



Protecting our prairies: Research and policy actions for conserving America's grasslands

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ABSTRACT

Grasslands are among the most endangered ecosystems in the world. They supply vital resources for society, support an abundance of wildlife species, and store rich carbon reserves beneath their surfaces. Despite this, only a fraction of original grasslands in the United States now remains, and their rate of conversion to cropland has recently reaccelerated. This paper discusses opportunities that are immediately available to reduce the loss of U.S. native grasslands (i.e., prairie) and advance toward collective goals in grassland conservation. Potential solution-oriented actions include inventorying and monitoring remaining prairie, reconsidering public and private incentives for conversion and conservation, and establishing an industry-led moratorium on natural ecosystem loss. There is also a need among the engaged communities to develop unified messaging and a shared vision for grassland conservation in the U.S., such as “no prairie conversion” or “zero net loss of grasslands.” Additional tangible steps for action are outlined across the science, policy, and public-driven support arenas and offered for multiple stakeholder groups, including agricultural producers, policymakers, academics, and conservation organizations.

1. Introduction

Grasslands provide immense benefits to society including recreational space, livestock forage, and climate regulation services, among many others (Bengtsson et al., 2019; Lemaire et al., 2011) (Fig. 1). Yet in the United States, approximately half of all grasslands have been converted to cultivated cropland or other uses compared to their extent prior to European settlement (Samson and Knopf, 1996). As a result, remaining “native” grasslands—those that have never been planted or plowed and contain mostly original plant communities, referred to hereafter as prairies—are among the most endangered ecosystems in the world (Carbutt et al., 2017; Henwood, 2010; Hoekstra et al., 2005). These historic grasslands include a mix of grasses and forbs and provide irreplaceable habitat for wildlife, support an abundance of plant, animal, and microbial species, and store rich carbon reserves in their soils (Bakker and Higgins, 2009; Blair et al., 2014; Spawn et al., 2019).

Despite their importance, conversion of both prairie and non-native grasslands has reaccelerated in recent years. U.S. cropland area expanded in the late 2000s and 2010s, which broke a previous 30-year trend of crop area decline and reasserted pressure on all types of grasslands to be converted to crop production (Yu and Lu, 2018; Hendricks and Er, 2018; Lark et al., 2015). Regarding prairies in

particular, a recent case study in the midwestern U.S. found that the annual rate of conversion of these distinctive habitats more than quadrupled after 2008 compared to the previous 15 years (Lark et al., 2019). Surveys of farmers in the Northern Great Plains reported similar widespread prairie transformation (Wimberly et al., 2017). Given the magnitude of conversions, halting the ongoing loss of grasslands has been deemed the largest natural opportunity to address climate change in the U.S. agricultural sector and would also generate substantial co-benefits for the nation's waters, soils, and biodiversity (Fargione et al., 2018).

The prevailing driver of grassland conversion is the profitability of cropland relative to grassland agriculture (Claassen, 2012; Wang et al., 2017). When crop prices are high, conversion rates are amplified as returns on cropland increasingly outweigh the costs and risks associated with plowing new land. Once prairie is converted, however, the transformation is permanent, and its functionality may never return to its pre-cultivated state (Dodds et al., 2008; Isbell et al., 2019). Robust counterincentives are thus necessary to withstand undulations in market pressures and preserve remaining prairie across generations.

Protecting prairies and grasslands is imperative, and the time to act is now. The current lull in crop prices provides ideal conditions to pursue conservation investments that are more difficult and costly

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Fig. 1. Examples of grasslands from across the United States. U.S. grasslands vary by location and type, and include those managed for wildlife, livestock, recreation, or other uses, as well as unmanaged systems. Grasslands are characterized by predominantly herbaceous vegetation like grasses and forbs and can contain a mixture of native and/or introduced species. In this paper, the term “prairie” is used to refer to the subset of grasslands that have never been planted or plowed and contain mostly original plant communities, of which the top two photos are likely examples. All photos are from the USGS (Soulard et al., 2000).

when farm revenues are high and which better support agricultural livelihoods during periods of downturn (Powell, 2015). At the same time, recent innovations in environmental governance have created new opportunities to establish partnerships and collaborate on conservation.

