Ecoflows tool: Indicators of Hydrologic Alteration in the Context of Indiana Streams

Mark Pyron

Ball State University

Department of Biology

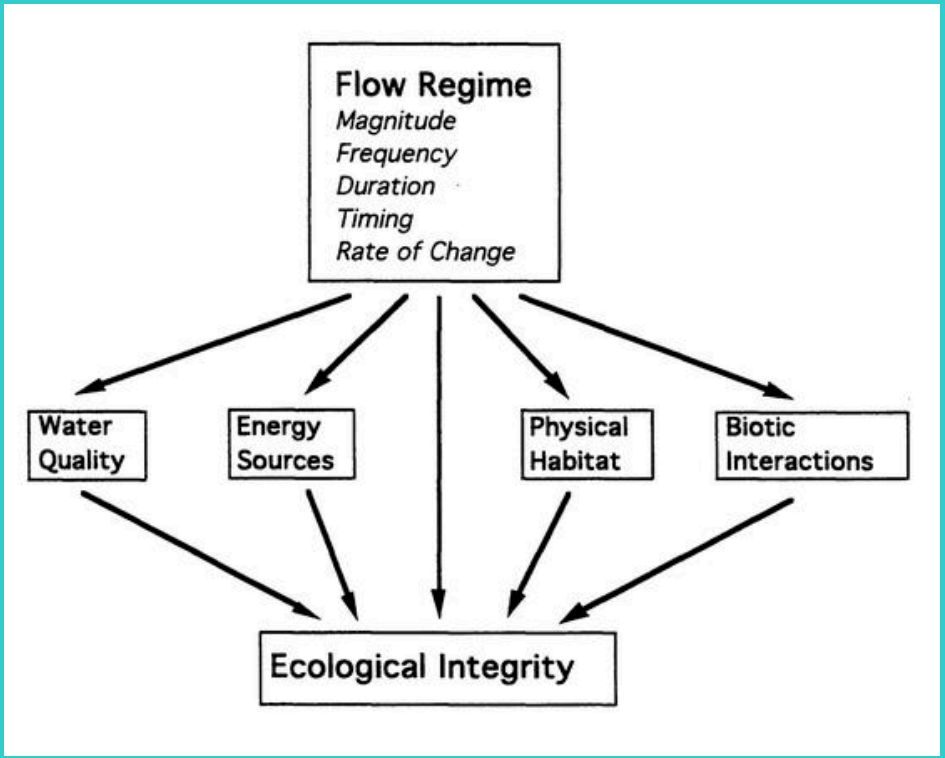
MACRO

MACROECOLOGICAL RIVERINE SYNTHESIS

BALL STATE UNIVERSITY

The natural flow regime

(Poff et al. 1997 Bioscience)



Hydrologic alteration

- Changes in natural flow regime
- A natural flow regime results in scouring and deposition patterns
- Shapes streams and provides habitats for native organisms

Altered flows disrupt ecosystems:

- Dams
- Agricultural drainage
- Water removal
- Channel modifications

Effects of altered flow regime:

- **Stream organisms:** adaptations for natural flow regime attributes
- **Alterations =** losses of inverts and fishes: changes in assemblages

Based on publication:

RIVER RESEARCH AND APPLICATIONS

River. Res. Applic. **24**: 1175–1184 (2008)

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(www.interscience.wiley.com) DOI: 10.1002/rra.1155

HYDROLOGIC ALTERATIONS IN THE WABASH RIVER WATERSHED, USA

MARK PYRON[a]* and KLAUS NEUMANN[b]

[a] *Department of Biology, Ball State University, Muncie, IN 47306, USA*
[b] *Department of Geology, Ball State University, Muncie, IN 47306, USA*

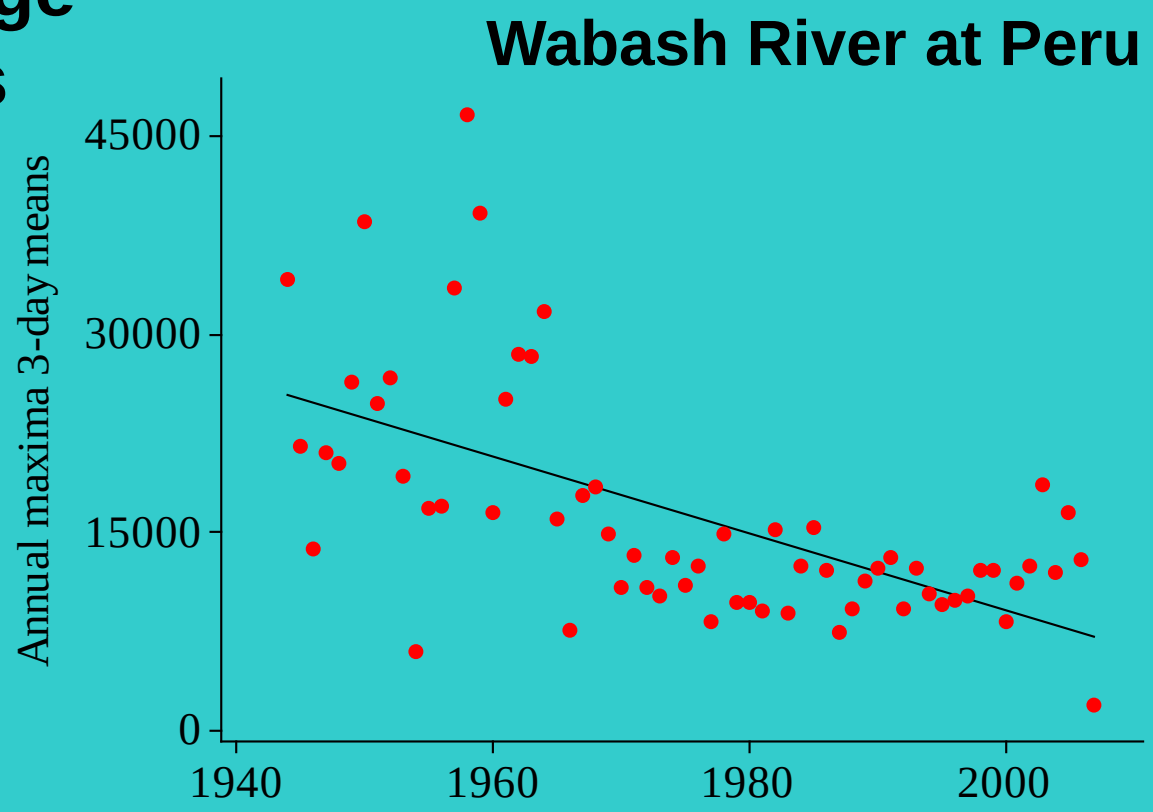
ABSTRACT

Flow alteration of streams from anthropogenic impacts is ubiquitous worldwide. In this paper, we examine flow alteration in a single watershed, the Wabash River and suggest potential impacts on aquatic assemblages. The Indicators of Hydrologic Alteration (IHA) software was used to evaluate hydrological variables generated from daily discharge data of 80 USGS gauging stations, during the past several decades. We used the approach of regressions of hydrological variables against time to identify hydrologic change. An average of 6.9 hydrologic variables (of 33 variables) were significantly altered at each station, and stations with larger watersheds had an increased number of altered variables. A principal components (PC) analysis of altered hydrologic variables resulted in three of four PC axes that were correlated with watershed area. Significant results were: (1) larger streams were more likely to have hydrologic alteration than smaller streams; (2) streams with upstream dams had increased minimum flows for 1-, 3-, 7- and 30-day intervals, decreased maximum flows for 1-, 3-, 7- and 30-day intervals, increased fall rates, decreased summer monthly flows and decreased high pulse counts; (3) the presence of agriculture in upstream watersheds resulted in an increased number of zero flow days, increased low pulse counts and decreased high flows during October and April. No significant differences were detected in hydrologic alteration based on urban land-use of upstream watersheds. Hydrologic alterations in the Wabash River watershed have undoubtedly resulted in ecological degradation. We suggest that changes in assemblages during the past century are linked to these hydrologic alterations. Copyright © 2008 John Wiley & Sons, Ltd.

