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Beef Production Systems in Argentina

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Argentina is known as a pasture-fed beef producer. Traditionally, beef production in the country has been based on low-input systems which combine improved perennial and annual pastures to provide beef year around. Over time, systems have evolved adjusted to economics and market changes. Understanding the structure of such a systems and the logic behind, needs a description of a framework of constraints of larger scope.

Most cattle finishing takes place on land that has grain cropping potential. Beef is mostly consumed by domestic market. It is a sensitive item in the structure of the Argentinean cost of living. Therefore, its price is highly regulated by government policy, more so than grains. In gross margin comparisons, grains out compete beef. But, the need for diversification and optimizing of overhead costs keep beef production (of some kind) as a relevant alternative in pampas farms. A combination of activities, grain and beef cropping, in mixed systems dominate the landscape. History has proven that diversification and low-input are attributes that reduce risk, increase stability and improve sustainability in the Argentinean agriculture. High input monocultures have been proven to be responsible of mayor collapses, both economic and environmental in the central pampas.

Mixed systems are based on the concept that fields rotate between grain and beef production, seeded into improved pasture or planted to crop grain. Typically, a field is in perennial pasture (legume based) for a 4-to-6 year period, followed by a similar period of annual cropping for forage or grain. Figure 1 depicts a common rotation of a field over a 10 year period. It can be noted on the chart that the field is in perennial leguminous pasture 50% of the time (5 years out of 10). It is used for corn and sunflower grain 1 year every 10. Once every 10 years is planted for summer annual and 5 years over 10 has small-grain winter annuals. The use in summer and winter annuals does no take a full year as neither do annual crops, which allows for more than a crop a year. The result is a partial overlapping of land use of 20%. The chart depicts the fate of one field over 10 years and the instant picture of a 10-field farm in a given time. From the one year fate of every field of the whole farm, carrying capacity and quantity and distribution of forage supply can be estimated.

Estimating the forage production and knowing the acreage for every resource, the total annual available forage (on dry matter basis) can be calculated. Knowing the figures of available forage for each resource, taking into account average grazing efficiencies for each one, and assuming a daily DM intake per animal unit, the number of animal unit per year the system can carry is easily determined.

Rotations depend on the environment and soil and economics. Organic-matter rich soils tolerate rotations with longer cropping periods (e.g. 4:7 or 4:8; years of perennial pasture and years of annual crops, respectively). Marginal areas for cropping (sandy, low organic matter soils) are much less tolerant to annual cropping.

In mixed systems, beef production finds strengths and constraints imposed by the rotation and requirements of other alternatives. Farms that have beef production as the only alternative are rare in the Argentine pampas mixed systems are the rule. The size of the farm and enterprise, location, interactions and competition with the other alternatives shape the form and intensity of the beef operation.

It must be pointed that Argentinean domestic and foreign markets for beef do not have negative considerations about pasture finished beef. Grain fed beef is well accepted also in the domestic market. Economics and tenderness are the two most relevant single factors that drive decision making at consumer level.

Supplementation with energy grain (namely corn and sorghum) became common over the last 20 years. More recently the introduction of pen-feeding or confinement feeding has introduced other variants. Now-a-days, it is not rare to see combination programs. Argentinean beef production systems cover an ample array of options, based on the enterprise structure and price relationships, which could be grouped in 5 categories:

1. 100%-pasture rearing and finishing
2. Pasture rearing and finishing with systematic supplementation
3. Pasture rearing and finishing with strategic supplementation
4. Pasture rearing (stoker phase) coupled to a confinement finishing
5. Stoker rearing in pens (called beginning lots) and finishing on pastures

Most confinement feeding happens as an option to remove animals from land that has grain cropping possibilities, certain times of the year (depending on field rotation plans) and keeping the animals and their contribution to cash flow. Pen-feeding is conceived as a way to reduce competition for quality land and ensure finishing the steers in a short and predictable time after weaning. It is looked as a way to speed cash turnover and flow. Confinement feeding can take place at the end of the growing-finishing program (finishing lots) or at the beginning ("beginning lots") of the growing finishing (stocker phase).

This last option is being adopted by many farmers. Beginning lots (confinement feeding for 3 to 5 months after weaning) have been found a cost effective alternative (see comparisons in Table 1). It improves cash turnover while minimizing competition of the cattle finishing business with grain cropping for land. It basically reduces the need of small-grain winter annuals for grazing. In rotation with grain crops, winter annuals compete with winter wheat or use the moisture for a high yield summer crop (corn, sunflower or soybeans).

Year-around pasture based systems are least energy intensive and rely on adjusted forage chains and reliable rainfall. In rotation with grain cropping, forage chains use leguminous pastures (namely alfalfa based), and winter and summer annuals as the forage base. Pasture hay or millet hay make the common supplements. Most finishers try to make a strategic use of supplement energy if necessary. So far, no premium is expected for 100% grass-fed beef. Therefore, net benefit and management of investment risk are the only drive for decision making. Return per dollar invested and per unit of land are the two main indicators of overall efficiency.

Table 1 describes and compares production performance and gross margins of 7 beef production systems of central western pampas, from 100%-pasture fed to feedlot finished, with and without corn silage. The area receives 26 to 32 inches of rainfall annually and no snow. In average, the area has a carrying capacity of 0.5 to 0.6 head/acre. Models here analyzed summarize information collected over 4 years in 21 operations in the region. Fast programs finish cattle in 12 months (from weaning to slaughter). Such systems have different production levels depending on the amount of additional supplemental energy. Annual beef production ranges then from 250 to 670 lb/acre. But, gross margins do not follow the same trend. Finishing in confinement increases overall production, the cost per acre and per lb.

It can be noted that gross margins increase with performance on pasture. Confinement feeding of stockers for 4 months prior to finishing on pasture improves gross margins and provides stability. Including whole plant corn silage yields highest returns per acre. Target stocker gains are achievable on high silage diets and cost per lb produced is lower, compared to grain based diets. On the contrary, including corn silage at the finishing end in confinement feeding yields lower gains than high-energy grain based diets. Gross margin per head is greater as inputs are minimized and pasture use and management are maximized (B vs the other models).

The year-around pasture based systems (A, B, and C) are the most widely spread. More than 80% of the beef is still produced on improved pastures (perennial and annuals). The proportion produced in confinement feeding (20% or less) depends on beef to grain price relationships and the cost of energy.

Confinement feeding is performed with the minimum investment in infrastructure and overhead cost. Diets are based on mixing ingredients as they come to the farm, with little or no processing on place. As and example, most farms feed whole corn based diets. Even so, on net margin basis, feedlot beef is more costly to produce than pasture finished beef. Despite the cost, some farms include pen feeding to shorten and ensure the finishing period.

Producing on pasture takes from 12 months up to 24 months from weaning to slaughter. This period depends on weight and date calves enter the program, final target weight and daily gains. On straight forage, the fastest cycles imply systems where calves take no longer that 14 months to be finished and sold. The cheapest of these systems rely on alfalfa-based pastures to produce most of the gain. Calves that enter in summer go to alfalfa pastures until first frost, continue on winter annuals during winter and are finished on spring and summer pastures. If calves enter in late fall or early winter, the program includes pasturing on winter annuals until spring, continuing on perennial pastures during spring summer and fall, to be finished on winter annuals (second winter) or on alfalfa pastures the following spring. This scheme relies more on annuals than the previous, and it costs more.

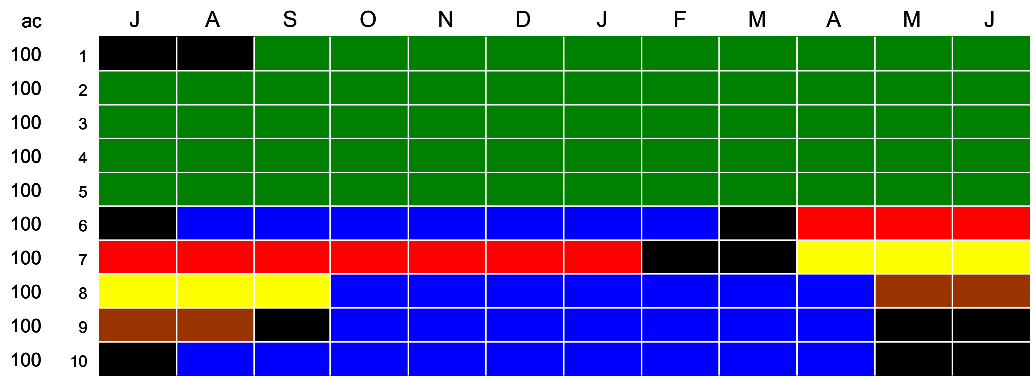
In its simplest, 100% pasture systems could be based on one type of pasture or two. Table 1 summarizes data from a simple 100% forage growing-finishing system under study in central Western Argentina. A simple system was based on winter annuals and alfalfa-based pasture. Targeted for maximum gains, forage supply was not restricted. With a stock efficiency of 103% and a gain of 1.91 lb/day, the system fattened Angus and black boldy steers in 12 months, and produced finishing gains at nearly all times. Performance from this study reflects the potential of a 100% pasture model. Greater performances are hard to achieve in temperate environments if grazing corn is not included.

Slower cycles include restriction and compensatory growth strategies. Calves are weaned into good pastures (perennial or annuals) and go into a restriction period during winter (on medium to low quality pastures, native ranges o stubbles). Good growth rates and compensatory growth is resumed in spring to continue at a slower rate in summer and fall. Growth continues at moderate rates during a second winter targeting for full finishing the following spring or summer. If initiated in winter, a program that incorporate restrictions, most likely will not get to finish steers on summer pastures. It will have to rely on winter annuals for the last 90 days. These programs take longer than 15 months and are planned around faster ones and grain cropping priorities. Stubbles and low producing, medium quality pastures or native ranges are included in the forage chain.

Heifers follow a fast growth route and they are slaughtered at lighter weight than steers (70 to 80% of steer weights). Heifers take 6 to 8 months from weaning (at 5 to 6 months of age) to slaughter. Waiting for heavier weights has no meat quality implications, but abattoirs doubt carcass yield consistency and pay less. Cull cows are pasture finished in 3 to 5 months, and sold for processed beef (for foreign markets).

Readiness for slaughter is based on overall fatness and minimum back fat deposition. Although positively correlated to finishing, live weights are only relevant if the market protocol requires a benchmark weight. Argentinean domestic markets pay top prices for beef that comes from cattle that grade high select – low choice, and most are not heavier than 1100 lb live weight at slaughter. Heifers reach top prices at 800 lb. Figure 2 shows a typical growth curve of heifers and steers and depicts a common forage chain on which such programs are based. Heavier cattle (1200 lb) are produced for European markets. Being the herd mainly British-breed based, and moderate to low frame (3 to 5), heavy weights tend to be over fatten. At present, this is the number one complain of the feedlot industry.

