UK COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY — COLLEGE OF AGRICULTURE

Profitability of Spring Hayfield Nitrogen Applications 2012 Guide

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<u>Introduction</u>:

Weather conditions during the 2011 hay season were generally good. Both spring and fall were especially wet and those conditions generally persisted through the winter. With high fertilizer prices last year, some producers used minimal fertilizer rates and experienced lower than expected hay production. Consequently, Kentucky's average non-alfalfa hay yields (2.2 tons/acre) remained unchanged from 2010, even with the better growing conditions. USDA estimated an 8.7% decrease in non-alfalfa hay acreage last year, much of which was shifted to crop production.

Increased rainfall resulted in excellent fall pasture growth and decreased winter feeding needs. Many operations that began feeding hay during the summer in 2010 were able to graze into late fall in 2011. This greatly decreased the amount of winter feed that was needed. Hay needs were also affected by another decrease in the size of Kentucky's beef cow herd, which fell by about 3% during 2011. This smaller cow herd will result in reduced demand for hay. Overall, we are likely going into spring 2012 with a higher hay inventory (on a per cow basis) compared to 2011.

In general, hay production costs increased during 2011 but are projected to remain fairly stable going into 2012. Abundant rainfall through the winter will mean good soil moisture conditions going into spring, but the heavy rainfall also means little residual nitrogen will be left in the soil for this years hay crop. This should result in a very good response rate to applied nitrogen.

The purpose of this publication is to evaluate the potential profitability of applying nitrogen to hayfields this spring. While the price of nitrogen is known with a relatively high degree of certainty at this point, the price that hay will sell for later this year is not. Consequently, a wide range of hay prices will be evaluated in this analysis. *The primary objective of this publication is to help identify specific situations where applying nitrogen to spring hayfields in 2012 will prove profitable*.

There are two main sections in this publication: 1) "Agronomic Basics of Spring Nitrogen Fertilization", and 2) "Profitability of Spring Nitrogen Applications". The first section provides basic guidance and information for applying nitrogen to spring hayfields. The second section describes the methods used in the profitability analysis, discusses assumptions, and provides a summary of the expected profitability given various scenarios. Three prices for nitrogen and five prices for hay are evaluated as well as multiple nitrogen response rates for tall fescue and orchardgrass hayfields.

Agronomic Basics of Spring Nitrogen Fertilization:

Cool-season grasses can respond dramatically to nitrogen fertilization. If moisture and fertility (phosphorus and potassium) levels are adequate, nitrogen (N) will significantly increase growth during peak production periods. Research has shown that tall fescue and orchardgrass yields can be increased from around 1 ton/acre to over 4 tons/acre with 200 lbs of elemental (unit basis) nitrogen. One study in Kentucky showed that 40 lbs/acre of nitrogen applied in mid-March increased tall fescue hay yields by 1.1 tons/acre when harvested in mid-May. This meant that there was a 55 lb increase in forage yield for every 1 lb of added nitrogen. Tall fescue is generally slightly more responsive to nitrogen applications than orchardgrass. Higher nitrogen application rates will result in higher forage yield, but the efficiency of nitrogen use drops with progressively higher levels of application. The most efficient use of nitrogen is at low to moderate rates when the grass is approaching peak growth rates. The highest nitrogen response levels will occur on better soils with good moisture holding capacity. Lower response rates will occur on fields with low yield potential due to shallow soil, rock outcroppings, etc.

There are several forms of nitrogen available for fertilization of spring hayfields, but the two most common types are urea and ammonium nitrate. Ammonium nitrate is an excellent form to use in late summer for stockpiling because surface volatilization losses are minimized. Urea, however, is generally a better choice for spring fertilization because it is cheaper and volatilization is generally not a problem at this time. Research in Kentucky has shown little difference in effectiveness between ammonium nitrate and urea for topdressing cool-season grasses during late winter and early spring. If urea is used during the warmer summer months, it is best to apply when rain is imminent or when a Urease inhibitor is used (most fertilizer dealers can do this for you).