This paper proposes immediately available actions to help surmount the drivers of grassland conversion and protect prairies across the U.S

(Fig. 2). These actions are organized across the science, policy, and public-driven support domains. Within each, a priority or emerging approach is described first, followed by a collection of additional or more well-established activities. Lastly, options for a community-wide vision for grasslands are discussed. This article thus serves as a draft blueprint to advance prairie protection and stimulate the exchange of ideas and tactics among those interested in grassland conservation.

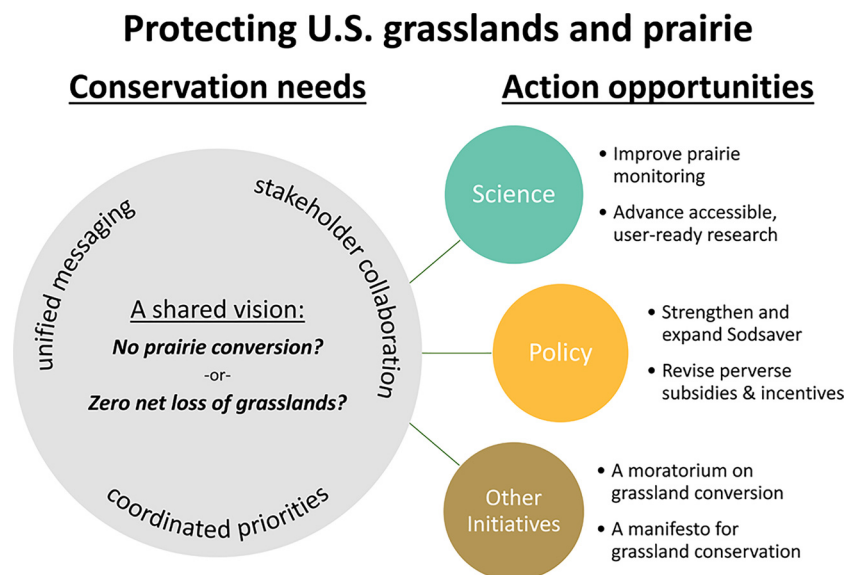


Fig. 2. Overview of opportunities to protect U.S. grasslands and prairie. Example actions are organized across the science, policy, and public driven support domains. A shared vision supported by the conservation community could bolster efforts.

2. Science and research opportunities

There are several science-based needs and opportunities to protect prairies, many of which support efforts within the policy and public-driven support domains. A critical first step is to improve the characterization and monitoring of remaining prairie sites to improve baseline knowledge. Currently, there is no spatially explicit nationwide register of native prairie in the U.S. This lack of data limits creation and improvement of policies and initiatives to conserve these lands. On state and regional levels, organizations have mapped and assessed remaining prairie (Bauman et al., 2016; Horton, 2010), and these efforts have made possible broader conservation planning and assessment (Gage et al., 2016; Minnesota Prairie Plan Working Group, 2011; Wimberly et al., 2018). Nationally, there is a need for better geospatial data on prairie locations and their quality. This would enable tracking of conversion, study of drivers of change and the effects of prairie loss, and evaluation of conservation outcomes so that more effective approaches may be designed.