Successful pasture-based programs have several attributes in common: a) a productive legume-based perennial pasture backbone –alfalfa or white clover and grass mixtures make up more than 50% of the forage supply-, b) winter and summer annuals are included in rotation, c) all pastures are highly productive –soil are well understood, d) quality hays or silages are produced, e) planning growth curves and forage requirements take place routinely, f) high intensity low frequency rotational grazing is implemented on all pastures, g) all low-input alternatives are constantly evaluated, and f) monitoring or results is performed routinely.



1000 ac			DM lb/ac	Use eff.%	DM lb/ac	DM tot		
Pastures	500	50%	7000	60	4200	2100000	365	days
Wintr annuals	400	40%	4000	70	2800	1120000	510	AU
Smr annuals	100	10%	10000	50	5000	500000	0.65	AU/ac
Corn grain	100					3720000	lbDM	
Sunflower	100					186000	AUeq/year	
	1200					20	lbDM/AU	
Overlap	1.2							

Figure 1. A 5-year perennial 5-year annual 10-year field rotation of a field of farm in central western Argentina.

Figure 2. Classic cumulative weights of forage finished heifers and steers in central Argentina and slaughter windows for both categories

Table 1. Production, performance and gross margin comparisons of 7 beef production models of Argentinean production systems.

		A	B	C	D	E	F	G
		Pasture	Pasture	Pasture	Stocker pen-feeding		Stocker on pasture	
		100%	100%	+ suppl	corn grain	w plt silage	Pen -feeding	
					Pasture finishing		corn grain	w plt silage
Perennial pastures		50	55	58	85	83	70	60
Winter annuals		30	35	21	10	10	30	30
Summer annuals		30	20	14	15	10	10	10.7
Grain supplements		0	0	17	0	0	0	0
Corn silage		0	0	0	0	7	0	9
	rations/acre							
Alfalfa pastures	178	89	98	103	151	148	125	107
Winter annuals	142	43	50	30	14	14	43	43
Summer annuals	146	44	29	20	22	15	15	16
Supplement	12	0	0	46	0	0	0	0
Total	0	175	177	200	187	177	182	165
Purchase weight	lb	353	353	353	559	559	331	375
Sale weight	lb	931	931	929	936	936	936	930
Weight at penning	lb	0	0	0	331	331	664	738
ADG on pasture	lb/day	1.28	1.46	1.58	1.54	1.54	1.21	1.32
ADG in pens	lb/day	0.00	0.00	0.00	1.87	1.87	2.98	2.09
Grazing period	months	16	13	12	8	8	9	9
Pen-feeding period	months	0	0	0	4	4	3	3
Stocking rate on	anim/acr	0.5	0.5	0.6	0.7	0.7	1.1	0.9

pasture	lb/acr	361	324	367	558	526	553	479
	AU/acr	0.47	0.46	0.56	0.76	0.71	0.86	0.72
Stocking rate on	anim/acr	0.53	0.49	0.59	0.50	0.47	0.84	0.65
year corrected	lb/acr	361	324	367	372	351	415	359
	AU/acr	0.47	0.46	0.56	0.50	0.48	0.64	0.54
Annual production	lb/acre	248	262	339	452	426	674	478
on pasture	lb/acre	248	262	339	281	265	371	313
in pen-feeding	lb/acre	0	0	0	171	161	303	165
Sales	anim/acr	0.39	0.44	0.58	0.73	0.69	1.09	0.84
	us$/acr	147	168	217	277	261	414	318
Sales- replacemnt	us$/acr	84	96	124	167	158	250	174
Direct cost	us$/acr	42	41	69	99	81	197	120
Gross margin	**us$/acr**	**42**	**55**	**55**	**69**	**76**	**52**	**54**
Supplement feed proportion		0.00	0.00	0.47	0.62	0.57	0.76	0.67
Direct cost, us$/								
lb stocker phase					0.359	0.286	0.199	0.165
lb finishing phase					0.085	0.086	0.496	0.487
lb produced		0.168	0.157	0.203	0.219	0.191	0.293	0.252
Gross margin	us$/head	109	124	96	94	111	48	64

A. Pasture 100% (A): Production 100% on pasture (perennial and annual resources and medium performance; B. Pasture 100% (B): Similar to A but improved performance; C. Pasture + suppl = Production on pasture similar to model B with additional supplemental energy; D. Stocker pen-feeding on grain based diet and finishing on pasture; E. Idem D with corn silage instead of corn grain based diets during pen-fed phase; F. Stocker phase on pasture and finishing in confinement on corn grain based diet; G. Stocker phase on pasture and finishing in pens on silage diet

Table 2. Potential of a pasture-based production system in central Argentina

Pordomingo et al., 2004; INTA Anguil Experiment Station

Phase 1. Winter annuals

First 2 months	ADG = 1.6 lb/day	96 lb	1 month of Fall, 3 months of Winter 1 month of Spring
Last 3 months	ADG = 2.7 lb/day	243 lb	

Phase 2. Alfalfa pasture

First 3 months	ADG = 2 lb/day	180 lb	Last 2 months of Spring, 3 months of Summer 2 months of Fall
Next 2 months	ADG = 1.5 lb/day	90 lb	
Last 2months	ADG = 1.5 lb/day	90 lb	

LV initial		152 kg – **332** lb
LV final		467 kg – **1032** lb
ADG	12 m	866 g/d – **1.91** lb/d
Production	12 m	317 kg – **699** lb
Stock eff.		103 %

Managing Perennial Pastures for Finishing

Jim Gerrish
American GrazingLands Services LLC

Finishing cattle on pastures requires a consistent supply of appropriate quality forage for as many days of the grazing season as possible. Geographical location and availability of soil moisture are the two primary determinants of pasture-finishing opportunities using perennial pastures. Grazing management is the primary determinant in how effective your finishing program will be. There is no wonder-forage that automatically guarantees animals will finish well on your pasture.

Pasture-finished beef usually targets a finish level of USDA High Select or greater to ensure beef will provide a consistently pleasant dining experience. This degree of finish requires animals to be gaining at least 2 lb/day as they near maturity. Animals should be gaining at this rate for a minimum of 60-90 days prior to harvest. Typical cow-calf pasture and grazing management will not achieve this target finish.

Standard feed tables give the minimum requirements for 2 lb ADG to be about 61% TDN and 10% crude protein. This is based on controlled feeding studies and requirements in real-world field situations is somewhat higher. Keeping pasture forage above 65% TDN and 12% CP provides consistent finishing quality forage. It is very easy to keep CP levels above the 12% requirement in cool-season pastures. Energy content is much more challenging. In warm-season pastures, CP levels can become limiting as grasses approach maturity.

Most perennial pastures have the capability of producing finishing quality forage for at least part of the growing season. Location dictates when the optimum finishing window will be for a particular forage. Strategic grazing management can extend the effective finishing window for most forages. Always remember it is the forage the animals are allowed or forced to eat that determines their dietary intake, not just the analysis of what's standing in the pasture.

Because energy is usually the limiting factor in pasture-finishing diets, our management needs to focus on maintaining high energy intake by grazing animals. Some forages are inherently higher in energy than others. Cool-season annuals are usually the highest energy plants available followed by cool-season perennials. Warm season annuals can be higher energy than cool season perennials during part of their growth cycle, but decline rapidly in energy with approaching maturity. Warm-season perennials are usually considered to be lowest on the energy scale. Within each of these groupings there are individual species and cultivars within species that contain higher energy levels.

Legumes can provide higher levels of digestible energy than grasses over much of the growing season. Legumes also provide much higher protein levels. When pastures become legume dominant, it is very easy to have excess non-protein N levels in the rumen and bloodstream which results in reduced animal performance as the energy:protein balance becomes increasingly skewed. Finishing pastures should not exceed 50% legume content. Some of the less desired 'grassy' flavor that some pasture-finished beef exhibits is due to chemical compounds found in legumes, not the grass.

Long-term sustainability of pastures demands we rely more on legume-fixed N and less on synthetic fertilizer N so we do need to maintain a minimum amount of legumes in pasture also. The required legume level for meaningful N fixation is about 30% so we need to be managing for a target range of 30-50% legume in the pasture.

Among cool-season grasses, perennial ryegrass (PRG) is generally considered the highest energy grass. If you can grow PRG in your environment, it is an excellent choice for finishing pasture. It takes less management to finish cattle on a forage that is naturally high in energy. Unfortunately, PRG does not do well in continental climates where summer heat and drought pervade and we are forced to use lower energy grasses along with legumes.

There is a good deal of variation in the energy content of warm-season grasses and cultivars. As an example, Tifton 85 bermudagrass was selected for increased digestibility and animal performance. It consistently produces animal gains well above Coastal bermudagrass even in midsummer. Selecting the right variety can significantly extend finishing opportunities where growing conditions dictate primarily warm-season grasses as the base pasture.

Grazing management becomes increasingly more important for finishing as the inherent energy content of forages is lower. Our challenge is to keep energy intake high across a range of growing conditions. Forage intake on pasture is controlled by the time the animals spend grazing, how many bites they can take, and the size of those bites.

Because ruminant animals must balance their daily activities among grazing, rumination, and rest, there is a limit to how many hours they can spend grazing. The better the pasture conditions, the fewer hours they must spend grazing. Higher energy forage requires less time spent in rumination, so they can spend more time grazing and increase total daily energy intake.

When pasture conditions are ideal, animals take fewer bites because every bite contains more mass. As pasture becomes shorter, they must take more bites every day. At some point, intake from a lot more short bites becomes less than the volume of fewer big bites and total energy intake is lowered. Plus they are expending more energy to take those added bites.

The one factor we try to manage is bite size. We do this primarily by regulating the forage mass in front of the animal at all time. It is easy to tell when a pasture is ready to be grazed again. Almost every grazier recognizes good pasture as they let cattle to a new paddock. In our work at U of Missouri, we found about 23% of grazing intake was explained by pre-grazing pasture mass. Not so many graziers recognize when cattle should be moved off a paddock even though it is a more important factor in determining

performance. We found post-grazing residual accounted for 82% of the variation in intake.
There are two basic strategies for maintaining high rates of gain on pasture. The first is to use a relatively low stocking rate with continuous grazing. Cattle have the opportunity to selectively graze throughout the season and can generally select a diet of adequate quality for the necessary gains. The problem with this approach is output per acre is too low to begin paying the bills. As stocking rate increase, individual performance declines and cattle may not achieve the target finish.