Besides the application of nitrogen, it is important that hayfields be limed and fertilized with phosphorus (P) and potassium (K) to acceptable levels. Although cool-season grasses will survive at fairly low soil test levels of P or K, the response to nitrogen will be poor. Therefore, soil test levels should be in the medium or high range for good production or be fertilized if the soil test is in the low range. This is especially important for hay production because moderate amounts of P and even larger amounts of K are removed from the field with each successive hay crop. For example, a 3 ton/acre hay crop of orchardgrass or tall fescue will remove approximately 50 lb/acre of P_2O_5 and 150 lb/acre of K_2O. Cool-season grasses will grow over a wide range of soil pH levels, but optimal growth occurs in the 5.5 to 6.5 pH range. Ideally, pH should be at the high end of this range to optimize fertilizer efficiency.

Legumes, like clover and alfalfa, have the ability to “fix” nitrogen from the air into a useable form by the plant. As a general rule, when legumes comprise 25% or more of the stand, no nitrogen application is recommended and additional nitrogen may actually lead to a loss of the legume component in the stand. Moreover, the response rate for nitrogen will decrease as the legume content of the stand increases. Thus hayfields that are mostly pure grass should be targeted for spring nitrogen applications.

Profitability of Spring Nitrogen Applications:

The analysis presented here accounts for the major factors that impact the profitability of nitrogen applications including the price of nitrogen, price of hay, response rate of nitrogen, increased hay production costs, increased nutrient removal, and increased quality of nitrogen fertilized hay. This analysis determines the changes in net revenue from one-time spring nitrogen applications of 40 and 80 units (87 lbs and 174 lbs of urea respectively) compared to the no application situation.

Two of the most important factors in this analysis are the price of nitrogen and the price of hay. The price of nitrogen was evaluated on an elemental basis[1] between $.55-.65 per unit ($510-600 per ton urea), which is representative of urea prices in early March 2012. Hay prices for the 2012/2013 marketing year are currently highly uncertain and thus a wide range of prices are evaluated. Prices of $40-80 per ton ($24-48 per 1200 lb bale) for round bales and $2.00-$4.00 per bale ($90-180 per ton) for small square bales are used in this analysis. Users of this publication need to use their best judgment for anticipated price(s) including those outside the range presented here. Keep in mind that orchardgrass hay generally sells at a premium over fescue hay, especially for small square bales.

The application cost for spreading the nitrogen was set at $5/acre. Machinery and labor costs of producing the extra hay were set to be representative of average Kentucky conditions.[2] This totaled $11.70 per 1200 pound bale (including moving to storage) and $1.48 per small square bale (including moving to storage) after adjusting for efficiencies created by increased forage density.[3] It was assumed that the buyer would arrange for transportation from your storage facility. If you are selling at a delivery point off the farm, deduct these additional transportation costs from the hay price you expect to receive. If you sell square bales directly out of the field, add roughly $.34 per bale ($15/ton) to the hay price you expect to receive. If you sell round bales directly out of the field, add roughly $5/ton to the hay price you expect to receive.

Increased removal of P and K was also accounted for in the analysis. Approximately 18 lbs of P_2O_5 and 50 lbs of K_2O are removed for each ton of hay.[4] It was assumed that the cost of replacing P_2O_5 was $.47/unit ($650/ton for 18-46-0) and the cost of replacing K_2O was $.53/unit ($630/ton for 0-0-60). Two scenarios are presented for P and K removal: 1) 100% replacement, and 2) 50% replacement. The user should use their best judgment as to which scenario best represents their situation related to the soil test in the field and recommended applications of P and K. If the soil test is in the high range, no P or K application is recommended, at least in the short-term. If the soil test is in the medium

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[1] To convert elemental N to urea: Multiply elemental value by 2.17. E.G. 40 lbs N = 40x2.17 = 87 lbs urea.

