Eastern U.S. Cattle Producer Willingness to Adopt Prescribed Grazing

Selected Paper 2014 Southern Agricultural Economics Association Meetings, Dallas, Texas,

February 1-4.

By

Kimberly L. Jensen, Dayton M. Lambert, Christopher D. Clark, Caroline Holt, Burton C.

English, James A. Larson, Edward Yu, and Chad Hellwinckel*

*All authors are faculty in the Department of Agricultural and Resource Economics at the University of Tennessee except for Caroline Holt, who is a former graduate research assistant now employed by the Tennessee Valley Authority.

Contact information - email: kjensen@utk.edu; phone: 865-974-7231; address: 302 Morgan Hall, 2621 Morgan Circle, The University of Tennessee, Knoxville, Tennessee 37996.

Keywords: Prescribed Grazing, Adoption, Triple Hurdle Model

Eastern U.S. Cattle Producer Willingness to Adopt Prescribed Grazing

Introduction and Objectives

Abstract

A triple hurdle model is used to estimate cattle farmer willingness to adopt prescribed grazing on farmland east of the 100th meridian in response to a hypothetical incentive program. First the interest in adoption is modeled, then willingness to accept a hypothetical incentive, followed by modeling of acreage converted. Farm size did not influence program interest, but positively impacted acres converted among those interested. The supply elasticity of program acres with respect to an incentive is 0.13; thus an additional percent incentive is projected to result in an additional 0.13 percent of acres enrolled into the program on owned acres.

Eastern U.S. Cattle Producer Willingness to Adopt Prescribed Grazing

Introduction and Objectives

Agriculture is responsible for about six percent of the United States' (U.S.) total

greenhouse gas (GHG) emissions (USEPA 2010) and is the largest contributor to U.S. nitrous

oxide and methane emissions (Ribaudo 2011). Within the agricultural sector, livestock are the

largest source of methane emissions (USEPA 2008), with cattle accounting for about three

quarters of these emissions (Johnson and Johnson 1995). In fact, beef cattle production is

responsible for approximately 2.2 percent of all U.S. GHG emissions (Gurian-Sherman 2011).

Reducing the GHG emissions associated with beef cattle production could significantly impact

on the GHG emissions associated with U.S. agricultural production, but also total U.S. GHG

emissions.

Prescribed grazing, Natural Resource Conservation Service (USDA/NRCS) Practice

Code 528, is a cattle production best management practice (BMP) that can help reduce GHG

emissions from cattle grazing by increasing the amount of carbon sequestered on pastureland.

Prescribed grazing is defined as the "controlled harvest of vegetation with grazing animals with

the intent to achieve a specific objective" (USDA/NRCS 2008). By controlling the harvest of

vegetation, producers can allow plants to grow longer during the grazing season, producing

higher quality forages as well as increasing forage production. Increased forage quantities can

also lead to increased carbon storage in soils, which can offset GHG emissions associated with

livestock production (Briske et al. 2013). Properly managed, the carbon will remain in the soil.

As one purpose of prescribed grazing is to reduce soil erosion and maintain or improve soil

quality (USDA/NRCS 2008), the adoption of prescribed grazing can improve soil management.

In addition, methane emissions from cattle in a prescribed grazing system may be lower than

cattle fed on conventional pasture systems (Cottle, Nolan, and Wiedemann 2011).[1] Prescribed

grazing can also provide private benefits for producers, including an increase in carrying

capacity of the land, better forage growth, an increase in the use of more diverse forage species,

less forage wasted, and moderation of soil erosion. Livestock producers can use prescribed

grazing to more evenly distribute manure, thereby reducing burning requirements. But the

benefits to the producer of adopting a BMP may not outweigh the costs (Lichtenberg and Smith-

Ramirez 2011). Potential disadvantages associated with prescribed grazing systems include

significant upfront cost and an increase in managerial effort. Uncertainty among producers about

the cost and management commitment can also reduce willingness to adopt livestock BMPs

(Kim, Gillespie, and Paudel 2008).

 To promote the provision of the public and private benefits associated with prescribed

grazing, the U.S. Department of Agriculture's (USDA) Environmental Quality Incentives

Program (EQIP) provides agricultural producers with incentives of 50 to 75 percent of the costs

of installing or implementing structures and management practices to adopt prescribed grazing

(Practice Code 528). However, as EQIP and many other programs designed to promote the

adoption of BMPs among agricultural producers are voluntary, their effectiveness is contingent

upon the willingness of producers to adopt the BMP given the incentive.

