



Grazier's Math: Calculating Carrying Capacity

Why Carrying Capacity Matters

Carrying capacity could be the most important concept in all of livestock agriculture. It is carrying capacity, specifically *incorrect* carrying capacity, also known as "overstocking", that drives most of livestock agriculture's environmental problems today. Also commonly referred to as "stocking rate," carrying capacity is the number of animals a parcel of land can support by providing adequate feed and retaining and recycling the nutrients they produce. In grazing systems, where livestock harvest their own feed and spread their own manure, carrying capacity is foundational to a long grazing season that results in healthy animals, healthy pastures and a healthy ecosystem.

A primary goal of every grazing operation should be to maximize the length of the grazing season. This is directly correlated to profit because grazed forages are the most inexpensive source of feed, and stored feeds are almost always the greatest expense. Management helps determine grazing season length. The principles of managed grazing – the *Three R's* of rotation, residual, and rest – drive pasture yield and quality and have a significant impact on the farmer's ability to lengthen the grazing season. But the *Three R's* only work when we get the *carrying capacity* right.

Farms that fail to determine carrying capacity correctly can be overstocked and run out of pasture before the end of the growing season or be



Figure 1. *Calculating carrying capacity is a critical step to successful grazing.*

understocked and grazing fewer livestock than the land could support, both resulting in reduced revenue.

Many factors influence carrying capacity. Some are inherent, such as soil type, topography, and climate. Others are choices, such as livestock class, management, and operational goals, like whether winter feed is produced on-farm or purchased off-farm.

Factors Influencing Carrying Capacity

The first step of determining carrying capacity is collecting information unique to the farming operation. The factors are broken into two groups – those that are more "foundational" to the particular type of livestock operation and are not likely to be changed, and "decision factors" that a farmer must determine from year to year.

Foundational Factors:

Grazing Management

Frequency of rotation has a significant impact on pasture yield. The more often animals are moved, the higher the overall yield will be. For this calculation, a minimal three-day rotation is assumed.

Soil Type

Wisconsin is well-known for its diversity of soil types. Within a farm, and even within a pasture there can be multiple different soil types. Soil type strongly influences pasture yield. When calculating carrying capacity, the predominant soil type is most relevant. This information can be found at the Web Soil Survey.

Land Base

The total acreage used for determining carrying capacity should include any acres intended to be grazed during the grazing season. Any additional acres that are not used for livestock feed should not be included.

Forage Yield

Some farms with a history of growing crops on their land have a good idea of the average forage yield on their operation. Obtaining accurate yield estimates can be challenging. In the absence of accurate yield estimates, it is acceptable to utilize average forage yields for the region and soil type. This information is also at the Web Soil Survey, in the Soil Data Explorer under "Vegetative Productivity."

It is very important to use *dry matter* yield per acre, and not wet or as-fed yields, because these are highly variable from differences in moisture content. Dry matter yield addresses these variations by correcting for moisture. Further, animal intake predictions, which will be covered later in this publication, are all based on intake of dry matter.

Carrying capacity

is foundational to the success of livestock agriculture, balancing land stewardship with financial goals. Determining what the land can support is not just an ethical responsibility, it's the first step toward a synergistic relationship among the farmer, the livestock, and the land.

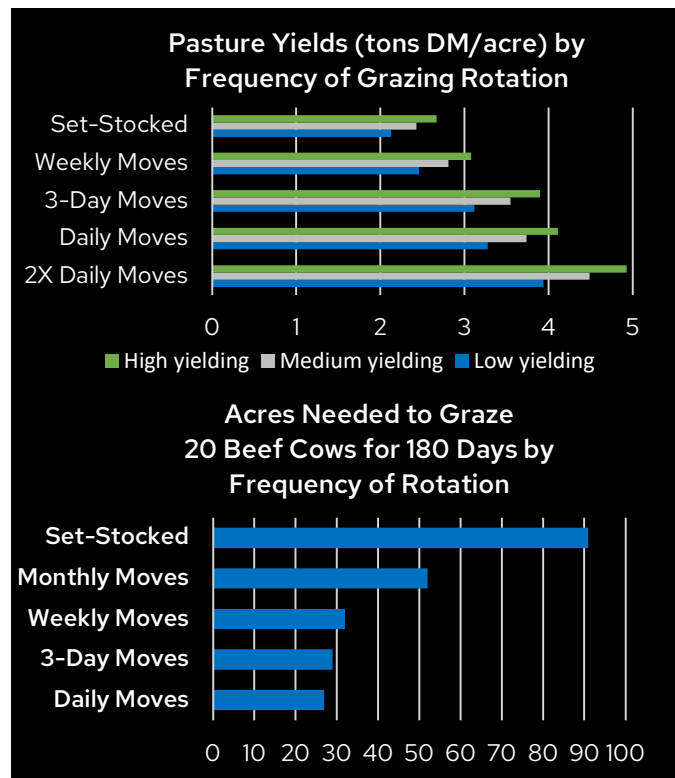


Figure 2. Pasture yield and carrying capacity for pastures established under various forms of grazing management. More frequent rotation leads to greater annual forage production (top) and less land required (bottom). Pasture yield data from UW-Madison (Chasen, 2023) and acreage requirement estimates from USDA-NRCS Forage Animal Balance Worksheet.

