Decreases in wastewater pollutants increased fish diversity of Chicago's waterways

Shedd AQUARIUM

Metropolitan Water Reclamation District of Greater Chicago

Wastewater Contaminant Higher
Dissolved Oxygen Lower

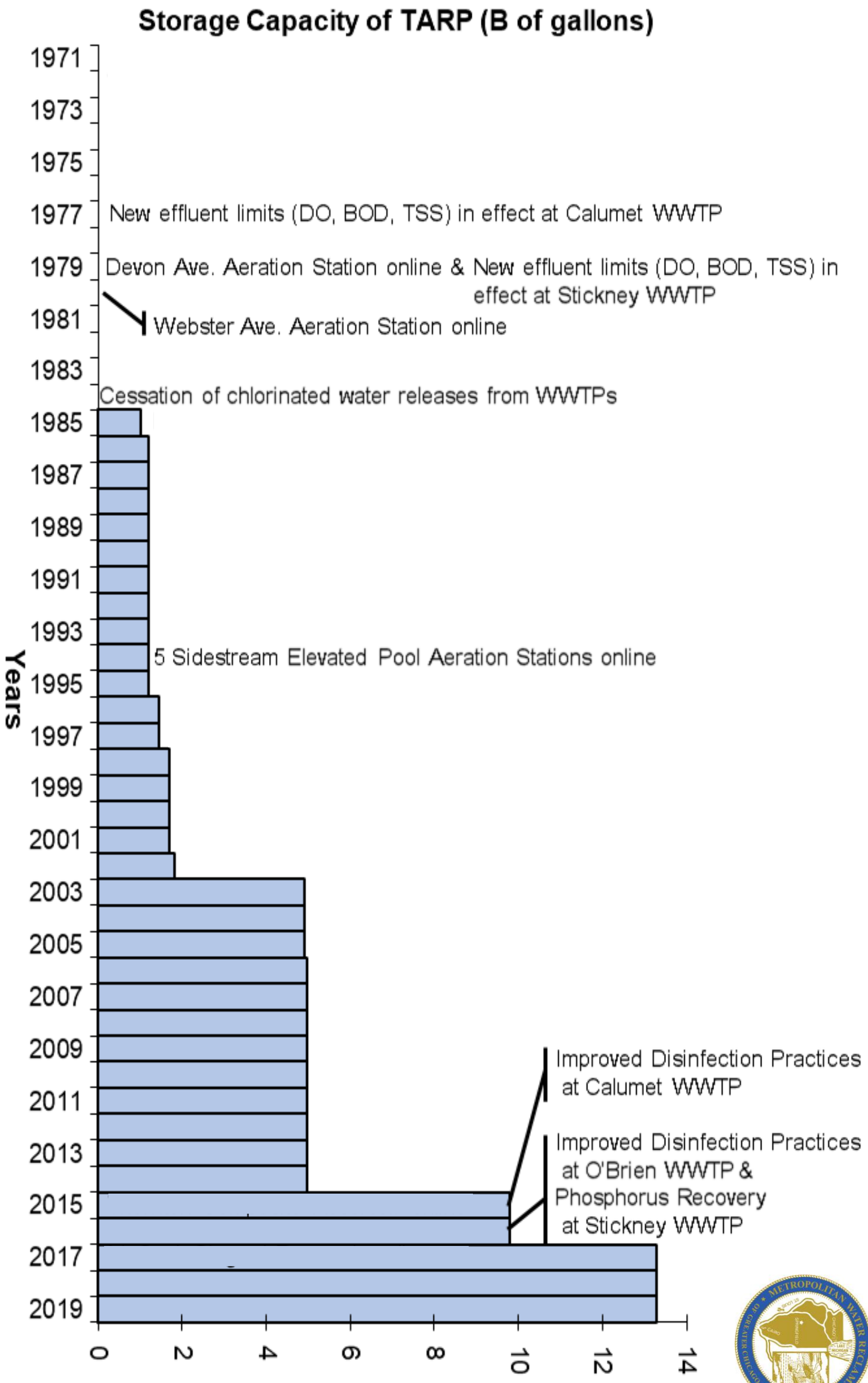
Wastewater Contaminant Lower
Dissolved Oxygen Higher

- Banded Killifish
- Bluegill
- Bluntnose Minnow
- Carp
- Emerald Shiner
- Gizzard Shad
- Golden Shiner
- Goldfish
- Green Sunfish
- Largemouth Bass
- Pumpkinseed
- Round Goby
- Spotfin Shiner
- White Sucker
- Yellow Bullhead

1985 → 2020

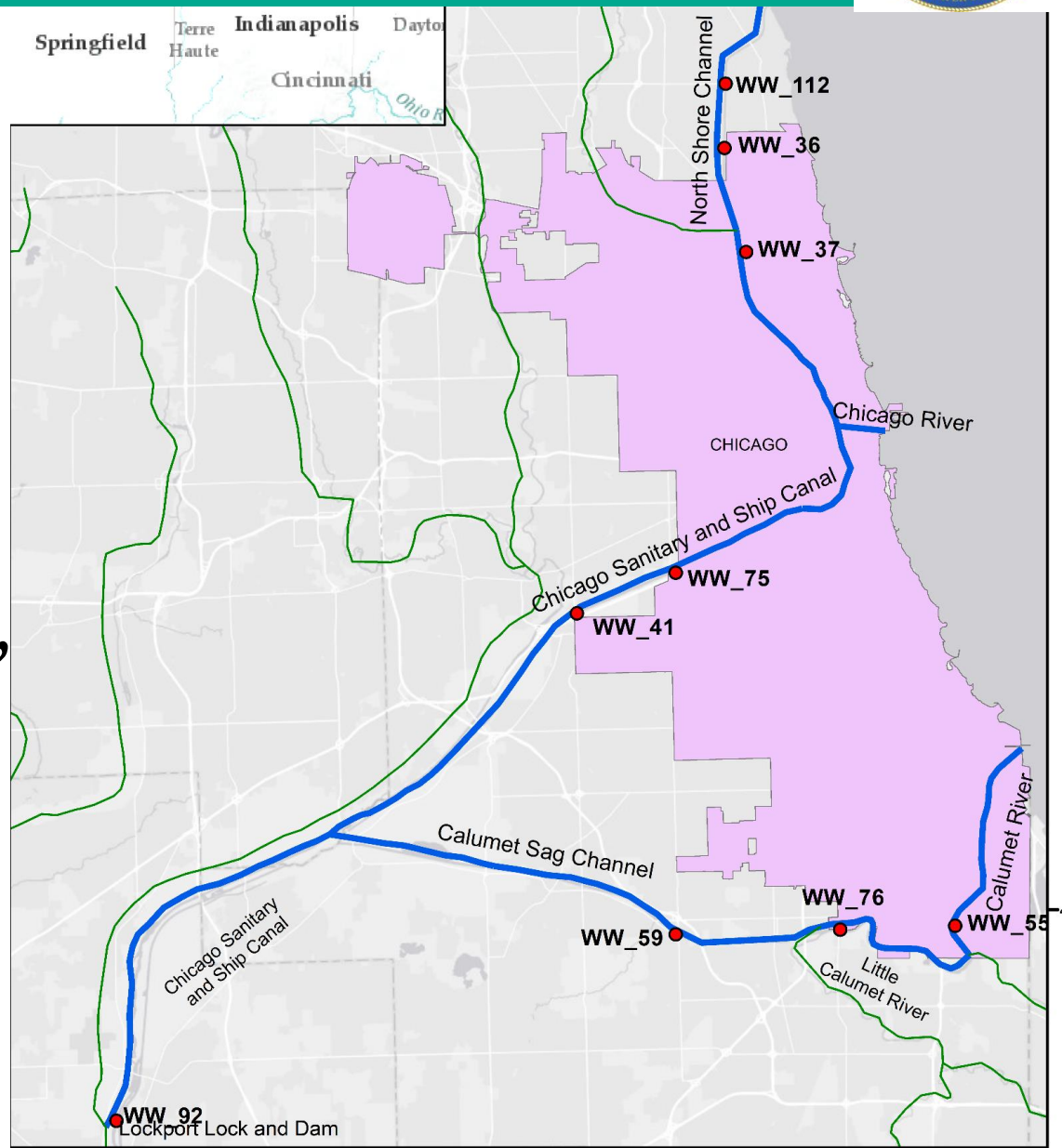
Chicago Area Waterway System

- >76 mile navigational waterway
  - "flows" through 3rd largest city
  - 75% man-made
  - Mostly (if not fully) channelized
  - >70% of flow from the effluent of 3 wastewater facilities
  - Combined Sewer Overflow system periodically dumps untreated sewage


Storage Capacity of TARP (B of gallons)
1971
1973
1975
1977
New effluent limits (DO, BOD, TSS) in effect at Calumet WWTP
1979
Devon Ave. Aeration Station online & New effluent limits (DO, BOD, TSS) in effect at Stickney WWTP
1981
Webster Ave. Aeration Station online
1983
Cessation of chlorinated water releases from WWTPs
1985
1987
1989
1991
1993
5 Sidestream Elevated Pool Aeration Stations online
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
Years
Improved Disinfection Practices at Calumet WWTP
Improved Disinfection Practices at O'Brien WWTP & Phosphorus Recovery at Stickney WWTP
0
2
4
6
8
10
12
14

MWRD Sampling

- Expanded/Consistent annual program began in 1985
  - Monthly WQ data collection
  - Electrofishing several locations, often in Aug – Oct.
    - 9 sites isolated from several
    - Represent 6 different waterways



Approach

1. How has the fish community changed over time?

1. Negative Binomial Regressions through the manyGLM() function in R (regression with community data as response variable).

