Opportunities and challenges to waterfowl habitat conservation on private land

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Abstract

The future of North American waterfowl populations is inseparably tied to management of private land in the United States (U.S.) and Canada. Private land ownership in major waterfowl habitat regions such as the Northern Great Plains, Lower Mississippi Alluvial Valley, Gulf Coast and California's Central Valley generally exceeds 90%, with agriculture being the dominant land-use in these regions. Planning and implementing avian conservation on private land in a strategic manner is complicated by a wide array of social, economic, political, administrative and scientific-technical issues. Prominent among these challenges are changing economic-drivers influencing land-use decisions, integration of bird conservation objectives at various scales, reconciling differences in wildlife habitat objectives between bird conservationists and land-users, administrative impediments to conservation planning and implementation, technology and scientific information gaps, and inadequate personnel capacity and financial constraints to effectively plan and deliver conservation. Given these unprecedented challenges to waterfowl habitat conservation, the need for effective public-private partnerships and collaboration has never been greater. With the goal of advancing collaborative waterfowl conservation on private land, the broad goals of this paper are to: (1) increase stakeholder awareness of opportunities and challenges to waterfowl habitat conservation on private land, and (2) showcase examples of collaborative efforts that have successfully addressed these challenges. To accomplish these goals this paper is organised into three sections: (1) importance of agricultural policy to private land conservation, (2) habitat potential on agricultural working land, and (3) strategic approaches to waterfowl habitat conservation. U.S. Department of Agriculture conservation programmes authorised through the Conservation Title of the 1985 Food Security

Act (hereafter, Farm Bill) and subsequent farm bills have provided unequalled potential for waterfowl habitat conservation on private land. Passage of the 2014 Farm Bill provides unique opportunities and alternative approaches to promote working land conservation strategies that are economically profitable and wildlife-friendly. However, reductions in private land conservation funding will require more effective targeting to maximise resource benefits. For example, in addition to conserving and restoring traditional habitats, we must work collaboratively to identify and promote working agricultural systems that are waterfowl-friendly and provide environmental services in addition to the production of food and fibre. Cultivation of rice *Oryza sativa* and winter cereals described below potentially represent two such situations. For over a quarter of a century the North American Waterfowl Management Plan (NAWMP) has served as a transformative model of partnership-based, landscape-scale conservation (DOI & EC 1986). Whereas the original plan and subsequent updates established abundant waterfowl populations as the plan's ultimate goal, the 2012 NAWMP revision seeks a formal integration of these objectives with societal needs and desires (DOI *et al.* 2012). The current plan recognises the critical importance of private working land; however, details are lacking, especially with respect to strategic targeting of conservation on private land. For example, the development of truly strategic plans to target waterfowl conservation on private land will require estimates of the benefits of various conservation alternatives, conservation costs, and the threat of habitat loss or conversion. We suggest development of spatially explicit models that inform landowners and managers at the field-level about the cost effectiveness of conservation and land-use options is critically needed.

Key words: agriculture, conservation, economics, environmental services, Farm Bill, habitat, private land, waterfowl.

The future of North American waterfowl populations is inseparably tied to the management of private land in the United States (U.S.) and Canada. Approximately 70% of the conterminous U.S. is held in private ownership, including > 90% of the land area in major waterfowl habitat regions such as the Northern Great Plains (NGP), Lower Mississippi Alluvial Valley (LMAV), Gulf Coast, Playa Lakes and California's Central Valley (Nickerson *et al.* 2011). Agriculture is the dominant land-use in these regions, with ~52% of the U.S. or 900 million acres (365 million ha) managed as cropland, pastureland or rangeland. Thus, the overwhelming majority of land-use decisions affecting waterfowl habitats are made by agricultural producers responding to a multitude of factors with various social and economic motivations.

The contemporary setting in which waterfowl managers operate is complex and continuously changing. Global factors associated with an increasing human population and natural resource exploitation and development have far-ranging impacts on land-use decisions, and ultimately on the availability and suitability of private land as waterfowl habitat. Competition in global commodity markets, water demands, current federal agricultural/energy policy and technological advancements in agriculture are fuelling agricultural intensification and expansion (Sohl *et al.* 2012). Moreover, the United Nation's Food and Agriculture Organization (FAO) projects that world food production will need to increase by 70% by 2050 to meet food demands for an estimated 9.1 billion humans (FAO 2009). The FAO anticipates 80% of production increases will come from increased yield and 20% from expansion of arable land; however, declines in the rate of growth in yields of major cereal crops from 1960 (3.2% per year) to 2000 (1.5% per year) suggest that FAO forecasts of production increases may be overly optimistic and additional land may need to be brought under cultivation.

Since passage of the 1985 Food Security Act (hereafter, Farm Bill), U.S. Department of Agriculture (USDA) conservation programmes authorised through the Conservation Title of the Farm Bill have provided unequalled potential for waterfowl habitat conservation on private land. This complex, multi-billion dollar legislation is typically reauthorised by Congress every five years and covers a broad range of programmes for commodities, crop insurance, farm credit, nutrition, forestry, energy and conservation. Recognised as the single largest private land conservation initiative in the U.S., the farm bill provides critical funding for important wildlife habitat, soil and water conservation programmes (Heard *et al.* 2000). Amendments to the original Farm Bill in 1990, 1996, 2002, 2008 and 2014 have retained and expanded conservation provisions such that there are now 13 agricultural conservation programmes with a combined funding level of $28.1 billion for 2014–2018 (CBO 2014). No other state or federal programme provides a comparable level of investment or impact for conservation initiatives on private land.

The consideration of fish and wildlife (hereafter, wildlife) in the delivery of conservation programmes was elevated in the 1996 Farm Bill. Wildlife currently is an explicit goal for the Conservation Reserve Program (CRP), the Environmental Quality Incentives Program (EQIP), and components of the Agricultural Conservation Easement Program (ACEP). Because of federal budget constraints and increased demand for agricultural commodities, the national cap on CRP acreage has been reduced from a peak of 45 million acres (18.21 million ha) in 1990 to 27.5 million acres (11.13 million ha) in 2014 and 24 million acres (9.71 million ha) in 2017 (Cuzio *et al.* 2013; Ducks Unlimited, unpubl. data). Declines in CRP acreage were only partially offset by increases in the size of the wetland easement programme (formerly the Wetland Reserve Program, WRP) from 2.125 to 3 million acres (0.86 to 1.23 million ha) through 2012. The attention of wildlife conservation groups has been focused on land retirement programmes in spite of the fact that farm bill's working lands programmes, such as EQIP, the

Agricultural Land Easement (formerly the Grassland Reserve Program, GRP), the Conservation Stewardship Program (CSP), and a "working lands" CRP concept, could receive greater funding and impact a far greater area. Consequently, the full potential for improving consideration of waterfowl and other wildlife in land-use decisions has yet to be realised.

Changes in climatic conditions (*e.g.* severe alterations in regional temperature and precipitation patterns), correlated to increasing levels of CO_2 and other greenhouse gases in the atmosphere, are already affecting the nation's natural resources, people, communities and economies that depend on healthy, functional ecosystems and the plants and animals that characterise them (NFWPCAS 2012). Uncertainties regarding the effects of climate change on ecosystems and associated biota, and on current land uses, pose significant challenges to both agricultural producers and waterfowl habitat managers.

Planning and implementing waterfowl habitat on private land is complicated by a wide array of social, economic, political, administrative and scientific/technical issues. Prominent among these challenges are how changing economic drivers influence land-use decisions, integration of bird conservation objectives at various scales, reconciliation of differences in wildlife objectives between bird conservationists and land-users, administrative impediments to conservation planning and implementation, technology and scientific information gaps, and constraints on the personnel and finances required to plan and deliver conservation effectively.

In the face of unprecedented challenges to waterfowl habitat conservation, the need for effective public-private partnerships and collaboration has never been greater. With the goal of advancing collaborative waterfowl conservation on private land, the broad aims of this paper are to: (1) increase stakeholder awareness of opportunities and challenges to waterfowl habitat conservation on private land, and (2) provide examples of collaborative efforts that have been successful in addressing these challenges. To accomplish these aims we have organised the paper into three sections: (1) importance of agricultural policy to private land conservation, (2) habitat potential on agricultural working land, and (3) strategic approaches to waterfowl habitat conservation.

Importance of agricultural policy to private land conservation

European settlement of North America beginning in the eighteenth century produced waves of change in land forms and vegetation (hereafter, landcover). Suitability of land for agriculture greatly influenced settlement patterns in North America (Maizel *et al.* 1998). As expansion rapidly proceeded westward during the 1800s and early 1900s, farms were created at the population frontier; areas too wet or too dry were farmed later when drainage or irrigation was possible. Other areas with poor climate, steep slopes, or soils unsuitable for use as cropland, grazed pasture or hay fields, were either farmed unsuccessfully or never farmed.

The influence of agriculture on pre-settlement landcover is especially evident in the fertile Great Plains region of North America. The vast grasslands, shrublands and savannas that characterise the region once represented the continent's largest ecosystem; however, conversion of grasslands to agricultural uses has been extensive, exceeding 99% in portions of the northern tallgrass prairie region of Iowa, Minnesota, eastern Dakotas and Manitoba (Samson & Knopf 1994; Noss *et al.* 1995). Associated with landcover change in the Great Plains came a concomitant change in communities of birds and other grassland-dependent wildlife. For example, dramatic declines in grassland bird species since the 1950s have been attributed to changes in the agricultural landscape of the region (Gerard 1995). Extensive loss and degradation of grasslands in the Great Plains resulted in its designation as one of the nation's most endangered ecosystems (Noss *et al.* 1995).

