Distance from Water as a Factor in Grazing Capacity of Rangeland

K. A. Valentine[1]

An important factor influencing use of range forage is nearness to water supply. The author points out how intensity of grazing use declines with increased distance from water. Applying these results to a specific pasture made possible a correction in ordinary range-carrying capacity estimates to values in accordance with good range use.

IT is a well-known fact that the distribution of water on rangeland has a direct bearing on its grazing capacity. This is especially true in the semiarid parts of the West, where much of the range is usable only after water developments are made. Range lying so far from water that domestic livestock cannot reach it has little or no effective or usable grazing capacity even though it may consist of an excellent stand of good forage plants. This condition is recognized and adjusted for in range surveys procedure through the application of utilization cuts because of poor distribution of water. These utilization cuts have the effect of eliminating or discounting the value of forage on areas so far from water that livestock cannot be expected to make full use of it.

It is less commonly recognized, or at least not commonly taken into account, that accessibility of range, and hence its grazing capacity, progressively decreases as distance from water increases (*4, 5, 12, 13*). Recognition of this fact is especially lacking with regard to level or gently rolling rangeland. On this kind of rangeland where water developments have been made to bring all of a given range area within reasonable walking distance of the livestock, it has been assumed that the range was all about equally accessible and that the utilization of forage would under proper management be fairly even throughout the area. Grazing capacity surveys have generally reflected this assumption and as a result have yielded figures in excess of the true grazing capacities of rangelands. Some earlier observers have noted a graduated use of forage out from water (*6*) but apparently it was not generally recognized as unavoidable since no adjustment based on graduated use has been incorporated in range survey procedure. This error continues to the present and is comprehended in current instructions for conducting range surveys (*8, 9, 10,* and *11*).

Overestimates of Capacity

Stoddart (*7*) has recently noted that early computations of grazing capacity made on the then Santa Rita Range Reserve in southern Arizona (*13*) (32 head per section) were well above the grazing capacity as determined by actual stocking of the range (nearer 15 head per section). Clip quadrat and hay harvest data were used to compute grazing capacity. Reasonable allowance for proper use of the grasses and for forage requirements of the livestock appears to have been made. No allowance was made for graduated use of forage, however, and it appears that failure to take this factor into consideration accounts for a large part of the discrepancy.

Records from the Jornada Experimental Range in southern New Mexico (*1*) also reveal a discrepancy between grazing capacity as determined by range surveys and by actual stocking. Here the vegetation records for one representative pasture which had a grazing capacity of 137 animal units according to range survey[2] showed a strong downward trend in density under an average stocking of 112 head per year for a 9-year period when rainfall was favorable. This trend was reversed when the stocking rate was reduced to an average of 76 head per year. Because of several years of very low stocking (42, 1, and 26 head) this average is probably below the number that could have been grazed without damage to the pasture. It seems clearly evident, however, that stocking to full capacity as determined by grazing survey procedures would have resulted in severe deterioration of the pasture. It showed he pointed out that the survey figure was not in error in its expression of the vegetation present in the pasture. Forage crop surveys conducted in this pasture for the past 8 years by means of clip transects, show an average yield of forage, if uniformly used, sufficient to carry 139 animal units.[2]

[1]In charge range management, New Mexico College of Agriculture and Mechanic Arts.

[2]Unpublished data supplied through courtesy of the Jornada Experimental Range, branch of the Southwestern Forest and Range Experiment Station, Tucson, Arizona.

The error in the range survey capacity value then does not derive from an error in the survey with respect to total amount of forage present or forage allowance per animal, but comes from the anticipation of uniform utilization of the vegetation instead of graduated utilization as distance from water increases.

Discrepancies such as those cited result no matter what method is used to make the grazing survey and no matter how accurately the survey expresses the amount of vegetation on the ground, so long as outlying range is considered to have the same accessibility and grazing value as range lying closer to water. This also applies to the recently developed "range condition class" method of determining grazing capacity of range as well as to the older range survey methods. Grazing capacity values obtained by means of forage utilization surveys likewise have often been excessive because these surveys also have assumed a more or less even utilization of vegetation as being proper, instead of graduated utilization.

