SRM Society for Range Management

A Review of Three Select Rangeland and Pastureland Quantitative Inventory Methods and Determining Estimated Stocking Rates

By Joseph A. May

On the Ground

- In this article, I provide general guidance for conducting select methods for quantifying principally herbaceous standing crop on rangelands and pasturelands, but also quantifying current year's shrub growth on rangelands.
- I discuss estimating by weight units, double-sampling, and harvesting methods.
- I also discuss the 1/100th-acre extended plot for determining current year's growth of medium to large shrubs on rangelands and determining the estimation of stocking rates for rangeland and pastureland.
- This article demonstrates how to determine the estimation of stocking rates for rangeland and pastureland.
- The conservation application of my article is to provide field personnel with sound quantitative methods for determining approximate standing crop of forage plants, in pounds per acre, for the express purpose of determining a current and defensible grazing capacity of a farm, ranch, or unit of public land.

Keywords: rangeland and pastureland quantitative inventory, estimating by weight units, double-sampling and harvest sampling, 1/100th-acre extended plot, estimated stocking rates.

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In this article, I provide general guidance for conducting selected inventory methods for quantifying principally herbaceous standing crop or current year's herbaceous growth on rangelands and pasturelands. I also include a method for quantifying current year's growth of shrubs on rangelands. The conservation application of this article provides the rangeland management specialist, professional agriculturist, soil conservationist, and extension agent and specialist with sound quantitative methods for determining approximate standing crop of forage plants, in pounds per acre, and from that the ability to determine a current and defensible grazing capacity of a farm or ranch, or unit of public land, and provide annual data to eventually determine carrying capacity of rangelands and pasturelands. Having knowledge of current grazing capacity or long-term carrying capacity, enables the conservationist to be better prepared to prevent overstocking and/or overgrazing of rangelands and pasturelands.

Background information on this topic can be found in Habich,[1] USDA NRCS,[2] USDA SCS,[3] Pechanec and Pickford,[4] and Wilm et al.[5] In this article, I discuss the following three methods in inventorying rangelands and pasturelands: estimating by weight units, double-sampling, and harvesting inventory.

Rangeland inventory methods provide information such as plant species composition; rangeland ecological condition and apparent trend or percent similarity index; annual herbage; amounts of usable forage present; and forage value present as used by a given kind or class of livestock or wildlife.

When preparing to use one of these methods to inventory a given unit of rangeland, the different rangeland ecological sites should be noted and separately delineated on the conservation plan map or rangeland inventory map. I do not address grazed forests and woodlands that may be separately delineated from rangeland ecological sites by their distinctive forestland ecological sites or forest association types.

The rangeland ecological site delineations should be reviewed to determine whether the ecological or forage conditions will change within the map polygons. Should this occur, stratified sampling likely is appropriate and separate transects should be located within each stratum. For example, stratified sampling may be needed to determine differences in rangeland ecological or forage conditions around livestock water developments, springs, or natural perennial streams and other water bodies.

Generally, a quadrat is the sampling unit, used along a range transect (Figure 1). Many conservationists prefer to randomly locate the quadrat along a linear transect of an outstretched 30.5 m (100-foot)-long measuring tape. A transect could be longer than 30.5 m (100 feet) if the rangeland ecological site polygon is longer or wider than 30.5 m (100 feet), and if the conservationist is capturing a much larger overview of the rangeland ecological site polygon.

There usually are 10 quadrat placements along a range transect. Common quadrat shapes and sizes are described in Figure 1. The 0.01-acre extended plot can be constructed by pacing off the distance from the outer corners of the 9.6-foot^2 quadrat or measuring off the distance with a measuring tape (Figure 1h). The corners of the 0.01-acre extended plot can be marked off with standard engineering flags, white engineering tape, or colored plastic flagging tape.

Estimating by the Weight Units Inventory Method

To use the estimating by weight units inventory method, begin by identifying all the major plants in the rangeland ecological site polygon. Then use the natural spread and diameter of your hand to overshadow a given plant and clip the current year's growth of the plant. These will be your "handfuls" recorded on the inventory worksheet. Only one weight unit or handful is necessary for each herbaceous plant species. The handful, weighed out in grams, for each species will be the "weight unit" for the inventory.