Intensive management of forage allocation is the second strategy. Many producers attempting pasture finishing move cattle to a fresh pasture every day. This should ensure fresh, high quality feed every day. This approach works well as long as adequate post-grazing residual is being left behind. Remember, what you leave behind is nearly 4X more important for determining intake (82% r^2 vs. 23% r^2). If your cattle are out of grass 8 hours into a 24-hour grazing period, they will not perform satisfactorily.

To be an effective grazing manager and maintain high rates of gain on pasture, it is critical to be constantly monitoring pasture conditions. Do not think just because you moved the cattle this morning that they have all they need to make it to tomorrow morning's move. This is the most common and most significant failure I see on the part of graziers whose cattle are not making grade.

If you are using grazing periods longer than a single day, the risk of inadequate nutrition on subsequent days in the grazing period increases. The most difficult pasture rotations to manage and achieve acceptable gains are those in the 4-10 day range. Periods of these durations allow greater and greater selective grazing to where the cattle cream the pastures in the first few days and then end up eating at maintenance level late in the grazing period. This roller coaster diet does not support consistent, high rates of gain.

Pastures for finishing can not be utilized to the same extent we typically think of grazing cow-calf pastures. The pasture canopy is a multiple strata of forage quality with the highest energy bites located high in the canopy and each lower bite being lower in energy. Because cows have lower nutritional requirements, we can force them to eat deeper into the canopy. Particularly with warm-season grasses, we may only have finishing quality forage in the top 25-35% of the canopy. Forcing finishing animals to utilize more than this will depress performance.

Summary:
Always choose the highest energy forages you can grow in your environment for a finishing program. But remember, planting a high-energy species that won't survive in your environment will not be profitable. As a general rule, how you manage the pasture is more important than what is growing in the pasture when it comes to finishing cattle. It is absolutely critical to maintain a high rate of daily forage intake to ensure consumption of adequate energy to support the rate of gain the cattle need to meet the finish target. Closely monitor post-grazing residual for effectiveness.

The Forage Chain

Anibal J. Pordomingo

Finishing cattle on pasture to the degree most consumers prefer is not always easy. At the heart of the challenge is the fact that growing a beef animal from weaning to slaughter takes a long time (a year or more). This means a high forage quality must be provided during all (or nearly all) seasons of the year.

The number one constraint in pasture finishing is the limitation in metabolizable energy content of forages. The second constraint is that forage quality and energy level are ever changing. This requires a high level of grazing management and a continuous forward planning to schedule the use of a whole sequence of forages and alternatives.

Different from concentrates, forages offer a limited amount of energy which set a limit to weight gains. A 3-lb-per-day target is common in a pen-fed finishing situation, but it is nearly impossible to achieve on grass for long periods. However, such performance may not be needed performance to produce grass-fed beef. Yet, depending on the program, we may be able to use some supplements and complementary resources to help reach target gains. Supplementing on pasture with energy supplements during fall or winter is common in many parts of the World.

Growing and finishing cattle on pasture for quality beef is a time race. And the market dictates many of the constraints of the race. A 100% grass , from weaning to slaughter is big constraint. Likewise, marbling, tenderness, flavor and color are conditioning factors. The older the animal at processing, the greater the chances for undesirable colors and flavors. Tenderness tends to worsen with age. More so if nutritional stress has taken place during part of the animal's life.

Periods of low gains (less than 1 lb/day), struggle for grass, uneasiness and fear, all work against performance, meat quality and consistency. These issues are common among the programs that produce poor quality. Most likely, grass-finished beef is going to be leaner and will have less cover (back) fat than feedlot beef. But, it will have sufficient fat for most Western cultures. We want the tenderness, the juiciness and the color present for a good eating experience. Putting enough marbling lipids (intamuscular fat) in grass-fed beef is a challenge that involves genetics and nutrition, and it all starts even before birth.

Having genetics for marbling ease also correlates with early maturing, medium frame cattle (frame 4 in our part or the World). Terminal cross breeding is a good tool to put together a good set of beef attributes with out having to wait at changing the cow herd. The old terminal cross concept can be easily adapted to produce beefy calves. Black or red boldy (Hereford x Angus) steers are the preferred ones in Argentina and Uruguay to finish on pasture. Likewise, low-frame Shorthorn x Angus is a desirable cross. Searching for the adequate biotype within breeds that fits the program is key. But, before doing so we need to develop a program, with our resources and constraints.

Producing a steer or heifer that marbles early and has a good yield would be easier if we start with a good nutritional management of the cow during the last half of gestation and during the first 4 months after calving. Starvation or malnutrition reduces the proliferation of fat cells (future fat in the animal tissue). Well nursed calves, will have the opportunity to express their potential for marbling. This fat cell proliferation and development process seems to be sensitive to nutrition early nutrition.

Creating reliable tender beef with attractive flavor and color from lean muscle on grass has to start early. Research has shown that marbling (or intramuscular fat) increases linearly with age under a good nutrition regime or nearly constant gain. Cover and organ fat shows an exponential increase with the energy concentration of feed and age of the animal. We also know that older animals tend to lay more fat than muscle, compared to younger ones. But, we must know that muscle growth and fat deposition are not separate compartments. Calves lay fat of all types if the energy status they are offered daily is exceeds requirements for growth . This means that we can start the process of producing desirable meat before weaning if we have the adequate feed. In other words, our product would be more consistent if we can rely on a forage base that has finishing quality at nearly all times. This, however, does not mean a 3-lb-per-day forage. We will find that steady gains of 1.8 lb/day can produce the beef we are looking for.

A short growing-finishing period is a good indicator of high performance of a finishing program. Length of the growing-finishing period (which in a grass-fed program starts when the calf is purchased or weaned until it is sold as finished steer or heifer) should be kept as short as possible. Periods of 12 to 15 months (from purchase to sale) produce some of the best grass-fed beef that Argentina is able to generate. Longer periods generally mean lower overall gains, periods of hardship, more than one summer or one winter in the program (higher costs per pound gained) and less chances of tender beef.

Consider forages capable of producing high weight gains

So, what is the definition of beef finishing quality forage? For most purposes, quality would be defined as the power of a grass to sustain a rate of gain (ADG) of at least 1.8 lb/day during its vegetative stage. A forage that does this has an adequate energy supply to produce marbling fat.

Table 1 shows the chemical composition of the deal forage to accomplish the high weight gains on pasture. The closer our forage is to this ideal, the greater its gain potential. Dry matter content (DM) is the first limiting factor of intake in quality forages. Low dry matter (below 20%) reduces forage intake. Effects are more severe as we reach dry matter below 15%. It is not uncommon to find winter annual species with 11 to 14% DM in late fall or early winter at first grazing. These forages have high digestibility (above 70%) but excessive water and low effective fiber.

Fiber content should be of concern when offered in excess. Neutral detergent fiber (NDF) and acid deter gent fiber (ADF) are chemical indicators of the cell wall and cellulose fractions, respectively. Although grazing ruminants digest fiber in the rumen and obtain most of the energy from it. The digestibility of the fiber is relevant. The greater the amount of fiber, the lower the rate of fermentation and total daily intake. As plants mature fiber increases along with indigestible lignified components of the cell wall. Research has shown that forages considered of high quality should have ADF content below 25% and NDF below 40%, which implies an "in vitro" digestibility (IVDMD) or TDN (total digestible nutrients) greater than 65%. This correlates with a metabolizable energy (ME) concentration of 2.4 Mcal/kg DM, or greater than 2.5% of body weight (on dry matter basis). Two additional components are crucial to describe fattening potential of forages: a) crude protein (CP) and b) soluble carbohydrates (SCH). The first is estimated from nitrogen content of the forage and the second could be direct measured by reducing sugar presence in the soluble fraction of the plant cell.

Protein is required for normal growth and development, and it is generated in the rumen (major fraction) by the rumen microbes from dietary nitrogen and de-amination of forage proteins during rumen fermentation. (A minor fraction is provided as such for the diet.) Nitrogen release in the rumen after a meal is fast, therefore the presence of an easily degradable carbohydrate helps to capture nitrogen in microbial mass. At first grazing, most small-grain winter annuals have crude protein levels in excess to animal requirements and could be marginal in soluble carbohydrates, more so if soils are heavily fertilized with nitrogen.

The greater the soluble carbohydrate content, the better the match with protein supply, and greater the chances of capturing nitrogen in microbial protein. The best ratios between crude protein and soluble carbohydrates are the ones close to 1:1. Small-grain winter annuals differ in the content of soluble carbohydrates. These carbohydrates are low in the early stages of growth and increase over time as growth slows down in winter. The first grazing is always the one with chances of low values. Generally, the faster the initial growth, the more unbalanced the forage is likely to be for beef finishing purposes. Dry matter and soluble carbohydrate contents tend to be lower is fast growing annual forages. Nitrogen fertilization can speed initial growth but it could worsen the unbalance. However, some species seem less sensitive and are genetically more unbalanced than others (e.g. annual ryegrass vs cereal rye).

Table 1. Desired composition of green forages for high individual production

Nutritional components	Values
Dry matter, %	above 20
Crude protein,%	range from 14 to 18
Soluble carbohydrates,%	above 18
CP/SCH	similar or below 1
NDF, %	below 40
ADF, %	below 25
In vitro digestibility, %	above 65
DM intake, %LW	above 2.5
ME concentration, Mcal/kg DM	above 2.4

Pastures that offered forage with composition and digestibility within the range above have been shown to produce daily weight gains of 2.2 to 3lb/day. This rate of gain was 100 to 200 percent higher than pastures that offered high digestibility, but too low SCH (less than 8%). For example, in Argentina, new alfalfa pastures in fall offer very lush and digestible grazing but disappointing weight gains (often less than a pound a day). Same syndrome takes place with small-grain winter annuals at first grazing. These types of pastures have low dry matter and SCH contents and high in crude protein. Feeding high quality hay helps to overcome these poor gain bottlenecks in 100% grass-fed beef programs.

Although highly digestible and low in fiber, washy feeds are most likely unbalanced (too high in protein, low in soluble carbohydrates and high in water content) and result in low gains (1 lb/day or less). We must remember than gains below 1.8 lb/day are not finishing gains (very low back fat and intramuscular fat deposition) and limit the finishing capabilities of the program. The more humid the environment is, the greater the risk of the low gain syndrome on 100% grass-fed programs and climate conditions favour this to take place in Fall. Shortening of day light and dropping temperatures slow energy capture in aerial biomass growth and promote a shift of the energy flux to reserves in roots in Fall. If no mechanisms of adjustment to low-temperature are triggered yet, and there is plenty of moisture, the plant most likely will become washy.