In recent years, as more attention has been given to the study of range utilization, it has become apparent that even well-watered, level range is not equally used near and away from water. Forage utilization has been found to decrease perceptibly and consistently as distance from water increases. Stoddart (*7*) discussing development of range watering places, gives recognition to this fact, indicating that the use on level land decreases in almost exact proportion to the distance from water. Glendening (*3*) working in northeastern Arizona, found that grazing use of the most important forage grasses showed a consistent and material decrease with distance from water. Campbell (*2*) has shown that utilization of black grama grass on the Jornada Experimental Range in southern New Mexico exhibits a similar decrease with distance from water.

Utilization Gradients

It is not the purpose of this paper to present utilization gradient values which can be applied to any specific set of conditions in the field, but rather to call further attention to the unavoidable effect of distance from water on accessibility and usability of range, and the need for taking this into consideration in range surveys and utilization survey procedures. Gradient values presented here are meager and are probably limited in value to range quite similar to that on which they were observed. Correct values for use under other conditions will probably be found to vary with season of use, class and age of livestock, grazing system, temporary availability of outlying water, snow or succulent forage, salting practice, presence of roads, trails and other cultural features, resistance of forage species to grazing and trampling, topography, and perhaps other factors.

Available data do, however, well illustrate the effect of distance from water on utilization of vegetation. The data presented were obtained in a utilization survey of a pasture on the experimental ranch of the New Mexico College of Agriculture and Mechanic Arts for the grazing year 1943-44. This pasture of 2,435 acres, consisting largely of good black grama (*Bouteloua eriopoda*) grassland, was stocked with cattle on a year-long basis, totaling 25.68 animal units. An animal unit, as used in these computations, is a thousand pound cow with her calf. A map of the pasture showing data obtained from a range survey is presented in Figure 1. In addition, the pasture is shown divided into concentric zone sections at half-mile intervals centering at the watering place, with areas and forage acres of the vegetation types and subtypes in each zone indicated.

A diagram of the utilization data is shown by Figure 2. Similar relationships between distance from water and utilization of vegetation have been observed in other pastures and in other years on the ranch. Those acquainted with utilization on the range will recognize that the general relationship shown is representative of conditions usually prevalent in the field. It will be noted that while there is considerable variation among utilization values for any given distance and some inversions in relationships over short distances, there is a consistent general downward trend as distance from water increases. It will also be noted that the gradient is a little greater close to water than at greater distances. It is thought that the gradient for this pasture might be reduced appreciably by certain management practices, such as stocking with greater numbers of stock for shorter periods, or stocking in fall, winter, and spring, when cattle can be expected to use forage at greater distances from water. There is no reason, however, to suppose that the gradient can be reduced to a point where it is not a material factor in determining the proper use and grazing capacity of the pasture.

It should be pointed out that the forage in this pasture consists largely of black grama grass, the climax dominant and most valuable forage species on this type of range. This grass is tentatively considered to have a proper use factor of about 50 percent. It will be seen that the utilization out to .2 mile from water averaged more than this. This area has been used to about the same degree in previous years and, as a result the range exhibits a deteriorated condition. The black grama grass is low in vigor and snakeweed (*Gutierrezia sarothrae*), a half-shrub of no forage value, has become conspicuous around the water. While it is generally recognized that such "sacrifice areas" around permanent water are unavoidable, little is known as to what size they should be allowed to develop in order to have the maximum amount of forage permanently available for livestock. Stocking lightly enough to eliminate such areas would undoubtedly result in unwarranted waste of forage. Stocking heavily enough to make fullest possible use of outlying vegetation would certainly result in excessive use of vegetation lying closer in and in permanent loss of grazing capacity through extension of the depleted sacrifice zone. It appears to be the opinion of those familiar with this type of range and the problems involved that range conservation and efficient livestock production are best served when this zone does not extend beyond ¼- to ½-mile from water. This means then, that for the pasture under discussion and with the management practices in use, the utilization gradient observed is about what can be expected if the sacrifice area is to be kept at present size and therefore should be considered as proper in making grazing capacity and utilization surveys.