Wetlands in the Great Plains and other arable regions such as the LMAV and California's Central Valley have been similarly affected. Dahl (1990) reported that between the 1780s and 1980s, the U.S. (except Hawaii and Alaska) lost 53% of its original wetlands. In Canada, an estimated 40% of wetlands within the Prairie Pothole Region (PPR) have been lost to drainage since settlement (Millar 1989). Twenty-two U.S. states have lost > 50% of their wetlands, with California having the greatest wetland loss (> 90%, Dahl 1990). Long-term trends show freshwater emergent wetlands, especially forested wetlands, sustained the greatest loss of any freshwater wetland type (Dahl 2000). The rate of wetland conversion between the mid-1950s and 1970s was estimated at 458,000 acres/yr (185,400 ha/yr; Frayer *et al.* 1983). Extensive wetland losses occurred in the LMAV as bottomland hardwoods were cleared and drained for cultivation of agricultural crops. The rate of wetland losses slowed somewhat (to 290,000 acres/yr or 117,400 ha/yr) during the decade before the Emergency Wetlands Resources Act of 1986 was enacted to protect wetlands (Dahl 2000). The Act required the U.S. Fish and Wildlife Service (USFWS) to monitor the status and trends of wetlands and report details to the Congress at 10-year intervals.

The vast majority of inland wetland losses were due to agricultural conversion (Dahl 1990). The 1985 Farm Bill sought to stem further wetland losses by linking wetland conservation on agricultural land to the landowner's eligibility for USDA farm programme benefits, a provision commonly referred to as "Swampbuster". Similarly, Highly Erodible Land (HEL) provisions commonly referred to as "conservation compliance" and "Sodbuster" required producers who cultivated sensitive land to have fully implemented a USDA-approved conservation plan by 1985. Provisions for protection of highly erodible land and wetlands were retained in revisions to the farm bills through to 2008. While these provisions did not create wildlife habitat directly, they did, "… provide strong motivation for producers to apply conservation systems on their highly erodible land, to protect wetlands from conversion to croplands, and apply for enrolment in other USDA conservation programmes, especially the Conservation Reserve and Wetland Reserve Programs" (Brady 2005:5). Implementation of these provisions contributed to a reduction in soil erosion rates between 1981 and 2001 (Brady 2005). Under Swampbuster, during an era of declining wetland losses (*i.e.* 506,000 acres (205,000 ha) lost in 1992–1997 *vs.* 281,600 acres (114,000 ha) lost in 1997–2002), gross wetland losses due to agriculture declined from 26% during 1992–1997 to 18% during 1997–2002 (USDA NRCS 2000; 2013). Wetland restorations through other conservation programmes, especially CRP and WRP, resulted in net wetland gain on agricultural land in both 1997–2002 and 2002–2007, although the change during 2002–2007 was non-significant at the 95% confidence level (USDA NRCS 2013).

The contributions of farm bill programmes to waterfowl habitat conservation have been substantial (Heard *et al.* 2000). In the PPR, Reynolds (2000) estimated that between 1992 and 1997, the CRP contributed to a 30% improvement in duck production or 10.5 million additional ducks. Grassland birds likewise benefitted from the CRP in the NGP (Johnson 2000) and Midwest (Ryan 2000), as did early successional bird species (*e.g.* Northern Bobwhite *Colinus virginianus*) in the southeast U.S. (Burger 2000).

While farm bill provisions have helped discourage grassland and wetland conversion to cropland and provided incentives for the establishment of perennial cover on highly erodible land, some producers have continued to convert native grasslands to croplands. For example, Stephens *et al.* (2008) estimated that 90,300 acres (36,540 ha) of native grassland were converted to croplands in the Missouri Coteau region of North and South Dakota during 1989–2003. Fuelled by demand for starch-based ethanol, development of drought-resistant crops, expiration of conservation contracts, and increasing commodity prices, wetland and grassland conversion has accelerated (Wright & Wimberly 2013). High commodity prices have made farmers less reliant on USDA commodity support programmes and effectively neutralised disincentives for habitat conversion. Specifically, new risk management tools provided by federally-subsidised crop insurance, which protect those farming marginally productive land from economic losses, contradict other policies aimed at conserving grasslands or protecting highly erodible land (Wright & Wimberly 2013). The annual wetland loss rate in the PPR of North and South Dakota (2001–2011) was 0.35% or 15,377 ac/yr (6,223 ha/yr, Johnston 2013). The rate of grassland conversion in the Western Corn Belt of North Dakota, South Dakota, Nebraska, Minnesota and Iowa from 2006 to 2011 ranged between 1 and 5.4% annually with a nearly 1.31 million acres (530,000 ha) net decline in grass-dominated land cover (Wright & Wimberly 2013). Since the mid-1980s, federal and provincial programmes in prairie Canada encouraged conversion of marginal cropland to perennial grassland (typically hay fields and pasture), and removal of grain transportation subsidies in the mid-1990s further encouraged conversion to grass-based agriculture (Riemer 2005). However, despite overall increases in grassland during the past 25 years, the absence of native grassland and wetland protection policies in prairie Canada have resulted in declines in native grassland and wetlands of 10% and 5%, respectively, during 1985–2001 (Watmough & Schmoll 2007).

The lack of effective disincentives for habitat conversion in current U.S. and Canadian agricultural policies, generous risk management tools and ongoing conversion of grasslands and wetlands to croplands pose a significant threat to waterfowl populations in the PPR. For example, 1.4 million temporary and seasonal wetlands of < 1 acre in size, located in crop fields in the eastern Dakotas and northeast Montana, are "at risk" of drainage without effective Swampbuster protections (R.E. Reynolds and C.R. Loesch, unpubl. data). Reynolds and Loesch (unpubl. data) further indicated that loss of these wetlands would reduce the current breeding habitat capacity by about one-third for the five most common breeding ducks in the region. Reversing trends in habitat loss in important waterfowl regions will be extremely challenging and if current rates of habitat conversion to croplands continue and habitat protection rates remain at current levels, regional habitat conservation goals and ultimately waterfowl population goals will need to be reduced (Doherty *et al.* 2013).

The 2014 Farm Bill: reforms, challenges and opportunities

The one-year extension of the 2008 Farm Bill expired on September 30, 2013, resulting in a temporary lapse in funding for farm bill programmes. Passage of a new farm bill was delayed over a year by political gridlock, as Congress debated how to achieve cost savings and streamline programmes to reduce the federal deficit. Finally, on 7 February 2014, the President signed into law a new farm bill called the Agricultural Act of 2014 (hereafter, 2014 Farm Bill) that reauthorised several important conservation programmes and enacted other policy reforms aimed at conserving critical grassland and wetland habitat on private land. In addition to the challenges and delays of getting a new farm bill passed, substantial funding reductions were made to conservation programmes estimated at ~$6 billion over the next 10 years (CBO 2014). The 2014 Farm Bill also included major reforms to commodity programmes, new crop insurance options and consolidated conservation programmes. Given the importance of farm bill programmes and agricultural policy to continental waterfowl populations, resource managers and conservation planners should be prepared to adapt, optimise and deliver targeted conservation programmes much more efficiently with significantly less federal financial resources from 2014–2018.

Re-linking conservation compliance to crop insurance

For nearly 30 years, U.S. agricultural producers have agreed to minimise impacts to HEL and Swampbuster-protected wetlands in exchange for farm programme benefits primarily offered through Title I commodity (*e.g.* direct payments, countercyclical payments, *etc.*) and other farm credit supports. These "conservation compliance" provisions were first established in the 1985 Farm Bill to help reduce adverse effects USDA programmes were having on environmentally-sensitive land by reducing soil erosion on HEL and slowing wetland conversion on agricultural lands. Current law allows agricultural producers to farm through wetlands during dry periods and still retain farm programme benefits provided they do not modify the hydrology of impacted wetlands, or if modifications were undertaken after 23 December 1985 steps must be taken to mitigate for equivalent wetland functions and values. Conservation compliance provisions also disallow USDA loans or payments to producers growing annually-tilled commodities on HEL without a soil conservation plan having first been approved by the Natural Resources Conservation Service (NRCS). According to the USDA, ~100 million acres (40.5 million ha) or 25% of all cropland in the U.S. is considered highly erodible (Claassen 2012). With assistance from USDA, producers have developed conservation plans on over 140 million acres (56.7 million ha) of farmed land and reduced soil erosion on HEL by nearly 40% or 295 million tons of soil per year (Claassen 2005).

From 1985 to 1995, conservation compliance requirements were also tied to federal crop insurance benefits, but Congress decoupled these requirements from crop insurance in the 1996 Farm Bill. A large increase in crop insurance enrolment from 99.7 to 202.6 million acres (40.3 to 82 million ha) occurred in 1994–1995 following the passage of the Federal Crop Insurance Reform Act of 1994; however, ~22 million fewer acres (8.9 million ha) were insured in 1996, suggesting that decoupling conservation compliance had little impact on crop insurance enrolment. For the past three decades, conservation compliance has been very effective at conserving farmed wetlands on private agricultural land (Brady 2005). According to the USDA, up to 3.3 million acres (1.3 million ha) of vulnerable wetlands within or adjacent to cropland were not drained because of conservation compliance policies enacted since the 1985 Farm Bill (Claassen 2012). As USDA works to implement newly authorised farm bill programmes during 2014–2018, it will be important to retain these effective conservation measures.

The 2014 Farm Bill eliminates several Title I (*e.g.* direct payments and counter-cyclical payments) programmes tied to conservation compliance provisions in the farm bill. Many groups within the conservation community advocated the need to reconnect these provisions to federal crop insurance benefits (Title XI). In recent years, many producers have opted out of Title I benefits completely, thereby allowing them to convert wetlands for agriculture, while still receiving federal crop insurance benefits without penalty. Since 1994, federal crop insurance has evolved to become the most important and highest-funded safety net and risk management tool for agricultural producers, particularly in the NGP. Indeed, estimated federal outlays for the crop insurance programme will total nearly $90 billion over the next 10 years (CBO 2014). Re-linking conservation compliance provisions to crop insurance premium subsidies would help ensure that farmers maintain a strong safety net, while ensuring long-standing protections for HEL and farmed wetlands remain in effect. After being decoupled from crop insurance since 1996, the 2014 Farm Bill reconnected conservation compliance provisions for farmed wetlands and HEL to federal crop insurance benefits. These provisions will provide critical protections for millions of farmed wetlands on agricultural land through 2018; however, USDA interpretation and implementation of this new policy will be a key factor in ensuring its effectiveness.