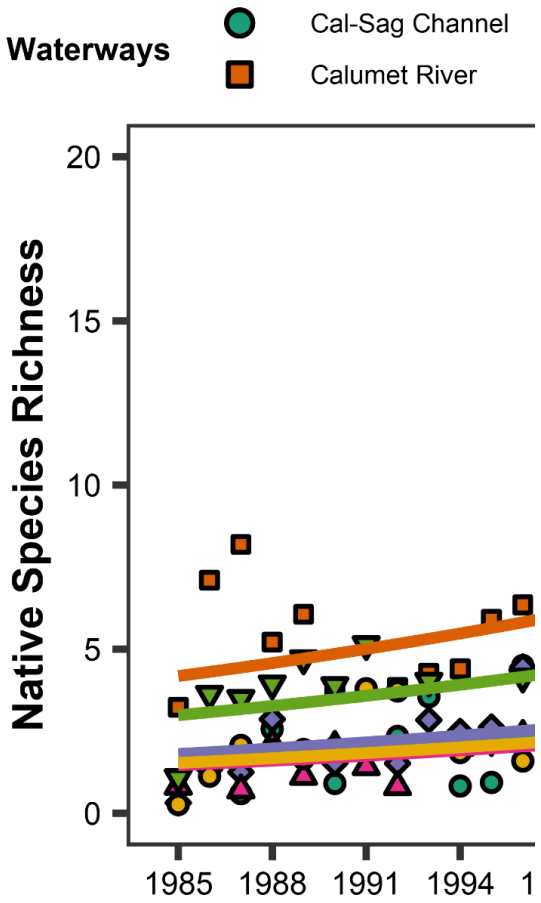
2. How has Water Quality Changed over time?

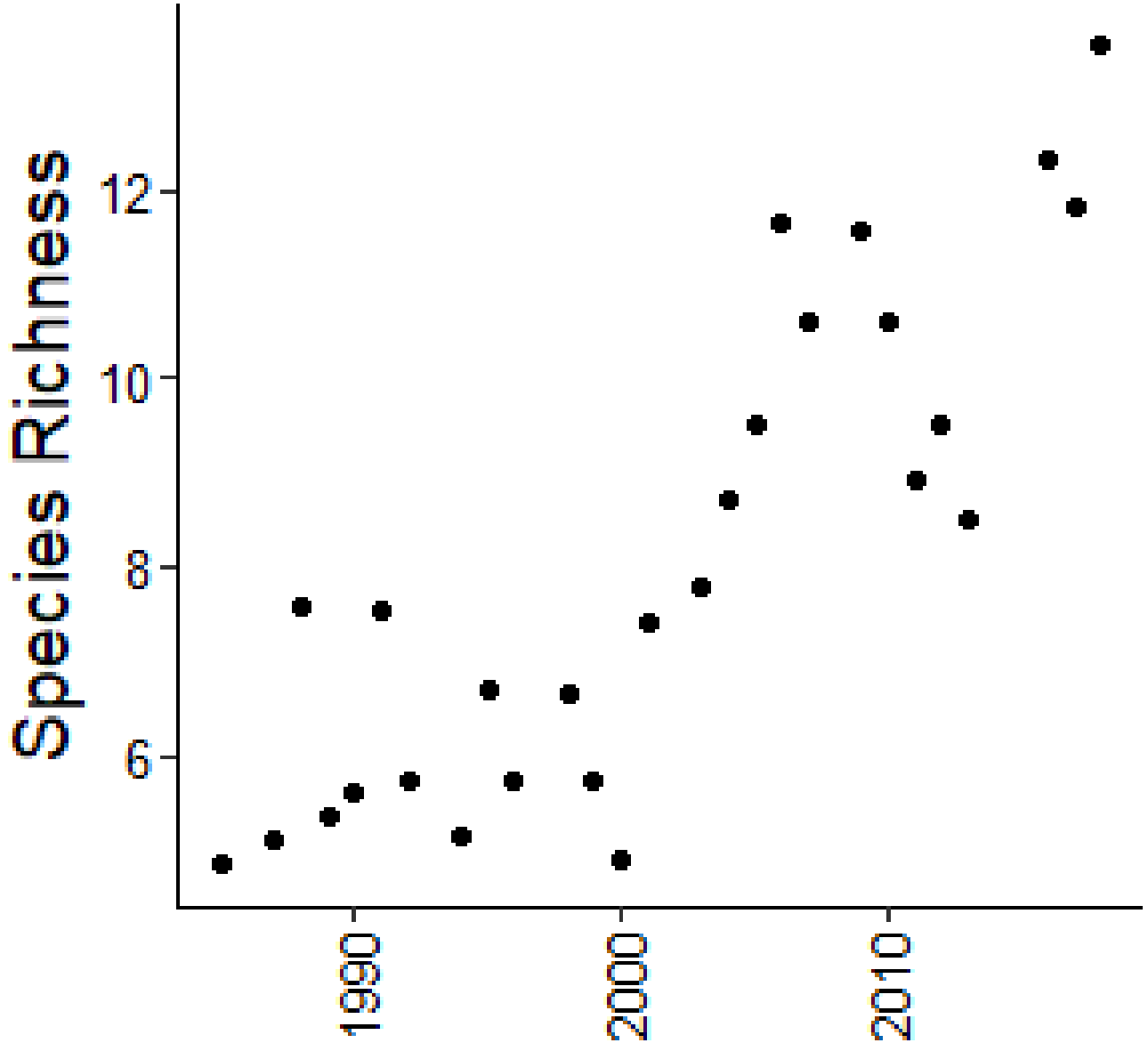
1. General data exploration and correlations with time.
2. Suite of some 14 variables, including some pollutants

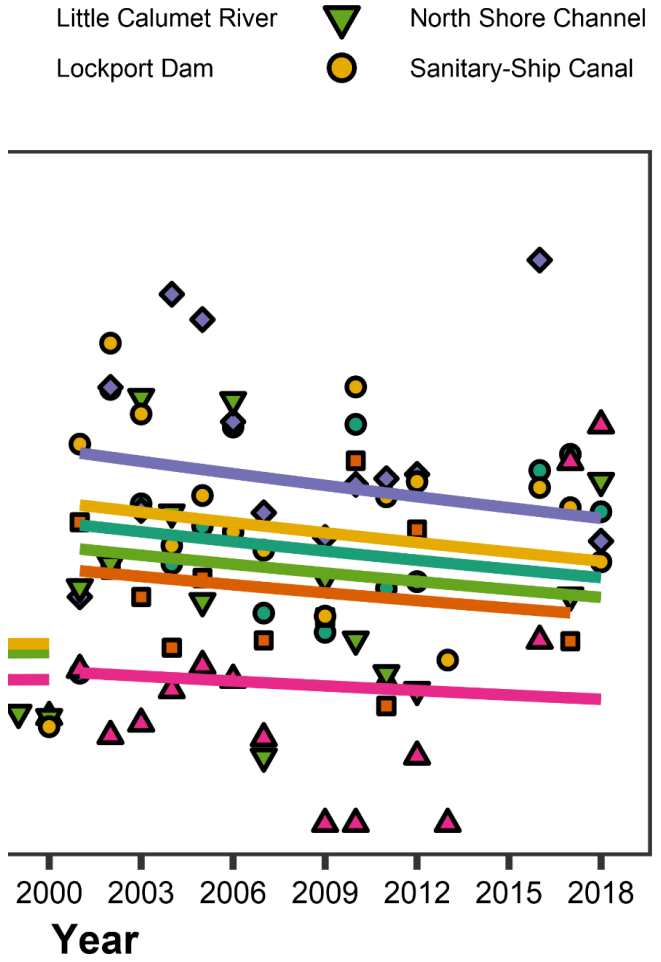
3. What Water Quality or Weather Parameters related best to the fish community data?

1. Conditional Random Forest Regressions – functions well with correlated variables and allows “Variable Importance” to be parsed out.
   - *cforest_unbiased(ntree=5000,mtry=5)*