Animal Weight

Animal weight can vary drastically from farm to farm and even within a particular farm. To calculate carrying capacity, the average animal weight for the herd or flock is used. It is advisable to stay conservative (overestimate animal weight, underestimate yield) with this estimate, as it is more costly to overestimate than to underestimate carrying capacity. This is especially important for growing animals. For example, calves continue growing through the grazing season and their weights are oftentimes underestimated. **When planning carrying capacity, estimate end of grazing season weights** for growing animals, such as calves. As with forages, many farms may not know the weights of their animals, but using standard values for different livestock classes is sufficient (for example, see Table 1 on Page 3).

Forage Intake & Allocation

"Intake" is a term that refers to how much feed or forage an animal consumes in a day. "Allocation" is

the term used for the amount of feed or forage planned or set aside for an animal per day. In general, most livestock consume about 3% of their body weight in dry matter per day, and that value is used to estimate intake. But calculating carrying capacity for year-round grazing systems must also account for material that is left behind via residual and trampling during the grazing season, as well as hay waste and increased consumption during cold weather. This is done by adding an extra 1% of dry matter to intake, so 4% of body weight is used to estimate forage allocation.

Livestock Class	Average Weight	Allocation (pounds DM/day)
Beef Bulls	1500	60
Beef Calves	400	16
Beef Cows	1300	52
Beef Stockers	900	36
Beef Yearlings	800	32
Dairy Heifers	800	32
Large Dairy Cows	1500	60
Small Dairy Cows	1000	40
Goats	150	6
Lambs	75	3
Sheep Ewes	150	6
Rams	200	8

Table 1. Forage dry matter allocation estimates based on 4% of body weight for each class of livestock. Actual values will vary from farm to farm depending on age, breed, and genetics, but those listed in the table can be utilized when actual values are not known.

Decision Factors:

Length of Grazing Season

The goals of each farm will vary, but most grazing operations interested in maximizing the grazing season have a goal of at least 180 days (6 months) of grazing. The irony of this value is that it is directly influenced by the farm's actual carrying capacity.

Stockpile Grazing

Stockpile grazing is one tool that can extend the grazing season and reduce costs by delaying the need for stored feed. If a farm does not stockpile

graze, this section can be ignored. Farms that do practice stockpiling need to start by identifying the target number of days they hope to stockpile graze. The number of grazing days will help to determine the length of stockpiling period and acres needed. A minimum of 30 days is recommended, but additional days can ensure more stockpiled forage. Forage growth rates slow as the season progresses and the stockpiling period exceeds 30 days. Thus, stockpiling pastures beyond 60 days is not likely to provide significantly more forage.

Stored-Feeding Season Length

No one can determine how long winter will be, but every farmer must estimate the number of days needed to feed livestock. Many grazing operations "outwinter," or feed on pasture through the winter. One of the most common methods of feeding hay through the winter is bale grazing (see the Extension publication: *Bale Grazing: A Winter Feeding Strategy*). For calculating carrying capacity, the duration of the stored-feed season will be the number of days remaining after the sum of grazing and stockpile grazing days are subtracted from 365 days. Many grazing farms with goals of 6 months of grazing and 2 months of stockpile grazing plan for 245 total grazing days and 120 days of stored feed.

For more information on how to implement stockpile grazing and bale grazing, refer to [*Bale Grazing: A Winter Feeding Strategy*](#) and [*Stockpile Grazing: A Strategy for Extending the Grazing Season*](#), available on Wisconsin's Grazing Roots resource library.



Figure 3. The process of calculating each component of carrying capacity is an opportunity for farmers to consider options such as making hay or stockpile grazing.

Crunching the Numbers

When it comes to putting these numbers to work, calculating carrying capacity is a step-by-step process involving multiple interconnected factors. For example, a farm custom-raising dairy heifers for the summer will have a much greater carrying capacity than a farm raising beef cows and calves because they need not account for acres for hay production. On the other hand, some farms employing winter-feeding may choose to purchase all hay to increase carrying capacity. These examples demonstrate how each step provides an opportunity for farmers to consider their options. Financial components of these decisions are not addressed here but must be part of the process. For example, some farms may consider alternatives to stockpile grazing for extending the grazing season such as annual cover crops, crop residues, etc.

