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Forage Economics

Forages are an essential part of a ruminant animal's diet and are an important factor in a profitable farm business. Many producers choose to grow some or all of their own forages, and this represents a significant cost. Cost is affected by decisions made in choosing, producing, harvesting, storing, and feeding forage. Years with low yields and production shortfalls create the need to buy additional feeds at added cost. Costs of alternative feeds and costs of alternative ways of procuring forages must also be considered as part of the profit equation. There are times when it is better to buy than grow forage. This publication discusses these aspects of forage economics.

Decisions about forage should be based upon several factors:

- The cost of production or procurement measured at the point where the animal consumes the forage,
- The impact of forage choices on total feed cost,
- The impact on animal performance, and
- The impact of year-to-year variations in yield and quality.

North Carolina has a wide variety of soil types, topography, and climate as you move from the coast to the mountains. There are numerous forage crop choices:

- Crops, including grasses and legumes, corn, and small grains;
- Harvesting and conservation options, including grazing, hay, silage, and haylage;
- Storage options, including barns, silos, and wrapped or bagged bales, and
- Feeding options.

Eastern North Carolina and the piedmont have a long growing season, but these sections of the state are subject to high summer temperatures and unpredictable amounts of summer rainfall. Many types of forage crops can be grown, but yields are unpredictable. Fewer options are available in the mountains because the growing season is shorter. This being the case, it is not possible to generalize and make recommendations that would fit all areas of the state. You must make decisions based on your goals, location, and resources.

Production Costs

Production costs are important considerations when choosing among alternative forage crops. These costs include operating expenses for items that are used up within one cropping season and fixed costs associated with investments in machinery and equipment. The cost structure is different when comparing annual crops, such as corn silage or winter rye for grazing, to perennial forage crops, such as fescue and Bermudagrass. For annual forage crops, all the production costs are incurred during the production cycle for a single crop. For perennial crops, costs can be separated into the start-up

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or establishment costs and the annual costs incurred thereafter. These establishment costs can be thought of as an up-front investment that must be allocated over the life of the crop.

Examples are provided in the following tables, based on the NCSU enterprise budgets. Costs are based on practices recommended by North Carolina Cooperative Extension forage specialists and reflect 2006 prices in North Carolina. Costs are based North Carolina conditions, assuming normal weather, typical soil types, and current production technology. Enterprise budgets are only guidelines and should be carefully evaluated and modified for your specific farm situation. They are not intended to be used "as-is." These and other North Carolina enterprise budgets are revised periodically. Ask for a current enterprise budget at your county Extension center or visit the Department of Agricultural and Resource Economics at NC State University online at http://www.ag-econ.ncsu.edu/extension/Ag_budgets.html.

The costs presented in Tables 1 through 3 are defined as follows:

- **Materials and services** include seed, seed

Table 1. Estimated establishment cost per acre for selected perennial crops in North Carolina, 2006.

Forage crop	Materials and services	Labor	Machine operating	Machine ownership	Total cost per acre[a]
	$				
Cool season perennial grasses[b]	165.63	7.80	7.76	14.16	195.35
Hybrid bermudagrass	279.28	24.19	24.93	30.39	358.78
Ladino clover and cool season perennial grass	183.79	7.80	7.27	14.16	213.01
Switchgrass	192.39	16.87	17.46	29.33	256.05

[a] Bermudagrass and switchgrass normally produce some usable forage during the establishment year, which can partially offset the establishment cost. The costs shown in this table are the full costs, with no allowance for the value of any production. Fall-sown cool season grasses do not produce a significant yield of usable forage in the establishment year. Items may not add to totals because of rounding.
[b] For example, orchard grass or tall fescue. Seed for endophyte-friendly tall fescue costs more.

Source: Enterprise Budget Guidelines, Department of Agricultural and Resource Economics, NC State University.

Table 2. Estimated annual cost of production per acre for selected annual and perennial forages, 2006.

