Waterfowl Response to the Conservation Reserve Program and Swampbuster Provision In the Prairie Pothole Region, 1992–2004

Reimbursable Funds Agreement 05-IA-04000000-N34

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February 27, 2007

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Executive Summary

The U.S. Department of Agriculture, through its Farm Programs, has the ability to impact wildlife populations in the Prairie Pothole Region (PPR) more than any other government agency. The Food Security Act of 1985 authorized the Conservation Reserve Program, and implemented the Wetland Conservation (Swampbuster) Provision of the Farm Bill. The CRP and Swampbuster have been part of every subsequent Farm Bill since 1985. These conservation actions drew immediate positive responses from the conservation community based on the anticipated benefits to wildlife. In this report we summarize the scientific literature relevant to the impact CRP and Swampbuster had on waterfowl in the PPR. We also updated earlier assessments about the impact of CRP on duck production, assess the importance of Swampbuster to maintaining breeding duck populations, discuss recommendations for delivering the CRP, and provide a tool for targeting CRP to achieve even greater benefit from future applications. Studies clearly show that the CRP has provided great benefits for duck production in the U.S. PPR. Since 1992, when CRP acres peaked, net increases of about 2 million additional ducks per year were produced in the PPR of North Dakota, South Dakota, and northeastern Montana. This represents an estimated 30% increase in duck production compared to the same area without the CRP cover on the landscape. During the period 1992–2004 we documented increased duck nest success in all major habitats throughout the PPR and concluded the CRP is having a positive impact on the entire landscape relative to duck production. CRP cover has also had a positive impact on wetlands by restoring biological function. We found that wetlands in CRP fields attracted about 30% more breeding duck pairs than similar classed wetlands in crop fields. We also evaluated the Wetland Conservation (Swampbuster) Provision of the Farm Program. We estimated that if Swampbuster was not part of the Farm Bill, a large number of small, shallow wetlands would be at risk to drainage. If this wetland loss occurred, the breeding duck population would decline in the U.S. PPR by 37%. Finally, we provide maps that can be used to target CRP cover toward areas of moderate to high breeding duck density in order to increase the Program's benefits to duck production.

Introduction

Declining duck populations during the early 1980s lead to the development and implementation of the North American Waterfowl Management Plan (NAWMP) by the United States and Canada [Environment Canada, Canadian Wildlife Service and U.S. Department of Interior, Fish and Wildlife Service (FWS)1986] and subsequently Mexico. The Plan identified wetland and grassland losses in the Prairie Pothole Region (PPR) of North America as major causes of waterfowl population declines. It emphasized the need to develop innovative habitat management practices on private and public lands, and to change land-use and agricultural practices on private lands. Wetland loss, due primarily to drainage for conversion to cropland, has been estimated at 35% and 49% in the PPR of South Dakota and North Dakota, respectively (Dahl 1990). Declining duck nest success throughout the PPR since ~1935 (Beauchamp et al. 1996) has been implicated as a major factor in declining duck populations. Klett et al. (1988) concluded that duck nest success (probability that ≥1 egg in a nest hatches) throughout much of the U.S. PPR was insufficient to maintain population levels for mallards (*Anas platyrhynchos*) and northern pintails (*A. acuta*) at that time, and Hoekman et al. (2002) concluded that nest success was the most important factor influencing population growth rates of mid-continent mallard populations. The decline in duck nest success in the PPR has generally coincided with the continuing conversion of grasslands to cropland in the region, and Greenwood et al. (1995) found that duck nest success in Prairie Canada was negatively related to the proportion of cropland in the landscape. As grassland cover decreases, ducks concentrate their nests in remaining perennial cover where predators such as red fox (*Vulpes vulpes*), striped skunk (*Mephitis mephitis*), and American badger (*Taxidea taxus*) focus their foraging efforts. Wildlife managers have recognized the importance of grassland cover to waterfowl for many years and the protection and restoration of grassland cover has been a major thrust for waterfowl management on lands managed by the U.S. Fish and Wildlife Service (USFWS), state, and non-government conservation organizations in the PPR.

In 1985, Congress passed the Food Security Act (Act) (Public Law 99-198), which contained two important components relative to waterfowl conservation in the PPR: 1) the Conservation Reserve Program (CRP), and 2) the "swampbuster" (wetlands conservation) provision. The Act, administered by the U.S. Department of Agriculture (USDA) had objectives to reduce soil erosion, reduce crop surpluses, and improve wildlife habitat. Under the CRP, landowners contracted with USDA to convert cropland to undisturbed perennial cover such as grass, in exchange for annual payments, usually for a period of 10 years. By 1992 there were about 4.7 million acres of CRP cover in the PPR of North Dakota, South Dakota and northeastern Montana, where the greatest number of breeding ducks occur in the conterminous states. The CRP and swampbuster were reauthorized with each subsequent farm bill since 1985 but the CRP underwent major revisions in eligibility and scoring criteria during and after the 1996 Farm Bill. Since 1996, the area enrolled in the CRP has increased in the PPR of North Dakota (~570,000 acres), and decreased in the PPR of South Dakota (~250,000 acres).

The conservation provisions of the 1985 Farm Bill when initiated in 1986 generated a great deal of enthusiasm from the wildlife conservation community in the northern Great Plains. Populations of many species of grassland nesting birds, including waterfowl, were declining (Robbins et al. 1986, Environment Canada, Canadian Wildlife Service and U.S. Department of Interior, Fish and Wildlife Service 1986) and, as mentioned previously, these declines were linked to grassland and wetland habitat loss due to conversion to cropland. Documented benefits to upland nesting birds from past national agricultural land-retirement programs provided reason for the enthusiasm generated by the conservation provisions of the 1985 Farm Bill. From 1956–1972, the USDA administered the Soil Bank Act of 1956, which converted up to 28.7 million acres of cropland to perennial cover nationwide (Berg 1994), and the Food and Agriculture Act of 1965 that established the Cropland Adjustment Program (CAP), with a goal to shift 40 million acres of cropland to idle cover. Benson (1964), Duebbert (1969), and Deubbert and Lokemoen (1976) documented high nest density and/or high hatching success by ducks in Soil Bank Program and CAP fields.

In 1986, CRP cover began to be planted in the PPR and by 1992 there were ~4.7 million acres in the PPR area of North Dakota, South Dakota and northeastern Montana . Soon after CRP cover became established, several studies were initiated to assess the impact of CRP cover on duck production. Following is a summary of pertinent literature regarding duck nesting and the CRP.

Literature review of breeding ducks and USDA cover programs with CRP type plantings

Benson, R. I. 1964. A study of duck nesting and production as related to land use in Pope County, Minnesota. Pages 107–126 *in* J. B. Moyle, editor, Ducks and land use in Minnesota. Technical Bulletin Number 8. Minnesota Department of Conservation, St. Paul, Minnesota, USA.

This study, conducted in west-central Minnesota from 1957 to 1960, provided information on the influence of newly retired Soil Bank lands (predecessor to CRP) on duck production. Apparent nest success in Soil Bank lands was 41% and was higher than other cover types searched in the area. Benson concluded that ducks could produce one-third more broods in Soil Bank cover compared to other vegetative types studied.

Duebbert, H. A. 1969. High nest density and hatching success of ducks on South Dakota CAP lands. Transactions of the North American Wildlife and Natural Resources Conference 34: 218–228.

This study assessed density and success of duck nests in one tract of land enrolled in the USDA Cropland Adjustment Program (CAP) authorized by the Food and Agriculture Act of 1965. The investigator recorded high duck nest density of 1 nest/2 acres, despite not conducting the first search for nests until June 4 (1968). Apparent nest success for 58 nests was 79%. In a predominately cultivated area 4 miles from the CAP study area, apparent nest success was only 30%. The concealment afforded by the dense CAP cover was credited with the high productivity of ducks nesting there. Duebbert also pointed out the importance of forbs such as alfalfa and sweet clover to nesting ducks. They reported that ~50% of mallard nests and 25% of all duck nests were located in sweet clover.

Duebbert, H. F. and J. T. Lokemoen. 1976. Duck nesting in fields of undisturbed grass-legume cover. Journal of Wildlife Management 40: 39–49.

This study of duck nests in cover enrolled in the CAP was conducted during 1971–73 in the Prairie Pothole Region of north-central South Dakota. Nest density was 4 times higher on CAP fields compared to nearby agriculture lands used for farming and grazing. Apparent success rate for 570 nests was 56%, and higher than nest success reported for other cover types during this period. The investigators concluded that land retirement programs patterned after the CAP could provide vital wildlife habitat in the north-central plains, particularly for ground nesting ducks and other game birds. They recommended plantings composed of tall, robust forms of cool season grasses and legumes, such as intermediate wheatgrass and alfalfa, which remain completely undisturbed for 5 to 10 years.

Horn, D. J., M. L. Phillips, R. R. Koford, W. R. Clark, M. A. Sovada, and R. J. Greenwood. 2005. Landscape composition, patch size, and distance to edges: interactions affecting duck reproductive success. Ecological Applications 15: 1367–1376.

This study investigated the affect of patch size and distance of nests from field edges, on duck nest success in CRP and Waterbank Program cover within low and high grass composition landscapes in North Dakotas, Prairie Pothole Region. Nest success was higher in landscapes with high amounts of perennial grass cover. I their high grass composition study sites, nests located >1313 ft. (400m) from field edges were most successful. These investigators were not able to draw strong conclusions about the relationship between nest success and distance from edge in their low grass study sites possibly because fields were not large enough to have areas >1244 ft. (379m) from edge habitat.

Kantrud, H. A. 1993. Duck nest success on Conservation Reserve Program land in the prairie pothole region. Journal of Soil and Water Conservation 48: 238–242.

Kantrud studied duck nest success in 6 CRP fields during 1989–1991 in south-central North Dakota and western Minnesota. Nest success in CRP cover averaged 23.1% [corrected using the methods of Mayfield (1961)] compared to 8.2% in grass cover on nearby Waterfowl Production Areas (WPAs). This investigator speculated that the higher success in CRP could be due to fields being generally farther from wetlands compared to WPA fields. Kantrud speculated that because this study took place during a period of drought, predator activity may have been more concentrated around remaining wetlands on WPAs. Another contributing factor may have been the larger size of CRP fields compared to WPA fields studied.

Krapu, G. L., R. J. Greenwood, C. P. Dwyer, K. M. Kraft, and L. M. Cowardin. 1997. Wetland use, settling patterns, and recruitment in mallards. Journal of Wildlife Management 61: 736–746.

Krapu et al. studied the selection of different wetland classes by breeding mallards in the Prairie Pothole Region of North Dakota and west-central Minnesota. Their major finding was that mallard females preferred temporary and seasonal wetlands over other wetland habitats particularly during pre-nesting and egg production. These authors suggested that efforts to increase nest success rates (through programs such as the Conservation Reserve Program) will reach more ducks/acre and be more cost effective if concentrated where temporary- and seasonally-flooded wetland habitat is plentiful and land use ensures productive pond conditions. They further suggested that increased waterfowl production could occur by focusing CRP in areas with high densities of cropped wetlands and perhaps other management activities.

Luttschwager, K. A., K. F. Higgins, and J. A. Jenks. 1994. Effects of emergency haying on duck nesting in Conservation Reserve Program fields, South Dakota. Wildlife Society Bulletin 22: 403–408.

This study was conducted in the Prairie Coteau physiographic region of eastern South Dakota in 1989 and 1990. Investigators compared nest success of ducks between hayed and unhayed CRP, and CRP mowed in blocks vs. strips. Average duck nest success in all fields combined was 23.4% (Mayfield corrected), which was higher than that considered adequate for population growth. Nest success across years was higher in both unhayed and hayed blocks, and in whole fields, compared to idled strips. Luttschwager et al. also concluded that residual cover provided by undisturbed CRP cover especially benefited early nesting species.

Phillips, M. L., W. R. Clark, M. A. Sovada, D. J. Horn, R. F. Koford, and R. J. Greenwood. 2003. Predator selection of prairie landscape features and its relation to duck nest success. Journal of Wildlife Management 67: 104–114.

These researchers studied red fox and striped skunk (both major nest predators in the Prairie Pothole Region) foraging patterns and use of habitat features in landscapes differentiated by amount of perennial grass cover. They found that red fox rarely used the interior areas of planted cover (e.g., CRP) in landscapes with high amounts of grass cover, but selected both edge and interior areas of isolated patches of planted cover in low grass landscapes. Skunks were attracted to agricultural wetland edges [164 ft. (50m) buffer around wetlands not within planted cover such as CRP] more than wetland edge in planted cover fields. They found no evidence of an edge effect on nest success in planted cover. They recommended the restoration of large blocks of perennial grass cover in landscapes with high composition of grasslands, and suggested that restoring small patches in fragmented landscapes is less likely to increase duck nest success. They also suggested that restoration of grass buffer strips around wetlands and riparian habitats would be selected heavily by fox and skunk.

Renner, R. W., R. E. Reynolds, and B. D. J. Batt. 1995. The impact of haying Conservation Reserve Program lands on productivity of ducks nesting in the Prairie Pothole Region of North and South Dakota. Transactions of the North American Wildlife and Natural Resource Conference 60: 221–229.

These investigators studied nest success and the number of hatched ducklings produced from hayed and idle portions of CRP fields. They found that nest success between hayed and idled cover did not differ, but nest density was much greater in idle CRP cover. Overall, 2.14 times more ducklings hatched per acre in idle CRP cover than in hayed CRP cover. Renner et al. (1995) acknowledged the potential benefit to CRP cover from managed haying and recommended that haying be prescribed on a rotational basis on no more than 20% of a contract annually, so that each stand would not be hayed more frequently than once every five years. They recommended that haying should not occur before July 20 to prevent destroying nests, incubating hens, and hatchlings.

Reynolds, R. E., T. L. Shaffer, J. R. Sauer, and B. G. Peterjohn. 1994. Conservation Reserve Program: Benefit for grassland birds in the northern plains. Transaction of the North American Wildlife and Natural Resource Conference 59: 328–336.

Results from this study provided evidence that duck nest success in perennial planted cover [i.e. CRP, Waterfowl Production Areas (WPA), Waterbank Program] during the period of the CRP was higher than nest success observed in similar cover prior to implementing the CRP. Results failed to detect a difference in nest success between CRP and WPAs as reported by Kantrud (1993). Researchers observed ample numbers of wetlands near and within both CRP and WPA fields.

Reynolds, R. E., D. R. Cohan, and A. Kruse. 1994. Which cropland to retire: A waterfowl perspective. Proceedings of the Conference: When Conservation Reserve Program contracts expire: The policy options. Soil and Water Conservation Society, 110–111 February 1994, Arlington, Virginia, USA.

This evaluation identified how targeting CRP distribution toward areas of high duck density in the Prairie Pothole Region of the Dakotas would increase duck productivity, increase protection of wetlands, increase protection of highly erodible land, and reduce cost compared to the distribution of CRP in place at that time.

Reynolds, R. E., T. L. Shaffer, R. W. Renner, W. E. Newton, and B. D. J. Batt. 2001. Impact of the Conservation Reserve Program on duck recruitment in the U.S. Prairie Pothole Region. Journal of Wildlife Management 65: 765–780.