KEY WORDS: hydrologic alteration; Wabash River; reservoir effect; agriculture effect

Indicators of Hydrologic Alteration
(Richter et al. 1996)

- **Software to quantify hydrology variables**
- **Use daily discharge from USGS gages**
- **33 hydrologic variables**



Conservation Practices

Water
Corporate Water Use
Environmental Flows
Concepts
Methods and Tools
Environmental Flow Components
Hierarchy Method
The Savannah Process
ELOHA
Indicators of Hydrologic Alteration
Libraries
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Water Infrastructure
Water Quality
Habitat Protection and Restoration
Financial Solutions
Saving Great Rivers
Setting Freshwater Priorities

Lands
Marine
Climate Change
Cities

Indicators of Hydrologic Alteration (IHA)

[IHA] - [Downloads] - [Publications] - [FAQs] - [Training]

Indicators of Hydrologic Alteration (IHA) is a software program that provides useful information for those trying to understand the hydrologic impacts of human activities or trying to develop environmental flow recommendations for water managers. Nearly 2,000 water resource managers, hydrologists, ecologists, researchers and policy makers from around the world have used this program to assess how rivers, lakes and groundwater basins have been affected by human activities over time – or to evaluate future water management scenarios.

This program was developed by scientists at The Nature Conservancy to facilitate hydrologic analysis in an ecologically-meaningful manner. The software program assesses 67 ecologically-relevant statistics derived from daily hydrologic data. For instance, the IHA software can calculate the timing and maximum flow of each year's largest flood or lowest flows, then calculates the mean and variance of these values over some period of time. Comparative analysis can then help statistically describe how these patterns have changed for a particular river or lake, due to abrupt impacts such as dam construction or more gradual trends associated with land- and water-use changes. The IHA software is described in a number of **scientific papers**.

Contact Us

If you have questions or comments regarding IHA, please contact James Limbrunner.

Key Resources

Wabash River at Peru

Wikipedia

USGS
science for a changing world

USGS Home
Contact USGS
Search USGS

National Water Information System: Web Interface

USGS Water Resources

Data Category: Current Conditions | Geographic Area: Indiana | GO

Click to hide News Bulletins

- Please see news on new formats
- Full News

Click to hide state-specific text

NOTE: USGS Indiana historic, recent, and real-time data will continue to be provided in Eastern Standard Time.

NOTE: During winter months, stage and discharge may be affected by ice. Click here for more information.

USGS 03327500 WABASH RIVER AT PERU, IN

PROVISIONAL DATA SUBJECT TO REVISION

Available data for this site Time-series: Current/Historical Observations | GO

Click to hide station-specific text

This gaging station is maintained in cooperation with:

- **The U.S. Army Corps of Engineers - Louisville District**
- **USGS Groundwater and Streamflow Information Program (GWSIP)**

The precipitation data for this station are temporary and will only be displayed for 120 days. Although the instrumentation is calibrated at least once/year, the temporary classification means that documented routine inspections and other quality assurance measures are not performed to make the data acceptable for archival, retrieval, or future use in general scientific or interpretive studies.

Boating safety tips

This station managed by the Indiana Water Science Center Office.

Available Parameters	Available Period
☐ All 3 Available Parameters for this site	
☑ 00045 Precipitation	2017-07-18 2017-11-15
☑ 00060 Discharge	1987-10-01 2017-11-15
☑ 00065 Gage height	2007-10-01 2017-11-15

Output format
- ◉ Graph
- ○ Graph w/ stats
- ○ Graph w/o stats
- ○ Graph w/ (up to 3) parms
- ○ Table
- ○ Tab-separated

Days (7)
-- or --
Begin date 2017-11-08
End date 2017-11-15

GO

Summary of all available data for this site
Instantaneous-data availability statement

---------- WARNING ----------
The data you have obtained from this automated U.S. Geological Survey database
have not received Director's approval and as such are provisional and subject to
revision. The data are released on the condition that neither the USGS nor the
United States Government may be held liable for any damages resulting from its use.
Additional info: http://waterdata.usgs.gov/in/nwis/help/?provisional
#
File-format description: http://waterdata.usgs.gov/nwis/?tab_delimited_format_info
Automated-retrieval info: http://waterdata.usgs.gov/nwis/?automated_retrieval_info
#
Contact: gs-w_support_nwisweb@usgs.gov
retrieved: 2006-10-12 13:37:05 EDT
#
Data for the following site(s) are contained in this file
USGS 03327500 WABASH RIVER AT PERU, IND.

#
Data provided for site 03327500
DD parameter statistic Description
01 00060 00003 Discharge, cubic feet per second (Mean)
#
Data-value qualification codes included in this output:
A Approved for publication -- Processing and review completed.
P Provisional data subject to revision.
e Value has been estimated.
#

agency_cd	site_no	datetime	01_00060_00003	01_00060_00003_cd
5s	15s	16s	14s	14s
USGS	3327500	10/1/1943	321	A
USGS	3327500	10/2/1943	306	A
USGS	3327500	10/3/1943	291	A
USGS	3327500	10/4/1943	276	A
USGS	3327500	10/5/1943	272	A
USGS	3327500	10/6/1943	267	A
USGS	3327500	10/7/1943	262	A
USGS	3327500	10/8/1943	262	A
USGS	3327500	10/9/1943	262	A
USGS	3327500	10/10/1943	228	A
USGS	3327500	10/11/1943	209	A
USGS	3327500	10/12/1943	209	A
USGS	3327500	10/13/1943	209	A