Correcting Capacity Estimates for Distance from Water

The effect of anticipating graduated utilization in computing grazing capacity in comparison with not anticipating this condition is brought out in Tables 1 and 2. Table 1 presents a compilation of the map data according to current range survey procedures. Using an annual forage acre requirement of 6.5, a value found to be suitable for this type of range, the grazing capacity of the pasture is 44.5 animal units. Table 2 presents a compilation of the same data but introduces in the fourth column factors taken from Figure 2 which express the proportion of full proper use of vegetation that should be had in each zone. These factors progressively reduce the original forage acre value for each zone to yield what might be called properly usable forage acres for the zone. This effects a considerable reduction in total forage acres and finally yields a grazing capacity of 24.5 animal units for the pasture. Similar treatment of range survey data obtained by different methods (square foot density, and estimation or measurement of weight on sample plots) will reveal similar departures in values between current standard methods and

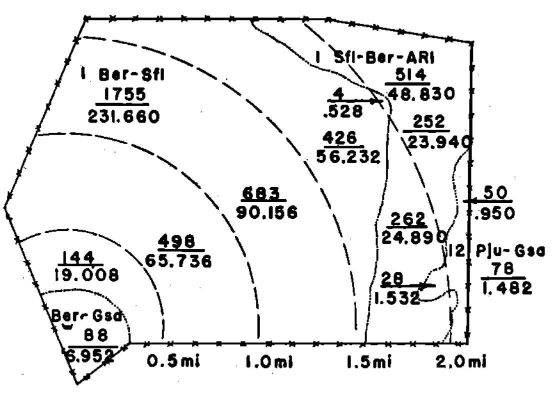

FIG. 1.—Map of Pasture No. 1, New Mexico Agricultural Experiment Station Ranch, showing the different vegetation types, subtypes, and concentric zone sections at half-mile intervals centering on the watering place. Surface acres (upper figures) and forage acres (lower figures) are shown for each whole type or subtype and also for each area delimited by type, subtype, and/or zone boundaries.

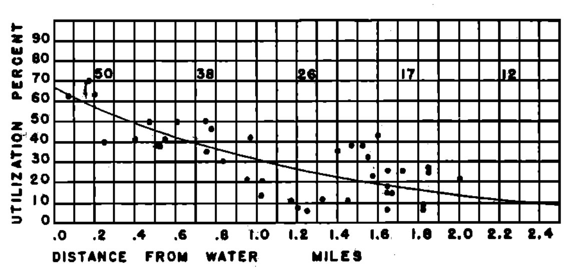

FIG. 2.—Effect of distance from water on degree of grazing use, New Mexico Agricultural Experiment Station Ranch, Pasture No. 1, 1943-44. The curve is located by inspection and is extrapolated through the 2.0-2.5 mile zone as no observations were made in this zone in 1943-44. The values above the curve are taken from the curve except for the 0-.5 mile zone. In this zone the high observations near water represent but a very small and unproductive part of the zone. The value 50 is more nearly representative of the zone when the better stand of vegetation on the greater area of the outer part of the zone is taken into account.

these same methods when factors comprehending graduated utilization are introduced.

The most dependable means of determining grazing capacity of range is through the use of actual stocking and forage utilization data, provided that the stocking values are accurate and the forage utilization values correctly reflect the actual and proper use of vegetation. In recent years much has been done to increase the accuracy of the expression of forage utilization through the development of methods which express utilization as a percent of weight. There remains, however, a considerable element of error in the forage utilization factor, if the practice of considering uniform use of vegetation as proper is followed. This treatment yields results which are generally comparable with those obtained through range survey data compiled on the basis of ungraduated utilization but are in excess of true grazing capacity values. Introducing an adjustment which takes into consideration graduated use will bring grazing capacity values as computed from utilization surveys and stocking records more in line with true values.