 Across the U.S., over 922 million acres are used for agriculture, with 409 million acres,

(or 44.3 percent), used for pastureland (USDA/NASS 2007). While pastureland is in every state

of the U.S., the eastern half of the U.S. is where the greatest potential benefits, for both cattle

producers and the environment, from prescribed grazing are likely to occur.[2] Thus, it would be

useful to understand the factors influencing the adoption of prescribed grazing by producers in

this region, possible barriers to adoption, and how an incentive program might influence

adoption. This study uses results from a 2013 mail survey of cattle producers to determine the factors influencing adoption or expansion of prescribed grazing on beef cattle farms east of the 100th meridian, including the effects of a hypothetical incentive program on a producer's willingness to adopt or expand a prescribed grazing system. The hypothetical program investigated in this study provides a 75 percent cost share of installation or implementation costs, along with an annual payment per acre for ten years to encourage continued use of the practice. The amount of the annual payment is randomized over respondents to estimate the effect of incentive levels on producer participation in the program and acreage conversion.

In addition, data regarding other factors that may influence the adoption decision making process, such as producer age, education level, off farm income, and other farmer or farm characteristics were collected and analyzed to understand the factors influencing producer willingness to adopt a prescribed grazing system. Understanding the characteristics that affect adoption, as well as the influence of cost share incentive levels, enables projections of the cost share and annual incentive rates needed to obtain desired levels of adoption or to reach specific environmental targets, such as a specified percentage reduction in GHG emissions associated with cattle production.

Previous Studies

Kim, Gillespie, and Paudel (2008) examined the effects of farmer cost share levels and other demographic variables on the willingness to adopt rotational grazing by Louisiana cattle producers. The farmer adoption cost share ranged from zero to 40 percent. They found that cost share levels had a positive influence on willingness to adopt, as did farmer age. Their results also suggest that the probability of farmer adoption could decline by as much as 0.0085 (0.85 percent) for each percentage of the farmer cost burden. Use of any rotational grazing type, higher debt to asset ratio, and plans for the family to take over the farm each positively influenced the adoption

3

decision. In addition, respondent agreement with the assertion that laws regulating excess soil erosion are needed also had a positive effect on adoption. While Kim, Gillespie, and Paudel did evaluate the effect of a cost share on farmer willingness to adopt rotational grazing, they did not evaluate either the effect of an incentive on acres converted or the influence of continuing per acre payments on adoption or acreage conversion.

From a survey of Connecticut dairy farmers, Foltz and Lang (2005) found that education and having less rented land had a positive influence on the likelihood of adopting rotational grazing. Jayasinghe-Mudalige and Weersink (2004) found that the number of environmental management systems adopted by Canadian farmers, including grazing practices (rotational grazing for livestock), was positively influenced by farm profitability, farm size, and land ownership, but inversely associated with age. Regional macro-variables positively influencing the adoption of these systems were population density. Also, farms with mixed crop and livestock systems had the highest adoption rates, while livestock-only operations had the lowest.

An assortment of other studies has examined the financial incentives required for producer adoption of environmentally friendly practices. For example, Kurkalova, Kling, and Zhao (2006) estimated the financial incentives required for adopting conservation tillage and distinguished between the expected payoff and premium of adoption based on the observed behavior by Iowa farmers. Some non-adopters did not use conservation tillage because the expected profit gain alone did not compensate them fully for the increased risk and possibility of irreversible lost profits associated with conventional tillage practices; hence premiums may play a significant role in farmer adoption decisions. Kurkalova, Kling, and Zhao found that if a uniform conservation tillage adoption subsidy had been offered in 1992, about 86 percent of the program payments would have been income transfers to existing and low-cost adopters. With

4

regards to demographic effects, they found farmer age to negatively affect the adoption premium, as did off-farm income and returns to conventional tillage. However, land tenure raised the adoption premium.

Cooper and Signorello (2008) also examined premiums encouraging the voluntary adoption of conservation plans. They found the risk premium for the conservation plan analyzed was approximately 36% of the mean minimum willingness to accept value. In their study, they did not evaluate the willingness to accept value or risk premium across demographic or attitudinal factors.

Rolfe et al. (2006) examined the effects of payment levels on buffer strip width and also minimum grass biomass at the end of the dry season as measures of improvements in grazing practices. Results from their study suggested that respondents were more likely to select alternatives with higher payment levels, and less likely to select alternatives with increases in buffer width or minimum biomass conditions. As for the effects of demographics, the results suggested that respondents with higher levels of education, and those with more extensive clearing on their property were more likely to choose the status quo option (no rebate). Respondents with larger streams or waterways on their property, those who focused more on environmental than production outcomes, and those with dependent children, were more likely to select a rebate option.

The current study builds upon findings from previous research, encompassing a much wider geographic area (east of the 100th meridian) than is typically investigated. Our research estimates incentive effects on the probability of adoption, and also on acres converted. Adoption and participation intensity are conditioned on demographic and attitudinal factors.

Data and Economic Modeling

Survey Data

The survey conducted for this study used a random sample of beef cattle, cow/calf, and backgrounding/stockering operations from the eight Economic Research Service (ERS) Regions east of the 100th meridian (Figure 1). The ERS regions are based on commodity production, geographical specialization, and other characteristics. The sample was drawn by USDA's National Agricultural Statistics Service (NASS) and was limited to those operations with at least 20 head of cattle as reported by the 2007 Census of Agriculture to decrease the likelihood of sampling hobby farms. A total of 8,875 operations were randomly chosen from the population of 267,413. The survey sample represented three percent of the total available population. The sampling intensity and design was based on a 3 percent margin of error at a 95 percent confidence interval. Post stratification weights were developed based on the cross tabulation of farm sales classes and ERS regions. The survey was fielded by USDA/NASS in early 2013 with an initial mailing, a reminder postcard (one week later), and second follow up mailing (two weeks later). A total of 2,258 completed surveys were returned for a 26 percent response rate.

