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# A Report on a Pilot Study on Cattle Grazed Patches in Herbaceous Vegetation

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# A REPORT ON A PILOT STUDY ON CATTLE GRAZED PATCHES IN HERBACEOUS VEGETATION

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ACKNOWLEDGEMENTS

There are two ways of spreading light; to be the candle, or the mirror that reflects it.

Anon.

I express my deepest gratitude to Dr. Ben Norton, for providing me with the opportunity to do this study, and for his confidence in me, even during times when my own was lacking. His willingness to provide technical assistance and moral support never faltered. And never before have I imposed on so many busy people in persuit of my own endeavors. I would especially like to acknowledge my appreciation to Keith Owens, Patricia Johnson, and George Gardiner, all of whom are range science Ph.D. students at USU. They had so much patience, they should become doctors-of medicine! But seriously, I am indebted to them for the time they devoted to my efforts. And I especially appreciated Keith's sense of humor, which was uplifting during the discouraging moments of the study.

Not to be forgotten for the superb assistance I received in the field, are Brad Althouse and Lloyd Mendez. I can only hope they receive as good assistance in their own field work.

Finally, my family deserves much of the credit. Although not necessarily obvious to the reader, my parents devoted many years of hard work to me. I am also thankful to my brother, who helped provide me with enough resources to start my studies at USU. And what can I say about my wife, who has made many sacrifices to assist me? Suffice to say that she smiled when this report was completed!

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## INTRODUCTION

Since the late 1960's, the term station (Goddard 1968), feeding station (Novellie 1978, Underwood 1982), and feeding site (Underwood 1983) have been used to describe the area in front of a foraging animal in which it can access forage without moving its front legs. The area is a hypothecial semi-cirle in front of the grazing animal, but the vegetation actually impacted by defoliation may be considered a "grazed patch," which may be the sum of several feeding stations. As animals graze the vegetation in an area, grazed patches are created. Presently, it is undocumented if such patches influence the behavior of grazing animals during subsequent grazing events. A pilot study was therefore conducted to explore the effect of grazed patches on grazing distribution. The purpose of the study was to determine if cattle remove more phytomass from patches of grazed vegetation in a relatively homogeneous environment (in terms of species composition, topography, soils, and climate).

## LITERATURE REVIEW

Some practical problems of studying grazed patches include defining a patch; with what criteria is a patch delineated? What parameters should be observed to monitor the effect of grazed patches on cattle behavior? To gather some information on grazed patches created in herbaceous vegetation by domestic livestock, a literature review was conducted. A thorough search has convinced me that information on any type of grazed patch is scarce. Therefore

I have reviewed some of the general concepts of patch in the natural sciences. Some typical definitions of patch are considered, and described are some usages of the patch concept in various fields of study.

Definitions on what constitutes a patch have been various, but most authors acknowledge that for an area to be considered a patch, it must in some way be different than its surroundings. Implicit is the idea that the patch is important to some organism. Therefore, some authors define a patch based on the activites of the organism which utilizes the patch (Hassell and Southwood 1978, Wiens 1976). The majority of the definitions of patch focus on the differences between patch characteristics and the characteristics of the area surrounding the patch.

Patches have been described as "a 'hole', a bounded, connected, discontinuity in a homogeneous reference background" (Levin and Paine 1974), and as spatial patterns with both vertical (height) and horizontal (area and shape) characteristics (Wiens 1976). One field of study that has intensively studied the difference between a patch and its surroundings has been island biogeography (MacArthur and Wilson 1976). Instead of a patch, it is known as an island, analagous to an oceanic island, usually because the area is so completely different from its surroundings. Examples of these discrete units are woodlot islands surrounded by corn fields (Gottfried 1979), forest fragments (Whitcomb 1977), forest islands (Gali et al. 1976), and red mangrove islands

(Simberloff 1976). Other discrete islands studied were islands of deer cover (Picton and Mackie 1980), an isolated pool (Fernald adn Hirata 1977), and literal islands in bodies of water (Dueser and Brown 1980, Gill 1971, Lomolino 1982). Inasmuch as these discrete units could be called patches, island biogeography deals more with the population dynamics of organisms that colonize and inhabit the island (Boyce and Daley 1980, Dingle and Anora 1973, Lomnicki 1980). Defining other characteristics of the island seem to be of secondary importance, other than how they relate to the colonizing organisms.

Patch characteristic depend on how the patch was formed. They can be formed naturally or by artificial means. In Paine and Levin's (1981) study of patch dynamics in mussel beds, patches were formed by waves and were defined by areas of bare rock. From a landscape perspective, patches have been described as community or species assemblages surrounded by dissimilar assemblages (Forman and Godron 1981). Vegetational heterogeneity has been under objective study since at least the beginning of the 20th centry (Arrhenius 1921 and 1923, Ashby 1936, Blackman 1935, Gleason 1922, Levy and Madden 1933) and technical methods have been developed in vegetation analysis and classification. Description of the methodology and parameters used to delineate clumps or patches of plants or communities are beyond the context of this paper; suffice to say that such methodology exits.

