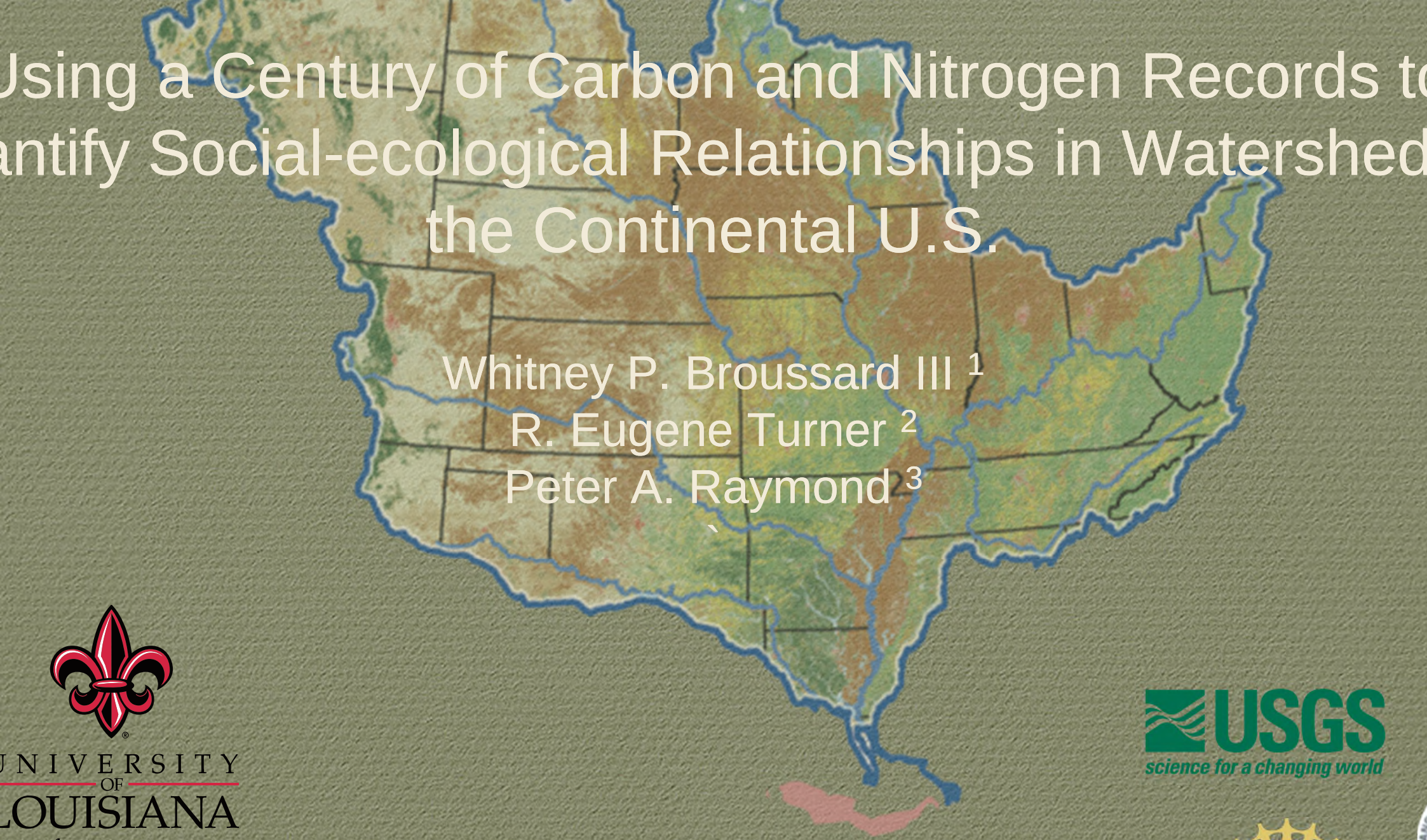
Using a Century of Carbon and Nitrogen Records to Quantify Social-ecological Relationships in Watersheds of the Continental U.S.

Whitney P. Broussard III [1]
R. Eugene Turner [2]
Peter A. Raymond [3]



Session E7: Century Scale Trends in Water Quality
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UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

WATER-SUPPLY PAPER 236

THE QUALITY OF SURFACE WATERS IN THE UNITED STATES

PART I.—ANALYSES OF WATERS EAST OF THE ONE HUNDREDTH MERIDIAN

BY

R. B. DOLE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1909

DEPARTMENT OF THE INTERIOR

HUBERT WORK, Secretary

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, Director

Professional Paper 135

THE COMPOSITION OF THE RIVER AND LAKE WATERS OF THE UNITED STATES

BY

FRANK WIGGLESWORTH CLARKE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1924

Analyses of water from Bull Run River near Bull Run, Oreg.

[Parts per million, except as otherwise designated.]

Date (1911–12). From—	To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
Aug. 1	Aug. 10	2	15	0.02	6.1	1.7	.....	.....	.....	4.1	.....	0.40	45	2.9	134	0.5	16
11	20	1	13	.05	4.7	1.7	6.4	0.0	20	4.6	Tr.	1.3	41	2.8	122	.03	13
21	30	Tr.	15	.02	3.7	1.6	3.9	.0	20	3.9	Tr.	.75	40	2.7	97	.03	11
31	Sept. 9	1	14	.10	4.4	1.6	4.2	.0	19	3.5	Tr.	.75	40	3.0	184	1.34	20
Sept. 10	19	3	9.8	.10	3.5	1.0	3.3	.0	16	4.8	0.04	1.30	33	3.6	377	.6	34
20	29	Tr.	12	.05	3.2	1.3	3.0	.0	16	3.1	.20	1.30	38	3.2	211	.3	22
30	Oct. 9	Tr.	7.7	.01	2.9	.76	2.7	.0	11	2.6	.40	1.30	27	3.7	423	1.3	31
Oct. 10	19	Tr.	10	Tr.	2.9	.80	3.5	.0	13	3.4	3.8	1.30	29	3.7	402	.0	31
20	29	Tr.	12	.03	2.8	1.0	2.4	.0	12	2.5	1.1	1.4	22	3.1	198	.0	17
30	Nov. 8	2	9.4	Tr.	3.0	.70	4.3	.0	13	3.6	.42	1.30	22	4.0	867	2.3	75
Nov. 9	18	3	8.5	.02	2.1	.42	2.3	.0	9.0	3.5	.94	1.0	26	5.9	2,417	35.2	169
19	28	1	11	.02	2.5	.60	2.0	.0	11	4.3	.40	.65	29	5.1	1,450	.0	144
29	Dec. 8	Tr.	8.4	.01	2.3	.34	3.1	.0	11	2.0	.34	.85	25	4.1	616	.0	41
Dec. 9	18	Tr.	7.6	.01	2.2	.20	2.4	.0	8.8	4.0	.20	1.0	24	5.1	1,137	.0	77
19	28	Tr.	5.8	Tr.	2.3	.16	2.6	.0	8.5	3.1	.10	.85	22	4.5	845	.0	30
29	Jan. 7	Tr.	8.7	.01	2.2	.20	3.7	.0	12	2.6	.32	1.8	27	3.8	422	.0	31
Jan. 8	17	Tr.	6.2	.01	2.0	.10	3.5	.0	9.8	3.9	.08	1.3	24	.....	3,743	.0	263
18	27	Tr.	6.3	.06	1.7	.04	2.9	.0	9.8	1.7	.08	.75	21	4.8	1,183	.0	67
28	Feb. 6	Tr.	5.9	.13	1.7	.04	2.3	.0	8.5	2.7	.16	.50	22	5.3	1,845	.0	110
Feb. 7	16	Tr.	6.4	.02	2.1	.08	2.7	.0	8.1	1.1	.08	2.0	22	5.8	2,212	.0	121
17	26	Tr.	4.1	.01	1.9	.20	3.3	.0	8.5	2.1	.15	.25	23	5.3	1,799	.0	112
27	Mar. 7	Tr.	5.8	.01	2.2	.16	3.0	.0	10	3.3	.09	1.0	25	3.7	479	.0	32
Mar. 8	17	Tr.	7.6	.01	2.1	.16	3.9	.0	11	3.8	.06	1.3	27	3.4	335	.0	24
18	27	Tr.	5.1	Tr.	2.1	.14	4.3	.0	11	3.4	.09	1.7	28	3.6	439	.0	33
28	Apr. 6	1	8.0	.01	2.9	.40	6.3	.0	13	2.3	.90	3.9	360	8.2	560	8.2	50
Apr. 7	17	.1	6.6	.01	2.7	.12	3.8	.0	11	2.1	.26	1.8	25	3.9	563	7.6	38
17	26	Tr.	5.2	.01	2.8	.40	3.8	.0	11	1.9	.20	1.0	22	3.8	502	.0	30
27	May 6	Tr.	5.8	Tr.	2.4	.10	4.1	.0	10	1.8	.60	2.0	23	4.4	906	.0	56
May 7	16	Tr.	5.6	.01	2.5	.10	5.0	.0	11	2.5	.26	2.5	26	4.4	900	.0	63
17	26	Tr.	16	.06	2.7	.16	3.0	.0	11	5.6	.42	.75	29	4.0	613	.0	65
27	June 5	Tr.	7.7	.02	2.6	.10	2.6	.0	11	2.3	.28	1.3	27	3.9	884	.0	64
June 6	15	Tr.	8.3	.02	2.7	.18	5.3	.0	14	2.1	.72	2.5	31	3.6	434	.0	36
16	25	1	8.6	Tr.	2.5	.70	3.2	.0	12	5.8	.60	1.8	34	3.8	301	2.0	46
26	July 5	5	12	.06	2.7	.60	1.8	.0	16	1.6	.28	.25	33	3.6	408	.....	36
July 6	15	6	12	.11	3.8	.40	3.2	.0	18	3.8	.68	1.8	42	3.2	273	.....	31
16	25	7	13	.09	2.9	.96	3.6	.0	20	2.8	Tr.	1.3	40	2.9	178	.....	19
Mean.....		Tr.	9.0	.03	2.7	.53	[a] 3.1	.0	12	3.1	.31	1.3	30	.....	.....	[b] 630	[b] 21,000

