

A COMPARATIVE STUDY OF THE VEGETATION OF
GRAZED AND UNGRAZED CANYONS OF THE
WASATCH RANGE, UTAH¹

WALTER P. COTTAM AND FREDERICK R. EVANS

University of Utah, Salt Lake City, Utah

INTRODUCTION

The past two decades have been marked by intensified governmental efforts in range rehabilitation. These efforts have been handicapped by lack of definite information about the pristine nature of grazed lands as well as about quantitative and qualitative changes which grazing has doubtless induced in the plant cover. The meagerness of the historical record concerning the vegetation over the vast grazing areas of the West at the time of settlement, together with the almost total absence of preserved primitive areas, makes the problem of reconstructing the original plant cover difficult though not impossible to solve. In these problems ecology finds both a duty and a privilege to serve the land-use program.

The Wasatch Mountains east of Salt Lake City, Utah, afforded an opportunity to ascertain some of the effects of nearly a century of intensive, unregulated grazing and other human influences on the native vegetation and soil of various elevations and slope exposures. This study was confined to vegetational problems of Emigration and Red Butte canyons, while the results of parallel but independent soil investigations were reported by Croft *et al* ('43) of the same and other areas of the Wasatch Mountains. Emigration and Red Butte canyons were selected for study because of their comparability in position, physiography, and historical use.

¹Acknowledgments are due the Intermountain Forest and Range Experiment Station, Ogden, Utah, for valuable suggestions and financial aid in the pursuit of this study.

CLIMATIC, PHYSIOGRAPHIC, AND
GEOLOGIC FEATURES

The Wasatch Mountains constitute the northeastern rim of the Great Basin. They rise abruptly as an escarpment from a desert floor with an elevation of 4500 feet up to altitudes of 12,000 feet. The range is deeply dissected by numerous canyons having a general east-west direction, of which Red Butte and Emigration canyons are typical. These two canyons are parallel to each other with their mouths directly east of and adjacent to Salt Lake City and discharge their streams westward into Salt Lake Valley. Red Butte Canyon, which lies one mile to the north of Emigration Canyon, drains an area of approximately 25 square miles. Emigration Canyon drains an area of approximately 40 square miles.

It is characteristic of the canyons of the Wasatch Mountains that the south-facing slopes are less precipitous than their north-facing counterparts. Since the drainage area of Red Butte Canyon is less and its length shorter than those of Emigration Canyon while both canyons at their mouths are approximately the same depth, both slopes of Red Butte Canyon are in general steeper than those of Emigration Canyon.

In soil and geological features these two canyons show important differences. Emigration Canyon is composed principally of Jurassic limestone while Red Butte Canyon consists in part of a complex mixture of Triassic shale, sandstone, and limestone. Considering the great difference in grazing use, it was suggested by Croft, Woodward, and Anderson ('43) that the soils of Red Butte

Canyon erode much more easily than do those of Emigration Canyon. It is generally recognized also that sandstone soils are basically less favorable for plant growth than are limestone soils (Hilgard, '06). These facts would seem to favor a more abundant vegetation in Emigration Canyon and are important in the analysis of vegetation in this paper.

The Wasatch front, because of its western exposure and its abrupt rise from the desert, is considerably more xeric than the canyons that dissect it. Precipitation, which averages 16.13 inches annually at Salt Lake City, increases with elevation to a maximum of about 40 inches at 9000 feet. The growing season shortens with higher altitude; Salt Lake Valley has a frostless period of about 160 days while Brighton Canyon, 10 miles south of Emigration Canyon, with an elevation of 8700 feet, has an average growing season of about 90 days.

HISTORY OF RANGE USE AND OWNERSHIP

Soon after the settlement of Salt Lake Valley in 1847, both Red Butte and Emigration canyons came under private ownership and both were utilized for grazing purposes. In 1888 the United States government began the purchase of Red Butte Canyon for the purpose of establishing Fort Douglas at its mouth, and by 1909 had acquired title to the entire watershed. Protection from grazing probably commenced with the first purchase of the land. Even then, however, gully erosion was manifest in the canyon. It is assumed that depletion of the plant cover was responsible because, under protection, gullies have become revegetated and severe erosion at present is only half that found in Emigration Canyon. Ring counts from trees growing on these old erosion scars place their age at approximately 40 years, a date which coincides with the purchase of Red Butte Canyon by the War Department.

