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Revisiting Land Use Conversion Trends in the Margins of U.S. Corn Belt

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In the United States, grazing lands declined from 587.2 million in 2007 to 584.8 million acres in 2017 (USDA-NRCS, 2021). During the same period, U.S. croplands increased from 358.9 million to 367.5 million acres, mainly from expiring Conservation Reserve Program (CRP) land and grassland conversion. From 2008 through 2016, 88% of expanded croplands in the United States were originally grasslands, and nearly 70% of expanded croplands generated yields below the national average (Lark et al., 2020). Located at the western margin of the Corn Belt, South Dakota (SD) had been a hotspot of conversion from grassland to cropland (GTC). As the Corn Belt expands westward, about one-fifth of SD grasslands were converted to cropland between 1980 and 2000; this conversion accelerated between 2006 and 2011 (Wright and Wimberly, 2013; Greer, Bakker, and Dieter, 2016).

The loss of grasslands can lead to various environmental issues, such as increased soil erosion, nutrient loss, and soil organic carbon (SOC) loss (Zhang et al., 2021; Lai et al., 2022). Even under no-till, GTC conversion could lead to a notable SOC decrease (Zhang et al., 2021). Additionally, GTC conversion causes the loss of wildlife and avian habitats, which further reduces biodiversity and native grass species (Greer, Bakker, and Dieter, 2016; Lark et al., 2020). In contrast, cropland-to-grassland (CTG) conversion has the potential to generate environmental benefits, including increased SOC stock and reduced nutrient runoff (Eagle et al., 2012; Zhang et al., 2021). For instance, switching from tilled corn–soybean production to grassland generated an average SOC stock of 0.08 tons per acre per year in the U.S. Midwest (Zhang et al., 2021).

To curtail the GTC conversion trend and encourage CTG conversion on land unsuitable for crop production, numerous policies and conservation programs have been made available, including Grassland-CRP, Grassland Easements, the Sodsaver provision, and Second Century Working Lands Habitat Program. The first two programs offer compensation to incentivize grassland preservation for wildlife habitat and grazing purposes (USDA-FSA, n.d.; USDA-NRCS, n.d.). The Sodsaver provision, established by the 2014 Farm Bill, disincentivizes grassland conversion by reducing crop insurance premium subsidies during the first 4 years of crop production on previously native sod land (Schnepf, 2014). The last program, started in 2019, offers payments for converting cropping marginal land in South Dakota into wildlife habitat with an option for grazing uses (Second Century Habitat Fund, n.d.).

The literature investigating trends in GTC conversion indicates a dramatic net decline in grassland cover from 2006 to 2012, especially in the Dakotas east of the Missouri River (Wright and Wimberly, 2013; Wang et al., 2018; Joshi et al., 2019). Over 2012–2017, the GTC conversion rate declined when compared with the 2006–2012 period (Wang et al., 2018; Joshi et al., 2019). However, land use conversion trends after 2017 remain a gap in the literature. To provide better understanding about recent land use conversion trends and motivations behind the conversion decisions in the margins of U.S. Corn Belt, we carried out a survey among 3,500 SD farmers in 2023. Our findings illustrate the most recent trends in land use conversions (2018–2022), future land conversion intentions (2023–2027), motivations for such conversion, and regional factors and farm characteristics that potentially affect land use conversion decisions. This article also offers policy implications that help preserve the remaining grassland in the margins of the U.S. Corn Belt.

Survey Description

We surveyed 3,500 SD agricultural producers from January to March 2023 using samples purchased from DTN. The sampling selection criteria are that each farm operate a minimum of 100 acres of grassland with at least 50 livestock. Each sample was contacted up to four times based on a modified Tailored Design Method (Dillman, Smyth, and Christian, 2014). First, advance letters were sent to notify producers about the project

Table 1. Summary Statistics of the Survey Responses

Variable	Mean	Std. Dev.	Range	Obs.
Age (years)	63.4	10.6	28–92	448
Farming experience (years)	36.0	13.6	1–75	461
Grassland (acres)	3,165.3	4,828.0	0–58,000	453
Cropland for cash crop (acres)	657.1	1,284.6	0–15,000	453
Cropland for feed (acres)	425.9	630.9	0–6,400	453
Total farmland (acres)	4,248.3	5,259.5	35–60,500	453

with an option to answer the questionnaire online (first wave). For those who did not respond, a paper questionnaire was mailed with an addressed and stamped return envelope (second wave), followed by a reminder postcard after 2 weeks (third wave). Last, we sent out the second paper questionnaire to those who did not respond to the previous online/paper surveys (fourth wave).