Next, estimate how many weight units of each plant species occur in each quadrat then multiply the sum of the weight units of each plant species by the earlier determined number of grams that each weight units represents. The product is the estimated amount of grams, in green weight, of a particular plant species that is presently occurring in the quadrat. Repeat this method on all 10 quadrats in the transect.

The estimating by weight units is the most time efficient of the three methods discussed in this article. Once weight units have been determined, in many cases, you can conduct additional transects in a relatively rapid fashion. The drawback with this method is that relatively inexperienced field conservationists can easily under- or overestimate current, standing crop production. This particular method is best used by field conservationists who have extensive field inventory experience.

As with all three inventory methods discussed here, you will be able to determine percent plant species composition by volume that are occurring in the rangeland ecological site polygon or forage suitability group polygon, and especially annual, standing crop production. The latter is indeed necessary for determining estimated stocking rates. Percent cover can be determined by sight, within the bounds of the quadrat, if necessary, although I do not discuss estimating cover here. Information determined by these three methods can be more advantageous to the conservationist in conservation planning over other inventory methods.

To convert weight units from grams to pounds per acre of total production see Tables 1 and 2.[1] Standing crop, in grams, in one or more plots totaling 96 feet^2 converts directly to pounds per acre. The following is an example of how to convert from green weight to air-dried or oven-dried weight. Assume that the original weight unit sample of sideoats grama, in an inventory, was 9 g in green weight. The sideoats grama was placed in a paper bag and air-dried. After air-drying, the sideoats grama weighed 4 g. Divide the 4 g air-dried weight, by the 9 g green weight to obtain the ratio of air-dried to green weight, in this case 4 g dry weight divided by 9 g green weight is 44%. To convert green weight pounds per acre to dry weight pounds per acre, multiply green weight by the percent previously calculated (i.e., 1,000 pounds green weight per acre × 44% = 440 pounds dry weight per acre).

This process can then be conducted for the total pounds per acre green weight of all plants that were inventoried in the transect. The total of air-dried weight pounds per acre of all plants in the transect is the total production for that rangeland ecological site. This amount can be used to determine a suggested, initial stocking rate, which is discussed later in this article.

Double-Sampling Inventory Method

Determining weight units for each major plant species present on the rangeland ecological site polygon should be done immediately before sampling the transects when using the estimating by weight units inventory method. Plants should be clipped to the ground level. All plants rooted within the quadrats should be included. After estimating weight units by species in each of 10 quadrats, return for clipping by plant species to two randomly selected quadrats. These clipped weights will provide a correction factor used to adjust for underestimation or overestimation of the weights of the plants present. The clipped weight information also improves the validity of overall transect information. The correction factor is calculated by dividing the clipped weight of a given plant in grams by the estimated weight of the same plant in grams. This calculation is computed for each plant species clipped within the quadrats. According to the USDA SCS,[3] the number of plots harvested depends on the number estimated. The USDA SCS further states that past research indicates that at least one plot should be harvested for each seven estimated plots to adequately correct the estimates. Therefore, the USDA SCS recommends that at least 2 plots be harvested if 10 are estimated, and three plots if 20 plots are estimated.

The correction factor ratio to use equals the plant species clipped weight (g) divided by plant species estimated weight (g). A correction factor >1 means an underestimation of the weight of a given plant in the quadrat that was clipped. Likewise, a correction factor <1 means an overestimation of the weight of a given plant species in the quadrat that was clipped.

