The role of prairie wetlands in regulating water quality and quantity in prairie watersheds

Pascal Badiou[1], Johann Walker[2], and Bryan Page[1]

[1]Ducks Unlimited Canada, Institute for Wetland and Waterfowl Research

[2]Ducks Unlimited Inc., Great Plains Regional Office

Ducks Unlimited Canada
Conserving Canada's Wetlands

RESCUE OUR WETLANDS
WATER—WILDLIFE—YOU

Introduction / Background

- Ongoing debate in the Canadian prairies regarding the role of prairie wetlands in regulating water quantity and water quality.

- Very little research conducted on PPR wetlands in Canada

Why are we concerned about prairie wetlands

- Historical assumption that the lack of connectivity indicates that these systems are not important to downstream water quality and quantity
- We have dramatically altered watersheds in the prairies, particularly through the draining of GIWs

Ducks Unlimited Canada
Conserving Canada's Wetlands

RESCUE OUR WETLANDS
WATER—WILDLIFE—YOU

NONPOINT SOURCE POLLUTION (NPSP)

- In North America nonpoint sources are now the dominant supply of pollutants, including nutrients, to surface waters (Carpenter et al. 1998; Singh 1997; Daniel et al. 1998).
- Agricultural runoff now contributes significant amounts of nutrients and other contaminants to rivers, lakes, streams, and wetlands.

INCREASING EVIDENCE FOR THE LINKAGE BETWEEN WETLAND DRAINAGE AND FLOODING

- Schottler et al (2013): Watersheds with large land-use changes had increases in seasonal and annual water yields of >50% since 1940 that were highly correlated with artificial drainage and loss of depressional areas.

- Pomeroy et al (2014): Using the PHM showed that wetland drainage increases the contributing area of wetland-dominated prairie basins, and can increase annual and peak daily flows substantially, with notable increases in the flood of record.

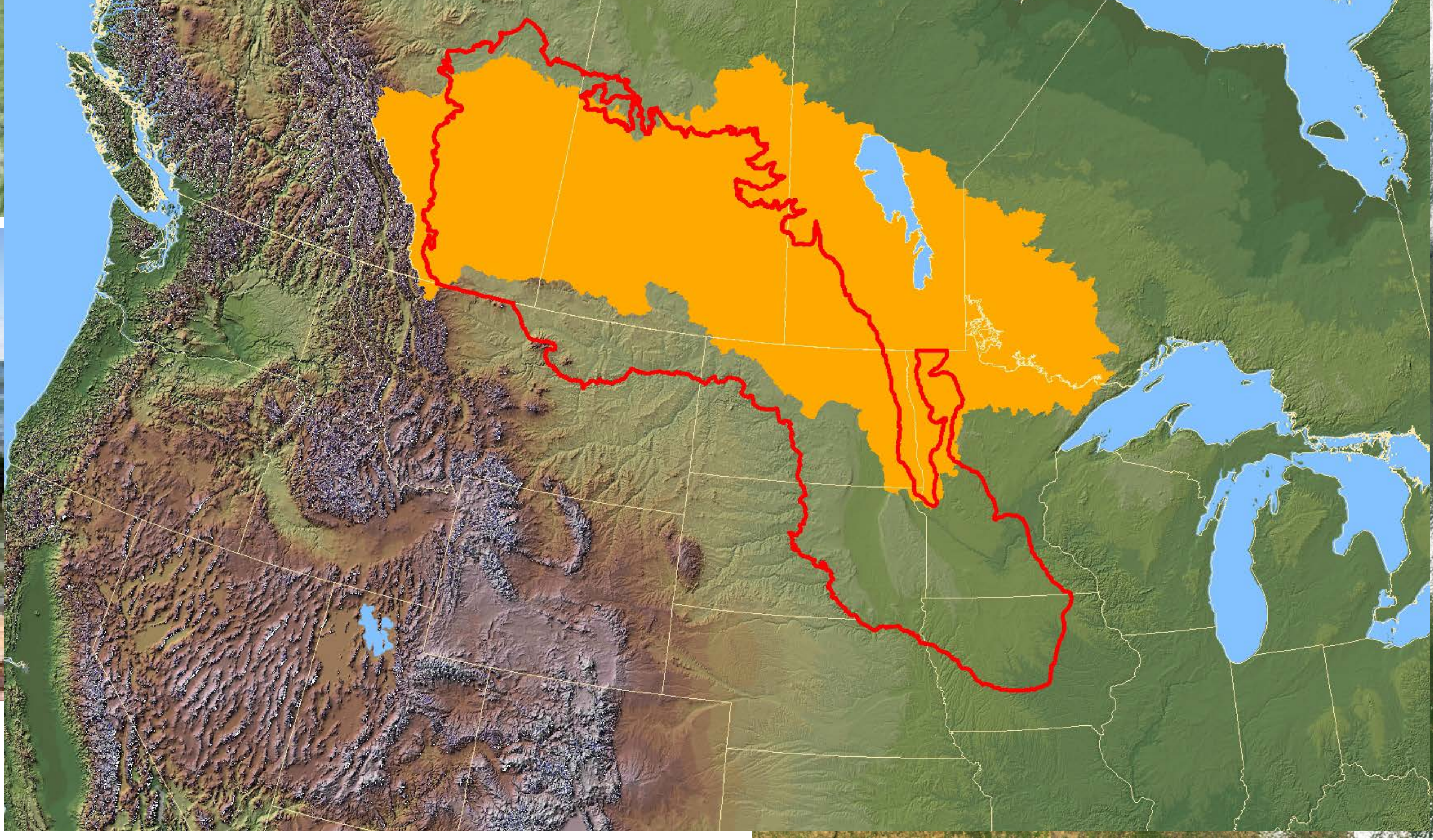
LINK BETWEEN HIGH FLOW EVENTS AND NUTRIENT EXPORT

- McCullough et al., (2012), flood years roughly double TP concentration in the Red-Assiniboine River watershed, and increases in discharge explains most of the increase in nutrient loading to Lake Winnipeg (32%), relative to increases in anthropogenic loading (14%)

Approximately 40:1 watershed to lake area

Non-point sources main source of nutrients

Wetland drainage facilitates transfer of non-point sources



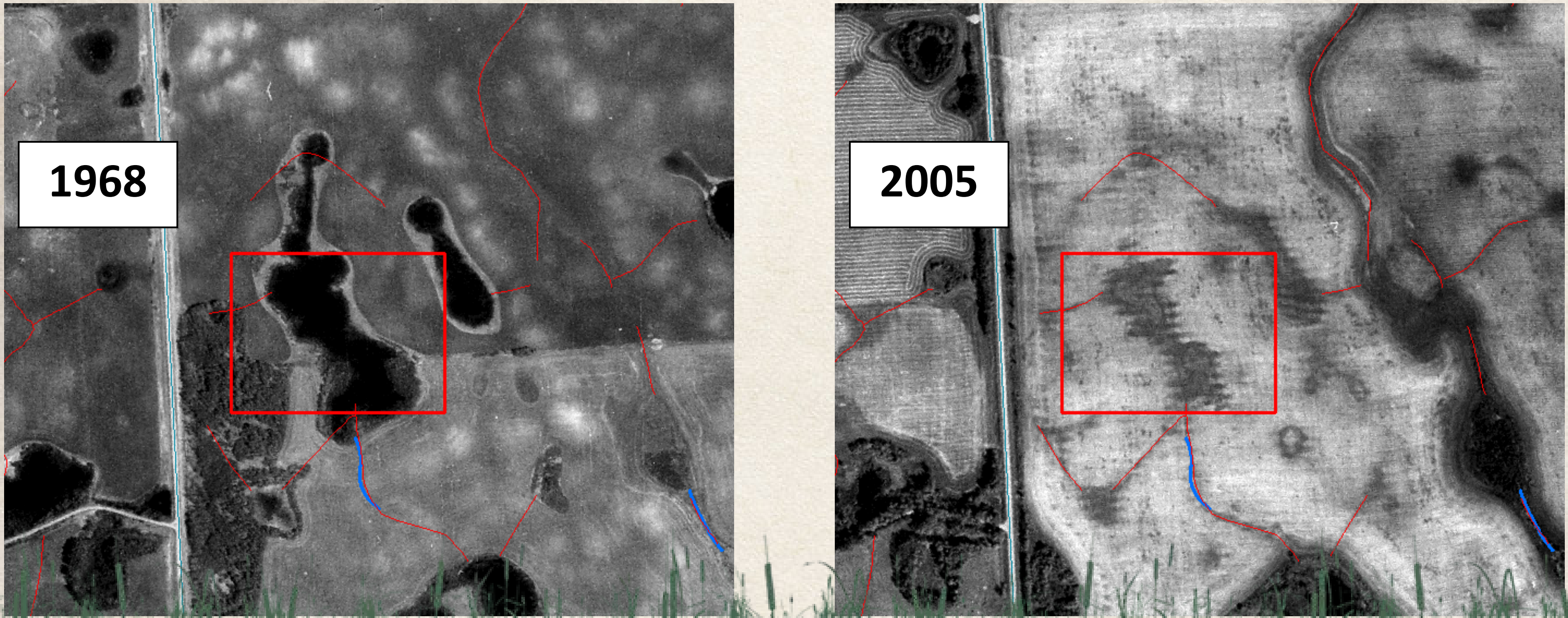
Goal of wetland EGS research

- Determine the impacts of wetlands and the loss of wetlands on water quantity and quality at a watershed level.

