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Adopting Rotational Grazing and Cover Crops: Drivers and Complementarities

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Both rotational grazing (RG) and cover crop (CC) grazing extend the grazing period while requiring additional investment in fencing and water systems. Using a 2023 farmer survey in South Dakota, we found that 33.9% and 9.3% of respondents had adopted RG and CC grazing only, respectively, while 37.2% had adopted both practices. Our regression results further highlight the complementary relationship between RG and CC grazing, which indicates the potential to expedite CC adoption through financially incentivizing RG implementation. Additionally, integrated crop and livestock enterprises with a more balanced share of grassland and cropland acreage could be a target group for promoting CC adoption.

Key words: conservation, decision-making, grazing management practices, integrated crop-livestock, producer survey

Introduction

Livestock producers often face numerous challenges due to the increasing frequency of drought, which affects feed prices, shortens the grazing period, and increases the need for hay. These issues can potentially reduce profit margins from grass-based livestock production (Cook, Mankin, and Anchukaitis, 2018; Cheng, McCarl, and Fei, 2022). To reduce feed costs, it is of paramount importance to adopt grazing strategies that lengthen the grazing period.

Grazing management plays a vital role in promoting grassland health. Continuous grazing—-livestock grazes the entire area for the whole season—-is associated with a long grazing period. This grazing system increases the risk of overgrazing in the preferred area. Insufficient recovery of grassland can lead to decreased grass productivity, reduced soil infiltration, increased nutrient runoff and soil erosion, loss of soil carbon, and vulnerability to drought (Wilson and MacLeod, 1991; Pratt, 1993; Kairis et al., 2015; Fan et al., 2017). In contrast to continuous grazing, rotational grazing (RG) divides the grazing area into multiple sections (called paddocks), with one paddock being grazed at a time, allowing the other paddocks to rest (Teague et al., 2013; Wang et al., 2020a). The resting period is critical for plants to regrow and restore nutrients, deepen their root system, and maximize forage productivity (Undersander et al., 2014). If properly managed, RG can extend the grazing period, increase stocking rates, and reduce the use of hay and other feedstuffs, thereby lowering input cost and increasing profitability (Paine, Undersander, and Casler, 1999; Wang et al., 2022; Wang and Kreuter, 2025; Augustine et al., 2023). Other potential benefits of RG include reduced fertilizer use from more even manure distribution, improved soil erosion, weed control, and enhanced soil organic carbon storage (Undersander et al., 2014; Mosier et al., 2021; Augustine et al., 2023).

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Despite the aforementioned benefits, some experiments have identified potential negative consequences from RG adoption, such as no change in vegetation productivity and decreasing animal weight gain from higher stocking densities and lower diet quality consumed (Briske et al., 2008; Augustine et al., 2020, 2023). Additionally, farmers may face financial and technical barriers with RG adoption. Importantly, the implementation of RG requires an initial investment in items such as conventional or electric fencing and accessible water systems in each paddock (Undersander et al., 2014; Wang et al., 2020a). In addition, producers need to develop a grazing plan, monitor forage growth, and move animals across paddocks (Undersander et al., 2014). An effective RG implementation plan requires considerable time for farmers to adjust and develop, as it varies based on climate, region, farming goals, the selection of rotation frequency, number and size of paddocks, stock density, and grass species (Undersander et al., 2014).

Cover crops (CC) have been widely promoted in recent years given their benefits in increasing plant diversity, improving pest and weed control, reducing soil erosion and nutrient runoff, and mitigating climate change through soil carbon storage (Adetunji et al., 2020; Plastina et al., 2020). Utilizing CC for grazing purposes can extend the grazing season, reduce livestock feed costs, and increase soil nitrogen and organic matter as animals leave manure in the soil (Poffenbarger, 2010; Liebig et al., 2012; Williams et al., 2018; Tobin et al., 2020). Furthermore, CC grazing can reduce herbicide usage if grazing is used as a cover crop termination method (Williams et al., 2018).

Amid the potential benefits of CC grazing, cover crop implementation generates extra costs (e.g., seeds, planting equipment, and labor). The cover crop mix selection should also match livestock types and grazing goals (Williams et al., 2018). Like RG, CC grazing also requires initial investment in fencing and water systems, training animals to electric fencing, and moving livestock across different paddocks or fields (Undersander et al., 2014; Williams et al., 2018). Hence, producers with adaptive RG experiences should face fewer challenges in adopting CC grazing management. These two practices can complement each other to achieve higher economic and environmental benefits in the integrated crop–livestock production systems.

In the United States, the usage of RG has been declining, while the CC adoption rate remains limited (US Department of Agriculture, 2022). At the national level, we observe a reduction in the RG adoption rate as the number of RG adopters declined much faster than the number of cattle grazing operations from 2007 to 2022 (US Department of Agriculture, 2007, 2022). Even though the CC adoption rate has gradually increased over time, only 13.3% of US farm operations had adopted CC as of 2022. The sluggish increase in the CC adoption rate potentially stems from additional costs and potential risks associated with the adoption.

Previous literature has extensively examined factors affecting RG and CC adoption decisions in separate manners (Bergtold et al., 2012; Arbuckle and Roesch-McNally, 2015; Jensen et al., 2015; Hyland et al., 2018; Boyer et al., 2022). Yet, no study has investigated potential complementarities in farmers' adoption decisions for these two practices. Using a 2023 agricultural producer survey in South Dakota, our study addresses two main objectives: (i) identify driving factors of adoption decisions of RG and CC grazing and (ii) explore the potential complementary relationship between these two practices.

Survey Description

This study uses data collected from a mail survey of agricultural producers in South Dakota during January–March 2023. A list of 3,500 farmer samples was purchased from DTN. Each producer operated at least 100 acres of grassland and had at least 50 livestock under grazing. These sampling criteria were used because small farms are not likely to find it profitable to adopt RG or CC (Gillespie, Kim, and Paudel, 2007; Wang et al., 2018, 2020b). The survey was implemented following the modified tailored design method proposed by Dillman, Smyth, and Christian (2014), with each survey sample being contacted up to four times. First, we sent an advance letter notifying farmers about the upcoming survey with an option to answer the online questionnaire. Then, we sent a paper questionnaire with a prepaid return envelope to those who did not respond online, followed by a reminder/thank you postcard. Last, the second paper copy of the questionnaire was sent with a prepaid return envelope to the remaining nonresponding producers. Of 3,500 survey samples, 412 producers were ineligible due to no longer farming and undeliverable addresses. Overall, the response rate was 14.8%, with 473 responses.

We evaluate the representativeness of our data by comparing them with (i) the 2022 Census of Agriculture (US Department of Agriculture, 2022) and (ii) the information of nonrespondents from DTN. The average age of primary operators among survey respondents is 63.4 years, with an average farming experience of 36.0 years; both significantly exceed the census data at 57.2 and 25.8 years ($p < 0.01$), respectively. In addition, the average farm size of our survey data is 4,248.3 acres, significantly higher than the state average farm size of 2,368 acres for beef cattle enterprises ($p < 0.01$). Nevertheless, the median value of farm size from our respondents is 2,400 acres, close to the census average for beef cattle enterprises, which indicates a right-skewed farm size distribution of our sample. This could be attributable to the sample selection criterion of having a minimum of 100 acres of grassland. Furthermore, we compare the number of cattle heads, pasture, and crop acres between respondents ($N = 469$) and nonrespondents ($N = 3{,}031$). The average number of cattle heads is similar for respondents and nonrespondents (329 vs. 319 heads, $p = 0.64$). Additionally, our survey respondents have an average pasture size of 2,271.8 acres, which is not significantly different from the average of 1,975.9 acres among nonrespondents ($p = 0.14$). By contrast, our respondents' mean of cropland acres is significantly lower than that for nonrespondents (980.3 vs. 1,230.9 acres, $p < 0.01$). This gap suggests potential bias in the adoption rate of CC grazing, as the practice is related to cropland acres.

Data Description

The survey contains questions that enable us to define the adoption status of the RG and CC grazing and the factors that possibly influence producers' adoption decisions of these practices, such as farm and farmer characteristics, farmers' perceptions of soil and grassland health, and information/education sources.