These investigators studied the impact of the CRP on duck production in the PPR of North Dakota, South Dakota, and northeast Montana during 1992–1997. They found that planted cover was the most preferred nesting habitat for 5 species of upland nesting ducks (mallard, gadwall [*A. strepera*], blue-winged teal [*A. discors*], northern shoveler [*A. clypeata*], northern pintail), Nest Success was higher in CRP than other major cover types, and nest success was positively related to the amount of perennial grass cover on their 4-mile^2 study sites. They also found that nest success in other cover types was higher during the period when CRP cover was available compared to the period just prior to the CRP and concluded that CRP cover had a positive effect on duck nest success throughout the landscape. They estimated that the CRP was responsible for 2.1 million additional ducks produced annually in the PPR during the period 1992–1997.

Reynolds, R. E. 2005. The Conservation Reserve Program and duck production in the United States' Prairie Pothole Region. Pages 144–148 *in* A. W. Allen and M. W. Vandever, editors. The Conservation Reserve Program–planting for the future: Proceedings of a national conference. U.S. Geological Survey, Biological Resources Discipline, Scientific Investigations Report 2005-5145.

In this paper the investigator extrapolated the results from an earlier study (Reynolds 2001) to years 1998–2003 assuming no change in the distribution of CRP since 1997 and used duck population estimates derived from operational surveys conducted annually by the FWS. The updated assessment estimated that 2.2 million additional ducks were produced annually during the period 1998–2003 bringing the incremental increase in production to 25.7 million ducks for the period 1992–2003. Reynolds cautioned that future assessments should account for changes in the amount and distribution of CRP cover in the PPR since 1997.

Reynolds, R. E., and C. R. Loesch. 2005. Impact of CP23a and Modified CP23a on duck production in the Prairie Pothole Region of the Dakotas. U. S. Fish and Wildlife Service, Habitat and Population Evaluation Team, unpublished report.

This report presented results from using a stochastic mallard productivity model (Cowardin et al. 1988) that simulated the difference in duck production between applying CRP Conservation Practice CP23a (post-2004 wetland CRP) and a proposed modification of CP23a that would result in more whole-field enrollments. Analyses of duck nest data show that nest success tends to be lower in small patches of upland cover such as that around wetland margins compared to nest success in large fields with embedded wetlands. Simulation exercises predicted productivity from landscapes with applications of current CP23a would be slightly lower than if no CRP were present, and applications of the modified CP23a (whole field) would be substantially higher than the same landscapes with no CRP or current CP23a.

Reynolds, R. E., T. L. Shaffer, C. R. Loesch, and R. R. Cox Jr. 2006. The Farm Bill and duck production in the Prairie Pothole Region: Increasing the benefits. Wildlife Society Bulletin 34:963–974.

In this study the investigators 1) identified areas where the application of CRP cover could be targeted to provide the greatest benefits for duck production, and 2) addressed the importance of swampbuster in conserving waterfowl breeding populations. They used spatially explicit models developed from wetland and breeding duck surveys and digital wetland habitat data to estimate the long-term population size and distribution of 5 duck species on ~2.6 million wetlands in the PPR of North Dakota and South Dakota. This approach provided a method to identify areas where grass cover such as CRP will be accessible to the greatest number of upland-nesting ducks in the region. Results were presented as maps that can be used by field personnel to assess the relative priority for applying CRP nesting cover to different land units in the Prairie Pothole Region.

Reynolds et al. also simulated the impact of converting to cropland certain wetlands that are classified as temporary or seasonal water regime (Cowardin et al. 1979), or are ≤ 1.0 acre size. They assumed that wetlands in these classes and embedded in cropland would be at-risk to drainage in the absence of Swampbuster because they could be farmed the majority of years, and therefore, are the most likely wetlands to be drained and converted to cropland in the absence of protective regulations. They concluded that if these at-risk wetlands were drained, the average breeding duck population in the U.S. PPR would decline by 37%.

Sherfy, M. 2004. Density and success of upland duck nests in Conservation Reserve Program fields seeded with native and introduced grasses. U.S. Geological Survey, Northern Prairie Wildlife Research Center, Project Summary Report.

This study was conducted during 2002 and 2003 and focused on differences in duck nest density and success in native vs. introduced plant mixes used in CRP. Nest density and nest success were similar in the two cover types. The report concluded that additional benefits to nesting waterfowl are not realized by establishing native grass CRP plantings compared to introduced plantings. This finding is relevant because during some sign-ups additional EBI points have been awarded for native plantings. Also, native plant seed mixes used in the PPR tend to be more costly than introduced plant seed.

Sovada, M. A., M. C. Zicus, R. J. Greenwood, D. P. Rave, W. E. Newton, R. O. Woodward, and J. A. Beiser. 2000. Relationships of habitat patch size to predator community and survival of duck nests. Journal of Wildlife Management 64: 820–831.

The focus of this study was on the relationship between habitat patch size and duck nest success in uplands that were enrolled in the Conservation Reserve Program. They reported that nest success was generally greater in larger habitat patches compared to smaller patches. They suggested that restoration of small isolated tracts of grassland habitat without accompanying predator management may have negative affect on duck populations, because females will be attracted to these areas and likely exposed to high levels of predation.

Conclusions from literature.

From these evaluations it is clear that the CRP has provided tremendous benefits for upland duck production in the U.S. PPR since 1985. However, as with any conservation program, the magnitude of the benefit is determined by how the program is delivered.

The preponderance of evidence from the literature supports 4 primary conclusions to increase the benefits from CRP for duck production 1) CRP cover should be located near areas where sufficient wetlands exist that attract moderate to high numbers of breeding hens that have access to the cover for nesting; 2) CRP cover should be planted in relatively large blocks to reduce edge; 3) Conservation Practices targeting wetlands in the PPR should allow whole field enrollment to reduce fragmentation and edge around wetlands; and 4) CRP enrollment criteria should, if possible, encourage CRP contracts in areas near other CRP cover, or other forms of existing perennial grass cover to avoid isolated patches. Additionally, plant mixes used in CRP should include legumes such as alfalfa and sweet clover, and haying for management purposes should be done on a rotational basis so that each stand is not hayed more frequently than once in a five year period. Portions of fields hayed should be in blocks.

Since 1997, changes occurred in the amount and distribution of CRP in the PPR, possibly as a result of changes in the Environmental Benefit Index (EBI) used by USDA to rank parcels for enrollment. CRP acres in eastern South Dakota declined by ~250,000 acres and in North Dakota CRP acres increased by ~ 570,000 acres since 1997. The increase of CRP in North

Dakota does not necessarily equate to additional benefit to ducks because the added contracts may not be distributed in areas where the cover is available to numerous breeding ducks. Reynolds' (2005) assessment was based on the assumption that the distribution of CRP did not change between the period 1992–1997 and 1993–2003. However, available evidence suggests that changes in the amount and distribution of CRP in the PPR occurred between these two periods that might influence duck production (U.S. Fish and Wildlife Service, unpublished data).

One aspect of the CRP not yet investigated is CRP's potential impact on function of wetlands located within or adjacent to CRP cover as related to breeding duck carrying capacity. Tilling and planting actions associated with crop production often disturb wetlands in crop fields. The removal of vegetation in tilled wetlands may reduce availability of plant and macro invertebrate food resources that are associated with vegetation. Vegetative cover in undisturbed wetlands may also provide protection from predators, and visual isolation between territorial pairs.

The Swampbuster provision of the 1985 and subsequent Farm Bills is another conservation action believed to potentially benefit waterfowl in the PPR. Agricultural operators that enroll lands in the Federal Farm Program may not be eligible for certain program benefits if they drain or fill wetlands subject to the Swampbuster provision. Many conservationists believe the disincentives associated with Swampbuster have prevented the drainage of countless wetlands that are vital to breeding ducks. Conversely, some agriculture groups have argued that many of the wetlands protected by Swampbuster interfere with cultivation and crop planting, and place an unnecessary burden on operators. They also have contended that small wetlands are less important to breeding waterfowl than larger, deeper wetlands. One farm organization has suggested that wetlands in North Dakota farmed as few as 2 out of 10 years, and temporary bodies of water ≤ 10.0 acres, be exempt from state and federal regulations (North Dakota Farm Bureau 2006 Policies, www.ndfb.org).

In 2007, ~2 million acres of CRP contracts in the PPR of the Dakotas and northeastern Montana are due to expire and by 2010 only about 13% of the current CRP in these states will remain unless reauthorized or extended (Barbarika et al. 2005). The Farm Security and Rural Investment Act of 2002 authorized CRP up to 39.2 million acres nationwide under 10–15 year contracts. This could generate challenges for deciding which contracts will be enrolled, extended, reenrolled, or allowed to expire. Wetland conservation provisions of the next Farm Bill may also be an issue. Conservation groups and farm groups likely will develop initiatives to promote a variety of interests in the next Farm Bill. We believe decisions can best be made when appropriate data and scientific methods are used to target conservation programs.

Study Objectives

In this investigation, we analyze breeding duck and wetland data for 1992–2004 relative to the Conservation Reserve Program in the Prairie Pothole Region of North Dakota, South Dakota and northeastern Montana. We use these analyses to estimate the change in duck carrying capacity and productivity associated with the CRP and to identify areas where the application of CRP cover will provide the greatest benefits for duck production. We also address the importance of Swampbuster in conserving waterfowl breeding populations. We developed spatially explicit models from wetland and breeding duck surveys and digital wetland habitat data to estimate the long-term population size and distribution of 5 ducks species on ~2.6 million wetlands in the PPR. This approach provides a method to identify areas where grass cover such as CRP will be accessible to, and thus benefit, the greatest number of upland-nesting ducks in the region. We present these data as maps that can be provided at different scales for use by field personnel.

We also simulated the impact of converting to cropland certain wetlands that are classified as temporary or seasonal (Cowardin et al. 1979), or are ≤ 1.0 acre. We assume that wetlands in these classes that are embedded in croplands could be farmed the majority of years, and therefore, are the wetlands most likely to be drained and converted to cropland in the absence of protective programs. The objectives of this study are to:

1. Provide a review of literature summarizing the response of waterfowl to CRP in the U.S. Prairie Pothole Region (provided above).
2. Estimate the breeding population response to CRP for 5 duck species (mallard [*Anas platyrhynchos*], gadwall [*A. strepera*], blue-winged teal [*A. discors*], northern shoveler [*A. clypeata*], and northern pintail [*A. acuta*]), and 13 combined species (above species and American wigeon [*A. americana*], green-winged teal [*A. crecca*], wood duck [*Aix sponsa*], redhead [*Aythya americana*], canvasback [*A. valisineria*], lesser scaup [*A. affinis*], ring-necked duck [*A. collaris*], and ruddy duck [*Oxyura jamaicensis*]) in the PPR of the Dakotas and northeast Montana.
3. Estimate the breeding duck populations associated with major Conservation Practices (CP) of the CRP in the PPR.
4. Investigate the impact (if any) that CRP had on breeding duck population carrying capacity of wetlands in CRP fields.
5. Use spatially explicit population and habitat information to develop models that identify areas for targeting CRP contracts to increase duck production.

6. Provide annual estimates (1992–2004) of productivity for 5 duck species in the PPR study area with CRP cover on the landscape and after simulating the conversion of CRP back to cropland.
7. Assess duck production associated with major CP types (CP 1, 2, 4, 10, and 23).
8. Provide an assessment of expected population relationships with CRP and species of concern.

Study area

Our study area was that portion of North Dakota and South Dakota that lies east or north of the Missouri River plus Daniels, Roosevelt, and Sheridan Counties, Montana (Figure 1). This area approximates the combined geographical regions of these states known as the glaciated Prairie Pothole Region (Kantrud and Stewart 1977) and glacial Lake Agassiz plain (Bluemle 1991). We refer to this area as the Prairie Pothole Region (PPR). The area contains >2.6 million depression wetland basins, most of which are not integrated with natural surface drainage connections. Most wetlands are small and shallow and tend to dry out rapidly during the growing season if not sustained by sufficient precipitation. Due to the periodic and highly variable precipitation and temperature extremes throughout the region, wetlands cycle between dry and deluge conditions at frequent intervals. The U.S. PPR is characterized by having the highest density of breeding dabbling ducks in the U.S. (Bellrose 1976). Agriculture is the predominant land use in the PPR with cattle production operations most common in the western area, and small grain and row crop production generally increasingly dominant from west to east.

In this report we sometimes present results for the entire study area and at other times we present results only for the PPR of North Dakota and South Dakota. This is due to differences in the availability of data for the PPR of the Dakotas compared to northeastern Montana. For example, Common Land Use (CLU) data for CRP contracts were not available in digital form for northeastern Montana when we were conducting our analyses, and therefore, we could not estimate the change in duck breeding populations associated with wetlands in CRP fields for this area. We tried to maintain consistency whenever possible.

Methods

Wetland data

We obtained digital data of wetlands in our study area, classified according to Cowardin et al. (1979), from the USFWS National Wetlands Inventory (NWI) office, Saint Petersburg, Florida. NWI classified multiple wetland zones within some wetland basins (see Cowardin et al. 1982). However, our breeding duck surveys were conducted on a sample of wetlands in which the entire basin was classified based on the deepest water zone, similar to that described by Stewart and Kantrud (1971). To maintain consistency between wetland classes used in our waterfowl survey sample and wetlands used to extrapolate across our entire study area, we translated NWI wetlands into basin classes following the procedures described by Cowardin et al. (1995) and Johnson and Higgins (1997). For palustrine system wetlands this process essentially dissolved the interior wetland polygons of complex basin wetlands and reclassified each wetland based on the deepest NWI water regime (Figure 2). Lacustrine system wetlands were combined with wetlands containing intermittently exposed and permanently flooded water regime polygons and redefined as lakes. We also separated riverine system wetlands from the other classes. Our final wetland classes were temporary, seasonal, semi-permanent, lake, and riverine. We determined the area of each wetland basin (*BASINAREA*) by summing the areas of individual polygons comprising the basin.

Sample design for wetland and breeding duck surveys

Basin wetlands. Primary sampling units for breeding duck surveys on basin wetlands were 335 4-mi^2 blocks (Figure 1) selected using a stratified random process described by Cowardin et al. (1995). We used ARC/INFO (Version 7.1.2, 1997 Environmental Systems Research Institute, Redlands, California, USA) geographic information systems (GIS) software to overlay our sample blocks with the wetland basin layer described above. We then randomly selected approximately 2,800 wetland basins from our sample blocks with the following distribution: 15% temporary, 45% seasonal, 35% semi-permanent, and 5% lake. This provided an optimal allocation for a stratified random sample that treated wetland basin classes as strata, and avoided over-sampling the more numerous temporary basins that are dry more frequently than other classes.

Riverine wetlands. Less than 0.03% of the wetland area in our study area was classified as riverine and because these wetlands are not the principal habitat for ducks in our study area (Kantrud and Stewart 1977) they were not included in our survey design. However, we believed riverine wetlands provided important duck habitat in some areas so we included them in our assessment. Duck pair data for riverine wetlands were obtained from surveys conducted on 338 stream sample miles in the PPR area of North Dakota during May 1983–1986 (U.S. Fish and Wildlife Service, unpublished report). Results from these surveys were translated into pairs/acre of riverine wetland class as mallard = 0.123; gadwall = 0.034; blue-winged teal = 0.143; northern shoveler = 0.028; and northern pintail = 0.006 and treated as constants in our estimation procedure.

