Persistence and quality of vegetation cover in expired Conservation Reserve Program fields

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Persistence and quality of vegetation cover in expired Conservation Reserve Program fields

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Abstract

For nearly 40 years, the Conservation Reserve Program (CRP) has implemented practices to reduce soil erosion, improve water quality, and provide habitat for wildlife and pollinators on highly erodible cropland in the United States. However, an approximately 40,470 ha (10 million acres) decline in enrolled CRP land over the last decade has greatly reduced the program's environmental benefits. We sought to assess the program's enduring benefits in the central and western United States by (1) determining the proportion of fields that persist in CRP cover after contracts expired, (2) identifying the type of agricultural production that CRP fields shift to after contract expiration, (3) comparing the vegetation characteristics of expired CRP fields that are persisting in CRP-type cover with enrolled CRP fields, and (4) identifying differences in management activities (e.g., haying, grazing) between expired and enrolled CRP fields. We conducted edge-of-field vegetation cover surveys in 1092 CRP fields with contracts that expired ≥3 years prior and 1786 currently enrolled CRP fields in 14 states. We found that 41% of expired CRP fields retained at least half of their area in CRP-type cover, with significant variation in persistence among regions ranging from 19% to 84%. When expired fields retained CRP vegetation, bare ground was low in all regions and grass cover was somewhat greater than in fields with current CRP contracts, but at the expense of forb cover in some regions. Evidence of more frequent management in expired CRP fields may explain differences between active and expired CRP fields. Overall, there is clear evidence that CRP-type cover frequently persists and provides benefits for more than three years after contract expiration. Retaining CRP-type cover, post-contract, is an under-recognized program benefit that persists across the central and western United States long after the initial retirement from cropland.

KEYWORDS

Conservation Reserve Program, CRP, expired CRP, forb cover, grass cover, grassland restoration, retired cropland, soil erosion

INTRODUCTION

In 1985, the US Congress used the Soil Bank Program of the late 1950s and early 1960s as a model to establish the Conservation Reserve Program (CRP) to reduce soil erosion and stabilize commodity prices by replacing highly erodible cropland with perennial conservation covers. Secondary objectives focused on ensuring the Nation's long-term capability to produce agricultural commodities, improving water quality, providing wildlife habitat, and supplementing farm income (USDA FSA, 2021). Within the first 25 years, the CRP was credited with preventing an estimated 7.3 billion Mt of soil from eroding, reducing nutrient loss by an estimated 274 Mt of nitrogen, and adding 2 million ducks per year (USDA FSA, 2012). To achieve these objectives, the US Department of Agriculture (USDA) provides annual rental payments and cost-share assistance for landowners to supplant agricultural production on environmentally sensitive land with perennial cover for 10–15 years. Under certain circumstances, CRP fields may be reenrolled for additional terms at the end of the initial CRP contract. Fields that do not qualify for reenrollment may convert back to crop production, be managed for livestock or forage production, or persist in CRP-type vegetation cover.

The wildlife and pollinator habitat, water quality, and soil erosion benefits provided by fields enrolled in CRP are a function of vegetation cover, and thus do not cease upon contract expiration if CRP-type vegetation remains (Bigelow et al., 2020). Some benefits, such as soil health, may accrue from the respite of cultivation. Other benefits may persist, such as cover for birds and floral resources for pollinators. Post-contract persistence of these benefits is poorly understood, however, and rarely quantified when estimating CRP returns on investment: information that could improve long-term assessments of the program's effects (Roberts & Lubowski, 2007). When CRP fields revert back to crop production, most residual benefits are quickly eliminated. For example, reduced soil erosion lasts less than one year after tillage (Gilley et al., 1997). Thus, there is a need to evaluate the extent to which CRP plantings persist post-contract and to quantify the continued services they provide.

Provisions in the 2008, 2014, and 2018 Farm Bills to reduce the financial incentives and amount of land enrolled in CRP decreased the CRP to the lowest level in 30 years (9.7 million ha), including a 25% reduction over the last decade (USDA, 2020; USDA ERS, 2014). This sharply contrasts with a recent effort to conserve 30% of US lands by 2030, commonly called the "30 by 30 Initiative" (Executive Order, 2021; US Department of the Interior et al., 2021), which aligns with the United Nations' "Decade on Ecosystem Restoration" (2021–2030), a challenge calling on countries to invest in restoration over the next decade (United Nations, 2019). CRP lands and private working lands with significant conservation value play an important role in meeting these national and international goals. As a result, there is an even greater need to understand the fate of CRP lands after contracts expire. Assessing vegetation cover on both enrolled and expired CRP fields enables the quantification of benefits that accrue while the conservation cover persists (Vandever et al., 2021a). Understanding the spatial distribution and characteristics of ex-CRP fields persisting on the landscape could help target conservation practices (CPs) toward areas likely to provide the greatest long-term provision of ecosystem services. Failure to estimate persistent, post-CRP benefits results in underestimating the program's value.

Our overall goal was to assess how often CRP fields persist and provide conservation benefits after contract expiration. We define persisting CRP fields as those that retain at least 50% area in vegetation cover typical of CRP (grasses, forbs, shrubs, and trees) for at least three years after contract expiration. Our specific objectives were to quantify, across different CRP practice types, regions, and states in the central and western United States: (1) the proportion of fields that persist in CRP-type vegetation after contract expiration; (2) the type of agricultural production to which converted fields shift; (3) the degree of similarity in vegetation cover characteristics between expired fields and enrolled fields; and (4) differences in disturbance or management activities (e.g., haying, grazing) between expired and enrolled CRP fields. We included three specific questions under objective 3 that relate to common assumptions about expired CRP fields. First, we asked whether erosion characteristics differ between enrolled and expired CRP fields, since frequent vegetation management is permissible in the latter. Second, we compared the percent cover and richness of native and invasive grasses and forbs. Control of noxious and invasive species is a requirement for fields enrolled in the CRP, but we expected that costly control efforts might decrease upon contract expiration. Third, we asked if shrub and tree presence is greater in expired fields compared with enrolled CRP fields with the additional time required for woody plants to establish.

METHODS

Study area

We acquired information from USDA for our study area. This area consisted of all, or part, of 14 central and western states in six USDA Farm Production Regions

(USDA, 2000): Corn Belt (Iowa and Missouri), Lake States (Minnesota), Mountain (Colorado, Idaho, and Montana), Northern Plains (Kansas, Nebraska, North Dakota, and South Dakota), and Pacific (Oregon and Washington) and Southern Plains (Oklahoma and Texas) (Figure 1). These states include a significant number of both enrolled and expired CRP fields in the six CPs of interest. We grouped CPs into three, broader "conservation practice types" based on their seeded attributes and common goals (Table 1).