- Hypothesis: increasing connectivity in a watershed via draining of wetlands will increase runoff and nutrient export at the watershed scale

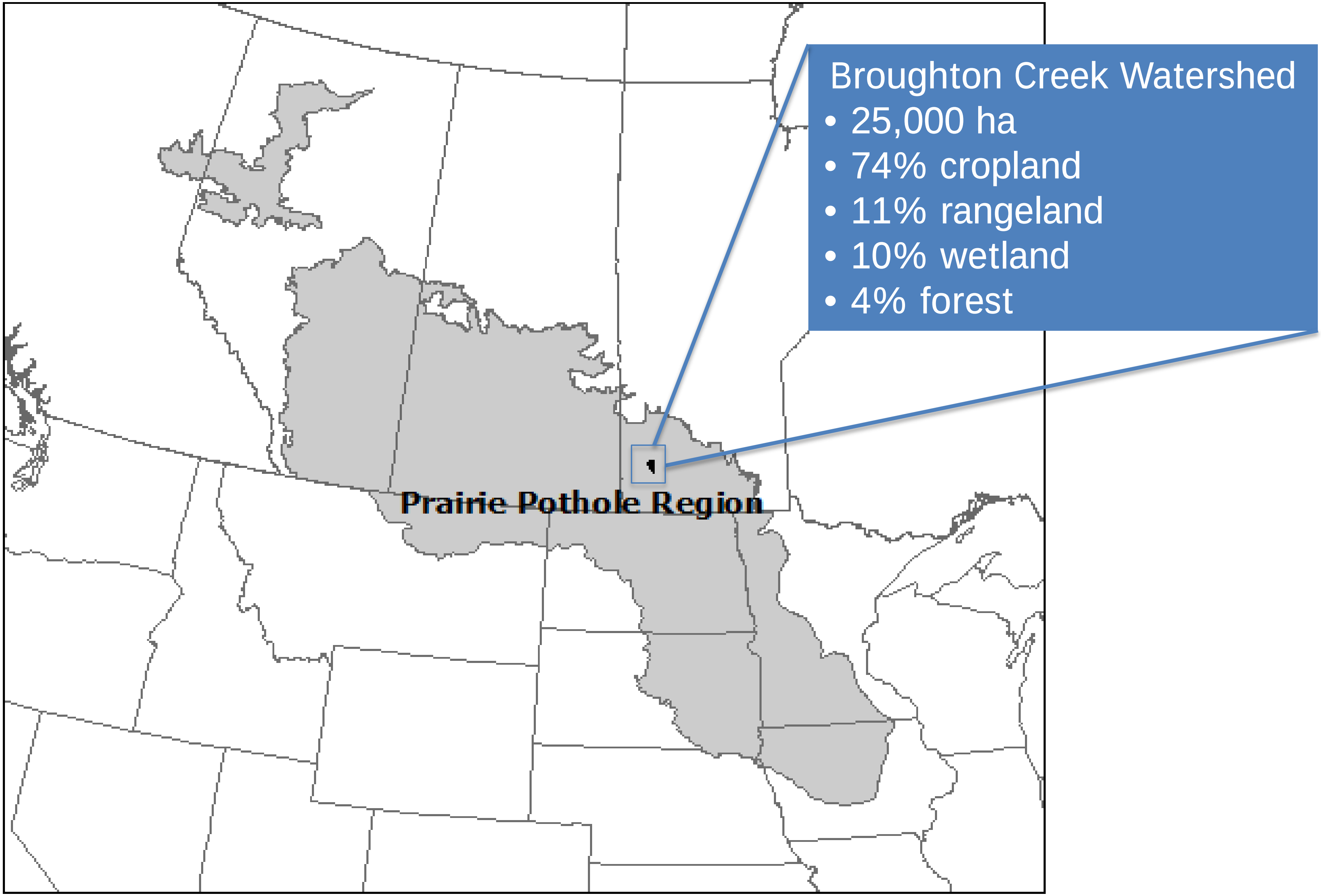
Broughton's Creek Research:

Nutrient Export From Drained Wetlands



Ducks Unlimited Canada
Conserving Canada's Wetlands

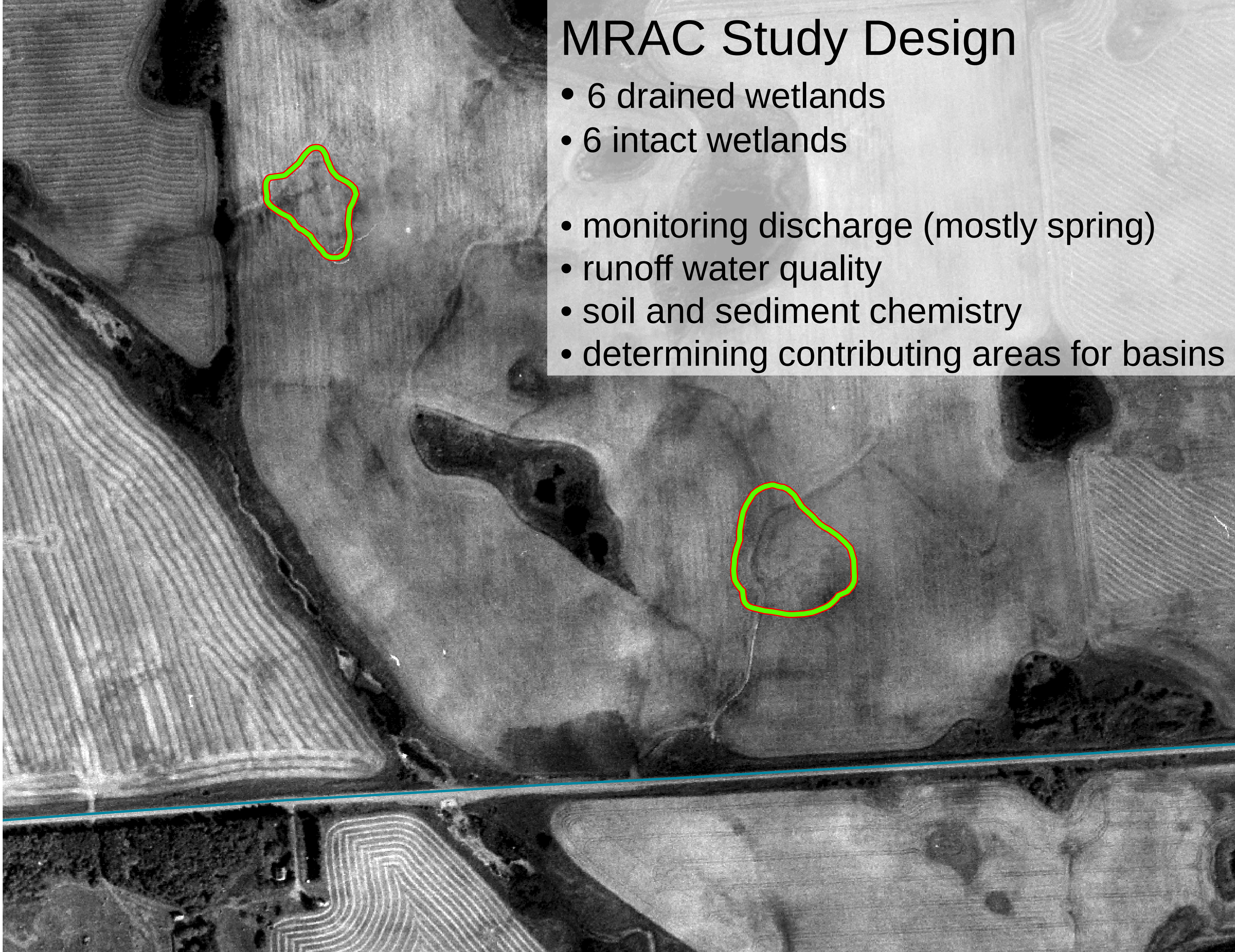
RESCUE OUR WETLANDS
WATER—WILDLIFE—YOU

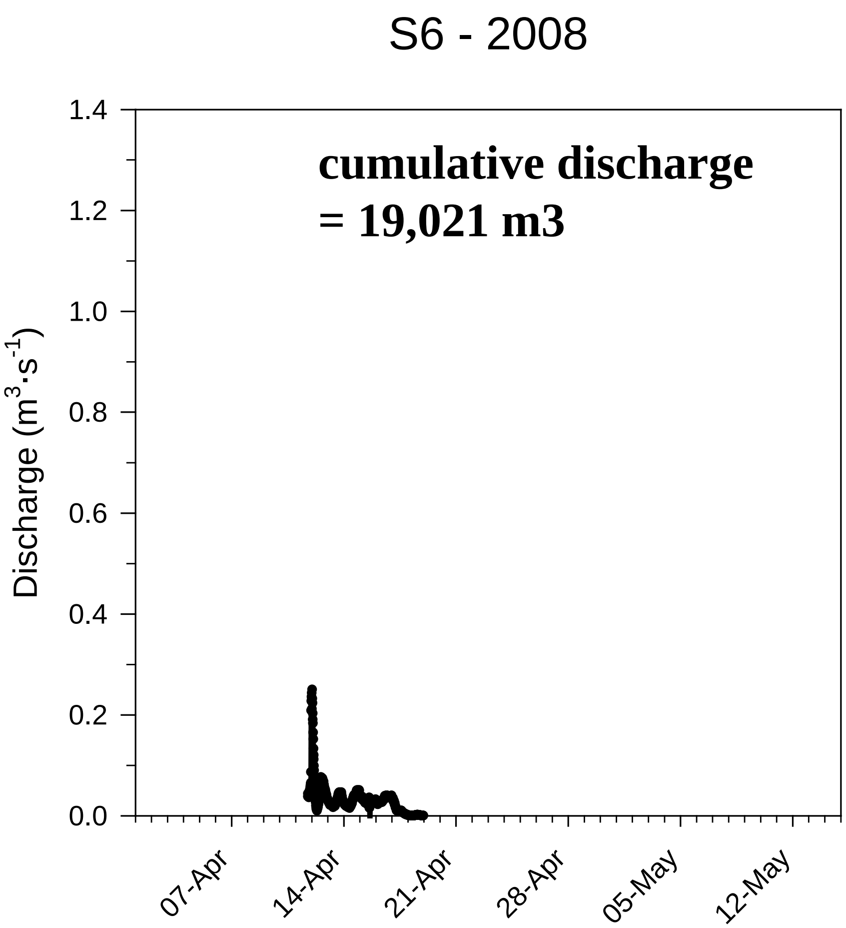

Broughton Creek Watershed
• 25,000 ha
• 74% cropland
• 11% rangeland
• 10% wetland
• 4% forest
Prairie Pothole Region