Unlike the U.S., Canada does not maintain similar federal wetland protection policies for wetlands on private land; consequently, current laws vary significantly among provinces and territories (Lynch-Stewart *et al.* 1993). In Canada, provinces have primary jurisdiction over wetland protection policies within their boundaries, whereas the territories generally share authority among federal, territorial and native agencies. However, Canada does maintain fairly robust wetland protection policies on federal Crown land and Environment Canada is the primary agency responsible for coordinating and implementing these policies (Government of Canada 1991). Generally, provincial laws cannot bind the federal Crown, which creates regional differences and geospatial challenges when trying to implement and enforce wetland protection policies on private land across a broad landscape. Current provincial wetland protection policies are being developed and/or implemented in Alberta, Saskatchewan, Manitoba, Ontario, New Brunswick and Nova Scotia. However, these regional and provincial disparities create a significant challenge to wetland conservation for waterfowl on private land in Canada.

Sodsaver: slowing native prairie conversion to croplands

Temperate grasslands are one of the most imperilled ecosystems on the planet, yet maintain one of the lowest habitat protection rates of any major terrestrial biome (Hoekstra *et al.* 2005). Native grasslands that support diverse wildlife populations and grass-based agriculture are being converted to cropland at unprecedented rates across many parts of North America. During 2012, nearly 400,000 acres (161,900 ha) of land with no prior cropping history was converted to crop production across the U.S., including >54,876 acres (22,207 ha) in Nebraska, > 27,128 acres (10,978 ha) in South Dakota, >26,395 acres (10,682 ha) in Texas and >24,961 acres (10,101 ha) in Florida (USDA FSA 2013). At current conversion rates, over half of the native prairie remaining in the U.S. areas of the PPR will be lost in the next 34 years (Stephens *et al.* 2008). Agricultural policies, emerging technologies and economic drivers are fuelling large-scale conversion of these rare and important prairie habitats. Native grasslands provide critical habitat for wildlife, including a globally-significant breeding range for many waterfowl and shorebird species (Ringelman *et al.* 2005). These habitats also support numerous grassland-dependent songbirds, which are experiencing a steeper population decline than any other avian guild in North America (Peterjohn & Sauer 1999). Additionally, native rangelands are fundamentally important for livestock production by providing forage and resilience to drought. Ranching, recreational hunting and ecotourism associated with the native prairie also provide economic diversity and stability to rural economies.

Today, the last remaining grassland-dominated landscapes are largely confined to areas with poor soils, steep topography and climatic conditions largely unsuitable for consistent crop production (Doherty *et al.* 2013). Unfortunately, accelerated grassland conversion is occurring in many of these areas, causing significant ecological and societal impacts. Further loss of native rangeland habitat is also an economically costly proposition, bringing additional disaster-prone land into production, while creating significant taxpayer liabilities through subsidised risk management. Sodsaver legislation enacted in the 2014 Farm Bill, will: 1) limit crop insurance coverage to 65 percent of the applicable transition yield (*i.e.* county average) for the first four years until an actual production history is established on newly broken land; 2) reduce crop insurance subsidies on newly-broken sod by 50 percentage points below the premium subsidy that would otherwise apply for the first four consecutive years of crop production; and 3) make newly-broken acreage ineligible for yield substitution. These provisions were included as a nationwide policy in the 2013 Farm Bill passed by the Senate, but were confined to only the U.S. PPR in the Farm Bill passed by the House of Representatives. As illustrated by the 2008 Farm Bill, a region-only Sodsaver provision is difficult to administer and can create inequities among agricultural producers within and across states. Instead, a national provision would create a more equitable and actuarially sound programme across the country.

The 2014 Farm Bill provides a new regional Sodsaver programme that applies to Montana, South Dakota, North Dakota, Minnesota, Iowa and Nebraska. This provision applies to the entire state, not just the PPR-portion, and is a mandatory requirement, in contrast to the state Governor opt-in programme of the 2008 Farm Bill. This provision will not completely stop native prairie conversion in these six states, but it will provide less financial incentive for converting native prairie, as the crop insurance subsidies have been reduced significantly. Grassland conversion continues to be a national issue that plagues many grassland-dependent species, such as Greater Sage-grouse *Centrocercus urophasianus*, Lesser Prairie-chicken *Tympanuchus pallidicinctus* and many migratory birds that depend on these rare and declining habitats across the U.S. In 2013, 89% of the nearly 400,000 acres (161,900 ha) of perennial cover converted to cropland occurred outside of the U.S. PPR (USDA FSA 2013). Thus, future farm bill policy efforts aimed at grassland protection should focus on enacting a national Sodsaver programme that applies to all states and creates other similar reforms that conserve critical native habitats. Additional policy reforms such as significantly reducing or eliminating crop insurance subsidies on non-arable land (*i.e.* soil classes 6–8) should also be considered.

The future of the Conservation Reserve Program in a changing landscape

The CRP is considered one of the most successful USDA conservation programmes in history and its landscape-level impacts on reducing soil erosion, improving water quality, sequestering carbon and enhancing wildlife habitat are well-documented (see Allen & Vandever 2012). However, growing global demand for commodities, escalating land and cash rent values, stagnant CRP rental rates, biofuel policies, and improved genetics and farming technologies are driving the loss of CRP acreage across much of the U.S. particularly in the PPR. For example, Wright & Wimberly (2013) documented conversion of 1.3 million acres (0.53 million ha) of perennial grasslands (*i.e.* native prairie, tame pasture and CRP) to cropland in 2006–2011, which represents a rate of change in grassland cover not seen since the "Dust Bowl" era of the 1930s. The Farm Service Agency estimates that < 6 million acres (2.43 million ha) of CRP will remain in the U.S. PPR in 2014. This loss represents a substantial decrease (31%) from its peak of 8.3 million acres (3.59 million ha) in 2007 and declining trends are expected to continue over the next 5 years (Fig. 1; USDA FSA 2013). The 2014 Farm Bill reduces the national CRP enrolment cap from 27.5 million acres (12.9 million ha) to 24 million acres (9.71 million ha) by 2017. In order to achieve cost savings, the national enrolment cap on the CRP Farmable Wetland Program (FWP) will also be reduced from 1 to 0.75 million acres (404,690 to 303,500 ha). However, in issuing guidance to USDA for new CRP rule-making, the Manager's report states "overall reduction in the maximum acres enrolled …

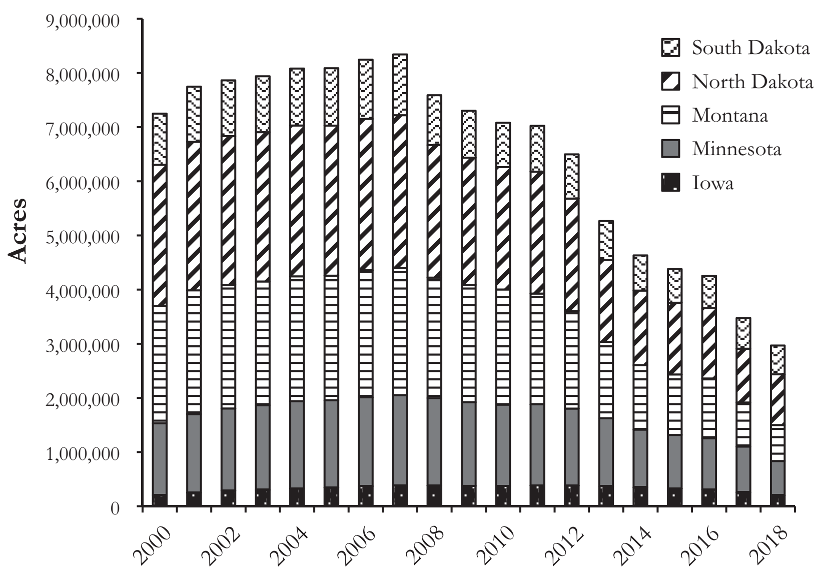

Figure 1. Actual (2000–2013) and projected (2014–2018) Conservation Reserve Program (CRP) enrolment area in the U.S. Prairie Pothole Region. Projected area assumes no new sign-ups and anticipated expirations based on Farm Service Agency reports for 2014–2018 (Ducks Unlimited, unpubl. data).

should not serve as an indicator of declining support for CRP. The Managers intend for CRP to be implemented at authorized levels, using the statutory flexibility, and for the program to continue as one of USDA's key conservation programs in concert with working lands conservation efforts."

Despite a significant reduction in the overall CRP acreage cap, several provisions were included in the 2014 Farm Bill to make the programme more flexible and attractive to producers, while promoting a "working lands" approach. For example, the Secretary of Agriculture will have greater authority to: 1) enrol newly eligible grasslands (up to 2 million acres, or 0.81 million ha); 2) flexibly apply prescribed grazing, burning, haying and other mid-contract management activities outside of the primary nesting season; 3) provide more allowances to use rather than dispose of residue removed from CRP land during contract maintenance and management; and 4) promote expanded use of continuous and Conservation Reserve Enhancement Practices (CREP) sign-up opportunities. Faced with these challenges and opportunities, resource managers will need to focus on making CRP more economically attractive and competitive by updating county rental rates, increasing land-use flexibility and management allowances, maximising continuous sign-up opportunities, and working to modify the national Environmental Benefit Index (EBI) scoring process to elevate the PPR to a national priority area.

Other working land opportunities

The 2014 Farm Bill also consolidates and streamlines 23 conservation programmes authorised under the 2008 Farm Bill into just 13 programmes. For example, former easement programmes such as the Farm and Ranch Lands Protection Program, GRP and WRP were merged into the ACEP. The ACEP establishes two separate tracks for wetland reserve easements (WRE) and agricultural land easements (ALE), while providing > $2 billion of funding for conservation on private land over the 2014–2018 period. It also allows a landowner donation for ALEs as long as another entity matches 50% of the Secretary's contribution and provides a waiver to pay up to 75% USDA cost-share for certain grassland conservation easements. This provision may create new public-private partnership opportunities among state, federal, private and NGO partners to develop easement programmes on private land. The new farm bill also reduces the former 7-year ownership rule to 2 years to become eligible for wetland easement enrolment. This may be an attractive incentive for conservation buyers looking to enrol land into the programme.