[a] Sodium and potassium, determined on combined alkali residues.

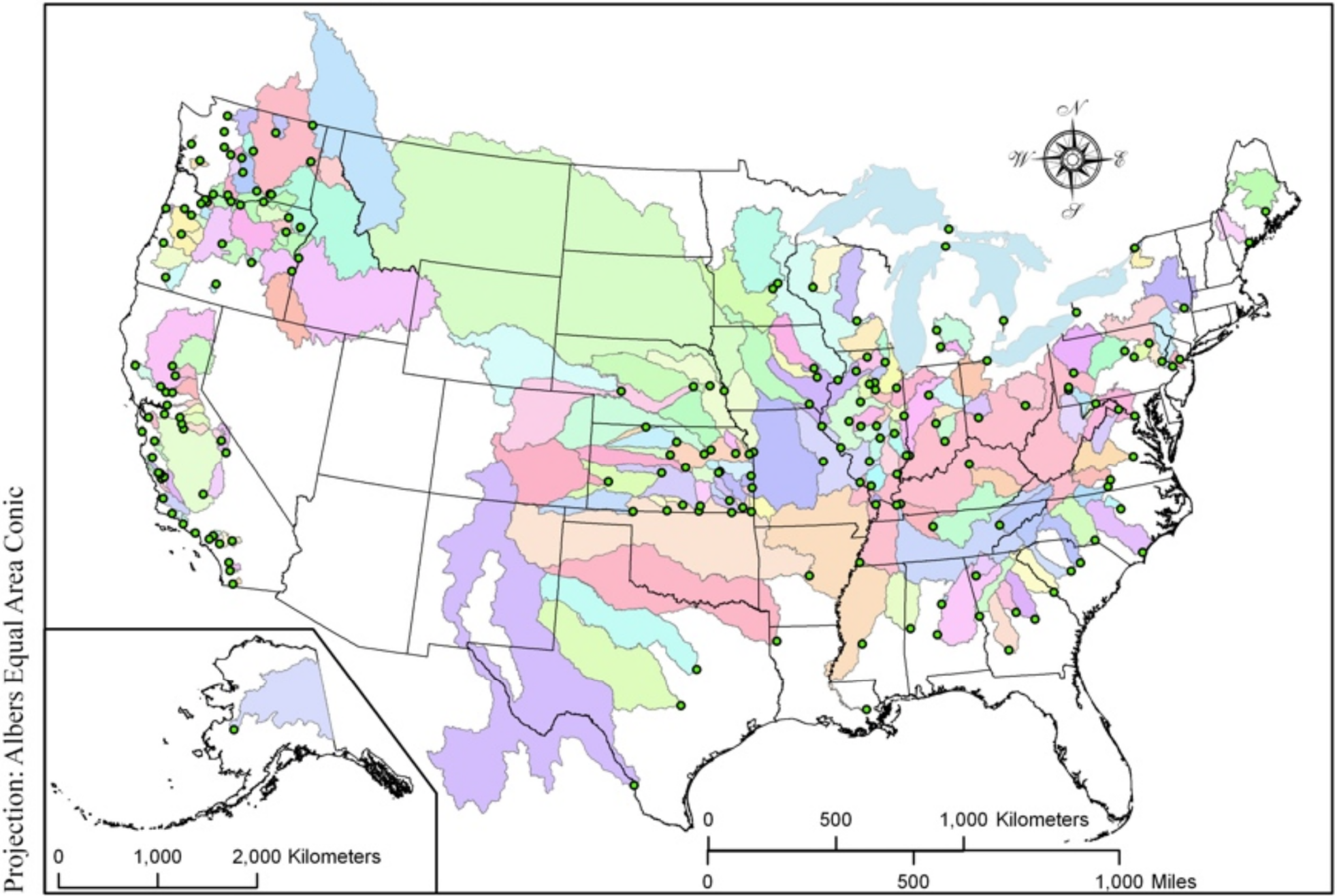
[b] Total annual denudation.

190 Stations | 152 Rivers and Lakes

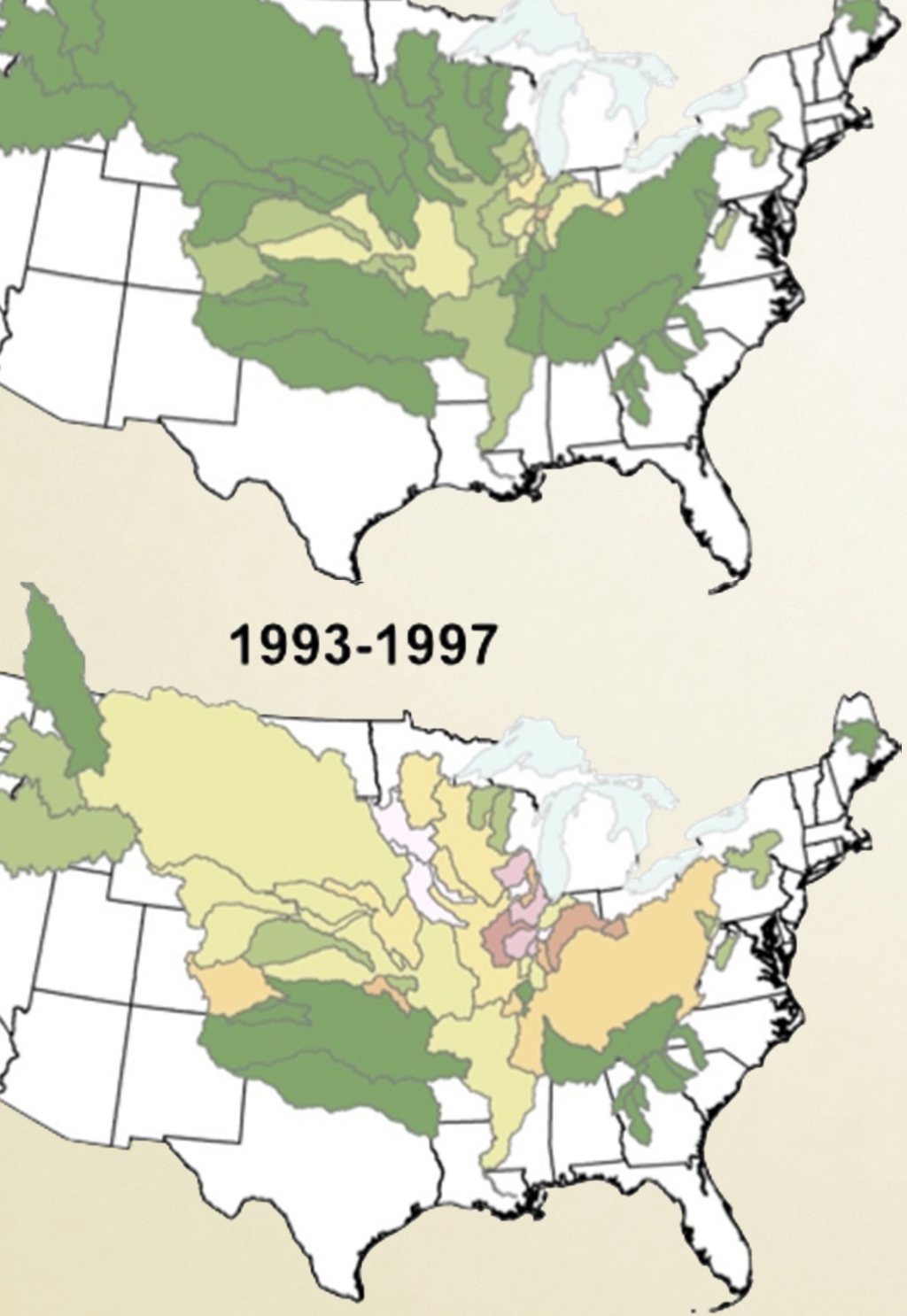
Composition of the Rivers and Lake Waters of the United States