The survey instrument was divided into three sections. The first section ("Your Farming Operation") focused on the characteristics of the producer and the operation they manage. The next section ("Prescribed Grazing") began by informing the respondent about what prescribed grazing is and how it might benefit both them and the environment. It also provided details on the actual management practices that, taken together, comprise prescribed grazing (See Figure 2). The information on prescribed grazing was followed by questions asking respondents if they had used any of the practices involved in prescribed grazing in the previous year and, if so, which ones. If respondents used some of the management practices, they were asked if they had

6

received government payments for these practices through federal programs such as EQIP. The respondents were then asked about a hypothetical program including an incentive level paid over a 10 year period as well as a 75 percent purchase and installation cost share to either expand the number of acres managed with prescribed grazing, for those who were already using these management practices and receiving government payments, or to adopt a prescribed grazing system, for those who were not. The installation cost estimates were based on existing cost estimates from program payment structures (EQIP) and aggregated to the USDA farm commodity production regions (See Figure 2) (USDA/NRCS 2013). Five versions of the survey were administered . Each version was the same in all respects, except for the hypothetical incentive level offered to adopt prescribed grazing. The incentive levels included were $10, $30, $50, $70, and $90. The sample was randomly divided across the five versions of the survey. The final section of the survey ("About You") included questions designed to obtain information on respondent demographics and factors that might influence willingness to adopt or expand prescribed grazing.

Economic Modeling and Estimation

Acreage enrolled in the management intensive grazing program is modeled as a sequence of decisions, beginning with interest in participating in the hypothetical program (*INTEREST*), willingness to adopt prescribed grazing given the cost share/annual payment offered (*ACCEPT*), and the number of acres the respondent is willing to enroll in the program (*ACRES*) given the hypothetical offer. A triple hurdle regression is used to model this decision sequence. The following summarizes this sequence as a tiered series of latent variables:

7

(1)
$$INTEREST_i^* = \beta'X_{1i} + u_i$$

$$INTEREST_i = \begin{cases} 1, & INTEREST_i^* > 0 \\ 0, & INTEREST_i^* \leq 0 \end{cases}$$

(2)
$$ACCEPT_i^* = \gamma'X_{2i} + v_i$$

$$ACCEPT_i = \begin{cases} 1, & ACCEPT_i^* > 0| INTEREST_i^* > 0 \\ 0, & ACCEPT_i^* \leq 0| INTEREST_i^* > 0 \end{cases}$$

(3)
$$\ln ACRES_i^* = \eta'X_{3i} + e_i$$

$$\ln ACRES_i = \begin{cases} \ln ACRES_i^*, & BID_i^* > 0 \\ -, & BID_i^* \leq 0 \end{cases}$$

In the first hurdle (equation 1), producers were asked whether they were interested in participating in the hypothetical prescribed grazing program following a detailed description of the program features. In the second hurdle (equation 2), interested producers ($INTEREST = 1$) were offered a per acre payment for enrolling acreage into the program and producers could either refuse ($ACCEPT = 0$) or accept the bid offer ($ACCEPT = 1$). The outcome equation (equation 3) models the acres supplied by producers given their interest in participating and acceptance of the offer (i.e., $INTEREST = 1$ and $ACCEPT = 1$).

The error terms of equations 1-3 are correlated and assumed to be multivariate normally distributed, with an expected value of zero:

(4)
$$\begin{bmatrix} u_i \\ v_i \\ e_i \end{bmatrix} \sim MVN \left(\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & \rho_{12} & \sigma\rho_{13} \\ \rho_{12} & 1 & \sigma\rho_{23} \\ \sigma\rho_{13} & \sigma\rho_{23} & \sigma^2 \end{bmatrix} \right).$$

Given these assumptions, the parameter vectors (β, γ, η)´and the covariance matrix in (4) can be jointly estimated using maximum likelihood. The log likelihood function for the system is:

(5) $\quad \ln L = \sum_{INTREST_i^* \leq 0} \ln\left(\Phi(-\beta' X_{1i})\right) + \sum_{\substack{INTREST_i^* > 0 \\ ACCEPT_i^* \leq 0}} \ln\left(\Phi_2(\beta' X_{1i}, -\gamma' X_{2i}, -\rho_{12})\right) +$

$$\sum_{\substack{INTREST_i^* > 0 \\ ACCEPT_i^* > 0}} \ln\left(h(ACRES_i | \beta' X_{1i}, \gamma' X_{2i}, \eta' X_{3i}, \rho_{12}, \rho_{13}, \rho_{23}, \sigma)\right)$$