Richness Increased

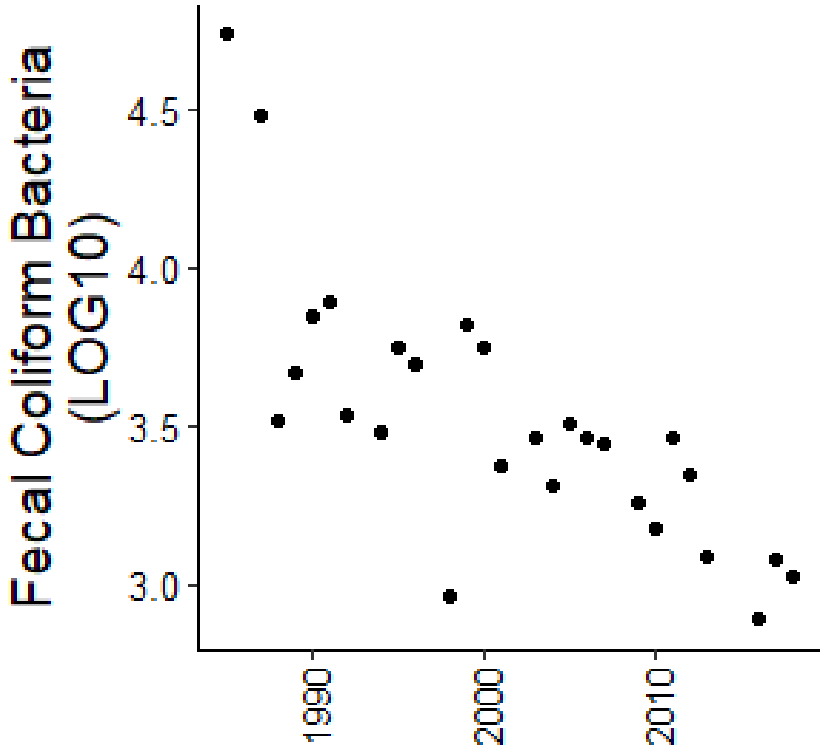


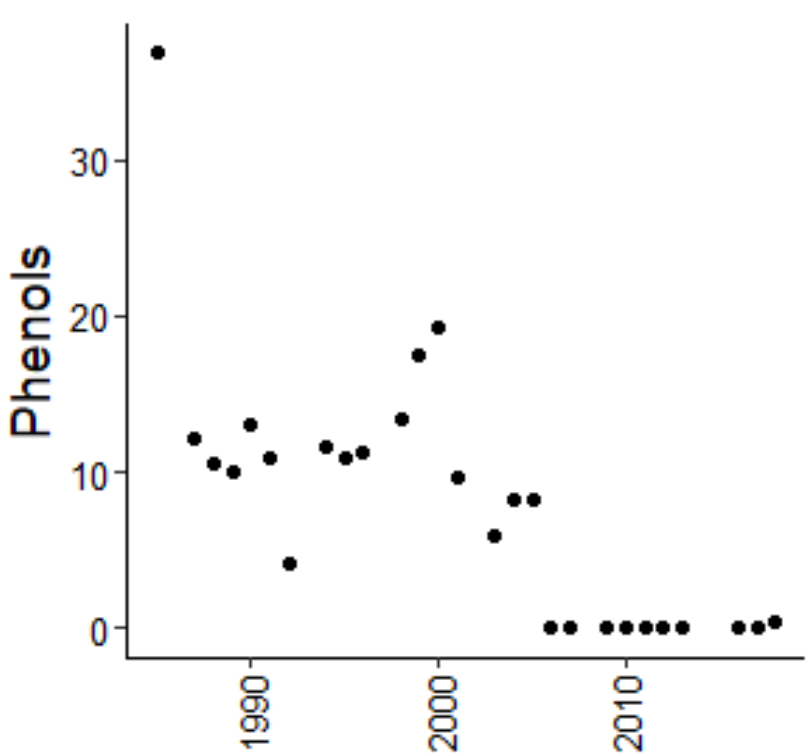


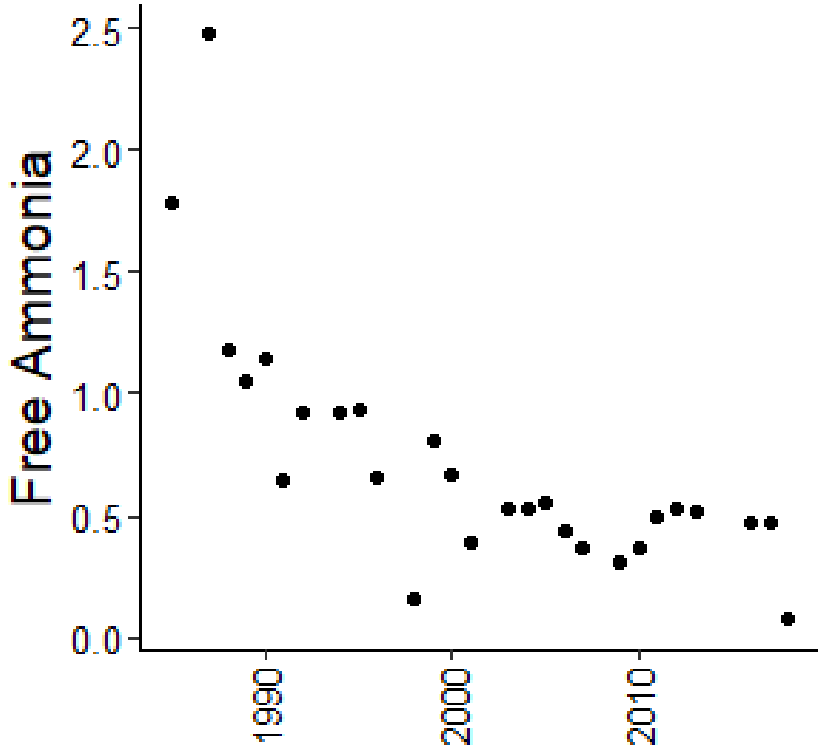


Standardized to 30 min o

Water Quality Improved







Water Quality Improved

Kendal's Tau Correlations with Year (*** denote significance)

Water Quality	
DO	0.243**
TEMP	0.248**
pH	-0.276**
ALK	0.010**
CL	0.636***
Tot. P	0.319**

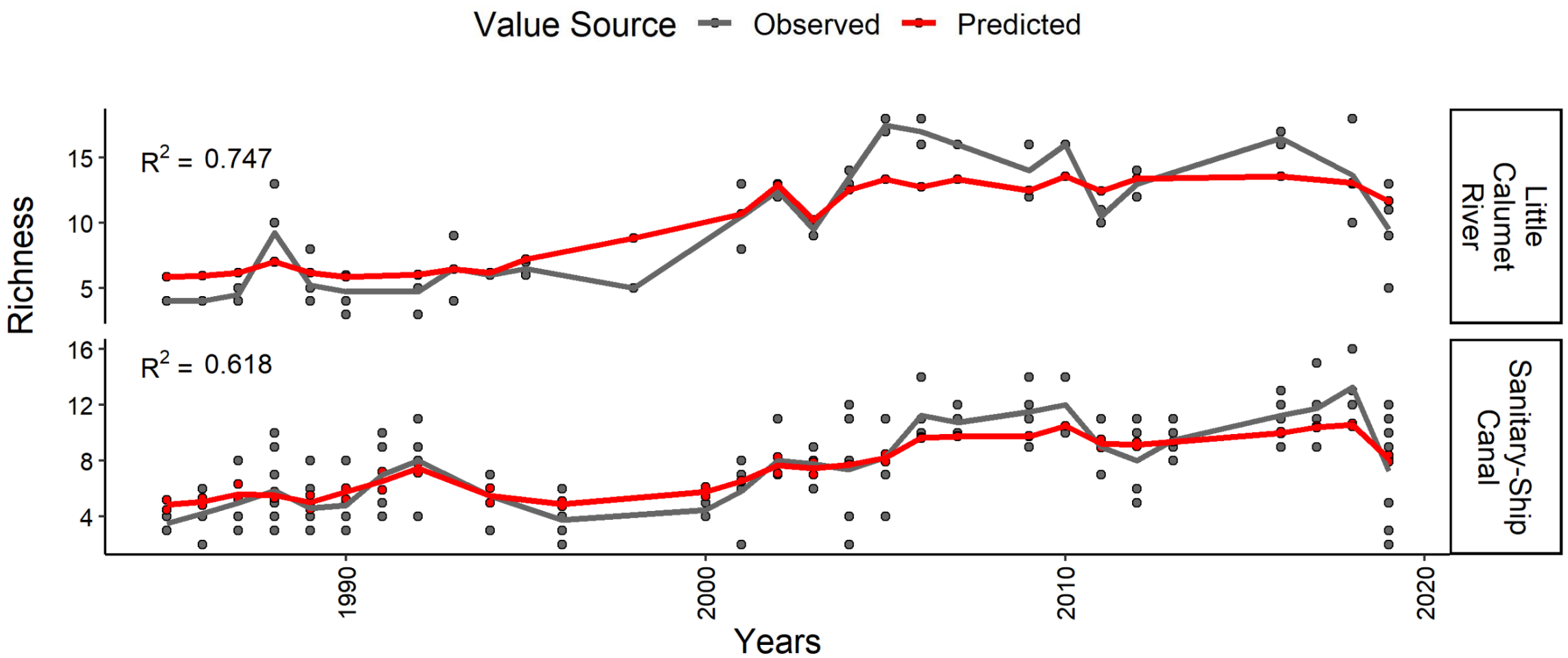
Sewage Related	
Phenol	-0.578***
FEC. COL.	-0.613***
TKN	-0.714***
SO_4	-0.258**
NH_3-N	-0.636***
NO_2-NO3	0.508***

Warmer/Hot Weather	
TMAX	0
HTDD	-0.073
DX32	0.039
DX70	0.148
DX90	0.021
EMXT	-0.197

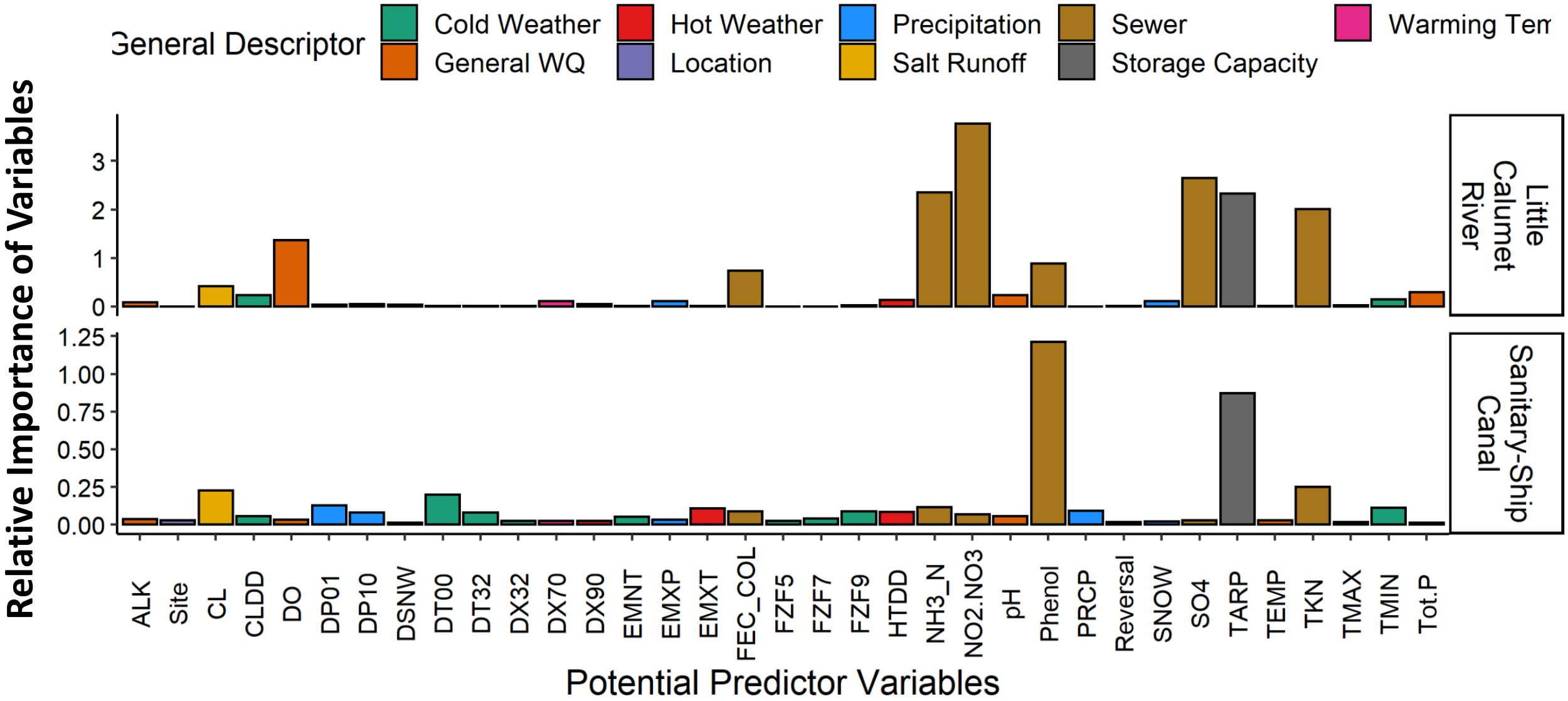
Precipitation		
DP01	0.367**	
DP10	0.381**	
DSNW		0.06
EMXP		0.087
SNOW		0.151
PRCP	0.302**	