As a result of a policy to protect its watershed, Salt Lake City has acquired

title to most of the land in Emigration Canyon. However, some of the canyon is included in the Wasatch National Forest, and a few sections still remain under private ownership. Because the permanent stream in Emigration Canyon is small and uncertain, the water is not used by Salt Lake City for domestic purposes, and little attention has been given to grazing or erosion problems. City property is still leased to private stockmen, and grazing in this canyon, therefore, has continued without regulation since the time of settlement.

In addition to the grazing abuses already recounted, Emigration Canyon for a distance of six miles is used as a stock trail to and from the higher summer ranges of the Wasatch and Uintah Mountains. The number of sheep passing over this trail varies from year to year. In the spring of 1935, for example, 97,550 sheep and 200 cattle used this trail; in the fall of the same year 123,000 sheep were herded down the canyon. By comparison, the spring drive of 1931 included 145,510 sheep, and the fall flocks totaled 209,203 sheep. Trailing here is said to have begun in the early "fifties." Each flock has the freedom of the canyon up to the six-mile point where the trail passes over Little Mountain into Parley's Canyon. It is not uncommon for a single flock to remain a week within the lower reaches of Emigration Canyon.

Many summer homes with their associated fenced enclosures are located in Emigration Canyon along the stream course, and the canyon is much used for camping and general summer recreation. On the other hand, civilians have been rigidly excluded from Red Butte Canyon since the turn of this century.

Fires at the mouths of both canyons are not uncommon. Especially is this true of Red Butte Canyon where vegetation is purposely burned to clear the land for target ranges. Both canyons have suffered from inadvertent burns at various places and times at higher elevations.

EARLY DESCRIPTIONS OF VEGETATION

No records are extant which refer particularly to the vegetation of Red Butte Canyon, and but few refer to the vegetation of Emigration Canyon in 1847. However, it is significant that available references describe Emigration Canyon as densely vegetated. William Clayton ('21), an early Mormon historian, stated that it was necessary, because of the dense growth of vegetation, for the pioneers to reconstruct a road through Emigration Canyon which had apparently been used by the Donner party only the year previous. In July, 1847, Erastus Snow and Orson Pratt traveled through Emigration Canyon in advance of the main pioneer party. Snow said that "The thicket down the narrows at the mouth of the canyon was so dense that we could not penetrate through it. I crawled for some distance on my hands and knees through this thicket until I

was compelled to return." (Quoted from Linn, '02.) Clayton ('21), in describing the pioneer trek down Emigration Canyon, said, "The grass on the creek grows from six to twelve feet high and appears very rank." (Doubtless *Elymus condensatus*.)² At their last encampment, a position six miles from the mouth of this canyon, he wrote, "The grass here appears even thicker on the ground than where we left this morning. The soil looks indeed rich, black and a little sandy. The grass is about four feet high and very thick on the ground and well mixed with rushes." At the present time the vegetation in Emigration Canyon has no such appearance, but, in general, these

² Authority for plant names is Tidestrom, Flora of Utah and Nevada, with the following exceptions: grasses, Hitchcock's Manual of the grasses of the United States; *Populus tremuloides* var. *aurea*, *Pseudotsuga taxifolia*, *Berberis repens*, and *Sisymbrium altissimum*, Kearney and Peebles, Flowering plants and ferns of Arizona.

