slopes between the steps are relatively mild. Johnson (1964) indicated that the upper steps, with their relatively deep soils, support the rhizomatous forb-grass community. The Lower Horseshoe study site is found on a well drained brink step.

Precipitation

Data from the Straight Canyon Barometer Watershed Study and the Meadows Weather Station have been the source of precipitation records used in this study. In fact, the Horseshoe Study Plots are located in the upper reaches of the Barometer Watershed. The Meadows Weather Station is located just below the Watershed Study Area at the head of Ephraim Canyon.

The Barometer Watershed studies were carried out between 1967 and 1978. Data for the same period of time were used from the Meadows Station records to compare precipitation on the east and west slopes of the plateau. The Seely Creek (east slope) Station, at the 9,900 foot elevation, had an average precipitation of 34.63 inches for that period of time. This Station is about 1 1/2 miles south of the Lower Horseshoe Exclosure which is at about the same elevation. Precipitation at the Meadows Station on the west slope was 36.69 at an elevation of 10,000 feet, or about 100 feet higher than the Seely Creek Station.

The Upper Horseshoe Exclosure is at about the same elevation as the Meadows Station, but on the east slope of the plateau.

Upper Horseshoe Plot Studies

The original Upper Horseshoe Exclosure was enclosed in 1915. It was 40 ft. x 40 ft. in size enclosed with a pole and post type fence. The original study plots included four M^2 quadrats, 21 E. and 21 W., 22 E. and 22 W., plus Major Plot 1. Quadrats 21 E. and 21 W. as well as Major Plot 1 were protected by the exclosure fence while quadrats 22 E. and 22 W. were grazed plots located just outside the exclosure. Major Plot 1 was a 33 foot square estimate plot. Relatively intensive measurements were made in the M^2 quadrats including stem counts of the forbs and a measure of basal area of the grasses in square centimeters (cm^2). The grass records were not started until 1924. Over the period of 45 years (1915 to 1960) 14 separate stem counts were made of the forbs and 12 cm^2 measurements of the grasses. Other plot studies were added after 1931 when the size of the exclosure was increased to 78 ft. x 110 ft.

In 1932, two more M^2 quadrats (No. 56 and 57) were established and they were observed four additional times after the 1932 observation. Four, 8 ft. x 8 ft. Major Plots were added at the same time. These plots had been protected 29 years before Johnson made his observations in 1960.

The Square Foot Density Method (Stewart and Huchings 1936) was introduced into the Upper Horseshoe Studies in 1936. In that year 18 circular 100 square foot plots were installed. Twelve were within the exclosure and protected from grazing; six were just south of the exclosure and were open to grazing use. Major Plot 14 is located 70 yards northeast of Major Plot 1. It was open to grazing throughout the study period. It was first studied in 1921 and has been studied 14 times from 1921 to 1960.

Between 1915, when the first plots were established, and 1960, a considerable number of people have been involved with the studies even to the point of introducing new methods. Johnson (1964) brought the Horseshoe Studies up-to-date in 1960. He made the following statement: "In 1960 when an attempt was made to duplicate the methods used in collecting these various types of records so as to establish a basis for comparing the present conditions with those of the past, some difficulties were encountered in obtaining comparable quantitative data from the plots. Not all methods used in the past have been outlined clearly enough to insure consistent examination techniques through the years."

Johnson's greatest effort was with the four M^2 quadrats, where stem counts of forbs and a cm^2 basal area measurement of grasses were taken, unfortunately only four square meters were studied with these methods. All the other determinations were by estimates. These included the Major Plots which varied from 33 ft. x 33 ft. to 8 ft. x 8 ft. plus 18 permanent estimate plots (100 square feet circular plots).

In discussing the Major Study Plots, Johnson said, "All representatives of this group have been inventoried by species cover estimates. Various investigators, using different methods, have participated in making these estimates; so, the cover valued obtained for the species in different years are not considered directly comparable. These data still have value, however, since the relative importance of each species to the total amount of plant cover should remain the same even if different methods resulting in different cover values are used" (Johnson, 1964).

GENERAL METHODS

In Johnson's (1964) study, a relative amount of the species cover was the main interest. He used what he called "cover value" estimates. In this system, total cover is estimated and individual species values are converted into a percent of the whole value.

With the exception of stem counts of forbs and basal area measurements for grasses, occurrence estimates were used to determine vegetation changes over the study years. The stem counts and the basal area measurements were only used on the four meter square (M^2) quadrats (two protected and two grazed). These four quadrats (21 E. 21 W. and 22 E. 22 W.) were originally marked with wooden stakes. The rest of the information came from ocular estimates.

The present author followed a data collection system more like Ellison (1954). The main procedures used for collecting field data was to classify the species into six categories according to their relative abundance as follows:

<u>PERCENT</u>	<u>MEAN</u>
1 = 51 to 100	75
2 = 26 to 50	37
3 = 12 to 25	18
4 = 6 to 11	9
5 = 3 to 5	4
6 = 1 to 2	2
Trace	"T"

These data were collected for each type studied and total cover also was estimated.

No attempt was made to use the forb stem count and grass basal area data from of the M^2 quadrats. Instead, the study area was divided into four major plots (three in addition to Major Plot 1). This resulted in three plots within the enclosure and one immediately to the south on the grazed range. Major Plot 14, 70 yards NNE of the enclosure was included but not added to the final tallies because the location markers were not found. Johnson (1964), based his conclusions on data from the grazed quadrat 22 W. which was almost barren in 1936. This barren spot had become occupied with Stipa lettermanii by 1961. Ellison (1954), discussed these barren spots in 1954. In his study of old records, he found that some of these bald spots were over 30 years old. This indicated that S. lettermanii has actually invaded the barren spot rather than replacing Elymus trachycaulus.

SECTION 1

METHODS FROM 1915 TO 1960

[From Johnson (1964)]

Johnson (1964) stated: "Vegetation changes are the main object of consideration in this paper. This study is concerned with some of the oldest permanent native vegetation study plots in the Western United States. They are located on Horseshoe Flats on the Wasatch plateau in Central Utah." (Section 1 is a record of these changes that took place prior to 1960. The present author has continued this work with the same objective).

In 1960 Johnson duplicated several of the studies. He gave considerable attention to four, meter square quadrats. Of these quadrats, two were located within the Upper Horseshoe Enclosure where they could be protected from grazing and two outside the enclosure where grazing was allowed. (Tables 1a, 1b, 2a, 2b.)

The first records in 1915, consisted of stem counts of the forbs. In addition, cover estimates were made on Major Plot 1, a 33 X 33 foot plot within the enclosure. This would include the M² quadrats that were protected and grazed. (Tables 1a, 2a, 3).

Basal area measurement of the grasses (cm²) were not started until 1924. It turned out that the data from two of the grasses, Stipa lettermanii and Elymus trachycalyx, formed the basis for Johnson's main conclusions.

SECTION 1

Summary of Tables 1A and 1B

Tables 1A and 1B are a summary of stem counts of forbs on the Upper Horseshoe meter square, (M^2), quadrats. These data give a good indication of the general trends of the forb species. The following discussion will furnish additional information for the major species.

In 1915, when the study was started, the protected quadrats (Table 1B) had almost twice the stem count of perennial forbs than the grazed plots (Table 1A). However, by 1919 when the second stem count was made they were about equal.

Achillea millefolium and Penstemon rydbergii furnished most of the stem count in 1915. Over the period of the study, A. millefolium declined, while P. rydbergii maintained a high position. Over the entire study period P. rydbergii maintained an average stem count of 321 on the grazed quadrats and 284 on the protected (Tables 1A and 1B).

Aster foliaceus first appeared on the grazed quadrats in 1940 and on the protected quadrats in 1948. Although A. foliaceus did not appear on the protected quadrats until 1948, it was recorded in Major Plot 1 in 1941, which includes the protected quadrats within its boundary. This rhizomatous species is a strong contender in Tall Forb Communities where it often forms near pure colonies.

Viguiera multiflora appeared on the protected quadrat in 1919 and practically took over by 1934 with 799 stems. At that date, V. multiflora and P. rydbergii furnished 85 percent of the stem counts. V. multiflora had another peak in 1941 and from that point declined until 1960 with 94 stems. It shows evidence of being a short lived perennial (Johnson 1964).

Viola nuttallii was an erratic species with abrupt and wide fluctuations. It was first recorded on the quadrats in 1919. Peaks based on stem counts on both protected and grazed quadrats were reached in July 1935 and in August 1943. This species is among the earliest species, with flowers often gone by August (Ellison 1954).

Geranium richardsonii started to become noticeable on both the grazed and protected plots in 1941 and it did not increase much. By 1960 only one stem was recorded on one of the grazed quadrats and eight stems on the protected quadrats.

Stellaria jamesii and Vicia americana have been persistent species throughout the study period.

In his summary of the trend between 1915 and 1960 Johnson stated, "Annuals increased during the early part of the study, reaching a peak in 1929. After that they maintained themselves at a relatively high level then dropped off sharply between 1930 and 1940.

Perennial forbs increased after the first observation in 1915, reaching a high peak of abundance in 1943, just three years after the annuals dropped off. Grasses tended to decrease on the study plots. Perennial forbs rose sharply, compensating for the decline in annual forbs. "A successional pattern from the annual forbs, through perennial forbs, to grasses is thus the order of change as it developed in these quadrats" (Johnson 1960).

It is difficult to make a relationship between grasses, which were represented by basal area measurement and forbs represented by stem counts, they can only be compared relatively.

TABLE 1A. UPPER HORSESHOE STUDIES

STEM COUNT OF FORB, (GRAZED)
METER SQUARE QUADRATS, 22 E. 22 W.
1915 - 1960

PERENNIAL FORBS	1915	1919	1924	1929	1932	1934	1935	1936	1940	1941	1943	1948	1958	1960
<i>Achillea millefolium</i> o	65	42	10	12	23	40	25	26	66	78	101	57	13	12
<i>Agoseris glauca</i>	0	41	3	20	5	0	0	0	0	2	1	6	12	10
<i>Arabis drummondii</i>	0	0	0	0	0	1	2	0	0	0	27	8	1	2
<i>Aster foliaceus</i> x	0	0	0	0	0	0	0	0	43	104	180	115	23	53
<i>Chaenactis douglasii</i>	0	0	0	0	1	0	0	0	0	0	0	0	0	0
<i>Delphinium menziesii</i> o	0	4	0	29	1	1	26	1	0	5	102	0	3	15
<i>Erigeron ursinus</i>	2	0	0	0	0	13	23	20	0	1	0	7	0	0
<i>Erysimum asperum</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0
<i>Erythronium grandiflorum</i>	0	0	0	0	0	0	2	1	0	0	13	0	0	1
<i>Geranium richardsonii</i> x	0	0	0	0	0	0	0	0	0	3	3	2	4	1
<i>Lathyrus lanszwertii</i> o	31	11	0	0	0	0	0	0	0	0	0	0	0	0
<i>Oenothera flava</i>	1	3	15	0	3	10	3	2	2	4	11	0	0	0
<i>Penstemon rydbergii</i> o	60	88	3	219	262	311	371	483	236	202	1208	559	351	266
<i>Plantago tweedyi</i>	0	12	26	0	4	11	4	4	1	3	12	8	1	0
<i>Smilacina stellata</i>	0	3	0	10	14	15	20	18	5	10	13	48	9	5
<i>Stellaria jamesiana</i>	0	1	0	3	11	2	18	22	13	17	82	30	71	48
<i>Taraxacum officinale</i> o	17	18	5	1	4	7	5	4	10	37	86	48	15	7
<i>Vicia americana</i> x	0	2	14	21	29	55	68	107	16	65	131	37	7	5
<i>Viguiera multiflora</i>	0	0	0	0	0	3	2	0	0	0	1	0	1	5
<i>Viola nuttallii</i>	0	218	55	129	124	49	189	128	32	167	316	7	1	12
TOTAL PERENNIAL FORBS	176	443	131	444	481	518	758	816	424	698	2287	892	513	449
ANNUAL FORBS	1915	1919	1924	1929	1932	1934	1935	1936	1940	1941	1943	1948	1958	1960
<i>Chenopodium album</i>	0	15	0	15	13	182	125	28	2	15	3	0	1	1
<i>Collomia linearis</i>	0	56	0	183	15	77	95	59	0	3	2	7	8	11
<i>Descurainia richardsonii</i>	2	1	0	2	11	2	11	10	0	2	0	0	0	0
<i>Orthocarpus tolmei</i>	0	0	0	0	0	0	2	4	0	13	12	334	4	0
<i>Polygonum douglasii</i>	0	332	0	728	418	484	579	555	64	169	179	7	2	6
TOTAL ANNUAL FORBS	2	404	0	928	457	745	812	656	66	202	196	348	15	18

Indicator Species: Negative = o, Positive = x

TABLE 1B. UPPER HORSESHOE STUDIES

STEM COUNT OF FORBS, (PROTECTED)

METER SQUARE QUADRATS 21 E. 21 W.
1915 - 1960

PERENNIAL FORBS	1915	1919	1924	1929	1932	1934	1935	1936	1940	1941	1943	1948	1958	1960	
<i>Achillea millefolium</i>	0	111	...	10	20	9	16	15	16	27	35	68	33	56	44
<i>Agoseris glauca</i>		0	0	0	0	0	0	0	0	0	0	0	5	10	1
<i>Allium acuminatum</i>		0	0	0	2	0	0	0	0	0	0	0	0	0	0
<i>Arabis drummondii</i>		0	0	0	0	0	0	0	0	0	0	0	0	1	0
<i>Aster foliaceus</i>	x	0	0	0	0	0	0	0	0	0	0	0	20	220	92
<i>Delphinium menziesii</i>	0	0	0	2	1	0	2	1	1	0	0	0	0	4	0
<i>Erysimum elatum</i>		0	0	0	0	0	0	0	0	0	0	0	0	4	2
<i>Geranium richardsonii</i>	x	0	17	0	1	3	0	0	0	0	1	6	6	7	8
<i>Lactuca serriola</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Penstemon rydbergii</i>	0	258	283	11	144	182	344	389	417	324	419	933	459	394	242
<i>Plantago tweedyi</i>		1	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Stellaria jamesiana</i>		0	24	17	31	65	48	98	111	29	63	169	85	161	52
<i>Taraxacum officinale</i>	0	23	3	0	1	0	1	1	0	0	1	4	0	0	0
<i>Vicia americana</i>	x	17	8	36	19	28	54	57	55	19	44	124	47	45	21
<i>Viguiera multiflora</i>		0	7	31	170	337	799	256	120	235	785	617	341	249	94
<i>Viola nuttallii</i>		0	74	14	70	86	79	179	116	40	47	256	101	37	11
TOTAL PERENNIAL FORBS	410	416	119	459	709	1344	997	836	674	1395	2177	1097	1188	568	

ANNUAL FORBS	1915	1919	1924	1929	1932	1934	1935	1936	1940	1941	1943	1948	1958	1960
<i>Androsace septentrionalis</i>	0	0	0	2	0	0	0	0	0	1	0	0	0	0
<i>Chenopodium album</i>	0	6	0	11	46	13	19	15	6	2	11	1	0	0
<i>Collomia linearis</i>	0	67	0	1365	59	19	32	19	24	40	37	150	25	1
<i>Descurainia richardsonii</i>	11	1	0	22	19	0	5	8	1	18	3	0	0	0
<i>Orthocarpus tolmei</i>	0	0	0	23	2	3	8	42	0	55	23	645	4	5
<i>Polygonum douglasii</i>	0	88	0	35	38	46	53	49	8	25	19	45	0	0
TOTAL ANNUAL FORBS	11	162	0	1458	164	81	117	133	39	141	93	841	29	6

Indicator Species: Negative = 0, Positive = x

Trends of Grasses on the Upper Horseshoe Studies

Basal area measurements of the grasses were not started on the M² quadrats until 1924, or nine years after the Upper Horseshoe Studies were started. By that time it is believed the grasses had made substantial gains on both the grazed and protected quadrats.

A general photograph of the Upper Horseshoe and its foreground was taken when the study was started in 1915 and it showed a very barren situation (Figure 3). This photo indicated quite strongly that vegetal cover was comparable within both the exclosure and the outside area. Vegetation was so sparse that the small white rocks and pebbles were clearly visible. Photos were taken of both the grazed and protected quadrats in 1919 (Figures 4 and 5). At that time a very sparse cover of forbs was observed on the grazed quadrats. Data records showed that Penstemon rydbergii and Viola nuttallii made up most of the cover. In contrast, a fair stand of Bromus carinatus was shown on the protected plots.

By 1924, when the first basal area measurements were made Elymus trachycaulus was at its peak on the grazed plots with a basal area of 644 cm². The same was true on the protected quadrats where B. carinatus was also at its peak with 1779 cm² of basal area. In fact, the early recovery within the M² quadrats were primarily from these two species of grass and from a few annual forbs. However, by the end of the 45 year study period when Johnson made his remeasurements both E. trachycaulus and B. carinatus as well as the annual forbs had been almost eliminated from the quadrats.

Stipa lettermanii first appeared on the grazed quadrats in 1929 with 2 cm² and increased gradually until 1943. From that point it increased rapidly to a peak 1720 cm² in 1958, then showed a decrease in 1960 when Johnson measured 1160 cm². On the other hand, S. lettermanii had nearly disappeared from the protected quadrats by 1932 while Stipa nelsonii made a fair increase on these protected quadrats.