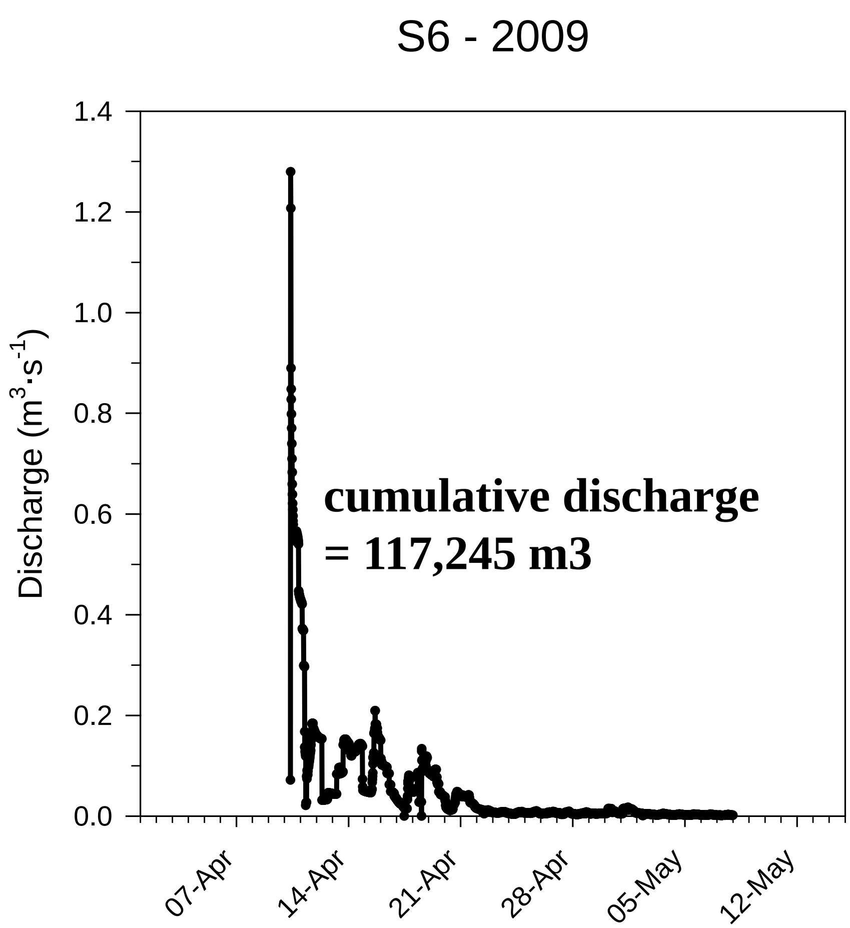
MRAC Study Design

- 6 drained wetlands
- 6 intact wetlands

- monitoring discharge (mostly spring)
- runoff water quality
- soil and sediment chemistry
- determining contributing areas for basins







Ducks Unlimited Canada
Conserving Canada's Wetlands
RESCUE OUR WETLANDS
WATER—WILDLIFE—YOU

Water Quality Findings from Drained Wetlands:

- Nutrient export measured from drained wetlands much higher than those measured from cropland in MB
- P concentrations at the outlets of drained wetlands were always very high (5 to 30x guideline for hypereutrophic systems)
- Nearly all P present in dissolved form

Ducks Unlimited Canada
Conserving Canada's Wetlands

RESCUE OUR WETLANDS
WATER—WILDLIFE—YOU

Comparison of P export from drained wetlands and the Lake Winnipeg Watershed:

- Average P export from drained wetland basins:
  - 2008 = 1.7 kg P/ha/yr
  - 2009 = 2.4 kg P/ha/yr
  - 2008/2009 ave. = 2.1 kg P/ha/yr

- Average P export from the Lake Winnipeg watershed (1994-2007): 0.07 kg P/ha/yr

- MB cropland P export (Tiessen et al., 2010):
  - 0.65 kg P/ha/yr (Cons. T)
  - 0.39 kg P/ha/yr (Conv. T)

DOES THE LOSS OF WETLANDS IMPACT WATER QUANTITY AND QUALITY AT THE WHOLE WATERSHED SCALE?

Strong relationship between runoff ratio (amount of ppt that leaves as runoff) and amount of watershed that is considered to effectively contribute

E. Ehsanzadeh et al. / Journal of Hydrology 414–415 (2012) 364–373

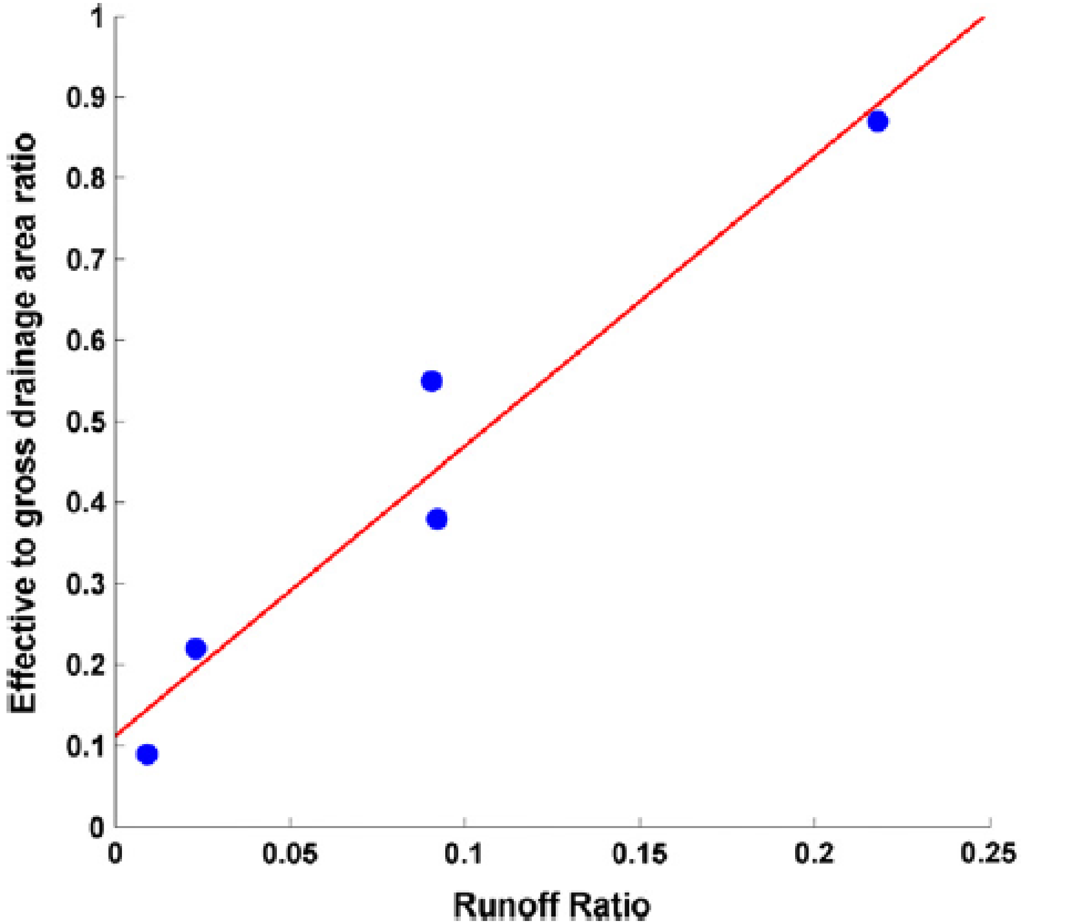
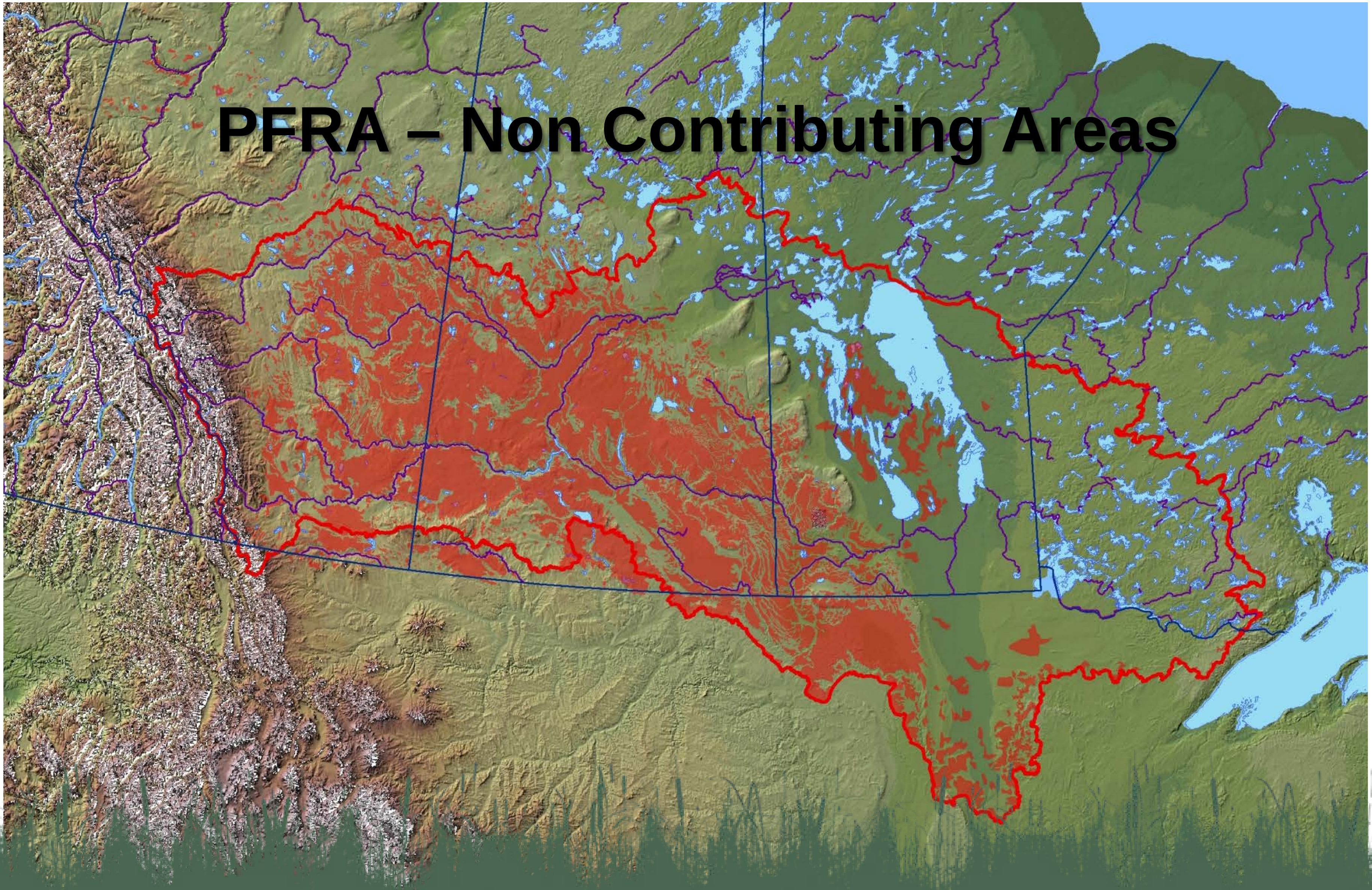