To illustrate how the correction factor is calculated, assume the conservationist had clipped 50 g of sideoats grama in a

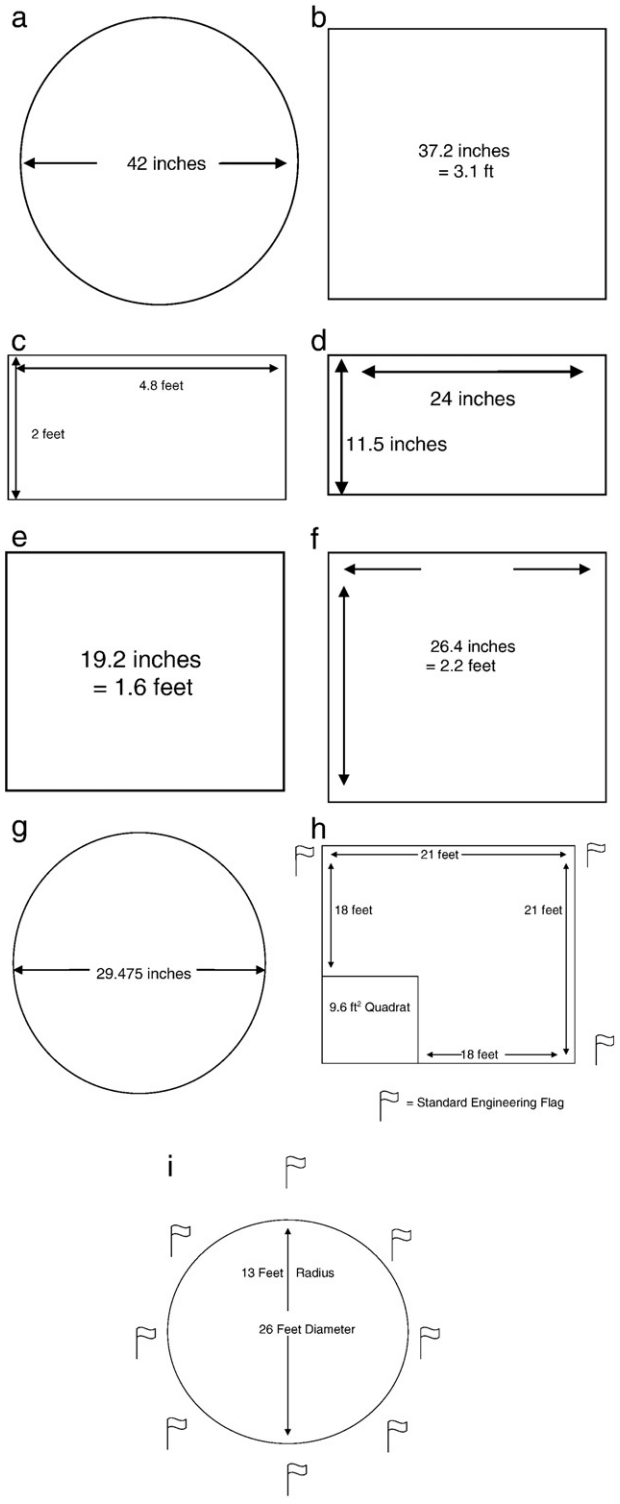

Figure 1. Common quadrat shapes include **a** Circular 9.6-foot^2 quadrat with diameter of 42 inches and circumference of 10 feet 11.8 inches, commonly referred to as the SCS range hoop and recommended size for quantitative inventory on the shortgrass steppe or desert/semi-desert rangeland; **b** Square 9.6-foot^2 quadrat with a square shape of 37.2inches æ 37.2 inches (3.1 feet æ 3.1 feet), lends itself to use in nested plots in rangeland areas with many medium or large shrubs (see also Figure 1h); **c** Rectangular 9.6-foot^2 quadrat with rectangular shape of 24 inches wide by 56.6 inches long (2 feet æ 4.8 feet) and used principally in research projects; **d** Rectangular 1.92-foot^2 quadrat is the smallest size quadrat used by NRCS and is 11.5 inches wide æ 24 inches long (0.96 feet æ 2 feet), used for inventorying tall grass prairie, irrigated and improved pasturelands, and the understory of riparian areas; **e** Square 2.40-foot^2 quadrat with 19.2 inches wide æ 19.2 inches (1.6 feet æ 1.6 feet) square used for inventorying tall grass prairie, irrigated, and improved pasturelands, and the understory of riparian areas; **f** Square 4.80 foot^2 quadrat with 26.4 inches wide æ 26.4 inches (2.2 feet æ 2.2 feet) square used for inventorying mid-grass prairie; **g** Circular 4.80-foot^2 quadrat with a diameter of 29.475 inches (2feet 5.7 inches) and circumference of 7feet 9.2 inches and may be used instead of the square in (1F); **h** Square 9.6-foot^2 quadrat nested in a square 0.01-acre extended plot; and **i** Circular 0.01-acre extended plot with 26-foot diameter. Note diagrams not to scale, examples only.