Cover estimates on both the protected and grazed plots told the same general story as told by the M² quadrats; a strong increase of S. lettermanii on the grazed quadrats accompanied by the loss of E. trachycaulus and B. carinatus on both the grazed and protected quadrats. S. nelsonii increased, particularly on the protected plots and quadrats.

The trend on the grazed circular plots also showed a strong increase in S. lettermanii between 1936 and 1960. From .6 percent cover to 24 percent. This and its increase on the grazed quadrats probably prompted Johnson (1964) to predict, "A successional pattern proceeding from annual forbs, through perennial forbs to grasses is thus the order of change as it developed on the quadrats."

The records from the circular plots helped bridge the gap between the different systems of measurement. For example, the increase of S. lettermanii to 1160 cm² on the M² grazed quadrats (22 E. and 22 W.) could be compared to the 24 percent cover on the grazed circular plots. How to compare them could be a problem. The total basal area of S. lettermanii would amount to about 6 percent of the total area of two M² quadrats. Certainly, percent cover would exceed the basal area, perhaps two or three times and could compare with the 24 percent cover.

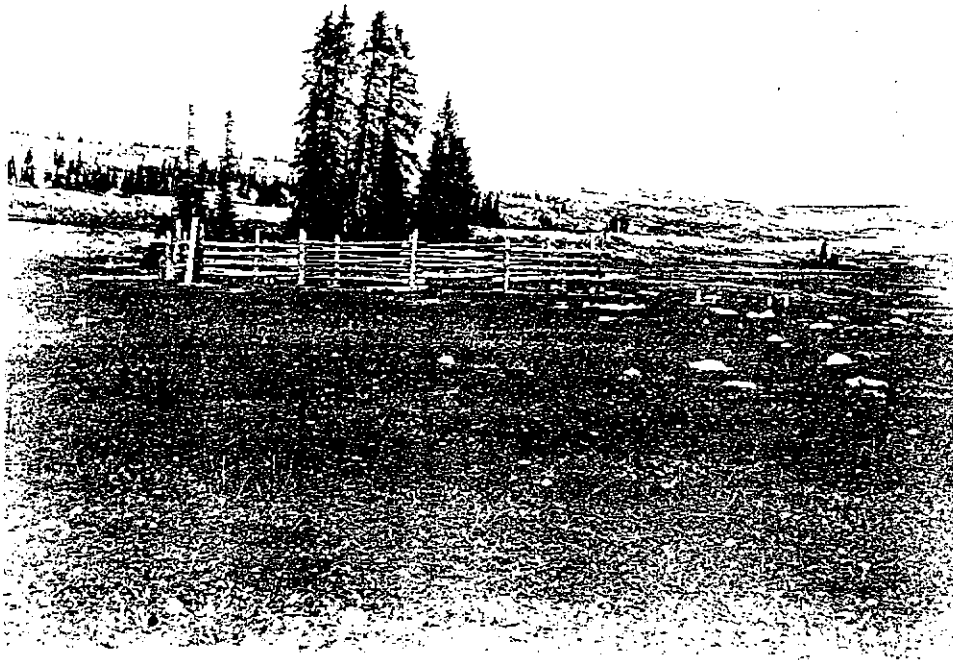


Figure 3. Upper Horseshoe Exclosure late in the fall after grazing, 1915 (exact month and day not known). The bareness of the area is evident. White stakes mark quadrats inside and outside the exclosure. Gopher mounds can be seen in the foreground (Johnson 1964).

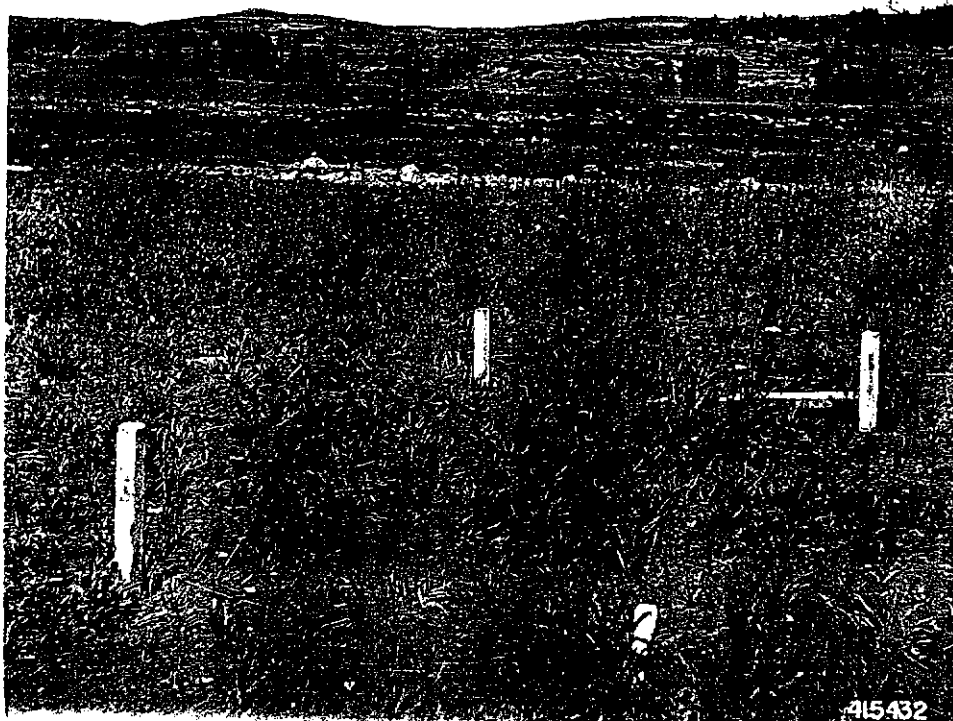


Figure 4. Grazed Quadrats 22 E. and 22 W., July 19, 1919, Upper Horseshoe. Vegetation is composed chiefly of scattered forbs, probably Penstemon rydbergii and Viola nuttallii. Some grass can be seen in the plot foreground but is not conspicuous in the area. The lack of grass may be a somewhat seasonal feature (Johnson 1964).

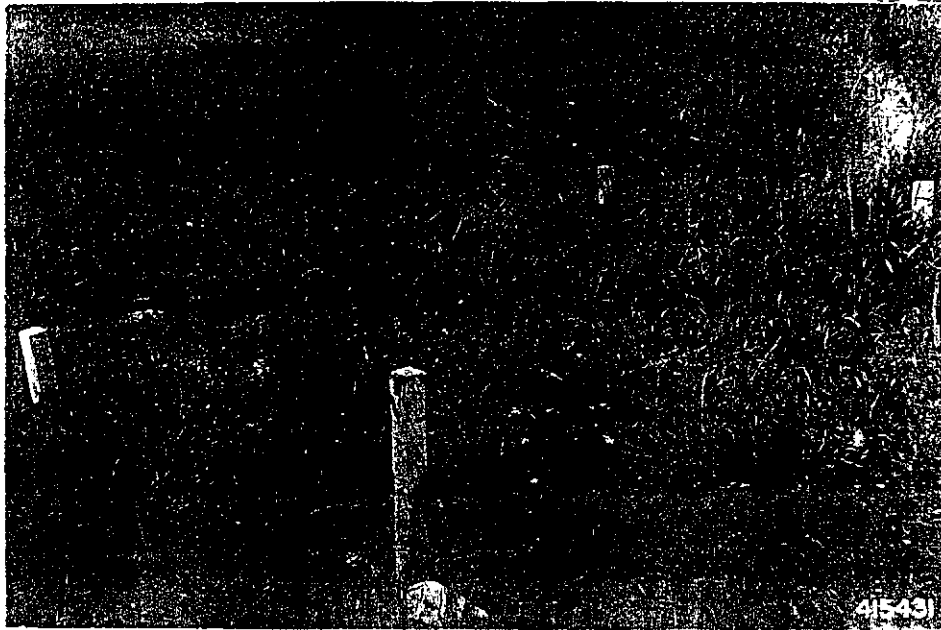


Figure 5. Protected Quadrats 21 E. and 21 W., July 30, 1919, Upper Horseshoe Exclosure. The most conspicuous grass is Bromus polyanthus¹. Gopher mounds are abundant. Large bare areas occur between the plants. The quadrat vegetation appears to be representative of the rest of the exclosure (Johnson 1964).

¹The name of this species has since been changed to Bromus carinatus.

TABLE 2A. UPPER HORSESHOE STUDIES

BASAL AREA IN CM2 FOR GRASSES

QUADRATS 22 E. 22 W., (GRAZED)
1924 - 1960

GRASSES	1924	1929	1932	1934	1935	1936	1940	1941	1943	1948	1958	1960
Elymus trachycaulus	644	137	437	231	84	121	89	55	38	37	5	2
Melica bulbosa	0	0	0	0	0	0	0	0	0	2	0	0
Stipa nelsoni	0	0	0	0	0	0	0	0	0	0	1	3
Stipa lettermanii	0	2	1	54	8	27	35	58	88	275	1790	1160
Trisetum spicatum	1	37	65	47	27	28	31	26	60	47	32	10
TOTAL GRASSES	645	176	503	332	119	176	155	139	186	361	1828	1175

TABLE 2B. UPPER HORSESHOE STUDIES

BASAL AREA IN CM2 FOR GRASSES

QUADRATS 21 E. 21 W., (PROTECTED)
1924 - 1960

GRASSES	1924	1929	1932	1934	1935	1936	1940	1941	1943	1948	1958	1960
Elymus trachycaulus	353	70	100	109	31	34	80	128	166	99	29	6
Bromus carinatus	1779	134	371	179	70	68	285	291	309	18	7	0
Melica bulbosa	0	0	0	0	0	0	1	10	12	9	5	1
Stipa nelsoni	0	0	0	0	0	4	2	0	2	3	65	33
Stipa lettermanii	198	19	0	0	0	0	0	0	0	3	0	1
Trisetum spicatum	42	0	0	0	0	0	0	0	0	14	1	1
TOTAL GRASSES	2372	223	471	288	101	106	368	429	489	146	107	42

Photograph Record

Only six species of perennial forbs were listed from the quadrats (21 E. and 21 W. protected, 22 E. and 22 W. grazed) in 1915 and only three species of major importance in trend determination were present. First was Achillea millefolium, which during the study period from 1915 to 1960 experienced a downward trend. Second was Penstemon rydbergii which held the dominant position through most of the 45 year study period. Third was a wide fluctuating species, Viguiera multiflora. V. multiflora was first listed on the protected quadrats in 1919. It thrived and exceeded the stem count of P. rydbergii three times during the course of the study period.

Photographs of the individual grazed and protected quadrats were shown in 1936 and 1940. Johnson repeated the photographs in 1961 with the following results:

Grazed quadrat 22 W. was almost bare of vegetation in 1936 except for a clump of P. rydbergii in the left-hand corner (Figure 6). By 1961, nearly half of the quadrat had been occupied by Stipa lettermanii (Figure 7). Data from 1960 shows that P. rydbergii and A. foliaceus were the principal forbs (Table 1A).

A statement under the 1936 photograph of quadrat 22 E., says "A clump of P. rydbergii covers most of the plot..." (Johnson 1964) (Figure 8). By 1961, Johnson's photograph showed an almost complete cover of vegetation (Figure 9) most of which was P. rydbergii and A. foliaceus, indicated by the 1960 data (Table 1A).

Protected quadrat 21 W. showed a sparse cover of vegetation in 1936 (Figure 10). The description with the photograph reads; "Bare disturbed soil covers most of the quadrat" (Johnson 1964). The vegetation present on the plot was mostly P. rydbergii. The photograph taken in 1961 of 21 W., showed an almost complete cover of vegetation (Figure 11). Johnson states, "Much of the open space apparent in 1936 has filled in with Aster sp." (Aster foliaceus) (Johnson 1964).

Part of the description of protected quadrat 21 E., in 1936, stated; "P. rydbergii clumps occur scattered over the quadrat (Figure 12). Grasses, Agropyron trachycaulum and Bromus polyanthus, are evident in the center of the plot" (Johnson 1964). In 1961, a statement of protected plot 21 E. reads, "Penstemon clumps have decreased in area and are restricted to the right side of the quadrat (Figure 13). Aster sp. occurs on the left side of the plot. Stipa columbiana is the most conspicuous grass" (Johnson 1964).

Photographs of the double quadrats 22 E. and 22 W. grazed and 21 W. and 21 E. protected were taken in 1940 (Figures 14 and 15). At that late date of August 19, 1940, the forbs did not show up well on either the grazed or protected quadrats. Nevertheless, data shows there had been a considerable increase in forb cover particularly on the protected quadrats 21 E. and 21 W. (Table 1A and 1B). There were, however, spots of bare soil. Data showed that P. rydbergii and V. multiflora represented most of the stem counts (Table 1B). The sparse cover of grass was mostly B. carinatus (Table 1A).

In 1960, there were other important species listed in the combined quadrats 21 E. and 21 W. in 1960 they are, V. multiflora and Stelleria jamesiana. The plot shows a good plant cover (Johnson 1964).

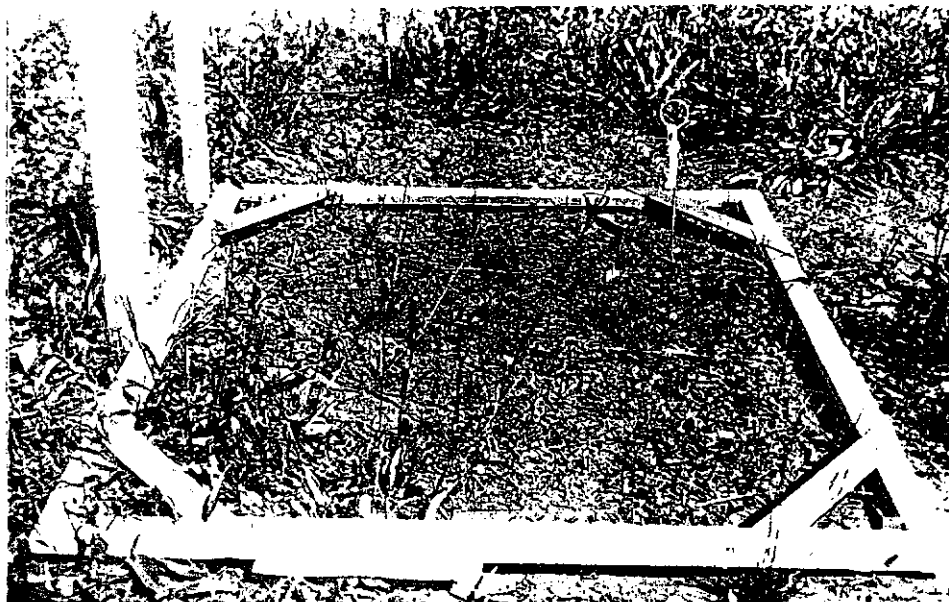


Figure 6. Grazed Quadrat 22 W., 1936 (month and day not known but judged to be late July), Upper Horseshoe. Much of the quadrat is bare. A few bunches of grass occur in the open area. A clump of Penstemon rydbergii, in blossom, occupies the lower left corner of the plot (Johnson 1964).

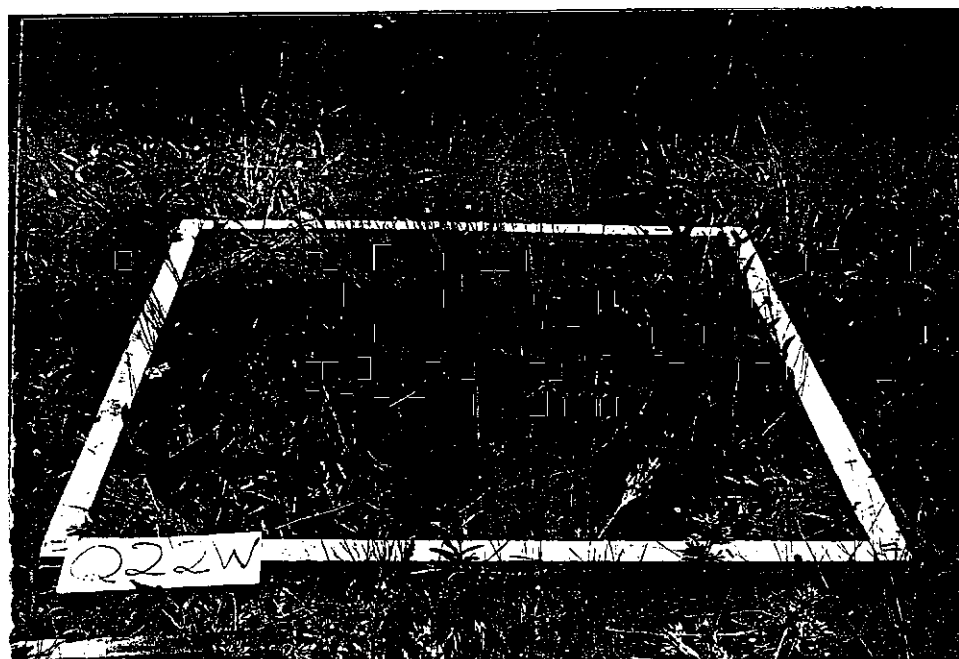


Figure 7. Grazed Quadrat 22 W., August 29, 1961, Upper Horseshoe. The large open area present in 1936 has filled in with grass (Stipa lettermanii). The clump of Penstemon still occupies the lower left corner of the plot (Johnson 1964).