Of the total surveyed samples, 312 producers were found ineligible due to reasons such as retirement from farming, while 100 mail addresses were undeliverable. In total, we received 473 responses at a 14.8% response rate. According to the 2022 Census of Agriculture, the number of respondents for our survey accounted for 6.7% of beef cattle operations in South Dakota. The aggregated grassland and cropland acres reported by 453 respondents are 1.4 and 0.5 million acres, respectively. As of 2022, the pastureland and harvested cropland areas in SD were 23.0 and 15.3 million acres, respectively (USDA-NASS, 2022). Therefore, the total grassland and cropland acres reported by our respondents occupy 6.2% of grassland and 3.2% of cropland in SD.

Table 1 reports summary statistics of survey respondent characteristics. The average age of the primary decision makers is 63.4 years, with 36 years of farming experience, both of which were significantly higher (*p*-value < 0.01) than the average age of producers (57.2 years) and farming experiences (25.8 years) in South Dakota as reported in the 2022 Census of Agriculture (USDA-NASS, 2022). On average, our surveyed respondents operated 3,165 acres of grassland and 1,083 acres of cropland; of the latter, 60.7% is used for cash crops and the rest for livestock feed. The average total operated farm size (4,248 acres) of our respondents is significantly larger than the state average size for beef cattle operations at 2,368 acres (*p*-value < 0.01). Yet our median farm size of 2,400 acres is very close to the census average farm size. The much higher mean value than the median suggests a right-skewed farm size distribution, which could partly be attributed to the exclusion of small farms (less than 100 grassland acres) from our survey sample.

Table 2. Literature Review on Land Use Conversion Rate in South Dakota

Study	Location	Duration	Annualized GTC Rate	Annualized CTG Rate	Annualized Net Grassland Change Rate	Avg. Annual GTC (thousand acres)	Avg. Annual CTG (thousand acres)	Annual Net Grassland Change (thousand acres)
Wright and Wimberly (2013)	SD	2006–2011	0.5%	0.4%	-0.4%	126.4	36.2	-90.2
Reitsma et al. (2015)	SD	2006–2012	1.2%	0.7%	-0.8%	300.6	103.0	-197.7
	Eastern SD	2006–2012	2.6%	0.6%	-1.6%	222.4	82.4	-140.0
	Western SD	2006–2012	0.5%	1.1%	-0.3%	78.3	20.6	-57.7
Wang et al. (2018)	SD	2007–2012	4.3%	0.9%	-3.8%	1,228.7	112.8	-1,115.9
		2012–2017	1.1%	1.2%	-0.2%	264.0	215.1	-48.9
Joshi et al. (2019)	SD	2006–2012	1.0%	0.7%	-0.7%	288.3	94.7	-193.6
		2012–2014	0.9%	1.3%	-0.3%	259.5	185.3	-74.1
	Eastern SD	2006–2012	2.5%	0.6%	-1.6%	197.7	65.9	-131.8
		2012–2014	2.7%	1.0%	-1.1%	210.0	123.6	-86.5
	Western SD	2006–2012	0.4%	1.2%	-0.3%	90.6	28.8	-61.8
		2012–2014	0.2%	2.2%	+0.1%	49.4	61.8	+12.4

Source: Wright and Wimberly (2013), Reitsma et al. (2015), Wang et al. (2018), Joshi et al. (2019), and authors' calculation.

Land Use Conversion in South Dakota and Future Trends

According to previous literature (Table 2), during the 2006–2012 or 2007–2012 periods, the annual GTC conversion rate ranged between 0.5% and 4.3%, yet the annual CTG conversion rate was only 0.4%–0.9% (Wright and Wimberly, 2013; Reitsma et al., 2015; Wang et al., 2018; Joshi et al., 2019). In contrast, lower GTC rates of 0.9% and 1.1% were found for the 2012–2014 and 2012–2017 periods, respectively, yet the annual CTG rates increased to 1.3% and 1.2%, respectively (Joshi et al., 2019; Wang et al., 2018).