Table 1. US quadrat-size conversion factor from grams to pounds per acre			
Quadrat size	**Weight unit**	**Conversion factor per plot**	**Conversion factor per 10 plots**
1.92 feet^2	Grams	50	5
2.40 feet^2	Grams	40	4
4.80 feet^2	Grams	20	2
9.60 feet^2	Grams	10	1
96.0 feet^2	Grams	1	0.1
0.01 acre	Grams	100	10
0.1 acre	Grams	10	1

Adapted from Habich.[1]

given quadrat and had previously estimated (by weight units) 35 g of sideoats grama; so:

$$\frac{50\ \text{g clipped weight}-\text{sideoats grama}}{35\ \text{g estimate weight}-\text{sideoats grama}} = 1.43.$$

The total pounds per acre of a given plant species are then multiplied by the correction factor to get the corrected total pounds per acre. For example, assume 440 pound per acre air-dried weight of sideoats grama was estimated for a given rangeland ecological site delineation; then:

440 pounds/acre sideoats grama
× 1.43 decimal correction factor
= 629 pounds/acre sideoats grama.

This example illustrates an underestimation of the weight of sideoats grama in the inventory (i.e., the correction factor was > 1). The correction factor increased the pounds per acre of sideoats grama to 629 pounds per acre to correct for the underestimation.

What if the correction factor had been < 1 (i.e., a correction factor of 0.43)? Then:

440 pounds/acre(sideoats grama) × 0.43 correction ratio
= 189 pounds/acre(sideoats grama).

Table 2. Metric quadrat-size conversion from grams to kilograms per hectare			
Quadrat size	**Weight unit**	**Conversion factor per plot**	**Conversion factor per 10 plots**
0.25 m^2	Grams	100	10
1 m^2	Grams	100	10
100 m^2	Grams	100	10
400 m^2	Grams	100	10

Adapted from Habich.[1]

The overestimated weight of sideoats grama in the inventory would be decreased using the correction factor of < 1 to correct for the overestimation.

The double-sampling method is more advantageous to the field conservationist than the estimating by weight units method because it provides a measure of safety against under- and overestimating annual, standing crop production. The double-sampling method of inventory data is particularly useful when revising or updating rangeland ecological site descriptions or pasture sections for forage suitability group descriptions or when defending the determination of annual standing crop for calculating estimated stocking rates for a unit of public land. Having some clipped field data is generally more defensible than ocularly collected data, as with the estimated by weight units method.

To convert pounds per acre to kilograms per hectare, simply multiply the pounds per acre figure by the conversion factor of 1.12[2]. To convert kilograms per hectare to pounds per acre, likewise, multiply the kilograms per hectare figure by the conversion factor of 0.891[2].

Harvesting Inventory Method

The harvesting inventory method involves clipping all the plants, by species, from each of the ten quadrats that comprise the transect. This method can be very time consuming over the other two previously discussed methods. It also is very good for collecting information where rangeland ecological site descriptions or pasture sections of forage suitability group descriptions need to be prepared or revised, or when defending the determination of annual standing crop for calculating estimated stocking rates for a unit of public land. Again, having much clipped field data is generally more defensible than ocularly collected data.

Pastureland Inventories

The goal of pastureland inventory should be to determine forage plant species percent composition as pounds of air-dried forage per acre. I suggest using either the

double-sampling or estimating by weight units inventory techniques for dryland pasture inventories being managed like rangelands.

Irrigated pastureland is usually or similarly managed (i.e., with principles of agronomy) like other kinds of cropland or farmland. There is usually an application of fertilizer and other soil amendments, and at times herbicides. Due to these management inputs, the amount of forage production may vary from farm to farm or ranch to ranch. To inventory irrigated pastureland, I suggest using either the double-sampling or harvest inventory techniques. Inventories may be necessary on an annual basis, depending on the availability of irrigation water or whether fertilizer applications or other soil amendments have been applied.