This may be done by first computing a weighted average proper use factor for a pasture, using as a weighting factor the amount of forage in each zone, and then making use of this weighted average value instead of a full proper use factor in an appropriate formula. Table 3 illustrates the computation of the weighted average proper use factor for pasture 1. The proper use value for each zone is taken from the curve shown in Figure 2 and the forage acre values from the third column of Table 2. The results obtained through computation of the data from Table 3 indicate that the weighted average proper use factor for this pasture is about 27 percent. Actual utilization of vegetation for any year may be compared with this value to determine the status of forage utilization for that year. Actual use values lower than the weighted average indicate under use; greater actual use values indicate over use, unless the greater actual use values arise from heavier use of outlying vegetation without attendant over use of vegetation lying closer in to water.

Computation of proper stocking from the weighted average proper use factor, actual stocking, and actual use may be done as follows:

$$\text{Proper stocking} = \text{Actual stocking} \times \frac{\text{Weighted average proper use factor}}{\text{Percent of vegetation utilization}}$$

Using values obtained from stocking and utilization survey of this pasture for the year 1939-40 in this formula:

$$\text{Proper stocking} = 22.7 \times \frac{27.1}{24} = 25.6 \text{ animal units.}$$

Values from the 1940-41 stocking records and utilization survey for this pasture yield a proper stocking figure of 23.0 animal units. Both these values, derived from actual stocking of the pasture, are well below the 44.5 animal units obtained by the current standard method of computing range survey data. On the other hand they both compare closely with the 24.5 animal units obtained from the modified computation.

The Key Zone Method

Determination of proper stocking by this method is not necessary in instances where the "key zone" method is applicable. In these instances, a range area is regarded as being properly used when the key zone, located immediately beyond the sacrifice zone, is properly used. Whatever degree of utilization is had beyond the key zone is accepted as proper without need for detailed observation, since it is the attainment of fullest possible use of the key zone consistent with the maintenance of highest productivity of this zone that alone determines proper use for the whole tributary range area.

It is not known at present, however, that utilization on outlying range is at all times in proportion to utilization on the key zone; hence, the key zone may not at all times during the grazing season be a reliable index of utilization on outlying areas. Utilization on the key zone may approach or reach proper considerably before utilization approaches or reaches proper on the outlying areas. Thus, utilization on the key zone may not correctly reflect utilization for a pasture or range area as a whole in those instances where it is necessary to determine proper stocking after partial but before complete or full utilization. In view of the present lack of information on this point, it would appear to be desirable to use a weighted average proper use factor as in the formula or a similar computation in order to determine proper stocking based upon stocking and utilization data obtained before complete utilization. In the event

TABLE 1.—COMPUTATION OF GRAZING CAPACITY FROM DATA PRESENTED IN FIGURE 1
(On the Basis of Uniform or Ungraduated Utilization)

Vegetation type	Surface acres	Forage acres
1 Ber-Gsa	88	6.952
1 Ber-Sfl	1755	231.660
1 Sfl-Ber-ARI	514	48.830
12 Pju-Gsa	78	1.482
	2435	288.924

Animal unit years = forage acres ÷ annual forage acre requirement
= 289 ÷ 6.5
= 44.5

TABLE 2.—COMPUTATION OF GRAZING CAPACITY FROM DATA PRESENTED IN FIGURES 1 AND 2
(on the Basis of Graduated Utilization)

Zone	Surface acres	Forage acres	Proportion of proper use for zone	Properly usable forage acres
.0- .5 mi.	232	25.960	50/50	25.960
.5-1.0 mi.	498	65.736	38/50	49.959
1.0-1.5 mi.	683	90.156	26/50	46.881
1.5-2.0 mi.	716	81.654	17/50	27,762
2.0-2.5 mi.	306	25.418	12/50	6.000
	2435	288.924		156.662

Animal unit years = forage acres ÷ annual forage acre requirement
= 156.662 ÷ 6.5
= 24.1