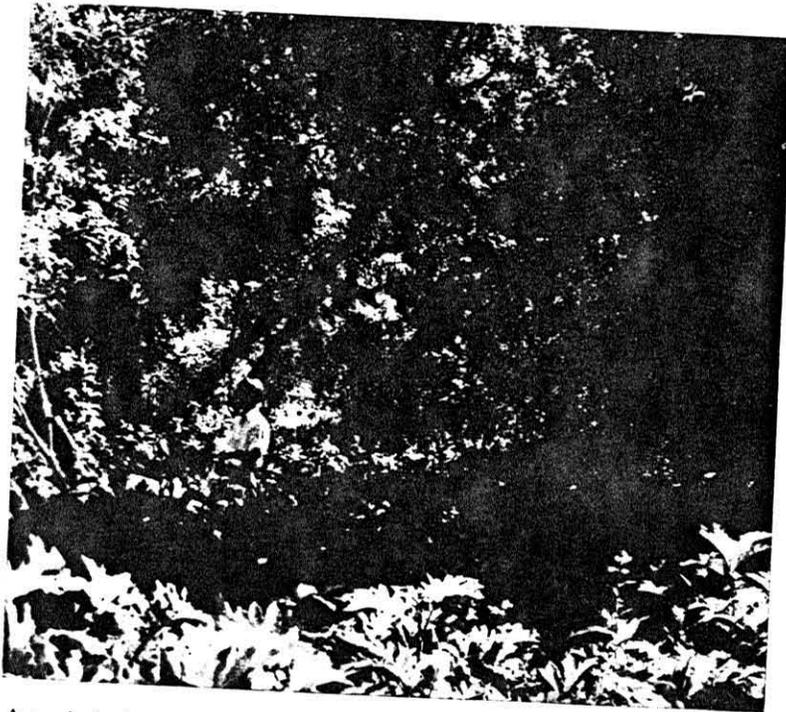


FIG. 1. A typical view midway up Red Butte Canyon showing the dense vegetation in the bottom of the canyon. Note the abundance of cow parsnip (*Heracleum lanatum*), a palatable weed rarely seen in Emigration Canyon.

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FIG. 2. Emigration Canyon contrasts unfavorably with corresponding areas in Red Butte Canyon. Note the hedged nature of the haw shrubs (*Crataegus rivularis*) and the low ruderal vegetation in the foreground.

descriptions apply to Red Butte Canyon as it appears today (figs. 1, 2).

Three more or less distinct belts of vegetation have been recognized on the Wasatch front. A grass-sagebrush climax extends from the valley floor to an average elevation of 5000 feet. Above this to about 7500 feet scrub oak (*Quercus gambeli*) dominates the landscape, while still higher there is a belt of aspen (*Populus tremuloides* var. *aurea*) and conifers consisting of white fir (*Abies concolor*), Douglas fir (*Pseudotsuga taxifolia*), and blue spruce (*Picea pungens*).

FIELD PROCEDURE

The length of Emigration Canyon to the main tributaries of its drainage was found by speedometer measurements to be approximately 12 miles. In order to sample adequately the vegetation in this canyon, four transects drawn at right angles to the direction of drainage and equidistant from one another were established. Transect I was located at the mouth of

the canyon, though its exact position was placed at random. From this point the center of each succeeding transect was established in the bottom of the canyon at exactly three-mile intervals by speedometer reading. Each transect consisted of 40 plots evenly spaced along a compass line and so distributed that 20 plots lay on each hillside. The first plot of each transect lay 100 feet from the stream bed, and the twentieth plot lay on or near the canyon ridge tops. Plots were separated by a distance of 200 feet, making the entire transect of 40 plots 8000 feet long. Each plot was circular in shape and 100 square feet in area.

Corresponding transects and plots were established for Red Butte Canyon, but since this canyon is not as long as Emigration Canyon, altitudes at the stream bed were recorded by means of an aneroid barometer for each transect in Emigration Canyon and the same altitude was used to locate the corresponding transect in Red Butte Canyon. Altitudinal positions for corresponding transects in each

canyon at the stream bed were as follows: I, 5000 feet; II, 5350 feet; III, 5600 feet; IV, 6800 feet. The point-observation-plot method of vegetational analysis devised by Stewart and Hutchings ('36) was adopted for this study.

The survey was made in the summer of 1935 (late June, July). Each summer since then the authors have made a cursory study of the two canyons. Conditions at present are essentially the same as those at the time of the original survey.

ANALYSIS OF VEGETATION

Data gathered in this study permit a comparative analysis of the vegetation in Red Butte and Emigration canyons with respect to the density of the plant cover as a whole and of the individual species, and grazing capacity.

Comparative densities: Graphic comparisons of plant densities of Red Butte and Emigration canyons are shown in figures 3 and 4. The density of the plant cover of Red Butte Canyon is approximately twice that of Emigration Canyon. The distribution of plant densities by transects in the two canyons (fig. 4) presents several interesting facts. (1) The canyons are nearly equal in the total amount of vegetation on transect I. (2)

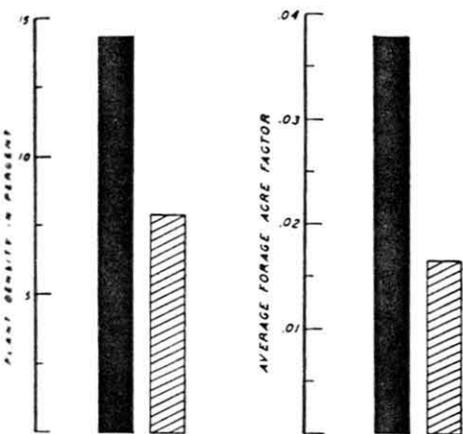


FIG. 3. Comparison of the density of plant cover and forage acre factor of Red Butte and Emigration canyons. Solid bars = Red Butte Canyon; cross-hatched bars = Emigration Canyon.