The 2014 Farm Bill also consolidates several former regional conservation programmes (*e.g.* the Chesapeake Bay Watershed Program and the Cooperative Conservation Partnership Initiative) into a new Regional Conservation Partnership Program (RCPP). Under RCPP, projects may focus on water quality, erosion, wildlife habitat and other regional resource concerns, and this new programme will create up to eight national critical conservation areas. The RCCP partnership agreements may extend up to 5 years and the programme provides mandatory funding of $100 million per year from 2014–2018. It will facilitate landscape-scale conservation initiatives leverage partnerships and enable managers to direct resources strategically towards priority regions for waterfowl, such as the PPR or the Gulf Coast.

The 2014 Farm Bill also merges EQIP and former Wildlife Habitat Incentives Program (WHIP) into one general EQIP programme, but specifies that "wildlife habitat development" is a defined programme purpose and sets a minimum 5% funding floor for wildlife habitat projects. The programme also requires that at least 60% of the total funds be invested for livestock purposes. The EQIP is one of the highest funded conservation programmes in the new farm bill, providing an average of $1.35 to $1.75 billion per year of conservation funding. The EQIP provides cost-share for a number of wildlife-friendly conservation (wetland development, grassland improvement, *etc.*) and habitat management practices (brush control, weed management, prescribed grazing, forage stand improvement, *etc.*) that may be very compatible with waterfowl and economically attractive to livestock producers, who prefer more short-term working land options as opposed to traditional 10–15 year set-aside programmes such as the CRP.

Habitat potential on agricultural working land

To the extent that waterfowl are able to adapt to habitat changes, or working agricultural lands retain or simulate ecological functions provided by historical habitats, the adverse effects of habitat loss may be dampened. Indeed, exponential growth in Lesser Snow Geese *Chen caerulescens* populations are attributed to behavioural and morphological adjustments that enabled birds to shift from historical to agricultural habitats (Linscombe 1972; Alisauskas 1998). There are numerous other examples of waterfowl using non-traditional or altered habitats, although the demographic consequences of these shifts are generally unknown. Thus, in addition to conserving and restoring traditional habitats, we must identify and work collaboratively to promote working agricultural systems that are both producer- and waterfowl-friendly and provide environmental services in addition to the production of food and fibre. Cultivation of rice *Oryza sativa* and winter cereals represent two such situations.

Agricultural working land and waterfowl: rice agriculture example

Rice agriculture is a major component of the contemporary landscapes of the Gulf Coastal Plain, LMAV, and Central Valley of California. Between 1985 and 2012, 2.3–3.6 million acres (0.93–1.46 million ha) of rice were planted annually nationwide with over half (60%) of this acreage located in the LMAV (Arkansas, Mississippi, Louisiana, and Missouri), 25% in the Gulf Coast region (Louisiana and Texas), and 15% in the Central Valley of California (USDA NASS 2014).

Cultivation practices

Rice is a warm-season crop typically planted in the spring and harvested in summer or autumn. Cultivation practices vary somewhat within and among rice-growing regions as a consequence of differences in climate, geography, soils, topography, surrounding land-uses, water supply, disease-pest issues, rotational cropping opportunities and farming traditions. In California and the LMAV, seeding of rice is similar to seeding practices for other cereal crops. That is, rice seed can be drilled or broadcast under dry to moist conditions in either reduced or conventional tillage systems ("dry seeding"). In southwest Louisiana, rice is most commonly cultivated using a water-seeding system in a 3-year rotation with crawfish (Order: Decapoda) and fallow or soybeans (69% water-seeded, 31% dry seeded; J. Saichuk, pers. comm.). In a water-seeded system, rice is planted aerially into flooded fields in March–June (Blanche *et al.* 2009). Shortly before planting (3–4 days), the seedbed is tilled rough, fertilizer is applied and incorporated, and the field is flooded. Alternatively, rough tillage conducted in autumn or winter may be followed by flooding and, shortly before seeding, water-levelling (tractor pulling a blade through the flooded rice field). Water-levelling agitates the soil and water, producing a thick slurry and level seedbed when the soil settles out of the water. Water-seeded fields typically are dewatered 24 h after seeding.

The principal advantage of water seeding is that it provides an excellent cultural method for control of weeds, especially Red Rice *Oryza punctate* (Webster & Levy 2009). Red Rice is the most troublesome and economically damaging competitor of rice; annually contributing to the loss of tens of thousands of dollars to rice producers in southern states (Webster & Levy 2009). Some producers flood harvested rice fields to facilitate feeding by wintering waterfowl on noxious Red Rice (Smith & Sullivan 1980). Water seeding is also preferred by farmers that plant extensive acreages in areas with high rain and is compatible with other uses of rice fields such as crawfish aquaculture.

Cultivation practices in water- and dry-seeded fields are similar after seeding. Fields are gradually (re)flooded when rice has sprouted 4–6 inches (10–15 cm) and remain flooded throughout the growing season until rice seeds mature. Most of the currently grown rice varieties need ~120 days from seed germination until the grain is ready for harvest. Fields are drained 4 weeks before harvest to allow combine harvesters to operate in the fields.

An assortment of dryland crops are rotated with rice in California and the LMAV, but rotational options are limited in coastal Louisiana and Texas. Along the Gulf Coast, rice typically is not cultivated in the same field during consecutive years because doing so would increase disease and weed prevalence and reduce yields. Management options for rice producers include production of a second or "ratoon" rice crop, preparing fields for winter–spring crawfish production, or idling land for fallow or dryland crop production the following spring–summer. Ratooning is the practice of harvesting grain from tillers originating from the stubble of a previously harvested crop (main crop). The climatic conditions of southwest Louisiana and the early harvest date of commonly grown rice varieties combine to create an opportunity for ratoon crop production, but weather, planting date, quality of the first crop and harvest conditions can all influence ratoon rice development and yield. In general, the first crop should be harvested by 15 August to ensure adequate time for ratoon rice to develop. Harvest of ratoon rice typically occurs in October–November.

The rice-crawfish-fallow (or rice-crawfish-soybean) rotational strategy commonly deployed in the region employs crawfish in a rotational system of rice and sometimes soybeans. Rice is grown and harvested during the summer, and crawfish are grown during autumn, winter and early spring in the same field. Louisiana crawfish producers rely on a forage-based system for providing nourishment to growing crawfish. Rice has become the standard forage crop for the industry because the plant exhibits the desired characteristics under the long-term flooded condition of a crawfish pond and partly because adequate stands of vegetation are achievable and predictable when recommended management practices are followed.

Rice fields managed for crawfish production are commonly fertilised and irrigated to achieve a ratoon crop (re-growth) of forage. Fields are initially flooded in October–December and remain flooded throughout the harvest period, January–June. In southwest Louisiana, fields are typically fallowed following drawdown in May–June, but some producers may drawdown crawfish ponds earlier (April) to plant soybeans (April–June). To control weeds in fields rotating back into rice cultivation, water control structures typically are closed in the autumn (after soybean harvest) to capture available rainfall. Producers may pump water onto fields if fields are leased for waterfowl hunting (November–January) or rainfall is inadequate to completely flood fields by January. Fields are drained in spring so that they may be tilled in preparation for rice planting as described above.

Waterbird use of rice

A wide variety of waterbirds (waterfowl, shorebirds and wading birds) and some landbirds use rice fields (Taft & Elphick 2007). Rice field use by wintering and migrating waterfowl and shorebirds is especially pronounced. Avian use is best documented in Californian rice fields where over 118 species representing 38 families have been recorded during winter (Eadie *et al.* 2008). Densities of non-breeding waterfowl and shorebirds observed in Californian rice fields averaged 730 (peak count = 3,600) and 252 (2,600) birds/km^2, respectively (Eadie *et al.* 2008).

The 2.5–3.75 million acres (1–1.5 million ha) of farmland in coastal Louisiana and Texas operated in rice-crawfish-fallow, rice-fallow, rice-pasture or rice-dryland crop rotational scheme simulate wet, early successional habitats that potentially are highly attractive to wetland-associated wildlife. The close proximity of fields to coastal marshes, their location at the terminus of two major migratory bird flyways, bird-friendly cultivation practices, high annual rainfall, and abundant plant and animal foods further enhance their potential value for waterbirds. Indeed, recent shifts in the distributions of waterbirds from coastal wetlands to inland agricultural wetlands (*e.g.* Fleury & Sherry 1995) coincide with the expansion of crawfish aquaculture and ongoing loss and degradation of coastal wetlands. A minimum of 67 species of waterbirds including 17 waterfowl, 33 shorebirds, 15 wading birds, 2 rail and 1 crane species have been observed using rice fields in coastal Texas and Louisiana (W.L. Hohman, unpubl. data). Peak densities of non-breeding geese, ducks, shorebirds, and wading birds recorded in these rice fields during winters 1996/97 or 1997/98 were 9,300, 4,300, 1,700, and 1100 birds/km^2, respectively (W.L. Hohman, unpubl. data). Estimated seasonal use by waterbirds (excluding geese) from October to May was 72.1 and 125.5 million use-days in 1996/97 and in 1997/98, respectively (W.L. Hohman, unpubl. data). However, because waterbirds use rotational crops (*e.g.* fallow), peak and seasonal use may have been underestimated by ≥50% (W.L. Hohman, unpubl. data).

Use of rice fields by waterbirds is potentially influenced by factors such as field size, timing, duration and extent of flooding, crop rotation, cultivation and harvest practices, grazing, height of vegetation, stubble treatments, frequency of disturbance and surrounding landscape features (*e.g.* land uses, cover types, amount of edge, distance to water, *etc.*). Waterbird richness and density are greater in flooded than unflooded rice fields in California (Eadie *et al.* 2008). Waterbird groups responded differently to water depth, with peak species richness and conservation value (species being indexed by their relative abundance in North America; Elphick & Oring 1998) observed at intermediate water depths (10–20 cm) (Elphick 1998; Eadie *et al.* 2008). In Californian rice fields, however, interpretation of waterbird responses to manipulation of rice straw was confounded by an interaction with the depth of flooding (Eadie *et al.* 2008).