Forman and Godron (1981) have described five types of patches within plant communities, the definitions of which can probably be extended to other levels of interest. The five patch types suggested were:

1. The "spot disturbance patch", resulting from disturbance of a small area, as in a small fire in a grassland, or patches of vegetation that have been grazed.

2. The "remnant patch", which is just the opposite of the spot disturbance patch. It involves widespread disturbance around a small area that has not been disturbed, as in a shrub covered island created by a flooded valley.

3. The "environmental resource patch", which reflects the normal heterogeneous distribution of resources, as in herbaceous vegetation growing around a desert oasis (where the water is the resource and the vegetation a patch).

4. An "ephemeral patch", caused by normal, short-lived fluctuations in resource levels, as in a localized bloom of annuals in a desert due to a rainstorm or grazing.

5. An "introduced patch", a patch created by people, as in fields of wheat or corn.

Since it is difficult to quantitatively define natural patches and their boundries, artifical (or introduced) patches are often created when patch characteristics are of consequence in specific studies. In documenting the pattern of grazing in pastures, Morris (1969) created clearly delineated patches by clipping small areas of vegetation to a uniform level of height. In studying the relationship between foraging behavior and rsource availablity, Hart (1981)created "food patches" of tile substrates for utilization by an aquatic insect. Kay and Keough (1981) investigated sponge occupation of artifically created patches on pier pilings. Cromartie (1975) used potted plants in tilled plots to study coloniozation by herbivorous insects. Kareiva (1982) also used tilled plots to create patches of collard plants in the study of herbivorous insects. Finally, theoretical patches have been used in predator-prey models (Comins and Blatt 1974, Hasting 1977, Hilborn 1975).

In summary, consideration of patches is justified because they are thought to have biological significance to some organism. Patches can be defined by the activity of the utilizing organism, or by comparing differences within and around the patch. Patch formation, whether artifical or natural, influences these differences. Artificially created patches usually have discreted boundries, while boundries of natural patches are often obscure. Methodology to quantitatively describe patches with obscure boundries is currently limited.

## STUDY AREA

The study was conducted in Juab County at the Tintic Research Area (Section 2, Range 3 West, Township 11 South), near Tintic, Utah. The Tintic Research Area is under the jurisdiction of the Bureau of Land Management, and is used and managed by Utah State Univerity for research purposes. Elevation ranges from 5584-5990 feet (Jensen 1983). Precipitation is usually low, about 12 inches per year, and comes mostly in the form of snow. Last year however, was an exception with approximately 18 inches of precipitation.

Two of four paddocks, each approximately 17 acres in area, located in Pasture 18 of the Tintic Research Area were used for the study (Appendix A). One of the paddocks not grazed in the previous year contained an abundant amount of straw (standing dead), and henceforth will be called the straw paddock. The other paddock had undergone heavy grazing by cattle during the boot stage of plant development in the previous year, which resulted in a relatively even grass height with almost no straw (henceforth called the no-straw paddock). These two paddocks were chosen because evidence of grazed patches from the previous year would be minimal, and observations about the influence of straw in patch dynamics could be observed.

Major perennial plant species in the paddocks include standard creasted wheatgrass (Agropyron desertorum), western wheatgrass (A. smithii), big sagebrush (Artemisia tridentata), and juniper (Juniperus spp). Jenson (1983) identifed four relatively similar soil types in the two paddocks: Tintic cobbly sandy loam, 3 to 12 percent slope; Calita sandy loam, 3 to 12 percent slope; Doyce loam, 3 to 6 percent slope; Juab coarse-loamy variant, 2 to 4 percent slope. Jenson's (1983) description of these soil types, as well as associated plant types and range sites are presented in Appendix B.

## METHODS

Once approach to determine if cattle are attracted to patches in herbaceous vegetation is to monitor defoliation of the herbaceous vegetation. Since the boundaries of naturally grazed patches are often obscure (making a quantitative description of the patch impossible), artificial patches were created before cattle were introduced to the paddocks. Unteated plots (controls) were also established before cattle entered the paddocks.

Each plot was defined by two concentric circles. The larger circle contained twice as much area as the inner circle. Three inner circle sizes were used: 1/4 $m^2$, 1 $m^2$, and 3 $m^2$. Area of the larger circles was 1/2 $m^2$, 2 $m^2$, and 6 $m^2$ respectively. The inner circle of a plot was considered a patch, and the area between the boundry of the inner circle and the ~~outside~~ boundary of the outer circle was considered the perimeter. With this arrangement, the area of a patch is equal to the area of its perimeter. For example, if the patch was 1 $m^2$, the perimeter would also be 1 $m^2$, and total plot size would be 2 $m^2$ (Figure 1).