IHA Annual Summary Statistics

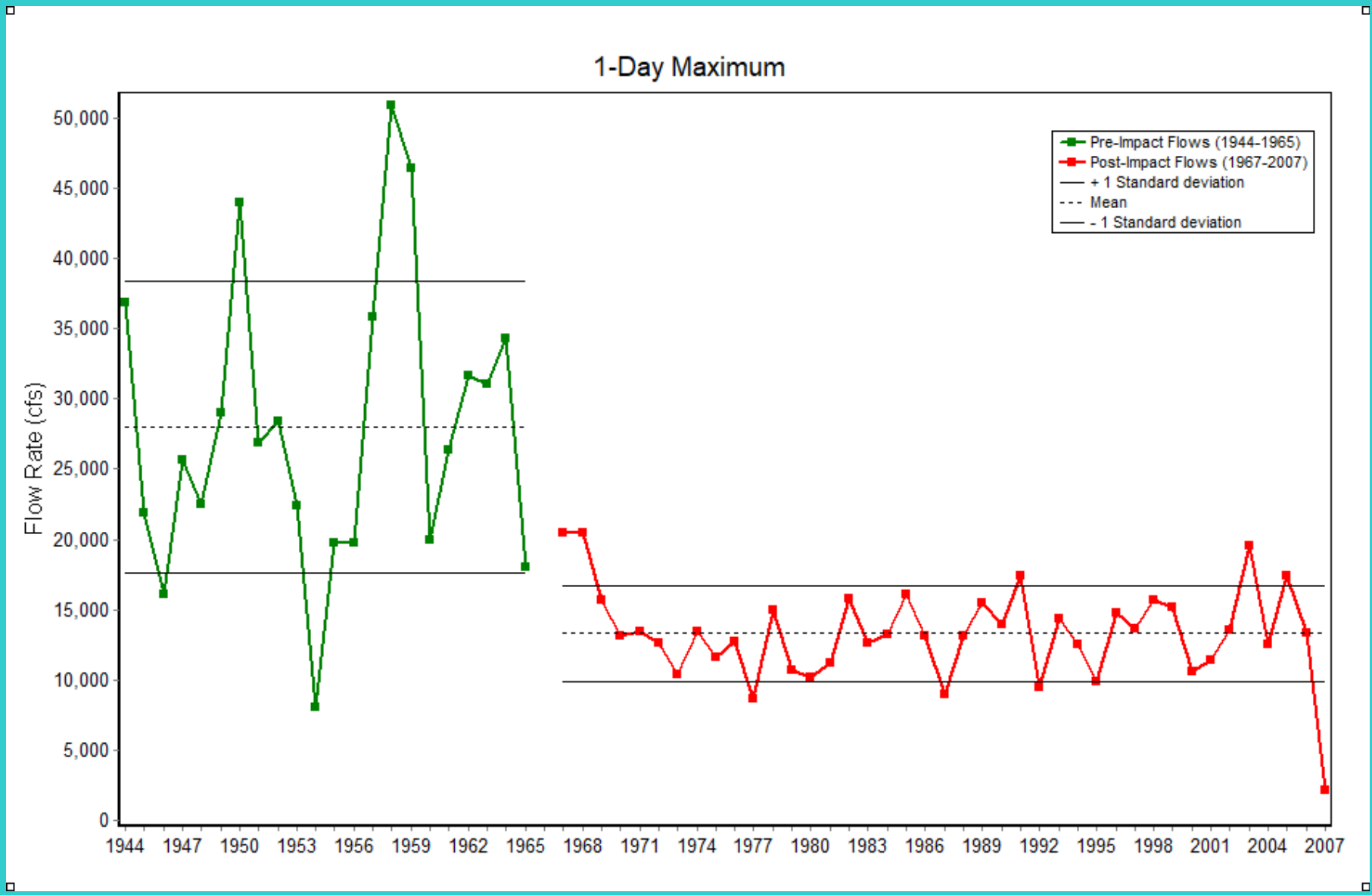
WabashPeru

Year	October	November	December	January	February	March	April	May	June	July	August	September	1-day min	3-day min
1944	266.1	616.3	268.9	236.1	1642	4378	10680	3096	532.3	175.2	231.6	138.2	92	100.3
1945	166.3	295.6	153.9	140.6	1921	5203	5286	3550	3729	728.8	818.8	571.3	74	82.67
1946	2364	734	2182	3515	2844	4278	678	3064	2519	700.1	202.7	129.1	98	104.7
1947	142.3	188.9	560.2	3089	1813	2201	5534	5191	6279	674.4	734.1	318.7	72	78.67
1948	315.7	418.2	670.5	3531	3547	8067	7372	3693	1060	1169	271.8	172.9	113	114.7
1949	198.1	1836	3905	12050	6103	2559	1868	1948	1839	1206	369.2	467.1	140	147.7
1950	1546	343.4	2554	18500	10250	6620	6537	1473	1709	1058	401.5	2457	226	244.7
1951	1200	3480	5746	5038	8194	4469	5080	2808	1228	1043	248.5	180.1	132	142.7
1952	286.4	759.7	3748	9512	5589	7363	5640	3258	1282	360	370	649	160	160
1953	231.3	506.5	1509	2658	2304	6254	2496	2837	806.5	648.5	483	128.7	102	102
1954	110.5	149.5	180.1	462.6	604.3	1455	2296	737.5	1458	312.9	424.3	135.4	78	81
1955	2078	711.7	1657	3963	2092	6649	2269	592.5	704.2	2022	673.7	149.9	112	112
1956	1559	4328	869.2	381.7	5960	4505	2051	2060	3074	1398	364.8	183.1	129	133.7
1957	145	201.8	551.1	1932	2394	1792	14840	4285	4260	5767	535.2	777.1	119	121.3
1958	1234	1583	8314	1668	1178	1964	1677	1498	14260	3563	2700	481.2	168	169.3
1959	388.5	2290	862.6	7529	10740	4288	7736	3968	1648	735	304.1	282.3	156	156
1960	728.4	1357	2197	3341	4494	2484	1878	1304	1423	1355	448.7	199.5	164	166.7
1961	180.3	209.9	163.5	166.2	842.6	7568	9528	2911	1146	815.1	1817	666.2	121	121
1962	403	1219	604.3	6501	3807	7093	1101	1620	1625	2957	366.3	309.9	170	192.3
1963	241	299.4	210.5	276.2	384.4	8128	2303	1078	904.1	503.9	179.4	118.9	108	111