Rangeland Shrub Inventory

To conduct rangeland inventories on shrub rangelands, set up a 0.01-acre extended plot to account for medium and large shrubs. This would include such shrubs as fourwing saltbush, rubber rabbitbrush, and big sagebrush. Only current year's growth is inventoried. The 0.01-acre extended plot is inventoried by the estimating by weight units method. Clip current year's growth from a given shrub. It is not necessary to clip an entire individual shrub; half of a shrub provides a representative weight unit. The weight unit should be recorded in grams. Inventory all the shrubs species present in the extended plot by weight units and record the total estimated weight of current year's growth for each shrub species in grams. Convert the total grams of the shrub species present in the extended plot, to pounds per acre green weight. Generally, two woody plot or extended plot inventories are conducted in the transect. An average of the two inventoried plots is generally taken when determining pounds per acre.

For example, 5,000 g (green weight) of fourwing saltbush were inventoried on a 0.01-acre plot. One pound equals 453.6 g per pound. Total grams on the 0.01-acre plot divided by 453.6 g per pound = pounds per 0.01 acre. Or 5,000 g/453.6 g per pound = 11.02 pounds in the 0.01-acre plot. To convert pounds per 0.01 acre to pounds per acre multiply by 100 (i.e., 11.02 pounds/0.01acre × 100 = 1,102 pounds per acre). Thus, in this example there are 1,102 pounds per acre of current year's growth of fourwing saltbush for a given rangeland ecological site delineation.

The calculated pounds per acre of green weight of current year's growth of a particular shrub species then need to be converted to pounds per acre air-dried or oven-dried weight as previously discussed under the section on estimating by weight units inventory method. Then sum the total of the air-dried pounds per acre of current year's growth of all shrubs, from the 0.01-acre extended plots, along with the air-dried pounds per acre of current year's growth of herbaceous plants, from the 10 smaller quadrats, to obtain total air-dried pounds per acre for the inventoried rangeland ecological site.

Determining Estimated Stocking Rates: The Final Goal of the Field Inventory

One of the primary outcomes of these quantitative inventory methods is to determine estimated stocking rates. Stocking rates are usually expressed as animal unit days (AUDs), animal unit years (AUYs), or animal unit months (AUMs). The calculated stocking rates should be part of a carefully prepared grazing management plan that includes a drought management plan, a planned grazing system, and proper grazing use factors. The calculated AUMs are suggested initial stocking rates to be used as a starting point in an overall management plan. These AUMs should be re-evaluated in above-average precipitation years, as well as drought years.

Calculating the AUM

The basic animal unit when a range specialist calculates stocking rates is the 1,000-pound cow or cow–calf pair. Studies on range cattle indicate that a 1,000-pound cow and its calf require approximately 26 pounds of air-dried forage per day (780 pounds per month in a 30-day month). However, rangeland researchers have determined that most grazing animals will consume enough dry matter equal to approximately 2% of their total body weight. Therefore, should you wish to determine a more precise figure of pounds of daily forage needed for a grazing animal, simply multiply the total body weight (of the given grazing animal) by 2%. A hypothetical example could be 1,500 pounds beef cow × 0.02 = 30 pounds. In this example, the 1,500-pound beef animal would require about 30 pounds of air-dried matter a day.

Historically, a general rule of thumb by the former USDA Soil Conservation Service recommended a proper grazing use factor of "take half, leave half" of the annual forage or herbage production, or 50% of the current year's growth of the total herbage produced by a given rangeland ecological site or improved pasture.

Past studies on rangeland have found that of the "take half" amount of the forage, only half of that amount is actually used by cattle, whereas the other half is rendered unusable due to trampling and the deposition of animal wastes, leaving only 25% of the total pounds of air-dried herbage available for cattle or other livestock grazing. This percent availability factor is referred to as "harvest efficiency." A 25% harvest efficiency is considered acceptable on extensively managed Western rangelands with relatively low stocking densities. However, on many irrigated, improved pasturelands or pasturelands in more humid areas, livestock producers are utilizing management-intensive grazing systems, such as short-duration–high-intensity or high-intensity–low-frequency grazing systems. With such grazing systems, paddocks are generally smaller in size as compared with Western rangeland pastures, and therefore stocking densities are usually higher. The harvest efficiency can be relatively high because of the smaller paddock system.