The natural logarithm of the acres to be converted is used to ensure no negative acreage values would be predicted. The unconditional expected mean acres can be calculated as (for example, Yen and Rosinski, 2008);

(6) $\qquad E(\ln ACRES_i) = \exp\left(\eta' X_{3i} + \frac{\sigma^2}{2}\right) \cdot \Phi_2(\beta' X_{1i} + \sigma\rho_{13}, \gamma' X_{2i} + \sigma\rho_{23}, \rho_{12}).$

The conditional mean is calculated as:

(7)

$$E(\ln ACRES_i | ACRES_i > 0, INTEREST_i = 1) = \exp\left(\eta' X_{3i} + \frac{\sigma^2}{2}\right) \cdot \frac{\Phi_2(\beta' X_{1i} + \sigma\rho_{13}, \gamma' X_{2i} + \sigma\rho_{23}, \rho_{12})}{\Phi_2(\beta' X_{1i}, \gamma' X_{2i}, \rho_{12})}.$$

The marginal effects equations (6) and (7) are estimated using a finite difference approximation (Cameron and Trivedi, 2009).

Results

Variable means and descriptions are reported in Table 1. Regression estimates for the acreage conversion decision process are shown in Table 2. As can be seen from the Wald χ^2 test, the model was significant overall. The *INTEREST* portion of the model correctly classified 79 percent of the observations, while the *ACCEPT* portion of the model correctly classified 72 percent. The correlation between the error terms of *ACCEPT* and *INTEREST* (ρ_{12}) was statistically significant.

The incentive (*INCENT*) coefficient was statistically significant and of the expected sign in both the *ACCEPT* and *lnACRES* equations. Farm size (in terms of acres) had a positive influence on both *lnACRES* and *ACCEPT*, but was not statistically significant in the *INTEREST* portion of the equation. Some regional differences were found, with Eastern Upland and

9

Southern Seaboard farmers being less likely to be interested in adopting or expanding prescribed grazing relative to producers located in the Mississippi Portal, Northern Crescent, Northern Great Plains, and Fruitful Rim farm resource regions (i.e., the reference group). Among those interested in prescribed grazing and willing to accept the incentive, farms in the Prairie Getaway or Eastern Uplands regions were willing to convert more acres relative to farms located in the reference group regions. Region did not appear to influence willingness to accept the incentive. A number of farm characteristics influenced *INTEREST*. Those with a positive influence on *INTEREST* included share of farmland in pasture, use of fertilizer on pastures as a pasture management practice, prior use of some type of prescribed grazing practice, other livestock on the farm, income greater than $150,000, being a college graduate, attendance at Extension workshops, use of the Internet in business decision making, and agreement with the assertions that government incentives are needed to encourage adoption of environmentally friendly practices and that as farmers they are stewards of the land. Variables negatively influencing *INTEREST* include age of the farmer and a preference for waiting until others adopt before adopting technologies or practices. While neither farm and household income nor prior adoption of any prescribed grazing practices had a significant influence on willingness to accept the bid (*ACCEPT*), agreement that the government should provide environmental incentives to farmers did have a positive influence.

The conditional and unconditional means for acres converted to prescribed grazing were calculated using the model estimates, individual values for the variables, and equations 6 and 7, respectively. The conditional mean number of acres was 161.51 (conditional upon *INTEREST* = 1 and *ACCEPT* = 1), while the unconditional mean was 105.03. The median values were 94.56 (conditional) and 63.26 (unconditional) acres. The correlation between the conditional acres and

10

the actual *ACRES* was 0.62, and the elasticity of acres converted with respect to the incentive is 0.13.

Marginal effects are reported in Table 2. It should be noted that the marginal effects for *ACRES* and *ACCEPT* are both conditional. For each dollar increase in the incentive, the number of acres that would be converted increases by 0.41, while the probability of accepting the incentive increases by 0.0012. Farm size impacts the acres that would be converted by 0.06 acres for each additional acre farmed. Among the regional effects, relative to the reference regions being located in the Prairie Getaway region has the largest possible effect on acres converted, at 70.89 acres, followed by Eastern Uplands at 29.90 acres. Farmers currently using some form of prescribed grazing would enroll, on average, 3.4 acres more than farmers not practicing prescribed grazing. An additional percent of the operated acres in pasture was associated with an additional 10.02 acres converted to program pastures. Farmers who agreed that environmental program government payments are needed were predicted to convert an additional 18.39 acres, while farmers who believed they were stewards of the land would convert an additional 7.51 acres. College educated farmers would convert an additional 3.36 acres over those who are not college graduates. Each year of farmer's age decreases acreage conversion by 0.13 acres. Attendance at Extension workshops increases the acreage conversion by 1.04 acres for each workshop, while use of the Internet for business decision making increases acres enrolled by 5.39 acres. Risk averse farmers who said they took a "wait and see" attitude toward new technologies and management practices were projected to adopt about 3.39 acres less than other farmers.