Study design

We acquired spatial data for enrolled and expired CRP fields in the study area from USDA. For expired CRP fields, we sampled from fields in the dataset that met the following criteria: (1) had been enrolled in a CRP CP of interest; (2) CRP contract expired prior to 2014 (i.e., expired at least three years and not reenrolled); and (3) met distance-from-road (<25 m) and field-size (>2.02 ha, or 5 acres) criteria. Expired fields were

TABLE 1 Conservation practices (CPs) in the Conservation Reserve Program that we evaluated.

Practice	Description	Practice type for analysis
CP1	Introduced grasses	Grassland
CP2	Native grasses	Grassland
CP10	Established grasses	Grassland
CP4D	Permanent wildlife habitat	Wildlife
CP25	Restoration of rare and declining habitat	Wildlife
CP23	Wetland restoration	Wetland

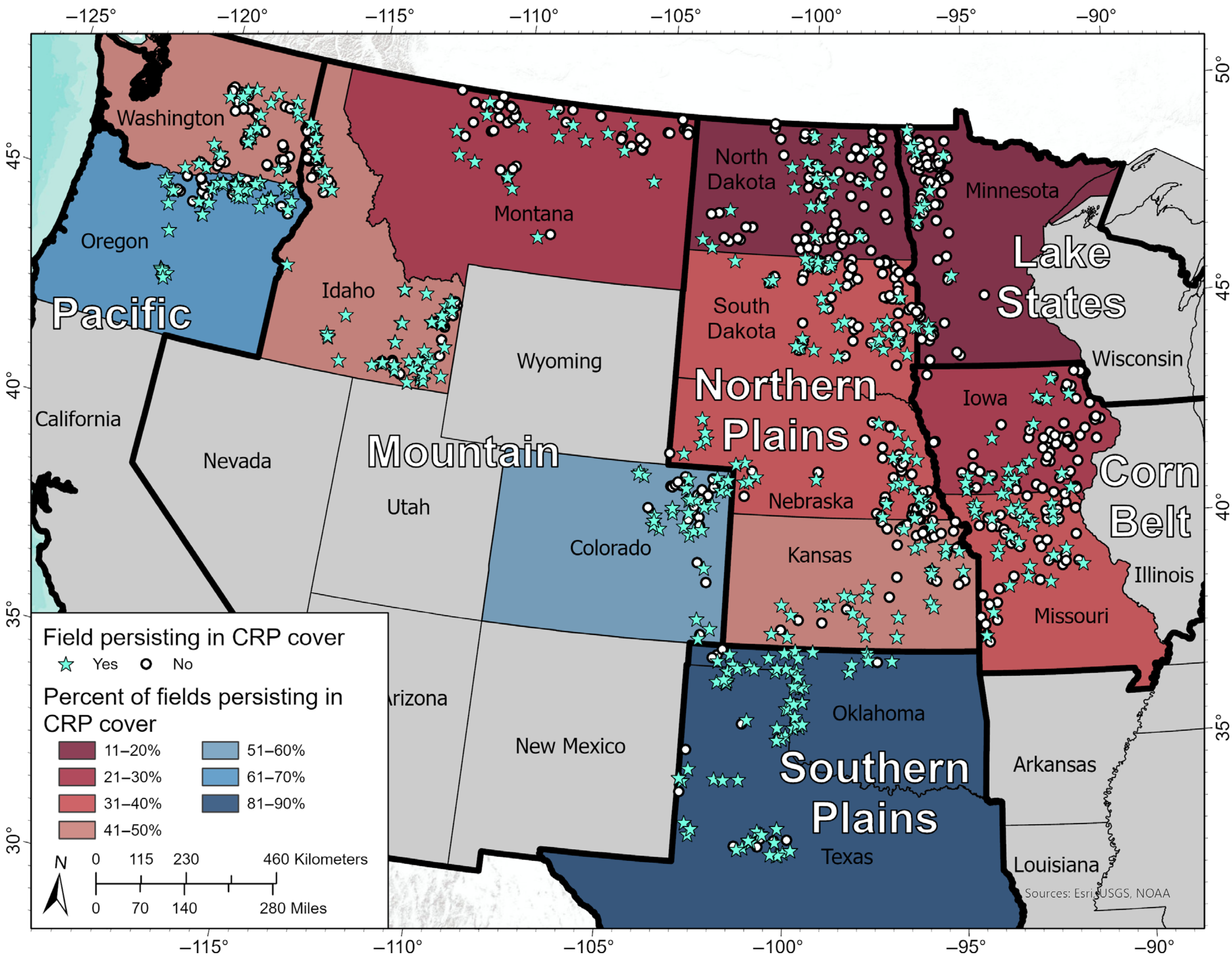

FIGURE 1 Locations of expired Conservation Reserve Program (CRP) fields selected for sampling, coded by whether the field was persisting in CRP cover or had been converted to other land covers or types. We defined fields persisting in CRP cover as having 50% or more of the field area in vegetation cover typical of CRP plantings for that practice type.

sampled from this population using a stratified (by state) random design to enable widespread spatial inference and interpretation at both state and regional scales. To ensure sufficient sample sizes, we only sampled CPs in each state for which there were at least 50 fields previously enrolled in the practice that met the above criteria. To ensure unique field contracts and reduce common land ownership, we enforced a minimum distance of 1 km between fields; however, we reduced this distance in a few cases in the Pacific Northwest region (<3% of fields) to meet the target sample size while accommodating access issues. As a result, we surveyed 1092 expired CRP fields. In a previous study, we sampled 1786 enrolled fields using a similar process and survey methods (see Vandever et al., 2021a).

Assessments of field status

Edge-of-field surveys were used to document the cover status of the 1092 expired CRP fields, including the percent of the field covered by vegetation characteristic of CRP plantings (i.e., noncrop grasses, forbs, shrubs, trees), and the percent of the field in other land use or cover types: soybeans, corn, wheat, other small grains (e.g., oats, barley, rye, millet), other crops (e.g., sunflower, cotton, canola), hay (e.g., alfalfa, clover), tilled, fallow/bare ground/weeds, and other converted fields (e.g., structure and oil and gas development). The majority of CRP fields were easily observed, but to assure higher confidence in surveys, fields were observed from all accessible boundaries prior to recording cover status. Surveys were conducted between June and October 2017 and July 2018, but 91% of fields were sampled between June and August to help capture both warm and cool species compositions in mixed stands.