[2] See Custom Machinery Rates Applicable to Kentucky (2012). http://www.ca.uky.edu/cmspubsclass/files/CustomRatesKentucky2012.pdf

[3] Increased forage density results in production cost efficiencies on a per bale basis. Improved efficiency factors of 40% and 20% were used for round and square bales respectively, the difference between the two primarily being due to labor requirements. Original rates before accounting for these efficiencies were $19.50 and $1.85 per bale for round and square bales respectively.

[4] See AGR-1 http://www.ca.uky.edu/agc/pubs/agr/agr1/agr1.pdf

range roughly a half-replacement application rate is recommended. Full replacement application rates are recommended in the low range. Keep in mind that even if you are in the high range and do not need to make applications in the current year that you are still to a certain extent mining the current "bank" of P and K, and this should be accounted for to some degree. Refer to AGR-1 for more detailed recommendations related to P and K fertilizations.[5]

Potentially the most influential factor used in this analysis is the response rate of grass to nitrogen. Response rates were estimated from previous studies for both tall fescue and orchardgrass in Kentucky with application rates of 40 and 80 pounds per acre. Since the response rate will also vary according to soil moisture conditions and the general fertility level of the soil, multiple response rates were evaluated in this analysis, ranging from 26-65 lbs of dry matter (31-76 lbs of hay) per unit of nitrogen[6]. Consult Table 5 to determine which nitrogen response rate is most appropriate given your soil fertility and soil moisture conditions. Since soil moisture levels are close to ideal in most of Kentucky as of late winter, only the medium and high response rates are evaluated for 2012. The choice of the response rate is an extremely important determinant in this analysis. When in doubt use the medium response rate as this will give you a more conservative result.

Finally, increased forage quality was accounted for in the analysis by assuming a 1.0 ton first cutting yield without nitrogen and valuing this hay less than the nitrogen fertilized hay. For round bales this value reduction was assumed to be $5 per ton ($3/bale) and for small square bales the reduction was assumed to be $10 per ton ($.23/bale).

Results – Round Bale Production:

Table 1 summarizes the estimated net benefits of applying nitrogen compared to no application on a per acre basis for round bales assuming 100% replacement of P and K. A net benefit of +$10 means that particular nitrogen application would be expected to increase net profit by $10 per acre, compared to no nitrogen application. Net benefits for the scenarios evaluated here ranged from a low of -$78 to a high of +$15 per acre. In general, nitrogen applications only became profitable once hay prices reached $80/ton. Where nitrogen applications were profitable, the 40 lb rate showed higher returns than the 80 lb rate in all cases.

Table 2 summarizes the estimated net benefits for round bales assuming 50% replacement of P and K. Net benefits for the scenarios evaluated here ranged from a low of -$48 to a high of +$41 per acre. In this case, nitrogen applications generally became profitable once hay prices reached $60-70/ton. Again, the 40 lb application rate showed higher net benefits than the 80 lb rate in all cases.

[5] See AGR-1 http://www.ca.uky.edu/agc/pubs/agr/agr1/agr1.pdf
[6] It was assumed that 5% of this additional forage would not end up being utilized (rain damage etc.).

For specific recommendations for round bales, use Table 5 to determine which response rate is most appropriate for your conditions and than use either Table 1 or 2 to estimate the optimal application rate (if any) based on your estimates for hay and nitrogen prices.[7]

Results – Small Square Bale Production:

Table 3 summarizes the estimated net benefit of applying nitrogen compared to no application on a per acre basis for small square bales assuming 100% replacement of P and K. Net benefits for the scenarios evaluated here ranged from a low of -$68 to a high of +$99 per acre. In general, nitrogen applications started to become profitable once hay prices reached $3.00/bale ($133/ton) and were very profitable at $3.50/bale (156/ton). 40 lb applications were generally more profitable then the 80 lb applications.

