NORTH DAKOTA GAME AND FISH DEPARTMENT

Final Report

Removing Sedimentation as a Technique for Restoring Palustrine Seasonal and Temporary Wetlands in the Northeast Drift Prairie of North Dakota

Project T-27-HM

July 1, 2008 – December 31, 2010

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Submitted by
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Project Title – Removing Sedimentation as a Technique for Restoring Palustrine Seasonal and Temporary Wetlands in the Northeast Drift Prairie of North Dakota – Final Report

SWG Federal Aid No. – T-27-HM

Cooperators – The North Dakota Natural Resources Trust, U.S. Fish and Wildlife Service, The North Dakota Game and Fish Department, Delta Waterfowl Foundation, Private Landowners

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North Dakota Game and Fish Deparmtent

EXECUTIVE SUMMARY

On July 10, 2008, partners from the U.S. Fish and Wildlife Service, the North Dakota Natural Resources Trust, Delta Waterfowl Foundation, and the North Dakota Game and Fish Department signed documentation that enabled the beginning of wetland habitat restoration within the Devils Lake Basin in northeastern North Dakota. The project, "Removing Sedimentation as a Technique for Restoring Palustrine Seasonal and Temporary Wetlands in the Northeast Drift Prairie of North Dakota", was fully funded by the State Wildlife Grant (SWG) program at $20,000. The project entailed wetland restoration of at least 50 wetland basins totaling an accumulation of 12.41 ha. (30 acres). Project wetlands were located on either on public or private lands, were photo documented, and 10 basins were selected to measure hydrophytic changes over a 5 year period which served as a measurement of restoration success predicated on an increase in hydrophytic species richness.

We began restorations during late summer of 2008, and completed work on 33 basins totaling 5.5 ha. (13.7 acres). By the end of the 2009, 40 more wetlands were restored totaling 4.9 ha. (12.3 acres). Finally, we continued into 2010 and restored an additional 13 wetlands totaling 2.1 ha. (5.1 acres). In summary, 89 wetland basins totaling 12.5 ha. (31.1 acres) were restored during the life of the grant. Of the 89 restored basins, 48 wetlands were temporary, and 41 were seasonal. All SWG funding of $20,000 was completely exhausted by the end of 2010, and construction costs ranged $400 - $763 per restored wetland acreage. The wide range was due to wetter than average restoration conditions in 2009 and 2010, however, this cost is slightly below the $800 average cost/acre experienced with other sediment removal wetland construction projects. While we slightly exceeded our 12.41 ha. (30 acre) restoration goal (12.5 ha, 31.1 ac.), we superiorly exceeded our goal of 50 wetland basins by 39 wetland basins. A step-down method for performing this restoration technique is given in this report.

Funding for this project was made possible via non-federal match dollars from the following agencies/organizations: Delta Waterfowl Foundation - $10,000, North Dakota Game and Fish Department - $7,500, and the North Dakota Natural Resources Trust - $2,500. The U.S. Fish and Wildlife Service (Service), while providing 0 match dollars, were the principal investigator for this project. The Services' in kind contributions came from construction design, implementation, and documentation, and this "above the line" match of local federal USFWS support equaled $7,241.

Wildlife response and hydrophyte species richness have exceeded expectations generally, and after 2 growing seasons, all 10 wetlands selected for plant inventory response have achieved the "fully successful" status. Fully successful was simply an increase of wetland vegetation richness by 50%, which in the case of the "pre-construction" wetland condition, rarely more than 2 - 3 species of wetland plants existed (hybrid or narrow leaved cattail, reed canary grass and slough sedge). By the end of the second growing season, abundant stands of rushes, sedges, grasses, and other hydrophytes were commonly observed, unfortunately some recolonization of cattail, albeit minimal, existed as well. As stated in our project proposal, we will continue to monitor these basins until the end of the 2013 growing season and provide a detailed addendum to this project at that time. Photos of many restored basins and their subsequent temporal development were also included in this document.

This project represented an outstanding partnership with all participants' desiring similar goals. Wetland functions were greatly improved and the ultimate benefactors were the natural resources each organization are responsible for maintaining for the American public. Finally, we would like to acknowledge the private landowners who graciously allowed us the opportunity to restore wetland

habitat on their properties; Jeff Sorum Family, Audrey Armey, William Henke and Albert Caron, Diane Cook, Gordon Munns, and James Cook – Fett Land.

INTRODUCTION

The Prairie Pothole Region (PPR) of North Dakota is a characterized by a mosaic of small to large wetlands in either grassland or cropland dominated landscapes. Conversion of grassland to cropland and drainage of wetlands across the entire PPR has resulted in wetland loss of up to 90% in some areas (Knutsen and Euliss 2001). In northeastern North Dakota where intensive agriculture has dominated the landscape for over 100 years, many wetlands have become degraded via sedimentation by wind or rill erosion. Cultivation of wetland catchments has exacerbated soil erosion; wetlands in agricultural fields receive more sediment from upland areas than do wetlands in grassland dominated landscapes (Gleason and Euliss 1998). To magnify the “dysfunction” of many Palustrine wetlands in the northeast Drift Prairie physiographic region (NEDP), hybridization of non-native narrow-leaved cattails (Typha angustifolia) with native broad-leaved cattail (T. latifolia) has evolved the invasive hybrid cattail (T. x glauca). The hybrid cattail is ideally suited for shallow water wetlands commonly found in the PPR in the northern Great Plains (Kantrud 1986, Ralston et al. 2006), and is considered an invasive species by many (Galatowitsch et al. 1999, Green and Galatowitsch 2001, Mulhouse and Galatowitsch 2003, Boers et al. 2007, Angeloni et al. 2006). Hybrid cattail expansion, first recognized during the mid-1950’s (Kantrud 1992), is a symptom of the main problem of excessive sedimentation of PPR wetlands. The unfortunate result is entire palustrine emergent temporary, seasonal and semi-permanent wetlands dominated by this invader. In either small or large wetlands, hybrid cattails reproduce vegetative by rhizomes and clone fragmentation and can be so aggressive, most other native hydrophytic vegetation are excluded (Linz 1992). Ultimately, habitat conditions for wildlife species dependent upon wetlands with diverse assemblages of sedges, rushes, wetland grasses and others native hydrophytes are compromised (Figure 1).

Figure 1. A .004 ha (.10 acre) palustrine emergent seasonal wetland dominated by hybrid cattails and impacted by > 20 cm. (8 in.) of sedimentation. Sediment depths like this are not uncommon in the NEDP wetlands of North Dakota.

PROJECT OBJECTIVES, GOALS AND WETLAND RESTORATION METHODS

The ultimate goal of this project is to provide improved PPR wetland habitat conditions for numerous endemic wildlife species, and additionally, some organisms listed in the North Dakota Game and Fish Department's Comprehensive Wildlife Conservation Strategy (Dyke et al. 2005). These goals required the successful completion of the following objectives; 1) identification and restoration of at least 50 "cattail choked/sediment impacted" wetland basins totaling 30 surface acres (12.1 ha) on Federal, State and/or private lands (CRP primarily) within the NEDP physiographic region; 2) to improve hydrophytic species richness from low diversity stands of cattails to diverse assemblages of hydrophytes that naturally occur(ed) in prairie pothole wetlands; 3) to measure these changes annually over a 5 year period on 10 randomly selected restored wetland basins; 4) ultimately assess project success or failure based upon hydrophytic responses as measured in objective 3. An increase of species richness by 50% during the first and second growing season constituted project success.

Restoration methods utilized heavy equipment owned by private construction contractors to gradually remove excessive sediment and cattails from generally small (< .80 ha) (.1 – 2 acre) wetland basins. A step-down process which identifies the basic restoration technique, how much sediment to remove, where to re-locate removed materials, and finally monitoring the restoration for success was created and used for a select number of restorable basins in this project.

Step-down wetland restoration process – a guideline to the sediment removal technique

1. Identify the impacted basin(s) by presence of narrow leaved or hybrid cattails, and measure the depth of sediment present in the basins. Using Geographic Information Systems, identify all basins on a tract of land for restoration. Photograph the wetlands in the "pre" restoration condition. Note vegetation communities and plant species present within wetland zones of each restorable wetland basin; wetland low-prairie, wet meadow, shallow marsh, deep marsh (Stewart and Kantrud 1971).
2. Investigate the soil profile and identify the critical soil horizons as not to disrupt the wetlands naturally occurring hydroperiod. Horizons are identified to the; Organic or sediment horizon, A-horizon, Bt or Bk horizon depending on the hydric soil type. Measure the depth of sediment to be removed, locate the hydric/non-hydric soil juxtaposition, and measure the size of the wetland basins either via ArcGIS or a handheld Global Position Satellite unit.
3. Use a sediment removal worksheet to identify your metrics which generate sediment removal calculations and potential costs (Appendix 1).
4. Identify the hydrological features of the wetland including the landscape catchment and surface water ingress and egress locations. Based upon the landscape hydrology, sediment removal must be placed away from the higher water ingress location as to maximize the amount of surface water run-off into restored basins during spring and summer deluges. Also pay close attention to the wet-meadow zone; if an intact wet meadow zone comprising a mosaic of diverse native species exist, be sure NOT to disrupt this area with spoil, find another location or abandon the wetland restoration efforts at that basin.
5. Amount of soil moisture must be considered, wetlands experiencing saturated organic sedimentation must be avoided. Avoidance of these conditions will ensure a more aesthetically complete and thorough wetland restoration. If water exists, wait until next year. If damp, proceed with caution.
6. Secure cultural resource approval from agency archeologists.

