United States Environmental Protection Agency

EPA Tools and Resources Webinar:
Nutrient Explorer

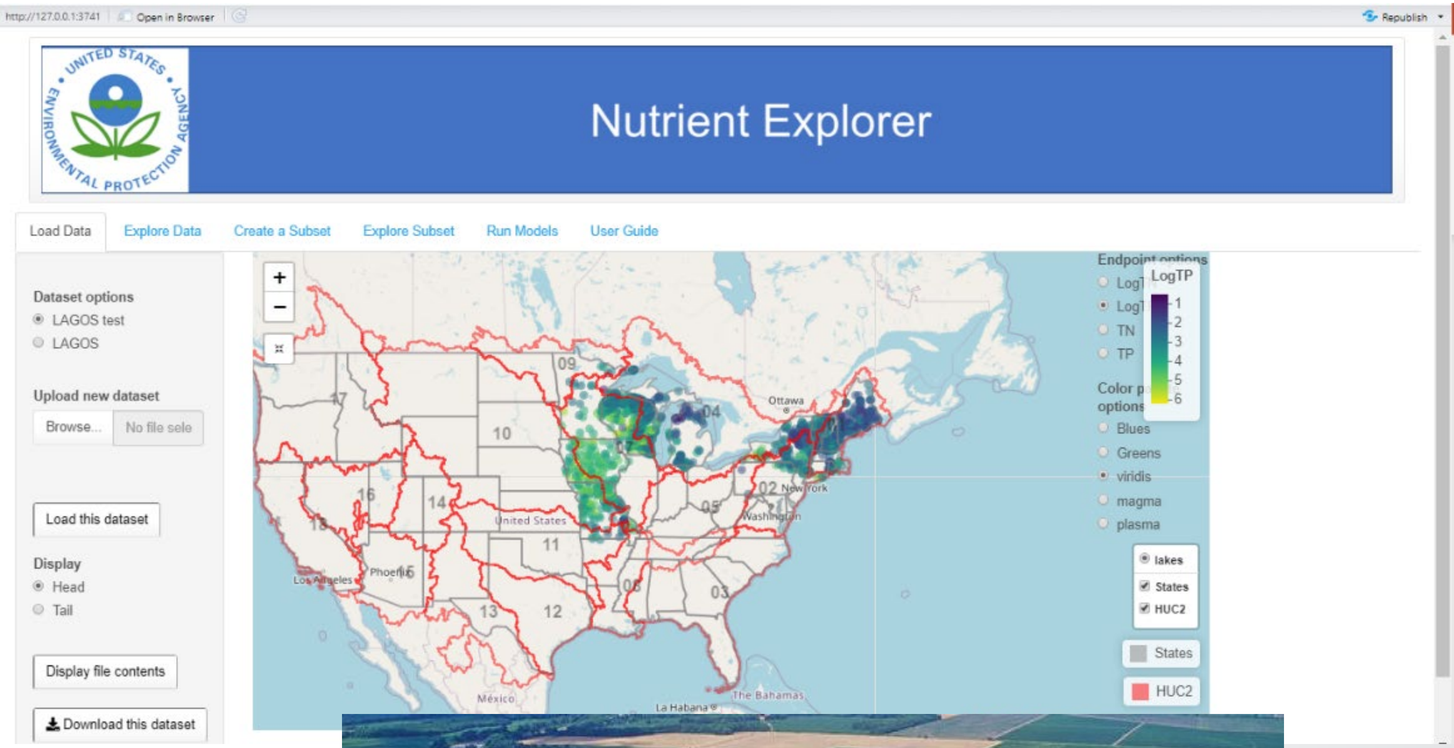
An analytical framework to visualize and investigate drivers of surface water quality

Michael Pennino, Meridith Fry, Robert Sabo and James Carleton
US EPA Office of Research and Development

March 13, 2024

Outline

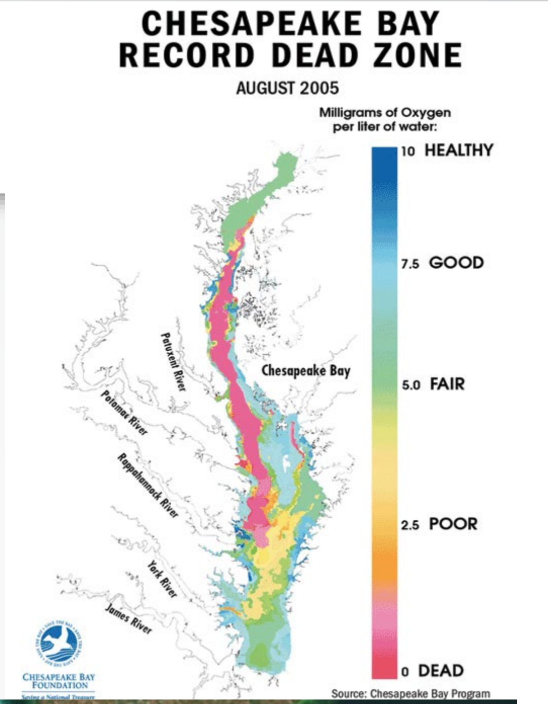
- Background / Motivation
- Purpose
- Features
- Demonstration
  - Default dataset
  - New user dataset
- Conclusions & Impacts

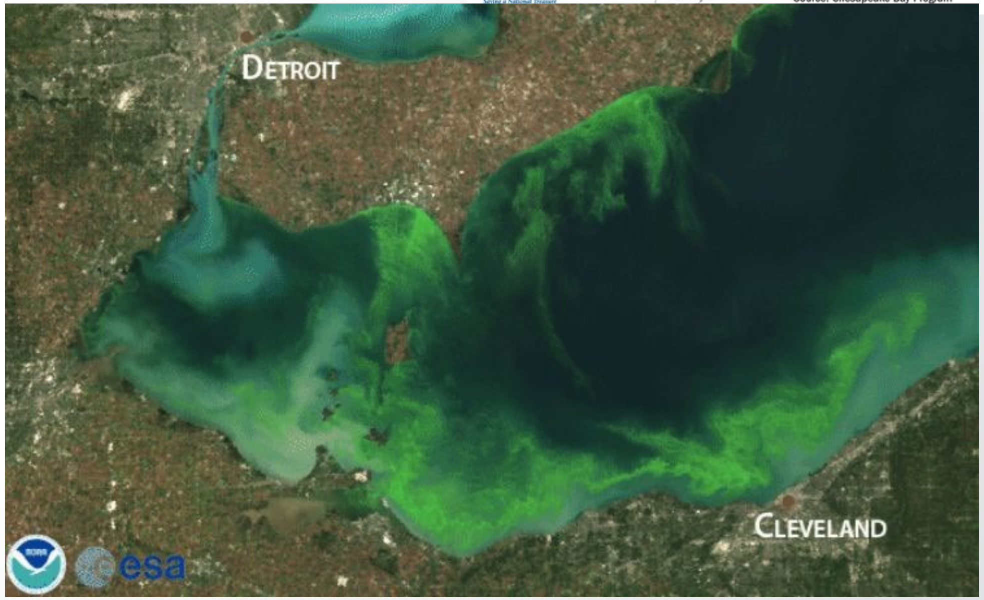



https://new.nsf.gov/news/agricultural-runoff-contributes-climate-change

Background and Motivation

- Excess nutrients (nitrogen and phosphorus) in lakes/rivers can lead to eutrophication, hypoxia, and algal blooms that may harm aquatic life and people.
- Some U.S. states have established numeric water quality criteria for nutrients to protect surface waters.
- However, monitoring to determine if criteria are being met is limited by resources and time.

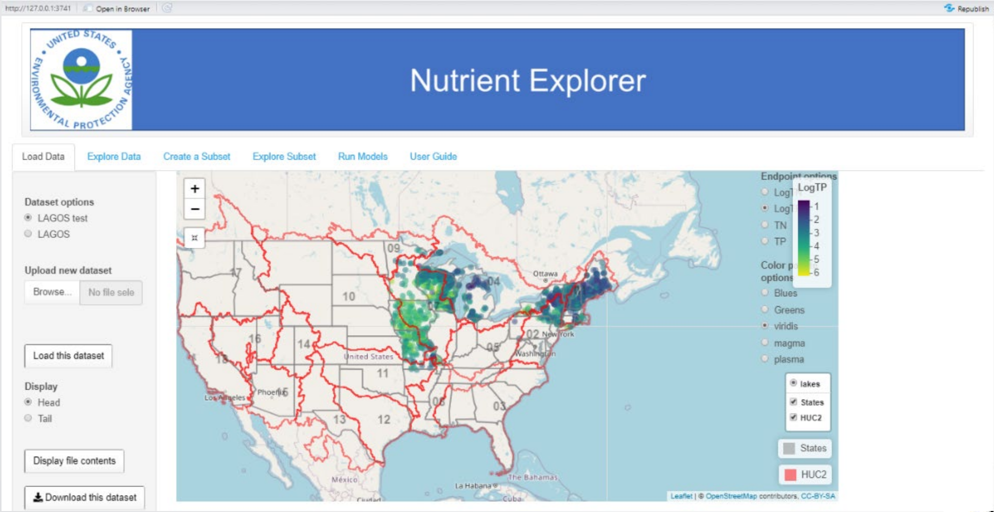


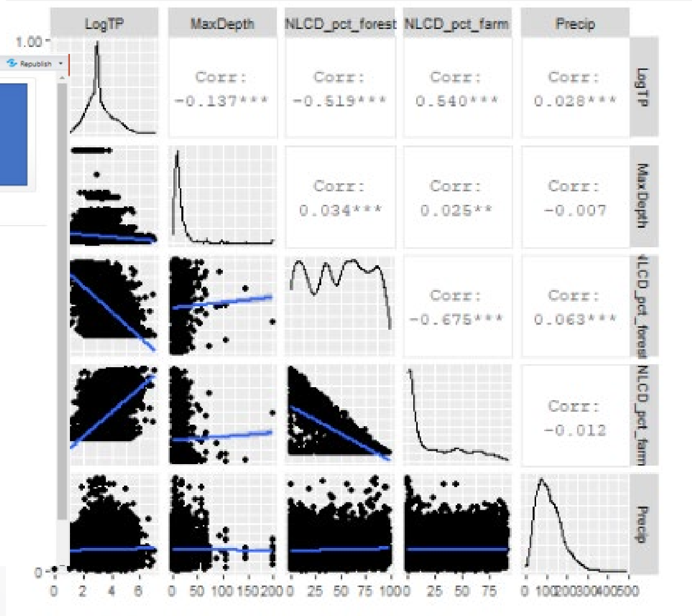


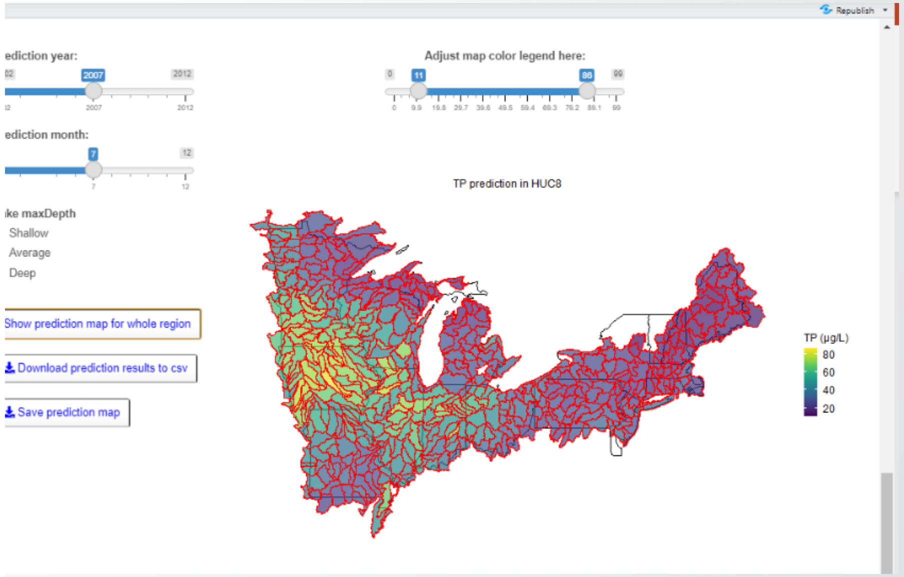
https://www.canr.msu.edu/

Purpose

- Design an analytical framework to investigate potential drivers of nutrient concentrations in surface waters (lakes, streams, rivers)
- Visualize patterns in nutrient concentrations using a graphical user interface
- Predict areas at risk of exceeding certain criteria, especially for locations lacking observations