Several opportunities are now available to work towards this goal. To develop a nationwide inventory of prairies, long-term remote sensing products can identify grasslands that have not been cultivated for the past four decades. Parcels so identified can serve as the starting point for further investigation. An example of this approach is shown in Fig. 3, where data from the USGS National Land Cover Database for 1992–2016 was combined with recent land use from the 2008 to 2017 Cropland Data Layer to identify potentially intact grasslands that have not been planted, plowed, or otherwise improved for at least 25 years (Boryan et al., 2011; Yang et al., 2018). Such maps could be further integrated with longer-term satellite (Sleeter et al., 2013; Zhu et al., 2016), landscape modeling (Comer et al., 2018), or cropping history data (Bauman et al., 2016). Emerging efforts to differentiate native

versus introduced grass species using remote sensing (Gholizadeh et al., 2019; Olimb et al., 2017) and the use of LIDAR technology to detect historical disturbances (Fisher et al., 2018) might also improve and refine identification of true native prairie. Crowd-sourcing and citizen science could supplement these efforts by verifying potential prairie sites (See et al., 2016).

Other notable research opportunities include synthesis of current studies on grasslands within the economic, environmental, and social science fields. Providing such data on both direct and indirect benefits of grasslands in the form of accessible, use-oriented reviews as well as summaries of ongoing research can help both policy and public efforts to promote the case for conservation. In addition, scientific assessment of conservation approaches and their outcomes (Blackman, 2013; Briske et al., 2017; Miao et al., 2016), along with careful consideration of their socio-ecological contexts (Auch et al., 2018; Haggerty et al., 2018) and the behavioral dimensions of grassland conversion (Sweikert and Gigliotti, 2019; Turner et al., 2014), can aid the design of more effective policies and conservation strategies.

Continuing the research into enhanced agronomic productivity of grasslands and into improvement of grassland products like pasture-raised livestock (Weber et al., 2008; Xue et al., 2010) and the selective harvest of biomass for cellulosic biofuels (French, 2019; LeDuc et al., 2017; Robertson et al., 2017; Tilman et al., 2006) can help protect grasslands by increasing the economic value of their provisioning services. Similarly, further developing and understanding the ability of grasslands to provide an abundance of regulating, cultural, and supporting services including pollination, wildlife habitat, and ecotourism can help promote grasslands' lesser-appreciated roles (Hungate et al., 2017; Iovanna et al., 2017; Powell et al., 2018). The need to understand the resilience of these ecosystems and their functions under climate change will also become increasingly important (Grand et al., 2019;