Table 4 summarizes the estimated net benefit of applying nitrogen for small square bales assuming 50% replacement of P and K. Net benefits for the scenarios evaluated here ranged from a low of -$40 to a high of +$130 per acre. Nitrogen applications started to become profitable at hay prices of $2.50/bale ($110/ton). There were some instances where 80 lb nitrogen applications were more profitable then 40 lb applications, but not many. For orchardgrass, the 40 lb applications were almost always more profitable.

For specific recommendations for small square bales, use Table 5 to determine which response rate is most appropriate for your conditions and then use either Table 3 or 4 to estimate the optimal application rate (if any) based on your estimates for hay and nitrogen prices.[8]

Conclusions:

With small square bales, nitrogen applications became profitable at the 40 lb rate for hay prices of $2.50-3.00 per bale. However, for large round bales, profitability of nitrogen applications occurred in fewer cases. In general, round bales needed to sell for $80/ton with 100% replacement of P and K, and $60-70/ton with 50% replacement of P and K. Moreover, 40 lb application rates were always more profitable than 80 lb application rates for round bale production.

It is important to note that nitrogen applications were more profitable with small square bales compared to large round bales. Even though production costs are higher with the small square bales, the increase in revenue from higher hay prices (on a per/ton basis) outweighed the increase in production costs. Hay producers should note these differences and concentrate nitrogen applications on fields that will be cut for small square bale production.

[7,8] Keep in mind that orchardgrass hay generally commands a price premium over fescue hay, especially for small square bales. Thus orchardgrass stands may be a better candidate for nitrogen applications, even though the nitrogen response rate is slightly lower.

Table 1 - Net Benefits of Applying Nitrogen to Spring Hayfields (2012)
1200 Lb Round Bales Kentucky - 100% Replacement P and K

		Tall Fescue				*Orchardgrass*			
		Med Response to N[1]		*High Response to N[2]*		*Med Response to N[3]*		*High Response to N[4]*	
Price Nitrogen ($/lb)[5]	*Price Hay ($/ton)*	*40 Lbs N Net Benefit ($/acre)*	*80 Lbs N Net Benefit ($/acre)*	*40 Lbs N Net Benefit ($/acre)*	*80 Lbs N Net Benefit ($/acre)*	*40 Lbs N Net Benefit ($/acre)*	*80 Lbs N Net Benefit ($/acre)*	*40 Lbs N Net Benefit ($/acre)*	*80 Lbs N Net Benefit ($/acre)*
$0.55	*$40*	-$38	-$63	-$43	-$70	-$37	-$61	-$41	-$67
$0.55	*$50*	-$27	-$50	-$28	-$52	-$26	-$49	-$28	-$51
$0.55	*$60*	-$16	-$37	-$14	-$34	-$16	-$37	-$15	-$35
$0.55	*$70*	-$5	-$23	$1	-$16	-$6	-$26	-$1	-$20
$0.55	*$80*	$6	-$10	$15	$2	$4	-$14	$12	-$4
$0.60	*$40*	-$40	-$67	-$45	-$74	-$39	-$65	-$43	-$71
$0.60	*$50*	-$29	-$54	-$30	-$56	-$28	-$53	-$30	-$55
$0.60	*$60*	-$18	-$41	-$16	-$38	-$18	-$41	-$17	-$39
$0.60	*$70*	-$7	-$27	-$1	-$20	-$8	-$30	-$3	-$24
$0.60	*$80*	$4	-$14	$13	-$2	$2	-$18	$10	-$8
$0.65	*$40*	-$42	-$71	-$47	-$78	-$41	-$69	-$45	-$75
$0.65	*$50*	-$31	-$58	-$32	-$60	-$30	-$57	-$32	-$59
$0.65	*$60*	-$20	-$45	-$18	-$42	-$20	-$45	-$19	-$43
$0.65	*$70*	-$9	-$31	-$3	-$24	-$10	-$34	-$5	-$28
$0.65	*$80*	$2	-$18	$11	-$6	$0	-$22	$8	-$12