Colder/Freezing Weather		
CLDD		0.135
EMNT		0.068
FZF5		0.126
FZF7		0.071
FZF9		-0.116
TMIN		0.156
DT00		-0.007
DT32		-0.13
TARP	0.860***	
Reversal		0.153

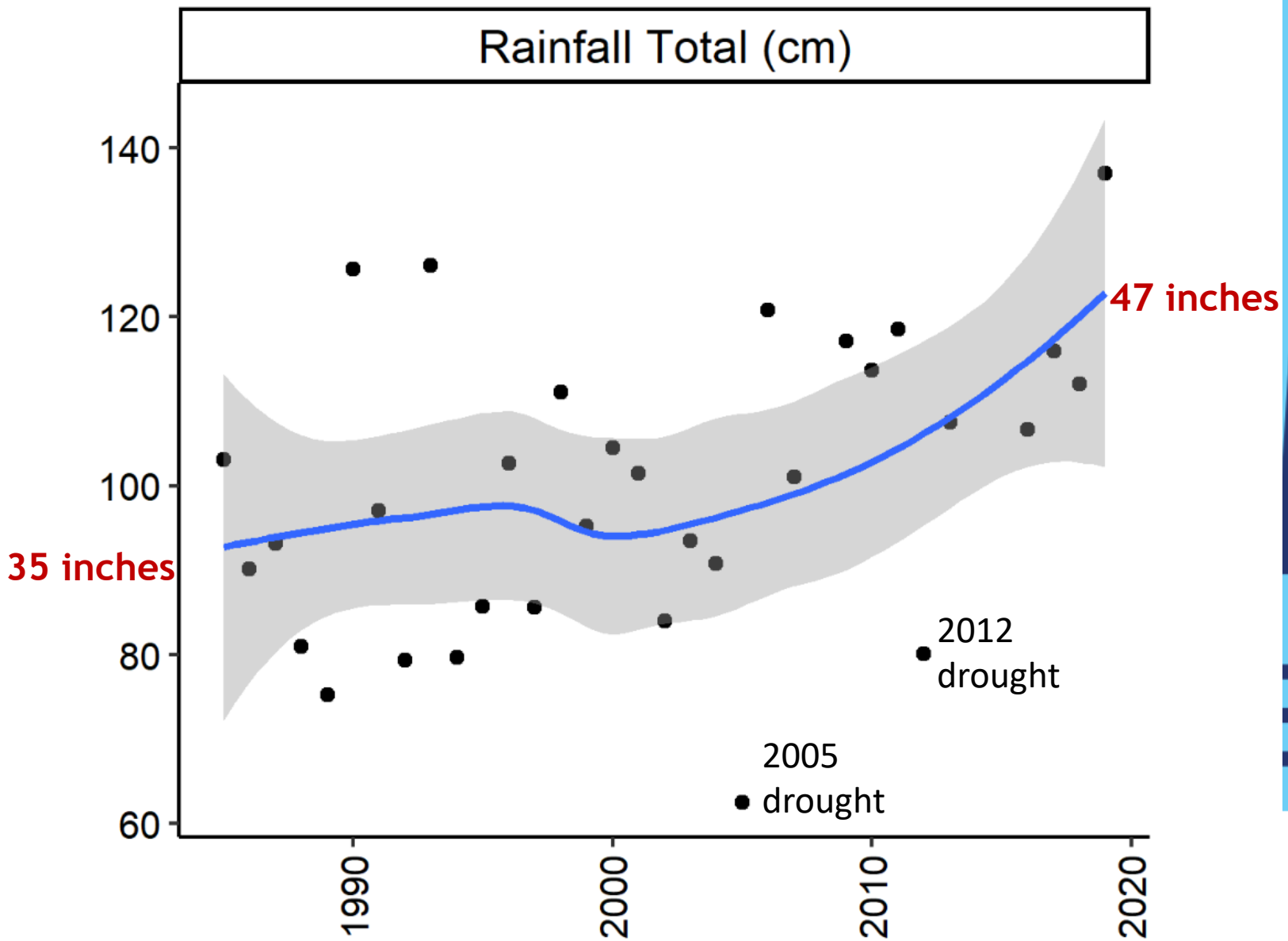
RF-Regression can make “jagged” predictions

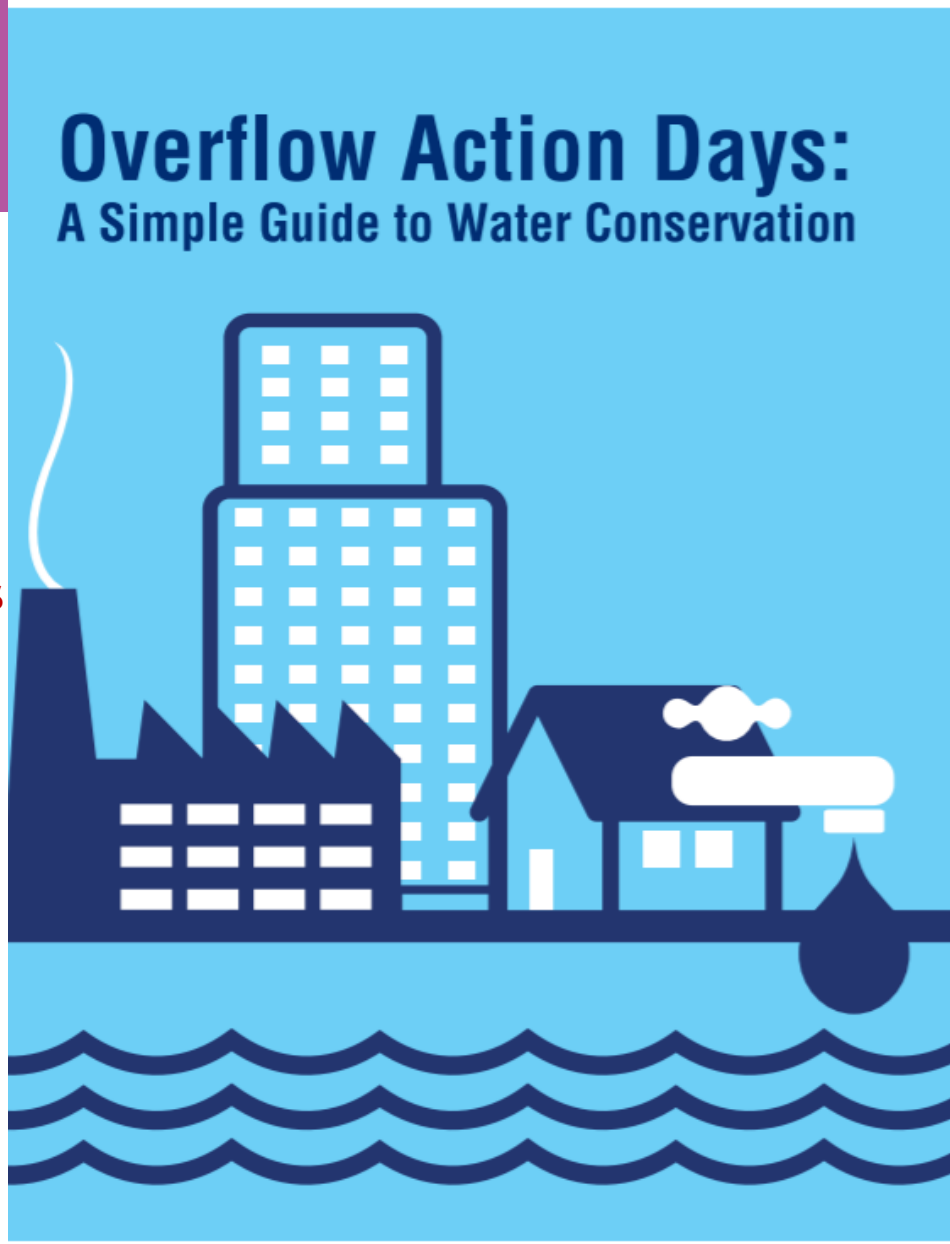


Can “tally” how many times a variable is used to infer <u>importance</u>



Weather is Changing





We affect our local waters!

WHY BE SALT SMART?