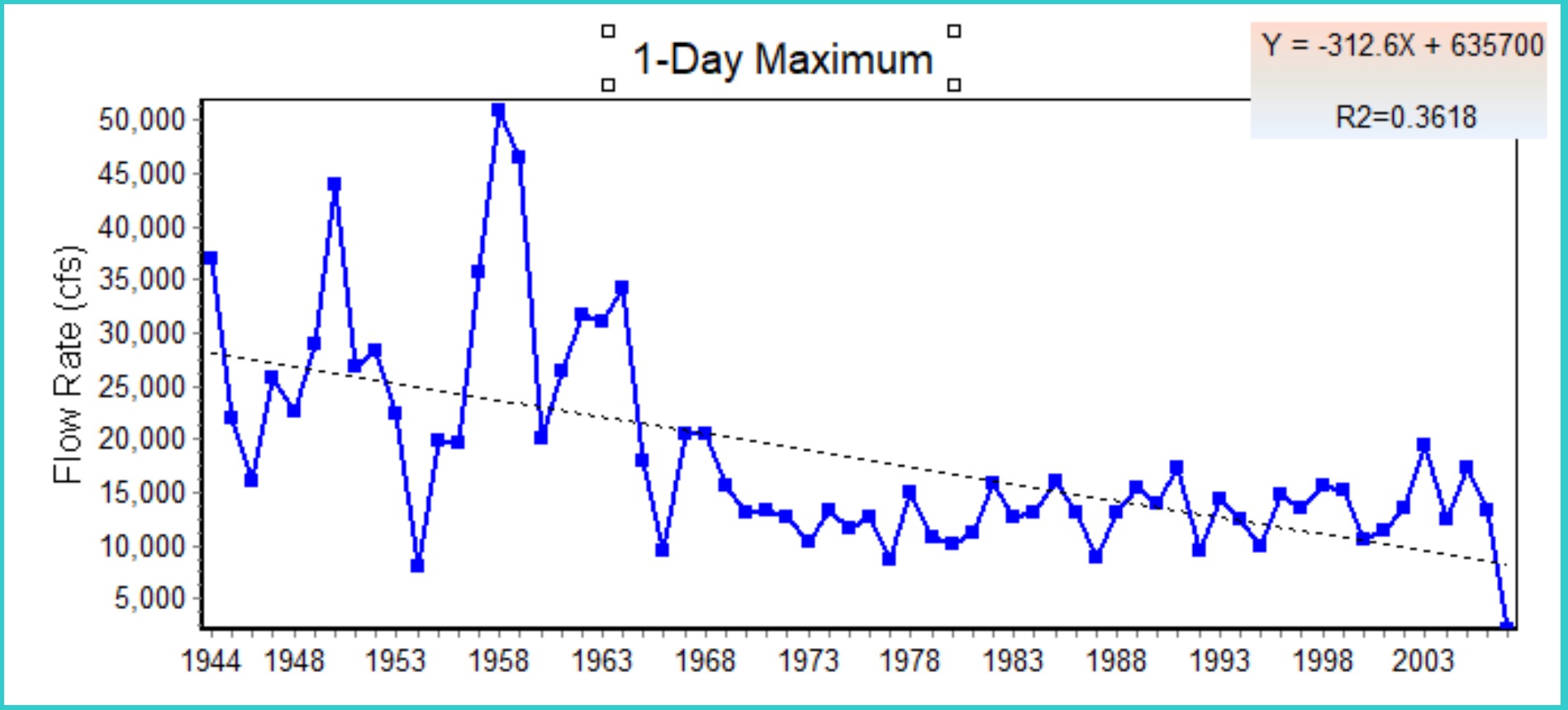
IHA results

Linear Regressions							
WabashPeru							
	Slope	YInt	Sigma	Corr	PValue	FStat	R2
October	21.09	-40470	1024	0.3603	0.005	9.252	0.1298
November	27.51	-52590	1421	0.3415	0.005	8.183	0.1166
December	21.46	-39670	2399	0.1656	0.25	1.747	0.02741
January	-9.972	23160	3478	-0.05374	0.5	0.1796	0.002888
February	-0.4292	4586	2694	-0.00299	0.5	0.0005556	0.000008943
March	-21.07	46120	2447	-0.1595	0.25	1.619	0.02544
April	-47.85	98450	2917	-0.2943	0.025	5.877	0.08659
May	4.992	-7341	1581	0.05916	0.5	0.2178	0.0035
June	13.39	-24000	2286	0.1093	0.5	0.7491	0.01194
July	29.34	-56290	1934	0.2738	0.025	5.026	0.07499
August	18.65	-35920	1155	0.2899	0.025	5.69	0.08406
September	17.91	-34490	945.4	0.335	0.01	7.837	0.1122
1-day minimum	2.131	-4028	73.18	0.4796	0.001	18.52	0.23
3-day minimum	2.644	-5030	84.91	0.5046	0.001	21.18	0.2547
7-day minimum	3.905	-7496	128.4	0.4959	0.001	20.22	0.2459
30-day minimum	6.066	-11660	170.8	0.5547	0.001	27.56	0.3077