This effect is more pronounced when fast growing species such as cereal rye and barley are chosen. Cereal oats, wheat and annual ryegrass follow in the list. Planted early in the Fall, cereal wheat and annual ryegrass are the most balanced ones. Ryegrass shows the longest season for balanced quality in most environments. Chemical analysis, including dry matter, crude protein, cellulose (ADF) and soluble carbohydrate contents, provides a good base to define the possibilities if our forage species. If no performance information is available, chemical data would be a good way to start the assessment of potential for weight gain of our forage base. If performance data is available for at least one category of animals, however, the degree of confidence would be much greater.

Expected gains are not well documented for all forages in most places. We must know that performance on the different forages is bound to change with soil, season, climate and animal characteristics. Season and climate can greatly affect growth potential of forages. Hot and dry summers can drop in more than half the growth potential of pastures compared to mild summers. Likewise, pastures can yield less than half the growth potential in rainy and foggy Falls, compared with drier ones. Likewise, legume pastures or winter annuals can result in "washy" feed in mild winter, compared with frost endured (winter hardened) grass.

White clover or alfalfa and cool-season-grass pastures, that express their highest potential in Spring, frequently run into a low digestibility scenario in Summer to resume growth and potential in early Fall. But the expected gains drop in mid and late fall again, this time as consequence of the unbalance described above as the "fall syndrome".

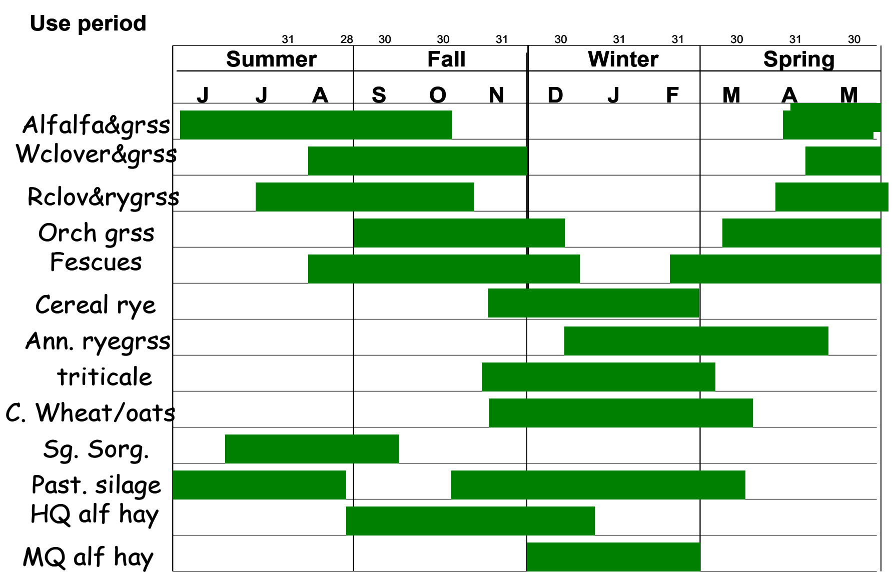
The first step: Finding the right forages

The most common perennial pasture used in beef finishing in Argentina is a mixture of alfalfa and perennial cool-season grasses such as orchard grass, fescue, brome and perennial ryegrass. These pastures provide grazing from mid-spring through fall. Winter annuals such as cereal rye, oats, triticale and annual ryegrass planted in early fall provide winter and early spring forage. The forage quality of perennial pastures is reinforced during the late summer and early fall period with summer annual forages, mainly corn and sorghum Sudan.

Finding the right plant species for our grass-fed program is critical. The first step in defining a forage sequence is to explore in depth the available species and varieties for our region. Strengths and weaknesses of each plant material regarding quality distribution over time and behavior under climate extremes must be studied. Digestibility of forages at grazing time must become our main concern. A few extra points in digestibility (or TDN content) could mean everything in critical periods for acceptable weight gains. Three points, from 62 to 65% digestibility in summer for example could imply that we can finish steers on 2 lb/day vs 1.5 lb/day. We must ask the question: - Have we explored enough for high quality plant materials? Exploring for new plant materials should be an endless task.

Development of a growing-finishing program requires of some background knowledge about the species that we could grow. The information needed has to do with the period of the year the grasses are to be grazed, the forage yield, the quality and the weight gain potential during the grazing period. Quality is highly associated with expected weight gain. The greater the quality, the larger the potential for gain of grasses. But, it is necessary to clarify our concept of quality for the relationship to hold true in all cases. Quality implies highly digestible feeds, which are rich in crude protein and low in lignified fiber. Fibrous forages (species bound and season or drought triggered) have low digestibility. Stemy plants, low in leaf content and frequently lignified are slowly digested in the rumen, voluntary intake is restricted and performance declines. It is common to find 20% drops in weight gains in early Summer and 50% in mid Summer, compared with Spring gains.

For a better visualization of the distribution of the forage supply, charting each forage use period and finishing gains achievable (high, medium and low at least) on a monthly or 15-day basis, would be recommended. The chart would give us a quick look at bottlenecks in quantity and even quality. In finishing programs of the Argentinean central pampas, early and late winter are bottleneck periods where the forage chain requires permanent adjustments. Mid-summer is another period where often quality becomes limiting and programs struggle to maintain good gains. From this analysis we should be able to discern between what we have and what we should and could have. After selecting the grass species, a monthly forage budget should be prepared. Monthly quantity and quality of forage supply should emerge from this budget.



Animal age, size, genetics, origin and background also affect the animal response to a given forage. It is easier to accomplish high gains with young cattle than with near-to-finish ones. Weight gain composition and maintenance requirements are different in these two categories. Grown steers lay more fat than growing ones; therefore, the energy content of such a gain is greater. Likewise, the amount of energy required for maintenance is higher in heavy steers compared with lighter ones. On the other hand, young growing cattle have greater requirements of vitamins, minerals and quality protein.

Previous considerations suggest that absolute values to define expected gains need to be used with caution. However, it is a needed tool to assess the possibilities and limits of the program for beef production in the season, and more important to produce finished beef. It is easy to grow a steer, but it could become very difficult to achieve a rate of gain that will lay the sufficient amount of fat in a finishing stage. Knowing the possible gains achievable for each of the forage sources, we can plan the proper "pasture route" of cattle within targets for age, finishing degree and time at slaughter. It is necessary to adjust the "finishing phase" to the potential of pastures and forages, and make all possible adjustments in the forage chain to enlarge the finishing phase.

Use period

		31	28	30	30	31	30	31	31	30	31	30
	Summer			**Fall**			**Winter**			**Spring**		
	J	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**
Alfalfa&grss	2.2	2.0	2.0	1.5	1.5						2.0	2.2
Wclover&grss			1.5	2.0	1.5	1.5				2.0	2.2	2.5
Rclov&rygrss		1.8	1.5	1.8	1.5						2.2	2.2
Orch grss				1.5	1.5	1.8				1.8	1.5	2.0
Fescues			1.0	1.5	1.8	1.5	1.5		1.5	2.0	1.8	1.5
Cereal rye						1.8	2.2	2.5	2.8			
Ann. ryegrss							1.8	2.2	2.5	2.8	2.0	
triticale						1.8	2.2	2.5	2.8			
C. Wheat/oats						1.5	2.0	2.5	2.5	2.0		
Sg. Sorg.		1.8	2.2	2.0								
Past. silage	1.0	1.2	1.5			1.0	1.2	1.5	1.5	1.5		
HQ alf hay				1.5	1.5	1.5	1.5					
MQ alf hay								1.0				

Table 1. Expected finishing gains of British-breed frame-4 steers on different forage sources (Pordomingo, 2002. Compiled data, unpublished)

Table 1 depicts the possible weight gains for grass-fed British breed steers in temperate sub-humid areas with bimodal Spring-early fall rainfall distribution, and cold dry winters. By no means is this chart universal. Every area and operation should develop its own chart using as much local information as possible, even based on the best guess-estimates from experienced people. The first finding to be derived from the analysis will be the season or period of the year where recourses with finishing potential are scarcest or in other words, when finishing would be most difficult or more vulnerable. In this exercise, fall would be such a time, and more so if no early winter annuals are a possibility. In such scenario, native ranges could become the only winter option and most likely quality will be not good enough to reach finishing gains. Spring is almost always plentiful of quality forage. Even native ranges and warm season perennials offer quality good enough to support high gains.

Summer quality could be limiting at times, which is highly depending on soil moisture and temperatures. Hot dry summers could trigger summer slumps and gains may drop to half of those of spring and jeopardize the finishing phase. If a hot dry summer is followed by an above normal humid fall, finishing gains may not be accomplished in either season. In this scenario, supplemental forages would be needed to counteract effects.

Pushing the limits with conserved forages

Hay or silage is commonly used to meet shortfalls in feed supply rather than to complement pasture quality. Supplemental forages are, however, a great tool to complementing diets. Well produced hays from pure legume stands or cereal oats are good resources to complement grass monocultures (annual or perennial ryegrass, annual winter forages). Argentinean research has pointed out that high quality alfalfa or oats-pasture hay can complement (and substitute) high- quality winter annuals up to 50% of the diet, improving dry matter content and nutrient balances. Results were similar or greater, overall intakes more stable and consistently high weight gains showed in beef steers.

Silages fit different purposes depending on protein and soluble carbohydrate contents and digestibility. Legume silages are commonly low in readily available carbohydrates and high in crude protein. Most frequently these silages are produced to transfer quantity to meet short ages. But, high-quality silages complement well with summer pastures or winter annuals reaching maturity (last grazing). Offering high-protein low-carbohydrate silages on lush high-protein fall or spring forages should be avoided. It will worsen the protein/energy imbalance of the diet and will not improve energy intake.

Silages or hays could be included systematically or strategically in a program. On the other hand, if they were introduced strategically to balance supply and quality, limited quantities could stabilize stocking rates, and more important sustain weight gains. Strategic more than systematic use of conserved forages is generally more economically efficient in grass-fed beef operations. If these conserved forages are needed as part of foundation of the production program, they are to be used systematically and in large quantities, we need to know their quality for gain. Relative feed value (RFV), protein (CP), NDF and ADF analysis help to efficiently use them. Low quality hays could rapidly become a liability and have the system collapse. .

The highest quality hay is produced from spring alfalfa-rich pastures that are cut before ten percent blooming. Frequently, this cutting stage produces less quantity than at mid-blooming, but the quality will match well with the winter annual forages. These high quality hays are the way we can maintain animal performance in mid-winter. Even, on 100%-hay diets we can sustain good gains if intake is not restricted.

Table 2 summarizes average expected responses on medium frame beef steers to some of the most common conserved forages (variability within in each material could be high and animal effects ever greater) and interaction effects when offered as supplemental feed on perennial cool-season pastures, winter annuals or summer annuals. Gains shown assume normal quality for the cited resource and the numbers must be taken for gross budgeting and planning only. As it could be noted, the most common conserved forages cited here do not have potential for high gains if offered as the only forage source. Therefore, a 100% grass-based operation should not base its program on these resources only and expect finishing gains. Most of these would be better used if they are considered tools to transfer feed and strategically balance diets, more so if interactions with grass base are understood.