Edge-of-field estimates of vegetation cover characteristics

If the expired CRP fields had 20% of their area in grass and forb cover that resembled typical CRP plantings for that CP, we further quantified vegetation cover, bare ground, soil erosion, and disturbance in that portion of the field using edge-of-field visual estimates. These variables are the same as those quantified for enrolled CRP fields in Vandever et al. (2021a). The edge-of-field estimates included the following: total cover of grasses, forbs, shrubs, trees, and bare soil; presence of soil erosion indicators (rills, gullies, pedestaling); and the amount, type, and timing of disturbances. In 47 fields that had high levels of disturbance, we assessed only bare ground and presence of erosion indicators. We identified species as native, non-native, or invasive/noxious (hereafter noxious) using the USDA Plants Database (USDA NRCS, 2000). Reed canarygrass (*Phalaris arundinacea* [L.]) has an ambiguous native status but was included as noxious because it inhibits native vegetation, commonly occurs as a non-native genotype (Lavergne & Molofsky, 2007), and is regulated in several states. Although non-native and sometimes considered invasive, smooth brome (*Bromus inermis* [Leyss.]) was not included in this group because it is often purposely seeded in CRP plantings. Multiple photos were taken of nearly all fields for reference, and a common-cover-class diagram was used by crew as a visual aid, facilitating data quality control checks. See Vandever et al. (2021a) for full description of these visual estimation methods and infield validation of our methods.

Analysis of the status of previously enrolled CRP fields

To evaluate the extent that expired CRP fields persist in CRP cover, we coded fields by dominant cover. Fields with 50% or more of their area remaining in vegetation cover typical of CRP plantings were coded as persisting CRP fields. We used logistic regression to examine the influence of time since contract expiration, region, state (nested within region), and conservation type on CRP cover persistence.

We used multinomial regression to examine the effect of these same factors on the frequency that CRP fields converted to other land use or cover categories (dominant covers of corn, soybeans, wheat and other small grains, other crops, hay, tilled, fallow/weeds/bare, and other/developed). We combined wheat fields with other small grains, as sampling occurred after harvest and to avoid confusion with similar-looking small-grain stubble.

Analysis of the characteristics of persisting CRP vegetation

For expired CRP fields that retained at least 20% of their area in CRP-type cover, we compared the characteristics of that retained vegetation (not the entire field) to the characteristics of enrolled CRP fields within the same region and practice type (Vandever et al., 2021a). This analysis was carried out at the regional (rather than state) level to ensure a sufficient sample size. Due to small sample sizes in some regions and cover classes, we used

Fisher's exact tests to test for differences in vegetation metrics between expired and enrolled CRP fields. To test whether the proportion of fields containing noxious forbs or grasses differed between enrolled and expired CRP fields, we used binomial proportion tests. All analyses comparing enrolled and expired CRP fields were conducted on a regional basis to ensure that observed differences were not due to regional differences in CRP contract expiration rates. Data pertaining to the enrolled and expired CRP fields are publicly available (Vandever et al., 2021b, 2022).

All statistical analyses were performed using R version 4.0.2 (R Core Team, 2020).

RESULTS

We assessed 1092 expired CRP fields (Figure 1; Appendix S1: Table S1) and conducted detailed edge-of-field vegetation assessments on 299 of those fields that retained ≥20% of the field area in typical CRP vegetation.

Persistence of CRP cover on expired CRP fields

Across all states and practices, 41% of expired fields had at least half of their area persisting in CRP cover three or more years after the contract expired (Figure 1). The proportion of CRP fields persisting varied strongly by state and region (Tables 2 and 3), with persistence highest in the Pacific, Mountain, and Southern Plains regions. At the state level, 81% and 89% of expired CRP fields persisted in CRP cover in Texas and Oklahoma, respectively, whereas only 20% and 19% of fields persisted in North Dakota and Minnesota, respectively. Grassland and Wildlife practices had nearly identical persistence (42.1% and 43.2%, respectively), but Wetland practices had significantly lower (18.4%) persistence (Table 3). Interestingly, a greater number of years since contract expiration was positively correlated with CRP persistence, increasing the probability the field remained in CRP cover.

Conversion of expired CRP fields

When expired CRP fields were converted to another land cover or use (i.e., >50% of the field area was in another land cover or use), the most common fate was reversion to agricultural production, and the most common crops were soybeans, corn, and wheat or other small grains (Figure 2). Variation in dominant land cover in expired converted CRP fields was largely geographical and reflected regional differences in dominant crops. Region and state nested within region both had large significant effects on land cover in expired,

TABLE 3 Analysis of deviance (Dev) showing the contribution of regional variation, state-level variation within regions, time since contract expiration, and type of conservation practice to the probability of Conservation Reserve Program cover persisting at least three years after contract expiration.

Source	df	Dev	Residual df	Residual Dev	*p*
Intercept			1091	1482.0	
Years since contract expiration	1	15.813	1090	1466.2	<0.0001
Region	5	116.761	1085	1349.4	<0.0001
State (nested within region)	8	28.353	1077	1321.1	0.0004
Conservation practice type	2	7.601	1075	1313.5	0.0224

TABLE 2 Number of expired Conservation Reserve Program (CRP) fields surveyed in each state and number and percentage of these fields persisting in CRP cover.

	Pacific		Mountain			Northern Plains				Lake States	Corn Belt		Southern Plains		
Metric	OR	WA	ID	MT	CO	ND	SD	NE	KS	MN	IA	MO	OK	TX	Total
No. expired CRP fields surveyed	97	85	109	60	62	102	101	78	64	85	81	78	37	53	1092
Fields persisting in CRP cover															
No.	59	38	52	17	33	20	35	28	28	16	22	29	33	43	453
Percentage	61	45	48	28	53	20	35	36	44	19	27	37	89	81	41

Note: We defined fields persisting in CRP cover as having 50% or more of the field area in vegetation cover typical of CRP plantings for that practice type.
Abbreviations: CO, Colorado; IA, Iowa; ID, Idaho; KS, Kansas; MN, Minnesota; MO, Missouri; MT, Montana; ND, North Dakota; NE, Nebraska; OK, Oklahoma; OR, Oregon; SD, South Dakota; TX, Texas; WA, Washington.