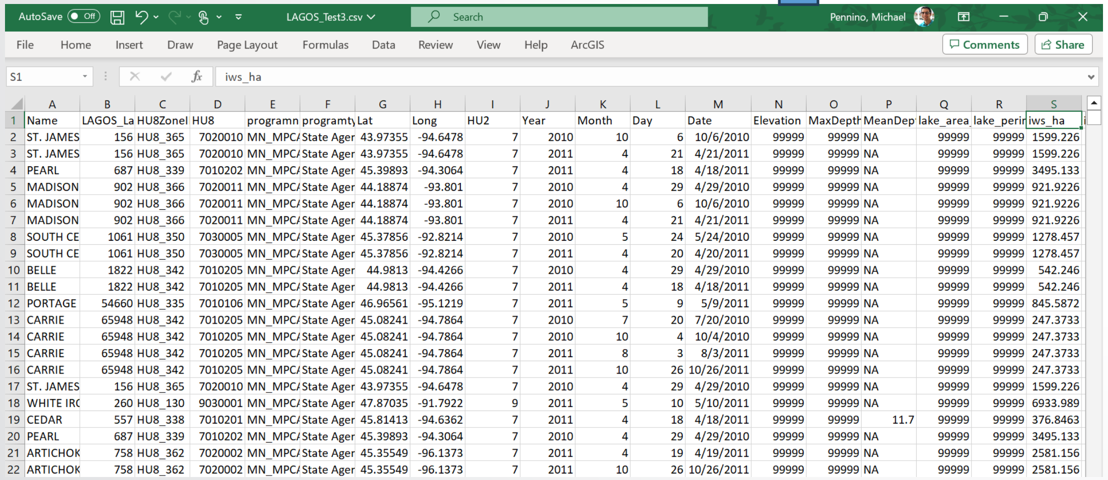






Nutrient Explorer – Features

- Upload total nitrogen (TN) or total phosphorus (TP) concentration data
  - Select default dataset for lakes in northeastern U.S.
  - Alternatively, upload a new, formatted dataset – for any surface waters (lakes, rivers, streams)
- Incorporate variables to predict nutrients in surface waters (e.g., land use, etc.)
- Create data subsets for further analysis, using characteristics of the variables, such as date, location, etc.



Name	LAGOS_La	HU8Zonel	HU8	programn	programty	Lat	Long	HU2	Year	Month	Day	Date	Elevation	MaxDepth	MeanDep	lake_area	lake_perin	iws_ha
ST. JAMES	156	HU8_365	7020010	MN_MPC/	State Ager	43.97355	-94.6478	7	2010	10	6	10/6/2010	99999	99999	NA	99999	99999	1599.226
ST. JAMES	156	HU8_365	7020010	MN_MPC/	State Ager	43.97355	-94.6478	7	2011	4	21	4/21/2011	99999	99999	NA	99999	99999	1599.226
PEARL	687	HU8_339	7010202	MN_MPC/	State Ager	45.39893	-94.3064	7	2011	4	18	4/18/2011	99999	99999	NA	99999	99999	3495.133
MADISON	902	HU8_366	7020011	MN_MPC/	State Ager	44.18874	-93.801	7	2010	4	29	4/29/2010	99999	99999	NA	99999	99999	921.9226
MADISON	902	HU8_366	7020011	MN_MPC/	State Ager	44.18874	-93.801	7	2010	10	6	10/6/2010	99999	99999	NA	99999	99999	921.9226
MADISON	902	HU8_366	7020011	MN_MPC/	State Ager	44.18874	-93.801	7	2011	4	21	4/21/2011	99999	99999	NA	99999	99999	921.9226
SOUTH CE	1061	HU8_350	7030005	MN_MPC/	State Ager	45.37856	-92.8214	7	2010	5	24	5/24/2010	99999	99999	NA	99999	99999	1278.457
SOUTH CE	1061	HU8_350	7030005	MN_MPC/	State Ager	45.37856	-92.8214	7	2011	4	20	4/20/2011	99999	99999	NA	99999	99999	1278.457
BELLE	1822	HU8_342	7010205	MN_MPC/	State Ager	44.9813	-94.4266	7	2010	4	29	4/29/2010	99999	99999	NA	99999	99999	542.246
BELLE	1822	HU8_342	7010205	MN_MPC/	State Ager	44.9813	-94.4266	7	2011	4	18	4/18/2011	99999	99999	NA	99999	99999	542.246
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CARRIE	65948	HU8_342	7010205	MN_MPC/	State Ager	45.08241	-94.7864	7	2010	7	20	7/20/2010	99999	99999	NA	99999	99999	247.3733
CARRIE	65948	HU8_342	7010205	MN_MPC/	State Ager	45.08241	-94.7864	7	2010	10	4	10/4/2010	99999	99999	NA	99999	99999	247.3733
CARRIE	65948	HU8_342	7010205	MN_MPC/	State Ager	45.08241	-94.7864	7	2011	8	3	8/3/2011	99999	99999	NA	99999	99999	247.3733
CARRIE	65948	HU8_342	7010205	MN_MPC/	State Ager	45.08241	-94.7864	7	2011	10	26	10/26/2011	99999	99999	NA	99999	99999	247.3733
ST. JAMES	156	HU8_365	7020010	MN_MPC/	State Ager	43.97355	-94.6478	7	2010	4	29	4/29/2010	99999	99999	NA	99999	99999	1599.226
WHITE IR(	260	HU8_130	9030001	MN_MPC/	State Ager	47.87035	-91.7922	9	2011	5	10	5/10/2011	99999	99999	NA	99999	99999	6933.989
CEDAR	557	HU8_338	7010201	MN_MPC/	State Ager	45.81413	-94.6362	7	2011	4	18	4/18/2011	99999	99999	11.7	99999	99999	376.8463
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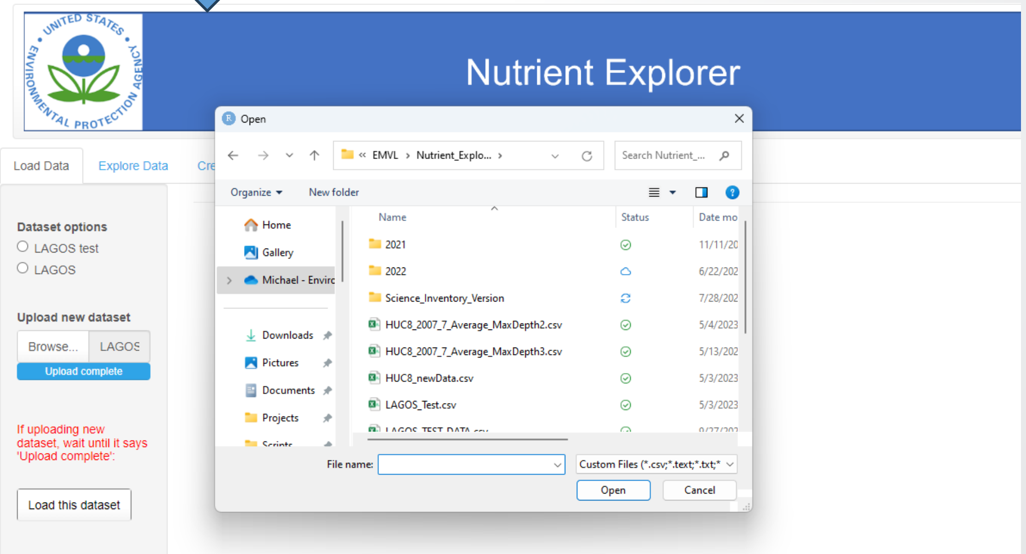
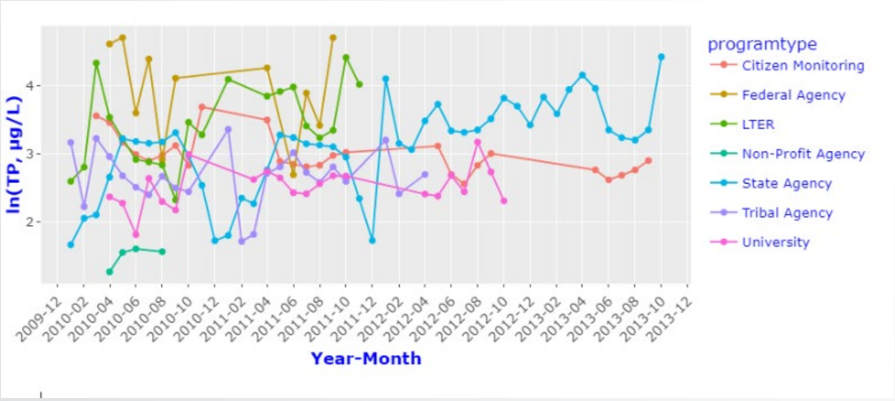
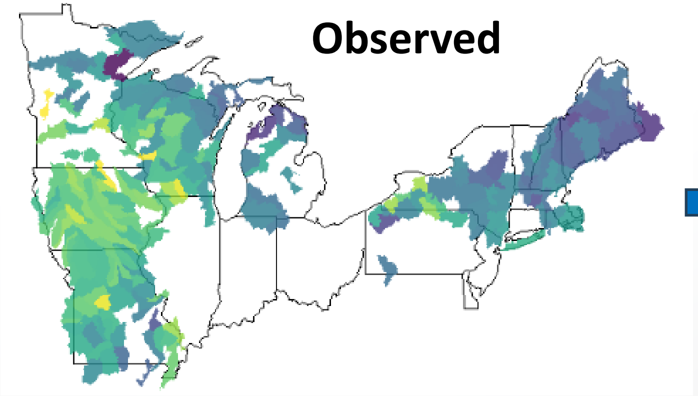
ARTICHOK	758	HU8_362	7020002	MN_MPC/	State Ager	45.35549	-96.1373	7	2011	4	19	4/19/2011	99999	99999	NA	99999	99999	2581.156
ARTICHOK	758	HU8_362	7020002	MN_MPC/	State Ager	45.35549	-96.1373	7	2011	10	26	10/26/2011	99999	99999	NA	99999	99999	2581.156

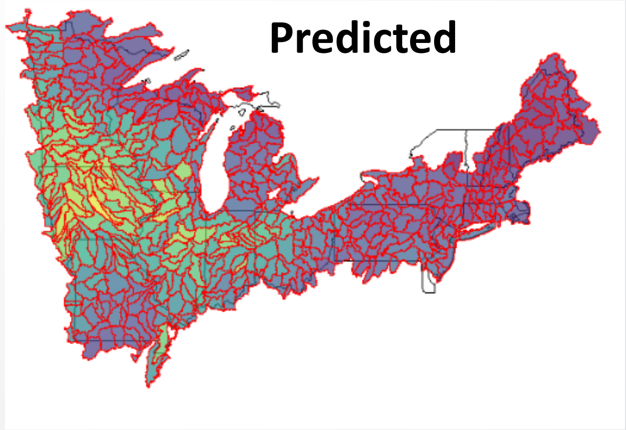


Nutrient Explorer – Features (cont.)