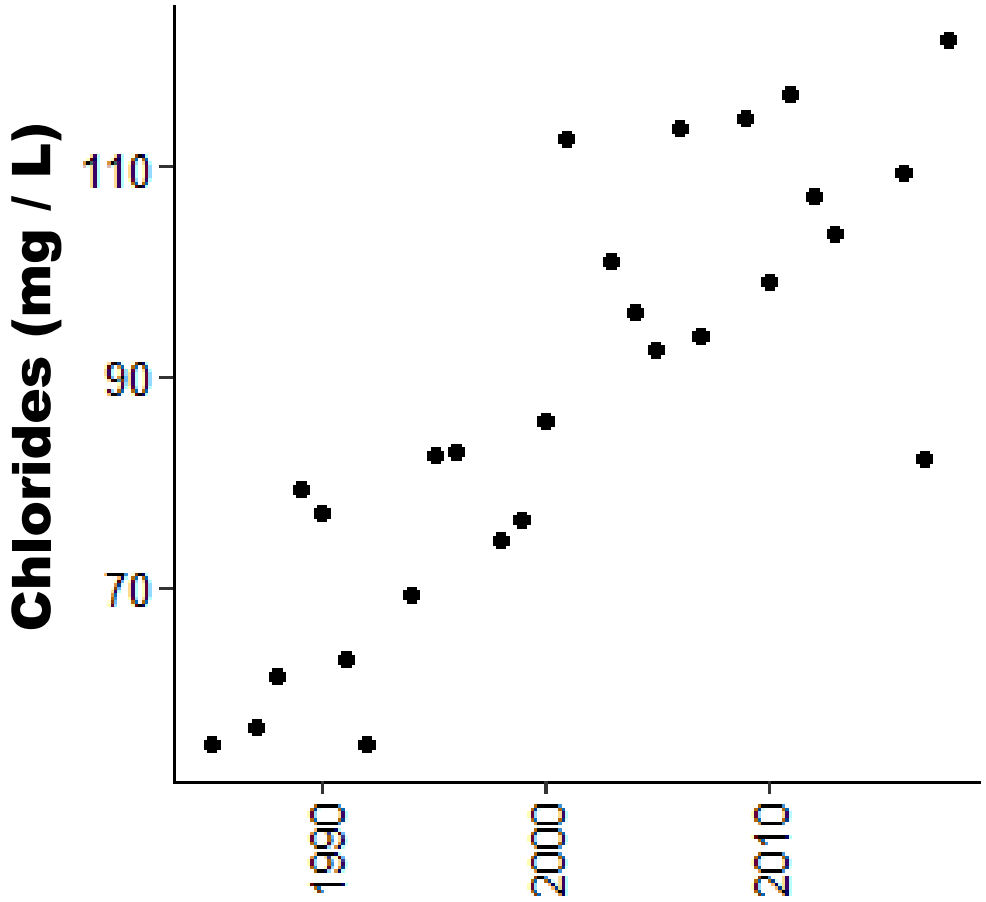
Salt is polluting our rivers.

Chloride levels are increasing in our rivers, streams, and groundwater. Once salt gets into the water, it is difficult to remove.

It only takes **one teaspoon of salt** to contaminate **5 gallons of water.**

Where does the salt come from?

Chlorides in our rivers primarily come from **winter road salt**, and also from **water softener salts.**