Discussion

  This study examines how cattle farmers might respond to a hypothetical program that would not only match 75 percent of the upfront installation costs, but also provide an annual payment for a period of 10 years to continue prescribed grazing. Overall, just over 68 percent of the respondents expressed interested in participating in the program to promote the adoption or expansion of prescribed grazing. Nearly 71 percent of those who were interested were willing to accept the bid offered, with the average bid level across the sample being just over $50 per acre. The average number of acres interested farmers would convert was 115.22.

  Results from the study suggest that an annual incentive payment program would have a positive effect on acreage in prescribed grazing, with each dollar increasing the likelihood of bid acceptance by 0.0012 and the number of acres among those accepting the bid by 0.41 acres. The results also suggest farm size effects, with larger farms willing to convert more acreage, and more willing to accept the bid if interested. Farm size had no effect on program interest in this hypothetical program. These latter results suggest that farmers operating both larger and smaller cattle farms are about as likely to be interested. However, inducing acreage conversion in smaller farms may require higher incentive levels.

  While farm size had little effect on interest, educational variables, such as being a college graduate, using the internet to make business decisions, and attendance at Extension workshops, had a positive influence on the probability of a producer being interested in the prescribed grazing program. This result likely reflects the importance of educational efforts about the potential environmental and business benefits of prescribed grazing to cattle farmers. These educational efforts could have particular influence on those who have a wait and see attitude toward technology and management practices adoption, which negatively influenced interest in a

prescribed grazing program. Not surprisingly, prior adoption of some type of prescribed grazing measures had a positive influence on interest as did positive attitudes toward the need for government incentives for farmers to adopt environmentally beneficial practices.

Some regional effects were observed with those in the Eastern Uplands being less interested in adopting, but among those interested being willing to convert more acreage than those in the reference region. The largest positive regional effects on acreage conversion are for the Prairie Getaway region. With this understanding of characteristics that affect adoption, as well as the influence of cost share incentive levels, projections of the effects of cost share and annual incentive rates to obtain desired adoption levels can be made. Further research will take the results presented here and extrapolate them across the region east of the 100th meridian to project overall additions to prescribed grazing acreage given varying incentive levels. Acreage conversion projections can then potentially be used along with environmental measures to formulate regional environmental impacts and incentive levels needed to attain environmental targets, such as GHG reduction.

References

Briske, D., J. Derner, D. Milchunas, and K.Tate. 2013. "An Evidence-Based Assessment of Prescribed Grazing Practices*." In* D. D. Briske (ed.) Conservation

Benefits of Rangeland Practices: Assessment, Recommendations, and Knowledge Gaps. Allen Press: Lawrence, KS.

Cameron, C. and P. Trivedi. 2005. *Microeconometrics: Methods and Applications*. Cambridge University Press, New York.

Cameron, A.C., and P.K. Trivedi. 2009. *Microeconometrics Using STATA*. STATA Press: College Station, TX.

Conant, R., J. Six, and K. Paustian. 2003. "Land Use Effects on Soil Carbon Fractions in the Southeastern United States. I. Management-Intensive Versus Estensive Grazing." *Biology and Fertility of Soils.* 38:386-392.

Cooper, J. 2003. "A Joint Framework for Analysis of Agri-Environmental Payment Programs." *American Journal of Agricultural Economics* 85: 976-987.

Cooper, J. and G. Signorello. 2008. "Farmer Premiums for the Voluntary Adoption of Conservation Plans." *Journal of Environmental Planning and Management* 51 (1): 1-14

Cottle, D., J. Nolan, and S.Wiedermann. 2011. "Ruminant Enteric Methane Mitigation: A Review." *Animal Production Science* 51: 491-514.

Fishe, R., R. Trost, and P. Lurie. 1981. "Labor Force Earnings and College Choice of Young Women: An Examination of Selectivity Bias and Comparative Advantage." *Economics of Education Review* (1)2: 169-191.

Foltz, J. and G. Lang. December 2005. "The Adoption and Impact of Management Intensive Rotational Grazing (MIRG) on Connecticut Dairy Farms" *Renewable Agriculture and Food Systems* 20(4):261-266.

Gurian-Sherman, D. 2011. "Raising the Steaks: Global Warming and Pasture-Raised Beef Production in the United States." Union of Concerned Scientists. February. Internet site: http://www.ucsusa.org/assets/documents/food_and_agriculture/global-warming-and-beef-production-report.pdf. (Accessed November 5, 2013).

Jayasinghe-Mudalige, U. and A. Weersink. 2004. "Factors Affecting the Adoption of Environmental Management Systems by Crop and Livestock Farms in Canada." *Sri Lankan Journal of Agricultural Economics. 6(1): 25-36.*

Johnson, K. and D. Johnson. 1995. "Methane Emissions from Cattle". *Journal of Animal Science* 73: 2483- 2492.

Kurkalova, L., C. Kling, and J. Zhao. "Green Subsidies in Agriculture: Estimating the Adoption Costs of Conservation Tillage from Observed Behavior." *Canadian Journal of Agricultural Economics* 54 (2006) 247–267.