- Visualize and summarize temporal and spatial patterns
- Apply random forest modeling or multiple linear regression to:
  - Assess which predictor variables best capture the spatial patterns in surface water nutrients
  - Predict nutrient concentrations for watersheds or locations lacking data
- Map which watersheds or locations may be predicted to exceed a certain threshold or water quality criteria







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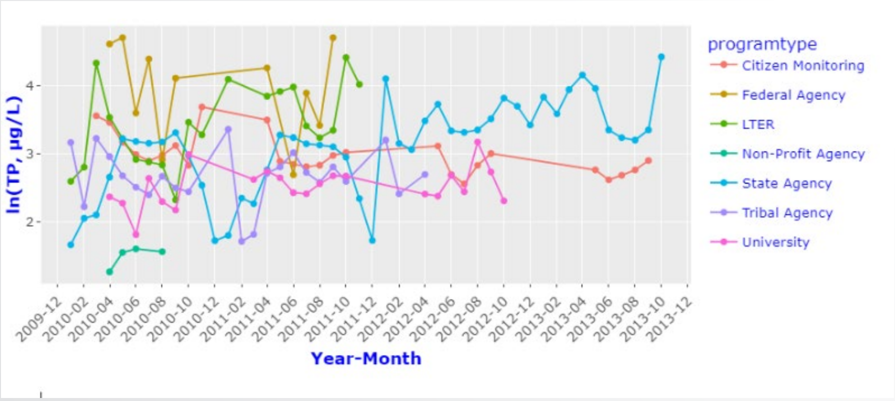
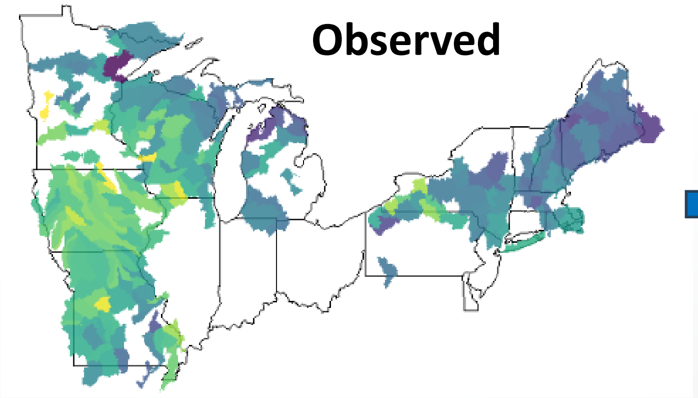
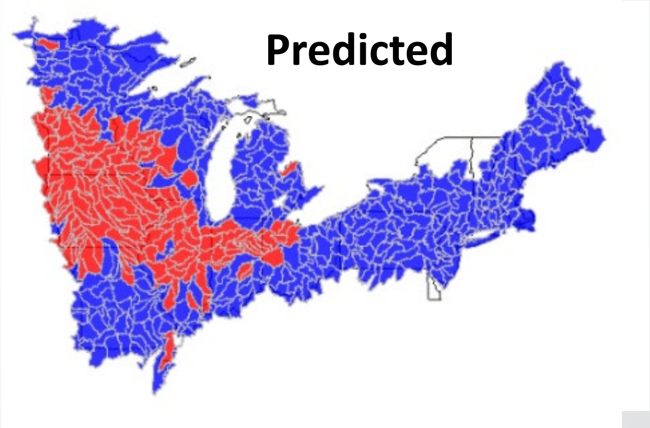






Default Datasets in Nutrient Explorer

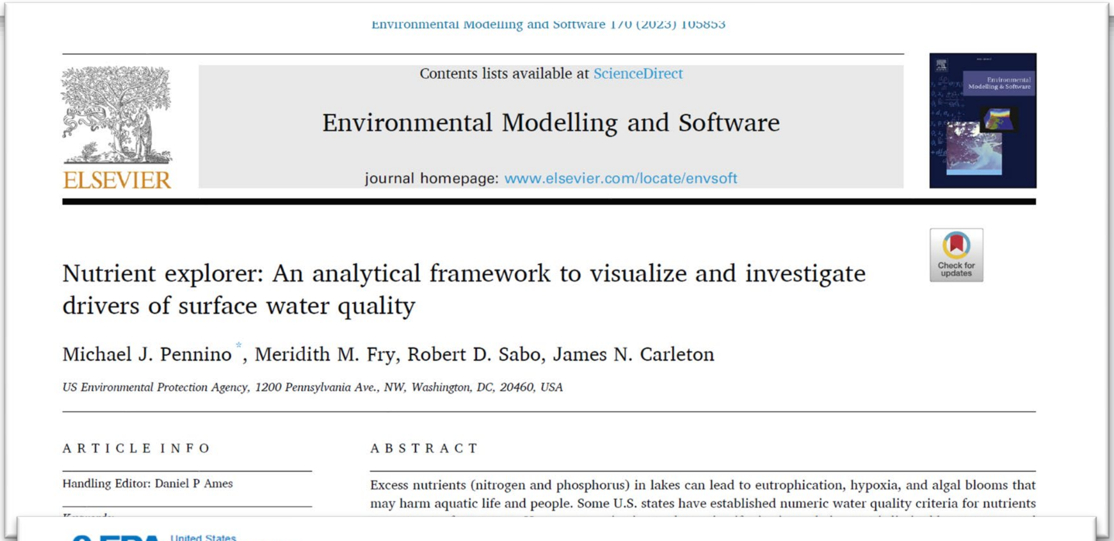
- Surface Water Nutrient Data: The app comes with a default dataset from the Northeastern U.S. lakes based on the Lake Multi-Scaled Geospatial and Temporal Database of the Northeast (LAGOS-NE) data (https://lagoslakes.org/lagos-ne/).
  - Used to demonstrate Nutrient Explorer
  - Includes nutrient concentrations for nitrogen and phosphorus
  - For >51,000 lakes >4-hectare surface area
- Landscape/Watershed Data: Lake observations were matched with landscape and other watershed level data.
  - Includes nutrient input data, climatic, land use, etc.

https://extension.missouri.edu/publications/g9221

Publication & Tool Links

- Published Article:
  - Describes application of Nutrient Explorer on LAGOS-NE Dataset for predicting total TP in northeastern U.S. lakes
  - Citation provided at end of presentation

- Where to Download the App:
  - **EPA's Science Inventory**: https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab=CPHEA&dirEntryId=358039
  - **EPA's GitHub**: https://github.com/USEPA/NutrientExplorer



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Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/envsoft

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US Environmental Protection Agency, 1200 Pennsylvania Ave., NW, Washington, DC, 20460, USA

ARTICLE INFO

Handling Editor: Daniel P Ames

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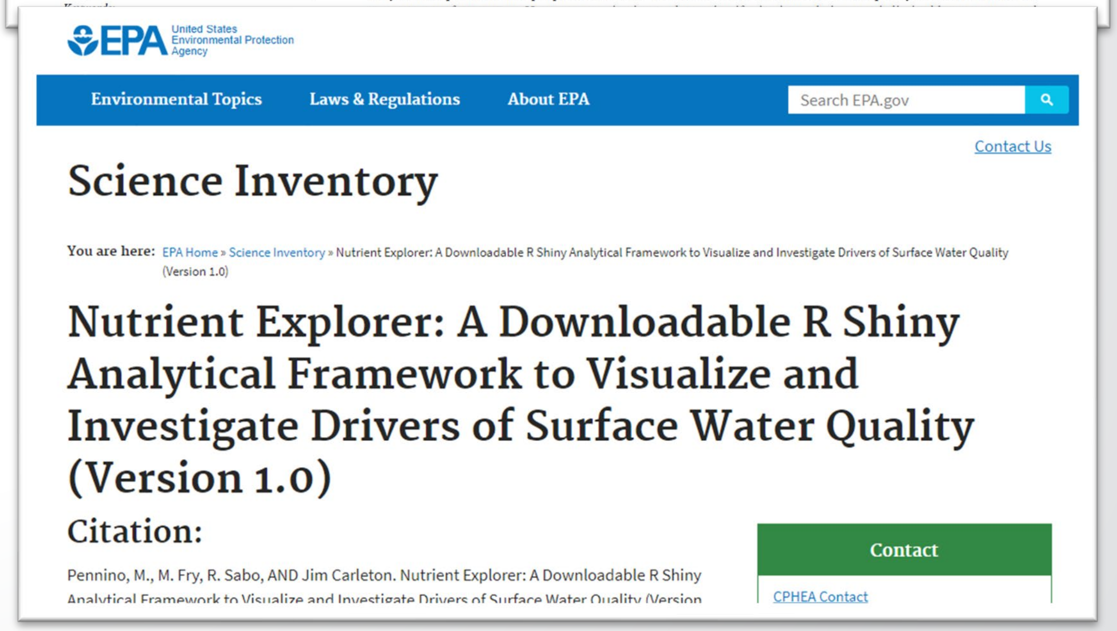
Excess nutrients (nitrogen and phosphorus) in lakes can lead to eutrophication, hypoxia, and algal blooms that may harm aquatic life and people. Some U.S. states have established numeric water quality criteria for nutrients



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Nutrient Explorer: A Downloadable R Shiny Analytical Framework to Visualize and Investigate Drivers of Surface Water Quality (Version 1.0)

Citation:

Pennino, M., M. Fry, R. Sabo, AND Jim Carleton. Nutrient Explorer: A Downloadable R Shiny

Contact

CPHEA Contact

Sections of the R Shiny App

1. Load Data
2. Explore Data
3. Create a Subset
4. Explore Subset
5. Run Models (Random Forest or Multiple Linear Regression)
6. User Guide

Start of Nutrient Explorer Demo

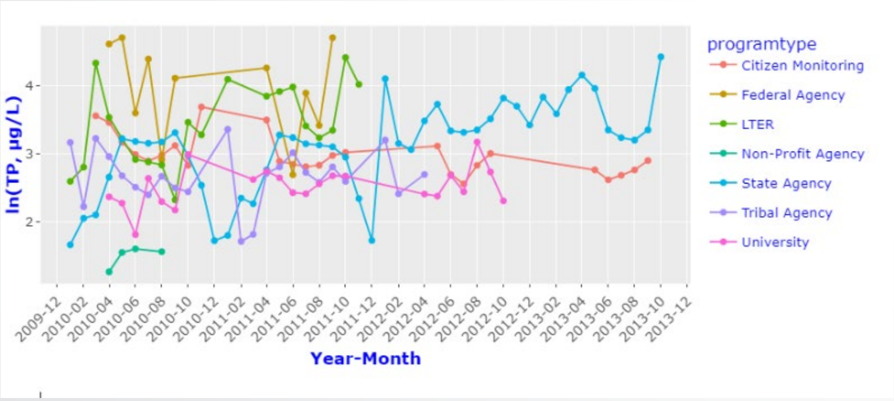
Demo Plan

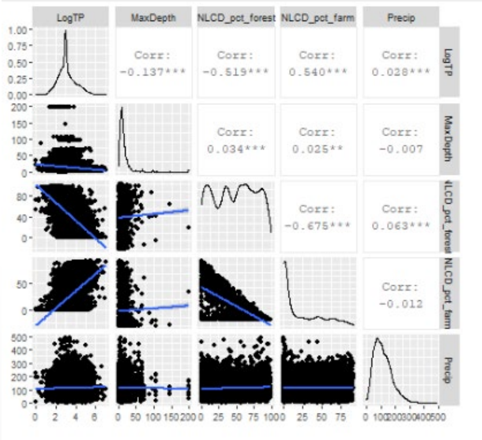
- Show Science Inventory & GitHub site for downloading
- Show how the User Interface opens from R Shiny application
- Walk through App

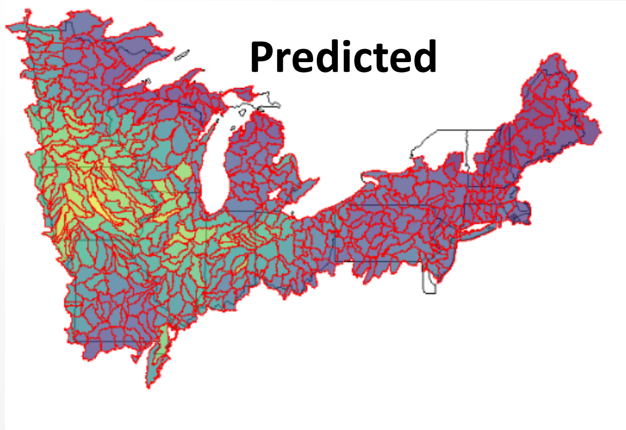
End of Nutrient Explorer Demo

Conclusions

- This application demonstrates how surface water nutrient concentrations and landscape variables can be used to predict water quality in data-poor locations.
- The R code and Shiny user interface developed have a variety of useful features including:
    1. Visualization of temporal and spatial patterns of an endpoint of interest
    2. Analysis of datasets to identify correlations between independent and dependent variables
    3. Modeling and prediction of concentrations that may be exceeding levels of concern.