Among the 1.4 million grassland acres operated by our survey respondents as of 2018, 0.5% were converted to crop production during the 2018–2022 period at an annualized GTC rate of 0.1%. Meanwhile, of the 0.5 million cropland acres operated by survey respondents as of 2018, 4.4% were converted to grasslands at an annualized CTG rate of 0.9%. The net conversion indicates net gain in grassland acres by approximately 1.1% over 5 years or 0.2% per year. Compared to the agricultural census data, total pastureland in South Dakota increased by 1.2%, from 22.7 million acres in 2017 to 23.0 million acres in 2022. In the meantime, the harvested cropland area declined by 6.7% from 16.4 million acres to 15.3 million acres (USDA-NASS, 2022). In this regard, our findings demonstrated a similar grassland expansion trend to the census data. Moreover, our survey results of GTC and CTG conversion for the 2018–2022 period align with the results of the 2012–2017 period.

Of all the respondents, 11.9% reported GTC conversion from 2018–2022 (see Table 3). Among producers who made the GTC conversion, 161.6 acres or 16.8% of grassland was converted to cropland on average. In addition, 11.4% of respondents plan to convert GTC in the next 5 years (containing 40% previous and 60% new converters), with an average intended conversion rate of 165.7 acres per farm. Among the 25.7% of the respondents who made CTG conversion in 2018–2022, an average of 223.5 acres or 23.8% of cropland was converted on a per farm basis. For the next 5 years (2023–2027), 14.8% of respondents plan to convert CTG (containing 33% previous and 67% new converters), with an average intended conversion rate of 127.2 acres per farm. Among 428 respondents, 4.9% implemented both GTC and CTG conversion during the past 5 years, and 4.0% have plans to convert both ways in the future.

Price and Policy Effects

The land use conversion trends are partly due to changes in crop and livestock prices. High crop prices relative to livestock prices can lead to an increase in GTC conversion due to higher profitability of crop production. The high GTC conversion rate during the 2006–2012 period corresponded with a period of rapidly rising corn prices and slowly increasing cattle prices (highlighted in gray in Figure 1). Specifically, corn futures prices increased by 105% from $1.44 per bushel in 2006 to $2.96 per bushel in 2012 after inflation adjustment. In the meantime, live cattle futures prices only rose 18%, from $0.44 per pound to $0.52 per pound. After 2012, corn prices declined relative to cattle prices. During our studied period (2018–2022), highlighted in green in Figure 1, corn prices did not display such an advantage in the first 3 years. The rapidly rising crop prices in 2021–2022, largely attributed to the record high fertilizer prices, were not likely to generate a profit advantage relative to cattle. Accordingly, our finding shows a declining GTC conversion rate since 2012, while the CTG conversion rate has risen. Besides price factors, government conservation programs and policies, such as the Grassland CRP, the Sodsaver provision, and Grassland Easements, could partially contribute to these land use conversion trends.

Proportion of Grazing Land

The decisions on land use conversion could be associated with the proportion of grazing land to total operated land. We divided respondents into two groups based on the median value of the percentage of grassland to total farmland, which equals 67%. The survey results indicate that 8% of farms with a large proportion of grazing land (≥ 67%) converted GTC in the past 5 years, significantly lower than the conversion rate of those with a small ratio of grassland (< 67%), at 15.4%. In addition, 6.6% and 15.1% of farms with a high and low proportion of grassland, respectively, have plans for GTC conversion in the next 5 years. In contrast, the percentage of grassland did not significantly impact the CTG conversion decisions in the past, yet producers with a high ratio of grassland are more likely to convert CTG in the future than those with a smaller ratio (18.9% vs. 11.5%). These results suggest that farms with lower grassland ratio are more likely to make GTC conversion decisions due to the specialization trend in United States (Hendrickson et al., 2008). Farms with a high proportion of grassland tend to become more specialized in livestock production and, therefore, have less desire to convert GTC.

Farm Size

A larger farm size was found to increase the probability of cropland expansion (Wimberly et al., 2017). We analyzed the correlation between farm size and land use conversion by dividing surveyed respondents into two groups: large and small farms. A threshold farm size of 2,400 acres was used, which is the median value of the survey data. Unlike the previous study, no significant difference between the GTC conversion rates of large farm size (≥ 2,400 acres) and small farm size (< 2,400 acres) was detected, even though the past conversion rate of the large farms was slightly higher, at 12.6%, relative to 10.9% for the small farms. Despite insignificant differences in the conversion rates, large farm operators plan to convert more acres of grassland to cropland than small farm operators. Similarly, farm

Table 3. Land Conversion Status in South Dakota (by location, ratio of grazing land, and farm size)