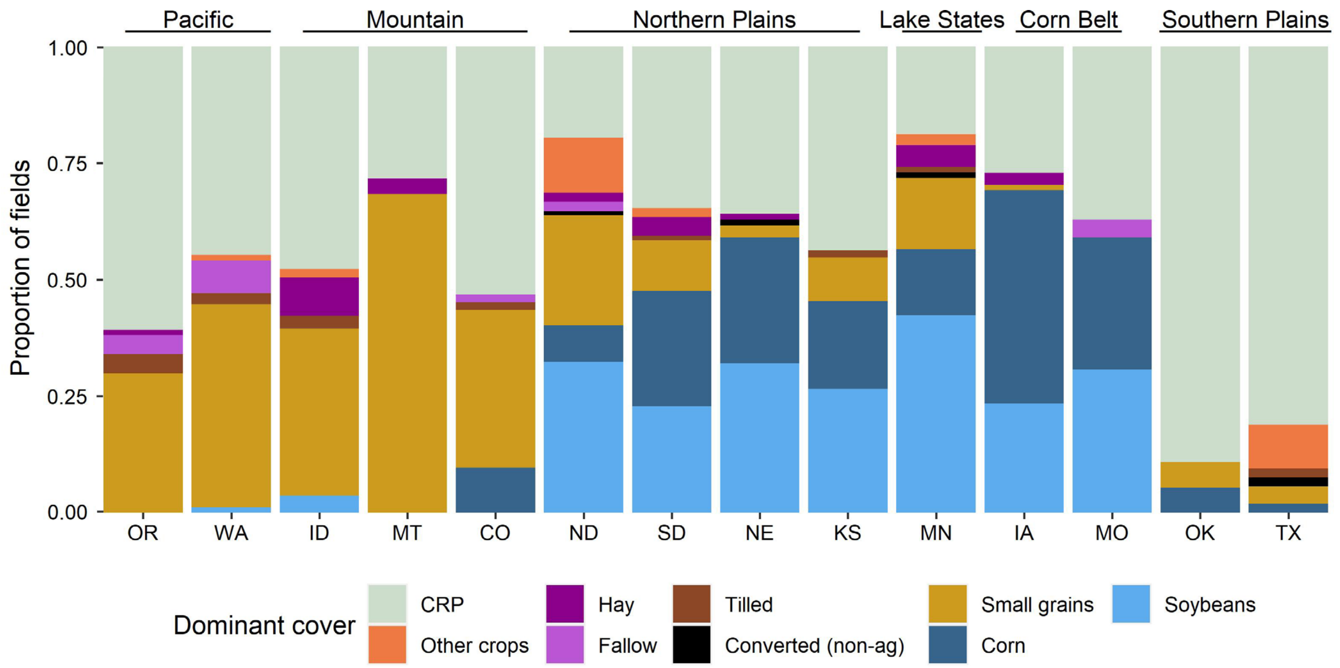

FIGURE 2 Dominant land cover/use on Conservation Reserve Program (CRP) fields whose contracts had expired ≥3 years prior. CO, Colorado; IA, Iowa; ID, Idaho; KS, Kansas; MN, Minnesota; MO, Missouri; MT, Montana; ND, North Dakota; NE, Nebraska; OK, Oklahoma; OR, Oregon; SD, South Dakota; TX, Texas; WA, Washington.

converted CRP fields ($p < 0.0001$). Corn and soybeans were the dominant crops in the Lake States, Northern Plains, and Corn Belt. Wheat and other small grains were common in the Southern Plains, Pacific, and Mountain regions. Fields in "other crops" in Texas were primarily in cotton. Time since expiration ($p = 0.35$) and CP type ($p = 0.43$) were not significantly correlated with land cover patterns in expired, converted CRP fields.

Comparing characteristics of enrolled CRP fields to expired-but-persisting CRP fields

We note here for clarity that all results in this subsection pertain to the portion of the expired CRP fields that persisted in CRP-type cover, and that only expired CRP fields with at least 20% of their area persisting in CRP-type cover were eligible for sampling of vegetation and thus included in this section.

Erosion

Erosional features were rarely encountered in fields with CRP-type cover, regardless of whether those fields were currently enrolled in CRP or expired. Rills, gullies, and pedestaling of vegetation were uncommon, found in only 1%–2% of fields, regardless of contract status. Only 7.4% of expired CRP fields had >20% bare ground (Figure 3). This was statistically indistinguishable from the 9.5% of enrolled CRP fields that had >20% bare ground (Fisher's exact test, $p = 0.279$). However, when bare ground was compared between enrolled and expired CRP fields within individual regions, four of six regions showed significant differences (Figure 3). A significantly higher proportion of expired fields in the Pacific Northwest region had >20% bare ground, compared with enrolled fields. In the Corn Belt and Northern and Southern Plains, the reverse was true, where fewer expired fields had >20% bare ground.

Total grass cover and native grass species richness

Grass cover exceeded 50% in the majority of fields, regardless of whether the field was currently enrolled in CRP or expired. Nevertheless, in some regions, there were noticeable differences between enrolled and expired fields. In the Northern and Southern Plains expired fields had significantly more grass cover than enrolled fields (Figure 4A; $p = 0.0003$ and $p < 0.0001$, respectively), suggesting an increase in grass cover after contract expiration in these regions. In the Corn Belt and Mountain regions, expired fields tended to have fewer intermediate values and more polarized values of grass cover than enrolled fields.

We found across all regions, both expired and enrolled CRP fields had up to seven native grass species present.