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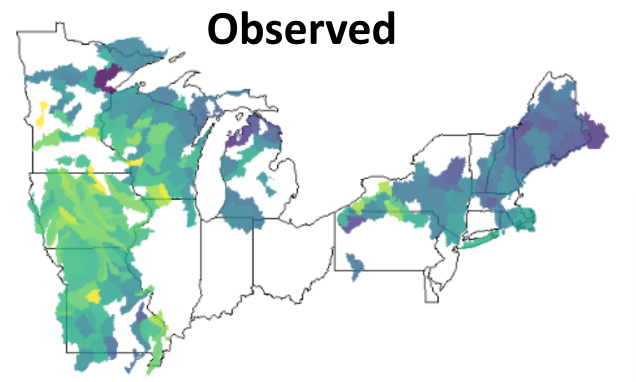
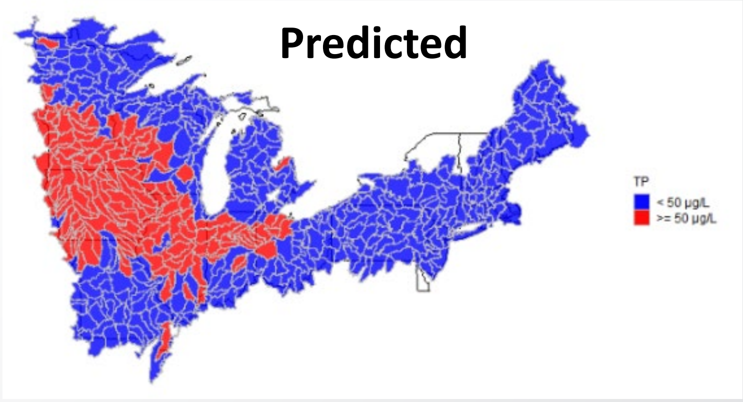
Impacts

- EPA's Nutrient Explorer is a framework for predicting nutrient concentrations in surface waters and can be used to help managers prioritize watersheds and waterbodies for mitigative activities.
  - Specifically, this application can help managers predict which regions are at higher risk for having nutrient concentrations above certain threshold or water quality criteria levels.
- The models can be used to assess the dominant factors (e.g., fertilizer amount) and their relative contribution to nutrient concentrations in surface waters.
- It is important to note that model predictions are not equivalent to observations and therefore cannot be used as sole determinants of waterbody impairment.

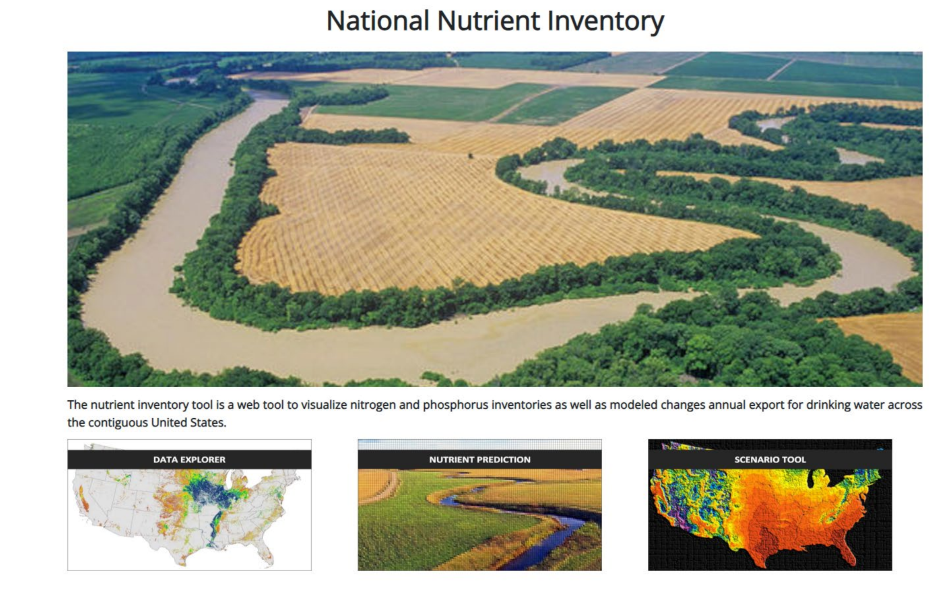
https://www.maine.gov/dep/water/lakes/algalbloom.html

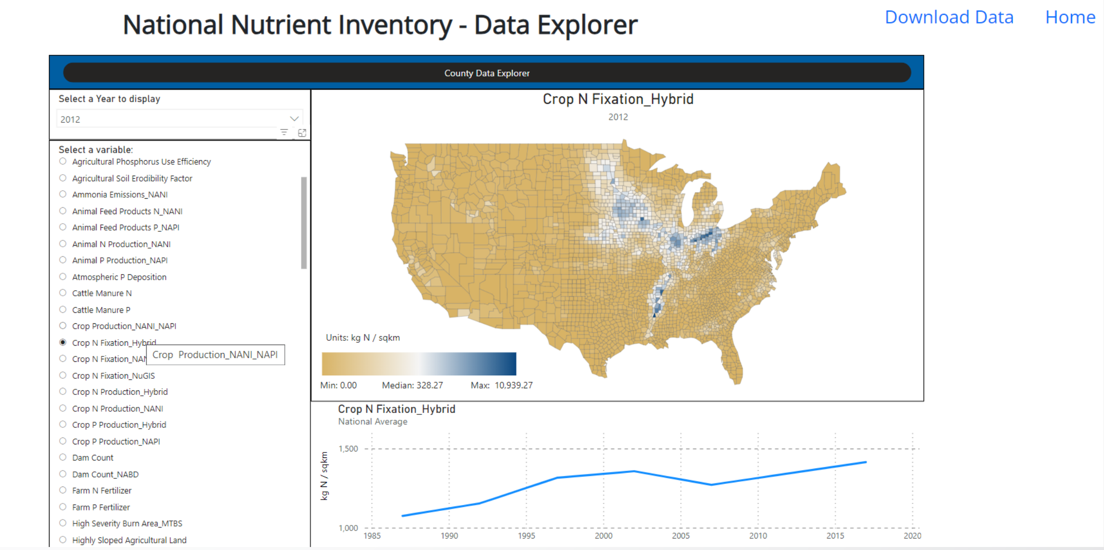




Future Iterations

- The version associated with the journal article will be maintained and will get minor updates periodically.
  - More flexibility in the required variable naming convention for user provided datasets.
- Aspects of Nutrient Explorer will be part of a new application being developed called “Nutrient Inventory Explorer,” headed by Robert Sabo.





Links & Citation

- EPA's Science Inventory: https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab=CPHEA&dirEntryId=358039
- EPA's Github: https://github.com/USEPA/NutrientExplorer
- Citation:
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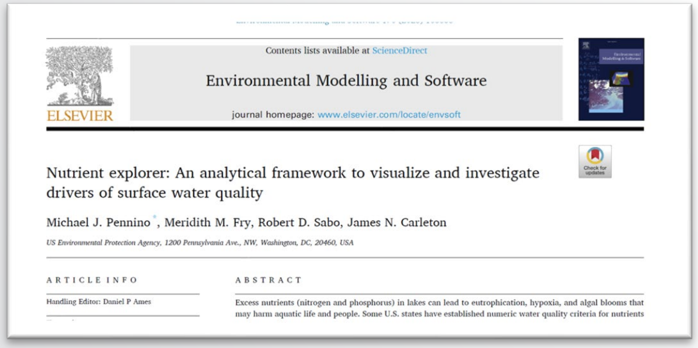
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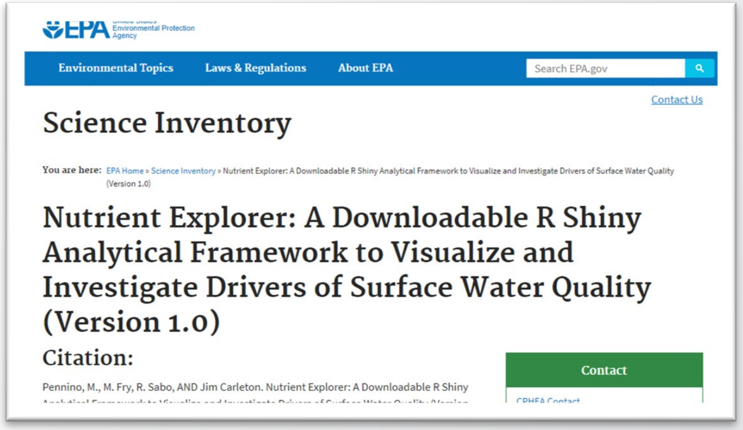
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Contact

Contact

Michael Pennino
Ecologist
Center for Public Health and Environmental Assessment
U.S. EPA Office of Research and Development
pennino.michael@epa.gov
202-564-8489

Acknowledgements

- Environmental Modeling and Visualization Laboratory (EMVL) members Yadong Xu and Ray Burton and EPA OMS's Heidi Paulsen for developing the R Shiny UI framework for this paper.
- Ben Washington (formerly at ORD) who helped develop the dataset used in this analysis and some of the initial R code for the visualizations and modeling.
- EPA's Sylvia Lee (ORD) and Micah Bennett (R5) who provided helpful comments and review of the application and associated manuscript.

Screenshots of Nutrient Explorer (if issues during live demo)

How to Download and Open Application

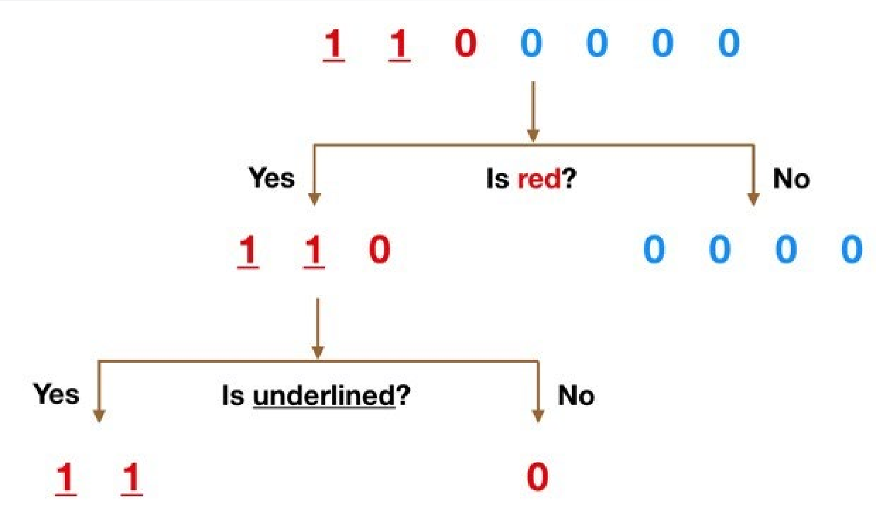
Opening the Application:

1. Download and unzip the Zip File containing the app and associated files (found here: https://github.com/USEPA/NutrientExplorer).
2. Open RStudio > Click on “Project” (blue box, upper right) > Select “Open Project.”
3. Navigate to the file folder where you saved the Application.
4. Click on the “Nutrient_Explorer.Rproj” file and select Open.
5. On bottom right panel of RStudio, under the Files Tab, click on “ui.R” to open this R code file.
6. On bottom right panel of RStudio, under the Files Tab, click on “server.R” to open this R code file.
7. Check to make sure you have all the necessary packages installed before the next step.
8. Near the Upper Right, click on the “Run App” button with the green arrow pointing to the right. This will open the User Interface for the application in a separate window.