To begin calculating carrying capacity, identify the necessary farm information in table 2.

Farm Information	
Predominant soil type (use Web Soil Survey)	
Land base for grazing (acres)	
Average forage dry matter (pounds/acre)	
Average animal weight (pounds)	
Grazing season length (days)	
Stockpile grazing length (days)	
Stored-feeding length (days)	
Forage dry matter accumulation (pounds/acre/day)	

Table 2. Farm information needed to calculate carrying capacity.

Soil type and forage production estimates for farms can be found in Web Soil Survey

(websoilsurvey.nrcs.usda.gov/app).

Forage estimates are found in the Suitabilities and Limitations for Use tab > Vegetative Productivity section > Yields of Irrigated/Non-Irrigated Crops.

Once the farm information is collected, calculating carrying capacity is a step-by-step process. Each step determines a different factor that helps the farmer consider operational options and decisions. The following factors are determined in the process laid out below. The calculations start with step 1 – Dry Matter Requirement Per Head on page 5 and proceed through each of the 7 steps.

Steps for Calculating Carrying Capacity

1. Dry matter required per head
2. Growing season acres required per head
3. Stockpile grazing acres required per head
4. Hay production acres required per head
5. Carrying capacity for the growing season
6. Carrying capacity for growing season + stockpile grazing
7. Carrying capacity for extended season grazing + hay production

Refer to the Bale Grazing and Stockpile Grazing publications at go.wisc.edu/extensiongrazing for more information on implementing these practices.



Steps and Formulas for Calculating Carrying Capacity

1. Dry Matter Requirement Per Head

	X	=	
Forage pounds dry matter per acre		Total acres for grazing	Total forage dry matter available annually
	X	=	
Average animal weight		4% of body weight*	Average dry matter allocated per head per day

*See "Forage Intake & Allocation" section on page 3

2. Growing Season Grazing Acreage Per Head

	X	=	
Average dry matter allocated per head per day		Number of days of growing season grazing	Total dry matter needed per head for growing season
	/	=	
Total dry matter needed per head for growing season		Average dry matter yield per acre	Total acreage needed per head for growing season

3. Stockpile Grazing Acreage Per Head

	X	=	
Average dry matter allocated per head per day		Number of days of stockpile grazing	Total dry matter needed per head for stockpile grazing
	/	=	
Annual dry matter pounds per acre		Number of days in entire grazing season	Pounds of dry matter accumulation per acre per day
	X	=	
Pounds of dry matter accumulation per acre per day		Number of days of stockpiling (up to 60*)	Total pounds of stockpiled dry matter available per acre
	/	=	
Total dry matter needed per head for stockpile grazing		Total pounds of stockpiled dry matter available per acre	Total acreage needed per head for stockpile grazing

*See "Stockpile Grazing" section on page 3

4. Hay Production Acreage Per Head

	X	=	
Average daily dry allocated per head per day		Number of days of feeding hay	Total dry matter needed per head for feeding hay
	/	=	
Total dry matter needed per head for feeding hay		Average dry matter yield per acre	Total acreage needed per head for feeding hay

5. Carrying Capacity for Growing Season Grazing

$$\frac{\text{Total acreage available}}{\text{Acreage per head (from step 2)}} = \text{Carrying capacity for growing season}$$

6. Carrying Capacity for Extended Season (Growing Season + Stockpile) Grazing

$$\frac{\text{Total acreage available}}{\text{Acreage per head (total of steps 2+3)}} = \text{Carrying capacity for growing season and stockpile grazing}$$

7. Carrying Capacity for Extended Season Grazing + Hay Production

$$\frac{\text{Total acreage available}}{\text{Acreage per head (total of steps 2+3+4)}} = \text{Carrying capacity for extended season grazing + hay production}$$

What if I have more animals than my land can support?

Determine the number of animals over carrying capacity and decide whether the goal is to reduce or maintain the herd size. If the goal is to keep them, you can:

- **Expand pasture base** – multiply the total acreage per head in steps 5, 6, or 7 by the additional animals to determine how much land to convert, lease, or purchase for pasture.
- **Purchase extra feed** – multiply dry matter allocated per head from step 1 by the number of additional animals to determine how much hay is needed.

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References

Chasen, E.M. 2023. Predicting pasture yield in Wisconsin: Yield potential predicted by soil, grazing management, and grass species-clover mix. Web-application. Grassland 2.0 project. University of Wisconsin-Madison. <https://connect.doit.wisc.edu/pasturePrediction/>

Resources

- [Bale Grazing: A Winter Feeding Strategy](#)
- [Stockpile Grazing: A Strategy for Extending the Grazing Season](#)
- [Pastures for Profit: A Guide to Rotational Grazing](#)

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