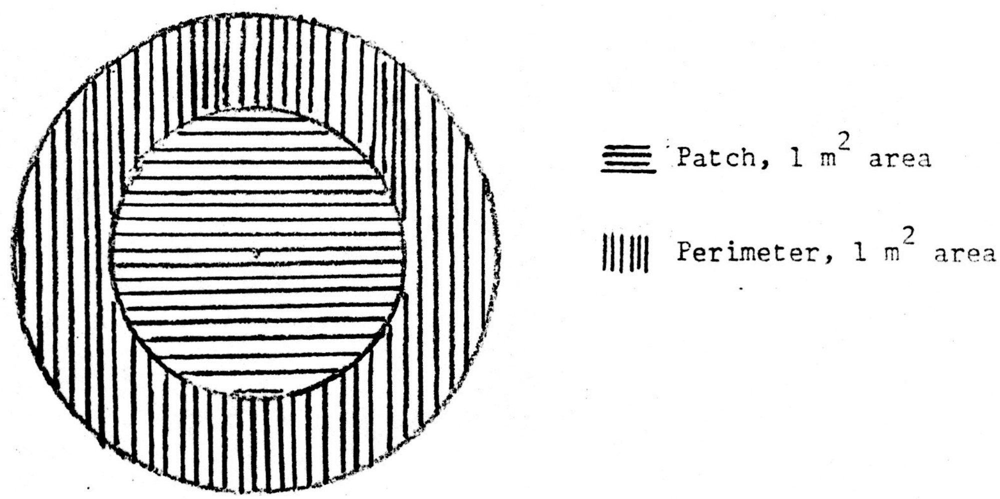


Figure 1. Configeration and area of a plot.

Each patch was subjected to one of four treatments (Table 1). Vegetation in the perimeter was always left unmanipulated.

Table 1. Treatments applied to the patch of a plot.

| Treatment No. | Description |
|---|---|
| 1 | Remove all straw (Straw paddock only) |
| 2 | Clip grass to 10 cm height[A] |
| 3 | Clip grass to 1 cm height[A] |
| 4 | Leave foliage unmanipulated |

[A] average grass height was 30cm

With this arrangement, treatments 1 through 3 created patches, and the forth treatment established a control plot. By establishing patches with no vegetation (treatment 3), slightly altered vegetation (treatments 1 and 2), and with unmanipulated vegetation (treatment 4), any preference patterns could be detected. Differentiating where the plots with patches were being impacted (i.e. the patch or perimeter) was also of interest.

Preference for different patch size was tested by incorporating the three plot sizes, to which each treatment was applied. Each combination of treatment/size was replicated three times. Thus there were 3 sizes x 4 treatments x 3 replications for a total of 36 plots in the straw paddock, and 3 sizes x 3 treatments[1] x 3 replications for a total of 27 plots in the no straw paddock.

Plots were established in the field using coordinates derived from random numbers. Coordinates were paced off in the field and marked with florescent orange painted

[1] Treatment 1, removing straw from the patch, could not be applied in the no-straw paddock

stakes. Approximately 20 centimeters of each stake was above ground. Orange color of the stake would enable faster relocation of plots, and the low stature of the stakes would not attract the presumably color-blind cattle, which use taller stakes and such as scratching posts for relief of an itchy chin or ear! As an added precaution, plots were established so that the outside boundary of the perimeter would be 1 meter from the stake. A small nail was driven part-way into the top of the stake to accommodate a square piece of thin wood with a hole in its center. This piece of wood, which had a thin slot from the center hole to one of its corners, was spun to determine a random line of direction from the stake to the plot center (same principle as spin the bottle). The distance of 1 meter plus the radius of the plot was measured along this line to determine location of plot center, which was marked by pushing a nail painted florescent orange into the ground until just the head was visible. Direction of the plot was noted by marking the top of the stake.

## DATA COLLECTION

Plot boundries were deliniated using rigid, circular quadrants of the prescribed size. Prior to the plot treatment, ocular estimates of canopy cover were made at each plot. Separate estimates were made for the patch and its perimeter, each potentially capable of having 100 percent cover, and was recorded as percent of the patch or perimeter covered with canopy foliage Only the foliage of <u>Agropyron desertorum</u>, whether rooted within the plot or just hanging into the plot, contributed to canopy cover estimates. Foliage from other species was not included in cover estimates. Spaces of approximately 5 cm or less between foliage of A. ~~desertoum~~ desertorum within the plot were ignored. After the canopy cover estimates were completed, the prescribed treatment was applied. if prescribed, straw was removed by "combing" the patch with both hands. Clipping was accomplished by using hand shears. Upon finishing the prescribed treatment, quadrants were gathered and coordinates for the next plot were paced off. The above described procedures were repeated for all 63 plots.

Observations began on May 26, 1983, the day cattle were put into the paddocks. Each of the paddocks were stocked with 30 Angus heifers, 1 Angus bull, and 20 Angus steers.