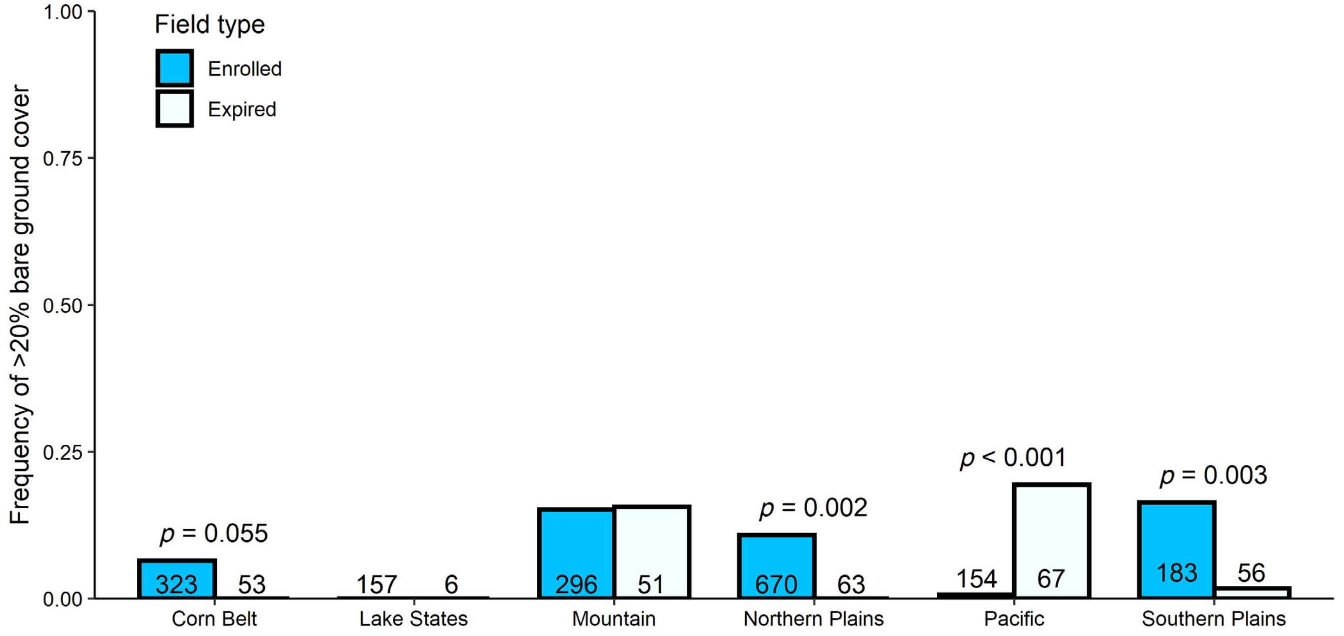

FIGURE 3 Percent of enrolled Conservation Reserve Program (CRP) fields and expired CRP fields (CRP fields whose contracts had expired ≥3 years prior) with persisting CRP cover that have >20% bare ground. Numbers at the base of each bar indicate sample size in each category. The *p* values are derived from Fisher's exact tests comparing the difference between enrolled and expired fields in the ratio of fields with <20% bare ground to fields with >20% bare ground. When Fisher's exact tests indicated a significant difference between enrolled and expired CRP fields, the *p* value is shown above the bar.

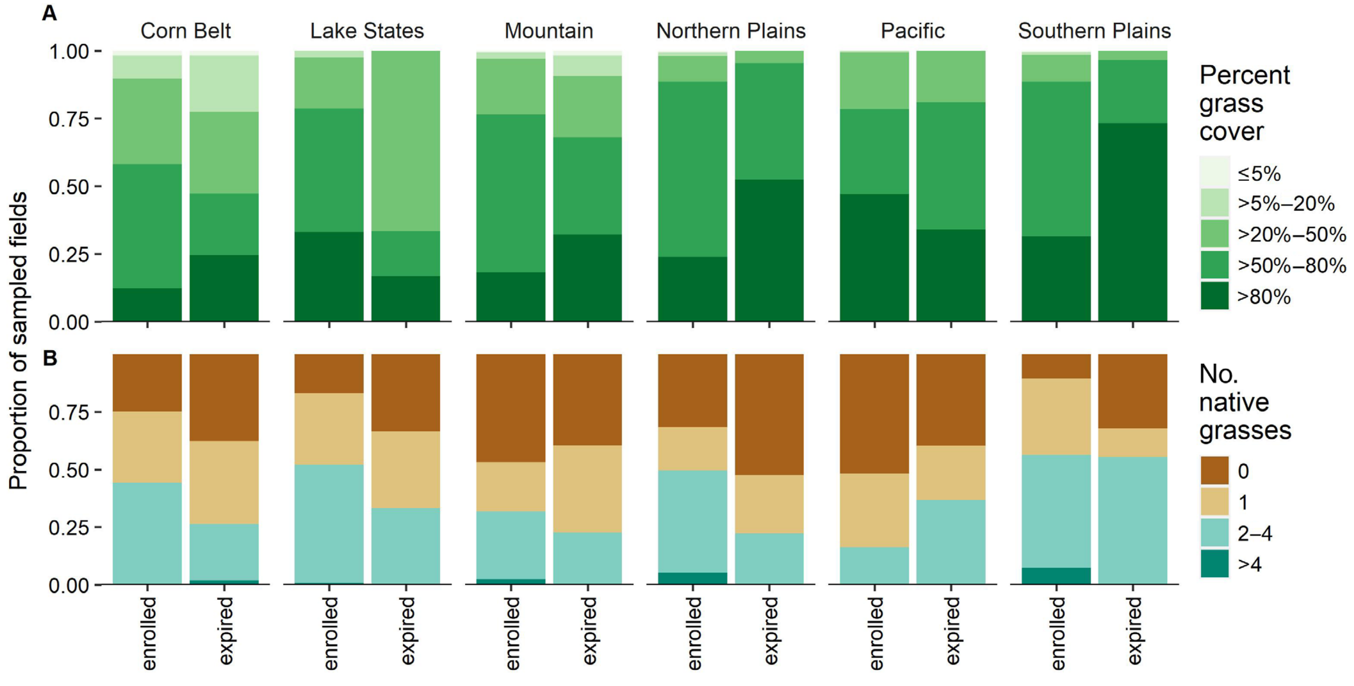

FIGURE 4 Percent cover of grasses (A) and number of native grass species (B) on fields currently enrolled in Conservation Reserve Program (CRP) and expired CRP fields (CRP fields whose contracts had expired ≥3 years prior) with persisting CRP cover.

Enrolled CRP fields had an average of 1.47 native grass species present compared with 1.07 species on expired CRP, but this contrast varied by region. Expired fields in the Corn Belt and Northern Plains had significantly fewer native grass species than enrolled CRP fields, while in the Pacific region native grass species richness was greater in expired fields (Figure 4B; Appendix S1: Table S2).

Total forb cover and native forb species richness

Persisting CRP vegetation in expired fields generally had lower forbs cover compared with enrolled CRP fields, and this difference was significant in the Mountain, Northern Plains, and Southern Plains (Figure 5A). None of the fields had greater than eight native forb species present, regardless of enrollment status. The richness of native forbs in persisting expired fields varied regionally as well, with more species in the Corn Belt and Pacific regions and fewer in the Mountain, Lake States, and Northern Plains regions (Appendix S1: Table S2). On average across regions, enrolled CRP fields exhibited greater richness of native forb species (1.88 species) compared with expired fields (1.29 species). In addition, twice as many expired fields (38%) had zero native forbs compared with enrolled CRP fields (19%). The difference in native forb richness between expired and enrolled CRP fields was greatest in the Lake States and Northern Plains, but also significant in the Southern Plains and Mountain regions (Figure 5B; Appendix S1: Table S2).

