GRAZIER'S ARITHMETIC — Lesson 5

Introduction

Determining the appropriate stocking rate for a particular grazing unit is a key decision affecting the profitability and viability of a grazing operation. Livestock intake and subsequent performance is very dependent upon forage available to the animal on a daily basis. Setting the stocking rate too low results in wasted forage and lost profit potential. Setting the stocking rate too high results in lowered intake and animal output and, very frequently, diminished profits. If a producer has been fairly successful in a traditional grazing system, a fairly good idea of appropriate stocking rate is already available. While in the long term carrying capacity will be increased with improved grazing management, do not expect to increase stocking rate substantially in the first year of a Management Intensive Grazing system.

Seasonal Carrying Capacity

Carrying capacity is the stocking rate that is economically and environmentally sustainable for a particular grazing unit throughout the grazing season. Carrying capacity is largely determined by four factors: 1) annual forage production, 2) seasonal utilization rate, 3) average daily intake, and, 4) length of the grazing season. These terms can be expressed in the mathematical formula below:

Equation 1: Carrying Capacity

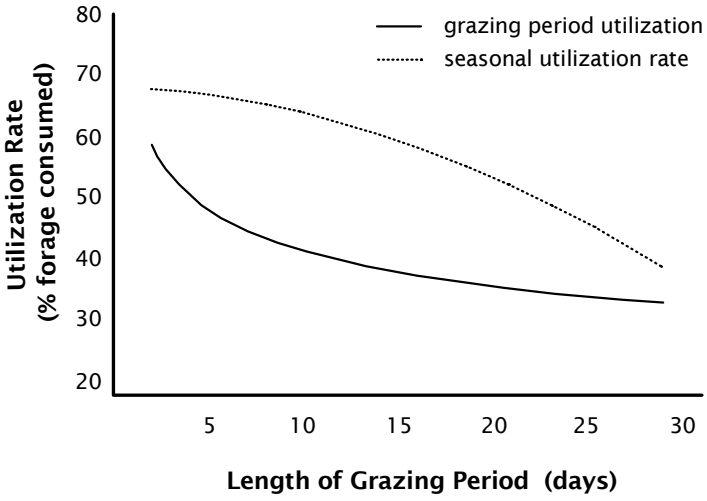
$$\text{Carrying Capacity} = \frac{\text{Annual Forage Production} \times \text{Seasonal Utilization Rate}}{\text{Average Daily Intake} \times \text{Length of Grazing Season}}$$

Annual forage production is the total amount of forage dry matter produced per acre on an annual basis *(see Lesson 1 for measurement techniques).* This would include both hay and pasture harvested from grazed acres. In the formula, this term should be expressed as pounds of forage per acre.

Seasonal utilization rate is the percentage of the annual forage production that will actually be harvested by the grazing livestock. This will be very dependent upon rotation frequency and expected level of animal performance. Figure 1 can be used to estimate approximate seasonal

utilization rate based on average grazing period length. For example on a 3-day rotation, a reasonable seasonal utilization rate would be 70 percent. Utilization rate is expressed as a unitless decimal fraction in the formula (ie 0.70).

Figure 1: Seasonal and grazing period utilization rates relative to length of grazing period.



Average daily intake should be set at the level that will be required to yield the desired animal performance level. This may well be the most difficult part of the entire process. To accurately determine the appropriate intake value, some estimate of forage digestibility and energy is required. These values cannot be reliably determined without careful forage sampling and laboratory analysis. For this reason we tend to insert arbitrary values in this space and error on the side of overestimating intake. Average forage intake values for high, medium, and low performance of either steers or cow-calf pairs would be 3.5 percent, 3.0 percent, or 2.5 percent as a percentage of the animal's bodyweight. (0.035, 0.03, 0.025)

For example, a 1200 lb. cow of medium milking ability would consume about 36 lbs. of forage dry matter on a daily basis (or 0.03 times body weight). In the calculation, intake is expressed as lbs. of forage/lb. of liveweight.

Length of the grazing period is a function of how many paddocks are available and the required rest period. Rest period requirements are going to vary for different species and environmental conditions, such as rainfall, temperature, etc. The choice for length of grazing period must be compatible with the utilization rate used in the calculation as indicated by Figure 1.

