Forage Management Application

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Introduction

When we talk about improving pasture management, most may think about expensive practices, heavy fertilization, improved cultivars or rotational stocking. While some of that is important, the truth is that with some planning and small changes, we can make a lot of difference at minimum or no cost! We first need to understand some basic concepts, then take the next steps on investing on our pastures. With issues like overgrazing and lack of adequate forage, other management techniques will have minimum to no effect while still costing labor and money. Thus, we need to first work on some base concepts and do a little planning. In an analogy to animal health, we should work on the causes of the disease (organizing your pasture scheme) instead of only treating its symptoms (feeding more purchased feedstuff). The most common "symptom" we see in pastures everywhere is the lack of forage due to overgrazing, followed by excessive hay feeding during the "off season". A great advantage of Florida over Northern and Western states is the possibility to grow forage virtually year-round. If it is limpograss for the fall and winter in the South Florida or small grains and ryegrass in North Florida, we can cover most of the gaps with some creativity and good planning.

A frequent *modus operandi* is to continuously do things as they have been done in the past, even when they did not work, in hope for a better year. Then, blaming previous failures on factors that were out of our control like the weather, in hope that this year will be better. Well, hope is not a strategy and in business if we do not have a well delineated strategy then,in times of need we may find ourselves desperate trying to find remediation for our problems. And that's expensive! Even for "uncontrolled" factors there can be some yearly planning based on the goals to be achieved for the farm and herd to reduce the negative effects of unpredictable weather and market. For this to occur, first it is essential to understand and become familiar with a few concepts that can help you better manage your pastures in an attempt to sustain forage production for animal performance. Our goal is to improve pasture utilization and create a system that is less dependent on purchased or stored feed and more resilient to variations in weather and market.

Principles to Begin with

Principles are the starting point - the basis of the system. The fundamental principle of pasture management is *carrying capacity*. In simple words, it means the maximum number of animals or animal units that your pastures can support in order to achieve a targeted animal performance without compromising the pasture (Allen et al., 2011). Carrying capacity can be calculated for a pasture or a whole ranch, for a specific period. My personal advice is to calculate for all available pastures for one-year period: this way you know what your options are and how much forage you can count on during that cycle. By knowing our carrying capacity, we can determine how many animals we can have in our system, and further plan our management strategies.

Why is carrying capacity the starting point? Well, if our system is overstocked (i.e. when we have more animals than it can support), we are starting with a negative budget, requiring extra feed (hay, concentrate, etc.) to match our herd's requirements. In that case, no other pasture management practice will be able to overcome that problem (Sollenberger and Vanzant, 2011). Some may argue that fertilizing pastures might help. Yes, but only to a point. Besides, it can be very expensive and little response if the

pasture is overgrazed, for example, with few leaves and roots, so plants cannot utilize that extra fertilizer properly. Thus, we need to start from the base of the system.

The second most-important concept is *herbage allowance* which refers to the amount of forage available per unit of animal. Although vital, it is a hard concept to grasp and similarly hard to apply on the real world, because it involves some effort on measuring pasture herbage mass (here we will focus only on the planning part, but for information on measuring pasture productivity, check the UF EDIS publication by Dubeux et al., 2019 - Estimating herbage mass on pastures for adjusting stocking rate). That is why people commonly use stocking rate (lb of live weight (LW)/acre or animal units per acre). However, stocking rate refers only to one side of the equation: the animal. There is no reference of how much forage you have. While one cow-calf par per acre in bahiagrass might seem much, is probably adequate for a pearl millet pasture, for example.

Herbage allowance is normally expressed as lb of herbage dry matter (DM) per lb of LW when we are measuring it on a pasture for that specific period. For planning, it is easier to think about how much the animals need, in % LW of forage available per day and use some predictions of pasture growth to calculate how much pasture you will have. Pasture growth is calculated using herbage accumulation rate (lb DM per acre per day). By calculating the herbage allowance, we can make sure that we are offering sufficient forage to our animals. And, very important: we should have two to three times more forage available than what the animals can consume. This will assure the animals can select what they are eating (i.e. with no restriction to intake) and there will be sufficient plant residual leaves for a fast regrowth. For example, let's consider a 1100-lb cow (1 animal unit - AU) with an intake of 2.5% of its LW per day (roughly between 1.8 and 3%). That means each day it will eat 27.5 lb of dry matter, so we need to offer it between 55 and 82.5 lb of DM per day, which is around 5 and 7.5% LW per day.