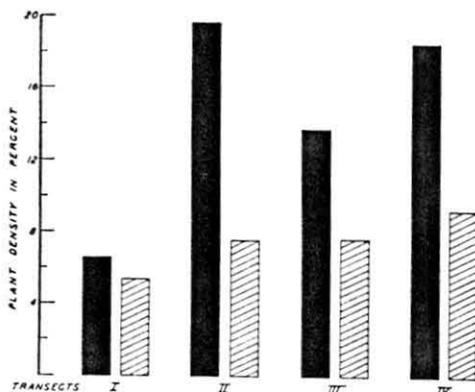


FIG. 4. Comparison of densities of all vegetation in each transect of Red Butte and Emigration canyons. Solid bars = Red Butte Canyon; cross-hatched bars = Emigration Canyon.

Except at the mouth, Red Butte Canyon shows plant densities far in excess of the corresponding areas in Emigration Canyon. (3) The vegetation midway up Red Butte Canyon (transect III) is less dense than on adjacent areas below and above (transect II and IV) in the same canyon. Field observations clearly reveal the reason for this in the prevalence of rock outcroppings and poor soil chiefly on the south slope of the canyon. (4) Except at the mouth, Emigration Canyon varies but slightly in the density of vegetation of all transects.

Vegetation types: Red Butte and Emigration canyons are both dominated by scrub oak (*Quercus gambeli*). Figure 5 gives a graphic comparison of the two canyons with respect to total amounts of weeds,³ shrubs, and grasses in each of the four transects. Some outstanding facts are illustrated by these graphs. (1) Shrub densities exceed the combined densities of weeds and grasses in all areas above the mouth in both canyons. (2) The mouth of Red Butte Canyon has a grass-weed aspect, while the mouth of Emigration Canyon is dominated by

³ The Forest Service classification of vegetation is used in this study. Weeds include all non-grassy herbaceous plants while the term "ruderal" is reserved for plants falling under the popular concept of "weed."



Red Butte Canyon. Ruderal vegetation in

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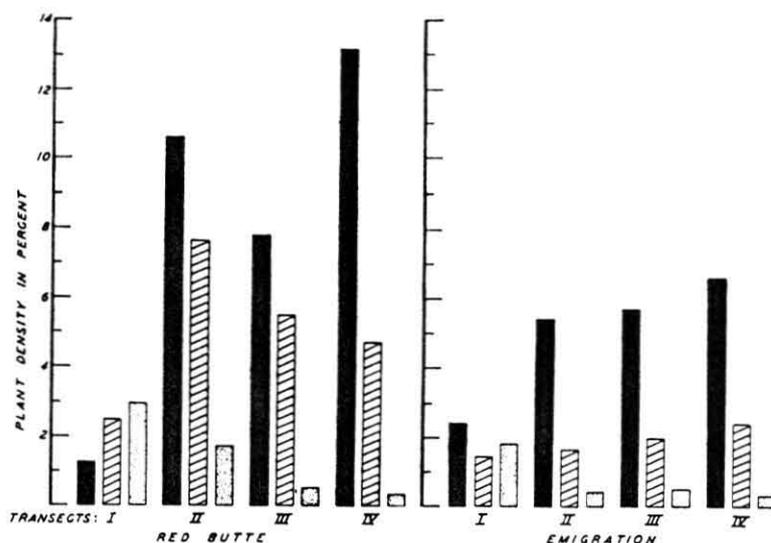


FIG. 5. Comparison of densities of shrubs, weeds, and grasses in each transect of Red Butte and Emigration canyons. Solid bars = shrubs; cross-hatched bars = weeds; stippled bars = grasses.

shrubs. The grassy slopes of Red Butte Canyon are burned by fire much more often than are the corresponding slopes of Emigration Canyon. (3) The proportions of shrubs, weeds, and grasses on the various transects of each canyon are, in general, similar. According to stratigraphic maps of the area, the portion of Red Butte Canyon in the vicinity of transect III possesses, in addition to limestone, some shale and sandstone, probably accounting in part for the fewer shrubs on that transect. Other differences in proportions of the three plant types (for example, on transect II of Emigration Canyon) may be accounted for chiefly by the influence of grazing, although the greater excess of shrubs (chiefly scrub oak) over weeds and grasses at the head of Red Butte Canyon is doubtless due to the fact that at this altitude climate and topography (steeper slopes) favor the maximum growth of shrubs.