It can be noted that hay promote positive interactions (match better and improve gains) of lush and washy pastures (perennial pastures and winter annuals during fall). In all cases the best results will be obtained with good quality hays. Hays of medium or low quality do not interact well with lush pastures because rates of ruminal degradation are different. Hay fiber breakdown will be too slow to sustain high overall intake.

Alfalfa or grass silages (high y moisture and low in sugars) would not be recommended for the fall situation, but would have a place in summer on perennial pastures or summer annuals. Dry summers result in lignified and fibrous forage, short in protein in many cases. Supply of a high moisture, highly digestible silage, rich in crude protein would help to speed pasture fermentation in the rumen. High quality alfalfa silages would be the choice supplement for summer pastures.

Interactive responses would be minimum when pastures are well balanced (winter annuals in winter and spring, summer annuals in spring, cool-season perennial pastures in Spring). During this time of the year, added supplemental hay or silage will increase carrying capacity but it will not significantly affect rates of weight gain. However, gains will not be affected if the supplemental feed is of good quality. Low quality hays or silages will decrease rates of gain because a well balanced forage will be substituted by one of lower quality.

Lastly, the amount of supplemental hay or silage offered is central to this discussion. Low quantities (below 0.5% of the animal's body weight on dry matter basis) do not significantly impact the gains and may have little overall effects. For interactive and substitution effects to occur, it would be necessary to supply 0.75 to 1.5% of the animal's body weight (dry matter basis), which means about 1/3 to 1/2 of the animal's voluntary daily intake in conserved forage. Research data has shown that up to ½ of the animal's intake could be provided in high quality legume-based hay or silage without significantly depressing gains in winter annuals during winter. It has been also shown that high quality hay supplied at the 1% body weight level would improve fall gain in 50 to 70%. Moreover, high RFV alfalfa hay can even yield finishing gains. xperimental data has shown alfalfa hays to produce up to 2 lb of gain in stocker cattle (which could yield 1.6 to 1.8 lb/day). A key factor here is consistency of hay quality. Stand composition (mix) affects the quality of hay substantially. Compared to pure alfalfa hays, grass and legume mixed hay is always lower in quality and weed infestation decreases quality even further. Haylage is another interesting option to sustain gains on conserved forages. Allows for wider haying window, given that the moisture content at baling does not become such a critical issue.

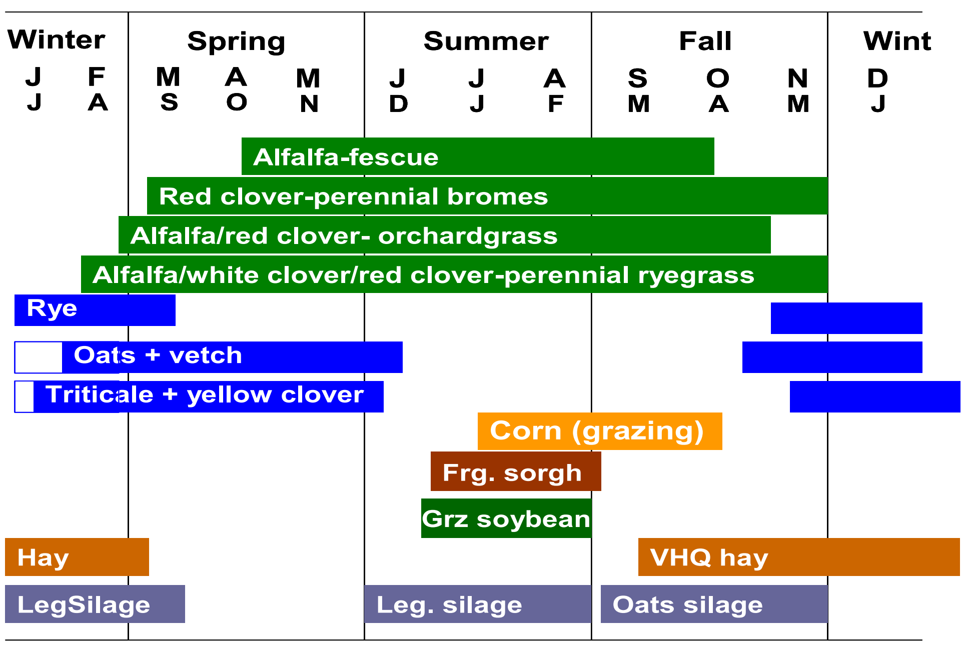
The second step. Putting together a forage sequence

The forage sequence does not need to be complicated but making it simple requires of intelligent choices based on knowledge. We need to know the forage resources for grazing or harvesting (hay or silage) that we can use. Sequencing them is a second step and an easy one, once we understand their possibilities and limits. Each operation will have different constraints and alternatives. The environment imposes the most relevant one, and the product itself, economics and culture others. Some programs can be based on year-around grazing and rely on perennial leguminous pastures as the backbone, complementing with winter and summer annuals. Strategic use of hay and silage help to balance quality and supply. Other operations run stockers on stockpiled perennials and hay to exploit to the maximum the spring ad summer forages in a more seasonal program. Summer annuals are included in systems where summer slump is common or fall rains are scarce. Likewise, early-planted winter annuals (cereal rye) improve forage supply in fall on year-around grazing on white clover and perennial ryegrass systems in New Zealand.

It is important to have more than one forage option at all times. Let's say winter annuals and hay or silage in quantity to take over the full diet if no grass is left. For many, in cold or snowy areas this is the case most winters. Leguminous perennial pastures are the preferred forage base, but the option of summer annuals brings an alternative to unpredicted events (heavy rains, drought, etc.). Alternatives give the opportunity of complementary grazing and balancing the diet for better results. Likewise, when using winter annuals, a combination of several options, planted separate, provides the opportunity of a supply of even quality (see discussion on winter annuals).

The second piece of information needed is the size and distribution of requirements the program will demand along the year. The shape of the curve .of nutrient demands will have to be followed by the nutrient supply curve. In particular, moments of the year of highest demands need to be identified. Nearly finished animals are a heavy burden due to their high body maintenance and should be closely matched with forages of high finishing potential. Stocker calf purchases should be adjusted so that finishing times will match periods of high finishing possibilities.

The shape and magnitude of forage demand charted on a monthly basis and the expected forage production helps us to define the acreage to allocate to each forage resource. The following are examples of perennial and annual pastures used in two different forage chains in year-around programs. Seasonal programs are likely based on leguminous perennial pastures, with overlapping of summer annuals and limited acreage of winter annuals to be use in late winter and early spring. Systematic use of large quantities of hay, haylage and silages are included to feed during winter months.



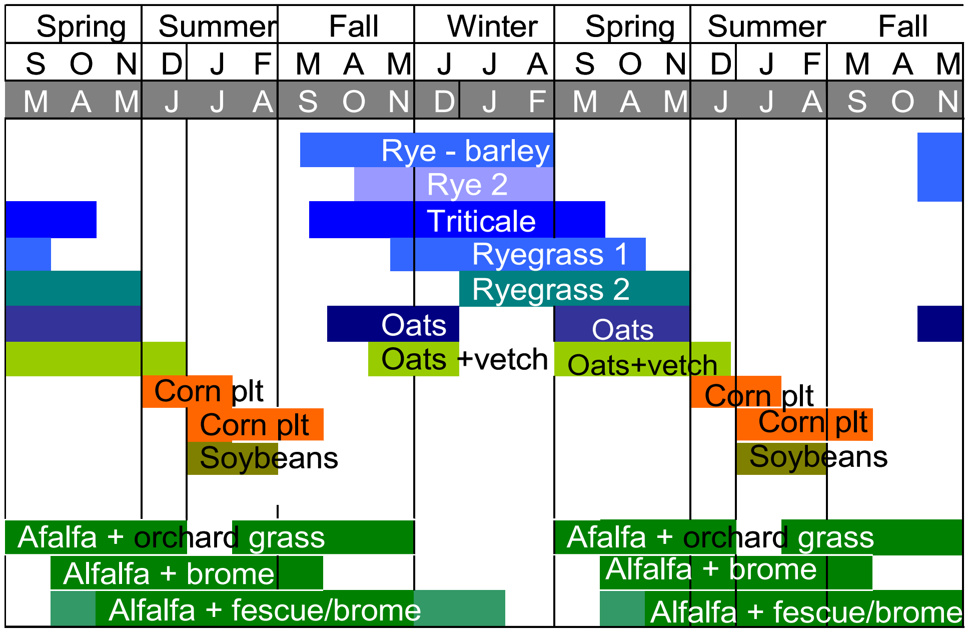

Spring
Summer
Fall
Winter
Spring
Summer
Fall
S O N D J F M A M J J A S O N D J F M A M
M A M J J A S O N D J F M A M J J A S O N
Rye - barley
Rye 2
Triticale
Ryegrass 1
Ryegrass 2
Oats
Oats
Oats +vetch
Oats+vetch
Corn plt
Corn plt
Soybeans
Corn plt
Corn plt
Soybeans
Afalfa + orchard grass
Alfalfa + brome
Alfalfa + fescue/brome
Afalfa + orchard grass
Alfalfa + brome
Alfalfa + fescue/brome

Table 2. Expected live weight gains (lb/day) for grass-fed medium frame beef steers in temperate sub-humid environments*

	Summer			Fall			Winter			Spring		
	J	J	A	S	O	N	D	J	F	M	A	M
Perennial pastures												
Alfalfa + orchard grass	2.2	1.5	1.8	2.0	1.5						2.0	2.4
Alfalfa + fescue	2.0	1.8	1.5	2.0	1.5	1.5				2.0	2.2	2.0
Alfalfa + crested wheatgrass	2.0	1.5	1.5	1.8	1.2	1.4				2.0	2.2	2.2
White clover + ryegrass		2.0	2.2	2.0	1.5	1.5				2.0	2.4	2.4
White clover + orchardgrass	2.0	1.8	2.0	1.5	1.5	1.5				2.0	2.4	2.3
Red clover + ryegrass		1.8	1.8	1.8	1.6	1.5				2.0	2.2	2.3
Red clover + fescue		1.5	1.5	1.8	1.5	1.4						
Red clover + orchard grass	2.2	2.0	1.6	1.8	1.6	1.3				2.0	2.4	2.4
Gamma grass	2.4	2.0	2.4	2.0	1.2						2.8	2.8
Jhonson grass	1.5	1.0	1.2	1.2	1.0	0.5				1.5	1.8	1.8
Annual winter pastures												
Cereal rye						1.5	2.0	2.4	2.0	1.8	1.5	
Annual ryegrass	2.0	1.8						2.0	2.4	2.5	2.5	2.2
Wheat						1.5	2.0	2.0	2.5	2.2	1.8	
Triticale							2.0	2.2	2.5	2.5	2.0	1.5
Cereal oats						1.8	2.2		2.0	2.4	2.0	1.6
Barley						1.6	2.2	2.2	2.0	2.4	1.8	
Annual winter legume + grasss												
Wheat + vetch						1.5	2.0	2.2	2.2	2.4	2.2	2.0
Oats + vetch							1.8	2.0	2.4	2.4	2.2	2.0
Triticale + yellow trifoil						1.5	2.0	2.2	2.3	2.5	2.2	2.0
Cereal rye + trifoils						1.5	2.0	2.5	2.2	2.0	1.8	1.8
Annual summer pastures												
Soghum sudan	1.8	2.0	2.0	1.8								1.8
Forage corn	2.2	2.5	2.8	2.8								
Pearl millet	1.5	1.8	1.5	1.0								
Forage soybeans	2.2	2.0	2.2									2.0

Compiled form research trials and commercial operations throughout central Argentina. Rates of gain reported assume a normal grown, non nutrient restricted plant. (Pordomingo, 2002; compiled data; unpublished)

Table 2. Expected gains on 100% based conserved forages and nature of interaction effects on gains when supplemented with green pastures.

