Calculating Yearlong Carrying Capacity – An Algebraic Approach

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Highlight: *Estimates of yearlong carrying capacity obtained by three different techniques are compared in terms of accuracy as measured by actual carrying capacity of a northern Utah cattle ranch. A new "algebraic" approach appears superior to two established techniques currently in use.*

An important and ever-present problem facing ranchers, public land administrators, and ranch appraisers is balancing forage production with forage use by livestock. Achieving this desired balance is particularly difficult on the seasonal ranges of the Intermountain area where total yearlong carrying capacity is comprised of many diverse sources of livestock feed. Privately owned meadows, U. S. Forest Service mountain summer range, Bureau of Land Management spring and fall foothill range, as well as purchased and home grown hay and concentrates, may all make important contributions to the feed requirements of a single ranch operation. A reliable method of establishing a stocking rate consistent with sustained yield of the forage resource would be welcomed by many practicing range managers.

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Case Study of a Utah Ranch

An actual northern Utah cow-calf operation will be used to compare three methods of balancing forage production and forage utilization. Various feed sources and quantities for the ranch are shown in Table 1.

The ranch currently supports 125 head of breeding cows. One bull is run for each 20 cows (6 bulls), and 20% of the breeding cows are replaced annually with 2-year-old heifers. Thus, 25 heifer calves are kept each year for replacements. Cull cows and 1 bull are sold in July, and at that time replacement heifers and a replacement bull enter the herd. The calf crop percentage averages 85%. Calves are born in March and sold in November at an average weight of 450 pounds. Calves are assumed to exert their initial demands on the forage in July at a weight of about 200 pounds. Using this information and defining 0.1 animal unit months (AUMs) of forage as that required per month by 100 pounds of live animal weight, a stock count chart was calculated (Table 2). The degree of balance between feed availability and feed requirement can be determined by comparing the "total" columns of Table 2. Such a comparison reveals that during all months of the year feed availability is equal to or greater than feed required. Thus, we may conclude that carrying capacity has been correctly estimated by the rancher and the current stocking rate of 125 mother cows is in balance with forage production and the various other sources of feed.

Table 1. Forage balance chart for northern Utah ranch (AUMs).

Month	Source of feed: Range	Seeded pasture	Aftermath	Hay	Total available
Jan				160	160
Feb				160	160
Mar				174	174
Apr				174	174
May	100	75			175
June	100	75			175
July	190				190
Aug	190				190
Sept	190				190
Oct	50		150		200
Nov			50	136	186
Dec				160	160
Total					2,134

Three Methods of Estimating Carrying Capacity

Average Month Method

The balanced situation existing on the case study ranch above may well be the result of a series of trial and error adjustments by the rancher. Often, concerns for the protection of the range resource will not allow sufficient time for such an intuitive approach. To provide a means of bringing forage production and forage utilization into balance, it has been common in the past to employ what we will call the "average month" method. This method of estimating yearlong carrying capacity consists of dividing the total annual feed available by 12 in order to calculate the number of AUMs of feed available for the average month:

$$\frac{2134 \text{ AUMs}}{12} = 178 \text{ AUMs}$$

Next, some appropriate rule of thumb is used to calculate the carrying capacity in terms of breeding stock (American Institute of Real Estate Appraisers, 1972); i.e. "on an Intermountain cow-calf operation where calves are dropped in March and 20 percent of the cow herd is replaced annually with home-grown heifers, 1.3 AUMs of feed are required for each breeding cow month." Thus

$$\frac{178 \text{ AUMs}}{1.3 \text{ AUMs/cow}} = \begin{array}{l}137 \text{ mother cows}\\ \text{capacity}\end{array}$$

Is 137 head of mother cows a meaningful estimate of yearlong carrying capacity? Obviously 137 head is 12 more cows than the ranch is currently supporting, and the rancher may be holding this amount of unused carrying capacity in reserve for various contingencies. However, to adequately answer this question we must calculate a stock count chart for 137 head (Table 3). Table 3 reflects the same birth dates, bull-cow ratios, replacement ratios, etc. as are currently being practiced for 125 head.

Comparison of total AUMs required for 137 head with total AUMs available in Table 3 reveals that a feed shortage exists for each month of the year, and the annual feed deficit is 175 AUMs. A breeding herd of 137 head is clearly in excess of the carrying capacity of the ranch. The "average method," since it focuses on feed needs of the average month and ignores the requirements of certain limiting months, has yielded an overly optimistic estimate of yearlong carrying capacity.