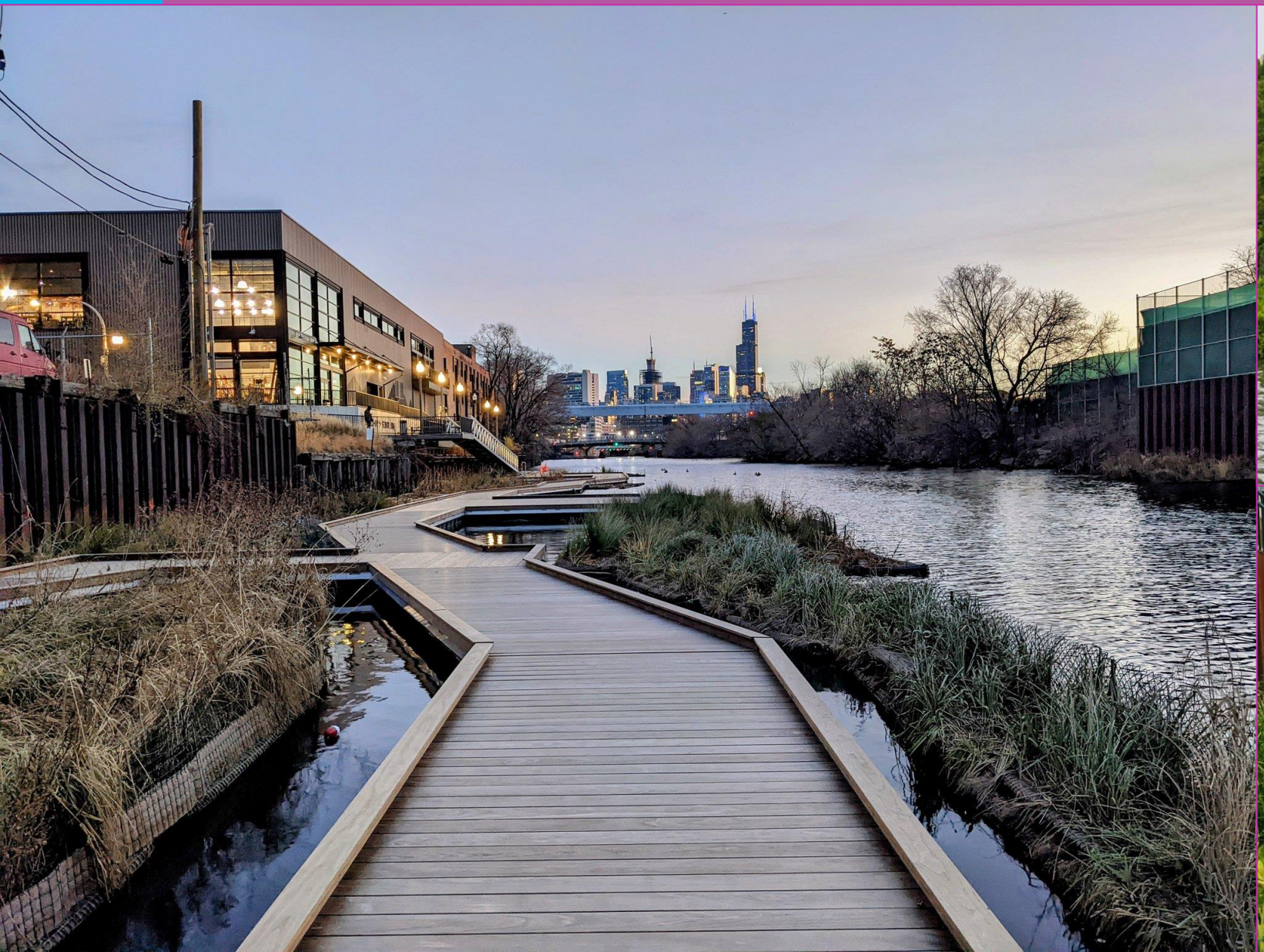


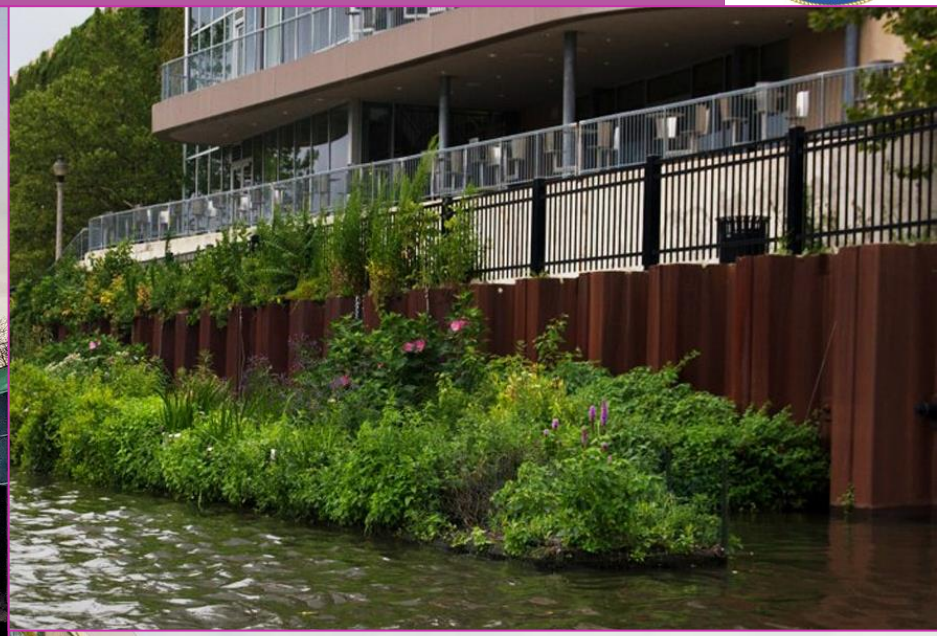
SALT SMART COLLABORATIVE

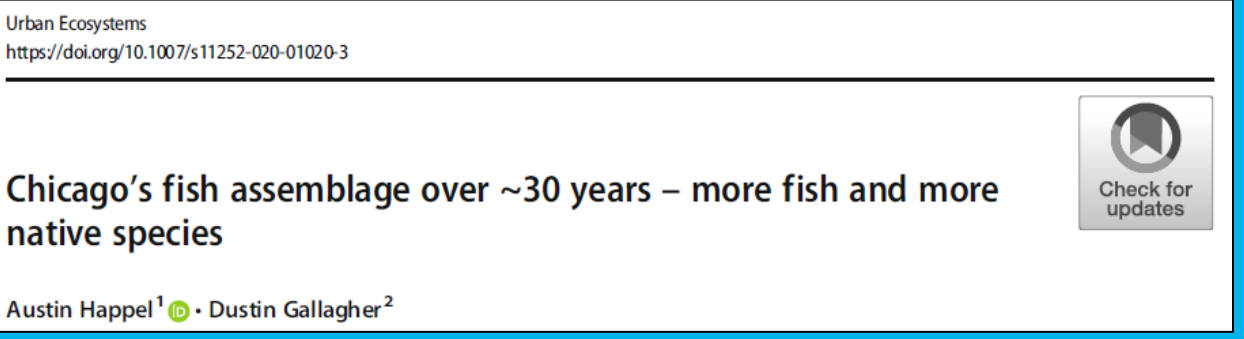
Learn more at saltsmart.org

Generally Habitat Void System

Species Respond to more than Water Quality

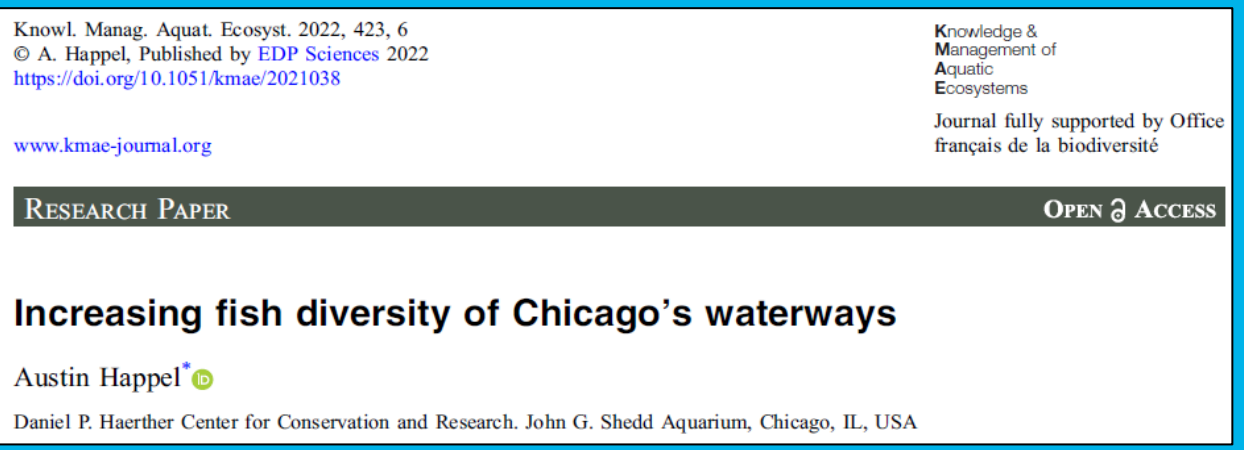





Urban Ecosystems
https://doi.org/10.1007/s11252-020-01020-3

Chicago's fish assemblage over ~30 years – more fish and more native species

Austin Happel[1] · Dustin Gallagher[2]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RESEARCH PAPER OPEN ACCESS

Increasing fish diversity of Chicago's waterways

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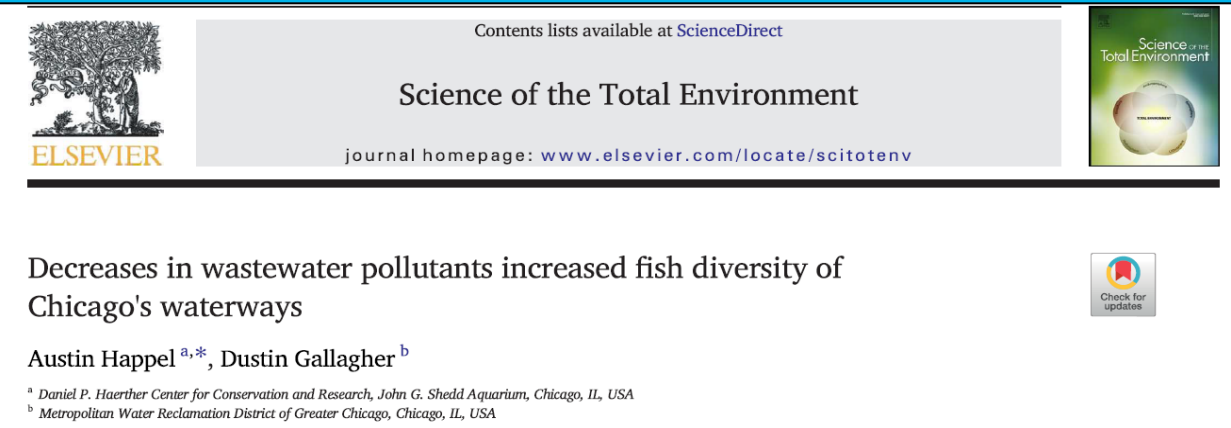
Daniel P. Haerther Center for Conservation and Research. John G. Shedd Aquarium, Chicago, IL, USA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Decreases in Wastewater Pollutants Increased Fish Diversity in the CAWS