Random Forest Modeling

Building the Model

Single Decision Tree

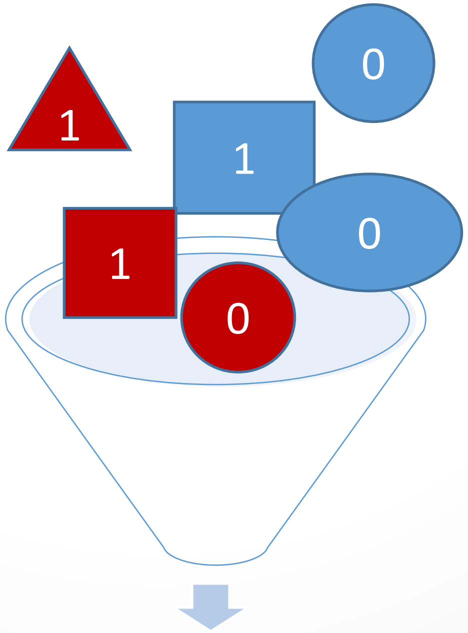


https://towardsdatascience.com/understanding-random-forest-58381e0602d2

- Train-Test Split
- Train Model on 90% of data
- Test model on remaining 10%
- Cross Validation

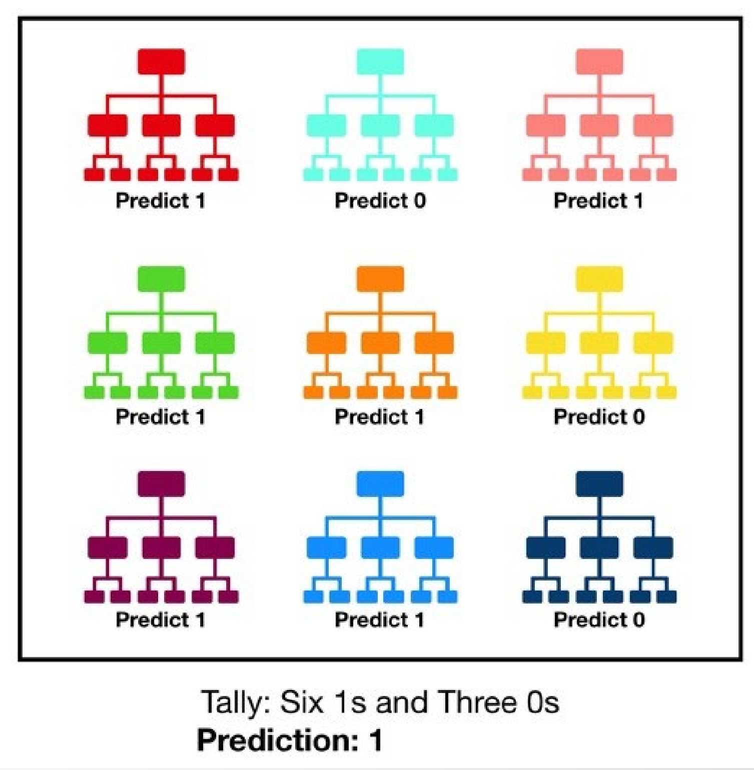
Build (train) the model with observed data

Create multiple Trees
Based on different subsets
of the data and variables



Trained model

Applying the model



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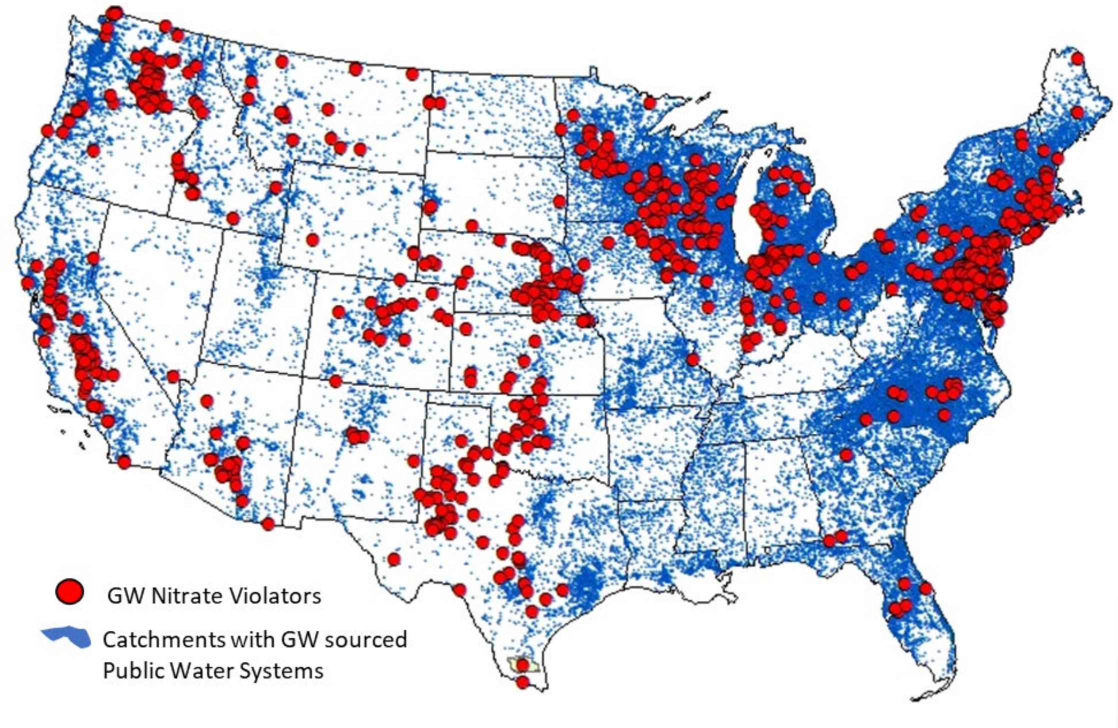
Random Forest Modeling: Classification

Response Variables (1s & 0s)

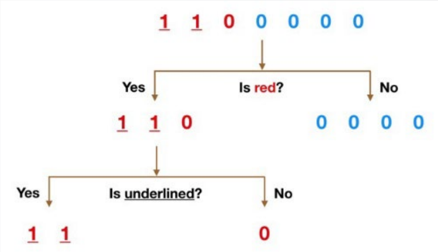
Observed catchments with Public Water Systems and nitrate violations



Predictor Variables

- Land use
- Soil Type
- Nitrogen inputs
- Climate

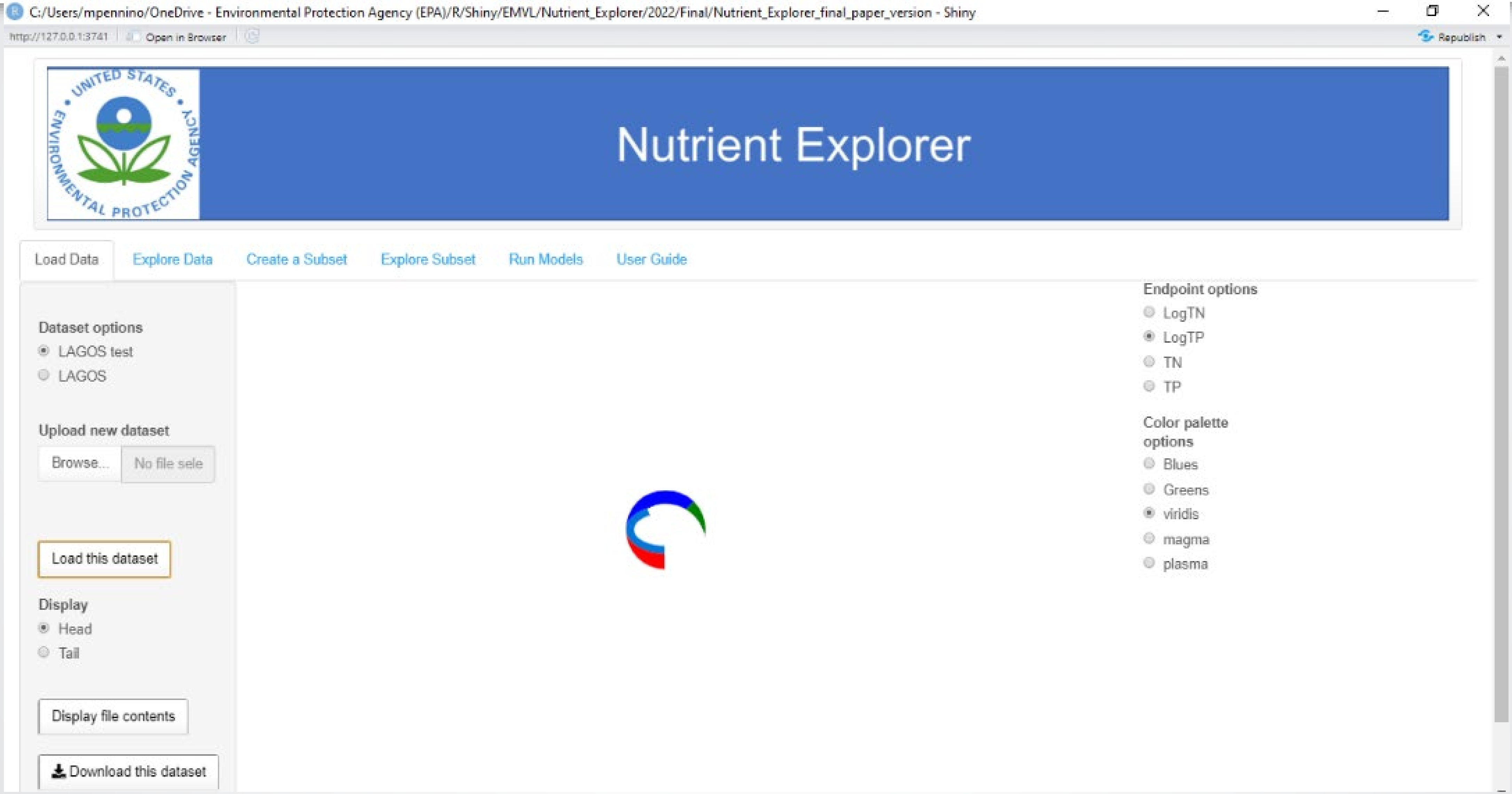
Decision Tree



Site	Nitrate Violation	% Cropland	Precip.	Fertilizer
1	1	10	12	70
2	0	9	33	5
3	1	22	41	50
4	1	31	51	60
5	0	7	20	10