Fig. 9. The relationship between runoff ratio and effective to gross drainage area ratio for the Central Saskatchewan WSC gauged watersheds used in the study.

Ducks Unlimited Canada
Conserving Canada's Wetlands

RESCUE OUR WETLANDS
WATER—WILDLIFE—YOU

PFRA – Non Contributing Areas



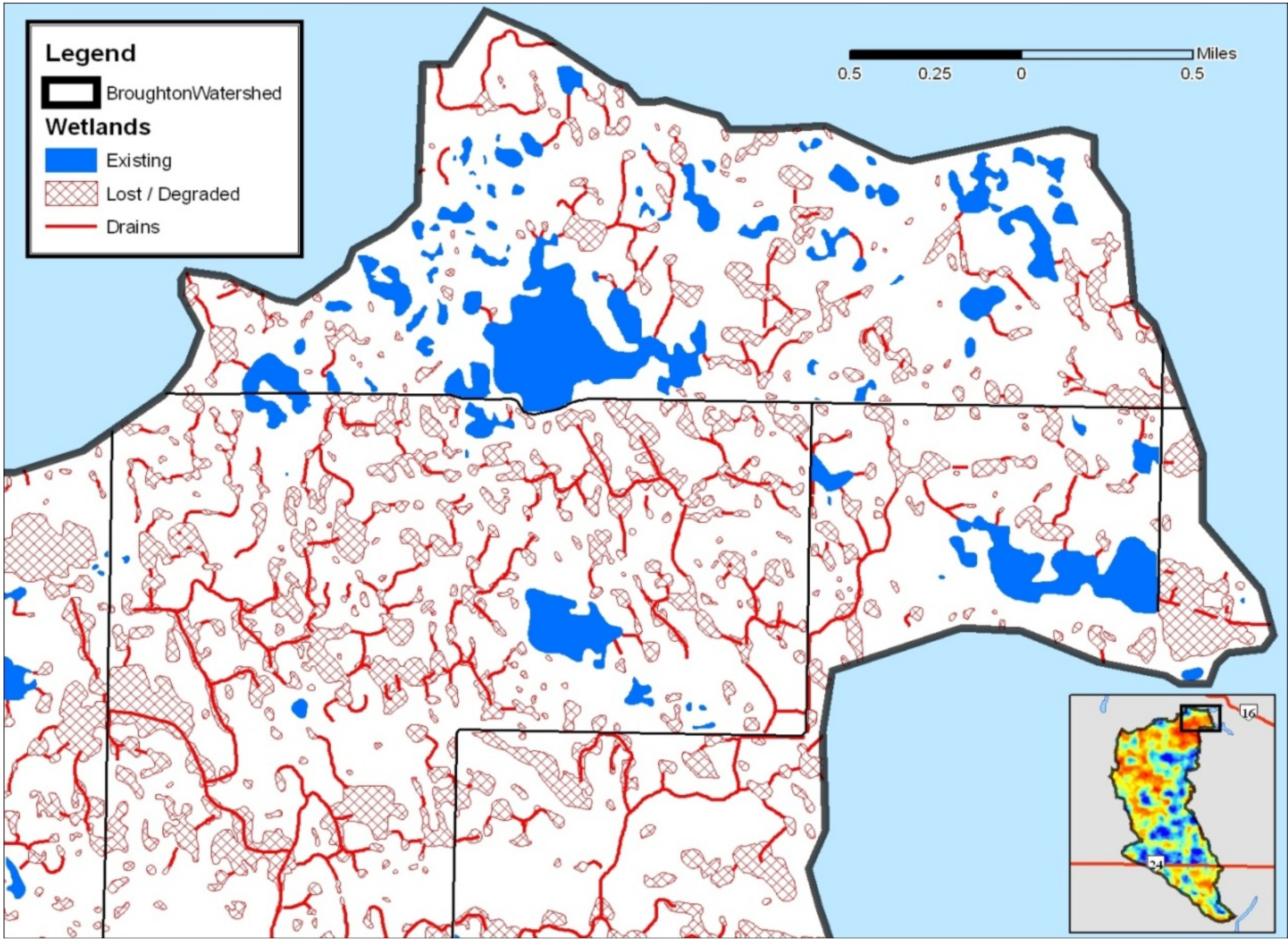
Wetland Loss in Manitoba

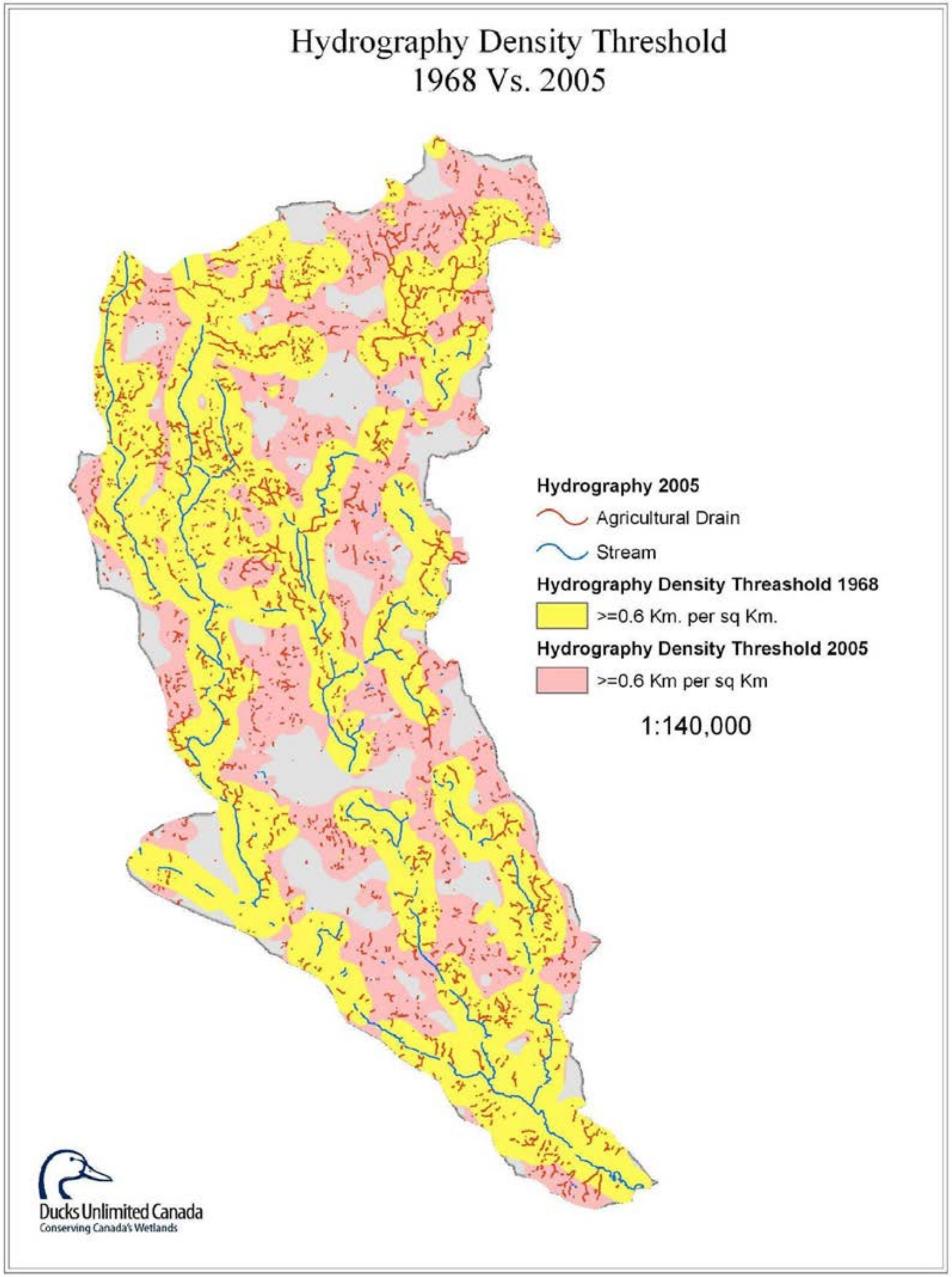
1968

2005

21% reduction in wetland area

69% of wetland basins have been lost or degraded





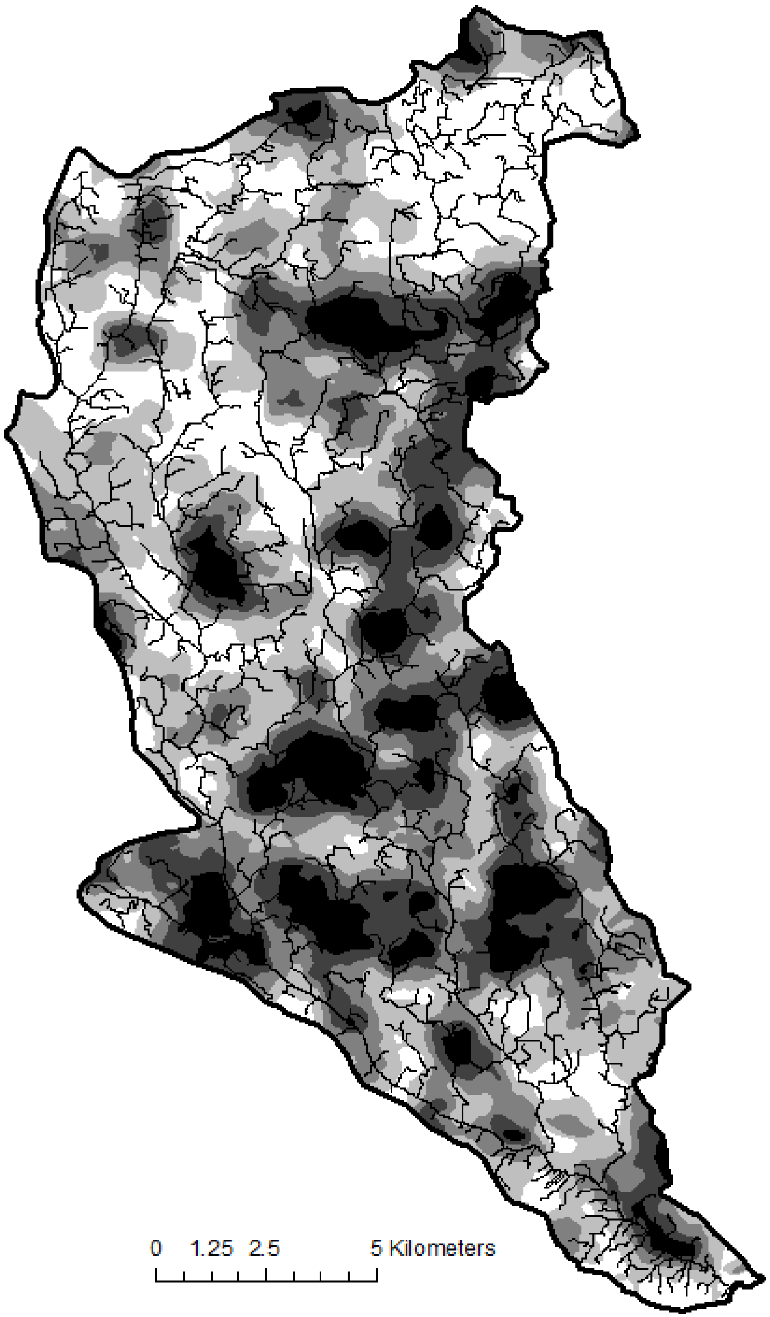