We define RG adoption status as a binary variable based on the number of paddocks currently operated (Wang et al., 2021, 2022). Specifically, the adoption status of *RG* equals 0 for nonadopters with one to three paddocks and 1 for adopters with four or more paddocks. We excluded operations with only two or three paddocks from the adopters due to the following reasons: (i) a minimum of four to five paddocks is typically recommended for a starter (Smith et al., 2011; Jensen et al., 2015); and (ii) one-third of producers with two to three paddocks did not use RG, but they used the additional paddocks for other purposes (Wang and Kreuter, 2025). Additionally, producers with four or more paddocks may have multiple herds grazing on each with no rotation involved. Therefore, respondents with four or more paddocks but who never rotated their animals or kept none of their grassland under RG management are also classified as nonRG adopters ($RG = 0$).

The question about the adoption status of CC grazing asked the respondents to choose whether CC grazing had been adopted. Thus, a binary variable is used to denote the adoption status, with 0 = nonadopters and 1 = adopters, as shown in Table 1.

Table 1 also provides descriptions of variables that could influence RG and CC grazing adoption decisions. Regarding farm characteristics, farm size (*FarmSize*) is the sum of grassland and cropland acres. The share of grassland (*Grass*) is calculated as grassland acres divided by *FarmSize*. To capture the degree of crop–livestock integration (*Integration*), we multiplied *Grass* by the proportion of cropland ($1 -$ *Grass*). A higher value of *Integration* indicates producers with a more balanced share of grassland and cropland. For each land category, we asked about the operated acres. *Ownership* is calculated as the owned land acres divided by the total farmland. Geographic and climatic factors, such as soil fertility and precipitation, could affect farmers' RG and CC adoption decisions. To capture the degree of RG and CC suitability in each county, we obtained the following two county-

Table 1. Variable Descriptions and Summary Statistics

Variable	Description	*N*	Mean	S.D.	Min.	Max.
Grazing management						
RG	The adoption of rotational grazing (0 = non-adopters; 1 = adopters)	446	0.83	0.37	0	1
CC grazing	The adoption of cover crop grazing (0 = non-adopters; 1 = adopters)	473	0.45	0.5	0	1
Farm characteristics						
FarmSize	Total farmland (thousand acres)	453	4.25	5.26	0.04	60.5
Grass	Percentage of grassland to total farmland	453	0.63	0.28	0	1
Integration	The share of grassland times the share of cropland = $Grass \times (1 - Grass)$	453	0.15	0.08	0	0.25
RGratio	The ratio of operations with rotational grazing by county	473	0.34	0.08	0.14	0.54
CCratio	The ratio of cover crop acres to total cropland by county	473	0.02	0.02	0	0.13
Ownership	Percentage of owned land to total farmland	453	0.68	0.3	0	1
Farmer characteristics						
Age	Age of primary farm decision maker (years)	448	64.38	10.64	28	92
Edu	Highest education (1 = less than high school, 2 = high school, 3 = some college/technical school, 4 = 4-year college degree, 5 = advanced degree)	456	3.05	0.93	1	5
DrougthPlan	Having a written drought management plan (0 = no and not plan to, 1 = not yet but in plan, 2 = yes)	426	0.61	0.75	0	2
Grazing goals and potential influencing source of information						
AFI	Attitudinal factor index for attitude toward grazing goals (1 = not important, 2 = slightly important, 3 = somewhat important, 4 = quite important, 5 = very important)	433	3.63	0.8	1	5
GrassMem	Membership in Grassland Coalition (1 = being a member, 0 = otherwise)	473	0.13	0.34	0	1
SoilMem	Membership in Soil Health Coalition (1 = being a member, 0 = otherwise)	473	0.07	0.25	0	1
GrazingEdu	Attending grazing schools, award recipient tours, pasture walks, grazing field days (0 = no influence on grazing decisions, 1–3 = the 3rd – 1st most influencing factor)	372	0.48	0.91	0	3
PeerAdvice	Advice from successful ranchers on how they changed their systems (0 = no influence on grazing decisions, 1–3 = the 3rd – 1st most influencing factor)	372	1.07	1.24	0	3

level adoption ratios from the 2022 Census of Agriculture (US Department of Agriculture, 2022): (i) RG ratio calculated as the number of operations using RG divided by the number of operations with cattle inventory (*RGratio*) and (ii) CC ratio calculated as the number of cover crop acres divided by the total cropland acres (*CCratio*). It should be noted that the variables *RGratio* and *CCratio* are the same value for all respondents operating in the same county.

Under the farmer characteristics category in Table 1, primary operators' age (*Age*) and highest education level achieved (*Edu*) are included. *Age* is calculated as the survey year (2023) minus the respondent's birth year. *Edu* is an ordinal variable, with 1–5 denoting "less than high school," "high school," "some college/ technical school," "4-year college degree," and "advanced degree," respectively. In addition, producers' risk preferences are reflected by a written drought management plan (*DroughtPlan*) as drought conditions have become more severe in South Dakota over the last 25 years (National Integrated Drought Information System, 2024). If the respondents do not have a drought plan and do not think one is necessary, they are potentially risk lovers; thus, *DroughtPlan* is equal to 0. On the other hand, *DroughtPlan* has a value of 1 when producers do not have a drought management plan but intend to have one. For those who have already made a drought management plan, *DroughtPlan* has a value of 2.

Four grazing management goals are considered as potential factors affecting adoption decisions: (i) increasing economic returns, (ii) maintaining stocking rate, (iii) enhancing grassland health, and (iv) improving soil health. Respondents can choose one of the five options that reflect the importance they placed on those goals, ranging from 1 = not important to 5 = very important. The goals of improving grassland and soil health can lead to increasing economic returns and stocking rate, resulting in significant correlation coefficients among these factors ($\rho = 0.21$–0.81, $p < 0.01$). Therefore, we developed an attitudinal factor index (*AFI*) using the unweighted average importance of these four goals to reflect attitudes toward grazing management.

To capture the effect of producer associations, we included two binary variables to capture respondents' membership status in the South Dakota Grassland Coalition (*GrassMem*) and the South Dakota Soil Health Coalition (*SoilMem*), as shown in Table 1. Each variable equals 1 if the respondent has a membership in the organization and 0 otherwise. These organizations are of interest because they provide educational and technical resources to promote practices that improve soil and grassland health as well as increase farm/ranch profitability. For example, the Soil Health Coalition provides a CC grazing worksheet, which is used to estimate the available forage and the number of CC grazing days (South Dakota Soil Health Coalition, 2022). The Grassland Coalition offers a variety of resources, including a grazing school (an intensive program focusing on grazing management techniques) and a consulting program (assistance in developing a custom grazing plan, such as fencing, water design, and a pasture rotations plan) (Rupp, 2024).

Moreover, respondents were asked to rank the top three options that most likely influence their grazing decisions. Scores of 1 to 3 mean the respondent designated the option the third most influential to the most influential factor, respectively, while 0 means the option was not chosen as one of the top three influencing factors. Table 1 includes two variables to capture the role of grazing education: "attending grazing schools, award recipient tours, pasture walks, and grazing field days" (*GrazingEdu*) and "advice from successful ranchers on how they changed their systems" (*PeerAdvice*). The listed activities in these two options provide education and hands-on experience in using regenerative grazing management practices.

Empirical Model

Agricultural producers are assumed to be rational and choose whether to adopt a certain conservation practice based on utility maximization, which is modeled as a linear function of farm and farmer characteristics, goals of grazing management, and sources of information. If the utility of adopting the practice is higher than the utility of nonadoption, producers will decide to adopt it. However, farmers' utility is unobservable. The observed outcomes are binary variables equaling 1 if the practice is adopted and 0 if not adopted. The correlation coefficient between the dependent variables RG and CC grazing is significant at 0.14 ($p < 0.05$), implying that the adoption decision of one practice is likely to be contingent on the other. The univariate probit regression for each practice that ignores the correlation between the residuals of both equations can result in biased marginal effects, as shown in Ogada et al. (2021). Even though the adoption of RG is observed at a finer level (categories of number of paddocks), only two outcomes (adopt or not adopt) are known for CC grazing. Therefore, we adopted a bivariate probit model to examine the factors affecting RG and CC grazing adoption decisions simultaneously. An ordered probit regression is also performed for the RG adoption, when RG adopters were separated into extensive and intensive groups, as demonstrated in the online supplement (see www.jareonline.org).