USGS P.P. 135

Corresponding Watersheds and Monitoring Stations

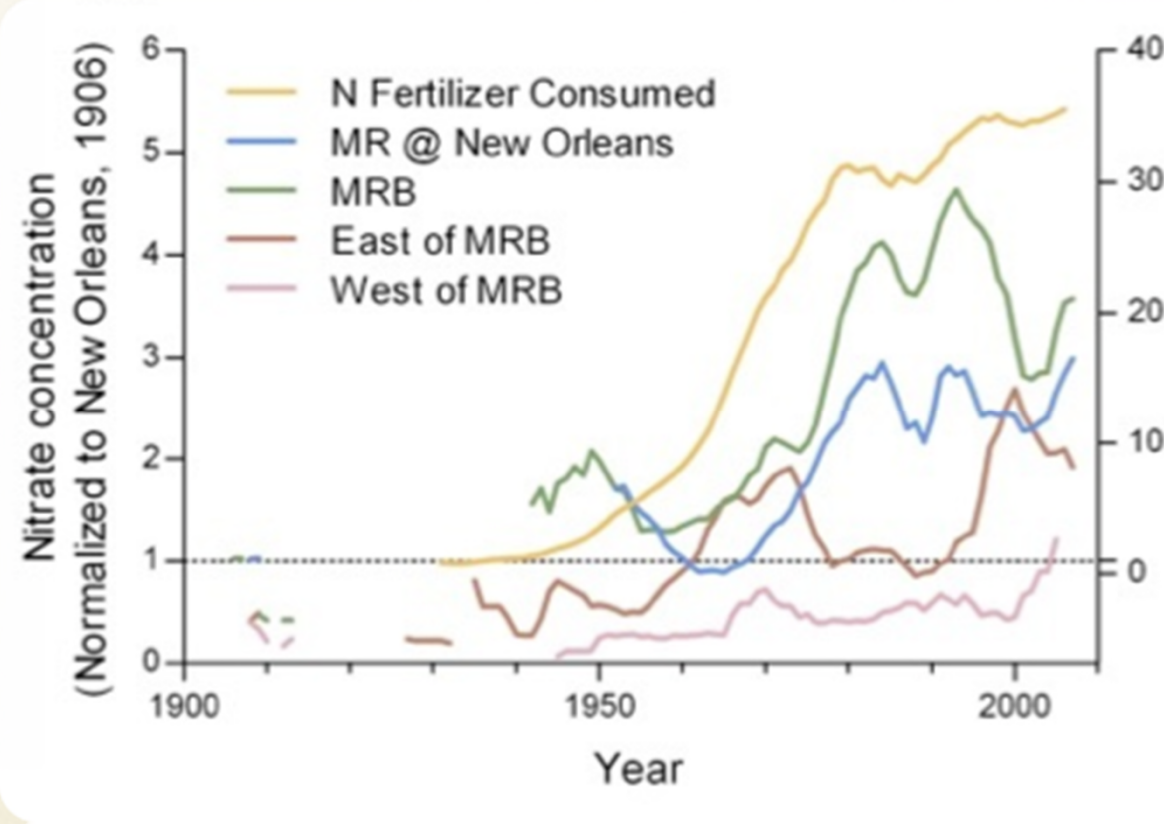


Projection: Albers Equal Area Conic

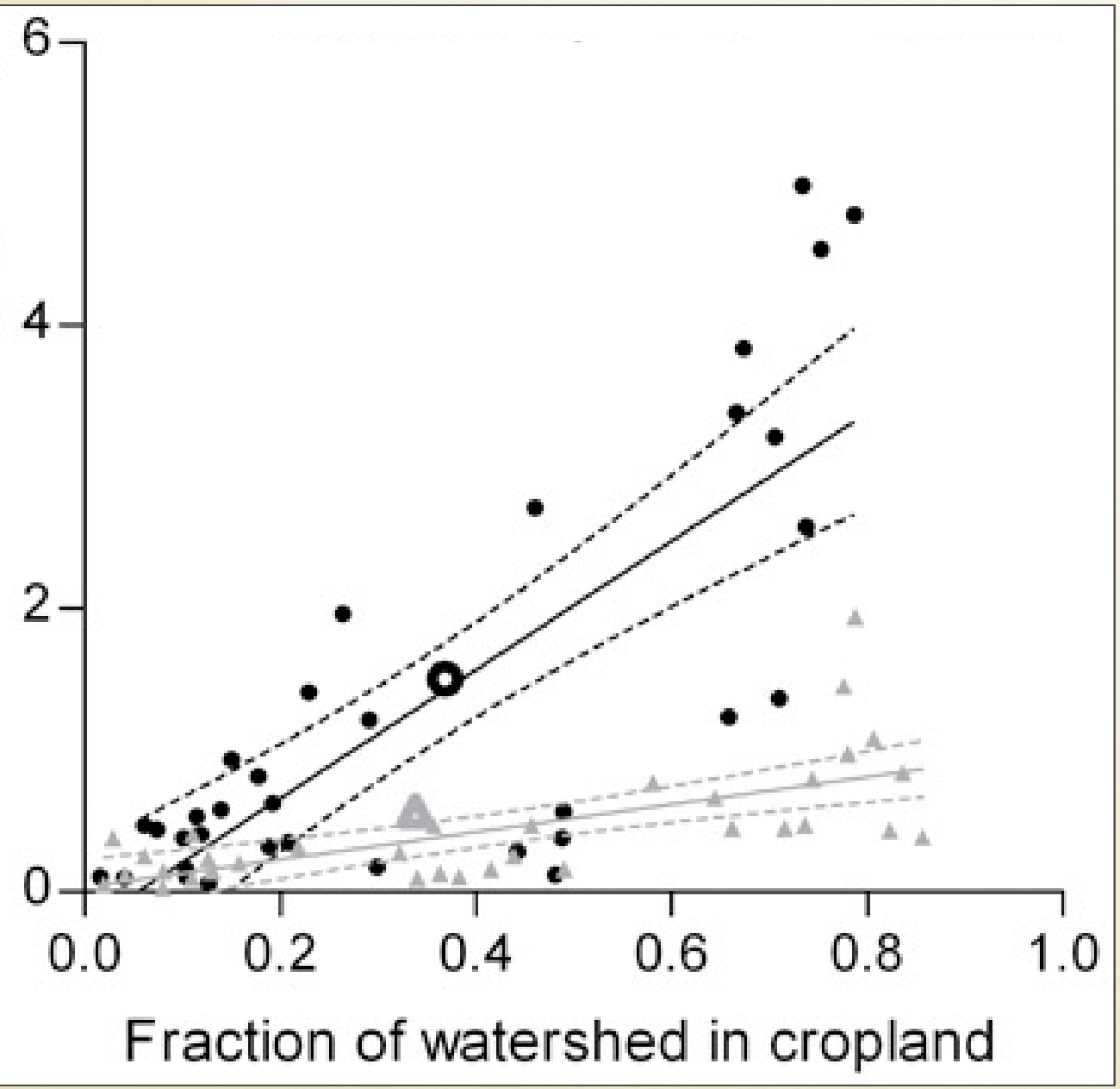


Nitrate Concentration (mg N L^{-1})