The following is an example of calculating AUMs.

- Total pounds of air-dry herbage per acre × 0.25 (assumed harvest efficiency) = adjusted pounds or available pounds of air-dried herbage per acre.

- Adjusted pounds per acre of forage ÷ 26 pounds (daily cattle need) ÷ 30 days (1 month) = AUMs per acre.
- OR adjusted pounds per acre of forage/780 pounds (forage for 1 AU/mo) = AUMs per acre.

To convert AUMs per acre to acres per AUM compute the reciprocal of the above:

- 1 ÷ AUM per acre = acres/AUM.
- For example, assume a loamy rangeland ecological site produced 900 pounds per acre in herbaceous or forage plants.
- 900 pounds total forage per acre × 0.25 = 225 pounds adjusted pounds of forage per acre.
- 225pounds ÷ 26pounds ÷ 30 days = 0.29 AUMs per acre.
- 1 ÷ 0.29 AUM per acre = 3.5 acres per AUM.

Adjustments for stocking rates are usually necessary for changes in terrain, and distance from watering points on rangeland (Tables 3 and 4).

Determining AUYs or AUs Per Section

In some parts the Western United States, the basic stocking rate is interpreted as AUYs or still AUs per section. A section is defined as a 640-acre square land unit.

The AUY can be simply calculated by the following steps:

Step 1 Total pounds of air-dried herbage per acre × 0.25 (assumed harvest efficiency) = adjusted pounds or available pounds of air-dried herbage per acre.

Step 2 Adjusted pounds per acre of forage × total acres of grazing management unit = total pounds of forage or herbage available for the grazing management unit.

Step 3 Total pounds of forage for the grazing management unit ÷ 780 pounds (monthly cattle need) = total AUMs for the grazing management unit.

Step 4 Total AUMs for grazing management unit ÷ 12 months = AUYs for the acreage of the grazing management unit.

Here is an example of how to calculate the AUY:

Assume a particular grazing management unit produced 900 pounds of air-dried forage per acre. Also assume the grazing management unit is 1,500 acres in size.

Table 3. Stocking rate adjustments for slope on rangelands

Percent slope	Percent adjustment
015	0
1530	30
3160	60
> ace60	100

Adapted from USDA NRCS.[2]

Table 4. Stocking rate adjustments for watering point distribution on rangelands

Distance (miles)	Percent adjustment
0.51	0
12	50
23	75

Adapted from USDA NRCS.[2]

- 900 pounds/acre × 0.25 (harvest efficiency) = 225 pounds of usable forage per acre.
- 225 pounds of usable forage per acre × 1,500 acres × 337,500 total pounds of forage available for the grazing management unit.
- 337,500 pounds ÷ 780 pounds = 433 AUMs per the 1,500-acre grazing management unit.
- 433 AUMs ÷ 12 months ÷ 36 AUYs for the 1,500-acre grazing management unit.

In other words, the 1,500-acre grazing management unit has an annual grazing capacity of 31 AUYs or 31 head of cattle.

AUs per section can be calculated as follows:

Step 1 Total pounds of air-dried herbage per acre × 0.25 (assumed harvest efficiency) = adjusted pounds or available pounds of air-dried herbage per acre.

Step 2 Adjusted pounds per acre of forage × 640 acres (amount of acres in a section) = total pounds of forage or herbage available for the section.

Step 3 Total pounds of forage for the section ÷ 780 pounds (monthly cattle need) = total AUMs for the section.

Step 4 Total AUMs for the section ÷ 12 = AUs for the 640-acre section.