When the appropriate values have been entered into the equation and calculations made, the resulting answer is the pounds of animal liveweight that each acre of the grazing unit will support for the indicated grazing season.

As an example, we will assume that an average acre of improved pasture and hay land will produce **7600 lbs. of forage dry matter annually**. If we plan to use an **average 3-day grazing period**, we find by referring to Figure 1 that the corresponding **seasonal utilization rate is approximately 68 percent**. The livestock will be steers that we hope to have gain 1.5 to 2 lbs./head/day. This would be a moderate performance level, so **intake** is entered **at 3 percent of bodyweight,** which is **.03 lb. of forage/lb. of liveweight**. It is important to enter intake in this format, not as 3 percent so that units cancel out. We will anticipate grazing the steers from May 1 to October 20 or a total of **164 days**.

We make the following calculation:

$$\frac{\text{7600 lb forage/acre X .68}}{\text{.03 lb forage/lb liveweight X 164 days}} = \text{1050 lb liveweight/acre = Carrying Capacity}$$

The 1050 lbs. liveweight/acre is an indication of the carrying capacity of this unit. If we purchase 525 lb. steers, can we stock the unit at 2 steers (1050 lb. liveweight/acre ÷ 525 lb./steer) to the acre? Only on the first day of the season! Why? Because the animals are, hopefully, gaining weight every day and quite likely the average forage availability in August is lower than that in May. If expected average daily gain is 1¾ lb./hd/day, the average weight of steers at mid-season will be 668 lb. (525 lb. + (82days X 1¾ lb./day)). Initial **stocking rate** could be set at **1.6 steers/acre (1050 lbs. liveweight/acre ÷ 668 lbs. liveweight/steer**). Remember this is a guideline to help make initial stocking decisions, and not a magical recipe for universal financial success.

GRAZING PERIOD STOCK DENSITY

After making basic farm stocking decisions, the time comes for every grazier to make the actual decision of where to place a break fence or how many animals to place in a particular paddock. That decision is based on the same principles used in the carrying capacity equation discussed above but modified to represent single grazing period conditions rather than seasonal values.

The **carrying capacity equation** (Equation 1) becomes the **stock density equation** (Equation 2) with the following modifications:

Equation 2: Stock Density

$$\text{Stock Density} = \frac{\text{Available Forage X Grazing Period Utilization Rate}}{\text{Average Daily Intake X Length of Grazing Period}}$$

Available forage is the quantity of forage dry matter that is actually allotted to the animals for a grazing period. Accurately measuring forage availability is time consuming and expensive so we tend to rely on estimations of yield. The simplest method is to look at a pasture and make an educated guess as to what the forage availability is likely to be. With practice, a good grazier can consistently estimate within 20 percent± the actual yield. A second method relates height and condition of the pasture to dry matter yield. Height X dry matter yield relationships for several types of pasture are given in Table 1.

Table 1. Estimated dry matter yield in pounds per acre-inch for several pasture types and stand conditions.

Pasture Species	Stand Condition, (lb./acre/inch)*		
	Fair	**Good**	**Excellent**
Bluegrass/Clover	150-200	250-300	300-350
Perennial Ryegrass/Clover	150-200	250-300	350-400
Orchardgrass/Legume	150-200	250-300	300-350
Timothy/Legume	150-200	250-300	300-350
Tall Fescue + Nitrogen	100-150	200-250	350-400
Mixed Pasture	150-200	250-300	300-350

*Values from Pasture Stick developed by Cornell University and NRCS

The stand condition is determined based on visual estimate of green plant ground cover after the paddock has been grazed to a 2-4 in. residual. An **excellent** stand has at least **90 percent** of the ground covered by green plant material or less than 10 percent exposed soil. The **good** condition has **75 - 90 percent** ground cover or 10 - 25 percent bare ground. **Fair** condition has **less than 75 percent** ground cover or greater than 25 percent bare ground exposed. In all cases, moderate soil fertility is assumed.

The following example illustrates how to determine where to place a temporary fence to create a paddock to feed a herd of **100 steers** weighing **600 lb./hd** for **3 days** with a rate of gain objective of **2.25 lb./hd/day**. The pasture is **orchardgrass-red clover 8-10 inch tall** and the area where the steers have just finished grazing has about **20 percent bare ground**. The pasture is **40 acres** and is **660 ft wide**. To use the stock density equation we must first determine the appropriate values.