Plots were re-located using a crude, hand drawn map, and by sighting the orange stakes. Once the plot center was found, the appropriate sized quadrants were placed on the plot with centers aligned. The parameter of interest for data collection was the extent of defoliation within the plot. Again, estimates for patches and perimeters were made separately. An ocular estimate of defoliation was recorded as the percentage of canopy cover impacted in the patch or perimeter. The percentage of canopy cover imacted was estimated using five percent intervals; 1 to 5 percent canopy cover impacted was recorded as 5 percent impact, 6 to 10 percent impacted was recorded as 10 percent impact, and so forth, with 95 to 100 percent impact recorded as 100 percent impact. Average stubble height for each impacted patch and perimeter was also measured with a straight-edge ruler and was recorded. The cumulative percent cover impacted within a patch or perimeter was recorded once per day, for a total of four consectutive days; the last day of data collection was on May 29, 1983. The average stubble height was measured daily, and if stubble height changed by more than 5 cm, a new average stubble height was estimated and recorded.

## DATA ANALYSIS

Daily change in percent canopy cover impacted for patches and perimeters were derived from the "daily totals." Since no daily grazing patterns were detected, cumulative results at the end of the four day study were analyzed. Extent of defoliation in terms of area and of foliage removed was used for the analysis. In order to do this, it was necessary to estimate phytomass within the plots. Using information from Johnson's (1984) research project at the Tintic Research Area, a regression equation which estimates phytomass from volume was used.[2] Since the area of the vegetation in the plots was recorded, and average

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[2] See Appendix C

grass height was 30 cm, it was possible to caluclate volume ($cm^3$) of foliage in each plot, from which phytomass (g) could be estimated.[3] Height-weight relationships previously derived[4] were used to estimate the portion of weight remaining in the patch of treatment 2 plots.

Percent of phytomass consumed (which was the basis of the analysis) was then derived from estimates of available phytomass. Assuming the phytomass is evenly distributed over the area of its canopy, the percentage of canopy area impacted by defoliation potentially targets the same percentage of total phytomass available for consumption (e.g. when 50% of the canopy is defoliated, up to 50% of the total phytomass can be removed by grazing). The amount actually removed depends on the height to which the grass is grazed. Using the height-weight relationship, the percentage of weight in the stubble was calculated, and hence the percentage of phytomass removed (the difference between 30 cm and stubble height) was also calculated. That percent of phytomass removed multiplied by the phytomass available in the impacted area equals the phytomass (g) removed by grazing. The quotient of the phytomass(g) removed divided by total phytomass (g) available is the percentage of phytomass removed. An analysis of variance was used to test for

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[3] There was no need to estimate biomass in the patch of treatment 3 plots, since vegetation was clipped to 1 cm height, and thus woudl be unavailable for grazing.

[4] See Appendix C

significant differences in percent phytomass removed between plots of a specific treatment and/or size, and also between patch and perimeters of plots.

## RESULTS AND DISCUSSION

The mean percentages of phytomass removed after four days for plots in the straw and no-straw paddocks are presented in Table 2. The value for each treatment/size combination represents the mean of the three replications.

Table 2. Mean percent phytomass removed, standard error of mean, F-statistics for plots in straw and no-straw paddocks

| | Straw Paddock | | No-straw Paddock | |
|---|---|---|---|---|
| Treatment/size[B] | Mean | S.e. | Mean | S.e. |
| T1S1 | 12.06 | 1.30 | | |
| T2S1 | 9.90 | 5.90 | 10.46 | 5.58 |
| T3S1 | 8.78 | .85 | 2.70 | 1.15 |
| T4S1 | 6.65 | 3.56 | 5.89 | 5.00 |
| T1S2 | 7.83 | 1.32 | | |
| T2S2 | 3.62 | .78 | 8.07 | 5.76 |
| T3S2 | 4.42 | 3.03 | 16.70 | 9.20 |
| T4S2 | 7.55 | 5.13 | 6.00 | 6.00 |
| T1S3 | 7.41 | 1.08 | | |
| T2S3 | 6.04 | 1.13 | 12.70 | 4.30 |
| T3S3 | 2.74 | .94 | 16.30 | 6.80 |
| T4S3 | 1.37 | .70 | 5.56 | 3.04 |
| | F=1.24[C] | | F=0.78[C] | |

[A]No treatment 1 plots in the no-straw paddock.
[B]Plot sizes include patch and perimeter
[C]Not significant at $\alpha=0.05$

The F-statistics were examined with $\alpha=0.05$; at this level, the percent of phytomass removed is not significantly different among plots in either the straw or no-straw paddocks. An analysis of variance was also performed to compare the pooled mean percent phytomass removed in the straw paddock and no-straw paddock (Table 3). At the $\alpha=0.05$ level, the two values for pooled, mean percent phytomass removed were not significanlty different.