Type of Conversion	Variables	Overall	Location of Ranch/Farm East	West	Diff.	Proportion of Grazing Land < 67%	≥ 67%	Diff.	Total Land Acres < 2400	≥ 2400	Diff.
Grassland to cropland	Conversion rate (%)	11.9	15.0	7.9	-7.1**	15.3	8.0	-7.3**	10.9	12.6	1.7
	Acres converted	161.6	98.4	288.0	189.6**	178.4	92.9	-85.5	58.7	210.6	151.9
	% of acres converted	16.8	16.5	17.5	1.0	17.3	3.7	-13.7***	20.2	8.2	-12.0**
	Planning to convert (%)	11.4	14.7	6.8	-7.9***	15.1	6.6	-8.5***	9.9	11.8	1.9
	Acres planned	165.7	127.9	270.0	142.1**	158.6	165.5	6.9	79.4	233.8	87.3***
Cropland to grassland	Conversion rate (%)	25.7	25.1	26.0	0.9	23.8	28.0	4.2	25.8	26.0	0.2
	Acres converted	223.5	117.9	331.2	213.3***	120.0	300.1	180.1**	99.3	340.8	241.5***
	% of acres converted	23.8	19.4	28.5	9.1*	9.9	32.8	22.9***	23.3	22.8	-0.5
	Planning to convert (%)	14.8	11.1	19.1	8.0**	11.5	18.9	7.4**	10.0	20.4	10.4***
	Acres planned	127.2	74.4	161.7	87.3***	81.0	154.9	73.9***	67.2	163.1	95.9***

Note: Single, double, and triple asterisks (*, **, ***) indicate that t-test results between contrasting groups are different at the 10%, 5%, and 1% significance levels, respectively. Conversion rate is calculated by the number of respondents who converted their land use in the past 5 years. Acres converted is the average acres associated with land use conversion in the past 5 years. % of acres converted is acres converted as a percentage of grassland/cropland given the conversion was made. Planning to convert is the ratio of respondents who plan their land use conversion in the next 5 years. Acres planned is the average acres intended for land use conversion in the next 5 years. Differences are calculated by means of West minus means of East, means of large grazing land proportion minus means of low grazing land proportion, and means of large farm size minus means of small farm size.

sizes had no effect on CTG conversion in the last 5 years, with conversion rates of 25.8%–26%. In the next 5 years, however, respondents operating large farms (2,400 acres or more) plan to convert an average of 163.1 acres of cropland to grassland, significantly more than the average 67.2 acres CTG conversion planned by the small farm operators with less than 2,400 acres.

Regional Differences

Table 2 also indicates that the geographic factor plays a role in farmers' conversion decisions. Specifically, 15% of respondents in eastern SD converted GTC, compared to 7.9% in western SD. Similarly, 14.8% of eastern SD respondents plan for GTC conversion in the next 5 years (2023–2027), 8 percentage points higher than the Western SD respondents. This result implies that a higher likelihood of GTC conversion for soil and weather conditions better suited for cropping purposes, as soil in eastern SD land is more fertile and better suited for crop production, yet western SD is mostly semiarid with limited opportunities for irrigation. In this regard, our findings show consistency with previous literature findings. During the period of 2006–2012, 2.5%–2.6% of grassland in eastern SD was converted to crop production each year, relative to 0.4%–0.5% in western SD (Reitsma et al., 2015; Joshi et al., 2019). Further, the annualized GTC conversion rates in eastern and western SD were 2.7% and 0.2%, respectively, from 2012 to 2014 (Joshi et al., 2019).

During the 2018–2022 period, we did not find any noticeable regional differences for the CTG conversion: 24.8% and 26.0% of the respondents in eastern and western SD, respectively. Nevertheless, 19.1% of the

Table 4. Top Three Motivations for Grassland to Cropland Conversion: Ratings by Producers Who Have Converted or Plan to Convert Grassland to Cropland

	Top Motivation	2nd Top Motivation	3rd Top Motivation	Top 3 Motivations
Profit	56.9	15.8	10.2	76.4
Pressure by landlord	5.6	5.3	0.0	9.7
Producing feed for livestock	19.4	12.3	16.3	40.3
Changing weather and climate patterns	0.0	7.0	4.1	8.3
Crop insurance policies	0.0	17.5	14.3	23.6
More efficient cropping equipment	2.8	22.8	20.4	34.7
Labor availability issues	0.0	12.3	26.5	27.8
Others	15.3	7.0	8.2	26.4

Table 5. Top Three Motivations for Cropland to Grassland Conversion: Ratings by Producers Who Have Converted or Plan to Convert Cropland to Grassland