GRAZING CAPACITIES

Differences of grazing use to which Red Butte and Emigration canyons have been subjected constitute a variable which should prove significant in a com-

parison of the vegetation of these two canyons. An analysis of the vegetation from the standpoint of livestock influences involved a re-examination of the vegetation in each canyon on the basis of the palatability for sheep and cattle. In this analysis the authors followed the Forest Service practice of determining the forage acre factor for the sections of each canyon through which the transects passed. The forage acre factor is a fractional unit of measurement from which actual stock-carrying capacity of a given range is estimated. The amount of forage on any given acre of range is dependent on two important measurable factors: first, the density of each forage species, and second, the utility (palatability)⁴ of each forage species to livestock.

Many laymen and even stockmen are prone to accept quantity of vegetation as the sole criterion of grazing capacity. The error in not considering quality of vegetation as well as quantity is illus-

⁴ Palatability tables used in this study were secured from the U. S. Forest Service. A palatability rating is given for each species of plant. Palatability is defined as the per cent of current growth of a given species of plant utilized by stock when the range is properly grazed.

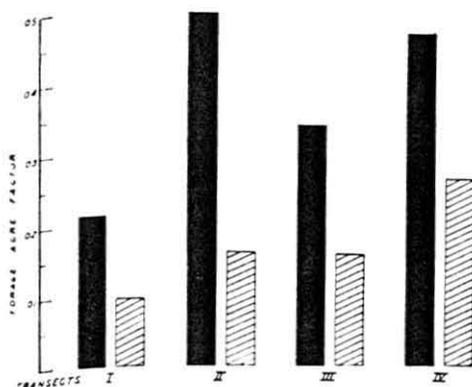


FIG. 6. Comparison of forage acre factors of each transect of Red Butte and Emigration canyons. Solid bars = Red Butte Canyon; cross-hatched bars = Emigration Canyon.

trated in figures 3, 4, and 6. The total density of vegetation of Emigration Canyon is 55 per cent of that of Red Butte Canyon, but the actual amount of forage is only 42 per cent as much (fig. 3). This fact stands out even more in comparing specific areas of the two canyons. The density of vegetation at the mouth of Emigration Canyon is 87 per cent of that at the mouth of Red Butte Canyon (fig. 4). Owing to the quality of the plant cover, however, the amount of forage at the mouth of Emigration Canyon is only 45 per cent of that at the mouth of Red Butte Canyon (fig. 6).

The difference between the forage acre factor and the density of plant cover in Red Butte and Emigration canyons is much greater at the mouths than elsewhere. This may be explained by the fact that at the mouth of Emigration Canyon there has been a greater change of vegetational types. It is here that the competition between grass and shrub types is in most delicate balance in the undisturbed range. These facts would seem to support the conclusion of Pickford (1932) and the unpublished observations of others that the foothill vegetation of the mountains on the eastern rim of the Great Basin at the time of the first white settlement was the grass type. Approximately one-third of the vegetation at the mouth of Emigration Canyon consists of such

plants as big sagebrush (*Artemisia tridentata*), rabbit brush (*Chrysothamnus speciosus*), and barberry (*Berberis repens*), all of low palatability to livestock. None of these plants was encountered in measurable quantities at the mouth of Red Butte Canyon.

DISCUSSION

In the absence of detailed historical data it was impossible to ascertain with accuracy the floristic changes which occurred in the vegetation of Emigration Canyon due to grazing and other factors. That the vegetation in Red Butte Canyon was rich both in quantity and quality of forage was evident to the writers at the outset of this study, and the foregoing analysis gives some numerical idea of the differences between the two canyons. The following more detailed consideration of the data on grasses, weeds, and shrubs points to the great probability that grazing is chiefly responsible for the impoverishment and the retrogressive succession of vegetation which has occurred in Emigration Canyon.

