

# Optimal Nitrogen Application Rates for Stockpiling Tall Fescue Pastures 2009 Guide (AEC 2009-09)

## Introduction:

Cow-calf operations have continued to struggle in 2009. One of the most significant challenges producers have faced are significantly higher input costs related to hay production. An opportunity that Kentucky cattle farmers have in reducing their hay requirements is to apply nitrogen on select pastures to stockpile for fall and winter grazing. By increasing the total pasture production during this time period, the grazing season can be extended and the amount of hay required can be reduced.

While this concept is pretty straightforward, the challenge is to determine the optimal nitrogen application rate given the economic and agronomic conditions present at this point in the summer. Since the response that a unit of nitrogen has on forage growth decreases as successive units are applied, there will be a point in which further applications of nitrogen will not pay. *Thus at some point, additional grazing days will become more expensive than feeding hay.*

Severe drought in 2007 and 2008 made stockpiling fescue extremely difficult, as soil moisture conditions were not very accommodating. In contrast, soil moisture conditions are favorable through most of the state this year as of mid-July. There are, however, some areas in the western part of Kentucky that are experiencing dry conditions. As a consequence, multiple response functions are used in this analysis to simulate different soil moisture conditions. Those areas that have received more rainfall will offer the best opportunities for applying nitrogen and stockpiling. However, it is still possible that areas with lower soil moisture levels may offer cost savings. *The primary objective of this publication is to help farmers identify those situations where applying nitrogen to late summer pastures will be profitable.*

There are two main sections in this publication: 1) “Agronomic Basics for Stockpiling Fescue”, and 2) “Potential Savings from Applying Nitrogen”. The first section provides the basics for applying nitrogen to late summer pastures and how to stockpile this forage for fall and winter grazing. The second section describes the methods used to determine the optimal nitrogen application rate, discusses assumptions used in this determination, and provides a summary of the optimal nitrogen rates and cost-savings given a variety of prices and conditions.

## **Agronomic Basics for Stockpiling Pastures:**

Stockpiling can be defined as growing pasture for later use. In Kentucky this typically means applying nitrogen (N) to tall fescue pastures in August, letting them grow through the fall, and then grazing during the late fall and early winter. Kentucky bluegrass and other cool-season grasses will also respond to nitrogen applications in the fall, but this publication focuses on tall fescue since it shows a higher N response and stockpiles better for winter grazing.

The best pastures to target are those with the thickest stands of fescue. Fescue responds extremely well to N applications in late summer and has an amazing ability to retain its nutrient value through the winter. Targeted pastures should have low concentrations of weeds and low amounts of clover since legumes do not stockpile well after frost and the yield benefit of added N is less than in pure fescue stands. Moreover, N has the potential to reduce the clover component of the sward as the additional fescue growth will compete with the legumes. A good rule of thumb is that where clover makes up more than 20% of the stand, the short-term yield increase from nitrogen will not typically outweigh the long-term forage quality and nitrogen fixation benefit of the lost clover.

Pastures should be grazed or mowed to reduce fescue height to 2 to 3 inches during early to mid-August. Remove animals before overgrazing occurs or initial regrowth will be slow. Grazing or mowing removes low quality summer growth and allows the plant to produce high quality leaves. Assuming that there is adequate soil moisture, a considerable amount of growth will occur within four to six weeks, but waiting 8 to 12 weeks before grazing is preferable.

The optimal time to apply N is in early to mid-August. Prior applications may encourage the growth of weedy grasses like crabgrass. Waiting until September will reduce the efficiency of N conversion into plant growth. For example, one Kentucky study showed that N conversion efficiency (lbs dry matter fescue growth per unit N) was 27:1 on Aug 1, 26:1 on Aug 15, 19:1 on Sept 1, and 11:1 on Oct 1. *Therefore, when N application is delayed until September or beyond, optimal N application rate will decrease, and you should carefully consider the benefit of increased fescue growth compared to the cost of purchased hay.* N response efficiency also depends on soil moisture. Without rain and/or adequate soil moisture, N response will be low, but even with small amounts of rain tall fescue has an amazing potential for fall growth. *In areas that are exceptionally dry, applying N can be somewhat of a gamble in terms of the response.*

Traditional “stockpiling” involves keeping cattle off the pasture until late fall, but this practice may be difficult when pasture production is low. If forage is needed, N fertilized pastures can be grazed in the early fall, but it is recommended that cattle be kept off these pastures for at least a month. An alternative strategy is to feed hay during the stockpiling period to supplement the pastures that cattle are on.

