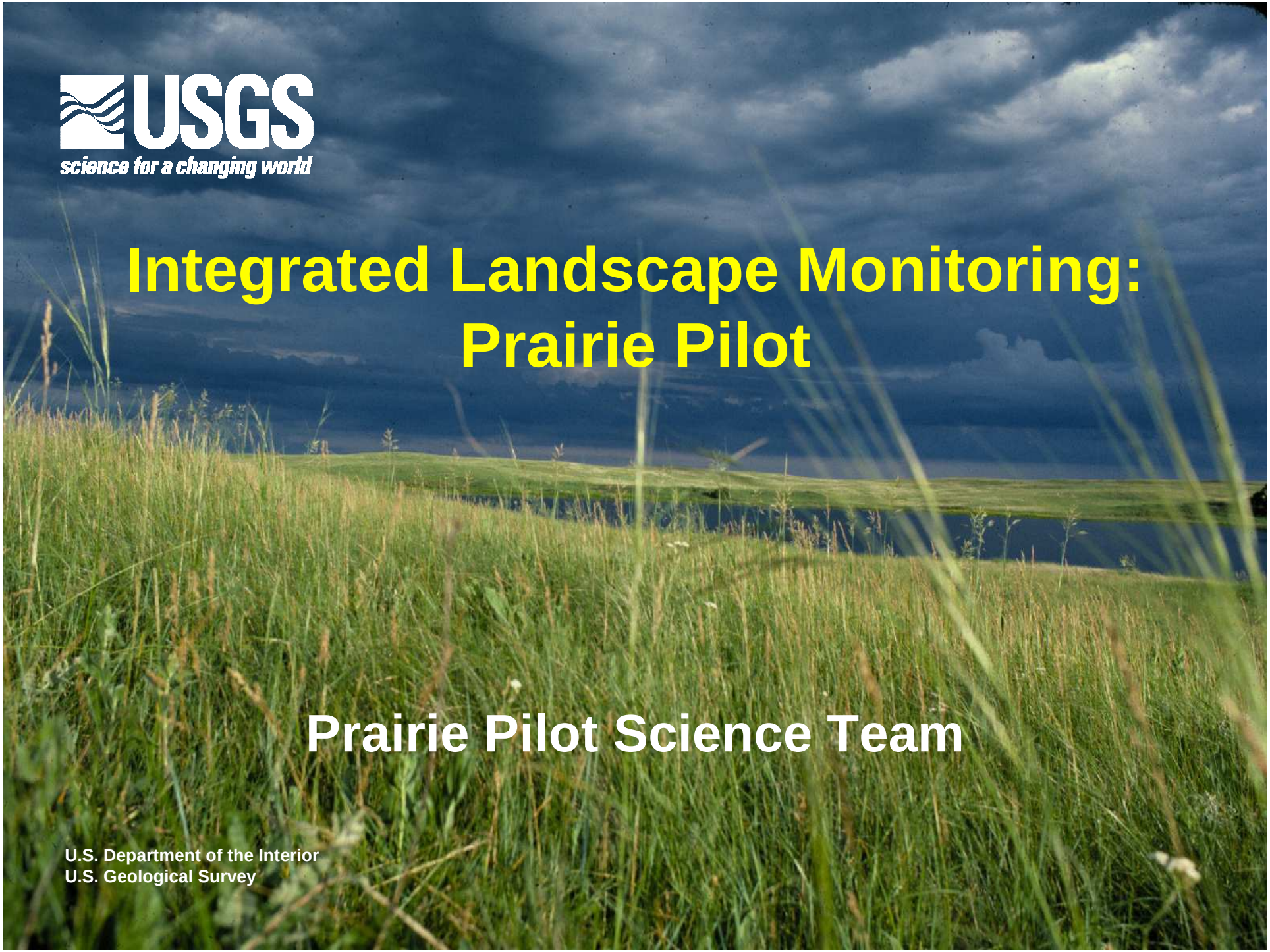

USGS
science for a changing world
Integrated Landscape Monitoring:
Prairie Pilot
Prairie Pilot Science Team
U.S. Department of the Interior
U.S. Geological Survey

JUSTIFICATION & NEED

USDA

- ✓ Agency influences 400 million acres of cropland and CRP land in the U.S. [2003 Annual NRI-Land Use, May 2006]
- ✓ Steward of 193 million acres of publicly-owned forests and rangelands in the U.S. [www.fs.fed.us/aboutus/, 12/1/2006]

USDOI

- ✓ Steward of 506 million acres of public lands [www.doi.gov/facts.html, 12/1/2006]
  - BLM 262 million acres
  - USFWS 94 million acres
  - NPS 85 million acres
  - BIA 56 million acres
  - BOR 9 million acres

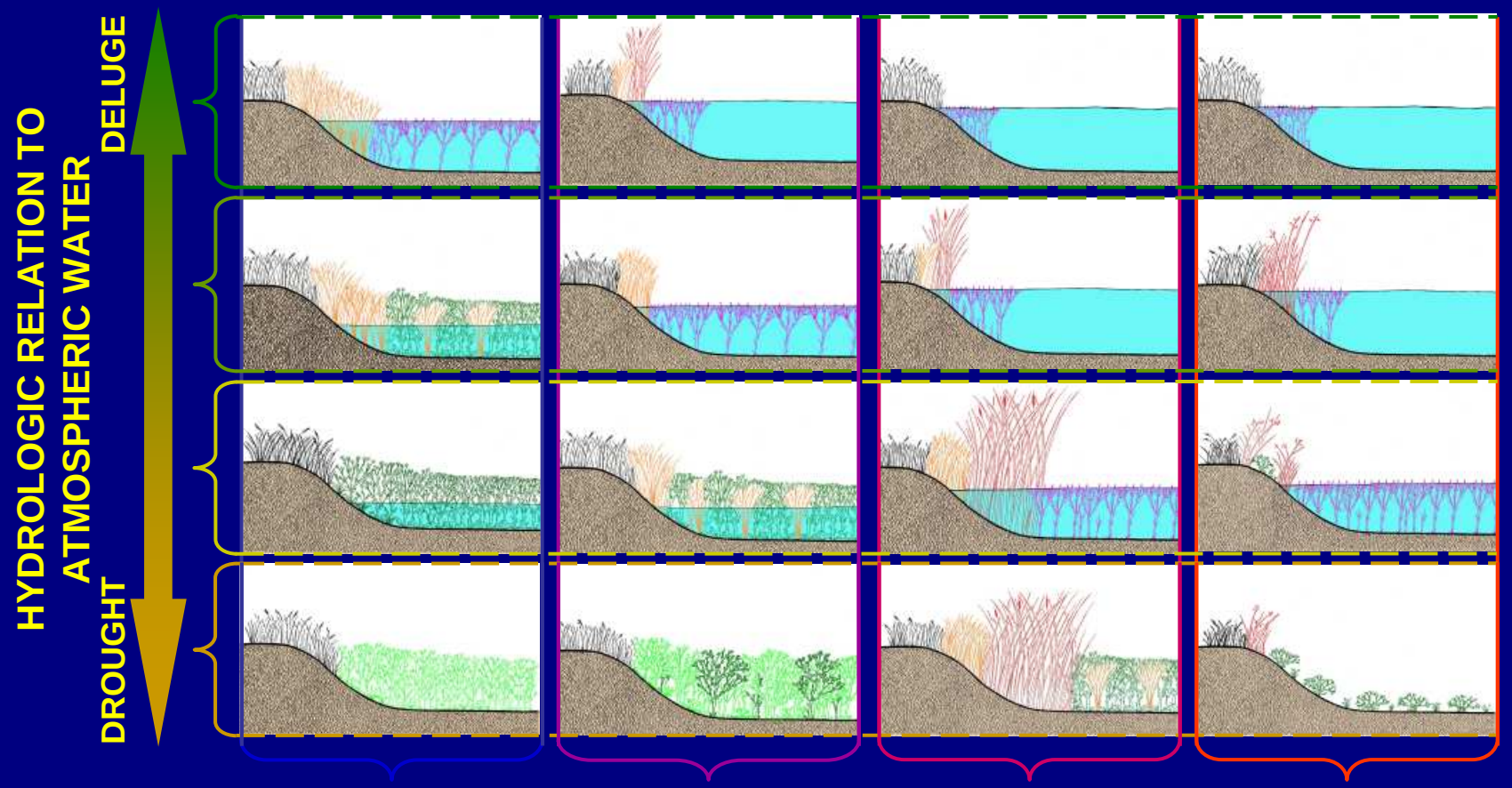
USGS

GOAL

Develop a Cost-Effective and Practical Methodology to Quantify Multiple and Simultaneous Outcomes of Conservation Practices, Programs, and Land Management Activities

USGS

THE WETLAND CONTINUUM



USGS

From Euliss et al. 2004

upland sub-zones

shoulder-slope

mid-slope

toe-slope

Upland zone

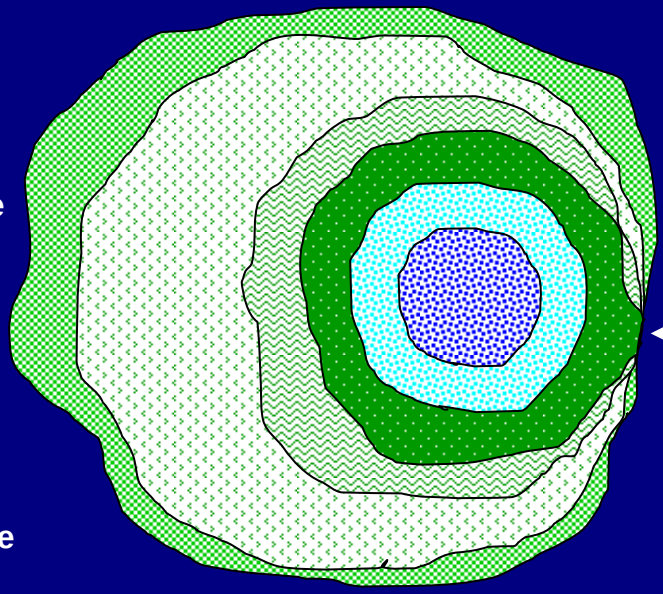
wetland sub-zones

wet-meadow

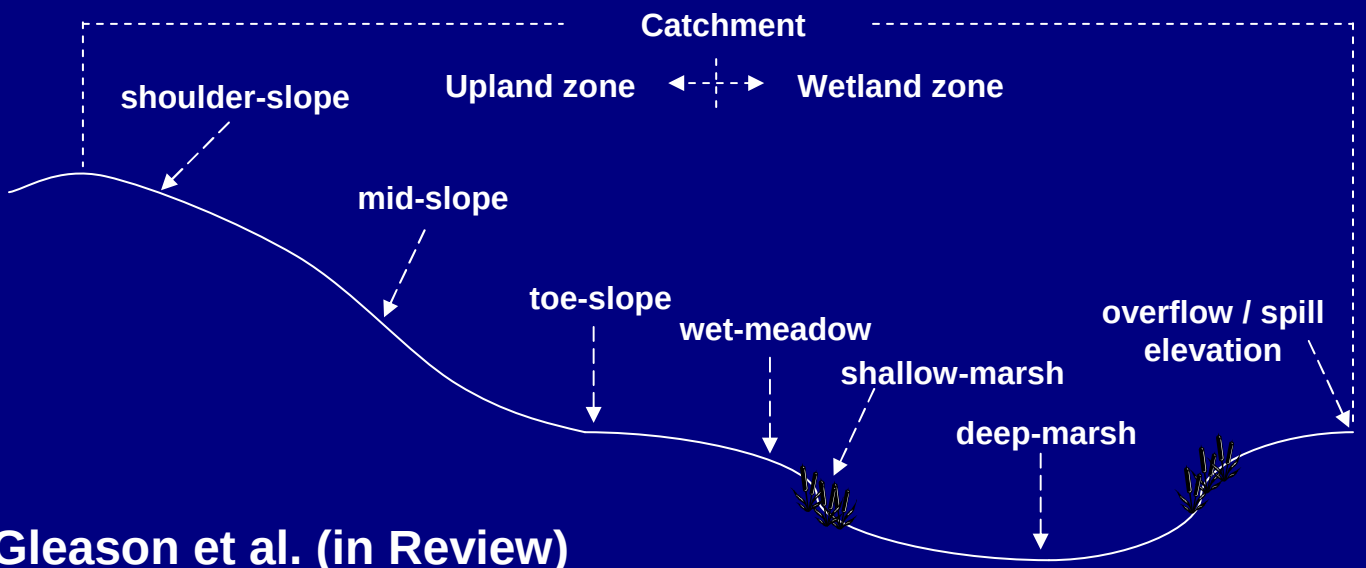
shallow-marsh

deep-marsh

Wetland zone



overflow / spill elevation

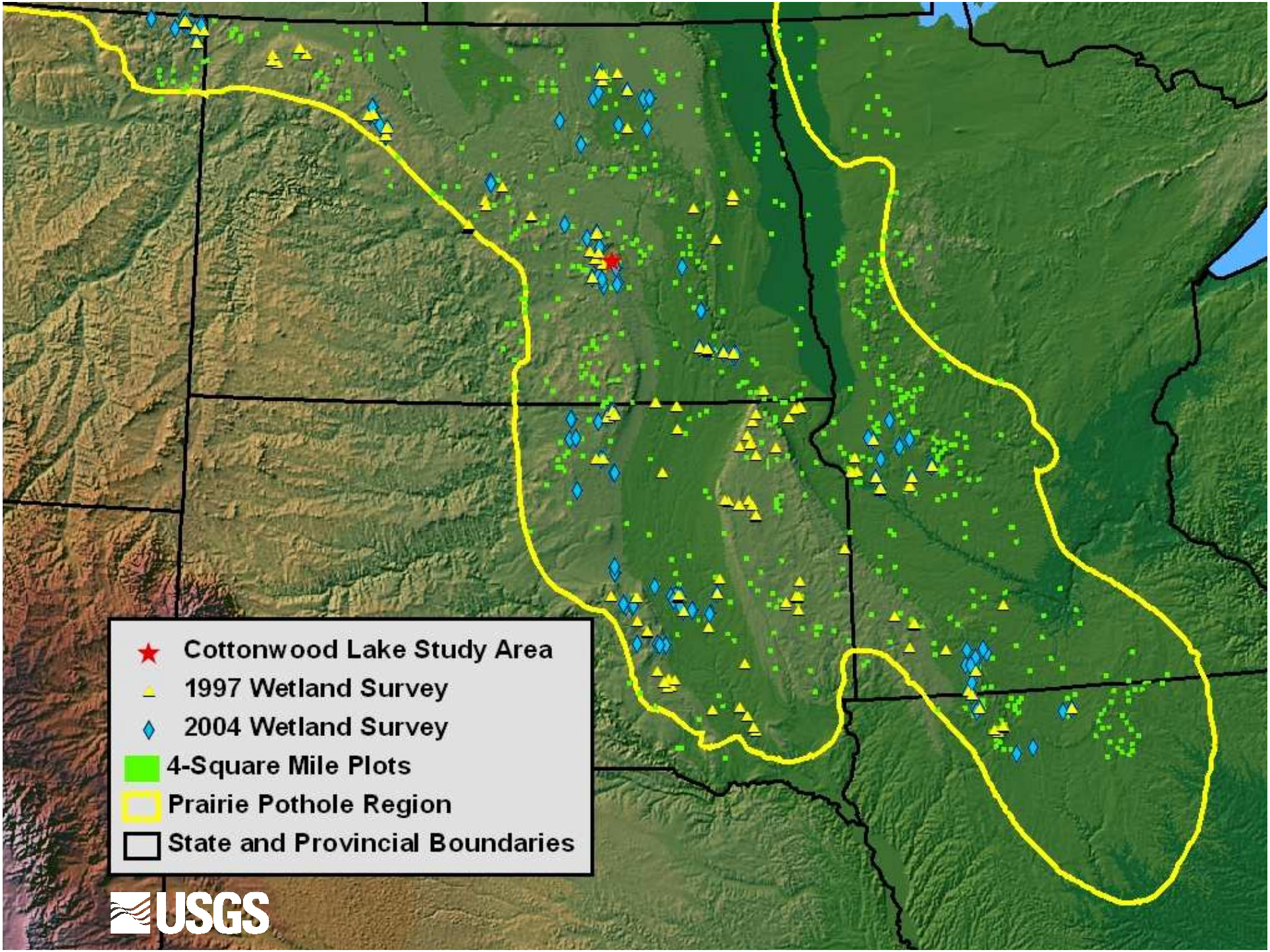


USGS science for a changing world

Gleason et al. (in Review)

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

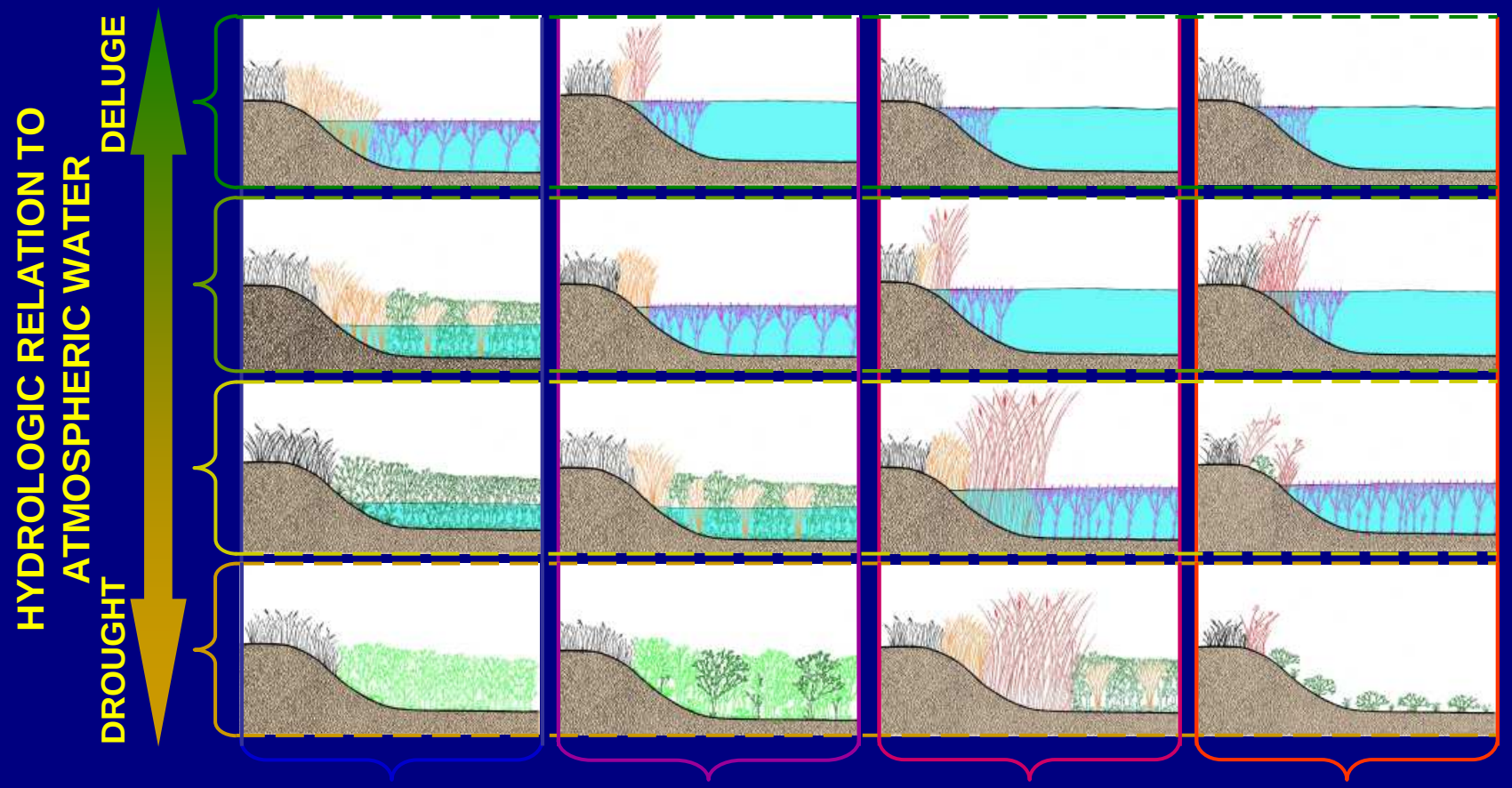
USGS
science for a changing world


Cottonwood Lake Study Area
1997 Wetland Survey
2004 Wetland Survey
4-Square Mile Plots
Prairie Pothole Region
State and Provincial Boundaries
USGS

Because wetlands are intricately linked with their upland catchments

It allows us to consider temporal wetland phases as ecosystem frames and to use our knowledge of land-use influences to make wall-to-wall landscape assessments and predictions

THE WETLAND CONTINUUM



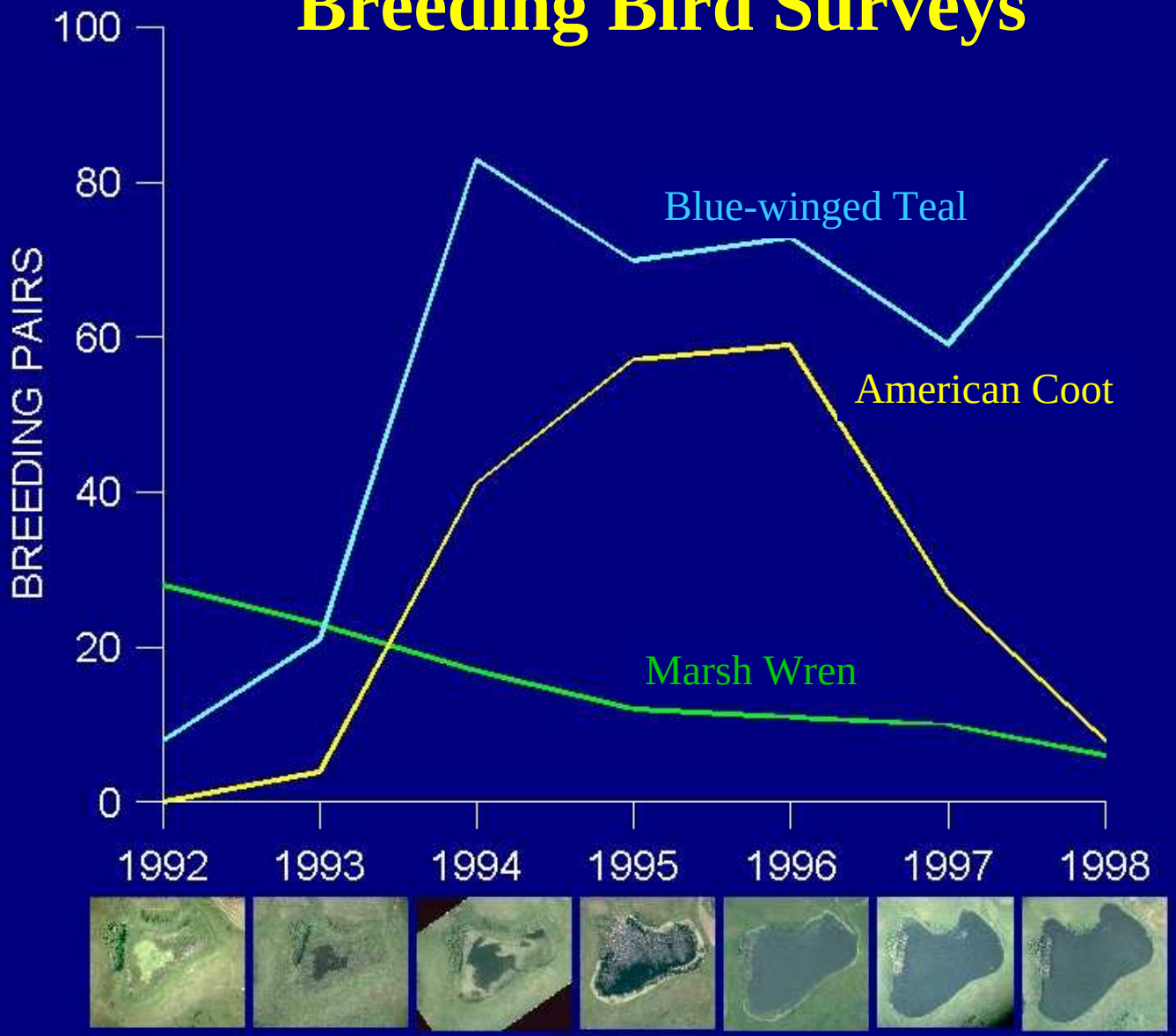
USGS

From Euliss et al. 2004

Cottonwood Lake Study Area
Wetland P7

USGS

Breeding Bird Surveys



USGS
science for a changing world

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

Impacts of CRP on Bird A and Carbon Sequestration

USGS

Impacts of CRP on Bird A and Carbon Sequestration

Climate Regime

Wetland Frames

Landscape A: 5 Wetlands

Landscape B: 5 Wetlands Plus CRP

Precipitation Regime

	precip	cum prob	prob
high	1	0.1	0.1
mid high	2	0.3	0.2
normal	3	0.8	0.5
low	4	1	0.2

frame	index	NEE (tonC/yr)
dry	1	0.2
degenrating	2	0.3
regenerating	3	0.4
lake	4	0.2

Wetland	rand	Precip Regime	The Frame a Wetland is in this year	Frame Transitions Previous Frame	Current Frame	NEE (tonC/yr)
A	0.78	3	degenrating	2	2	0.3
B	0.60	3	dry	1	1	0.2
C	0.81	4	dry	1	1	0.2
D	0.91	4	dry	1	1	0.2
E	0.24	2	lake	3	4	0.2

Number of Birds
Water Depth

Simulation Year: 0, 1

Wetland	1
Grassland	20
Crop	30
CRP	21

Landscape A (without CRP)

mile	1	2	3	4	5	6	7	8	9	10
1	30	30	30	30	30	20	20	20	20	20
2	30	30	30	30	30	20	30	30	20	20
3	30	30	30	30	30	C	30	30	20	20
4	30	30	30	30	30	30	30	30	20	20
5	30	30	30	30	30	30	D	30	20	20
6	30	30	30	30	30	30	30	30	20	20
7	30	20	30	30	30	30	30	30	20	20
8	30	20	30	30	30	30	30	30	20	20
9	30	A	20	30	B	30	30	20	E	20
10	30	20	30	30	30	30	30	20	20	20
11	30	30	30	30	30	30	20	20	20	20
12	30	30	30	30	30	30	20	20	20	20

Landscape B (with CRP)

mile	1	2	3	4	5	6	7	8	9	10
1	30	30	30	30	30	20	20	20	20	20
2	30	30	30	30	30	20	21	21	20	20
3	30	30	30	30	30	C	21	21	20	20
4	30	30	30	30	30	21	21	21	20	20
5	30	30	30	30	30	21	D	21	20	20
6	30	30	30	30	30	21	21	21	20	20
7	30	20	30	30	30	21	21	21	20	20
8	30	20	30	30	30	21	21	21	20	20
9	30	A	20	30	B	21	21	20	E	20
10	30	20	30	30	30	30	30	20	20	20
11	30	30	30	30	30	30	20	20	20	20
12	30	30	30	30	30	30	20	20	20	20

Model Parameters

C Gain under various precipitation for different systems

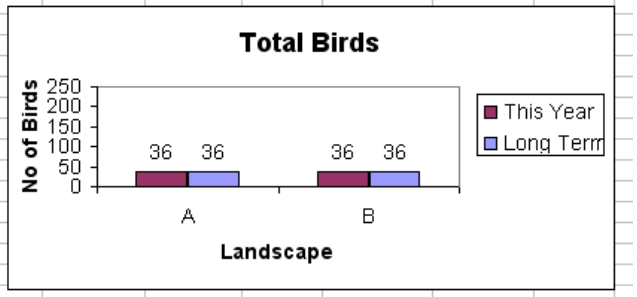
Ecosystem	Code	High	Mid-High	Normal	Low
		1	2	3	4
Wetland	1	0.2	0.4	0.3	0.2
Grassland	20	0.15	0.1	0	-0.1
Crop	30	0.1	0.05	0	-0.3
CRP	21	0.4	0.2	0.1	0

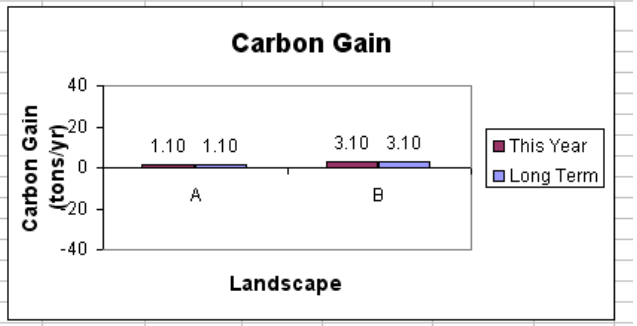
Bird A Ecology

	Dry	Regenerating	Degenerating	Lake
Bird A habitat quality (0-1)	0	1	0.6	0.4

	Minimum	Maximum
Impact of grassland extent (miles2) on	0	12
Maximum bird A population	50	

Year 1





USGS

Impacts of CRP on Bird A and Carbon Sequestration

Climate Regime

Wetland Frames

Landscape A: 5 Wetlands

Landscape B: 5 Wetlands Plus CRP

Precipitation Regime

	precip	cum prob	prob
high	1	0.1	0.1
mid high	2	0.3	0.2
normal	3	0.8	0.5
low	4	1	0.2

frame	index	NEE (tonC/yr)
dry	1	0.2
degenrating	2	0.3
regenerating	3	0.4
lake	4	0.2

Wetland	rand	Precip Regime	The Frame a Wetland is in this year	Frame Transitions: Previous Frame	Frame Transitions: Current Frame	NEE (tonC/yr)
A	0.78	3	degenrating	2	2	0.3
B	0.60	3	dry	1	1	0.2
C	0.81	4	dry	1	1	0.2
D	0.91	4	dry	1	1	0.2
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Model Parameters

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Crop	30	0.1	0.05	0	-0.3
CRP	21	0.4	0.2	0.1	0

Bird A Ecology

	Dry	Regenerating	Degenerating	Lake
Bird A habitat quality (0-1)	0	1	0.6	0.4

	Minimum	Maximum
Impact of grassland extent (miles2) on	0	12
Maximum bird A population	50	

Number of Birds
Water Depth

Simulation Year: 0, 1

Wetland	1
Grassland	20
Crop	30
CRP	21

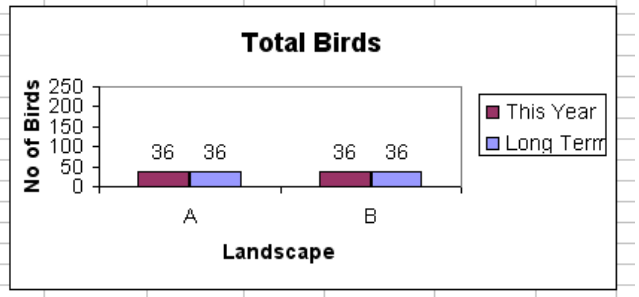
Landscape A (without CRP)

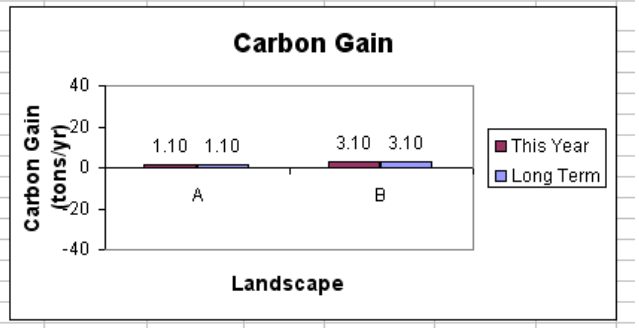
mile	1	2	3	4	5	6	7	8	9	10
1	30	30	30	30	30	20	20	20	20	20
2	30	30	30	30	30	20	30	30	20	20
3	30	30	30	30	30	C	30	30	20	20
4	30	30	30	30	30	30	30	30	20	20
5	30	30	30	30	30	30	D	30	20	20
6	30	30	30	30	30	30	30	30	20	20
7	30	20	30	30	30	30	30	30	20	20
8	30	20	30	30	30	30	30	30	20	20
9	30	A	20	30	B	30	30	20	E	20
10	30	20	30	30	30	30	30	20	20	20
11	30	30	30	30	30	30	20	20	20	20
12	30	30	30	30	30	30	20	20	20	20

Landscape B (with CRP)

mile	1	2	3	4	5	6	7	8	9	10
1	30	30	30	30	30	20	20	20	20	20
2	30	30	30	30	30	20	21	21	20	20
3	30	30	30	30	30	C	21	21	20	20
4	30	30	30	30	30	21	21	21	20	20
5	30	30	30	30	30	21	D	21	20	20
6	30	30	30	30	30	21	21	21	20	20
7	30	20	30	30	30	21	21	21	20	20
8	30	20	30	30	30	21	21	21	20	20
9	30	A	20	30	B	21	21	20	E	20
10	30	20	30	30	30	30	30	20	20	20
11	30	30	30	30	30	30	20	20	20	20
12	30	30	30	30	30	30	20	20	20	20

Year 1





USGS

Impacts of CRP on Bird A and Carbon Sequestration

Climate Regime

Wetland Frames

Land 5 We

Land 5 We Plus

Model Parameters

Precipitation Regime							NEE
	precip	cum prob	prob	frame	index		(tonC/yr)
high	1	0.1	0.1	dry	1		0.2
mid high	2	0.3	0.2	degenrating	2		0.3
normal	3	0.8	0.5	regenerating	3		0.4
low	4	1	0.2	lake	4		0.2

				Frame Transitions		
Wetland	rand	Precip Regime	The Frame a Wetland is in this year	Previous Frame	Current Frame	NEE (tonC/yr)
A	0.78	3	degenrating	2	2	0.3
B	0.60	3	dry	1	1	0.2
C	0.81	4	dry	1	1	0.2
D	0.91	4	dry	1	1	0.2
E	0.24	2	lake	3	4	0.2

C Gain under various precipitation for different systems

Ecosys...	Code	High	Mid-High	Normal	Low
		1	2	3	4
Wetland	1	0.2	0.4	0.3	0.2
Grassland	20	0.15	0.1	0	-0.1
Crop	30	0.1	0.05	0	-0.3
CRP	21	0.4	0.2	0.1	0

Bird A Ecology

	Dry	Regenerating	Degenerating	Lake
Bird A habitat quality (0-1)	0	1	0.6	0.4

	Minimum	Maximum

12	30	30	30	30	30	30	20	20	20	20	

USGS

Impacts of CRP on Bird A and Carbon Sequestration

Climate Regime

Wetland Frames

Landscape A: 5 Wetlands

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Precipitation Regime							NEE
	precip	cum prob	prob		frame	index	(tonC/yr)
high	1	0.1	0.1		dry	1	0.2
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D	0.91	4	dry	1	1	0.2
E	0.24	2	lake	3	4	0.2

Number of Birds
Water Depth

Simulation Year: 0, 1

Wetland	1
Grassland	20
Crop	30
CRP	21

Landscape A (without CRP)

mile	1	2	3	4	5	6	7	8	9	10
1	30	30	30	30	30	20	20	20	20	20
2	30	30	30	30	30	20	30	30	20	20
3	30	30	30	30	30	C	30	30	20	20
4	30	30	30	30	30	30	30	30	20	20
5	30	30	30	30	30	30	D	30	20	20
6	30	30	30	30	30	30	30	30	20	20
7	30	20	30	30	30	30	30	30	20	20
8	30	20	30	30	30	30	30	30	20	20
9	30	A	20	30	B	30	30	20	E	20
10	30	20	30	30	30	30	30	20	20	20
11	30	30	30	30	30	30	20	20	20	20
12	30	30	30	30	30	30	20	20	20	20

Landscape B (with CRP)

mile	1	2	3	4	5	6	7	8	9	10
1	30	30	30	30	30	20	20	20	20	20
2	30	30	30	30	30	20	21	21	20	20
3	30	30	30	30	30	C	21	21	20	20
4	30	30	30	30	30	21	21	21	20	20
5	30	30	30	30	30	21	D	21	20	20
6	30	30	30	30	30	21	21	21	20	20
7	30	20	30	30	30	21	21	21	20	20
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	Dry	Regenerating	Degenerating	Lake
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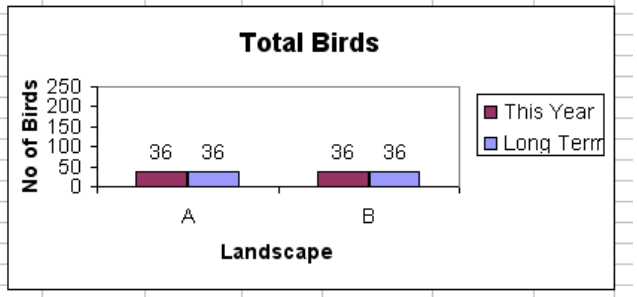
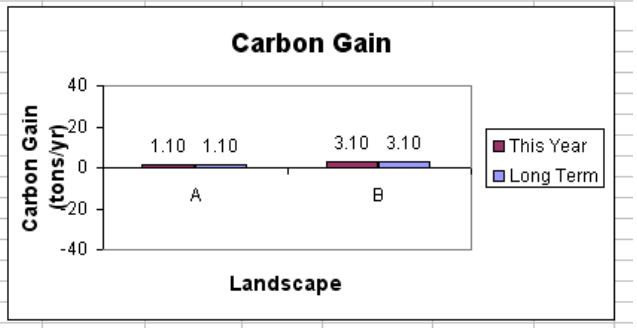
	Minimum	Maximum
Impact of grassland extent (miles2) on	0	12
Maximum bird A population	50	

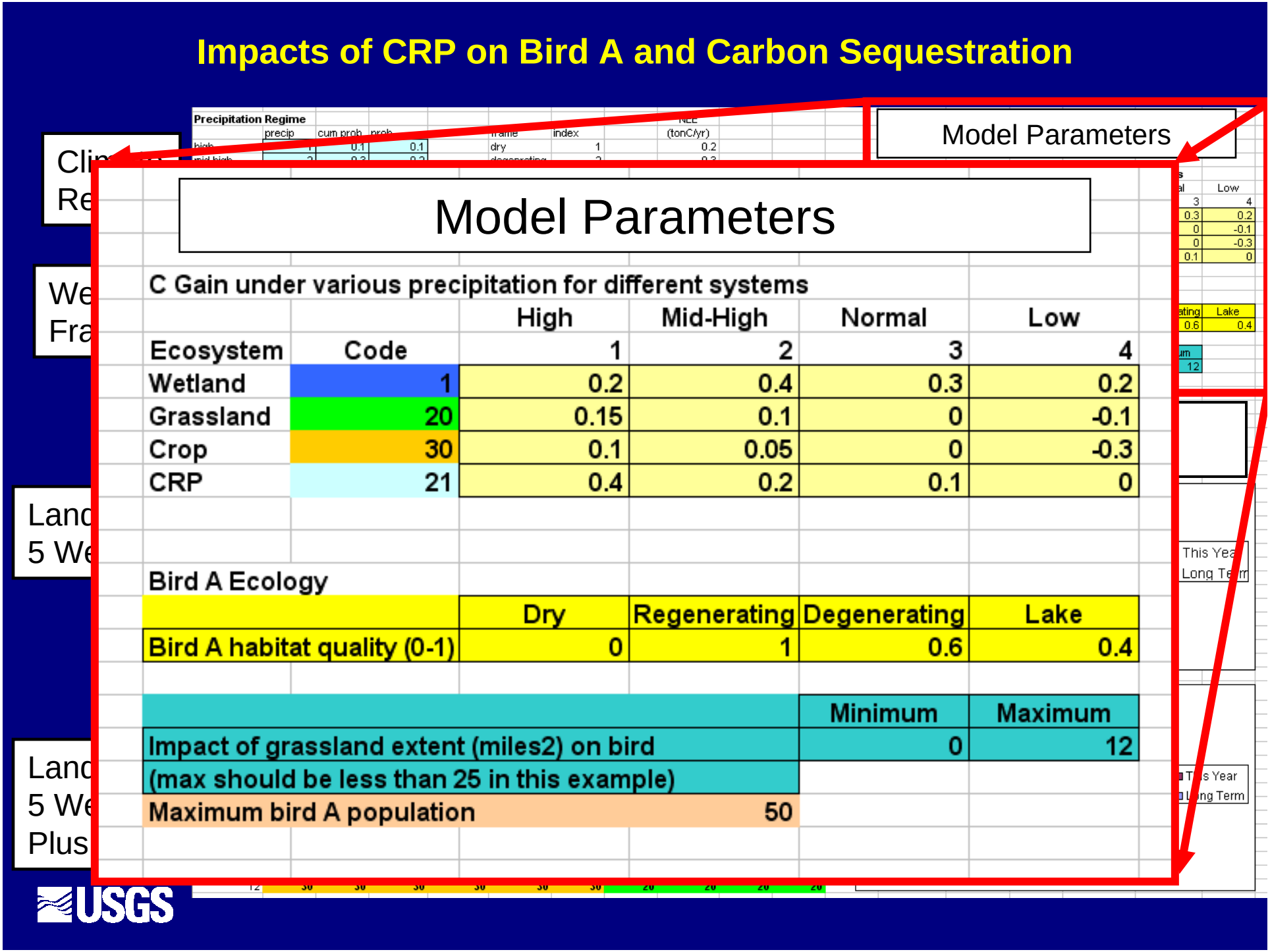
Year 1





USGS

Impacts of CRP on Bird A and Carbon Sequestration



Impacts of CRP on Bird A and Carbon Sequestration

Climate Regime

Wetland Frames

Landscape A: 5 Wetlands

Landscape B: 5 Wetlands Plus CRP

Precipitation Regime	precip	cum prob	prob
high	1	0.1	0.1
mid high	2	0.3	0.2
normal	3	0.8	0.5
low	4	1	0.2

frame	index	NEE (tonC/yr)
dry	1	0.2
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E	0.24	2	lake	3	4	0.2

Number of Birds
Water Depth

Simulation Year: 0 | 1

Wetland	1
Grassland	20
Crop	30
CRP	21

Landscape A (without CRP)

mile	1	2	3	4	5	6	7	8	9	10
1	30	30	30	30	30	20	20	20	20	20
2	30	30	30	30	30	20	30	30	20	20
3	30	30	30	30	30	C	30	30	20	20
4	30	30	30	30	30	30	30	30	20	20
5	30	30	30	30	30	30	D	30	20	20
6	30	30	30	30	30	30	30	30	20	20
7	30	20	30	30	30	30	30	30	20	20
8	30	20	30	30	30	30	30	30	20	20
9	30	A	20	30	B	30	30	20	E	20
10	30	20	30	30	30	30	30	20	20	20
11	30	30	30	30	30	30	20	20	20	20
12	30	30	30	30	30	30	20	20	20	20

Landscape B (with CRP)

mile	1	2	3	4	5	6	7	8	9	10
1	30	30	30	30	30	20	20	20	20	20
2	30	30	30	30	30	20	21	21	20	20
3	30	30	30	30	30	C	21	21	20	20
4	30	30	30	30	30	21	21	21	20	20
5	30	30	30	30	30	21	D	21	20	20
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7	30	20	30	30	30	21	21	21	20	20
8	30	20	30	30	30	21	21	21	20	20
9	30	A	20	30	B	21	21	20	E	20
10	30	20	30	30	30	30	30	20	20	20
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Model Parameters

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Ecosystem	Code	High	Mid-High	Normal	Low
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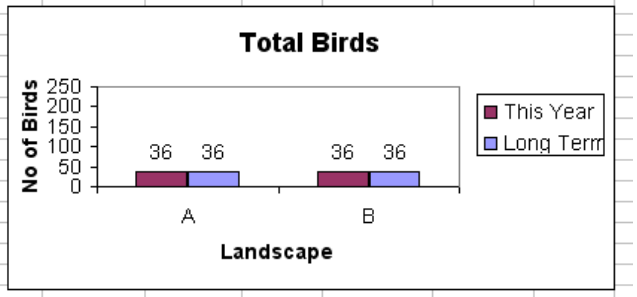
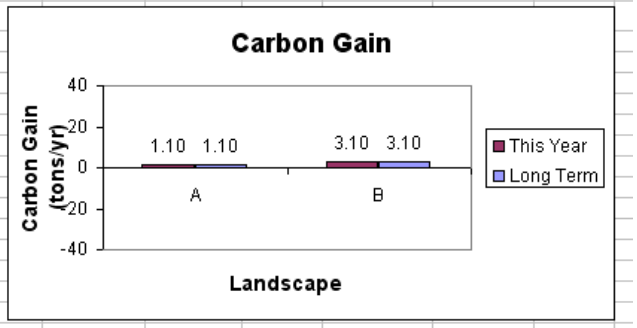
Bird A habitat quality (0-1)	0	1	0.6	0.4

	Minimum	Maximum
Impact of grassland extent (miles2) on	0	12
Maximum bird A population	50	

Year 1





USGS

Impacts of CRP on Bird A and Carbon Sequestration

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Precipitation Regime	precip	cum prob	prob
high	1	0.1	0.1
mid high	2	0.3	0.2
normal	3	0.8	0.5
low	4	1	0.2

frame	index	NEE (tonC/yr)
dry	1	0.2
degenrating	2	0.3
regenerating	3	0.4
lake	4	0.2

Wetland	rand	Precip Regime	The Frame a Wetland is in this year	Frame Transitions: Previous Frame	Current Frame	NEE (tonC/yr)
A	0.78	3	degenrating	2	2	0.3
B	0.60	3	dry	1	1	0.2
C	0.81	4	dry	1	1	0.2
D	0.91	4	dry	1	1	0.2
E	0.24	2	lake	3	4	0.2

Model Parameters

C Gain under various precipitation for different systems

Ecosystem	Code	High	Mid-High	Normal	Low
		1	2	3	4
Wetland	1	0.2	0.4	0.3	0.2
Grassland	20	0.15	0.1	0	-0.1
Crop	30	0.1	0.05	0	-0.3
CRP	21	0.4	0.2	0.1	0

Bird A Ecology

	Dry	Regenerating	Degenerating	Lake
Bird A habitat quality (0-1)	0	1	0.6	0.4

	Minimum	Maximum
Impact of grassland extent (miles2) on	0	12
Maximum bird A population	50	

Landscape B (with CRP)

mile	1	2	3	4	5	6	7	8	9	10
1	30	30	30	30	30	20	20	20	20	20
2	30	30	30	30	30	20	21	21	20	20
3	30	30	30	30	30	C	21	21	20	20
4	30	30	30	30	30	21	21	21	20	20
5	30	30	30	30	30	21	D	21	20	20
6	30	30	30	30	30	21	21	21	20	20
7	30	20	30	30	30	21	21	21	20	20
8	30	20	30	30	30	21	21	21	20	20
9	30	A	20	30	B	21	21	20	20	20
10	30	20	30	30	30	30	30	20	E	20
11	30	30	30	30	30	30	20	20	20	20
12	30	30	30	30	30	30	20	20	20	20

Landscape

USGS

Impacts of CRP on Bird A and Carbon Sequestration

Climate Regime

Wetland Frames

Landscape A: 5 Wetlands

Landscape B: 5 Wetlands Plus CRP

Precipitation Regime

	precip	cum prob	prob
high	1	0.1	0.1
mid high	2	0.3	0.2
normal	3	0.8	0.5
low	4	1	0.2

frame	index	NEE (tonC/yr)
dry	1	0.2
degenrating	2	0.3
regenerating	3	0.4
lake	4	0.2

Wetland	rand	Precip Regime	The Frame a Wetland is in this year	Frame Transitions Previous Frame	Current Frame	NEE (tonC/yr)
A	0.78	3	degenrating	2	2	0.3
B	0.60	3	dry	1	1	0.2
C	0.81	4	dry	1	1	0.2
D	0.91	4	dry	1	1	0.2
E	0.24	2	lake	3	4	0.2

Number of Birds
Water Depth

Simulation Year: 0, 1

Wetland	1
Grassland	20
Crop	30
CRP	21

Landscape A (without CRP)

mile	1	2	3	4	5	6	7	8	9	10
1	30	30	30	30	30	20	20	20	20	20
2	30	30	30	30	30	20	30	30	20	20
3	30	30	30	30	30	C	30	30	20	20
4	30	30	30	30	30	30	30	30	20	20
5	30	30	30	30	30	30	D	30	20	20
6	30	30	30	30	30	30	30	30	20	20
7	30	20	30	30	30	30	30	30	20	20
8	30	20	30	30	30	30	30	30	20	20
9	30	A	20	30	B	30	30	20	E	20
10	30	20	30	30	30	30	30	20	20	20
11	30	30	30	30	30	30	20	20	20	20
12	30	30	30	30	30	30	20	20	20	20

Landscape B (with CRP)

mile	1	2	3	4	5	6	7	8	9	10
1	30	30	30	30	30	20	20	20	20	20
2	30	30	30	30	30	20	21	21	20	20
3	30	30	30	30	30	C	21	21	20	20
4	30	30	30	30	30	21	21	21	20	20
5	30	30	30	30	30	21	D	21	20	20
6	30	30	30	30	30	21	21	21	20	20
7	30	20	30	30	30	21	21	21	20	20
8	30	20	30	30	30	21	21	21	20	20
9	30	A	20	30	B	21	21	20	E	20
10	30	20	30	30	30	30	30	20	20	20
11	30	30	30	30	30	30	20	20	20	20
12	30	30	30	30	30	30	20	20	20	20

Model Parameters

C Gain under various precipitation for different systems

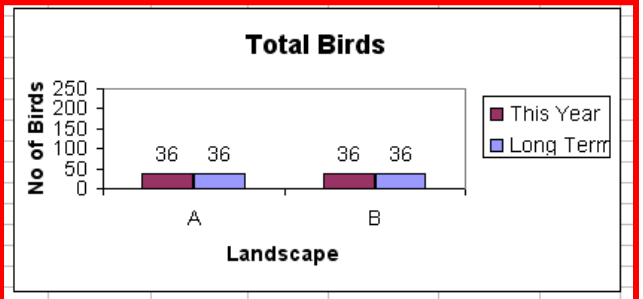
Ecosystem	Code	High	Mid-High	Normal	Low
		1	2	3	4
Wetland	1	0.2	0.4	0.3	0.2
Grassland	20	0.15	0.1	0	-0.1
Crop	30	0.1	0.05	0	-0.3
CRP	21	0.4	0.2	0.1	0

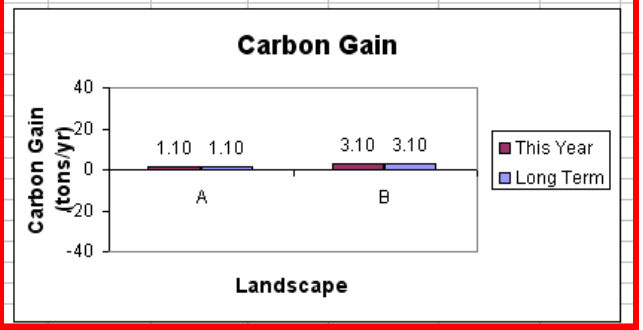
Bird A Ecology

	Dry	Regenerating	Degenerating	Lake
Bird A habitat quality (0-1)	0	1	0.6	0.4

	Minimum	Maximum
Impact of grassland extent (miles2) on	0	12
Maximum bird A population	50	

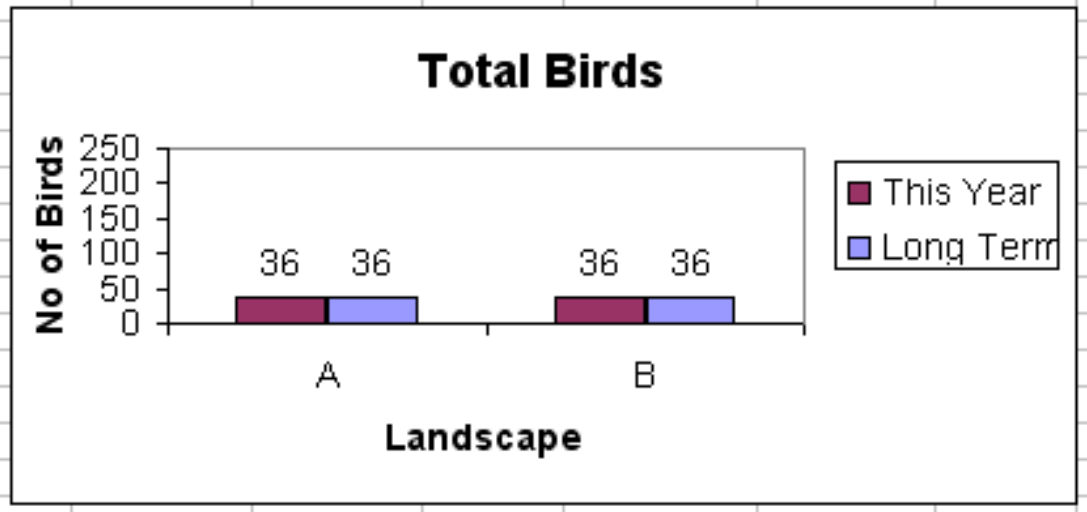
Year 1

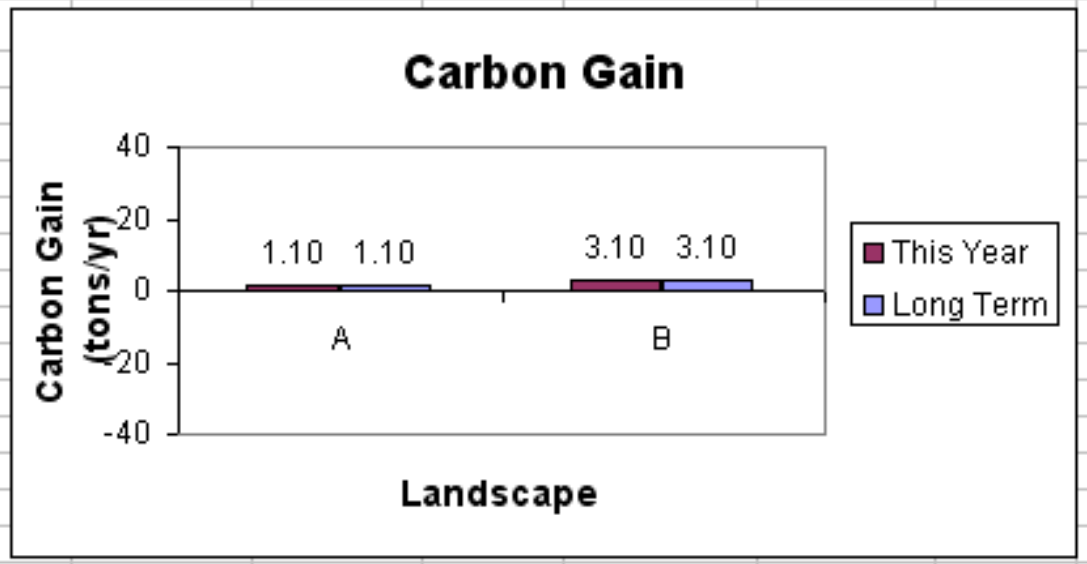




USGS

Impacts of CRP on Bird A and Carbon Sequestration





Model Parameters

C Gain under various precipitation for different systems

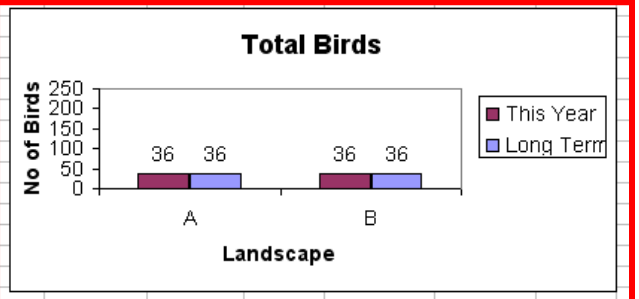
Ecosystem	Code	High	Mid-High	Normal	Low
		1	2	3	4
Wetland	1	0.2	0.4	0.3	0.2
Grassland	20	0.15	0.1	0	-0.1
Crop	30	0.1	0.05	0	-0.3
CRP	21	0.4	0.2	0.1	0

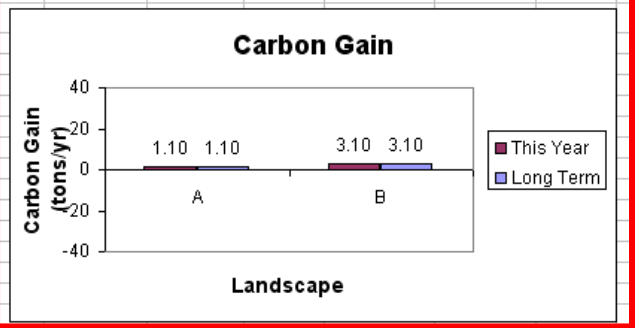
Bird A Ecology

	Dry	Regenerating	Degenerating	Lake
Bird A habitat quality (0-1)	0	1	0.6	0.4

	Minimum	Maximum
Impact of grassland extent (miles2) on	0	12
Maximum bird A population	50	

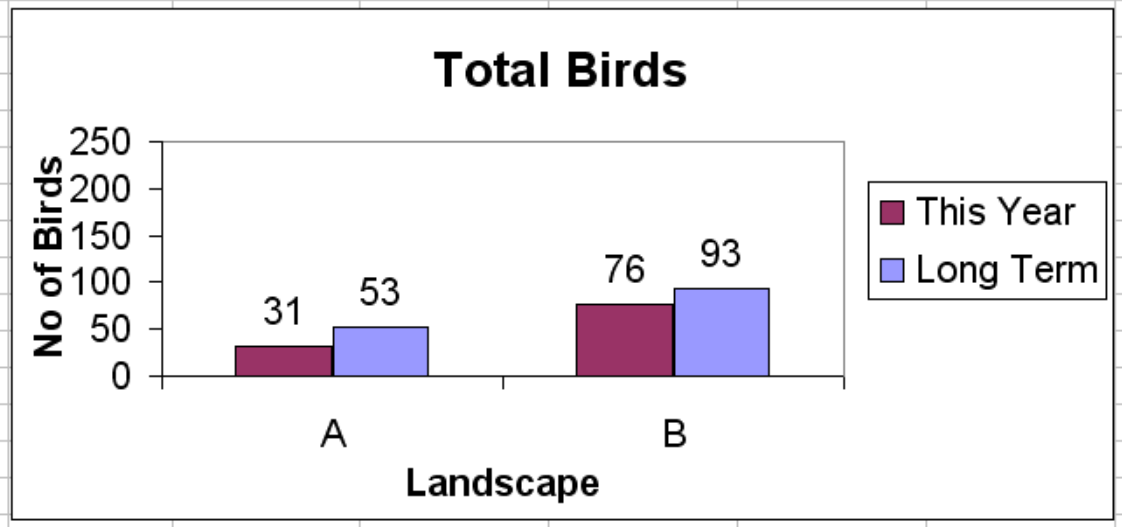
Year 1

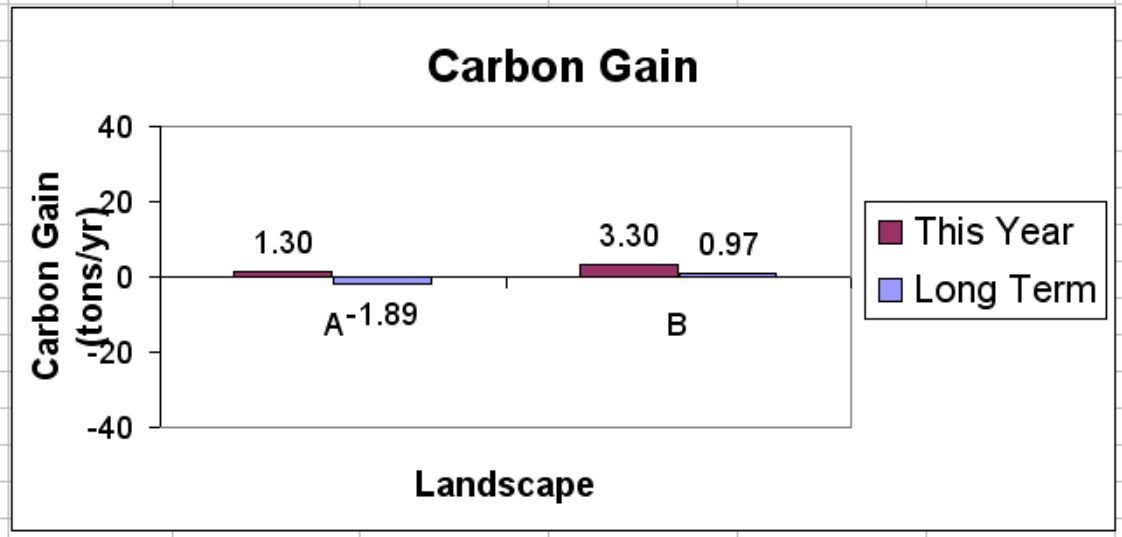




USGS

Impacts of CRP on Bird A and Carbon Sequestration





Model Parameters

C Ga under various precipitation for different systems

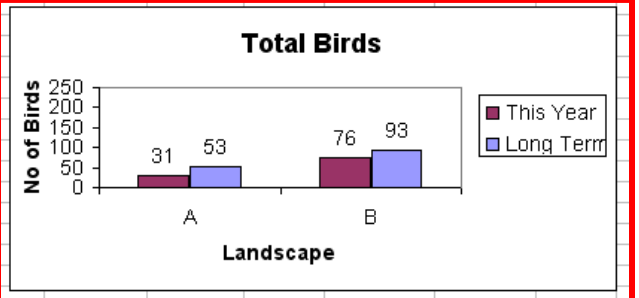
Ecosystem	Code	High	Mid-High	Normal	Low
		1	2	3	4
Wetland	1	0.2	0.4	0.3	0.2
Grassland	20	0.15	0.1	0	-0.1
Crop	30	0.1	0.05	0	-0.3
CRP	2	0.4	0.2	0.1	0

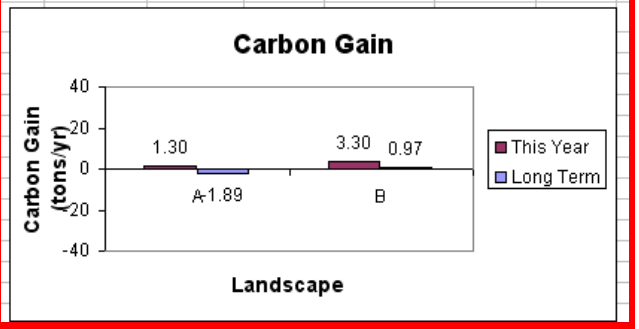
Bird A Ecology

	Dry	Regenerating	Degenerating	Lake
Bird A habitat quality (0-1)	0	1	0.6	0.4

	Minimum	Maximum
Impact of grassland extent (miles2) on	0	12
Maximum bird A population	50	

Year 100





10	30	20	30	30	30	30	30	20	E	20
11	30	30	30	30	30	30	20	20	20	20
12	30	30	30	30	30	30	20	20	20	20

USGS

Impacts of Climate Change on Bird A and Carbon Sequestration

USGS

Impacts of Climate Change on Bird A and Carbon Sequestration

Climate Regime

Wetland Frames

Land 5 We

Land 5 We Plus

Model Parameters

Precipitation Regime

	precip	cum prob	prob
high	1	0.1	0.1
mid high	2	0.3	0.2
normal	3	0.7	0.4
low	4	1	0.3

frame	index	NEE (tonC/yr)
dry	1	0.2
degenrating	2	0.3
regenerating	3	0.4
lake	4	0.2

Wetland	rand	Precip Regime	The Frame a Wetland is in this year	Frame Transitions Previous Frame	Current Frame	NEE (tonC/yr)
A	0.52	3	degenrating	2	2	0.3
B	0.29	2	lake	3	4	0.2
C	0.95	4	dry	3	1	0.2
D	0.97	4	degenrating	4	2	0.3
E	0.70	3	dry	1	1	0.2

C Gain under various precipitation for different systems

Ecosys	Code	High	Mid-High	Normal	Low
		1	2	3	4
Wetland	1	0.2	0.4	0.3	0.2
Grassland	20	0.15	0.1	0	-0.1
Crop	30	0.1	0.05	0	-0.3
CRP	21	0.4	0.2	0.1	0

Bird A Ecology

	Dry	Regenerating	Degenerating	Lake
Bird A habitat quality (0-1)	0	1	0.6	0.4

	Minimum	Maximum

Precipitation Regime

	precip	cum prob	prob
high	1	0.1	0.1
mid high	2	0.3	0.2
normal	3	0.7	0.4
low	4	1	0.3

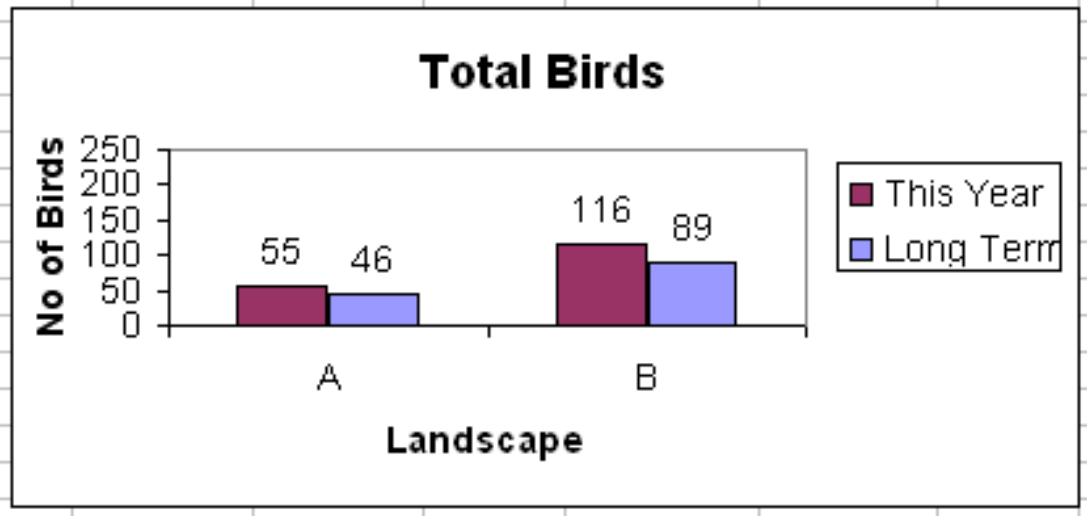
frame	index	NEE (tonC/yr)
dry	1	0.2
degenrating	2	0.3
regenerating	3	0.4
lake	4	0.2

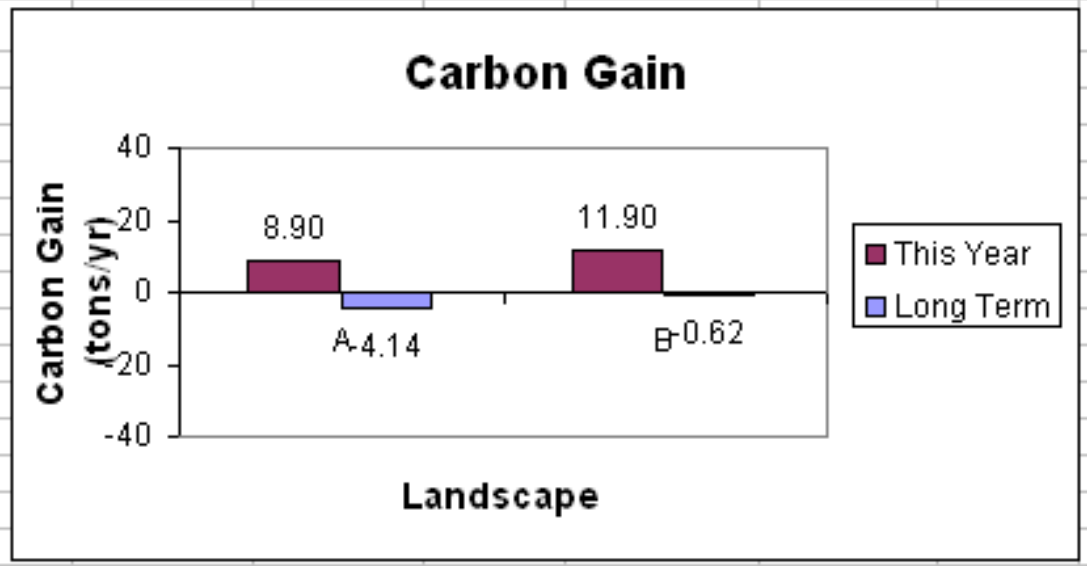
Wetland	rand	Precip Regime	The Frame a Wetland is in this year	Frame Transitions Previous Frame	Current Frame	NEE (tonC/yr)
A	0.78	4	dry	2	1	0.2
B	0.60	3	dry	1	1	0.2
C	0.81	4	dry	1	1	0.2
D	0.91	4	dry	1	1	0.2
E	0.24	2	lake	3	4	0.2

12	30	30	30	30	30	30	20	20	20	20

USGS

Impacts of Climate Change on Bird A and Carbon Sequestration





Model Parameters

C Gain under various precipitation for different systems

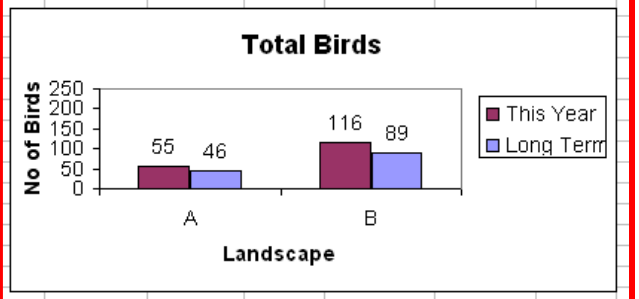
Ecosystem	Code	High	Mid-High	Normal	Low
		1	2	3	4
Wetland	1	0.2	0.4	0.3	0.2
Grassland	20	0.15	0.1	0	-0.1
Crop	3	0.1	0.05	0	-0.3
CRP	21	0.4	0.2	0.1	0

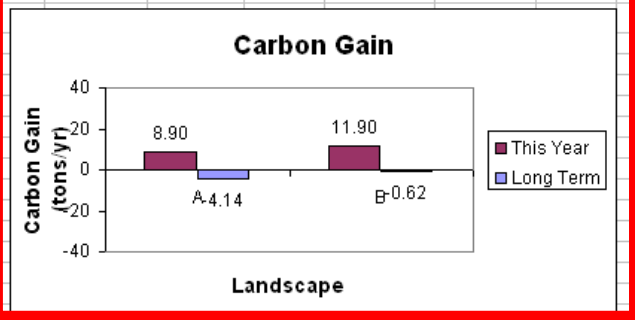
Bird A Ecology

	Dry	Regenerating	Degenerating	Lake
Bird A habitat quality (0-1)	0	1	0.6	0.4

	Minimum	Maximum
Impact of grassland extent (miles2) on	0	12
Maximum bird A population	50	

Year 100





11	30	30	30	30	30	30	20	20	20	20
12	30	30	30	30	30	30	20	20	20	

Two Possible Solutions to Offset the Effects of Climate Change

USGS

1. Restore Wetlands
2. Expand CRP

USGS

Impacts of Targeted CRP on Bird A and Carbon Sequestration

Climate Regime

Wetland Frames

Landscape A: 5 Wetlands

Landscape B: 7 Wetlands Plus More CRP

Precipitation Regime

	precip	cum prob	prob
high	1	0.1	0.1
mid high	2	0.3	0.2
normal	3	0.7	0.4
low	4	1	0.3

frame	index	NEE (tonC/yr)
dry	1	0.2
degenrating	2	0.3
regenerating	3	0.4
lake	4	0.2

Wetland	rand	Precip Regime	The Frame a Wetland is in this year	Frame Transitions Previous Frame	Current Frame	NEE (tonC/yr)
A	1.00	4	dry	2	1	0.2
B	0.68	3	dry	1	1	0.2
C	0.44	3	degenrating	4	2	0.3
D	0.42	3	dry	1	1	0.2
E	0.13	2	lake	4	4	0.2
F	0.94	4	dry	1	1	0.2
G	0.29	2	regenerating	1	3	0.4

Number of Birds
Water Depth

Simulation Year: 0 | 1

Wetland	1
Grassland	20
Crop	30
CRP	21

Landscape A (without CRP)

mile	1	2	3	4	5	7	8	9	10
1	30	30	30	30	30	20	20	20	20	20
2	30	30	30	30	30	20	30	30	20	20
3	30	30	30	30	30	C	30	30	20	20
4	30	30	30	30	30	30	30	30	20	20
5	30	30	30	30	30	30	D	30	20	20
6	30	30	30	30	30	30	30	30	20	20
7	30	20	30	30	30	30	30	30	20	20
8	30	20	30	30	30	30	30	30	20	20
9	30	A	20	30	B	30	30	20	E	20
10	30	20	30	30	30	30	30	20	E	20
11	30	30	30	30	30	30	20	20	20	20
12	30	30	30	30	30	30	20	20	20	20

Landscape B (with CRP)

mile	1	2	3	4	5	7	8	9	10
1	30	30	30	30	30	20	20	20	20	20
2	30	30	30	30	30	20	21	21	20	20
3	30	21	21	30	21	E	21	21	20	20
4	21	F	21	30	21	21	21	21	20	20
5	21	21	21	G	21	D	21	21	20	20
6	30	21	21	21	21	21	21	21	20	20
7	30	20	30	30	21	21	21	21	20	20
8	30	20	30	30	21	21	21	21	20	20
9	30	A	20	30	B	21	21	20	20	20
10	30	20	30	30	30	30	30	20	E	20
11	30	30	30	30	30	30	20	20	20	20
12	30	30	30	30	30	30	20	20	20	20

Model Parameters

C Gain under various precipitation for different systems

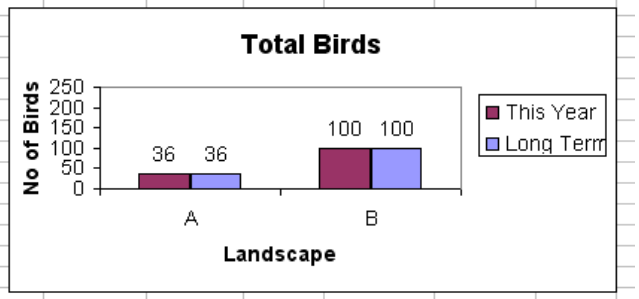
Ecosystem	Code	High	Mid-High	Normal	Low
		1	2	3	4
Wetland	1	0.2	0.4	0.3	0.2
Grassland	20	0.15	0.1	0	-0.1
Crop	30	0.1	0.05	0	-0.3
CRP	21	0.4	0.2	0.1	0

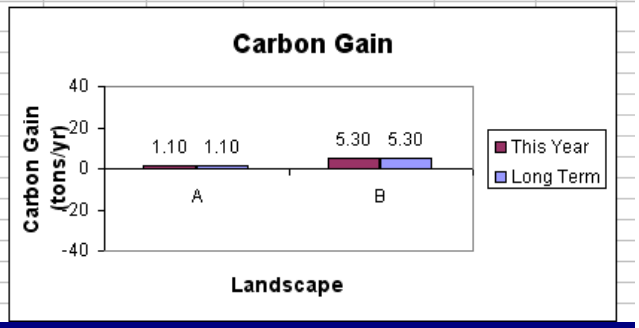
Bird A Ecology

	Dry	Regenerating	Degenerating	Lake
Bird A habitat quality (0-1)	0	1	0.6	0.4

	Minimum	Maximum
Impact of grassland extent (miles2) on	0	12
Maximum bird A population	50	

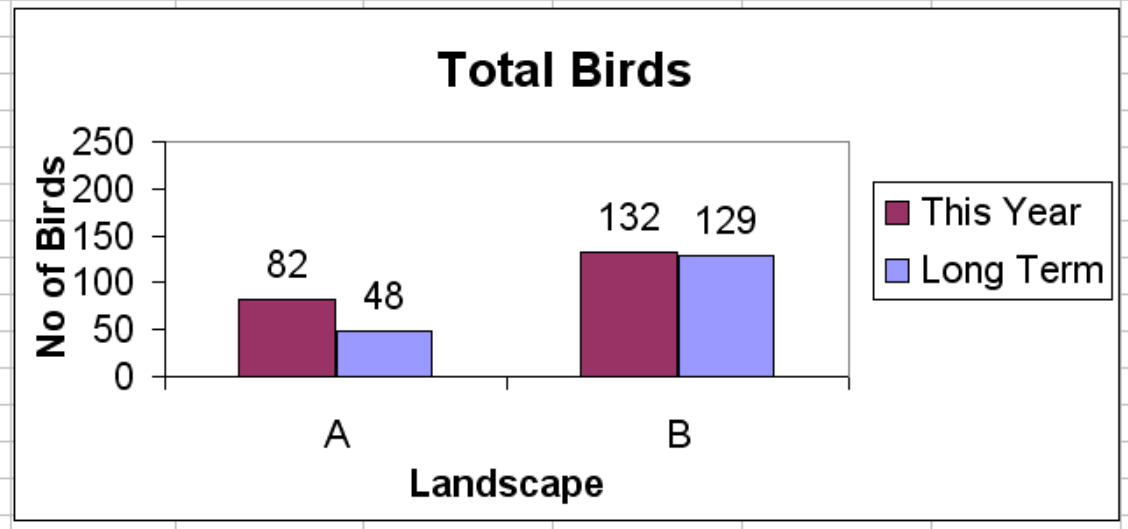
Year 1

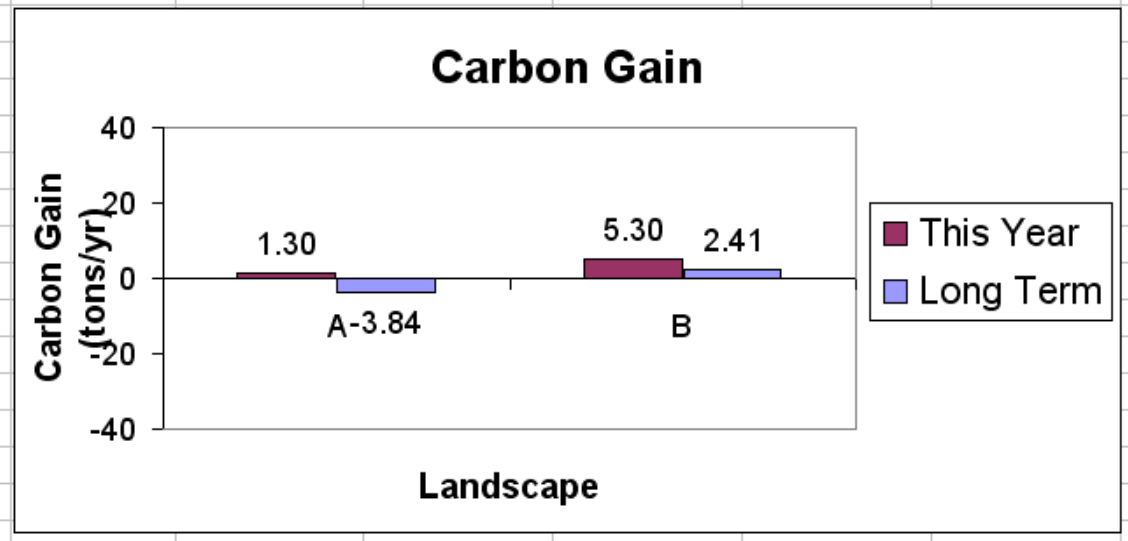




USGS

Impacts of Targeted CRP on Bird A and Carbon Sequestration





Model Parameters

C Gain under various precipitation for different systems

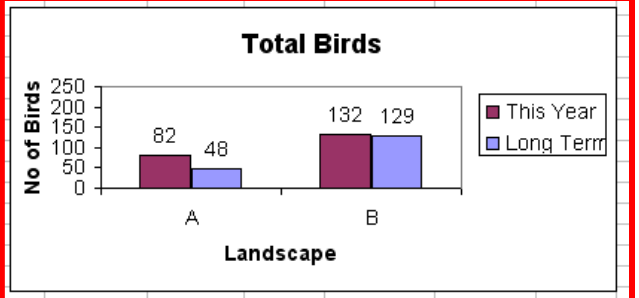
Ecosystem	Code	High	Mid-High	Normal	Low
		1	2	3	4
Wetland	1	0.2	0.4	0.3	0.2
Grassland	20	0.15	0.1	0	-0.1
Crop	30	0.1	0.05	0	-0.3
CRP	21	0.4	0.2	0.1	0

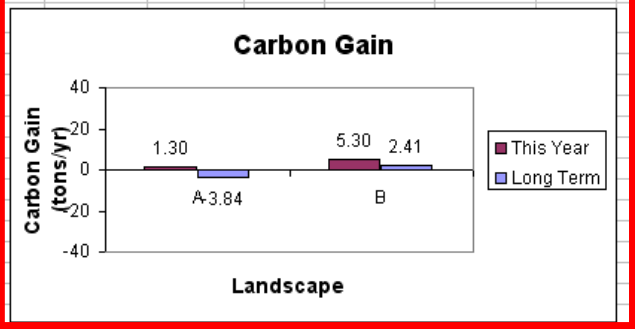
Bird A Ecology

	Dry	Regenerating	Degenerating	Lake
Bird A habitat quality (0-1)	0	1	0.6	0.4

	Minimum	Maximum
Impact of grassland extent (miles2) on	0	12
Maximum bird A population	50	

Year 100

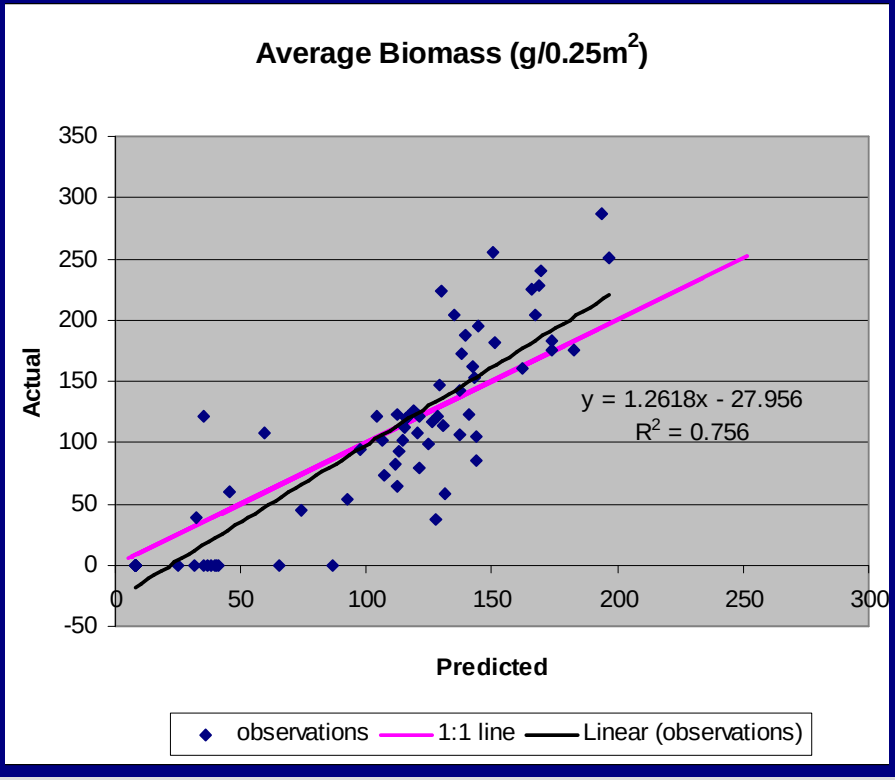




USGS

Comparison of Measured and Predicted Biomass Using Regression Trees and Landsat Data

Regression Statistics	
Multiple R	0.86946
R Square	0.75596
Adjusted R Square	0.752474
Standard Error	39.02076
Observations	72



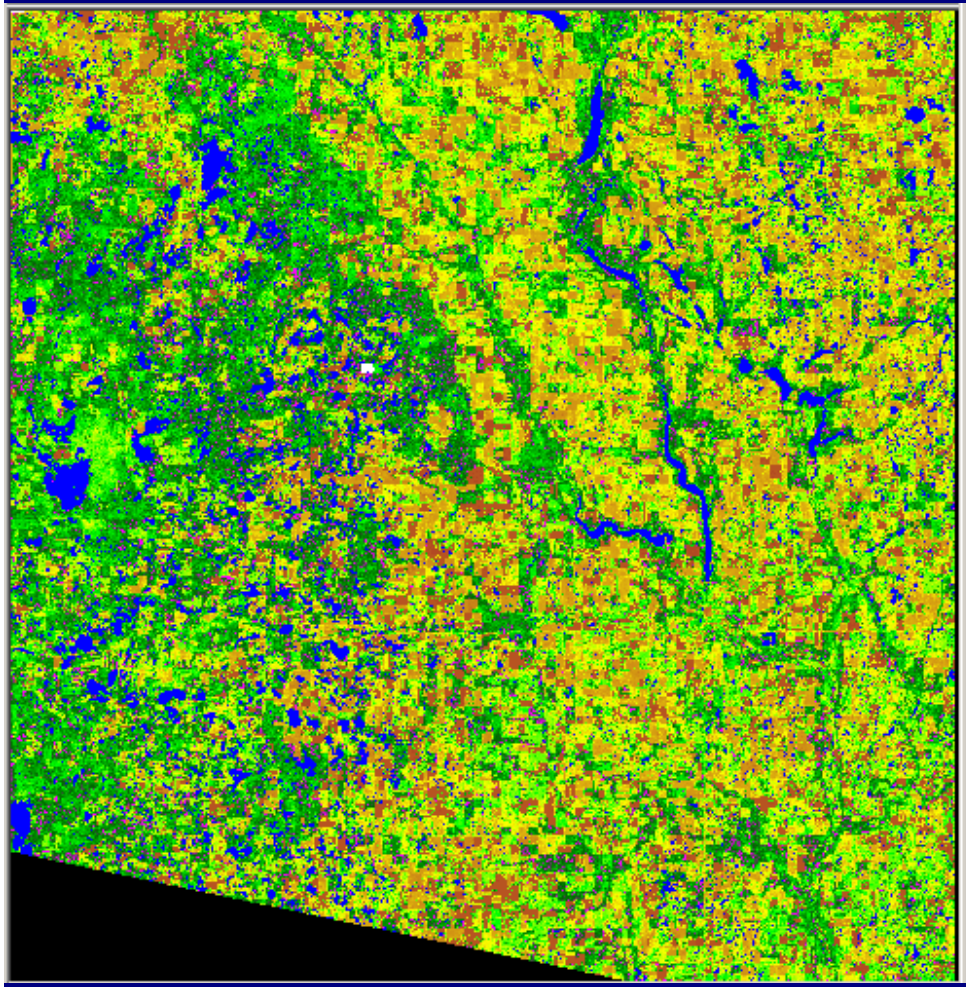
AVERAGE of 3 models

- MSAVI, Treat2, GNDVI, Moist
- Treat2, GNDVI, LAI, Moist, GEMI, NDVI, B2,3,4
- Treat2, GNDVI, LAI, Moist, GEMI, % water, NDVI

Variable	Description	Formula
Treat2	Crop/Grass	na
GNDVI	Green NDVI	TM (4 - 2) / (4 + 2)
LAI	Specific Leaf Area Index	TM (4) / (3 + 7)
Moist	Moisture Index	TM (4 - 5) / (4 + 5)
NDVI	Normalized Difference Vegetation Index	TM (4 - 3) / (4 + 3)
MSAVI	Modified Soil Adjusted Vegetation Index	1/2 (2 TM4 + 1 sqrt(((2 TM4 + 1) - 8(TM4 - TM3))))
GEMI		n * (1 - 0.25 * n) - (TM3 - 0.125) / (1 - TM3), where n = (2 ($TM4^2$ - $TM3^2$) + 1/5 TM4 + 0.5 TM3) / (TM4 + TM3 + 0.5)
% water	Percent Water	regression tree sub-pixel estimate
B2	Blue band	na
B3	Red band	na
B4	Near Infra-red	na

USGS

Predicted Biomass

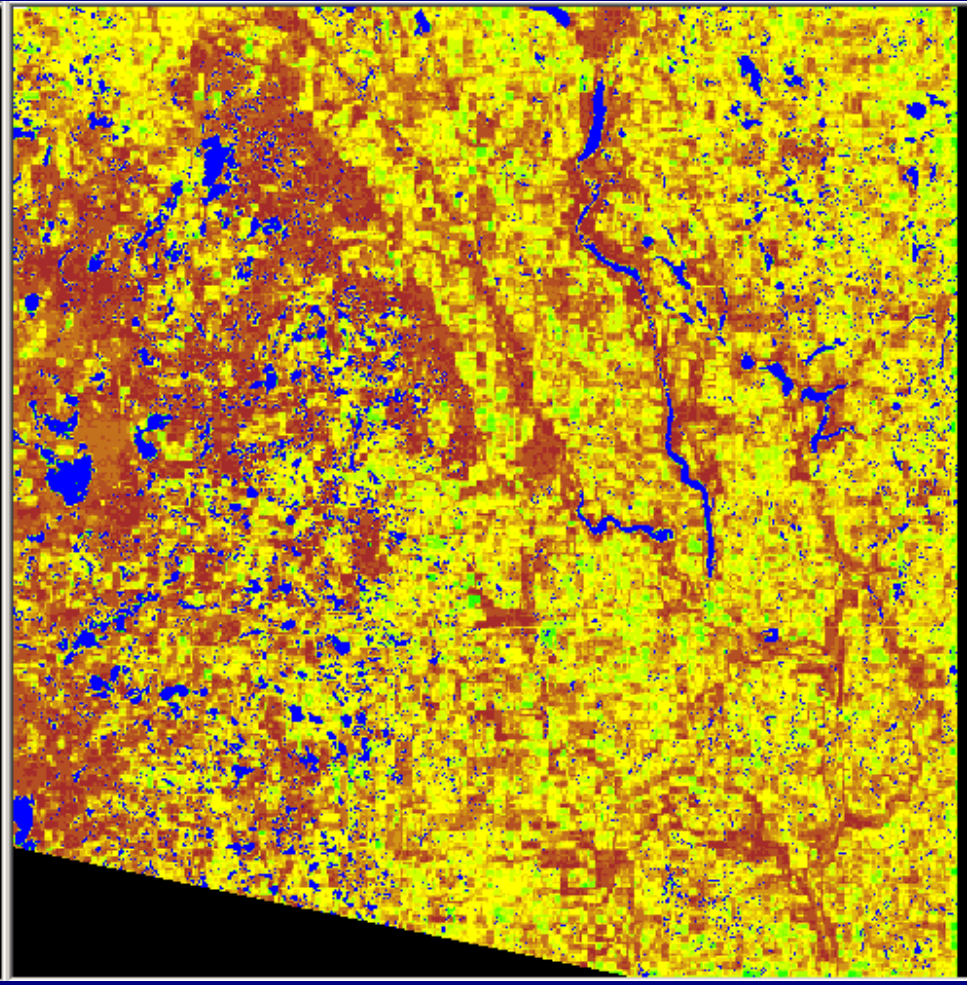


Biomass (g/0.25m^2)

0 | 40 | 80 | 130 | >168 | water

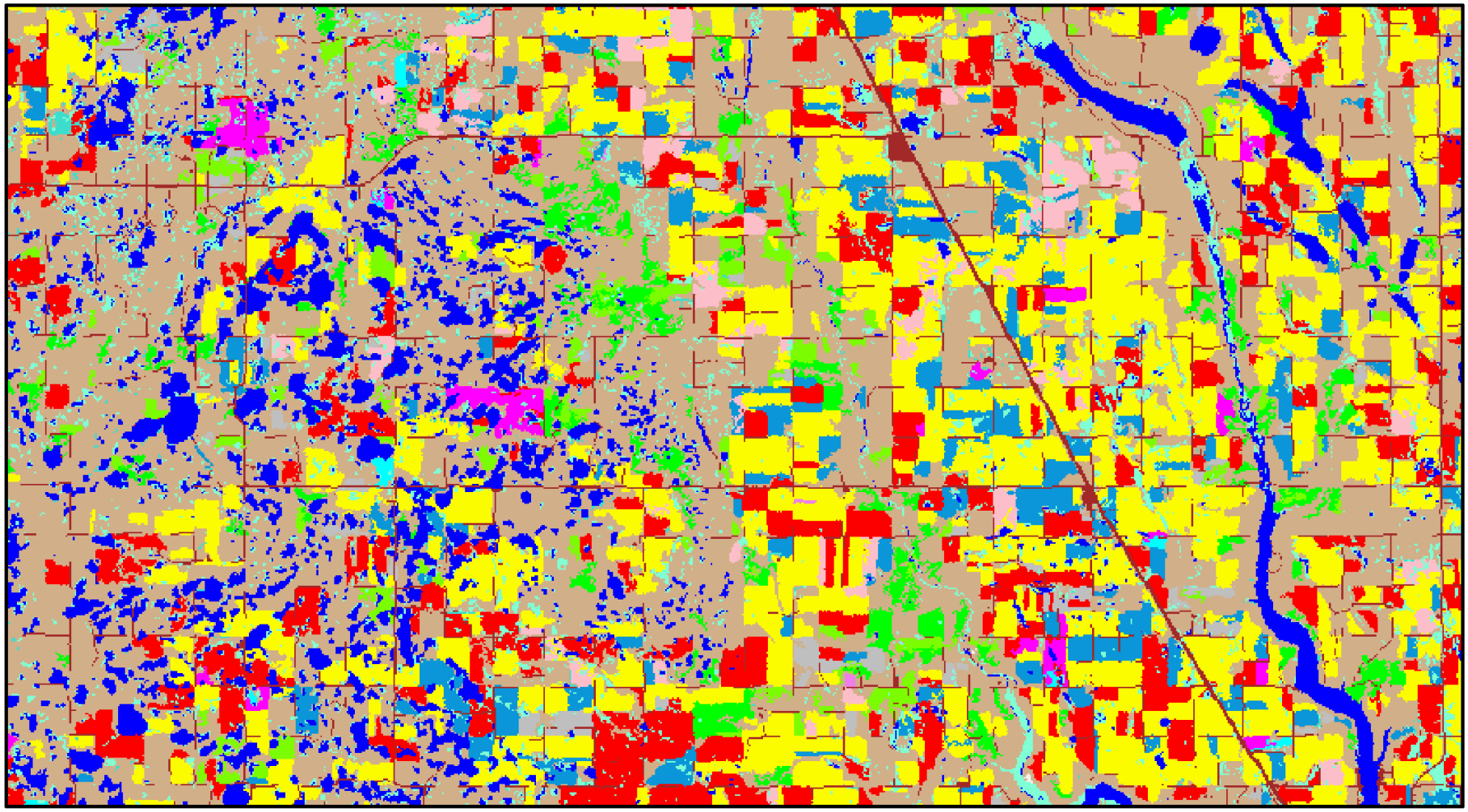
USGS

Confidence of Predicted Biomass



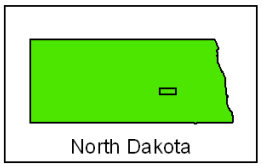
Coefficient of Variation

0 | 0.6 | 1.2 | >1.5 | water



Land Use Categories

- Corn
- Soybeans
- Sunflowers
- Durum Wheat
- Other Small Grains & Hay
- Beets
- Dry Edible Beans
- Potatoes
- All Other Crops
- Canola
- Fallow/Idle Cropland/CRP
- Pasture/Range/Non-Ag
- Woods
- Clouds
- Urban
- Water



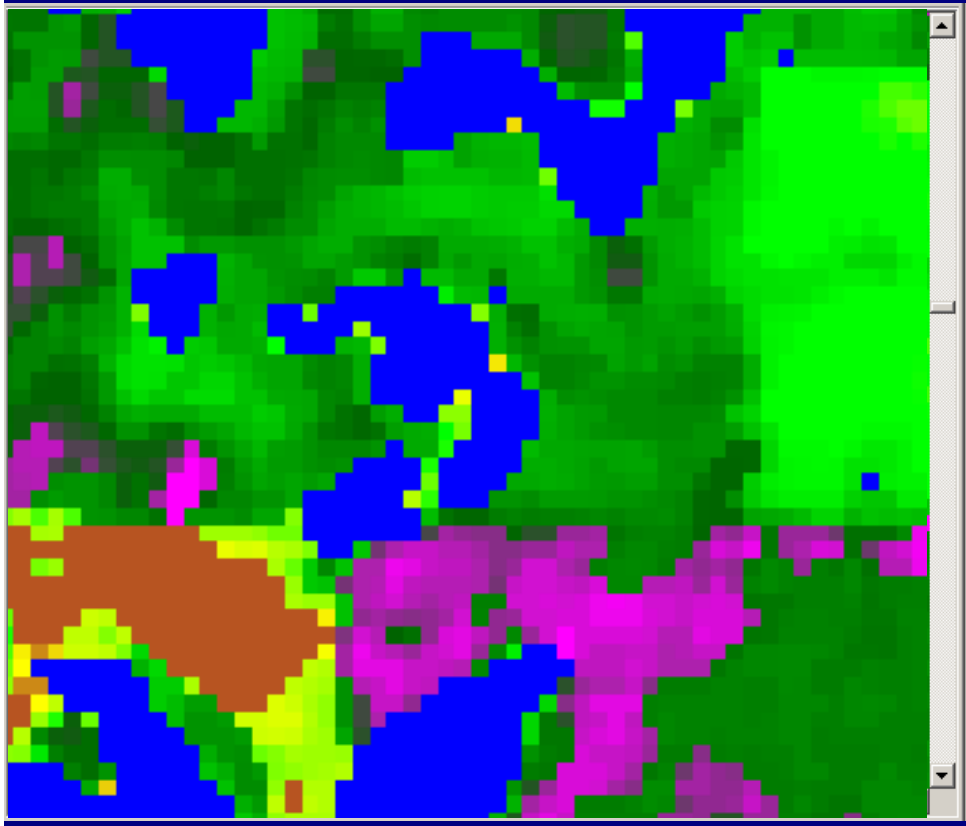
0 2.5 5 10 Miles

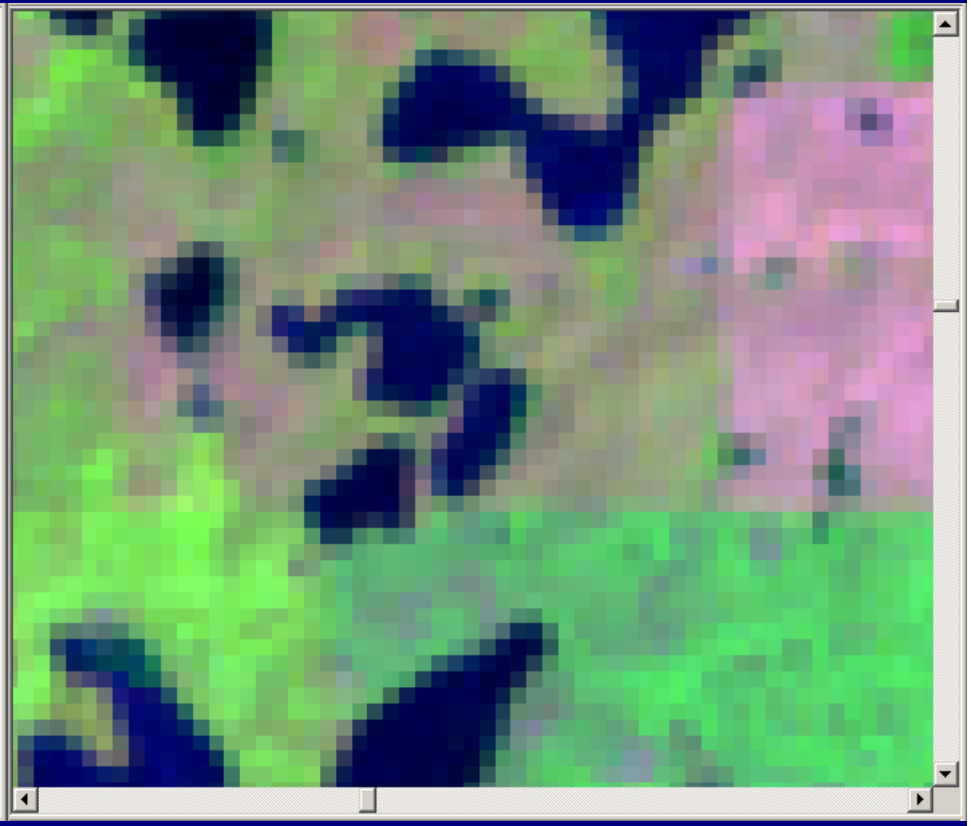
2006
National Agricultural Statistics Service
Cropland Data Layer

Cottonwood Lake Study Area

Predicted Biomass

Landsat TM (July 9, 2004, b5,b4,b3)



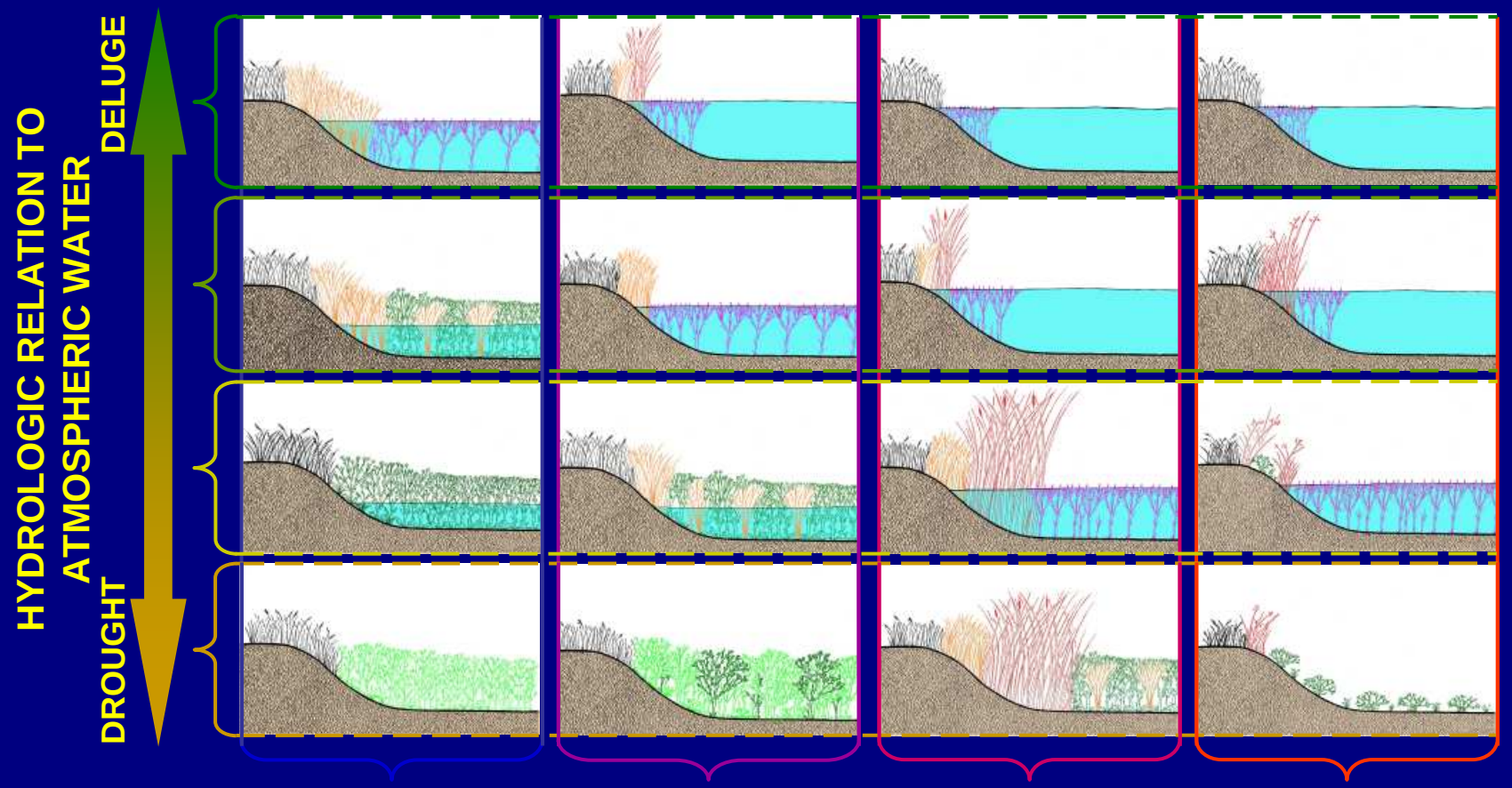


Biomass (g/0.25m^2)

0 | 40 | 80 | 130 | >168 | water

USGS

THE WETLAND CONTINUUM



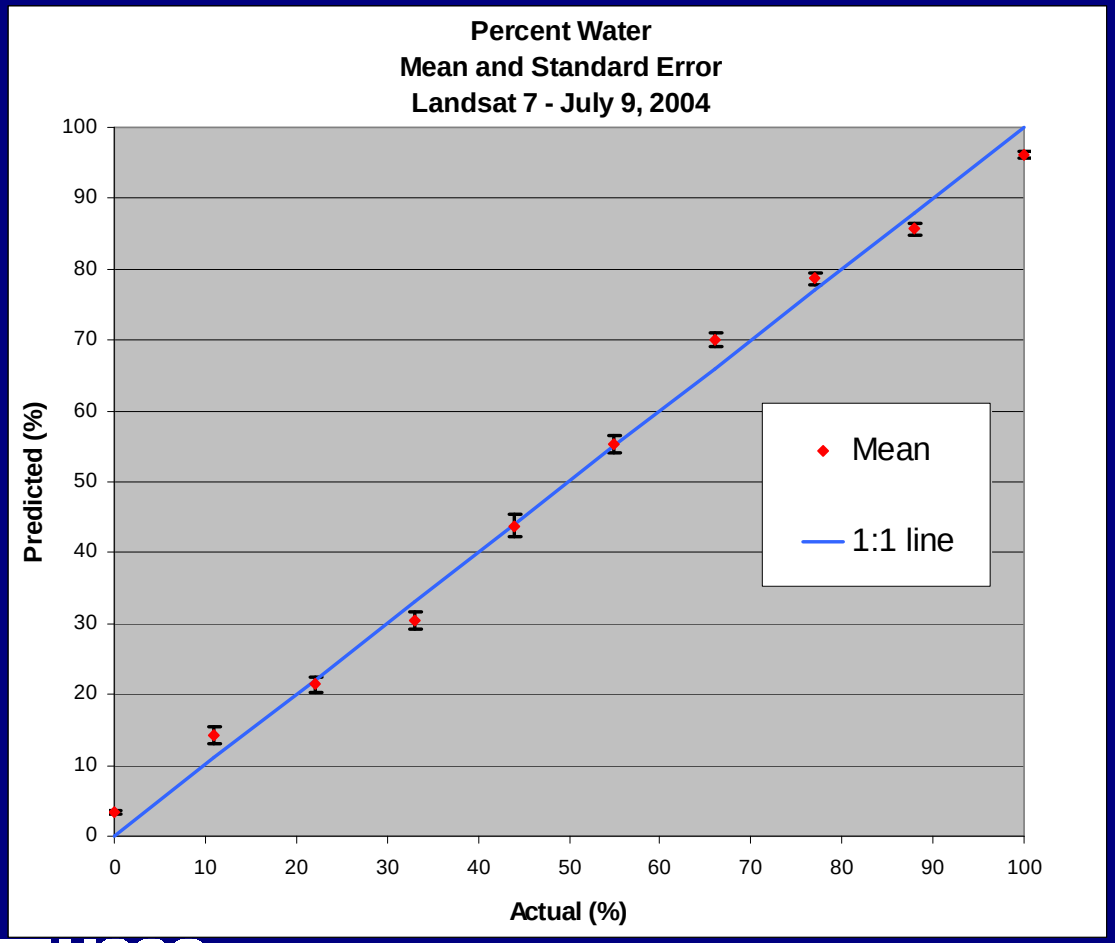
USGS

From Euliss et al. 2004

Percent Water Methods

Develop Training Data and Model for Percent Water (30m)

Evaluation on training data (1091 cases):



Landsat 7

Path 31 Row 27 July 9, 2004

Regression Statistics	
Multiple R	0.974227488
R Square	0.949119198
Adjusted R Square	0.949072475
Standard Error	8.307889804
Observations	1091

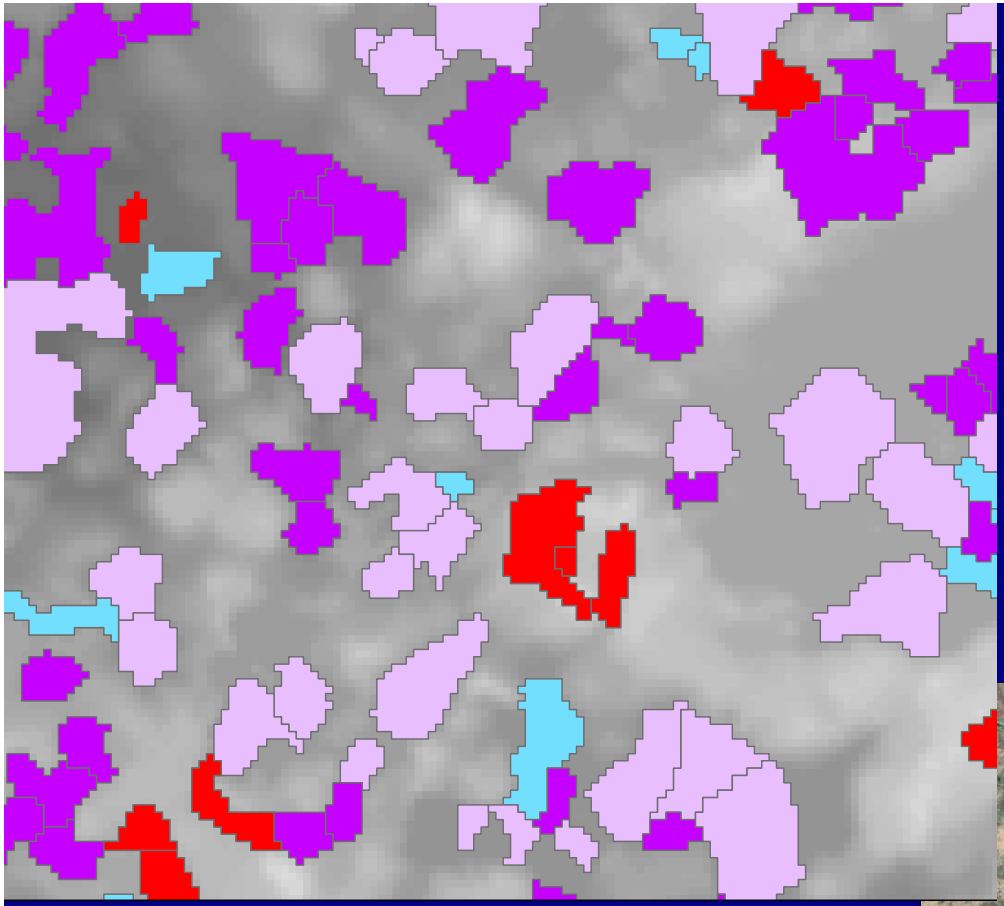
Landsat 5

Path 31 Row 27 May 12, 2003

Regression Statistics	
Multiple R	0.994566801
R Square	0.989163122
Adjusted R Square	0.989153097
Standard Error	2.918928739
Observations	1083

USGS

Using Landsat to Classify Wetland Hydrologic Function: Preliminary Results

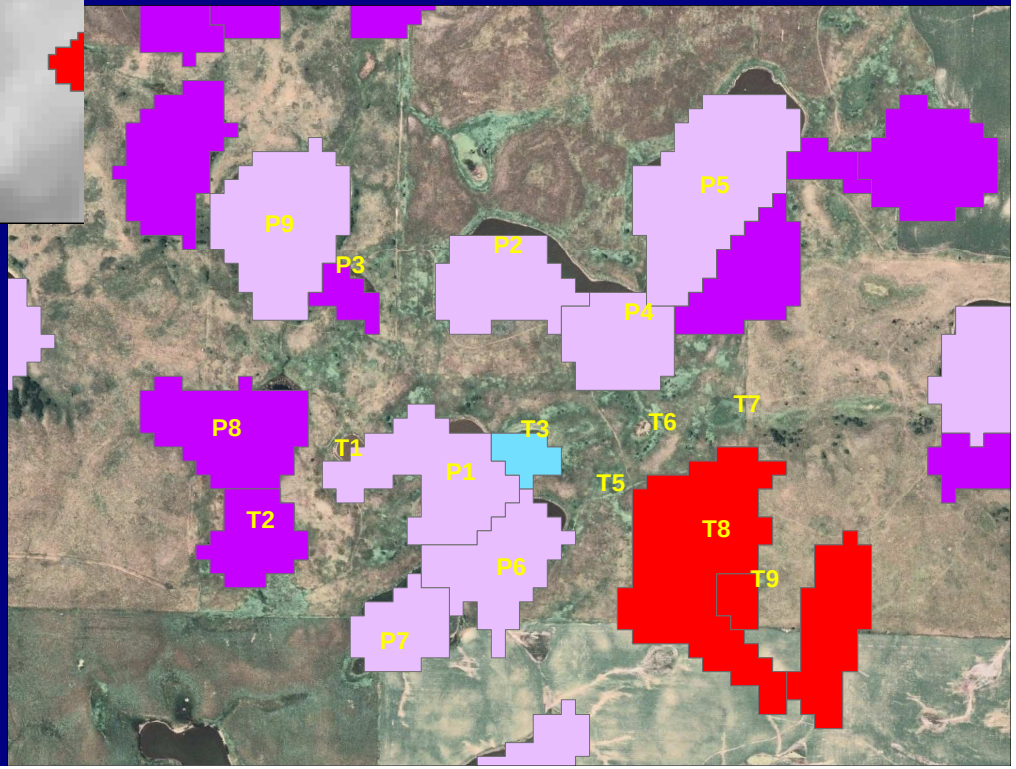


Recharge Wetland
Flow-Through Wetland
Open Discharge Wetland
Closed Discharge Wetland

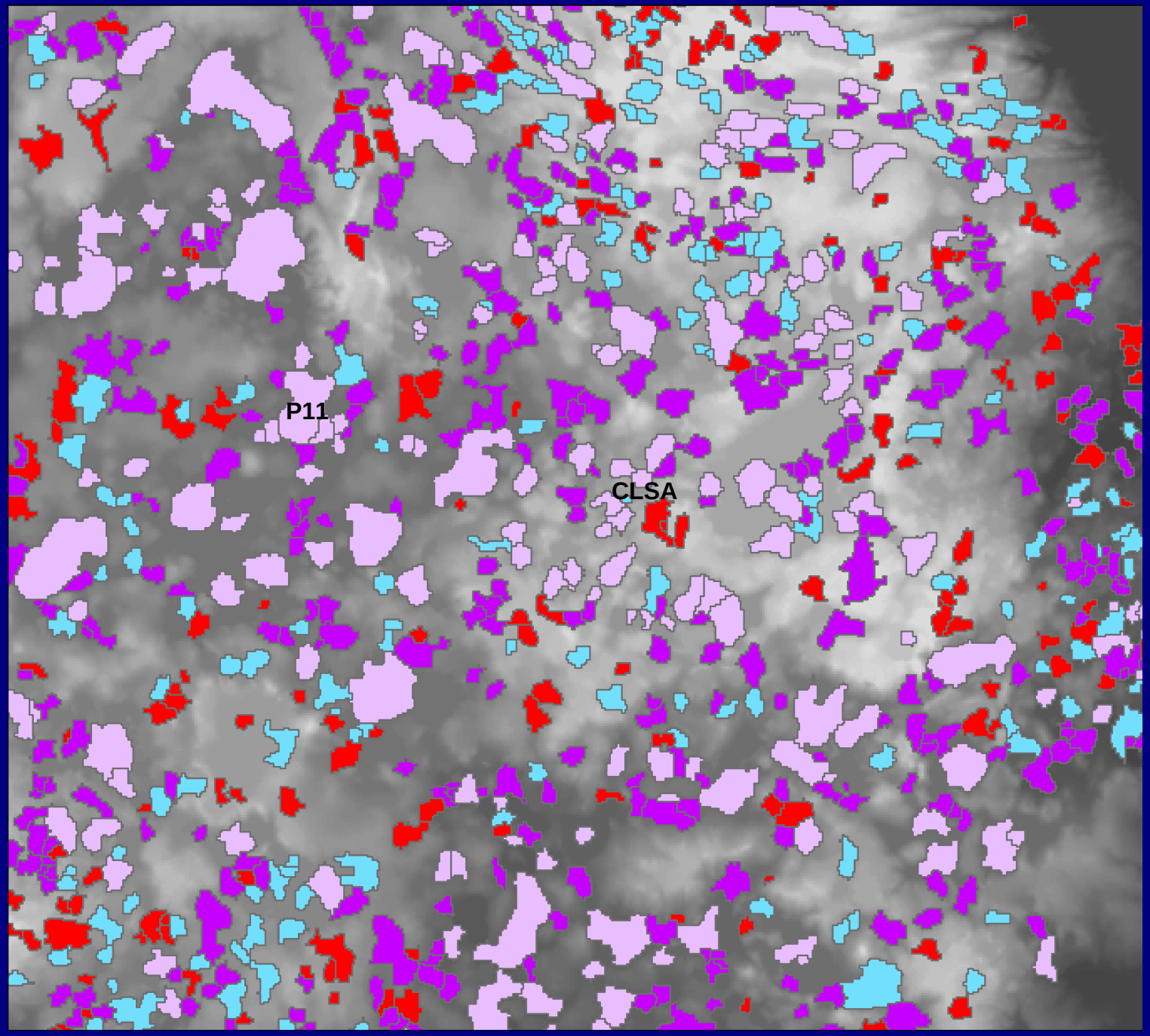
High Elevation: 598

Low Elevation: 492

USGS



Using Landsat to Classify Wetland Hydrologic Function: Preliminary Results



Recharge
Flow-Through
Open Discharge
Closed Discharge

High : 598

Low : 492

USGS

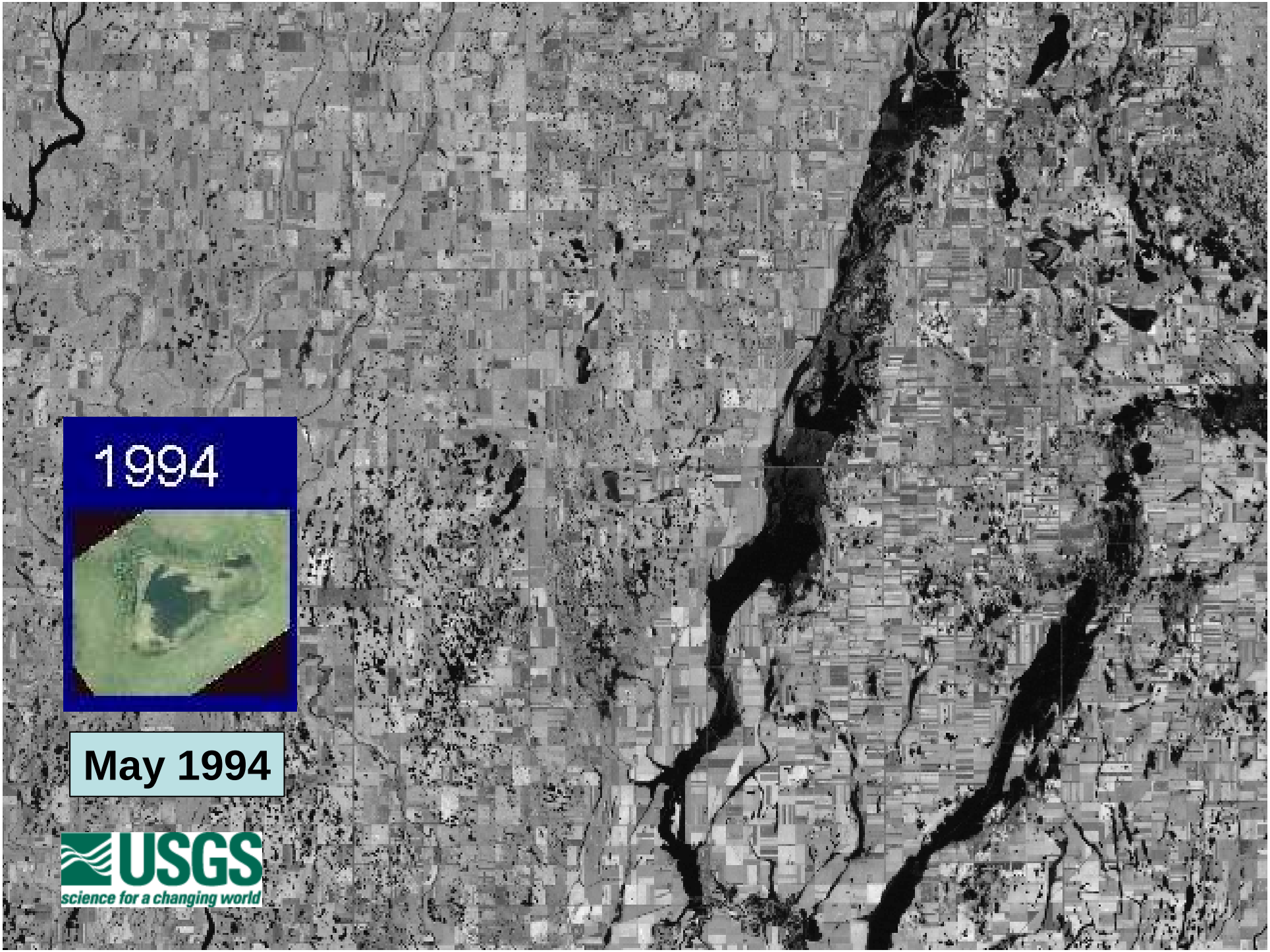
Inter-Annual Climate Variability

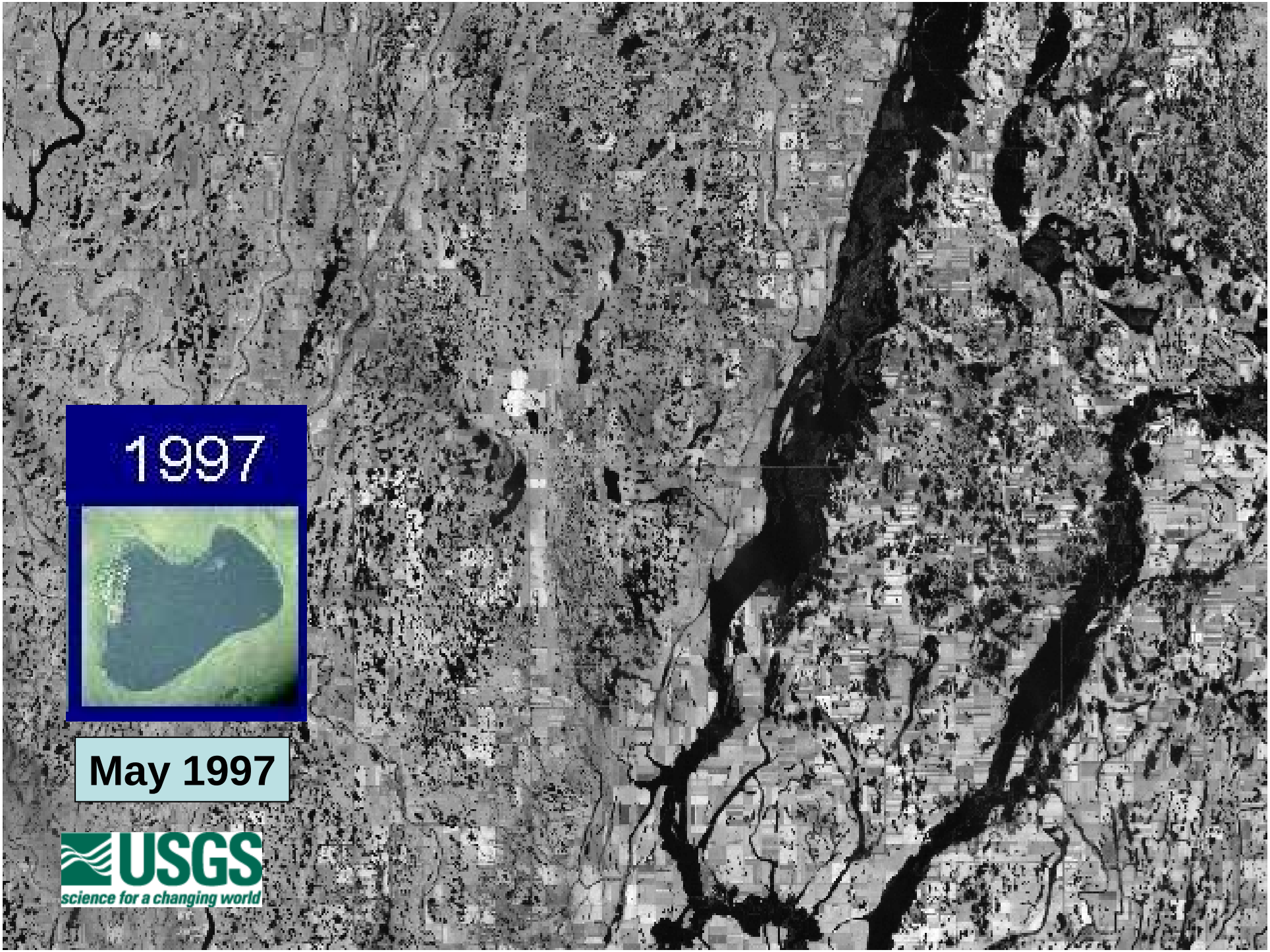
1992

May 1992

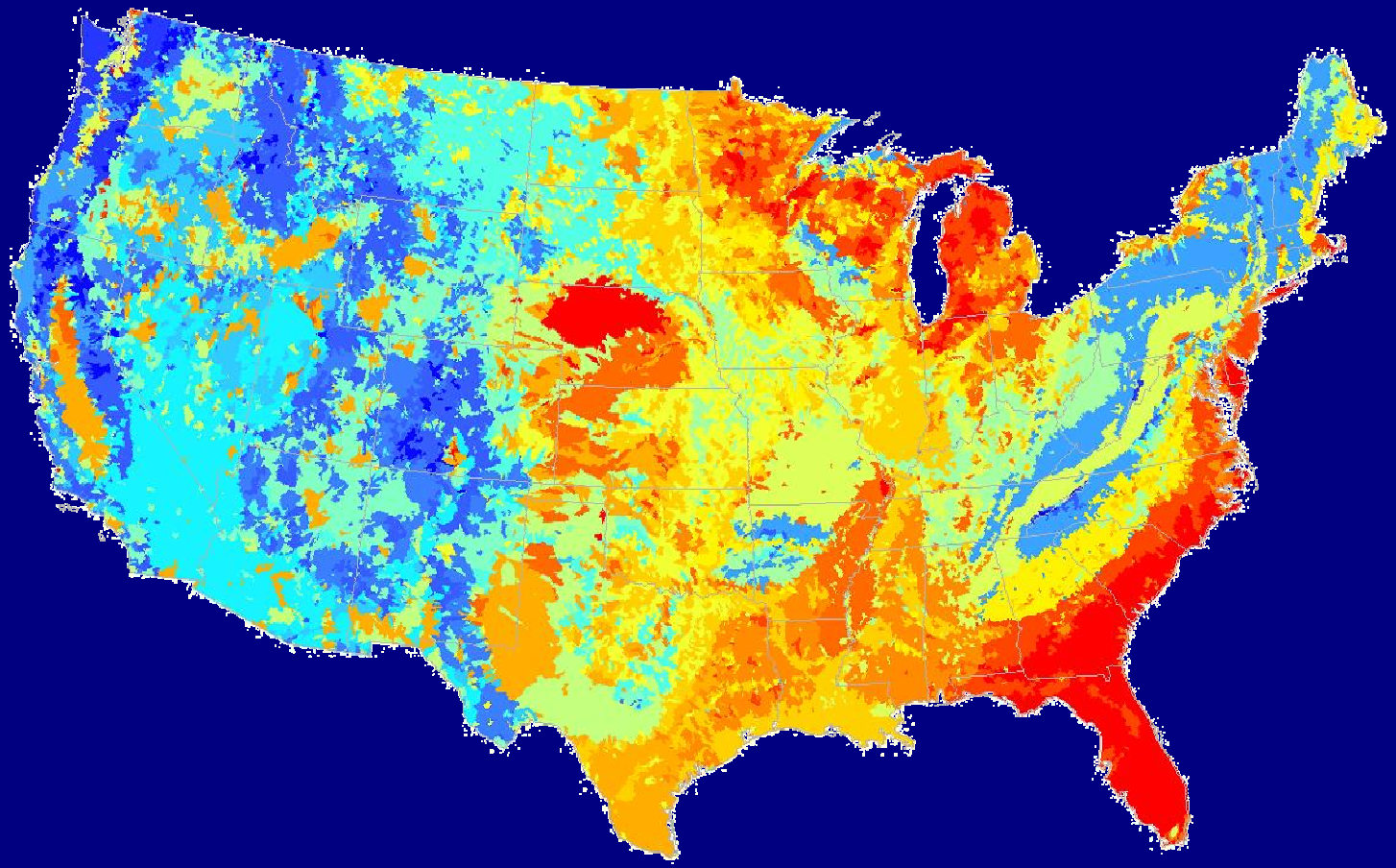
USGS
science for a changing world

Brown County, SD:
Landsat-5, mid-IR band


1994
May 1994
USGS
science for a changing world


1997
May 1997
USGS
science for a changing world

Hydrologic Landscapes Map



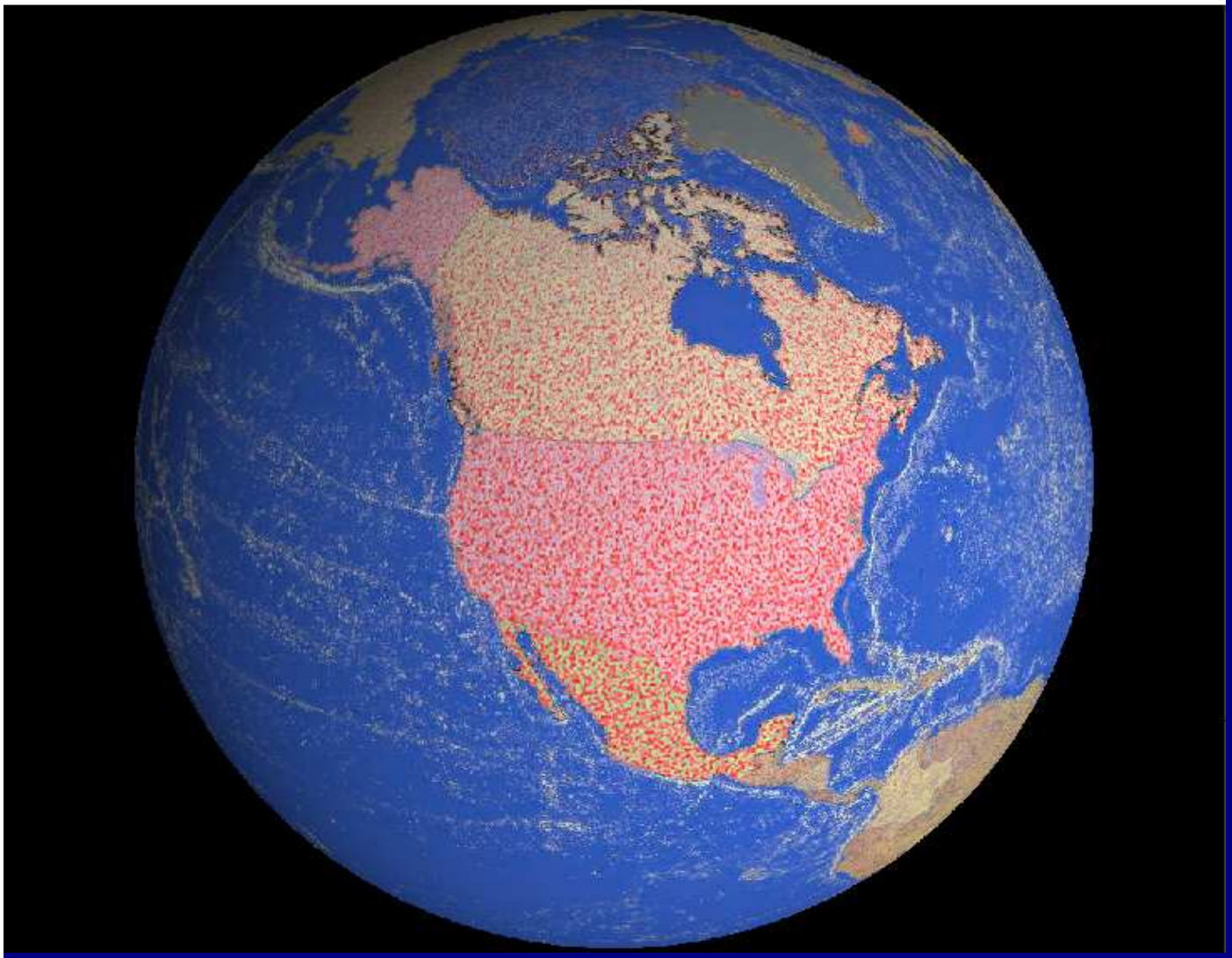
USGS

Servicio Geológico Mexicano

CANADA 1842 GEOLOGICAL SURVEY - COMMISSION GÉOLOGIQUE

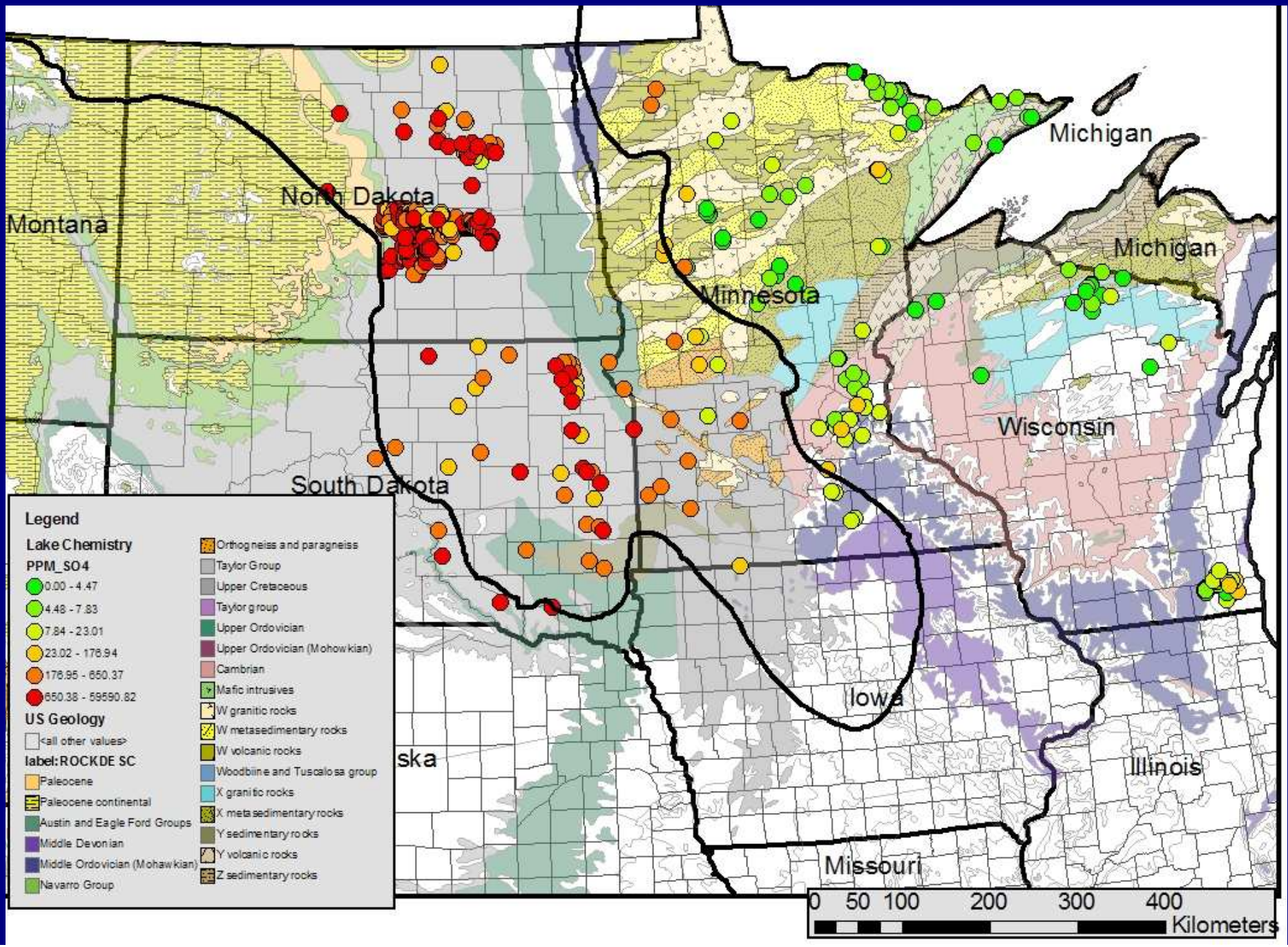
USGS science for a changing world

North American Soil Geochemical Landscapes Project

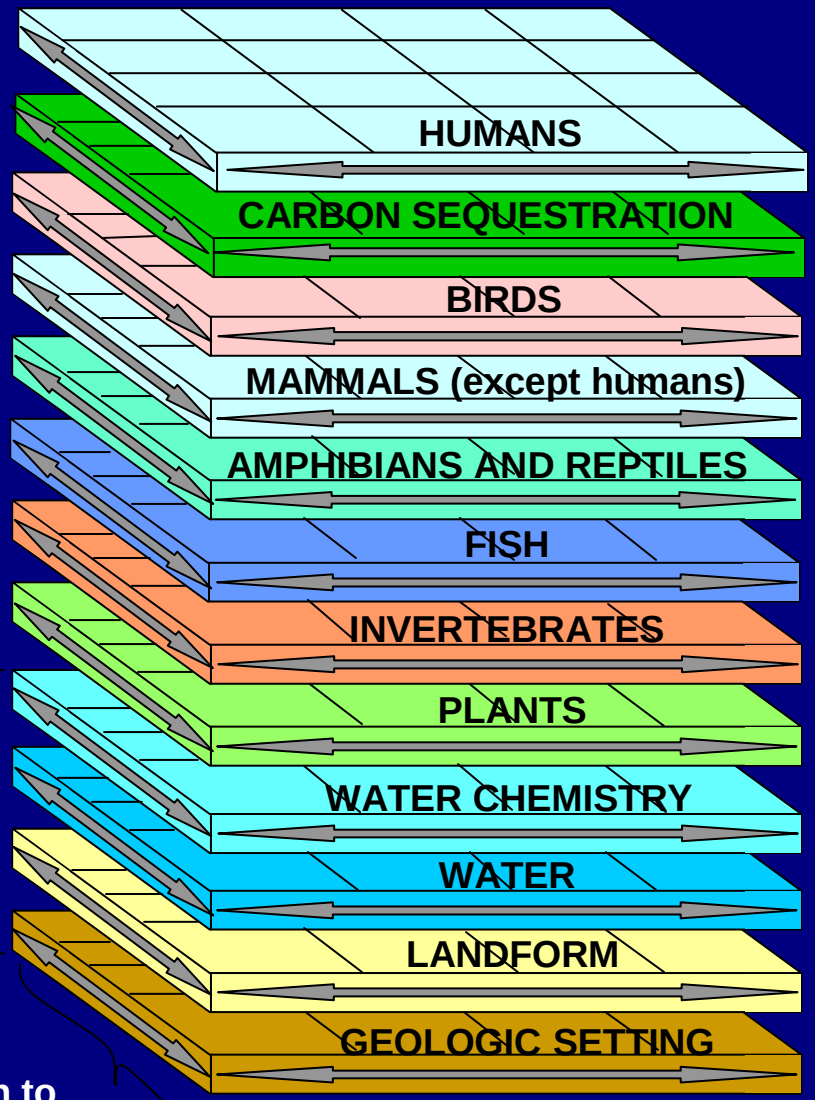


A spatially balanced array of 13,215 sample sites

Canada	6,183
USA	5,813
Mexico	1,216


Montana
North Dakota
South Dakota
Minnesota
Michigan
Michigan
Wisconsin
Iowa
Illinois
Missouri
ska
Legend
Lake Chemistry
PPM_SO4
0.00 - 4.47
4.48 - 7.83
7.84 - 23.01
23.02 - 176.94
176.95 - 650.37
650.38 - 59590.82
US Geology
<all other values>
label:ROCKDE SC
Paleocene
Paleocene continental
Austin and Eagle Ford Groups
Middle Devonian
Middle Ordovician (Mohawkian)
Navarro Group
Orthogneiss and paragneiss
Taylor Group
Upper Cretaceous
Taylor group
Upper Ordovician
Upper Ordovician (Mohowkian)
Cambrian
Mafic intrusives
W granitic rocks
W metasedimentary rocks
W volcanic rocks
Woodbiine and Tuscaloosa group
X granitic rocks
X metasedimentary rocks
Y sedimentary rocks
Y volcanic rocks
Z sedimentary rocks
0 50 100 200 300 400
Kilometers

Aquatic Systems Continuum (Tom Winter)



Biotic Interactions (Hanson et al. 2005)

Geochemical Landscape (Goldhaber, personal communication)

Hydrologic Landscape (Winter 2001)

Hydrologic Relation to Atmospheric Water (Euliss et al. 2004)

Hydrologic Relation to Ground Water (Euliss et al. 2004)

USGS