Kim, S., J. Gillespie, and K. Paudel. 2008. "Rotational Grazing Adoption in Cattle Production Under a Cost-Share Agreement: Does Uncertainty Have a Role in Conservation Technology Adoption?" *The Australian Journal of Agricultural and Resource Economics* 52: 235-252.

Lichtenberg, E. and Ricardo Smith-Ramirez. 2011. "Slippage in Conservation Cost Sharing." *American Journal of Agricultural Economics* 93:113-129.

Maddala, G. S. 1983. *Limited-Dependent and Qualitative Variables in Economics.* New York: Cambridge University Press, pp. 257-91.

Ribaudo, M. 2011. "Reducing Agriculture's Nitrogen Footprint: Are New Policy Approaches Needed?" *Amber Waves*. Sept 1.

Rolfe, J., J. Windle, A. Reeson, and S.Whitten. "Assessing The Incentives Needed to Improve Riparian Management in Grazing Systems: Comparing Experimental Auctions and Choice Modelling Approaches." Paper presented at the 50th Annual Conference of the Australian Agricultural and Resource Economics, Sydney, 7 – 10th of February, 2006.

United States Department of Agriculture, National Agricultural Statistics Service (USDA/NASS). *2007 Census of Agriculture*.

United States Department of Agriculture Natural Resource Conservation Service (USDA/NRCS). 2013. Internet site: "Equip Application Information by State" http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/programs/financial/eqip/?&cid=nrcs143_008223. (Accessed Dec. 5, 2013).

United States Department of Agriculture Natural Resource Conservation Service (USDA/NRCS). 2008. "Fact Sheet- Air Quality and Atmospheric Change: Greenhouse Gases and Animal Operations."

United States Environmental Protection Agency (USEPA). 2008. Clean Water Act, Laws and Regulations.

United States Environmental Protection Agency (USEPA). 2010. 2010 U.S. Greenhouse Gas Inventory Report, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008, April. *U.S. EPA #430-R-10-006*.

Yen, S. and J. Rosinski. 2008. "On the marginal effects of variables in the log-transformed sample selection models." *Economics Letters* 100: 4-8.

Table 1. Variable Names, Definitions, and Means

		Means		
		ACRES	ACCEPT	INTEREST
Variable Name	Definition	(N=589)	(N=816)	(N=1153)
Dependent variables:				
lnACRES	Natural logarithm of acres to be converted to prescribed grazing	4.7468		
ACCEPT	Whether will accept incentive level offered 0,1		0.7095	
INTEREST	Whether interested in adopting prescribed grazing 0,1			0.6812
Explanatory variables:				
INCENTIVE	Annual incentive payment offered per acre in hypothetical program, $10, $20, $50, $70, or $90	51.6453	50.2119	
ACFARM	Acres own that are farmed, acres	565.0041	532.1664	486.1936
EASTUPL	Eastern Uplands region, 0,1,	0.2347	0.2140	0.2329
HEARTLAND	Heartland region, 0,1	0.2394	0.2375	0.2408
PRAIRIE	Prairie Getaway, 0,1	0.2149	0.2301	0.2160
SOSEABD	Southern Seaboard, 0,1	0.0972	0.1132	0.1223
SHRPAST	Share of acres farmed in pasture, percent			0.5281
FERTPAST	Fertilize pastures as a management practice, 0,1			0.8242
UPGR	Use of prescribed grazing practices in 2012, 0,1		0.6444	0.5238
OTHLIV	Have livestock other than cattle, 0,1			0.2647
INC3049K	2012 taxable household income of $30-$49K, 0,1		0.2103	0.2509
INC5099K	" " $50-$99K, 0,1		0.2797	0.2576
INC100149K	" " $100-$149K, 0,1		0.1669	0.1409
INCG150K	" " at least $150K, 0,1		0.1537	0.1233
AGE	Age of farm operator, years			61.8148
SOLE	Operator is sole proprietor, 0,1			0.8174
COLLEGE	College graduate, 0,1			0.5827
EXTWK	Number of extension workshops attended in 2012			0.8644
INTERNET	Use Internet to make farm purchases or farm management decisions, 0,1,			0.4216
GOVINCENT	The government should offer incentives to adopt conservation practices,1 if agree, 0 otherwise		0.6698	0.5937
WADOPT	Tend to wait until others have adopted new technologies to adopt them, 1=strongly disagree,…,5=strongly agree			0.3760
STEWARD	Am a steward of the land and is my obligation to protect it for use by future generations, 1=strongly disagree,…,5=strongly agree			0.9311
FAMTKOV	Family will take over when cease farming, 0,1			0.6157