TABLE 3.—COMPUTATION OF THE WEIGHTED AVERAGE PROPER USE FACTOR FOR PASTURE 1

Zone	Forage acres	Proper vegetation use for zone	Forage acres × proper use for zone
		Percent	
.0- .5 mi.	25.960	50	1298.000
.5-1.0 mi.	65.736	38	2497.968
1.0-1.5 mi.	90.156	26	2344.056
1.5-2.0 mi.	81.654	17	1388.118
2.0-2.5 mi.	25.418	12	305.016
	288.924		7833.158

Weighted average proper use factor = 7833.158 ÷ 288.924
= 27.11

that further study discloses that utilization on outlying areas is at all times proportionate to uilization on the key zone, percent utilization on the key zone alone will be sufficient to determine proper stocking and the computation of weighted average values will be unnecessary.

It might be pointed out that the values obtained from the modified range survey data and from the utilization surveys may not represent the long-time average value for this pasture, since the pasture had not fully recovered from the severe drought of 1934 at the time these surveys were made. More recent utilization surveys, reflecting further recovery from the drought, yield values of about 35 animal units as the grazing capacity of the pasture.

The most important point growing out of the consideration of graduated utilization of range vegetation is the fact that the amount of vegetation alone, as ordinarily expressed, either in terms of forage acres or pounds, does not yield a true grazing capacity value for a pasture or range area. Size and shape of pastures and location of watering places greatly affect grazing capacity. Pastures which contain the same number of forage acres or pounds of the same kind of vegetation, but which are of considerably different size, may have quite different grazing capacities if they are not equally well watered. Pastures of the same area and having the same kind and amount of vegetation may have considerably different grazing capacities if they are of markedly different shapes. Pastures may be the same size and shape and contain the same kind and amount of vegetation and still have different grazing capacities if water locations in them are considerably different. For example, the pasture discussed would have had a grazing capacity of about 35 animal units, according to the modified computation of grazing survey data, instead of the 24.5 animal unit capacity it actually had, if the water had been centrally located in the pasture.

Literature Cited

1. **Ares, Fred N.** 1939. A 24-year grazing management study. Mimeog. Report. Jornada Expt. Range. Branch of the Southwestern Forest and Range Expt. Sta. Tucson, Ariz.
2. **Campbell, R. S.** 1943. Progress in utilization standards for western ranges. Journal Wash. Academy of Sciences. Vol. **33,** No. 6.
3. **Glendening, George E.** 1944. Some factors affecting cattle use of northern Arizona pine-bunchgrass ranges. Report No. 6. Southwestern Forest and Range Expt. Sta. Tucson, Ariz.
4. **Jardine, James T.** and **Clarence L. Forsling.** 1933. Range and cattle management during drought. U. S. Dept. of Agric. Bul. No. **1031.**
5. **Jardine, James T.** and **L. C. Hurtt.** 1917. Increased cattle production on Southwestern ranges. U. S. Dept. Agric. Bul. **588.**
6. **Nelson, Enoch W.** 1934. The influence of precipitation and grazing upon black grama grass range. U. S. Dept. Agric. Tech. Bul. **409.**
7. **Stoddart, Laurence A.** and **Arthur D. Smith.** 1943. Range management. McGraw-Hill Book Co. New York.
8. **United States Department of Agriculture,** Agricultural Adjustment Administration. 1940. Instructions to field range examiners for making range surveys.
9. **United States Department of Agriculture,** Soil Conservation Service. 1941. Standard procedures for range surveys.
10. **United States Department of Interior,** Division of Grazing. Grazing survey handbook.
11. **Western Range Survey Conference.** 1937. Instructions for range surveys formulated by the Inter-Agency Range Survey Committee.
12. **Wooton, E. O.** 1915. Factors affecting range management in New Mexico. U. S. Dept. Agric. Bul. **211.**
13. **Wooton, E. O.** 1916. Carrying capacity of grazing ranges in southern Arizona. U. S. Dept. Agric. Bul. **367.**