The response model and latent variable model for the bivariable probit regression are specified in equations (1)–(2):

$$\text{(1)} \qquad \Pr(Y_i = 1 \mid \boldsymbol{X}) = \Phi\left(\boldsymbol{X}^T\boldsymbol{\beta}\right),$$

$$\text{(2)} \qquad Y_i = \begin{cases} 1, \text{ if } Y_i^* = \boldsymbol{X}^T\boldsymbol{\beta} + u_i > 0 \\ 0, \text{ if } Y_i^* \leq 0 \end{cases},$$

where $\Pr(\cdot)$ is called response probability, ranging from 0 to 1, $\Phi(\cdot)$ is the bivariate standard normal cumulative distribution function, $Y_i = \{RG, CC\ grazing\}$ denotes the observed adoption behavior, and Y_i^* is the continuous latent adoption tendency, $\boldsymbol{X}$ is the vector of covariates hypothesized to affect the decisions to use RG and CC grazing and an intercept, $\boldsymbol{\beta}$ is the vector of coefficients to be estimated, and u_i denotes an error term with the assumption that u_{RG} and u_{CC} are jointly normally distributed. The dependent variables *RG* and *CC grazing* are binary (1 = adopters and 0 = nonadopters), as described in the previous section.

Equation (3) lists all covariates $\boldsymbol{X}$:

$$\text{(3)} \qquad \begin{aligned} \boldsymbol{X}^T\boldsymbol{\beta} = {} & \beta_0 + \beta_1 FarmSize + \beta_2 Grass + \beta_3 Integration + \beta_4 ratio + \beta_5 Ownership + \beta_6 Age \\ & + \beta_7 Edu + \beta_8 DroughtPlan + \beta_9 AFI + \beta_{10} GrassMem + \beta_{11} SoilMem \\ & + \beta_{12} GrazingEdu + \beta_{13} PeerAdvice. \end{aligned}$$

More detailed descriptions of explanatory variables are reported in Table 1. The variable *ratio* indicates the ratio of RG adoption at the county level (*RGratio*) for the RG equation and the share of CC acres at the county level (*CCratio*) for the CC grazing equation. As a result of the differences in explanatory variables in both equations, we estimate RG and CC grazing equations using seemingly unrelated bivariate probit regression.

Due to the nonlinear function of equation (1), the univariate marginal effect of each explanatory variable X_k on RG and CC grazing adoption are calculated in equation (4):

$$\text{(4)} \qquad \frac{\partial \Pr(Y_i = 1)}{\partial X_k} = \phi_i\left(\boldsymbol{X}^T\boldsymbol{\beta}\right)\frac{\partial \boldsymbol{X}^T\boldsymbol{\beta}}{\partial X_k},$$

where $\phi_i\left(\boldsymbol{X}^T\boldsymbol{\beta}\right)$ is the value of marginal standard normal probability distribution function at $\boldsymbol{X}^T\boldsymbol{\beta}$. For continuous explanatory variables (*FarmSize*, *RGratio*, *CCratio*, *Ownership*, and *Age*) or discrete ordinal (*Edu*, *DroughtPlan*, *AFI*, *GrazingEdu*, and *PeerAdvice*), we calculate their marginal effects as $\phi_i\left(\boldsymbol{X}^T\boldsymbol{\beta}\right)\frac{\partial \boldsymbol{X}^T\boldsymbol{\beta}}{\partial X_k} = \phi_i\left(\boldsymbol{X}^T\boldsymbol{\beta}\right)\beta_k$. The marginal probability effect for binary explanatory variables, $Member = \{GrassMem, SoilMem\}$, is computed as $\frac{\partial \Pr(Y_i=1)}{\partial Member} = \Phi_{\mathrm{i}}\left(\boldsymbol{X}^T\boldsymbol{\beta} \mid Member = 1\right) - \Phi_{\mathrm{i}}\left(\boldsymbol{X}^T\boldsymbol{\beta} \mid Member = 0\right)$, where $\Phi_i\left(\boldsymbol{X}^T\boldsymbol{\beta} Member = 1\right)$ and $\Phi_i\left(\boldsymbol{X}^T\boldsymbol{\beta} Member = 0\right)$ denote the value of marginal standard normal cumulative distribution function when $Member = 1$ and $Member = 0$, respectively. Multiple explanatory variables contain the proportion of grassland (*Grass*), as in equation (3): $\beta_2 Grass + \beta_3 Integration = \beta_2 Grass + \beta_3 Grass(1 - Grass)$. Therefore, the marginal effect of *Grass* is calculated as $\frac{\partial \Pr(Y_i=1)}{\partial Grass} = \phi_i\left(\boldsymbol{X}^T\boldsymbol{\beta}\right)\left[\beta_2 + \beta_3(1 - 2Grass)\right]$.

Results and Discussion

Adoption Rates of Rotational Grazing and Cover Crop Grazing

The majority of producers (71.0%) used RG, according to our definition, compared to 33% of South Dakota operations with cattle adopting RG from the 2022 Census. Nearly half (46.4%) of the respondents have adopted CC grazing, which is much higher than the 11.3% of South Dakota crop operations (regardless of having livestock) with CC reported in the 2022 census. This large difference is partly attributable to our sample selection criteria: Each farm operates at least 50 livestock. As pointed out by previous literature, producers with livestock are more likely to adopt CC due to the potential use for grazing to increase farm income (Arbuckle and Roesch-McNally, 2015; Wang et al., 2021; Han and Niles, 2023). A lower adoption rate of CC grazing compared to RG is expected as the use of cover crops has only been widely promoted in the United States for no more than 2 decades (Groff, 2015), yet the use of RG has been advocated since the mid-twentieth century (Briske et al., 2011).

The joint distribution of RG and CC grazing adoption status shows over one-third (37.2%) of the respondents have used both practices. About one-third of producers (33.9%) have adopted RG only, yet only 9.3% have adopted CC grazing solely. The adoption rates of RG and CC grazing at the county level (see map in online supplement) show that CC grazing is more concentrated in counties with more fertile soil and higher precipitation, mostly located on the central and the east side of the Missouri River. The average rainfall in counties in eastern South Dakota was 23.8 inches over 2014–2023, compared to 19.8 inches for counties in western South Dakota (National Oceanic and Atmospheric Administration, 2024). In semiarid regions, previous literature has found little or no effect of cover crops on improving soil water, carbon, and nitrogen storage (Liebig et al., 2015; Acharya et al., 2022). Further, cover crops might even increase water and nitrogen stress on following cash crops (Reese et al., 2014). According to the 2022 census, crop operations with CC are also more concentrated in eastern South Dakota (12.5% of crop operations) than in western South Dakota (7.9%) ($p < 0.01$). Therefore, farms in eastern South Dakota have a higher likelihood of adopting CC grazing. In comparison, land in western South Dakota is semiarid with low crop productivity, which is more suited for livestock production (Golla, 2021). Accordingly, 78.1% of farmland in western South Dakota is pastureland, while only 15.4% is cropland (US Department of Agriculture, 2022). In addition, 36.2% of farm operations with cattle and calves in western South Dakota use RG or management intensive grazing in 2022, higher than 30.0% in eastern South Dakota. Consistent with the census, our survey data shows higher RG adoption rates for central and western South Dakota counties.

Descriptive Statistics and Correlation Coefficients

Table 1 reports the descriptive statistics of all dependent and explanatory variables used in the regression models, while Table 2 shows correlation coefficients among regressors. Six variables for the farm characteristic category are examined as predictors of RG and CC grazing implementation. On average, respondents have the majority of their farm (63%) in grassland (*Grass*), and the mean *Integration* indicator, calculated as the proportion of grassland multiplied by the proportion of cropland, is 0.15. The correlation between *FarmSize* and *Grass* is positive and significant at 0.34, indicating that farms with a higher percentage of grassland generally have more acres. Grass is positively and negatively correlated with the county-level ratio or RG (*RGratio*) and the ratio of CC (*CCratio*), respectively, implying that the farms with a higher proportion of grassland (cropland) are located in the areas that are better suited for RG (CC). Meanwhile, the weighted average of operations with RG among respondents' counties is 34% of the total operations with cattle inventory. CC acres account for only 2% of the total cropland in a county. *Ownership* has an average value of 68%, ranging from 0 (all rented) to 1 (all owned), suggesting that farmers own over two-thirds of the land they operate on average.