Breeding pair and wetland habitat surveys

Each year during 1987–2004 survey personnel visited each sample wetland basin once during the period May 1–May 15 and again during the period May 20–June 5 to record the occurrence of all mallard, gadwall, American wigeon, green-winged teal, blue-winged teal, northern shoveler, northern pintail, wood duck, redhead, canvasback, lesser scaup, ring-necked duck, and ruddy duck. Two surveys were conducted to match the timing of data collection with the peak occurrence of species groups. We used methods described by Cowardin et al. (1995) to conduct surveys and followed the methods described by Hammond (1969) and Dzubin (1969) to record duck population data. Distinctive pairs (1 male and 1 female), and lone male ducks are considered to represent pairs. Dabbling ducks in groups of 2–5 were calculated as pairs except American wigeon and northern shoveler for which only distinctive pairs and lone males were considered pairs. For diving ducks, lone females and females in flocks ≤5 were classified as representing pairs. All other groupings were considered as migrants or non-breeding ducks and were not used to calculate breeding pairs (Cowardin et al. 1995).

Observers carried maps with boundaries of all ponds to be surveyed. At the time of the survey, observers made visual estimates of the proportion of the mapped wetland that was covered by water. This percent full estimate (*PFULL*) was recorded on the field data form and was used to calculate the surface area of water for each wetland visited during the survey. Some wetland basins extended beyond the boundaries of our sample blocks and therefore were not completely surveyed. When this occurred we expanded both the percent full and duck population data to the entire wetland basin area.

Upland habitat classification

For each of the 335 sample blocks, we identified and mapped upland and wetland habitats according to the classification described by Cowardin et al. (1988). Upland classes were grassland (i.e., pastureland), idle grassland, hayland, cropland, woodland, scrubland, planted cover, road and railroad rights-of-way, barren land, and other (e.g., rock piles, small grass patches and buffers, shelter belts, etc.). For use in models, woodland, scrubland, and other classes were combined into a single odd area class (Klett et al. 1988). Planted cover was separated further into CRP, WPA, and Waterbank Program, all which had similar vegetative characteristics, but were established through different programs. Changes in CRP acres among years on sample blocks were tracked using beginning and ending dates of contracts which we obtained from the FSA for the period of our study. This was an improvement over previous analyses (i.e., Reynolds 2005) to expand duck production estimates for the PPR to years beyond 1997 because it allowed us to account for changes in the distribution of CRP among years. Upland habitat areas were delineated at the scale of 8 inches/mile on hard copy maps that were georeferenced and digitized with ARC/INFO. Digital wetland data obtained from NWI for each block was derived from high-altitude (1:63,360), color-infrared photography acquired during the late 1970s and early 1980s. This wetland data layer was combined with our digital upland data layer to form complete land classification coverage for each of the 335 sample blocks. We also calculated the Universal Transverse Mercator (UTM) easting and northing coordinates, projected in zone 14, for the center of each block.

Wetland Assessment

Each year during May 1987–2004, we measured the number and wet area of all wetland basins that contained water on all sample blocks. Wetland information was derived from aerial videography taken vertically at an altitude of approximately 13,000 feet above ground from small, fixed-wing aircraft. Video imagery was later replayed, and a fixed scene was captured onto a computer (equipped with a video capture card) and saved as a Raster Vector CAD file into Map and Image Processing System (MIPS; MicroImages, Lincoln, Nebraska, USA) GIS software. Captured video scenes were then overlaid with digital wetland polygon data obtained from the National Wetlands Inventory. Using the original video as a reference, wet areas ∃0.02 acres were delineated for all wetland basins on our sample blocks.

Annual estimates of breeding duck populations

Annual estimates of numbers of breeding duck pairs for 13 species were derived from a survey conducted on the 335 sample blocks to estimate breeding duck pairs and production for the USFWS, Region 6 portion of the Prairie Pothole Joint Venture, North American Waterfowl Management Plan (Cowardin et al. 1995). We used aerial videography, as described above, to determine the wet area of all wetland basins on each sample block, and we conducted ground counts of breeding duck pairs on a sub-sample of those wetland basins. These data were used in regression-ratio models (Cowardin et al. 1995) to estimate breeding duck pairs on each sample plot in our study area. The regression-ratio estimator was

$$\hat{Y}_R = \gamma\left(\sum_{p=1}^{N} f(a_p)\right), \quad (1)$$

where (corrected for annual and geographic variation, a_p was the area of pond p, N was the number of ponds on a sample block, and $f(a_p)$was the uncorrected estimate of breeding population, $f(a_p) = A \times (a_p) + B \times \sqrt{a_p}$. For A and B, we used regression coefficients provided by Cowardin et al. (1995:7). We computed the correction factor "γ" for each USFWS, Wetland Management District (Cowardin et al. 1995) in our study area each year as

$$\gamma = \frac{\sum_{p=1}^{n} y_p}{\sum_{p=1}^{n} f\left(a_p\right)}, \tag{2}$$

where y_p was the number of breeding ducks counted on pond p, and n was the number of ponds surveyed.

Annual estimates of duck productivity

We used models presented by Cowardin et al. (1995: equations 3–7) and Krapu et al. (2000) to estimate production parameters for 5 upland nesting duck species (mallard, gadwall, blue-winged teal, northern shoveler and northern pintail) for years 1992–2004 (peak-CRP period) on 335 sample blocks. These production models require input data of breeding population size estimated from equations 1 and 2, availability of various nesting habitats, nesting habitat preference, nest success by habitat, wetland condition, brood survival, and brood size at fledging to estimate duck production from 4-mi^2 landscapes (size of our sample blocks; Table 1). Except for brood survival of gadwall and brood size at fledging for all species, inputs to production models were derived from Reynolds et al. (2001) including estimates of nest success in CRP cover from 98 sample blocks (Figure 1). Brood survival for species other than gadwall was estimated for each sample block using a proportional hazards model for mallard brood survival presented by Krapu et al. (2000) in which brood survival is a function of 1) percent seasonal wetlands with water; 2) hatch date; and 3) precipitation events. We assumed this model was appropriate for blue-winged teal, northern shoveler, and northern pintail. For gadwall we treated brood survival as a constant (0.84) based on data collected within our study area (Pietz et al. 2003). Brood size at fledging was taken from Cowardin et al. (1995). Principal production parameters estimated for each block were: 1) overall nest success; 2) recruitment rate (number of females fledged/adult female in the breeding population); and 3) recruits (total males and females fledged). We expanded estimates from the sample blocks to our entire study area following the methods of Cowardin et al. (1995) and calculated weighted means for some parameters, using weights equal to the breeding duck populations estimated annually (1992–2004) on sample blocks.

We estimated duck production during 1992–2004 under 2 scenarios: 1) assuming actual landscape configuration (CRP present); and 2) assuming that cropland had never been converted to CRP cover. Northern Prairie Wildlife Research Center (NPWRC) maintains a repository of waterfowl nest records submitted by researchers and managers from numerous independent studies conducted throughout our study area. We used daily survival rate (DSR) estimates from nest data collected during 1990–1994 and submitted to the NPWRC Waterfowl Nest File for all habitats except CRP and WPA cover to estimate duck production under actual landscape configuration during 1992–2004. The 1990–1994 period is the most recent for which data are available that coincided with the CRP period. Because the nest file did not contain sufficient data from northeast Montana, we used DSR estimates from central North Dakota (see Klett et al. 1988) for sample blocks in Montana. We used data collected in our field studies during 1992–1995 to estimate DSR in CRP and other forms of planted cover.

To simulate duck production under the scenario in which cropland replaced CRP cover, we used DSR estimates from the NPWRC Waterfowl Nest File for 1980–1984, the latest 5-year pre-CRP period. We also used the nest file to determine the preference (probability that a female will select a particular habitat for nesting, given all habitats are equally available) of nesting females for different nesting habitats. This analysis followed the methods of Klett et al. (1988) and included data from 1966–1994 (USGS Northern Prairie Wildlife Research Center nest files presented by Reynolds et al. 2001). Preference values were derived from data for central North Dakota and were assumed to apply elsewhere in our study area. Preference for CRP, WPA, and Waterbank Program covers were assumed to be the same. DSRs for nests initiated in planted cover enrolled in the USDA Waterbank Program were assumed to be the same as CRP. We used these preference values and availability of habitat types on each sample plot as inputs to our production models.

Pair regression models to estimate long-term average breeding duck population size and distribution

In addition to producing annual estimates of breeding duck pairs during the peak CRP years (1992–2004), we developed models from survey data collected in 1987–1998 to estimate the long-term average population size for 5 individual species and 13 species combined on all wetlands in our study area. We used these models in combination with digital data of land-cover/land-use to segregate duck pairs associated with different wetland classes, land use characteristics around wetlands (i.e., wetlands in crop fields) and wetlands associated with CRP cover. We developed regression models relating duck pairs to wetland and spatial variables with PROC MIXED (SAS Version 6.12, 1997). Because we intended to apply our models to all wetland basins (~2.6 million) in our study area, we considered only predictor variables that could be measured for all wetlands. Cowardin et al. (1988) found a non-linear relationship between duck pairs and wetland size for the 4 classes of basin wetlands in our sample. Their best-fitting models included wet area and square root of wet area. On large wetlands, dabbling ducks tend to occur more frequently along the shallow water (shoreline) zone than in the deepwater zone (Kantrud and Stewart 1977). The square root of wet area was considered a proxy for shoreline length.

Stewart and Kantrud (1973) found that ducks were not distributed equally throughout the biotic regions of the PPR in North Dakota. Therefore, we determined the spatial position (UTM coordinates) of each wetland in our sample.

We developed pair-wetland regression models (n = 20) for each combination of wetland class (n = 4) and duck species (n = 5). We used backward stepwise procedures to fit each model, deleting terms with $P > 0.05$ in each step. Explanatory variables in the most complex model for each analysis included: 1) area covered by water for each sample basin measured in May of each year 1987–1998 (*WETAREA*); 2) $\sqrt{WETAREA}$; 3) $WETAREA \times \sqrt{WETAREA}$; 4) $\sqrt{WETAREA} \times$ UTM easting (*UTME*); 5) $\sqrt{WETAREA} \times$ UTM northing (*UTMN*); and 6) $\sqrt{WETAREA} \times UTME \times UTMN$. Because the same ponds were surveyed each year, we accounted for lack of independence among repeated measures using a repeated statement, with ponds as subjects. We maintained a Toeplitz structure among repeated measures because extensive evaluation indicated that this structure was most appropriate. We weighted each observation by the product of the proportion of each pond counted multiplied by $1/\sqrt{WETAREA}$. The first term in the weighting factor reflected our reduced confidence in pair counts from partially surveyed ponds, and the second term was necessary because the variance in number of pairs increased in proportion to $\sqrt{WETAREA}$.

We used cross-validation (Snee 1977) to evaluate the predictive ability of each model. The cross-validation procedure consisted of estimating the coefficients of the model from randomly selected subsets (80%) of ponds and applying the model to the remaining 20% of the ponds. We then computed the mean squared error between predicted and observed number of pairs to assess the predictive ability of the model. We repeated this process 1000 times for each model. We also computed R^2 values based on predicting numbers of pairs occupying wetlands on landscapes of approximately 16 mi^2.

Incorporating hydrologic variation into pair regression models

The area inundated by water of individual wetlands during our survey (May) vary both temporally and spatially. To apply our breeding pair regression models to all wetlands in our study area required an estimate of *WETAREA* for each wetland. We did not directly account for temporal variation in *WETAREA*, but instead based our analyses on the average value among years ($\overline{WETAREA}$). We made use of the relationship $\overline{WETAREA} = \overline{PFULL} \times BASINAREA$ and accounted for spatial variation in $\overline{WETAREA}$ by developing a model in which $\overline{PFULL}$ varied spatially. We averaged values of *PFULL* from sample wetlands across years (1987-1998) and used multiple regression to relate $\overline{PFULL}$ to 1) *BASINAREA*, 2) *UTME*, 3) *UTMN*, and 4) *UTME* × *UTMN*. We transformed all predictor variables by using a natural log function (ln) to reduce skewness and stabilize variance in the residuals. We developed separate models for each wetland class and selected models that contained predictor variables that were significant ($P < 0.01$) and had the lowest mean-squared error. We used a similar approach to model $\overline{\sqrt{PFULL}}$ and to estimate $\overline{\sqrt{WETAREA}}$ for use in our breeding pair regression models. Because the relation between $\overline{\sqrt{PFULL}}$ and $\overline{PFULL}$ was very strong for lakes ($R^2 = 0.98$), we used a cubic polynomial regression model to estimate $\overline{\sqrt{PFULL}}$ from $\overline{PFULL}$.

The above procedure was effective in accounting for large-scale spatial variation in percent full. However, when we examined residuals from the above regression models, we found evidence of spatial correlations; wetlands near one another tended to have similar residuals compared to wetlands farther apart. This was true for all wetland classes except lake, and suggested that predictions could be improved by developing a "kriging" model for the residuals. A kriging estimate for any given point is a weighted average of the points surrounding it; weights typically decrease with increasing distance based on a variogram function that is estimated from the data. We used PROC VARIOGRAM (SAS Institute 1996) to estimate the variogram functions, and then used PROC KRIGE2D (SAS Institute 1996) to generate predictions of residuals from our models for uniformly spaced points on a 3.1-mile grid. We used search radii of 66 mi, 88 mi, and 76, mi respectively, for temporary, seasonal and semi-permanent wetlands. The choice of search radius is generally not critical as long as the value is large enough to capture most of the spatial correlation. We verified that predicted values were not sensitive to our choice of search radius by trying different values. Estimates of $\overline{PFULL}$ and $\overline{\sqrt{PFULL}}$ from the regression models were then adjusted based on results of the kriging exercise to obtain final estimates. Final estimators for $\overline{PFULL}$ and $\overline{\sqrt{PFULL}}$ were:

$$\overline{PFULL} = [e^{b_0 + b_1 \times \ln(x) + b_2 \times \ln(y) + b_3 \times \ln(x) \times \ln(y) + b_4 \times \ln(BASINSIZE)}] - 0.5 + \hat{Z} \qquad (3)$$

$$\overline{\sqrt{PFULL}} = [e^{c_0 + c_1 \times \ln(x) + c_2 \times \ln(y) + c_3 \times \ln(x) \times \ln(y) + c_4 \times \ln(BASINSIZE)}] - 0.5 + \hat{W} \qquad (4)$$

where b_0–b_4 and c_0–c_4 were estimated regression coefficients, *x* and *y* were UTM easting and northing for the centroid of each wetland and, $\hat{Z}$ and $\hat{W}$ were estimates of small-scale spatial variation from the kriging models.