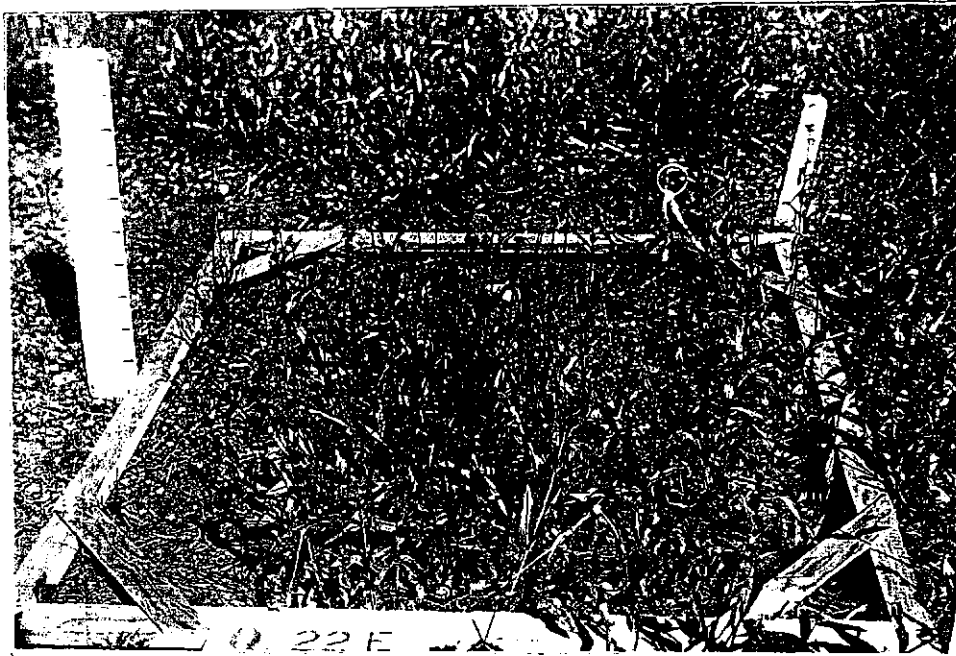


Figure 8. Grazed Quadrat 22 E., 1936, (month and day not known but judged to be late July), Upper Horseshoe. A clump of Penstemon rydbergii covers most of the plot. Some grass can be seen in the open area to the left of the Penstemon (Johnson 1964).

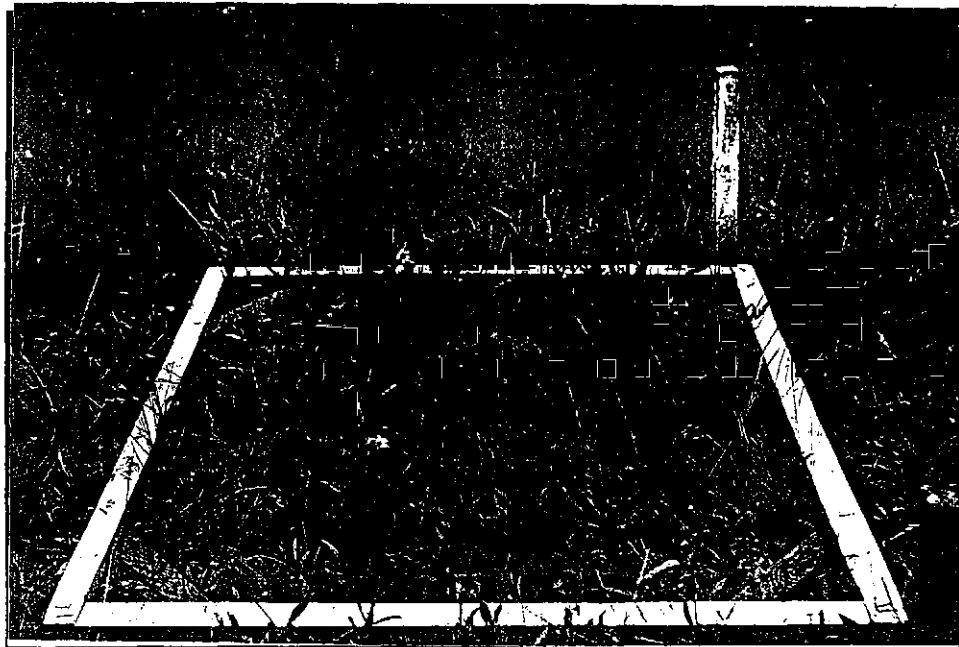


Figure 9. Grazed Quadrat 22 E., August 29, 1961, Upper Horseshoe. The bare areas have filled in with plants. Plot vegetation has a more varied composition than it did in 1936. Grass is conspicuously scattered throughout. Aster ssp. and Achillea lanulosa are in bloom (Johnson 1964).

¹The name of this species has since been changed to Achillea millefolium ssp. lanulosa.

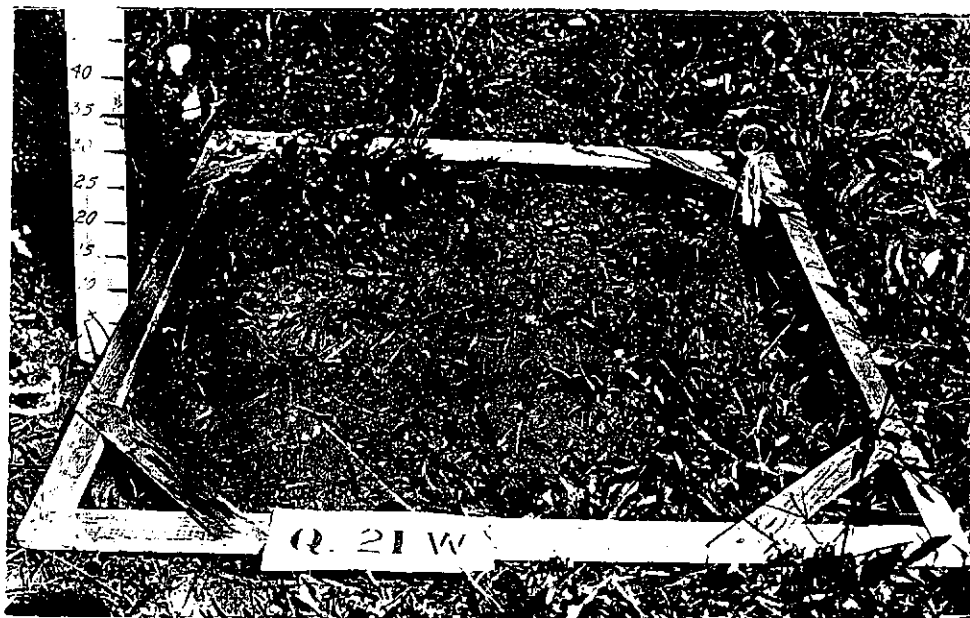


Figure 10. Protected Quadrat 21 W., 1936 (month and day not known but judged to be late July), Upper Horseshoe Exclosure. Bare disturbed soil covers most of the quadrat. Penstemon rydbergii provides most of the plant cover (Johnson 1964).

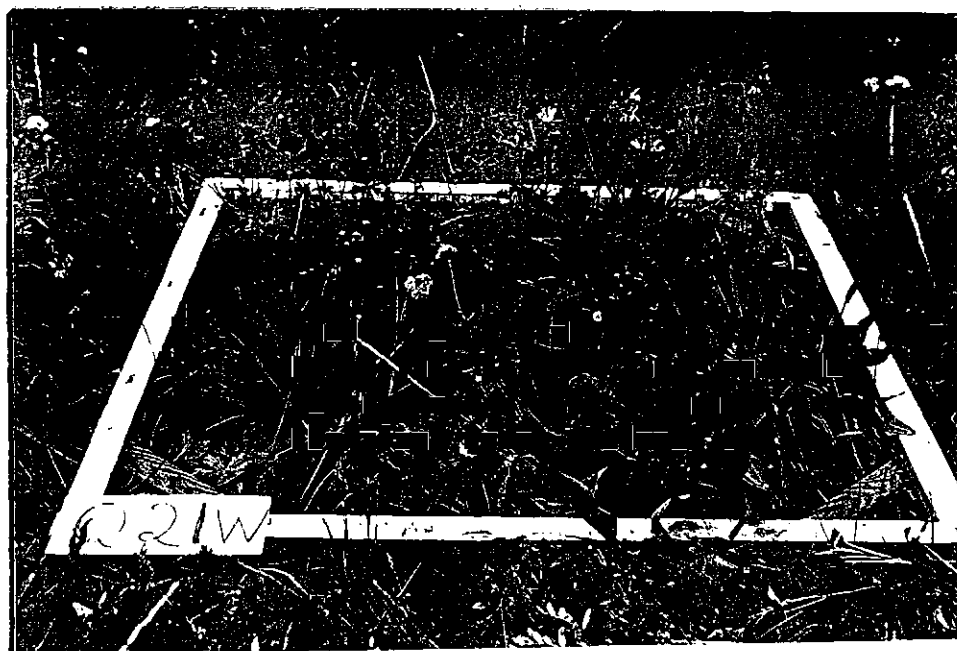


Figure 11. Protected Quadrat 21 W., August 29, 1961, Upper Horseshoe Exclosure. Much of the open space apparent in 1936 has filled in with Aster ssp. Plant cover has become more varied and provides improved protection for the soil (Johnson 1964).

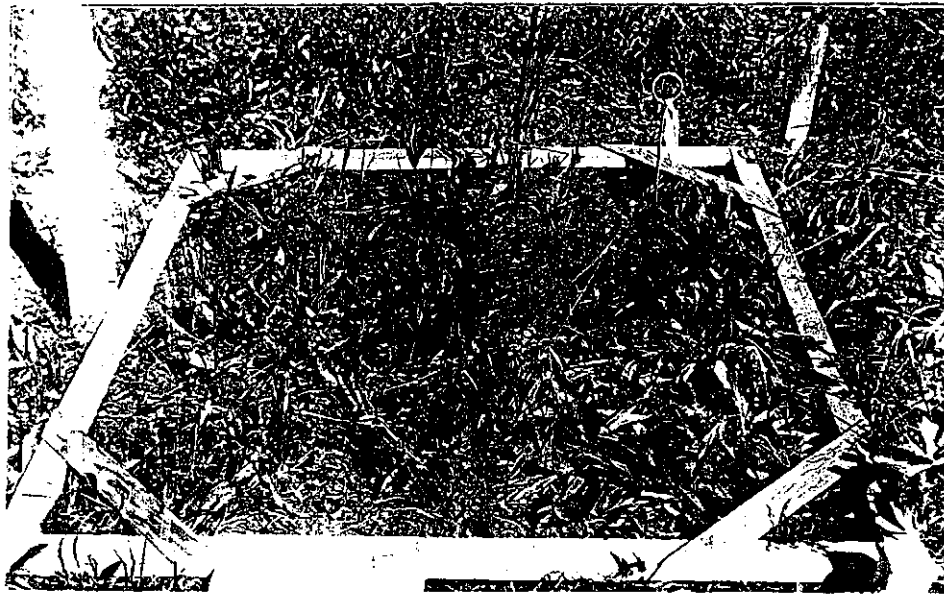


Figure 12. Protected Quadrat 21 E., 1936 (month and day not known but judged to be late July), Upper Horseshoe Exclosure. Penstemon rydbergii clumps occur scattered across the quadrat. Grasses, Agropyron trachycaulum and Bromus polyanthus¹ are evident in the center of the plot (Johnson 1964).

¹The name of this genus and species has since been changed to Elymus trachycaulus.

²The name of this species has since been changed to Bromus carinatus.



Figure 13. Protected Quadrat 21 E., August 29, 1961, Upper Horseshoe Exclosure. Penstemon clumps have decreased in area and are restricted to the right side of the quadrat. Aster ssp. occurs on the left side of the plot. Stipa columbiana is the most conspicuous grass (Johnson 1964).

¹The name of this species has since been changed to Stipa nelsonii.

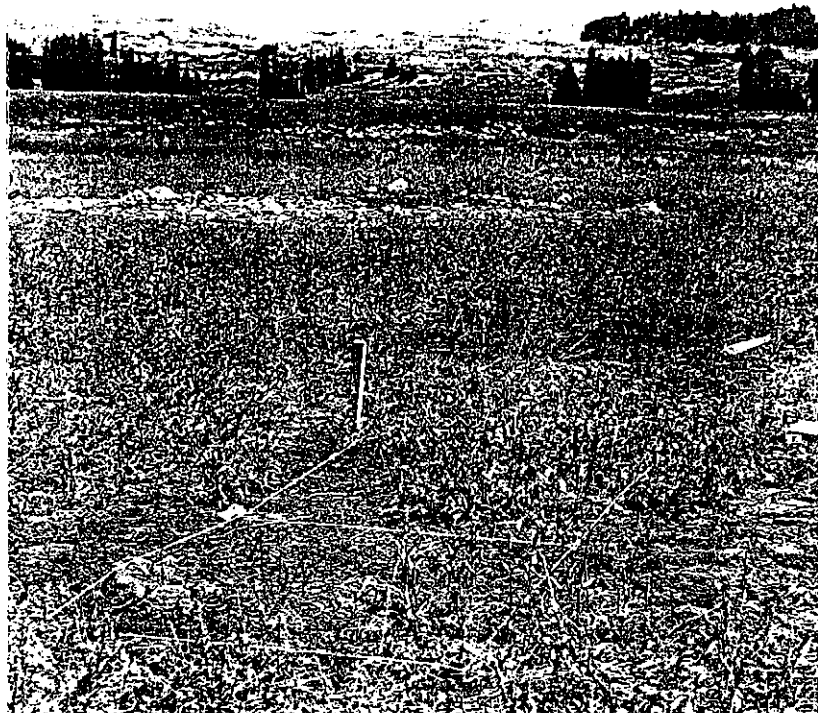


Figure 14. Protected Quadrats 21 E. and 21 W., August 19, 1940, Upper Horseshoe Exclosure. Some bare areas visible in 1919 have filled in. The open areas remaining are covered with litter. The vegetation has become more varied. Forbs are more in evidence than they were in 1919 (Johnson 1964).



Figure 15. Protected Quadrats 21 E. and 21 W., August 29, 1961, Upper Horseshoe Exclosure. Plant cover has increased on the plot and in the surrounding area since 1940. Achillea lanulosa¹ in bloom in the foreground and Aster ssp. is in bloom in the center of the plot. Most of the visible grass is Stipa columbiana² (Johnson 1964).

¹The name of this species has since been changed to Achillea millefolium ssp. lanulosa.

²The name of this species has since been changed to Stipa nelsonii.

Summary of Table 3

Major Plot 14 (Table 3) stands almost alone. Because of its distance from Major Plot 1 (70 yards) and soil differences, it cannot be compared directly with Major Plot 1. Major Plot 14 was established in 1921, six years later than the other Horseshoe study plots. It improved from 1915 until it was first studied in 1921 like the other Horseshoe plots. This improvement in the vegetation after 1915 was probably due to restricted grazing resulting from the enforcement of the so-called "mile limit". Livestock were not allowed to graze the crest of the plateau (generally a mile-wide strip) until after the period of high intensity storms was passed. July and August were generally the months of high summer precipitation. This restriction was only enforced for a few years. The Horseshoe plots were within the mile limit so should have benefited by limited grazing use. One of the results of reduced grazing was the overall increase in species. This increase is shown in Major Plot 1 (Table 4). In 1915 when first established, there were six perennial forbs, and four grass species. By 1921 it had 18 perennial forbs and six grass species.

In 1921 when Major Plot 14 was first studied, it had 20 perennial forbs and seven grass species. It is realized that a large number of species is not always an indicator of improved condition. Any experienced plant collector knows that a relatively bare knoll may have many more species than the surrounding areas of heavy vegetation cover where competition is more intense. However, it is of interest to note that 12 of the 28 species were included in Ellisons' list that he considered as important species in the pristine upland herb community (Ellison 1954).

One of the important things the records of Major Plot 14 showed was that many of the better species were still available for re-establishment at that period of time even though the vegetative cover had been severely damaged.

Another point to consider was that Major Plot 1 had fewer species than Major Plot 14, but it had nearly twice the ground cover at the end of the study in 1960.

Special consideration needs to be given to Artemisia ludoviciana because of its prominence in the present upland herb community. Since 1913, it has replaced Achillea millefolium as the dominant forb.

A. ludoviciana was not listed in either the grazed or protected square meter quadrats but was present in small amounts in Major Plot 1 of the Horseshoe study site (Table 4). It was quite abundant, however, in Major Plot 14 (Table 3) it was second to Penstemon rydbergii in 1921 when the plot was established. It then declined to 8 percent in 1960 after some fluctuations over the period of study.

At the present time, A. ludoviciana is the most abundant forb species in the upper basins of the study area.

TABLE 3

MAJOR PLOT 14

Major Plot 14 is located 70 yards NNE of Major Plot 1, which is within the Upper Horseshoe Exclosure. This plot is on open range which was grazed during the study period.

The first study was made in 1921, followed by 12 more studies between 1921 and 1960.

This plot is on poor rocky soil, in contrast to Major Plot 1. Table 3 is a summary of the study from 1921 and 1960. Efforts were made to relocate the plot with no success, therefore an analysis of the indicator species was made. (O = Negative and X = Positive).

The six positive indicators showed an increase between 1921 and 1960, but when compared with the negative indicators it was still quite small.

Aster foliaceus and Geranium richardsonii are both strong invaders.

Stipa lettermanii recorded its highest percentage in 1946, with a total of 24.3 percent.