7. Selection of the proper excavation equipment and contractors for project implementation is important. Underpowered equipment is costly in the long run and will not thoroughly perform a complete wetland restoration. Select operators who understand the nature of the restorations, and who strive to continually improve their techniques as more wetland basins are restored. This is a money saver.
8. Safety and environmental stewardship are important and must not be overlooked. Be certain that fueling and servicing equipment standards are meet with the highest environmental ethics, off-loading and approach locations are selected before the contractor moves to the new site. Orange clothing and hardhats are worn at all times, and in particular, be certain to ascertain eye contact with a contractor when working in close proximity to heavy equipment.
9. Supervise the implementation of the project, stake the basin(s) for the contractor and be sure to explain wetland hydrology and why we are paying for the work. Explain how the wetlands are to be restored, and how a wetland functions with the surrounding landscape. Why it is important for precipitation ingress, how materials must be fully removed above the hydric line, how the sediment spoil piles must be "finished" for an aesthetically pleasing restoration. If drains are available, use these sites first to "hide" excavated sediment.
10. Photograph in completed mode.
11. Once cattails and sediment are removed and placed on the adjoining uplands, use a small disk or large disk if available to smooth the sediment spoil for future seeding.
12. Seed the sediment spoil piles, selection of species are entirely up to the restoration biologist. We use grasses initially as the potential of broad-leaved invasive species (namely Canada thistle) will colonize these sites. The use of a broad-leaved herbicide (normally Milestone®) may be needed, but if easily established grass species are selected, the problem is moot. A suggested option is to use quality diverse native wet-meadow hay and to spread across the spoil and within the edge of the restored wetland. This approaches a complete ecological restoration and must be considered.
13. Return the following spring season, measure water depth and ensure wetland hydrology is functioning. Measure wildlife use if any and notice and record whatever metric may be desired.
14. Periodically return over time and using a broad-scale phytosociological site measurement technique such as Braun-Blanquette (1932) or R.F. Daubenmire (1959), evaluate hydrophyte responses. Compare over time, ideally beyond 10 years. Other potentially desirable metrics include; invertebrates, algae, diatoms, water chemistry, soil chemistry, total dissolved solids, salinity, and macrofauna et al. Be patient, long term success should be your goal and would be measured by improved hydrophyte richness beyond 10 years post restoration. Many hydrophyte species are short lived and may be abundant and present in years 1-5, but may decrease beyond that time period. Other hydrophytes are longer term, and should recolonize in years 5 and beyond. One significant question is when, if, and how abundant hybrid cattails re-colonize restored sites.

RESULTS

Wetland Restoration Totals

Between August, 2008 thru November 2010, we restored 86 wetland basins totaling 12.5 surface hectares (31.1 ac.) across 7 sites in various locations in northeast North Dakota (Table 1).

Table 1. Summary table of wetland restoration sites, basins, restored acres, counties and UTM locations of the NW property corner as a result of this grant project "Removing Sedimentation as a Technique for Restoring Palustrine Seasonal and Temporary Wetlands in the Northeast Drift Prairie of North Dakota".

Site	Basins Restored	Hectares Affected	County	UTM Location (NW Corner)
Nikolaisen WPA	18 basins	2.3 ha (5.6 ac)	Towner	484533 5381670
Jeff Sorum	10 basins	1.5 ha (3.8 ac)	Ramsey	486722 5338767
Audrey Armey	8 basins	1.7 ha (4.3 ac)	Towner	486161 5387301
Bill Henke	20 basins	2.5 ha (6.3 ac)	Benson	467008 5317873
Diane Cook	20 basins	2.4 ha (6.0 ac)	Benson	474634 5319494
Gordon Munns	10 basins	1.5 ha (3.6 ac)	Nelson	570820 5296004
Fett (James Cook)	3 basins	.6 ha (1.5 ac)	Ramsey	544404 5356632
7 Sites	89 Basins	12.5 ha (31.1 ac)	4 Counties	

Characteristic of the PPR – NEDP region are many wetland basins and complexes of wetlands with diverse wetland hydroperiod regimes. Our restored wetland basin site selection included restoration of palustrine emergent temporary (PEMA) and seasonal (PEMC) wetlands (Cowardin et al. 1979), and precaution was taken to preserve the integrity of each wetland regime/hydroperiod. This meant each basin was only restored by removing sediment, and no addition "A" horizon material was removed to potentially enhance/disrupt a wetland basins natural hydroperiod. Table 2 represents the 89 wetland basins restored during this project, and each basins specific wetland regime. Wetland regime determination was based upon National Wetland Inventory data.

Table 2. Wetland regimes and acreage of 89 restored wetlands as a result of this grant project, "Removing Sedimentation as a Technique for Restoring Palustrine Seasonal and Temporary Wetlands in the Northeast Drift Prairie of North Dakota, 2008 - 2010".

Site	PEMA Basins Restored	PEMA Hectares Affected	PEMC Basins Restored	PEMC Hectares Affected	Total Hectare Summary
Nikolaisen WPA	4	.44 ha.(1.10 ac)	14	1.82 ha (4.50 ac)	2.3 ha (5.60 ac)
Jeff Sorum	9	1.13 ha (32.80ac)	1	.40 ha (1.00 ac)	1.5 ha (3.80 ac)
Audrey Armey	6	.25 ha (.61 ac)	2	1.49 ha (3.69 ac)	1.7 ha (4.30 ac)
Bill Henke	15	1.31 ha (3.25 ac)	5	1.23 ha (3.05 ac)	2.5 ha (6.30 ac)
Diane Cook	2	.17 ha (.44 ac)	18	2.25 ha (5.56 ac)	2.4 ha (6.00 ac)
Gordon Munns	9	.89 ha (2.21 ac)	1	.56 ha (1.39 ac)	1.5 ha (3.60 ac)
Fett (James Cook)	1	.04 ha (.10 ac)	2	.57 ha (1.40 ac)	.60 ha (1.50 ac)
Sites	48	4.23 ha (14.20 ac)	41	8.32 ha (16.69 ac)	12.5 ha (31.10 ac)

Funding to achieve these results was obtained with the assistance of non-federal matching dollars, and was stipulated as the only matching funds for a State Wildlife Grant. The following table represents the accumulation of in-kind funds expended by project partners, brief match description, equipment and contractors used during project implementation, and annual costs for the 2008, 2009 and 2010 field seasons broken down by wetland restoration cost per hectare (and acre).

Table 3. Match funding used and grant expenditures during this grant project, "Removing Sedimentation as a Technique for Restoring Palustrine Seasonal and Temporary Wetlands in the Northeast Drift Prairie of North Dakota, 2008 -2010".

Agency – Purpose	Amount	SWG Grant Award	Year SWG Funds Expended, Location, Contractor and Equipment Used, Restoration Cost/year, Acres Restored and Cost/Acre		
DELTA WF Funds for studying waterfowl pair use of existing and restored wetlands	$10,000		2008 (Armey and Nikolaisen)	2009 (Cook, Henke, Sorum)	2010 (Munns, Fett)
NDGF - PLOTS funding used to acquire public access or hunting, incentivize conservation	$7,500		Mikkkelsen Bros, Langdon ND, Komatsu D-65 dozer, D-4 Cat dozer, JD 120 back-hoe	Durbin Constr. Devils Lake, ND JD 650 Dozer, JD 790 backhoe	Mikkkelsen Bros, Langdon ND, Komatsu D-65 dozer, D-4 Cat dozer, JD 120 back-hoe
NDNRT Expenditures to administer this grant	$2,500		$3,960	$12,320	$3,720
USFWS – Above the line – federal funds to design and deliver the project	$7,241[A]		Acres restored 5.5 hectares (13.7 acres)	Acres restored 4.9 hectares (12.3 acres)	Acres restored 2.1 hectares (5.1 acres)
Totals	$20,000 Match	$20,000 SWG	Cost Per Hectare $720.00/ha ($400.00 ac)	Cost Per Hectare $2,514/ha ($765.22 ac)	Cost Per Acre $1,771/ha ($729.41 ac)

A – Ineligible as SWG match (estimated 6 weeks – 240 hrs.)

Project Photography

Photo documentation is critical in displaying the effectiveness of habitat restoration activities utilizing this aggressive restoration technique. Since this technique was accepted, many presentations displaying the significance of the sediment/invasive cattail problems have been given in many locations. Many individuals were not or are not aware of the sheer magnitude of this problem which is particularly worse in the eastern drift plains where intensive agriculture and grassland conversion have dominated the landscape for nearly 100 years. The following photographs display before and after wetland habitat conditions capturing the essence of the restorations; removing sediment and cattails to increase ponding and sunlight penetration which will result in improve hydrophytic species richness perpetuating increased species richness of micro and macro fauna. The following photos are selected for their quality, and many more photos are included and attached on an accompanying flash drive to be kept with the original project report.

