STUDIES IN RANCH ECONOMICS [1]

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Studies in ranch economics and related problems comprise a relatively new and fertile field for agricultural research workers. Not only is this an inviting field for the research economist, but also for the animal husbandman, the botanist, the pathologist, the experimental breeder, the chemist, and the nutrition specialist. In fact it is the combined and correlated efforts of the several types of specialists that is necessary to render the industry the maximum of research service.

Such work was initiated in Texas about 1915 when the governing board established a Ranch Experiment Station in a typical ranching area on the Edwards Plateau. The problem was (1) to focus the activities of the different research specialists—the chemist, the botanist, the entomologist, and the animal husbandman—on the varying problems of the range livestock industry; (2) to coordinate the research activities of these physical and biological research workers with those of the research agricultural economist; (3) to find the most important of the ranch problems; (4) to develop research methods especially suited to the different studies to be made; and (5) to make headway with appropriate projects.

Some of the major objectives of ranch economics research, considered from the point of view of the industry as well as that of the investigator, are:

(1) To study with a view of improvement and better utilization of the carrying capacity of our ranges;
(2) To improve the quantity and also the quality of our ranch products;
(3) To effect a consistent way to lower production and marketing costs;

[1] This paper was read at the Sixteenth Annual Meeting of the American Farm Economic Association, held in New York, December 28, 1925.

(4) To eliminate wastes and losses such as occur from inefficient organization of the ranch, from diseases, from parasites, accidents, poor equipment, poor management, and so forth.
(5) To perfect systems of herd, and, in fact, general ranch management;
(6) To perfect ranch financial practices;
(7) To perfect an efficient and practical marketing system.

The writer will content himself with a discussion of carrying capacity, which he considers to be the heart and soul of ranch economic studies, and will present a method for its more scientific calculation.

To begin with, it is necessary to discuss some definitions. The term "carrying capacity" is employed with different meanings in different parts of the country. On the steer ranches in Southwest Texas it means the number of steers per section of land. In other places it may mean the number of acres grazed per animal per annum. In the Northwest it may mean the number of livestock that may be grazed on a given area during the winter or summer grazing season. In the case of tenants, carrying capacity may mean the number and kinds of livestock that a given ranch will carry during the period of the lease. We in Texas usually think in terms of annual carrying capacity. On a good year it may be 75 heads of cattle per section, an average year 40, and on a poor year only 20, with corresponding variations in the number of sheep, goats, horses, and mules which may be carried on the same range.

Among cattlemen, the cow is ordinarily the unit of measurement of carrying capacity. Bulls and other classes of cattle one year old and over are considered, head for head, as consuming the same amount of vegetation as a cow. As a rule calves are not counted. In the old-time cow business on the free open ranges, this was a practical way of dealing with carrying capacity, but it is not sufficiently accurate for scientific purposes or for the highly intensified ranching methods of the present time. The ranchmen's method is especially inadequate for use in a section practic-

ing diversified grazing, including cattle, sheep, and goats, such as the Edwards Plateau.

For some years past, therefore, it has been the aim of the present writer to develop if possible a more scientific method of computing carrying capacity so that one range or section of the country might be fairly compared with another. Fortunately we have in physics and animal nutrition a very accurate scientific basis for defiining carrying capacity and determining a unit for its measurement. It is said that the ruminants, such as cattle, sheep, and goats, digest range forage with approximately equal efficiency and that age makes no appreciable difference. In order, therefore, to determine the feed requirements of the different classes of range animals, it is necessary to know the initial weights of the different types and classes of animals studied and their increases in weights during the grazing period.

It must be recognized, however, that the different types of range animals vary in size and that they differ in range and grazing habits so that one may utilize carrying capacity to a greater advantage than another. In making our study of Sutton County, Cox and I selected the range mother cow, whose weight at the beginning of the year was 675 pounds, whose average weight was 712½ pounds, and whose weight at the end of the year was 750 pounds, as the unit of measurement of carrying capacity.

Our definition, therefore, of the carrying capacity unit is, *"the amount of forage or dry matter required to maintain a mother cow averaging 712½ pounds on the range for one year."* Normal carrying capacity may be defined as, *"the number of available carrying capacity units produced one year with another over a period of years covering at least one weather cycle."* By this is meant, *"the power of the range to provide maintenance and gains in weight to certain numbers and proportions of livestock, year in and year out, with benefit rather than injury to the desirable vegetation."* The actual carrying capacity produced in any particular year may be estimated by keeping records as to the numbers, weights, types, and classes of animals which may be run on a definite area.