Grasses: The density of palatable grasses, including *Agropyron spicatum*, *A. pauciflorum*, *A. dasystachyum*, *Bromus brizaeformis*, *B. carinatus*, *Poa pratensis*, and *P. secunda*, is five times greater in Red Butte Canyon than in Emigration Canyon. The density of *Bromus tectorum*, an introduced species, is one and one-half times greater in Red Butte Canyon than in Emigration Canyon. This grass, though palatable for a short time early in the growing season, has a low palatability rating most of the summer. The successful invasion of this species in Red Butte Canyon (table I) is doubtless due to the frequent burning at its mouth. That *Bromus tectorum* is primarily a grass of the foothill environment of the intermountain west is generally observed and specifically shown for both Red Butte and Emigration canyons.

Grasses (except *B. tectorum*) are most abundant at lower elevations in Red Butte Canyon, but in Emigration Can-

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TABLE I. A comparison of densities in per cent of *Bromus tectorum* and combined native grasses in the various transects of Red Butte and Emigration canyons

Transects	Red Butte Canyon		Emigration Canyon	
	<i>Bromus tectorum</i>	Combined native grasses	<i>Bromus tectorum</i>	Combined native grasses
I	2.01	0.85	1.62	0.11
II	0.86	0.66	0.08	0.09
III	0.21	0.18	0.25	0.01
IV	0.06	0.08	0.11	0.14

yon the reverse is true (table I). Several factors are probably responsible. Red Butte Canyon with its more precipitous slopes and its less open upper drainage is more favorable to shrubs and less favorable to grasses. This phenomenon is common to narrow canyons of the Wasatch Mountains. The near absence of native grasses midway up Emigration Canyon (table I, transect III) is explained by the fact that the sheep trail passes over Little Mountain near this point, and, consequently, grazing is heaviest in this vicinity. Despite grazing, grasses are more dense in the upper areas of Emigration Canyon (table I, transect IV) than at the corresponding elevation of Red Butte Canyon. This observation gives credence to the probability that grass was abundant in Emigration Canyon in pioneer days.

Ten native grasses were found in Red Butte Canyon which were not observed in Emigration Canyon (table III). Conversely, all but one of the native grasses encountered in the plots of Emigration Canyon appeared in Red Butte Canyon. These facts would seem to emphasize the danger of complete extermination of rare and highly palatable species in overgrazed areas. A comparison of the palatability and density of three principal grasses (table II) leaves little doubt as to the damaging influence of severe grazing on palatable grasses.

Weeds: The influence of heavy grazing on the native herbaceous flora⁵ of Emi-

⁵ All species of weeds which averaged in density at least one-eighth of one per cent per plot and

gration Canyon is seen in the following significant data: (1) The density of weed vegetation with low palatability is twice as great in Emigration Canyon as in Red Butte Canyon. The density of more palatable species, on the other hand, is only one-fifth as great in Emigration Canyon as in Red Butte Canyon. (2) Herbaceous vegetation of low palatability is twice as dense as palatable weeds in Emigration Canyon; in Red Butte Canyon the density of palatable weeds is five times that of unpalatable weeds. (3) Highly palatable species of weed vegetation, probably once abundant in Emigration Canyon, are on the verge of extinction (table II).

TABLE II. Percentage palatability of important species with comparative densities in per cent in Red Butte and Emigration canyons

	Palatability	Density	
		Red Butte	Emigration
Grasses:			
<i>Agropyron spicatum</i>	80	0.23	0.03
<i>Bromus tectorum</i>	15	0.78	0.50
<i>Poa longiligula</i>	85	0.15	0.02
Weeds:			
<i>Achillea lanulosa</i>	40	0.12	0.04
<i>Balsamorhiza sagittata</i>	40	0.90	0.18
<i>Geranium fremontii</i>	45	0.22	0.04
<i>Lathyrus leucanthus</i>	20	0.25	0.14
<i>Leptotaenia multifida</i>	50	0.25	0.07
<i>Wyethia amplexicaulis</i>	15	1.11	0.28
Shrubs:			
<i>Amelanchier alnifolia</i>	75	0.39	0.19
<i>Artemisia tridentata</i>	0	0.04	0.53
<i>Berberis repens</i>	0	0.13	0.14
<i>Chrysothamnus speciosus</i>	0	trace	0.55
<i>Quercus gambeli</i>	20	4.51	2.56
<i>Rosa spp.</i>	50	0.64	0.16
<i>Symphoricarpos vaccinioides</i>	50	0.80	0.21

Mule's ear (*Wyethia amplexicaulis*), an herb of low palatability (15 per cent), is much more abundant in Red Butte Canyon than in Emigration Canyon (table II). A possible explanation is that stock in Emigration Canyon is forced to subsist on plants of low palatability and that sheep are fond of the seed heads and thereby interfere with the natural reproductive processes of the plant.