Table 2. Triple Hurdle Regression Estimates and Marginal Effects

	Estimated Coefficients			Marginal Effects		
	lnACRES	ACCEPT	INTEREST	ACRES	ACCEPT	INTEREST
INCENTIVE	0.0028*	0.0041**	----	0.4088	0.0012	----
ACFARM	0.0006***	0.0001*	0.0001	0.0642	3.75E-05	1.86E-05
EASTUPL	0.2775**	0.2083	-0.3385**	29.9020	0.0554	-0.0967
HEARTLAND	-0.0237	0.0202	-0.1372	-3.7470	0.0056	-0.0384
PRAIRIE	0.7765***	-0.2313	0.0061	70.8866	-0.0675	0.0017
SOSEABD	-0.0590	-0.2454	-0.4204**	-21.1249	-0.0732	-0.1215
SHRPAST	----	----	0.6907***	10.0246	----	0.1911
FERTPAST	----	----	0.3595**	5.7335	----	0.1044
UPGR	----	-0.1772	0.5624***	3.3984	-0.0484	0.1656
OTHLIV	----	----	0.2405**	3.4078	----	0.0656
INC3049K	----	-0.1758	-0.0853	-7.1325	-0.0508	-0.0238
INC5099K	----	-0.0263	0.0767	0.2447	-0.0073	0.0211
INC100149K	----	-0.0539	0.2403	1.5087	-0.0152	0.0647
INCG150K	----	-0.1507	0.4702**	0.6864	-0.0436	0.1219
AGE	----	----	-0.0090**	-0.1309	----	-0.0025
SOLE	----	----	-0.1323	-1.8725	----	-0.0361
COLLEGE	----	----	0.2232**	3.3594	----	0.0632
EXTWK	----	----	0.0678*	1.0393	----	0.0192
INTERNET	----	----	0.3642***	5.3905	----	0.1022
GOVINCENT	----	0.2856**	0.5315***	18.3877	0.0828	0.1539
WADOPT	----	----	-0.2239**	-3.3947	----	-0.0626
STEWARD	----	----	0.4464***	7.5121	----	0.1319
FAMTKOV	----	----	0.0050	0.0724	----	0.0014
Constant	4.1401***	0.5848**	-0.7116*	----	----	----
σ	0.9567					
ρ_{12}	0.3722					
ρ_{13}	-0.5742					
ρ_{23}	-0.8061**					
Observations	589	816	1153			
Wald Test Against Intercept Only (40 df)	396.26***					
Percent Correctly Classified	78.58%	72.18%				
Conditional ACRES	161.5062					
Unconditional ACRES	105.0254					
Elasticity of ACRES With Respect to INCENT	0.1311					
Correlation with Condit with ACRES	0.6168					

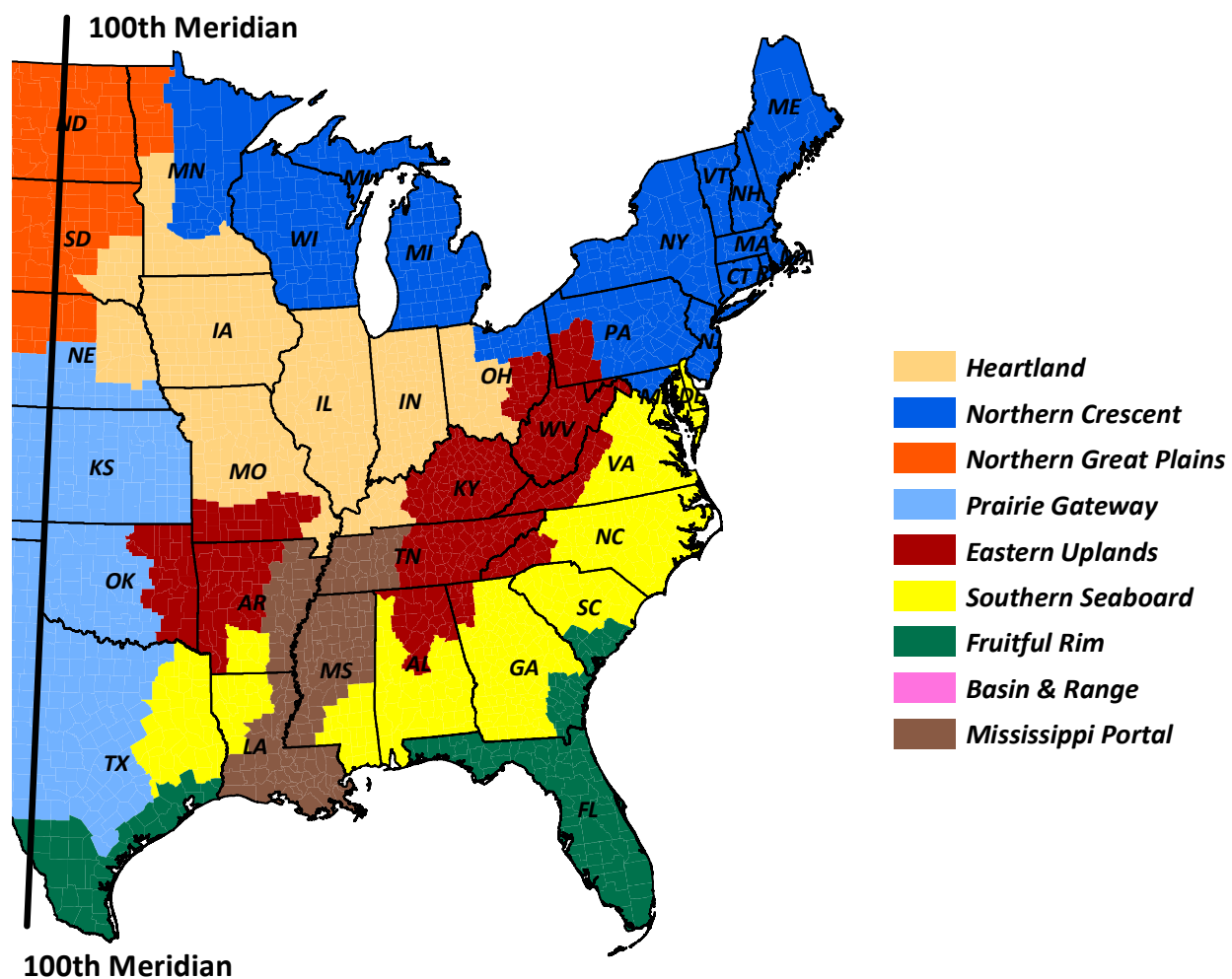$^{*}p < .1,\ ^{**}p < .05,\ ^{***}p < .01$