	Top Motivation	2nd Top Motivation	3rd Top Motivation	Top 3 Motivations
Better utilization of marginal land	66.7	14.3	3.2	82.1
Improving wildlife habitat	2.4	13.4	17.9	28.5
Changing weather and climate patterns	1.6	5.4	12.6	16.3
Changing crop/livestock prices	3.3	15.2	17.9	30.9
Increased stocking capacity	11.4	33.0	17.9	55.3
Labor availability issues	4.1	8.9	15.8	23.6
Others	10.6	9.8	14.7	27.6

respondents in western SD plan for future CTG conversion, statistically higher than 11.1% in eastern SD. Consistent with the results in Reitsma et al. (2015) and Joshi et al. (2019), the annual CTG conversion rate in 2006–2012 was 0.6% in eastern SD and 1.1%–1.2% in western SD. The conversion trend continued after 2012 as 1.0% and 2.2% of eastern and western SD cropland, respectively, was converted to grassland between 2012 and 2014. Further, compared with western SD, the net grassland loss is more concentrated in eastern SD (Reitsma et al., 2015; Joshi et al., 2019). The only net grassland gain was detected in western SD between 2012 and 2014 at an annual rate of 0.1% (Joshi et al., 2019).

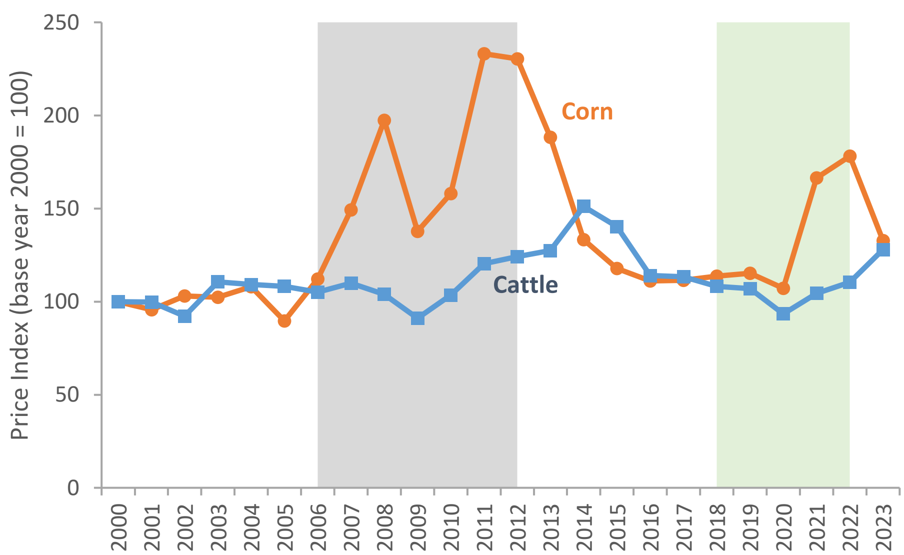
Producer Rated Motivations for Land Use Conversion

Table 4 reports the top three motivations for GTC conversion for producers who converted or are planning for the conversion. Profit is the lead motivation, with 76.4% of respondents listing it as one of the top three motivations. Similar to our finding, previous studies also listed the economic reasons (increased net returns and crop prices) as drivers for the land use conversion (Wright and Wimberly, 2013; Reitsma et al., 2015; Wang et al., 2017).

Meanwhile, producing feed for livestock ranks second, with 40.3% of producers rating it as one of their top three motivations. Technology improvement in crop production, a frequently mentioned factor, ranks third in this survey with a 34.7% response rate. Improved seeds, more efficient seeding equipment, and technologies for moving soil and rocks further contributed to cropland expansion by increasing the ability to produce in formerly unproductive areas, decreasing the cost of conversion, and enhancing crop yields (Reitsma et al. 2015; Wang et al., 2017; Wimberly et al. 2017).