The correlation coefficients between *Age* and *Ownership* of 0.29 ($p < 0.01$) and Age and *FarmSize* of −0.11 ($p < 0.05$) suggest that older farmers are more likely to operate a smaller farm with a higher share of owned land. Meanwhile, the highest education level achieved (*Edu*) averages

Table 2. Correlation Coefficients of Explanatory Variables

	FarmSize	*Grass*	*Integration*	*RGratio*	*CCratio*	*Ownership*	*Age*	*Edu*	*DroughtPlan*	*AFI*	*GrassMem*	*SoilMem*	*GrazingEdu*	*PeerAdvice*
FarmSize	1													
Grass	0.34***	1												
Integration	−0.31***	−0.55***	1											
RGratio	0.09	0.26***	−0.19***	1										
CCratio	−0.09	−0.25***	0.06	−0.05	1									
Ownership	−0.08	0	0.03	0.05	0.04	1								
Age	−0.11*	0.04	−0.02	0.02	0.01	0.29***	1							
Edu	0.10*	0.06	−0.05	0.05	0	−0.01	−0.04	1						
DroughtPlan	0.05	0.22***	−0.13**	0.06	−0.14**	−0.09	−0.12**	0.10*	1					
AFI	0.04	0.02	−0.05	−0.04	−0.02	−0.07	0.17***	−0.05	0.02	1				
GrassMem	0.01	0.11**	−0.03	0.05	−0.07	−0.09	−0.03	0.18***	0.20***	0.04	1			
SoilMem	−0.06	−0.06	0.11*	0.01	−0.01	−0.18***	−0.08	0.11*	0.11*	0	0.49***	1		
GrazingEdu	−0.03	0.14**	−0.05	0.05	−0.12**	−0.09	0.01	0.12**	0.19***	0.05	0.27***	0.25***	1	
PeerAdvice	0.08	−0.04	−0.06	0	−0.06	−0.02	−0.15***	0.02	−0.13**	0.12**	0.03	0.06	0.09	1

Notes: Single, double, and triple asterisks (*, **, ***) indicate statistical significance at the 10%, 5%, and 1% level.

Table 3. Bivariate Probit Regression of Rotational Grazing and Cover Crop Grazing Adoption Decisions (*N* = 313)

	Rotational Grazing		Cover Crop Grazing	
Variable Name	**Estimates**	**Marginal Effects**	**Estimates**	**Marginal Effects**
FarmSize	0.091***	0.022***	−0.016	−0.005
Grass	0.394	0.02	0.238	−0.32***
Integration	1.878	–	4.622***	–
RGratio	1.189	0.292	–	–
CCratio	–	–	8.632**	2.827*
Ownership	0.535*	0.131*	−0.438*	−0.143*
Age	−0.017*	−0.004*	−0.022***	−0.007***
Edu	0.03	0.007	−0.04	−0.013
DroughtPlan	0.382***	0.094***	−0.039	−0.013
AFI	0.171	0.042	0.216*	0.071*
GrassMem	0.964***	0.181***	0.343	0.113
SoilMem	0.51	0.108	1.238***	0.376***
GrazingEdu	0.308**	0.075**	0.061	0.02
PeerAdvice	−0.007	−0.002	0.116*	0.038*
Intercept	−0.965	–	−0.266	–
ρ		0.262**		

Notes: Single, double, and triple asterisks (*, **, ***) indicate statistical significance at the 10%, 5%, and 1% levels. *Integration* = *Grass* × (1 − *Grass*).

about some college/technical school (mean of 3.05). The average of *DroughtPlan* is 0.61, reflecting that the majority of farmers do not have or plan to have a drought management plan for their operation.

The attitude toward grazing management goals (*AFI*) is perceived as between somewhat to quite important (mean of 3.63). Among all respondents, 13% have membership in the Grassland Coalition (*GrassMem*), while 7% are Soil Health Coalition (*SoilMem*) members. Education on grazing management (*GrazingEdu*) averaged 0.48, while advice from successful producers (*PeerAdvice*) has a higher average of 1.07. Not surprisingly, membership variables (*GrassMem* and *SoilMem*) have significant correlations with *GrazingEdu* and *DroughtPlan* between 0.11 and 0.27 ($p < 0.10$ for *SoilMem* and *DroughtPlan*, $p < 0.01$ for others). These relationships indicate that members in these organizations perceive the importance of grazing education and exhibit more risk aversion. In addition, Edu is positively and significantly related to *GrassMem*, *SoilMem*, and *GrazingEdu*, implying that producers with a higher educational level placed higher values on these two organizations. Hence, they are more likely to participate in the related grazing education activities.

Probit Regression on Rotational Grazing Decisions

Table 3 shows the results of bivariate probit regression on RG adoption decisions. Despite the presence of correlations among explanatory variables, multicollinearity is not detected, according to low values (< 2) of all variation inflation factors with a mean of 1.25. The estimated univariate marginal effect shows that a 1,000-acre increase in farm size (*FarmSize*) raises the probability of RG use by 2.2 percentage points, on average. Previous literature also had similar findings, citing lower barriers to adoption (Wang et al., 2020a) and economies of scale (O'Hara et al., 2023). Additionally, adopting RG in larger farms has the potential to reduce labor associated with animal health checks compared to a smaller farm because of more frequent animal contact from moving animals. *Ownership* is found to positively influence RG adoption. A 1-percentage-point increase in the ratio of owned land (an average of 42.5 acres per operation) can increase the possibility of RG use by 13.1 percentage points. The positive influences of a higher share of owned land on RG adoption are possibly due to the investment in fencing and water sources, which is unlikely profitable for short-term operations on leased land (Jayasinghe-Mudalige and Weersink, 2004; Wang et al., 2020a). The high marginal effect of *Ownership* implies the importance of increasing land access opportunities, especially for beginning, socially disadvantaged, veteran producers, or producers with limited resources to enhance conservation practice adoptions and improve the environment.

Age is found to be negatively related to RG adoption, and a 1-year increase in age reduces the probability of RG use by 0.4 percentage points. A comprehensive review shows that a negative correlation between age and the adoption of conservation practices is more frequently found than a positive relationship (Prokopy et al., 2019), which is partially due to their shorter planning horizons on farming (Jensen et al., 2015; Kuehne et al., 2017; Lambert et al., 2020). Regarding risk attitudes, farmers who exhibit a higher degree of risk aversion, indicated by having or planning to have a drought management plan, are more likely to adopt RG. Previous studies also found that minimizing risks and drought management could greatly affect grazing management decisions (Barton, Bennett, and Burnidge, 2020).

Furthermore, membership in the Grassland Coalition could raise the possibility of RG adoption by 18.1 percentage points. In addition, receiving education on grazing management (*GrazingEdu*) is found to be significant to RG uses. These outcomes highlight the importance of grazing management education, which is corroborated by previous findings that extension education significantly influences RG adoption decisions (Jensen et al., 2015; Holley et al., 2020; Boyer et al., 2022; Wang et al., 2022). These variables' relatively high marginal effects emphasize the importance of social network opportunities, education, and hands-on experience with new grazing management techniques. These factors are more likely to enhance further RG adoption than only focusing on financial incentives (see online supplement for more information).

Probit Regression on Cover Crop Grazing Decisions

Table 3 shows that the crop–livestock integration level (*Integration*) significantly increases the likelihood of CC grazing, implying that farms with a more balanced distribution in cropland and grassland are more likely to implement CC grazing. A 1-percentage-point increase in cropland proportion (about 42.5 acres per farm operation) enhanced the likelihood of CC grazing adoption by an average of 32.0 percentage points. Intuitively, producers with more crop acres are more likely to plant cover crops due to economies of scale (Arbuckle and Roesch-McNally, 2015). On the other hand, producers with more grassland acres have a higher likelihood of RG adoption and, therefore, more expertise in implementing CC grazing.