Shrubs: Scrub oak is by far the most common shrub in both canyons. Deciduous shrubs which were given palatability ratings by the U. S. Forest Service are included in the data.

yon is seen in the following data: (1) The density of weed with low palatability is twice in Emigration Canyon as in Red Butte Canyon. The density of more palatable weeds, on the other hand, is only one-half as great in Emigration Canyon as in Red Butte Canyon. (2) Herbaceous weeds of low palatability is twice as abundant in Emigration Canyon as in Red Butte Canyon; in Red Butte Canyon the density of palatable weeds is five times as great as in Emigration Canyon. (3) Highly palatable species of weed vegetation, which are abundant in Emigration Canyon, are on the verge of extinction in Red Butte Canyon.

Percentage palatability of important weeds and comparative densities in per cent in Red Butte and Emigration canyons

Species	Palatability	Density	
		Red Butte	Emigration
<i>Ambrosia</i>	80	0.23	0.03
<i>Chenopodium</i>	15	0.78	0.50
<i>Desmodium</i>	85	0.15	0.02
<i>Elymus</i>	40	0.12	0.04
<i>Eragrostis</i>	40	0.90	0.18
<i>Hordeum</i>	45	0.22	0.04
<i>Lactuca</i>	20	0.25	0.14
<i>Lepidium</i>	50	0.25	0.07
<i>Lythrum</i>	15	1.11	0.28
<i>Setaria</i>	75	0.39	0.19
<i>Sida</i>	0	0.04	0.53
<i>Sisymbrium</i>	0	0.13	0.14
<i>Stachys</i>	0	trace	0.55
<i>Thymus</i>	20	4.51	2.56
<i>Trifolium</i>	50	0.64	0.16
<i>Urtica</i>	50	0.80	0.21

Wyethia amplexicaulis, an abundant weed in Red Butte Canyon, has a palatability (15 per cent), is abundant in Red Butte Canyon. A possible explanation is that stock on Emigration Canyon is forced to subsist on weeds of low palatability and that the density of scrub oak in Emigration Canyon is by far the most abundant in both canyons. Density of weeds is given by the U.S. Department of Agriculture and are included in the data.

TABLE III. List of grasses occurring in plots of Red Butte and Emigration canyons. Presence of a species is indicated by a plus sign and absence by a zero sign

Species	Red Butte	Emigration	Species	Red Butte	Emigration
<i>Agropyron dasystachyum</i>	+	+	<i>Festuca kingii</i>	+	+
<i>Agropyron pauciflorum</i>	+	+	<i>Festuca subulata</i>	+	0
<i>Agropyron smithii molle</i>	+	0	<i>Glyceria elata</i>	+	0
<i>Agropyron spicatum</i>	+	+	<i>Glyceria striata</i>	+	0
<i>Agropyron subsecundum</i>	+	0	<i>Hordeum jubatum</i>	+	+
<i>Agrostis alba</i>	+	+	<i>Koeleria cristata</i>	+	0
<i>Agrostis exarata</i>	+	0	<i>Melica bulbosa</i>	+	+
<i>Agrostis idahoensis</i>	0	+	<i>Munroa squarrosa</i>	0	+
<i>Agrostis verticillata</i>	+	0	<i>Oryzopsis hymenoides</i>	+	0
<i>Aristida longiseta robusta</i>	+	0	<i>Phleum pratense</i>	+	+
<i>Bromus brizaeformis</i>	+	+	<i>Poa annua</i>	0	+
<i>Bromus carinatus</i>	+	+	<i>Poa compressa</i>	+	0
<i>Bromus tectorum</i>	+	+	<i>Poa longiligula</i>	+	+
<i>Calabrosa aquatica</i>	+	0	<i>Poa pratensis</i>	+	+
<i>Dactylis glomerata</i>	0	+	<i>Poa secunda</i>	+	+
<i>Deschampsia caespitosa</i>	+	+	<i>Setaria viridis</i>	0	+
<i>Elymus condensatus</i>	+	+	<i>Stipa columbiana</i>	+	+

* Introduced species

Despite the fact that this shrub has a palatability rating of only 20 per cent, the density of scrub oak in Emigration Canyon is but half of that in Red Butte Canyon. The density of other species of shrubs with high palatability is less than one-third as much in Emigration Canyon as in the other. Sagebrush and rabbitbrush with little forage value have a density 13 times greater in Emigration Canyon than in Red Butte Canyon.

