UNITED STATES DEPARTMENT OF AGRICULTURE
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ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

NOTES FROM

THE MANITOU EXPERIMENTAL FOREST [1]

See 1948 AR under Johnson

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The Rocky Mountain Forest and Range Experiment Station is maintained at Fort Collins, Colorado, in cooperation with Colorado A&M College. The research program of the Station is under the general direction of W. G. McGinnies, Director; D. F. Costello, in charge of Range Management Research; L. D. Love, in charge of Watershed Management Research; and B. R. Lexen, in charge of Forest Management Research.

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THE MANITOU EXPERIMENTAL FOREST

The Manitou Experimental Forest is a branch of the Rocky Mountain Forest and Range Experiment Station. It is in the Pike National Forest, 28 miles north and west of Colorado Springs.

This experimental area of 26 square miles was established in 1936 to study problems of watershed management, grazing, and other kinds of land use in the Front Range of the Colorado Rockies. Studies were started in 1936 to find out what factors of land use are most important in controlling stream-flow and soil erosion. Range management studies were begun in 1941 and range reseeding tests in 1945.

The Experimental Forest is typical of most of the Front Range and results obtained are directly applicable to similar areas in Colorado and neighboring states.

Annual precipitation is about 17 inches. Three-fourths of this comes as light storms during the summer months.

The soils are derived principally from granite, are low in fertility, and very susceptible to erosion. There are two distinct types of topography: broad gently rolling valleys and plateaus, and rugged mountains with narrow steep-walled canyons.

The native vegetation is typical of that found in Ponderosa pine forests of the southern Rocky Mountains. Ponderosa pine, Douglas fir, lodgepole pine, and aspen are the predominant tree species. The herbaceous vegetation consists mostly of bunchgrass--Arizona fescue and mountain muhly being the most abundant.

THE FRONT RANGE

The Front Range is a physiographic unit of the Southern Rocky Mountains ranging in elevation from 5,000 to over 14,000 feet. It borders the plains on the east and includes the hilly and mountainous area east of the Continental Divide in Colorado. Some of the mountains are high and rugged, while others are scarcely more than broad rolling hills. The eastern portion is made up of sedimentary rocks tilted by the Rocky Mountain uplift. The sedimentary rocks have been weathered away throughout the central and western part of the Front Range leaving metamorphic and igneous rocks exposed.

The climate is cool temperate with short warm summers and cold winters. Precipitation varies from about 15 inches at the lower elevations to 30 inches or more at the highest elevations. At the higher elevations snow accumulates during the winter and supplies water for streamflow far into the summer.

The lower foothills of the Front Range are grass covered, but above 7,000 feet the area is largely forested to timberline. However, there are many open grassy parks and valleys throughout the Front Range. Ponderosa pine, Douglas fir, and lodgepole pine are the principal coniferous trees and aspen is the most abundant broad leaf tree.

Water production, grazing, recreation, timber growing, and farming are the most important land uses.

Water is by all odds the most important item in the Front Range Watershed. All available water is being used at the present time and cities and irrigation districts are reaching across the Continental Divide to get more water for their needs.

The water yield varies from about one-fourth acre foot per acre of watershed up to 1-1/2 or 2 acre feet at the highest elevations. The average yield for the entire Front Range is about 1/2 acre foot for each acre of watershed. This water is valued at $2.00 to $3.00 an acre foot on the watershed, and it is estimated that each acre foot of water used in irrigation increases farm production about twenty dollars. The principal watershed problem is to develop a system of management that will provide a maximum of clear water with a minimum of sediment over the longest possible season.

In addition to irrigation uses, municipal demands for water are great. The entire water supply of Denver, Colorado Springs, Greeley, Boulder, Fort Collins, and other cities is obtained from mountain streams.

Grazing of range livestock is also an outstanding land use in the Front Range. More than 300,000 head of cattle are grazed here; some yearlong and some only for a few months. Not all of the area is suitable for grazing use but on those areas that are, forage in terms of beef produced has an estimated value of more than a dollar per acre per year.