$\mu NO_3 = 0.60$ mg N



$\mu NO_3 = 1.79$ mg N



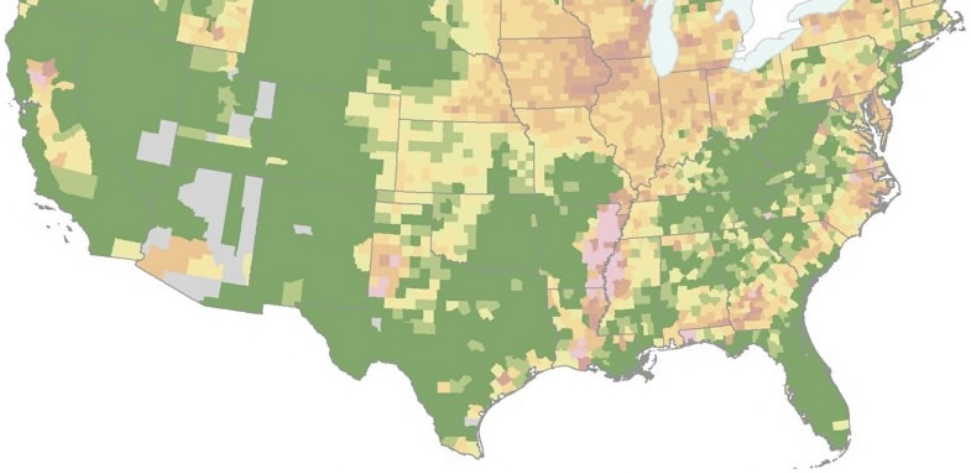
1993-1997 (r^2 = 0.61, p < 0.0

1906-1912 (r^2 = 0.46, p < 0.0

MRB

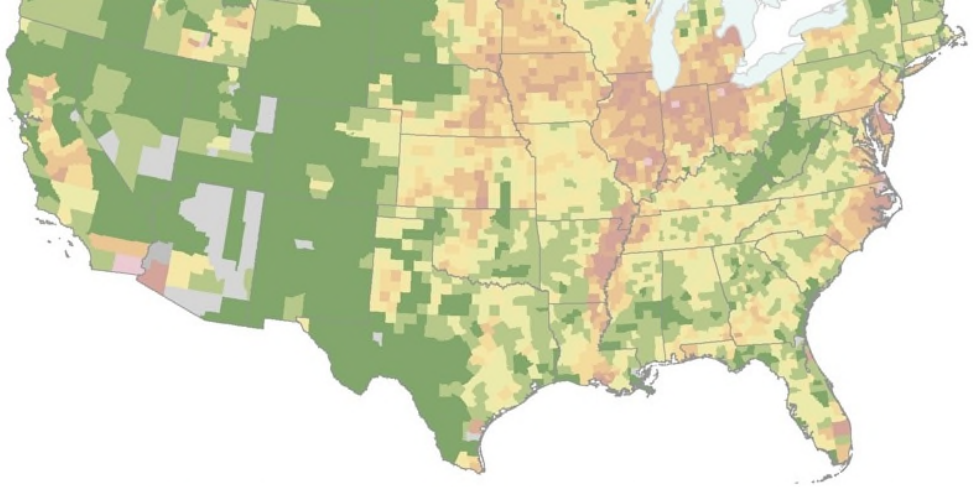
1993-1997

1906-1912



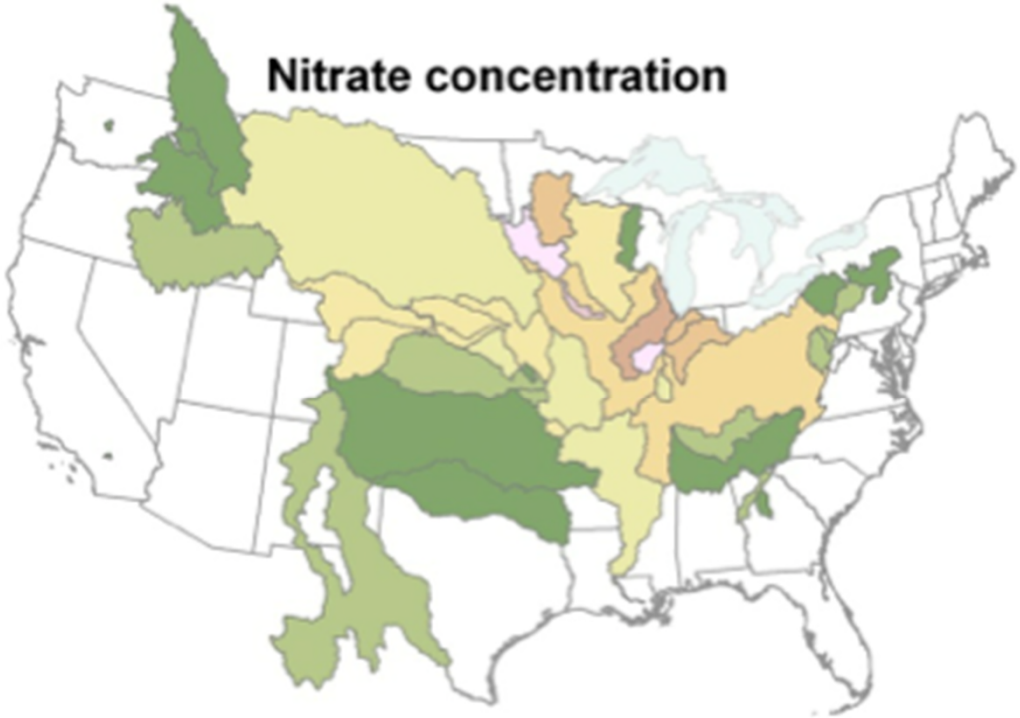
Total government payments ($ per acre farmland)

0.00 - 4.00
4.01 - 6.00
6.01 - 8.00
8.01 - 10.00
10.01 - 14.00
14.01 - 18.00
18.01 - 22.00
22.01 - 26.00
26.01 - 48.00
No Data