Figure 2. Select photographs of habitat restorations during the State Wildlife Grant project titled, "Removing Sedimentation as a Technique for Restoring Palustrine Seasonal and Temporary Wetlands in the Northeast Drift Prairie of North Dakota".

Before and After photo, Sorum site – Ramsey County, wetland 7 (a habitat monitoring wetland).

Fall 2009

Figure 3. One year post restoration, wetland 1-Summer 2010 – Sorum site – Ramsey County (note spoil piles already populated with grass – a habitat monitoring wetland).

Figure 4. Armey site – Towner County, wetland 10 - .71 ha (1.75 ac) PEMC restoration (a habitat monitoring wetland).

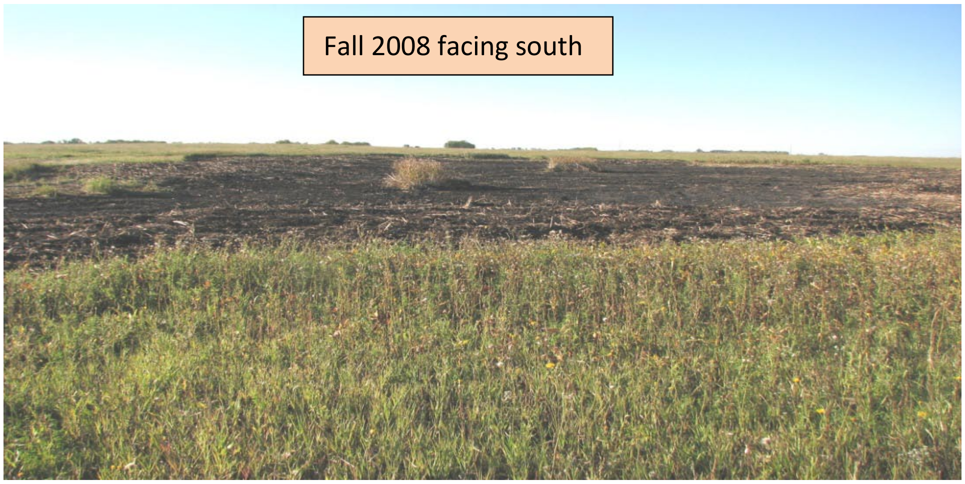


Figure 5. Armey Site – Towner County, wetland 8 - .78 ha (1.94 ac) PEMC restoration (a habitat monitoring wetland)

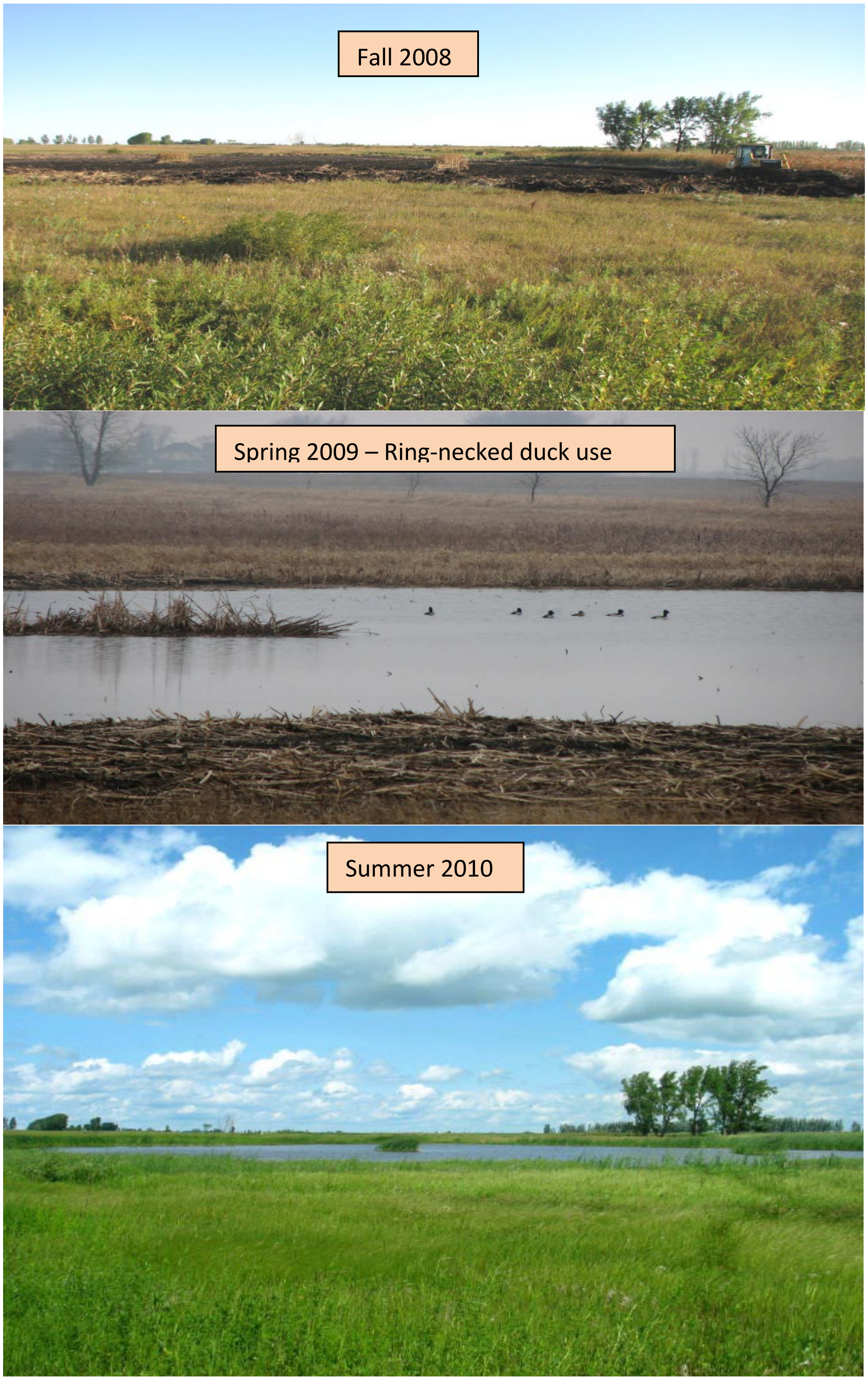


Figure 6. Spring 2009 air photography of Armey wetland restoration sites in Towner County.

 = wetlands restored

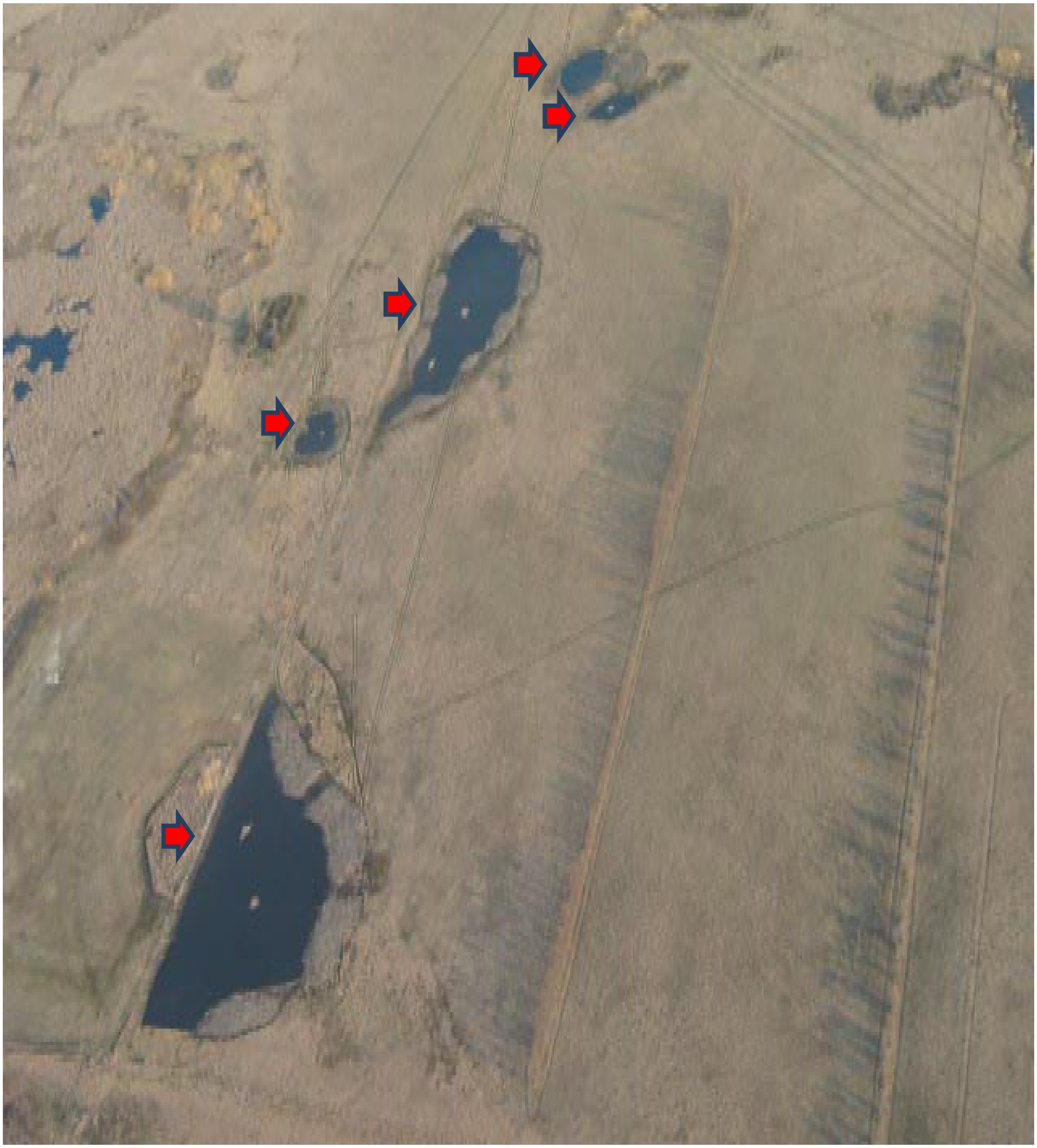


Figure 7. Wetland restorations at the Henke restoration site, Benson County, wetland - .14 ha (0.35 ac) PEMA restoration**.**