The suitability for CC adoption, partly captured by *CCratio*, positively influences CC grazing implementation. Specifically, a 0.1-percentage-point increase in the proportion of CC acres in the county (approximately 231.4 acres per county) increases the possibility of CC grazing by 28.3 percentage points. The low shares of CC acres currently adopted imply that the slight increase in CC adoption will largely improve the use of CC grazing.

For demographic factors, the age of primary operators (*Age*) is negatively correlated with the possibility of CC grazing ($p < 0.01$). A year increase in age decreases the probability of adoption by 0.7 percentage points, slightly higher than the effect of *Age* on RG adoption. As a combination of cover cropping and grazing, the learning curve of CC grazing could be steeper than either of the practices. Practice complexity can delay adoption (Kuehne et al., 2017).

The attitude toward economic and environmental goals (*AFI*) positively affects CC grazing decisions, which is consistent with previous findings for CC adoption (Wang et al., 2021). Additionally, being a member of the Soil Health Coalition (*SoilMem*) increases the probability of CC grazing by 37.6 percentage points since Soil Health Coalition offers knowledge and tools for CC grazing. Advice from successful ranchers (*PeerAdvice*) also partly contributes to the higher adoption of CC grazing. These outcomes are consistent with the findings of Wang et al. (2020b), which shows nonformal education (extension workshops and social networks) positively affects farmers'

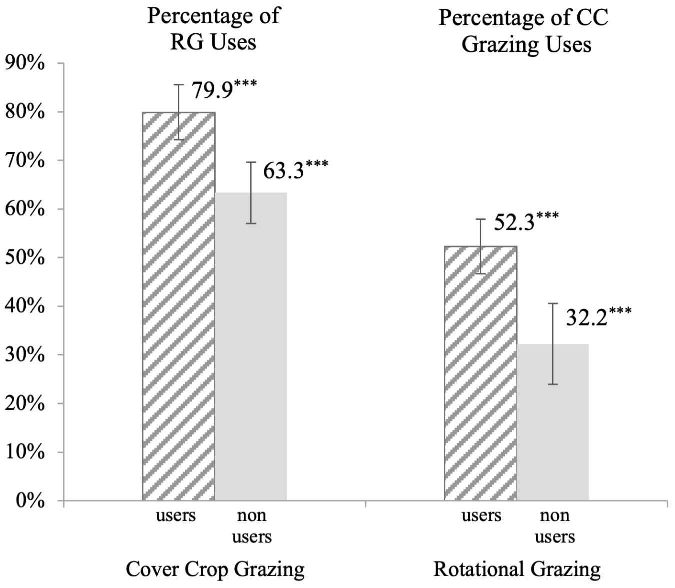

Figure 1. Percentage of Rational Grazing (RG) and Cover Crop (CC) Grazing by Adopters and Nonadopters of Other Practices

Notes: The first two columns depict the RG adoption rates among users and nonusers of CC grazing, respectively, while the last two columns show the adoption rates of CC grazing users among users and nonusers of RG, respectively. Triple asterisks (***) indicate significance at the 1% level. Error bars indicate 95% confidence interval.

perceived profitability of cover crops. Similar to the RG outcomes, the high estimated marginal effects of coalition membership and peer advice suggest that providing information and education on conservation practice implementation and its potential benefits may play a vital role in enhancing CC grazing adoption.

Complementary Relationship Between Rotational Grazing and Cover Crop Grazing

Table 3 shows that the correlation coefficient (ρ) between residuals of RG and CC grazing equation is significant at 26.2% ($p < 0.05$), indicating their complementarity. This relationship is likely caused by their common benefits (i.e., extending the grazing period and reducing overgrazing risks) and implementation requirements (i.e., fencing and water systems and regularly moving animals). Similar complementarity in the adoption status of these two practices is observed in Figure 1. Among the CC grazing adopters, 79.9% have used RG, significantly higher than 63.3% of the RG adoption rate among nonadopters of CC grazing. Likewise, the RG users have a significantly higher CC grazing adoption rate (52.3%) than those among the non-RG users (32.2%). Consistently, the mean conditional probabilities based on the bivariate probit regression, reported in Table 4, indicate that the likelihood of RG adoption is higher when CC grazing has been used (82.6% vs. 71.8%). Likewise, the probablity of adopting CC grazing is greater for RG adopters (55.0% vs. 35.6%).

Similar to Ward et al. (2018), we compute multiplier effects to verify the complementary relationship between RG and CC grazing. The two practices are complements if the multiplier effect is greater than 1, substitutes if the multiplier effect is less than 1, and independent if the multiple effect equals 1. In other words, complementarity is detected when the conditional probability of using both practices is higher than that of using only one practice. Table 4 shows that the estimated multiplier effect of RG on CC grazing adoption (computed as $\frac{\Pr(CC\ grazing=1|RG=1,X,\rho)}{\Pr(CC\ grazing=1|RG=0,X,\rho)}$) is equal to 1.86, significantly higher than the multiplier effect of CC grazing on RG adoption (computed as $\frac{\Pr(RG=1|CC\ grazing=1,X,\rho)}{\Pr(RG=1|CC\ grazing=0,X,\rho)}$) at 1.19 ($p < 0.01$). These outcomes confirm the practices' complementarity.

Table 4. Conditional Probabilities and Multiplier Effects from Bivariate Probit Regression

Conditional Probability	Mean
$\Pr(RG = 1 \mid CC\ grazing = 1, \boldsymbol{X}, \rho)$	0.826
$\Pr(RG = 1 \mid CC\ grazing = 0, \boldsymbol{X}, \rho)$	0.718
$\Pr(CC\ grazing = 1 \mid RG = 1, \boldsymbol{X}, \rho)$	0.550
$\Pr(CC\ grazing = 1 \mid RG = 0, \boldsymbol{X}, \rho)$	0.356
Multiplier Effect on:	**Mean**
Rotational grazing	1.195
Cover crop grazing	1.860

A greater multiplier effect for RG on CC grazing adoption suggests that RG adoption has a stronger impact on CC grazing adoption decisions than vice versa. These results are possibly due to the longer average adoption duration of RG practice compared to CC grazing. On average, the RG usage years among the adopters was 18.7. In comparison, the 2022–2023 National Cover Crop Survey report indicates that 61% of national cover crop adopters have used cover crops for 10 years or less (Sustainable Agriculture Research and Education, 2023). The experience in RG could facilitate the adoption of CC grazing due to their similarity in resource requirements (fencing and water systems), agronomic activities (periodic animal relocation), and private benefits (extending grazing periods).

Literature found that the complementarity between practices generates indirect (spillover) effects (Lichtenberg, 2004; Fleming, 2017; Holley et al., 2020). Therefore, providing financial incentives for adopting one practice will likely encourage farmer investment to adopt its complementary practice. A better understanding of the complementarity relationship among practices can help reduce public spending on conservation practices. Given that RG practice is complementary to CC grazing, conservation programs that aim to promote RG practice will likely positively enhance the adoption rate of CC grazing. Additionally, promoting RG and CC grazing as a bundle in regions with a high degree of integrated crop–livestock production will likely be more cost-efficient.

Concluding Remarks

Amid abundant literature on factors influencing rotational grazing (RG), our study contributes to the literature by examining the factors affecting cover crop (CC) grazing and identifying the potential complementary relationship between RG and CC grazing adoptions. Using a 2023 farmer survey in South Dakota, we found that 37.2% of survey respondents have used both RG and CC grazing. Our results indicate that farm size and proportion of grassland could affect adoption decisions related to RG and CC grazing. In addition, age is negatively related to the adoption decisions of both practices. We found that while RG is widely used across South Dakota, the implementation of CC grazing is more prevalent on the eastern side of the state, likely due to more CC acres there resulting from more fertile soil and higher precipitation. Additionally, CC grazing is more likely to be adopted in operations with more balanced crop and livestock production. Our results also emphasize the importance of producer association with education-prioritized organizations in promoting RG and CC grazing.

Importantly, RG and CC grazing share many similarities, such as requirements for practice implementation (resources and skill sets) and potential benefits (extended grazing period and decreased hay cost). In this paper, we identified a complementary relationship between the two practices, and adopting the RG has a multiplier effect of 1.86 on CC grazing adoption. Such complementarities indicate the potential to incentivize the adoption of both practices simultaneously with lower public spending. For instance, the CC grazing adoption could be more efficiently promoted by offering financial and educational support for RG only or for a bundle of practices. In addition to direct promotional efforts, consideration of complementarities can indirectly expedite CC adoption on integrated crop and livestock operations through a broader acceptance of RG practice.