Forage availability can be estimated from Table 1 using the average sward height of 9 inches and the stand condition as good. The corresponding value for an orchardgrass-legume pasture is approximately 250 lbs./acre-inch, so the available forage is **2250 lbs./acre** (9 inches X 250 lbs./acre-inch).

Figure 1 can be used to estimate the appropriate **utilization rate** for a **3 day grazing period**. As an average daily gain of **2.25 lbs./hd/day** is a high performance objective, utilization cannot be excessive or else intake will be limited. To maintain an intake rate of **3.5 percent of bodyweigh**t, a **50 percent utilization rate** appears to be appropriate to use in the calculation. Assuming the 3 day grazing period, we can make the following calculation:

$$\frac{\textbf{2250 lbs. forage/acre X .5 utilization rate}}{\textbf{0.035 lbs. forage/lb. liveweight X 3 days}} = \textbf{10,714 lbs. liveweight/acre}$$

The steers weigh **600 lb/head** and each acre will support **10,714 lbs. liveweight**, so the pasture can be stocked at the rate of **17 steers/acre/3 day period** (10,714 lbs. liveweight/acre ÷ 600 lb.

liveweight/steer). The herd of **100 steers** will require **5.8 acres/paddock (100 steers ÷ 17 steers/acre)**.

For ease of figuring, assume 6 acres per feed strip. It is better to give a little more and waste a little feed than to allow too little and limit intake. To determine where to place the fence, calculate the total square footage in the 6 acres **(6 acres X 43,560 ft^2 /acre = 261,360 ft^2**) and divide by the known width **(261,360 ft^2 ÷ 660 ft = 396 ft)**. Placing the temporary fence at approximately 400 ft will give adequate forage for the 100 steers for the 3 day grazing period.

It is very important that values used for the parameters in the equation are realistic in how they relate to one another. All of the parameters are interrelated and inserting an inappropriate value for any one parameter will result in erroneous conclusions. For example, if available forage is below 1500 lbs./acre, an intake of 3.5 percent would be impossible to achieve. For this reason, the equation cannot be used as most mathematical formulas where if all but one value is known the remaining value can be calculated. A calculation can be made, but the result may be biologically meaningless.

AN EVEN SIMPLER APPROACH

For those who find equations like those above a bit intimidating or take a very simple approach to life, forage allocation can be made even simpler. If we compute the average for each stand density from Table 1, we come up with 216, 325, and 433 lbs./acre-inch for **fair**, **good**, and **excellent** pasture, respectively. If we assume that a **1000 lb. lactating cow will consume around 3%** of her bodyweight, we can figure a **"cow-day" to be equal to 30 lbs. of forage consumed (see Table 2 for livestock consumption data)**. If we divide 30 lbs. of forage/cow-day into the lbs. of forage /acre-inch, we find that the **"cow-day" yield of fair**, **good**, and **excellent** pasture to be about **7, 10, and 14 cow-days/inch of pasture consumed.**

This becomes a simple method of allocating pasture:

1) Look at the pasture and determine it to be fair, good, or excellent
2) Measure or estimate the height of the pasture to be allocated
3) Subtract from the total height the height of stubble you want the animals to leave
4) Multiply the difference between starting height and ending height by the cow-days/inch to figure available cow-days/acre
5) Divide the number of cows in the herd by cow-days/acre to figure how much area should be allocated.

EXAMPLE:

Step 1. We look at the grass and say, "This is average grass" which gives us a cow-day/inch factor of 10.

Step 2. We measure the height to be 8".

Step 3. We would like to leave a 3" residual, so 8" - 3" = 5" to be grazed.

Step 4. 5 inch grazed X 10 cow-days/acre-inch = 50 cow-days/acre.

Step 5. If we have 100 cows, we should allocate 2 acres/day.