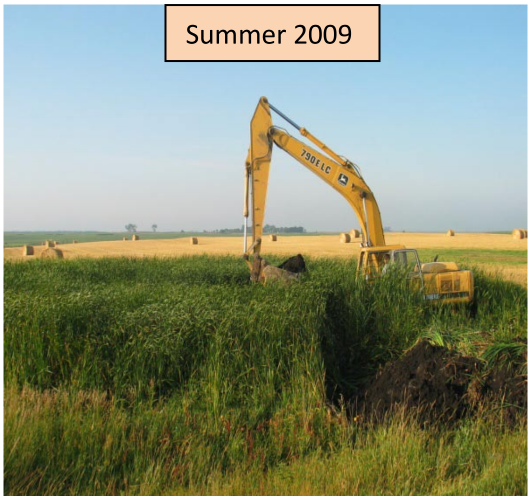


Figure 8. Wetland restoration of a PEMC wetland basin at the Nikolaisen WPA, Towner County (2008 – 2010).

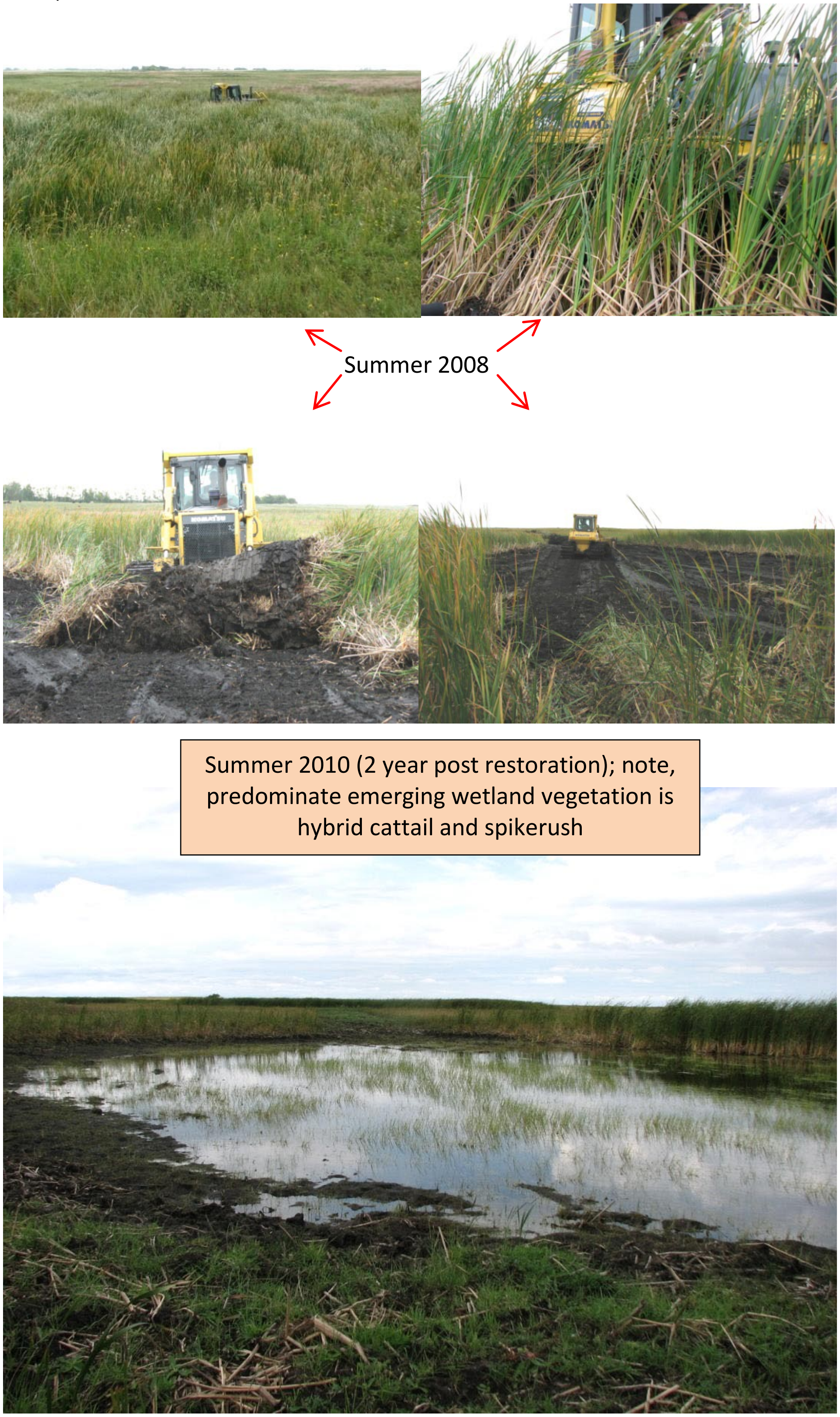
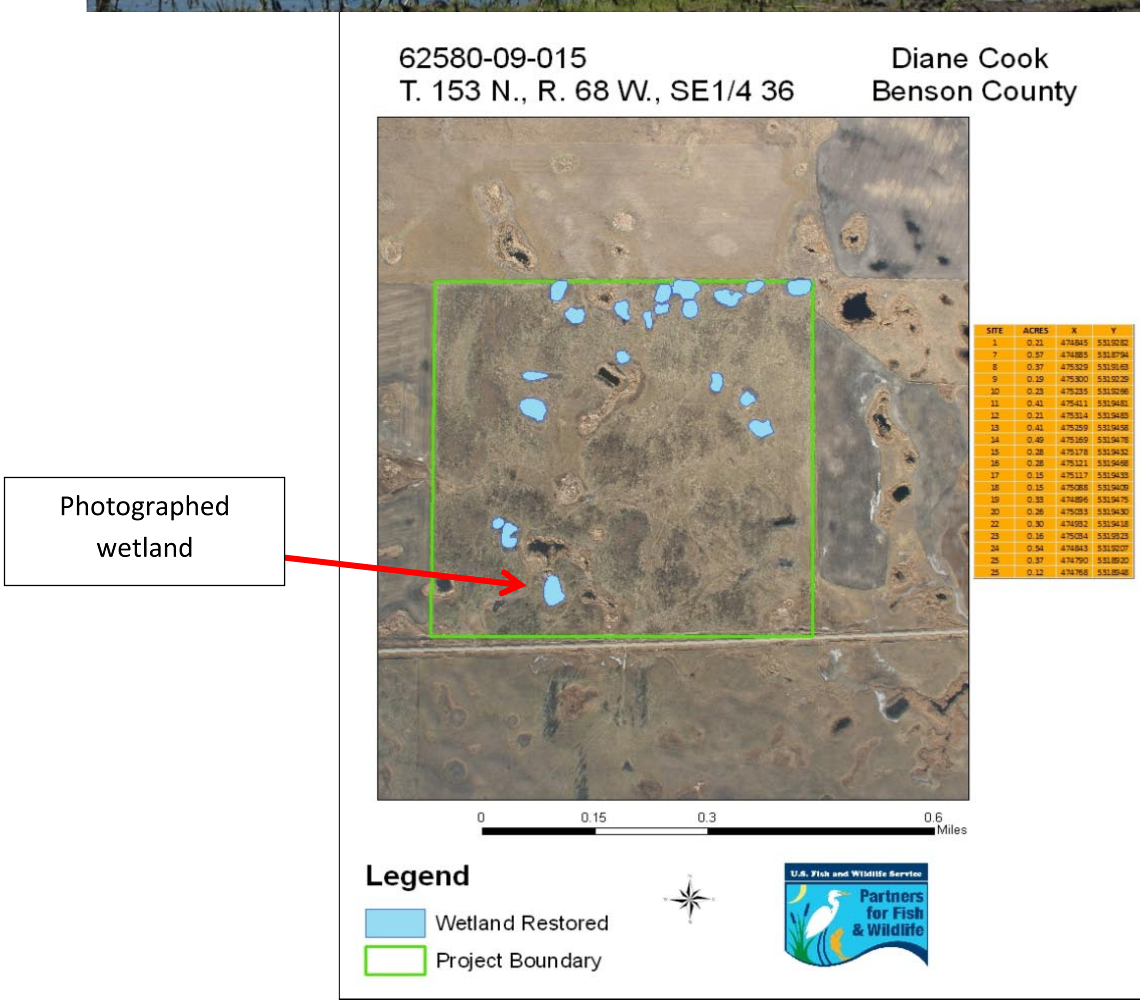


Figure 9. Blue-winged teal brood using a restored PEMC wetland, Diane Cook site, Benson County.