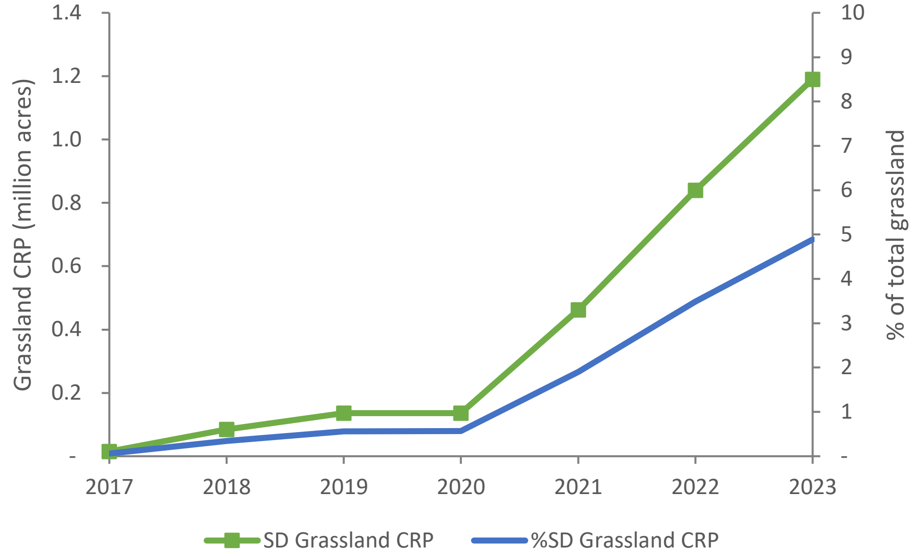
In addition, 23.6% of respondents regarded subsidies from crop insurance programs as one of the top three incentives for GTC conversion. Other reasons specified by the surveyed respondents include labor availability issues (26.4% of respondents), land use restriction from landlord (9.7%), reduced herd size or retirement from livestock production (3.9%), and land use rotation between grassland and cropland (2.3%).

Figure 1. Corn and Live Cattle Futures Price Indices, 2000–2023



Note: Futures prices are inflation-adjusted using consumer price index – food in U.S. city average.
Source: Investing.com (2024), U.S. Bureau of Labor Statistics (2024).

Figure 2. SD Grassland Conservation Reserve Program Enrollment



Source: USDA-FSA (2023a) and USDA-NASS (2024).

The top motivation for CTG conversion is better utilization of marginal land, with 82.1% producers listing them as the top three motivations (Table 5). This finding is consistent with Wang et al. (2021), who found the environmental-oriented management goal significantly increased the likelihood of CTG conversion. The increased stocking capacity and changes in crop and livestock prices rank second and third in the survey with 55.3% and 30.9% response rates, respectively, both indicating increased grassland profitability will motivate farmers to convert CTG. While 28.5% of producers list improving wildlife habitat as one of their top three motivations (rank fourth), only 2.4% of the producers list it as the top motivation. In addition, six respondents (4.3%) mentioned improved soil health as one of the motivations. Other factors include increased pasture area or hay production (6.5%) and the high cost of crop production (1.4%).

Policy Implications

CTG conversion plays an important role in mitigating greenhouse gas emissions. It was found that annual carbon stock increase rate from CTG conversion (1.0 ton of carbon dioxide equivalent per acre: $tCO_2e\ ac^{-1}$) doubled the rate from no-till adoption (0.5 $tCO_2e\ ac^{-1}$) (Eagle et al., 2012). Financial support—such as soil carbon sequestration payment, cost-share for CTG conversion cost, fencing, and water facilities—can also help increase the expected net returns on grassland and expand grassland acres. Further, to facilitate producer decision making, more extension and outreach efforts should be made to help farmers understand the environmental benefits and profit change associated with CTG conversion, especially on marginal land or land with saline and sodic conditions. Increasing cropland acres with soil saline and sodic conditions has become a concern for farmers not only in South Dakota but also in other Northern Great Plains states, such as Montana, North Dakota, Nebraska, Wyoming, and Minnesota (Fiedler et al., 2021). Because soils in the affected zones have low crop yields, utilizing them as grassland offers farmers a potential environmental and economically feasible solution.

In addition to enhancing the CTG conversion, preventing GTC conversion is equally important, especially in GTC conversion hotspots. Cropland from converted grassland can generate soil carbon loss 5 times greater than grassland, even under the no-till regime (Lark et al., 2020). Aligned with the government climate goal, expanding the existing program's acreage cap will keep more acres from GTC conversion. For example, the Grassland CRP enrollment in SD rapidly increased from 15,000 acres when the program launched in 2017 to over 1.1 million acres in fiscal year 2023 (USDA-FSA, 2023a). Nonetheless, the participation rate was only 4.9% of total grassland (see Figure 2), suggesting a high potential for additional grassland CRP enrollment. The enrollment is competitive based on the ranking factors, such as priority zone, expiring CRP, and threats of conversion (USDA-FSA, 2023b). Our survey results suggest that producers who operate farmland in eastern SD and those have smaller proportions of grassland are more likely to convert GTC and should therefore be prioritized for funding from programs such as Grassland CRP.