Table 3. Pooled mean percent phytomass removed, standard error of of mean, and F-statistic for straw and no-straw paddocks

| Paddock | N | Mean | S.e. | |
|---|---|---|---|---|
| Straw | 12 | 6.53 | 2.75 | |
| No-Straw | 9 | 9.38 | 8.26 | |
| | | | | F=2.61[A] |

[A]Not significan at $\alpha=0.05$

As evident in the results, it could not be demonstrated that cattle graze more phytomass from any plots with patches than control plots. It could also not be shown that the presence of straw (on a plot basis) influences cattle grazing behavior.

I state these conclusions while cognizant of the limitations of the study, which include the subjectivity of observations, variablity due mainly to a relatively complex experimental design with insufficient treatment replications, and data analysis techniques utilizing data from other research.

Subjectivity is inherent in the ocular estimation of initial canopy cover (upon which available phytomass is estimated). Ocular estimates of percent canopy cover impacted by defoliation is also subjective. since these estimates are made subjectively, it is realized that the results are only as good as the estimation skills of the observer. A limitation in this study is that there was no training period for estimation of area. This is especially important considering that estimation of percent canopy cover and percent impact to canopy cover is not as simple as it may first appear to be. Consider the 1/4 $m^2$ patch with 10% canopy cover; a five percent impact to canopy cover requires that only about 3 $cm^2$ be defoliated. For the very next estimate, it may be necessary to appreciate that 4,050 $cm^2$ of defoliated canopy in a 3 $m^2$ patch with 90% cover is also a 5% impact to canopy cover. Consider also that estimates must be made for perimeter areas, which like doughnuts, have holes in their center; estimating a 5% impact to canopy distributed over the perimeter is more difficult than making the estimate for canopy clumped together in the patch. The need for a training period is obvious. I would be relatively simple, prior to data collection, to estimate various areas and then measure them. Since this was not done, consistency and accuracy of ocular estimates are not know.

Evident in the preceding examples on cover estimation is the magnitude of avriability due to experimental design. I am convinced that the design used was too complex for a pilot study. Four treatments, three sizes and two paddocks necessitates extensive data collection and also a lot of variability which must be dealt with by the observer (e.g. defoliation of 3 $cm^2$ and 4,050 $cm^2$). In addition, concentration of the observer is divided among so many different details (treatment, size, patch, perimeter, etc), that it is difficult to note other items of general interest (such as cattle behavior). With this shotgun approach to the study, too much enegy was devoted to collecting data from too many treatments, with the result that too few replications were available for powerful statistical analysis. Having only three replications for each treatment creates good potential for large variability. For a pilot study, it would be better to establish fewer treatments with more replications. It would also be a good idea to reduce the range in plot sizes. From personal experience, I would not recommend studying patches smaller than 1 m , and 6 m should certainly be the maximum size for plots in relatively small pastures. Patches smaller than 1 m are relatively inconspicuous, and plots of 6 $m^2$ or more are simply too big; estimating canopy cover and percent impact to canopy becomes very difficult. In addition, a 6 $m^2$ quadrant is cumbersome to transport in the field.

Another limitation of the study is use of the regression equation which was derived from plants collected from another pasture. One disadvantage is that plants collected from pasture 19 may not be statistically representative of plants in pasture 18. A major drawback from using the regression approach was its derivation from volume and phytomass of single plants, where as foliage volume in the study was estimated for the whole patch or perimeter and involved groups of plants. Therefore the phytomass relationship may be significantly different for the volume of plants in the plot. Plants used to establish the height-weight relationship were collected in a different year and from entirely different pasturesthan the one in which the study was conducted in. Whether these grasses are satistically representative of the grasses used for the study is completely unknown. Despite the obvious drawbacks with the height-weight relationship and the regression approach these were used for the data analysis. A preliminary analysis of variance on the estimated percent cover impacts produced uninterpetable results, as did Chi square analysis. 95% confidence intervals for analysis of variance were extremely wide, and Chi square analysis was limited because half the cells had expected frequencies less than 3. It is likely that the variability due to small sample size is responsible for the unusable results. It was then recognized that percent phytomass removed would allow for a better analysis, since it not only considers area of cover impacted, but also the extent to which it was impacted. Since it was not anticipated that an analysis would be done based on phytomass, no phytomass data was collected during the study, and hence it was necessary to use the regression equation and height-weight relationship derived by Johnson (1984).

Despite the weaknesses of the study, I feel that it was an overall success. Results of the pilot study could not show that patches of grazed vegetation influence cattle behavior. This indicated to me that if patches do influence the behavior of cattle, it is in the ways which are not so easily detected. Three of the most obvious characteristics of the patch were analyzed in this study; patch area, height of vegetation in the patch, and presence of straw. There are other variables which could influence the dynamics of grazed patches, many of which are not related to vegetational characteristics at all. It could have more to do with stocking density, grazing season, schedule of use, animal nutritional status and general health, animal age, shape or size of the pasture, etc. The point is that there are many variables to be considered; I looked at three of the more obvious. Although the methods have their weakness and the statistical analysis may lack power, useful information was derived from the study. In acknowledging the problems with the study, similar problems in future studies of the same type can be avoided.