Table 2. Livestock consumption data* (pounds daily dry matter intake based on body weight & level of performance)

Species	3.5%	3.0%	2.5%
Dairy cow (1400 lbs)	49	42	35
Dairy heifer (1000 lbs)	35	30	25
Sheep (250 lbs)	8.75	7.5	6.25
Sheep (125 lbs)	4.4	3.75	3.1
Beef cow-calf pair (1600 lbs)	56	48	40
Beef cow-calf pair (1200 lbs)	42	36	30
Beef steer (600 lbs)	21	18	15
Horse & equines (1000 lbs)	35	30	25
Horse & equines (1600 lbs)	56	48	40
Goat (75 lbs)	2.6	2.25	2.0
Goat (150 lbs)	5.25	4.5	3.75
Elk (800 lbs)	28	24	20
Red Deer (220 lbs)?	7.7	6.6	5.5
Fallow Deer (150 lbs)	5.25	4.5	3.75
Alpaca (250 lbs)	8.75	7.5	6.25
Llama (500 lbs)	17.5	15	12.5

* For accuracy check the weights of your own animals.

If you are going to use a flexible paddock system where temporary fences are strung between two permanent subdivision fences, it is very desirable to set the main fences at a spacing that allows for simple calculation of acre increments. It is very handy to have the line posts in the permanent fences set at known intervals that mark fractional acre increments. For example, if the permanent strips are 300 ft. wide, then line posts at 50 ft. intervals mark about 1/3 acre strips. Forward planning at fence building time can make future operation of the system much simpler.

This example works fine for 1000 lb. cows, but what about other classes of livestock. As grazing management is an imprecise science due to ever changing conditions, we are only looking for an approximation, not perfection. If cows are anywhere in the 900 to 1200 lb. range, the simple approach used above will probably be adequate. If you have livestock of different weights, you can add up the total estimated weight of all the livestock in the herd, divide by 1000 and be fairly close to "cow-day" equivalents.

SUMMARY

Initial stocking rate of a grazing unit can best be determined by having an estimate of total forage production from the unit and a target for livestock performance. Do not expect to immediately increase the stocking rate of a particular unit above its current use level without making other improvements in the pasture condition. Daily allocation of forage to livestock can be challenging initially. The examples shown in this lesson offer processes for making educated guesses as to daily stocking decisions, but experience is still the best guide to learning grazing management. No amount of studying and calculating replaces daily experience with a particular group of animals on a particular pasture.

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Appendix A:

Relative proportion of grass, Forbs and browse in the diets of cattle, sheep and goats.

Kind of forage	Cattle	Sheep	Goats
Grass	60%	40%	20%
Forbs	20%	40%	30%
Browse	20%	20%	50%

Appendix B:

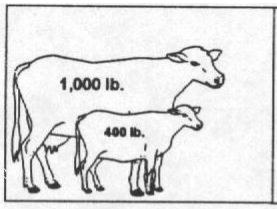
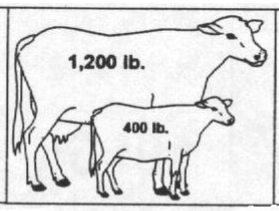
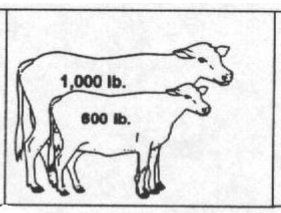
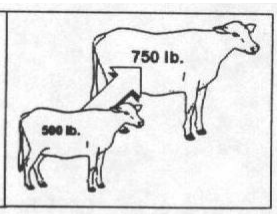
A method used in many locations to express carrying capacity is the Animal Unite (AU) model. This program defines animals according to their forage dry matter intake. An AU is defined as the average annual amount of forage required for a 1,000 lb. mature cow of average milking ability with a calf less than 4 months old, expected to wean at 400 lbs. This is roughly 10,080 lbs. of forage dry matter per year. Other classes of livestock are defined relative to this standard. Stocking rate and carrying capacity can then be expressed in AU months (AUM), about 840 lbs. of air-dried forage, and different animals are expressed in terms of their AU equivalents (AUE). Therefore a 1,200 lb. Cow would be 1.2 AUE. A 400 lb. weaned calf would be 0.4 AUE. Other general conversions are listed in the table below.