Tall fescue growth will occur without added N, but University of Kentucky Cooperative Extension emphasizes the importance of adding N for maximum growth and forage quality. In Kentucky, nitrogen (90 units or actual lbs N) increased forage production by over a ton and protein by 5 percentage points. In Ohio, nitrogen (90 units or actual lbs N)

increased protein by 9 percentage points and improved overall digestibility. Another reason to stockpile fescue is that it retains its quality extremely well through the winter months. In an Arkansas research study, stockpiled fescue was higher quality (12% CP and 55% TDN) even in early March than average quality hay. This attribute can be particularly beneficial for a late winter or spring calving cow-herd.

There are several forms of N available for pasture use, but the two main types are ammonium nitrate and urea. Ammonium nitrate is an excellent form to use in late summer because it is not subject to surface volatilization. Urea is generally a cheaper source of N, but a significant amount of N can be completely lost under hot, humid conditions favoring volatilization. Typical urea losses in late summer range from 15-30%, but can approach 40-50% when there is no rainfall for several days after application. Fortunately, urease inhibitors (e.g. Agrotain) have been recently developed to reduce volatilization losses with urea (see AGR-185 referenced on last page). Even though they add to the overall cost, urease inhibitors are recommended in the summer for urea due to the unpredictable rainfall in August. Be aware that all urease inhibitors are not equally effective.

Besides the application of N, it is important that stockpiled fields be limed and fertilized with P and K to acceptable levels (see AGR-1 referenced on last page). Where possible, stockpiled tall fescue fields should be strip grazed and stocked heavily enough to graze down each paddock in 7 to 10 days or less. This allows the forage to be efficiently utilized without excessive trampling and waste. Since tall fescue does not re-grow in the winter, a back fence is not needed when strip grazing stockpiled growth.

Greater detail of the stockpiling process can be found in the UK extension publication AGR-162 “Stockpiling for Fall and Winter Pasture” which can be found at: <http://www.ca.uky.edu/agc/pubs/agr/agr162/agr162.pdf> or your county extension office.

### **Potential Savings from Applying Nitrogen:**

The analysis presented here is based on a mathematical model that accounts for the major factors that impact the optimal nitrogen application rate. On a technical note, the optimal rate occurs when the marginal cost of grazing (on a per day basis) from applying the last unit of nitrogen just equals the cost of feeding hay. This rate will change depending on the price of N, the price of hay, soil moisture conditions, and other factors. For example, as the price of N increases, the optimal N rate will decrease. As the price of hay increases, the optimal N rate will increase. As soil moisture conditions improve, the optimal N rate will increase. The model determines this optimal N rate as well as the corresponding savings compared to feeding hay.

In order to compute the optimal application rate, a number of parameter values must be estimated that are representative of this year’s conditions. Two of the most important values are the price of nitrogen and the price of hay. The price of nitrogen was evaluated on an elemental (lbs actual N) or unit basis<sup>1</sup> between \$.40-.60 per unit<sup>2</sup> and hay values

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<sup>1</sup> To convert elemental N to urea: Multiply elemental value by 2.17. E.G. 100 units N = 100x2.17 = 217 lbs urea. To convert elemental N to ammonium nitrate: Multiply elemental value by 2.99. E.G. 100 units N = 100x2.99 = 299 lbs ammonium nitrate.

were evaluated on a per ton basis between \$45-90. These values should capture most of the variability that is likely to occur this year.

The application cost for spreading the nitrogen was set at \$5/acre. Waste rates for both grazing and hay feeding (the latter includes both losses from weathering and feeding) were set at 35%. Machinery and labor costs were set to be representative of the average Kentucky cow-calf operation in both size (30 cow herd) and management intensity. This resulted in a labor cost of \$.06 per cow day for grazing<sup>3</sup>, and machinery and labor cost of \$.25 per cow day for hay feeding. Feeding hay results in imported nutrients being deposited in pastures. It is assumed that 50% of the P and K from feeding hay are effectively recycled into the soil and this value is accounted for in the analysis.

Finally, three nitrogen response rates were used in the analysis: low, medium, and high. Consult Table 2 to determine which nitrogen response curve is most appropriate for your specific condition. *The choice of response rate is probably the single most important determinant in the analysis.* These response rates are based on a four-year Missouri study. The high response rate used in the model was actually the average of the four years from this study that included both wet and dry years. However, the study site was on deep, fertile soil and would be representative of the best soil types in Kentucky. Thus adjustments needed to be made from this base response rate depending on the soil quality and the specific soil moisture conditions present. University of Kentucky agronomists (Drs. Lloyd Murdock and Ray Smith) adjusted the response functions for various combinations of soil quality and moisture conditions (see Table 2).