In summary, there are many variables involved in the grazed patch pehenomenon. Three of the more obvious--patch, area, height of vegetation, and presence of straw--were investigated. An analysis of results could not demonstrate that patches of grazed vegetation influence cattle grazing behavior. Subjectivity of obsevations, lack of a training period to acquire estimation skills, complexity of the experimental design, the large variablity inherent in the study, questionable extrapolation of data from other research to estimate phytomass are the major weakness of the study. Some of these problems can be overcome by planning for a training period to acquire estimation skills, reducing the complexity of the experimental design, reducing the difference in size between plots, and planning for phytomass data collection if such a parameter is desired in the analysis. The methods used were appropriate for relatively small pastures where heterogeneity is likely to be less of a problem, but should be carefully evaluated before use in larger areas, where vegetation, soils, and topography are not uniform.

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APPENDIX A

MAP OF PASTURE 18

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MAP OF PASTURE 18

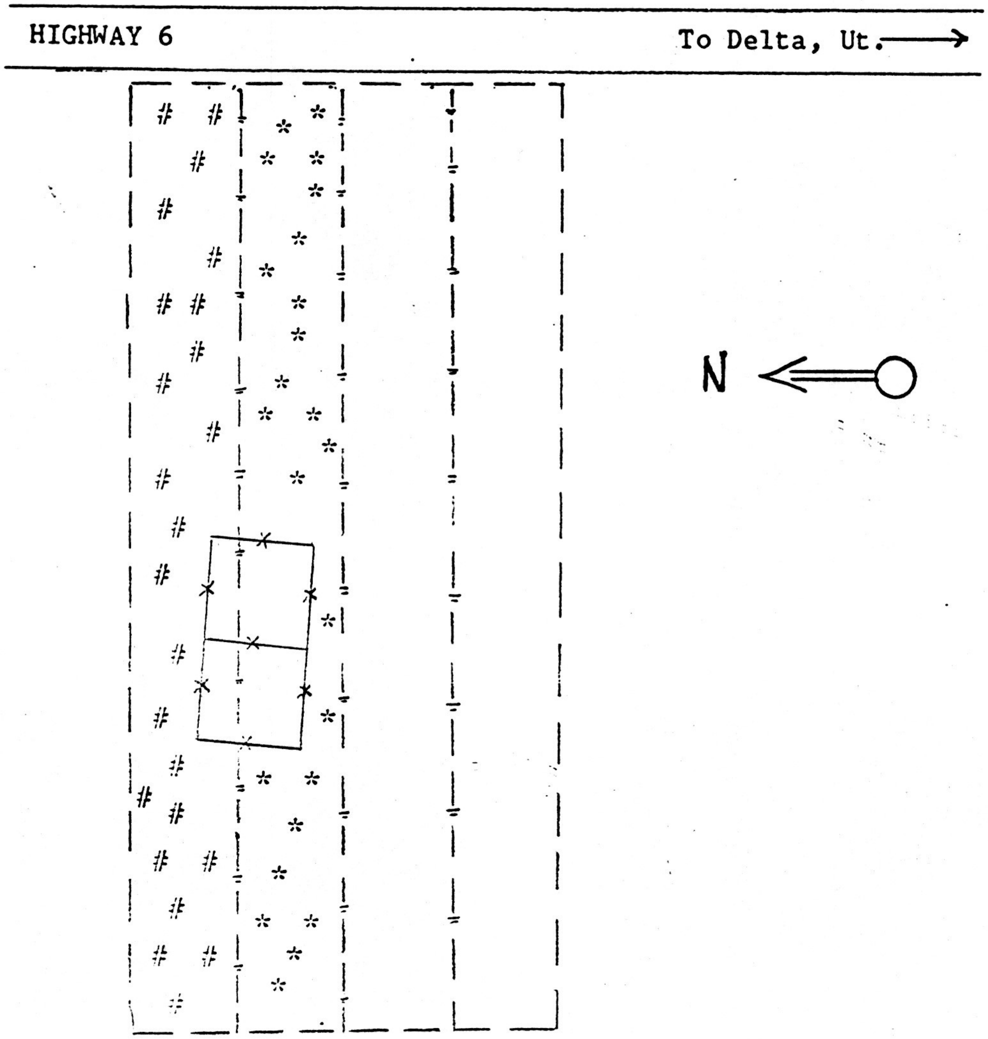


Figure 1A. Pasture 18 and study area.

LEGEND

— — — Fencelines

— —ı— 3 Stand Electric Fence

—x— Grazing Exclosure

# Straw Paddock

* No-Straw Paddock

# APPENDIX B

## JENSON'S (1983) DESCRIPTION OF SOIL TYPES, VEGETATION, AND RANGE SITES IN PASTURE 18 OF THE TINTIC RESEARCH AREA

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JENSON'S (1983) DESCRIPTION OF SOIL TYPES, VEGETATION, AND RANGE SITES IN PASTURE 18 OF THE TINTIC RESEARCH AREA

Tintic cobbly sandy loam, 3 to 12 percent slope

This map unit was delineated on rolling ridge crests, and in association with Deerlodge and Doyce soils on broadly convex, undulating landscapes. On ridgecrest positions, Tintic soils comprise relatively broad, convex positions with hummocky relief. On undulating landscapes, the Tintic soil occurs on crests and southern exposures of convex positions with smooth relief. These delineations are long and narrow and run parallel to the general slope of the landform.