Forbs

Positive Indicator	1921	1960	Negative Indicator	1921	1960
Aster foliaceus	2.2	7.2	Achillia millefolium	7.7	T
Geranium richardsonii	.2	8.4	Artemisia ludoviciana	12.3	8
Ligusticum porteri	0	T	Delphinium menziesii	.6	T
Polemonium foliosissimum	0	T	Lathyrus lanszwertii	.7	0
Potentilla gracilus	.2	0	Penstemon rydbergii	53.6	70.0
Vicia americana	0	.7		74.9	78.0
	2.6	16.3			

Graminoids

NEGATIVE INDICATOR	1921	1946	1960
Elymus trachycaulus	3.0	2.8	1.0
Stipa lettermanii	.3	24.3	3.5
TOTAL GRASSES	3.3	27.1	4.5
TOTAL PERENNIAL FORBS	86.1	63.9	95.0
TOTAL ANNUAL FORBS	34.3	21.0	24.9

Summary of Table 4

The following information is a summary of Major Plot 1 (Table 4), from 1915 to 1960. Elymus trachycaulus with 6.2 percent and Trisetum spicatum with 5.8 percent were the main grasses found on Major Plot 1 in 1915. Stipa lettermanii was estimated at 1.5 percent and Bromus carinatus was only a trace. E. trachycaulus reached its peak in 1927 with 12 percent and B. carinatus with 16.4 percent practically dominated the meter square (M²) quadrats with the bounds of Major Plot 1 in 1915 when it was first listed. Trisetum spicatum has continued to decline after its peak in 1915. By 1960 B. carinatus and T. spicatum was recorded at only a trace. S. lettermanii never did make much headway on the protected plots. It reached its peak in 1946 with 3 percent, but was down to 1.5 percent in 1960. Stipa nelsonii made a big gain with 11 percent in 1960.

Penstemon rydbergii and Achillea millefolium made up 80 percent of the vegetation cover in 1915 when the total cover was at its lowest point. P. rydbergii maintained its position as a dominate species until 1960 even though its percentage had to be shared with other species as the total cover increased. It has been one of the most persistent species throughout the study period. This is shown by its average stem count on both the grazed and protected quadrats. Achillea millefolium was also persistent as indicated by its high occurrence rating, but its cover percentage declined sharply. One of the more aggressive species in Major Plot 1 was Viguiera multiflora. It increased from a trace in 1915 to the most abundant species in 1927 with a cover of 28 percent. It continued as one of the major species for the rest of the study period, but it experienced relatively wide fluctuations.

Geranium richardsonii had a slow start in 1921, with a cover of .1 percent. It made slow progress until 1936 with 2.5 percent and then increased to 10.8 percent in 1960.

Aster foliaceus was another species that gained a high position on Major Plot 1. It was not listed in 1915. It increased slowly until near the end of the 45 year study period. It reached a peak of 11.5 percent of the cover in 1948, however in 1960 its relative cover decreased to 6.6 percent. It is doubtful that A. foliaceus actually decreased during the period between 1948 and 1960, but the other species had also changed. By 1960 it ranked second to P. rydbergii, with a cover percentage of 12 percent.

A third level of species with an estimated cover of 5 percent were the forbs: Orthocarpus tolmei, an annual, Viguiera multiflora, a perennial, and two grasses, Bromus carinatus and Melica bulbosa.

Forbs maintained a high cover of 80 percent while the grasses averaged 20 percent of the cover over the 45 year study period.

Annual forbs were quite abundant until 1935, after which they were quite sparse and were not counted in Table 4.

TABLE 4. UPPER HORSESHOE STUDIES - (PROTECTED)

Major Plot 1

(PERCENT COVER) - (ESTIMATED) 1915 - 1960

PERENNIAL FORBS	1915	1921	1925	1927	1929	1932	1934	1935	1936	1940	1941	1946	1948	1960
<i>Achillea millefolium</i>	o 16.2	4.6	1.4	1.7	2.2	2.4	2.1	1.7	.9	1.0	1.7	1.6	6.1	3.6
<i>Agoseris glauca</i>	...	.6	T	...	T	T	...	...	T	...	...	1	T	T
<i>Arabis drummondii</i>	...	...	T	...	...	...	...	...	...	...	...	...	...	T
<i>Artemisia ludoviciana</i>	o .4	.3	T	.2	.6	.6	.3	.2	.5	1.0	.8	T	.8	.3
<i>Aster foliaceus</i>	x 1.0	T	1.8	2.0	2.1	.4	.2	.8	5.0	...	2.3	11.5	6.6	...
<i>Delphinium menziesii</i>	o .6	T	...	...	T	...	T	...	...	...	.8	...	...	T
<i>Eriogon ursinus</i>	...	...	T	...	...	...	...	...	...	...	...	...	...	...
<i>Erysimum elatum</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	T
<i>Geranium richardsonii</i>	x 1.1	T	...	.3	1.6	.7	.4	.7	2.5	5.0	2.4	5.2	7.8	10.8
<i>Penstemon rydbergii</i>	o 64.5	51.0	21.5	13.3	8.0	21.2	33.7	26.4	36.2	28.0	28.2	15.8	34.8	39.0
<i>Plantago tweedii</i>	...	T	...	...	...	...	...	...	...	...	...	...	...	...
<i>Polemonium foliosissimum</i>	x 1.1	T	...	.1	.8	T	.2	.5	2.0	3.0	1.5	...	.1	1.2
<i>Potentilla pulcherrima</i>	x 1.1	T	...	.1	1.2	T	.1	.1	.2	...	.1	...	.6	.3
<i>Ranunculus inamoenus</i>	...	T	...	...	...	...	...	...	...	...	...	...	...	...
<i>Smilacina stellata</i>	...	T	...	...	...	...	...	...	...	...	T	...	...	T
<i>Stellaria jamesiana</i>	...	1.4	4.3	.3	2.8	1.5	T	2.2	1.0	...	5.6	T	...	T
<i>Taraxacum officinale</i>	o 5.4	.2	T	T	...	...	...	...	...	T	.6	...	.1	...
<i>Thalictrum fendleri</i>	T	.2	T	.1	.2	.5	.2	.1	...	2.0	.4	T	.4	T
<i>Vicia americana</i>	x 2.1	5.8	.5	7.2	3.0	2.7	3.2	.6	...	3.3	T	1.0	9.6	...
<i>Viguiera multiflora</i>	T 3.7	17.2	28.0	13.0	21.6	28.6	21.0	15.1	8.0	14.4	36.6	9.4	10.8	...
<i>Viola nuttallii</i>	...	6.7	7.1	.4	8.0	22.0	9.0	17.7	26.5	...	24.1	...	2.2	3.0
TOTAL PERENNIAL FORBS	86.5	72.6	57.3	46.8	47.6	75.6	77.7	74.0	86.3	53.0	84.0	61.5	74.8	85.2

GRASSES	1915	1921	1925	1927	1929	1932	1934	1935	1936	1940	1941	1946	1948	1960
<i>Elymus trachycaulus</i>	6.2	11.3	10.0	12.0	3.6	3.0	2.9	2.8	6.0	2.0	.2	1.6	1.7	1.5
<i>Bromus carinatus</i>	T 5.7	12.3	16.4	12.8	8.6	5.5	3.7	6.2	35.0	7.3	...	4.4	T	...
<i>Melica bulbosa</i>	...	.4	1.4	.4	1.9	3.3	2.4	1.2	.1	T	1.8	16.2	2.2	.3
<i>Poa spp.</i>	...	.1	T	...	...	...	...	...	T	2.0	...	...	...	...
<i>Elymus elymoides</i>	...	...	T	...	...	...	...	...	...	...	...	...	...	...
<i>Stipa nelsoni</i>	...	...	1.4	.4	1.0	1.0	.5	.3	.5	5.0	1.6	14.5	7.1	11.4
<i>Stipa lettermanii</i>	o 1.5	1.0	T	.1	...	...	T	T	T	1.0	T	3.0	1.6	1.5
<i>Trisetum spicatum</i>	5.8	.8	1.4	.2	.3	T	1.0	T	...	2.0	...	...	...	T
TOTAL GRASSES	13.5	19.3	26.5	29.5	19.6	15.9	12.3	8.0	12.8	47.0	10.9	35.3	17.0	14.7

INDICATOR SPECIES: Negative=0, (... = Species found in overall study but not in year indicated)
Positive=x

SECTION 2

METHODS FROM 1915 TO 1990

The object of this study was to bring information together that will help to define vegetation changes that have occurred on the Wasatch Plateau between 1915 and 1987. The first information was furnished by A. W. Sampson and his associates at the Great Basin branch of the Intermountain Forest and Range Experiment Station (1912 - 1921).

Sampson started many preliminary studies with numerous plots and exclosures to determine effects of livestock grazing. He set up guides relating to vegetation trends and wrote the first guides to classification of plant successional stages and their relation to livestock grazing. He concluded that a forest would eventually take over the open uplands, but he thought that wheatgrass (Elymus trachycaulus) would be the first to dominate these areas so he called it the "wheatgrass consociation" (Sampson 1919). He had good reasons for this conclusion. Elymus trachycaulus was one of the main grasses to come in on both the grazed and protected quadrats in the Upper Horseshoe.

Johnson (1964) carried on with the established study procedures in 1960, even with some problems of following and coordinating them. Such information was furnished by the M² quadrats species. Fluctuations in stem count of forbs and basal area measurements of grasses have been important.

However, rather than follow the full procedure, it was decided to use cover estimates entirely which would be in line with present studies. In this process, five large major plots were used to carry on the study of trend. Four of these major plots were in connection with the Upper Horseshoe Exclosure (Figure 16). Major Plot 14, the fifth major plot, was some distance from the exclosure and was considered separately. (The same procedure was followed on the Lower Horseshoe studies).

Major Plots 2, 3 and 4 were new. Estimate records from Major Plot 1 extended back to 1915. Other studies were included within the areas of all the major plots except Major Plot 3.

The author followed the procedures used by Johnson (1964), but with some modifications. The major difference was that cover estimates were made on all the plots including the M² quadrats. Basal area of grasses could be determined with a fair degree of accuracy. However, the stem counts posed some questions particularly if clumpy forbs were recorded by basal area.

An additional problem encountered had to do with the precise location of some quadrats. Corners were found for the protected quadrats within the exclosure 21 E. and 21 W., but actual location of the grazed quadrats 22 E. and 22 W. is questionable. Photographs from 1915 and 1919 show four 2" x 2" stakes defining the area of the two adjoining quadrats (Seen in Johnson 1964). In 1961 when Johnson photographed the plots, only one original stake was left standing. The



same was true in 1986. When measurements from a known location were used (the center peg of a circular plot), the peg was too far away to fit the reconstructed quadrats location .

Cover was estimated on the rest of the plots, but the square foot density method (Stewart and Hutchings, 1936) was not used.

Three plot groups were emphasized in this report which included four M^2 quadrats, two of the large Major Plots, 1 and 14 (33' x 33'), and twelve of the 100 square-foot circular plots. However, to make a more complete coverage, two additional major plots were initiated in 1947. This brought in 12 additional plots within the exclosure and six grazed plots outside. The protected plots consisted of six additional 100 square foot circular plots plus two M^2 quadrats and four 8' x 8' plots. Six 100 square foot circular and two M^2 quadrats 22 E. and 22 W., were included within the boundary Major Plot 3.

The M^2 quadrats were established in 1915 and stem count data was recorded for the forbs. No basal area measurement (CM^2) were recorded until 1924. All of the records from Major Plot 1 extended back to 1915, including the grasses. The 100 square-foot circular plots (called permanent protected plots) covered the period from 1936 to 1960. Twelve of these plots were within the exclosure and six immediately south of it.

Follow-up was tied to the three major studies which included summarizing and analyzing the data up to 1987. Most attention was given to Major Plot 1 because it includes within its boundary M^2 quadrats 21 E. and 21 W. as well as six of the 100 square-foot circular plots.

Of the grazed plots outside the Upper Horseshoe Exclosure, Major Plot 14 stands alone. It is 70 yards north northwest of the northeast corner of Major Plot 1. The plot was never found so an estimate was made of its location and a species cover study made. Its records cover the period from 1921 to 1960.

At a later time, after the Upper Horseshoe Exclosure was enlarged in 1931, additional studies were started. In 1932, two more M^2 quadrats were started. The same measurement procedures were used as in the original quadrats. In 1936, when 100 square-foot circular plots were installed, six of the plots extended into the area north of Major Plot 1. These are now included within Major Plot 2. Both of these studies would fit into a 33 x 33 foot area, so in order to follow past procedures, the area was designated as Major Plot 2 with only one estimate of plant cover.

In 1990 the author visited the area, retook photographs inside the exclosure, and made general evaluations of changes that have occurred since 1915.

VEGETATION CHANGE FROM 1960 TO 1990

Data from grazed circular plots adjacent to the quadrats showed an estimated cover of grass at 25 percent, most of which was Stipa lettermanii. In 1986, 25 years later, a forb aspect had been established on both the grazed and protected plots. In fact, a photograph of grazed quadrats 22 E. and 22 W. (Figure 17) showed an almost complete cover of forbs. At this date, two species, Geranium richardsonii and Penstemon rydbergii made up most of the cover in the quadrats. This distorted the true situation. The photograph showed the area adjacent to the quadrats had a fair stand of G. richardsonii, but not a 60 percent cover. Data from a study site just south of the enclosure showed G. richardsonii to be the most abundant species with about a 30 percent cover. Even by 1960, G. richardsonii had reached a high ranking in cover on the protected plots (Figure 18). This trend continued until it became the major forb on both the protected and grazed plots.

Another species that made substantial progress was Aster foliaceus. This rhizomatous species tends to form almost pure stands. It made more progress on the protected plots than those that were open to grazing. Along with P. rydbergii, it ranked second in cover on protected Major Plot 1 in 1986. This was not the case on grazed plots where it made only minimal gains. Observations showed that this species had a relatively high preference rating for sheep, at least under the present plant composition.

P. rydbergii continued to hold a strong position on both the grazed and protected plots. Average stem counts show it has maintained its individual abundance on the M² quadrats. Photographs, however, show both an increase and decrease on study plots. Where competition is not strong, it may take over the entire plot or some species may become established within its protective microclimate and force it to give up area (Ellison 1949). On one quadrat it had to share the area with A. foliaceus. Regardless of its changes, P. rydbergii has remained one of the stronger competitors.

Viguiera multiflora ranked third on the grazed plots and fourth on those protected with about 5 percent cover each. This species has been subject to wide fluctuations over the period of the study. For example, the first recorded stem count on the protected quadrats showed 6 stems in 1919. The count rose quite rapidly to its first peak of 799 stems in 1934. By 1936, only 120 stems were recorded. A second peak of 785 stems occurred in 1941. Johnson counted 94 stems in 1960.

The fluctuations of the stem count would suggest that V. multiflora is a short-lived perennial as Johnson₂ (1964) has stated. V. multiflora never became well established on the grazed M² quadrats before 1960. The highest count of five stems was recorded in that year. Since 1960, there has been an increase on the grazed quadrats. An estimated cover of 4 percent was recorded.

Achillea millefolium, with some fluctuations, has declined since 1915 when it and P. rydbergii were the dominant species on the Upper Horseshoe study plots. It was the dominant species throughout the upper basin and ridges in 1913, according to Range Reconnaissance records. Regardless of the decline (both in stem counts and percent cover), A. millefolium has been very persistent and takes off in any opening in the cover as does Taraxicum officinale.

Vicia americana, though not too abundant, has been a persistent species on both

the grazed and protected plots and recorded only 5 stems on the grazed quadrats in 1960. However, he estimated a cover of 9.6 percent on protected Major Plot 1. An estimate of 5 percent was made in 1986. The strong surge of Geranium richardsonii was certainly a factor in its percentage change

Artemisia ludoviciana, an aggressive forb, has not been too obvious on the Upper Horseshoe plots during the study period. Although it appeared to have been controlled, at least on the protected plots, it maintained a high occurrence rating. Its cover estimate was 2 percent on Major Plot 1 in 1986. It even showed a decrease on grazed Major Plot 14. Cover was estimated at 12 percent in 1921 and 8 percent in 1960. The grazed study site south of the Upper Horseshoe exclosure showed less than 1 percent. This species has increased on the grazed upper basins (site studies) to where it has become codominant with Stipa lettermanii.

A relatively unpalatable species, Senecio crassulus, has become established in the area of the Upper Horseshoe study plots. It was observed in one corner of Major Plot 1 and was abundant on the grazed area outside the exclosure. A site study run outside the exclosure found it to be codominant with G. richardsonii with an estimated cover of 26 percent.

Some of the more desirable species that are considered as natural constituents of the mesic forb community have shown up in the Upper Horseshoe Exclosure. Polemonium foliosissimum have appeared in Major Plot 1 in fair amounts. Even an indicator species, Valeriana occidentalis has been recorded.

All these changes are a trend towards a natural Tall Forb Community.