A limitation of our analysis is that we did not consider the duration of adoptions, the intensity of adoptions (i.e., the percentages of farmland under the two conservation practices studied), and the interaction between these variables. Future studies can utilize these additional variables to assess the adoption sequence among different conservation practices. Other than the binary adoption decisions, further research should explore the factors influencing the adoption intensity of these practices. Moreover, a farmer survey implemented in broader geographic regions will likely provide further insights.

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Online Supplement: Adopting Rotational Grazing and Cover Crops: Drivers and Complementarities

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Robustness Checks

We conduct additional regressions using different terminology for RG adoption, model specifications, and estimation methods. First, one of the criteria for rotational grazing (RG) adoption is having four paddocks or more. According to Wang and Kreuter (2024), about two-thirds of producers with 2–3 paddocks indicate the use of RG. Here, we redefine operations with RG adoption as having two paddocks or more. Same as in the original terminology, two additional questions are also used to exclude non-RG adoption: (i) answering "never" for the frequency of rotation commonly used and (ii) "none" of their grassland currently involved in RG. The new terminology results in 79% of respondents using RG, compared to 71.0% in the original terminology. Table S1 shows the results of bivariate probit regression with new RG terminology and the same set of explanatory variables. Overall, the results are similar to the original regression (Table 3). All signs of coefficients in the RG equation are unchanged. On the other hand, the marginal effects of *FarmSize*, *GrassMem*, and *GrazingEdu* are slightly lower, and the significance levels for *Ownership* and *AFI* change. Meanwhile, the results for CC grazing are close to Table 3 results in terms of signs, significance, and values of marginal effects.

The survey data allows the analysis of RG adoption intensity, whereas CC grazing adoption is obtained as binary outcomes. Hence, we analyze the factors influencing different levels of grazing management by following the terminology of RG adoption intensity in Wang et al. (2022). Operations with 1–3 paddocks are classified as continuous grazing (CG), 4–15 as extensive RG, and 16 paddocks or more as management-intensive grazing (MIG). The proportion of these grazing managements among our respondents is shown in Figure S1.

The estimation is conducted using ordered probit regression, and the results are shown in Table S2. Similar results are found on *FarmSize*, *DroughtPlan*, *GrassMem*, and *GrazingEdu*, showing the positive impact of these variables on RG adoption intensity. The coefficients of *Age* and *Ownership* maintain the same sign, but they are not significant in the model despite their significance at the 10% level in Table 3. The grassland ratio (*Grass*) is likely to increase the possibility of extensive RG adoption, but not MIG. Meanwhile, education on grazing management has a critical role in enhancing MIG adoption as the marginal effects of being a member of the Grassland Coalition (*GrassMem*) and Soil Health Coalition (*SoilMem*) are positive and significant.

We also include two variables for financial incentives: *CostShare* – "Cost-share funding to offset expenses from cross fencing and water resources" and *TaxIncen* – "Tax incentives for good land stewardship practices." These options are among the eight options given in the same question as *GrazingEdu* and *PeerAdvice*; therefore, they range from 0 to 3, with 0 = no influence on grazing decisions and 1–3 = the 3rd – 1st most influencing factor. The results for bivariate probit regression with the original RG terminology and two additional explanatory variables are reported in Table S3. The impacts of *TaxIncen* are not significantly different from zero in both RG and CC grazing equations, while *CostShare* is significant at the 10% level. However, the effect of *CostShare*

The material contained herein is supplementary to the article named in the title and published in the *Journal of Agricultural and Resource Economics* (*JARE*).

(marginal effect = 0.038) is slightly lower than *GrazingEdu* (marginal effect = 0.086). In the meantime, the marginal effects of other explanatory variables are close to the original results.

Table S1. Bivariate Probit Regression with New Terminology for Rotational Grazing Adoption

	Rotational Grazing				Cover Crop Grazing			
Variable Name	**Estimates**		**Marginal Effects**		**Estimates**		**Marginal Effects**	
FarmSize	0.054	**	0.012	**	-0.016		-0.005	
Grass	0.258		0.066		0.250		-0.318	***
Integration	-0.376		–		4.658	***	–	
RGratio	1.482		0.319		–		–	
CCratio	–		–		8.973	**	2.932	**
Ownership	0.282		0.061		-0.436	*	-0.143	*
Age	-0.017	*	-0.004	*	-0.023	***	-0.007	***
Edu	-0.051		-0.011		-0.040		-0.013	
DroughtPlan	0.422	***	0.091	***	-0.040		-0.013	
AFI	0.211	*	0.045	*	0.218	*	0.071	*
GrassMem	0.724	**	0.122	***	0.346		0.114	
SoilMem	0.322		0.062		1.242	***	0.377	***
GrazingEdu	0.297	*	0.064	*	0.061		0.020	
PeerAdvice	0.026		0.005		0.116	*	0.038	*
Intercept	-0.018		–		-0.288		–	
ρ	0.243**							
Number of Obs.	313							

Notes: Single, double, and triple asterisks (*, **, ***) indicate statistical significance at the 10%, 5%, and 1% levels. *Integration* = *Grass* × (1–*Grass*).

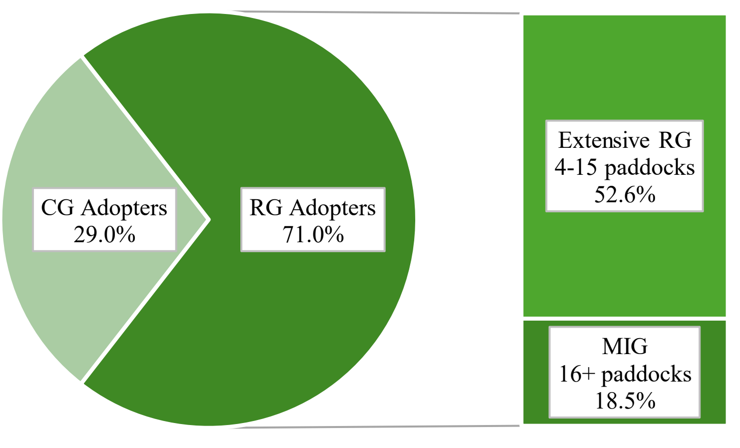

Figure S1. The Share of Respondents Classified by Grazing Strategies and the Number of Current Paddocks.

Notes: Continuous Grazing (CG) adopters operate one paddock, never rotate their animals, or have none of their grasslands currently involved in rotational grazing.
Extensive Rotational Grazing (RG) adopters rotate their animals on 4–15 paddocks.
Management Intensive Grazing (MIG) adopters rotate their animals on 16 or more paddocks.

Table S2. Ordered Probit Regression for Rotational Grazing

		Marginal Effects		
		CG	RG	MIG
Variable Name	Estimates	1-3 Paddocks	4-15 Paddocks	16+ Paddocks
FarmSize	0.091 ***	-0.022 ***	0.005 **	0.018 ***
Grass	0.870 ***	-0.172 **	0.123 *	0.049
Integration	1.315	–	–	–
RGratio	0.845	-0.208	0.042	0.165
Ownership	0.382	-0.094	0.019	0.075
Age	-0.011	0.003	-0.001	-0.002
Edu	0.051	-0.013	0.003	0.010
DroughtPlan	0.289 ***	-0.071 ***	0.014 *	0.056 ***
AFI	0.101	-0.025	0.005	0.020
GrassMem	0.679 ***	-0.141 ***	-0.021	0.162 **
SoilMem	0.591 **	-0.123 **	-0.015	0.138 *
GrazingEdu	0.240 ***	-0.059 ***	0.012 *	0.047 ***
PeerAdvice	-0.053	0.013	-0.003	-0.010
Pseudo R^2	0.207			
Number of Obs.	313			

Notes: Single, double, and triple asterisks (*, **, ***) indicate statistical significance at the 10%, 5%, and 1% levels. CG = Continuous Grazing, RG = Rotational Grazing, and MIG = Management Intensive Grazing. *Integration* = *Grass* × (1–*Grass*).