There are a few other important concepts that we will not get into much detail. *Resting period* will be inherent to our grazing intensity. The higher the grazing intensity the longer the resting period required for your pasture to recover. Also, a longer resting period will likely reduce total biomass production and nutritive value of the pasture. In fact, resting period can be short if grazing intensity is around 40% (i.e. graze only 40% of initial biomass or canopy height), and this can result in greater herbage production because of the large residual leaf area while also improving animal performance by grazing only the top leaves, which have higher nutritive value. Note that grazing intensity can be high or low with the same carrying capacity and stocking rate, since both parameters are calculated based on a whole area. It is just a matter of how to arrange animals in the paddocks. For example, when you divide the pasture in several paddocks for rotational stocking, the number of animals in each paddock at one time is called *stocking density*. Both, *rotational or continuous stocking* are always hot topics in pasture management discussions. Rotational stocking can improve pasture utilization, while in general animal performance is similar to continuous. But it all conveys to carrying capacity or herbage allowance. As it was mentioned before, rotational stocking will not fix overgrazing.

Planning Your Pasture Management

We often get asked "*How much pasture do I need for my herd?".* The essential question, however, is "*How much forage can I produce*?", then, we can determine how many animals we can feed. Otherwise, we are likely going to face a negative forage budget sooner than later. The first step to improve your grazing management starts before we put the boots on the pasture: it's planning and learning your inventory.

How much forage can we produce? Pasture productivity depends on multiple variables, including species and cultivar, fertilization management, grazing pressure, and climatic factors such as rainfall and temperature. Some of those, like rainfall, are beyond your control unless you have irrigation. But you can manage many other variables. For example, let's think about bahiagrass which is the backbone of our cow-calf industry in Florida. We can roughly say that bahiagrass will produce between 5,000 and 10,000

lb of DM/acre (A) in a season and use that as starting point for our carrying capacity calculation (Table 1). What determines if you are closer to the bottom or to the top range is basically fertility and grazing management (e.g. low fertility and overstocked, then you are probably even below the 5,000 lb/A). When gathering pasture productivity numbers, it is better to use local information (i.e. from research stations closest to your ranch) that have similar weather conditions. If no information is available consult your local extension agent. You can use data from other stations or even start collecting your data[1]. Always on planning, if unsure, shoot for less so there is little risk of lack of forage.

Calculating carrying capacity. On Table 1, the total biomass production of Argentine, Pensacola and UF Riata bahiagrass are presented for Gainesville and Ona, FL, under different nitrogen fertilization rates. On the study conducted by Interrante et al., (2009), forage production was measured from early-May to mid-October (~ 170-d) for three years. On our previous example, our cow eating 27.5 lb DM/d, would then need 4,675 lb/DM for that period. If we were to offer two times that value (9,350 lb DM), then the carrying capacity of our Pensacola bahiagrass (which produced 9,300 lb DM/A) in Gainesville would be around 1 AU/A. The problem, however, is that we will be overstocked both at the start and end of our growing season. Note that we are talking about a *170-d season, not a whole year*. We will also need to do the same calculation for the remaining months, accounting for stockpiled forage, winter pastures or conserved forage (hay, haylage or silage).

Table 1. Total herbage production (lb DM/A) of three bahiagrass cultivars in two sites in Florida managed under grazing with different fertilization rates.

		Cultivar			
Site	**N**	**Argentine**	**Pensacola**	**UF Riata**	**Source**
	lb N/A yr^{-1}		lb DM/A		
Gainesville	180	10,800	9,300	8,400	Interrante et al., 2009
Ona	50	4,800	4,100	4,900	Vendramini et al., 2014
Ona	100	10,000	9,200	-	Mislevy et al. 2005

It is important to understand that the total forage production *does not gives us a sense of forage distribution throughout the year*, so in order to calculate our forage budget, we need to know how much we can produce monthly. The bahiagrass production is more concentrated during the summer months (Figure 1), but, in central Florida, for example, it starts growing probably around April and goes until October or so. An early frost will cut the season short, but a mild fall can result in green grass all the way up to November (that does not mean it is growing much, though).