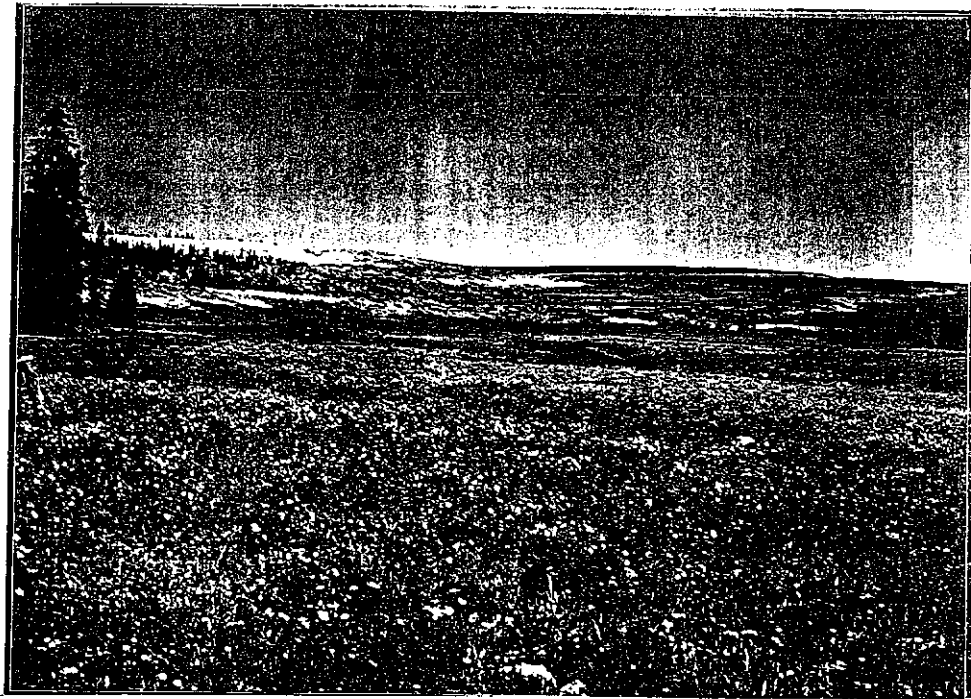


Figure 17.

Grazed: Upper Horseshoe, August 21, 1986.
The area has an almost complete cover of forbs with Geranium richardsonii and Penstemon rydbergii being the most dominant.



Figure 18.

Protected: Upper Horseshoe Exclosure, August 21 1986.
A strong surge of Geranium richardsonii and other forb species indicate a trend toward a natural Tall Forb Community.

Summary of Table 5

This is a summary of Table 5, Major Plot 1. Major Plot 1 was the only estimate plot that records specie changes from 1915 to 1986 (Table 5). It was felt necessary to carry these records through that time period.

In 1915 when the study was started three species made up most of the plant cover. Penstemon rydbergii was the most abundant with 64.5 percent cover. Achillea millefolium 16.2 percent, Taraxicum officinale 5.4 percent and Artemisia ludoviciana followed. The total percent of the four species was 86.5 percent. All three species were classified as negative indicators.

In 1960, A. millefolium dropped to 3.6 percent. P. rydbergii was estimated at 39 percent (part of the loss was due to the addition of other species). New species were Aster foliaceus (6.6 percent), Geranium richardsonii (10.8 percent), Polemonium foliosissimum (1.2 percent), Vicia americana (9.6 percent) and Potentilla gracilis (.3 percent) all were classified as positive indicators.

More changes occurred in 1986. Positive indicators were A. foliaceus (12 percent), G. richardsonii (40 percent), P. foliosissimum (3 percent), Potentilla gracilis (3 percent), Valeriana occidentalis and V. americana both with 1 percent.

Negative indicators were A. millefolium (2 percent), Artemisia ludoviciana (2 percent), P. rydbergii (12 percent) and Senecio crassulus (1 percent).

Note - In this Upland Herb-Shrub Zone, where the Horseshoe Studies are located, only one grass species is used as and indicator species, Stipa lettermanii. The rest of the indicator species are forbs.

Table 5

Major Plot 1 Upper Horseshoe
Estimated, (Protected)
Percent Cover (Perennials)

<u>GRASSES</u>		<u>1915</u>	<u>1960</u>	<u>1986</u>
<u>Elymus trachycaulus</u>		6.2	1.5	T
<u>Bromus carinatus</u>		T	T	5
<u>Melica bulbosa</u>		...	.3	5
<u>Poa spp.</u>		...	...	...
<u>Elymus elymoides (Sitanion)</u>		...	...	...
<u>Stipa nelsonii</u>		...	11.4	T
<u>S. lettermanii</u>	o	1.5	1.5	T
<u>Trisetum spicatum</u>		5.9	T	...
<u>Total Grasses</u>		13.6	14.7	10
<u>PERENNIAL FORBS</u>				
<u>Achillea millefolium</u>	o	16.2	3.6	2
<u>Agoseris aurantiaca</u>		...	T	T
<u>Artemisia ludoviciana</u>	o	.4	.3	2
<u>Aster foliaceus</u>	x	...	6.6	12
<u>Collomia linearis</u>		...	...	T
<u>Delphinium menziesii</u>	o	...	T	T
<u>Erigeron ursinus</u>		...	...	...
<u>Erysimum asperum</u>		...	T	...
<u>Erythronium grandiflorum</u>		...	...	T
<u>Geranium richardsonii</u>	x	...	10.8	40
<u>Orthocarpus tolmei</u>		...	...	5
<u>Penstemon rydbergii</u>	o	64.5	39.0	12
<u>Plantago tweedvi</u>		...	...	...
<u>Polemonium foliosissimum</u>	x	...	1.2	3
<u>Potentilla gracilis</u>	x	...	.3	3
<u>Ranunculus inamoenus</u>		...	...	...
<u>Senecio crassulus</u>		...	...	1
<u>Smilacina stellata</u>		...	T	...
<u>Stellaria jamesiana</u>		...	T	1
<u>Taraxacum officinale</u>	o	5.4	...	...
<u>Thalictrum fendleri</u>	x	T	T	2
<u>Valeriana occidentalis</u>	x	...	...	1
<u>Vicia americana</u>	x	...	9.6	1
<u>Viguiera multiflora</u>	x	T	10.8	5
<u>Viola nuttallii</u>		...	3.0	T
<u>Total Forbs</u>		86.5	85.2	100.00

(... = Species found in overall study but not in year indicated.)

Indicator species:

Positive x

Negative o

Summary of Table 6

The following information is a summary of Major Plot 2 (Table 6). Major Plot 2, one of the new major plots, is just north of Major Plot 1. It is a protected plot within the enclosure, although it was not protected until 1931 when the enclosure was extended.

The first studies installed in 1932 were four 8 ft.x 8 ft. major plots. At that time, Elymus trachycaulus was the most abundant grass species with a 12.8 percent cover. By 1960 it had decreased to 1.9 percent cover and then fell to "0" percent cover in 1986.

Stipa nelsonii, another common grass, showed a .3 percent cover in 1932. It increased to 12.8 percent in 1960 and declined to 4 percent in 1986. Stipa lettermanii increased from a trace in 1932 to 8.7 percent in 1960, it then fell to "0" in 1986.

When 1986 estimates were compared with those of 1960, Achillea millefolium, P. rydbergii, and Vicia americana had a strong downward trend, while it was only moderate for Viguiera multiflora.

The major species that increased in cover were A. foliaceus, G. richardsonii with strong increases, and Artemisia ludoviciana, Thalictrum fendleri and Valeriana occidentalis with moderate gains. The later species is one of the highly palatable indicator species.

TABLE 6

Major Plot 2 Upper Horseshoe
(Protected), Estimated

	FOUR		SIX - 100 SQ.FT		
	8' X 8' PLOT		CIRCULAR PLOTS		
GRAMINOIDES	1932	1960	1936	1960	1986
<i>Elymus trachycaulus</i>	12.8	1.9	1.8	.6	...
<i>Bromus carinatus</i>	...	...	T	...	2
<i>Carex hoodii</i>	...	...	...	...	T
<i>Hordeum brachyantherum</i>	2.4	...	.2	...	...
<i>Melica bulbosa</i>	.2	T	T	.2	...
<i>Phleum alpinum</i>	...	T	T	T	...
<i>Poa spp.</i>	T	.3	T	.4	T
<i>Stipa nelsonii</i>	.3	12.8	.2	12.7	4
<i>S. lettermanii</i> o	T	8.7	T	8.6	...
<i>Trisetum spicatum</i>	.6	T	T	T	...
TOTAL GRASSES	16.3	23.7	2.2	22.5	6
PERENNIAL FORBS					
<i>Achillea millefolium</i> o	5.8	4.4	5.7	4.8	1
<i>Agoseris glauca</i>	T	T	.2	4.1	T
<i>Artemisia ludoviciana</i> o	10.1	5.5	8.4	9.1	8
<i>Aster foliaceus</i> x	...	4.9	1.8	2.3	15
<i>Delphinium menziesii</i> o	.3	T	T	T	...
<i>Eriqeron ursinus</i>	1.0	2.2	4.3	4.1	...
<i>Geranium richardsonii</i> x	.2	4.1	.7	7.1	38
<i>Lathyrus lanszwertii</i> o	...	...	T	...	...
<i>Licusticum porteri</i> x	...	.5	T	.2	...
<i>Penstemon rydbergii</i> o	51.6	35.1	51.9	26.0	12
<i>Plantago tweedyi</i>	2.8	...	1.6	...	...
<i>Cymopterus lemmonii</i>	...	...	T	.3	...
<i>Potentilla gracilis</i> x	2.8	5.2	...	...	1
<i>Ranunculus inamoenus</i>	...	...	T	...	...
<i>Senecio crassulus</i>	.7	.5	1.1	.4	T
<i>Stellaria jamesiana</i>	.7	.5	...	...	T
<i>Taraxacum officinale</i> o	.4	T	1.4	T	...
<i>Valeriana occidentalis</i> x	...	2.2	...	8.6	5
<i>Smilicina stellata</i>	...	...	...	T	...
<i>Vicia americana</i> x	1.4	6.0	2.9	1.8	1
<i>Viguiera multiflora</i>	3.5	3.5	1.4	1.6	8
<i>Viola nuttallii</i>	1.2	T	3.0	T	2
<i>Orthocarpus tolmei</i>	...	...	...	...	1
<i>Thalictrum fendleri</i>	...	...	...	...	2
<i>Valeriana edulis</i> x	...	...	...	...	T
TOTAL PERENNIAL FORBS	82.50	74.60	84.40	70.40	94.00
TOTAL GRASSES	16.30	23.70	2.20	22.50	6.00
ANNUAL FORBS	1.10	1.60	5.40	.40	
GRAND TOTAL	99.90	99.90	92.00	93.30	100.00

(... = Species found in overall study, not in year indicated)

Indicator Species: o = Negative, x = Positive

Summary of Table 7

The following information is a summary of Major Plot 3 (Table 7). Major Plot 3 is north and adjacent to Major Plot 2. This plot was installed to obtain a more complete coverage of the Upper Horseshoe Exclosure. It was only half as wide as Major Plot 1. It furnished valuable information even though it could not be compared directly as it was a new plot.

Geranium richardsonii and Valeriana occidentalis, both being positive indicators, were the two major forb species. This was an important introduction for V. occidentalis. It was not present in Major Plot 1, but appeared in Major Plot 2 in 1960 with 8.6 percent cover, it decreased to 5 percent in 1986.

It was interesting to note that Elymus trachycaulus was the most abundant of the grasses in 1990 with 6 percent cover. However, it continued to decline in all other study sites.

Ligusticum porteri, another positive indicator was also present on Major Plot 3, with a 3 percent cover.

TABLE 7

Major Plot 3 Upper Horseshoe
(Protected), Estimated
1990

<u>GRASSES</u>	PCT. COMP.	FREQUENCY	
		NO.	PCT.
<i>Elymus trachycaulus</i>	6	10	100
<i>Bromus carinatus</i>	3	5	50
<i>Stipa lettermanii</i>	o 2	5	50
<i>Melica bulbosa</i>	1	3	30
TOTAL	12		

FORBS

<i>Geranium richardsonii</i>	x 23	9	90
<i>Valeriana occidentalis</i>	x 22	8	80
<i>Penstemon rydbergii</i>	o 13	7	70
<i>Artemisia ludoviciana</i>	o 7	6	60
<i>Viguiera multiflora</i>	5	4	40
<i>Aster foliaceus</i>	x 4	4	40
<i>Potentilla gracilis</i>	x 4	6	60
<i>Ligusticum porteri</i>	x 3	3	30
<i>Vicia americana</i>	x 2	7	70
<i>Achillea millefolium</i>	o 1	6	60
<i>Stellaria jamesiana</i>	1	6	60
<i>Thalictrum fendleri</i>	1	1	10
<i>Senecio integerrimus</i>	1	2	20
<i>Delphinium menziesii</i>	o T	1	10
<i>Agoseris glauca</i>	T	1	10
<i>Dodecatheon pulchellum</i>	T	1	10
TOTAL	88		

INDICATOR SPECIES:

POSITIVE x
NEGATIVE o

Summary of Table 8

The following information is a summary of Major Plot 4 (Table 8). Major Plot 4 made very little progress between 1936 and 1960. In fact it suffered a loss if Stipa lettermanii is considered, when it increased from .6 percent to 24 percent (Table 8). However, this was compensated as there was some drop in Penstemon rydbergii from 63 percent to 47.5 percent.

In 1986 the positive indicators almost caught up with the negative indicators. Although this change has slightly spread beyond the Horseshoe study sites, this is not the condition of the entire upland area. Site studies in the Upper Basins, south of the Horseshoe Flat studies, show a different story. These basins have been grazed by sheep continuously since the 1870's.

Plant cover has about doubled since 1936, when a range survey recorded plant coverage at an averaged of about .3 percent.

Site studies in the Upper Basin showed that the dominant species were Artemisia ludoviciana, Penstemon rydbergii, and Achillea millefolium all of which were negative indicators (Table 8).

Studies have also shown that these Upper Basins are Tall Forb Habitats. Better soils are still found in portions of this area. The Upper and Lower Horseshoe study sites are on relatively good soils even though part of the top soil has been partially removed by erosion. On the eroded areas such species as Ivesia gordonii have become established.

When the author first saw the Horseshoe Basin in 1936, the skyline road ran through it. If his memory serves him correctly, much of the road was on soil at the time, now much occurs on bedrock.

TABLE 8

Major Plot 4 And Six 100 Sq. Ft. Circular Plots
Estimated, 1936 - 1986, (Grazed)

		Percent Cover		
		Six Plots		Major Plot 4
		1936	1960	1986
<u>Graminoides</u>				
<u>Bromus carinatus</u>		T	...	4
<u>Elymus trachycaulus</u>		1.3	T	T
<u>Melica bulbosa</u>		T	T	T
<u>Phleum alpinum</u>		...	...	T
<u>Poa fendleriana</u>		T	T	T
<u>Stipa lettermanii</u>	o	.6	24.0	16
<u>Stipa nelsonii</u>		T	1.1	T
<u>Trisetum spicatum</u>		T	T	...
Traces		...	...	1
Total Grass		1.9	25.1	21.0
<u>Forbs</u>				
<u>Achillea millefolium</u>	o	2.6	3.8	T
<u>Agoseris glauca</u>		.2	.1	...
<u>Agoseris aurantiaca</u>		...	...	T
<u>Arabis drummondii</u>		T	T	T
<u>Artemisia ludoviciana</u>	o	6.0	9.2	8
<u>Aster foliaceus</u>	x	T	.1	10
<u>Castilleja sulphurea</u>	x	...	...	...
<u>Delphinium menziesii</u>		...	...	T
<u>Eriqeron speciosus</u>	x	...	...	T
<u>Eriqeron ursinus</u>		.7	.2	T
<u>Epilobium brachycarpum</u>		...	...	T
<u>Erythronium grandiflorum</u>		...	T	...
<u>Geranium richardsonii</u>	x	1.5	1.7	18
<u>Lathyrus lanszwertii</u>		.6	...	T
<u>Ligusticum porteri</u>	x	.4	.4	...
<u>Orthocarpus tolmei</u>		...	...	T
<u>Penstemon rydbergii</u>	o	63.0	47.5	30
<u>Polemonium foliosissimum</u>	x	T	...	...
<u>Potentilla gracilis</u>	x	4.9	3.8	8
<u>Ranunculus inamoenus</u>		T	...	...
<u>Senecio crassulus</u>	o	...	...	1
<u>Stellaria jamesiana</u>		.2	.1	2
<u>Taraxicum officinale</u>	o	.7	T	...
<u>Thalictrum fendleri</u>		1.7	3.4	2
<u>Valeriana edulia</u>		...	T	...
<u>Vicia americana</u>	x	.9	4.6	...
<u>Viguiera multiflora</u>		2.1	.1	...
<u>Viola nutallii</u>		3.9	.2	...
Total percent forbs		89.40	75.20	79.00
Total Annual forbs		9.4	.2	...
Total Grass		1.9	25.0	21.0
Grand Total		100.7	100.4	100.0

Indicator Species: x = Positive, o = Negative

(... = Species found in overall study but not in year indicated)

Indicator Species

In the Wasatch Upland, which includes both Upper and Lower Horseshoe Study areas, forbs are used to determine the condition of the range since they are more sensitive to grazing use. The more desirable species are selected by animals first, therefore, they are first to be reduced or eliminated by heavy grazing. Species in this group are classified as positive indicators. The species that survive, or are least selected, are negative indicators. Selecting the indicator species is done by comparing the species composition on the heavily grazed range with the non-grazed Tall Forb Type in Upper Ephraim Canyon and the Elk Knoll Research Natural Area.

Positive Indicator Species do not necessarily mean that all species have to be highly palatable. Several of the annuals are palatable but would be negative indicators. Geranium richardsonii is a species of medium palatability. It has been one of the species that has replaced the negative species.