Table S3. Bivariate Probit Regression with Financial Incentives Variables

	Rotational Grazing		Cover Crop Grazing	
Variable Name	Estimates	Marginal Effects	Estimates	Marginal Effects
FarmSize	0.094 ***	0.023 ***	-0.016	-0.005
Grass	0.402	0.028	0.226	-0.318 ***
Integration	1.788	–	4.585 ***	–
RGratio	1.136	0.275	–	–
CCratio	–	–	8.647 **	2.814 **
Ownership	0.519 *	0.126 *	-0.451 *	-0.147 *
Age	-0.015	-0.004 *	-0.022 ***	-0.007 ***
Edu	0.033	0.008	-0.041	-0.013
DroughtPlan	0.373 ***	0.090 ***	-0.043	-0.014
AFI	0.167	0.040	0.210 *	0.068 *
GrassMem	0.958 ***	0.179 ***	0.374	0.123
SoilMem	0.455	0.098	1.206 ***	0.367 ***
GrazingEdu	0.355 **	0.086 **	0.098	0.032
PeerAdvice	0.076	0.018	0.174 **	0.057 **
CostShare	0.158 *	0.038 *	0.111	0.036
TaxIncen	-0.021	-0.005	-0.006	-0.002
Intercept	-1.437	–	-0.552	–
ρ	0.252**			
Number of Obs.	313			

Notes: Single, double, and triple asterisks (*, **, ***) indicate statistical significance at the 10%, 5%, and 1% levels. *Integration* = *Grass* × (1–*Grass*).

Mapping Adoption Rates of RG and CC Grazing at the County Level

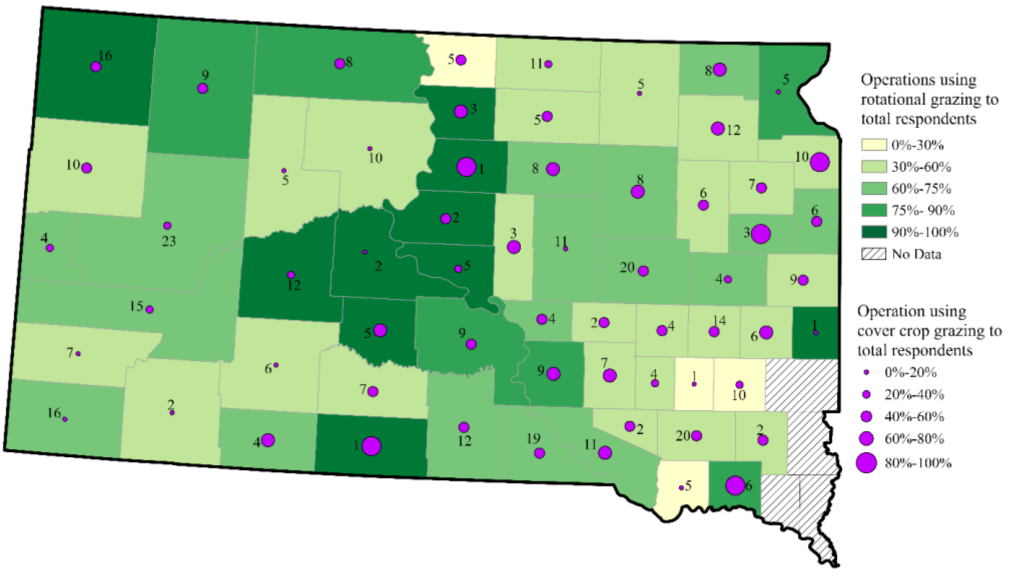

Figure S2. The Percentage of Rotational Grazing and Cover Crop Grazing Adoptions in South Dakota

Notes: The darker shades indicate a higher degree of rotational grazing adoption, while bigger sizes of circles show a higher degree of cover crop grazing adoption. The number shown represents the number of survey respondents in each county.

Survey Instrument

Part A. Basic Information on Your Ranch/Farm Operation

1. What type of livestock do you graze? (Check all that apply)

   ☐ Cattle ☐ Bison ☐ Sheep ☐ Other

2. How long have you been the primary decision maker on your ranch/farm? _______ years

3. In what county is most of the grazing land that you operate, including rented land, located?

   ____________________________County

4. On your current operation, please indicate how many acres are:

		Total acres operated	Of which, acres rented
i.	Grassland (for grazing purpose)	______________	______________
ii.	Cropland		
	For cash crops	______________	______________
	For feed	______________	______________

5. In a typical year:

How long is your grazing season?	______________ days/year
How long do you feed hay to your cattle?	______________ days/year
Start of grazing season in 2022:	Month ________ Day_______
End of grazing season in 2022:	Month ________ Day_______

6. During the past 10 years, how has grassland productivity changed on your operation?

   ☐ Significantly declined ☐ Slightly declined ☐ About the same

   ☐ Slightly improved ☐ Significantly improved

7. During the past 10 years, how have the following items changed on your operation (<u>including both owned and rented acres</u>)?

	Decreased by > 10%	*Decreased by 5-10%*	*About the Same*	*Increased by 5-10%*	*Increased by >10%*
Your grassland acres	☐	☐	☐	☐	☐
Your herd size	☐	☐	☐	☐	☐

Part B. Grassland Management Practices and Decisions

8. How many pastures do you currently have and desire to have in the next 5 years on your ranch?

Number of pastures	*1*	*2-3*	*4-8*	*9-15*	*16+*
Current number	☐	☐	☐	☐	☐
Desirable number	☐	☐	☐	☐	☐

9. How often do you most commonly rotate animals from one pasture to the next one?

	Daily	*Between 2-6 days*	*Weekly*	*Monthly*	*Never*
Fast grass growth period	☐	☐	☐	☐	☐
Slow grass growth period	☐	☐	☐	☐	☐

10. On what percentage of your grassland do you currently use rotational grazing practices to allow for a recovery period after the grazing period?

☐ 0% ☐ < 25% ☐ 25–50% ☐ 51–75% ☐ 76–100%

11. How satisfied are you with your current grassland management practices?

☐ Not satisfied ☐ A little satisfied ☐ Fairly satisfied ☐ Very satisfied

12. How likely are you to change your current management practices within the next five years?

☐ Very Unlikely ☐ Unlikely ☐ Somewhat Likely ☐ Likely ☐ Very Likely

13. How long have you been using rotational management practice? (Write 0 if you never used)

_________________years

14. Please rank the **top three benefits** that matter to you most from rotating and resting pastures: (If you haven't started the rotational practice yet, please choose the three most desirable benefits to you. 1=most beneficial, 2= 2nd most beneficial, and 3=3rd most beneficial)

____	Increase in desirable grass/soil health	____	Increase in grassland productivity
____	Increase in water infiltration/decrease runoff	____	Improve wildlife habitat
____	Increase in drought resilience	____	Longer grazing season
____	Increase in economic profit	____	Affordable labor/management time
____	Shorter duration use/longer recovery on pastures	____	Trend toward increased organic matter

15. Please rank the **top three limiting factors** that prevent you from rotating more (1 = most limiting factor, 2 = 2nd most limiting factor, and 3 = 3rd most limiting factor).

____ High installation cost
____ Unfavorable neighborhood opinions
____ Water source constraint
____ Lack of information/education/support
____ Labor/management time constraints
____ Rental agreement restrictions
____ Cash flow constraints
____ Distance between pastures

16. If you are continuously grazing pastures all season long, do you think your grassland profitability would likely increase if you grazed rotationally?

☐ Very Unlikely ☐ Unlikely ☐ Somewhat Likely ☐ Likely ☐ Very Likely

17. To implement rotational grazing on your grassland, please give your best estimate of the realized or potential costs in $/acre for both fencing and water system:

a. Initial investment costs ($/acre):

☐ < $10 ☐ $10 - $25 ☐ $26 - $40 ☐ $41 - $70 ☐ $70+

b. Annual maintenance costs ($/acre/year):

☐ < $1 ☐ $1 - $5 ☐ $6 - $10 ☐ $11 - $20 ☐ $20+

c. Total acres involved in above cost estimation:

☐ < 100 acres ☐ 101-400 acres ☐ 401-1,000 acres ☐ 1000+ acres

18. If you have **NOT** adopted rotational grazing yet, would you consider adoption if cost-share funding is available in the following amount to offset expenses from cross fencing and water resources?

