Notes

Assessing Wetland Changes in the Prairie Pothole Region of Minnesota From 1980 to 2007

Fred T. Oslund,* Rex R. Johnson, Dan R. Hertel

U.S. Fish and Wildlife Service, Habitat and Population Evaluation Team, 18965 County Highway 82, Fergus Falls, Minnesota 56537

Abstract

Wetlands in the Minnesota Prairie Pothole Region are critical landscape elements because of their unmatched importance to breeding waterfowl, and other wildlife. They provide vast benefits to store runoff or act as nutrient sinks and offer other environmental and socio-economic returns. Data on location, extent and types of wetlands collected by the U.S. Fish and Wildlife Service National Wetlands Inventory is used for developing conservation strategies and evaluating net landscape changes affecting fish and wildlife populations. Minnesota wetlands were mapped 27 y ago by the National Wetlands Inventory. We examined 176 10.2-km^2 (4-mi^2) sample plots in the Minnesota Prairie Pothole Region, using aerial photo interpretation techniques, to determine the current accuracy of the National Wetlands Inventory data used in the eastern Prairie Pothole Region for conservation planning and evaluation. We stratified our analysis by Bailey's (1995) Ecological Subsections. We estimated that across the entire Minnesota Prairie Pothole Region 4.3% of wetland area has been lost since 1980 with losses varying from 0 to 15% among Ecological Subsections. Implications of these findings suggest that National Wetlands Inventory data should be regularly updated in areas subject to rapid wetland change.

Keywords: National Wetlands Inventory; Minnesota; Prairie Pothole Region; wetlands

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* Corresponding author: fred_oslund@fws.gov

Introduction

The Prairie Pothole Region (PPR) covers portions of Minnesota, Iowa, North Dakota, South Dakota, Montana, and the prairie provinces of Canada that were historically grassland and covered by the last advance of Pleistocene glaciers. The PPR was once one of the largest grassland–wetland ecosystems on earth before crop-based agriculture transformed the landscape (Prairie Pothole Joint Venture 2005). The region is composed of millions of small depressional wetlands, called potholes, which were left in the wake of retreating glaciers (Johnson et al. 2008). Prairie potholes provide crucial habitat for breeding waterfowl and other migratory birds. In wet years, the PPR may contribute over 70% of the total duck production of species that comprise the majority of the North American harvest (Batt et al. 1989). As well as being essential habitat, potholes provide nutrient and sediment sinks from surrounding agricultural and urban lands, retain runoff (which reduces flooding), promote groundwater recharge, sequester large amounts of organic carbon, and have other environmental and socio-economic values (Johnson et al. 2008).

Prairie potholes historically covered up to 20% of the PPR and often exceeded 40 basins/km^2 ([100/mi^2] Kantrud et al. 1989; Johnson and Higgins 1997; R.R. Johnson, U.S. Fish and Wildlife Service, unpublished data). A five-county area in west-central Minnesota historically estimated to support approximately 300,000 breeding dabbling-duck pairs is able to support less than 59,000 breeding pairs today (−80%; Johnson et al. 2008). In this same area, 81% of historic wetlands and 49% of

wetland area have been converted to agriculture, illustrating the propensity of farmers to drain small, shallow wetlands.

Although prairie pothole drainage began as early as the last quarter of the 19th century at the time of European settlement (Wooten and Jones 1955; Dahl and Allord 1996), it reached its zenith from the 1950s through the 1970s as more powerful farming implements became commonplace (McManis 1964). Most Minnesota prairie wetlands (>75%) had been drained by 1980 (R. Johnson, unpublished).

The National Wetland Inventory (NWI) was established in 1974 to develop and provide information on the location, extent, and types of wetlands (U.S. Fish and Wildlife Service [USFWS] NWI 2002). The NWI delineated wetlands in the Minnesota PPR using circa 1980 high-altitude color-infrared photographs at a 1:63,000-scale (Johnson and Higgins 1997; who also provide a description of basic NWI mapping conventions in the PPR, B. Huberty, USFWS, personal communication). By about 1980, the estimated statewide number of wetland acres in Minnesota had been reduced by 42% to 3,521,000 ha (8,700,000 ac; Dahl 1990), which primarily occurred within Minnesota PPR.