NUTRITION REQUIREMENTS OF DIFFERENT TYPES AND CLASSES OF LIVESTOCK (1)

1	2	3	4	5	6	7	8
Type of Animal	Class	Average of estimated wts. at end of period (Pounds)	Estimated increase in wt. during period (Pounds)	Age at time of sale (Mo.)	Period of growth and maintenance	Pounds of dry matter required (Fraps' estimates)*	Per cent of carrying capacity required considering the mother cow as Unity (Fraps' ratio)
Cattle	Bulls	1,200	0	72-120	1 year	6,965	1.25
	Mother cows	750	75	36-144	1 year	5,591	1.00
	Dry cows	750	0	72-144	1 year	5,162	.92
	Calves	350	225	9	9 mos.	3,260	.58
	Yearling heifers	550	200	12-24	1 year	4,854	.87
	Two-year-old heifers	700	150	33	1 year	5,800	1.04
	One-year-old steers	600	250	21	1 year	5,371	.96
	Two-year-old steers	750	150	33	1 year	5,934	1.06
	Three-year-old steers	850	100	46	1 year	6,360	1.14
Sheep	Rams	125	0	36-72	1 year	949	.17
	Ewes	95	10	24-72	1 year	849	.15
	Lambs	55	47	7	7 mos.	420	.08
	Yearling Ewes	90	45	14	7 mos.	620	.11
	Yearling Muttons	90	45	14	7 mos.	877	.11
	Muttons	100	10	26	1 year	877	.16
Goats	Bucks	100	0	36-84	1 year	823	.15
	Does	80	8	36-84	1 year	747	.13
	Kids	40	34	7	7 mos.	294	.05
	Yearling Does	80	40	14	7 mos.	571	.10
	Mutton Wethers	85	45	14	7 mos.	654	.12**

*Ratios computed by Dr. G. S. Fraps, Chief, Division of Chemistry; State Chemist; Texas Agricultural Experiment Station, Agricultural and Mechanical College of Texas, College Station, Texas.

**Sheep and goats may be converted into cattle equivalents by multiplying the number in each class by the corresponding ratio. For example: 100 ewes × .15 = 15 cattle equivalents; which is to say that 100 ewes consume as much range forage as 15 mother cows, and so forth.

(1) "An Economic Study of a Typical Ranching Area on the Edwards Plateau of Texas," Texas Station Bulletin No. 297, page 166.

Using a mother cow averaging 712½ pounds in weight as unity, Doctor Fraps computed the ratios for the different classes of cattle, sheep, and goats shown in the last or 8th column of the table on page 301:

Details as to the Method

The method of calculating carrying capacity is based upon the chemical and physiological principles of animal nutrition. Maintenance and gain requirements are based on Tables I, II, and IV, "The Nutrition of Farm Animals," by Armsby, pp. 711-714. The tables appear at the close of this discussion.

This method was used by Cox and the writer in our studies in Sutton County in 1920-1922 and has since been used by Gabbard and the writer in connection with a class of senior students in Ranch Economics. In this calculation, range forage is assigned a value of 35 therms for each 100 pounds of dry matter consumed, or 1 therm equals 2.86 pounds of dry matter, referred to herein as the *dry matter equivalent.*[2]

The unit of measurement employed is 5,591 pounds of dry matter, the amount necessary to maintain a mother cow for one year, weighing 675 pounds at the beginning of the year, 750 pounds at the end of the year, averaging 712.5 pounds, and providing for a gain of 75 pounds during the year. This was arrived at from estimates made by 97 ranchmen on the weight of their mother cows. For any particular ranch it would be better to use the actual weight of the mother cows carried as the carrying capacity unit for that ranch. For example, our mother cows on the Ranch Experiment Station for the year 1924 showed an average weight of 910 pounds. In case the ranch were to be stocked on the basis of the standard unit of a 712.5 pound cow instead of a 910 pound cow it would more than likely be overstocked at the beginning.