IHA results



IHA results – 2 periods

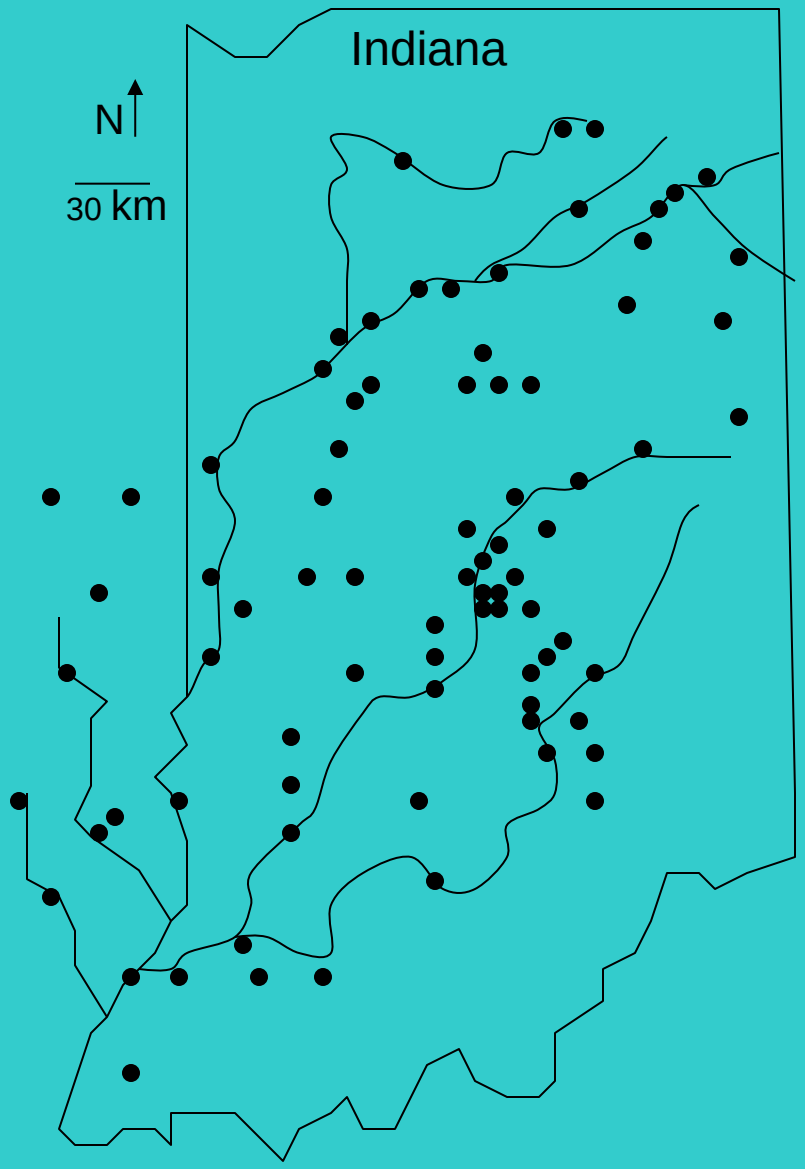


IHA results – single period

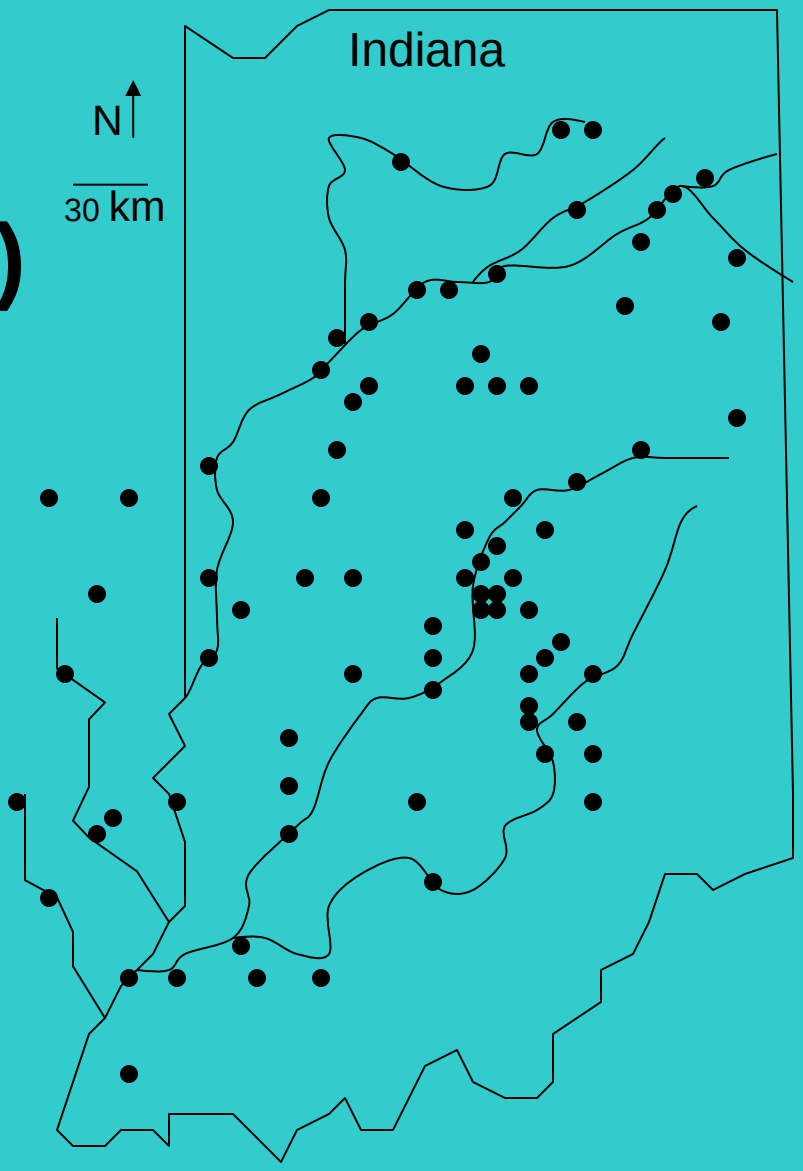
Wabash River Watershed:

80 gauging stations

> 20 year record

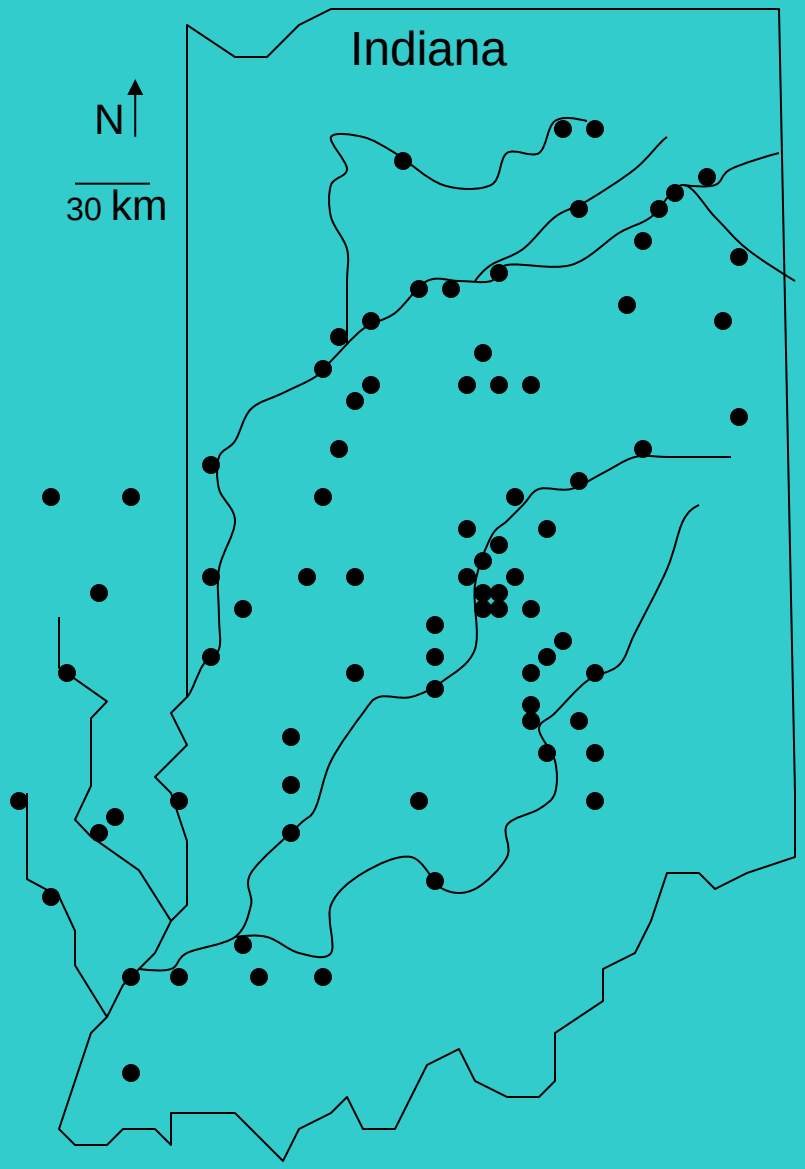


- **Impacts?**
- **Upstream dams (39)**
- **Land cover:**
  - **Agriculture (62)**
  - **Urbanization (24)**



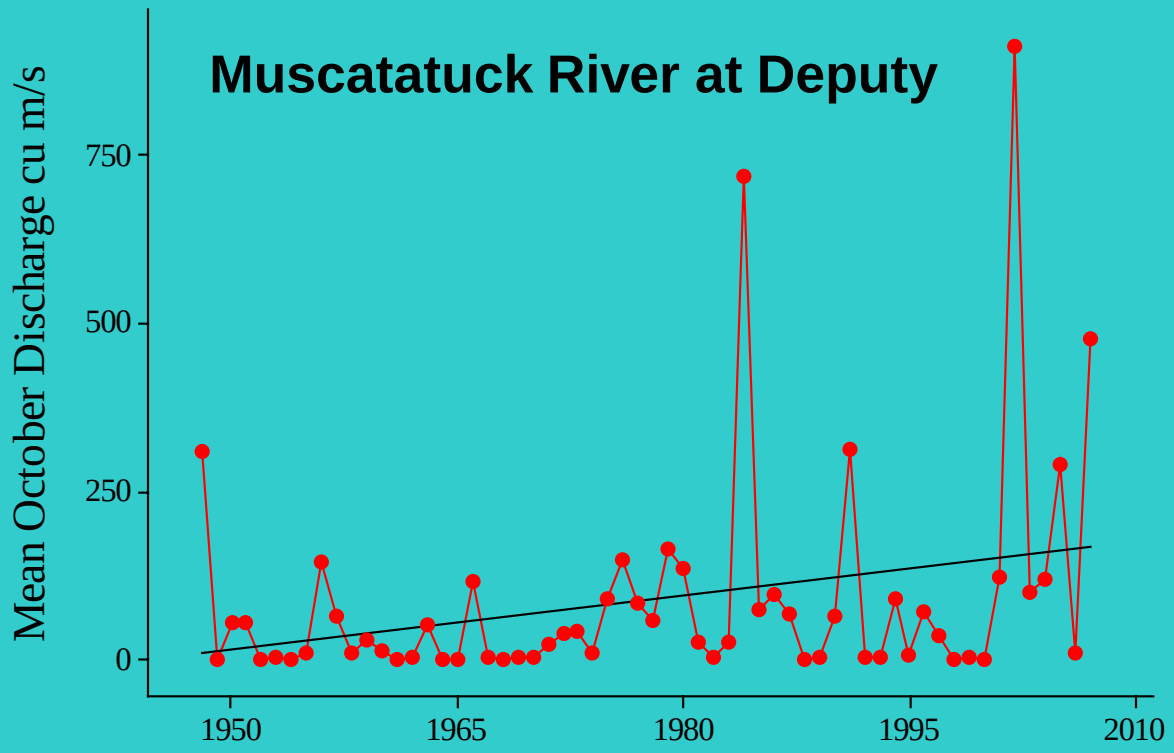
Wabash River Watershed:

Did hydrology change with time?



Analyses

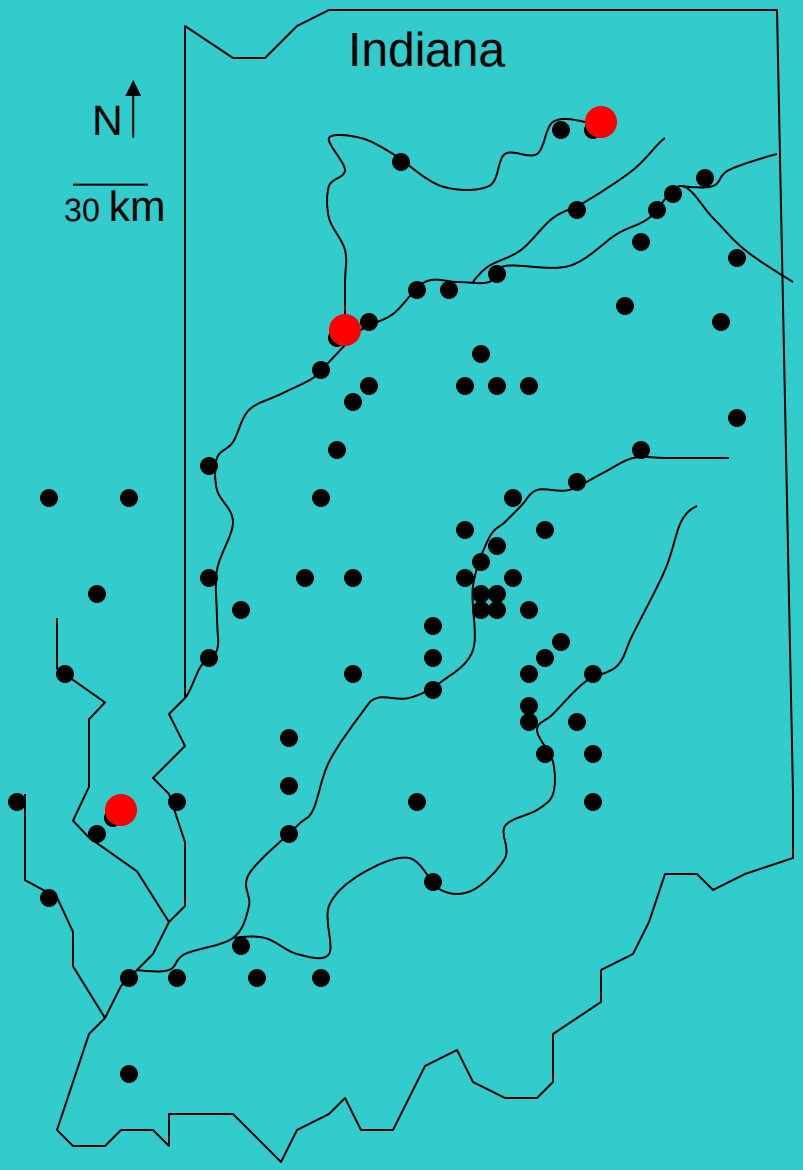
- **Regress IHA variables with time**
- **Reduce 33 variables with PCA of *r* values**



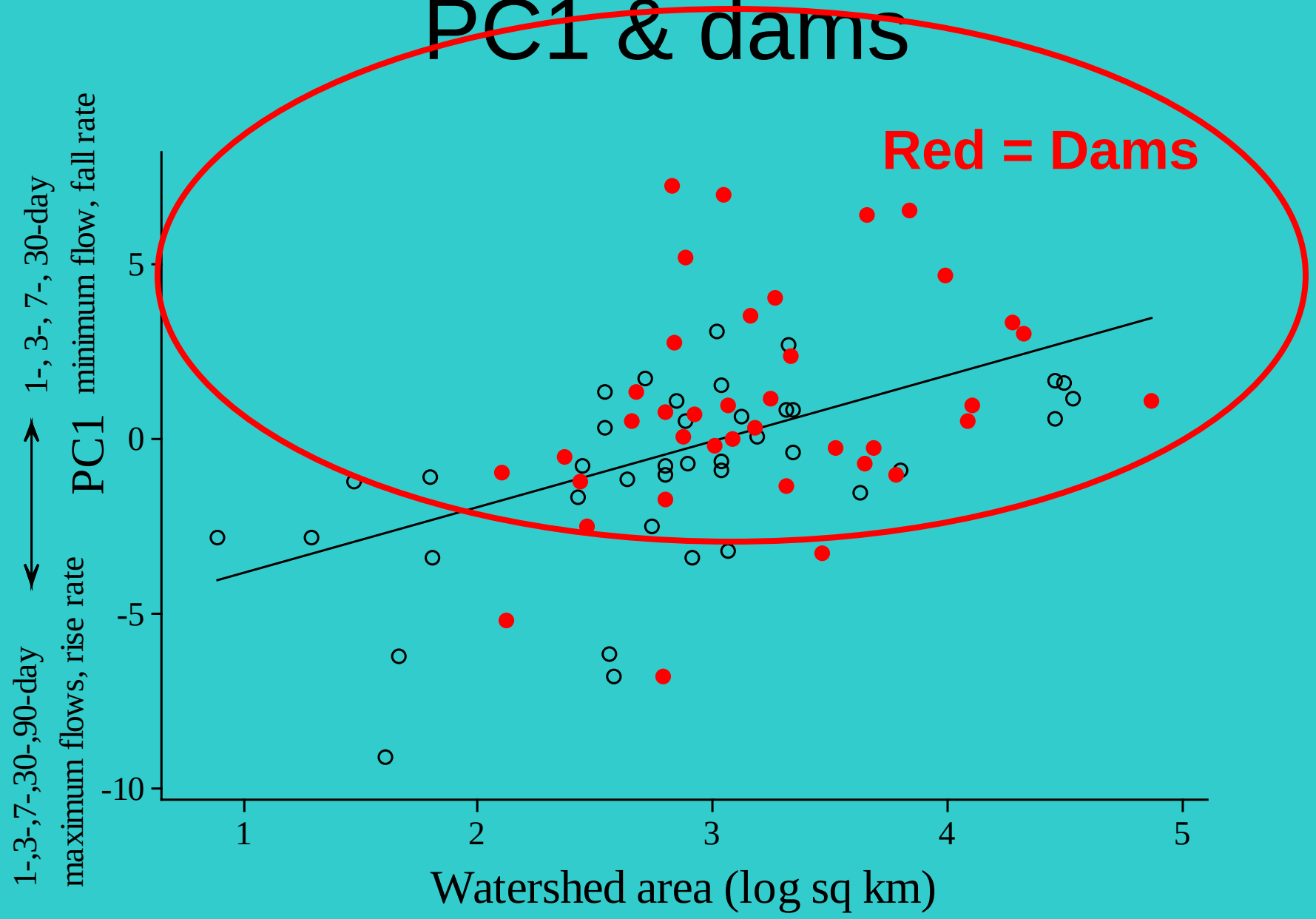
INDIANA
OHIO
ILLINOIS
KENTUCKY
Tippecanoe
Fort Wayne
Eel
Little
Wabash
Salamonie
Wildcat
Kokomo
Marion
Mississinewa
Wabash
Lafayette
Muncie
Champaign
Danville
Vermilion
Anderson
Sugar
Big Raccoon
Indianapolis
Embarras
Terre Haute
Flatrock
Eel
White
Columbus
Bloomington
Little Wabash
East Fork White
Muscatatuck
Ohio
Patoka
Louisville
Evansville