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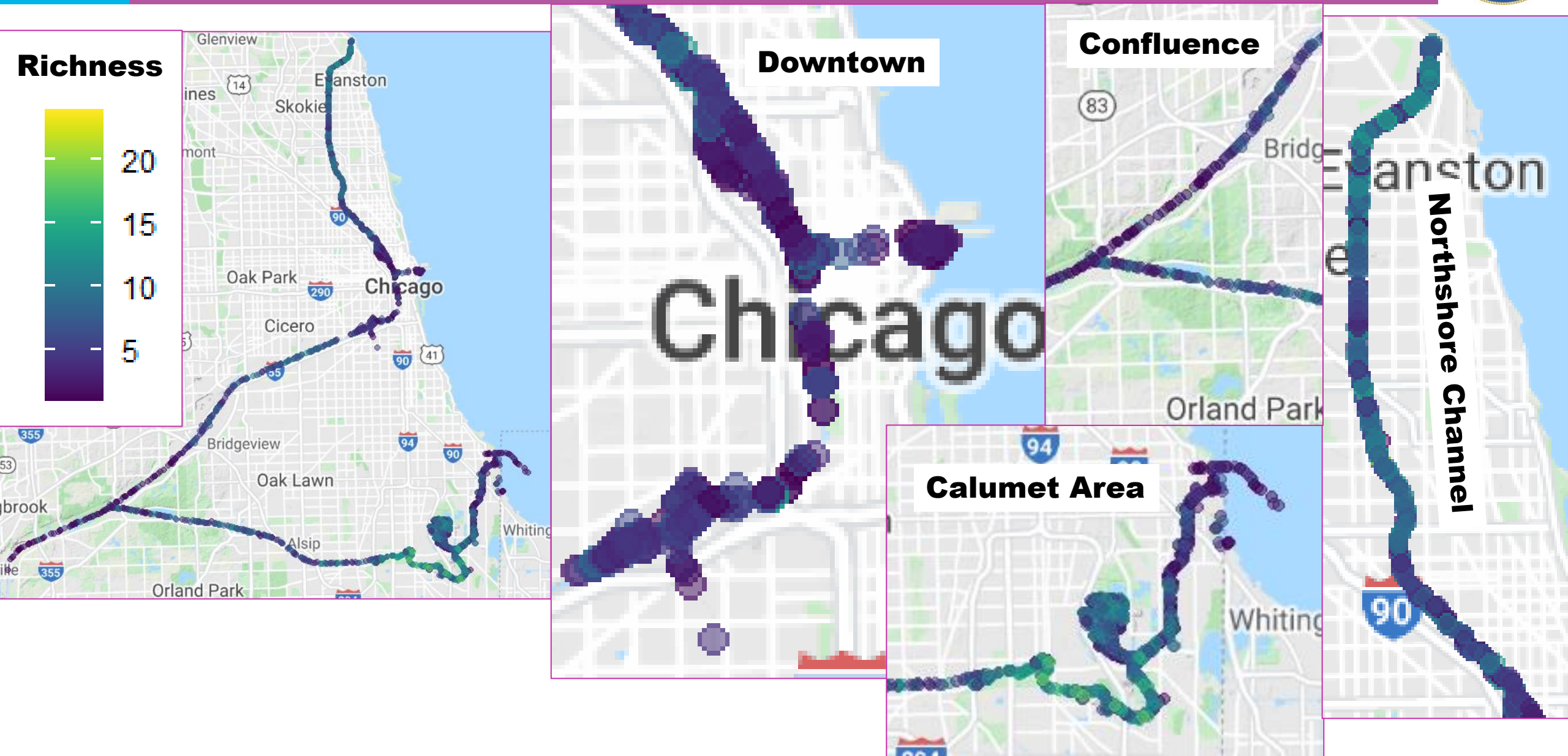
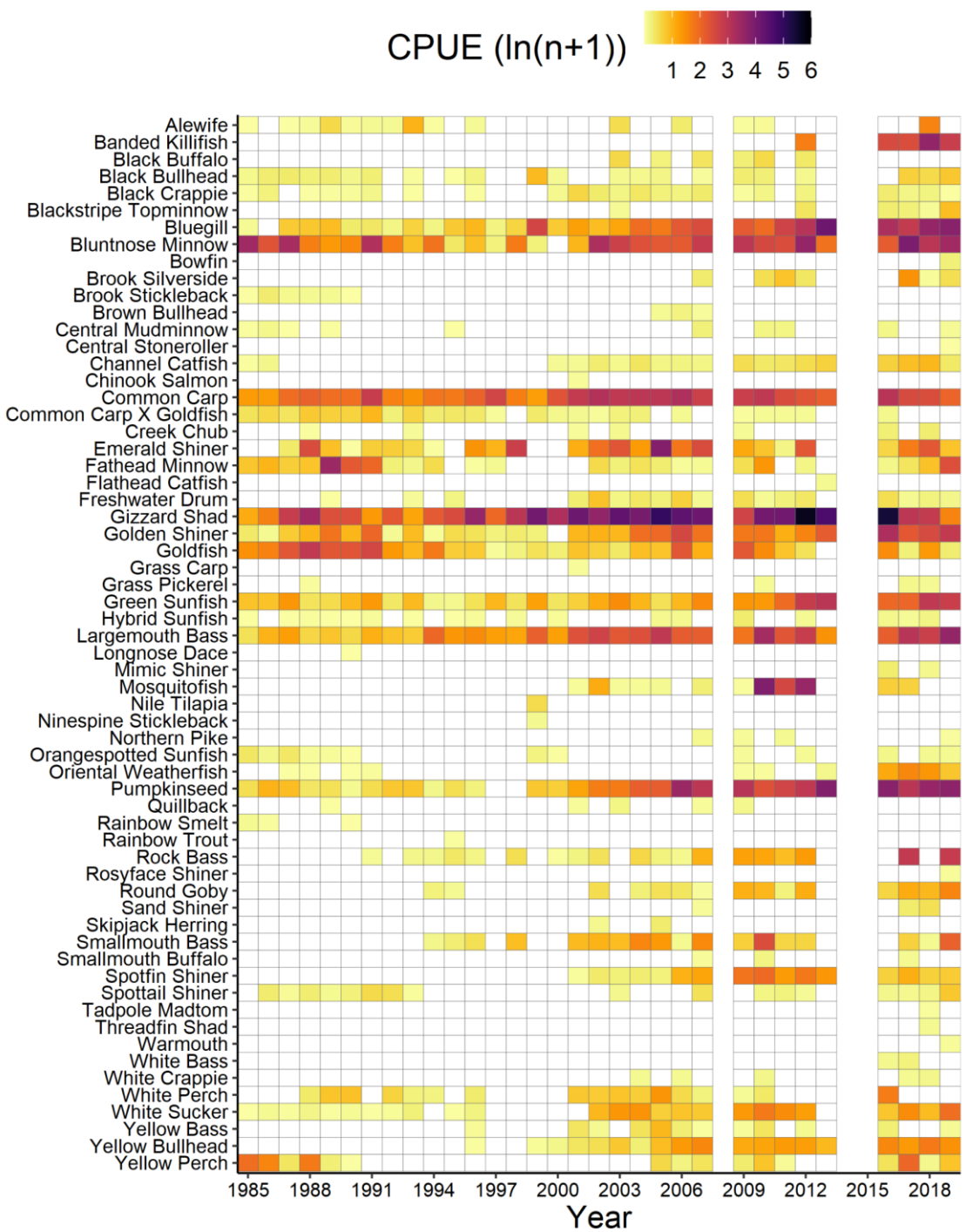
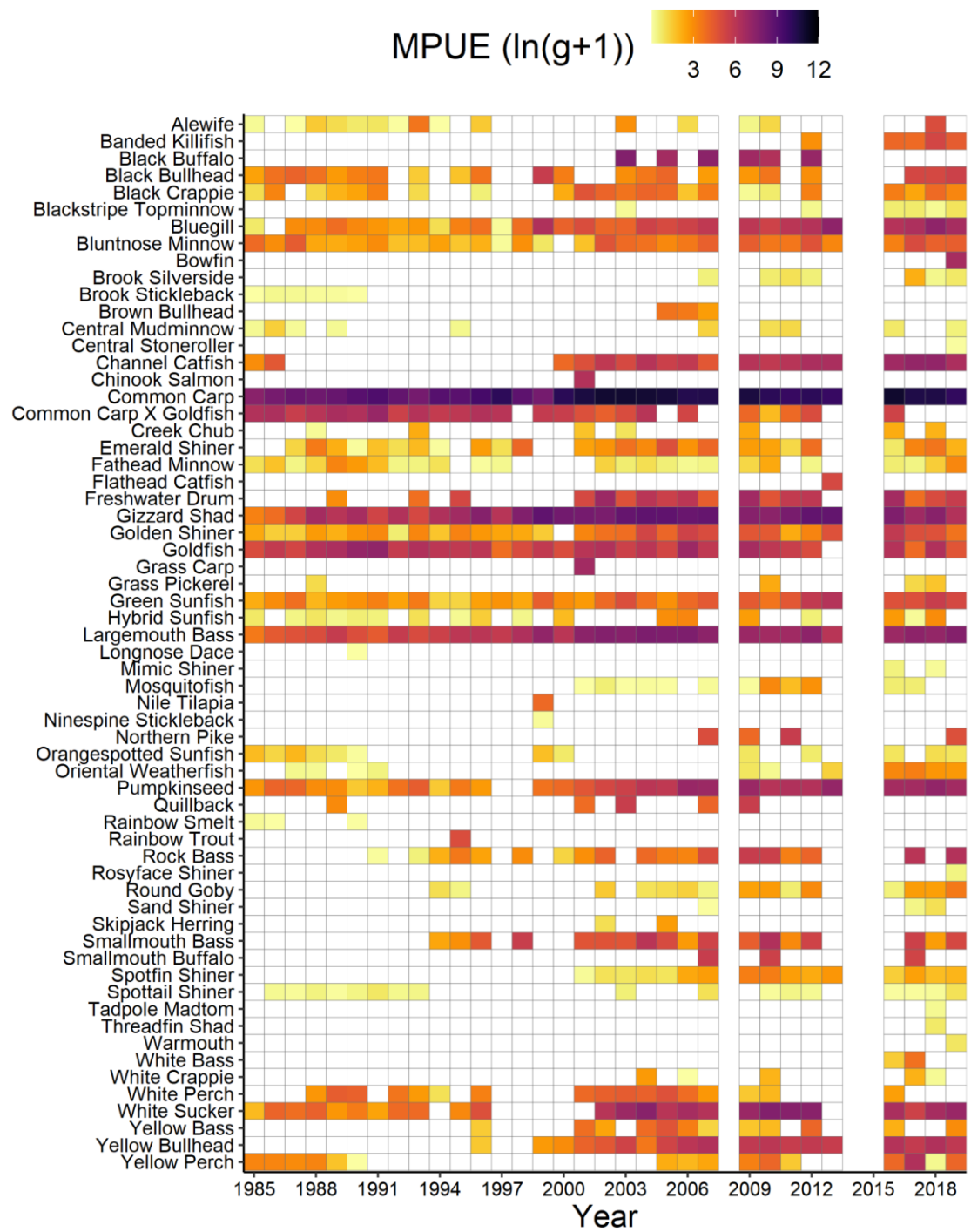
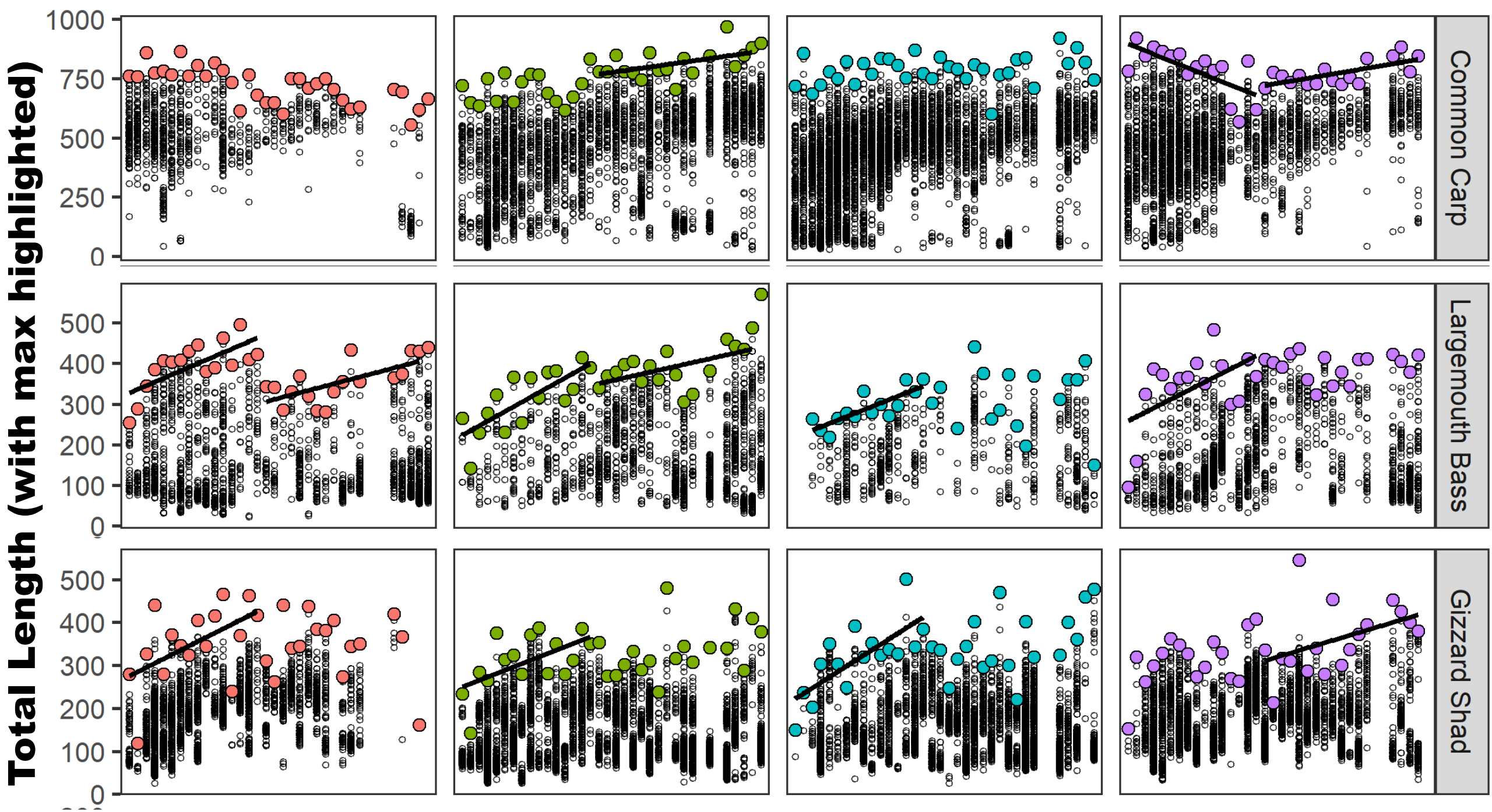
Metropolitan Water Reclamation District of Greater Chicago