Ruderals: The ruderal flora of Red Butte and Emigration canyons includes the following species: *Ambrosia psilostachya*, *Asclepias speciosa*, *Bromus tectorum*, *Caulanthus hastatus*, *Camelina microcarpa*, *Chenopodium album*, *Helianthus annuus*, *Lactuca scariola*, *Lepidium apetalum*, *Lepidium perfoliatum*, *Marrubium vulgare*, *Polygonum douglasii*, *Salsola pestifer*, *Sisymbrium altissimum*, *Sophia parviflora*, and *Zygadenus paniculatus*.

Most ruderals are practically valueless as forage and many are exotic annuals. They appear either as pioneers on denuded areas or as the last stage in retrogressive succession. In Red Butte Canyon, with the exception of *Bromus tectorum*, they are confined to the lower elevations of the canyon where fire or disturbed soil about Fort Douglas permit

their growth. In Emigration Canyon, however, a major highway, a long-used sheep trail, heavy grazing, and summer homes all contribute to conditions favorable to an abundant ruderal flora. The density of ruderals in Red Butte Canyon is 12 per cent less than in Emigration Canyon (fig. 7). Excepting *Bromus tectorum*, the density of ruderals in Emigration Canyon is seven times as great as in Red Butte Canyon. These ruderals are most abundant in burned areas on transect I, along the denuded sheep trail, and in fenced areas near summer homes where

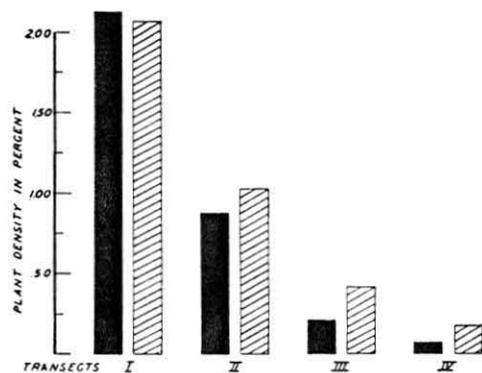


FIG. 7. Comparison of densities of ruderals in each transect of Red Butte and Emigration canyons. Solid bars = Red Butte Canyon; cross-hatched bars = Emigration Canyon.



on Canyon constitute

phy, slope exposure, and elevation, were compared in respect to quantity and quality of plant cover.

2. In their pristine condition, because of more favorable soil types, Emigration Canyon probably contained a vegetation equal to or surpassing that which now exists in Red Butte Canyon.

3. For a period of at least 40 years Red Butte Canyon has been protected against grazing. Emigration Canyon has been grazed heavily since settlement in 1847.

4. Palatable vegetation has probably decreased, and unpalatable vegetation has probably increased in Emigration Canyon. Only 42 per cent as much forage is produced here as in equal areas in Red Butte Canyon.

5. Ten native grasses found in Red Butte Canyon were not encountered in Emigration Canyon, suggesting the danger of complete extermination of highly palatable species through grazing abuse.

6. Evidence points to the probability of the complete substitution of the original grass type with unpalatable shrubs plus *Bromus tectorum* at the mouth of Emigration Canyon.

7. Some highly palatable shrubs in Emigration Canyon have a density less than one-third that in Red Butte Canyon. Other shrubs of low palatability in

Emigration Canyon have 13 times the density of the same shrubs in Red Butte Canyon.

8. The density of ruderals in Emigration Canyon is 12 per cent greater than in Red Butte Canyon. Excepting *Bromus tectorum*, the density of ruderals in Emigration Canyon is more than seven times greater than in Red Butte Canyon.

9. Sheet erosion is general throughout Emigration Canyon and advanced gully erosion is common along a sheep trail.

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poverishment of the plant
heet erosion is generally in
dvanced gully erosion is es-
eable on the slopes of Little
here the trail passes out of
Canyon. Here barren areas
e than ten acres in extent
ff which reaches flood pro-
en snows melt and heavy
A cloudburst in this vicinity
in a flood that would destroy
lt Lake City lying directly
That this menace is a very
evidenced by the fact that
has already occurred in Dry
ich lies about one and one-
to the north (Alter, '21).
rainage area is not nearly as
e in Emigration Canyon, and
cover is considerably more

SUMMARY

anyons, Red Butte and Emi-
ending parallel to each other,
d generally similar in geogra-