	100%	Alf/clvr past			Wntr annual			Smr annual	
	lb/day	Sprg	Smr	Fall	Fall	Wntr	Sprg	Smr	Fall
Hays									
Good alfalfa hay	1.7	=	++	++	++	=	+	+	++
Alfalfa + grass hay	1.5	=	+	+++	+++	=	=	+	+
White clover + grass hay	1.7	=	+	+++	+++	=	=	+	+
Millet hay	1.0	-	-	+	+	=	-	=	-
Mid quality pasture hay	0.9	-	-	+	+	=	-	-	=
Low quality pasture hay	0.5	-	--	-	-	--	--	--	--
Winter annual grass hay (cereal triticale, oats, wheat)	1.5	+	+	+++	+++	=	+	-	+
Winter annual+ annual leg. hay (cereal oats + vetch)	1.5	=	++	++	+	=	+	-	+
Silages									
Alfalfa silage	1.1	--	+++	---	---	=	+	++	+++
Alfalfa+ grass silage	1.3	-	++	--	--	=	=	++	++
Unwilted direct cut leg. silage	1.3	+	+++	-	---	+	++	+++	+++
Mid qual. Leg. pasture silage	0.8	+	++	--	--	=	=	+	++
Winter annual + vetch silage	1.4		++	---	---	=	+		
Millet silage	1.1	=	+	+	+	=	=	=	-
Sugar sorghum silage (no grain)	1.2	=	+	+	+	=	=	=	-
Corn plant (earless) silage	1.4	+	++	++	++	+	+	+	=

+ Possible positive interactive effects. Improvements would be noted compared to grass alone
++ Positive interactions will be evident
+++ Positive interactions will maximize
- Possible negative effects on gains compared to grass alone
-- Negative interactions will take place depressing gains
= No interactions expected. Response will be similar in gain. Under no grass shortage, effect will be substitutive.

Drought Management Before, During, and After the Drought

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Farming is full of risks and experienced farmers know that they are gamblers. The purpose of this paper is to outline management strategies that producers can use:

- before a drought to reduce risk exposure to droughts,
- during a drought to minimize the damage caused be the drought, and
- after a drought to speed recover from a drought.

For our purposes we are going to define drought as the percent of times that forage yield drops a given amount below the average (mean) forage yield on the farm. As most farmers will tell you there is no average year. As one farmer said: "to understand what an average is put one hand in a bucket of ice water and one hand in a bucket of hot water, on average the temperature is fine but it hurts like heck".

Since farmers are gamblers it is important that they know how to measure their odds. If you play poker you know that there are four aces in the deck of card. How do we know the odds of "drawing" a dry year. In pasture and hay research we measure forage yield over years at different locations and calculate the mean yield. Yields will be below average 50-percent of the time and above average 50-percent of the time. We can also calculate the standard deviation (SD) of the yield. The SD of a mean yield is a measure of the variation of the yield about the mean from year to year. The practical meaning of the SD is that about 33-percent of the yield observations lie between the mean and 1-SD below the mean and about 33-percent lie between the mean and 1-SD above the mean. For example when the mean hay yield is 3.0 tons/acre and the SD of yield is 0.85 tons/acre; about one year in three the hay yield will be between 2.15 and 3.0 tons/acre and about one year in three the hay yield will be between 3.0 and 3.85 tons/acre. The rest of the time hay yields will be above or below this 1-SD band. About one-sixth of the time yields are less than 2.15 tons/acre (1-SD below mean) and about one-sixth of the time yields are greater than 3.85 tons/acre (1-SD above the mean).

The coefficient of variation (CV) is a way of expressing the SD as the ratio of the SD divided by the mean. This allows us to express the odds of achieving certain yield levels as a fraction (or percentage) of the mean.

For cool-season grasses and legumes growing in the Northeast as mean yield goes up the SD of the yield also goes up (Fig. 1, A). For example, 3 and 5 ton/acre yields have a SD of 0.85 and 1.30 ton/acre respectively. However, mean yield goes up faster than the SD so that the yield CV goes down (Fig. 1, B), the 3 and 5 ton/acre yields have CVs of 0.30 and 0.25 respectively.

Before the drought

Pre-drought planning will help reduce the risk exposure to drought and includes all or part of the following stratagies:

- optimize the use of soils and forage species,
- determine the optimum stocking rate,
- develop a marketing plan that will make money when reducing stocking rate,
- develop a hay storage plan, and
- develop a relocation plan for the base herd to an area not affected by drought.

Optimize the use of soils and forage species

Knowing the soils on your farm, what forage species are most adapted to them, and how to manage those forages is similar to knowing the genetics of and how to manage your cattle. Some soils are deep, some soils are shallow. There is little value planting a deep rooted crop like alfalfa on a shallow soil. Likewise if a shallow rooted forage such as bluegrass is grown on a deep soil it will not take advantage of soil water in the lower horizons during a drought. In many parts of the county there are alluvial soils that are deep, well drained and sub irrigated if a deep rooted crops such as alfalfa, chicory, or switchgrass are grown on them. Other soils may be wet and be better adapted to grasses such as reed canarygrass, tall fescue or eastern gamagrass that will produce forage during a dry period on these soils. Soil characteristics that you need to know are; the depth of the soil to bedrock, hardpan, or seasonal water table which will limit the rooting depth of plants growing on the soil. Other factors that affect forage species adaptation to a soil include surface drainage and internal soil drainage within the rooting zone.

Combining several adapted forage species in a mixture in pastures reduces the year to year variability in pasture production (Tracy and Sanderson, 2004). Also, manage the forage stands in all years to maintain healthy, deep rooted plants that will be least affected by dry weather.

Determine the optimum stocking rate

Experienced grazers understand that stocking rate affects animal performance per head and per acre. At very low stocking rates gain per head is high since there is plenty of forage per animal and forage intake can be high. However, gain per acre will be low since there are few head of livestock per acre. As stocking rate is increased gain per acre will increase. However, at some point forage intake will decrease as the forage produced on the pasture is spread over more animals and there is competition for the best grazing. Gain per acre will continue to increase because adding more animals per acre at a high rate of gain has more impact on gain per acre than the slightly lower feed intake has on reducing gain per head. However, as stocking rate continues to be increased gain per head goes down even more, gain per acre increased to a maximum, and then decreases as gain per head is greatly depressed as reduced forage mass limits forage intake per head and the forage stand becomes overgrazed. If this continues animal health will be impacted and the forage stand may be severely damaged.

This relationship was modeled for stocker cattle grazing on an orchardgrass forage system where excess spring growth was harvested from selected paddocks and sold as hay (Rayburn 2003). Seasonal gain of 700 pound medium frame steers was predicted using the 1984 NRC Nutrient Requirements of Beef Cattle and expected pasture intake based on stocking rate. Cattle were custom grazed at $0.25/lb gain to eliminate the marketing risk of buying and selling cattle. Mean annual yield (4.8 tons/acre) was varied at random based on the yield SD (1.22 tons/acre) for each run of the model. The model was run 500 times; gain per head, gain per acre and net income to land, labor, and management were calculated for each run; then the mean and 15- and 85-percentile probability levels were calculated for each measure (Fig. 3 A and B).

Models are not perfect but do point out principles. Differences in forage production from year to year had little effect on gain per head and gain per acre at low stocking rates. As stocking rate increase above 1.5 head per acre in this scenario, the effect of differences in annual forage production started to be seen in greater variation in animal performance (spread between the 15- and 85-percentile lines). Mean net income was highest at 3 head/acre but the highest net income with least variation in income occurred at 2 head/acre. At 3 head/acre the average net income was about $120/acre, ranging from $80-$160/acre. At 2 head/acre the average net income was about $110, ranging from $100-$120/acre. The optimum economic stocking rate is partly a function of how much risk the producer is willing to take. If an income of over $90/acre is required then stocking 3 head/acre results in years where income will fall below that needed while stocking at 2 head/acre results in less income on average but fewer years when income falls below $90/acre.

This model does support an old Texan saying that stocking at 85% of the biological optimum will take care of drought 85% of time.

Develop a marketing plan that will make money when reducing stocking rate

Some droughts get so severe that selling cattle is the only practical means of reducing the stocking rate to put livestock forage demand in balance with forage supply. It is important to remember that the animals you are selling are your capital investment and need to generate a good income and not be sold at a loss. How you organize the sale of cattle will depend on if you are running a cow-calf operation, stocker cattle, finishing animals on pasture or some combination of the above animal classes. In any case to make money when marketing cattle to reduce the stocking rate you have to:

1. have good cattle that others want to buy and
2. sell the cattle at a time and location where the market is not depressed.

When you accomplish these two goals you can make money on the transaction. Also, mentally divide the herd into animals that will be sold in the early stages of a drought, those for sale when the drought is hard, and the base herd (for a cow-calf operation) that you do not want to sell.

Develop a hay storage plan

Grazing is the low cost option for feeding livestock, but in some areas making or buying hay is required for wintering cattle. When hay making is part of the normal management practice it is an option for drought management. Storing hay for drought requires a hay barn or hay stacked on deep gravel pads and covered with good tarps that will provide adequate protection from weather damage. Also, the hay needs to be rotated, that means feed the oldest hay first each year and hold over hay from this year for use next year if the yield was above average. Haying and hay storage are expensive options and during a drought hay is valuable and you may make more money by selling the hay than feeding it to your own animals.