Percent cost-share	*Rotate livestock on 4-15 paddocks over the grazing season*			*Adaptively manage grazing for adequate rest on 16+ paddocks*		
	Yes	*No*	*Not sure*	*Yes*	*No*	*Not sure*
20%	☐	☐	☐	☐	☐	☐
30%	☐	☐	☐	☐	☐	☐
50%	☐	☐	☐	☐	☐	☐
70%	☐	☐	☐	☐	☐	☐

19. Do you have a written grassland management plan?

☐ No, I don't think it is necessary
☐ Not yet, but would like assistance to develop one
☐ Not yet, will develop one on my own
☐ Yes

Do you have a written drought management (contingency) plan?

☐ No, I don't think it is necessary ☐ Not yet, but would like assistance to develop one

☐ Not yet, will develop one on my own ☐ Yes

20. If you have switched from season-long grazing to rotational grazing, was there a specific event that led to the switch, or any specific evidence that made you feel the change was effective?

21. Which of the following practices have you used? (Check all that apply)

☐ Calving on grass April-June
☐ Bale grazing
☐ Grazing all season long (no recovery period)
☐ Rotating time of year a pasture is grazed
☐ Rotating livestock type
☐ Grazing cover crops
☐ Selling livestock early in a drought year

Part C. Land Use Conversion Decisions

22. During the past 5 years, have you made any of the following agricultural land use changes?

	No	*Yes*	*If yes, acres Involved*
Conversion of grassland to cropland	☐	☐	________________ acres
Conversion of cropland to grassland	☐	☐	________________ acres

23. In the next 5 years, do you plan to make any of the following agricultural land use changes?

	Not likely	*Likely*	*If likely, acres to be involved*
Conversion of grassland to cropland	☐	☐	________________ acres
Conversion of cropland to grassland	☐	☐	________________ acres

24. If you have converted or plan to convert **grassland to cropland**, what are your top three motivations? (1 = top motivation, 2 = 2nd top motivation, and 3 = 3rd top motivation).

____ Profit ____ Crop insurance policies

____ Pressure by landlord ____ More efficient cropping equipment

____ Producing feed for livestock ____ Labor availability issues

____ Changing weather/climate patterns ____ Other (please specify: ________________)

25. If you have converted or plan to convert **cropland to grassland**, what are your top three motivations? (1 = top motivation, 2 = 2nd top motivation, and 3 = 3rd top motivation).

____ Better utilization of marginal cropland
____ Changing crop/livestock prices
____ Improving wildlife habitat
____ Increased stocking capacity and profit
____ Changing weather/climate patterns
____ Labor availability issues
____ Other (please specify: ____________)

Part D. Perceptions about Soil Health and Grazing Practices

26. How often do you carry out the following activities on your grassland?

	Never	*Occasionally*	*Regularly*
Taking a spade to your grasslands to check soil structure and roots	☐	☐	☐
Measuring existing ground cover after grazing	☐	☐	☐
Timing water infiltration rates to compare across different pastures/areas	☐	☐	☐
Inventorying species diversity on pastures	☐	☐	☐
Comparing soil surface temperatures on bare soil vs. soil covered with forage	☐	☐	☐

27. Please rate the importance of the following issues when you make grazing management decisions:

	Not Important	*Slightly Important*	*Somewhat Important*	*Quite Important*	*Not sure*
Increase economic returns	☐	☐	☐	☐	☐
Maintain high stocking rate	☐	☐	☐	☐	☐
Enhance grassland health	☐	☐	☐	☐	☐
Improve soil health	☐	☐	☐	☐	☐

28. How important are each of these grazing principles to you?

	Not Important	*Slightly Important*	*Somewhat Important*	*Very Important*	*Not sure*
Rotate livestock in multiple pastures during the grazing season	☐	☐	☐	☐	☐
Vary the time of year livestock graze a certain pasture	☐	☐	☐	☐	☐
Rotate the type of livestock on a pasture (cattle, sheep, goats, etc.)	☐	☐	☐	☐	☐
Allow ample time for grazed pasture to rest and recover after grazing	☐	☐	☐	☐	☐
Adjust stocking rates to prevent overgrazing in summer, and utilize grass in spring/fall	☐	☐	☐	☐	☐
Do not overgraze during drought (remove livestock to ensure 1,000 lbs. material are still on the soil surface)	☐	☐	☐	☐	☐
Encourage diversity in plant species	☐	☐	☐	☐	☐
Take half, leave half of plants	☐	☐	☐	☐	☐
Manage grazing to feed soil microbes	☐	☐	☐	☐	☐

29. How important do you feel healthy soil is to healthy, productive grasslands?

☐ Not important ☐ Slightly important ☐ Somewhat important ☐ Very important

30. To what extent do you agree that overgrazed grassland adversely affect soil health?

☐ Strongly disagree ☐ Disagree ☐ Not sure ☐ Agree ☐ Strongly agree

31. For how many years have you been managing your grasslands to improve soil health?

☐ Not managed yet ☐ < 3 years ☐ 3-5 years ☐ 6-10 years ☐ > 10 years

32. How important do you think healthy soil is in building grassland resiliency during and after a drought?

☐ Not important ☐ Slightly important ☐ Somewhat important ☐ Very important

33. If your thoughts on grazing management have changed in the past 10 years, how so and what caused the change?

Part E. Influential Factors for Ranching

34. How helpful (actionable) is each source of information for your grassland management?

	Not helpful	*Slightly helpful*	*Somewhat helpful*	*Very helpful*
NRCS	☐	☐	☐	☐
SD Grassland Coalition	☐	☐	☐	☐
SDSU extension	☐	☐	☐	☐
Independent consultants	☐	☐	☐	☐
Other ranchers	☐	☐	☐	☐

35. Are you a member of the following producer groups? (Check all that apply)

____ Cattlemen's ____ Soil Health Coalition ____ Farmers' Union

____ Sheep Growers ____ Grassland Coalition ____ Other (Specify:

____ Stockgrowers ____ Farm Bureau ____________________)

36. Please rank the **top 3 things that most likely influence your grazing decisions**, where 1 = most likely to influence, 2 = 2nd most likely to influence, and 3 = 3rd most likely to influence:

______ Cost-share funding to offset expenses from cross fencing and water resources
______ Tax Incentives for good land stewardship practices
______ Carbon credits for increased carbon sequestration
______ One on one planning consultations with NRCS
______ One on one planning consultations with grazing consultant
______ Advice from successful ranchers on how they changed their systems
______ Attending grazing schools, award recipient tours, pasture walks, grazing field days
______ Attending regular meetings of groups such as South Dakota Grasslands Coalition

37. Which of the following resources have you used in the past two years to improve your grassland management?

______ Attended educational events on grazing practices (grazing school, pasture walk)
______ Watched/listened to grassland management videos/podcasts/webinars
______ Read feature articles on grasslands management
______ Talked with ranchers experienced in grazing principles like rotate, rest and recover

38. Where did you learn the techniques that you are now using to manage grasslands?

Part F. Demographic Information

39. In which year were you born? ____________

40. What is your gender? ☐ Male ☐ Female

41. What is the highest level of education that you have completed?

☐ Less than high school
☐ High school
☐ Some college/technical school
☐ 4-year college degree
☐ Advanced degree (Masters, etc.)

42. Approximately what percentage of your total household income is from your grassland operation?

☐ Less than 25%
☐ 25% up to 50%
☐ 51% up to 75%
☐ 76% or more

43. Please indicate the level of your livestock enterprise gross sales in a typical year.

☐ Less than $50,000
☐ From $50,000 up to $99,999
☐ From $100,000 up to $249,999
☐ From $250,000 up to $499,999
☐ From $500,000 up to $999,999
☐ $1 million or more

44. What is the ratio of total liabilities to total assets for your farming/ranching operation?

☐ 0%
☐ 1 - 20%
☐ 21 - 40%
☐ 41 - 60%
☐ 61 - 80%
☐ More than 80%

45. Please record any further comments you have regarding rotational grazing or MIG practices.

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