Animal Unit Equivalents (AUE) for different species and classes of livestock and wildlife

Animal	AUE
Mature ewe with lamb	0.2
Ram	0.2
Weaned wether	0.17
Doe goat with kid	0.17
Buck Goat	0.17
Weaned wether (goat)	0.14
Horse (adult)	1.25
Elk	0.07
Whitetail deer	0.14

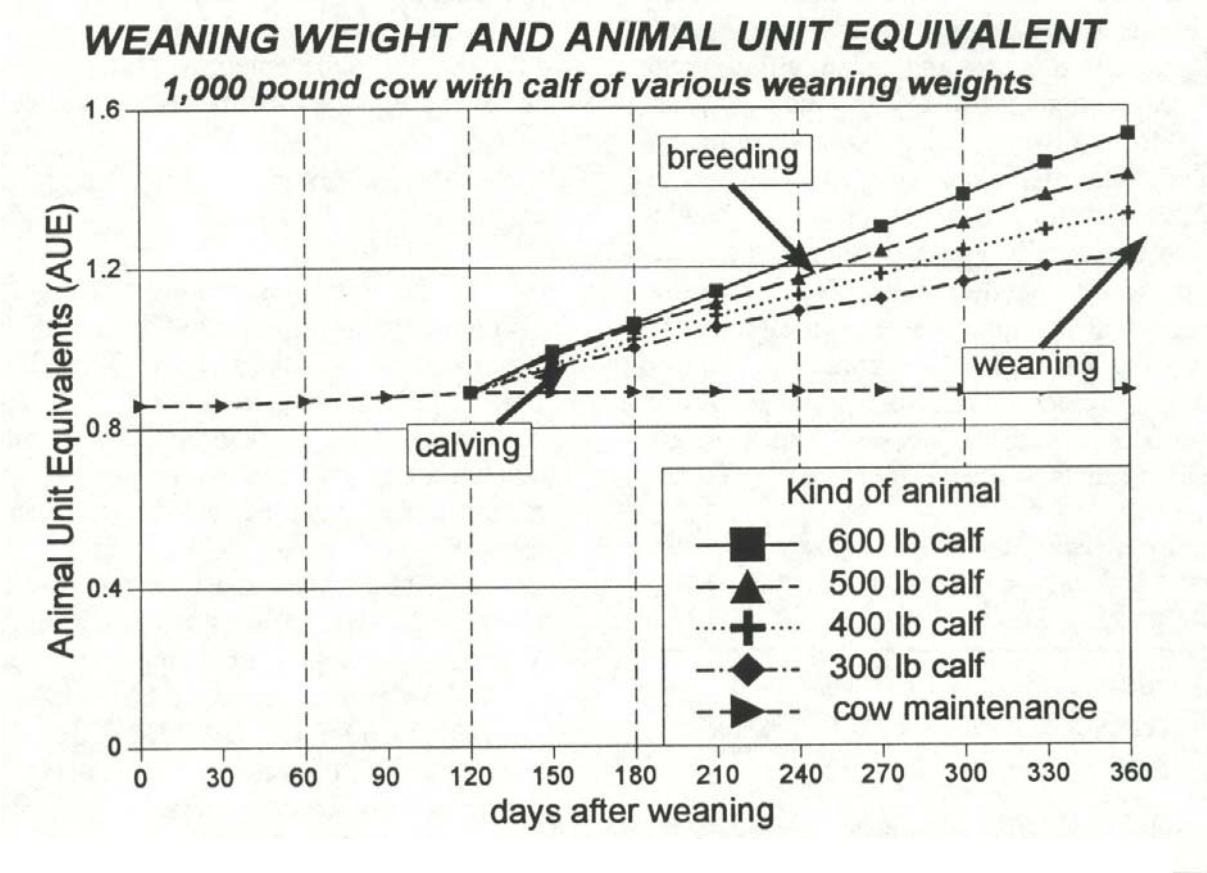
Appendix C:

Calculating the AUE of different classes of cattle

				
Animal	1,000-pound cow average milking Graze 6 months Wean calf at 400 lbs.	1,200-pound cow average milking Graze 6 months Wean calf at 400 lbs.	1,000-pound cow average milking Graze 6 months Wean calf at 600 lbs.	500-pound stocker grazing 5 months to 750-pound weight
AUE	Defined as 1.0 AUE	Cow is larger $\frac{\text{1,200-lb.}}{\text{1,000-lb.}}$ = 1.2 AUE	Calf is larger $\frac{\text{1,000}}{\text{1,000}}$ = 1.0 AUE	Stockers $\frac{\frac{\text{500 lb. + 750 lb.}}{2}}{\text{1,000}}$ = 0.625 AUE
AUM				
Cow	1.0 AUE X 6 months = 6.0 AUM	1.2 X 6 months = 7.2 AUM	1.2 X 6 months = 7.2 AUM	0.625 X 5 months = 3.125 AUM
Calf	0.3 AUE X 6 months = 1.8 AUM	0.3 AUE X 6 months = 1.8 AUM	$\frac{\text{(600-lb. - 400 lb.)}}{\text{1,000}}$ (0.2 + 0.3)AUE X 6 months = 3.0 AUM	NA
Total AUM	7.8 AUM	9.0 AUM	10.2 AUM	3.125 AUM

Appendix D:

The relationship of weaning weight to Animal Unit Equivalents for a 1,000-pound cow with various weaning weights.



Appendix E:

Estimating Pasture Carrying Capacity

Pasture	Site or Fertilizer Rate	Acres	Condition	Pounds/Ac	Animal Days/Ac	Comments

Appendix F:

Converting Harvested Forage to AUM

Forage	Kind	Acres	Ton/Ac	Animal Days/ton	Comments

Appendix G:

Summary of Forage Need
(Livestock Needs)

Month

Kind of animal	Number	Animal Days	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total

Lesson 5 Quiz Grazier's Arithmetic

1) T or F Determining proper stocking rates will have little effect on profitability for a grazing operation.

2) If your stocking rate is too low you will _____ and if your stocking rate is too high, it will result in _____.
   a. waste forage; higher gains
   b. increase utilization; higher gains
   c. waste forage; lower animal intake & output
   d. increase utilization; lower gains

3) Name three factors used to determine carrying capacity.
   a. _____
   b. _____
   c. _____

4) T or F Annual forage production is the total amount of forage produced per acre that is harvested mechanically.

5) T or F Seasonal utilization rate is the percentage of the annual forage production harvested by grazing livestock.

6) T or F Average daily intake should be set at the level that will be required to yield the desired animal performance level.

7) Between the Carrying Capacity and Stock Density equations, which one uses a quantity of forage dry matter actually allotted to the animals for a grazing period?

8) Which of the following is most representative of the length of a grazing season in Maine?
   a. 5 days
   b. 60 days
   c. 165 days
   d. 365 days

9) According to Figure 1, what would your approximate seasonal utilization rate be if your grazing period length were 10 days?
   a. 30%
   b. 43%
   c. 55%
   d. 65%

10) Again, according to Figure 1, what would your approximate grazing period utilization rate be if your grazing period length were 10 days?
    a. 30 %
    b. 43%
    c. 55%
    d. 65%

11) A producer is grazing steers weighing 750 lb/hd with a daily rate of gain goal at 2.0 lb/hd. His/her timothy/legume pasture is 8-12 inches tall with 20% bare ground after the last grazing. He/she wishes to graze the paddock for 4 days. The producer figures his/her utilization rate is around 50% and intake is approximately 3.5% of body weight. Using the dry matter table and the stock density formula, what should the stocking density be?
    a. 10500 lb/ac
    b. 6250 lb/ac
    c. 3000 lb/ac
    d. 12500 lb/ac

12) Using the information from problem 11, how many head could the producer stock/acre/4 day grazing period?
    a. 7
    b. 8
    c. 11
    d. 13

13) Again, using the information from problem11, how big would the producer need to make the paddock if he/she is grazing 40 steers?
    a. ½ acre
    b. 1 acre
    c. 2.5 acres
    d. 4.8 acres

14) According to the simple approach, if a producer was grazing 1000 lb beef cows in thick pasture that is 12 inches tall and wishes to graze the forage down to 4 inches, how many acres/day does the producer need to graze 80 cows?
    a. .33 acre/day
    b. .91 acre/day
    c. 1.4 acres/day
    d. 1.8 acres/day

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Name _____ Phone _____

Address _____

(Optional) Fax _____ E -mail _____