Incorporating accessibility into models

Upland-nesting duck species use nesting cover that is distant from core wetlands used for feeding and resting (Coulter and Miller 1968, Duebbert et al. 1983). Therefore, the proximity of CRP cover to wetlands used by breeding pairs is an important consideration in determining how many breeding hens will have access to that cover for nesting and potentially capitalize on its benefits. We used published data on home range characteristics for the five most common upland nesting species studied and created additional models that measured potential accessibility by female ducks to specific land-units within our study area based on the number of pairs occupying wetlands in the surrounding area. Accessibility models, also referred to as gravity models and spatial interaction models are based on the principles of Newtonian physics have been used by social scientists for over a century to measure human social phenomena such as market areas (Carey 1858) and more recently to measure access to health care facilities (Joseph and Bantock 1982). Newton's hypothesis states that the interaction between two objects is directly proportional to the mass of the objects and inversely proportional to the distance between the two objects (Thrall and del Valle 1997). In our models, land-area units (hereafter referred to as cells) were the first-order objects with constant size (mass) of 1280 X 1280 ft (37.6 acre), and the population of breeding duck pairs was the second-order object with mass determined by the density of breeding duck pairs estimated to occupy the community of wetlands within a finite distance from a cell. Distance was classed as proximity zones (Laurini and Thompson 1992) based on home range metrics for each of the five duck species (Table 2). We calculated potential accessibility to cells for each species (PA_s) as

$$PA_s = \sum_{i=1}^{n_d} pop_i / a_d \tag{5}$$

where pop_i was the number of pairs predicted to occur on wetland i, a_d was the area (mi^2) of the proximity zone calculated by buffering each cell by distance d (distance that hens will travel from core wetlands to nesting sites) (Table 2), and n_d was the number of wetland basins ≤ d

miles from the cell. We scaled pop_i by a_d because the size of proximity zones varied among species and we wanted a common metric (density) to project our results. The potential accessibility index (*PA*) for total breeding hens for cells in our study area was derived by summing PA_s for the five species we studied. We divided our entire study area into 37.6 acre cells (~1.4 million) and used GIS techniques to solve equation 5 for each cell. We assumed all breeding hens within a species' proximity zone had equal access to that particular cell. Because the distance across proximity zones was always greater than the distance across cell units, all breeding hens in our analysis (and in nature) had access to more than one cell. This did not affect the usefulness of our results because we were interested in the relative differences in accessibility among cells.

Applying pair regression models to wetlands and land unit cells

We used ARC/INFO to apply spatially explicit models to wetlands and 37.6 acre cells within our study area. We first estimated $\overline{WETAREA}$ and $\overline{\sqrt{WETAREA}}$ for every wetland basin in our study area from equations (3) and (4). We then used these estimates as inputs to the pair-wetland regression models. This gave us estimates of the long-term average breeding duck population associated with every wetland basin identified from NWI digital data in our study area. Finally, we incorporated accessibility into our models by applying proximity models (equation 5) to determine *PA* for every 37.6 acre cell in our study area. Large values for *PA* indicated cells that were accessible by the greatest number of nesting hens and that could potentially benefit from the relative high nest success associated with CRP cover if occurring on that cell.

Estimating the influence of CRP on breeding duck carrying capacity

We analyzed our breeding population and habitat data for 1987–2004 to estimate the influence that CRP cover had on duck carrying capacity of wetlands embedded in or adjacent to

CRP fields by incorporating cover class surrounding wetland basins into a suite of population models presented below in this section. We then used the results of those analyses to adjust the long-term average breeding duck pair estimates for ducks associated with wetlands in CRP fields in our study area, and calculated the overall average change in breeding pairs as a result of the CRP. For this exercise we obtained attributed digital shapefiles of Common Land Units classified as CRP from the state FSA offices in North Dakota and South Dakota. Certified CLU data for 4 counties in North Dakota were not available when we conducted this study so uncertified data were used instead for those counties. We overlaid the CLU shapefiles with our digital wetland basin data layer to identify wetlands that were embedded in CRP fields.

We developed a series of pair-wetland regression models for each principal duck species (n = 5) and for the remaining 8 species in aggregate. We conducted separate analyses for 1) temporary wetlands, 2) seasonal wetlands, and 3) semipermanent wetlands and lakes combined. We evaluated six models of duck breeding pairs for each class of temporary and seasonal wetlands. Models corresponded to the following sets of predictor variables:

1. $LOCATION, \sqrt{WETAREA}$
2. $LOCATION, \sqrt{WETAREA}, WETAREA$
3. $LOCATION, \sqrt{WETAREA}, WETAREA, \sqrt{WETAREA} \times WETAREA$
4. $LOCATION, \sqrt{WETAREA}, UCLASS$
5. $LOCATION, \sqrt{WETAREA}, WETAREA, UCLASS$
6. $LOCATION, \sqrt{WETAREA}, WETAREA, \sqrt{WETAREA} \times WETAREA, UCLASS$

LOCATION denotes the spatial position of an individual wetland and was specified in the models as UTM easting (*UTME*), UTM northing (*UTMN*), and $UTME \times UTMN$. *WETAREA* was the area covered by water for each sample basin measured in May of each year 1987–2004 and

UCLASS is a categorical covariate that indicates the cover type of adjacent uplands. Values for *UCLASS* were 'CRP' if the wetland was adjacent to any amount of CRP cover; 'OTHER GRASS' if the wetland was not adjacent to CRP cover, but was adjacent to any amount of grassland habitat; and 'CROP' if the wetland was not adjacent to CRP or other grass cover, but was adjacent to or surrounded by cropland.

We considered 12 models of duck breeding pairs on semipermanent wetlands and lakes. Models corresponded to the following sets of predictor variables:

1. $LOCATION, \sqrt{WETAREA}, WCLASS$
2. $LOCATION, \sqrt{WETAREA}, WETAREA, WCLASS$
3. $LOCATION, \sqrt{WETAREA}, WETAREA, \sqrt{WETAREA} \times WETAREA, WCLASS$
4. $LOCATION, \sqrt{WETAREA}, WCLASS, \sqrt{WETAREA} \times WCLASS$
5. $LOCATION, \sqrt{WETAREA}, WETAREA, WCLASS, \sqrt{WETAREA} \times WCLASS, WETAREA \times WCLASS$
6. $LOCATION, \sqrt{WETAREA}, WCLASS, UCLASS$
7. $LOCATION, \sqrt{WETAREA}, WETAREA, WCLASS, UCLASS$
8. $LOCATION, \sqrt{WETAREA}, WETAREA, \sqrt{WETAREA} \times WETAREA, WCLASS, UCLASS$
9. $LOCATION, \sqrt{WETAREA}, WCLASS, \sqrt{WETAREA} \times WETAREA, UCLASS$
10. $LOCATION, \sqrt{WETAREA}, WETAREA, WCLASS, \sqrt{WETAREA} \times WCLASS, WETAREA \times WCLASS, UCLASS$
11. $LOCATION, \sqrt{WETAREA}, WETAREA, WCLASS, \sqrt{WETAREA} \times WCLASS, WETAREA \times WCLASS, UCLASS, \sqrt{WETAREA} \times WCLASS \times UCLASS$

12. *LOCATION,* $\sqrt{WETAREA}$, *WETAREA, WCLASS,* $\sqrt{WETAREA}$ ×*WCLASS, WETAREA* × *WCLASS, UCLASS,* $\sqrt{WETAREA}$ ×*WCLASS* × *UCLASS, WCLASS* × *UCLASS*

The categorical covariate *WCLASS* indicated the wetland class (semipermanent or lake).

We used information-theoretic methods (Burnham and Anderson 2002) to assess the relative support (i.e., model weight) for each model and calculated Akaike's Information Criterion with small size adjustment (AIC_c). Our final predictive model was based on model averaging. Model averaging reduces bias and avoids the need to choose a single "best" model when the evidence for a single best model is equivocal.

We used PROC GENMOD (SAS Version 6.12, 1997) to fit log-linear models corresponding to the above sets of predictor variables. We weighted each observation by the product of the proportion of each pond counted multiplied by $1/\sqrt{WETAREA}$. The first term in the weighting factor reflected less confidence in pair counts from partially surveyed ponds, and the second term was necessary because the variance in number of pairs increased roughly in proportion to $\sqrt{WETAREA}$.

We specified a Poisson distribution for the response variable—number of duck pairs—anticipating that the data would be overdispersed relative to the variance of the Poisson distribution. We accounted for this by estimating an overdispersion parameter $\hat{c}$ by dividing the goodness-of-fit chi-square value from the global models (Model 6 for temporary and seasonal wetlands; Model 12 for semipermanant and lake wetlands) by the degrees of freedom (Burnham and Anderson 2002:68). We then adjusted the AIC_c variance for our global models using quasi-likelihood methods and used the modified AIC_c ($QAIC_c$) as an indication of relative support for that particular model (Burnham and Anderson 2002:70). We also computed model weights and used them in model-averaging.

We based values of $QAIC_c$ (and model weights) on analyses in which we assumed that repeated counts on the same wetland were independent. Many of the wetlands in our sample were surveyed for breeding ducks in multiple years, adding a repeated measures component to our study. Therefore, we also fitted each model under the assumption that repeated counts were correlated. This was accomplished by specifying a correlation structure in which we assumed that the correlation involving counts from any two years on any pond was the same as for any other two years on any other pond (compound symmetry assumption). We considered more complex structures as well but encountered difficulties getting models to converge. Parameter estimates from analyses based on the assumption of compound symmetry were then model-averaged using the model weights described above. We could not compute model weights from the compound symmetry analyses alone because those analyses were not likelihood-based.

Identifying priority areas for CRP

We assigned each 37.6 acre cell in our study area to a low, medium, or high breeding pair density zone based on the value of *PA*. These zones can be considered as areas where the application or retention of CRP cover will be available for nesting by different numbers of breeding ducks, and thus, provide different levels of benefit for duck production. CRP tracts located in areas of high *PA* provide nesting cover accessible to the greatest number of ducks, whereas CRP tracts in areas with low *PA* provide cover for the least number of pairs. We used GIS techniques to determine how much current (ca. July 2005) CRP occurred in each of the 3 *PA* zones within the PPR of North and South Dakota. We obtained certified digital data for CRP fields in our study area for all but 4 counties in North Dakota from the USDA Farm Service

Agency (FSA). For the remaining 4 counties we used preliminary digital data obtained from the FSA.

Assessing the impact of removing wetland protection

We examined the potential impact on duck breeding populations of removing wetland protection on small and shallow wetlands as provided by the Swampbuster provision of the Farm Bill. To accomplish this we developed criteria to identify wetlands at-risk to drainage defined as meeting all the following criteria: 1) temporary or seasonal class or < 1.0 acre; 2) partially or totally imbedded in cropland; and 3) not protected by USFWS ownership or perpetual easement. Wetlands meeting these criteria are virtually all on privately owned lands used for crop production, and >90% were enrolled in federal farm support programs (D. Campbell and B. Natwick, Farm Service Agency, personal communication). To identify wetlands that met the above criteria we used GIS techniques and combined 3 layers of digital data for our entire study area as follows: 1) basin wetland data; 2) cropland classified from LANDSAT imagery; and 3) lands protected by the USFWS (National Wildlife Refuge lands and perpetual easements). We then used the output of our pair-wetland regression models to simulate the impact of drainage on duck populations by removing the breeding duck pairs associated with at-risk wetlands from our pair summaries.

Results

Breeding population and habitat surveys.

During 1987–2004 we visited an average of 2,344 wetland basins twice each year and recorded observed ducks and the extent of wet area for each wetland basin. During 1992–2004 (the period we used to evaluate production from CRP), the number of wet ponds varied depending primarily on precipitation, but was generally high compared to long-term pond counts conducted since 1987 (Figure 3). Pond numbers were particularly high in 1997, 1999, and 2001.

Regression models for wetness (i.e., $\overline{PFULL}$ and $\sqrt{\overline{PFULL}}$) indicated that wetness varied spatially and with basin area. In general, wetness increased from northwest to southeast in our study area and as basin size increased. In addition to the large-scale spatial variation, kriging models for residuals revealed smaller-scale variation in wetness patterns. In other words, small-scale wetness patterns were embedded within large scale wetness patterns probably due to such factors as soil characteristics, slope, aspect, watershed, size or micro-climate.

During 1987–2004 we recorded 259,306 duck pairs or indicated pairs on 30,843 wet pond-years. These data were used to develop models to estimate the annual number of breeding pairs and recruits, and long-term estimates of populations and their relationship with wetlands in CRP fields. Models used to estimate the long-term breeding population predicted number of pairs increased with wetland size non-linearly, indicating higher pair densities on smaller wetlands. Cross-validation indicated these models performed substantially better than models that did not account for spatial variation or non-linearity (see Reynolds et al. 2006).

Breeding duck population response to CRP

During the 1992–2004 period the average annual breeding population for 5 upland nesting species combined was 5,018,676 pairs (Table 3). Species composition of breeding population during this period was 26% mallard, 18% gadwall, 38% blue-winged teal, 9% northern shoveler, and 9% northern pintail.

We identified 199,018 acres of cropped temporary, seasonal, and semi-permanent wetlands that were embedded in CRP fields and 592,318 acres of non-cropped wetlands for which some part was embedded in or adjacent to CRP cover in our study area of the Dakotas (Tables 4 and 5). We refer to these wetlands as being impacted by CRP cover if they demonstrated different function for breeding ducks (i.e., carrying capacity) compared to similar wetlands in crop fields. All five dabbling duck species studied individually showed positive response to at least one class of wetlands impacted by CRP cover compared to similar wetlands in crop fields. The other 8 species combined showed only weak response to wetlands in CRP fields. Figures 4–9 show the relative strength for 5 duck species to select wetlands in CRP fields versus wetlands in crop fields, or wetlands in other grass cover which was treated as a baseline for these comparisons. For the 5 primary duck species studied, 10 of 15 duck species-wetland class combinations showed a positive response to CRP; 5 were neutral, and none were negative. We estimated that CRP has resulted in an average annual increase of 167,092 additional duck pairs (334,184 breeding ducks) attracted to the PPR of the Dakotas during 1992-2004. Table 6 shows the percent increase in the numbers of breeding ducks that settled on wetlands impacted by CRP cover compared to similar wetlands in crop fields. Data are presented by wetland class for the combined 5 major CRP types (CP1, CP2, CP4, CP10, and CP23) contracted in the PPR (Appendix I). Of the 3 wetland classes studied, seasonal wetlands in CRP fields realized the greatest increase in use by the five principal species studied (+40.3%) compared to wetlands in crop fields (Table 6).

Duck Production and CRP

We used recruitment models for 5 upland-nesting duck species (mallard, gadwall, blue-winged teal, northern shoveler, and northern pintail) to estimate numerous parameters associated with productivity and to simulate the impact of CRP cover on recruitment.

Reynolds et al. (2001) found that planted cover (which includes CRP) was the preferred major cover type for nest placement by upland-nesting species in the PPR. In this study we estimated that 33% of nests for the 5 species studied were initiated in CRP cover. CRP cover accounted for <6% of the land area in the study area. Average estimated percent of nests initiated in CRP cover and nest success in CRP cover varied among the 5 species studied (Table 7).

During the period 1992–2004 duck production varied annually (Tables 8–13), primarily reflecting changes in numbers of wetlands and breeding pairs (Figure 3, Table 3). Recruits produced were lowest in 1992, following several years of drought, and highest in 1997, 1999, and 2001, when pond numbers were highest (see Figure 3). Across the PPR study area production of recruits averaged 8,472,474 ducks per year. We estimated that for the 5 duck species studied an average ~2 million additional recruits were produced annually during the peak period of CRP (1992–2004) compared to the same period when we simulated the scenario with cropland in place of CRP. Average percent increases in production resulting from CRP were: 38% mallard, 22% gadwall, 33% blue-winged teal, 31% northern shoveler, 27% northern pintail, and 31% for these five species combined. Estimates of annual recruits produced for 5 principal species, with and without CRP (simulated removal), are presented in Tables 8–13.