IHA results:

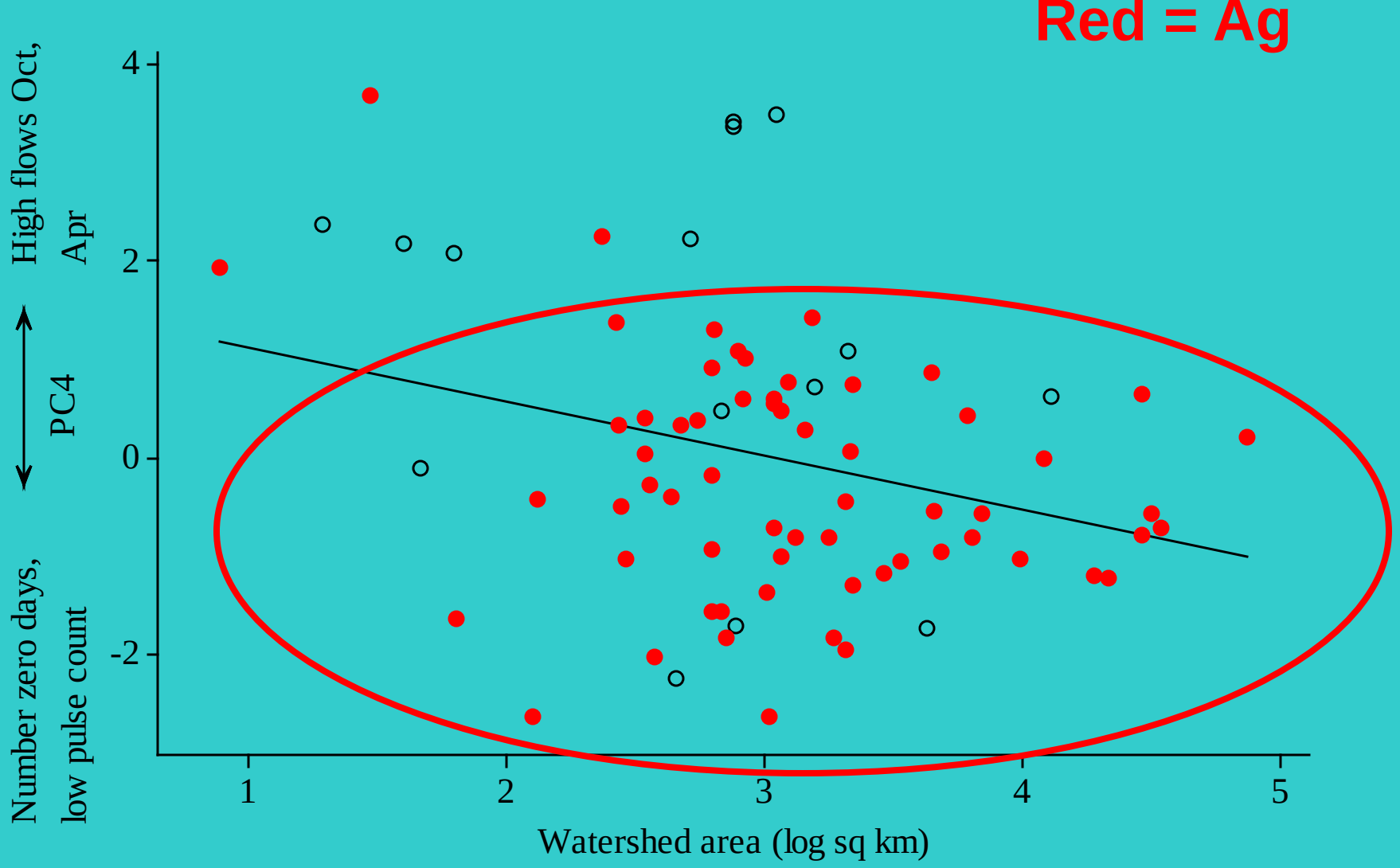
- **Altered variables:**
- **$\bar{X}$ = 8 hydrologic variables altered at each site**
- **3 sites unchanged**



PC1 & dams

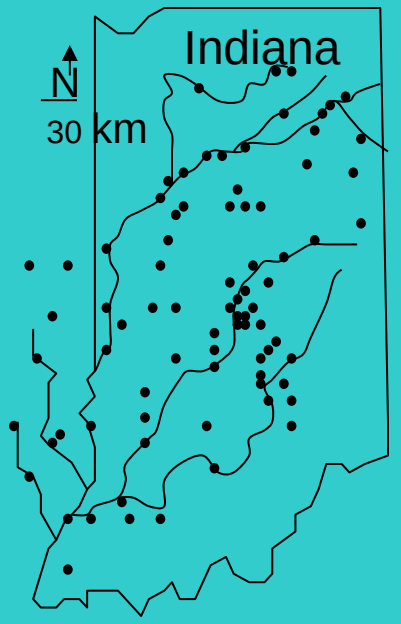

Red = Dams
1-, 3-, 7-, 30-day minimum flow, fall rate
PC1
1-,3-,7-,30-,90-day maximum flows, rise rate
5
0
-5
-10
1
2
3
4
5
Watershed area (log sq km)

PC4 & agriculture



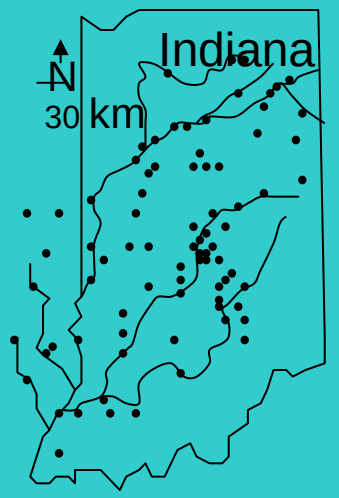
Results of IHA analyses

- **96 % of Wabash River watershed stations have altered hydrology**
- **Causes = dams and agriculture**
- **Could not detect urban effects**



IHA Summary

- 96 % of Wabash River watershed sites - altered hydrology



Conservation of aquatic ecosystems

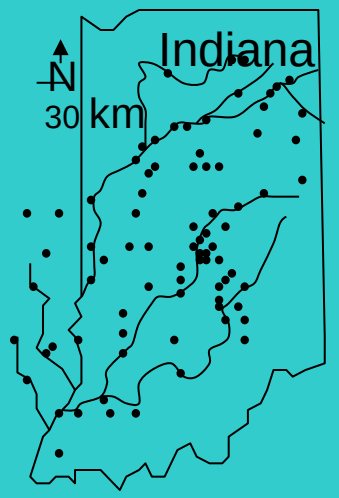
- Improvements require restoration of natural flow
- Dams
  - Modify release to mimic natural flow
  - Removal of unnecessary dams

Conservation of aquatic ecosystems

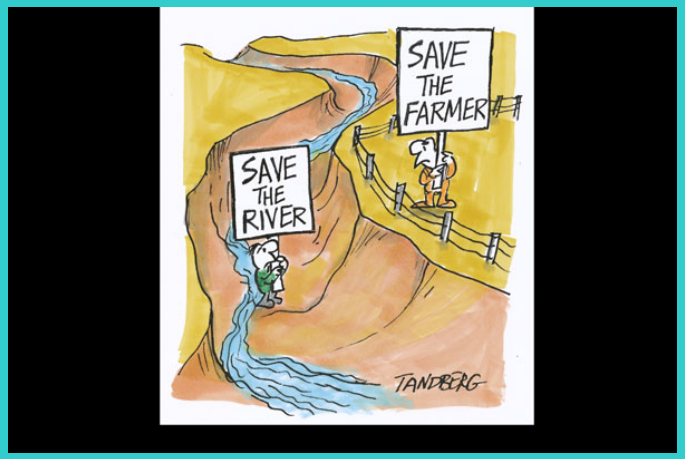
- **Agriculture**
  - **Avoid or reduce:**
  - **channelization**
  - **tile drainage**

Summary

- **96 % of Wabash River watershed sites - altered hydrology**

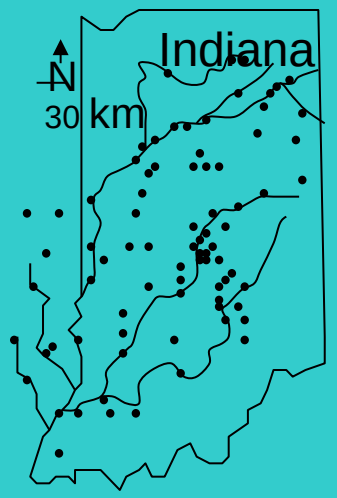


- **Causes = dams, agriculture**



Summary

- **96 % of Wabash River watershed sites - altered hydrology**
- **Causes = dams, agriculture**
- **Prediction: impacts on river ecosystems**



IS IT JUST ME OR DO YOU FEEL A WARM CURRENT PASSING BY?
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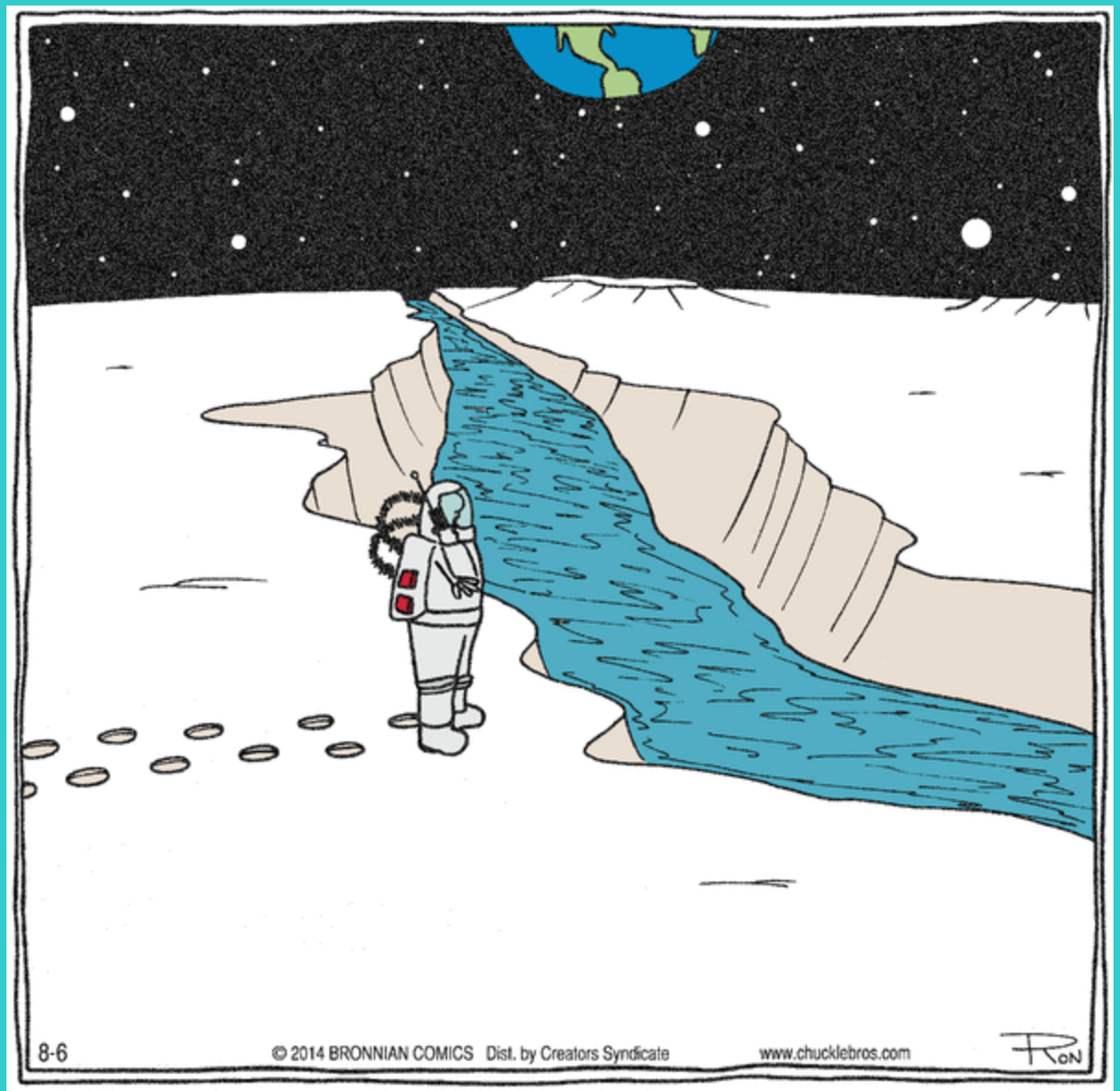

"Hey, Andy. It's Neil. Listen: I just thought of a great idea for your next hit song."