Pennino et al. 2020 STOTEN

Load Default Dataset



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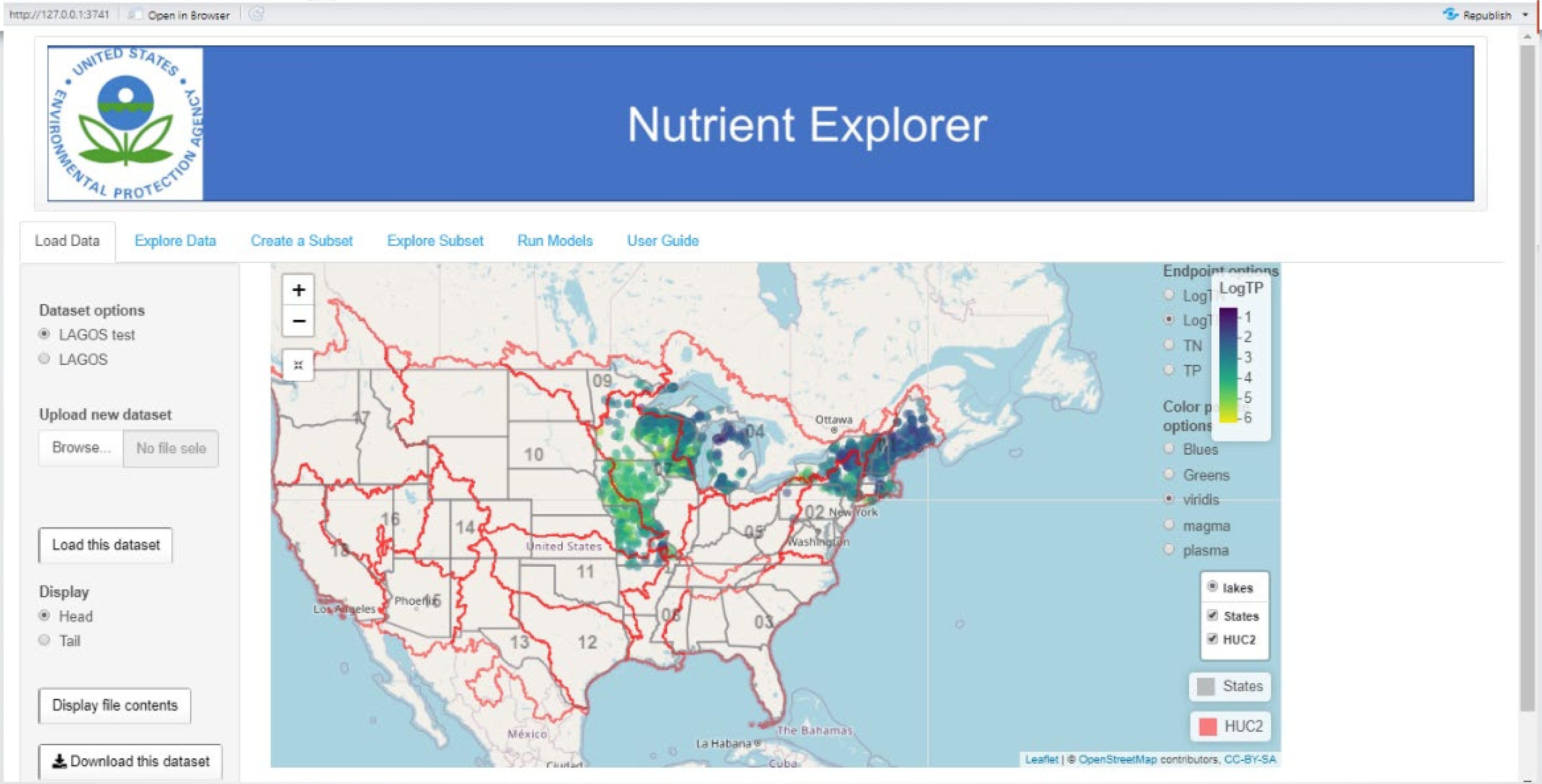
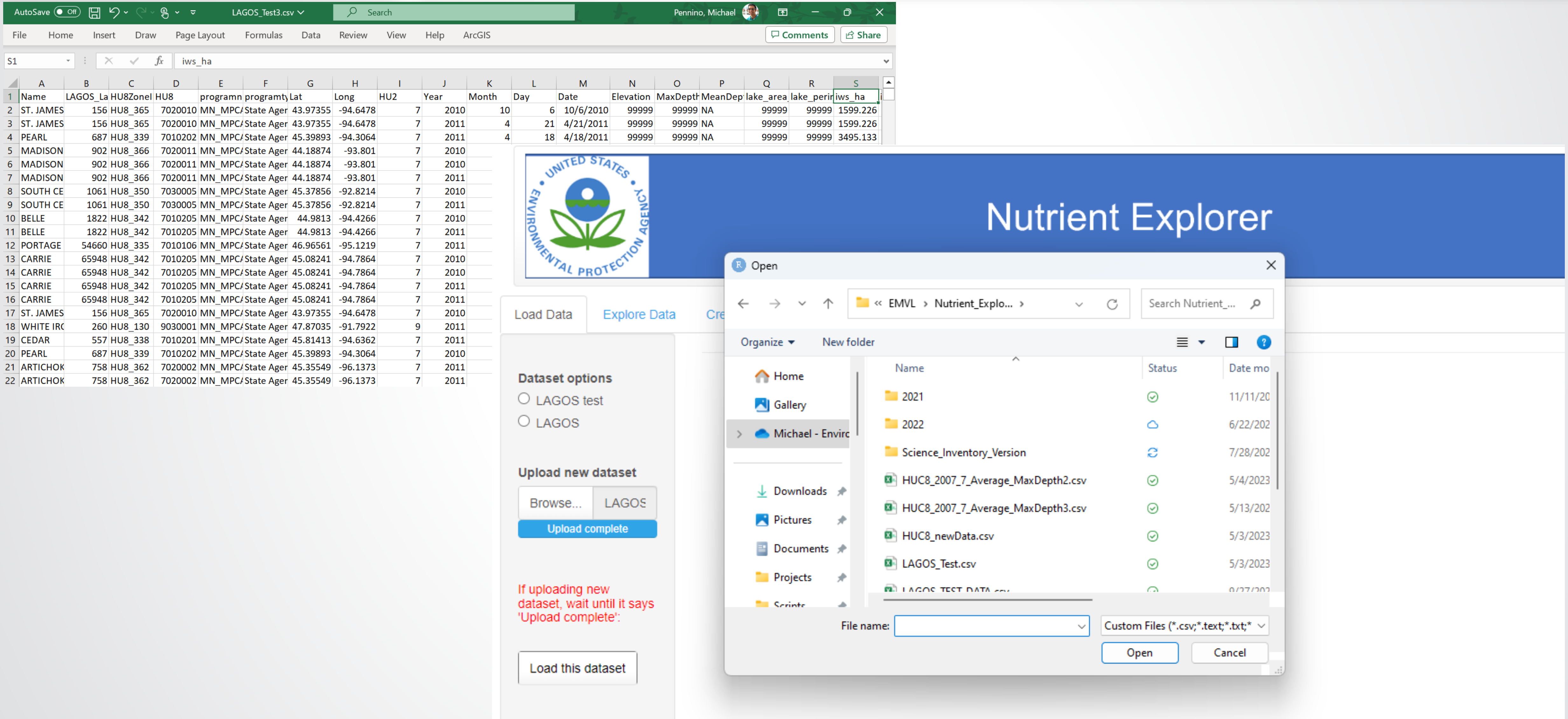


Or Load User Provided Dataset



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3	ST. JAMES	156	HU8_365	7020010	MN_MPC/	State Ager	43.97355	-94.6478	7	2011	4	21	4/21/2011	99999	99999	NA	99999	99999	1599.226
4	PEARL	687	HU8_339	7010202	MN_MPC/	State Ager	45.39893	-94.3064	7	2011	4	18	4/18/2011	99999	99999	NA	99999	99999	3495.133
5	MADISON	902	HU8_366	7020011	MN_MPC/	State Ager	44.18874	-93.801	7	2010									
6	MADISON	902	HU8_366	7020011	MN_MPC/	State Ager	44.18874	-93.801	7	2010									
7	MADISON	902	HU8_366	7020011	MN_MPC/	State Ager	44.18874	-93.801	7	2011									
8	SOUTH CE	1061	HU8_350	7030005	MN_MPC/	State Ager	45.37856	-92.8214	7	2010									
9	SOUTH CE	1061	HU8_350	7030005	MN_MPC/	State Ager	45.37856	-92.8214	7	2011									
10	BELLE	1822	HU8_342	7010205	MN_MPC/	State Ager	44.9813	-94.4266	7	2010									
11	BELLE	1822	HU8_342	7010205	MN_MPC/	State Ager	44.9813	-94.4266	7	2011									
12	PORTAGE	54660	HU8_335	7010106	MN_MPC/	State Ager	46.96561	-95.1219	7	2011									
13	CARRIE	65948	HU8_342	7010205	MN_MPC/	State Ager	45.08241	-94.7864	7	2010									
14	CARRIE	65948	HU8_342	7010205	MN_MPC/	State Ager	45.08241	-94.7864	7	2010									
15	CARRIE	65948	HU8_342	7010205	MN_MPC/	State Ager	45.08241	-94.7864	7	2011									
16	CARRIE	65948	HU8_342	7010205	MN_MPC/	State Ager	45.08241	-94.7864	7	2011									
17	ST. JAMES	156	HU8_365	7020010	MN_MPC/	State Ager	43.97355	-94.6478	7	2010									
18	WHITE IRC	260	HU8_130	9030001	MN_MPC/	State Ager	47.87035	-91.7922	9	2011									
19	CEDAR	557	HU8_338	7010201	MN_MPC/	State Ager	45.81413	-94.6362	7	2011									
20	PEARL	687	HU8_339	7010202	MN_MPC/	State Ager	45.39893	-94.3064	7	2010									
21	ARTICHOK	758	HU8_362	7020002	MN_MPC/	State Ager	45.35549	-96.1373	7	2011									
22	ARTICHOK	758	HU8_362	7020002	MN_MPC/	State Ager	45.35549	-96.1373	7	2011									

Summary Table

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Download this dataset

Summary table

```
Note 1: There are 314 variables in total for this dataset,they are divided into 11 groups as listed under 'Variabl
Note 2: You can use the radio buttons on the right to select a variable group to see their summary statistics.
```

	variable	minimum	mean	median	maximum	sd
1	LAGOS_Lake_ID	16.00	18,306.25	5,320.00	140,866.00	32,736.77
2	Month	1.00	7.00	7.00	12.00	1.74
3	Day	1.00	16.72	17.00	31.00	8.66
4	iws_ha	0.70	20,746.06	753.08	1,482,385.00	109,505.79
5	iws_perimkm	1.96	110.26	24.30	3,826.51	336.97
6	iws_lakeareaha	4.01	1,199.27	80.59	113,496.40	7,266.71
7	lake_area_ha	4.01	1,199.27	80.59	113,496.40	7,266.71
8	lake_perim_meters	797.62	37,171.26	5,958.78	1,326,792.00	137,004.80
9	MeanDepth	0.30	5.77	4.27	88.60	8.33
10	MaxDepth	0.30	13.83	10.10	198.40	17.21
11	iws_tri_mean	0.04	0.63	0.49	5.35	0.48
12	iws_slope_mean	0.29	4.50	3.56	33.19	3.33
13	iws_road_density_mperha	0.00	33.15	25.89	174.85	28.15
14	iws_canopy2001_mean	0.00	51.29	58.09	96.13	28.15
15	iws_damdensity_pointsperha	0.00	0.00	0.00	0.54	0.00
16	Lat	36.49	43.80	44.19	48.19	2.29
17	Long	-96.36	-85.80	-89.42	-67.27	8.30

Variable group options

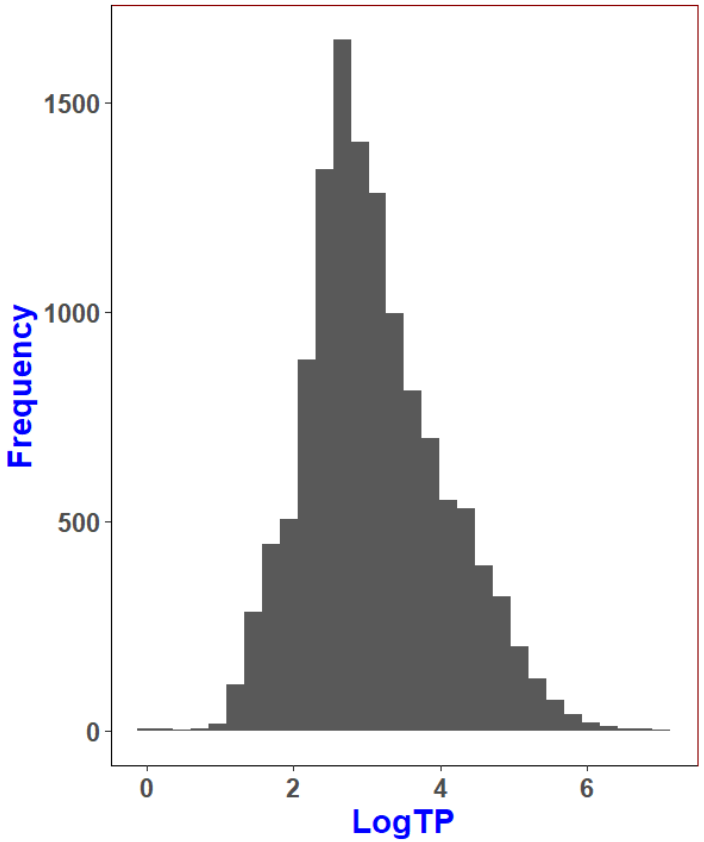
- (●) Default Group
- ( ) NLCD Land Use
- ( ) Weather related
- ( ) Vegetation related
- ( ) Aerosol related
- ( ) N Inventory Raw
- ( ) N Inventory Scaled
- ( ) P Inventory Raw
- ( ) P Inventory Scaled
- ( ) Deposition
- ( ) Sampling Information