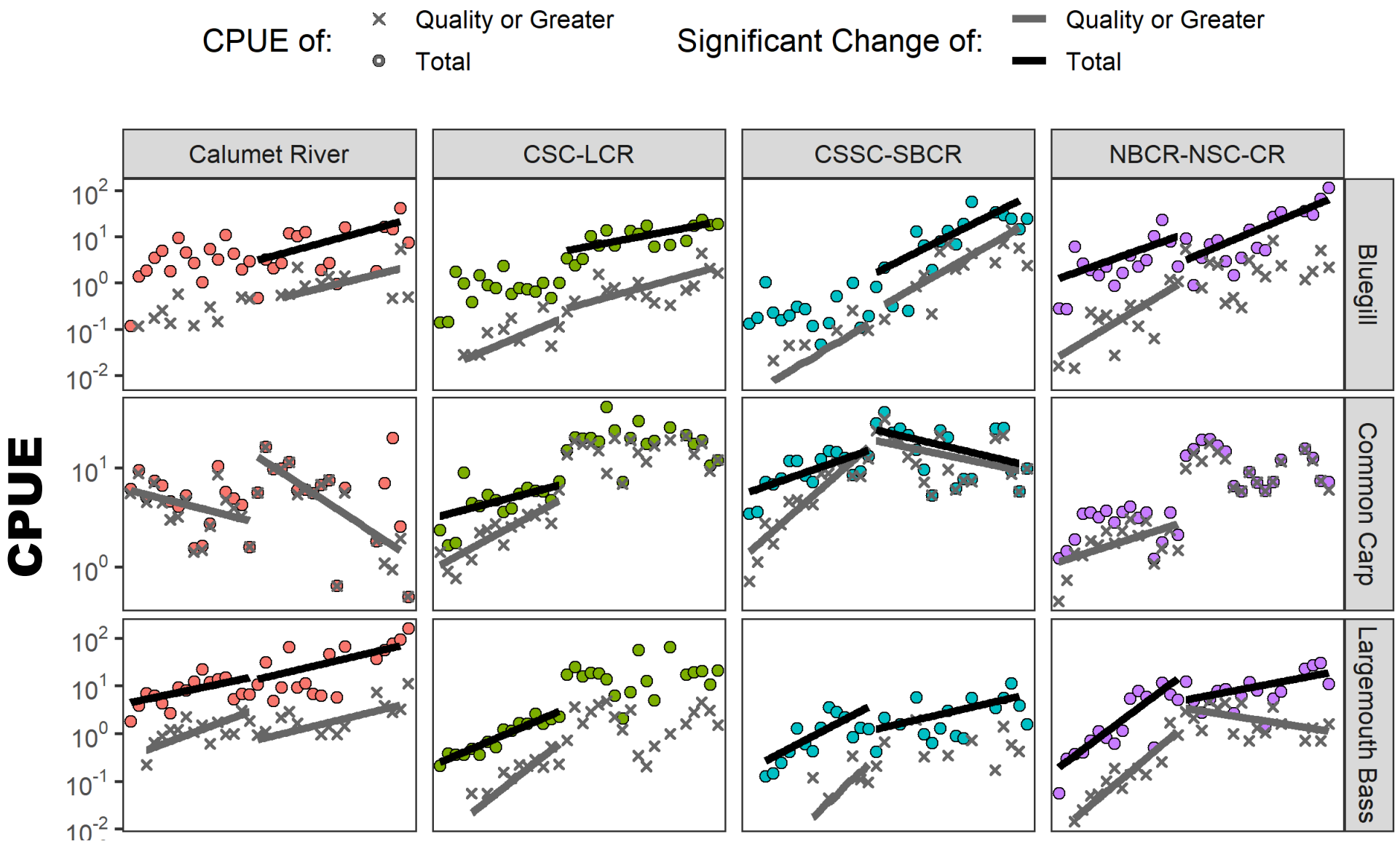
Repurposing Seasonal Intensive Monitoring Data



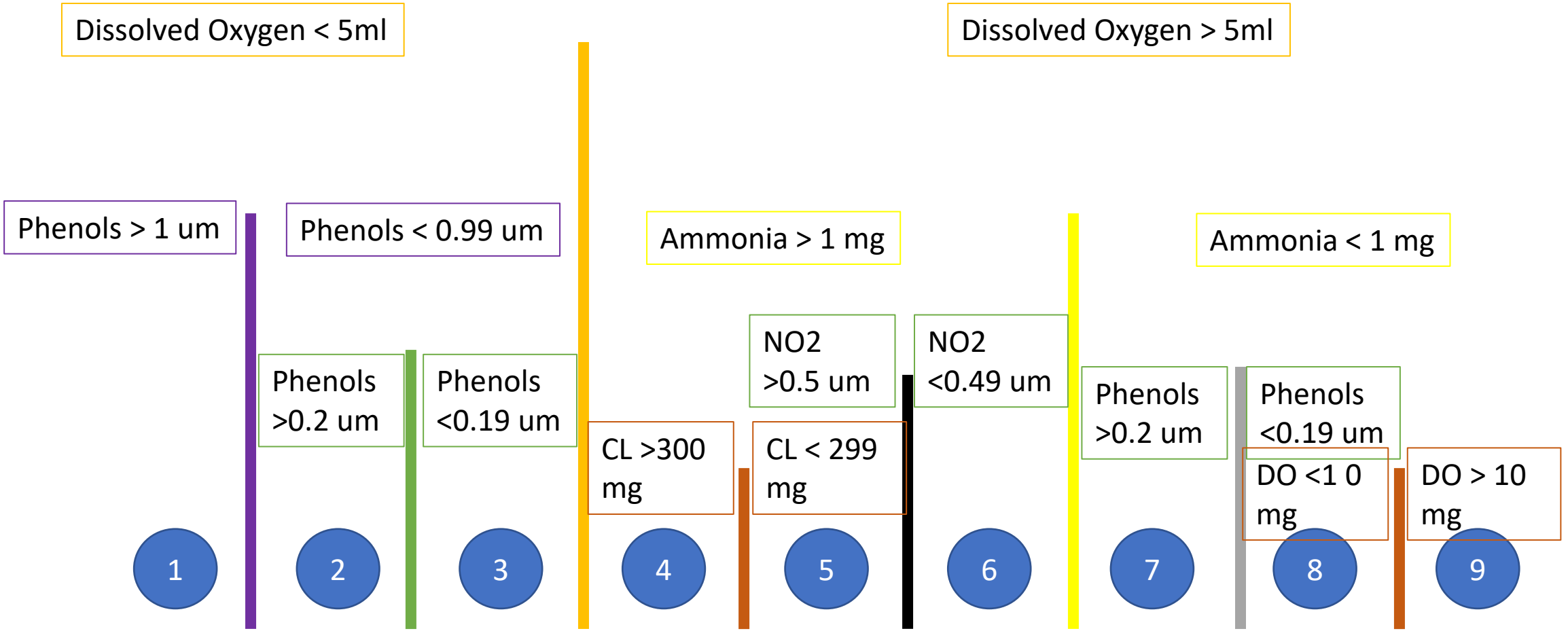

CPUE (ln(n+1))
1 2 3 4 5 6
Alewife
Banded Killifish
Black Buffalo
Black Bullhead
Black Crappie
Blackstripe Topminnow
Bluegill
Bluntnose Minnow
Bowfin
Brook Silverside
Brook Stickleback
Brown Bullhead
Central Mudminnow
Central Stoneroller
Channel Catfish
Chinook Salmon
Common Carp
Common Carp X Goldfish
Creek Chub
Emerald Shiner
Fathead Minnow
Flathead Catfish
Freshwater Drum
Gizzard Shad
Golden Shiner
Goldfish
Grass Carp
Grass Pickerel
Green Sunfish
Hybrid Sunfish
Largemouth Bass
Longnose Dace
Mimic Shiner
Mosquitofish
Nile Tilapia
Ninespine Stickleback
Northern Pike
Orangespotted Sunfish
Oriental Weatherfish
Pumpkinseed
Quillback
Rainbow Smelt
Rainbow Trout
Rock Bass
Rosyface Shiner
Round Goby
Sand Shiner
Skipjack Herring
Smallmouth Bass
Smallmouth Buffalo
Spotfin Shiner
Spottail Shiner
Tadpole Madtom
Threadfin Shad
Warmouth
White Bass
White Crappie
White Perch
White Sucker
Yellow Bass
Yellow Bullhead
Yellow Perch
1985 1988 1991 1994 1997 2000 2003 2006 2009 2012 2015 2018
Year


MPUE (ln(g+1))
3 6 9 12
Alewife
Banded Killifish
Black Buffalo
Black Bullhead
Black Crappie
Blackstripe Topminnow
Bluegill
Bluntnose Minnow
Bowfin
Brook Silverside
Brook Stickleback
Brown Bullhead
Central Mudminnow
Central Stoneroller
Channel Catfish
Chinook Salmon
Common Carp
Common Carp X Goldfish
Creek Chub
Emerald Shiner
Fathead Minnow
Flathead Catfish
Freshwater Drum
Gizzard Shad
Golden Shiner
Goldfish
Grass Carp
Grass Pickerel
Green Sunfish
Hybrid Sunfish
Largemouth Bass
Longnose Dace
Mimic Shiner
Mosquitofish
Nile Tilapia
Ninespine Stickleback
Northern Pike
Orangespotted Sunfish
Oriental Weatherfish
Pumpkinseed
Quillback
Rainbow Smelt
Rainbow Trout
Rock Bass
Rosyface Shiner
Round Goby
Sand Shiner
Skipjack Herring
Smallmouth Bass
Smallmouth Buffalo
Spotfin Shiner
Spottail Shiner
Tadpole Madtom
Threadfin Shad
Warmouth
White Bass
White Crappie
White Perch
White Sucker
Yellow Bass
Yellow Bullhead
Yellow Perch
1985 1988 1991 1994 1997 2000 2003 2006 2009 2012 2015 2018
Year


Total Length (with max highlighted)
1000
750
500
250
0
500
400
300
200
100
0
500
400
300
200
100
0
Common Carp
Largemouth Bass
Gizzard Shad


CPUE of:
Quality or Greater
Total
Significant Change of:
Quality or Greater
Total
Calumet River
CSC-LCR
CSSC-SBCR
NBCR-NSC-CR
Bluegill
Common Carp
Largemouth Bass
CPUE
10^2
10^1
10^0
10^{-1}
10^{-2}

The Jist of Random Forest Regression



Observed Species Richness Values