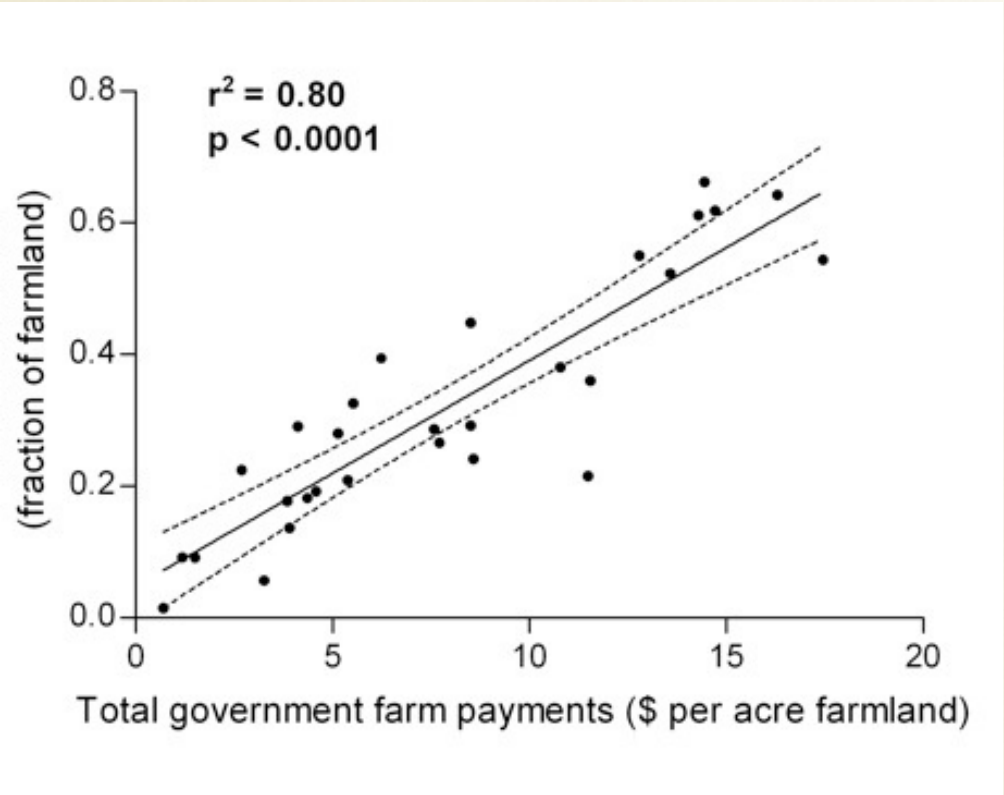


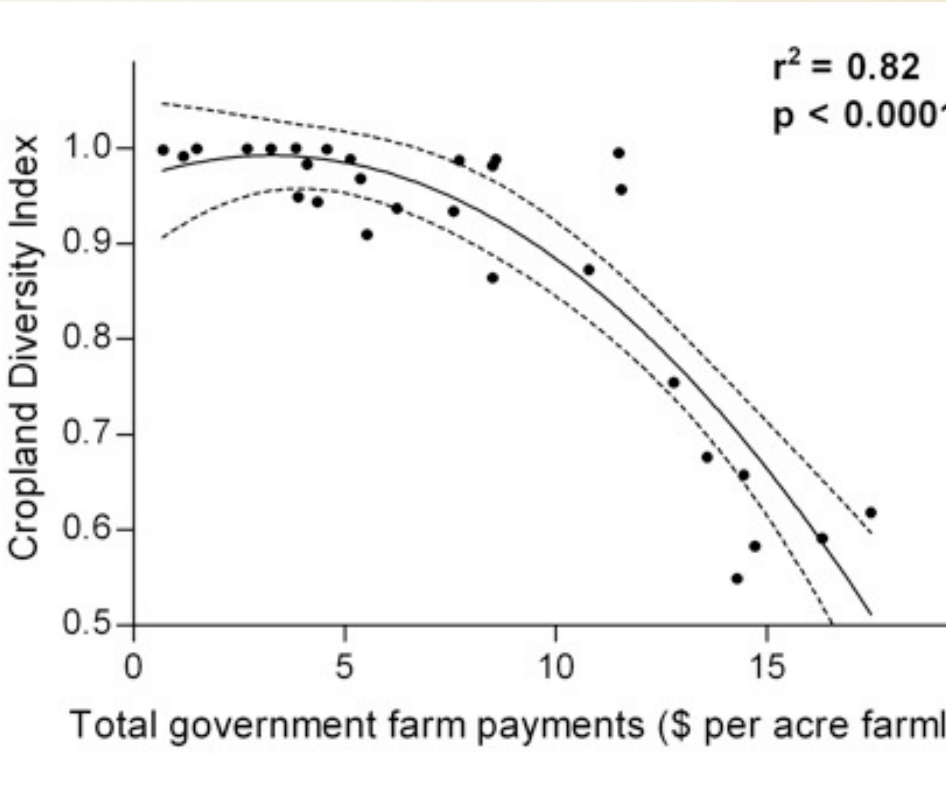
Fertilized farmand (percent of total farmland)

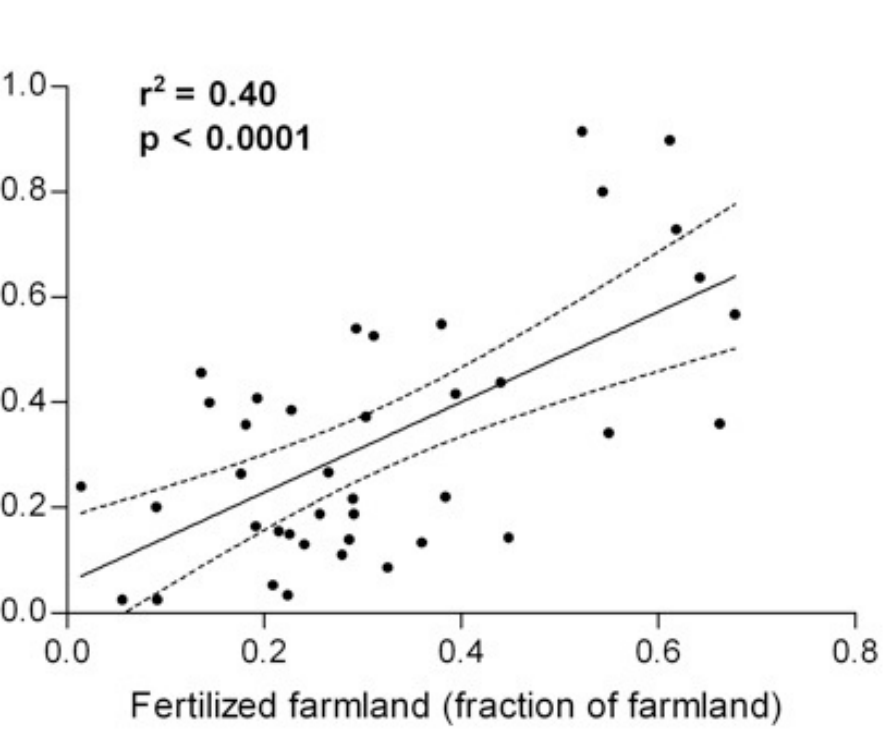
0% - 10%
11% - 20%
21% - 30%
31% - 40%
41% - 50%
51% - 60%
61% - 70%
71% - 80%
81% - 100%
No Data

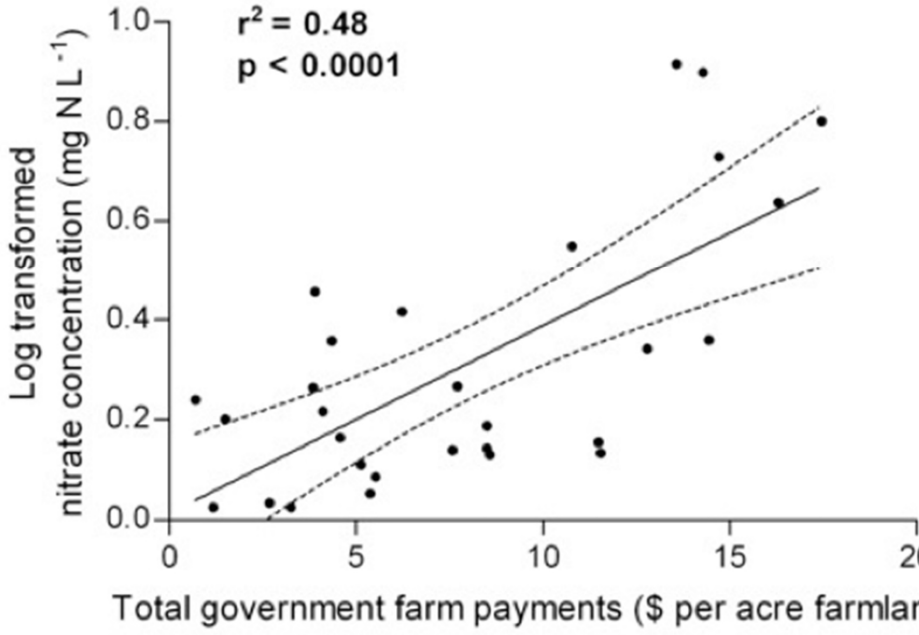


Nitrate concentration (mg N L^{-1})


r² = 0.80
p < 0.0001
(fraction of farmland)
Total government farm payments ($ per acre farmland)