Surface horizons are grayish brown cobbly or gravelly sandy loam about 13 cm thick. The subsoil is very calcareous light brownish gray gravelly sandy loam about 15 cm thick. The subtending layer is white to pale brown cobbly sandy loam which is slightly cemented by secondary lime and silica. A strongly cemented hardpan underlies the weakly cemented layer at a depth of about 50 cm.

The Tintic soil is shallow to moderately deep and somewhat excessively drained. Infiltration is moderate. Permeability to the hardpan layers is moderate and slow to very slow through these layers. During one intense precipitation event water was observed puddling on the surface. Also, a white (10YR8/2) carbonaceous clay was observed seeping out of a channel cut at a depth of about 30 cm below the surface. A pale brown (10YR6/3) sticky goop formed on boots to a much greater degree in wet Tintic soil than for other soil types. Runoff is slow and the water retention difference (WRD) is very low (5 cm). Erodibility is moderate (K =

0.28). Long, narrow delineations of Tintic soils are moderately eroded by sheet erosion and subsurface eluviation. Broad delineations are moderately eroded by both rill and sheet wash in corridors between juniper canopies.

The most conspicious vegetation is juniper. Bitterbrush, indian ricegrass, and big sagebrush with low stature were also observed. The range site is Semidesert Shallow Hardpan.

Included in this map unit are areas of Deerlodge soil on positions with more mesic aspects. This soil comprises about 15 percent of delineations.

Tintic soils are differentiated from all other soil types described in having a silica and lime cemented hardpan at a depth ranging from 30 to 60 cm.

Calita sandy loam, 6 to 12 percent slope

This soil occurs on relatively long slope positions of convex ridges in pastures 17, 18 and 19. The position is very similar to that described for the Deerlodge soil except slopes are considerably longer. Tintic soils occur at the apex of the ridges while Doyce or Juab soils are in convave positions between ridgeslopes.

Surface layers of Calita soil are brown sandy loam about 15 cm thick. The subtending stratum is a brown to pale brown eluvial horizon about 15 cm thick. Subsoils are light brown and very pale brown fine loams and sandy clay loams with significant accumulations of illuvial clay and carbonate (argillic horizons). A white, very strongly calcareous (calcic) horizon with massive structure extends from 100 to over 150 cm. A few fine and very fine roots penetrate to depths well below 120 cm.

The Calita soil is well drained with moderately rapid infiltration through the epipedon, moderate permeability to about 100 cm and moderately slow to slow permeability below 100 cm. Runoff is very slow and WRD is moderate (21 cm). Erodibility is moderate (K = 0.17) and surfaces are uneroded.

Vegetation includes widely scattered juniper, big sagebrush, and low rabbitbrush. The range site is Upland Loam.

Included in map delineations are small areas on Tintic soil. These occur on convex positions near ridgecrests and comprise about 10 percent of delineations. Transitions to Doyce soil at the bottoms of slopes are gradual. Doyce soil may constiture 10 percent of delineations.

Calita soils are very similar to Deerlodge soil. Soil morphology to a depth of about 100 cm are nearly identical. Deerlodge soil have a silica and lime cemented hardpan at or below 100cm. Calita soil has a massive calcic horizon penetrable by plant roots. Calita soils differ from Tintic soil in not having a hardpan above 60 cm depth. They differ from Doyce and Juab soils in forming on slope positions rather than in concavities. Calita soils differ from Donnardo and KI soils in having fine-loamy particle size class.

Doyce loam, 3 to 6 percent slope

The Doyce soil occurs in concave positions between low ridges of Deerlodge and Tintic soils and between taller ridges of Calita soil. They occupy fluvial positions of the landscape, though little evidense of recent fluvial erosion or deposition were noted. Areas of Doyce soil appear to be relatively stable sinks for sediments and illuvial material derived from Tintic, Deerlodge and Calita soils.

Surface horizons of the Doyce soil are brown, noncalcareous loam about 15 cm thick. Epipedons are subtended by brown eluvial horizon of loam texture. Subsoils are fine loams, silt loams, and clay loams with significant accumulations of illuvial clay and carbonates (argillic horizons). In some polypedons argillic horizons extend to a depth of about 120 cm and directly overly a silica and lime cemented hardpan. In other areas horizons with fine-loamy particle size class extend to depths greater than 150 cm.

The Doyce soil is well drained with moderate infiltration. Permeability is moderate to moderately slow. Water retention difference (WRD) is high (25 cm). Runoff is very slow. Erodibility is moderate (K = 0.27); surfaces are uneroded except for an occassional shallow rill at the center of the concave positions.