Distribution of CRP relative to distribution of breeding ducks

The impact that a program such as CRP has on duck populations is determined by the amount and distribution of the CRP cover. Neither CRP contracts nor duck populations are uniformly distributed across the PPR landscape. We examined the distribution of CRP relative to the distribution of breeding duck pairs for the Dakotas PPR where CRP contract data were available in spatial format. We applied accessibility models by using results from our pair models to the entire study area and then assigned cells to priority zones as follows: high, areas with > 50 pairs/mile^2 ; medium, areas with 25–50 pairs/mile^2; and low, areas with < 25 pairs/mile^2. We overlaid digital data for existing CRP contracts in North and South Dakota to identify the amount of CRP area in the different priority areas. Results from this analysis showed that in both states ~75% of CRP acres were in the combined areas of high and medium duck accessibility zones, and ~25% of CRP acres were in the low duck accessibility zone (Table 14). In North Dakota, 91% of breeding ducks have access to 64% of the land area which contains 75% of CRP acres. In South Dakota, 93% of breeding ducks have access to 70% of the land area that contains 75% of CRP acres. In other words, 25% of CRP acres are in areas of the PPR where only 9% and 7% of the duck population can access it for nesting in North Dakota and South Dakota, respectively.

CRP acres are also distributed dissimilarly among CP types relative to the distribution of ducks settling on wetlands in CRP fields. As presented earlier in this report, wetlands embedded in CRP cover are more attractive to breeding ducks than similar wetlands in crop fields. Therefore, increased benefits to duck production can be realized by CRP practices that focus CRP cover plantings around wetlands, particularly temporary, seasonal, and small semi-permanent wetlands. Table 15 shows the percent distribution of CRP acres in the Dakotas compared to the percent distribution of duck pairs occurring on wetlands impacted by CRP cover. The results show that for both North Dakota and South Dakota, CP23 is targeted most favorably to positively impact breeding ducks compared to other CP types.

Swampbuster and breeding duck populations

We applied the above basin wetness and pair-wetland models to 2,634,262 basin wetlands and applied ratio estimators to 7,766 riverine wetlands to estimate the long-term mean number of breeding duck pairs occurring on each wetland in our study area. The estimated mean number of breeding pairs for 5 duck species in our study area was: mallard, 928,517; gadwall, 672,774; blue-winged teal, 1,471,187; northern shoveler, 372,471; northern pintail, 469,244; and total, 3,914,193. Pair density for all species combined, by wetland class, was: temporary, 1.04/acre; seasonal, 1.10/acre; semi-permanent, 0.58/acre; lake, 0.17/acre; and riverine, 0.34/acre.

From our analyses we identified 1,371,388 (52% of all basin wetlands in our study area) wetlands that met our criteria for being at-risk to drainage in the absence of protection. We estimated these wetlands supported an average breeding population of 1,434,911 pairs. The results suggest that if all at-risk wetlands were drained, the average breeding duck population would decline by 37% in the PPR of North Dakota and South Dakota (Figure 10a, b). All species studied showed substantial potential decline in populations due to wetland drainage, but northern pintail suffered the greatest decline (-41%) and gadwall the smallest decline (-33% Table 16).

Prioritizing Areas where CRP will Increase Duck Production.

For CRP cover to benefit breeding ducks it must be accessible to nesting hens. During the breeding season ducks are more sedentary with smaller travel ranges than at other times of the year. Therefore, somewhat precise targeting of CRP cover on the landscape is necessary to ensure that maximum benefits are realized for duck production. Accessibility models that account for breeding hen travel distances or home range characteristics were developed and results are provided to achieve this targeting. As described in the method above, we combined the results from our pair models with accessibility models for the entire study area and then assigned each 37.6-acre cell in our study area to breeding pair density zones as follows: High accessibility (areas with > 50 pairs/mile^2); medium accessibility (areas with 25–50 pairs/mile^2); low accessibility (areas with < 25 pairs/mile^2). A map representing the distribution of different breeding duck pair density areas is presented in Figure 11.

Discussion

The PPR of the United States supports some of the highest breeding duck populations in North America, particularly many of the heavily harvested species such as mallard, blue-winged teal, and gadwall (Preliminary Estimates of Waterfowl Harvest and Hunter Activity in the United States During the 2003 ad 2004 Hunting Season; U.S. Fish and Wildlife Service 2005). The PPR of North and South Dakota covers about 7% of the traditional waterfowl survey area (Cowardin and Blohm 1992) that is the principal breeding area for ducks in North America. During recent years (1996–2005), 20% of all breeding ducks surveyed in the traditional area occurred in the PPR of the Dakotas (U.S. Fish and Wildlife Service 1996–2005, Trends in duck breeding populations, unpublished reports).

Because of the scale of production agriculture in the U.S. PPR, it is no surprise that federal Farm Programs would have significant impacts on waterfowl production in this region. Based on our current study and review of literature, there remains little doubt that Farm Bill conservation provisions since 1985, particularly the CRP and Swampbuster, have provided substantial benefits to continental waterfowl populations.

In this study we documented positive impacts the CRP is having on breeding duck carrying capacity for wetlands completely or partially embedded in CRP cover. We estimated that wetlands in CRP fields attracted 5.0–43.2% (species dependent) more breeding duck pairs than if those wetlands had occurred in crop fields. The principal dabbling duck species showing the greatest response to wetlands in CRP fields were: mallard, blue-winged teal, gadwall, northern shoveler and northern pintail (*in order from greatest to least response*). All wetlands in CRP fields showed increased function (i.e., increased breeding duck carrying capacity) due to CRP cover, but seasonal wetlands showed the greatest increase compared to other classes. Seasonal wetlands are occupied at high density by breeding ducks and are frequently tilled when occurring in crop fields. Other species (n = 8) examined collectively did not show a strong preference for wetlands in CRP fields. Of these species, 5 are diving duck species and 3 are dabbling duck species that mostly use larger, deeper wetlands (Bellrose 1976) that are less likely to be impacted by cultivation. We identified ~199,000 acres of cropped wetlands and another ~592,000 acres of non-cropped wetlands positively impacted by CRP cover. Additionally, we estimated that CRP was responsible for 25.9 million (1.99 million /year) additional ducks produced in the PPR of the Dakotas and northeast Montana during 1992–2004 compared to the production expected in the absence of the CRP. This is slightly less than the increased duck production presented by Reynolds' (2005) where he estimated 25.7 million additional ducks produced during 1992–2003 (2.14 million/year). Reynolds (2005) estimates were based on the assumption that the area and distribution of CRP in the PPR of the Dakotas was similar between 1992–1997 (monitored) and 1998–2003 (not monitored). However, Reynolds (2005) pointed out that changes in the distribution of CRP had occurred and suggested these changes should be accounted for in future attempts to evaluate the impact of CRP on duck production beyond 1997, which we did for this study. The difference between current and earlier estimates of duck production suggests that the current distribution of CRP is slightly less optimal for ducks compared to the distribution during 1992–1997. Nevertheless, the nearly 2 million additional ducks produced per year as a result of the CRP is a significant increase in duck production. Up to this point we have considered the impact of the CRP on duck breeding populations and production separately. Realistically, the influence of the CRP on breeding pairs and production should be considered in combination. Because of the different methods used to model the influence of the CRP on duck production (annually) and on breeding pair carrying capacity (long-term), we were not able to directly combine the two population parameters. However, it seems reasonable to suggest that of the 2 million additional recruits produced each year due to the CRP, up to 200,000 resulted from the increased breeding duck population associated with wetlands in CRP fields.

The other major component of the Farm Bill relating to breeding ducks in the PPR is the Swampbuster provision. Temporary and seasonal wetlands are preferred by the 5 species of breeding ducks we studied, and these wetlands comprise >90% of the wetlands in the PPR (U.S.

Fish and Wildlife Service unpublished data). Temporary and seasonal wetlands commonly are tilled (Stewart and Kantrud 1973) and because of their small size and shallow depth, these wetlands are most likely to be drained for conversion to crop production. Our results indicate that for the 5 species of breeding ducks we studied, 37% of ducks depend on the nearly 1.4 million wetlands that would be at risk to drainage if Swampbuster protection were removed. We estimated that draining at-risk wetlands in the PPR would result in a 37% decline in breeding duck populations (range among 5 species = -33 to -41 percent) for the PPR of North Dakota and South Dakota (Table 16, Figure 10 a, b). The presence of these at-risk wetlands was sufficient to maintain duck populations at levels that allowed duck-hunting regulations to be more liberal than might otherwise have occurred during some years of the period 1995–2005 (based on adjustments made to mallard breeding populations 1995–2005 and applied to Table 8 in U.S. Fish and Wildlife Service [2005]). Swampbuster may be particularly important in light of the 2001 decision by the United States Supreme Court (Solid Waste Agency of Northern Cook County vs. United States Army Corp of Engineers) that may reduce the protection of isolated wetlands under Section 404 of the Clean Water Act.

We believe the future of ducks in the U.S. PPR will depend heavily on the future of federal farm programs. Greater than half of the CRP area (~2.5 million acres) in North Dakota and South Dakota was due to expire in 2007. Reenrollments or extensions have been offered by FSA to most contract holders. However, to maintain current waterfowl production capacity into the future, the Environmental Benefit Index (EBI) used to determine which CRP contracts are accepted by USDA under the general signup, and CRP conservation practice standards, which determines the programs effectiveness for waterfowl and other wildlife, will require careful consideration. EBI criteria and conservation practices have changed considerably since general signups in 1997–2000 when most of the CRP currently in the PPR was contracted. For example, the criteria for general signups during 1997–2000 included points for offers in the PPR National Conservation Priority Area, proximity to wetlands (including potholes), and proximity to state water, air, or wildlife-quality priority areas (Barbarika et al. 2005) such as USFWS Waterfowl Production Areas. Since 1997, FSA has administered the Continuous CRP (CCRP) which enrolled lands and conservation practices designed to provide high environmental benefits without requiring landowners to wait for a general signup. The CCRP is designed to encourage participation in the CRP and obtain greater environmental benefits. All CRP lands provide conservation benefits (Hyberg 2005), but some are not suited best for meeting nesting habitat requirements of upland nesting ducks. For example, idle grass plantings in strips and buffers are similar to road rights-of-way and other fragmented habitats described by Cowardin et al. (1988). Although these areas may be attractive to nesting hens, nests in these habitats suffer high failure rates from depredation (Klett et al. 1988, Reynolds et al. 2001). Conversely, landscapes associated with high nest success tend to have large (≥32-ha) blocks of CRP associated with other perennial grass cover, including other CRP cover. Whole-field enrollments, such as most contracts that currently exist in North Dakota and South Dakota, have been demonstrated to meet the productivity requirements of upland-nesting ducks (Reynolds et al. 2001).

After the 2002 Farm Act all wetland practices became eligible for the CCRP. Because wetland practices could be enrolled at any time they were not considered for enrollment in the general signup CRP. Initially, the CRP for restored wetlands (CP23) was a general signup practice that targeted certain wetlands with a cropping history, required planting a 6:1 ratio of CRP cover-to-wetland area, and allowed certain non-cropped wetlands to determine the upland buffer for enrollment. Because CP23 specifically focused on wetlands, it offered potentially great benefits for waterfowl and other wetland birds. When CP 23 was replaced by a continuous practice (CP23a) only those wetlands meeting cropping history criteria and uplands up to a 4:1

ratio of CRP cover-to-wetland area were eligible for that practice. This had the unintended effect of requiring farmers enrolling in CP23a to either fragment fields in a way that farming the non-CRP portion was impractical, or enroll land using both continuous and general CRP signups. Consequently CP23a was not popular with farm operators in most of the PPR, as indicated by the low enrollment after this change (Barbarika et al. 2005). To address concerns associated with CP23a in the PPR the FSA, in 2006, initiated the "Duck Nesting Habitat Initiative" (CP37). This initiative resolves fragmentation and biological issues raised concerning CP23a.

CP37 eligibility criteria targets wetlands in areas with more than 25 breeding duck pairs per square mile, and permits landowners to enroll wetlands with cropping history and a 10:1 ratio of upland-to-wetland using both cropped and certain non-cropped wetlands to determine the upland buffer. Because most wetlands in the PPR are small (81% ≤0.40 ha), a ratio of 10:1 will allow more entire fields to qualify for enrollment, eliminating problems with fragmentation. The earlier CP23 with a 6:1 upland-to-wetland ratio was very popular with landowners in the PPR as evidenced by over 770,000 acres and 390,000 acres contracted in North Dakota and South Dakota respectively. In April 2002, CP23 accounted for 24% of all CRP in North Dakota and South Dakota. CP37 in the PPR also addresses concerns about CP23a by some wildlife conservation groups because duck nest success in planted cover around wetland edge (similar to CP23a) tends to be low (3–13%, Phillips et al. 2003]) compared to that observed in entire fields of CRP (19–27%, Reynolds et al. 2001).

In summary, changes in enrollment criteria and the EBI have occurred annually since 1997 as the Farm Service Agency has adapted the CRP to enhance the environmental benefits for wildlife, water quality and soil productivity. It is impossible to discuss the impacts that each individual change had on the amount and distribution of CRP enrolled in the PPR of the Dakotas.

However, it is evident that in the more recent sign-ups the acceptance rate of CRP offers in the PPR has declined (U.S. Department of Agriculture, unpublished report).

Management Applications

The USDA FSA and Natural Resources Conservation Service have expressed a desire to assess and improve the conservation benefits derived from USDA conservation programs (Hyberg 2005, Kellogg 2005). Budget constraints and conflicting ideas about how program objectives should be emphasized undoubtedly will impact decisions about the future of the CRP and other conservation components of the Farm Program. We assume that future decisions about Farm Bill conservation programs will rely heavily on science and objective assessments of program results. For example, Congress is looking for quantifiable measures of benefits derived from conservation programs (Hyberg and Lederer 2005) and Johnson and Stephenson (2005) anticipated that applications of GIS techniques would serve an increasing role in future CRP decision processes.

In this study we used GIS techniques, biological data, and spatially explicit models to assess the impact of CRP on duck breeding populations and productivity, and to identify priority areas in the PPR of North Dakota, South Dakota, and northeastern Montana where CRP cover would be accessible to (and benefit) the greatest number of breeding female ducks. This information can be used to help prioritize existing CRP contracts for reenrollment and target additional contracts for future enrollment. Although our study focused primarily on North Dakota, South Dakota, and northeastern Montana, the FWS has already provided similar data for the PPR of Minnesota, Iowa, and the remainder of Montana for use in targeting the recently announced “Duck Nesting Habitat Initiative” (CP37). For convenience, USFWS has provided duck-pair accessibility data in digital form that can be used to produce hardcopy or computer-based maps of virtually any size and resolution for any area in the PPR. When combined with other readily available digital data (roads, survey grid, ownership) this approach can provide a simple, user-friendly method to determine the relative duck accessibility rating for all 37.6-acre cells (land units) in the PPR.

We realize that many factors besides waterfowl will be considered when deciding the future direction of the CRP and other conservation programs administered by USDA. However, due to the national (and international) importance of waterfowl production from the United States PPR, we assume waterfowl will remain a priority wildlife group relative to decisions about conservation provisions of future farm bills. Indeed, Reynolds et al. (1994) presented evidence that, by targeting CRP toward areas of high duck density in the PPR, greater conservation of wetlands and highly erosion-prone uplands would occur compared to the targeting criteria in place at that time. We conclude that by targeting CRP cover toward areas identified as high priority for breeding ducks, additional benefits to duck production will occur, and many other wildlife benefits and conservation objectives such as soil and water conservation will also be realized.

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Table 1. Input parameters for duck population models presented by Cowardin et al. (1995), and data sources used in analyses to estimate production for 5 principal duck species in the U.S. Prairie Pothole Region, 1992-2004, under 2 scenarios: (1) actual landscape configuration, and (2) cropland in place of Conservation Reserve Program cover.