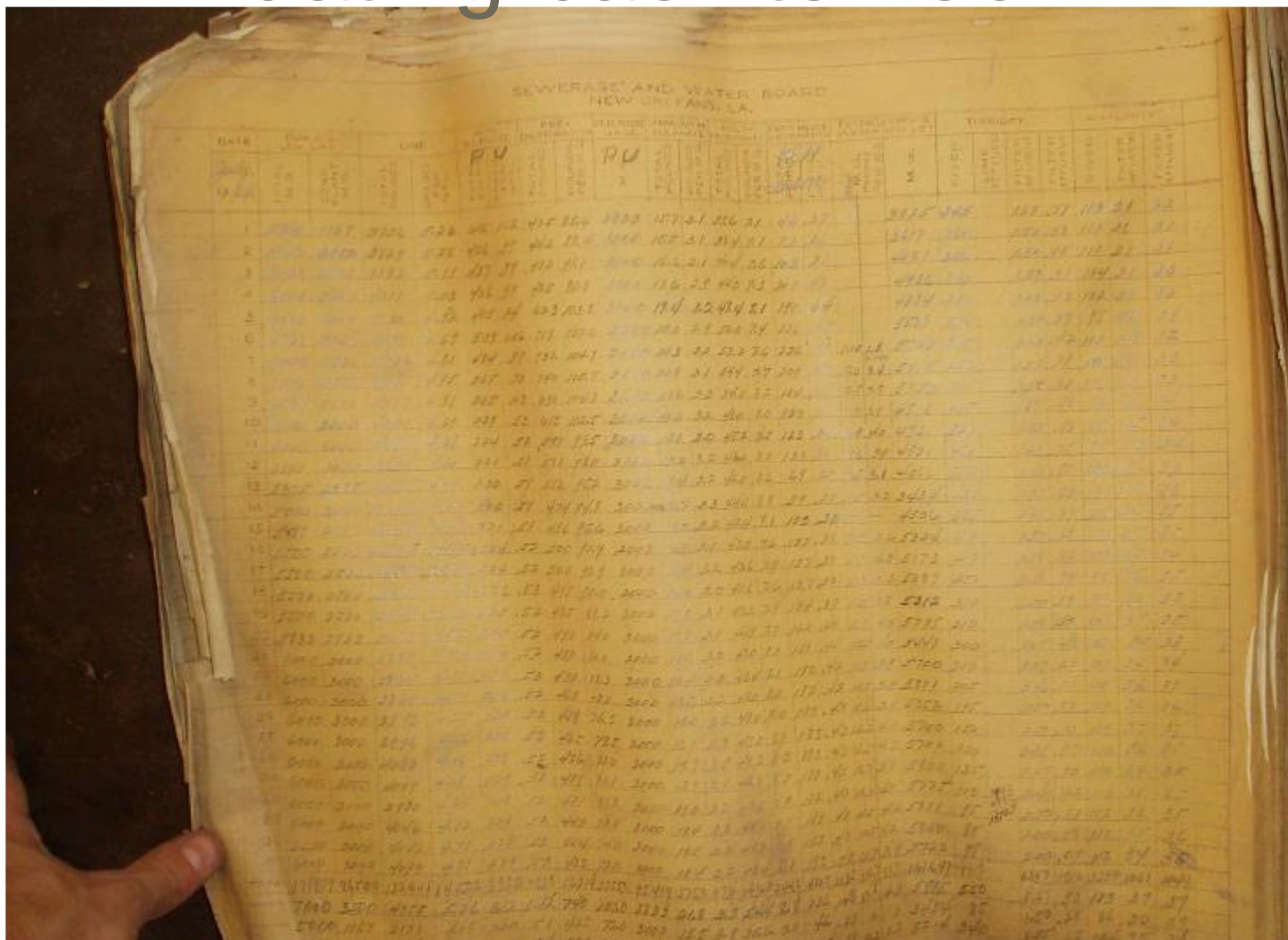

r² = 0.82
p < 0.0001
Cropland Diversity Index
Total government farm payments ($ per acre farml


r² = 0.40
p < 0.0001
Fertilized farmland (fraction of farmland)

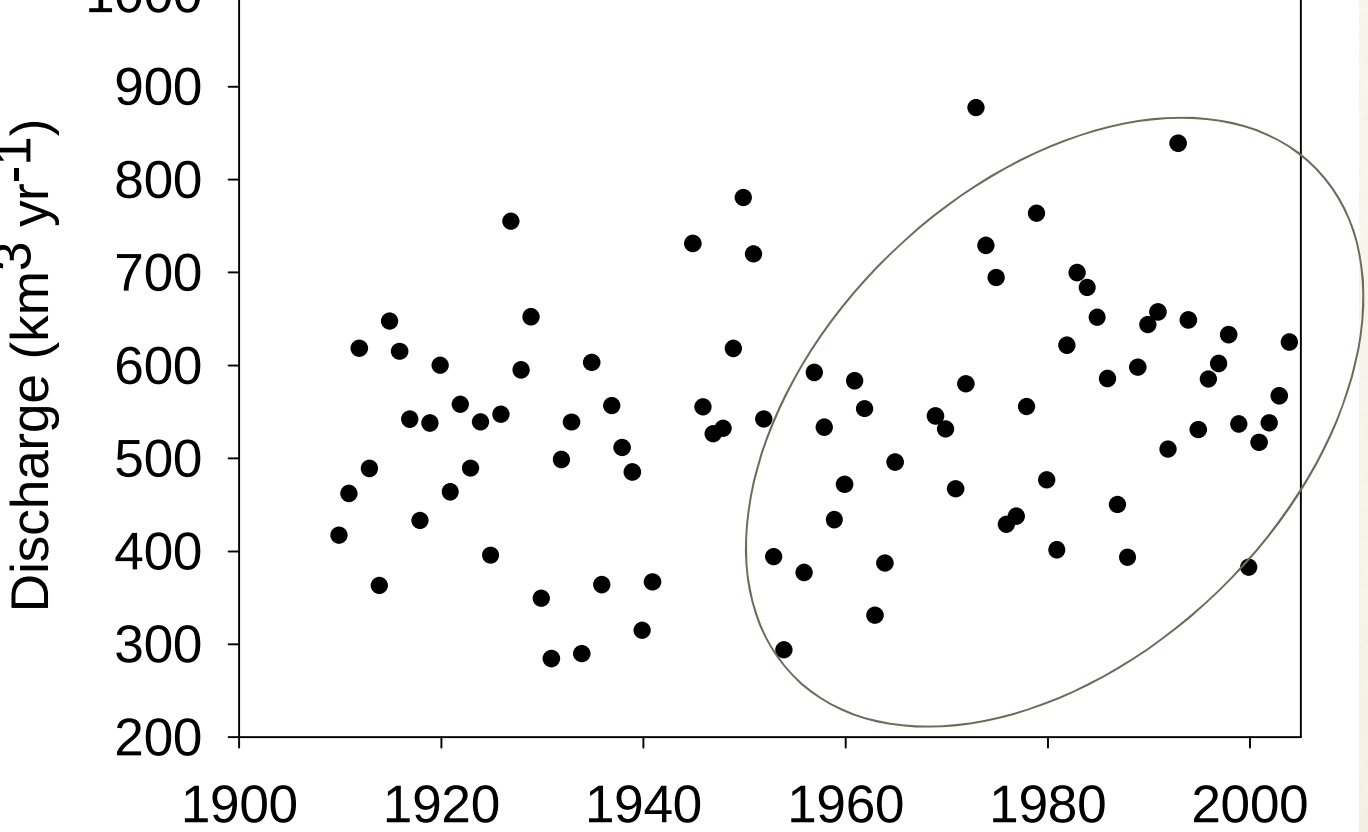

r² = 0.48
p < 0.0001
Log transformed
nitrate concentration (mg N L⁻¹)
Total government farm payments ($ per acre farmlan

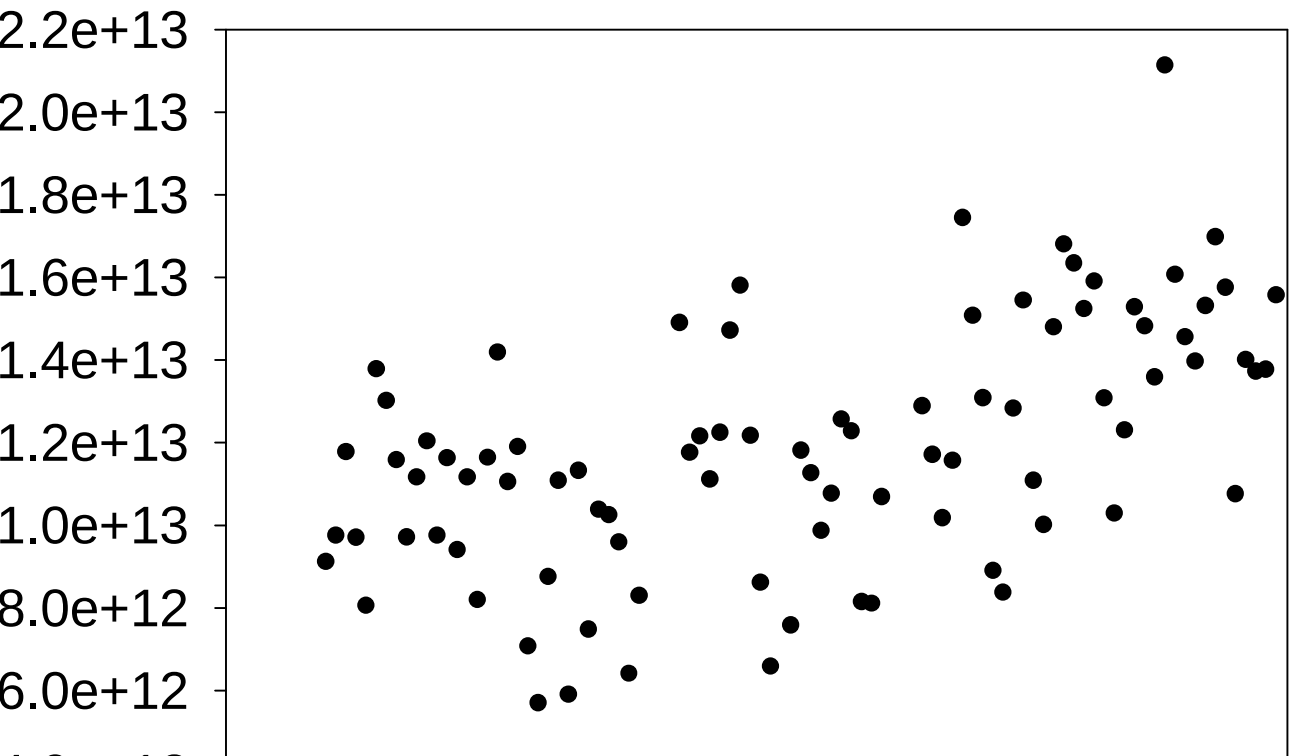
- Carrollton water treatment plant, New Orleans
- >100 years old
- Treat water with lime to protect system of pipes
- Measure alkalinity of the Mississippi since 1900