Penstemon rydbergii was one of the plants that actually represented the plant cover at its lowest ebb. P. rydbergii is not necessarily a bad member in the cover, but when it is the dominant species it is a problem. Ellison includes Delphinium occidentale as a member of the tall forb community, which is true (Ellison 1954). It is a species of pristine areas. However Ellison found that it was one of the species that furnished habitat for other species including positive indicators (Ellison 1954).

Stipa lettermanii is one of the species that can revegetate bare areas yet it often indicates that the areas have been over-grazed. However, in some settings it can be an important successional step in restoring the best plant cover.

See overall summary changes in indicator species (Tables 9, 10, 11, and 12).

The Tall Forb Communities, in pristine condition, are beautiful to behold. Studies indicate that the Tall Forb Communities on the Wasatch Plateau originally occupied the upper basins on both sides of the plateau. They were found mostly above the 10,000 foot elevation on areas receiving approximately 35 inches of annual precipitation.

The Following Species Are Classed As Positive Indicators:

FORBS:

Aquilegia caerulea
Aster foliaceus
Erigeron speciosus
Geranium richardsonii
Valeriana edulis
Valeriana occidentalis

Osmorhiza occidentalis
Polemonium foliosissimum
Potentilla gracilis
Heracleum lanatum
Ligusticum porteri
Mertensia arizonica

The Main Negative Indicators Are:

FORBS:

Artemisia ludoviciana
Taraxicum officinale
Lathyrus lanszwertii

Achillea millefolium
Penstemon rydbergii

GRASSES:

Stipa lettermanii

*Grasses, such as Elymus trachycaulus, are counted as negative indicators when they exceed a reasonable amount of cover.

Table - 9

Major Plot 1

Upper Horseshoe Studies
 Summary Of Indicator Species
 (Protected), Estimated
 1915 - 1960 - 1986

Negative Indicators	1915	1960	1986
<i>Achillea millefolium</i>	16.5	3.6	2
<i>Artemisia ludoviciana</i>	.4	.3	2
<i>Penstemon rydbergii</i>	64.5	39.0	12
<i>Stipa lettermanii</i>	1.5	1.5	0
<i>Taraxacum officinale</i>	5.4	0	0
TOTAL	88.0	44.4	16
Positive Indicators	1915	1960	1986
<i>Aster foliaceus</i>	0	6.6	12
<i>Geranium richardsonii</i>	0	10.8	40
<i>Polemonium foliosissimum</i>	0	1.2	3
<i>Potentilla gracilis</i>	0	.3	3
<i>Valeriana occidentalis</i>	0	0	1
<i>Vicia americana</i>	0	10.0	1
TOTAL	0	28.90	60

Major Plot 1 was the first estimate plot in the Upper Horseshoe Exclosure in 1915. This exclosure was 33 ft. x 33 ft. in size. The same two M² quadrats were studied at the same time by stem counts for the forbs and basal area in cm² for the grasses.

Other studies were added later. Six 100 square foot circular plots were added in 1936.

Table 10

Major Plot 2
Upper Horseshoe Studies
Summary Of Indicators
(Protected), Estimated
1932 - 1960 - 1986

	Four 8'x 8' Plots		6-100 Sq. Ft. Circular Plots		
Negative Indicators	1932	1960	1936	1960	1986
<i>Achillea millefolium</i>	5.8	4.4	5.7	4.8	1
<i>Artemisia ludoviciana</i>	10.1	5.5	8.4	9.1	8
<i>Delphinium menziesii</i>	.3	T	T	T	0
<i>Penstemon rydbergii</i>	51.6	35.1	51.9	26.0	12
TOTAL	67.8	45.0	66.0	39.9	21
Positive Indicators	1932	1960	1936	1960	1986
<i>Aster foliaceus</i>	0	4.9	1.8	2.3	15
<i>Geranium richardsonii</i>	.2	4.1	.7	7.1	38
<i>Ligusticum porteri</i>	0	.5	T	.2	0
<i>Potentilla gracilis</i>	2.8	5.2	0	0	1
<i>Valeriana occidentalis</i>	0	2.2	0	8.6	5
<i>Vicia americana</i>	1.4	6.0	2.9	1.8	1
TOTAL	4.4	22.9	5.4	20.0	60

Major plot 2 is one of the plots that was added to the Upper Horseshoe Exclosure in 1986. It was the same size as Major Plot 1 (33'x 33'). It had within its boundary four, 8 x 8 foot major plots installed in 1932 and six 100 sq. ft. circular plots (1936). Both were compared with Johnson's studies in 1960. Only the indicator species were used for comparison.

The negative indicators slowly declined throughout the study period, but because of the large percentage of *Penstemon rydbergii* at the beginning with its tenacious character, it wasn't until 1986 that the positive indicators gained a strong position.

Table 11

Major Plot 3
Upper Horseshoe Studies
Summary Of Indicators
(Protected), Estimated
1990

<u>Negative Indicators</u>	<u>1990</u>
<u>Penstemon rydbergii</u>	14
<u>Artemisia ludoviciana</u>	7
<u>Achillea millefolium</u>	1
<u>Delphinium menziesii</u>	T
TOTAL	22

<u>Positive Indicators</u>	<u>1990</u>
<u>Geranium richardsonii</u>	23
<u>Valeriana occidentalis</u>	22
<u>Aster foliaceus</u>	4
<u>Potentilla gracilis</u>	4
<u>Ligusticum porteri</u>	3
<u>Vicia americana</u>	2
TOTAL	58

Major Plot 3 is north of and adjacent to Major Plot 2. This plot was installed to obtain a more complete coverage of the Upper Horseshoe Exclosure. It furnished valuable information even though no past records were available for comparison.

Valeriana occidentalis, an important positive indicator species, first occurred as a trace in the 8 X 8 foot plots in 1934. In 1990 it was second to Geranium richardsonii in percent composition. Ligusticum porteri also another important positive indicator, showed up first in 1936. Penstemon rydbergii was still persistent.

The scene in Figure 19 shows the general change toward a tall forb species listed in Table 11, above.



Figure 19.

Protected: Upper Horseshoe Exclosure, July 28, 1990.
General scene inside the exclosure showing continued
recover toward a Tall Forb Community (see species list,
Table 11). The author, Mont E. Lewis is evaluating
cover changes that have occurred on this area.

Table 12

Major Plot 4
Upper Horseshoe Studies
Summary Of Indicators
(Grazed), Estimated
1936 - 1960 - 1986

NEGATIVE INDICATOR	1936	1960	1986
<i>Achillea millefolium</i>	2.6	3.8	1
<i>Artemisia ludoviciana</i>	6.0	9.2	8
<i>Penstemon rydbergii</i>	63.0	47.5	30
<i>Taraxicum officinale</i>	.7	.1	2
TOTAL	72.30	60.6	41

POSITIVE INDICATORS	1936	1960	1986
<i>Aster foliaceus</i>	T	.1	10
<i>Castilleja sulphurea</i>	0	0	T
<i>Erigeron speciosus</i>	0	0	T
<i>Geranium richardsonii</i>	1.5	1.7	18
<i>Ligusticum porteri</i>	.4	.4	0
<i>Polemonium foliosissimum</i>	T	0	0
<i>Potentilla gracilis</i>	4.9	3.8	8
TOTAL	6.8	6.0	36

This grazed plot is just south of the Upper Horseshoe Exclosure. In 1936, most of the plant species were classed as negative indicators. It wasn't much different in 1960.

In 1986 positive indicator species had made a fair increase while the negative indicators declined. This indicates that the grazed range in this area is making a slow recovery. Additionally, *Erigeron speciosus*, an important positive indicator species appeared. This was its first appearance in the Upper Horseshoe study area. This is an aggressive species and should continue to increase.

DISCUSSION

Sampson's Studies

In 1912, Arthur W. Sampson, a plant ecologist, was appointed as the first director of the Great Basin Experiment Station located in Ephraim Canyon. He was appointed by James T. Jardine, the first director of the Forest Services Office of Grazing Studies. One of Sampson's first professional papers, Plant Succession in Relation to Range Management, was published in 1919.

Sampson spoke of the Uplands where the present study is located. He said, "The wheatgrasses (Agropyron) broadly considered, constitute the climax herbaceous cover. In the vegetation cover as a whole, however, the wheatgrasses are the subclimax type, the timber species, of course, constituting the true climax" (Sampson 1919).

There are small scattered clusters of conifer throughout the study area but they are found only at specific sites on the brink of the glacial steps (Edmund Spieker, Marland Billings 1940).

Continuing the grass discussion, Sampson said, "In its unhampered development, the wheatgrass consociation occupies all well-drained timberless or sparsely timbered areas in the subalpine belt, where the soil is well decomposed and of at least average fertility" (Sampson 1919).

The two main species he was discussing were Elymus trachycaulus, (present name) and Elymus lanceolatus, previously named Agropyron dasystachyum.

E. lanceolatus, a turf forming rhizomatous, species occurs in almost pure stands on Tom and Buck ridges. There is also a stand on Nelson Mountain.

E. trachycaulus is a wide spread grass species, but, it does not have the tenacious character of E. lanceolatus. It doesn't compete in the Tall Forb Community. It was quite abundant in 1915 but almost died out in subsequent years in Major Plot 1. This same drop was seen in the M² quadrats.

Ellison's Studies

Lincoln Ellison was the second Range Ecologist to study the upland vegetation of the Wasatch Plateau. Two of his publications were published, one in 1949 and the other in 1954. The 1949 paper dealt with the establishment of vegetation on depleted sub-alpine range. It spoke primarily of the association with other species.

"Permanent plot records show that soil surfaces which are essentially bare of perennial vegetation may persist in that condition for many years. At the same time, adjacent surfaces covered with a growth of dense, rhizomatous vegetation, particularly Penstemon rydbergii, maintain their identity, and under some conditions change very little in appearance over similar long periods of time. A corollary of this observation is that new plants of other species tend, for the most part, to become established within the P. rydbergii patches, and not in bare spaces. Artemisia discolor, Erigeron ursinus, and Aster foliaceus form similar, though less persistent patches" (Ellison 1949).

"Demonstrable association leads to the conclusion that the favorable influence of vegetation on the micro-environment outweighs its influence in composition, which presumably is greater within established vegetation than away from it" (Ellison 1949).

"A Range-Watershed Manager is concerned with bringing about restoration of vegetal cover as quickly as possible. The observation of this paper indicates that he should regulate grazing so as to provide, through the influence of vegetation already on the ground, the best possible micro-environment for establishing new plants" (Ellison 1949).

"Grasses, Agropyron trachycaulum, Bromus carinatus, and Stipa lettermanii are usually among the earliest invaders of raw surfaces of roadbanks, fills and natural landslips. They are usually the first persistent perennials to invade harsh, eroded soils dominated by Madia glomerata" (Ellison 1949).

Johnson's Conclusion

Johnson (1964), based his major conclusion on the changes of two grass species, namely Stipa lettermanii and Elymus trachycaulus. He showed how E. trachycaulus was replaced by S. lettermanii over a period between 1924 and 1960. He said "a successional pattern proceeded from annual forbs to grasses, this was the order of change as it developed on these₂ quadrats" (Johnson 1964). This could be the case if only one M² quadrat (22 W.) was concerned. A 1936 photograph from Johnsons thesis showed quadrat 22 W. was nearly bare except for a few scattered clumps of grass and a clump of Penstemon rydbergii in the lower left corner (Figure 6, pg. 19). By 1961 the large bare area was filled with S. lettermanii. The companion quadrat 22 E. was filled mostly by P. rydbergii. In 1961 such forbs as Aster foliaceus and Achillea millefolium were mentioned, as was a scattering of grasses. This would suggest that Johnson based his conclusion on one M² quadrat (Johnson 1964), (Table 1A, 2A).

Ellison (1954), in a review of past studies, found photos of bare spots that were over 30 years of age.

Johnson's Three General Considerations

1. Johnson (1964), in his discussion of vegetation change in the Upper Horseshoe study plots, cited conclusions by Sampson (1919) and Ellison (1954). "Sampson considered climax to be a conifer forest, supposedly preceded by a rather stable subclimax, Agropyron consociation. Ellison considered the climax to be a mixed herbaceous association, rich in species of grasses and forbs. Sampson's early view can easily be understood from Horseshoe Flats data. Agropyron trachycaulum (Elymus trachycaulus) increased early in the study and followed a trend of increasing prominence during the time covered by Sampson's investigation. After his publication however, E. trachycaulus decreased under both protection and grazing. Both of these studies still fall short of the types of climax proposed by Ellison. The Stipa-Chrysothamnus community at the Lower Horseshoe seems to be quite stable in its present state. The upper site is still changing and seems to be developing a richer composition of long-lived forbs and grasses (Johnson 1964).
2. It is doubtful that the plant cover will ever revert to its primeval condition even if left alone (Johnson 1964).
3. The forage quality of the vegetation, as it has developed and changed under complete protection and reduced grazing has not been considered. It should be pointed out that although the bulk of the vegetation inside the exclosures is of a quality more palatable to sheep than that on the outside, this does not necessarily mean that such composition should be maintained for maximum livestock production. Further studies should be made to determine which species show strong persistence under grazing, such as Stipa lettermanii (Johnson 1964).

For example, it is known that in areas where S. lettermanii provides most of the plant cover it is utilized by sheep, but it is not known how gains made on such vegetation compare with those made on vegetation composed of more palatable species (Johnson 1964).

Lewis' Response To Johnson's Three General Considerations

The following discussion is a response to Johnson's "Three General Considerations".

It is realized that conditions have changed since Johnson studied the Upper Horseshoe study plots from which he wrote his thesis. This discussion is not considered to be a criticism, but an effort to update changes since Johnson's study.

Present evidence shows that Ellison was correct in his appraisal of the upland vegetation. His main guidance were the forbs on Elk Knoll which had been protected from livestock grazing, to a large degree since 1908. He also studied other areas that had been protected as a result of poor accessibility. Since that time, considerable attention has been given to tall forb studies. Dr. Jim Bowns, a teacher at Southern Utah University, studied a pasture on the Dixie National Forest that had been protected to a high degree for many years. The vegetation was mostly palatable tall forbs. Many of the species that were present were the same as those found on the Manti-LaSal National Forest.

One of the major recent efforts in the tall forbs study has been by Dr. Hank Mayland and Robert Murray, in Idaho. Their study, when published, will provide information on geographic distribution, general composition, and some of the ecological features unknown to occur in areas supporting, or capable of supporting, the Tall Forb Type.

The possibility that plant cover can be restored to its primeval condition depends heavily on the health of the soils. Studies being carried out at the present time by Tiedenamm and Clemmedson show a heavy loss of soils. This is obvious in the Horseshoe Basin area where rocks bared of lichens, lie on the soil surface.

The Upper Horseshoe study site is located on one of the better sites with soils up to 30 inches in depth. Both Ellison, as well as Tiedenamm and Clemmedson agreed that topsoil has been lost. The latter estimated that only about one inch is left.

Regardless of the soil condition, tall forbs have nearly taken over the exclosure. Positive indicators Geranium richardsonii, Aster foliaceus, and Valeriana occidentalis are some of the main species. Another positive indicator is Potentilla gracilis. Ligusticum porteri was also present. The estimate of the total was .85 percent.

In the Lower Horseshoe, Stipa lettermanii went from 40 percent in 1925 to a low of 3 percent in 1986. It recovered with a drop in Chrysothamnus viscidiflorus cover in 1986 but ended with 5 percent in 1990. These records indicate that forbs will eventually replace both the C. viscidiflorus and S. lettermanii at the 10,000 foot elevation.

Another statement that should be addressed is forage cover. It has been known for many years in Idaho that better lamb are produced on lush forb ranges because the ewes give more milk.

Stipa lettermanii

Stipa lettermanii is considered to be an invader in the Upper Mesic Basins. Ellison (1954), was the first to write on the subject in his paper on the subalpine vegetation of the Wasatch Plateau.

Data from the Horseshoe Plots furnishes some of the best clues as to its habitat requirements. Ellison classified S. lettermanii as an xeric species which is favored by heavy sheep grazing (Ellison 1954).

When the first grass studies were documented in 1924, only protected quadrats 21 E. and 21 W. recorded S. lettermanii with 198 CM². From that point on, the trend was down. It was not ever recorded between 1932 and 1943. It was recorded twice after 1943, with 3 CM² in 1948 and 1 CM² in 1960. S. lettermanii never appeared on the grazed quadrats until 1929, with 2 CM².

There was an upward trend on the grazed quadrats. From a slow start in 1929, it became the dominant grass by the end of the study period in 1960. The same trend was observed on the grazed circular plots where it increased from 6 percent cover in 1936 to 24 percent in 1960. It was persistent but sparse on protected Major Plot 1.

By 1986, S. lettermanii had decreased on all examined Upper Horseshoe protected plots. Photographs taken in 1961 by Johnson indicated grass (mostly S. lettermanii) was conspicuous on the grazed range (Figure 9, pg. 20). A photograph taken in 1986 showed a predominantly perennial forb community both inside and outside the exclosure (Figures 17 and 18, pg. 33). Reduced use had allowed a big increase in perennial forbs on the grazed area outside the exclosure. These species were of a lower quality. S. lettermanii was 16 percent in 1986 on Major Plot 4.

There was a strong decline in grass on Major Plot 14. It was at its peak in 1946, with 36 percent cover (24 percent S. lettermanii) and then fell to 4.5 percent in 1960. This plot was not found in 1986 but its strong trend to perennial forbs by 1960 was in step with the general trend of the area as shown by the other study plots. It is located on poor rocky soil that left more open area for the S. lettermanii to survive.