Limiting Month Method

In an attempt to avoid the high estimate of yearlong carrying capacity given by the "average month" method, we now turn to the "limiting month" approach, which has also been widely used in the past. The limiting months are May and June, when only 175 AUMs of feed are available (Table 1). The months of January, February, March, April, and December have an even smaller feed supply; but during each of these months, purchased

Table 2. Stock count chart for northern Utah ranch (current stocking rate of 125 head).

Month	Bulls (1.5AU) Head	Bulls (1.5AU) AUMs	Cows (1.0AU) Head	Cows (1.0AU) AUMs	2-year heifers (0.9AU) Head	2-year heifers (0.9AU) AUMs	Yearling heifers (0.7AU) Head	Yearling heifers (0.7AU) AUMs	Calves (0.325AU) Head	Calves (0.325AU) AUMs	Total required AUMs	Total available[1] AUMs
Jan	6	9	125	125			25	17.5	25	8.1	159.6	160
Feb	6	9	125	125			25	17.5	25	8.1	159.6	160
Mar	6	9	125	125	25	22.5	25	17.5	Born		174.0	174
Apr	6	9	125	125	25	22.5	25	17.5			174.0	174
May	6	9	125	125	25	22.5	25	17.5			174.0	175
June	6	9	125	125	25	22.5	25	17.5			174.0	175
July	6	9	125	125			25	17.5	106	34.5	186.0	190
Aug	6	9	125	125			25	17.5	106	34.5	186.0	190
Sept	6	9	125	125			25	17.5	106	34.5	186.0	190
Oct	6	9	125	125			25	17.5	106	34.5	186.0	200
Nov	6	9	125	125			25	17.5	106	34.5	186.0	186
Dec	6	9	125	125			25	17.5	25	8.1	159.6	160
Total											2,104.8	2,134

[1] From Table 1.

Table 3. Stock count chart for northern Utah ranch (average month method carrying capacity of 137 head).

	Animal class											
	Bulls (1.5AU)		Cows (1.0AU)		2-year heifers (0.9AU)		Yearling heifers (0.7AU)		Calves (0.325AU)		Total required	Total available[1]
Month	Head	AUMs	Head	AUMs	Head	AUMs	Head	AUMs	Head	AUMs	AUMs	AUMs
Jan	7	10.5	137	137			27	18.9	27	8.8	175.2	160
Feb	7	10.5	137	137			27	18.9	27	8.8	175.2	160
Mar	7	10.5	137	137	27	24.3	27	18.9	Born		190.7	174
Apr	7	10.5	137	137	27	24.3	27	18.9			190.7	174
May	7	10.5	137	137	27	24.3	27	18.9			190.7	175
June	7	10.5	137	137	27	24.3	27	18.9			190.7	175
July	7	10.5	137	137			27	18.9	116	37.7	204.1	190
Aug	7	10.5	137	137			27	18.9	116	37.7	204.1	190
Sept	7	10.5	137	137			27	18.9	116	37.7	204.1	190
Oct	7	10.5	137	137			27	18.9	116	37.7	204.1	200
Nov	7	10.5	137	137			27	18.9	116	37.7	204.1	186
Dec	7	10.5	137	137			27	18.9	27	8.8	175.2	160
Total											2,308.9	2,134

[1] From Table 1.

hay or concentrates could be used to offset any deficit. During May and June green forage is available, and cattle normally do not relish hay or concentrates. Thus, during May and June, supplements to forage are not effective, and forage availability during these 2 months limits yearlong carrying capacity.

The "limiting month" approach also employs a rule of thumb concerning monthly feed requirements. If we retain the 1.3 AUMs per breeding cow month used above (American Institute of Real Estate Appraisers, 1972) and apply this requirement to the months of May and June, our calculations are as follows:

$$\frac{175 \text{ AUMs}}{1.3 \text{ AUMs/cow}} = \text{135 breeding cows yearlong carrying capacity}$$

The next logical question is whether or not 135 head is a good estimate of the yearlong carrying capacity of the ranch. An accurate answer to this question again depends on the stock count chart showing the monthly AUM requirements for 135 head. Since the feed requirements for 135 head are only slightly less than those of 137 head shown in Table 3, we may conclude that the "limiting month" method has also seriously overestimated carrying capacity of the ranch.