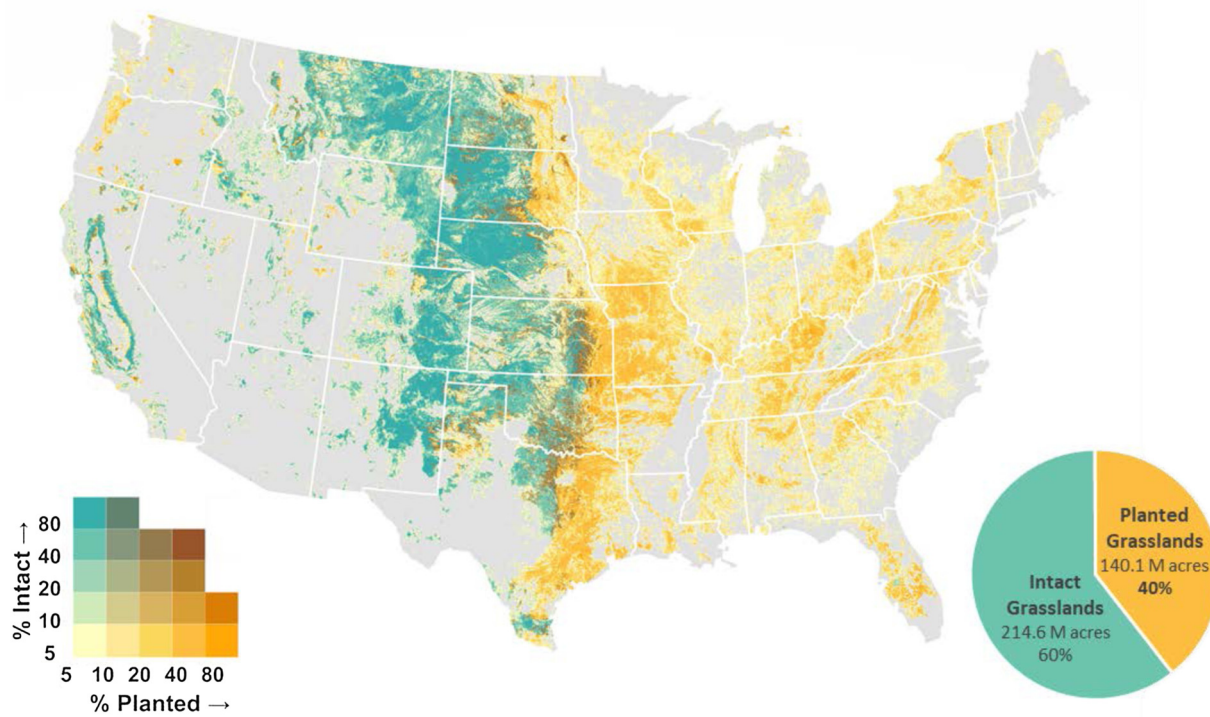


Fig. 3. Map of potentially intact grasslands versus grasslands that have been planted or improved. Potentially intact grasslands were identified as those not planted, plowed, or otherwise improved for at least 25 years according to data from the USGS National Land Cover Database and the USDA Cropland Data Layer. There were approximately 354.7 million acres of grasslands remaining in the U.S. as of 2017, of which roughly 60 % were potentially intact.

Isbell et al., 2015). Collectively, advancing accessible research on grasslands and the value of their ecosystem services can help raise their public profile and support the creation of science-based conservation strategies.

3. Policy opportunities

Federal policies affect the incentives and regulations for converting grasslands to other uses and thus provide key opportunities to aid protection of prairies. Currently, publicly funded crop insurance encourages the conversion of prairie to cropland by subsidizing the risk that would otherwise be associated with cultivating these lands (Claassen, 2012; Miao et al., 2016). One program that seeks to directly ameliorate this effect is Sodsaver, which reduces crop insurance subsidies for the first four years on any cropland converted from prairie. However, this protection applies only to the six states that surround the prairie pothole region. A proposal to expand Sodsaver nationwide (Thune et al., 2017), which was mostly left out of the 2018 Farm Bill, should be revisited, strengthened, and fully included in future policy efforts.

Other federal policy provisions similarly try to reduce the ingrained incentives for converting land. For example, to be eligible for Farm Bill crop insurance programs, producers must conform to conservation compliance requirements of Swampbuster (also known as Wetland Conservation) and Sodbuster (also known as Highly Erodible Land Conservation) (Claassen et al., 2017a; Rude and Weersink, 2018). For an estimated 2.6 million acres of current wetlands and 12 million acres of highly erodible grasslands, the financial incentives to comply with these programs may outweigh the production value from cultivating these sensitive areas, thus discouraging their conversion (Claassen et al., 2017a). However, the effectiveness of these motivations and of detecting violations is unknown other than that severing compliance requirements would decrease any potential impact they might have. As such, if aiming to protect grasslands, these policies should likely be maintained but pursued with further evaluation and toward augmentation of their effects.

In contrast to Sodsaver and conservation compliance, conservation easements and other programs aim to reward protection rather than discourage conversion. Due to uncertainty about the “additionality” of their protection, however, easements are considered to provide only modest reductions in grassland conversion, though the impact could be improved by targeting grasslands that are most vulnerable to cropland expansion (Claassen et al., 2017b; Savage et al., 2014). Other incentive programs like Conservation Reserve Program (CRP) Grasslands (USDA, 2018a), which supports maintaining grasslands as grazing lands, and the Conservation Stewardship (CSP) and the Environmental Quality Improvement (EQIP) Programs, which can help cost-share grazing operational expenses and improvements, also support keeping grasslands on the landscape (Augustine et al., 2019). All these programs are conducive to prairie conservation and ideally should be expanded. Enhanced livestock insurance and other policies to improve ranching profitability and its competitiveness with crop production would also help maintain prairie (Brunson and Huntsinger, 2008; Davidson, 2016; Hendrickson et al., 2018).