In Gainesville, FL, Stewart et al (2007) evaluated three management strategies for Pensacola bahiagrass: low, medium and high intensity; based on nitrogen fertilization and fixed stocking rate (Table 2). Although average herbage accumulation rate (the amount of biomass the pasture accumulates per day) for the low intensity treatment was 15 lb DM/A d^{-1}, it ranged from ranged from around 9 to almost 40 lb DM/A.d^{-1} (Figure 1). The authors also noted that for one of the four years of the trial, because of the dry spell during April and May, the grazing season only started in mid-June, when pastures achieved minimum herbage mass to support the animals (~1200 lb DM/A). Had they used the pastures prior to that, the bahiagrass would likely to be overgrazed resulting in reduction of total herbage production and delay in peak of production and reduction of carrying capacity.

[1]Check Dubeux et al. (2019) UF/IFAS EDIS publication on Estimating forage mass on pastures for adjusting stocking rate (in press)

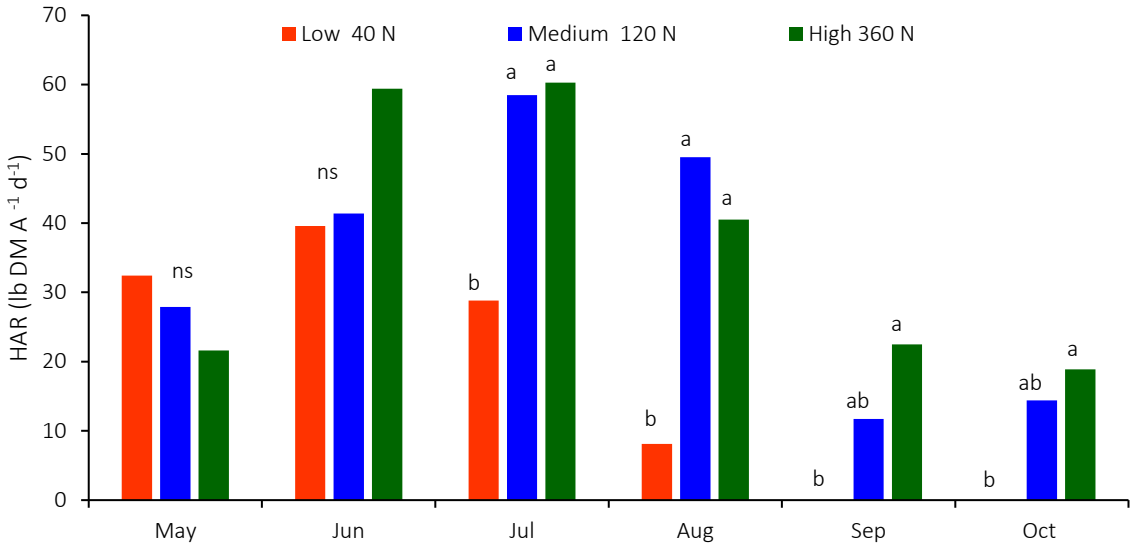

Figure 1. Herbage accumulation rate (in lb of DM A^{-1} d^{-1}) of Pensacola bahiagrass in Gainesville, FL under three management intensities: low, medium and high intensities (adapted from Stewart et al., 2007). See text and Table 1 for treatment description. Different letters on top of bars mean statistical difference between treatments at $p<0.05$; ns = no statistical difference between treatments.

In this study from Stewart et al. (2007), the low management represents the average Florida cow-calf systems while medium and high intensity represent alternative practices to increase the system's productivity. The N rates were split-applied in 3 or 4 times for medium and high management intensities. That resulted in more forage produced and longer growing season. Table 2 shows the 4-yr average of main pasture parameters and animal performance for each treatment. Note the inverse relation between stocking rate and herbage allowance: as we increase our stocking rate, there is less forage for each animal up to a point that we are then limiting intake, thus limiting performance (average daily gain). This can be justified if we are looking at the total gain per area, however, the extra gain from moderate to intensive management came at 2.6 times greater cost and was not economically viable (Stewart et al., 2007).

Table 2. Productivity of bahiagrass pastures and animal performance under different management intensity levels (nitrogen fertilization and stocking rate), in Gainesville, FL. Adapted from Stewart et al. (2007).