In addition to the response rates, the model also separately evaluates pastures that are predominantly fescue, and stands that are a fescue-clover mix. “Fescue-clover” stands in the Missouri study had an average of 20-30% clover (mostly red). “Fescue” stands were on average about 95% tall fescue. Thus if you had a fescue-clover stand that contained 10-15% clover you would probably want to average the optimal nitrogen rate for the two stand types. As mentioned earlier, nitrogen has the potential to reduce the clover component of the sward, so nitrogen applications are not normally recommended where clover makes up more than 20% of the stand.

### Results:

Table 1 summarizes the optimal nitrogen application rates and corresponding savings from stockpiling on a per acre basis. Net savings for the scenarios presented here ranged from a low of \$0 (no nitrogen applied) to a high of \$125 for the situation where nitrogen is priced at \$.40/unit (lb), hay is priced at \$90/ton, and we assume a high production response to nitrogen for a pure tall fescue stand (a combined scenario that has a low probability of occurrence). In general, the price of hay was a more important factor than the price of nitrogen at the levels evaluated in this analysis.

Using the most likely price estimates for nitrogen (\$.60/unit or actual lbs N for ammonium nitrate) and hay (\$60/ton) resulted in a net loss compared to feeding hay if nitrogen was applied at any level assuming a low response rate to nitrogen. Assuming a

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<sup>2</sup> \$.40/unit N = \$268/ton Ammonium Nitrate and \$368/ton Urea; \$.50/unit N = \$335/ton Ammonium Nitrate and \$460/ton Urea; \$.60/unit N = \$402/ton Ammonium Nitrate and \$552/ton Urea.

<sup>3</sup> Assumes open-access to stockpiled pasture (not “strip grazed”).

medium response rate resulted in net savings of \$15 per acre stockpiled (fescue) and a net loss (fescue-clover). This corresponds to an optimal nitrogen application rate of 75 units<sup>4</sup> per acre for the fescue stands. Assuming a high response rate resulted in net savings of \$45 (fescue) and \$5 (fescue-clover) per acre stockpiled, which corresponds to an optimal nitrogen application rate of 95 units<sup>5</sup> for fescue stands and 65 units<sup>6</sup> for fescue-clover stands. Thus where good soil moisture conditions exist (medium to high response rate), nitrogen applications to fescue stands look favorable given the most likely prices for nitrogen and hay. Fescue-clover stands, however, do not generally look favorable in this situation. Note that even where potential cost savings in the fescue-clover stands exist, they need to be balanced with the potential loss of clover due to N applications.

Use Table 2 to determine which response function is most appropriate for your soil conditions and then use Table 1 to estimate the optimal application rate (if any) based on your estimates for hay and nitrogen prices. *Make sure to use an appropriately lower nitrogen response rating if applications are to occur after mid-August.*

If you plan to use urea (without an effective urease inhibitor) as your nitrogen source, you should make adjustments in Table 2 to reflect volatilization losses generally experienced at this time of year. There are two ways to do this: 1) Increase the effective price of the nitrogen. An increase from \$.40 to \$.45/unit N will approximate a 13% volatilization loss, while an increase from \$.40 to \$.50/unit N will approximate a 25% volatilization loss. 2) Use a response rating one level below what you would have otherwise. This will approximate a 25% volatilization loss. In either case, you will have to adjust the optimal nitrogen application rates upward by the expected volatilization loss (e.g. if you expect a 25% loss multiply the optimal N rate in Table 1 by 1.25).

If your assumptions for waste rates, labor and machinery costs, nutrient recycling rates, etc. are much different than those used here, you will want to run your specific parameter estimates through the model. Contact your county extension agent or the authors (contact information on the last page) and they will be happy to assist you.

### Conclusions:

Mostly pure fescue stands present good opportunities for applying nitrogen and stockpiling in 2009 with current nitrogen and hay prices. Hay prices at or above \$45/ton offer significant savings at both the medium and high response rates, while prices will need to be at or above \$75/ton before significant savings occur with a low response rate.

Fewer cost savings opportunities exist in the mixed fescue-clover stands. Assuming a medium response rate, hay prices need to be nearly \$90/ton before significant savings occur, while prices need to be nearly \$75/ton with a high response rate in these mixed stands. Additionally, any potential savings in the fescue-clover stands need to be balanced against the potential loss of clover due to N applications.