Noxious grass presence and species richness

Apart from the Pacific Northwest, few fields contained noxious grasses (disregarding reed canarygrass) and virtually all fields with noxious grasses had only one species present. The proportion of fields containing noxious grasses did not significantly differ between enrolled and expired CRP fields in any region (Figure 6A; Appendix S1: Table S3). There was strong regional variation in both the mean number of noxious grass species in expired fields (Kruskal–Wallis, $p < 0.001$) and in the proportion of expired fields where noxious grasses were present (Fisher's exact test, $p = 0.0005$), but these regional differences in expired CRP fields followed the same pattern as enrolled CRP fields. Specifically, the presence of noxious grasses and number of noxious grass species were higher in the Pacific Northwest than any other regions, and lowest in the Southern and Northern Plains (Figure 6A; Appendix S1: Table S3).

Noxious forb presence and species richness

Noxious forbs were found more frequently than noxious grasses. Noxious forbs varied regionally by mean number of species (Kruskal–Wallis, $p < 0.001$) and in the proportion of expired fields where they were present (Fisher's exact test, $p = 0.0005$; Figure 6B; Appendix S1: Table S4). Fields containing noxious forbs had up to five species present. In expired CRP fields, the number of noxious forb species was highest in the Corn Belt and the Pacific Northwest, and lowest in the Lake States and Northern and Southern Plains. Unlike noxious grasses, field contract status did influence the proportion of fields with noxious forbs in some regions. Specifically, significantly more expired fields had noxious forbs present compared with

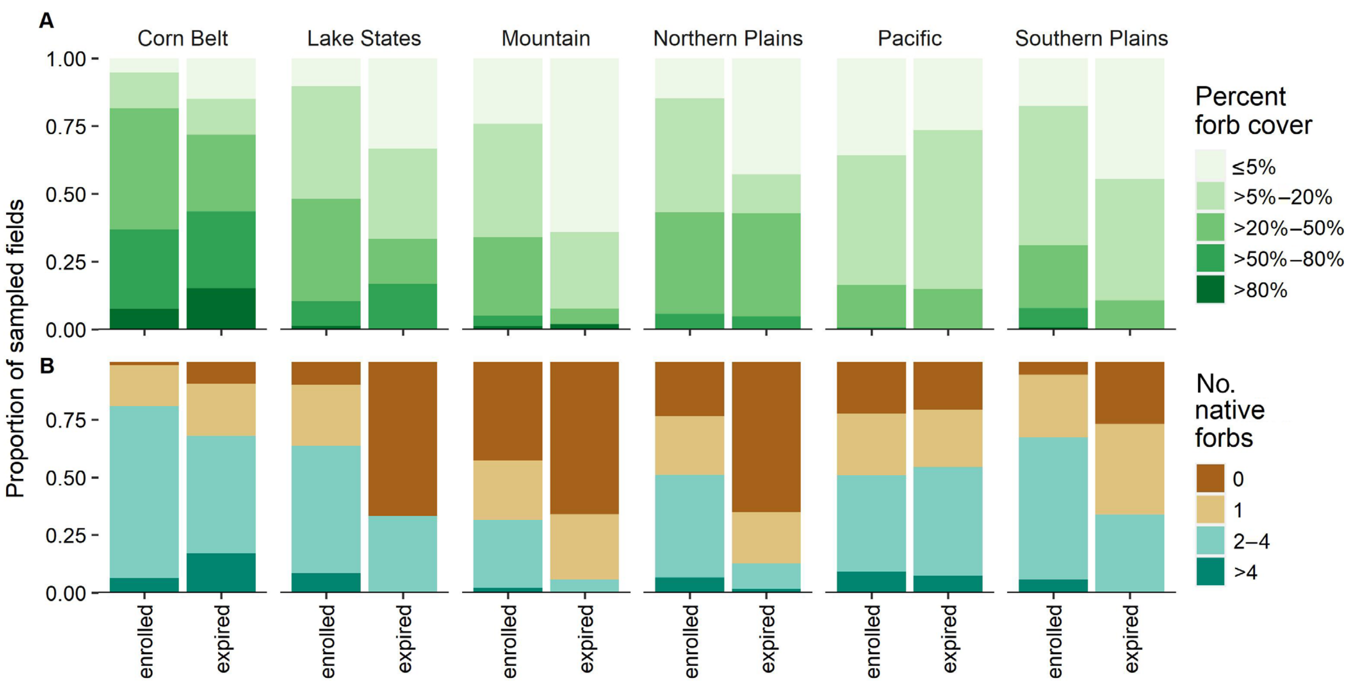

FIGURE 5 Percent cover of all forbs (A) and number of native forb species (B) on fields currently enrolled in Conservation Reserve Program (CRP) and expired CRP fields (CRP fields whose contracts had expired ≥3 years prior) with persisting CRP cover.