In order to calculate the carrying capacity units used the following data must be available:

[2] Estimates of Dr. G. S. Fraps, Chief, Division of Chemistry; State Chemist; Texas Agricultural Experiment Station.

a. The type and class of animal grazed.
b. The number of animals grazed.
c. The total number of days grazed.
d. Weight at beginning of period and end of period from which the average weight maintained, as well as the gains made, may be ascertained.
e Therms required for maintenance for one day and per pound. This is indicated for cattle and horses at weight intervals of 50 pounds, ranging from 150-1,500 pounds in Table I-a, and for sheep and goats in Table II, with weight intervals of 20 pounds, ranging from 20 to 200 pounds.
f. Therms required for making one pound of gain. This is derived from Table IV.

With the above information given, the following formulas may be applied:

1. Maintenance:

$$\frac{(\text{No. animals}) \times (\text{Av. wt.}) \times (\text{therms required for one day per lb.}) \times (\text{total days grazed}) \times (\text{dry matter equivalent})}{5{,}591}$$

= carrying capacity units used for maintenance.

2. Gain:

$$\frac{(\text{therms required for gains per lb.}) \times (\text{pounds gained}) \times (\text{dry matter equivalent})}{5{,}591} = \text{carrying capacity units for gain}$$

The total carrying capacity units used is the sum of maintenance and gain requirements. To illustrate, let us take 9 dry cows grazing for a period of 76 days, having an average weight of 970.56 pounds, and making a total gain of 960 pounds. Substituting in the formulas we have for maintenance:

$$\frac{9\times970.56\times.0061\times76\times2.86}{5{,}591}=2.0715$$

for gain:

$$\frac{3.25\times960\times2.86}{5{,}591}=1.5960$$

Total units consumed $2.0715+1.5960=3.6675$

To further illustrate let us take a problem in which sheep are involved. Seven muttons are grazed for a period of 30 days. The average weight for this period is 105.43 pounds and the gain made is 18 pounds. How many carrying capacity units are consumed? Again we will substitute in the formula for maintenance, and we have:

$$\frac{7\times105.43\times.0079\times30\times2.86}{5{,}591}=.0895$$

Substituting for gain, and we have:

$$\frac{3.25\times18\times2.86}{5{,}591}=.0299$$

Total: $.0895+.0299=.1194$, the number of units consumed by the muttons in the above problem.

At this point it might be well to go back to the first illustration and explain how .0061, the therms required for maintaining one pound for one day of cows weighing an average of 970, was obtained. Turning to Table I-a we find that 950 is the nearest given weight to our average and that the therms required for maintaining one pound for one day of an animal weighing 950 pounds is .0061—hence its appearance in the calculation. A further explanation should be given in connection with the calculation of units required for gains. Some one asks, "How did you obtain 3.25, the therms required for gains per pound?" If we turn to Table IV-a, we find that mature animals, 24-30 months old, require 3.25 therms for each pound of gain made.

As a last word I wish to say that too much emphasis cannot be placed on the importance of having animals weighed

TABLE I*

MAINTENANCE REQUIREMENTS OF CATTLE AND HORSES, PER DAY AND HEAD

Live Weight Pounds	Cattle: Digestible Protein Pounds	Cattle: Net Energy Therms	Cattle: Net Energy Per Lb.	Horses: Digestible Protein Pounds	Horses: Net Energy Therms	Horses: Net Energy Per Lb.
150	0.08	1.69	.0113	0.08	1.16	.0077
250	0.13	2.38	.0095	0.13	1.63	.0065
500	0.25	3.78	.0075	0.25	2.58	.0052
750	0.38	4.95	.0066	0.38	3.39	.0045
1,000	0.50	6.00	.0060	0.50	4.10	.0041
1,250	0.63	6.96	.0055	0.63	4.76	.0038
1,500	0.75	7.86	.0052	0.75	5.37	.0035

*The Nutrition of Farm Animals, 1917, p. 711, Armsby, H. P., The MacMillan Co., New York.

TABLE I a

MAINTENANCE REQUIREMENTS OF CATTLE AND HORSES PER DAY AND POUND—INTERPOLATED GRAPHICALLY†

150 = .0113	600 = .0071	1,100 = .0058
200 = .0103	650 = .0069	1,150 = .0057
250 = .0095	700 = .0067	1,200 = .0055
300 = .0089	750 = .0066	1,250 = .0055
350 = .0085	800 = .0064	1,300 = .0054
400 = .0081	850 = .0063	1,350 = .0054
450 = .0078	900 = .0062	1,400 = .0053
500 = .0075	950 = .0061	1,450 = .0053
550 = .0073	1,000 = .0060	1,500 = .0052
	1,050 = .0059	

†Interpolations by Gabbard.