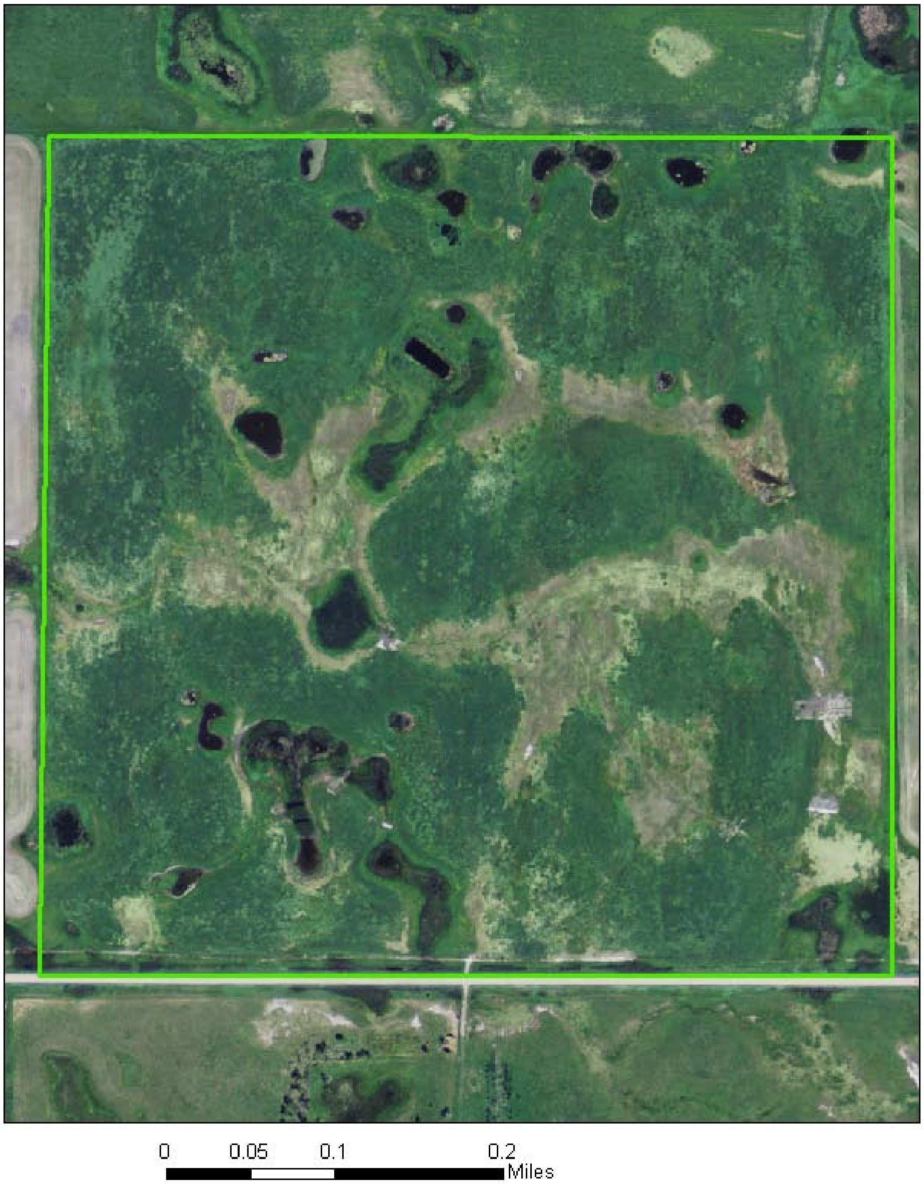


SITE	ACRES	X	Y
1	0.21	474845	5319282
7	0.57	474885	5318794
8	0.37	475329	5319163
9	0.19	475300	5319229
10	0.23	475235	5319266
11	0.41	475411	5319481
12	0.21	475314	5319485
13	0.41	475259	5319458
14	0.49	475169	5319478
15	0.28	475178	5319432
16	0.28	475121	5319468
17	0.15	475117	5319433
18	0.15	475088	5319409
19	0.33	474896	5319475
20	0.26	475033	5319430
22	0.30	474932	5319418
23	0.16	475034	5319323
24	0.54	474843	5319207
25	0.37	474790	5318920
25	0.12	474768	5318948

Figure 10. Diane Cook site; summer 2010 air photo – Landscape view of habitat restorations displaying 20 restored wetlands during the summer of 2009.

62580-09-015
T. 153 N., R. 68 W., SE1/4 36

Diane Cook
Benson County



SITE	ACRES	X	Y
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7	0.57	474885	5318794
8	0.37	475329	5319163
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13	0.41	475259	5319458
14	0.49	475169	5319478
15	0.28	475178	5319432
16	0.28	475121	5319468
17	0.15	475117	5319433
18	0.15	475088	5319409
19	0.33	474896	5319475
20	0.26	475033	5319430
22	0.30	474932	5319418
23	0.16	475034	5319323
24	0.54	474843	5319207
25	0.37	474790	5318920
25	0.12	474768	5318946

Legend

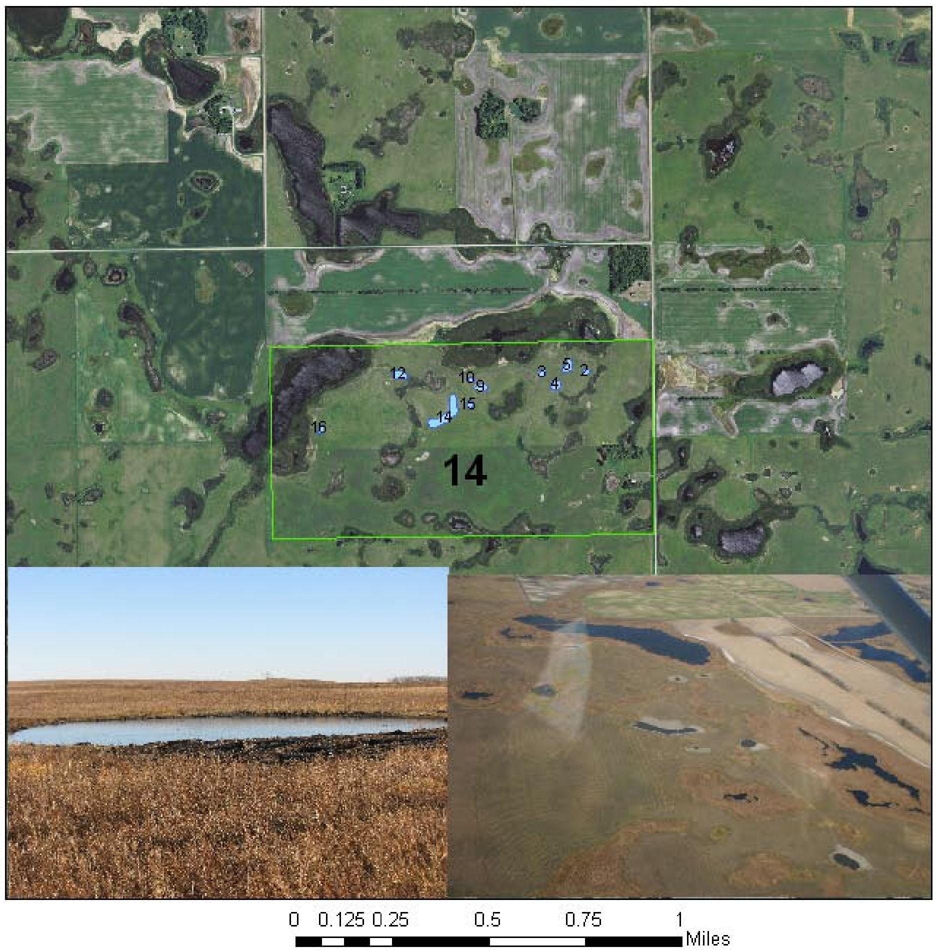
Project Boundary

U.S. Fish and Wildlife Service
Partners for Fish & Wildlife

Figure 11. Gordon Munns site (Nelson County); Landscape view of habitat restorations displaying 10 restored wetlands during the fall of 2010. (Note inset photos, 2 inch precipitation event 1 day after restorations (Fall 2010) filled basins to nearly 100% of normal water levels).

ND 62580-10-001
T.150 N., R. 58 W. Sec. 14

Gordon Munns
Nelson County



Legend

Project Boundary

Wetland Restored

U.S. Fish and Wildlife Service Partners for Fish & Wildlife

SITE	ACRES	X	Y
2	0.15	572156	5295911
3	0.20	571975	5295903
4	0.30	572031	5295852
5	0.37	572079	5295933
9	0.33	571721	5295843
10	0.11	571677	5295876
12	0.46	571378	5295896
14	1.39	571571	5295734
15	0.17	571671	5295773
16	0.15	571048	5295668

Many additional photographs were taken during this project, and are attached as a project addendum item on an accompanying project CD.