Assumptions: Additional costs include production, nitrogen/application, and P & K removal from increased hay production ($.47 P_2O_5 and $.53 K_2O).
Assumptions: Production costs for round bales are $19.50 based on custom rates (include move to storage); 40% efficiency gain for inc. forage density = $11.70 per bale.
Assumptions: Tall fescue and orchardgrass stands assumed to contain less than 10% legumes; 5% waste rate of additional forage produced due to rain damage, etc.
Assumptions: 1.0 ton/acre first-cutting yield without nitrogen application valued at $5/ton less then nitrogen fertilized hay.
Fescue[1]: 49 lb avg. dry matter response per lb N (40lbs) and 30 lb avg. dry matter response per lb N (80lbs)
Fescue[2]: 65 lb avg. dry matter response per lb N (40lbs) and 40 lb avg. dry matter response per lb N (80lbs)
Orchardgrass[3]: 45 lb avg. dry matter response per lb N (40lbs) and 26 lb avg. dry matter response per lb N (80lbs)
Orchardgrass[4]: 60 lb avg. dry matter response per lb N (40lbs) and 35 lb avg. dry matter response per lb N (80lbs)
Nitrogen Price[5]: $.55/lb N = $510/ton urea; $.60/lb N = $550/ton urea; $.65/lb N = $600/ton urea; 40 lbs N = 87 lbs urea; 80 lbs N = 174 lbs urea.
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Table 2 - Net Benefits of Applying Nitrogen to Spring Hayfields (2012)
1200 Lb Round Bales Kentucky - 50% Replacement P and K

		Tall Fescue				*Orchardgrass*			
		Med Response to N[1]		*High Response to N[2]*		*Med Response to N[3]*		*High Response to N[4]*	
Price Nitrogen ($/lb)[5]	*Price Hay ($/ton)*	*40 Lbs N Net Benefit ($/acre)*	*80 Lbs N Net Benefit ($/acre)*	*40 Lbs N Net Benefit ($/acre)*	*80 Lbs N Net Benefit ($/acre)*	*40 Lbs N Net Benefit ($/acre)*	*80 Lbs N Net Benefit ($/acre)*	*40 Lbs N Net Benefit ($/acre)*	*80 Lbs N Net Benefit ($/acre)*
$0.55	*$40*	-$19	-$40	-$18	-$39	-$19	-$40	-$18	-$39
$0.55	*$50*	-$8	-$27	-$3	-$21	-$9	-$29	-$5	-$24
$0.55	*$60*	$3	-$13	$11	-$3	$1	-$17	$9	-$8
$0.55	*$70*	$14	$0	$26	$15	$11	-$5	$22	$8
$0.55	*$80*	$25	$14	$41	$33	$21	$6	$36	$23
$0.60	*$40*	-$21	-$44	-$20	-$43	-$21	-$44	-$20	-$43
$0.60	*$50*	-$10	-$31	-$5	-$25	-$11	-$33	-$7	-$28
$0.60	*$60*	$1	-$17	$9	-$7	-$1	-$21	$7	-$12
$0.60	*$70*	$12	-$4	$24	$11	$9	-$9	$20	$4
$0.60	*$80*	$23	$10	$39	$29	$19	$2	$34	$19
$0.65	*$40*	-$23	-$48	-$22	-$47	-$23	-$48	-$22	-$47
$0.65	*$50*	-$12	-$35	-$7	-$29	-$13	-$37	-$9	-$32
$0.65	*$60*	-$1	-$21	$7	-$11	-$3	-$25	$5	-$16
$0.65	*$70*	$10	-$8	$22	$7	$7	-$13	$18	$0
$0.65	*$80*	$21	$6	$37	$25	$17	-$2	$32	$15