Unfortunately, incentive-based conservation programs require increased funding in order to scale their influence, and therefore their potential impact depends largely on receiving greater allocation of financial resources. Alternatively, by reducing the current perverse incentives to convert land, provisions like Sodsaver and conservation compliance or reform of existing crop insurance may be able to contribute additional grassland protection without additional funding nor diversion of resources from other conservation programs. Furthermore, these approaches may be able to avoid common concerns about conservation policies such as increased regulatory costs or loss of value for existing landowners. For instance, expanding Sodsaver is projected to save more than \$50 million over ten years (Thune, 2017), and these

savings could be redirected to reward-based programs and the landowners who participate in them, thereby maintaining the net benefits to stakeholders while substantially reducing antithetical incentives.

There are also policy opportunities outside of traditional Farm Bill programs as well within local, state, and federal agencies. As part of the U.S. Renewable Fuel Standard, for example, enforcement of statutory land protections designed to make areas converted from prairie to row crops ineligible for biofuel feedstock production could help curtail conversion (Wright et al., 2017). More broadly, no net loss of grasslands could be established as an interagency goal at the federal level, analogous to that which exists for wetlands. Further, Section 404 of the Clean Water Act or other legislation could be expanded to require compensatory mitigation of adverse impacts of grassland loss. Such a policy would mirror the required “mitigation banking” of wetlands, where restoration, establishment, enhancement, or preservation is required for jurisdictional wetland and stream modification (US EPA, 2015). In lieu of these comprehensive federal efforts, state governments and their wildlife agencies could pursue similar, more targeted policy actions.

At local scales, county and municipal planning authorities can discourage exurban growth and encourage higher densities and infill development to reduce grassland conversion pressure from peripheral sprawl. Even though the amount of grassland converted directly to developed land in the U.S. over the last decade was roughly an order of magnitude smaller than the amount converted to cropland (USDA, 2018b), the growth of built-up and developed areas remains an ongoing significant threat (Carter et al., 2019; Reeves et al., 2018). Continued development may also be adding indirect pressure on grasslands through the displacement of existing cropland (Emili and Greene, 2014; Lark et al., 2019; Sylvester et al., 2016).

Across all levels of administration, policy makers should look toward tribal governments and Indigenous communities as partners in conservation and leaders in the stewardship of natural lands. Despite centuries of tumultuous federal policy, sovereign tribal nations have maintained millions of acres of grasslands as intact and ecologically diverse habitat, including roughly 10 % of the unplowed grasslands in the Northern Great Plains (First Nations Development Institute, 2018b). The knowledge and values that anchor many Native American cultures, like a shared responsibility to care for the land and an obligation to do right by the next generation (First Nations Development Institute, 2018a), are central to grassland conservation. Further supporting and incorporating these principles within grassland policies and initiatives as well as expanding collaborations with tribal citizens and organizations represent important opportunities to cooperatively improve prairie protection.

4. Public-driven support

There are a wide variety of additional opportunities to further grassland conservation outside the research and policy domains. A commonality of many of these approaches is that they either generate or depend upon public support. Example opportunities range from corporate initiatives within public-facing companies, to targeted communications by conservation organizations, to individual community member actions.

Establishment of an industry-led moratorium on the conversion of natural ecosystems in the U.S. is a particularly primed and emerging opportunity to curb prairie loss. Voluntary pledges by corporate entities to improve the sustainability of their supply chains are increasingly common and hold promise to reduce undesirable environmental outcomes (Lambin et al., 2018). For example, Brazil’s soy moratorium, an agreement by major grain traders to refuse to buy soybeans grown on recently deforested land, has helped to alter producer behavior and decrease Amazon deforestation in soy supply chains (Gibbs et al., 2015). In the same way, an agreement to preserve natural ecosystems among major grain processors, biofuel refiners, and animal production

facilities in the U.S. could alter market incentives and help reduce conversion of the American prairie to agriculture.