Crop	Materials and services	Labor	Machine operating	Ownership[a]	Total cost per acre[b]
	$				
Bluegrass and white clover for pasture	70.07	4.87	4.34	9.21	88.49
Cool season grasses for pasture	106.32	9.73	8.69	54.17	178.91
Ladino clover and cool season perennial grass for pasture	55.56	9.73	8.69	60.87	134.86
Hybrid bermudagrass for pasture	127.11	9.73	8.69	42.65	188.18
Summer annuals for pasture	136.98	8.52	8.85	11.03	165.38
Winter annuals for pasture	117.25	10.59	10.52	11.00	149.37
Switchgrass for hay and pasture	85.29	20.60	22.01	48.98	176.88
Hybrid bermudagrass for hay (round bales)	183.01	58.49	62.13	103.43	407.06
Corn silage	195.23	42.17	47.68	92.19	377.27
Small grain silage	130.81	42.02	41.06	88.55	302.44

[a] Includes the amortized cost of establishment of perennial crops.
[b] Items may not add to totals because of rounding.

Source: Enterprise Budget Guidelines, Department of Agricultural and Resource Economics, NC State University.

Table 3. Hay harvesting costs, per cutting per acre, 2006.

Harvest method	Yield, per cut per acre	Materials and services	Labor	Machine operating	Ownership	Total cost per ton of dry matter[a]
	tons of dry matter	$				
Hay, small square bales	1.0	4.28	22.85	23.21	25.75	76.09
Hay, large round bales	1.0	2.79	18.99	20.16	22.36	64.28

[a] To convert cost from a dry matter basis to an "as made" basis, multiply this cost by the dry matter percentage of the hay. Items may not add to totals because of rounding.

Source: Enterprise Budget Guidelines, Department of Agricultural and Resource Economics, NC State University.

inoculants, herbicides, lime and fertilizer, and custom application. An interest charge is included at the annual rate of 7.5 percent, calculated on the cost of each item purchased and based on the average length of time the money spent on these items is used during the calendar year.

- **Labor** costs are charged at $9.00 per hour for machinery operators and $8.50 for other labor. This hourly rate reflects everything you pay: cash wages, benefits, and payroll taxes. If you do the work yourself, think of this charge as the minimum return you would expect on your labor or the opportunity cost of alternative uses for your labor.
- **Machinery operating** costs consist of fuel, lubricants, and maintenance and repairs.
- **Machinery ownership** costs, also called fixed costs, include depreciation, property taxes, insurance premiums, and an interest charge on the investment. These costs are estimated based on new equipment prices in 2006.

Estimates of the start-up costs for some commonly grown perennials are presented in Table 1. Table 2 contains estimates of the annual costs of production for several commonly grown crops. For perennials, these include the amortized cost of establishing the crop. Many forage crops are grown for grazing and hay production. Estimates of the cost of making hay are shown in Table 3. Note that the cost of growing the grass crop is not included. Add these production costs to the cost of harvesting the hay to estimate the cost of producing hay.

Table 4 summarizes the costs of producing and harvesting various types of forages based on the information presented in the previous tables. Because moisture content varies widely and because nutrients are contained in the dry matter of the forage, these cost estimates are calculated on a dry matter basis for ease of comparison. However, the nutrient composition of the dry matter varies among forages, so cost per pound of dry matter should not be the only criterion for selecting among forage types.

Production costs shown in Table 4 vary from around 2.3 cents per pound of dry matter for perennial pastures for grazing to 6.2 cents per pound of dry matter for grass hay. These costs are based on typical yields, but variation in yields and moisture content at harvest can have a big impact on total dry matter production and costs, as shown by the examples in Tables 5 and 6. Table 5 shows the dry matter yield per acre for different combinations of corn silage yields and moisture content of the fresh material. For example, a 15-ton per acre yield of silage at 35 percent dry matter contains 5.25 tons of dry matter. Decrease the percent of dry matter to 28 percent and that same 15-ton per acre yield only contains 4.2 tons.