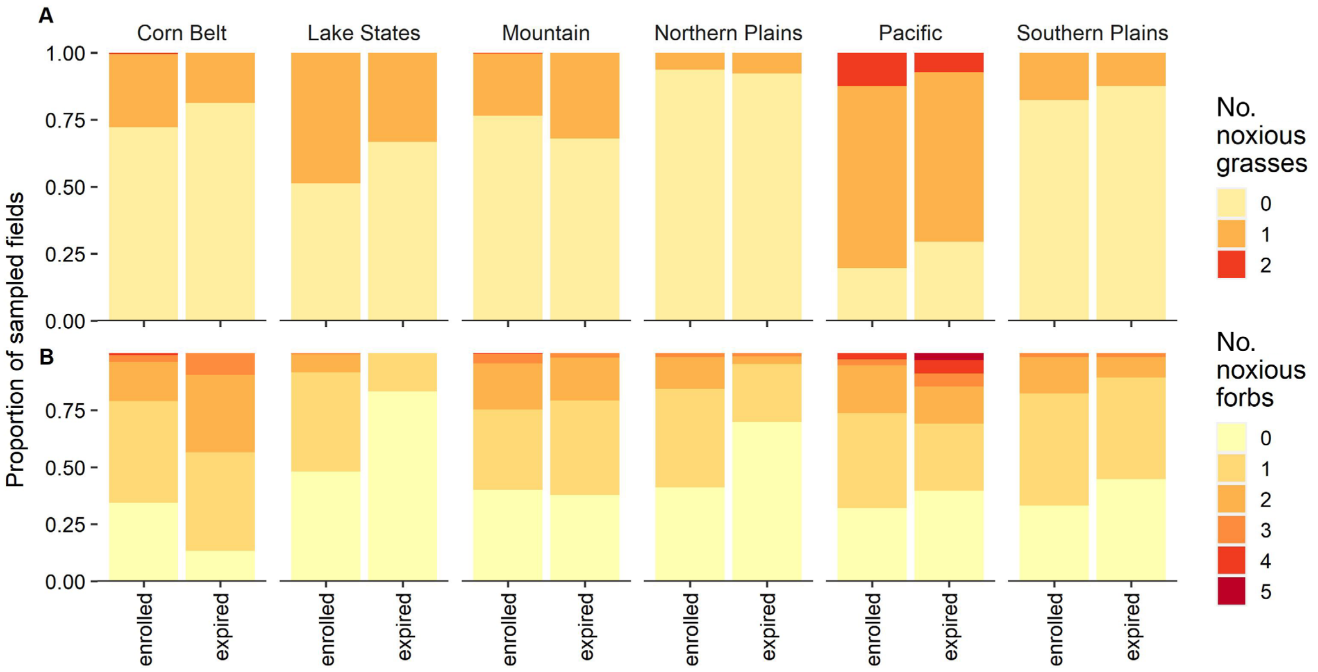

FIGURE 6 Number of noxious grasses (A) and forbs (B) in currently enrolled Conservation Reserve Program (CRP) fields and expired CRP fields (CRP fields whose contracts had expired ≥3 years prior) with persisting CRP cover.

enrolled fields in the Corn Belt ($p = 0.0014$; Figure 6B; Appendix S1: Table S4). Conversely, in the Northern Plains, expired fields were significantly less likely to contain noxious forbs ($p < 0.0001$).

Tree and shrub cover

Shrub cover was low overall in expired fields, with only 13% having greater than 5% shrub cover averaged across all regions, but we observed a large amount of regional variation. None of the expired fields in the Northern Plains or Lake States, and only 1.9% in the Corn Belt, had >5% shrub cover. In the Pacific region though, 36.8% of fields exceeded 5% shrub cover. The Mountain and Southern Plains regions had intermediate frequencies (13.2% and 10.3%, respectively) of fields exceeding 5% shrub cover. These differences largely reflected regional patterns in enrolled CRP fields, although expired fields had significantly lower shrub cover than enrolled fields in the Corn Belt (Fisher's exact test, $p = 0.028$) and marginally higher shrub cover in the Pacific region ($p = 0.077$). The response of shrub cover to field expiration status also depended somewhat on the type of CP. Fields in Wetland and Wildlife practices were not significantly influenced by expiration status, but expired fields in Grassland practices had significantly more shrub cover than enrolled fields (Fisher's exact test, $p = 0.035$). Averaged across regions, 15.1% of expired grassland practice fields had >5% shrub cover, while only 10.1% of enrolled grassland practice fields exceeded this same threshold. Tree cover was low across the study region with 92.6% of fields having <5% tree cover, and while this percentage exhibited a small but significant degree of regional variation ($p = 0.006$), it did not differ significantly between expired and enrolled fields, nor did it differ by state or practice type ($p > 0.05$).

Grass management on expired CRP fields with persisting CRP cover

Nearly half (49%) of the expired CRP fields with persisting CRP cover showed evidence of grass management (e.g., grazing, haying, mowing). This was significantly more frequent than management in enrolled CRP fields, where only 14% showed similar evidence (Fisher's exact test, $p < 0.0001$). Of the expired persisting fields where grass management was evident, grazing was the predominant use (59%), followed by haying (26%) and mowing (9%). This differed from enrolled fields, where management was predominantly haying (44%), followed by mowing (27%) and grazing (18%). In expired fields, prescribed management was more commonly observed in the Northern Plains, Pacific, and Lake States regions where approximately 60%–75% of fields were managed. Management was least frequent in the Corn Belt, where only 39% of persisting fields showed visible evidence of management.

DISCUSSION

One metric of success tied to the CRP is the amount of environmentally sensitive, annually cultivated cropland replaced with perennial vegetation. From the outset of CRP nearly 40 years ago, this metric has been tracked as the number of actively enrolled hectares, a number that has shifted dramatically by millions of hectares. Our findings show that this number is a significant underestimate; close to 4 of 10 expired CRP fields persist in CRP-type cover and our figures are consistent with state averages in several other studies (Bigelow et al., 2020; Janssen et al., 2008; Johnson et al., 1997). The application of edge-of-field assessments enabled us to observe that the majority of persisting CRP fields continued to provide environmental benefits for at least three years after expiration. When CRP fields remain in conservation covers post-contract, they provide added opportunities for sportsmen, wildlife, and landowners who invested their land in conservation at the local scale. At the landscape scale, persistent CRP fields represent a large and poorly recognized contribution to agroecosystem integrity that contributes significantly to the US goal of conserving 30% of US lands by 2030.

Conversion and persistence of CRP cover on expired CRP fields

We observed a wide range in the persistence of conservation cover in expired fields. CRP persistence was greater in the seven drier states (Pacific, Mountain, and Southern Plains regions) than in the seven wetter states (Northern Plains, Lake States, and Corn Belt regions). Because these drier regions have both higher CRP persistence and lower expected restoration success (Hardegree et al., 2011; Munson & Lauenroth, 2012), persistence of CRP vegetation after contract expiration may be especially important to grassland restoration in these regions. When CRP vegetation did not persist, we and others (Bigelow et al., 2020; USDA FSA, 2021) found most fields were replanted to one of the three major crops: corn, soybeans, or wheat. We found that region factored more in persistence of expired CRP fields than CP type, but careful study is needed to address questions on how climate and other regional drivers such as social, economic, and cultural factors affect landowner decisions to convert expired CRP fields back to cropland.

Comparing characteristics of enrolled CRP fields to expired-but-persisting CRP fields

There were many similarities between the vegetation of expired, persisting CRP and enrolled CRP. To the extent that vegetation structure is a proxy for ecosystem function (Gaitan et al., 2014), this suggests expired persisting CRP continues to provide ecological functionality, potentially across millions of hectares. For example, we found expired CRP fields were just as effective as enrolled fields at reducing erosional features. A national survey of CRP participants showed 85% of respondents believe CRP has controlled erosion on their CRP lands (Allen & Vandever, 2003), and our findings suggest these enduring benefits exist post-contract and commensurate with program goals.