Much of the area has a high recreational value, and this recreational use is worth many millions of dollars to the region. Timber production and farming, although of less importance than other uses, furnish a living for many local residents, and are important in the economy of the region.

The unwise use of land for one purpose may and often does seriously impair its value for other equally important uses. For example, in these easily eroded soils, too heavy grazing of the naturally thin vegetative cover increases surface runoff and erosion, causes clogged stream channels, silted-up reservoirs, and muddy unusable water. Similarly, unwise timber cutting often followed by fire, destroys valuable forage, injures the watershed, and appreciably lessens its value for recreational purposes. Unwise farming has also robbed soils of productivity and allowed soil erosion so that these lands are no longer suitable for farming. In addition they produce less forage and timber and have contributed silt to reservoirs, canals, and farm lands.

In our area, like the Front Range where the pressure for all kinds of land use is so great, it is obvious that the wise and efficient coordination of all uses is of utmost importance. Such coordination must be based on facts. The Manitou Experimental Forest was established to help obtain these facts.

SUMMARY OF RESEARCH RESULTS

Grazing Studies

Over a period of 6 years yearling Hereford heifers have been grazed for a 5-month season, June 1 to October 21, on 6 pastures of approximately 300 acres each. Three rates of stocking representing heavy, moderate, and light use of the vegetation have been studied. Local ranchers are cooperating by furnishing cattle. Here are some of the results.

The amount of herbage grazed is the key to efficient range use.

If more than 40 percent of the annual growth of vegetation is removed by grazing, the vigor of the plants is seriously reduced. Subsequently, the plants produce less and less foliage and the weight gains of livestock also decline. In the experimental pastures the average rate of herbage utilization beginning in 1942 is shown below.

Percent of Herbage Grazed

Stocking Rate	YEAR					
	1942	1943	1944	1945	1946	1947
Heavy	34	49	65	63	65	68
Moderate	23	37	35	38	35	33
Light	14	15	10	17	13	13

At the heavy rate of stocking there is less and less herbage produced from year to year and that remaining has to be grazed more closely to support the animals.

Heavy grazing use retards height growth of forage plants

On the heavily stocked pastures the principal forage species not only begin growth later, but grow more slowly than on lightly stocked pastures. We measure the height at the beginning of the season when the cattle are turned into the pastures. As the following table shows the height of Arizona fescue and mountain muhly, the two most important forage plants, on the heavily stocked pastures averaged less than half the height of the same grasses on the lightly and moderately stocked pastures.

Stocking Rate	Arizona Fescue		Mountain Muhly	
	Height growth in inches at start of growing season			
	1947	1948	1947	1948
Heavy	6.8	3.9	1.9	1.8
Moderate	10.6	10.3	4.2	4.8
Light	11.6	12.7	4.5	4.9

Herbage production is greatly reduced by too heavy grazing

Herbage production on the heavily stocked pastures has decreased from 350 pounds per acre in 1942 to 195 pounds in 1947, a decrease of 47 percent. On the moderately and lightly stocked pastures herbage production during 1947 was slightly less than 1942, but this decrease was caused by weather conditions and not by grazing use of the forage.

Stocking Rate	1942	1947
	Pounds of herbage produced per acre	
Heavy	350	195
Moderate	363	334
Light	318	303

Yearling heifers require 10 to 12 pounds (air-dry weight) of forage per day. On these heavily stocked pastures an average of only 15 pounds of usable herbage (air-dry weight) was available. As a result, the plants were grazed so heavily that they were no longer able to grow vigorously. In the moderately stocked pastures there was 30 pounds of herbage available per day and in the lightly stocked pastures 44 pounds. The removal of 10 to 12 pounds of forage in these pastures left ample margin for vigorous vegetative growth and for soil protection.

Cattle on heavily stocked pastures make poor gains

During the 5-month grazing season the average gain of cattle on the heavily stocked pastures has been 40 to 55 pounds less than similar cattle on more lightly stocked areas.