In the Texas and Louisiana rice fields, waterbird species richness/diversity was highest in fallow fields and rice crop cover types, greatly exceeding other crop covers (W.L. Hohman, unpubl. data). Fields in 3-year rice-fallow rotation had higher richness and diversity scores than fields in 3- or 4-year rice rotations with dryland crops. Richness was decreased by grazing and increased by flooding. Duck densities were affected by crop rotation scheme, shorebird densities were affected by crop cover and grazing, and wader densities were affected by both crop cover and rotation scheme. Densities of all three groups increased with flooding.

Louisiana rice fields also provide habitat for breeding waterbirds (Hohman *et al.* 1994), at least one of which (King Rail *Rallus elegans*) has been given special status in 12 states. Increase in the nesting density of King Rails in Louisiana's rice fields is attributed to expansion of crawfish aquaculture. Other common to rare nesting birds include Fulvous Whistling Duck *Dendrocygna bicolor*, Purple Gallinule *Porphyrula martinica*, Common Moorhen *Gallinula chloropus* and Least Bittern *Ixobrychus exilis*.

Opportunities for management of rice fields for waterfowl

Waterbirds are attracted to rice fields because of the abundant foods that occur there. Potential waterbird foods include waste grain, seeds of water tolerant (*i.e.* moist soil) plants, green forage and invertebrates. Rice fields are highly dynamic systems and, although vegetation is highly monotypic, rice fields essentially function like early successional, seasonally-flooded wetlands. That is, they have high detrital (*i.e.* straw) inputs that, when flooded, serve as forage for production of crawfish and other aquatic invertebrates. Further, reduced pesticide use in fields managed for crawfish production may benefit other aquatic invertebrates (McClain *et al.* 2009).

Waterbirds also use rice fields as resting areas. The general openness of the rice agricultural landscape is attractive to many species that during migration and winter must remain vigilant for potential predators (Elphick 2000). Rice agriculture has become especially important for Northern Pintail (*Anas acuta*, hereafter Pintail) wintering in California's Central Valley and along the Texas–Louisiana Gulf Coast (Miller 1987; Cox & Afton 1997). Pintail and other waterbirds may shift to rice field refuges to avoid disturbance in other habitats or, alternatively, hunting disturbance may result in daytime avoidance of rice fields (Rave & Cordes 1993; Cox & Afton 1996).

Agronomic practices typically followed during the 3-year rice-crawfish-fallow or rice-fallow rotational schemes are generally "waterbird friendly." So in most cases, management of Gulf Coast rice fields for wintering and migrating waterbirds involves only minor changes in existing management practices. Because of high annual rainfall, use of flooding for weed control, practice of water-levelling, water-seeding of rice, crawfish aquaculture and the leasing of rice fields for waterfowl hunting, Gulf Coast rice fields tend to be wet and therefore available to waterbirds throughout much of the year. Additionally, many coastal rice fields are left unplanted (*e.g.* pasture rotation) or fallowed every other year. Moist soil plants that grow in fallowed fields produce abundant seeds that are highly preferred foods of wintering waterfowl (Fredrickson & Taylor 1982). Indeed, samples taken at waterfowl feeding sites in Louisiana rice fields indicated biomass of moist soil plant seeds in rice fields may be equivalent to that found in public areas managed specifically for that purpose (Hohman *et al.* 1996). With average rainfall, passive management (*e.g.* simply closing water control structures) is likely to be sufficient to meet the diverse habitat needs of most waterbird species; however, the productivity and attractiveness of Gulf Coast rice fields for waterfowl and other waterbirds may be further enhanced by timely manipulations of rice stubble and flooding, precise control of water levels during rice cultivation, minimising disturbances in fallow fields during March–May, or establishment of some single crop ponds managed solely for crawfish production (W.L. Hohman, unpubl. data).

Following the 2010 Deepwater Horizon Gulf Oil Spill, the USDA NRCS established the Migratory Bird Habitat Initiative (MBHI) to provide inland waterbird habitats to compensate for potential oil impacts on coastal wetlands. Through EQIP, WHIP, and WRP, the MBHI has provided incentives for private landowners in eight states (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Missouri and Texas) to enhance and increase availability of shallow-water habitats for migrating and wintering waterfowl, shorebirds, and other waterbirds along the Gulf Coast and within the LMAV. The provision of financial assistance and compatibility of management activities with normal agronomic practices and recreational use of sites contributed to the enthusiastic response by landowners who offered almost 1 million acres (> 400,000 ha) for possible enrolment in EQIP or WHIP. To qualify for enrolment the proposed management activity must represent a change from normal agronomic practices (*i.e.* "enhancement"). Approximately half of the offers were accepted into the programme with most of the contracts awarded in the rice growing region of southwest Louisiana. In coastal Louisiana and Texas, the primary management practices implemented through the MBHI entailed manipulations of rice stubble and shallow flooding of rice fields in early autumn or late winter. Stubble manipulations and early flooding were implemented to benefit autumn-migrating shorebirds which pass through the region in August and September; late flooding targeted spring-migrating waterfowl. The net result was that shallow-water habitats were available in coastal regions for an extended duration. Activities undertaken through EQIP and WHIP on agricultural working land were similar, but eligibility differences between the programmes enabled the USDA NRCS to serve a broader clientele.

An evaluation of waterbird responses to MBHI practices by researchers at Mississippi State University is ongoing, but preliminary results further substantiate the importance of rice agriculture for waterbirds. Fields in which a ratoon was produced and subsequently disced were especially important habitat for non-breeding waterbirds, if they were flooded through assistance from MBHI or other means (Marty 2013).

Challenges to management of rice fields for waterfowl

The potential for rice agriculture to provide habitat for waterfowl is substantial on the Gulf Coastal Plain, as it is in other rice growing regions. Challenges to the management of rice fields as waterfowl habitat identified by Eadie *et al.* (2008) include: 1) the provision of habitat for non-target, undesirable or nuisance wildlife (*e.g.* Red-winged Blackbird, *Agelaius phoeniceus*, American Coot *Fulica americana*; Snow Geese, *etc.*); 2) water quality concerns (*e.g.* release of nutrients, particulate matter in water releases from rice fields); 3) additional time and financial costs associated with management (*e.g.* delayed field work and costs of pumping and stubble manipulations); 4) declining rice acreage due to urban growth, farm economics or human disturbance; 5) increased habitat fragmentation; 6) increased harvest efficiency or changes in agronomic practices (*e.g.* straw management, development of glyphosate-tolerant rice varieties) that reduce the availability of waste grain and moist soil plant seeds; 7) decreased availability of water (*e.g.* conflicts caused by increased demand and use by other user groups); and 8) conservation of endangered species.

Additionally, agricultural policy that favours production of other crops or restricts farmer participation in conservation programmes may contribute to a reduction in rice acreage. For example, Louisiana continues to fund MBHI through EQIP, and MBHI was expanded to include activities designed to provide nesting and brood-rearing habitat for resident waterbirds such as the Mottled Duck *Anas fulvigula*. Although this species has adapted to survive on the wet agricultural/coastal marsh interface, it is vulnerable to urban encroachment, coastal land loss and conversion from "wet" agriculture (such as rice and crawfish production) to dry land crops such as soybean, sugarcane and milo (Hohman *et al.* in press). Initial interest in this component of MBHI was constrained by confusion about the level of compensation that was to be provided for various management scenarios. Programme restrictions are also limiting expansion of MBHI. Specifically, the EQIP requirement that only allows for provision of financial and technical assistance for the application of a new practice or activity prevents producers from re-enrolling fields in MBHI. Consequently, the acreage enrolled in MBHI has declined because producers are unwilling to bear the increased costs of management without compensation.

Management of rice fields for recreational activity and income derived from hunting leases can provide a strong motivation for producers to manage rice fields as waterfowl habitat. The value of rice fields for waterbirds in southwest Louisiana was estimated to be > $100–1,028/acre ($247–2,538/ ha) based on the value of hunting leases or the restitution value of waterbirds using rice fields during the breeding and non-breeding periods (W.L. Hohman, unpubl. data). Further, the value of rice fields as waterbird habitat exceeded the return realised by farmers for production of rice and crawfish ($208/acre, or $494/ha; W.L. Hohman, unpubl. data). Knowledge of the value that rice agriculture provides to ecosystem services, and efforts to minimise mismatches between the value of these services and income derived from agricultural production, should further advance stewardship of rice agriculture for the conservation of waterfowl and other wildlife.

Although waterbird use of Californian rice fields is well documented, the extent to which rice fields provide a reasonable substitute for natural wetlands is unclear (Elphick 2000; Eadie *et al.* 2008). The functional equivalence of rice agriculture in comparison with historical wetland habitats along the Texas–Louisiana coast likewise is unknown; nonetheless, Louisiana and Texas have experienced extensive loss and degradation of coastal wetlands. From 1932–2000, coastal Louisiana lost > 4,900 km^2 of land, primarily marsh, with the annual rate of wetland loss estimated to be 43 km^2 between 1985–2010 (Couvillion *et al.* 2011). Continued loss of coastal wetlands, and reductions in rice acreage in coastal Texas–Louisiana, have important implications for waterbird conservation in North America. Enhanced management of agricultural wetlands along the Gulf Coast (*e.g.* as undertaken in response to the Deepwater Horizon oil spill through the NRCS's MBHI) may represent the best opportunity to accommodate waterbirds displaced by wetland loss associated with sea-level rises and other environmental change.