Here is an example of how then to calculate the AUs per section:

- Assume a particular section produced 900 pounds of air-dried forage per acre. Also assume the section is 640 acres in size.
- 900 pounds per acre × 0.25 (harvest efficiency) = 225 pounds of usable forage per acre.
- 225 pounds of usable forage per acre × 640 acres = 144,000 total pounds of forage available for the section.
- 144,000 pounds ÷ 780 pounds = 185 AUMs per the 640-acre section.
- 185 AUMs ÷ 12 months = 15 AUs for the 640-acre section.

In other words, the 640-acre section has an annual grazing capacity of 13 AUs or 13 head of cattle.

Determining Stocking Rate for a Unit of Rangeland

In the following example, I provide steps for determining stocking rate for a unit of rangeland:

Assume a delineation of a sandy rangeland ecological site in good rangeland ecological condition, a delineation of shallow sandy rangeland ecological site in good rangeland ecological condition, and a delineation of a clayey rangeland ecological site also in good rangeland ecological condition.

Assume a unit of state land that is 640 acres that has been inventoried.

Annual production of the delineations is as follows: The sandy rangeland ecological site is about 400 pounds of air-dried forage per acre, shallow sandy rangeland ecological site is 250 pounds of air-dried forage per acre, and clayey rangeland ecological site is 300 pounds per acre of air-dried forage.

Using the method for determining AUMs acres per AUM on rangelands, assume: 7.8 acres per AUM for the sandy rangeland ecological site, 10.4 acres per AUM for the clayey rangeland ecological site, and 12.5 acres per AUM for the shallow sandy rangeland ecological site.

The sandy rangeland ecological site delineations occur on the rolling plains of the 640-acre state section, and comprise a total acreage of 320 acres. The clayey rangeland ecological site delineation occurs along a low drainage and adjoining playa, which comprises about 100 acres. The shallow sandy rangeland ecological site occurs low ridges that comprise about 220 acres. There is sandstone rock outcrop that is very visually apparent in the low ridges. The published soil survey report states that one can expect the rock outcrop to comprise about 20% of any given soil map unit delineation that comprises the shallow sandy rangeland ecological site delineation. Therefore, we might wish to adjust the shallow sandy rangeland ecological site delineations to 176 grazeable acres, and the sandstone rock outcrop will comprise about 44 acres of no grazeable value. The 44 acres of no grazeable value sandstone rock outcrop was calculated by simply multiplying 220 acres by 20% (220 acres × 0.20 = 44 acres). The 176 acres of grazeable shallow sandy rangeland ecological site delineations was calculated by simply subtracting 44 acres of sandstone rock outcrop from the original total of 220 acres of shallow sandy rangeland ecological site delineations (220 acres − 44 acres = 176 acres).

- Sandy rangeland ecological site delineations AUMs: 320 acres ÷ 7.8 acres per AUM = 41 AUMs.
- Shallow sandy rangeland ecological site delineations AUMs: 176 acres ÷ 12.5 acres per AUM = 14 AUMs.
- Sandstone rock outcrop: 0 AUMs.
- Clayey rangeland ecological site delineations AUMs: 100 acres ÷ 10.4 acres per AUM = 9.6 AUMs.

Total grazeable acres for the state section of rangeland are 596 acres with 64.6 AUMs available for livestock use.

Determining an Estimated Stocking Rate for a Pasture/Paddock of Irrigated Pastureland

The following example for determining an estimated stocking rate for a pasture or paddock of irrigated pastureland is derived from the University of Idaho Cooperative Extension Service's "Lost River Grazing Academy":

$$\frac{\text{Pounds of hay production per acre} \times \text{harvest efficiency}}{\text{912.5 pounds consumed per AUM}} = \text{AUMs per acre for season}$$

harvest efficiency (information from Lost River Grazing Academy)

Continuous grazing: 30–50%
Weekly rotation: 50–60%
3–5-day rotation: 60–70%
1–2-day rotation: 80–90%