Management	N rate	Stocking rate	Herbage allowance	Total forage mass*	Average herbage mass	Herbage accumulation rate	Average daily gain	Gain per area
	lb/A	AU/A	lb DM/lb LW	lb DM/A		lb DM/A d^{-1}	lb LW/d	lb LW/A
Low	36	0.5	4.8a§	3340	3040a	15b	0.75a	90b
Moderate	107	1.1	2.0b	6250	2550b	34a	0.77a	185a
High	320	1.7	1.4c	6840	2630b	36a	0.62b	224a

* calculated from data presented in Stewart et al. (2007)

§ different letters denotes statistical difference ($p<0.05$) within columns

So, after we calculate the amount of forage we can produce, then it comes the question of *how much to use*. This is called *harvesting efficiency*. It can range from 25% for rangelands up to 70% for annual forages. However, for our tropical forages a safe number is between 40 and 50%. This is similar to the concept of offering 2 times more than the animal can consume. It is important to highlight that harvesting efficiency is different than conversion efficiency: you will not necessarily produce more animal weight by harvesting more forage. Simply because by increasing grazing pressure – to increase harvesting efficiency – you are forcing animals to graze lower quality material; then as you graze closer and closer to the ground, you limit intake by limiting bite mass, while also limiting plant growth by limiting residual leaf area.

For example, let's use the value calculated for total biomass production from Stewart et al. (2007) to calculate carrying capacity, considering the average herbage accumulation rate from May to October (184-d) under the intermediate intensity management (120 lb N/A):

$$34\ lbs\ DM/A.day\ \times 184\ days\ =\ 6{,}256\ lbs/acre$$

then, assuming that we can use 50% of that herbage produced (*harvest efficiency*),

$$6256\ lbs\ DM/A \times\ 0.5\ grazing\ efficiency =\ 3{,}128\ lbs\ DM\ available/acre$$

so, we have available 3,128 lb DM/A. If we use that same animal unit from earlier eating 27.5 lb DM per day, during 184-d, it would require 5,060 lb DM, then we would need

$$\frac{herbage\ needed\ per\ cow}{herbage\ \ available\ per\ acre} = \frac{5060}{3128} = 1.6\ acres/AU$$

In other words, our carrying capacity is

$$\frac{3128\ lb\ DM/acre}{5060\ lb\ DM/AU} = 0.6\ AU/acre$$

This is already a good start, but we can fine-tune it. As we saw on Figure 1, herbage accumulation rate is variable across the season. This means that we are likely to have a shortage of forage in the edges, while an excess in the middle. In other words, we may be overgrazing in the beginning of the season, which could delay peak of pasture production, and having extra herbage accumulating in the middle of summer, which would result in decreased nutritive value for our pasture. With the same example as before (from Stewart et al., 2007), on Table 3 we have the same calculation as above but broken down by month instead of for the whole season. We multiply herbage accumulation rate by the number of days in each month to get total dry matter production. Then, we determined how much herbage is available and compare to the animal needs for the same period (intake per day times the number of days in each month).

Table 3. Monthly forage production and animal intake to calculate carrying capacity. (Data from Stewart et al., 2007).

Parameter	Unit	May	Jun	Jul	Aug	Sep	Oct
Herbage accumulation rate	lb DM/A d^{-1}	28	41	59	50	12	14
Days		31	30	31	31	30	31
Total DM production	lb DM/A	865	1242	1814	1535	351	446
DM available (50% total)	lb DM/A	432	621	907	767	176	223
1100-lb cow needs	(27.5 lb DM d^{-1})	853	825	853	853	825	853
Pasture needed	acres/AU	2.0	1.3	0.9	1.1	4.7	3.8
Carrying capacity	AU/A	0.5	0.8	1.1	0.9	0.2	0.3

Note that based on our set stocking rate of 0.6 AU/A, we are above that carrying capacity (i.e. overstocked) in May, September and October. This also means that our monthly carrying capacity is more than double in July compared to May. Then, if we stock based on May, we have excess forage in Jun through Aug, which means more dead material and lower nutritive value; but, if we stock based on July, then we are overgrazing all other months. In Table 4, we simulated a forage budget using the prior data for herbage accumulation rate and three stocking rates (0.6, 1.0 and 1.7 AU/A). This differs from the previous example because now we are calculating the balance between how much forage is produced, how much is consumed, and how much carries over to the following month. In addition to calculating the amount of forage produced in the target months, we also added an initial herbage mass of 1200 lb DM/A, which represents the pasture growth during the prior months.

There are two main ways of looking at this: one is assuring we never go below that 1200 - 1500 lb DM/A target; or we always keep at least double the forage needed (i.e. cumulative biomass should be twice as much as intake for most of the season). This exercise helps to visualize the dimension of the excess or lack of forage on pastures in each condition and understand how it will impact animal performance in each scenario. At lowest stocking rate scenario (0.6 AU/A), there is always between 3 and 9 times more biomass than our total needs. The extra herbage left over from the previous month accumulates and, consequently, the nutritive value will decrease. In this scenario, pasture utilization is low and gain per area will be affected. On the other hand, under the highest stocking rate (1.7 AU/A), the cumulative biomass is always very low (much below 1200-lb DM/A target), and gets negative towards the end of the season. This means we will not have enough forage to feed our animals.