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<sup>4</sup> Equivalent to 224 pounds of ammonium nitrate or 163 pounds of urea.

<sup>5</sup> Equivalent to 284 pounds of ammonium nitrate or 206 pounds of urea.

<sup>6</sup> Equivalent to 194 pounds of ammonium nitrate or 141 pounds of urea.

**Table 1 - Cost Savings of Applying Nitrogen to Late Summer Pastures Kentucky (2009)**

		<i>Low Response to Nitrogen</i>				<i>Medium Response to Nitrogen</i>				<i>High Response to Nitrogen</i>			
		<i>Fescue<sup>1</sup></i>		<i>Fescue-Clover<sup>2</sup></i>		<i>Fescue<sup>3</sup></i>		<i>Fescue-Clover<sup>4</sup></i>		<i>Fescue<sup>5</sup></i>		<i>Fescue-Clover<sup>6</sup></i>	
<i>Price Nitrogen (\$/unit)</i>	<i>Price Hay (\$/ton)</i>	<i>Opt. N Rate (acre)</i>	<i>Savings (\$/acre)</i>	<i>Opt. N Rate (acre)</i>	<i>Savings (\$/acre)</i>	<i>Opt. N Rate (acre)</i>	<i>Savings (\$/acre)</i>	<i>Opt. N Rate (acre)</i>	<i>Savings (\$/acre)</i>	<i>Opt. N Rate (acre)</i>	<i>Savings (\$/acre)</i>	<i>Opt. N Rate (acre)</i>	<i>Savings (\$/acre)</i>
\$0.40	\$45	60	\$5	-	-	85	\$15	-	-	100	\$40	75	\$10
\$0.40	\$60	80	\$15	-	-	100	\$35	70	\$5	115	\$65	95	\$25
\$0.40	\$75	95	\$25	60	\$5	110	\$55	90	\$15	120	\$95	110	\$40
\$0.40	\$90	105	\$40	80	\$10	115	\$75	105	\$30	125	\$125	120	\$55
\$0.50	\$45	-	-	-	-	65	\$10	-	-	90	\$30	-	-
\$0.50	\$60	60	\$5	-	-	85	\$25	-	-	105	\$55	80	\$15
\$0.50	\$75	80	\$20	-	-	100	\$45	70	\$10	115	\$85	95	\$30
\$0.50	\$90	90	\$30	60	\$5	110	\$65	85	\$20	120	\$110	110	\$45
\$0.60	\$45	-	-	-	-	50	\$5	-	-	80	\$20	-	-
\$0.60	\$60	-	-	-	-	75	\$15	-	-	95	\$45	65	\$5
\$0.60	\$75	65	\$10	-	-	90	\$35	55	\$5	105	\$70	85	\$20
\$0.60	\$90	80	\$20	-	-	100	\$55	70	\$10	115	\$100	95	\$35