Agricultural working land and waterfowl: autumn cereals example

Opportunities for management of autumn cereals for waterfowl

The glaciated PPR region of central North America serves as the primary breeding area for many of North America's waterfowl and shorebirds (Batt *et al.* 1989; Skagen & Thompson 2007). Historically, extensive native grasslands and diverse wetlands provided ideal habitat for successful waterfowl reproduction in this area (Stephens *et al.* 2005). Since human settlement, however, a majority of the PPR has become an important agricultural production zone for small-grain, oil-seed and row crops. Conversion of grassland to annual cropland, along with drainage and degradation of wetlands, has made significant alterations to the landscapes in which breeding waterfowl and shorebirds nest (Stephens *et al.* 2008). Today, this region of North America is one of the most intensively cropped landscapes in the world, with > 80% of some counties in cropland production (Foley *et al.* 2005; Statistics Canada 2011).

Conversion of grasslands to cropland and associated alteration of predator communities in the PPR are thought to be the primary reason for long-term declines in waterfowl production in this region (Sargeant *et al.* 1993; Greenwood *et al.* 1995; Beauchamp *et al.* 1996; Stephens *et al.* 2008). In addition, the intensity of cropping practices has increased on existing cultivated land in recent history. The largest and most economically and environmentally significant change in agricultural land-use since the 1970s has been the decline in summer fallow, a practice where cropland is left uncropped for alternate growing seasons for moisture accumulation, nitrogen release and weed control (Carlyle 1997). In prairie Canada, the practice of summer fallowing has declined by ~18.8 million acres (7.6 million ha) between 1971–2011 (Statistics Canada 2012). In its place, continuous cropping under minimum and zero-tillage practices with high nutrient and pesticide inputs has prevailed. Podruzny *et al.* (2002) suggested that declines in populations of some bird species, such as Pintail, may have been the result of reduced nest survival as continuous cropping replaced relatively safe nest sites located in summer fallow.

Cropland conversion to grassland began in the U.S. under the CRP in the late 1980s, and in Canada with removal of grain transportation subsidies in 1995. Recent trends and long-term projections of cropland area suggest that conversion of grassland to cropland is again on the rise (Rashford *et al.* 2010; Wright & Wimberly 2013). Biofuel-driven agricultural commodity prices are expected to increase pressure to convert grasslands to croplands in the foreseeable future (Wright & Wimberly 2013). While waterfowl benefited greatly from programmes such as the CRP (Reynolds *et al.* 2006), these benefits are expected to diminish as remaining grasslands are converted to cropland (Stephens *et al.* 2008; Rashford *et al.* 2011). Not all croplands are equal, however, in their potential to affect breeding waterfowl. While many waterfowl species can benefit from croplands as a food resource during non-breeding periods (reviewed in Taft & Elphick 2007), few crops provide relatively safe nesting habitat like the grasslands they replace. Early nesting species, such as Mallard *Anas platyrhynchos* and Pintail, are especially susceptible to nest failure in croplands, but some autumn-seeded cereal crops including winter wheat *Triticum* sp. and autumn rye *Secale cereale* may provide viable nesting habitats (Devries *et al.* 2008).

In North America, wheat has two distinct growing seasons. Winter wheat, accounting for 70–80% of U.S. wheat production, is planted in the autumn, harvested the following summer and is generally grown from the Texas Gulf Coast to prairie Canada (Acquaah 2005). Spring wheat is planted in early spring, harvested in late summer/early autumn and produced primarily in the prairies of the northern U.S. and southern Canada (Acquaah 2005). Within the PPR, the majority of wheat grown is the spring-seeded variety. For example, of 75 million acres (30.4 million ha) of cropland in prairie Canada in 2012, ~21 million acres (8.5 million ha) were wheat, of which only ~1 million acres (0.4 million ha) were winter wheat (Statistics Canada 2012). In North and South Dakota, about 10 million acres (4.1 million ha) out of 40 million cropland acres (16.2 million ha) were wheat in 2012, of which ~2 million acres (0.8 million ha) were winter wheat. Other autumn-seeded cereal grains like autumn rye and triticale (*Triticum* × *Secale* hybrid) generally comprise less than a couple of hundred thousand acres in the PPR.

Croplands are commonly ignored in waterfowl nesting studies despite their documented use by nesting birds (Goelitz 1918; Earl 1950; Milonski 1958; Higgins 1977; Lokemoen & Beiser 1997). This is likely because most waterfowl nesting studies historically avoided searching seeded cropland, or limited timing and frequency of searches relative to other habitats due to crop damage concerns. Hence, our understanding of cropland use by nesting ducks is limited despite the dominance of cropland as potential nest habitat in many landscapes important to breeding waterfowl. Where data are available, nest survival in cropland is typically low due to predation and destruction of nests by machinery during spring-seeding operations (Cowardin *et al.* 1985; Klett *et al.* 1988; Greenwood *et al.* 1995; Richkus 2002).

Autumn-seeded cereal grains, such as winter wheat and autumn rye, however, can provide relatively undisturbed nesting cover for birds during the breeding season and may complement grassland nesting habitats that are available to birds. Several recent studies suggest that autumn cereals may provide high value nesting habitat for breeding waterfowl relative to spring-seeded crops and grasslands. Devries *et al.* (2008) conducted complete nest searches on 4,247 ha of cropland in southern Saskatchewan, including spring-seeded (wheat and barley) and autumn-seeded cereals (winter wheat and autumn rye). Autumn rye and spring-seeded crops were used for nesting by five duck species (Mallard, Pintail, Blue-winged Teal *Anas discors*, Northern Shoveler *A. clypeata*, and Gadwall *A. strepera*), while winter wheat was used by all of the aforementioned species, as well as by Green-winged Teal *A. crecca*, and Lesser Scaup

Aythya affinis). Nest densities were 0.39 and 0.25 nests/ha in winter wheat and autumn rye, respectively, compared to 0.03 nests/ha in spring-seeded cereals. Critically, nest survival was consistently very high throughout the nesting season in winter wheat and autumn rye (~38% and 18%, respectively) whereas survival in spring-seeded crops varied from close to 0% in early nests to close to winter wheat levels for late nests (Devries *et al.* 2008). High nest survival has also been found in winter wheat in comparable studies in North Dakota (Duebbert & Kantrud 1987; B.R. Skone, unpubl. data). Further, nest success rates in autumn-seeded crops are generally greater than those found in grassland habitats throughout much of the PPR (*e.g.* Klett *et al.* 1988; Greenwood *et al.* 1995). Additional research comparing waterfowl nest density and success in winter wheat and adjacent grassland habitat is currently ongoing (B.R. Skone, unpubl. data).

Together, the density and success of waterfowl nests in autumn-seeded cereals suggests that these crops have the potential to recruit many more waterfowl young to breeding populations than spring-seeded cropland, and are comparable to grassland habitats (Devries *et al.* 2008). Providing high nest survival early in the nesting season conveys added value, given the importance of early hatched nests to waterfowl recruitment (*e.g.* Dzus & Clark 1998). The value of autumn-seeded cereals may be most evident in landscapes with high breeding waterfowl populations, many wetlands and extensive croplands. Pintail, especially, could benefit from expansion of autumn-seeded cereal crops, as they nest extensively in cropland stubble (Milonski 1958; Klett *et al.* 1988; Miller & Duncan 1999), initiate nests early in the season prior to spring-seeding operations (Austin & Miller 1995) and re-nest minimally (Austin & Miller 1995; Guyn & Clark 2000). Further, Pintail tend to settle in highly cropped landscapes, especially at high population density (J.H. Devries, unpubl. data). Other priority bird species (*e.g.* Long-billed Curlew *Numenius americanus*) that are known to nest early in cropland stubble are also likely to benefit from autumn cereals (Lokemoen & Beiser 1997; Devries *et al.* 2010).

Challenges for management of autumn cereals for waterfowl

Given the potential benefits of autumn-seeded cereals to nesting waterfowl, Ducks Unlimited (DU), an international non-profit organisation focused on conserving waterfowl habitat, has taken great interest in winter wheat. Efforts by DU include promoting winter cereals in landscapes that have high wetland densities and attract high densities of Pintail and other wetland-dependent birds. As with most agricultural commodities, the primary drivers of winter wheat production are agronomic and in this sense, winter wheat has several advantages. Winter wheat on average provides a 20% yield advantage over spring wheat and generally has lower input costs (Statistics Canada 2013). Further, indirect benefits include: 1) spreading out the annual workload; 2) earlier seeding of spring-seeded crops; 3) decreased exposure to poor spring seeding weather; 4) winter wheat takes full advantage of spring moisture; 5) early growth avoids exposure to certain pests; and 6) winter wheat often outcompetes spring grassy weeds.

Despite the agronomic benefits, barriers to the growth of winter wheat remain. First, extremely cold winters, especially in prairie Canada, challenge existing winter wheat varieties with winter kill. Also in Canada, where hard red spring wheat has been the "gold standard" of the grain market, challenges remain with developing markets for alternate wheat varieties (Mulik & Koo 2006). Finally, changing long-held traditional farming practices remains an impediment, as seeding in September, shallow seeding, seeding into standing stubble and earlier harvests, challenge farmers to make substantial changes to their operations.

To address these challenges, DU has embraced several non-traditional activities for a conservation organisation. Recognising the limitations of available winter wheat varieties, DU provided financial support for the development of new winter wheat varieties at a time when winter wheat variety development in Canada was concluding. Currently, > 90% of winter wheat varieties grown in prairie Canada are those developed with DU support. Further, DU is investing in collaborative research to improve cold-hardiness of winter wheat varieties while providing direct technical assistance to farmers regarding best crop management practices. While incentive payments were initially part of the programme, evaluations have shown that technical expertise provided by agronomists was more attractive and sustainable than cash incentives (DU, unpubl. data). Ducks Unlimited has recently expanded their winter wheat programme in partnership with Bayer Cropscience. A focus of the partnership with Bayer, "Winter Cereals – Sustainability in Action", includes additional extension outreach to increase the acreage of winter wheat planted in the PPR and expansion of winter wheat breeding programmes at several universities across the U.S. and Canada. Since DU initiated the winter cereals programme in 1999, winter wheat acreage in North Dakota has increased over 12-fold from 60,000 acres (24,300 ha) in 1999 to 750,000 acres (303,600 ha) planted in 2012 (USDA NASS 2013). Over the same time period in prairie Canada, winter wheat has grown from 245,000 acres (99,100 ha) to 1.1 million acres (459,500 ha, Statistics Canada 2012).