Input Parameter	Data Source
Breeding duck pair estimates	This study, following methods of Cowardin et al. (1995)
W, percentage of wetland basins containing water	This study, using aerial videography
α, index to nesting intensity derived from *W*	Cowardin et al. (1995):equation 6
Nesting habitat preference of female ducks	NPWRC[1] files analyzed for Reynolds et al. (2001) following methods of Klett et al. (1988)
Area of available nesting habitat	This study
Duck nest success	
CRP and planted cover	Reynolds et al. (2001)
Other nesting cover types (grassland, hayland, cropland, etc.)	NPWRC nest files analyzed for Reynolds et al. (2001) following methods of Klett et al. (1988)
Z, survival rate of broods	This study, using model from Krapu et al. (2000)
B, average brood size at fledging	Cowardin et al. (1995)

[1]U.S. Geological Survey, Northern Prairie Wildlife Research Center

Table 2. Distances used to determine proximity zones for calculating the number of duck pairs (5 species) that could access specific 37.5-acre land units in the Prairie Pothole Region of North Dakota, South Dakota, and northeastern Montana. Distances were derived from home range studies.

Species	Distance (miles)	Source
Mallard	2.25	Dwyer et al. (1979), Lokemoen et al. (1984), Cowardin et al. (1985)
Gadwall	1.00	Gates (1962)
Blue-winged teal	1.00	Dzubin (1955)
Northern Shoveler	0.75	Poston (1974)
Northern Pintail	2.50	Derrickson (1975)

Table 3. Estimated number of breeding pairs for 5 duck species and those species combined in the Prairie Pothole Region of the North Dakota, South Dakota, and Northeastern Montana, 1992–2004.

BREEDING PAIRS

	Mallard		Gadwall		BWT		N. Shoveler		N. Pintail		Species Combined	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Year												
1992	505,257	26,008	309,809	18,848	414,028	25,674	134,315	7,275	132,137	6,763	1,495,546	78,684
1993	809,078	32,295	523,488	21,182	890,691	41,518	302,437	13,390	297,467	12,788	2,823,161	113,451
1994	944,238	36,077	656,173	24,149	1,807,494	85,381	504,481	20,313	495,129	20,064	4,407,515	178,709
1995	1,241,713	49,617	826,748	33,224	2,586,930	119,925	597,364	25,170	606,867	27,751	5,859,622	248,965
1996	1,167,343	48,562	856,899	36,904	2,217,859	97,104	537,839	24,852	442,842	21,101	5,222,782	222,786
1997	1,714,214	68,273	1,506,461	69,179	3,543,977	184,172	609,367	33,688	620,427	29,643	7,994,446	376,470
1998	1,635,628	93,053	1,105,094	61,654	2,536,389	167,628	454,706	29,125	504,269	34,522	6,236,086	376,401
1999	1,491,681	67,329	1,139,934	55,993	2,318,188	116,084	557,948	29,619	463,478	23,566	5,971,229	287,994
2000	1,601,097	93,278	1,118,499	72,432	2,206,830	163,372	455,125	39,339	388,157	26,373	5,769,707	386,698
2001	2,096,973	91,621	1,249,727	65,996	2,149,552	115,375	605,992	37,181	749,475	41,440	6,851,719	344,531
2002	1,411,881	84,682	968,343	61,611	1,689,291	96,728	429,110	24,659	432,736	28,937	4,931,360	291,654
2003	1,069,403	53,586	838,581	46,764	1,335,479	74,942	302,964	17,377	204,096	12,991	3,750,523	197,553
2004	1,119,684	61,259	703,743	44,516	1,247,226	70,740	370,178	22,575	243,901	18,167	3,684,733	203,584
Average	1,303,181	52,247	909,156	38,457	1,924,888	88,193	452,223	20,018	429,228	18,804	5,018,676	214,139

Table 4. Acres of cropped temporary, seasonal, and semi-permanent wetlands embedded in Conservation Reserve Program (CRP) cover[1] that provide increased functions for breeding ducks as a result of the CRP in the Prairie Pothole Region of North Dakota and South Dakota.

	Wetland Acres		
Wetland Class	North Dakota	South Dakota	Combined
Temporary	37,219	26,039	63,258
Seasonal	67,250	22,486	89,736
Semi-Permanent	27,820	18,204	46,024
Total	132,289	66,729	199,018

[1] Based on the distribution of CRP Common Land Units, July 2006.

Table 5. Acres of non-cropped temporary, seasonal, and semi-permanent wetlands adjacent to Conservation Reserve Program (CRP) cover[1] that provide increased functions for breeding ducks as a result of the CRP in the Prairie Pothole Region of North Dakota and South Dakota.

	Wetland Acres		
Wetland Class	North Dakota	South Dakota	Combined
Temporary	24,337	17,281	41,618
Seasonal	111,177	46,323	157,500
Semi-Permanent	233,948	159,252	393,200
Total	369,462	222,856	592,318

[1] Based on the distribution of CRP Common Land Units, July 2006.

Table 6. Estimated percent increase of breeding duck pairs (carrying capacity) for wetlands impacted by Conservation Reserve Program[1] cover compared to model predictions for the same wetlands if occurring in crop fields in the Prairie Pothole Region of North Dakota and South Dakota, 1992-2004.

	Wetland Class			
Species	Temporary	Seasonal	Semi Permanent	Combined Classes
Mallard	22.7	39.9	61.4	43.2
Gadwall	NC[2]	55.8	42.5	38.6
Blue-winged Teal	NC	61.4	41.7	40.4
Northern Shoveler	NC	24.1	6.7	13.0
Northern Pintail	12.3	NC	NC	5.0
5 Species Combined	9.7	40.3	32.4	29.7
Other 8 Species [3]	NC	1.6	6.7	4.9

[1] Major CRP types CP1, CP2, CP4, CP10 and CP23

[2] Values < 1.0 percent are expressed as NC (No Change)

[3] Includes American wigeon, green-winged teal, wood duck, redhead, canvasback, lesser scaup, ring-necked duck, and ruddy duck.

Table 7. Estimated average nest success and percent total nests initiated in Conservation Reserve Program (CRP) cover for 5 species of upland nesting ducks, 1992–2004.

	Percent of all nests initiated that occurred in CRP cover		Nest Success in CRP	
Species	Estimate	SE	Estimate	SE
Mallard	35.5	2.7	18.4	1.7
Gadwall	38.3	3.1	20.9	2.1
Blue winged-teal	30.9	2.6	23.3	2.4
Northern Shoveler	32.8	2.8	25.2	2.6
Northern Pintail	26.4	2.5	20.6	2.5
Species Combined	33.2	2.7	21.3	2.1

Table 8. Estimated number of mallard recruits produced with and without Conservation Reserve Program (CRP) cover in the Prairie Pothole Region of North Dakota, South Dakota, and northeastern Montana, 1992–2004.

	Recruits without CRP		Recruits with CRP		Difference	
	Estimate	SE	Estimate	SE	Estimate	SE
Year						
1992	234,298	17,933	308,829	21,575	74,531	5,727
1993	613,852	27,300	823,161	36,636	209,309	15,093
1994	950,155	37,097	1,278,949	47,653	328,795	21,279
1995	1,272,574	48,805	1,748,394	68,152	475,820	28,875
1996	1,095,541	45,226	1,521,486	65,483	425,946	30,371
1997	1,856,466	78,592	2,567,625	106,555	711,160	42,045
1998	1,255,619	79,960	1,706,824	109,163	451,205	37,672
1999	1,569,575	70,930	2,142,646	97,505	573,071	39,840
2000	1,065,843	57,520	1,486,093	85,428	420,250	36,963
2001	2,419,967	103,305	3,386,766	143,041	966,799	57,981
2002	943,318	51,019	1,324,494	77,902	381,175	33,988
2003	747,657	35,204	1,009,671	46,340	262,014	16,882
2004	736,429	42,244	989,023	56,895	252,595	22,581
Average	1,131,269	42,662	1,561,684	58,335	430,415	24,594

Table 9. Estimated number of gadwall recruits produced with and without Conservation Reserve Program (CRP) cover in the Prairie Pothole Region of North Dakota, South Dakota, and northeastern Montana, 1992–2004.

	Recruits without CRP		Recruits with CRP		Difference	
	Estimate	SE	Estimate	SE	Estimate	SE
Year						
1992	354,658	21,572	431,304	27,541	76,645	8,492
1993	747,559	29,878	904,599	36,453	157,041	12,670
1994	1,144,912	42,566	1,361,915	49,267	217,004	17,135
1995	1,469,367	61,530	1,788,771	76,676	319,404	24,520
1996	1,379,921	58,384	1,691,447	75,523	311,526	26,226
1997	2,626,102	116,872	3,237,006	144,169	610,904	43,238
1998	1,566,094	84,542	1,895,253	108,553	329,159	35,576
1999	1,983,839	87,779	2,389,660	111,025	405,821	36,719
2000	1,452,737	81,788	1,814,342	124,002	361,605	51,922
2001	2,256,632	116,870	2,793,542	151,317	536,910	52,980
2002	1,225,338	67,369	1,482,308	98,610	256,970	41,075
2003	1,169,296	60,889	1,389,047	84,533	219,751	33,780
2004	929,733	54,631	1,083,605	69,270	153,872	24,389
Average	1,406,848	55,283	1,713,053	72,177	306,205	26,533

Table 10. Estimated number of blue-winged teal recruits produced with and without Conservation Reserve Program (CRP) cover in The Prairie Pothole Region of North Dakota, South Dakota, and northeastern Montana, 1992–2004.

	Recruits without CRP		Recruits with CRP		Difference	
	Estimate	SE	Estimate	SE	Estimate	SE
Year						
1992	358,329	24,051	462,702	31,831	104,373	9,937
1993	1,253,250	66,990	1,657,040	99,875	403,789	38,623
1994	3,052,797	133,119	3,999,885	179,189	947,089	60,369
1995	4,839,107	222,063	6,343,234	298,299	1,504,126	97,023
1996	3,482,745	153,579	4,669,284	226,944	1,186,539	88,693
1997	6,609,496	365,512	8,785,433	459,610	2,175,937	132,387
1998	3,213,153	230,382	4,272,802	315,900	1,059,650	106,603
1999	4,039,844	203,998	5,317,182	270,668	1,277,338	90,166
2000	2,491,811	156,595	3,408,853	252,896	917,042	110,254
2001	4,280,146	220,829	5,672,697	295,020	1,392,551	103,310
2002	1,924,696	103,413	2,577,187	152,033	652,490	59,133
2003	1,629,081	79,254	2,126,617	104,390	497,536	34,262
2004	1,434,161	79,356	1,868,809	117,765	434,648	47,814
Average	2,967,524	122,286	3,938,921	165,675	971,397	59,674

Table 11. Estimated number of northern shoveler recruits produced with and without Conservation Reserve Program (CRP) cover in the Prairie Pothole Region of North Dakota, South Dakota, and northeastern Montana, 1992–2004.

	Recruits without CRP		Recruits with CRP		Difference	
	Estimate	SE	Estimate	SE	Estimate	SE
Year						
1992	83,566	5,113	111,238	6,504	27,672	2,116
1993	342,988	15,779	451,284	22,704	108,296	9,026
1994	833,496	37,142	1,043,934	45,054	210,438	16,022
1995	992,360	45,047	1,247,815	55,812	255,455	19,153
1996	759,694	37,127	968,962	44,202	209,268	14,544
1997	971,234	52,893	1,253,970	70,108	282,736	22,276
1998	498,384	33,000	652,680	43,661	154,296	13,957
1999	847,105	43,213	1,106,807	57,304	259,702	19,853
2000	415,415	24,158	575,604	38,397	160,189	17,822
2001	966,376	57,230	1,321,508	81,634	355,132	29,330
2002	385,099	19,845	534,741	28,516	149,642	11,614
2003	347,553	25,135	452,310	30,180	104,757	8,135
2004	345,695	19,442	477,721	27,748	132,026	12,190
Average	599,300	24,614	785,395	31,978	186,095	11,599

Table 12. Estimated number of northern pintail recruits produced with and without Conservation Reserve Program (CRP) cover in the Prairie Pothole Region of North Dakota, South Dakota, and northeastern Montana, 1992–2004.

	Recruits without CRP		Recruits with CRP		Difference	
	Estimate	SE	Estimate	SE	Estimate	SE
Year						
1992	59,564	3,864	74,550	4,446	14,986	1,197
1993	214,044	9,057	271,994	12,410	57,950	5,174
1994	505,818	22,390	620,497	27,705	114,679	10,491
1995	596,976	27,872	772,612	40,021	175,635	16,272
1996	395,863	18,889	498,867	24,035	103,004	8,664
1997	627,738	28,736	800,211	39,972	172,473	15,793
1998	385,259	26,973	468,479	32,123	83,220	9,591
1999	480,754	22,221	586,352	28,326	105,598	10,871
2000	252,854	15,453	335,365	24,760	82,511	10,986
2001	718,603	37,000	968,670	56,267	250,068	24,181
2002	271,702	17,593	348,788	25,387	77,086	10,526
2003	169,228	14,357	202,119	15,705	32,892	3,418
2004	165,271	11,250	205,714	17,489	40,443	7,936
Average	372,578	15,442	473,421	21,087	100,843	8,467

Table 13. Estimated number of recruits for five combined species[1] produced with and without Conservation Reserve Program (CRP) cover in the Prairie Pothole Region of North Dakota, South Dakota, and northeastern Montana, 1992–2004.

	Recruits without CRP		Recruits with CRP		Difference	
	Estimate	SE	Estimate	SE	Estimate	SE
Year						
1992	1,090,416	66,295	1,388,622	83,796	298,206	24,051
1993	3,171,693	133,927	4,108,078	189,923	936,385	72,737
1994	6,487,178	256,628	8,305,181	331,911	1,818,003	114,690
1995	9,170,384	390,160	11,900,825	522,064	2,730,440	173,767
1996	7,113,763	298,713	9,350,046	417,476	2,236,283	159,010
1997	12,691,036	620,756	16,644,246	795,647	3,953,210	238,821
1998	6,918,508	436,576	8,996,038	585,141	2,077,530	189,047
1999	8,921,118	414,150	11,542,647	548,414	2,621,529	185,700
2000	5,678,661	325,901	7,620,257	512,377	1,941,597	219,734
2001	10,641,724	520,117	14,143,184	705,649	3,501,460	247,668
2002	4,750,154	244,972	6,267,517	364,128	1,517,363	147,530
2003	4,062,816	196,711	5,179,764	256,267	1,116,949	86,566
2004	3,611,289	192,072	4,624,872	271,804	1,013,583	106,482
Average	6,477,518	251,179	8,472,473	338,500	1,994,955	123,215

[1] Mallard, gadwall, blue-winged teal, northern shoveler and northern pintail

Table 14. Percent distribution of Conservation Reserve Program (CRP) cover (circa 2006), average breeding duck populations for 5 combined species[1] 1987–1998, and percent of land area in 3 breeding duck density zones[2] in the Prairie Pothole Region of North Dakota and South Dakota.

	% Distribution		
Duck density zone	CRP Cover	Breeding duck pairs	Area
North Dakota			
High	36	61	31
Medium	39	30	33
Low	25	9	36
South Dakota			
High	44	72	40
Medium	1	21	30
Low	25	7	29

[1] Mallard, gadwall, blue-winged teal, northern shoveler, and northern pintail.