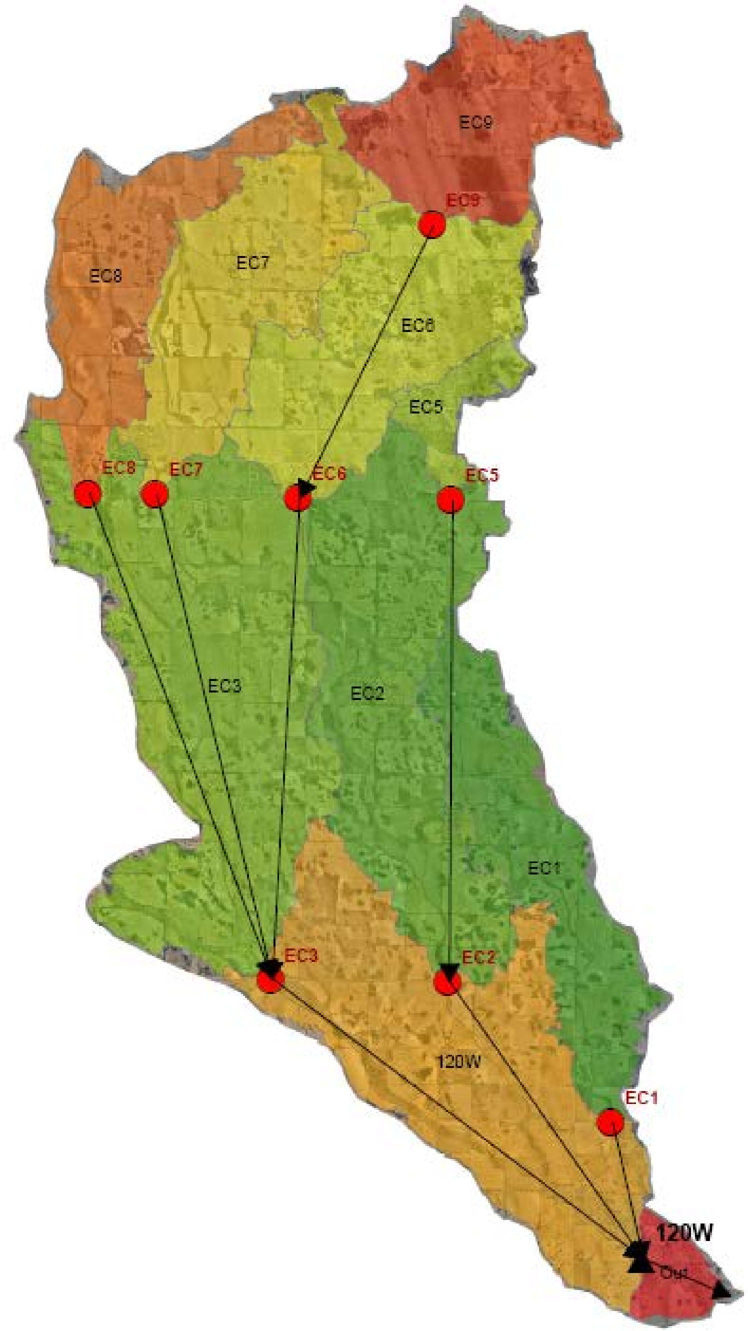
Contributing area increased from 14,668ha (1968) to 22,507ha (2005), an increase of over 53.4%

Ducks Unlimited Canada
Conserving Canada's Wetlands

RESCUE OUR WETLANDS
WATER—WILDLIFE—YOU

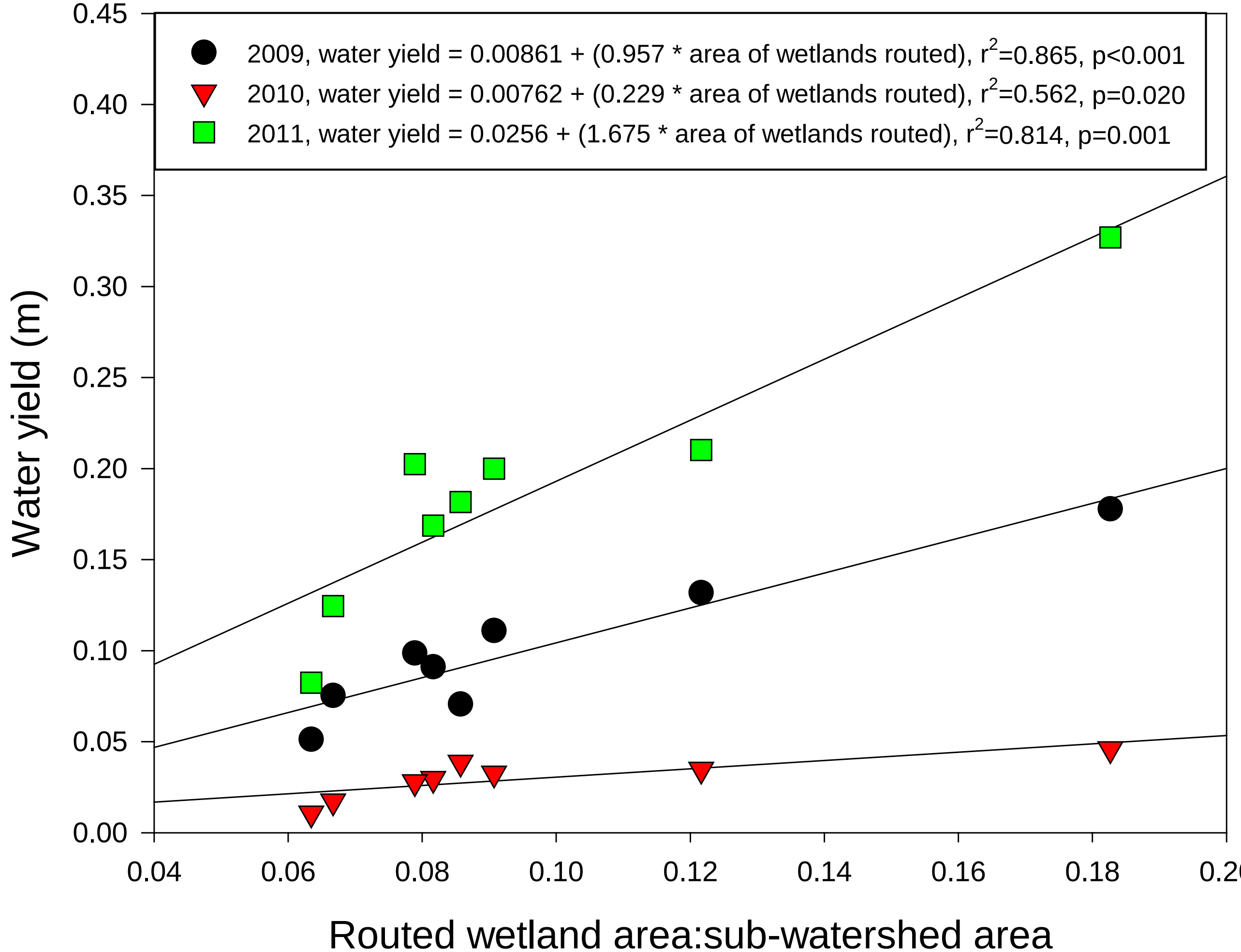
Data Requirements/ Methods

- Detailed Wetland Inventory/ Change detection analysis.
- LiDAR (segment watersheds into sub-basins spanning a gradient of drainage and wetland cover.
- Detailed discharge measurements across sub-basins.
- Detailed water chemistry across sub-basins.