The remaining barriers to expansion of winter wheat can be overcome. New cold-tolerant varieties are in constant development and additional varietal development is focused on yield, quality and disease resistance. Markets for winter wheat, especially in Canada, are beginning to expand, and realised agronomic benefits should overcome traditional barriers to autumn-seeding. Finally, further research is being conducted to determine whether winter wheat provides landscape-level impacts on duck and shorebird nest survival in addition to the apparent habitat-specific increase in nest survival for nests within winter wheat fields (B. Skone, Montana State University, pers. comm.).

The challenges of strategic conservation targeting on private land

The need to target conservation strategically has long been recognised by policy makers, ecologists and economists. Faced with limited resources (*e.g.* budgets or labour-hours), conservationists cannot select all available projects that produce biological benefits (*e.g.* easement locations or management activities); thus, they seek to select projects that generate the greatest biological benefits possible given resource constraints. What constitutes strategic targeting and how to achieve it, however, can differ substantially across different interest groups and academic disciplines. Moreover, the challenges specific to targeting waterfowl conservation on private land depend on the definition of strategic targeting. These challenges become clear if we begin from the strategic habitat conservation (SHC) framework developed by the USFWS (USFWS 2008).

The SHC framework describes strategic targeting as an iterative process involving biological planning, conservation design and delivery, and monitoring and research that provides feedback to inform the process. Essential to the SHC framework are: 1) defining and measuring specific population objectives (*i.e.* as opposed to simply focusing on habitat area protected, which are inputs to species-specific objectives); 2) using the best scientific information, including population-habitat models and decision support tools, to inform and update iteratively the SHC process; and 3) developing partnerships to design and deliver conservation programmes.

For over a quarter of a century the North American Waterfowl Management Plan (NAWMP; DOI & EC 1986) has served as a transformative model of partnership-based, landscape-scale conservation delivery. The original plan and subsequent updates in 1994, 1998 and 2004 established abundant waterfowl populations as the plan's ultimate goal. A science-based understanding of waterfowl habitat requirements throughout their annual cycle and population responses to habitat, enabled managers to step-down continental population objectives to important waterfowl regions; regional partnerships between public and private parties (Joint Ventures) were formed to implement management and assess progress towards the achievement of objectives. As in the SHC framework described above, information gathered during monitoring efforts was used to improve population-habitat models and provide a sound science-base for management actions.

The NAWMP was substantially revised in 2012 to reflect, "… the rising challenges presented by a changing climate, social changes, the effects on land-use decisions of global economic pressures, and fiscal restraint faced by agencies …" (DOI *et al.* 2012:iv). Specifically, the 2012 NAWMP seeks to formally integrate objectives for waterfowl populations, habitat conservation, and societal needs and desires. The central thesis of the revised plan is that "… conservation goals can only be achieved with broad public support and by influencing land-use decisions over extensive areas of the continent" (DOI *et al.* 2012:12). The 2012 NAWMP recognises that most of these areas are privately owned "working lands" noting that, "While some conservation outcomes are achieved through regulations and policies, others result from collaborations that lead to voluntary actions. Support from the public and participation by landowners hinges on striking the right balance between conservation outcomes and the socioeconomic drivers that influence land-use decisions. That balance is always shifting, depending on the relative value placed on conservation versus other drivers."

Despite general similarities between the NAWMP and SHC frameworks, many details are lacking, especially with respect to strategic targeting of conservation on private land. The SHC framework is "strategic" only in the sense that conservation activities are based on specific objectives, scientific planning and design, and regular evaluation. In areas dominated by private land, such as the U.S. and Canadian prairies, private landowner incentives, land-use change and agricultural policy significantly complicate the design and delivery of waterfowl conservation. In addition, the SHC framework does not provide sufficient guidance on how to evaluate conservation success. Metrics to evaluate conservation success are especially lacking on private land where conservation delivery can be orders of magnitude more expensive than conservation on public land, spatially targeting conservation is limited by each landowner's willingness to accept conservation, and many conservation activities can focus as much on agricultural activities as on ecological activities (*e.g.* working land conservation; Lewis *et al.* 2011). Measuring success, and thus targeting conservation, in terms of biological benefits as implied by the SHC framework (*e.g.* changes in species-specific populations), can lead to conservation plans that are highly inefficient (*i.e.* waste scarce resources; Duke *et al.* 2013).

There is a general consensus in the economic and ecological literature that three primary factors affect efficiency of conservation delivery: biological benefits, conservation cost and threat of habitat loss or conversion (see Newburn *et al.* 2005 for a review of alternative targeting strategies). Biological benefits, measured in physical units or dollars, refer to the outcomes of conservation. Although some studies focus on targeting biological benefits exclusively (*e.g.* Niemuth *et al.* 2009), the broader literature has consistently demonstrated that benefits must be weighed against conservation costs to generate efficient conservation plans (Naidoo & Iwamura 2007; Duke *et al.* 2013). Plans that maximise benefits only (*e.g.* by selecting sites for protection that have the greatest biological value) often lead to inefficient conservation outcomes because limited budgets are quickly exhausted on high-benefit, high-cost projects (Duke *et al.* 2013). Incorporating costs, using a cost-benefit or return on investment criterion, tends to increase conservation efficiency by maximising the conservation benefit per dollar expended.

More recently, the literature focused on conservation targeting established the important role that threat plays in designing efficient conservation plans (Merenlender *et al.* 2009). Threat refers to the risk that biological benefits will be lost in the absence of conservation. In the case of waterfowl nesting habitat, for example, threat could refer to the probability that dense grassland cover is converted to intensive cropland. Ignoring threats can also result in conservation inefficiencies because limited resources are targeted to areas likely to produce benefits even in the absence of explicit conservation. Incorporating threat, along with benefits and costs, therefore improves efficiency by targeting limited resources towards projects that generate the greatest avoided loss per dollar expended (Newburn *et al.* 2005; Murdoch *et al.* 2007; Withey *et al.* 2012).

Despite the large and growing strategic conservation targeting knowledge base, there has been relatively little research targeted specifically to the design of efficient waterfowl habitat conservation plans. Several studies reported the costs and benefits of specific management treatments (see Williams *et al.* 1999 for a review) and others explored the cost-effectiveness of waterfowl management in hypothetical settings (*e.g.* Rashford & Adams 2007). Several waterfowl studies have considered landscape-level conservation targeting but have focused on conservation benefits only (*e.g.* Reynolds *et al.* 2006; Niemuth *et al.* 2009; Johnson *et al.* 2010), have considered benefits and costs but not threats (Loesch *et al.* 2012), or have considered threats and benefits but not cost (Stephens *et al.* 2008). Rashford *et al.* (2011) demonstrated the cost-benefit-threat tradeoffs associated with targeting grassland conservation in prairie Canada, but their application was for a hypothetical and unrealistic conservation scheme (*i.e.* a fixed payment to all grassland).

Given the consensus in the literature, developing truly strategic plans to target waterfowl conservation on private land will require estimates of benefits for various conservation alternatives (*e.g.* changes in recruitment), conservation costs and measures of threat levels. Much of this information already exists, particularly for the waterfowl breeding grounds of North America. Population-habitat models exist to predict waterfowl distributions and response to landscape-level conservation (Cowardin *et al.* 1995; Reynolds *et al.* 1996; Johnson *et al.* 2010). Conservation costs can also be estimated from existing data (*e.g.* published cropland rental rates to proxy for the cost of conservation easements); however, significant heterogeneity in costs across space and information asymmetry (*i.e.* landowner's private costs are not observable) imply that estimating conservation costs at the landscape level could be complex. Moreover, cost tends to be highly correlated with threat. For example, locations that have a high probability of converting from grassland to intensive cropland will have a high opportunity cost of remaining in grassland, and thus high conservation costs.

Estimating threat or risk of grassland or wetland conversion can also be challenging because conversion in the region is a largely private decision influenced by economic, physical and social factors that are not completely observable. Agricultural policy reform, global commodity markets and stochastic weather patterns are difficult to quantify or predict and can also contribute to uncertainty related to threats. Since these factors are highly heterogeneous across space (*e.g.* soil quality varies considerably across the prairies), conversion risk is likely to be highly heterogeneous (see below).

Given spatially heterogeneous conversion risk, conservation targeting that considers only benefits and cost will be inefficient (Newburn *et al.* 2005). Additionally, effectiveness of voluntary conservation programmes, such as CRP and WRP, are also influenced by threat, *e.g.* land with high conversion threat and thus high opportunity costs of entering conservation programmes is less likely to be enrolled given a fixed payment level (Lewis *et al.* 2011). It is therefore crucial to understand factors affecting private land-use decisions, and thus habitat conversion risk.

Private land-use decisions and habitat conversion risk

Studies in ecology, economics and geography have a long history of modelling private land-use change and its drivers (see *e.g.* Verburg *et al.* 2004). Although theories and approaches differ across disciplines (*e.g.* geographers and ecologists tend to focus on social drivers at the macro-scale, whereas economists tend to focus on private drivers at the micro-scale), there is a general consensus that economic, bio-physical and social/policy factors drive land-use change. A relatively recent and growing body of literature which has specifically examined agricultural land-use change, both in the PPR and in the NGP, suggests several key drivers of land-use change and the risk of habitat conversion (Stephens *et al.* 2008; Rashford *et al.* 2010; Gutzwiller & Flather 2011; Rashford *et al.* 2011; Sohl *et al.* 2012; Feng *et al.* 2013; Wright & Wimberly 2013; Attavanich *et al.* 2014). Although the identified drivers are not mutually exclusive, we categorise and describe them under the broad headings of biophysical, economic and policy drivers.