Assumptions: Additional costs include production, nitrogen/application, and P & K removal from increased hay production ($.47 P_2O_5 and $.53 K_2O).
Assumptions: Production costs for round bales are $19.50 based on custom rates (include move to storage); 40% efficiency gain for inc. forage density = $11.70 per bale.
Assumptions: Tall fescue and orchardgrass stands assumed to contain less than 10% legumes; 5% waste rate of additional forage produced due to rain damage, etc.
Assumptions: 1.0 ton/acre first-cutting yield without nitrogen application valued at $5/ton less then nitrogen fertilized hay.
Fescue[1]: 49 lb avg. dry matter response per lb N (40lbs) and 30 lb avg. dry matter response per lb N (80lbs)
Fescue[2]: 65 lb avg. dry matter response per lb N (40lbs) and 40 lb avg. dry matter response per lb N (80lbs)
Orchardgrass[3]: 45 lb avg. dry matter response per lb N (40lbs) and 26 lb avg. dry matter response per lb N (80lbs)
Orchardgrass[4]: 60 lb avg. dry matter response per lb N (40lbs) and 35 lb avg. dry matter response per lb N (80lbs)
Nitrogen Price[5]: $.55/lb N = $510/ton urea; $.60/lb N = $550/ton urea; $.65/lb N = $600/ton urea; 40 lbs N = 87 lbs urea; 80 lbs N = 174 lbs urea.
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Table 3 - Net Benefits of Applying Nitrogen to Spring Hayfields (2012)
Small Square Bales Kentucky - 100% Replacement P and K

		Tall Fescue				*Orchardgrass*			
		Med Response to N[1]		*High Response to N[2]*		*Med Response to N[3]*		*High Response to N[4]*	
Price Nitrogen ($/lb)[5]	*Price Hay ($/ton)*	*40 Lbs N Net Benefit ($/acre)*	*80 Lbs N Net Benefit ($/acre)*	*40 Lbs N Net Benefit ($/acre)*	*80 Lbs N Net Benefit ($/acre)*	*40 Lbs N Net Benefit ($/acre)*	*80 Lbs N Net Benefit ($/acre)*	*40 Lbs N Net Benefit ($/acre)*	*80 Lbs N Net Benefit ($/acre)*
$0.55	*$2.00*	-$30	-$55	-$34	-$60	-$29	-$53	-$33	-$58
$0.55	*$2.50*	-$6	-$25	-$2	-$20	-$7	-$27	-$3	-$23
$0.55	*$3.00*	$19	$5	$30	$19	$16	-$1	$27	$12
$0.55	*$3.50*	$43	$35	$63	$59	$38	$25	$57	$47
$0.55	*$4.00*	$67	$64	$95	$99	$60	$51	$86	$82
$0.60	*$2.00*	-$32	-$59	-$36	-$64	-$31	-$57	-$35	-$62
$0.60	*$2.50*	-$8	-$29	-$4	-$24	-$9	-$31	-$5	-$27
$0.60	*$3.00*	$17	$1	$28	$15	$14	-$5	$25	$8
$0.60	*$3.50*	$41	$31	$61	$55	$36	$21	$55	$43
$0.60	*$4.00*	$65	$60	$93	$95	$58	$47	$84	$78
$0.65	*$2.00*	-$34	-$63	-$38	-$68	-$33	-$61	-$37	-$66
$0.65	*$2.50*	-$10	-$33	-$6	-$28	-$11	-$35	-$7	-$31
$0.65	*$3.00*	$15	-$3	$26	$11	$12	-$9	$23	$4
$0.65	*$3.50*	$39	$27	$59	$51	$34	$17	$53	$39
$0.65	*$4.00*	$63	$56	$91	$91	$56	$43	$82	$74