0
1.25
2.5
5 Kilometers

EC9
EC9
EC8
EC7
EC6
EC5
EC8
EC7
EC6
EC5
EC3
EC2
EC1
EC3
EC2
120W
EC1
120W
Out

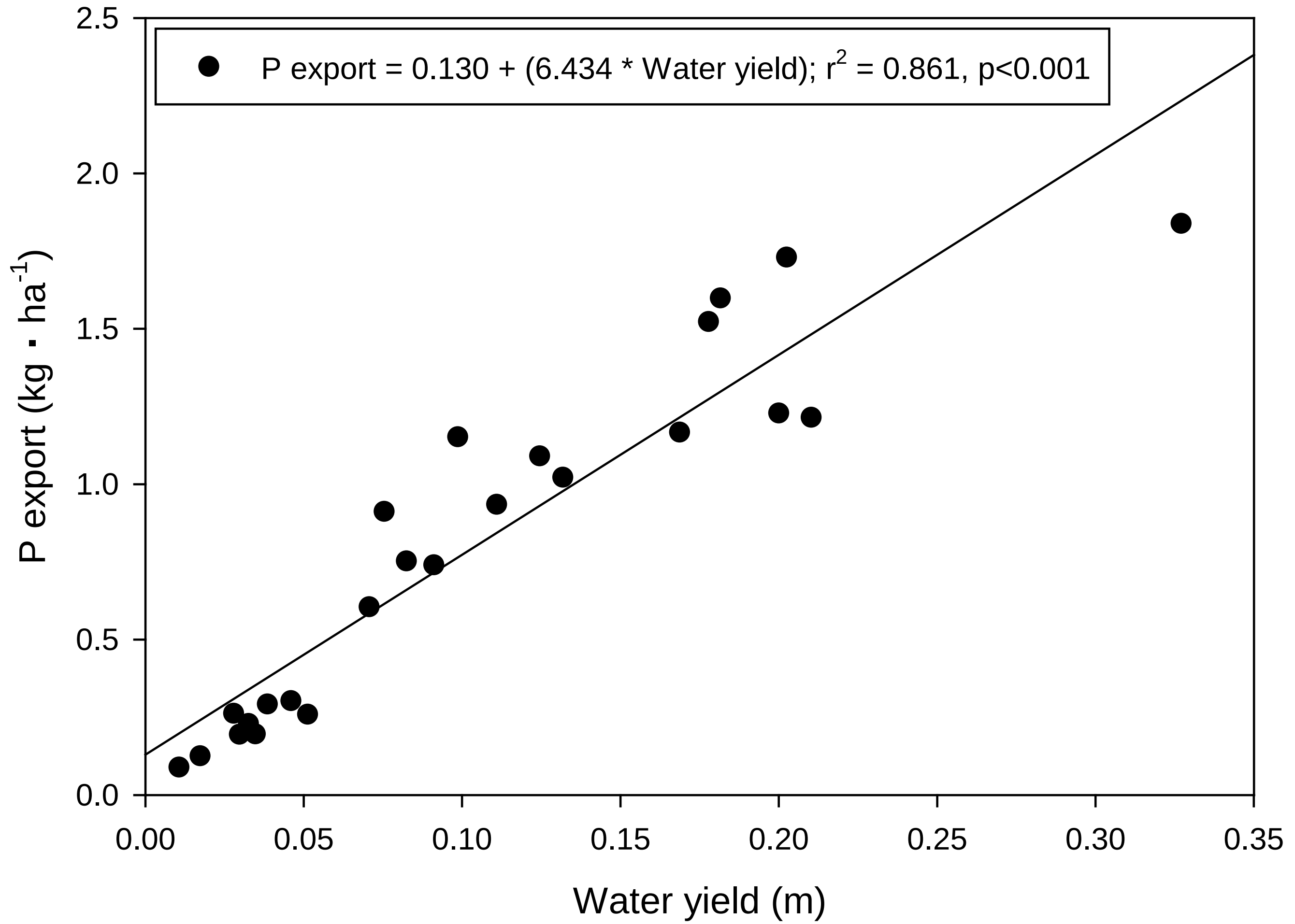
Combining Wetland and Drainage Metrics with Flow and Water Quality

- As wetland drainage increases, runoff increases regardless of event size
- This demonstrates the need to account for wetland drainage, storage, as well as changes to contributing area

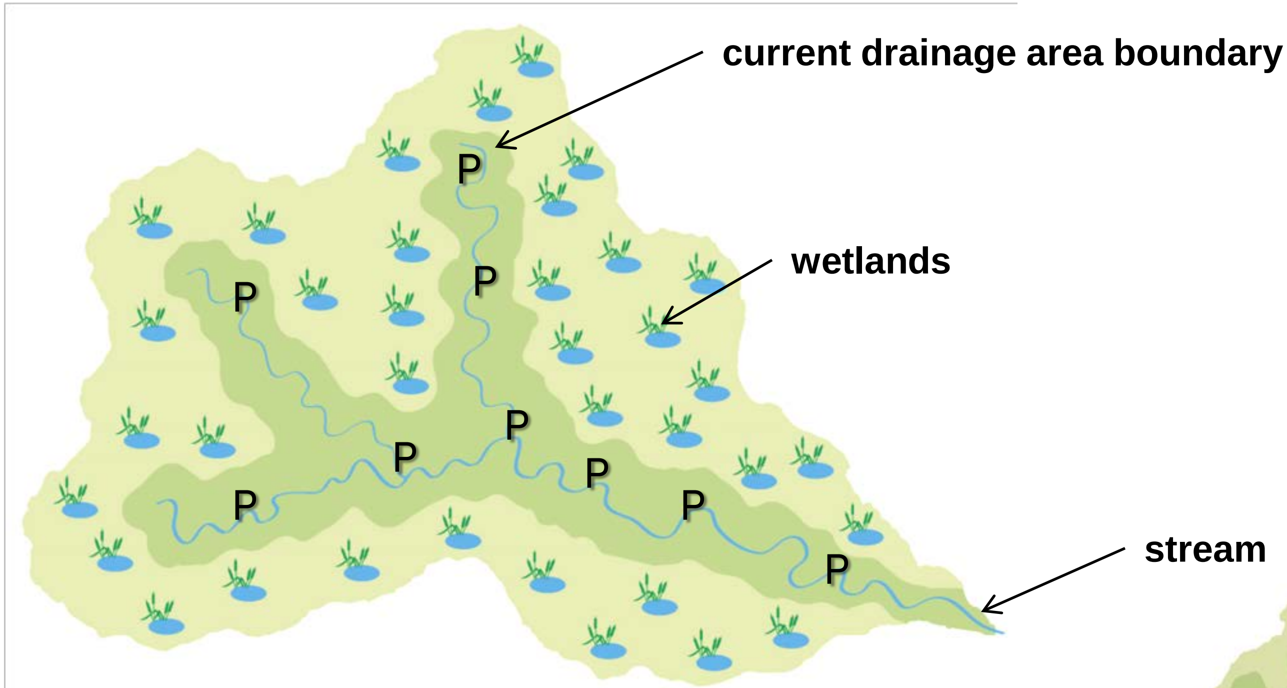


Combining Wetland and Drainage Metrics with Flow and Water Quality

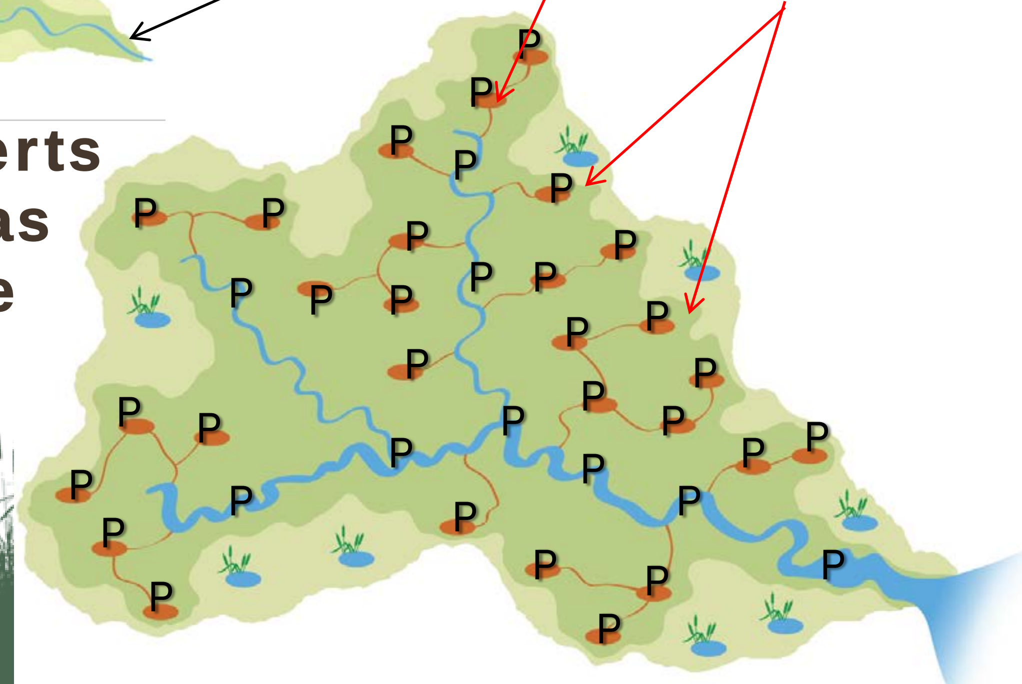
- More drained wetland greater water yield.
- Greater water yield, greater P export
- Therefore wetland drainage increases P export at the watershed scale



Ducks Unlimited Canada
Conserving Canada's Wetlands
RESCUE OUR WETLANDS
WATER—WILDLIFE—YOU



Wetland drainage converts areas that were acting as P sinks to critical source areas for P export



Ducks Unlimited Canada
Conserving Canada's Wetlands

RESCUE OUR WETLANDS
WATER—WILDLIFE—YOU

Conclusions

- Wetland loss has had a dramatic effect on water quality and quantity across the Canadian prairies.

- If wetland loss is allowed to continue, it will exacerbate non-point source pollution in the Canadian prairies.

- We need to find a balance between the desire to increase agricultural productivity and wetland conservation.

Ducks Unlimited Canada
Conserving Canada's Wetlands

RESCUE OUR WETLANDS
WATER—WILDLIFE—YOU

Souris River Watershed Wetland Inventory and Change Detection:

Estimating the effects of wetland distribution and loss on water quality and quantity in a large prairie watershed

Pascal Badiou, Bryan Page, and Johann Walker
Ducks Unlimited Canada & Ducks Unlimited Inc.

Ducks Unlimited Canada
Conserving Canada's Wetlands

YEARS OF CONSERVATION EXCELLENCE

Project Goal

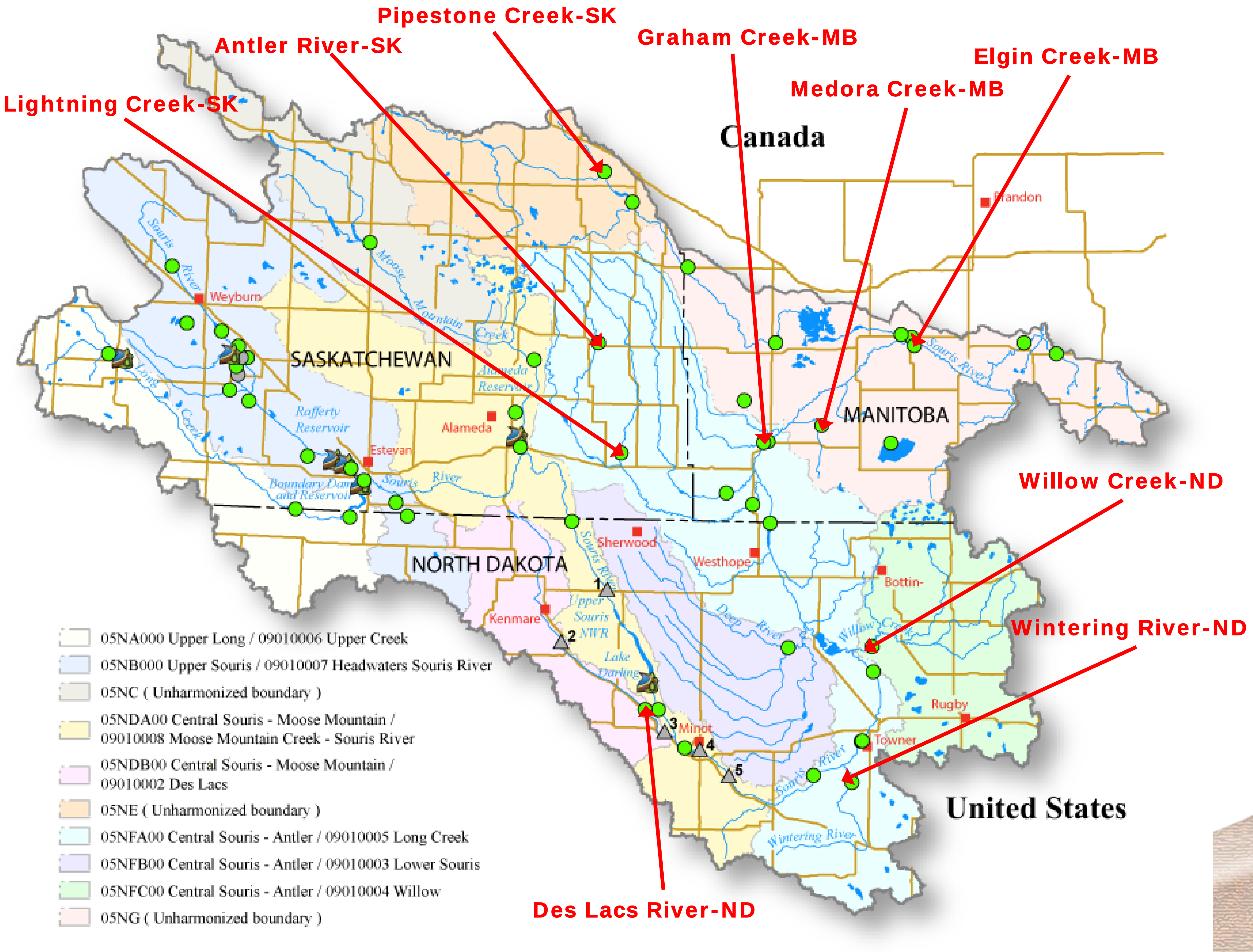
- To determine the role of wetlands in mitigating nutrient export in a large hyper-eutrophic prairie watershed and to generate the necessary information to develop a methodology for targeting wetland restoration and conservation efforts in the PPR.

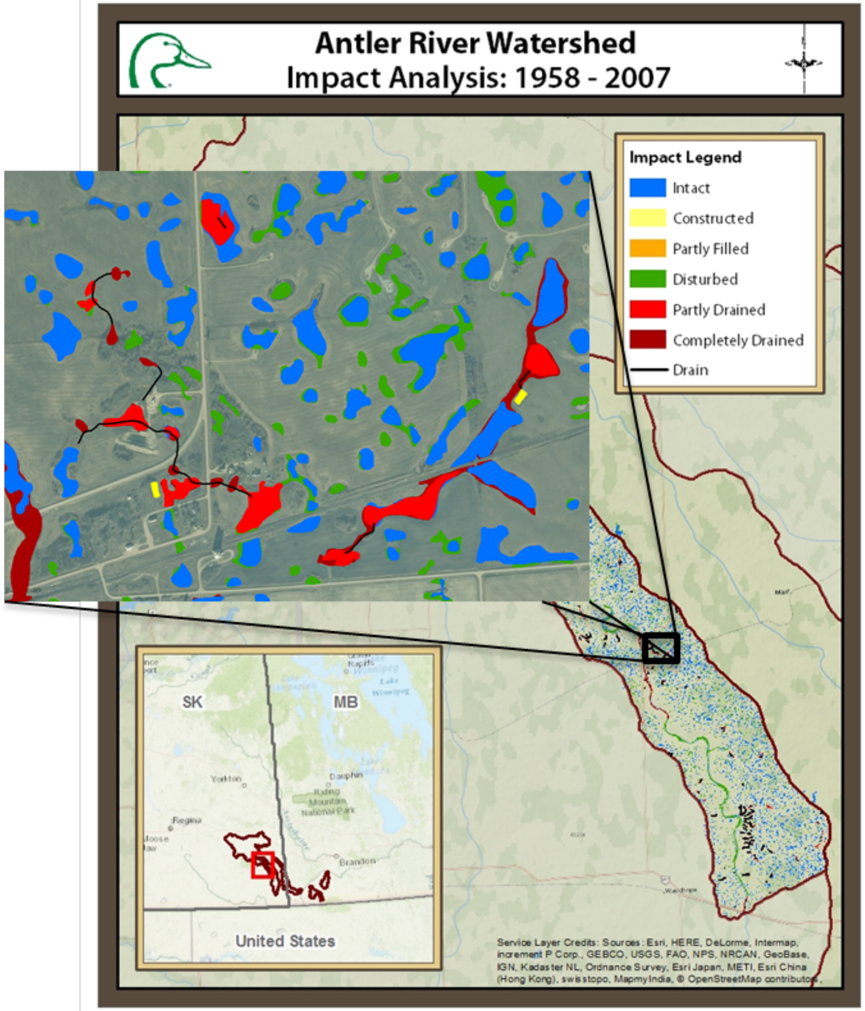
Project Objectives

- Complete and harmonize a wetland inventory for the entire Souris River watershed.
- Conduct a change detection analysis in 9 sub-watersheds of the Souris River watershed.
- Determine the relationship between current water quality and landscape wetland metric such as wetland area intact, wetland area lost, wetland storage intact, and wetland storage lost.
- Develop a methodology to target wetland conservation and restoration efforts to maximize water quality benefits.

Ducks Unlimited Canada
Conserving Canada's Wetlands

RESCUE OUR WETLANDS
WATER—WILDLIFE—YOU


Pipestone Creek-SK
Antler River-SK
Graham Creek-MB
Elgin Creek-MB
Medora Creek-MB
Lightning Creek-SK
Canada
Brandon
Weyburn
SASKATCHEWAN
MANITOBA
Alameda
Estevan
Rafferty Reservoir
Alameda Reservoir
Boundary Dam and Reservoir
Souris River
Moose Mountain Creek
Long Creek
Willow Creek-ND
Wintering River-ND
NORTH DAKOTA
Sherwood
Westhope
Bottin-
Kenmare
Upper Souris NWR
Lake Darling
Minot
Towner
Rugby
Deep River
Willow Creek
Wintering River
United States
Des Lacs River-ND
05NA000 Upper Long / 09010006 Upper Creek
05NB000 Upper Souris / 09010007 Headwaters Souris River
05NC (Unharmonized boundary)
05NDA00 Central Souris - Moose Mountain / 09010008 Moose Mountain Creek - Souris River
05NDB00 Central Souris - Moose Mountain / 09010002 Des Lacs
05NE (Unharmonized boundary)
05NFA00 Central Souris - Antler / 09010005 Long Creek
05NFB00 Central Souris - Antler / 09010003 Lower Souris
05NFC00 Central Souris - Antler / 09010004 Willow
05NG (Unharmonized boundary)



Antler River	
Impact	**Hectares**
None	3,437
Constructed	11
Partly Filled	0
Disturbed	1,078
Partly Drained	556
Completely Drained	157

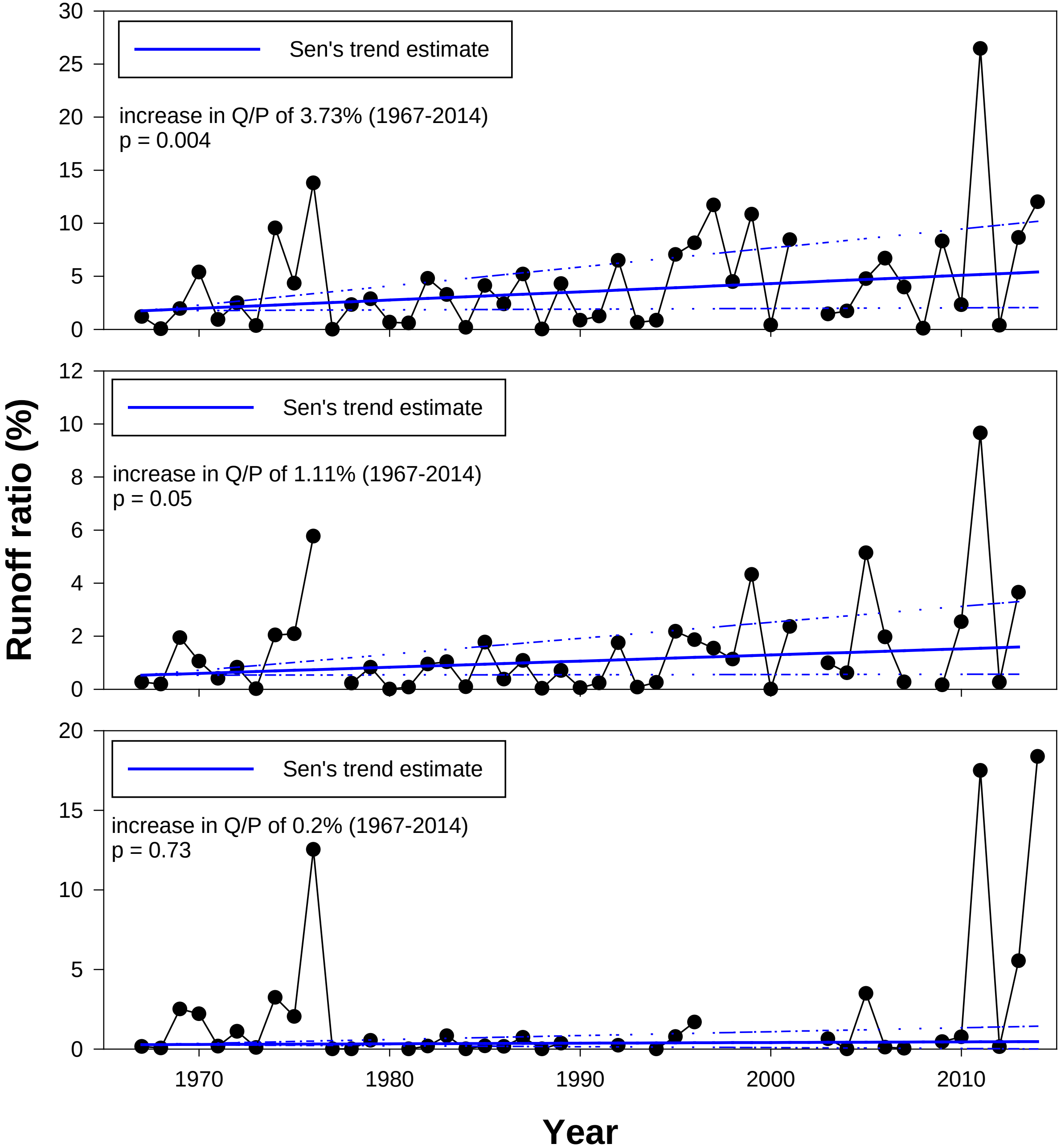
Graham Creek	
Impact	**Hectares**
None	7,008
Constructed	22
Partly Filled	0
Disturbed	1,473
Partly Drained	665
Completely Drained	184

Lightning Creek	
Impact	**Hectares**
None	6,445
Constructed	36
Partly Filled	0
Disturbed	2,902
Partly Drained	556
Completely Drained	598

Medora Creek	
Impact	**Hectares**
None	2,098
Constructed	24
Partly Filled	0
Disturbed	138
Partly Drained	540
Completely Drained	108

Pipestone Creek	
Impact	**Hectares**
None	26,440
Constructed	62
Partly Filled	0
Disturbed	8,360
Partly Drained	1,605
Completely Drained	2,234

Elgin Creek	
Impact	**Hectares**
None	1,533
Constructed	6
Partly Filled	0
Disturbed	160
Partly Drained	776
Completely Drained	197



Elgin Creek

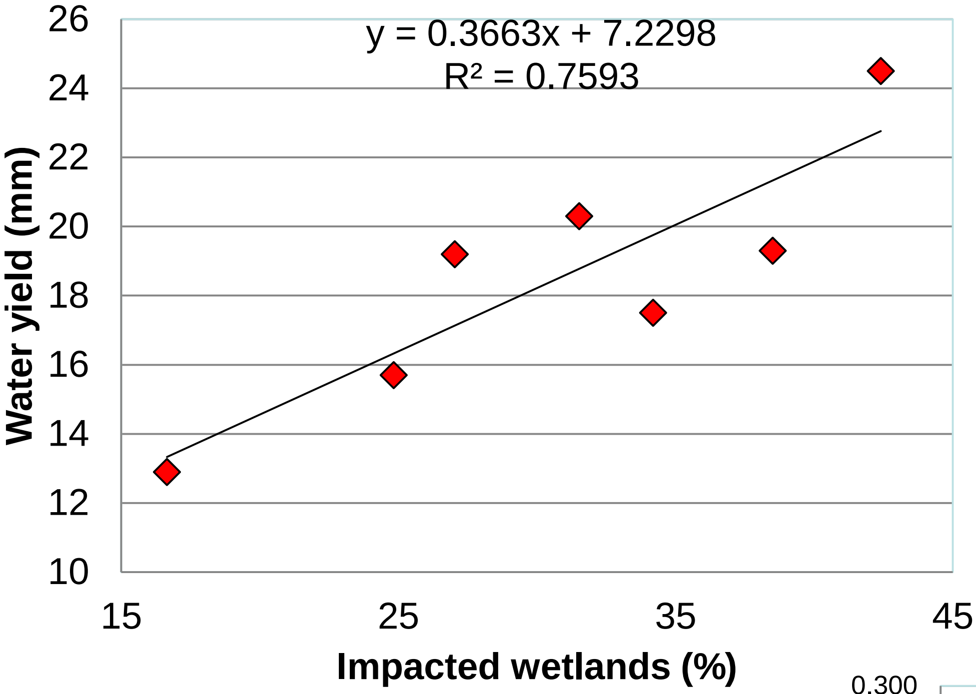
- 500 km^2
- Wetland cover ~ 3% (5%)
- Ratio of intact:drained = 1.6

Medora Creek

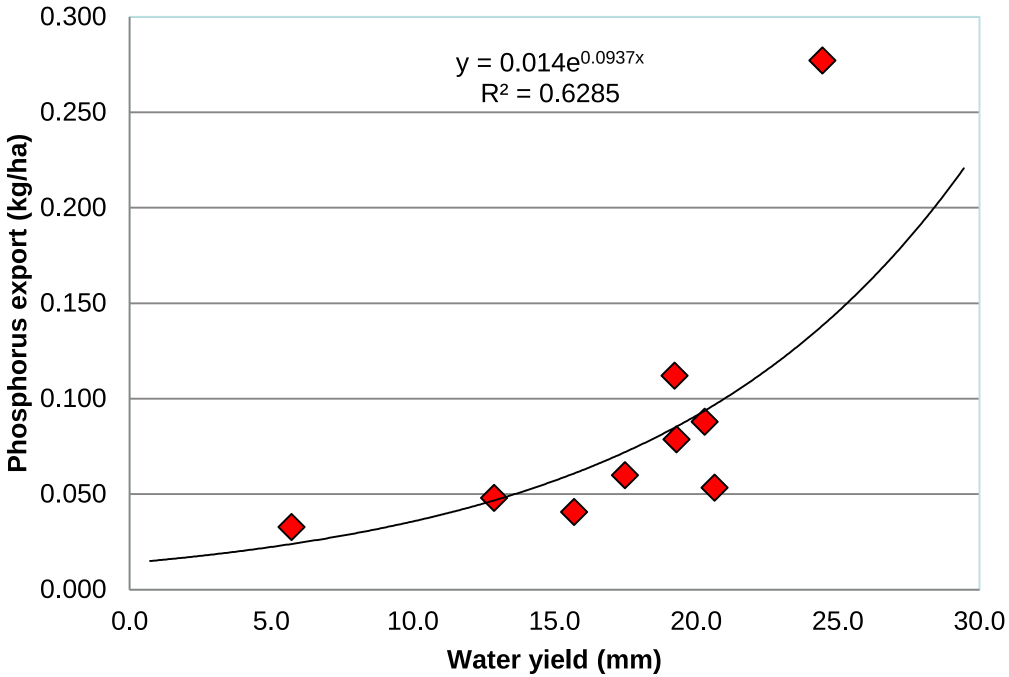
- 1,025 km^2
- Wetland cover ~ 2% (3%)
- Ratio of intact:drained = 3.2

Graham Creek

- 741 km^2
- Wetland cover ~ 10% (13%)
- Ratio of intact:drained = 8.3



y = 0.3663x + 7.2298
R² = 0.7593
Water yield (mm)
26
24
22
20
18
16
14
12
10
15
25
35
45
Impacted wetlands (%)



y = 0.014e0.0937x
R² = 0.6285
Phosphorus export (kg/ha)
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.0
5.0
10.0
15.0
20.0
25.0
30.0
Water yield (mm)

Thank you

Ducks Unlimited Canada
Conserving Canada's Wetlands

RESCUE OUR WETLANDS
WATER—WILDLIFE—YOU