Our objective of this study was to assess the current accuracy of NWI data in Minnesota, which were mapped using color-infrared photography collected 27 y ago. Evaluation of post–NWI-mapping wetland gains and losses was necessary to quantify the amount, type, and distribution of wetland change. It is important to determine the current reliability of NWI data because they are used extensively for conservation planning in the Minnesota PPR.

Study Area

We evaluated wetland change in five Ecological Subsections ([ES] Bailey 1995; Figure 1) within the Minnesota PPR. The Prairie Coteau, Minnesota River Prairie, and Red River Prairie ES comprise the Prairie Parkland Province (Bailey 1995). This province was historically dominated by tall grass prairie but now is intensely farmed. The Aspen Parklands ES lies within the Tall Grass Aspen Parklands Province, which is a transitional area between prairie and semihumid mixed conifer–deciduous forests, and although frequently farmed in the early 20th century retains large areas of grassland pasture, hayland, and aspen-dominated *Populus tremuloides* deciduous forest. The Hardwood Hills ES lies in the Eastern Broadleaf Forest, an area regarded as a transitional zone from open grassland to forest and woodland (Minnesota Department of Natural Resources 2008; Figure 1).

Methods

We used existing 10.2-km^2 (4-mi^2) breeding waterfowl and wetland survey plots, which were randomly selected in 1987, for this assessment. Existing plots were used because color-infrared aerial photography of each plot has been acquired every spring (1991–present) as part of the 4-mi^2 waterfowl survey, which allowed this long-term data set to be compared to NWI data (Figure 2). For estimating waterfowl population estimates, plots were stratified based on land ownership: Federal—the plot contained at least 65 ha (160 ac) of USFWS Waterfowl Production Area; Easement—the plot contained 65 ha (160 ac) of USFWS wetland easements; Refuge—the plot contained any amount of land in a National Wildlife Refuge; or Private—the plot contained >94% private land and contained no National Wildlife Refuge. Plots were assigned to Bailey (1995) subsections for this assessment (Figure 1) and we acknowledge that the sample design was not designed for an assessment of estimated wetland change.

A subset of aerial photographs of each sample plot collected from 1991 to 2007 was used to determine wetland change. We overlaid NWI data layer onto aerial photographs, which allowed for detection of wetland alteration (Figure 2). We used TNT Map and Image Processing System software (MicroImages, Inc.), version 7.3, to compare and map changes in wetland condition and add or delete wetlands on aerial photographs by comparing them to NWI data (circa 1980). National Wetland Inventory wetland delineations were assumed to be accurate at that time. Data on presence, absence, classification and size were recorded for every wetland that occurred in the NWI data base or on aerial photos for each plot. Wetlands that were significantly altered in extent, including those that were completely drained or restored, were recorded as losses (*Supplemental Material*, Table S1, http://dx.doi.org/10.3996/122009-JFWM-027.S1).

Wetlands were recorded as completely or partially drained if they showed altered hydrology (e.g., altered size or duration of ponding) in four consecutive years of recent aerial photography from 2004 to 2007 or we saw evidence that indicated tiling, ditching, filling, or intensive cultivation without crop damage that usually results from short-duration ponding. If partially drained, the remaining wetland area was delineated and compared to the NWI delineation to determine wetland area loss.

"Restored" wetlands resulted when a wetland was purposely restored or a drainage system fell into disrepair. Wetlands were classified as restored when water or emergent vegetation was visible on aerial photographs in at least two consecutive years between 2004 and 2007. Deliberately restored wetlands were usually easily identified because there was a dike, water control structure, or ditch plug visible on aerial photos.

Wetlands that were affected by drainage (i.e., generally partially drained) were assigned by Cowardin a *d* modifier (e.g., partially drained) in circa-1980 NWI data (Cowardin et al. 1979). Altered wetlands with *d* modifiers were compared with those without *d* modifiers to determine whether drainage rates differed between altered wetlands and wetlands unmodified by drainage (circa 1980).