When expired CRP fields do not return to cropland, they largely remain in grass-dominated cover. Grass dominance tended to decrease and forbs increased in the more mesic regions (Corn Belt and Lake States) while dominance shifted strongly toward grasses in the drier Pacific, Southern, and Northern Plains, reflecting the higher water use efficiency of C4 grasses (Waller & Lewis, 1979). Despite these regional patterns, overall grass and forb dominance and richness were similar between expired and enrolled CRP fields, with a few important regional exceptions. Grass dominance strongly declined in expired, compared with enrolled fields in the Lake States, but dramatically increased in the Southern Plains. Contract expiration thus seems to amplify the regional pattern in grass dominance seen in enrolled fields. This might be caused by natural successional patterns, but interestingly, the more mesic regions (Corn Belt and Lake States) also had the least amount of management (haying and grazing). These results suggest a better understanding of interactions between climate and management might improve future outcomes for enrolled and expired CRP land.

We found persisting CRP cover was greater than Bigelow et al. (2020) reported using National Resources Inventory data, likely due to differences in cover classifications and other methodological differences. Time may also be a factor; fluctuating commodity prices might be expected to affect persistence though this has not to our knowledge been documented. But both Bigelow et al. (2020) and our study found persistence of CRP vegetation in Oklahoma and Texas was approximately twice the study area averages.

We saw evidence of native species diversity loss over time, which may diminish ecosystem services (Tilman et al., 2001). USDA guidance for planting CRP varies by CP, soil, and state, but requires a minimum of two grass species in all but one CRP practice (CP1). We did not find the diversity of native grasses representative of their original plantings; expired CRP fields averaged just over one native grass species compared with approximately 1.5 grass species on enrolled fields. This decline was small but significant in most regions and happened in a short time, emphasizing the need to explore the rate of diversity loss. Watson et al. (2021) also found lower than expected plant diversity in Kansas CP2 and CP25 fields. But precipitation gradient may influence plant species richness more than richness of CP seed mix (Watson et al., 2021). We also found that enrolled fields in four regions and expired fields in all regions had more than 25% of fields devoid of any native grass species. The substantial number of these native species-poor fields may warrant additional investigation into direct or indirect effects on CRP establishment success (Meissen et al., 2020).

Increasing grass dominance during succession can be a detriment to forb cover (Cade et al., 2005; Dickson & Busby, 2009), and we found evidence of decreased forb cover across all regions in expired CRP fields. Three of the top four regions where haying and grazing occurred (Mountain and Northern and Southern Plains) experienced the strongest forb declines. It is possible that roadside surveys underestimate forb cover, particularly due to forb characteristics: smaller stature, smaller populations, and flowering phenology that made identification difficult after bloom, but any potential methodological effect is unlikely to differ between expired and enrolled fields. Munson and Lauenroth (2012) reported that forb cover decreased in semiarid grasslands over time since CRP enrollment, and we found in five of the six regions more expired fields without any native forbs compared with enrolled fields.

Most CRP practices require planting multiple native forbs because they provide important ecosystem functions to wildlife and pollinators in CRP habitat (Doxon & Carroll, 2010; Rodgers, 1999; Vandever & Allen, 2015; Wen et al., 2021). Forb diversity can number hundreds of species in remnant prairies (Howe, 1994), leading to greater pollinator abundance and richness (Kennedy et al., 2013). A comparison of CRP fields to non-CRP fields and roadsides in Michigan found that CRP land provided more diverse floral resources, which were associated with a greater abundance of both honey bees and wild bees (Quinlan et al., 2021). This evidence implies that declines in forb cover or diversity after contract expiration represent a decline in ecosystem services compared with enrolled CRP.

Noxious species have always been a topic of contention in CRP, as landowners perceive CRP plantings and poorly maintained fields as a weed source (Allen & Vandever, 2003). Our previous study in enrolled CRP fields found relatively low average cover of noxious grasses (≤20%) and forbs (<5%) (Vandever et al., 2021a). We find a similar pattern in expired CRP fields, where noxious grasses were entirely absent in 70% of fields, and even when present, occurrences had <20% cover 65% of the time (data not shown). Noxious forbs were found more frequently but were still absent in 43% of fields. There is regional variation in noxious forb presence in expired CRP, for example, expired CRP fields in the Corn Belt showed a higher tendency to harbor noxious forbs than enrolled fields, but the trend is reversed in the Northern Plains. The Corn Belt and Pacific regions, which have significantly different soils, climate, and CRP seed mixes, averaged the greatest noxious forb counts per field. Overall, the presence and species richness of noxious weeds in our study are lower than reported in other farmland-associated habitats such as old fields and roadsides (Freemark et al., 2002), indicating the value of CRP, including expired CRP fields, in reducing noxious weeds in the agricultural landscape.

Grass management on expired CRP fields persisting in CRP cover

Interestingly, our findings closely resemble ex ante predictions for post-CRP land use nationally (Roberts & Lubowski, 2007; Skaggs et al., 1994) and in South Dakota (Janssen et al., 2008), where ex-CRP fields were projected to remain in grass for livestock, hay, or wildlife habitat at 40%, 42%, and 39%, respectively (Table 2). Across all regions, we found an average of 41% of expired fields persist in CRP cover, and nearly half (49%) of those CRP fields were managed, mostly by grazing (29%) or haying (13%), supporting previous study findings that landowners intended to use the grass as forage. This is double what Vandever et al. (2021b) observed in a similar survey of enrolled CRP fields (15%), but permissible use of CRP for forage has timing, frequency, and intensity restrictions while under contract.

CONCLUSIONS

Since 1985, enrolled CRP fields have been used to protect environmentally sensitive lands, improve water quality, restore habitat, and avert soil erosion (Allen & Vandever, 2012). The ecological success of the CRP is tied to the number of cropland hectares it replaces with perennial cover, but with national estimates of 80% of expired CRP lands reverting to crops (Bigelow et al., 2020), there is a need to quantify the benefits accrued from land that remains in conservation cover. We found that 4 of 10 expired CRP fields persist at least three years post-contract in conservation cover with attributes comparable to enrolled CRP fields. The evidence that persisting CRP cover quality remains similar to that of enrolled CRP fields suggests environmental benefits may endure in the absence of rental payments. This persistence is largely overlooked when evaluating environmental benefits imparted by the program, as benefits typically are assessed only for the duration of the 10–15-year CRP contract. Our findings suggest that CRP benefits are currently underrepresented.

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CONFLICT OF INTEREST

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DATA AVAILABILITY STATEMENT

Data (Vandever et al., 2021b) are available from the USGS ScienceBase Catalog: https://doi.org/10.5066/P9XCC65W.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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