[2] High pair density $\geq$ 50 pairs/mi^2, Medium pair density $\geq$ 25 pairs and < 50 pairs/mi^2, Low pair density <25 pairs/mi^2

Table 15. Percent distribution of breeding duck pairs occurring on wetlands impacted by Conservation Reserve Program (CRP) cover among 5 major CP types[1] in North Dakota and South Dakota.

	North Dakota		South Dakota	
CP Type	% of CRP Acres[2]	% of Duck Pairs	% of CRP Acres	% of Duck Pairs
1	10.6	9.5	12.8	10.9
2	2.1	2.1	19.6	16.0
4	19.7	17.3	7.4	5.7
10	38.2	31.4	24.3	23.5
23	29.3	39.6	35.9	43.9

[1] See Appendix II for CP type descriptions.

[2] Percent of total for 5 CP Types listed.

Table 16. Predicted change in average number of breeding duck pairs consequential to draining of at-risk[1] wetland basins in the Prairie Pothole Region of North Dakota and South Dakota, USA, using 1987-1998 survey data.

Species	Estimate (1987-1998 average)	Predicted (postdrainage)	% change
Mallard	928,517	573,109	-38
Gadwall	672,774	447,562	-33
Blue winged-teal	1,471,187	941,541	-36
Northern Shoveler	372,471	239,567	-36
Northern Pintail	469,244	277,503	-41

[1]At-risk wetland basins were defined as temporary or seasonal class (Cowardin et al. 1979) or <1.0 acre in area, and totally or partially embedded in cropland, and not protected by United States Fish and Wildlife Service ownership or perpetual easement.

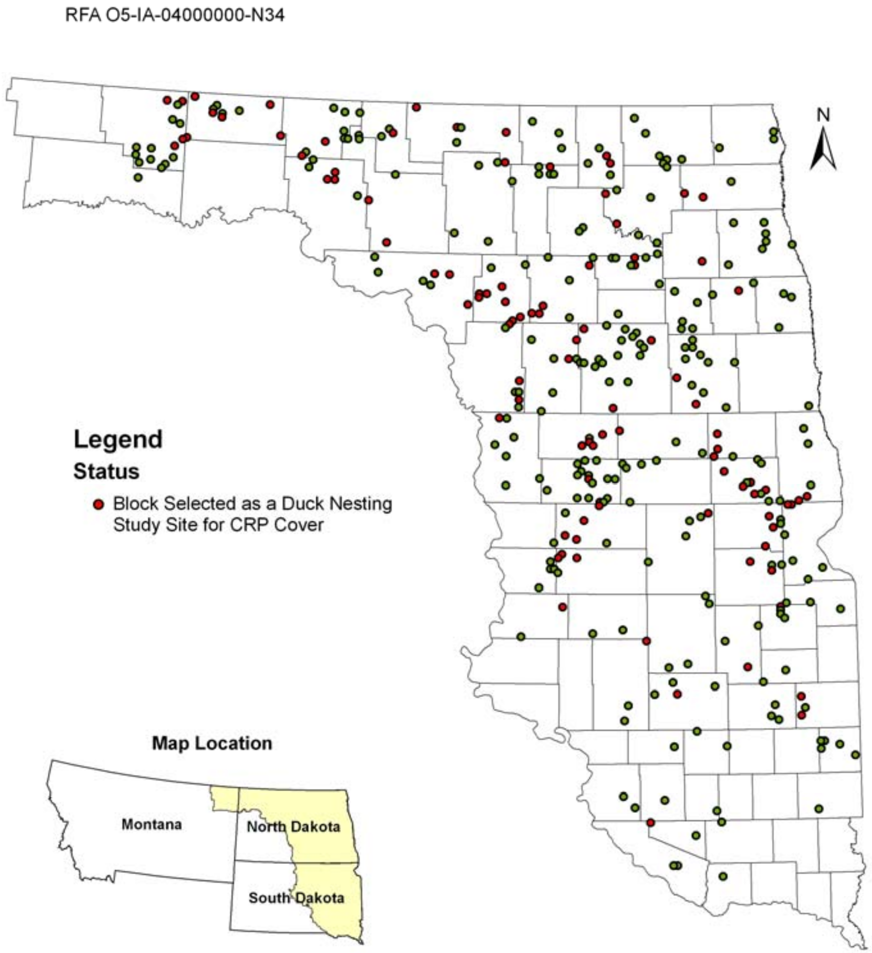

Figure 1. Locations of 335 4-mi^2 sample blocks used to survey duck populations and habitat (all dots) during 1987-2004, and 98 sample blocks (red dots) used to study nest success in Conservation Reserve Program cover for five species of ducks during 1992-1995 in the Prairie Pothole Region of North Dakota, South Dakota and northeastern Montana.

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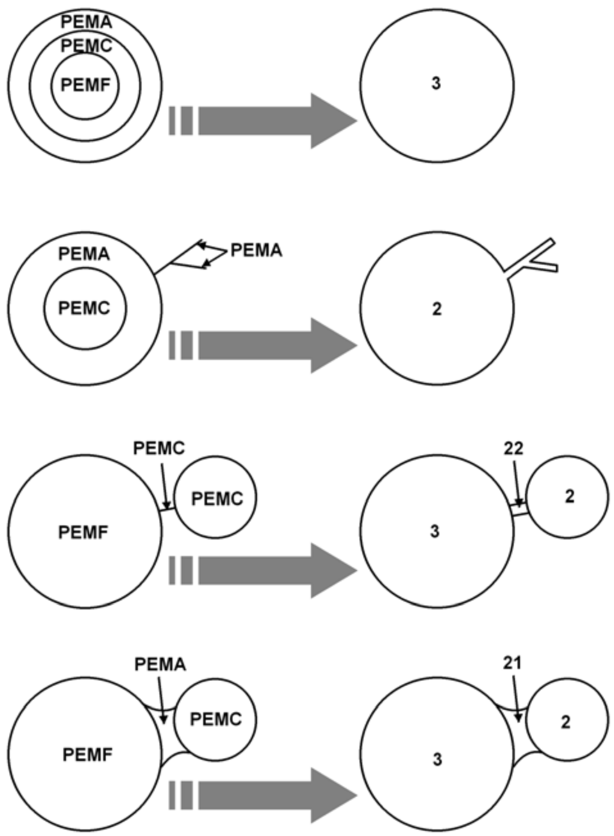

Figure 2. Wetlands delineated by National Wetlands Inventory were converted to basins by dissolving arcs and classifying the basins's water regime by the most permanent wetland within it. 3=Semipermanent; 2=Seasonal; 22=Seasonal ditches; 21=Temporary (from Johnson and Higgins 1997).

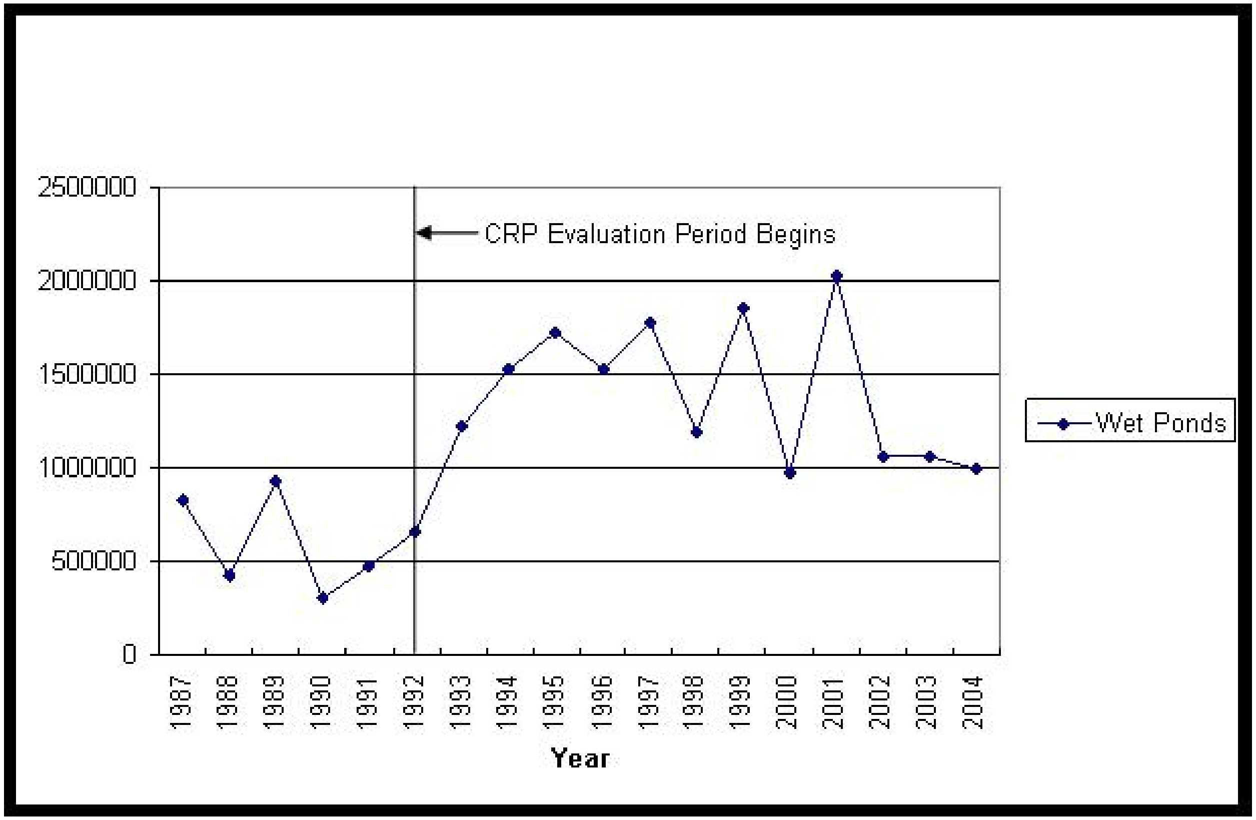

Figure 3. Estimated pond numbers for the Prairie Pothole Region of North Dakota, South Dakota, and northeastern Montana, 1987–2004.

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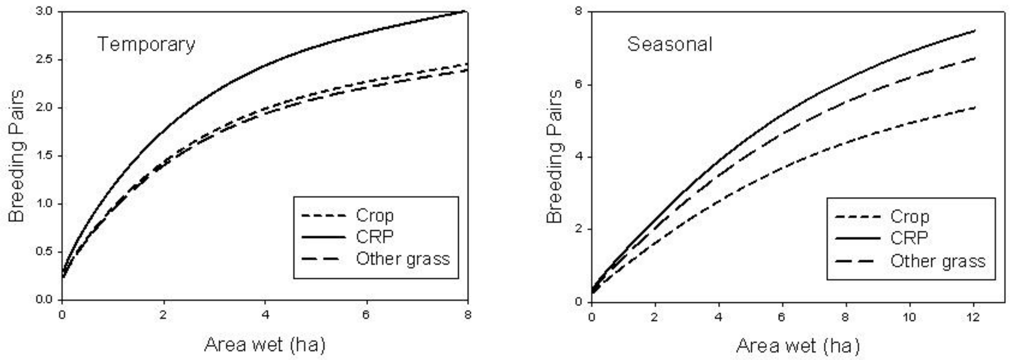

Wetland Selection by Mallards

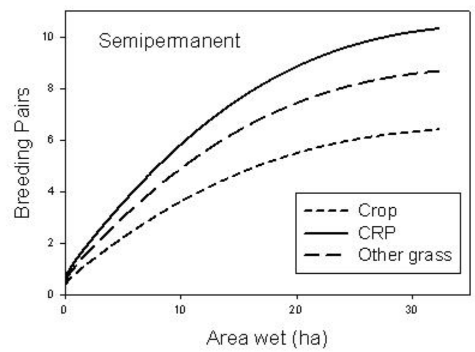

Figure 4. Relative difference for mallards to select temporary, seasonal, and semipermanent wetlands totally or partially embedded in CRP fields vs. wetlands in crop fields or other grass cover. Both cropped and non-cropped wetlands were included in analyses.

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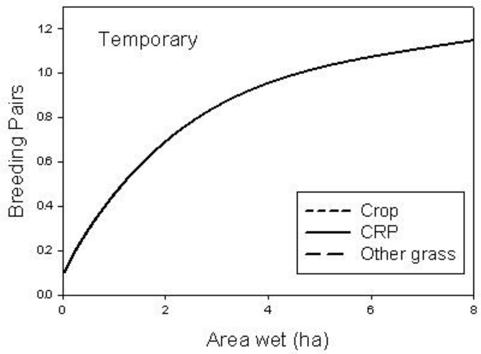

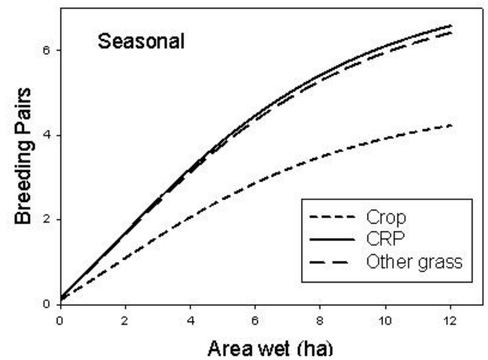

Wetland Selection by Gadwall

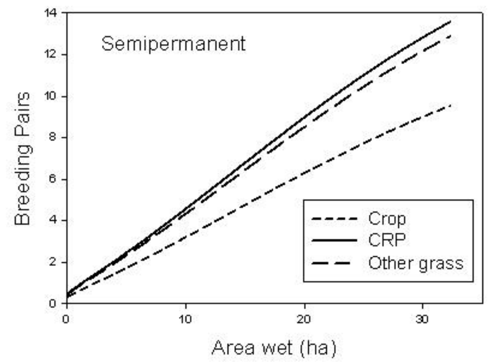

Figure 5. Relative difference for gadwall to select temporary, seasonal, and semipermanent wetlands totally or partially embedded in CRP fields vs. wetlands in crop fields or other grass cover. Both cropped and non-cropped wetlands were included in analyses.

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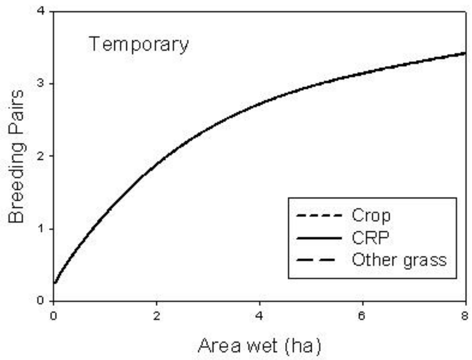

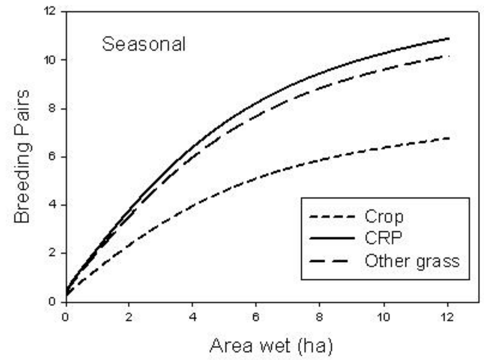

Wetland Selection by Blue-winged Teal

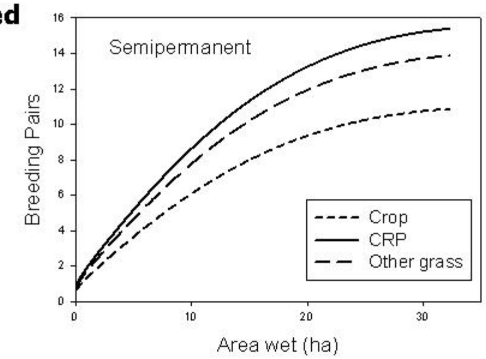

Figure 6. Relative difference for blue-winged teal to select temporary, seasonal, and semipermanent wetlands totally or partially embedded in CRP fields vs. wetlands in crop fields or other grass cover. Both cropped and non-cropped wetlands were included in analyses.