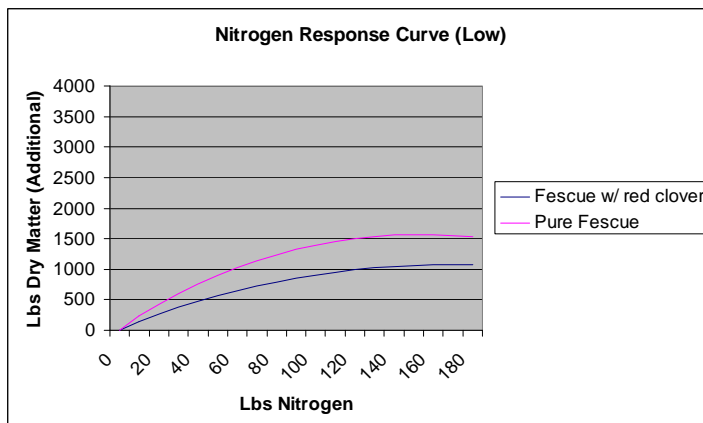
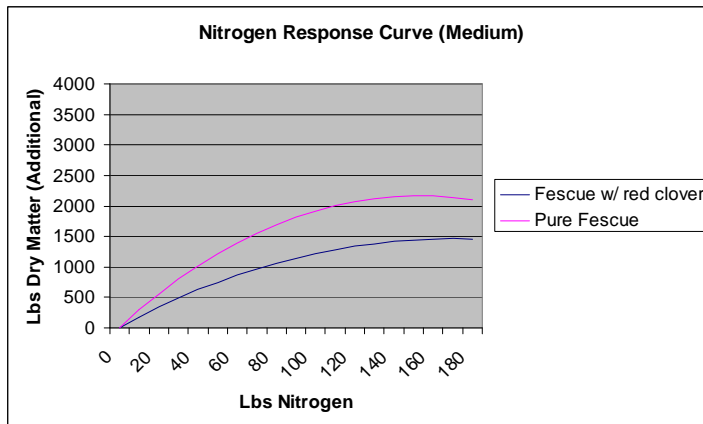
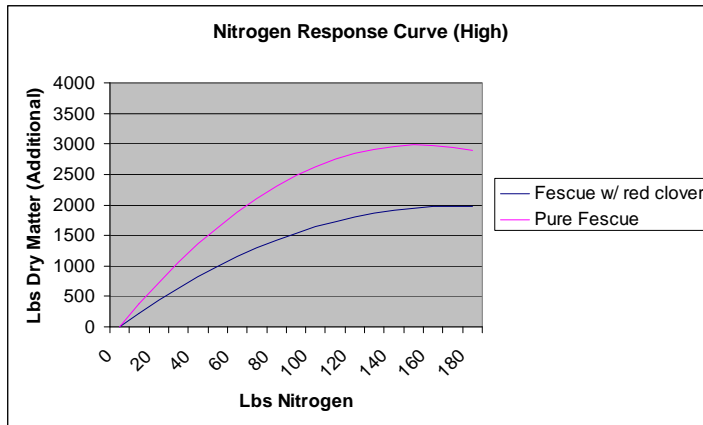
Note: Results are applicable for ammonium nitrate. For urea, use a lower response rating or a higher effective N cost to approximate volatilization losses.  
 Note: \$.40/unit N = \$268/ton AmmNit and \$368/ton Urea; \$.50/unit N = \$335/ton AmmNit and \$460/ton Urea; \$.60/unit N = \$402/ton AmmNit and \$552/ton Urea.  
 Assumptions Cattle: Spring Calving (late pregnancy in mid-winter); 30 cow herd.  
 Assumptions Grazing: TDN=65%; Waste=35%; Application cost N = \$5/acre; labor cost = \$.06/cow/day with open access to entire pasture.  
 Assumptions Feeding Hay: TDN=55%; DMI=2.0% hay+grain; Waste=35%; labor and machinery cost=\$.25/cow/day.  
 Assumptions Nutrient Value of Hay: Assumes 50% of P and K effectively recycled into pasture; \$.40/lb P<sub>2</sub>O<sub>5</sub>; \$.65/lb K<sub>2</sub>O.  
 Fescue<sup>1</sup>: 14 lb avg. dry matter response per lb N (100 lb application)  
 Fescue-Clover<sup>2</sup>: 9 lb avg. dry matter response per lb N (100 lb application); savings need to be balanced with potential loss of clover due to N applications.  
 Fescue<sup>3</sup>: 19 lb avg. dry matter response per lb N (100 lb application)  
 Fescue-Clover<sup>4</sup>: 12 lb avg. dry matter response per lb N (100 lb application); savings need to be balanced with potential loss of clover due to N applications.  
 Fescue<sup>5</sup>: 26 lb avg. dry matter response per lb N (100 lb application)  
 Fescue-Clover<sup>6</sup>: 16 lb avg. dry matter response per lb N (100 lb application); savings need to be balanced with potential loss of clover due to N applications.  
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**Table 2 – Recommended N Response Rating Based on Soil Type/Moisture Condition**

	Soil Moisture Conditions		
Soil Type	Ideal	Avg.	Low
Excellent	High	Med/High	Low/Med
Good	High	Medium	Low
Fair	Med/High	Low/Med	Low

**Note:** N should be applied by mid-August for maximum effectiveness. Use appropriately lower N response rating for later applications.

Based on consultations with faculty at the University of Kentucky, Department of Plant and Soil Sciences.



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**Publications and References (most are available at UK County Extension Offices):**

AGR-162: Stockpiling for Fall and Winter Pasture  
<http://www.ca.uky.edu/agc/pubs/agr/agr162/agr162.pdf>

AGR-185: Nitrogen Transformation Inhibitors and Controlled Release Urea  
<http://www.ca.uky.edu/agc/pubs/agr/agr185/agr185.pdf>

AGR-1: Lime and Fertilizer Recommendations:  
<http://www.ca.uky.edu/agc/pubs/agr/agr1/agr1.pdf>

NRCS Online Soil Survey (can also access soil survey data at County Extension Office):  
<http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx>