Prairie Pothole Region Assessment

Impact of U.S. Department of Interior and U.S. Department of Agriculture Programs on Ecological Services Derived from Restored Prairie Wetlands and Adjacent Grasslands

U.S. Department of the Interior
U.S. Geological Survey

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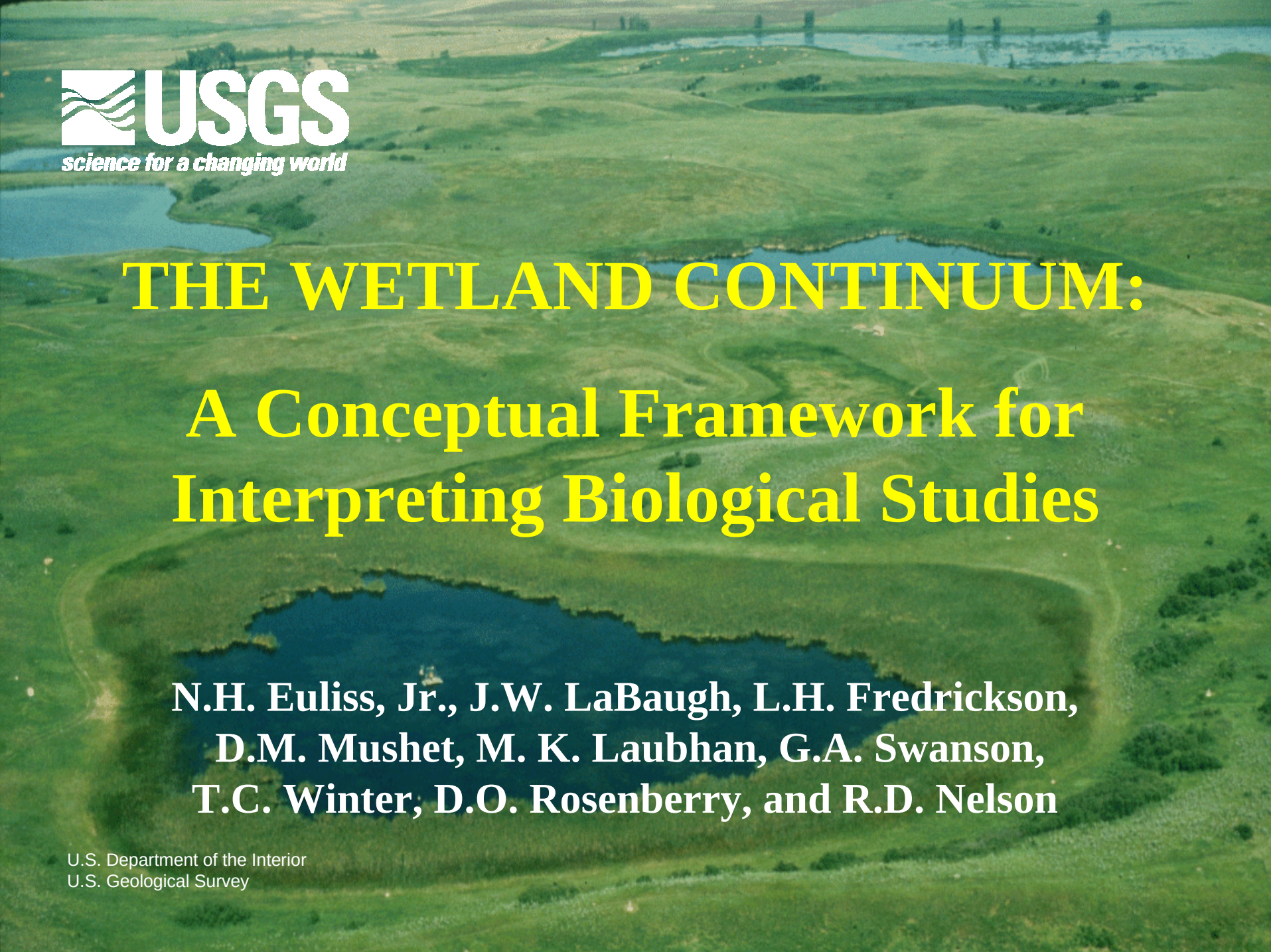

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THE WETLAND CONTINUUM:

A Conceptual Framework for Interpreting Biological Studies

N.H. Euliss, Jr., J.W. LaBaugh, L.H. Fredrickson, D.M. Mushet, M. K. Laubhan, G.A. Swanson, T.C. Winter, D.O. Rosenberry, and R.D. Nelson

U.S. Department of the Interior
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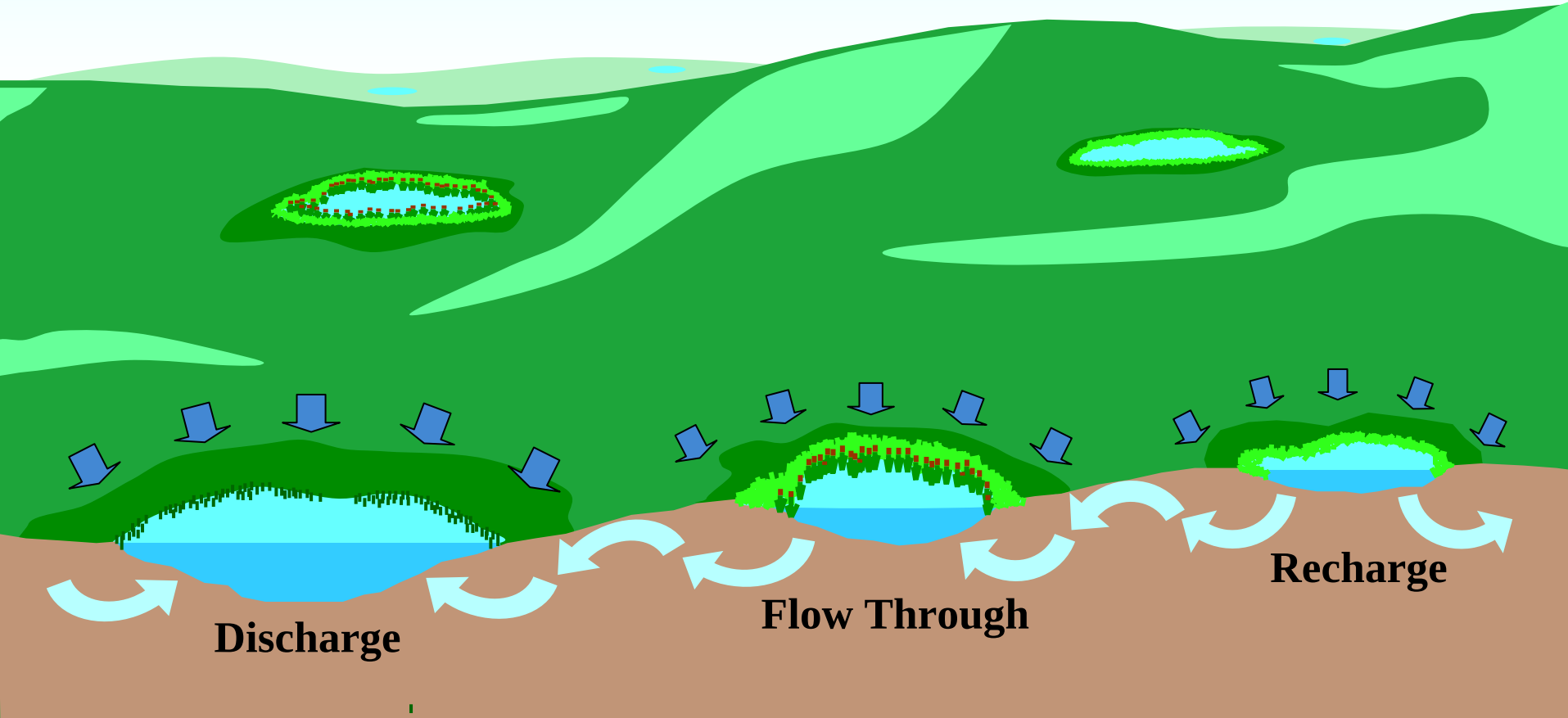
Wetland Hydrological Functions



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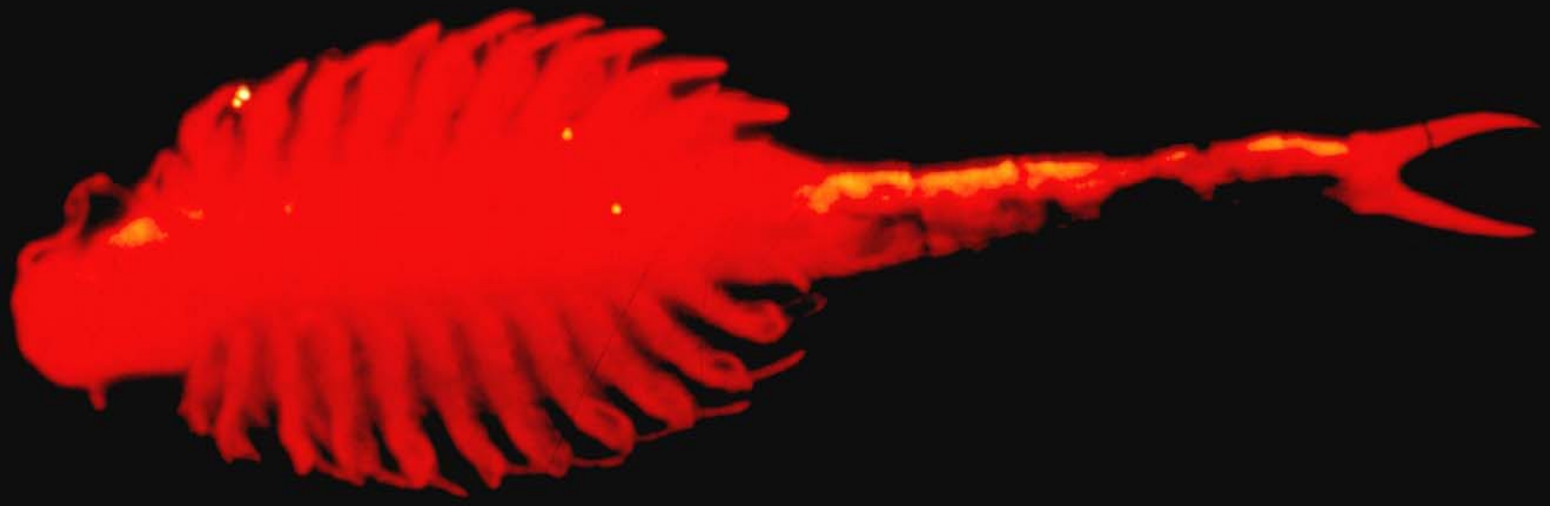

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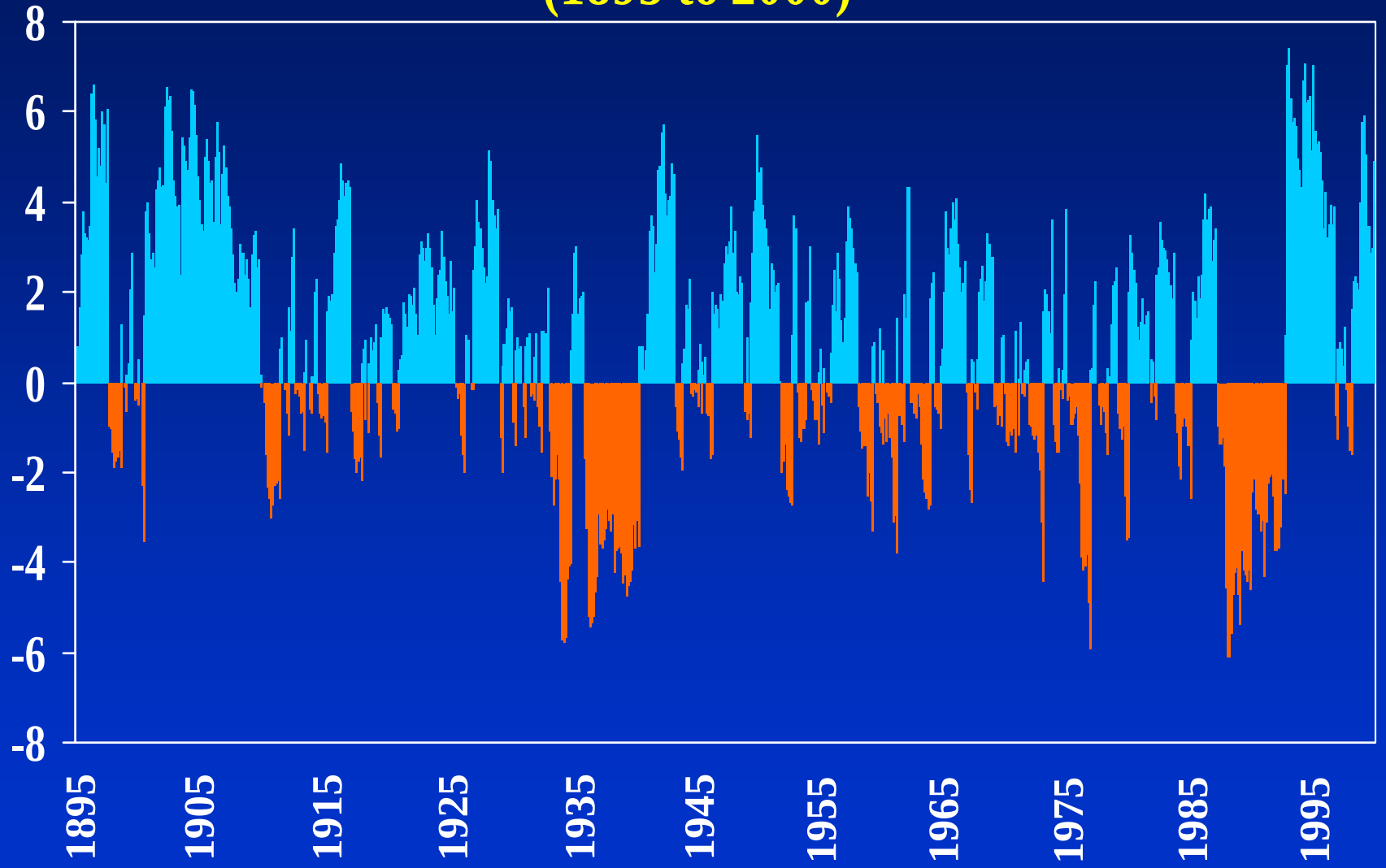
Palmer Drought Severity Index, Division 5, ND
(1895 to 2000)



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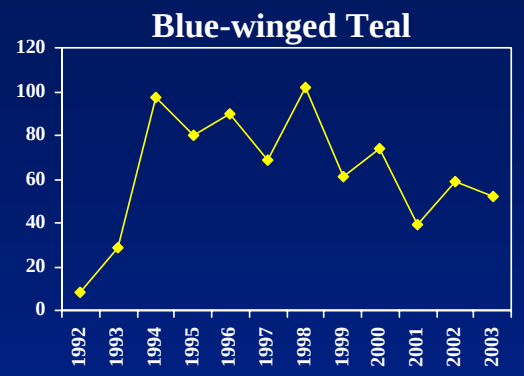
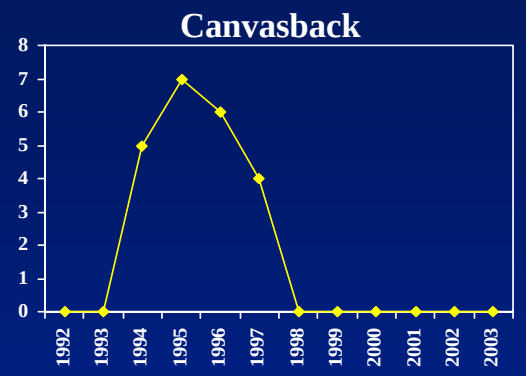
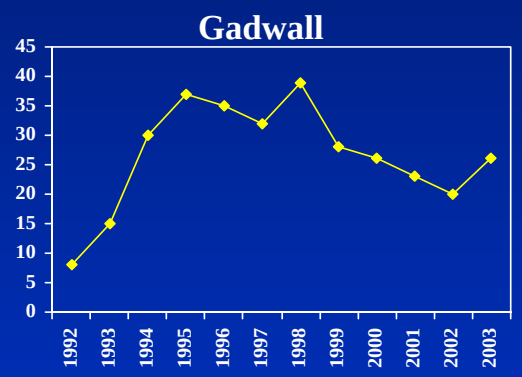
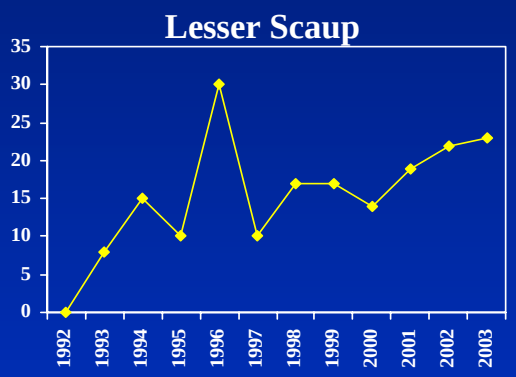
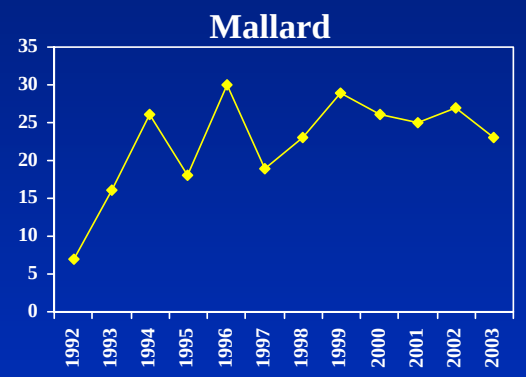
Breeding Waterfowl Pairs at the Cottonwood Lake Study Area, 1992-2003

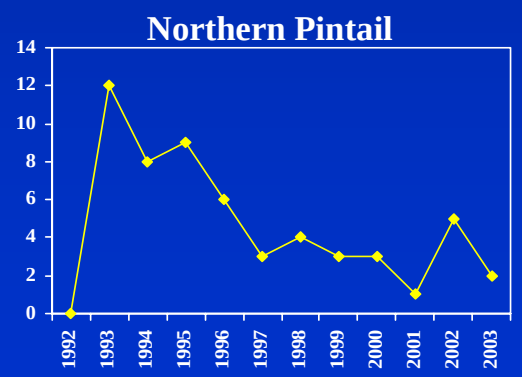


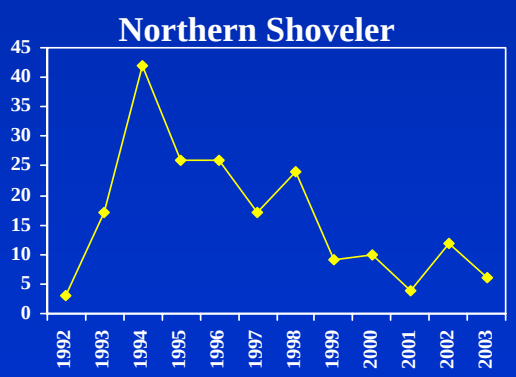


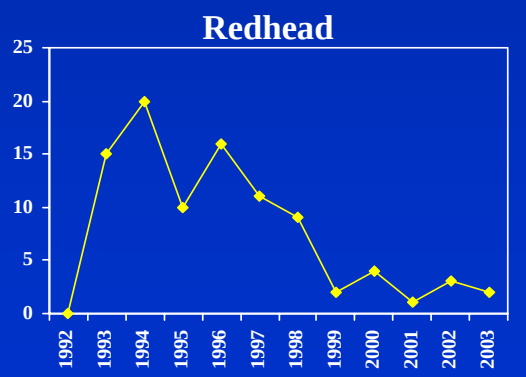












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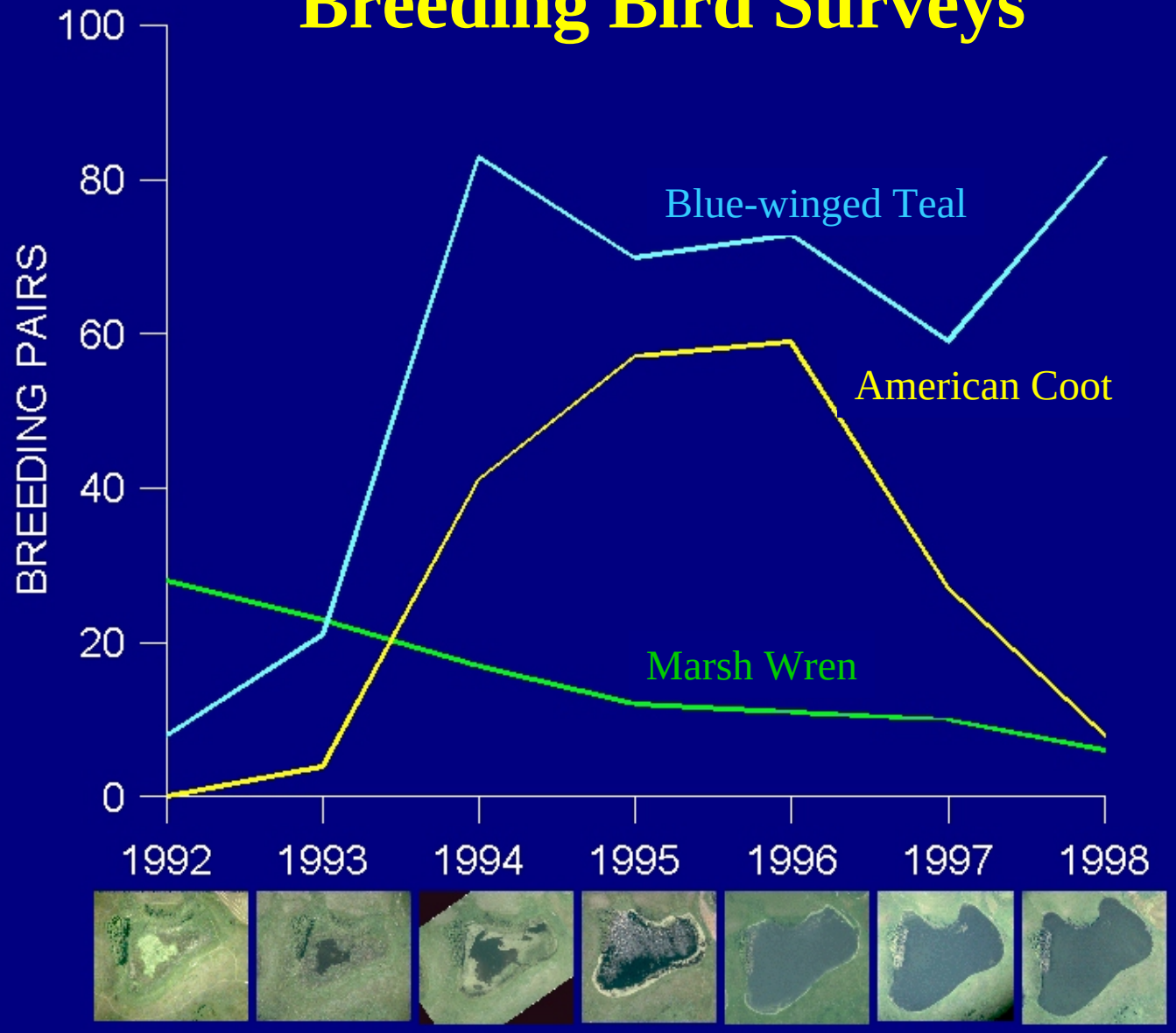
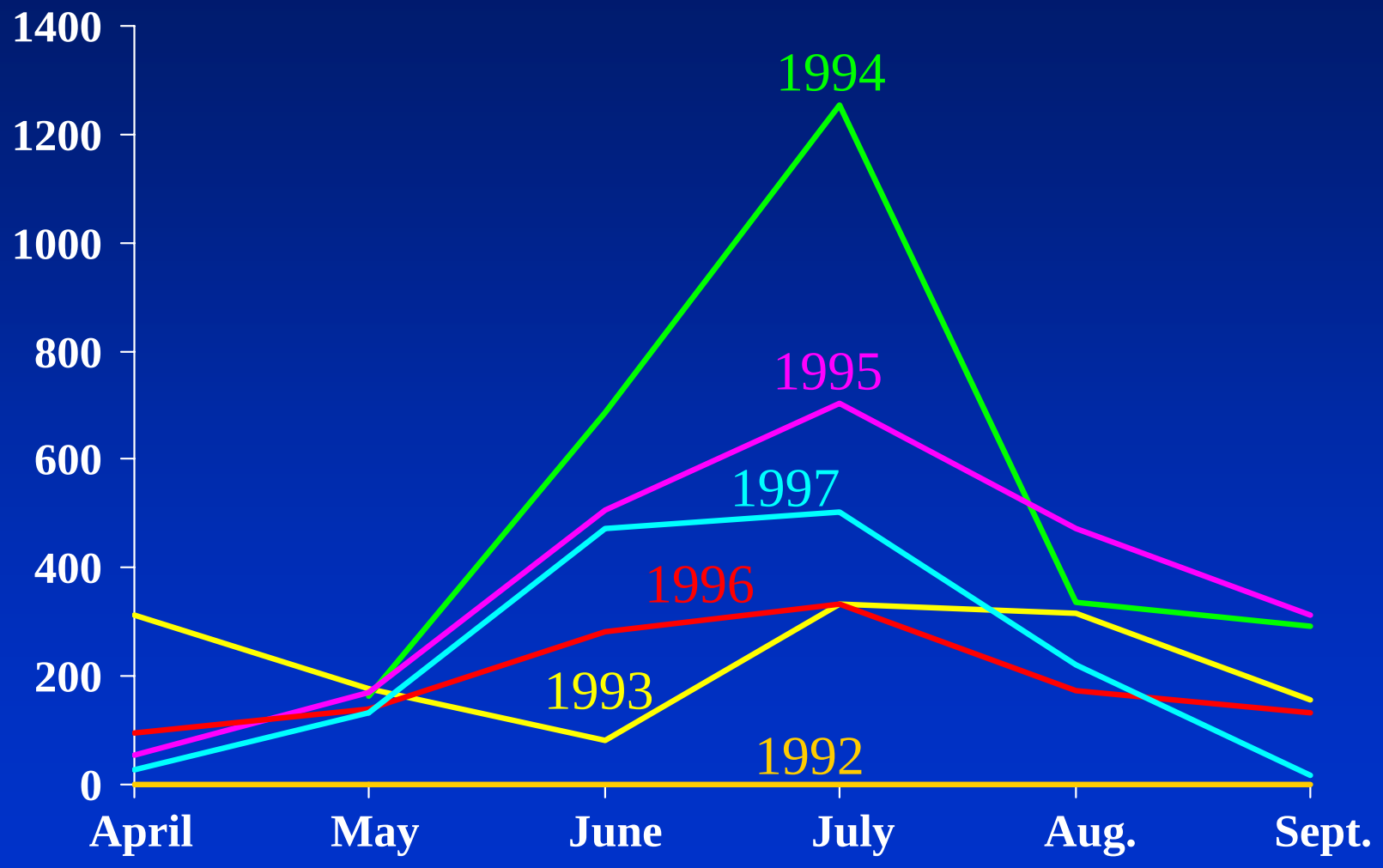
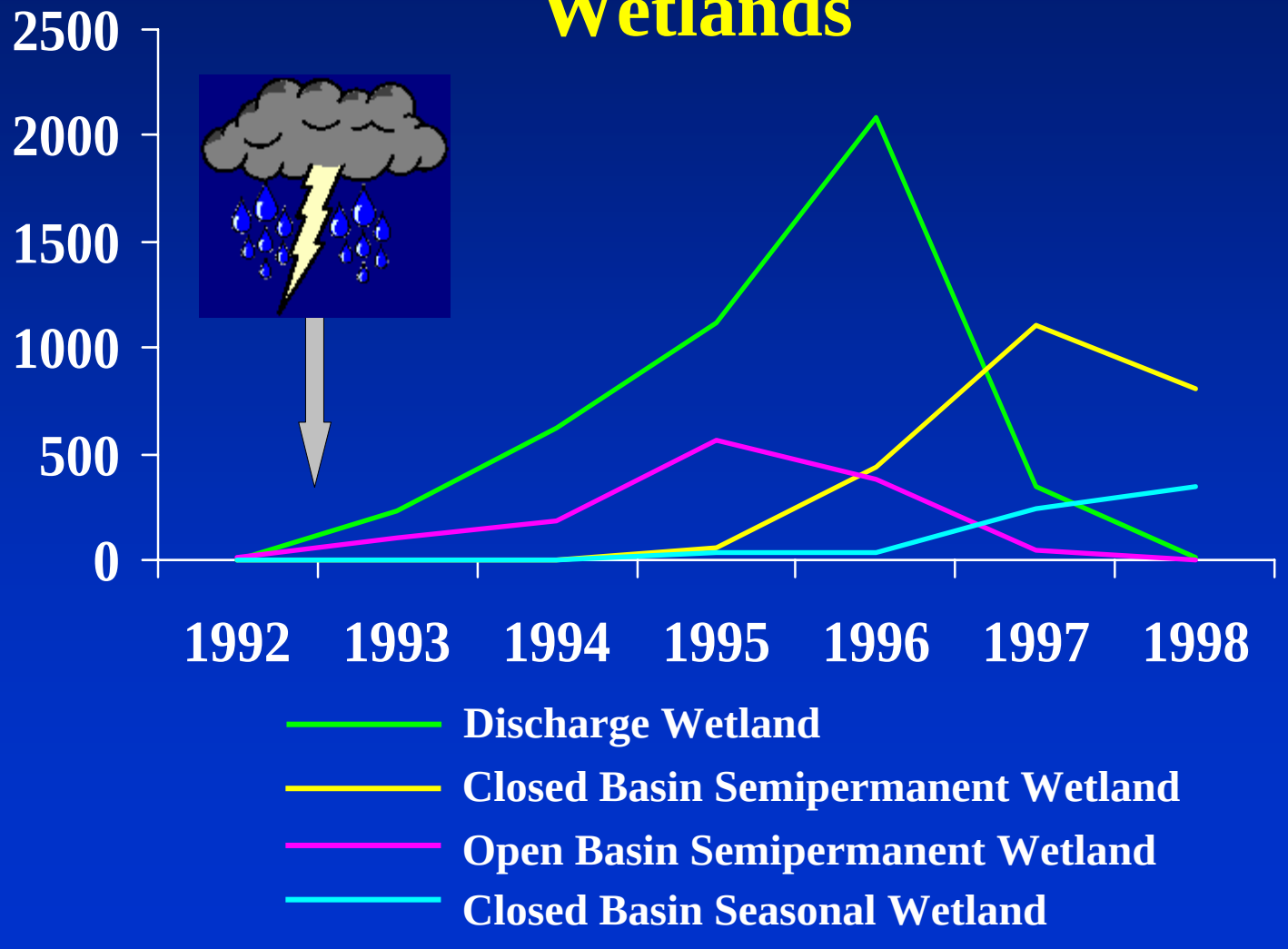
Breeding Bird Surveys



Invertebrate Biomass (grams x 100)



Tiger Salamander Captures in Cottonwood Lake Study Area Wetlands



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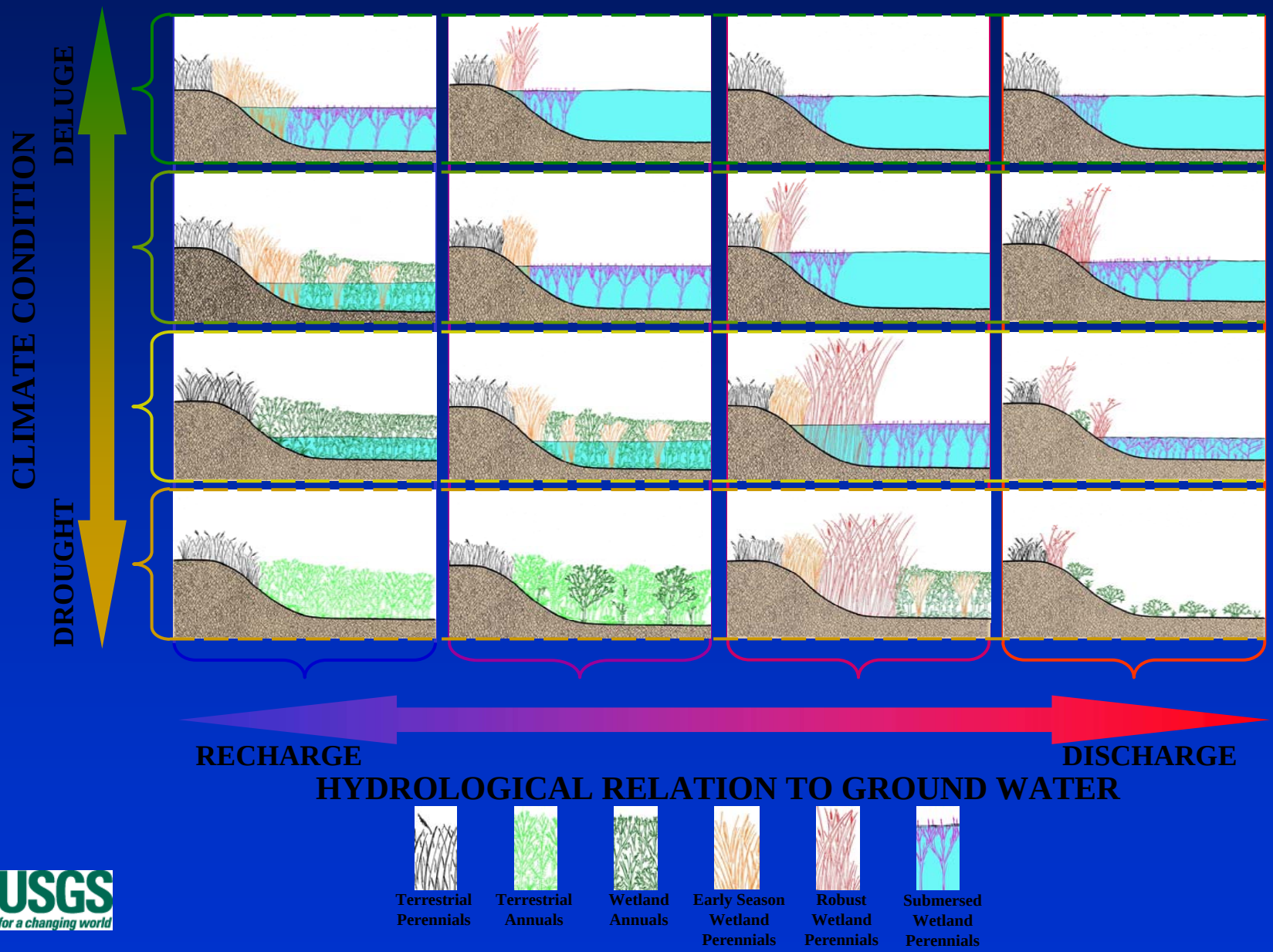
THE WETLAND CONTINUUM



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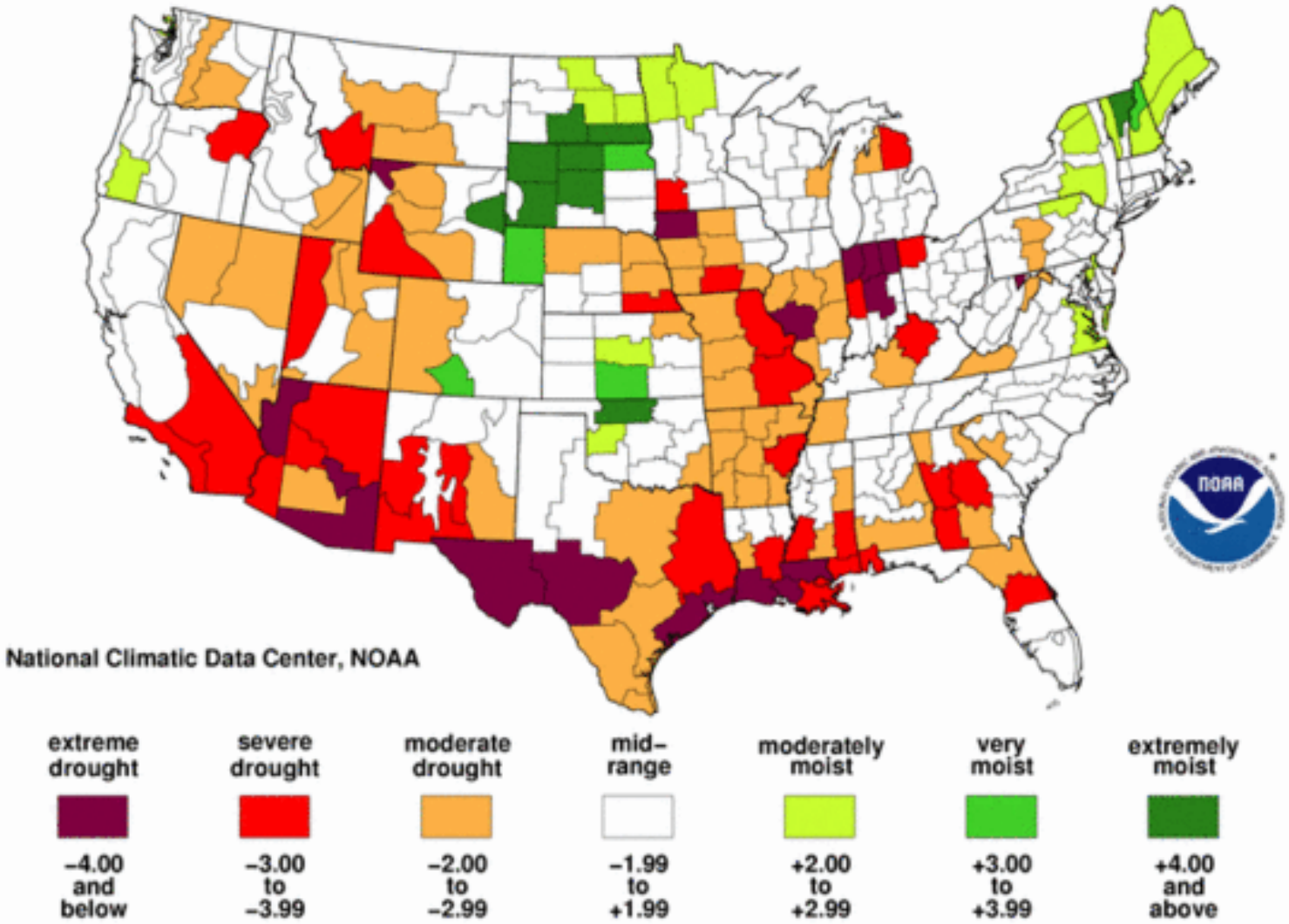
Palmer Drought Severity Index
April, 2000



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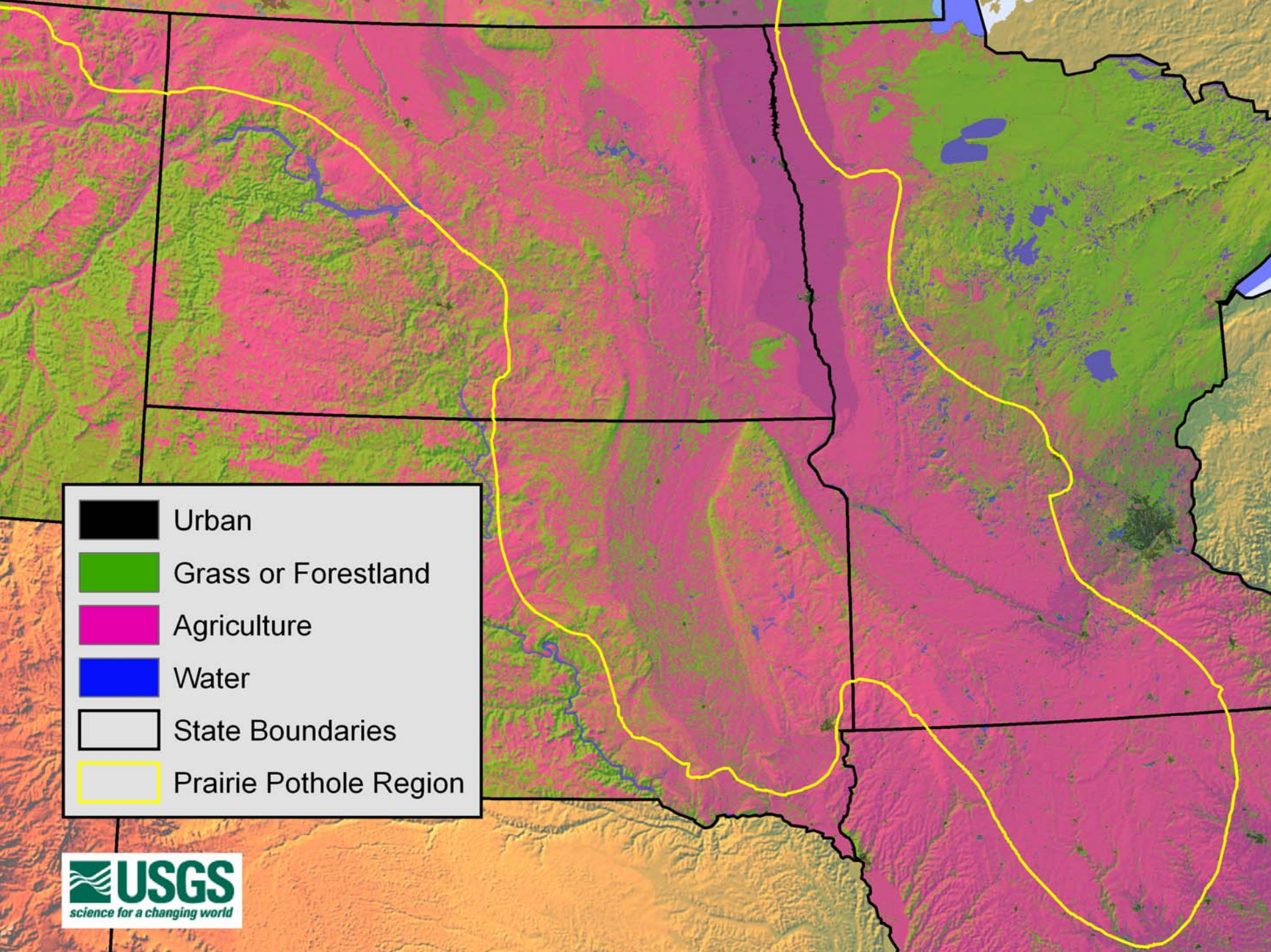
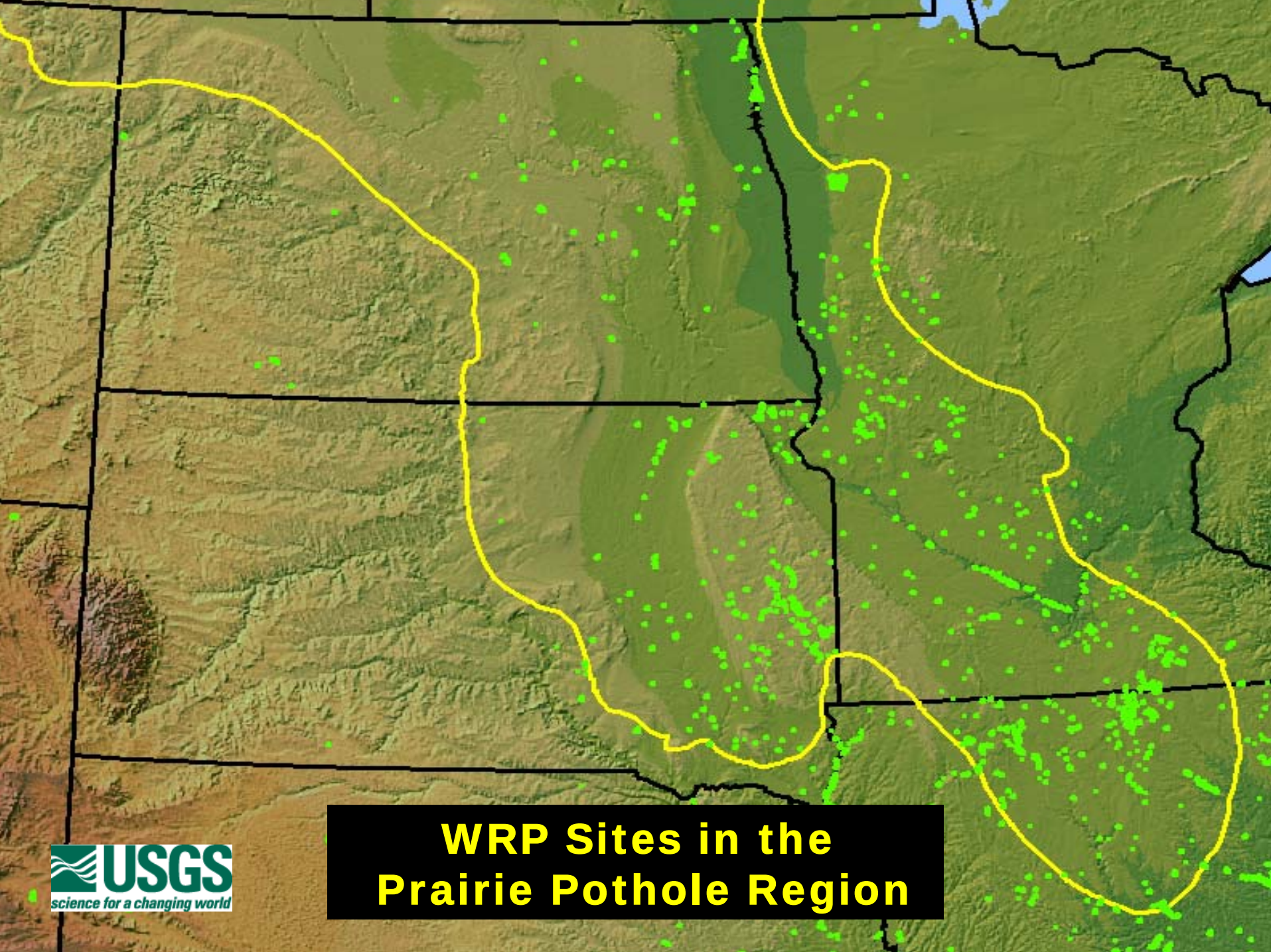

Urban
Grass or Forestland
Agriculture
Water
State Boundaries
Prairie Pothole Region
USGS
science for a changing world


WRP Sites in the
Prairie Pothole Region
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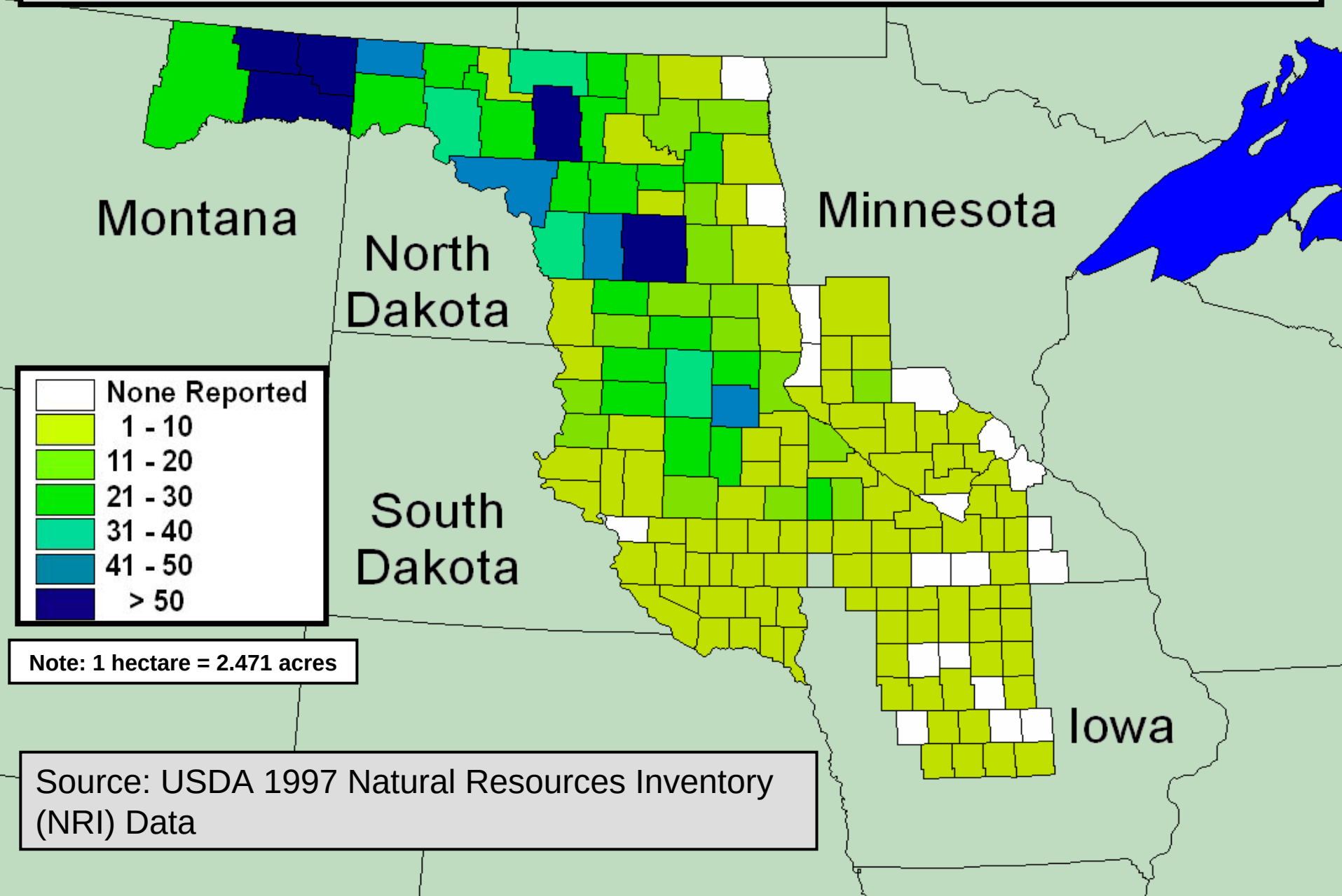
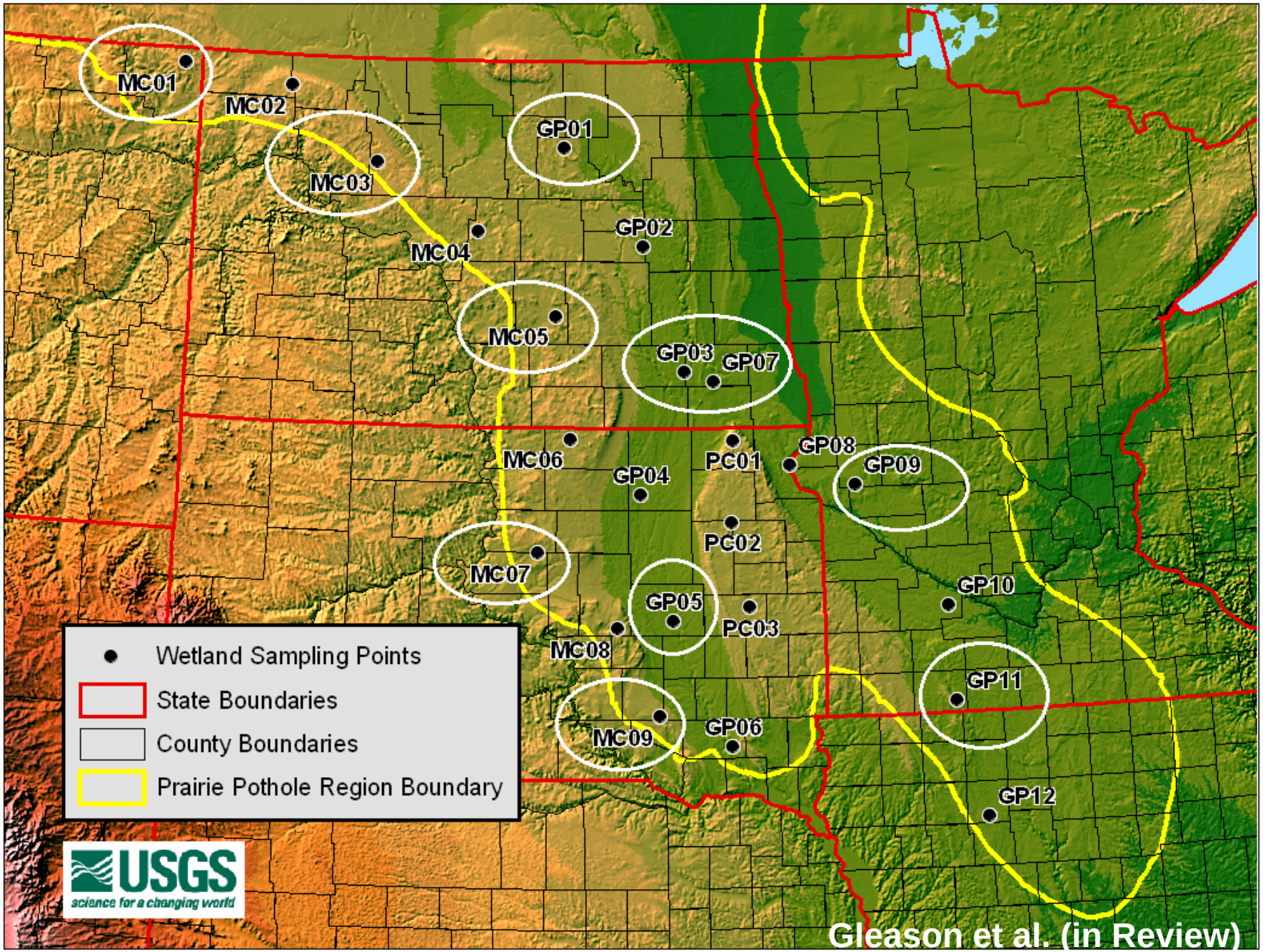
Hectares (in 1,000s) of CRP by County in the PPR

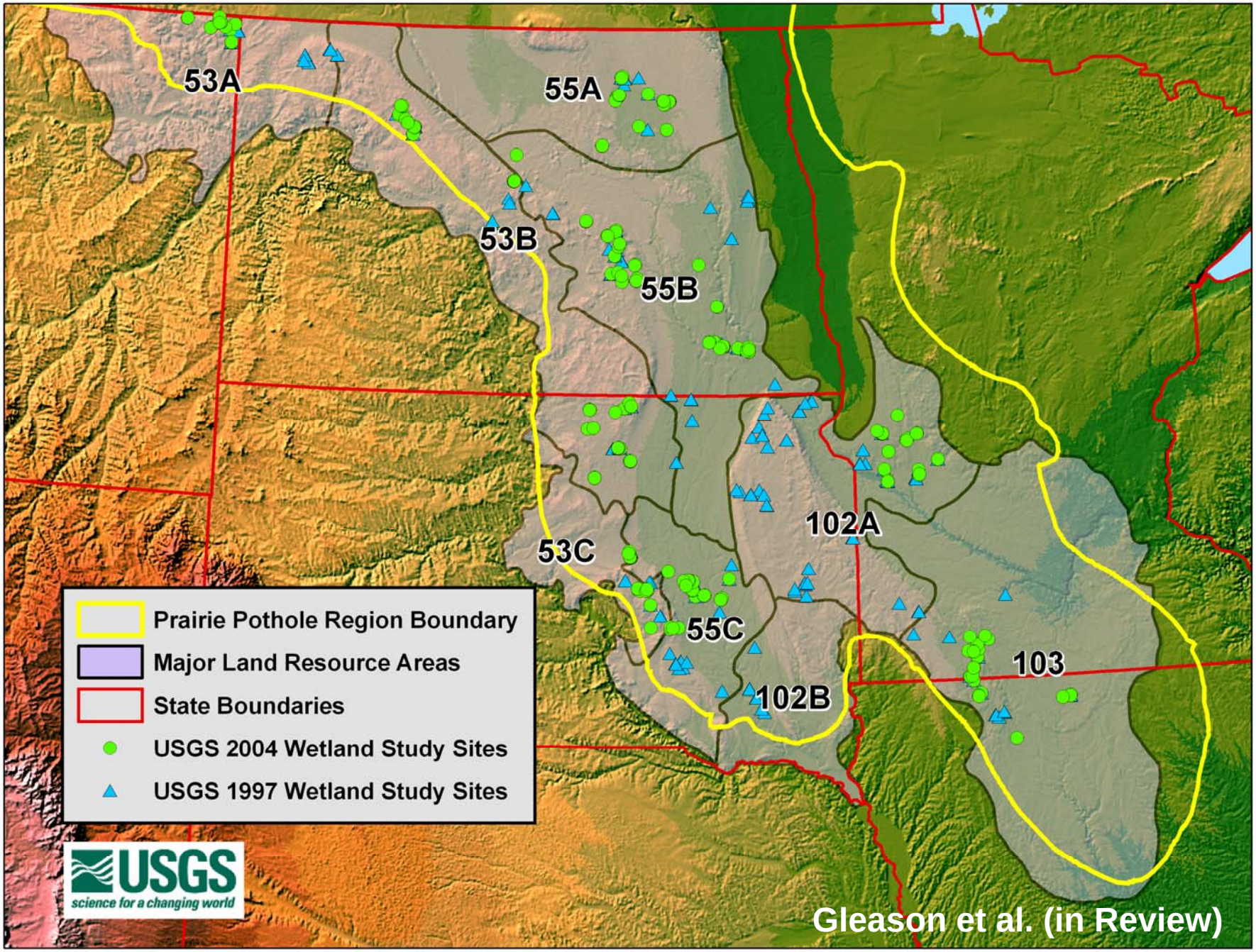


Note: 1 hectare = 2.471 acres

Source: USDA 1997 Natural Resources Inventory (NRI) Data



Gleason et al. (in Review)


53A
55A
53B
55B
53C
55C
102A
102B
103
Prairie Pothole Region Boundary
Major Land Resource Areas
State Boundaries
USGS 2004 Wetland Study Sites
USGS 1997 Wetland Study Sites
USGS
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Gleason et al. (in Review)

Highly Altered **Relatively Unaltered**

Condition Gradient

Drained Cropland

Nondrained Cropland

Hydrologically Restored

Nondrained Restored

Native

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	CRP or WRP Lands								
	Hydrologic restoration			Nondrained restoration					
	Years restored			Years restored			Croplands		Native Prairie
Region Wetland Class	1<5	5<10	>10	1<5	5<10	>10	Drained	Nondrained	Reference
Missouri Coteau									
Temporary	5	5	5	5	5	5	5	5	5
Seasonal	5	5	5	5	5	5	5	5	5
Semipermanent	5	5	5	5	5	5	5	5	5
Glaciated Plains									
Temporary	5	5	5	5	5	5	5	5	5
Seasonal	5	5	5	5	5	5	5	5	5
Semipermanent	5	5	5	5	5	5	5	5	5

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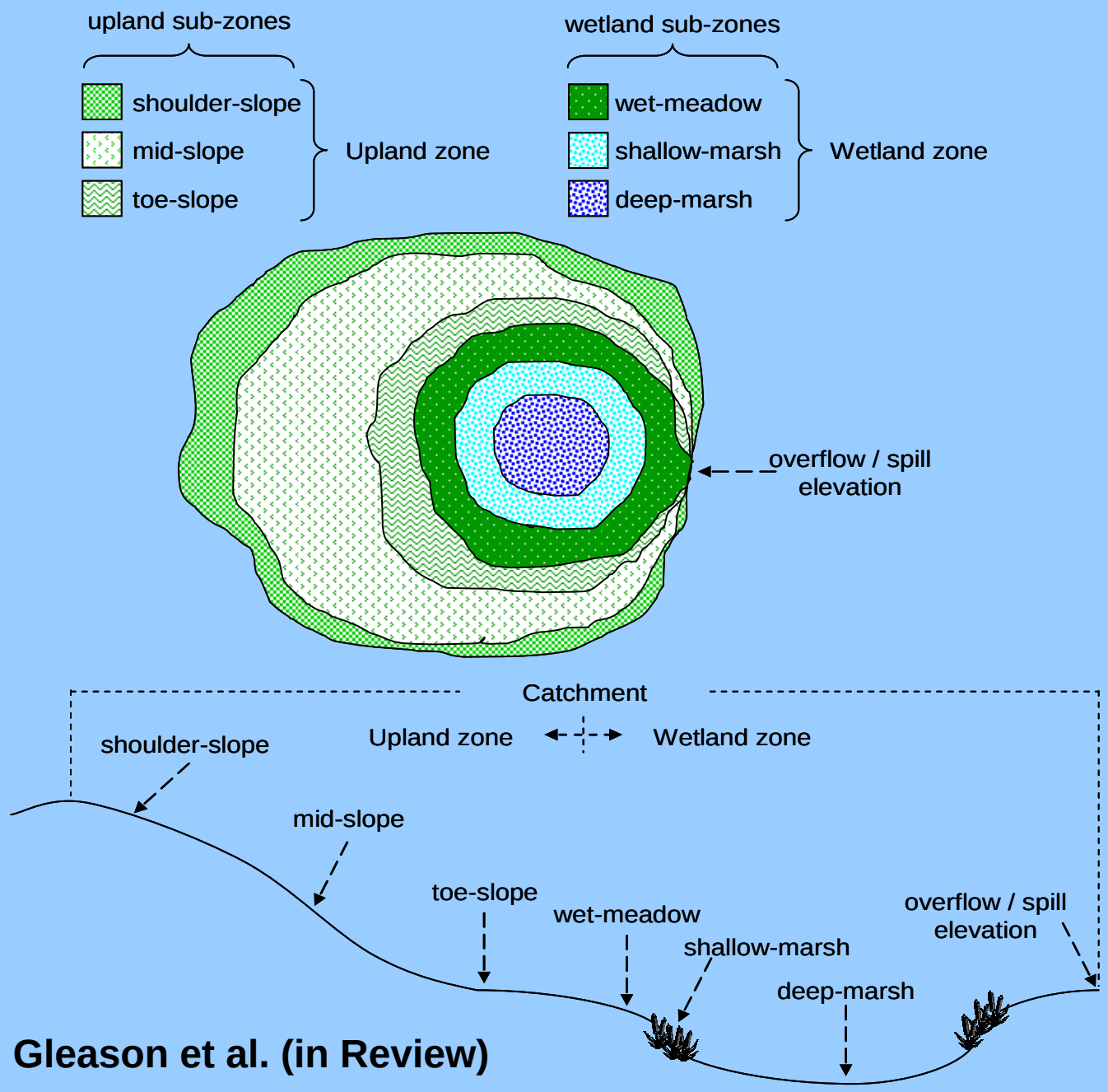

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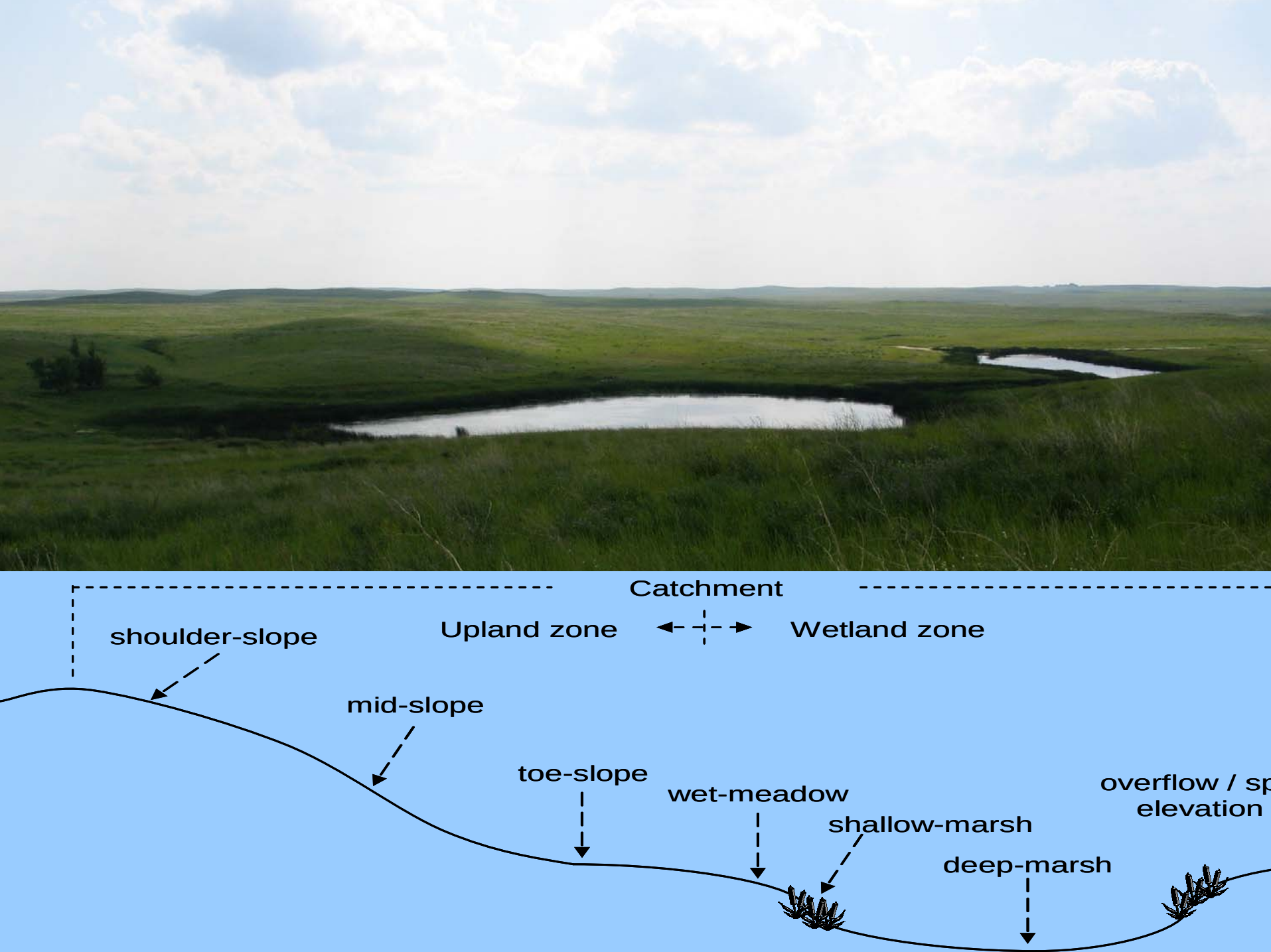
Catchment
Upland zone
Wetland zone
shoulder-slope
mid-slope
toe-slope
wet-meadow
shallow-marsh
deep-marsh
overflow / sp
elevation

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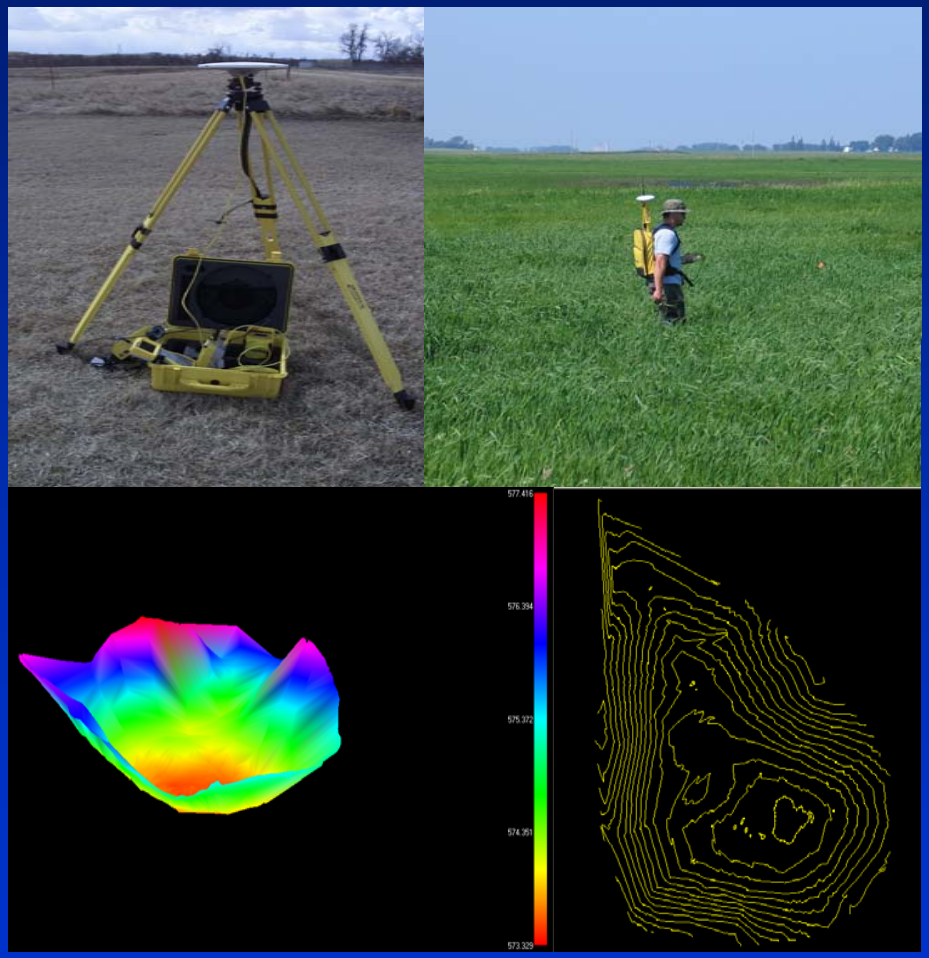
TOPOGRAPHIC SURVEYS

- **Wetland**
  - **Area**
  - **Volume**
  - **Perimeter**
- **Catchment**
  - **Area**
  - **% slope**
  - **Slope lengths**
- **Interception**
  - **Area**



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SOIL SURVEYS

- **Profile descriptions**
  - **Horizon descriptions**
  - **Texture, Consistence**
  - **Redoximorphic features**
- **Chemistry**
  - **OC, IC, P, N, EC**
- **Physical**
  - **Particle size**
  - **Bulk density**

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VEGETATION SURVEYS

- **Wetland and Catchment**
  - **Cover estimates**
  - **Species lists**
  - **Litter depths**
  - **Visual obstruction (Robels)**
  - **Biomass clippings (dry wt, TOC, P, N)**

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SPECIES SURVEYS??????????

- **Wetland and Catchment**
  - **Species observations**
  - **Species lists**

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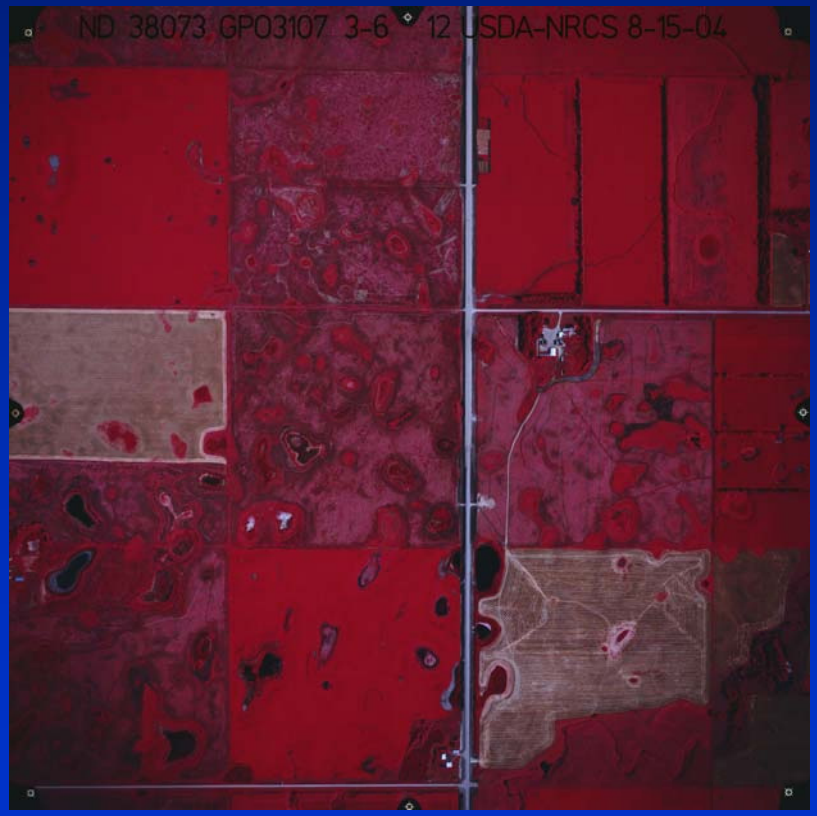
LANDSCAPE FEATURES

- **Landscape features at multiple scales, e.g.,**
  - **Wetland density**
  - **Nearest neighbor measures**
  - **Landuse types**



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		RESTORATION STUDY (1997)	FY2004 PROJECTS
History	Type of drainage	X	X
	Date of drainage		X
	Completeness of drainage		X
	Age of restoration (years)	X	X
Morphology (3-D topo survey)	Area (wetland, zones, catchment; ha)	X	X
	Shoreline length (m)	X	X
	Elevations (hydric, veg, zones, spill, etc.; m)	X	X
	Volumes (ha-m)	X	X
	GPS location, lat/long	X	X

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Gleason et al. (in Review)

		RESTORATION STUDY (1997)	FY2004 PROJECTS
Vegetation	Number of veg zones	X	X
	Width of veg zones (m)	X	X
	Wetland class	X	X
	% open water	X	X
	Water Depth (m)	X	X
	Floristic composition	X	X
	Cover estimates (%)	X	X
	Catchment cover type	X	X
	Litter depth (m) and dry mass (g)	X	X
	Robel readings and dry mass (g)	X	X
	Seed banks	X	
Invertebrates	Egg banks	X	

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		RESTORATION STUDY (1997)	FY2004 PROJECTS
Soils/ Sediment	Soil Samples		
	OC, IC, P, N, PSA, texture (%)	X	X
	EC (milimhos/cm), Ph (pH units)	X	X
	Bulk density (grams/cm^3)	X	X
	Mini-soil profile description		
	Soil classification (family)	X	X
	Litter thickness (cm)	X	X
	Biomass	X	X
	Redox characteristics	X	X
	Texture	X	X

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Gleason et al. (in Review)

		RESTORATION STUDY (1997)	FY2004 PROJECTS
Soils/ Sediment	Soil Quality		
	Root pores		X
	Soil consistency		X
	Grade		X
	Size		X
	Form		X
	Hydric soil boundary	X	X
	Buried horizons	X	X
	Sedimentation	X (n=19)	
	137-Cs and 210Pb dates	X (n=19)	
Hydrology	Water depth (actual and maximum; m)	X	X
	Natural outlet and inlets	X	X
	Wetland class	X	X

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Service	Measure
Floodwater Storage	Estimate of water storage potential
Biodiversity/Habitat Quality	Floristic quality, taxon richness, habitat suitability
Erosion, Sedimentation and nutrient loading potential	Sedimentation and nutrient loading for wetlands in cropland, restored grassland and native prairie
Carbon Sequestration	Estimates of soil and wetland vegetation carbon stocks
Greenhouse Gas Emissions Reduction	Comparison of rates of reduction greenhouse gas emissions from wetlands in cropland, restored grassland and native prairie

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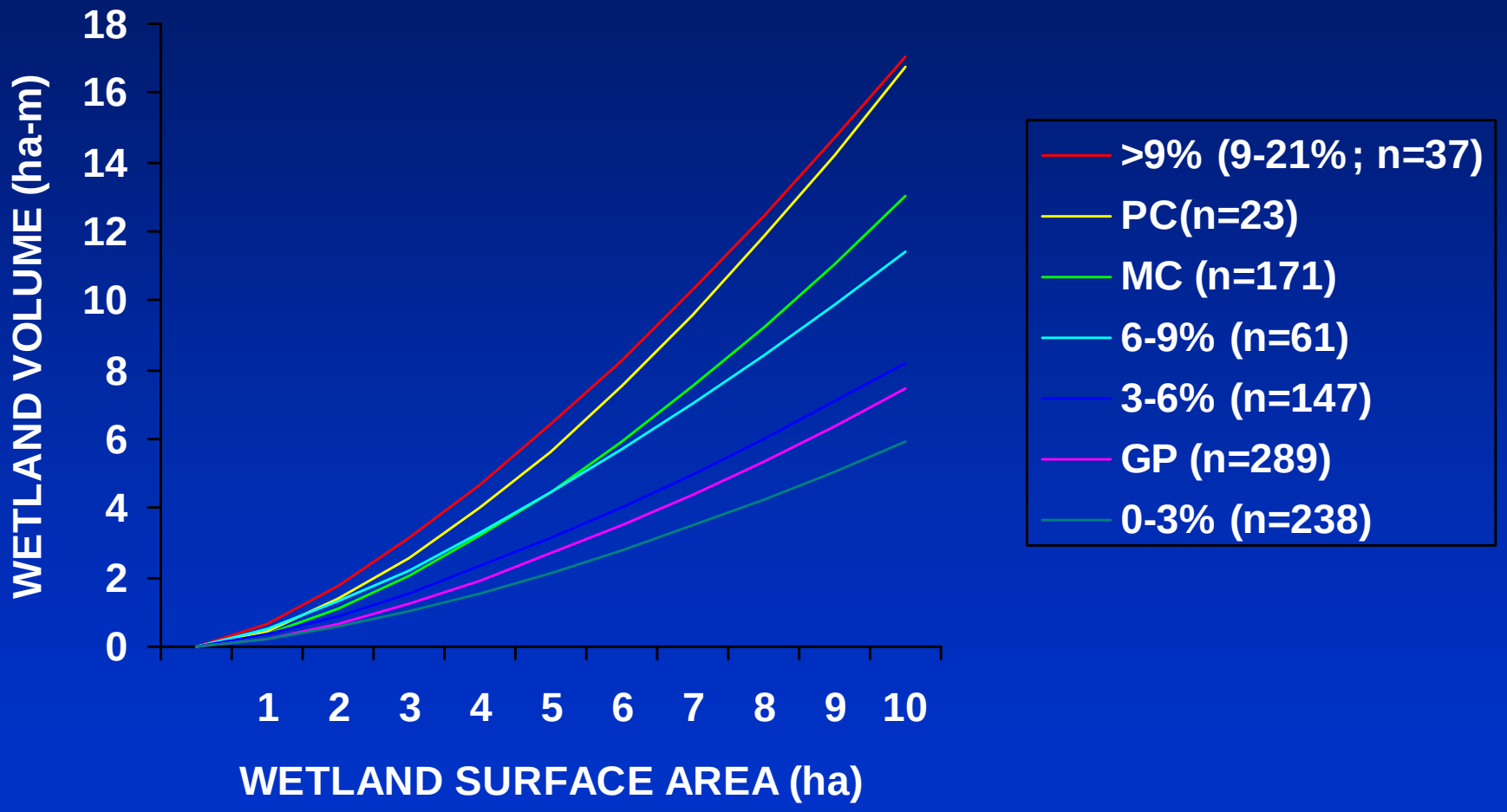
SURFACE AREA-VOLUME PREDICTIVE MODELS



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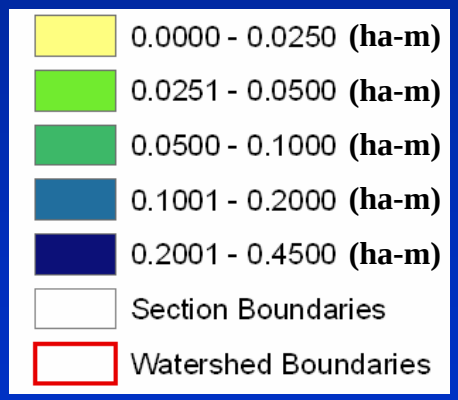
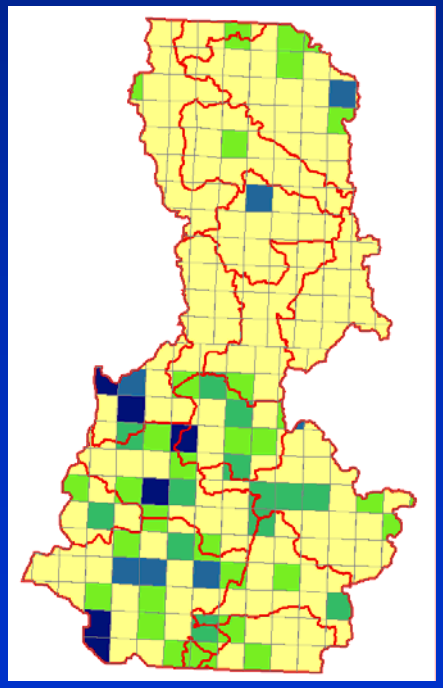
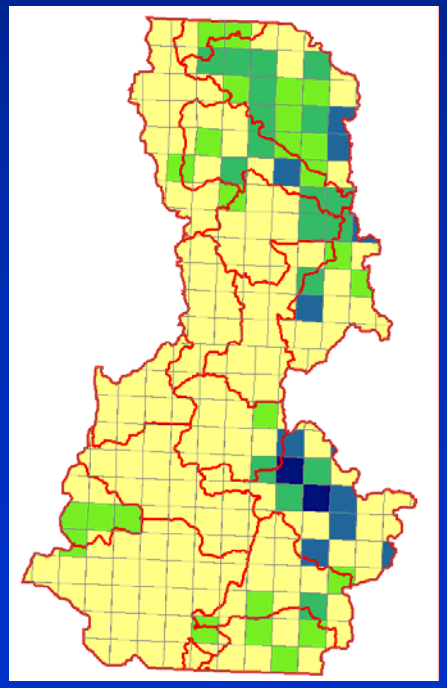
Flood Water Storage Service



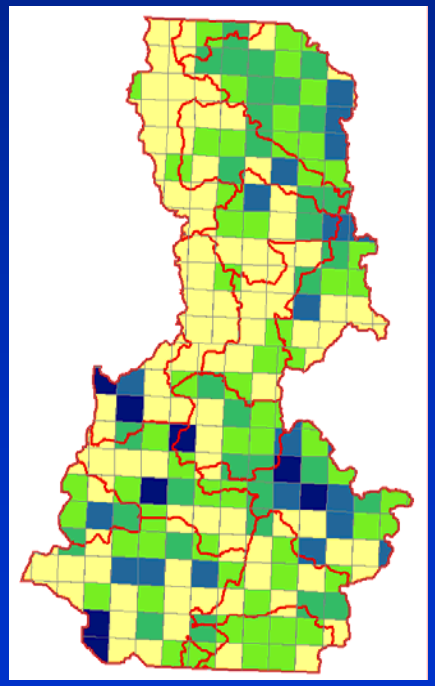
Existing Storage



Potential Storage



Existing and Potential Storage



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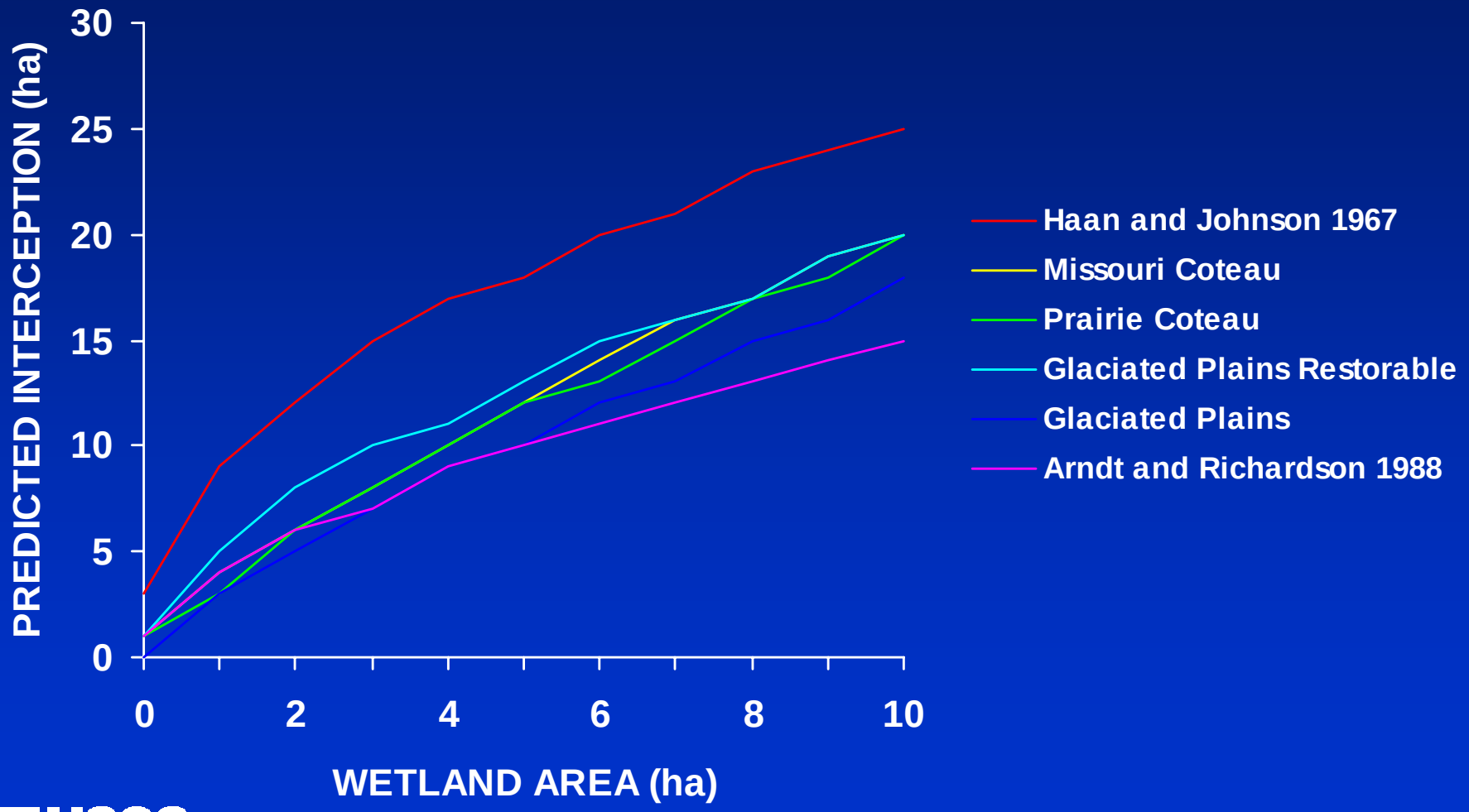
INTERCEPTION AREA PREDICTIVE MODELS



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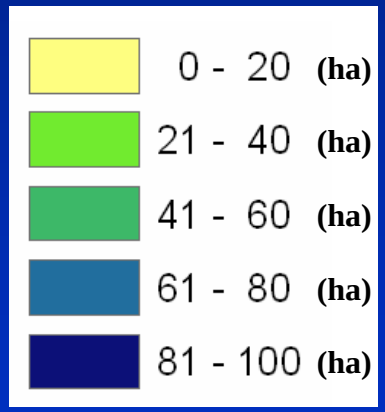
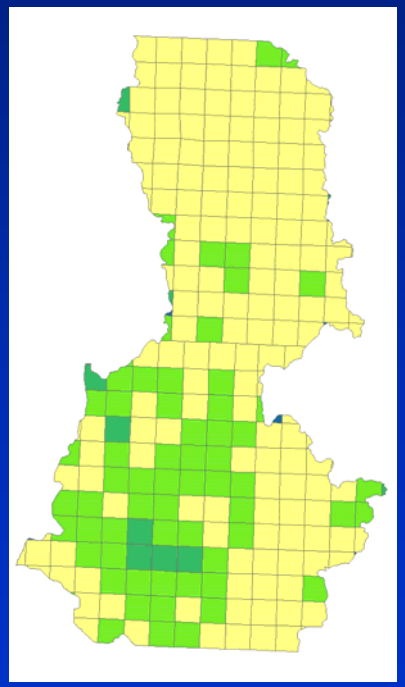
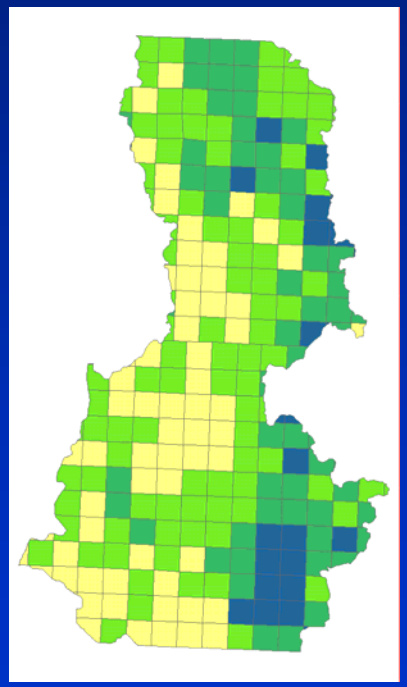
Interception Area



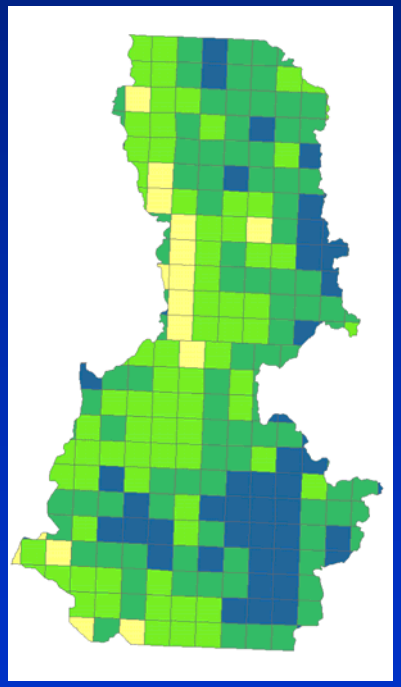
Existing Interception



Potential Interception



Existing and Potential Interception



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Erosion, Sedimentation, and Nutrient Loading Reduction Service

Estimate overall erodibility of catchment before and after restoration using Universal Soil Loss Equations

Predicted soil loss from catchment (Mg/year)

Before	After
4.69	0.06

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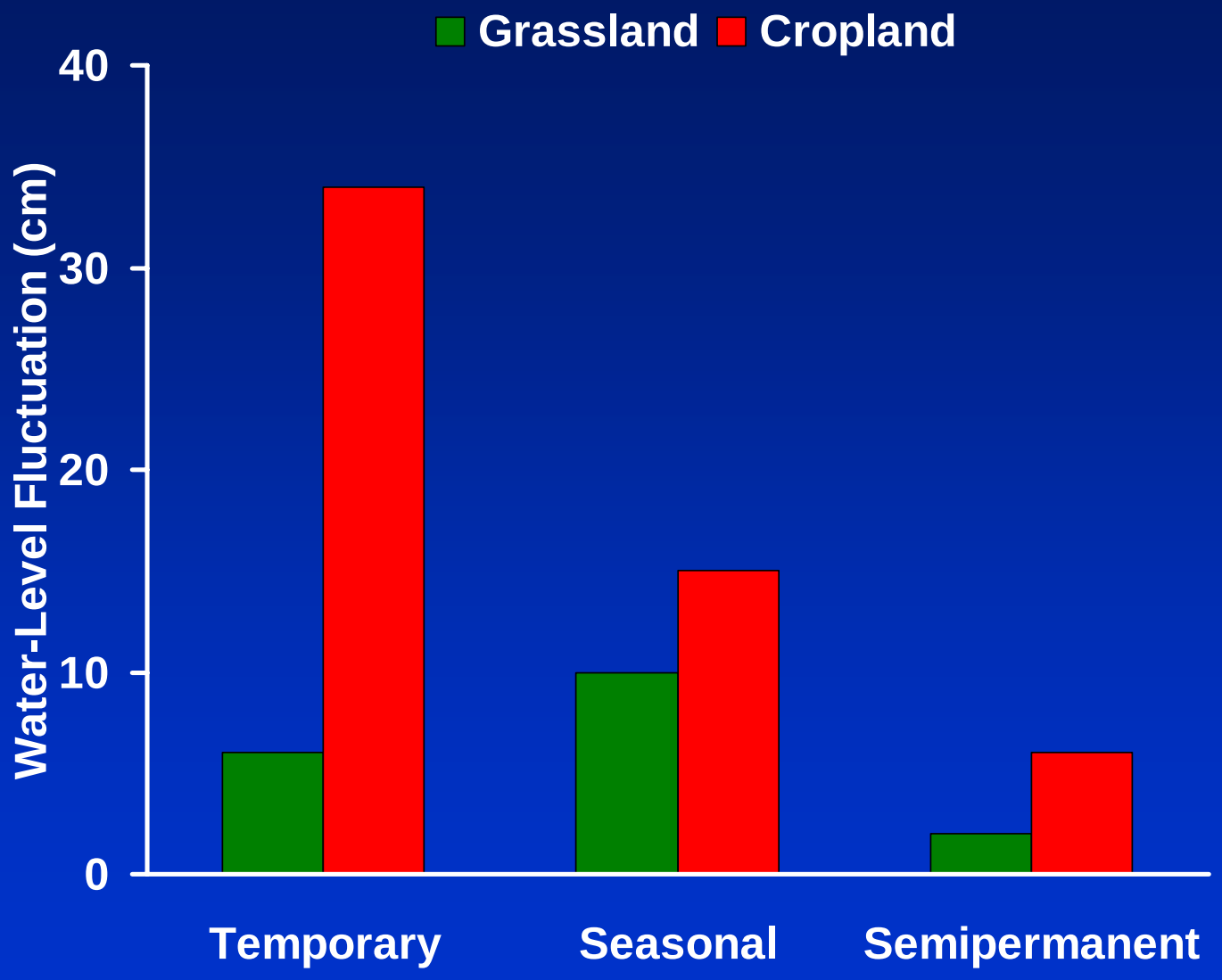
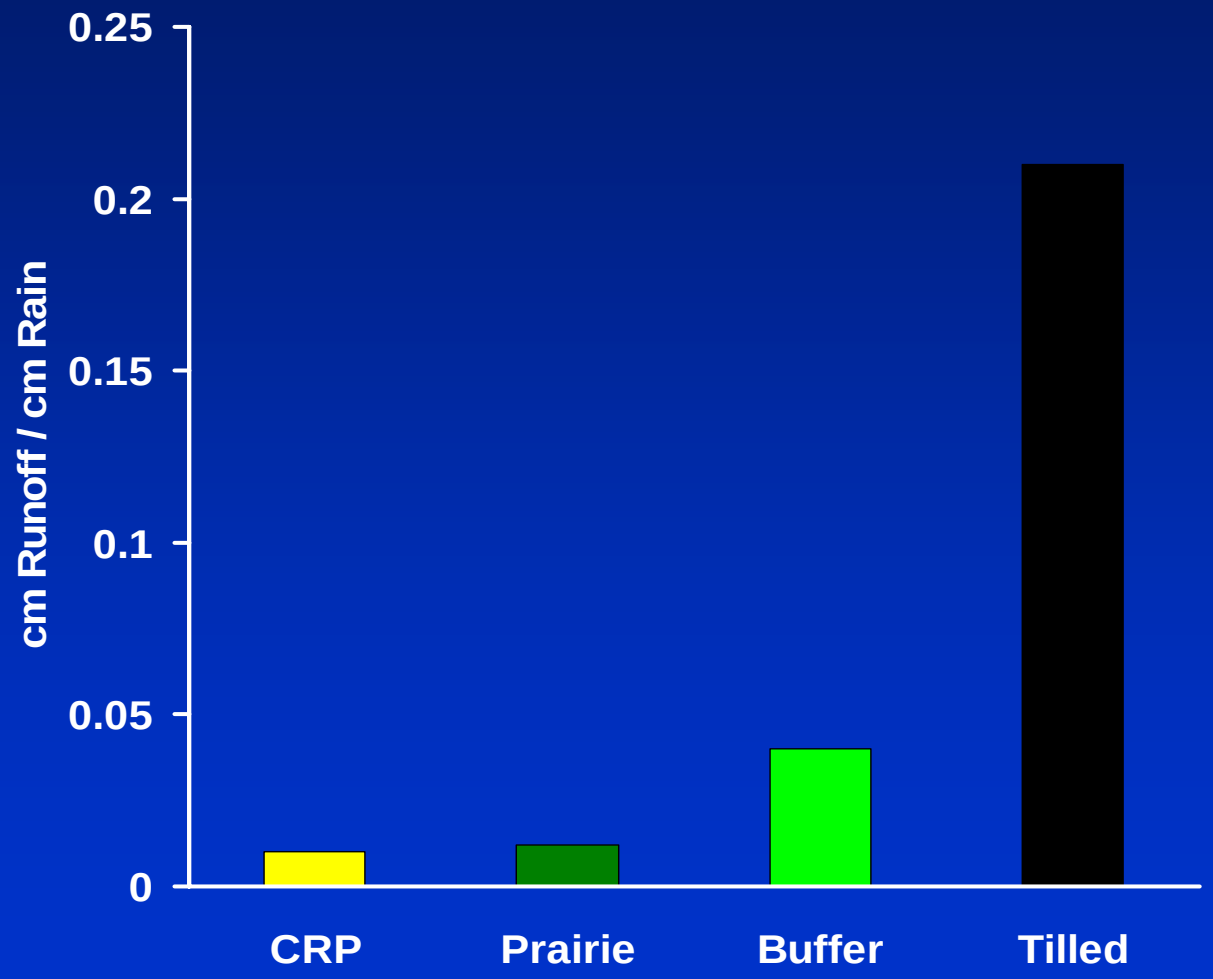
Influence of Surrounding Land Use



* Data from Euliss and Mushet 1996

Influence of Surrounding Land Use



* Data from Gleason 1996

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North American prairie wetlands are important nonforested land-based carbon storage sites

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[e]*Environment Canada, National Water Research Institute, Burlington, ON, Canada L7R 4A6*
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Abstract

We evaluated the potential of prairie wetlands in North America as carbon sinks. Agricultural conversion has resulted in the average loss of 10.1 Mg ha^{-1} of soil organic carbon on over 16 million ha of wetlands in this region. Wetland restoration has potential to sequester 378 Tg of organic carbon over a 10-year period. Wetlands can sequester over twice the organic carbon as no-till cropland on only about 17% of the total land area in the region. We estimate that wetland restoration has potential to offset 2.4% of the annual fossil CO_2 emission reported for North America in 1990.
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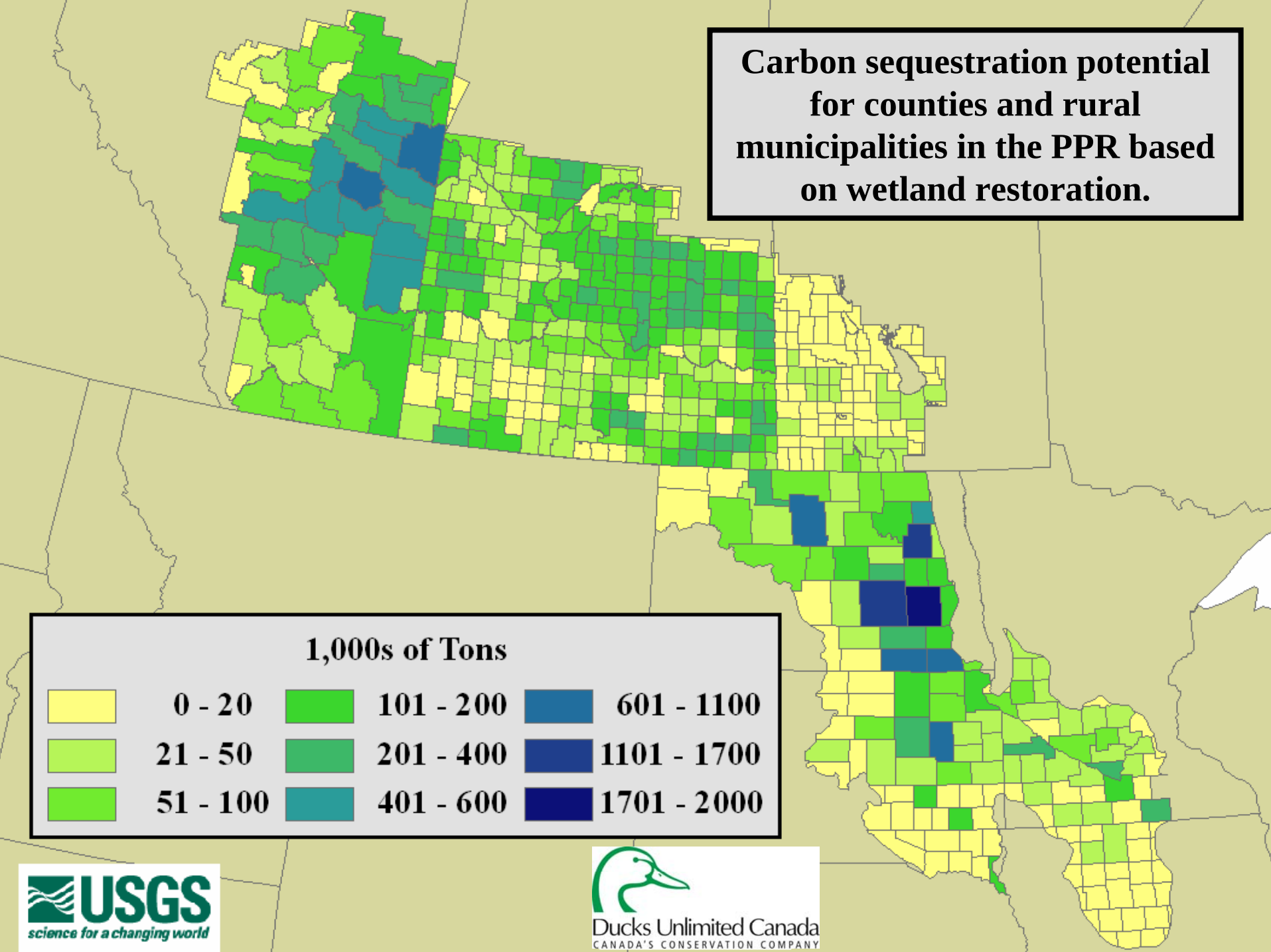
Keywords: Carbon sequestration; Wetlands; Prairie pothole region; Global climate change


Carbon sequestration potential for counties and rural municipalities in the PPR based on wetland restoration.
1,000s of Tons
0 - 20
21 - 50
51 - 100
101 - 200
201 - 400
401 - 600
601 - 1100
1101 - 1700
1701 - 2000
USGS
science for a changing world
Ducks Unlimited Canada
CANADA'S CONSERVATION COMPANY

Carbon Sequestration Service

Highly Altered

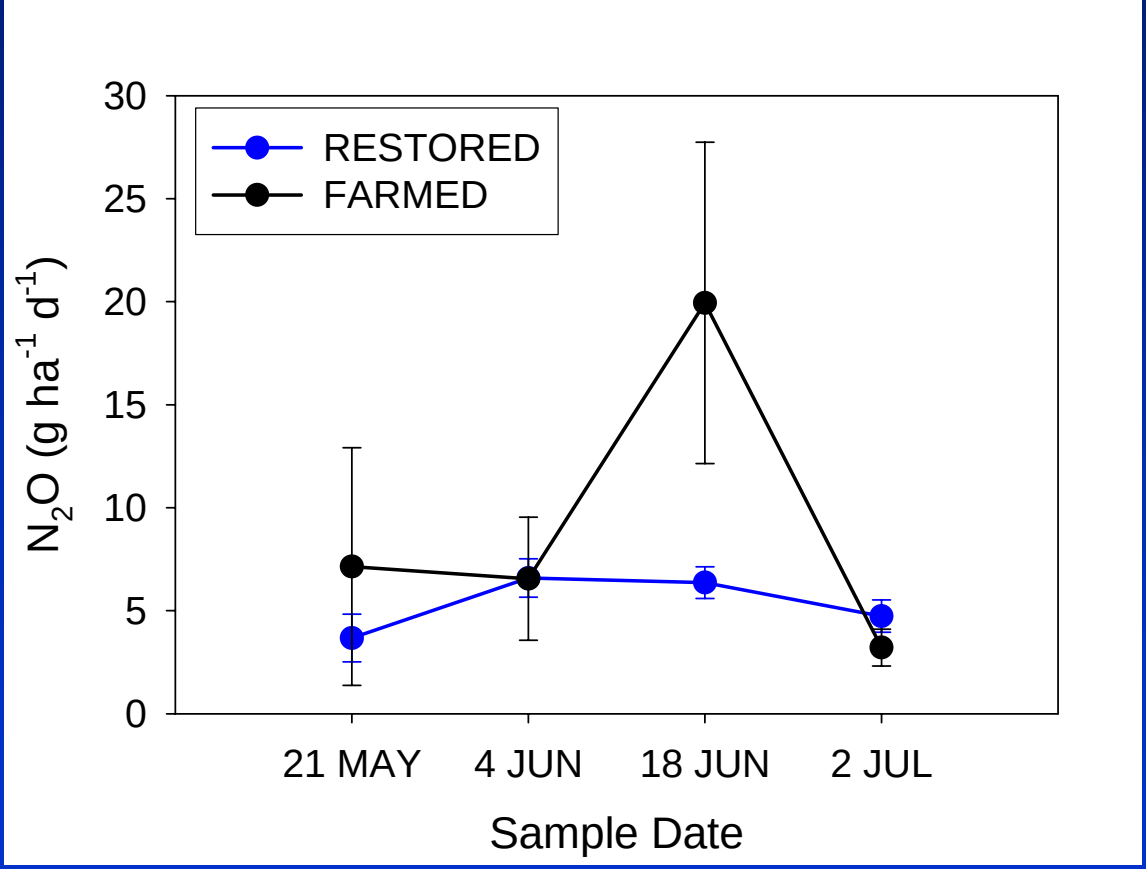
Relatively Unaltered

Condition Gradient

MLRA	Cropland (OC Mg/ha)	Restored (OC Mg/ha)	Native (OC Mg/ha)
102A	48.1	?	73.4
103	56.2	?	76.7
53C	50.9	?	54.9

USGS
science for a changing world

Nitrous Oxide Flux From Farmed and Restored Wetlands



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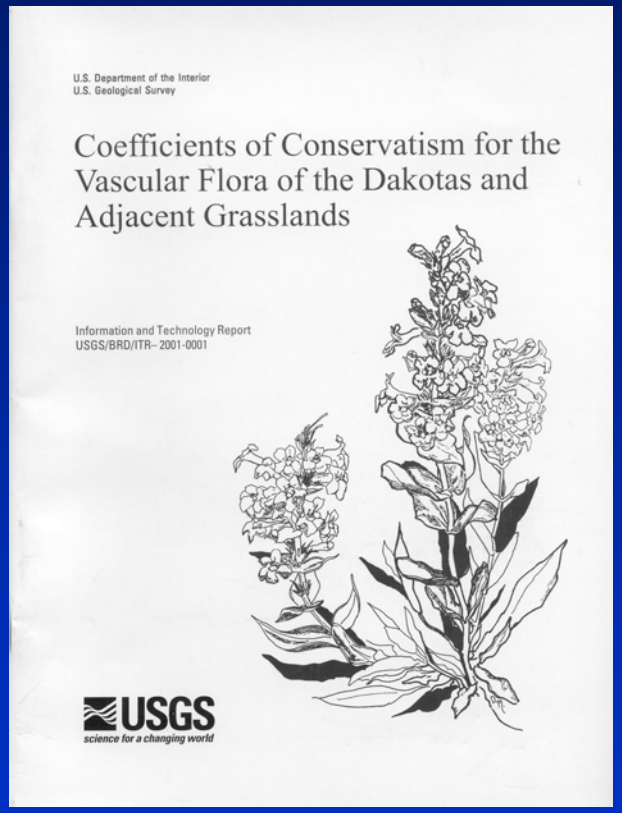
Vegetative Biodiversity Service



Coefficient of Conservatism (C)

- Value from 0-10 assigned to each native species
- Values depict species tolerance to disturbance
- 0 = High tolerance to disturbance
  10 = Low tolerance to disturbance

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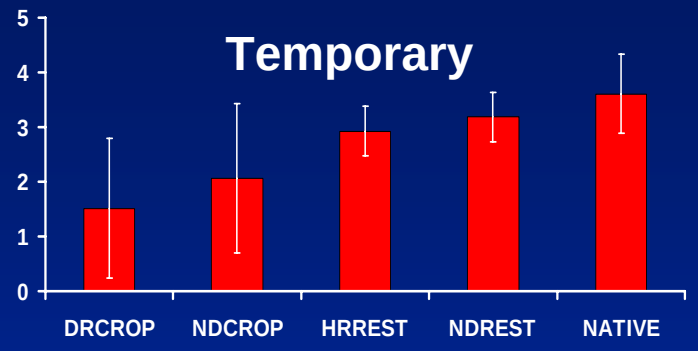
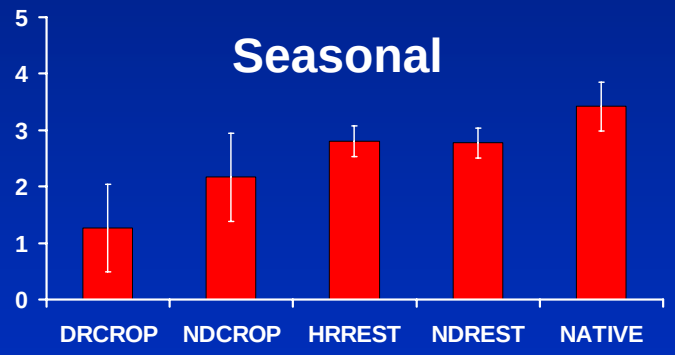
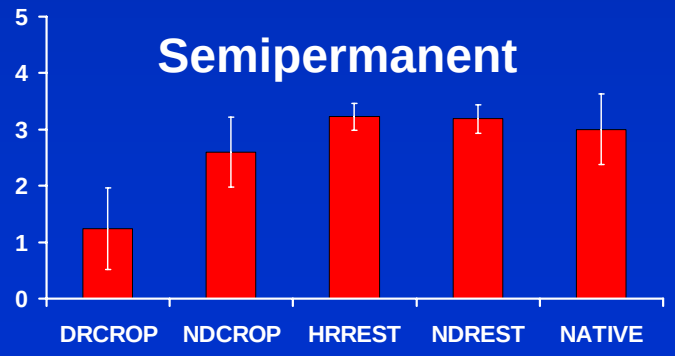
Vegetative Biodiversity Service







Mean C Value

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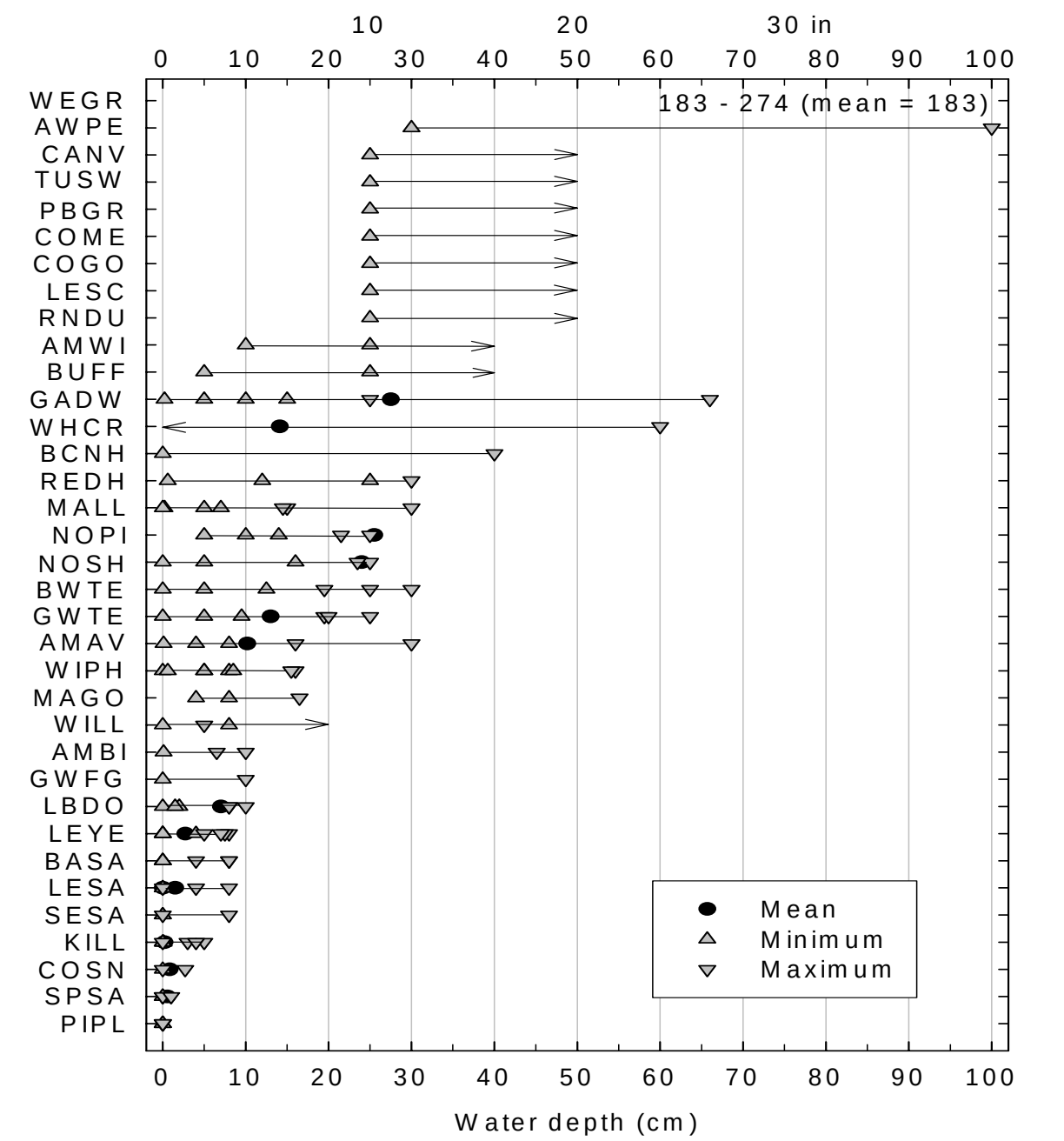
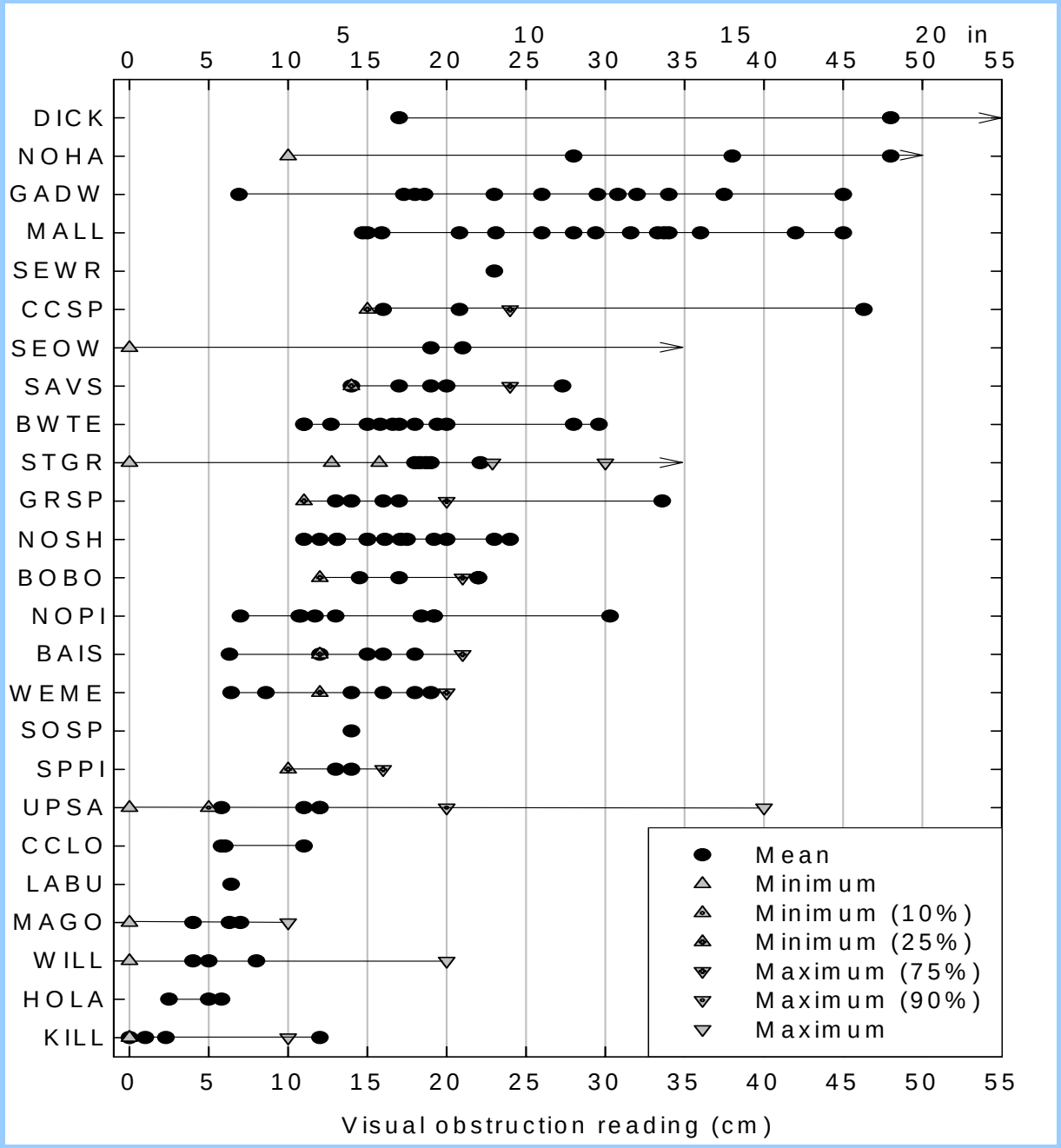
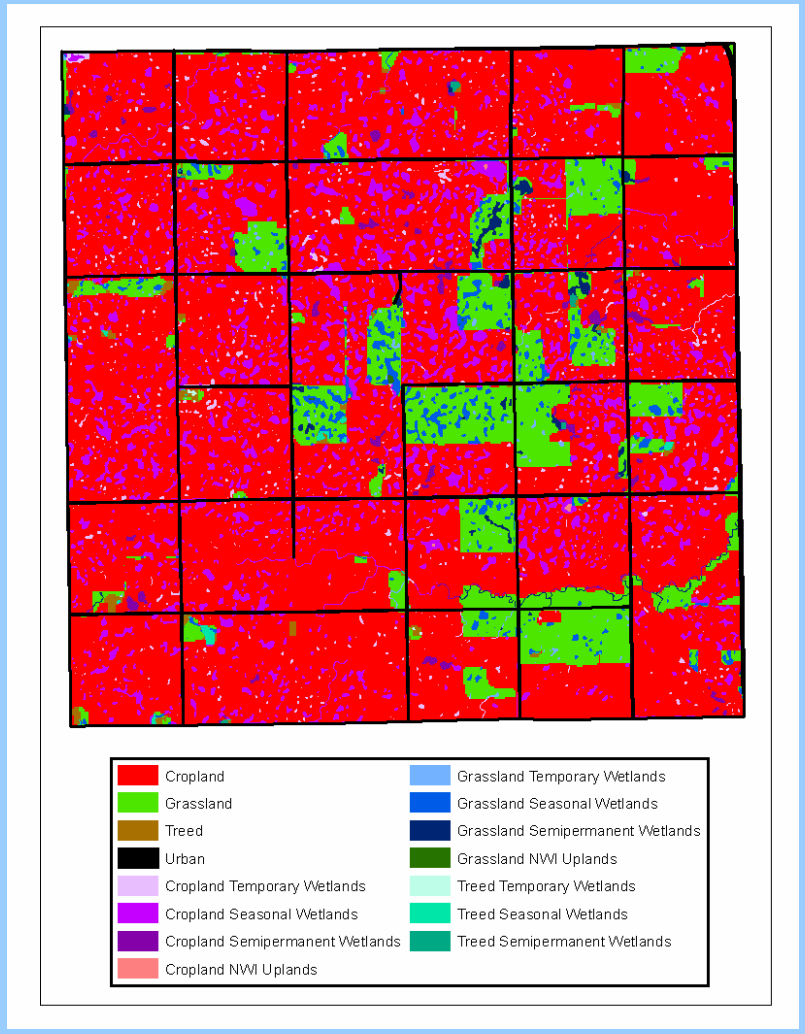
Wildlife Habitat Service

- Compare published information on species habitat requirements to existing abiotic and vegetation conditions in wetlands surveyed to assess the potential habitat suitability

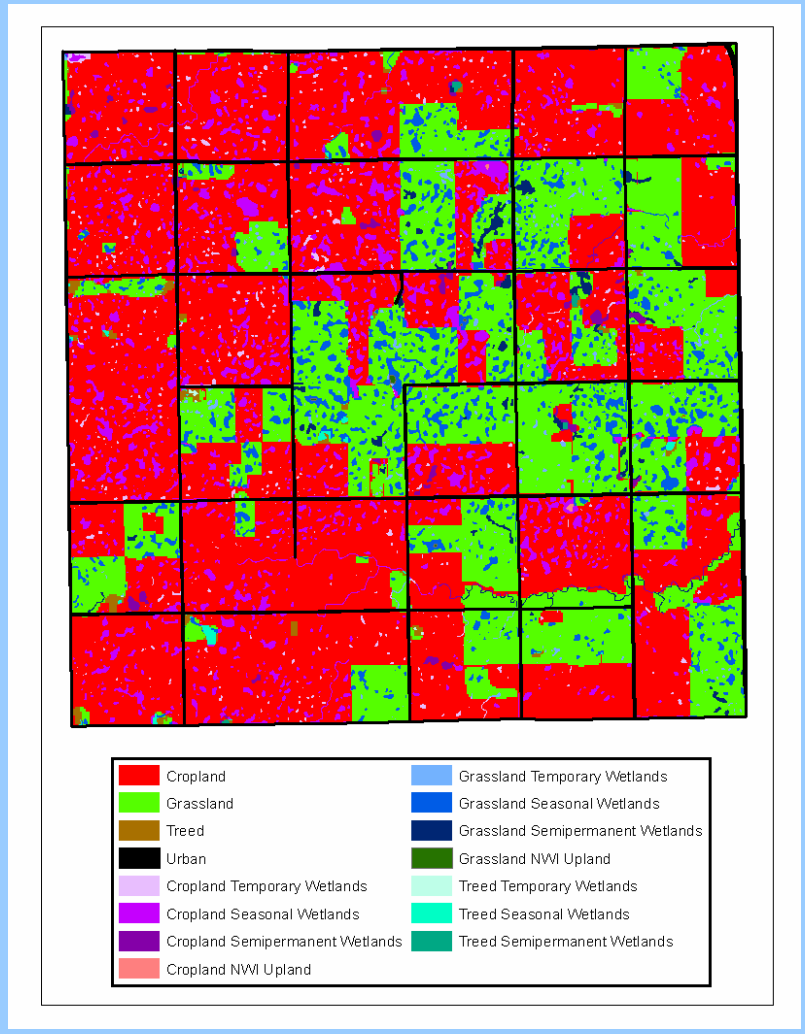

10
20
30 in
0
10
20
30
40
50
60
70
80
90
100
183 - 274 (mean = 183)
WEGR
AWPE
CANV
TUSW
PBGR
COME
COGO
LESC
RNDU
AMWI
BUFF
GADW
WHCR
BCNH
REDH
MALL
NOPI
NOSH
BWTE
GWTE
AMAV
WIPH
MAGO
WILL
AMBI
GWFG
LBDO
LEYE
BASA
LESA
SESA
KILL
COSN
SPSA
PIPL
Mean
Minimum
Maximum
Water depth (cm)


5 10 15 20 in
0 5 10 15 20 25 30 35 40 45 50 55
DICK
NOHA
GADW
MALL
SEWR
CCSP
SEOW
SAVS
BWTE
STGR
GRSP
NOSH
BOBO
NOPI
BAIS
WEME
SOSP
SPPI
UPSA
CCLO
LABU
MAGO
WILL
HOLA
KILL
Mean
Minimum
Minimum (10%)
Minimum (25%)
Maximum (75%)
Maximum (90%)
Maximum
Visual obstruction reading (cm)

Land Use in a Single Township in the Glaciated Plains of the Prairie Pothole Region



Prior to Implementation of the Conservation Reserve Program (CRP)



After Implementation of the Conservation Reserve Program (CRP)

USGS

(Laubhan et al. in Review)

Change in number of patches and area of land use classes prior to (pre-CRP) and following (post-CRP) implementation of the Conservation Reserve Program in a single township in the Glaciated Plains of the Prairie Pothole Region.

	Number of patches			Area (ha)		
Land-use class	**Pre-CRP**	**Post-CRP**	**Change**	**Pre-CRP**	**Post-CRP**	**Change**
Cropland/wetland complex						
Cropland upland	54	87	+33	6,752	5,273	-1,479
Cropland wetlands	2,771	2,019	-752	1,131	818	-313
Total	2,825	2,106	-719	7,883	6,092	**-1,791**
Grassland/wetland complex						
Grassland upland	134	114	-20	1,055	2,534	1,479
Grassland wetlands	378	1,087	+709	227	540	+313
Total	512	1,201	+689	1,283	3,074	**+1,791**

USGS

(Laubhan et al. in Review)

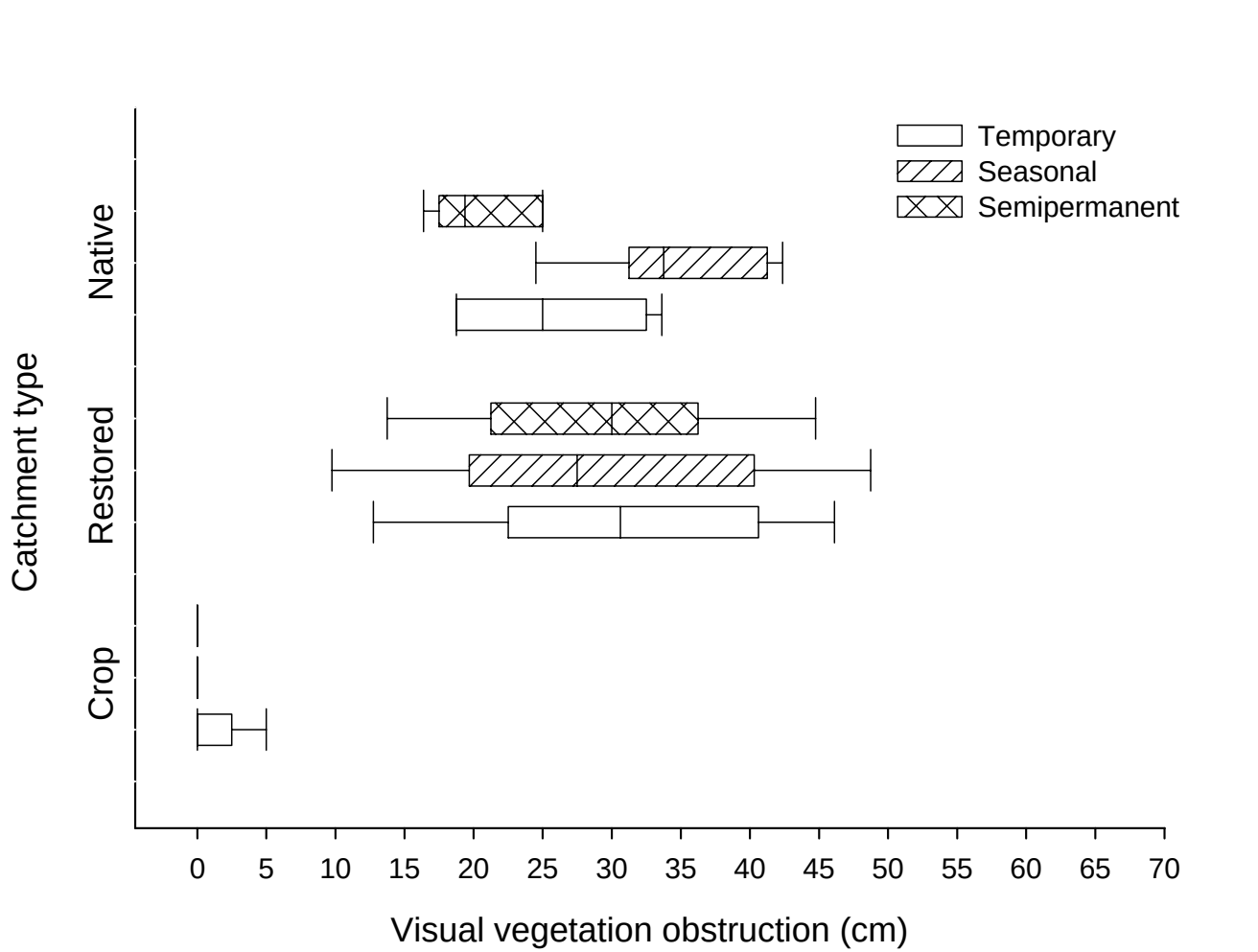
Change in the number of suitable grassland patches for five grassland-dependent bird species in a PPR township.

Species	Spatial metric	Requirement of bird (ha)	State	Citation	Patch number		
					Pre-CRP	Post-CRP	Change
Upland Sandpiper	Minimum area	>10	MO	Samson 1980	26	34	+8
		>70	MO	Winter 1998	4	13	+9
	Perimeter:area	<0.008	NE	Helzer and Jelinski 1999	6	21	+15
Savannah Sparrow	Minimum area	>75	IL	Walk and Warner 1999	4	13	+9
	50% incidence	>40	IL	Herkert 1994	10	21	+11
	Territory	>15	IL	O'Leary and Nyberg 2000	21	30	+9
Vesper Sparrow	Minimum area	>10	MO	Samson 1980	26	34	+8
	50% incidence	>20	ME	Vickery et al. 1994	18	27	+9
Grasshopper Sparrow	Minimum area	>12	IL	Walk and Warner 1999	22	32	+10
	50% incidence	>30	IL	Herkert 1994	15	25	+10
		>70	IA	Horn 2000	4	13	+9
	Perimeter:area	<0.018	NE	Helzer and Jelinski 1999	28	36	+8

USGS

(Laubhan et al. in Review)

Median (–), interquartile (25-75%) range (box), and 10-90 quantile (10-90%) range (stems) of vegetation obstruction measurements for nine catchment types in the vicinity of the Prairie Pothole Region township used as an example to illustrate a habitat-based approach for determining wildlife habitat suitability.



USGS

(Laubhan et al. in Review)

Range (50% of observations) of visual obstruction measurements in the upland zone of 54 catchments sampled (n = 9 catchments in each type) in the vicinity of the example township in the Glaciated Plains and the range of visual obstruction estimates at nest sites of 10 bird species reported in the literature. Species that potentially could occur in a catchment type based on visual obstruction measurements are denoted with an “X”.

		Species (range of reported visual obstruction [cm])[1,2]								
Catchment type	Interquartile range of upland vegetation obstruction (cm)	Mallard (14.7-42.0)	Sharp-tailed Grouse (15.0-30.0)	Northern Harrier (10.0-48.0)	Willet (0.0-20.0)	Upland Sand-piper (0.0-40.0)	Clay-colored Sparrow (16.0-46.3)	Grass-hopper Sparrow (13.0-33.6)	Dickcissel (17.0-67.0)	Bobo-link (19.2-22.0)
Crop										
Temporary	0.0-2.5				x	x				
Seasonal	0.0-0.0				x	x				
Semiperm-anent	0.0-0.0				x	x				
Restored										
Temporary	22.5-40.6	x	x	x		x	x	x	x	
Seasonal	20.0-40.0	x	x	x	x	x	x	x	x	x
Semiperm-anent	21.3-36.3	x	x	x		x	x	x	x	x

USGS

Bird species recorded by observation from vantage points and one walking survey conducted prior to measuring vegetation and abiotic variables in 263 catchments.

	Catchment type					
	Cropped		Restored		Native	
Common Name	Number	%	Number	%	Number	%
American Bittern	2	3.51	5	2.82	1	3.45
American Coot	2	3.51	6	3.39	2	6.90
American Goldfinch	1	1.75	4	2.26	1	3.45
American Robin	1	1.75	2	1.13	0	0.00
American White Pelican	1	1.75	1	0.56	0	0.00
American Widgeon	0	0.00	0	0.00	1	3.45
Barn Swallow	6	10.53	10	5.65	2	6.90
Black Tern	3	5.26	10	5.65	0	0.00
Black-Crowned Night Heron	1	1.75	5	2.82	0	0.00
Blue-Winged Teal	3	5.26	40	22.60	5	17.24
Bobolink	0	0.00	36	20.34	6	20.69

USGS

Supporting Model

SEDIMENT AND NUTRIENT REDUCTION

BIOVERSITY And HABITAT QUALITY

Functions

- Element cycling and transformation
- Ground water recharge
- Trophic structure support
- Organic matter production, decomposition and export
- Plant biomass production

Highly Altered

Relatively Unaltered

Condition

Gradient

CARBON SEQUESTRATION

GREENHOUSE GAS EMISSIONS REDUCTION

FLOOD WATER STORAGE