Presentations and Videos – Project Outreach

In addition to project photographs, a PowerPoint presentation titled, "An Escape from Mediocrity; Removing Sedimentation as a Technique to Restore Palustrine Seasonal and Temporary Wetlands in the Northeast Drift Prairie of North Dakota" was created. This presentation was given several times both locally to interagency personnel and also publically. This PowerPoint presentation was attached to the accompanying CD. The following list of venues where this project was presented included;

- North Dakota Academy of Wetland Scientists, February 2010, Mandan, North Dakota.

- State Wildlife Grant Update and Coordination Briefing Conference, April 2010, Bismarck, North Dakota.

- USFWS Partners for Fish and Wildlife, Regional Meeting, April 2010, Aberdeen, South Dakota.

Lastly, a video was produced and aired on statewide television news channels during the summer of 2009. This project was displayed as part of the popular North Dakota outdoors series locally known as, "North Dakota Outdoors with Tom Jensen". This video is available for viewing by following this link:

http://gf.nd.gov/multimedia/ndoutdoors/ndoutdoorstv.html

Once at the site, scroll down to "Wetland restoration (7mb)" to view the Tom Jensen/Sediment removal/North Dakota Outdoors video.

Lastly, several tours were provided to visiting federal, state and non-governmental entities. Although these tours may not have specifically been directed towards these projects outcomes, many of the restoration activities accomplished with SWG dollars were visited.

- Pre-construction Site Tour to NDGF – summer 2008
- Tour of Garrison Diversion – Wildlife Development Area Team included BOR staff W. Fairbanks et al., NDGF staff - R. Kreil and S. Peterson, USFWS - R. Hollevoet, L. Jones and K. Baer.
- Tour for Assistant Chief, National Wildlife Refuge System, USFWS - Washington D.C. (Summer 2010)
- Tour for Assistant Regional Director – Region 6 – USFWS (Spring 2010)
- Tour of Plains and Potholes Landscape Conservation Cooperative Coordinator – Summer 2010

Future tours are pending.

- Area 1 NRCS Conference Winter 2011
- Site Visit – With South Dakota NRCS & DU (Spring 2011)
- Presentation to UND – Date TBD
- NDGF staff visiting completed project (summer 2011)

Habitat Assessment and Monitoring

We monitored restoration success or failure via aquatic plant responses to the previously described habitat restoration sites. We selected 10 wetland basins during the study which served to represent the entire project. The basins were assessed in their pre-restoration habitat condition, and then subsequently assessed during each summer/fall thereafter until 5 years after project completion. This is an incomplete section of this project however, and the table below describes which basins were monitored, where located and how many years of monitoring to date.

Table 4. Habitat monitoring locations of 10 selected wetland basins during the habitat restoration project, "Removing Sedimentation as a Technique for Restoring Palustrine Seasonal and Temporary Wetlands in the Northeast Drift Prairie of North Dakota".

Site	County	Year Restored	Number of Years Monitored[A]	Hydroperiod Regime of Wetland	Sediment removed cm (inches)	Surface hectares (acres)	Average Spring Water Depth in cm	Mapped Wetland Number
Armey	Towner	2008	2	PEMC	25.4 (10in)	.78 (1.9ac)	71.2 (28in)	8
Armey	Towner	2008	2	PEMC	25.4 (10in)	.70 (1.7ac)	76.2 (30in)	10
Nikolaisen	Towner	2008	2	PEMC	20.3 (8in)	.25 (.60ac)	71.2 (28in)	3
Nikolaisen	Towner	2008	2	PEMC	20.3 (8in)	.10 (.26ac)	60.9 (24in)	10
Nikolaisen	Towner	2008	2	PEMA	15.3 (6in)	.02 (.06ac)	45.7 (18in)	16
Sorum	Ramsey	2009	1	PEMC	20.3 (8in)	.39 (.96ac)	55.8 (22in)	1
Sorum	Ramsey	2009	1	PEMA	15.3 (6in)	.22 (.55ac)	66.0 (26in)	2
Sorum	Ramsey	2009	1	PEMA	10.2 (4in)	.08 (.22ac)	66.0 (26in)	7
Henke	Benson	2009	1	PEMA	20.3 (8in)	.14 (.35ac)	53.3 (21in)	11
Henke	Benson	2009	1	PEMA	25.4 (10in)	.08 (.21ac)	60.9 (24in)	18

A = years monitored as of the date of this report.

The vegetative quality and quantity relate to species richness, and was measured in both the pre and post restoration conditions over a 5 year post restoration window. The ultimate judge of project success was dependent upon the hydrophyte responses from minimal, poor diversity wetlands to increased species richness by 50%. The following table describes the pre and post monitoring effort, and tentative results, albeit unfinished. Only the presence of species identified in restored wetlands was given, frequency of each will be assessed and presented after the 5th year of monitoring.

Table 5. Vegetation responses of 10 restored wetlands during the 2009 and 2010 growing seasons as part of, "Removing Sedimentation as a Technique for Restoring Palustrine Seasonal and Temporary Wetlands in the Northeast Drift Prairie of North Dakota" project. Current results only represent 1 - 2 years of post-restoration monitoring (Fall 2010).

Site (years post restoration)	Mapped Wetland Number	Pre – restoration Vegetation	Post – restoration vegetation, these plants are identified in the mudflat and shallow marsh zones[A]	Dominate wet meadow zone vegetation
Armey (2 years)	8	Hybrid cattail (99%) Slough sedge (1%)	spikerush, alkali & hardstem bulrush, slough sedge, rushes sp., American sloughgrass, barnyard grass, water plantain, white water crowfoot, hybrid cattail, curly dock, reed canary grass, smartweed sp.,	Quackgrass + Canada thistle, sow thistle
Armey (2 years)	10	Hybrid cattail (99%) Slough sedge (1%)	spikerush, alkali & hardstem bulrush, slough sedge, rushes sp., American sloughgrass, barnyard grass, water plantain, white water crowfoot, hybrid cattail, curly dock, reed canary grass, smartweed sp.,	Quackgrass + Canada thistle
Nikolaisen (2 years)	3	Hybrid cattail (99.5%) Slough sedge (<1%)	Spikerush, alkali bulrush + am. 3 square bulrush, slough sedge, rushes, American sloughgrass, barnyard grass, water plantain, curly dock, arrow leave + hybrid cattail, smartweed sp.,	Quackgrass, 3 square bulrush, northern reedgrass, cinquefoil, prairie cordgrass, Sunflower sp., Canada thistle, Poa sp., foxtail barley
Nikolaisen (2 years)	10	Hybrid cattail (99.5%) Slough sedge (<1%)	Spikerush, alkali bulrush, slough sedge, rushes, American sloughgrass, fowl manna grass?, barnyard grass, water plantain, narrow leave + hybrid cattail, smartweed sp.	Quackgrass, 3 square bulrush, curly dock, northern reedgrass, prairie cordgrass, cinquefoil, Sunflower sp, Canada thistle, Poa sp., foxtail barley
Nikolaisen (2 years)	16	Hybrid + narrow cattail (>99%) Slough sedge (<1%)	Spikerush, rushes, slough sedge, American sloughgrass, water plantain, alkali bulrush, narrow and hybrid cattail	Quackgrass, Sunflower sp., Canada thistle, Poa sp., Brome sp., foxtail barley
Sorum (1 year)	1	Hybrid + narrow cattail (>99%) Slough sedge (<1%)	White water crowfoot, water plantain, hardstem bulrush, slough sedge, American sloughgrass, curly dock, am. bugleweed, rushes, hybrid cattail	Quackgrass, alfalfa, sow thistle, Canada thistle, reed canary grass
Sorum (1 year)	2	Hybrid + narrow cattail (>99%) Slough sedge (<1%)	White water crowfoot, water plantain, hardstem bulrush, spikerush, slough sedge, American sloughgrass, rushes, hybrid cattail	Quackgrass, alfalfa, sow thistle, Canada thistle, reed canary grass
Sorum (1 year)	7	Hybrid + narrow cattail (>99%) Slough sedge (<1%)	Hardstem bulrush, water plantain, spikerush, rushes, American sloughgrass, curly cock, smartweed sp., hybrid cattail	Quackgrass, alfalfa, sow thistle, Canada thistle, reed canary grass
Henke (1 year)	11	Hybrid cattail (>99%) Slough sedge (1%)	Water plantain, spikerush, hardstem bulrush, slough sedge, barnyard grass, American sloughgrass, rushes, hybrid cattail	Poa sp, Quackgrass, Canada thistle, reed canary grass
Henke (1 year)	18	Hybrid cattail (99%) Slough sedge (1%)	Water plantain, spikerush, hardstem bulrush, slough sedge, barnyard grass, American sloughgrass, rushes, hybrid cattail	Poa sp. Quackgrass, Canada thistle, sow thistle, reed canary grass

A = Frequency of plant species present will be given in year 5 of monitoring efforts and final results will be reported in a separate addendum to this report.