Table 4. Detailed forage budget with estimates of forage production and animal intake.

Parameter	Unit	Initial herbage mass	May	Jun	Jul	Aug	Sep	Oct
Herbage accum. rate	lb DM/A d^{-1}		28	41	59	50	12	14
Days			31	30	31	31	30	31
Total DM production	lb DM/A		865	1242	1814	1535	351	446
Total intake 0.6 AU/A	lb DM/A		512	495	512	512	495	512
Cumulative biomass	lb DM/A	1200	1553	2300	3602	4625	4481	4416
Total intake 1 AU/A	lb DM/A		853	825	853	853	825	853
Cumulative biomass	lb DM/A	1200	1212	1629	2590	3272	2798	2392
Total intake 1.7 AU/A	lb DM/A		1449	1403	1449	1449	1403	1449
Cumulative biomass	lb DM/A	1200	616	455	819	905	-147	-1150

Dealing with Seasonality

In the previous examples we saw that as pasture production fluctuates, we need to adjust the stocking rate to better use the forage available. Easier said than done! In a research setting this is straight forward: we bring animals in from other paddocks, put them as needed in the experiments, then remove them when forage production decline. But how can we do something equivalent in the real world? There are several strategies that can help you dealing with seasonality of forage production. First and most common is by harvesting hay: you cut the excess growth form the summer to feed during the winter. On Table 4, for the 1 AU/A stocking rate simulation, if we think about maintaining a residual biomass between 1200 and 1500 lb DM/A, there is about 1000 to 1500 lb DM/A excess during July and August. Thus, we can fence off around 30% of our pasture (i.e. increase stocking density by concentrate our herd in the remaining 70%), which will increase utilization efficiency and allow us to cut hay or stockpile the remaining. The challenge is being able to dry and bale hay in the rainy Florida summer. Alternatively, that area can be stockpiled for deferred grazing (late summer and fall).

The other problem of the seasonality is the "off-season". Most perennial warm-season forage species, as bahiagrass and bermudagrass, go dormant during the wintertime. In south Florida, mild winters might spark some early growth of bahiagrass, but it is generally not very significant. To overcome this, most producers relay on hay, but there are other alternatives such as stockpiled forage, stored feedstuffs or other supplements, depending on price and availability of them, that could also be used (Prevatt et al., 2018). Winter feeding may be 35 to 47% of annual cost of operation (Redmon, 2000) which directly impact farmer`s profit margins, however it may assure gain or maintenance of animal body condition and can be an advantage later when selling them. For this reason, adequately planning your farm forage is crucial to guarantee forage production and quality throughout the year.

Diversifying your pasture base is another important management practice. For example, in North Florida, a common practice is to overseed pastures with cool-season species to provide up to 150-d of additional grazing during the winter and spring (Fontaneli, 1999). Cool-season species are high quality feed that allow for high animal performance (Macoon et al., 2011), and can often be planted as multi-species pastures, including legumes to allow for biological nitrogen fixation and/or just optimize the peak of production throughout the season. In general, the most used species are annual ryegrass, ryegrass, oats, white clover, crimson clover, and red clover. In South Florida, limpograss has become an important alternative for farmers as stockpiled forage, due to slow decline in digestibility over maturity and growth potential during winter months (Wallau et al., 2015). Stockpiled forages tend to be low in nutritive value and will require supplement to achieve desired animal performance.

Wrapping Up

This is not an exact science, but the key message is to *plan*. Forage budgeting takes some calculation, but it is quite simple and can prevent a lot of headaches. Create different scenarios (including one where pasture productivity is reduced by half), and think about strategies to overcome the challenges that might rise. Perhaps, a way to start is just doing a simple evaluation of total pasture production, as we did in our first examples. Basically, you just need to start somewhere, but initially do not worry too much about many details. Those simple concepts will help you understanding how your system works and will facilitate your planning later. As times go by, planning becomes natural and you will be able to make adjustments based on experience and results from previous years. However, it is important to remember that even when you have laid out an adequate plan ahead, you must prepare for eventual situations you might need to overcome. So, flexibility will be essential. *Hope is not a strategy, so in hopes for a good year we can go broke. Planning can prevent it.*

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