It costs almost as much to produce a high yielding crop as a low yielding one. Table 6 builds on the cost estimates in Table 2 to show the impact of differences in yield and moisture content on the cost per ton of dry matter produced. Using a corn silage production cost of $377 per acre from Table 2, the range in cost per ton of dry matter is $135 to $50. This

Table 4. Estimated cost of production and harvesting selected forages, per acre and per pound of dry matter, 2006.

Crop	Annual operating	Annual fixed[a]	Total cost per acre[b]	Harvested yield of dry matter	Cost per lb. of dry matter harvested
	$			tons	¢
Cool season perennial grass for grazing	125	54	179	3.0	3.0
Clover and cool season perennial grass for grazing	74	61	135	3.0	2.3
Bermudagrass for grazing	146	43	188	3.0	3.1
Summer annual for grazing	154	11	165	2.5	3.3
Winter annual for grazing	138	11	149	2.5	3.0
Cool season grass hay, per cut, round bales	84	40	124	1.0	6.2
Bermudagrass hay, round bales	304	103	407	4.5	4.5
Corn silage	285	92	377	5.6	3.4
Small grain silage	214	89	302	3.0	5.0

[a] Includes the amortized cost of establishment of perennial crops.
[b] Items may not add to the total because of rounding.
Source: Enterprise Budget Guidelines, Department of Agricultural and Resource Economics, NC State University.

Table 5. Impact of harvest yield and dry matter (DM) percentage on dry matter yield per acre of corn silage.

Silage moisture (% DM silage)	Yield=10 tons/acre	Yield=15 tons/acre	Yield=20 tons/acre
	tons of DM/acre		
28	2.8	4.2	5.6
33	3.3	4.95	6.6
35	3.5	**5.25**	7.0
38	3.8	5.7	7.6

Source: Calculated by the authors from the NCSU corn silage enterprise budget.

Table 6. Impact of yield and dry matter (DM) percentage on cost per ton of dry matter for corn silage produced at a cost of $377 per acre.

Silage Moisture (% DM silage)	Yield=10 tons/acre	Yield=15 tons/acre	Yield=20 tons/acre
	$/ton DM		
28	135	90	67
33	114	76	57
35	107	**72**	54
38	99	66	50

Source: Calculated by the authors from the NCSU corn silage enterprise budget.

illustrates the importance of knowing forage yields and the dry matter content of the harvested crop.

Forage Procurement Options

North Carolina farmers have several choices for obtaining forages. You may grow your own forage, rent pasture, get a custom operator to perform some or all of the production activities, purchase hay or silage, purchase by-product feed as forage substitutes or forage extenders, and/or have silage grown under contract. Depending on your farm's situation, there may be more profitable alternatives to growing your own forages.

Pasture may be rented by the acre or per head of livestock. It may be rented for multiple years, for a single year, or by the month. The rental agreement may require you to apply lime or fertilizer, or to maintain fences, lanes, and water supply. The budgets presented above can provide some guidance to landowners in setting rents but note that these budgets include no land ownership costs, such as property taxes or interest on land investment. Similarly, these budgets, coupled with estimates of pasture productivity and livestock performance, can help a potential renter estimate the profitability of specific rental arrangements.

Changing from producing your own forages to custom work or contracting can affect many parts of the business, including production costs, level of investment, cash flow, income, risk, and workload. The impact on profitability and cash flow cannot be evaluated unless you have a good grasp of current forage production costs, quality, total ration costs, and livestock performance.

Table 7 shows cost estimates for selected pieces of equipment based on new equipment prices in 2006. Ownership costs include depreciation, interest on the investment, insurance, and taxes. Operating costs include repairs, maintenance, and fuel and lube for tractors and other self-propelled equipment. Each farm is different and will have different costs. For example, if you buy used equipment, you would have lower ownership costs but higher operating costs, particularly for repairs. The table also does not show hourly labor costs. When you figure labor costs for hired employees, be sure to include fringe benefits and employment taxes in addition to the actual cash wages paid. We recommend also charging for your own and/or unpaid family labor. Use the going rate for hired labor, the value (reservation price) that the family members attach to their labor, or the desired return per hour from the work they provide.