Example A:

$$\frac{\text{4 tons of hay per acre} \times \text{continuous grazing}}{\text{912.5 pounds per AUM}} = \text{AUMs per acre for the season} \frac{\text{8000 pounds} \times 0.40}{\text{912.5 pounds}}$$

$$= 3.55 \text{ AUMs per acre for the grazing season}$$

Example B:

$$\frac{\text{4 tons of hay per acre} \times \text{2-day rotation}}{\text{912.5 pounds per AUM}} = \text{AUMs per acre for the season} \frac{\text{8,000 pounds} \times 80\%}{\text{912.5}}$$

$$= 7 \text{ AUMs per acre for the grazing season}$$

Adjusting Stocking Rates for Kinds and Classes of Livestock

A stocking rate is generally developed around the cow–calf pair. If other livestock are involved, stocking rates should be adjusted accordingly. Adjustments are made by applying animal unit equivalents (AUEs; Table 5). For example: 5 sheep AUEs = 1 cow–calf pair AUE (hence, the historic US Forest Service rule of thumb in the National Forest System, in the past, of 5 sheep = 1 cow–calf pair).

After inventorying the number, kinds, and classes of animals, apply the animal unit equivalents to determine the needed number of AUMs for a particular operation. The total number of needed AUMs compared with the total number of available AUMs for a given operation will indicate whether operation has a surplus (is understocked), deficiency (is over stocked), or is at grazing capacity.

An example of this is that a hypothetical ranch carries 250 mature cows and 10 bulls. The livestock is on the ranch 12 months of the year.

- 250 cows × 1.00 AUE = 250 AUs.
- 10 bulls × 1.35 AUE = 13.5 AUs.
- 250 + 13.5 = 263.5 total AUs.
- 263.5 AUs × 12 months = 3,162 AUMs needed.

Table 5. Determining animal unit equivalents	
Kinds and classes of livestock	**Animal unit equivalents**
Cow, dry	1.00
Cowcalf pair	1.00
Bull	1.35
Steer/heifer, 1 year old	0.60
Steer/heifer, 2 years old	0.80
Horse	1.25
Sheep	0.20
Goat	0.15

Adapted from USDA NRCS.[2]

In this particular example, the entire ranch herd requires 3,162 AUMs for the entire year. The 3,162 AUMs, needed by the herd, should then be compared with the total available AUMs, produced by the forage base, to determine whether there is a deficiency or surplus in AUMs or whether the ranch is at grazing capacity.

Closing Statement and Conservation Application

Once again, my purpose for writing this article was to provide general guidance for conducting select inventory methods for quantifying principally herbaceous standing crop or current year's herbaceous growth on rangelands and pasturelands. The conservation application is to provide the rangeland management specialist, professional agriculturist, soil conservationist, and extension agent and specialist with sound quantitative methods for determining approximate standing crop of forage plants, in pounds per acre. From that, the conservationist is able to determine a current and defensible grazing capacity of a farm or ranch, or unit of public land, and provide annual data to eventually determine carrying capacity of rangelands and pasturelands. Armed with the knowledge of current grazing capacity or long-term carrying capacity, the conservationist is better prepared to prevent overstocking and/or overgrazing of rangelands and pasturelands.

Acknowledgments

The author dedicates this article to past range conservationists of the USDA-SCS, and present rangeland management specialists of the USDA-NRCS.

References

1. Habich, E.F. 2001. Ecological site inventory. Technical Reference 1734-7. Denver, CO, USA: U.S. Bureau of Land Management. [112 pp.].
2. USDA, Natural Resources Conservation Service [USDA NRCS], 2003. National range and pasture handbook. Revision 1. Washington, DC, USA: Grazing Lands Technology Institute. [450 pp.].
3. USDA, Soil Conservation Service [USDA SCS], 1976. National range handbook [Washington, DC, USA].
4. Pechanec, J.F., and G.D. Pickford. 1937. A Weight Estimate Method for the Determination of Range or Pasture Production. *Journal of the American Society of Agronomy* 29:894-904.
5. Wilm, H.G., D.F. Costello, and G.E. Klipple. 1944. Estimating forage yield by the double sampling method. *American Society of Agronomy Journal* 36:194-203.

Author is former State Rangeland Management Specialist-Hawaii, Idaho and Nebraska, and formerly USDA, Natural Resources Conservation Service. At present, in private employment, and currently residing in Rio Rancho, New Mexico, 87124 USA (josephmay8@gmail.com).