Explore Data: Summary Info

http://127.0.0.1:3741 | Open in Browser | Republish

Load Data | Explore Data | Create a Subset | Explore Subset | Run Models | User Guide

Summary Info | Time Series | Endpoint HUC2 Summaries | Predictor Variables HUC2 Summaries | Correlations | Maps | Misc

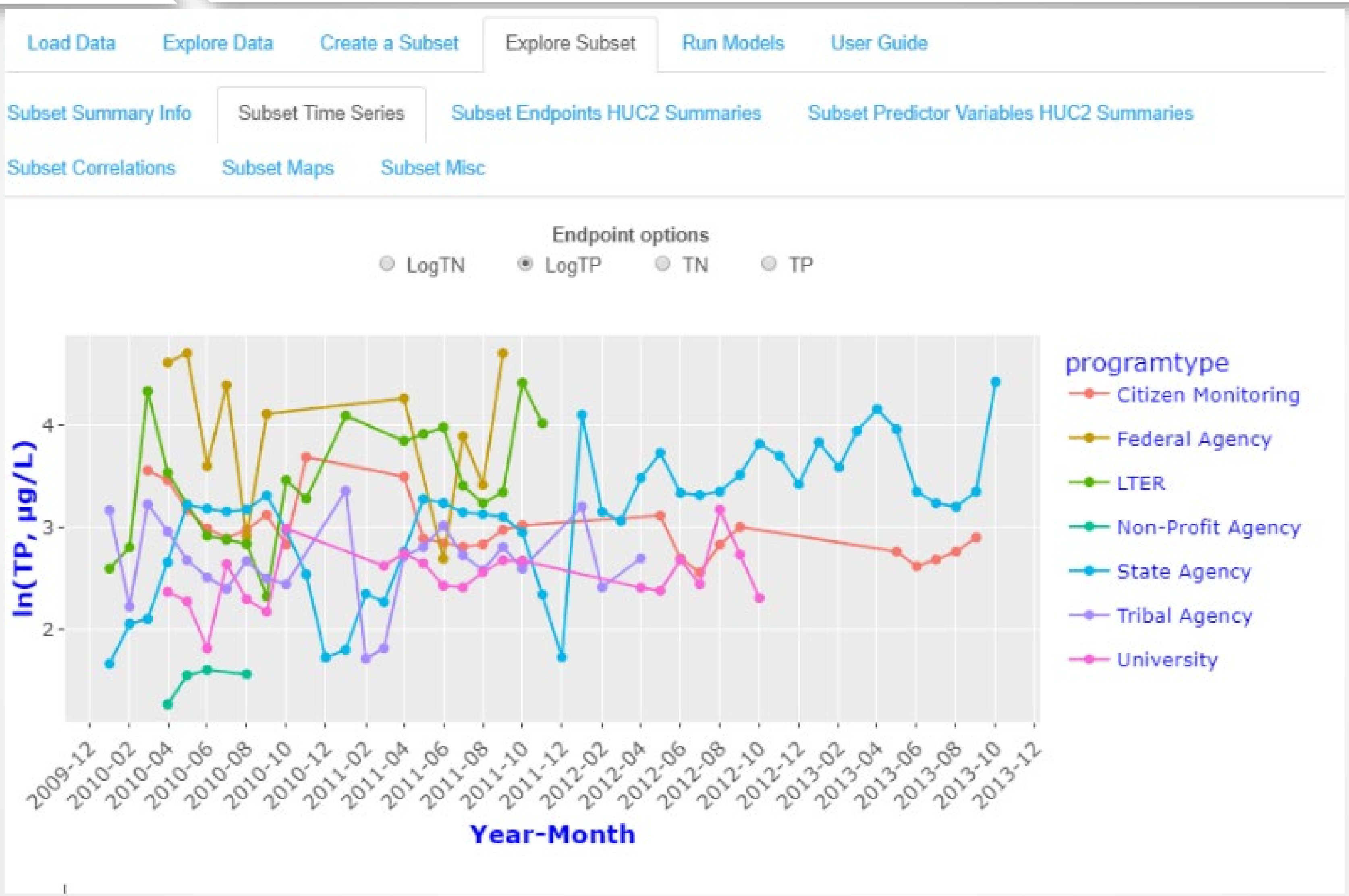


Stats	Value
Mean	3.10
Median	2.96
Min	0.00
Max	7.02