Vegetation includes western wheatgrass, big sagebrush, tall rabbitbrush and short rabbitbrush. The range site is Upland Loam.

Included in map delineations are areas of Deerlodge soil. These occur on the flanks of the concave positions and comprise less than 10 percent of delineations.

The Doyce soil is different from Tintic and Deerlodge soil in not having a hardpan above 110 cm depth. It is characterized from Calita soils in not having a massive calcic horizon below 100 cm. It differs from Juab, Donnardo and KI soils in having a fine-loamy particle size class.

KI soils are differentiated from Tintic and Deerlodge soil by the absence of a hardpan. They differ from Calita, Doyce, and Jua soils in having a cobbly or gravelly substratum. They are distinguisted -om Donnardo soil by having few or no stones and cobbles at the soil su face.

Juab coarse-loamy variant, 2 to 4 percent slope

This soil occurs in fluventic positions in the lowest porti ıs of the study area. The landform is generally broadly concave and even although shallow rills and deep gullies are apparent in some delineati ıs. The unit includes a somewhat broad range of particle-size classes /hich may differ considerably between distinct delineations. All soils lescribed are coarse loamy or marginal to fine loamy class.

Typically, the epipedon is grayish brown sandy loam or loam ıbout 35 cm thick. Substrata are pale brown sandy loam or loam texture. Some polypedons have cambic horizons; others have little pedogenic d ·elopment below the epipedon. Buried genetic horizons were noted in some ›rofiles. The stratification of relatively distinct textural classes and 'rregular decrease in organic matter content with depth is characteristic : fluventic deposition.

The Juab soil is very deep and well drained. Both infiltr :ion and permeability are moderate. Water retention difference is modera to high (20 to 27 cm). Runoff is slow. Erodibility is moderate (K = 0. ;). The degree and form of active erosion is highly variable. Some area are uneroded; other areas are slightly eroded in the form of shallow egetated rills; deep gullies resulting from active fluvial erosion were noted in some areas. Gullies tend to form at the interface between Juab soil and steeper sloping upland types. Rills and gullies are active for short periods during spring runoff some years. Ephemeral drainages originate on the western slopes of the East Tintic mountains.

Vegetation includes big sagebrush, tall rabbitbrush, and western wheatgrass. The range site is Upland Loam.

Included in this map unit are areas of KI, Deerlodge and Doyce soils. The KI and Deerlodge soils occur at transitions to upland areas and may comprise 10 percent of delineations. Boundaries between these types and Juab soil are very diffuse. The Doyce soil occurs less frequently in shallow concavities within the broadly concave landform. Morphological characteristics of this inclusion are transitional to those of the Juab soil. These may comprise 5 percent of map units. Also included are soils with epipedons too light or thin to be rigorously defined as Mollisols. These occur at the lower extremes of the study area and may comprise 15 percent of some delineations.

The Juab soil differs from Tintic, Deerlodge, Calita, and Donnardo soils in occuring in broadly concave, fluventic positions. It is different from Doyce soil in having coarse-loamy particle size class and from KI soil in not having gravelly or cobbly substrata.

# APPENDIX C

## INFORMATION ABOUT JOHNSON'S (1984) REGRESSION EQUATION AND HEIGHT-WEIGHT RELATIONSHIP

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INFORMATION ABOUT JOHNSON'S (1984) REGRESSION EQUATION AND HEIGHT-WEIGHT RELATIONSHIP

Patricia Johnson derived the regression equation and height-weight relationship for the study using information from her research at the Tintic Research Area.

The regression equation was derived using volume and phytomass data collected on 45 plants from pastures 18 and 19. The data was collected May 26 and 31, 1983. Volume was based on an imaginary cylinder around each plant; the phytomass was calculated by harvesting and weighing the foliage of each plant. The regression equation which was derived is: $\ln V (.937) - 6.67 = \ln PM$

where:

ln is the natural log

V is the volume in $cm^3$

PM is the phytomass

Estimates of biomass were obtained by deriving the anti-log of the solution to the regression equation. The regression equation has an $r^2$ value of 87.3 when adjusted for the degrees of freedom.

Plants used in deriving the height-weight relationship were collected during 1981 from pastures 8, 17, and 19. Plants used were all between 20cm and 35cm in height, with a mean height of 23cm. Weight was measured in 3cm intervals from shoot bases to 15cm, and then 5cm increments thereafter. Data was the percent of total plant weight found in each height increment (Table C1).

Table C1. Mean percent of total plant weight per increment of height.

| Height Increment cm | 1-3 | 3-6 | 6-9 | 9-12 | 12-15 | 15-20 | 20-25 | 25-30 |
|---|---|---|---|---|---|---|---|---|
| Mean percent | 23.14 | 23.93 | 19.35 | 14.53 | 9.06 | 7.16 | 2.31 | .44 |