Observed Wildlife Use

Periodically throughout the project, anecdotal wildlife sightings were noted but not measured in any capacity. Particularly interesting were waterfowl observations using restored wetlands, primarily Canada geese (*Anser canadensis*), mallards (*Anas platyrhynchos*), Northern pintail (A. acuta), blue-winged teal (*A. discors*), green-winged teal (*A. crecca*), northern shoveler (*A. clypeta*), and ring-necked ducks (*Aythya collaris*). Also, duck broods were minimally observed using restored wetlands if these wetlands had adequate water (see figure 9). Shorebirds were also occasionally observed, both breeding and migratory. A small flock of 45 semi-palmated sandpipers (*Calidris pusilla*) was noted on one site visit, and additionally least (*C. minutilla*), white-rumped (*C. fusicollis*) and Baird's (*C. bairdii*) sandpipers, dunlin (*C. alpina*), short-billed dowitcher (*Limnordromus griseus*) and lesser yellowlegs (*Tringa flavipes*) were also noted. Breeding shorebirds only included killdeer (Charadrius vociferous) and Wilson's phalarope (*Phalaropus tricolor*). Particularly exciting was the presence of 2 migratory Peregrine falcons (*Falco peregrinus*) harassing shorebirds within the restoration complex at the Armey restoration site. Lastly, chorus frog (*Pseudacris triserata triserata*) adults were observed within several restored wetland basins at the Nikolaisen WPA, Sorum and Armey sites. Northern leopard frogs (*Rana pipiens*) and Canadian toads (*Bufo hemiophrys hemiophrys*) were detected in adjacent uplands near restored wetlands. No mammalian or fish use of restored wetlands were observed.

Nektonic invertebrate productivity was also briefly investigated; a dip was used to collect aquatic freshwater invertebrates in 3 post restoration wetlands. Although we did not perform any pre-restoration sampling, the following invertebrate taxon were observed and included; aquatic freshwater crustacean, water fleas (*Daphnia sp - collector.*), aquatic freshwater arthropoda, damselfly larvae (not keyed), mayfly larvae (not keyed), aquatic beetles – *Dystsicidae (predator) and Hydrophillidae (collector)*, water boatmen adults and nymphs (*Corixidae - predator*), back swimmer adult and nymph (*Notenectidae – scraper)*, mosquito larvae (*Culicidae – collector, shredder)*. No benthic invertebrate sampling was attempted.

DISCUSSION

Aquatic Plant Vegetation

Wetland plant development and increased species richness for this project was not unexpected. Colonization of wetland plant species during the early successional stages has shown to be the most productive in many wetland restoration efforts (Aronson and Galatowitsch et. al. 2008). The largest input of growth from wetland seed banks occurs in the first and second years after restoration, when exposed sediments are quickly colonized by populations of mudflat annual species (Wienhold and van der Valk, 1989). Revegetation of restored prairie pothole wetlands is often attributable to recruitment from the wetlands remnant seed bank (Knutsen and Euliss 2001). The mud-flat annual guild is the most prolific and resilient vegetative group in the PPR, and therefore, this group normally comprises the majority of seed bank vegetative contributions of restored wetlands (Wienhold and van der Valk, 1989). Unpublished results from sediment/cattail wetland restoration projects conducted within the past 8 years in the DLWMD have shown similar development during the early successional stages. Species richness however fails significantly when directly compared with vegetative diversity of naturally functioning PPR wetlands. Galatowitsch and Van der Valk (1996b) compared floristic composition in restored (via tile disruption) versus native wetlands in Iowa and found natural wetlands had a mean of 46 species compared to 27 species for restored wetlands. Floristic shifts in restored wetland also decrease over time. Aronson and Galatowitsch (2008) examined 37 restored wetlands (dikes, tile disruption, ditch plugs) over a 19 year period which revealed a rapid increase in species richness (125 species in 189) to 279 species in 2007; but the net gain of species after the 19 year period began to decrease; however species richness still remained high. It is likely that our restoration efforts will show similar results due to the restored hydrology and mechanical removal of sediment and invasive hybrid cattails, but will hybrid cattail re-invasions occur. If cattail re-growth is prolific, can we expect to have some resemblance of hydrophytic richness similar to a fully functioning prairie pothole wetland in 5-10 years and beyond?

Other wetland zones which showed little if any increase in species richness were the low prairie and wet meadow zones. This was not surprising and again was predicted from past restoration efforts and literature for restored wetands. Seed bank presence and/or viability seem to be very poor or non-existent in these wetland zones. Consistent with the results of numerous studies that showed a lack of diverse wet-meadow zones in restored PPR wetlands, wet-meadow species were poorly represented in seed banks (Galatowitsch and van der Valk, 1996a, Euliss and Knutsen 2001). Given that our wetlands were located in formerly intense agricultural areas; our wet meadow vegetation was degraded or non-existent, and consisted of primarily quackgrass and Canada thistle, and others report similar results for this zone of wetlands after restorations (Seabloom and van der Valk 2003). Galatowitsch and van der Valk (1996a) attribute this lack of the diverse wet meadow vegetation based on the physical location in the basin (upper zone) which is only seasonally flooded and therefore the most efficiently drained zones of prairie wetland. Our situation with sediment removal was different as all restored basins were not drained, but our failure to entice wet meadow vegetation were likely caused from historically intensive agriculture and invasive species encroachment in restoration areas. It was likely our wet-meadow seed bank consisting of native vegetation has long since vanished. However, the DLWMD planted over 3,000 stems of prairie cordgrass (*Spartina pectinata*) during the spring of 2005, and results of success for this hand planted species exceeded 90% (Figure 12.). For complete landscape ecological restoration with this project, particularly within the wet-meadow zone, some treatment or restoration should have been attempted and monitored. These re-establishment methods were suggested by others; direct seeding, high quality native hay spread across this zone, inoculating the wetland with small amounts of soil from a donor wetland, using donor soil with its root and seed, coconut mats with embedded desirable native seeds, hand planting desirable rhizome stock (sedges and p. cordgrass et al.). Galatowitsch and van der Valk (1994) report that these restoration activities must begin within 1 year after restoration, primarily because this zone is prone to invasive species invasion which makes it difficult for desirable species to become established thereafter. Unfortunately, re-seeding of this wetland zone has not shown successful results in the PPR for a variety of reasons (Marburger 1992, Galatowitsch and van der Valk 1994), but others have had mixed success (Knutsen and Euliss 2001). This should not be construed in any way as a reason to avoid attempts to restore this wetland zone.

Figure 12. Prairie cordgrass thriving after 2 years after being hand planted from rootstock (3,000 stems in 2006) on the Nikolaisen Waterfowl Production Area in Towner County, North Dakota. To date, no naturally occurring cordgrass plants have been discovered within this restoration area.

We set an easy criterion for our definition of restoration success, but recording the progression of wetland development up to and beyond a 5 year period will be a valuable endeavor and must continue. Longer term vegetation monitoring (circa. 8 year post restoration) efforts are pending results from current investigations of other DLWMD-NEDP sediment removal restoration projects by others (C. Dixon, USFWS, pers. comm.). Most literature of hydrophyte recolonization is from ditch plug and tile disruption efforts, especially from Iowa and Minnesota (Galatowitsch and van der Valk 1996a,b, Aronson and Galatowitsch 2008). Our sediment removal efforts consisted of removal of invasive organic sediment along with invasive, persistent hybrid cattails. Setting stronger restoration goals and objectives, and evaluating spatial and temporal changes of wetland hydrophytes and other biota will provide valuable information, particularly whether or not this restoration technique is tenable. Long term hydrophyte richness must be measured.

Aquatic Freshwater Invertebrates (AFI)

Our basic assumption predicated upon immediate hydrophyte responses to restored wetlands would be increased AFI species richness and diversity. Enhanced vegetative diversity results in an increase in invertebrate species richness in natural prairie wetlands (Driver 1977). Murkin (1991) concluded that high abundance and diversity of invertebrates in prairie wetlands were due to the diversity and interspersion of vegetation types. Conversely, decreased wetland plant diversity is a major factor leading to low richness related to aquatic freshwater invertebrates (R. Gleason pers. comm). Another aspect related to AFI is most taxa tend to quickly recolonize restored wetlands; AFI populations tend to be large the first 2 years of inundation due to enhanced nutrient release from the decay of prerestoration vegetation (Whitman 1976). If wetland vegetation continues to increase in species richness, we should be able to infer invertebrate diversity will likewise increase. Of course, aquatic invertebrates are a key nutritional component for macrofauna use, particularly in newly restored or manipulated wetlands for migratory and breeding waterfowl (Madsen 1987, Sewell 1989, Delphey 1991, VanRees-Siewert 1993, Murkin et al. 1982, Murkin and Batt 1987, Krapu and Reinecke 1992).