Finally, data were compiled by ES and the plot-based estimates were expanded to each ES based on the ratio of plots sampled to total number of plots in each ownership stratum within the ES. This, combined with NWI data, enabled us to estimate the overall change in wetland area and number in each ES.

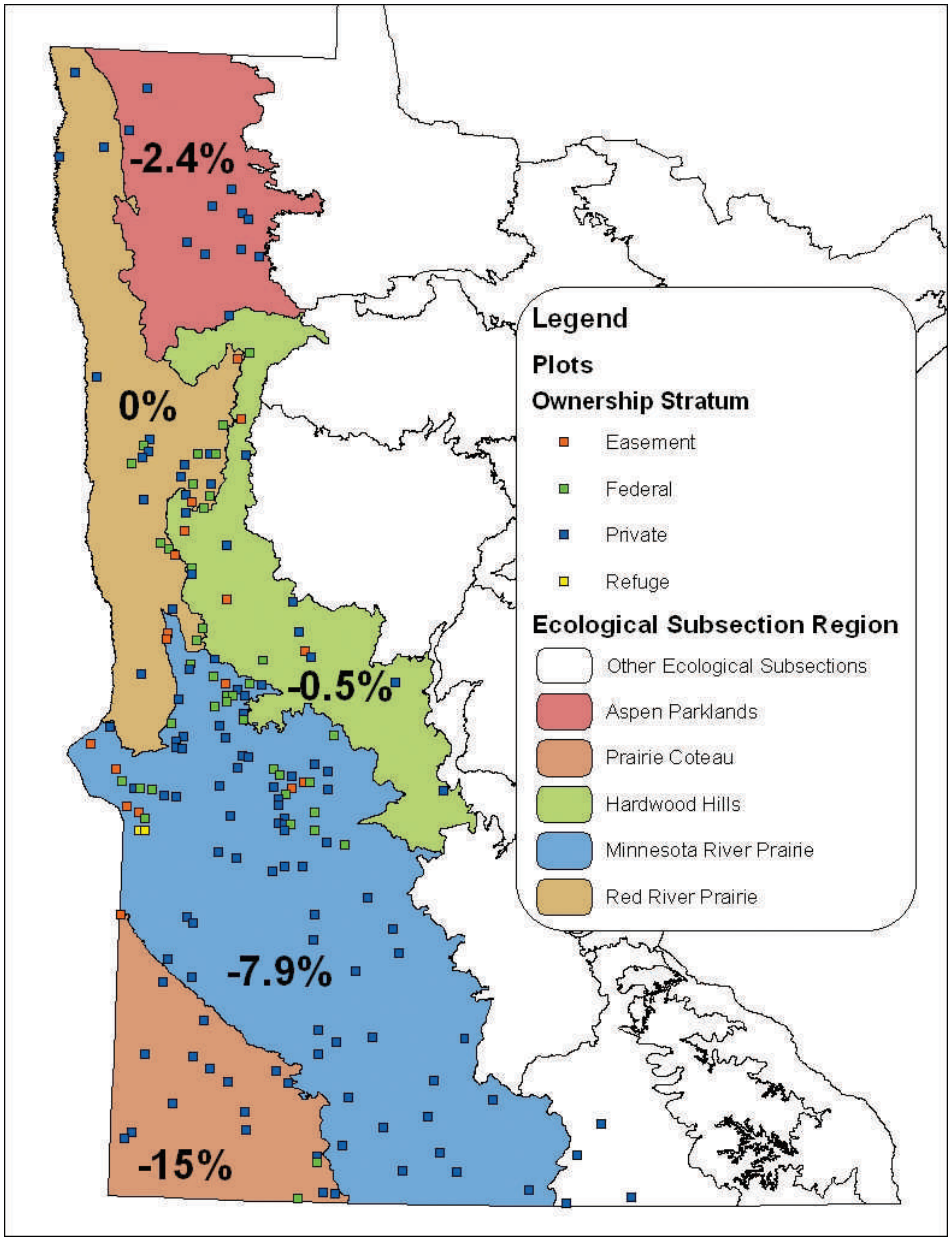

Figure 1. The Prairie Pothole Region (PPR) of western Minnesota showing locations of sample plots and percent change by Ecological Subsections (ES) evaluated (1980–2007).