To encourage such an agreement, there is a need to expand public awareness and support for prairies. Corporate actions to improve sustainability frequently arise as a response to public expectations or to mitigate reputational risk, and recent exposés and media reports have aimed to heighten this attention and pressure (Unger, 2017; Von Reusner, 2017). Public policy efforts are similarly driven by constituent support, which relies on public understanding and engagement. To further promote these processes stakeholders may consider uniting in the drafting of a conservation manifesto or declaration for North American grasslands—a collective statement of ecosystem value and importance emulating that of the *Cerrado Manifesto* for South American savannah (FAIRR, 2017; World Wildlife Fund, 2019). Likewise, a shift in the New York Declaration on Forests—the United Nations-led effort to end deforestation—from its current focus on natural forests towards that of all natural ecosystems could encourage participating entities to extend their protections to prairies as well.

Additional strategic communication opportunities for grassland stakeholder organizations include creating public service announcements about the value of grasslands and prairies, branding organizational initiatives around grassland conservation, and even renaming entire agencies to heighten recognition. The U.S. Forest Service, for example, could become the U.S. Forest and Grasslands Service—a change that would better align the agency’s title with its scope and that is seemingly more feasible given other recent shifts in USDA organization and naming.

Lastly, consumers can financially support grassland-based products that have sufficient traceability or markets for grassland-based ecosystem services. To expand the effect of ecosystem services payments, programs could carefully consider allowing the stacking, bundling, or side-by-side grouping of ecosystem service credits (Banerjee et al., 2013; Blackburn et al., 2017; Robertson et al., 2014). This would require comprehensive accounting of supplied services through additional research but could potentially better reward producers and landowners for the multitude of benefits that their stewardship of grasslands provides. Ultimately, for individuals or organizations looking to advance the conservation of grasslands, any action that garners public interest, advocacy, or financial aid for grasslands can help improve protection.

5. Setting a common goal and priorities

Pressing environmental problems require actions to be prioritized such that limited resources can be used to the greatest effect. However, prioritization requires value-based decisions and clearly defined goals. Collectively setting a common vision across the grassland conservation community would assist this process and enable stakeholder organizations to develop unified messaging, improve collaboration, and more efficiently implement actions across sector lines.

Two desirable visions for the grassland conservation community to consider are first, “no prairie conversion,” and next, “zero net loss of grasslands.” The first is an aspiration of no further native grassland loss—i.e. total prevention of any future conversion of prairie to cropland, development, or other uses. While so absolute a benchmark may be unattainable, it establishes a clear objective that is valuable for prioritization. It is simple to understand, straightforward for policy alignment, and its ambitious nature may help inspire dedicated actors and stakeholders.

The more realistic goal may be “zero net loss of grasslands,” where the aim is to maintain the current total area of natural grasslands—including true native prairie, restored prairie, and other biodiverse grasslands that are functioning in a nearly native state or possess a valuable conservation role. Within this framework, the loss of natural grasslands in one area can be compensated by adding high quality natural grasslands in another. This approach acknowledges the

potential contribution of restoration efforts in maintaining balance in ecosystem services and provides greater leeway in how conservation goals are achieved (Dodds et al., 2008; Possingham et al., 2015). It also accommodates protection of non-native locations of high ecological value (e.g. endangered species critical habitat or highly erodible grasslands) that may offer greater environmental benefits than some native grasslands. Tradeoffs of the “zero net loss” approach are that it provides less guidance for prioritization efforts because it does not give clear preference to any single grassland type, nor does it inherently establish how or by whom eligible grasslands should be defined. Either of the proposed visions—no native conversion or zero net loss—offer desirable outcomes for grassland conservation as they would represent a freeze in the continued irreversible loss of prairie or a reversal in the current trend of net grassland area decline.