Records of specie cover changes in the Alpine Cattle Pasture also showed a decline of S. lettermanii under protection. On a Penstemon rydbergii / S. lettermanii range type, S. lettermanii declined from 17 percent cover in 1929 to 5 percent at the time of Ellison's study (Ellison 1954).

Very little S. lettermanii was observed in the Alpine Cattle Pasture in 1986. None was recorded for the "site studies". One small patch was observed on the south point of a ridge.

S. lettermanii has become well established in the upper basins and upper ridges where grazing use has been continuous since about 1870. It has become codominant with Artemisia ludoviciana in the upper basins and with

Elymus trachycaulus on the upper ridges. Most of the increase has occurred since 1913 when it was estimated at 3 percent.

One area extending southwest from where the Skyline Road turns into Reeder Canyon consisted mostly of forbs (80 percent). The three major species were Achillia millefolium, Ivesia gordonii, and Penstemon rydbergii all of which were of relatively low quality. Grass species present were Poa ssp., Elymus trachycaulus and Trisetum spicatum. Over half of the cover consists of S. lettermanii at the present time.

According to 1913 range reconnaissance data, S. lettermanii was one of the major associates of Chrysothamnus viscidiflorus on the eastward extending benches and ridges furnishing 3 to 30 percent of the vegetation. However, at that time, Elymus trachycaulus was equally abundant.

S. lettermanii reacted strongly to the fluctuation of the yellowbrush (C. viscidiflorus). In 1979 when yellowbrush was at its peak in the Lower Horseshoe Exclosure, S. lettermanii was estimated at 3 percent. By 1986 after a drop in the yellowbrush cover from 59 percent to 35 percent, S. lettermanii and other grass species gained much of their former status, but the big gain was made by the forbs.

S. lettermanii ranks first in abundance of 12 grass species found in the yellowbrush-grass community. This community is found mostly on open ridges and south slopes, on the north third of the plateau. It is more xeric than the upper basin, yet several of the mesic forbs are present. Even small quantities of the indicator species, Osmorhiza occidentalis is present.

Bromus carinatus

Range Reconnaissance data shows that Bromus carinatus is found to be more common in the Aspen Communities than in the upland Tall Forb Communities. Here it often occurs as the major grass. It was found in both the Alpine Cattle Pasture, 4 percent, and the transect study just north of the cattle pasture, 5 percent.

Only a 1 percent occurrence was found in the site study of the Upper Basin and only a trace on the Upper Ridge. B. carinatus is subject to heavy fluctuations. This has been shown in the Upper Horseshoe Studies as well as observations over the years. Whole patches of B. carinatus have been observed dieing out.

Our perennial form of B. carinatus appears to have some of the characteristics of an annual. It is short-lived and a strong seeder. It would obviously depend on annual seeding to maintain a stand.

One other characteristic should also be considered. It is very subject to smut, a fungus of the order Ustilaginales.

Trends of Forbs

It is considered in this report that trend on protected sites is a movement towards the original Tall Forb Communities common to the upper mesic basins. This has been the belief of several people and was one of the main themes of Ellison's report on the subalpine zone of the Plateau in 1954. Also, by first hand historical accounts by Beauregard Kenner and Carl Wilberg of the original vegetation (Lewis, History of Early Grazing, in preparation).

Data from long time studies on permanent plots, both grazed and protected, gives evidence of this trend. The more aggressive forb species found in the Upper Horseshoe protected plots by 1986 were Geranium richardsonii, Aster foliaceus, Penstemon rydbergii and Viguiera multiflora. Other aggressive species found on Elk Knoll and Alpine Cattle Pasture are Erigeron speciosus, Ligusticum porteri and Valeriana edulis.

Forb species most aggressive on heavily grazed areas are Artemisia ludoviciana, P. rydbergii and Taraxicum officinale and Achillea millefolium.

In 1915 when the Upper Horseshoe Studies were started, P. rydbergii and A. millefolium made up most of the sparse plant cover. This was true on both the grazed and protected plots. The stem count of A. millefolium was at its peak on the M² quadrats as well as on Major Plot 1. Its trend was down thereafter. Range Reconnaissance records showed the same downward trend. A. millefolium was not only the dominant forb, but the dominant species in the upper basins and ridges in 1913. By 1980 it still had a relatively high occurrence rating but a considerable reduction in cover. It was further reduced in 1986, however, it is realized that total cover has increased over the same period of the study and would somewhat temper the percentages.

P. rydbergii has been a very persistent species throughout the 79 year study period. Rate of grazing pressure has not seemed to have much effect on its abundance. The average stem count over a period of 45 years was about the same on both the grazed and protected quadrats. It appears to have lost some ground in the Alpine Cattle Pasture, where it ranked downward in its relative position.

Aster foliaceus

Aster foliaceus never became fully established on the Upper Horseshoe study plots until the latter part of the 1915 through 1960 study period. This was true for both the grazed and protected plots. Aster spp. was noted on both protected Major Plot 1 and grazed Major Plot 14 in 1921, Johnson never determined the Aster species in 1960. It was probably never identified during the early study periods. Johnson carried on the name as he found it in the records. The species found in Major Plot 1 is A. foliaceus var. parryi.

A. foliaceus was quite common on Major Plot 14 in 1921 and 1925, but practically disappeared from the plot until 1948. Johnson estimated a cover of 7 percent in 1960. Major Plot 1 maintained a high occurrence rating, but like other plots it reached a high in composition in 1948 through 1960. It evidently maintained its relatively high position. It was one of the three major species in Major Plot 1 in 1986.

This is a strong rhizomatous species that was able to compete on grazed (only moderate for the last few years) plots as well as those protected from grazing.

A break in the exclosure fence allowing access of grazing sheep gave some idea of specie selection by the grazing animals. Even with moderate grazing use A. foliaceus received the heaviest use. No utilization was observed on Geranium richardsonii at the same time.

Studies run on Elk Knoll showed a utilization rate of 28 percent on A. foliaceus, probably by deer (Hougaard, Jack; Skablund, Paul 1959).

A. foliaceus was only an occasional species in the heavily grazed eastside basins. It was one of the major species on Elk Knoll and the Alpine Cattle Pasture (protected areas).

Geranium richardsonii

The dominant forb found in the Upper Horseshoe study site in 1986 was Geranium richardsonii.

G. richardsonii had made a big increase on both grazed and protected plots by 1986. It could be said that G. richardsonii was not necessarily favored by protection, however, other studies show that it was. There has been a big increase on both the Alpine Cattle Pasture and Elk Knoll. Both areas have been protected in recent years. The big proof of the results of continuous heavy grazing use is from the "site studies" from the upper east side basins. Here G. richardsonii was relatively sparse.

The areas around the Upper Horseshoe Study site had obviously been given some release from heavy grazing pressure in recent years (after 1960) as indicated by increase in some of the better forb species. Even so, the species composition in the protected plots within the enclosure was considerably better than those open for grazing.

A transect study made on Philadelphia Flat in 1987 showed G. richardsonii to be the dominant species where native species had become established.

The dominance of G. richardsonii does not suggest a Tall Forb pristine Community. However, its increase has been a step in the right direction. In study sites selected for near pristine conditions, it ranked sixth.

G. richardsonii is not considered to be particularly palatable to livestock but is an important constituent of the Tall Forb Community.

Other forb species associated with the G. richardsonii units upward trend was Osmorhiza occidentalis, Eriqeron speciosus, Aster foliaceus, Viguiera multiflora, and Lupinus argenteus. Penstemon rydbergii was one of the strong survivors from excessive use.

This appears to be the pattern of the Tall Forb trend. G. richardsonii has been one of the major species to make a strong upward trend under protection from livestock grazing. On the cattle pasture, G. richardsonii was dominant on three site studies and present on seven.

G. richardsonii, thought to be low in palatability, was observed to have been used under heavy grazing, but not utilized under light grazing pressure. However, it received moderate use under moderate grazing pressure. Cattle have been observed to make moderate use of G. richardsonii in Manti Canyon.

G. richardsonii is not a major species in the Aspen-fir zone, but is quite prominent in open spruce-fir communities.

It is certain that past heavy grazing use would have adverse effects on G. richardsonii, in fact, Ellison (1954), reported dead roots on areas where the species no longer occurs.

Bromus carinatus still persisted. In 1986, an estimate of 5 percent cover was made on Major Plot 1. No estimate was made on the protected quadrats or the circular estimate plots because they were within the boundaries of Major Plot 1.

Artemisia ludoviciana a rhizomatous specimen, often forms circular patches as it invades new areas. Even though it has replaced the better species under heavy grazing use, it does have important value as a soil binder. Gullies on slopes have been observed to disappear as they reach the A. ludoviciana patch. They are then seen to reappear below the patch.

It is also a persistent species that maintains a strong position where the Tall Forb Community becomes reestablished.

Sheep Use

Both the Upper and Lower Horseshoe studies are located within the Becks Ridge Sheep Allotment.

Records of the number of sheep permitted on this ground go back to the year 1921, when 1721 sheep were allowed. By the year 1942 the numbers had been reduced to 1400. In 1960, when Johnson was writing his thesis, the number was 1090 sheep. In the period between the years 1960 and 1971, the average number of sheep permitted were 1081. Between 1972 and 1985 the numbers had a small drop to an average of 936. Considerable fluctuation took place between 1986 and 1991. In 1986 and 1991, numbers were below 400 (376 and 380). The average number was 688.

It would be important to know how much sheep grazing use has been done in the area around the Upper Horseshoe Exclosure, at least since Johnsons' studies in 1960. There has been a considerable reduction in permitted sheep with a change from 1721 sheep in the year 1921, to 1090 sheep in 1960. It was farther reduced between 1960 and 1987.

The data from 1936 to 1960 shows a big increase in Stipa lettermanii, from .6 percent cover in 1936 to 24.0 percent in 1960. Another negative indicator Artemisia ludoviciana increased from 6.0 percent to 9.2 percent. This would indicate a downward trend between 1936 and 1960.

An opposite trend was found in 1986. Such positive indicators as Aster foliaceus, Geranium richardsonii and Potentilla gracilis made fair increases. Additionally, Erigeron speciosus, an important positive indicator species appeared in Major Plot 4. This was its first appearance in the Upper Horseshoe study area. This is an aggressive species and should continue to increase quite rapidly.

The sheep have not been very noticeable around the Upper Horseshoe Exclosure at the time the later studies were going on. It appears that the herders have given the study area some protection.

Philadelphia Flat

Philadelphia Flat is in the head of Ephraim Canyon. There are records that reach back into the 1860's, or earlier. These records have been compared with the Upper Horseshoe Studies. The following information is used.

A check was made of Philadelphia Flat in 1987. It was a surprise to see the change that had occurred since the 1940's. In 1940 heavy grazing use had destroyed the original Tall Forb Community. Efforts to restore a suitable plant cover was a failure. The method used was cultivating and seeding.

In 1987 when the area was checked, some success had been observed on a knoll. Here a fair stand of crested wheatgrass (Agropyron cristatum) was attained. The rest of the Flat had a stand of native vegetation.

Like the Upper Horseshoe study area, Geranium richardsonii is the major specie on the area where native species are dominant and estimated to make up nearly one fourth of the vegetation of the entire flat. Viguiera multiflora ranked second with about 10 percent cover. This was also similar to the Upper Horseshoe. Other conspicuous species with 5 percent estimates were Aster foliaceus, Erigeron speciosus, Lupinus argentius, Osmorhiza occidentalis, Penstemon rydbergii, Potentilla gracilis, Valeriana occidentalis, Viguiera multiflora and Vicia americana. All of the species were positive indicators.

In 1991 the Flat was visited again. This time the vegetation was grazed nearly to ground level. Only a few dry stems were left. This meant that the vegetation was tall and thick.

In 1941 I had a discussion with Carl Wilberg, a resident of Castle Dale, Utah. His early profession was logging timber. He told me the following story: He had logged some timber above Philadelphia Flat and dragged them onto the Flat. The next summer, when he planned to move the logs to the saw mill, he had trouble finding his logs due to the tall vegetation. This was certainly tall forbs.

SECTION 3

LOWER HORSESHOE - METHODS

The Lower Horseshoe studies are located in the southeast part of Section 14, T. 17 S., R. 4 E., about 100 yards north of the Ephraim-Orangeville road. The Upper Horseshoe Studies are about 1/4 mile to the north east of Lower Horseshoe.

A log and block exclosure was constructed in 1921 on the Lower Horseshoe study area. The first studies were started in 1925 when correlation studies were run.

The main studies were started in 1936 when 20 permanent estimate plots were established, 10 within the exclosure and 10 outside the exclosure. The original studies were made by personnel from the Great Basin Experiment Station. A follow-up study was made by Johnson in 1960. Johnson used the "square foot density method" for estimating the cover in 1960. The author made ocular estimates of the plant cover and took photographs both inside and outside the exclosure in 1979. In 1986 only a photograph and notes were taken for the area outside the exclosure (Johnson's thesis was not available at that time).

Vegetation Change From 1925 to 1990

Table 13 is a summary of vegetation cover changes that took place within the exclosure on the Lower Horseshoe. Table 14 is a summary of cover estimates from outside the exclosure also on the Lower Horseshoe.

In 1979 the author made an ocular estimate of the plant cover inside the exclosure and took photographs both inside and outside of the exclosure (Figures 20 and 21), (Johnson's thesis was not available at that time).

In 1979, Chrysothamnus viscidiflorus almost dominated the vegetation within the exclosure (Figure 20). The individual brush were tall (about 14 inches) and bushy, they represented a major part of the cover. Ellison (1954) described this same situation in other areas. In 1979 a photo (Figure 21) was taken outside the exclosure, it showed an equal cover of C. viscidiflorus and Stipa lettermanii.

In 1986 a major change had taken place. A cover estimate was made and photographs were taken inside and outside (Figure 22 and 23) the exclosure. The largest change was in the C. viscidiflorus cover. It had been reduced to almost half. The individual plants were shorter (14 inches in 1979 to 8 inches in 1986) and somewhat scattered. This change gave an opening for other species to fill in. Both graminoides and forbs were beginning to show up. Nine forbs

were listed. They were Achillea millefolium 2 percent, Astragalus miser 1 percent, Erigeron speciosus and E. eatonii each a trace, E. ursinus 2 percent, Penstemon rydbergii 2 percent, Taraxicum officinale 3 percent, Potentilla gracilis and Viguiera multiflora each a trace. Carex eqglestoni was also observed with having a trace of cover.

Another visit was made to the Lower Horseshoe plots on July 28, 1990. Photographs were taken in order to record the major changes that had taken place (Figures 24 and 25). The most conspicuous change was the increase of Erigeron speciosus and the forbs in general. The grasses also made significant changes, in that Stipa nelsonii replaced S. lettermanii as the most abundant grass. (At this date grasses show their best while many of the forbs were past their flowering period.) The patch of B. carinatus had been reduced in cover as the result of new fence construction. C. viscidiflorus maintained its position with about one-third of the cover.

TABLE 13

Lower Horseshoe Exclosure
Changes Occurring
(Protected), Estimated
1925 - 1936 - 1960 - 1979 - 1986 - 1990

FORBS		1925	1936	1960	1979	1986	1990
<i>Achillea millefolium</i>	o	2	3.2	T	T	0	T
<i>Arabis drummondii</i>		1	T	T			
<i>Aster foliaceus</i>	x	0	.2	.1		T	T
<i>Astragalus miser</i>		0	T	0			
<i>Castilleja sulphurea</i>	x	0				1	1
<i>Clematis hirsutissima</i>			.8	4.7	3	2	2
<i>Erigeron speciosus</i>	x	0	T	1.4	8	12	24
<i>Erysimum asperum</i>		0			T		
<i>Geranium richardsonii</i>	x	1	T	.2	T	3	3
<i>Lathyrus lanszwertii</i>	o	0				8	5
<i>Lesquerella hemiphsaria</i>		0	T				0
<i>Penstemon rydbergii</i>	o	0			2	2	2
<i>Phacelia sericea</i>		0	.6	.3	5		
<i>Polemonium foliosissimum</i>	x	0			1	T	1
<i>Potentilla glandulosa</i>	x	0	T				T
<i>Silene douglasii</i>			T	T			0
<i>Taraxacum officinale</i>	o	2	12.1	T			0
<i>Thalictrum fendleri</i>					1		1
<i>Vicia americana</i>	x	4	4.6	T		1	1
<i>Viola nuttallii</i>			.1				
TOTAL		10	21.6	6.60	20	29	40
GRAMINOIDES							
<i>Bromus carinatus</i>			.1	.5	1	15	5
<i>Elymus trachycaulus</i>		13	7.5	4.6	5	4	5
<i>Melica bulbosa</i>						T	T
<i>Poa ssp.</i>			.2	T	1	0	0
<i>Stipa nelsonii</i>		6	.6	9.4	5	4	15
<i>Stipa lettermanii</i>	o	40	12.8	16.3	3	12	5
TOTAL		59	21.2	30.8	15	35	30
SHRUBS							
<i>Chrysothamnus viscidiflorus</i>		31	55	60	59	35	30
<i>Ribes cereum</i>						1-	T
TOTAL		31	55	60	59	35	30
TRACES			3			1	

INDICATOR SPECIES:

Positive x

Negative o

Table 14

Lower Horseshoe Studies
(Grazed Plots), Estimated
1936 - 1960 - 1986

Shrubs	Estimated Percent Cover		
	1936	1960	1986
<i>Chrysothamnus viscidiflorus</i>	54.0	37.5	50
<i>Eriogonum umbellatum</i>	.6	T	0
<i>Ribes cereum</i>	.2	T	0
Total	54.8	37.5	50
Graminoides			
<i>Carex egglestoni</i>	0	0	T
<i>Elymus trachycaulus</i>	2.2	1.7	15
<i>Poa ssp. (fendleriana)</i>	.4	1.4	5
<i>Elymus elymoides</i>	1.9	1.3	0
<i>Stipa nelsonii</i>	T	0	0
<i>Stipa lettermanii</i>	o 32.0	49.0	20
Total	36.5	53.4	40
Forbs			
<i>Achillea millefolium</i>	o 3.9	2.4	2
<i>Artemisia ludoviciana</i>	o T	2.7	0
<i>Aster ssp. (chilensis)</i>	T	T	0
<i>Astragalus miser</i>	1.5	3.4	1
<i>Clematis hirsutissima</i>	T	.1	0
<i>Erigeron speciosus</i>	x 0	0	T
<i>Erigeron eatonii</i>	0	0	T
<i>Erigeron ursinus</i>	.3	T	2
<i>Lesquerella (hemiphysaria)</i>	T	T	0
<i>Penstemon rydbergii</i>	x .2	.2	.2
<i>Phacelia sericea</i>	.8	T	0
<i>Potentilla glandulosa</i>	.3	.2	0
<i>Potentilla gracilis</i>	0	0	T
<i>Silene drummondii</i>	T	T	0
<i>Taraxacum officinale</i>	o 1.9	.4	3
<i>Thalictrum fendleri</i>	.3	T	0
<i>Viguiera multiflora</i>	0	0	T
<i>Vicia americana</i>	x .6	.1	0
<i>Viola nuttallii</i>	.2	0	0
Total	10.0	9.5	10

* Estimates were made on permanent plots in 1936 and 1960. The 1986 estimates were made on a comparable sized area just west of the enclosure.