TABLE II*

MAINTENANCE REQUIREMENTS OF SHEEP, PER DAY AND HEAD

Live Weight Pounds	SHEEP (and GOATS†): Digestible Protein Pounds	Net Energy Therms	Net Energy Per Pound
20	0.011	0.27	.0135
40	0.022	0.43	.0107
60	0.033	0.56	.0093
80	0.044	0.68	.0085
100	0.055	0.79	.0079
120	0.066	0.89	.0074
140	0.077	0.99	.0071
160	0.088	1.09	.0068
180	0.099	1.17	.0065
200	0.110	1.25	.0063

*The Nutrition of Farm Animals 1917, p. 711, Armsby, H. P., The MacMillan Co., New York.

†Not in Armsby's tables but written in here because we are using this table for both sheep and goats.

under similar conditions each time. If it is more convenient to weigh after animals have had water, particular care should be taken to see that all animals have access to water before being weighed. It is easy to see how animals weighed into a pasture without water and weighed out of it with water might show good gains when no gains were made. In addition to observing uniform conditions for weighing, ample notes should be kept on both the behavior of the animals and the vegetation being grazed.

Obviously the range cow on the Edwards Plateau is not up to the standard in size for the whole Western country. We need, therefore, some compromise in the weight of the standard mother cow which could be used as the carrying capacity unit of measurement throughout the West. In the Northern Great Plains we found many cows weighing more than a thousand pounds and it seems that the size of cows gradually declines as one goes from Montana to the Gulf of Mexico. It might be desirable, for example, to have a cow whose average weight is 900 pounds as unity. It is, however, rather important that the unit adopted be model for the weights of range cows. If we had such a unit universally agreed upon, then it would be a very easy matter to conduct studies which would enable us to compare the carrying capacity of one section with another. I would like to know, for example, how the carrying capacity around Miles City, Montana, compares with that around Houston, Texas. I understand that it takes 25 or 30 acres to a cow around Miles City and that only 5 acres are required for a cow around Houston, yet I personally know that there is a big difference in cows, weighing more than a thousand pounds at Miles City, and scrubs around Houston, weighing 500 to 600 pounds. In the absence of a unit of measurement for both sections, however, we cannot compare the ranges around Houston with those around Miles City.

Of course it is just as easy to use one weight for unity as another. *What we ought to do is to find out how many therms we shall consider as unity, convert these into dry matter, and determine the ratios for the different types and classes of*

TABLE IV*

REQUIREMENTS FOR GROWTH WITH NO CONSIDERABLE FATTENING

a. PER POUND OF INCREASE IN LIVE WEIGHT, IN ADDITION TO THE MAINTENANCE REQUIREMENT

Age	CATTLE (AND SHEEP)	
	Minimum of Digestible Protein†	Net Energy
Months	Pounds	Therms
0-1	0.23	1.170
1-2	0.22	1.272
2-3	0.22	1.374
3-6	0.21	1.680
6-9	0.21	1.986
9-12	0.20	2.292
12-18	0.18	2.904
18-24	0.16	3.000
24-30	0.14	3.250

b. PER DAY AND HEAD, INCLUDING MAINTENANCE

(1) Cattle

Age	BEEF BREEDS		
	Live Weight	Digestible Protein‡	Net Energy
Months	Pounds	Pounds	Therms
1	125	0.70	3.7
2	175	0.85	4.2
3	200	0.90	4.2
6	350	1.15	5.0
9	450	1.25	5.7
12	550	1.40	6.5
18	750	1.40	8.2
24	900	1.30	9.3
30	1,000	1.30	9.9

(2) Sheep (and Goats)

	WOOL BREEDS		
Age Months	Live Pounds	Digestible Protein‡ Pounds	Net Energy Therms
3	37	0.13	0.78
6	65	0.18	0.95
9	82	0.17	1.06
12	90	0.15	1.12
18	100	0.12	1.19

**The Nutrition of Farm Animals*, 1917, p. 712, Armsby, H. P., The Macmillan Co., New York.
†Estimated protein content of increase.
‡Based on Kellner's Standards.

livestock on such ranges. Such studies of the ranges would prove valuable to the country in that we would have more information as to the actual carrying capacity of the ranges of our different sections and we could use this not only as a basis for properly stocking the ranges at all times, but also for securing legitimate credits for the purchase, stocking, and operation of ranch units.