Fortunately, such goals need not be mutually exclusive. Multiple targets could be combined into a single conservation framework, such as one that establishes different zones of no native conversion and zero net loss based on expert guidance and simplified biophysical criteria. Any sector that leads in this type of goal setting can help set a precedent for others. For example, a vision for grasslands from the conservation community could be easily adopted by corporations and industrywide associations, which often look to expert societies for guidance. Likewise, federal policy such as Sodsaver can signal to the agricultural industry that prairies are a priority and help align producers and incentives around shared conservation goals. Any goal or vision should also be considered in the context of other proposals, such as the historic ‘Buffalo Commons’ (Popper and Popper, 1999) or modern movements (Huffman, 2019), and reviewed over time in response to changing values, new understanding, or observed efficacy.

A vision for grassland conservation will help define priorities for action, though some initial steps are appropriate regardless of ultimate goals and can illuminate the goal-setting process. For one, improved monitoring of prairies and conversion would enable the focusing of policy and protection efforts on those locations of highest need. Because much more prairie exists than can be permanently protected, it is also immediately sensible to reduce the policy and market incentives that drive prairie conversion—e.g. via Sodsaver or a conversion moratorium. Reducing the incentives to convert grasslands to other uses also lessens the costs associated with attaining protections or perpetual easements. By this means, a greater number of parcels can be protected. Thus, while many efforts can benefit grasslands, the priorities offered here leverage multiple synergies and co-benefits.

Will implementing these initial steps halt the conversion of prairie? Likely not. Monitoring by itself does nothing to slow conversion, Sodsaver may currently alter incentives by too little to be effective (Claassen et al., 2018), and previous supply-chain agreements have had mixed results or only partly contributed to improved outcomes (Lambin et al., 2018). However, these actions establish the conditions, systems, and awareness needed to make further progress in this endeavor. While alone they are not enough, together they represent critical strides needed to advance conservation.

6. Conclusion: a role for all

Stakeholders from all sectors can and must play a role in protecting prairies. Researchers and the academic community have a clear opportunity and a responsibility to advance the science and public understanding of grassland ecosystems, their value, and effective methods for their protection. Furthermore, scientists can increase communication with policy makers and the public to support efforts in those spheres. Policy makers and those involved in influencing policy play a pivotal role in refining governmental incentives for or against grassland conversion, as it is often legal and financial policy decisions that have the greatest influence on conservation actions and outcomes. Agricultural producers are at the heart of grassland conservation, and little can be accomplished without their commitment and support.

Furthermore, the producers who champion grassland conservation are often the most effective advocates for any proposed policy or action. Lastly, any member of the public can play a role in the process. Enjoying grasslands for recreation adds value to their preservation, which in turn helps foster protection for these treasured ecosystems. Individuals can also vote for grasslands every day, both literally and figuratively, by supporting politicians that favor grassland preservation and by preferentially purchasing or supporting products that do the same.

We are at an opportune time to protect what remains of the American prairie and preserve its heritage for future generations, and the urgent climate and biodiversity crises obligate immediate action on this front (IPCC, 2018; IPBES, 2019). Enhancing prairie monitoring is a crucial first step to enable further efforts. Reducing the federal incentives to convert prairie would generate time and funding to implement more permanent protections. An industry-led moratorium on the destruction of natural ecosystems could quickly reduce demand-side drivers of land conversion while other solutions are developed and deployed. Within each of these actions every member of the stakeholder community will find a role, and success in prairie protection will be greatest if all parties are committed and engaged. By coming together to develop a unified vision for America's grasslands and coordinating efforts across stakeholder groups, we can achieve a more robust outcome and future for these critical ecosystems and all who depend on them.

CRediT authorship contribution statement

Tyler J. Lark: Conceptualization, Investigation, Visualization, Writing - original draft, Writing - review & editing.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.landusepol.2020.104727>.

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