Daily alkalinity measurements of the Mississippi River since 1961 and monthly record dating back to 1902



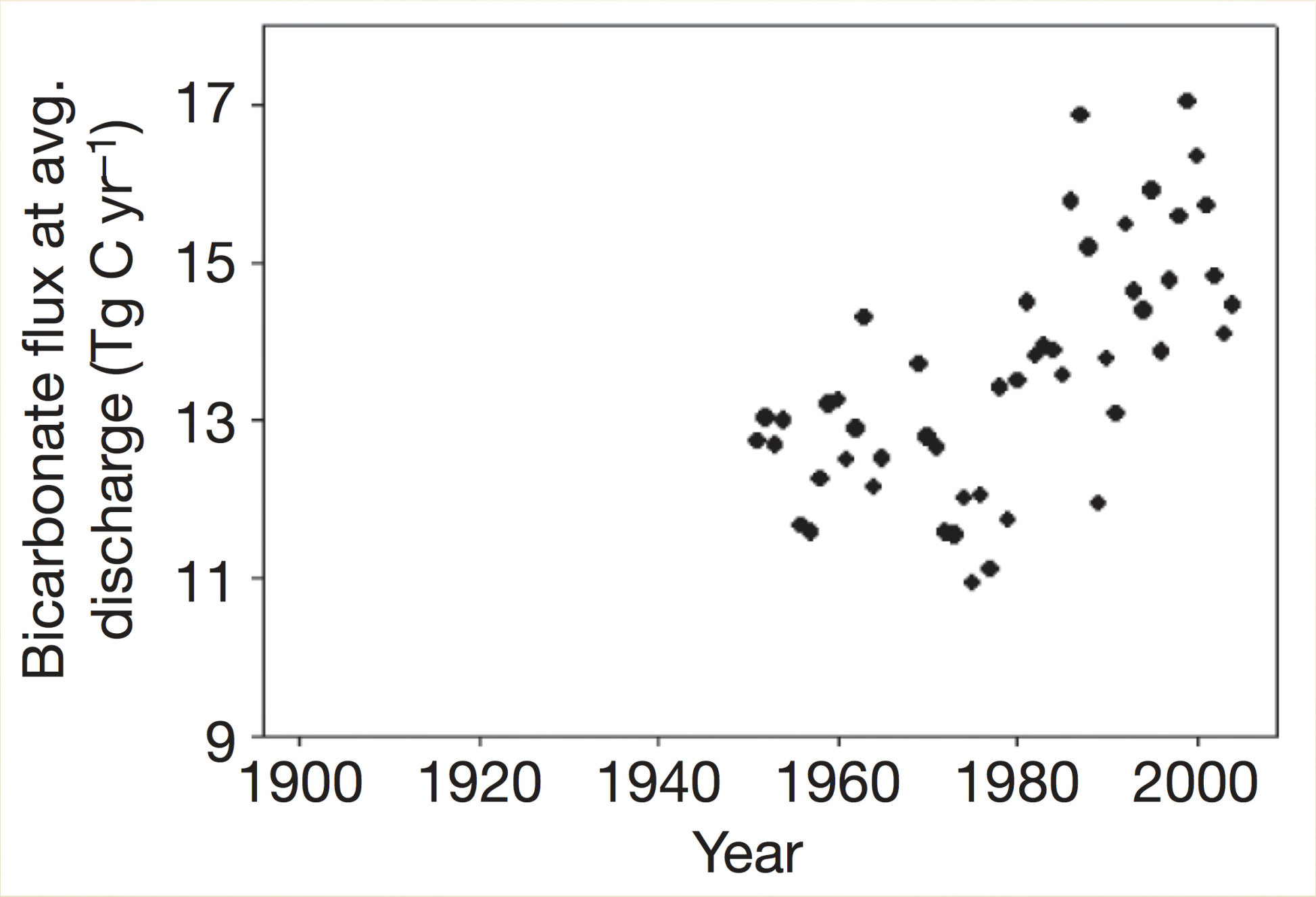
data set used here
esents tens of thousands
easurements over 100
s and is therefore the
t complete long-term
set for riverine carbon
major world river ever
rted and a data set of
ary importance with
ect to understanding



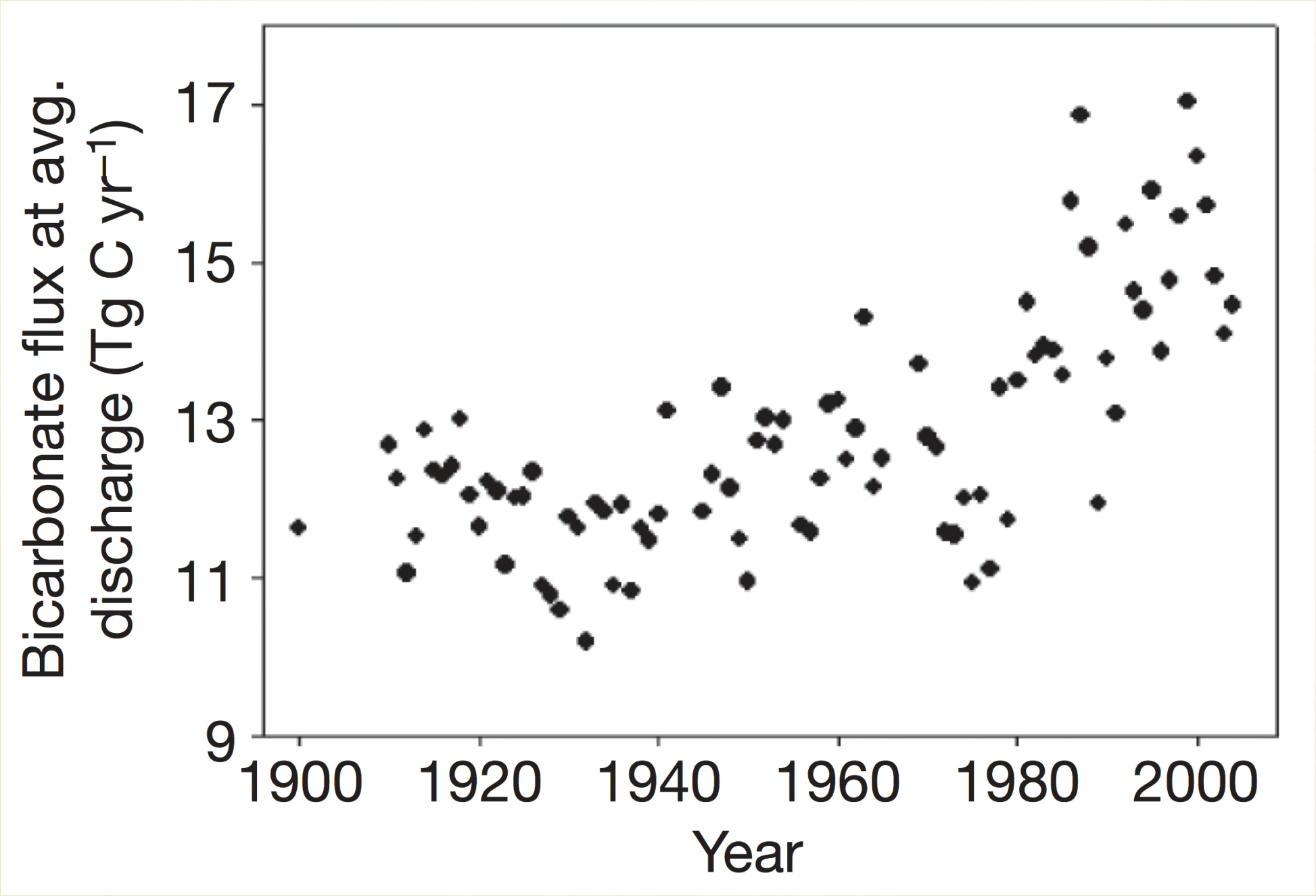


Mississippi Annual Averages

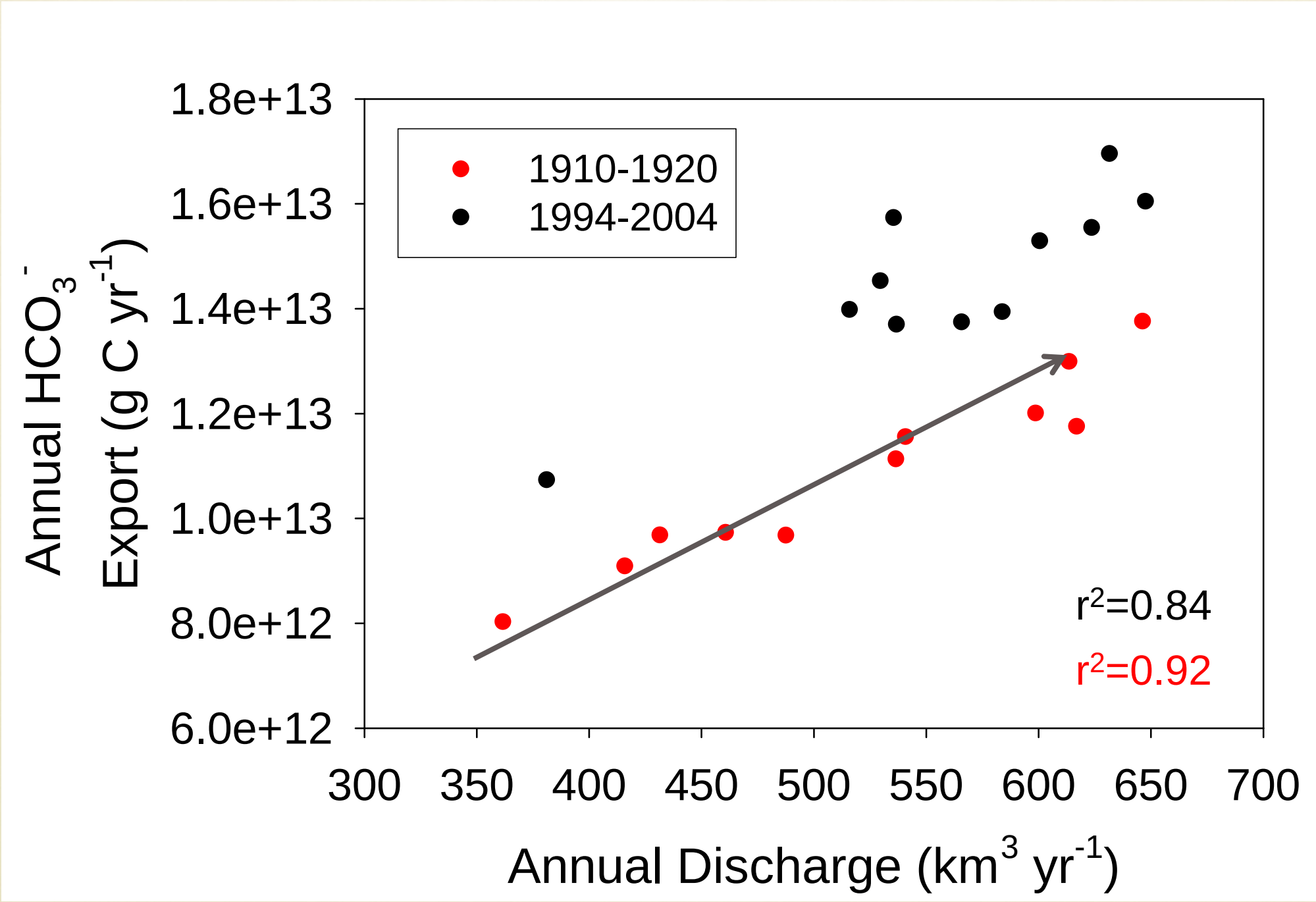
Time Series of Watershed Response Facto



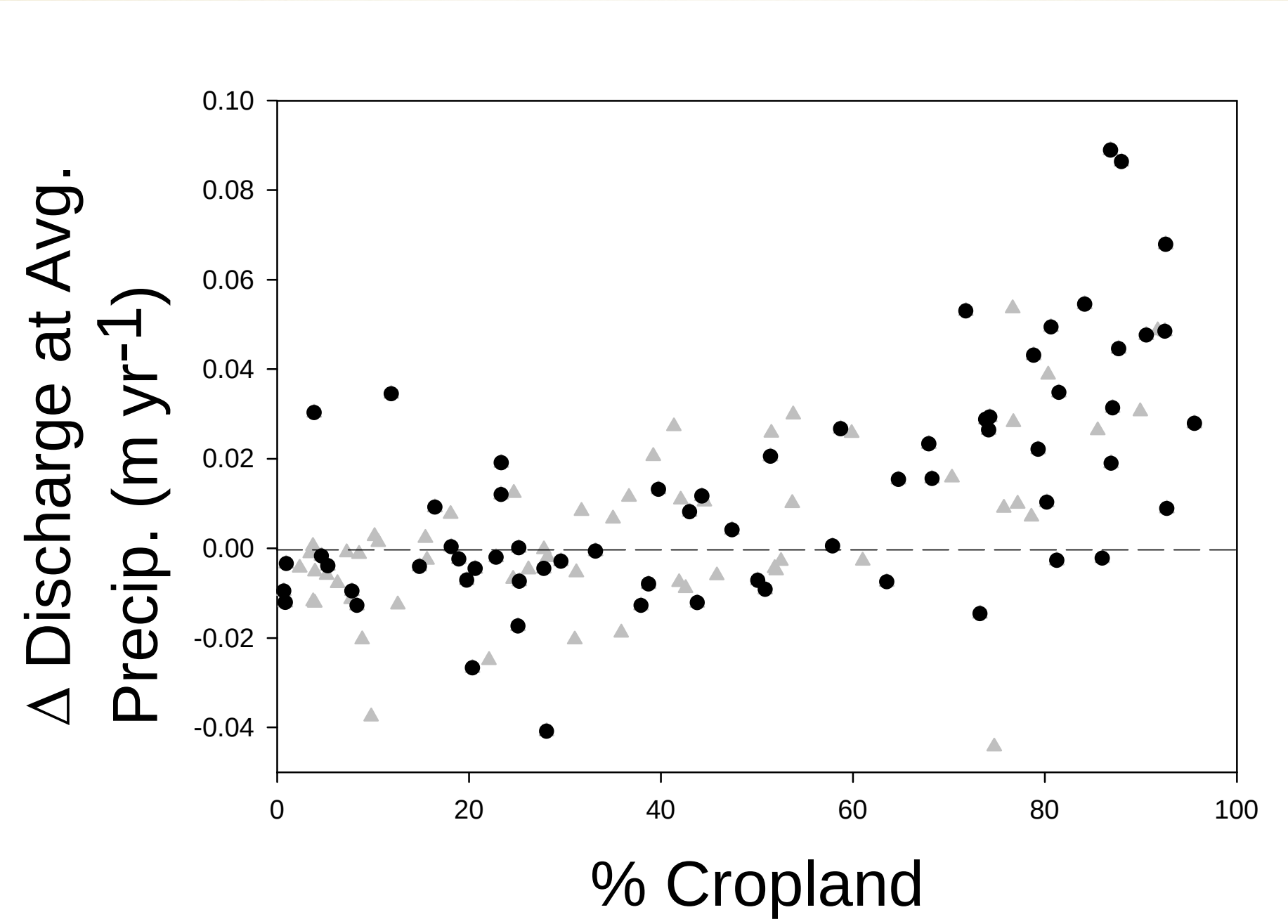
Time Series of Watershed Response Facto



Shift in Watershed Response Factor



Anthropogenic Forcings Increase Discharge



Mississippi River discharge is increasing and the proportion of water from agricultural land cover is also increasing - which is changing the chemistry of the River.

- Nitrate concentrations across the continental US have increased on average by 300% in the last century.
- Bicarbonate fluxes from the Mississippi have increased 50% in the last half century.
- Increases are partly due to climate, fertilizer use, liming and changes in ag hydrology (tile drainage, mechanical tillage).
- Linear relationship between NN and land in cropland at the beginning and end of the 20th Century.
- Anthropogenic land management practices increased NN concentration, discharge, and bicarbonate flux.
- Federal farm policies do influence land use and water

There is still a lot to learn about how land use and climate change are impacting food production in the United States and how these interactions alter water quality and quantity.

Large spatial data sets like Clarke and long term data sets like Carrollton are rare but tremendously importa when studying these issues.

Than
You!