During 2017–2022, the top five states with most pastureland losses were New Mexico (2.1 million acres), Colorado (1.1), Oklahoma (0.9), California (0.7), and Texas (0.7) (USDA-NASS, 2022). Together, pastureland acres lost in those five states accounted for about 50% of national pastureland loss. Yet by 2023, Grassland

CRP enrollments in these states were still below 2% of their total pasture area, except for Colorado (6.2%). This calls for more preservation efforts in those grassland loss hotspots, such as expanding Grassland CRP enrollment acres to protect grassland in environmentally sensitive areas.

Concluding Remarks

Grassland converted for crop production could lead to many environmental concerns (such as soil erosion, nutrient pollution, soil carbon loss, and wildlife habitat loss) in South Dakota. Our results based on the 2023 survey data of SD farmers suggest a low GTC conversion rate at 0.1% per year, in contrast to a CTG conversion at 0.9% during the 2018–2022 period, which will likely lead to a net grassland gain. Factors such as proportion of grassland, farm size, and regional and soil characteristics can affect farmers' land use conversion decisions. Profit remains the leading motivation for GTC conversion, while the top motivation for CTG conversion is better utilization of marginal land.

To help producers make sustainable land use decisions, both educational and financial support should be provided, especially to those prone to GTC conversion. In addition to research and outreach efforts that facilitate producers' decisions on marginal land, financial support that rewards carbon benefits and compensates costs associated with CTG conversion will help. Further, promoting enrollment in grassland preservation programs, such as Grassland CRP and grassland easement programs, will likely play an important role in preserving and further expanding grassland in environmentally sensitive areas.

Appendix

Correction Methods for Inconsistency Issue

We found 21 responses containing inconsistencies between the amount of land operated and rented (e.g., total operational acres < rented acres). It is possible that those producers mistakenly entered their owned acres as the operational acres. For robustness check purpose, we carried out two alternative correction methods by (1) correcting their responses in operational acres by summing operational and rented acres and (2) dropping the inconsistent responses. While the latter method allows us to keep a higher number of observations, it does increase average farm size. The mean of farm size from the first method is 4,248.3 acres, given 453 observations. Using the second method, the average size of farms declines slightly to 4,198.9 acres, with 432 observations. The median values of proportion of grazing land and farm size are unchanged. The results shown in Table A1 are similar to those in Table 3, indicating the robustness of our findings.

Calculation Method for the Survey Data

The surveyed respondents reported the number of grassland and cropland acres at the end of 2022 and the conversion acres during the 2018–2022 period. This study assumes that grassland and cropland are converted between each other, meaning no conversion for other purposes or from other land use covers. Therefore, the annualized grassland-to-cropland (GTC), cropland-to-grassland (CTG) conversion rates, and annual grassland change from the conversion are calculated as follows:

(A1) Annualized GTC conversion rate = $(G_{end}/G_{begin})^{1/y} - 1$

(A2) Annualized CTG conversion rate = $(C_{end}/C_{begin})^{1/y} - 1$

(A3) Annualized CTG conversion rate = $(C_{end}/C_{begin})^{1/y} - 1$

where

G_{begin} = grassland acres before conversion = $G_{net} - (PCTG - PGTC)$,
G_{end} = grassland acres after conversion (not the net grassland) = $G_{begin} - PGTC$,
G_{net} = net grassland acres at the end of period,
C_{begin} = cropland acres before conversion = $C_{net} - (PGTC - PCTG)$,
C_{end} = cropland acres after conversion (not the net cropland) = $C_{begin} - PCTG$,
C_{net} = net cropland acres at the end of period,
y = the number of years in the study, which equals 5,
$PCTG$ = the cropland acres converted to grassland in the studied period,
$PGTC$ = the grassland acres converted to cropland in the studied period.

Calculation Method for Reitsma et al. (2015) and Joshi et al. (2019)

Reitsma et al. (2015) and Joshi et al. (2019) reported CTG and GTC conversion acres as well as unconverted grassland (GTG) and cropland (CTC). Under the same assumption of no conversion to and from other land use covers, the grassland and cropland acres in the beginning period are the summation of converted and unconverted acres. The annualized GTC, CTG conversion, and net grassland changes rates are calculated as equations (A1)–(A3), where

G_{begin} = grassland acres before conversion = GTG + GTC acres,
G_{end} = grassland acres after conversion (not the net grassland) = GTG acres,
G_{net} = net grassland acres at the end of period = GTG + CTG acres,
C_{begin} = cropland acres before conversion = CTC + CTG acres,
C_{end} = cropland acres after conversion (not the net cropland) = CTC acres,
y = the number of years in the study.