Figure 1. Area Surveyed East of the 100th Meridian

What is prescribed grazing?

- Prescribed grazing is the *controlled harvest* of vegetation by grazing animals.
- Controlled harvest means managing the duration, intensity, distribution, frequency, and season animals graze on a pasture.
- Management practices include:
  - Rotating cattle around a number of paddocks (fenced fields) in an ordered sequence;
  - Monitoring forage stubble height for the best grazing start and stop times; and
  - Removing cattle from grazing areas to allow forage recovery.

How would prescribed grazing benefit you?

- Grow more and better quality forage;
- Allow higher stocking rates (estimates are up to 40% increases); and
- Increase use of forage from pastures.

How would prescribed grazing affect the environment?

- Increased yields and efficiency per unit of land means less pollution; and
- Concentrating livestock in paddocks for days at a time lets animals graze lightly but evenly, encouraging roots to grow deeper into the soil, storing more organic matter (carbon).

Photo: NRCS.

What would you need to do to practice prescribed grazing?

Manage forage by:
- Balancing livestock consumption and forage production;
- Adjusting livestock numbers, fertilizer rates, or purchased feed to meet livestock forage needs;
- Limiting feed (hay, silage, gluten, hulls, grain, etc.) to no more than 50% of total livestock diet; and
- Creating a weed control plan and controlling weeds in pastures by clipping, spraying, high density grazing, mixed species grazing and/or weed wiping as needed.

Rotate livestock by:
- Using at least 5 different paddocks or fields for grazing;
- Grazing livestock for no more than 14 continuous days on any paddock or field (except during extreme weather conditions);
- Buffering sensitive areas like wells, depressions, sinkholes, and all water areas in paddocks;
- Developing a conservation plan that includes a grazing component with a technical consultant; and
- Not grazing more than 20% of the pasture to less than minimum grazing heights of:
  - 2" for bermudagrass, ryegrass;
  - 3" for cool season grasses (e.g. tall fescue, orchardgrass, cereal grains); and
  - 6" for tall upright grasses (e.g. native grass, millet, sorghums).

Recordkeeping:
- Keep records to show continued use of prescribed grazing practices.

Region*	Prescribed grazing ($/AC)	Fence ($/Strand Foot)	Watering facility ($/Gallon)	Heavy use area ($/Sq Ft)
Northeast	34.86	1.86	2.34	1.76
Lake States	36.09	1.34	1.31	1.16
Corn Belt	23.38	1.12	1.80	1.21
Northern Plains	24.96	1.36	1.72	1.72
Appalachia	31.07	1.49	2.43	1.18
Southeast	21.35	1.09	1.14	1.23
Delta	48.26	1.42	0.61	1.20
Southern Plains	28.82	1.38	1.72	1.35

*Northeast: CT, DE, ME, MD, MA, NH, NJ, NY, PA; **Lake States**: MN, WI, MI; **Corn Belt**: IL, IN, IA, MO, OH; **Northern Plains**: KS, NE, ND, SD; **Appalachia**: KY, NC, TN, VA, WV; **Southeast**: AL, FL, GA, SC; **Delta**: AR, LA, MS; **Southern Plains**: OK, TX

Figure 2. Description of Prescribed Grazing and Estimated Regional Costs

[1] Estimated carbon (C) sequestration rates grazing management practices have been estimated at .30 to 1.30 Mt/acre (Follet, et. al, 2001).

[2] In the western parts of the United States prescribed grazing would not be as beneficial to the producers or the environment because of the climate and limitations on forage growth that exist due to the land quality and the weather (Conant et al 2003).