Develop a relocation plan for the base herd to an area not affected by drought

An alternative to selling cattle is to lease pasture land in a part of the country not affected by the drought. This is a viable option since there are graziers who do not want to own cattle but do want to sell grass and management. It will often be less expensive to move cattle and rent pasture and management than to buy hay and truck it into a drought area. However, moving cattle to a different part of the country may mean moving them to a forage type that they have never experienced resulting in grazing behavioral problems and possible nutritional or other health issues. Before moving cattle to a different type of forage it will be of worthwhile reading Fred Provenza's work at the *Behave* web site on the topic of how animals learn what to graze and what not to graze:
http://www.behave.net/products/booklet.html

During the drought

Pre-drought planning prepares us mentally as well as managerially for the drought while the drought will test our drought management plan. During the drought it is important to accomplish the following management tactics to minimize the droughts effect on profitability, animal health and pasture health:

- inventory forage supply,
- graze plants to target stubble height,
- rest pasture until target grazing height is achieved,
- don't open up the gates,
- improve grazing efficiency,
- wean calves early,
- reduce grazing of cow herd,
- feed hay or grain, and
- implement livestock marketing/relocation plans.

Inventory forage supply

When pastures are growing well it is easy to get lax and not keep a forage budget. However, when you are looking at the possibility of a drought it is important to keep a close eye on the forage supply. Now is the time to break out and dust off the old pasture plate; walk the paddocks weekly, keep a record of forage mass, and estimate the pasture growth rate. These two measures will enable you to see how the drought is progressing and when you will need to implement your planned drought management tactics.

Graze plants to target stubble height

At all times, before or during a drought it is important to graze pastures to the proper stubble height and allow plants to rest until they reach the proper grazing height in order to maintain plant health and pasture diversity. During the drought this is still important so that the health and diversity of the pasture is not adversely impacted by the drought. The rain will return and we want a healthy pasture that will take off growing rapidly when it does, to provide forage for our livestock.

Rest pasture until target grazing height is achieved

At all times, before or during a drought it is important to graze pastures to the proper stubble height and allow plants to rest until they reach the proper grazing height in order to maintain plant health and pasture diversity. During the drought this is still important so that the health and diversity of the pasture is not adversely impacted by the drought. The rain will return and we want a healthy pasture that will take off growing rapidly when it does, to provide forage for our livestock. Yes, I am repeating myself.

Don’t open up the gates

One of the worst errors to make during a drought is to open up all the gates and let the livestock graze where ever and what ever they want to. During drought plants will be photosynthesizing, even if they are not growing, as long as they have live leaves to intercept the sunshine. Since the plant is not growing, because there is no moisture for growth, the carbohydrates produce by photosynthesis will increase in the plants leaves and storage organs. When the rain returns the plants will exhibit rapid (in a sense compensatory) growth because they have an above average carbohydrate status in the stubble or root reserves. Grazing the pastures into the ground prevents this. So don’t open up the gates.

Improve grazing efficiency

At the early signs of drought it can pay to improve grazing efficiency by subdividing large paddocks to improve forage utilization and increase the rest interval. There may be forage available for grazing that would not normally be grazed such as pond dikes (fence off the water so the pond is not damaged), ditch and creek banks, aftermath hay that is too short to hay but rested adequately for grazing, crop residue from corn or small grains (ensure that there are no herbicide or insecticide restrictions on their use), or farm road sides that are normally mowed.

Wean calves early

For the cow-calf producer, early weaning of calves is an important drought management practice. Keeping calves on cows late in lactation, on a drought stressed pasture, does not help the calf and hurts the cows and the pasture. By weaning the calf early, the calf can be sold or put on hay and supplement to maintain a profitable rate of calf gain and then sold when ready to reduce the stocking rate on the farm. By drying off the cow, the cow has a lower energy requirement and can maintain body condition on less feed or lower quality feed.

Reduce grazing of cow herd

By drying off the cow the forage demand of the cow herd will be reduced. The grazing of the cow herd can also be restricted by limiting the time spent grazing, keeping them in an abuse area when not grazing. When restricting the feeding of cows during a drought it is important to monitor body condition and not let it drop to a level that will be costly to rebuild or costly in terms of reduced health or calf crop. When finishing animals on pasture, give them first choice on the best pasture and after moving them to a new paddock let the dry cows clean up after them.

Feed hay or grain

When the pasture and aftermath hay fields have been grazed to the target stubble height and none have grown to the target grazing height and we have kept the rule of *Don't open up the gates* we may have to feed hay or grain in an abuse area to maintain cow body condition or growth of young stock. Feeds such as homegrown hay or purchased hay and supplemental grain should be feed in a hay meadow or pasture that will benefit from the added nutrients provided by these feeds. Another option is to cross fence the pastures and start feeding the hay or grain on pasture, to extend the grazing and spread the nutrients over more acres. By feeding hay in August, when pastures are not growing due to a drought but are healthy and fixing carbohydrates, we set up a situation where there will be rapid pasture growth when fall rains return to moisten the soil.

Implement livestock marketing/relocation plans

The livestock marketing/relocation plans should have different set points for different drought intensities. The first stage of the marketing plan should be implemented in the early stages of the drought. Animals marketed in stage one are those that are sold in the normal course of business (calve, yearling etc.) and animals that can be sold without a negative impact on the herd (older cows). The second set of animals that assigned for sale are cows at the lower end of the herd based on age, performance, temperament, and conformation. This leaves the top end of the herd that might be relocated outside of the drought area instead of being sold. In most cases in the Northeast droughts do not get this severe. When selling the first two groups of cattle the quality of the herd remaining after a drought is greatly increased due to the strict culling enforced by the drought management.

After the drought

The sound of a soft soaking rain is one of the most beautiful sounds, especially after a drought. It also marks the time when we should get to work on repairing damage caused by the drought. When soil moisture marks the end of the drought we need to accomplish the following management to help get the operation back on course:

- rest pastures until the target grazing height is achieved
- graze pastures to target stubble height
- use N fertilizer to increase production
- reseed legumes and grasses as needed
- use annual forages during pasture renovation

Rest pastures until the target grazing height is achieved

Did I mention that, before or during a drought it is important to graze pastures to the proper stubble height and allow plants to rest until they reach the proper grazing height in order to maintain plant health and pasture diversity? After the drought this is still important. Since we did not open the gates, the plants' growth rate has jumped and those stored carbohydrates are being rushed to make new leafs. It is tempting to get the cattle back out on grass. However, to do so in the early stage of growth will really damage the plant by reducing leaf area after the carbohydrates have be used up to start leaf growth, resulting in slow plant growth after defoliation (about one half the normal growth rate). By waiting a few more weeks the plants will have grown to their full target height, restored their reserve carbohydrates, and be ready for grazing and good growth after grazing.

Graze pastures to target stubble height

By this time you probably get the idea that optimum grazing height and stubble height are important (or that the guy writing this is a nut or all of the above).

Use N fertilizer to increase production

Feeding home grown hay during a drought puts a dent in the winter feed supply. Therefore, in dry years it is even more important to extend the grazing season into the winter and to have early spring pasture to reduce the need for hay feeding. The use of nitrogen fertilizer on grass stands such as tall fescue can do this for us. Nitrogen should be used on healthy grass stands that are low in legume content. This will provide the best response to the nitrogen and provide grazing past the hard freezes of early winter that kills legumes and reduces their available forage later in the winter. Nitrogen fertilized south facing slopes will also provide the earliest spring grazing. When these areas are used for winter grazing, do not graze them too short, which could prevent the stand getting an early and rapid growth in the spring. These sites may benefit from another application of nitrogen in early spring to get early yield. In these situations feed a mineral supplement containing magnesium since the risk of grass tetany increases when grazing early spring pasture that has been fertilized with nitrogen. If the soil is low in phosphorus add phosphate to the fertilizer since it will help the plants take up magnesium and increase animal utilization of magnesium reducing the risk of grass tetany.

Reseed legumes and grasses as needed

Where pasture or hay fields have been thinned by the drought they can be thickened back up by the use of fall nitrogen and proper grazing or by the seeding of grasses and legumes into the stand. When nitrogen prices are high it is probably best to use nitrogen only on the better grass stands in order to get the best yield from the nitrogen purchased. Then reseed the thin stands since there will be less competition to the new seedling in these thin stands. No-till seeding is a good option since it causes less soil disturbance and less soil moisture loss than plowing and disking.

Use annual forages during pasture renovation

Some pastures may be so damaged or weedy that they need complete renovation. On these sites use summer or winter annuals to provide high quality forage as well as a means of cleaning up weeds and providing a good seed bed for the establishment of a new pasture or hay field. When choosing an area for feeding during a drought this option should be kept in mine.

Conclusion

Droughts happen, about half the time, the only question is how bad. There are many management options for reducing drought risk to a pasture system. Confinement operations are also at risk to drought. The difference is that pasture systems feel the affects in real time while confinement systems feel the affects about six months later.

To make it through a bad drought; with the least damage financially, emotionally, and to the animals and pasture; requires a drought management plan. Then when the drought hits, damage will be minimized by the thoughtful implementation of the drought management plan along with continual good forage and livestock management. It is the planning and management of the plan that will reduce the risk and cost associated with a drought.