Calculation Method for Wright and Wimberly (2013)

Wright and Wimberly (2013) reported the areas converted from grassland to corn/soy production (GTC), lands in corn/soy to grassland (CTG), and net grassland loss. The authors obtained agricultural land cover data from the NASS Cropland Data Layer (CDL) (USDA-NASS, 2024), so we acquired the total cropland (corn/soybeans and grassland acres at the beginning of the studied period (2006) for the calculation from the same source. Likewise, the annualized GTC, CTG conversion, and net grassland changes rates are calculated as equations (A1)–(A3), where

G_{begin} = grassland acres in 2006 obtained from USDA-NASS (2024),
G_{end} = grassland acres after conversion (not the net grassland) = $G_{begin} - GTC$,
G_{net} = net grassland acres at the end of period = $G_{begin} - GTC + CTG$,
C_{begin} = cropland acres in 2006 obtained from USDA-NASS (2024),
C_{end} = cropland acres after conversion (not the net cropland) = $C_{begin} - CTG$,
y = the number of years in the study.

Calculation Method for Wang et al. (2018)

Unlike other literature analyzed in this study, Wang et al. (2018) reported the GTC and CTG conversion rates (%) over the studied period (2007–2012 and 2012–2017) and the beginning and ending grassland and cropland acres in each period. Hence, the annualized GTC, CTG conversion, and net grassland changes rates are calculated as equations (A1)–(A3), where

G_{begin} = grassland acres in the beginning of the studied period provided in the paper,
G_{end} = grassland acres after conversion (not the net grassland) = $G_{begin} - GTC$,
G_{net} = net grassland acres at the end of period = $G_{begin} - GTC + CTG$,
C_{begin} = cropland acres in the beginning of the studied period provided in the paper,
C_{end} = cropland acres after conversion (not the net cropland) = $C_{begin} - CTG$,
GTC = grassland acres converted to cropland = (GTC rate × $G_{begin})/y$
CTG = cropland acres converted to grassland = (CTG rate × $C_{begin})/y$
y = the number of years in the study.

Table A1. Land Conversion Status in South Dakota after Dropping the Inconsistent Responses

Type of Conversion	Variables	Overall	Location of Ranch/Farm: East	West	Diff.	Proportion of Grazing Land: < 67%	≥ 67%	Diff.	Total Land Acres: < 2400	≥ 2400	Diff.
Grassland to Cropland	Conversion rate (%)	12.0	14.8	8.3	-6.5**	15.1	8.5	-6.6**	11.0	12.6	1.6
	Acres converted	163.0	98.4	288.0	189.6**	181.2	92.9	-88.3	58.7	215.0	156.3
	% of acres converted	16.3	15.6	17.5	1.8	16.6	3.7	-12.9***	20.2	6.9	-13.2***
	Planning to convert (%)	12.0	15.3	7.2	-8.1**	15.8	7.0	-8.8***	10.5	12.3	1.8
	Acres planned	165.7	127.9	270.0	142.1**	158.6	165.5	6.9	79.4	233.8	154.4***
Cropland to Grassland	Conversion rate (%)	26.0	24.5	27.6	3.1	23.0	29.5	6.5	25.4	27.1	1.7
	Acres converted	226.6	117.6	331.2	213.6***	119.9	300.1	180.2**	97.8	340.8	243.0***
	% of acres converted	24.3	20.1	28.5	8.4	9.9	32.8	22.9***	24.2	22.8	-1.4
	Planning to convert (%)	15.2	11.5	19.6	8.1**	12.0	19.3	7.3**	10.5	20.8	10.3***
	Acres planned	128.6	75.5	161.7	86.1***	82.6	154.9	72.3**	68.1	163.1	95.0***

Note: Single, double, and triple asterisks (*, **, ***) indicate that t-test results between contrasting groups are different at the 10%, 5%, and 1% significance levels, respectively. Conversion rate is calculated by the number of respondents who converted their land use in the past 5 years. Acres converted is the average acres associated with land use conversion in the past 5 years. % of acres converted is acres converted as a percentage of grassland/cropland given the conversion was made. Planning to convert is the ratio of respondents who plan their land use conversion in the next 5 years. Acres planned is the average acres intended for land use conversion in the next 5 years. Differences are calculated by means of West minus means of East, means of large grazing land proportion minus means of low grazing land proportion, and means of large farm size minus means of small farm size.

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