Results

Our 176 sample plots contained 22,497 ha of wetlands. A total of 1,028 wetland ha were lost to drainage and 479 total wetland ha were restored (Table 1). A total wetland area net loss of 549 ha or approximately 2.3% occurred on sample plots since 1980 (Table 1). Estimates increased to a loss of 4.3% wetland areas when stratified samples were expanded to the entire Minnesota PPR (Table 2). Total wetland losses in the Minnesota PPR were estimated at 52,097 ha and an estimated 13,011 ha were restored (Table 2). The difference between the two estimates indicated a net loss of 39,086 ha since 1980. Estimates of net change by ES are provided (Table 2).

Wetlands with *d* modifiers in the NWI data base accounted for 72% of post-1980 losses. Wetlands without prior drainage history or with no drainage evidence accounted for 28% of all losses.

Discussion

A routine assumption of conservation planning is that geospatial data are accurate. Accuracy assessment is crucial if we are to have confidence in the outcomes of conservation planning and evaluation. Accuracy for land cover and wetlands data may be expected to degrade over time. Periodic accuracy checks and remapping when warranted is essential to developing credible conservation strategies.

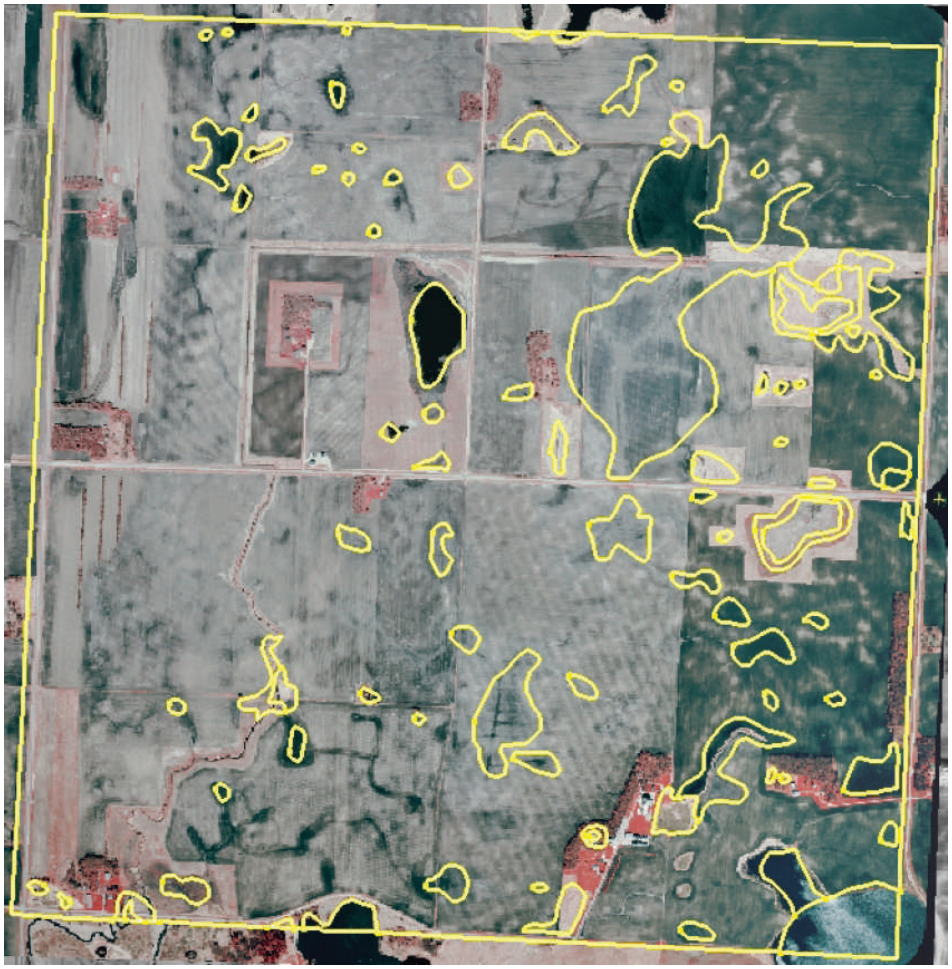

Figure 2. National Wetlands Inventory (NWI) data overlaid on aerial photographs allowed for detection of altered wetlands. Lines displayed show where wetlands were on the landscape during the mapping process in 1980 (circa 2006).

Although this assessment indicated that wetland changes throughout the entire Minnesota PPR were relatively small (−4.3% of total area) over nearly a 30-y span, data for some regions are more outdated than others, which should be a consideration when prioritizing remapping efforts. For example, net change ranged from 8 to 15% for ES in west-central and southern Minnesota. Remapping wetlands in these regions may be a high priority for conservation partnerships in the state. We believe that most losses can be attributed to fixing or enhancing preexisting drainage systems. Regardless of the legality of this drainage, it represents a significant loss of wetland functions in these areas. Finally, much of the new drainage (post-1980) can be attributed to the loss of small temporary wetlands (temporarily flooded, palustrine, emergent wetlands; Cowardin et al. 1979), which accounted for 61.2% of wetland losses observed. Temporary wetlands are routinely cultivated, altering their depth due to redistribution of soil to the extent that they become incapable of retaining water in wet years.