Contract production of corn silage is growing in popularity, particularly among dairy farmers. There is some interest in contract hay production also. No standard contract or price exists, so the terms of each contract must be negotiated. Begin with a clear understanding either of what you expect the contractor to do or of what the contractor is offering, depending on who makes the initial contact. The specific details of the arrangement will affect what it is worth to each party, the production costs for the grower, and what the buyer can afford to pay. However, as with all business deals, the final agreement must be acceptable to both parties.

The following discussion relates to contract silage production but the same principles apply to contract hay production. The first questions to ask are "What am I buying, and what is it worth to me?"

- Are you buying silage by the ton or by the acre? If you contract for production by the ton, then the grower takes the risk that there will be a poor growing season. If you contract by the acre, you bear a greater risk and the price should be lower as a consequence. Tables 5 and 6 illustrate the effects of yield on cost.
- If you are buying by the ton, specify the dry matter content and a base price. Adjust the price

Table 7. Selected forage machinery and equipment costs, 2006.

Item	Purchase price	Annual ownership cost	Ownership cost per hour[a]	Operating cost per hour	Total cost per hour[b]
	$				
Tractor, 55 HP	19,700	2,355	4.71	7.75	12.46
Tractor, 75 HP	25,420	3,038	6.08	10.50	16.58
Tractor, 95 HP	44,420	5,143	10.29	13.79	24.08
Forage harvester, self-propelled	88,000	17,448	116.32	19.78	136.10
Pickup, 3/4 ton	25,000	3,066	6.13	9.63	15.76
Chisel plow	5,740	679	6.79	1.72	8.51
No-till grain drill	16,510	1880	18.80	1.65	20.45
Sprayer	3,030	345	3.45	0.91	4.36
Bush hog	4,250	511	5.11	0.43	5.54
Mower-conditioner-windrower, PTO	15,720	1,889	18.89	6.29	25.18
Spider rake	2,670	329	4.39	0.71	5.10
Round baler, 1/2 ton	11,310	1,577	12.61	0.90	13.51

[a] The useful life and annual hours of use assumed in these calculations are different for each piece of equipment. "Estimating Farm Machinery Costs," Ag Decision Maker A3-29, Iowa State University, University Extension, April 2002, a useful publication explaining machinery costs, can be found online at http://www.extension.iastate.edu/agdm/crops/html/a3-29.html.
[b] This cost is for each item of machinery or equipment only and does not include labor costs or charges.
Source: Enterprise Budget Guidelines, Department of Agricultural and Resource Economics, NC State University.

for any differences in dry matter content. Tables 5 and 6 illustrate the effects of differences in moisture content on cost.

- Specify what the finished product will be. Some corn is sold as a standing crop, some is sold as fresh chopped material in the field, and some is sold delivered to the silo. If you have trench silos, who will do the spreading, packing, and covering?
- Will you supply any of the land, equipment, or labor? The more you provide, the lower the payment to the contractor should be.

The NC State University corn silage budget separates out preharvest, harvesting, transportation, and silo-filling costs. Use it to estimate costs under alternative arrangements.

Reliability and continuity of supply is an additional area of concern for contract silage. Because silage is high in moisture and bulky, transportation costs are high. Most producers have only one or two potential contractors to work with. In order to take full advantage of using a contractor, equipment must be sold and labor let go or put to other work. It is difficult to undo these changes if the contracting arrangement is ended at short notice. The only way to protect against this situation is through a long-term, written agreement. It can also be useful to include an arbitration procedure in this agreement for resolving any disagreements that might arise.

Harvesting, Storage, and Feeding

The methods used for storage and feeding also affect the cost of feeding livestock. Each alternative has different operating, labor and investment costs. Based on discussions at many grazing schools held in North Carolina, the costs of feeding out hay during winter or during summer droughts when pasture is short can be $20 or more per large round bale even when livestock are located within a reasonable distance from the farmhouse. This includes the cost of labor and the full cost of the equipment used to move hay from storage to livestock on pasture fields or a sacrifice area. Considerable variation will occur from farm to farm, however.