INDICATOR SPECIES:

Positive x

Negative o



Figure 20.

Protected: Lower Horseshoe Exclosure, 1979 (month and day not known but judged to be late July). Chrysothamnus viscidiflorus has become dense (with 59 percent cover) and is approximately 14 inches in height.

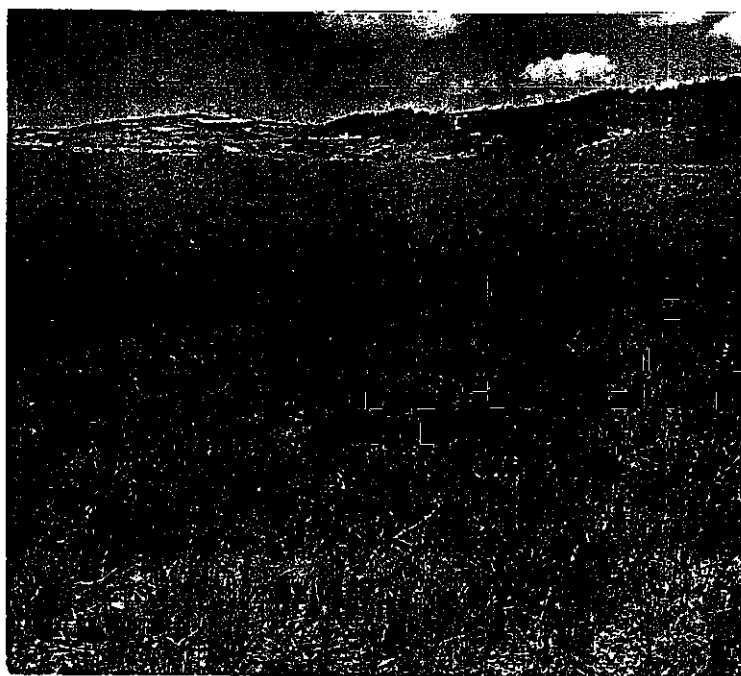


Figure 21.

Grazed: Lower Horseshoe, 1979 (month and day not known but judged to be late July). This photo was taken immediately west of the Lower Horseshoe Exclosure. The vegetation cover is mostly Chrysothamnus viscidiflorus and Stipa lettermanii.

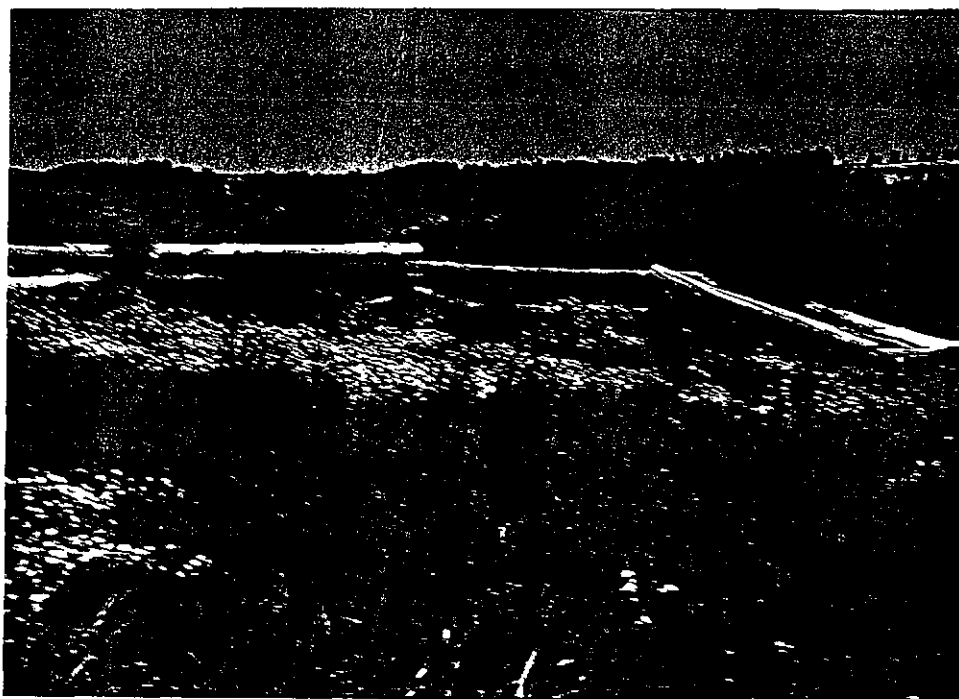


Figure 22.

Protected: Lower Horseshoe Exclosure, July 1986. Major plant species include, Erigeron speciosus (pink colored flowers) with Elymus trachycaulus, and Stipa nelsonii scattered throughout.



Figure 23.

Grazed: Lower Horseshoe, July 1986. A major difference in this grazed area versus the protected area in Figure 22 above, is the continued presence of Chrysothamnus viscidiflorus and Stipa lettermanii. The area is gradually showing improvement, as evidence by the presence of Poa fendleriana and several forb species.

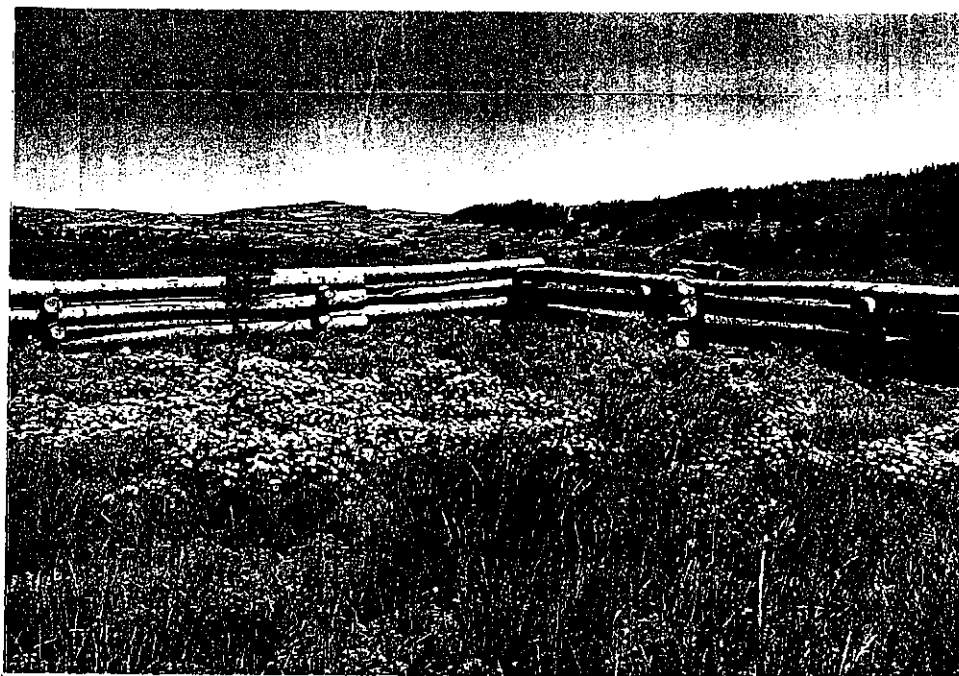


Figure 24.

Protected: Lower Horseshoe Exclosure, July 28, 1990. The most conspicuous change is the continued increase of Erigeron speciosus and the forbs, in general. Stipa nelsonii has replaced S. lettermanii as the most abundant grass.



Figure 25.

Grazed: Lower Horseshoe, July 28, 1990. General scene showing an increase in Chrysothamnus viscidiflorus and several grasses. Major forb species are inconspicuous due to late phenology and mechanical damage caused during replacement of the original exclosure fence. Remnant logs in background are from that fence.

Chrysothamnus viscidiflorus

Evidence from the Lower Horseshoe Studies shows that the present Chrysothamnus viscidiflorus - Stipa lettermanii community was not a natural combination at this location. The increase of tall forbs in the Lower Horseshoe Exclosure would indicate they are taking over the site. This exclosure is approximately at the 10,000 foot elevation. Ellison (1954) felt that C. viscidiflorus was a lowland species that had invaded the area as a result of overgrazing. He was not familiar with the genetic variation within the species at that time. The high elevation plant is C. viscidiflorus ssp. lanceolatus. Four other subspecies have been collected on the Wasatch Plateau, all from low elevations.

Obviously, this high elevation taxon did work upward in elevation as competition was lowered by heavy grazing (Ellison 1954). Sheep will graze this subspecies, C. viscidiflorus, late in the season also. The author has observed use of 30 to 50 percent in August.

The original upward extent is not known, however, the rain shadow effect may furnish some idea. The upper basins on both the east and west side of the plateau are quite comparable as far as precipitation is concerned. However, a considerable change comes about at lower elevations and on the long ridges that extend into Joe's Valley. For example, Upper Seely Creek at an elevation of 9,900 feet, averages about 35 inches of precipitation. The Wagon Road Weather Station at 10,000 feet elevation, averages about 21 inches. The rain shadow effect becomes more obvious farther out on the ridges and lower elevations. Here the climate is warmer and dryer. Vegetation maps from the 1936 to 1939 Range Survey showed that C. viscidiflorus was quite common on the whole length of Wagon Road Ridge where it occurred in patches with S. lettermanii and various combinations of species. Such areas as Clay Bench, Ridley Ridge, Beck Ridge, and Toms Ridge also had patches of C. viscidiflorus. Wagon Road Ridge was shown to have five patches with one at the lower tip of the ridge. This should have been the driest site.

With the exception of Wagon Road Ridge, patches were found on ridges and flats where the elevation is over 10,000 feet, but they extend farther to the east of the Lower Horseshoe study site where the rain shadow effect could be a factor. Swasey Ridge, at an elevation of over 10,000 feet, has a yearly precipitation of about 25 inches. This would be about 10 inches less than the Lower Horseshoe study site. This could be a precipitation amount that would not favor the Tall Forb Communities.

Eleven study sites were selected in the north end of the plateau for continued study of C. viscidiflorus. The eleven study sites were selected part in Upper Benyon Creek, along the Price River and along Skyline Drive. Elevations were between 9,000 and 9,500 feet.

Viquiera multiflora

Between 1915 and 1960, Viquiera multiflora was found almost entirely on the protected plots of the Upper Horseshoe study sites. By 1986, it had spread onto some of the grazed plots. For example, it was estimated at 5 percent on the grazed M² quadrat. On a larger study site south of the exclosure, it made up about 2 percent of the cover. It was never recorded on grazed Major Plot 14 until 1960.

Records of stem counts showed strong fluctuations of the species over the 1915 to 1960 study period. V. multiflora reached a high rating in 1929, 1934 and 1941. At these peaks it became the dominant species replacing Penstemon rydbergii which was usually the dominant species. V. multiflora reached its maximum on Major Plot 1 in 1946 where it made up 36.6 percent of the plant cover. It reached a low point of 8 percent in 1940 ending with 10.8 percent in 1960. Summer precipitation did not appear to be a factor in the cover fluctuation. Although no precipitation data was available for 1946, the second highest stem count was recorded in 1934 which was a very dry year. The lowest cover percent occurred on a wet year. Johnson (1964) stated that V. multiflora was a short-lived perennial. Perhaps its cover record supports Johnson's statement.

V. multiflora is one of the major herbaceous species occurring in the head (south branch) of Ephraim Canyon which includes both protected and moderately grazed range. It also occurred in fair quantities on Elk Knoll. The species has a relatively low palatability. Observations in one site showed about 10 percent utilization.

CONCLUSIONS

All evidences from the Lower Horseshoe studies indicate that Chrysothamnus viscidiflorus and Stipa lettermanii communities in the Upper Horseshoe area historically belonged to the Tall Forb Type and are now proceeding to that end. These studies, as well as other studies in the nearby Alpine Cattle Pastures, indicate a trend toward this successional sequence.

It appears that the Tall Forb Type in this portion of its range originally occurred on relatively deep, fertile soils with approximately 35 inches of annual precepitation. At lower elevations (< 8500 feet) and in sections of the Wasatch Plateau that receive lower amounts of precipitation, due to specific weather patterns and to rain shadow influences, other plant community types were present. Many of the plant species from these more xeric types moved into the Tall Forb settings during the heavy grazing years. As grazing pressure has been reduced these species are gradually becoming shaded out by the original Tall Forb species. However, in drier portions of the Plateau species such as S. lettermanii, C. viscidiflorus, as well as most of those forb species listed as negative indicators on page 43 of this report will likely continue to maintain their dominance.

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APPENDIX I

Scientific And Common Names Of Plant Species Found In This Study

SCIENTIFIC NAME	COMMON NAME
<u>FORBS</u>	
Achillea millefolium	Milfoil Yarrow
Agoseris aurantiaca	Orange Agoseris
Agoseris glauca	Mountain Dandelion
Arabis drummondii	Drummon Rockcress
Aster chilensis	Pacific Aster
Aster foliaceus	Leafybract Aster
Astragalus agrestis	Field Milkvetch
Astragalus miser	Weedy Milkvetch
Artemisia ludoviciana	Wormwood
Chaenactis douglasii	Douglas Dustymaiden
Collomia linearis	Sagebrush Collomia
Delphinium menziesii	Low Larkspur
Delphinium occidentale	Western Larkspur
Descurainia richardsonii	Tansy Mustard
Erigeron speciosus	Oregon Daisy
Erigeron ursinus	Bear Daisy
Erysimum album	Western Wallflower
Erythronium grandiflorum	Dogtooth Violet
Geranium richardsonii	Richardson Geranium
Hackelia floribunda	Showy Stickseed
Helenium hoopesii	Orange Sneezeweed
Lathyrus lanszwertii	Lanszwert Sweetpea
Ligusticum porteri	Southern Ligusticum
Lomatium kingii	Stinking Lomatium
Lupinus argenteus	Silvery Lupine
Lupinus sericeus	Silky Lupine
Oenothera flava	Yellow Evening Primrose
Orthocarpus tolmei	Yellow Owl-Clover
Osmorhiza occidentalis	Western Sweetcicely
Penstemon rydbergii	Rydberg Penstemon
Penstemon Watsonii	Watson Penstemon
Plantago tweedyi	Plantain
Polemonium foliosissimum	Leafy Jacobs ladder
Potentilla gracilis	Slender Cinquefoil
Ranunculus inamoenus	Drab Buttercup
Rudbeckia occidentalis	Western Coneflower
Senecio crassulus	Thick Groundsel
Senecio serra	Saw Groundsel
Smilacina stellata	False Solomon Seal
Stellaria jamesiana	Janes Starwort
Taraxacum officinale	Common Dandelion
Thalictrum fendleri	Fendler Meadowrue
Valeriana edulis	Valerian Edible
Valeriana occidentalis	Western Valerian
Vicia amaricana	American Vetch
Viguiera multiflora	Showy Goldeneye
Viola nuttallii	Nuttall Violet
Viola purpurea	Pine Violet

APPENDIX I

-Continued-

SCIENTIFIC NAME	COMMON NAME
<u>GRAMINOIDES</u>	
Bromus carinatus	California Brome
Carex egglestoni	Sedge
Carex hoodii	Hood Sedge
Elymus elymoides (Sitanion hystrix)	Squirreltail
Elymus trachycaulus	Slender Wheatgrass
Eriogonum umbellatum	Sulfer Buckwheat
Hordeum brachyantherum	Meadow Barley
Melica bulbosa	Oniongrass
Phleum alpinum	Alpine Timothy
Poa fendleriana	Muttongrass
Stipa lettermanii	Letterman Needlegrass
Stipa nelsonii	Nelson Needlegrass
Trisetum spicatum	Spike Trisetum

SHRUBS

Chrysothamnus viscidiflorus	Yellowbrush
Ribes cereum	Wax or Squaw Currant