Bio-physical drivers

The biophysical attributes of land, such as soil quality, hydrology and slope, directly and indirectly affect private land-use. In some cases, biophysical attributes may restrict the set of land uses that are physically possible (*e.g.* land too steep to be tilled). Biophysical attributes also affect yields that can be realised from the land, and thus, the economic returns private landowners can derive from alternative land uses. As a result, land with characteristics that are suited to crop production tends to be placed in crop production. Studies have found strong positive correlations between high soil quality and grassland conversion (Wright & Wimberly 2013). In addition, PPR grassland habitats in land capability Class 1 and 2 (*i.e.* best soils for agricultural production) were found to be 30% to 200% more likely to be converted to cropland than grassland of lower soil capability (Rashford *et al.* 2010). Likewise, hydric soils, when drained, may provide productive farmland, and removal of in-field wetlands can improve the efficiency of tillage operations by removing "obstacles" to farm machinery.

Climatic conditions have also been found to strongly influence land-use decisions. Temperature, precipitation and CO_2 concentrations affect yield and yield variability, and thus the economic returns and risk associated with alternative land uses (Adams *et al.* 1990). Studies in the PPR and NGP have generally found strong positive correlations between climate change and grassland habitat conversion (Sohl *et al.*

2012; Attavanich *et al.* 2014). Warmer and wetter conditions in the PPR are predicted to increase wheat production at the expense of significant pastureland (Fig. 2; B.S. Rashford, unpubl. data). Potential effects of climate change, however, are highly heterogeneous across space and are moderated by other drivers (*e.g.* soil quality). Research in the NGP, where predicted climate changes and soil quality are highly heterogeneous, indicates that grasslands in the central Dakotas will be at increasing risk of conversion, while grassland in the western NGP will remain relatively secure or increase (Fig. 3; B.S. Rashford, unpubl. data). Such climate-induced land-use changes can exacerbate the effect of climate change on waterfowl and must therefore be considered when targeting conservation to mitigate climate change. Attavanich *et al.* (2014), predicted climate and land-use change impacts on waterfowl in the PPR and reported that ignoring land-use response would underestimate the effects of climate change on waterfowl by as much as 10% (300,000 breeding pairs).

Economic drivers (prices)

Economic theory assumes that landowners allocate land to the use that generates the highest discounted stream of returns (Rashford *et al.* 2010). Hence, any factors that affect current or future returns will drive land-use decisions. Many studies in the NGP and PPR concluded that agricultural prices or their derivatives (*e.g.* land rental rates) are important drivers of land-use and habitat conversion (Stephens *et al.* 2008; Rashford *et al.* 2010; Rashford *et al.* 2011; Feng *et al.* 2013). For example, recent research in the NGP indicated that, holding all else constant, a 10% increase in the

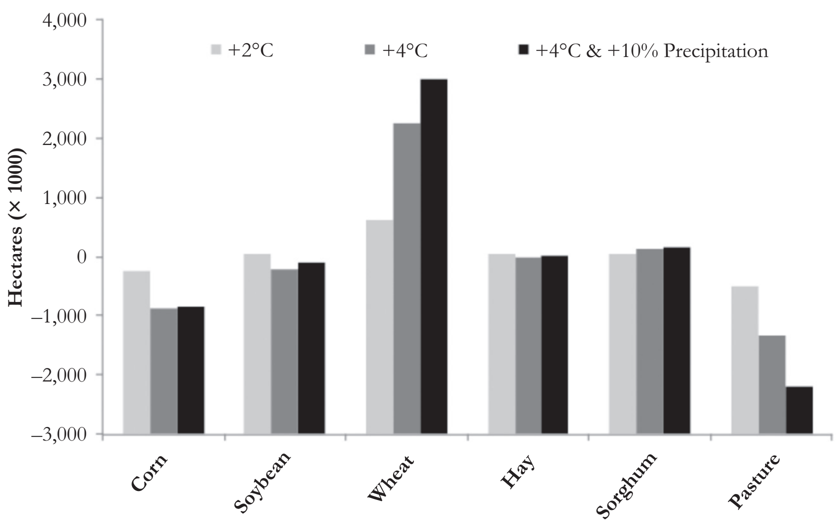

Figure 2. Predicted change in area (1,000s ha) by land use in the North and South Dakota portion of the Prairie Pothole Region for three future climate scenarios (+2°C, +4°C, and +4°C with +10% precipitation) (B.S. Rashford, unpubl. data).

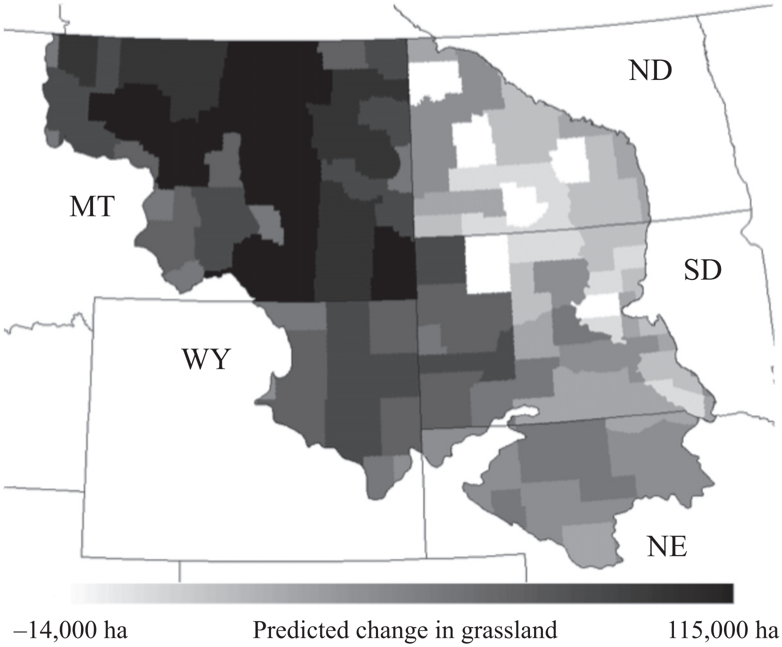

Figure 3. Predicted change in expected grassland area (ha) in 2030, based on the Intergovernmental Panel on Climate Change's A2 scenario (B.S. Rashford, unpubl. data; IPCC 2000). ND = North Dakota, SD = South Dakota, NE = Nebraska, WY = Wyoming and MT = Montana.

returns to cropland would induce ~22,000 ha of grassland to convert to cropland (B.S. Rashford, unpubl. data).

Policy drivers (government payments, crop insurance, conservation payments)

As discussed above, the U.S. farm bill provides a number of programmes that provide incentives for private landowners to choose certain land uses or production practices. Subsidised crop insurance can reduce the financial risk of growing crops on lower quality soils or in areas with less than suitable climates (*i.e.* areas that would be more likely to remain in native covers in the absence of insurance). Thus, increases in crop insurance subsidies have been correlated with increases in crop acreage and decreases in CRP enrolment (Feng *et al.* 2013). Recent research in the NGP suggests that the probability of a field being used for crop production would be as much as 30% lower if there were no direct government payments to agricultural producers, which would imply ~5.4 million additional acres (2.2 million ha) of grassland (B.S. Rashford, unpubl. data).

Future directions for strategically targeting conservation on private land

Strategically targeting conservation in a manner that accounts for economic efficiency, private land-use incentives, and threat of loss may require a slight reconsideration of the current SHC framework. First, conservation agencies will need to consider alternative measures of efficiency when evaluating conservation accomplishments and updating conservation targeting strategies. Simply evaluating programme outcomes in terms of biological benefits will not provide the comprehensive information necessary to decide which programmes should be applied where. Given limited budgets, the cost of achieving outcomes across space must be considered to target conservation cost-effectively. Incorporating costs can imply shifts in conservation focus that are counter to biological targeting, such as focusing resources in regions where the incremental biological benefits are relatively low but the benefits per dollar are high due to low conservation costs. Similarly, the identification of priority areas in the SHC framework could be informed by incorporating costs and conversion threat. For example, prioritising habitat protection for breeding waterfowl based on pair densities may overlook the fact that the costs of achieving population objectives could be reduced by focusing in regions with lower pair densities but relatively less conversion threat (and therefore lower conservation costs).

The decision-support tools critical to the SHC framework may also need to be expanded to make it effective for targeting and delivering conservation on private land. Models of the relationship between habitat and populations may misinform the SHC process if the effects of private land-use decisions are not considered. For example, targeting easements in a particular region may appear to generate a large population response given the current distribution of land-use; however, if probability of land-use change were accounted for, the population response may be substantially different. Additionally, targeting conservation on private land effectively may require wholly different decision support tools than the typical tools that focus on population-habitat relationships. For instance, the use of models that complement traditional population-habitat models, by informing landowners about how different conservation alternatives (*e.g.* working-land conservation or farm bill programmes) can be economically compatible with (or beneficial to) their agricultural production. A site-specific decision support tool, demonstrating the economic and ecological tradeoffs between alternative crop rotations, could thus be used as a conservation delivery mechanism by leading to increased adoption of winter wheat.

Lastly, strategically targeting waterfowl conservation on private land will require recognition that many effective conservation "activities" may have little resemblance to more traditional biological activities. Forming a partnership, itself an emphasis of the SHC framework, to lobby politically for "waterfowl friendly" agricultural policies (*e.g.* conservation compliance) or to invest in agricultural research (*e.g.* new winter wheat varieties) may prove as effective as more traditional direct habitat management. Although many non-profit conservation groups currently use such activities as highlighted in previous sections, incorporating such activities explicitly within the SHC framework would focus the process. Additionally, designing conservation activities for private land should be incorporated specifically (to improve leverage) in farm bill conservation programmes. Farm bill programmes are not particularly well targeted across space, for example, because they largely depend on voluntary participation and opportunistic enrolment. Consequently, it is difficult to control the spatial allocation of such programmes, because of inherent inability to control, or even easily predict, which landowners will choose to participate. A broadened SHC framework that considers existing voluntary enrolment, however, could be used to target other conservation activities to leverage benefits of farm bill programmes, for instance by targeting easements near existing CRP to create larger blocks of waterfowl nesting cover.

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Photograph: Aerial view of southwest Louisiana rice fields, by John K. Saichuk/Louisiana State University AgCenter.