Assumptions: Additional costs include production, nitrogen/application, and P & K removal from increased hay production ($.47 P_2O_5 and $.53 K_2O).
Assumptions: Hay production costs for 45 lb square bales are $1.85 based on custom rates (include haul/store); 20% efficiency gain for inc. forage density = $1.48/bale.
Assumptions: Tall fescue and orchardgrass stands assumed to contain less than 10% legumes; 5% waste rate of additional forage produced due to rain damage, etc.
Assumptions: 1.0 ton/acre first-cutting yield without nitrogen application valued at $10/ton less then nitrogen fertilized hay.
Fescue[1]: 49 lb avg. dry matter response per lb N (40lbs) and 30 lb avg. dry matter response per lb N (80lbs)
Fescue[2]: 65 lb avg. dry matter response per lb N (40lbs) and 40 lb avg. dry matter response per lb N (80lbs)
Orchardgrass[3]: 45 lb avg. dry matter response per lb N (40lbs) and 26 lb avg. dry matter response per lb N (80lbs)
Orchardgrass[4]: 60 lb avg. dry matter response per lb N (40lbs) and 35 lb avg. dry matter response per lb N (80lbs)
Nitrogen Price[5]: $.55/lb N = $510/ton urea; $.60/lb N = $550/ton urea; $.65/lb N = $600/ton urea; 40 lbs N = 87 lbs urea; 80 lbs N = 174 lbs urea.
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Table 4 - Net Benefits of Applying Nitrogen to Spring Hayfields (2012)
Small Square Bales Kentucky - 50% Replacement P and K

		Tall Fescue				Orchardgrass			
		Med Response to N[1]		High Response to N[2]		Med Response to N[3]		High Response to N[4]	
Price Nitrogen ($/lb)[5]	Price Hay ($/bale)	40 Lbs N Net Benefit ($/acre)	80 Lbs N Net Benefit ($/acre)	40 Lbs N Net Benefit ($/acre)	80 Lbs N Net Benefit ($/acre)	40 Lbs N Net Benefit ($/acre)	80 Lbs N Net Benefit ($/acre)	40 Lbs N Net Benefit ($/acre)	80 Lbs N Net Benefit ($/acre)
$0.55	*$2.00*	-$11	-$31	-$9	-$29	-$11	-$32	-$9	-$30
$0.55	*$2.50*	$13	-$2	$23	$11	$11	-$6	$20	$5
$0.55	*$3.00*	$38	$28	$56	$51	$33	$20	$50	$39
$0.55	*$3.50*	$62	$58	$88	$90	$56	$46	$80	$74
$0.55	*$4.00*	$86	$88	$120	$130	$78	$72	$110	$109
$0.60	*$2.00*	-$13	-$35	-$11	-$33	-$13	-$36	-$11	-$34
$0.60	*$2.50*	$11	-$6	$21	$7	$9	-$10	$18	$1
$0.60	*$3.00*	$36	$24	$54	$47	$31	$16	$48	$35
$0.60	*$3.50*	$60	$54	$86	$86	$54	$42	$78	$70
$0.60	*$4.00*	$84	$84	$118	$126	$76	$68	$108	$105
$0.65	*$2.00*	-$15	-$39	-$13	-$37	-$15	-$40	-$13	-$38
$0.65	*$2.50*	$9	-$10	$19	$3	$7	-$14	$16	-$3
$0.65	*$3.00*	$34	$20	$52	$43	$29	$12	$46	$31
$0.65	*$3.50*	$58	$50	$84	$82	$52	$38	$76	$66
$0.65	*$4.00*	$82	$80	$116	$122	$74	$64	$106	$101

Assumptions: Additional costs include production, nitrogen/application, and P & K removal from increased hay production ($.47 P_2O_5 and $.53 K_2O).
Assumptions: Hay production costs for 45 lb square bales are $1.85 based on custom rates (include haul/store); 20% efficiency gain for inc. forage density = $1.48/bale.
Assumptions: Tall fescue and orchardgrass stands assumed to contain less than 10% legumes; 5% waste rate of additional forage produced due to rain damage, etc.
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Table 5
Recommended Nitrogen Response Rating Based on Soil Type and Moisture Condition

	Soil Moisture Conditions		
Soil Fertility Level[1]	**Ideal**	**Good**	**Low**
Excellent	*High Response*	*Med/High Response*	*Low/Med Response*
Good	*High Response*	*Medium Response*	*Low Response*
Fair	*Med/High Response*	*Low/Med Response*	*Low Response*

Note[1]: Fertility is defined as relative average productivity due to soil type, drainage, P and K levels, pH level, etc.

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