Algebraic Method

The "Algebraic" method which we propose as a solution to the problem of obtaining an accurate estimate of yearlong carrying capacity consists of the following steps: (1) A stock count chart is constructed (Table 4) in which the number of head of each animal class is expressed as a percent of breeding cow carrying capacity (X). Since one bull is required for 20 cows, we list 0.05 X bulls; and since 20% of the breeding herd is replaced annually, we list 0.20 X yearling heifers, etc. Table 4 reflects the calf crop percentage, birth dates, etc., which actually exist for the 125 head of breeding cows currently supported on the ranch. (2) The total AUMs of feed required for each month are calculated in terms of X by summing the requirements for each animal class (for January the total requirement = $.08X + 1.00X + .14X + .07X = 1.29X$). (3) Total breeding cow capacity is calculated for each month by solving the 12 algebraic equations (for January, we solve the equation $1.29X = 160$ for X and obtain 124 breeding cows). (4) The most limiting month is identified

Table 4. Stock count chart employed in algebraic method to determine yearlong carrying capacity.

	Animal class												
	Bulls (1.5AU)		Cows (1.0AU)		2-year heifers (0.9AU)		Yearling heifers (0.7AU)		Calves (0.325AU)		Total required	Total available[1]	Breeding cow capacity
Month	Head	AUMs	Head	AUMs	Head	AUMs	Head	AUMs	Head	AUMs	AUMs	AUMs	Head
Jan	.05X	.08X	X	1.00X			.20X	.14X	.20X	.07X	1.29X	160	124[2]
Feb	.05X	.08X	X	1.00X			.20X	.14X	.20X	.07X	1.29X	160	124
Mar	.05X	.08X	X	1.00X	.20X	.18X	.20X	.14X	Born		1.40X	174	125
Apr	.05X	.08X	X	1.00X	.20X	.18X	.20X	.14X			1.40X	174	125
May	.05X	.08X	X	1.00X	.20X	.18X	.20X	.14X			1.40X	175	125
June	.05X	.08X	X	1.00X	.20X	.18X	.20X	.14X			1.40X	175	125
July	.05X	.08X	X	1.00X			.20X	.14X	.85X	.28X	1.50X	190	125
Aug	.05X	.08X	X	1.00X			.20X	.14X	.85X	.28X	1.50X	190	125
Sept	.05X	.08X	X	1.00X			.20X	.14X	.85X	.28X	1.50X	190	125
Oct	.05X	.08X	X	1.00X			.20X	.14X	.85X	.28X	1.50X	200	133
Nov	.05X	.08X	X	1.00X			.20X	.14X	.85X	.28X	1.50X	186	124
Dec	.05X	.08X	X	1.00X			.20X	.14X	.20X	.07X	1.29X	160	124
Total											16.97X	2,134	125[3]

[1] From Table 1.

[2] For January: $.08X + 1.00X + .14X + .07X = 1.29X$
$1.29X = 160$
$X = 124$ head

[3] Total: $16.97X = 2{,}134$
$X = 125$ head

and our estimate of yearlong carrying capacity is complete. May and June are again the limiting months for the reasons mentioned above. Thus, our estimate of the yearlong breeding cow carrying capacity of the ranch is 125.

It should be noted that once the limiting feed months (May and June) have been identified, solution of the algebraic equations for these months is sufficient to calculate yearlong carrying capacity. For the purpose of illustration we have included solutions to all 12 equations in Table 4. We have also provided a solution in terms of total *annual* feed requirement and availability which also yields the correct estimate of 125 head: $16.97X = 2134$, $X = 125$.

Since 125 cows are currently being carried (and this number has been adequately supported for the last several years), the 125 cow estimate yielded by the "algebraic" method appears better than those obtained by either the "average" or "limiting" methods. If the rule of thumb for the number of AUMs required per breeding cow month had been set at 1.4 in our example, both the "average" and "limiting" methods would have produced the correct estimate of 125 head. It is the use of the inflexible rule of thumb factor of 1.3 which is responsible for the incorrect estimates of carrying capacity by these two methods. The greater accuracy of the "algebraic" method is due to its ability to compare *month-by-month* estimates of feed requirement with monthly feed availability. Future use of the "algebraic" method will result in more accurate estimates of yearlong carrying capacity and help avoid both over- and understocking of seasonal ranges.

Literature Cited

American Institute of Real Estate Appraisers. 1972. Real Estate Appraisal Course V. Grazing lands and cattle ranches. Logan, Utah. June 24-July 1. 160 p. (Mimeo).