In stocking a ranch of known carrying capacity, ratios are about all that is needed in order to properly proportion the different types and classes on the ranges. But if one wishes to study the productivity of the ranges and the influence of different methods of management upon carrying capacity, then *actual carrying capacity should be determined by actually weighing the different types and classes of cattle in and out of pastures.* At first our method seemed rather complicated, but now that we have become accustomed to it it seems to us very simple and we use it with ease.

Carrying Capacity of Ranch Experiment Station Pastures in 1924

Our first attempt at using this method of measuring carrying capacity was in connection with our economic study of ranching in the Edwards Plateau in 1920-1921. Our next use of it was in connection with a project to determine the annual and normal carrying capacity of the pastures on the Ranch Experiment Station in Sutton County, Texas. The first records were taken in 1923, but owing to the failure of some of the men on the Station to understand the method thoroughly, we threw out the data for that year and used it only as a guide to better work in 1924.

The pastures were designated as B, C, D, E, G, and I, and cattle, sheep, goats, mules, and horses were weighed in and out of pastures at the beginning and end of the grazing periods, the exact time of weighing depending upon the conditions of the pasture and the necessity for moving the livestock. In 1920 our estimate of the normal carrying capacity of the ranges, of which our Ranch Experiment Station

was a part, was 70 carrying capacity units per section and we attempted to stock accordingly, but under our grazing study our effort was to make the best utilization of the range, "with benefit rather than injury to the desirable vegetation." The following table shows what the actual carrying capacity of the Ranch Experiment Station was during the year 1924:

CARRYING CAPACITY UNITS USED BY ALL RANGE LIVESTOCK ON 4.92 SECTIONS OF THE RANCH EXPERIMENT STATION BY PASTURES, 1924

Pasture	Area in Acres	Sections	Total carrying capacity furnished by pasture	Rate of carrying capacity per section by pastures
Total	3,151.8	4.92	507.19	Av. 103.9
B	378.68	.59	60.68	102.84
C	884.00	1.38	146.18	105.92
D	583.86	.91	85.60	94.06
E	686.87	1.09	103.94	95.35
G	114.00	.18	13.35	74.16
I	494.39	.77	97.44	126.54
Average number of carrying capacity units per section of 640 acres------				103.09

We do not attach a great deal of importance, however, to the increase in carrying capacity indicated in the figures given between the years 1920 and 1924. Undoubtedly there was considerable improvement in the ranges due to superior management, but during the year 1924 the rainfall was unusually favorable to the production of range forage. Instead of using these figures to show any particular result, therefore, we are merely using them to show the use to which we are putting our method of computing carrying capacity. The work will, of course, be continued through a period of years and in due time published by the Texas Station.

It seems desirable to initiate ranch economic studies with carefully designed and competently conducted surveys which give the investigator an introduction or "a speaking acquaintance" with the industry and its problems. Undoubtedly the surveys are in themselves insufficient and must be followed by more definite records covering a period of years and, in addition to these, the different scientists on our experiment station staffs should be put to work on special projects covering dif-

ferent aspects of ranch problems. Some of these will be conducted by the Station chemist, others by the entomologist, others by the animal husbandman, others by the farm and ranch economist, others by the plant and animal pathologist, and still others by the botanist. Thus the work may be distributed to the various specialists on the experiment station staff, just as farm problems are so distributed, until the ranch problems of the country receive a scientific research service adequate for the purposes held in view and in no sense secondary to such service rendered the farmers of the country.

Sarvis of North Dakota is making excellent botanical studies of the Northern Great Plains region. Cory, at the Texas Station, is beginning such work and also has well under way studies of the range habits of cattle, sheep and goats which are proving very interesting but have not gone far enough yet for publication. It is hoped that all of our western states and our Federal Department of Agriculture in its several bureaus and subdivisions will take advantage of their wonderful opportunities to do scientific research work in the field of ranching by which is meant the production of livestock primarily upon the native vegetation of our western ranges, so that our semi-arid grazing lands may be made to produce the greatest and most valuable product possible and that the people who live in the ranch country may have closer communication and live more comfortable and satisfactory lives.