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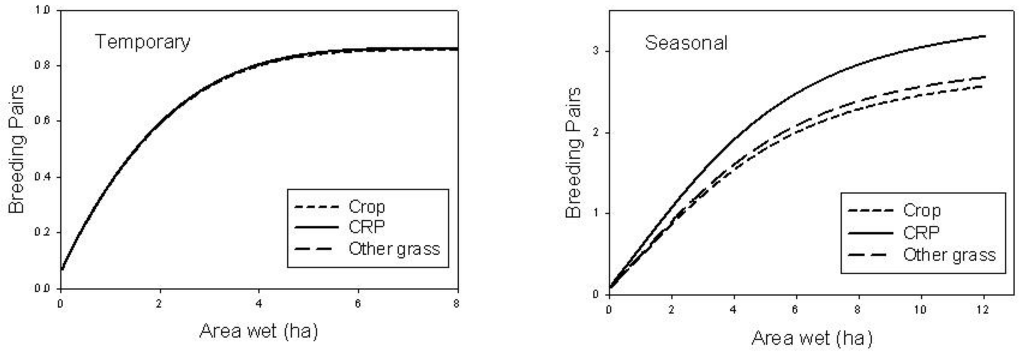

Wetland Selection by Shovelers

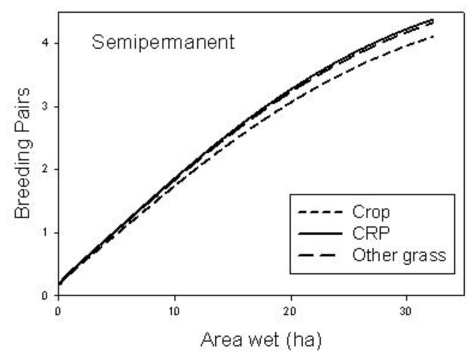

Figure 7. Relative difference for northern shoveler to select temporary, seasonal, and semipermanent wetlands totally or partially embedded in CRP fields vs. wetlands in crop fields or other grass cover. Both cropped and non-cropped wetlands were included in analyses.

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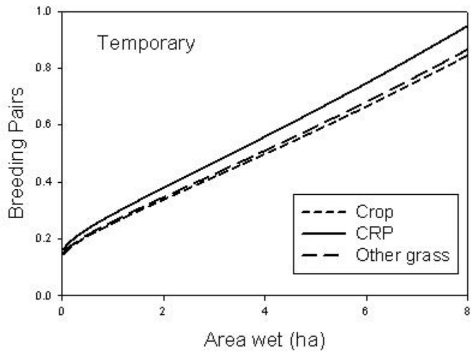

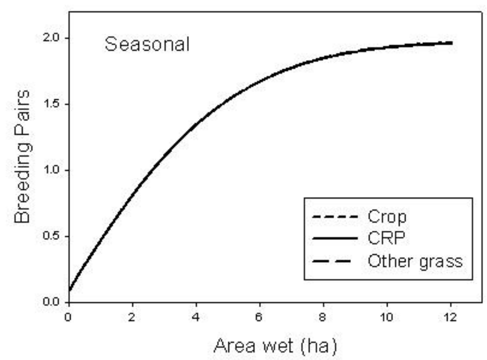

Wetland Selection by Pintail

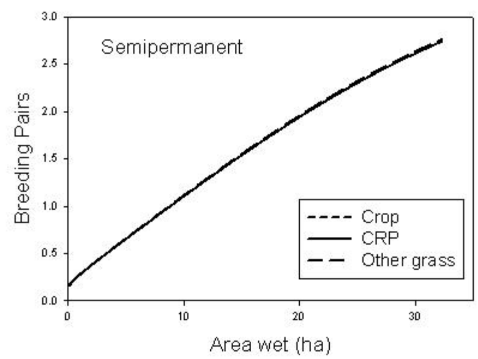

Figure 8. Relative difference for northern pintail to select temporary, seasonal, and semipermanent wetlands totally or partially embedded in CRP fields vs. wetlands in crop fields or other grass cover. Both cropped and non-cropped wetlands were included in analyses.

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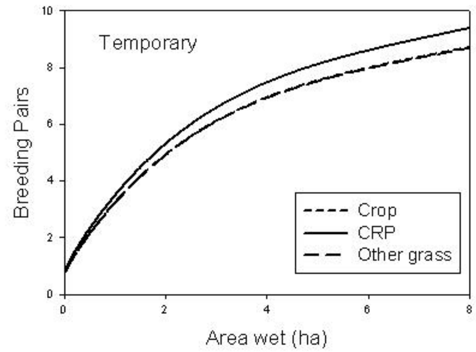

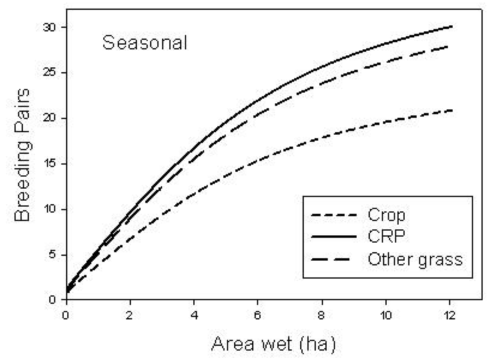

Wetland Selection by Five Duck Species

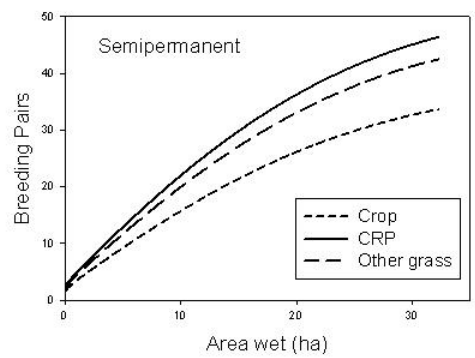

Figure 9. Relative difference for five combined dabbling duck species to select temporary, seasonal, and semipermanent wetlands totally or partially embedded in CRP fields vs. wetlands in crop fields or other grass cover. Both cropped and non-cropped wetlands were included in analyses.

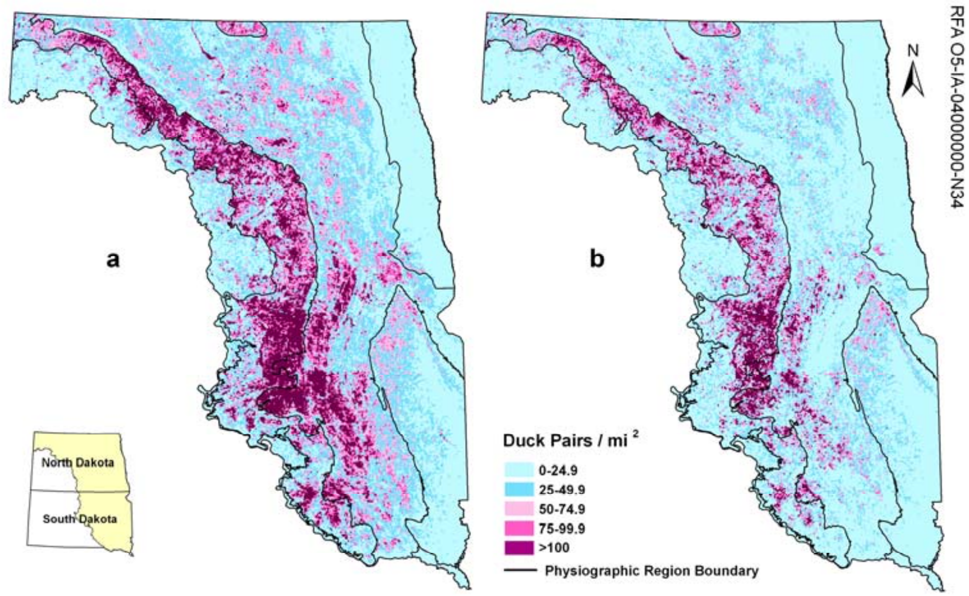

Figure 10. Average (1987-1998) size and distribution (a) of breeding ducks (mallard, gadwall, blue-winged teal, northern shoveler, and northern pintail combined) in the Prairie Pothole Region of North Dakota and South Dakota, and the predicted change (b) if drainage occurred on approximately 1.37 million at-risk wetlands protected by the Swampbuster provision of the Farm Bill. (a) represents approx. 3.91 million duck pairs, and (b) represents approximately. 2.48 million duck pairs [a decline of 37% from (a)]. At-risk wetlands are defined as temporary or seasonal class or <1.0 acre in area, and totally or partially embedded in cropland, and not protected by U.S. Fish and Wildlife Service ownership or perpetual easement.

Appendix I. Frequency and acres of Conservation Reserve Program contracts, by CP-type in the Prairie Pothole Region of North Dakota and South Dakota, determined from Common Land Unit digital data provided by USDA Farm Service Agency.

	North Dakota			South Dakota		
CP Type	Contracts	Acres	% of Total	Contracts	Acres	% of Total
1	6,960	266,619	10.0	3,269	124,562	12.0
2	1,662	54,016	2.0	4,760	191,065	18.4
3	8	40	<0.1	2	63	<0.1
3A	15	192	<0.1	1	6	<0.1
4	200	8,760	0.3	149	6,654	0.6
4A	1	2	<0.1	3	73	<0.1
4B	1	5	<0.1	5	6	<0.1
4C	1	<1	<0.1	1	3	<0.1
4D	12,260	489,469	18.4	1,966	65,253	6.3
5	23	45	<0.1	338	899	0.1
5A	1,465	3,118	0.1	3,500	9,988	1.0
6	1	15	<0.1	0	0	0
7	0	0	0	2	3	<0.1
8	1	11	<0.1	13	28	<0.1
8A	105	114	<0.1	357	649	0.1
9	8	69	<0.1	49	691	0.1
10	24,977	963,715	36.3	6,036	253,942	22.7
11	122	1,329	0.1	87	703	0.1
12	182	668	<0.1	202	1,647	0.2
13	20	136	<0.1	8	36	<0.1
13A	0	0	0	2	4	<0.1
13C	19	119	<0.1	55	360	<0.1
13D	1	1	<0.1	7	35	<0.1
14	2	34	<0.1	8	85	<0.1
15	0	0	0	3	166	<0.1
15A	0	0	0	81	103	<0.1

15B	0	0	0	6	41	<0.1
16	11	21	<0.1	289	856	0.1
16A	1,465	2,565	0.1	3,268	8,415	0.8
17	3	11	<0.1	4	26	<0.1
17A	43	97	<0.1	43	108	<0.1
18	16	616	<0.1	13	255	<0.1
18A	1	4	<0.1	3	27	<0.1
18B	82	1,072	<0.1	22	319	<0.1
18C	4,318	98,447	3.7	250	4,297	0.4
19	2	82	<0.1	0	0	0
20	0	0	0	3	117	<0.1
21	1,426	7,284	0.3	1,294	6,076	0.6

Appendix I. continued

	North Dakota			South Dakota		
CP Type	Contracts	Acres	% of Total	Contracts	Acres	% of Total
22	116	1,501	0.1	689	3,311	0.3
23	15,443	740,192	27.9	8,535	349,219	33.6
23A	3	178	<0.1	2	113	<0.1
24	12	1,014	<0.1	9	174	<0.1
25	3	18	<0.1	164	2,941	0.3
27	434	682	<0.1	379	2,338	0.2
28	981	10,513	0.4	1,462	17,507	1.7
Unknown	61	2,284	0.1	284	7,836	0.1

Appendix II. Definitions of Conservation Reserve Program, CP Types used in this report.

CP Type	Definition
1	New planting. Introduced grasses and legumes.
2	New planting. Native grasses (may include introduced legumes.)
3	New planting. Softwood trees.
3A	New planting. Hardwood trees.
4	Wildlife habitat planting. Old planting. Easement.
4A	Wildlife habitat planting. Easement.
4B	Wildlife habitat planting. Corridor.
4C	Wildlife habitat planting. Unknown.
4D	Wildlife habitat planting. Non-easement.
5	Field windbreak. Easement.
5A	Field windbreak. Non-easement.
6	Diversion.
7	Erosion control structure.
8	Grass waterway. Easement.
8A	Grass waterway. Non-easement.
9	Shallow water area for wildlife.
10	Existing grass. Introduced and native.
11	Existing trees. Softwood and hardwood.
12	Wildlife food plots.
13	Filter strips. Easement.
13A	Filter strips. Grass. Easement.
13B	Filter strips. Trees. Easement.
13C	Filter strips. Grass. Non-easement.
13D	Filter strips. Trees. Non-easement.
14	Bottomland timber on wetlands.
15	Contour grass strips. Easement.
15A	Contour grass strips. Non-easement.
15B	Contour grass strips. Unknown.

16	Shelter belt. Easement.
16A	Shelter belt. Non-easement.
17	Living snow fence. Easement.
17A	Living snow fence. Non-easement.
18	Permanent vegetation to reduce salinity. Easement.
18A	Salt tolerant vegetation. Easement.
18B	Permanent vegetation to reduce salinity. Non-easement.
18C	Salt tolerant vegetation. Non-easement.
19	Alley cropping.
20	Alternative perennials.

Appendix II. continued

CP Type	Definition
21	Grass filter strips.
22	Riparian forest buffer.
23	Wetland restoration (Includes cropped wetlands and 6:1 upland buffer on cropped and certain non-cropped wetlands).
23A	Wetland restoration (Includes cropped wetlands and 4:1 buffer on cropped wetlands).
24	Cross wind trap strips.
25	Rare and declining habitats.
27 and 28	Farmable wetlands.

Acknowledgments

We thank the many participants from the U.S. Fish and Wildlife Service Refuge field offices who collected population and habitat data used in this study. We thank the field crew members from Ducks Unlimited, U.S. Geological Survey, and U.S. Fish and Wildlife Service that worked long hours under sometimes difficult conditions to collect nesting data in CRP cover. Randy Renner (Ducks Unlimited) co-lead the field effort for the duck nesting study in CRP cover. Kevin Willis (U.S Fish and Wildlife Service) identified sources of information about the Farm Program and provided advice for our analyses. Jim Jost (U.S. Department of Agriculture, Farm Service Agency) assisted in acquiring information about the location of CRP fields in our study area and helped define CRP Practices. Mike Linsenbigler, Sally Benjamin and Toby Lloyd (USDA, Farm Service Agency) were instrumental in providing access to landuse data that was critical to virtually every part of our study. Mike Estey (U.S. Fish and Wildlife Service) assisted with preparation and acquisition of spatial data. We thank Marsha Sovada (USGS, Biological Resouces Discipline), Neal Niemuth (U.S. Fish and Wildlife Service), and Skip Hyberg (USDA, Farm Service Agency) for reviewing draft versions of this report. Skip Hyberg also provided advice and wisdom that kept us focused on the relevant aspects of our study. And finally, we thank Barbie Reynolds for help with preparing this report.