Similarly, the budgeted cost of pasture for grazing does not include any charges for managing cattle on pastures. Under typical North Carolina conditions, it costs $8 to $10 each time cattle are moved to fresh grazing. This includes the cost or

value of time spent traveling to the pasture fields and moving cattle and waterers. It also includes the full cost of equipment used for transportation, such as a pickup truck. These costs do not include the ownership or fixed costs associated with investments in fencing, lanes, and watering systems.

In addition to the costs described above, there are "hidden" costs in the form of crop losses through chemical changes, spoilage, and waste. The losses will depend on many factors including the specific crop; the particular harvesting, storage, and feeding systems in place on the farm; and the level of management. Table 8 provides estimates of the various types of loss for various crops. Total losses for forage crops range from 15 to 50 percent of the standing crop at the time harvesting begins. Storage and feeding losses for concentrate feeds are likely to be around 5 percent of the purchased amount in a well-managed storage and feeding system. However, treat these loss estimates as guidelines; there is likely to be wide variation from farm to farm.

Clearly, these losses can have a major impact on costs. For example, Table 4 shows the estimated cost of making large round bale grass hay as $124 per ton on a dry matter basis. If storage and feeding losses run 30 percent, then the cost of the hay actually consumed by the livestock increases to $177 per ton! Similarly, the cost of growing and harvesting corn silage is estimated to be $67 per ton of dry matter. The cost of the silage actually eaten increases to $84 per ton when storage and feeding losses are 20 percent.

Impact on Animal Performance, Total Feed Costs, and Profitability

Forage type, quantity, and quality determine the amounts and balance of specific nutrients available to the animal. Sample and analyze each of the major forages used on your farm every year in order to develop balanced and economically formulated rations needed for animal performance. Use the analysis to evaluate the impact of different forages on animal performance, including growth rates, milk production, reproduction, and body condition.

The most effective way to compare alternative forage crops and procurement options is to develop nutritionally balanced rations capable of achieving the desired level of animal performance. Consider the various forage alternatives, and other feedstuffs and their costs. Send samples for chemical analysis, and use these actual values if possible. Evaluate total feed costs, including all the ration components. This approach requires placing a value on homegrown forages. Use the fair market price for a comparable product if a ready market is available. If there is no reliable market price, estimate the cost of production calculated at the point of consumption by the animal.

The value of different forages and feeds can change over time. Many ration balancing programs generate a "shadow price," which is the break-even price for any one of the available feedstuffs or ingredients. Use this shadow price to evaluate the maximum economic value of individual forages. If the price or cost of a particular forage is greater

Table 8. Forage crop harvest, storage, and feeding losses.[a]

Crop	Harvest and storage system	Harvest losses	Storage losses	Feeding losses	Total losses
		%			
Cool Season Grasses	Grazed extensively	50	—	—	50
	Grazed intensively	15	—	—	15
	Hay; square bales, in a shed	10	3	5	18
	Hay; square bales, outside, covered	10	5	5	20
	Hay; round bales, shed	10	3	15	28
	Hay; round bales, outside, covered	10	5	15	30
	Hay; round bales, outside, uncovered	10	15 to 20	15	40 to 45
Corn	Silage, metal upright	5	5	5	15
	Silage, concrete upright	5	10	5	20
	Silage, bunker, covered	5	12	5	22
	Silage, trench, covered	5	15	5	25
	Silage, bags	5	5	5	15
Grasses/mixes	Haylage	13	5 to 15	5	23 to 33
Concentrates	Bin	NA	minimal	5	5

[a] Forage losses are based on the quantity of standing forage in the field at the time harvest begins. Concentrate losses are based on quantities purchased.