Table 1. Wetland change data from 1980 through 2007 collected from sample plots within each Ecological Subsection. Negatives represent a loss in wetland hectares.

Ecological region	Total wetland hectares in sample	Wetland hectares drained	Wetland hectares restored	Net change (ha)	% Change
Aspen Parklands	3,718.7	78.5	0.7	−77.8	−2.4
Prairie Coteau	529.9	55.4	10.1	−45.4	−8.6
Hardwood Hills	4,962.8	45.8	42.1	−3.6	−0.1
Minnesota River Prairie	11,592.9	769.7	333.3	−436.4	−3.8
Red River Prairie	3,295.8	78.2	92.6	14.4	0.4
Total	24,100.1	1,027.7	478.8	−548.9	−2.3

Table 2. Estimates of wetland change from 1980 through 2007 expanded to Ecological Subsection and the entire Minnesota Prairie Pothole Region (MN PPR). Negatives represent a loss in wetland hectares.

Ecological region	Total wetland hectares in MN PPR	Wetland hectares drained	Wetland hectares restored	Net change for PPR (ha)	% Change
Aspen Parklands	345,256.3	8,181.1	72.9	−8,108.1	−2.4
Prairie Coteau	19,675.5	3,022.1	73.1	−2,949.0	−15.0
Hardwood Hills	54,907.2	1,958.2	1,703.5	−254.7	−0.5
Minnesota River Prairie	353,883.2	35,204.1	7,382.7	−27,821.4	−7.9
Red River Prairie	127,781.3	3,732.0	3,778.6	46.6	0.0
Total	901,503.5	52,097.4	13,010.8	−39,086.6	−4.3

Improvements in drainage technology, including pattern tiling fields around wetlands (which intercepts runoff), are likely to exacerbate these losses in the future.

Finally, it is difficult to overstate the importance of reliable up-to-date NWI data for conservation planning and evaluating progress toward objectives. For example, conservation partnerships need to periodically assess changes in wetland status to assess net progress toward objectives for wetland goods and services. We recommend that the NWI make regular wetland mapping updates a high priority in regions of the United States experiencing rapid changes in wetland abundance, type, or distribution.

Supplemental Material

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Table S1. Minnesota Prairie Pothole Region wetland data. Observations on wetland alterations are recorded in the Status column of each tab.

Found at DOI: 10.3996/122009-JFWM-027.S1 (5 MB XLS).

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