Hybrid Cattail – Sedimentation and Hydrology – Climate Change

Hybrid cattails have become prolific across the PPR, especially in the northeast drift prairie (NEDP) of North Dakota. Ralston et al. (2006) measured cattail abundance and discovered roughly 40% of NEDP wetlands contained cattails. Coupled with wet conditions and average or below average summer temperatures during this period, these invaders have flourished. Patrick and Khalid (1974) and Lee et al. (1977) report that as soil becomes anaerobic due to increased use by microbial organisms, Ferric iron ($Fe3+$) is chemically reduced to Ferrous iron ($Fe2+$) which releases phosphorus and makes it available to plants. Excessive phosphorus and nitrogen presence in wetland sediments coupled with continued anaerobic, static water levels are likely the key factors leading to wetland habitat degradation. The end result is a perfect growing environment for invasive cattail species and a reduction in overall wetland productivity, especially hydrophytes and invertebrates. Evapotranspiration over the past 4 years within the DLWMD has been negligible. An example is that many seasonal wetlands in this region have not been dry during this wet deluge time period; areas in central Towner County near the Armey and Nikolaisen sites received 9 inches of precipitation in a single rainfall event during August, 2010. The consistent deluge of seasonal and some temporary wetlands combined with sedimentation have exacerbated the invasive cattail situation, and has shown no sign of relenting. If most wildlife does use these cattail choked, sediment rich basins, the best and most productive habitat to date is the outer edge within the wet meadow zone away from the center of the wetland basins. This zone consists of very few natural hydrophyte species in the NEDP and is abundantly inhabited by quackgrass, Kentucky bluegrass (Poa pratensis) and Canada thistle. Abundant use of cattail dominated wetlands by white-tailed deer (*Odocoileus virginianus)*, ringed-necked pheasants (*Phasianus colchicus*) and red-winged (*Agelaius phoeniceus*) and yellow-headed blackbirds (Xanthocephalus xanthocephalus), is well documented (Linz 1992).

Most wetlands in the PPR are closed basins that lack integrated drainage networks (Richardson et al. 1994). Sediments can infiltrate prairie wetlands in a variety of ways, either from aeolian mixtures of snow and dirt ("snirt") (Adomaitis et al.1967), or directly from rill erosion directly from the surrounding landscape. Martin and Hartman (1987) and Gleason and Euliss (1996) found that sediment rates were nearly twice as high in wetlands with cultivated catchments than with catchments occurring in native or non-native grasslands. Annual tillage and lack of adequate landscape cover exemplified in the NEDP is the primary cause of excessive sedimentation of wetlands, especially on private lands, but is also present on state and federal lands. Many of the state and federal lands have been purchased within the past 50 years and have had cropping histories and/or wetland drainage history prior to fee title acquisition. It is very likely that sediment loads currently occurring within PPR wetlands have accumulated for nearly 100 years, with rapid acceleration occurring during the 1930's – 1960's (R. Gleason pers. comm.). Fortunately, current Farm Bill practices such as grassed waterways, the Conservation Reserve and Wetland Reserve programs, other federal and state programs, crop stubble residue management and a gradual shift away from deep plowing to no-till or minimal tillage methods has slowed the problem. Unfortunately, the damage has been done. Some of the most severely impacted basins have filled with so much sediment that they no longer pond water; such wetlands have lost their capacity to perform most natural wetland functions (Gleason and Euliss 1998).

Impending climate change has potentially exacerbated the increase in emergent cattail vegetation by creating stable water conditions which has been reported as a key factor in hybrid cattail invasions (Wilcox et al. 1985, Shay et al, 1999). Sedimentation of DLWMD-NEDP wetlands over time within this intensively farmed physiographic region of North Dakota has provided a perfect growth medium for hybrid cattails, and to a lesser extent, reed canarygrass (*Phalaris arundinacea*) and common reed (*Phragmites sp*.). As precipitation is generally predicted to increase in northern latitudes, this could disrupt the natural hydroperiod and hydrology of PPR wetlands, and compromise the ratio of emergent plant cover to open water. Also, disruption of species composition and water permanence will likely result (Johnson et al. 2005). Northeast North Dakota has undergone 18 consecutive years ((1994 – 2011) of excessively wet, annual rainfall conditions as exemplified by the current flooding of Devils Lake and its associated mosaic of PEMA, PEMC and semi-permanent wetlands. Local residents and professional land managers have personally observed a significant increase of invasive hybrid cattails in many PPR wetlands. The author of this paper has personally observed this acceleration of hybrid cattails since arriving to the NEDP in spring 2002. Long term climate models predict an increase of roughly 3 °C over the next 50 years for southwestern Minnesota, with an increase of annual precipitation as well (Galatowitsch et al. 2009). The DLWMD will likely see similar shifts in precipitation and temperature given its proximity to the eastern edge (tallgrass/mixed grass prairie) of the PPR. With increased precipitation, prairie wetlands may fail to achieve a normal wet-dry nutrient cycles resulting in decreased wetland productivity. Only the reestablishment of macrophytes during the dry marsh stage 'unlocks' these nutrient and reestablishes the diversity of nutrient pools characteristic of productive prairie wetlands (Murkin et al. 2000, Johnson et al. 2005). Only the increase in temperature and increased evapotranspiration may provide normal hydroperiod conditions for PPR wetlands, but this is uncertain.

CONCLUSION

Financial considerations combined with temporal project success must be continually evaluated if this restoration technique is warranted. Removing cattails and sediment can be costly and is a very slow method for achieving landscape level results. However, if native hydrophyte recolonization results can withstand invasive species pressures for at least 10years and beyond, this technique is a viable tool for restoration of PPR wetlands across the landscape. Preliminary results are promising, and this technique has shown excellent results when used in combination with other landscape restoration projects, namely native grassland restoration. Each restored wetland responds to treatments differently, and the amount of sediment removed, seed bank viability, etc. are all important factors for successful restorations. Further investigations of other wetland zones and utilizing other methods than reliance upon seed bank stock, especially in the wet meadow zone, and must continually be evaluated. Restoration which serves to vegetatively restore the entire wetland basin should be the project goal, with the sediment/hybrid cattail removal technique an objective to reach that goal. More monitoring of wetland habitats in the "pre-restoration" condition need to be conducted which will ensure avoidance of potential critical habitat for secretive marsh taxa such as rails and bitterns. Results demonstrated during this project have temporarily improved degraded wetlands, increased or restored ponding and wetland hydrology, and provided wetland dependent avifauna with improved habitat conditions. For how long is at question.

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Appendix 1. Sediment removal spreadsheet used to calculate sediment materials to be removed per restored wetlands, and used to generate sediment excavation costs. Spreadsheets like this were used for every wetland restored during this project. Normally costs utilized by this project planning tool overestimate restoration costs by roughly 30%. Depths of cut measurements are in 1/10th's of a foot, are excavated materials are calculated to cubic yards. Dry and wet yardage costs are based upon NRCS-FOTG guidelines, or by a specific contractor price.

NORTH DAKOTA Partners for Fish and Wildlife

U.S. Fish and Wildlife Service
Devils Lake Wetland Management District
P.O. Box 908; 221 Second Street NW
Devils Lake, ND 58301
(701) 662-8611 EXT. 361

WETLAND NO(S): 1 THRU 6
OR WETLAND NO'S.

LANDOWNER INFORMATION:

LAST NAME: Smith
FIRST NAME: John
ADDRESS: 3456 34rd St NE
CITY: Bismarck
STATE: ND
ZIP CODE: 58503
PHONE NUMBER: (701) 223-4567

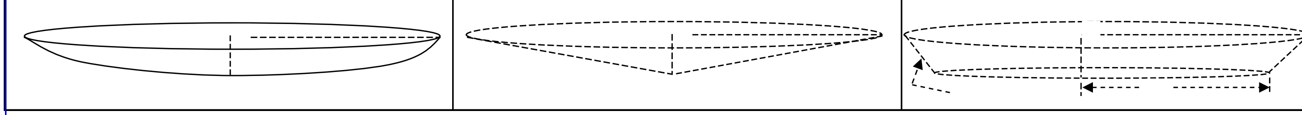
DESIGNED BY: Mark Fisher
WEA NO. ND-62580 EXAMPLE

COUNTY: Towner

TOWNSHIP: 143 **RANGE:** 87 **SEC.:** 6 **QRT:** **QRT:**

SEDIMENT REMOVAL DIMENSION TYPES

TYPE I	TYPE II	TYPE III



Enter Side Slope for Type III 1 :1

Dry Yds^3 Rate $1.85 Wet Yds^3 Rate $2.30

Sediment Calculator

Wetland No.	Surface Acres	Removal Type	Max. depth of cut (h)	TYPE I YDS^3	TYPE II YDS^3	TYPE III YDS^3	Wet or Dry Excavation	Price Estimation	UTM Coordinate Northing /	Easting
1	0.3	I	0.5	81	0	0	Dry	$149.24	486933	5338306
2	0.1	I	0.5	40	0	0	Dry	$74.63	487043	5338501
3	0.1	II	0.8	0	43	0	Dry	$79.59	487095	5338395
4	0.6	II	0.4	0	129	0	Dry	$238.77	486897	5338020
5	1.2	III	0.4	0	0	774	Dry	$1,431.53	486803	5337991
6	0.7	III	0.4	0	0	451	Dry	$834.86	486792	5338560
	0.0		0.0	0	0	0	Dry	$0.00		
	0.0		0.0	0	0	0	Dry	$0.00		
	0.0		0.0	0	0	0	Dry	$0.00		
	0.0		0.0	0	0	0	Dry	$0.00		
	0.0		0.0	0	0	0	Dry	$0.00		
6	3.0	0	0.3	121	172	1,225		$2,808.62		