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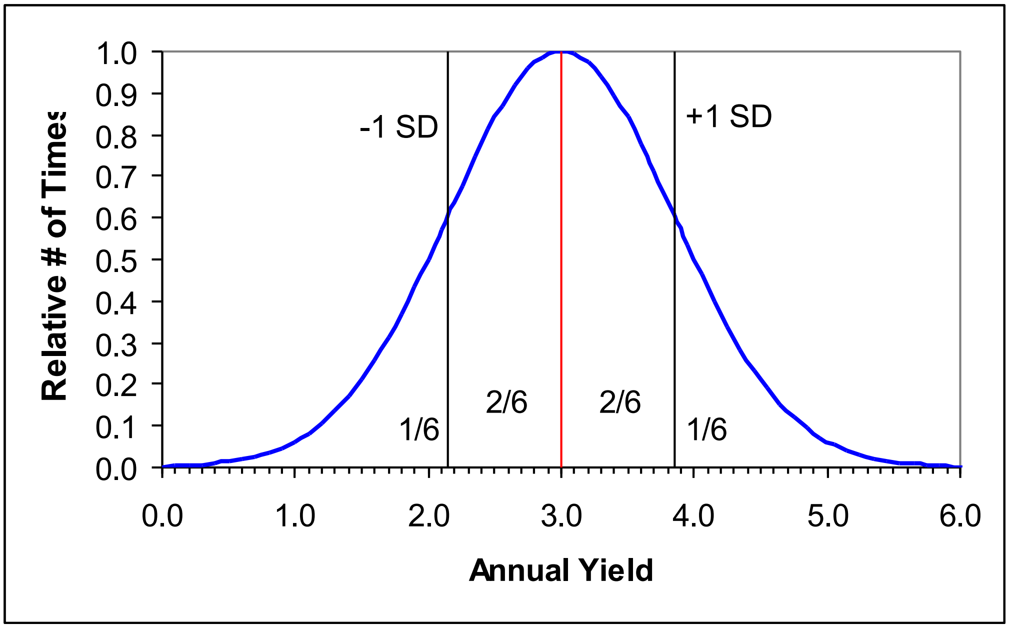
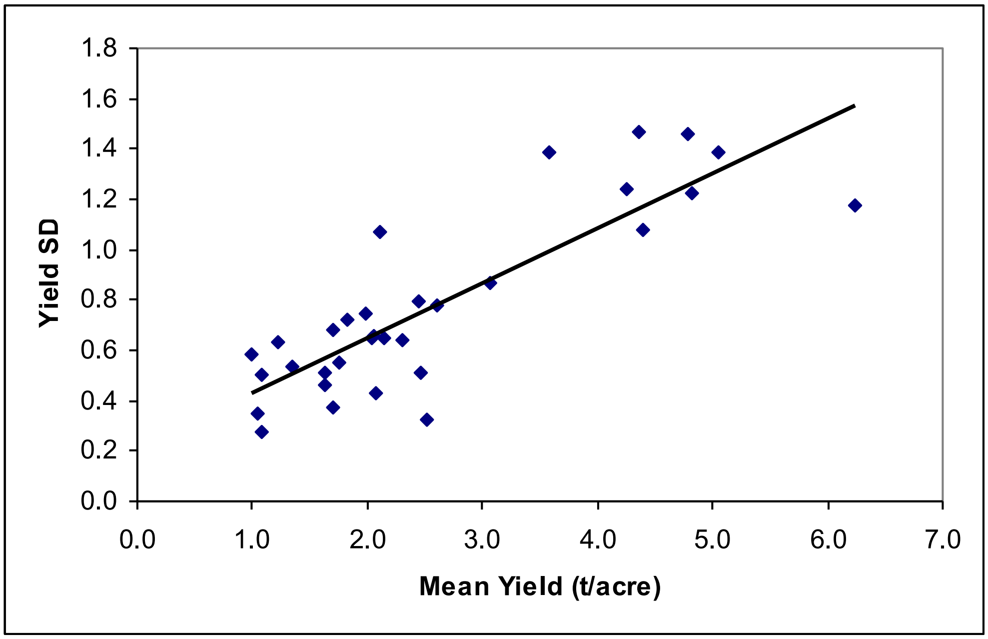


Figure 1. In the Northeast when mean forage yield is 3 tons/acre the standard deviation (SD) of yield is about 0.85 tons/acre. Fifty percent of the time yields are below the mean and about fifty percent of the time yields are above the mean. About one third (2/6) of the time yields are above or below the mean by as much as one SD. About one-sixth of the time yields are less than 1 SD below the mean and about one-sixth of the time yields are greater than 1 SD above the mean.

A



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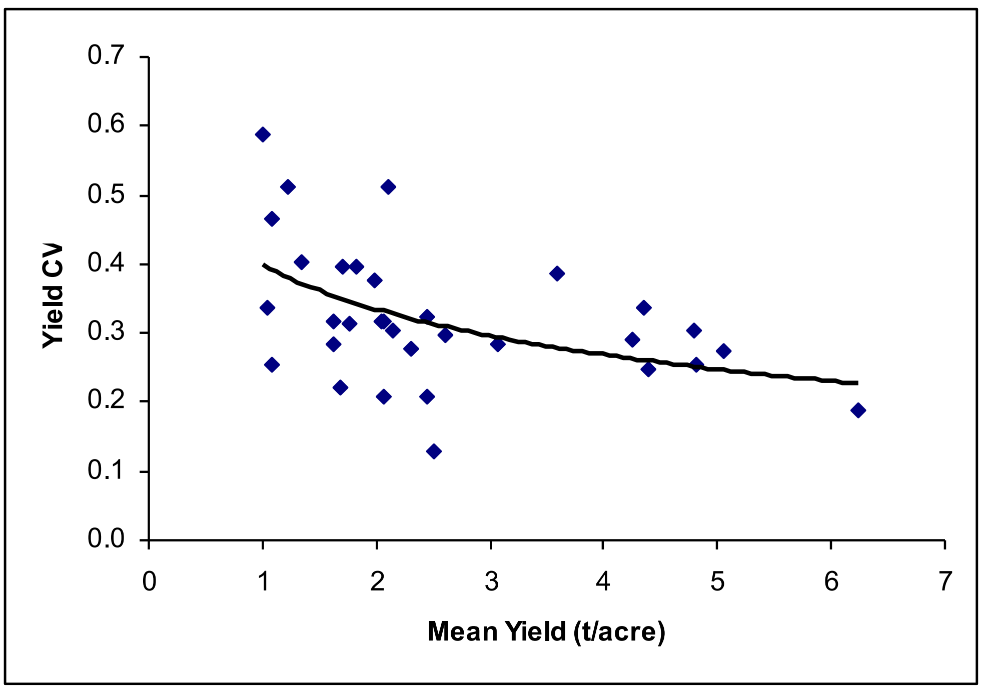
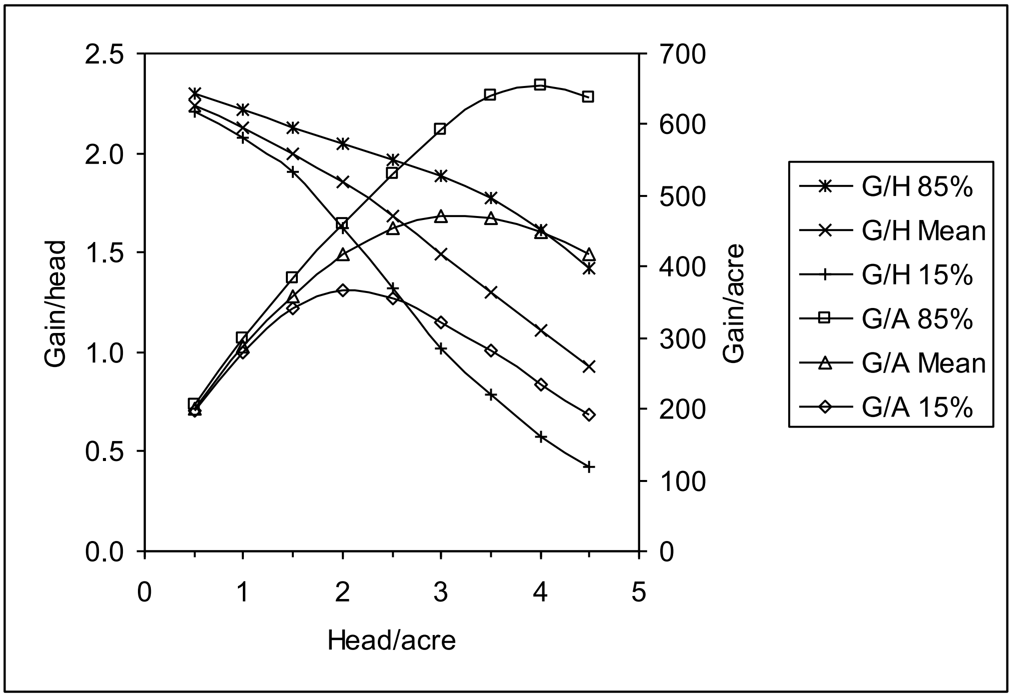


Figure 2. The relationship of mean yield and yield standard deviation (SD) (A) and mean yield and yield coefficient of variation (CV) (CV=SD/average) (B) for cool-season grasses and legumes grown in the Northeast.

A



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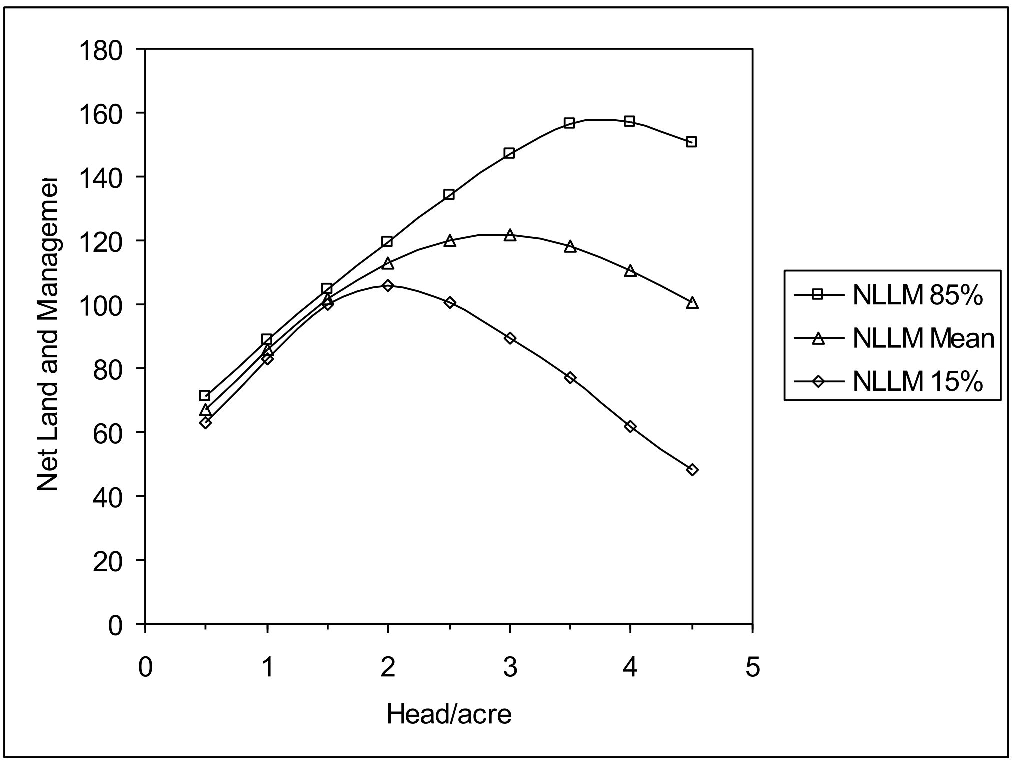

Figure 3. Stocking rate effect on mean and 15% and 85% probability level of gain per head (G/H), gain per acre (G/A) (A), and net income to land, labor, and management (NLLM) (B) for a contract stocker orchardgrass pasture-hay system growning on deep soils in the Northeast.