Stocking Rate	SEASON 1942	1943	1944	1945	1946	1947	Average
	Weight gain in pounds per animal						
Heavy	185	153	223	181	110	182	181
Moderate	215	206	253	239	200	220	222
Light	230	236	255	230	218	243	235

The greatest gains are made during June and July when the forage is growing most rapidly. During September and October, cattle make very small gains and if snowstorms occur, losses in weight amounting to 20 pounds per head may be expected.

Too heavy stocking is poor livestock economy

From 1942 to 1947 the estimated average return from a section (640 acres) of bunchgrass range properly stocked amounted to $735.42 per year. In comparison, a similar area too heavily stocked returned only $484.48. Factors responsible for the increased income under moderate rates of stocking are greater livestock gains, smaller initial investments, and higher market values. Cattle from moderately stocked pastures sell for $1.00 to $2.00 more per hundred pounds than animals from heavily stocked pasture. Details of the economic returns from different degrees of grazing are shown in the following table.

Comparison of average returns per section from different stocking rates, ponderosa pine-bunchgrass range, 1942-1947

Item	Heavy stocking	Moderate stocking	Light stocking
Number of animals per section	54	39	26
Average initial weight (pounds)	375	375	375
Average final weight (pounds)	555	597	609
Average gain, 5 mo. season (pounds)	180	222	234
Total gain per section (pounds)	9,720	8,658	6,084
Average initial value per head at $11.43 per cwt.	$ 42.86	$ 42.86	$ 42.86
Total initial value, all animals	2,314.44	1,671.54	1,114.36
Average final value per cwt.	10.00	11.00	11.00
Average final value per head	55.50	65.67	70.04
Total final value all animals	$3,007.00	$2,561.13	$1,821.04
Gross return per section	$ 692.56	$ 889.59	$ 706.68
Costs: Death loss 1% final value	$ 30.07	$ 25.61	$ 18.21
Interest on investment, 5% - 6 months	57.86	41.79	27.86
Salt & miscellaneous at 50 cents per head	27.00	19.50	13.00
Grazing fees, N.F. Range	93.15	67.27	44.85
Total	$ 208.08	$ 154.17	$ 103.92
Net return per section	$ 484.48	$ 735.42	$ 602.76
Ratio:	66%	100%	82%

Range Reseeding

The revegetation of abandoned farm lands and depleted ranges is one of the most important problems in the Front Range. Thousands of acres are idle because past farming has lowered the fertility and allowed the topsoil to erode so that these lands are no longer productive as farm lands. They are now producing weeds and grasses of low forage value. Through reseeding, however, they can be made to produce good forage. Depleted range lands can likewise be improved by seeding to grass. Successful seeding of these lands accomplishes two purposes: (1) stabilizes the soil, and (2) increases forage production.

Nursery trials show 60 species will grow under Front Range conditions.

More than 80 different kinds of range plants have been tested under nursery conditions. Sixty of these have shown climatic adaptation and have produced good to excellent stands of forage in the nursery where they do not compete with weeds.

Seven grasses have proved successful under range conditions

Plants that grow well in the nursery are tested under actual field conditions to find those which are not only adapted to the climate but which can compete with native plants. Results of these field tests show that the following seven grasses are well suited for seeding abandoned farms and depleted ranges of the Front Range: crested wheatgrass, intermediate wheatgrass, slender wheatgrass, russian wildrye, smooth brome, meadow brome, and meadow fescue.

High forage yields are obtained from reseeded fields

The most productive lands in the valleys of the Front Range were farmed at one time or another. When these lands were abandoned, low value weeds and grasses came in and even after many years these lands have little value for grazing. However, if they can be seeded to good grasses and legumes they not only produce 10 to 20 times more forage than they are now producing, but usually outyield good native ranges under similar conditions. For example, sixty acres of abandoned farm land were reseeded in the fall of 1945 and the spring of 1946, to crested wheatgrass, smooth brome, and to a mixture of these two grasses and yellow sweet clover. Forage yields during the second growing season are shown below.