Source: Sustainable Dairy Farming Systems Manual, Universities of Kentucky and Tennessee, 1998.

than its shadow price, there is a more economical way of feeding the animals to achieve a target level of performance. Repeat this analysis periodically because the shadow price (value) of one feed is affected by the prices of other feeds and ingredients. Rethink your forage production strategy if the costs of production exceed the value of the forage.

Budgets can be developed to compare the profitability of alternative forage production and feeding systems. These budgets should incorporate any animal performance differences and the resulting effects on income or costs. You may want to ask your county Extension agent or another qualified person for help in performing this analysis.

Risk Management

Because North Carolina's climate does not support consistent yields from year to year, most farmers have strategies to cope with short crops. One approach is to plan on buying additional feed, either as forages or as by-products with a significant fiber content to stretch forage supplies. Some producers grow extra forage. In a short crop year this extra forage may be used to meet livestock needs during the coming winter. In years of normal or better than normal yields, the surplus can be used to build buffer stocks for future use. However, this strategy requires additional storage facilities and incurs carrying costs in the form of spoilage and interest on the crop investment. Alternatively, any surplus can be sold as silage, shell corn, or hay, depending on the crop. However, you may not fully recoup your added planting and harvest costs.

Another strategy is to diversify the types of crops grown. For example, many dairy farmers grow small grains double-cropped with tropical corn or sorghum in addition to corn. The different crops, planting dates, and growing seasons allow you to spread the risk of a major shortfall. However, the total cost of the mix of forages produced under this approach may be higher than the cost of specializing in corn silage alone.

Analyze these alternative strategies to determine the most cost-effective one, based on the frequency and severity of production problems in your area. Your county Extension agent or another qualified person can help you perform this analysis.

Summary

Forages are an essential part of ruminant's and other grazing animal's diets and are an important part of a profitable livestock enterprise. Growing forages represents a significant cost. This cost is affected by the choice of forage crop and how it is produced, harvested, stored, and fed. Forage availability and quality affects livestock performance, including growth rates, milk production, and body condition. Variable weather conditions can cause low yields and risk management strategies create added costs.

When making decisions about forage, consider the:

- Cost of production, measured at the point where the animal consumes the forage,
- Impact of forage choices on total feed cost,
- Impact on animal performance, and
- Impact of year-to-year variations in yield and quality.

Cost and quality considerations are important considerations when choosing among alternatives. Production costs range from around two cents per pound of dry matter for perennial pastures for grazing to six cents per pound for grass hay. Yields and moisture content at harvest have a big impact on dry matter production and costs. However, in addition to these production costs, there are hidden costs in the form of crop losses through chemical changes, spoilage, and waste. Losses will vary among different crops and different harvesting, storage, and feeding systems. Field to mouth losses can range from 15 to 50 percent and have a significant impact on costs.

Farm equipment and labor cost estimates can be helpful when evaluating the cost and profitability of custom work alternatives. Also consider the reliability of the custom operator and the timeliness and quality of his or her work.

The most effective way to compare alternative forage crop production or procurement options is to develop balanced rations capable of achieving animal performance targets, using the various forage alternatives and other available feedstuffs. Evaluate the total feed costs, including all the ration components. Forage type and forage quality can affect animal performance. If this is the case, consider the impact of different levels of animal performance on profitability as well as any differences in forage production costs and total feed costs.

Forage production is a risky business in North Carolina due to our climate. Strategies to cope with short crops include buying additional forages or stretching the forage supplies already on hand by purchasing commodity and by-product feeds with a significant effective fiber content. Or, you can plant additional acreages of forage crops. In normal or above-normal years, the surplus can be used to build buffer stocks for future use or can be sold. You also can diversify the types of crops grown. Each of these risk-management strategies has associated costs that you must analyze to identify the most cost-effective strategy.

Clearly, there are no simple answers to questions on the economics of alternative forage crops and different production and procurement systems. Each alternative has several aspects that should be considered. However, every decision must start with a clear understanding of the costs involved and the impact on animal performance and income.

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