Location	Mixture	Smooth Brome	Crested Wheatgrass	Native Bunchgrass
		Pounds per acre		
Sinclair field	2,891	1,489	2,497	--
Nursery field	3,313	1,090	1,181	--
Average	3,102	1,290	1,839	523

Cattle gains exceed 2 pounds per day on reseeded fields

An average gain of 55 pounds per head was recorded for yearling heifers during a 25 day grazing season in May of this year. These gains were obtained from a study to determine the best method of managing reseeded stands of crested wgeatgrass, smooth brome, and a mixture of these grasses with sweet clover.

Watershed Management Studies

Heavy grazing reduces absorption of water by soil

One of the most important effects of grazing is the change in the water-absorbing capacity of the soil. This has been tested by applying artificial rainfall to small plots scattered throughout the six experimental pastures. Estimates of absorption rates were obtained for light, moderate, and heavy grazing which were, in turn, checked against similar measurements in areas entirely free from grazing since 1941. Grazing has caused an average decrease in rates of water absorption and the deficiencies are in proportion to the intensity of grazung use.

Intensity of grazing use	Deficiency in absorption rates 1/ Inches of "rainfall" per hour
Light	0.76
Moderate	1.17
Heavy	1.70

1/ Average differences between ungrazed check plots and grazed plots.

The above figures indicate that increased grazing pressure has progressively reduced the chance for rainfall to enter the soil. Under the best of conditions found at Manitou Experimental Forest, the rate of absorption is about

3 inches of rainfall per hour. Heavy grazing has reduced this by more than half. Many of our summer showers equal or exceed a rate of 3 inches per hour for short intervals, and more than half of the water from these storms must therefore run off the surface of heavily grazed areas. Water lost in this fasion is not utilized efficiently, either in forage production on areas from which it flows, or in downstream irrigation projects.

Heavy grazing causes excessive runoff and erosion

Decreased absorption of rainfall is always accompanied by increased runoff and often by damaging erosion. How this is affected by grazing use has been studi on 6 permanent plots, each 1/100 acre in size. Two of these have been grazed heavily, two moderately, and two left ungrazed. Runoff and erosion results from natural precipitation and is measured for individual plots after each storm. The following tabulation shows the total runoff in inches of equivalent precipitation and erosion in pound per acre for the last 5 years of grazing treatment.

Treatment	Surface Runoff		Soil Loss	
	Inches	Ratio	Lbs/acre	Ratio
No grazing	4.6	1.0	734	1.0
Moderate	6.9	1.5	777	1.1
Heavy grazing	6.9	1.5	1,374	1.9

Moderate grazing does not increase erosion

A definite increase in runoff has resulted from grazing indicating a reduction in the rate at which water enters the soil. Both moderate and heavy grazing cause about 50 percent more water to flow off the plot surface. Soil loss, however, is not substantially increased until grazing has reached the stage of heavy use. Apparently, somewhere beyond moderate intensity of grazing a critical point is reached where the forces of land deterioration begin to take effect. Our observations indicate that this stage is characterized by two conditions associated with overgrazing; (1) mechanical compaction from excessive trampling, and (2) a reduction in amount of organic matter normally provided by grass litter.

Organic material keeps soil porous

All soils are porous to some degree. If this were not true we wouldn't have springs and permanently flowing streams. The addition of grass litter each year helps maintain this porosity. Continual heavy removal of grass by grazing reduces this normal return of organic matter to a danger point.

Another example of the importance of organic material has been shown in a series of tree-covered plots. In 1941, we removed all the needles and other litter which had accumulated for several years. The immediate result was excessive erosion. In two months, soil had been eroded off the plots at the rate of 4 tons per acre which exceeded normal amounts by 70 times.

Experimental watersheds supplement plot studies

In addition to the studies just described, a series of experimental watershed have been established to study the influence of soil and vegetative changes on runoff and erosion. These are natural drainage units in which precipitation streamflow groundwater movement, and erosion are all carefully measure The effects of vegetative changes such as those due to tree cutting and grazi can thus be evaluated in terms of the effect upon water movement and soil los for the entire watershed.

At the present time there are a total of ten such watersheds in the Manitou Experimental Forest. They vary in size from 1 acre to 4,700 acres. Six are now ready for treatment to bring about vegetative changes after having gone through a period in which the influence of present cover conditions has thoroughly measured.