Variance	0.88
SD	0.94

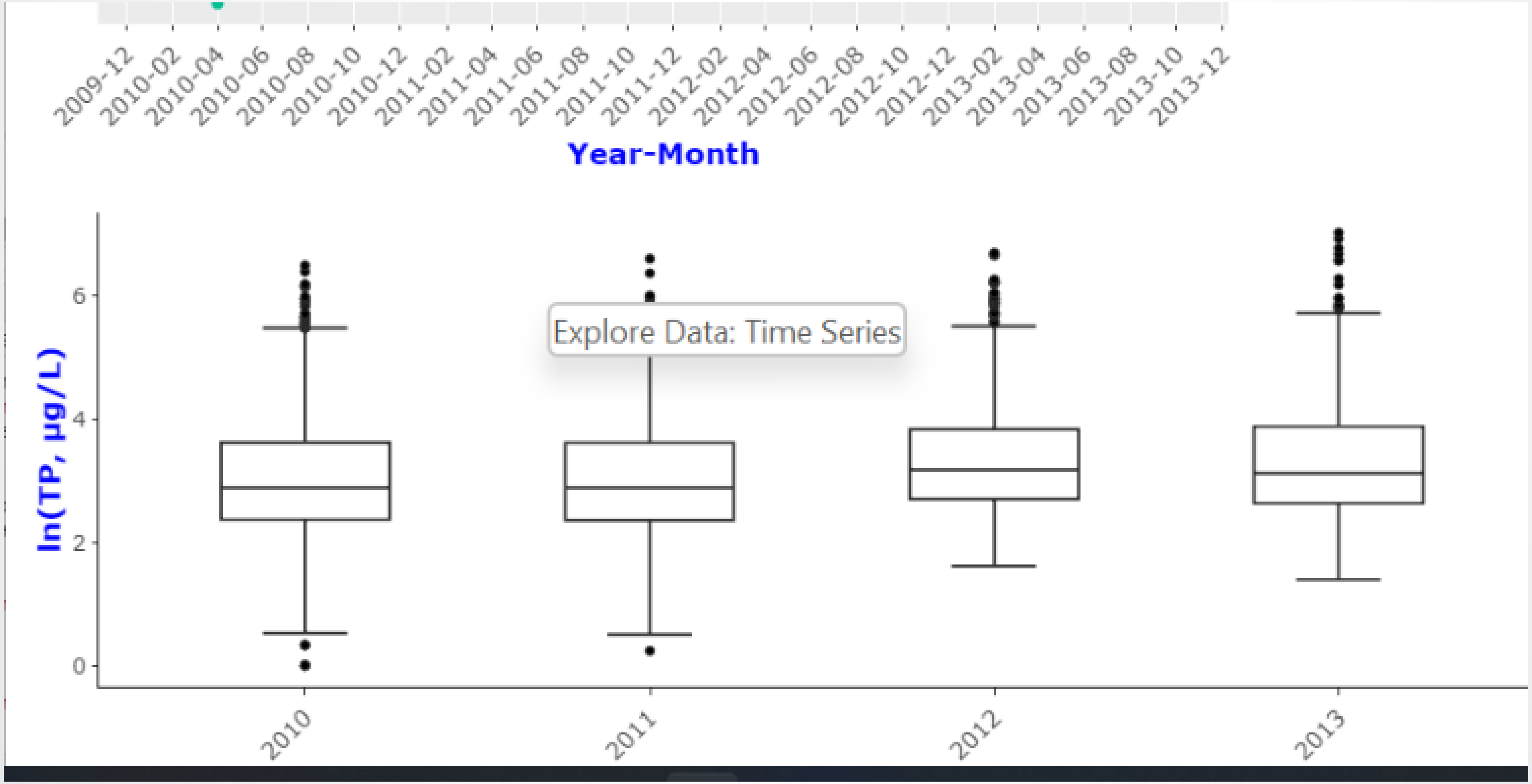
Endpoint options

- LogTN
- LogTP
- TN
- TP

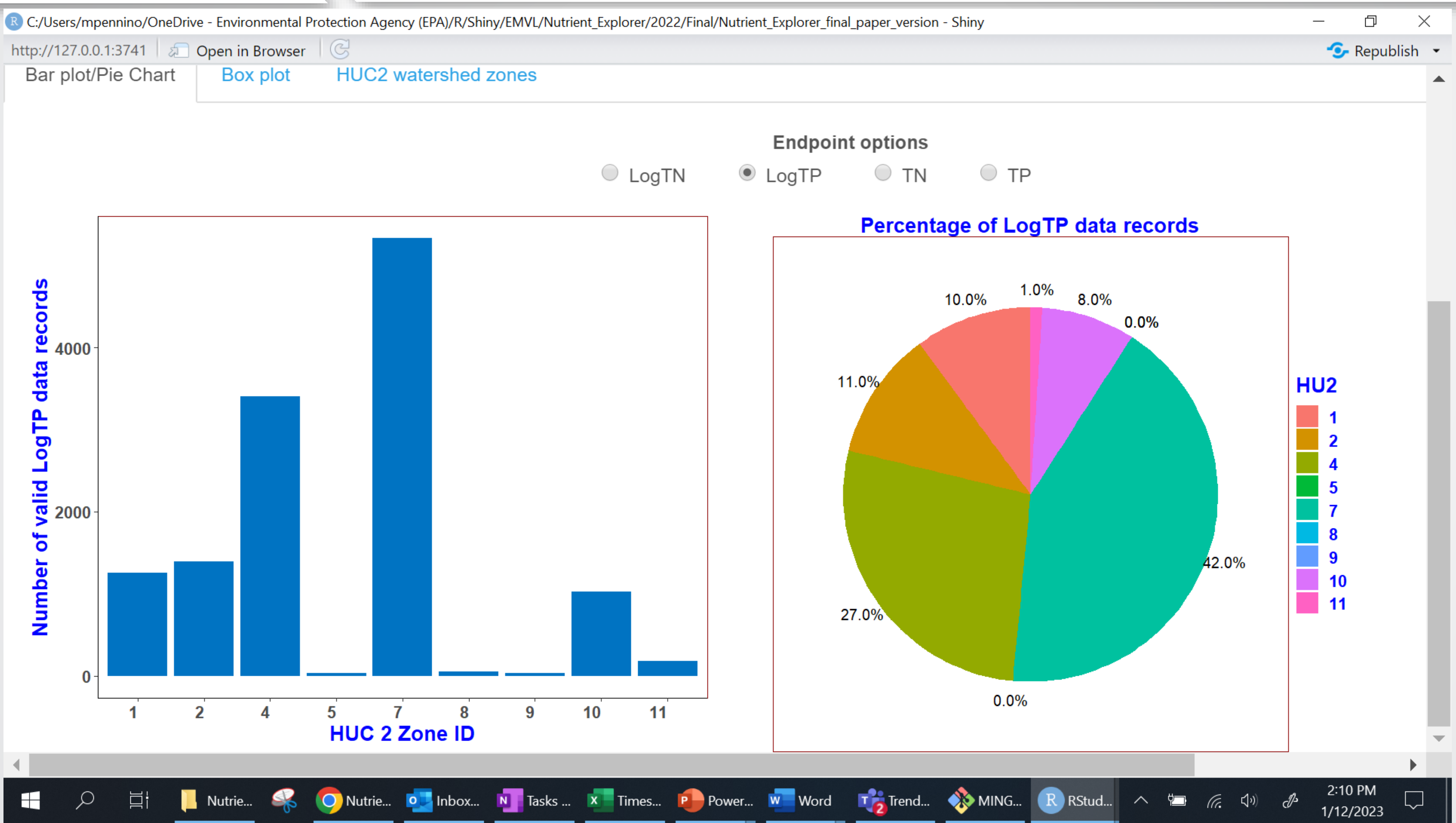
Explore Data: Time Series



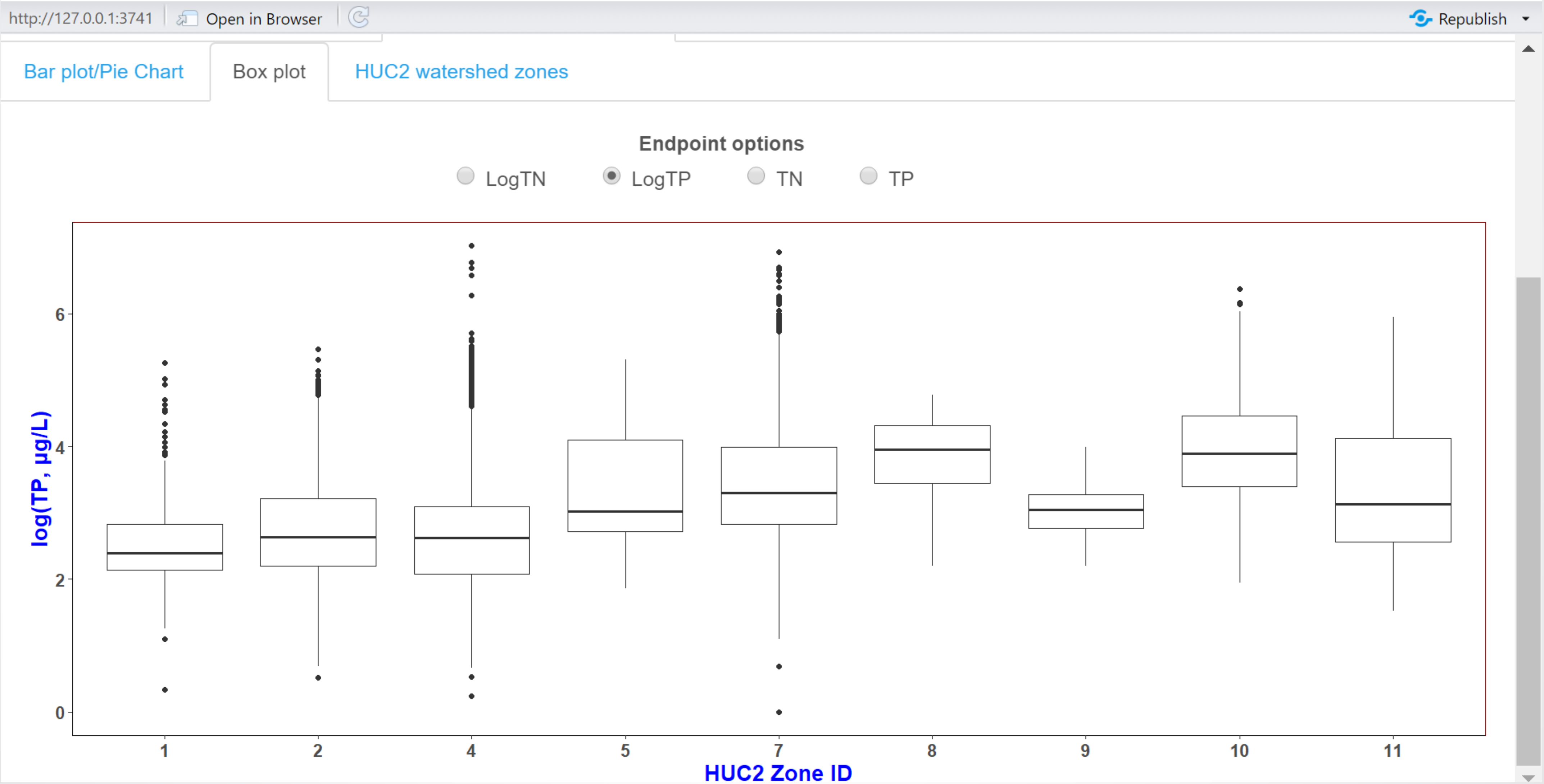
Explore Data: Time Series



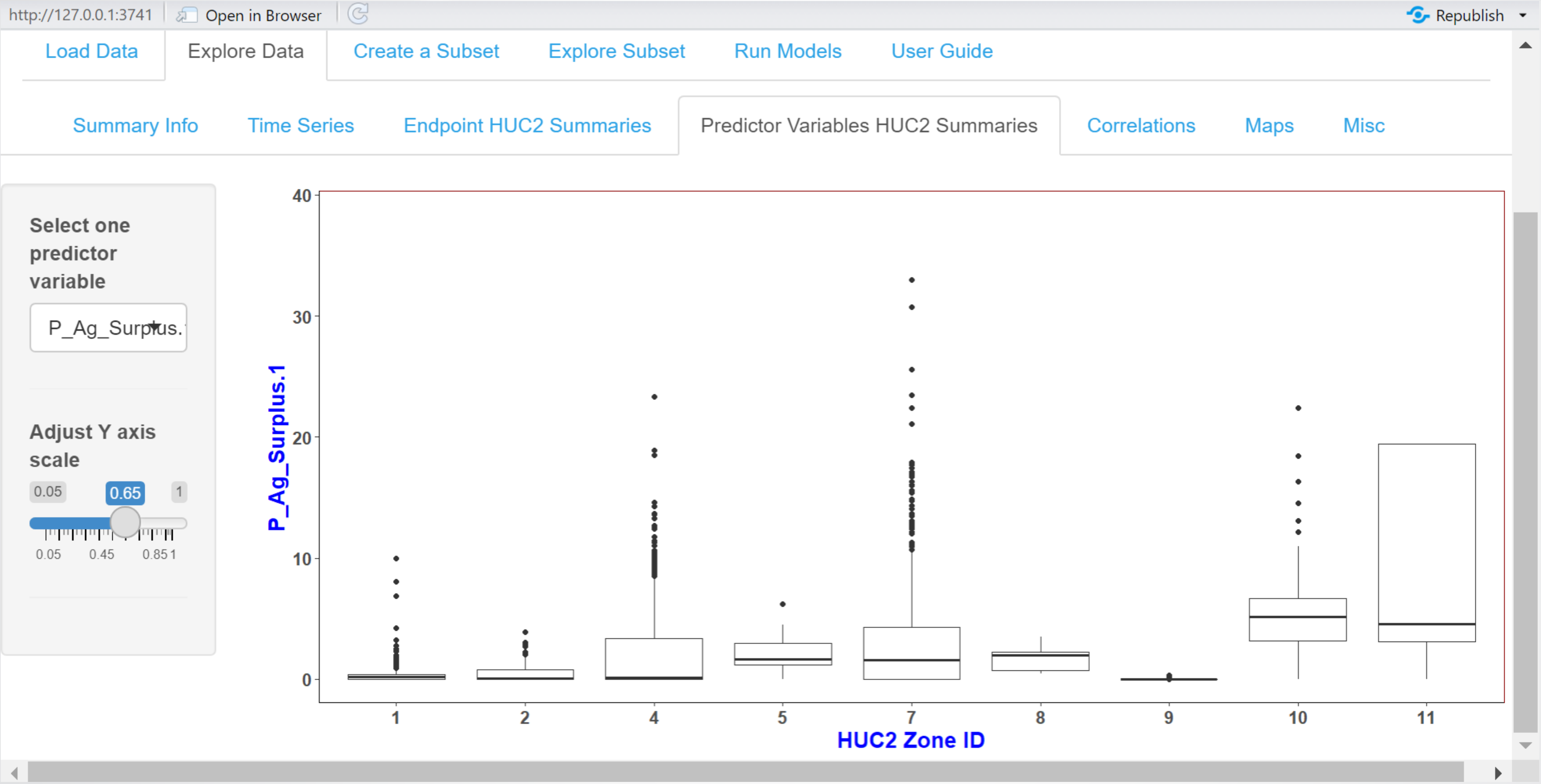
Explore Data: HUC2 Summaries



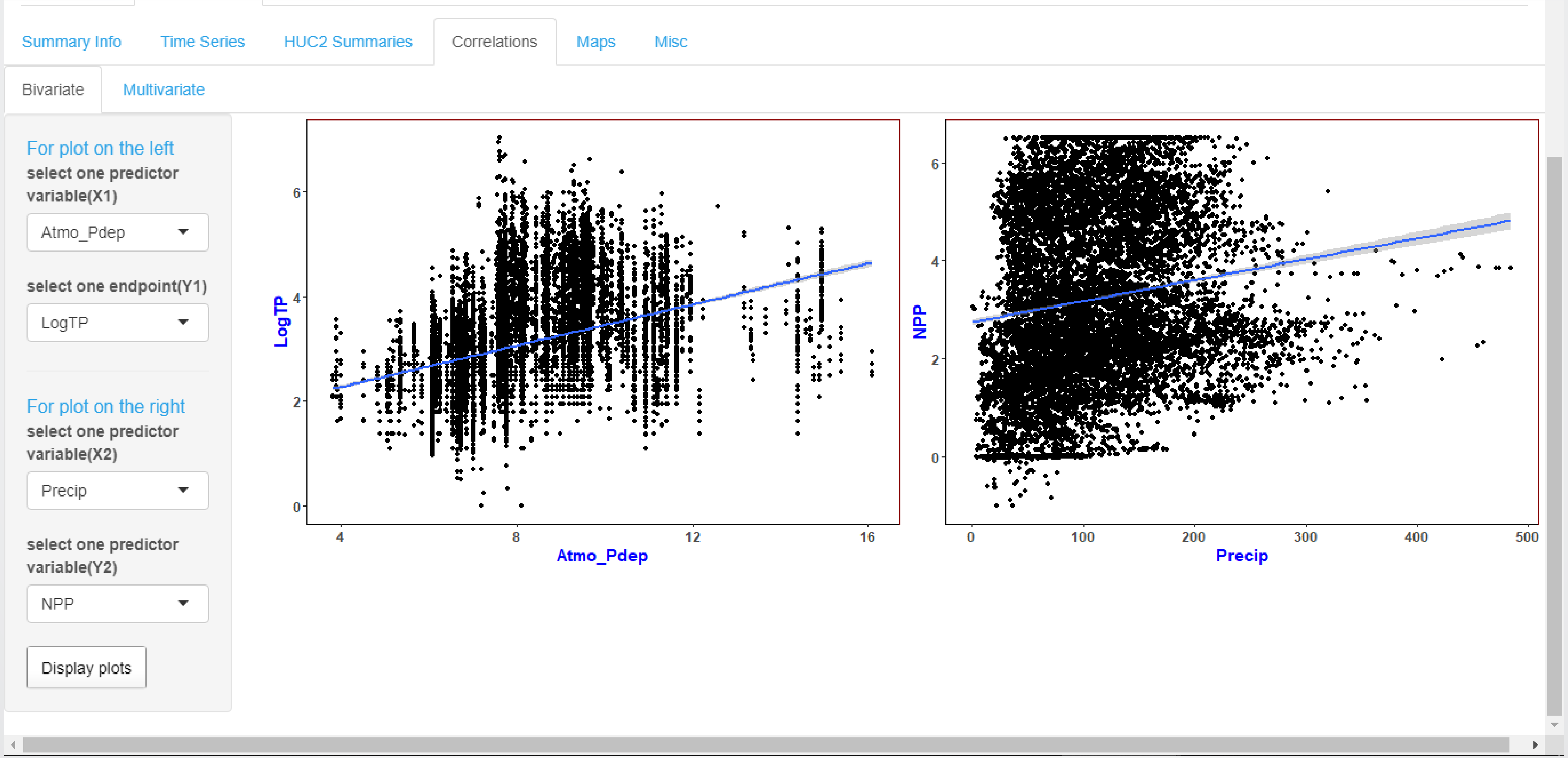
Explore Data: HUC2 Summaries



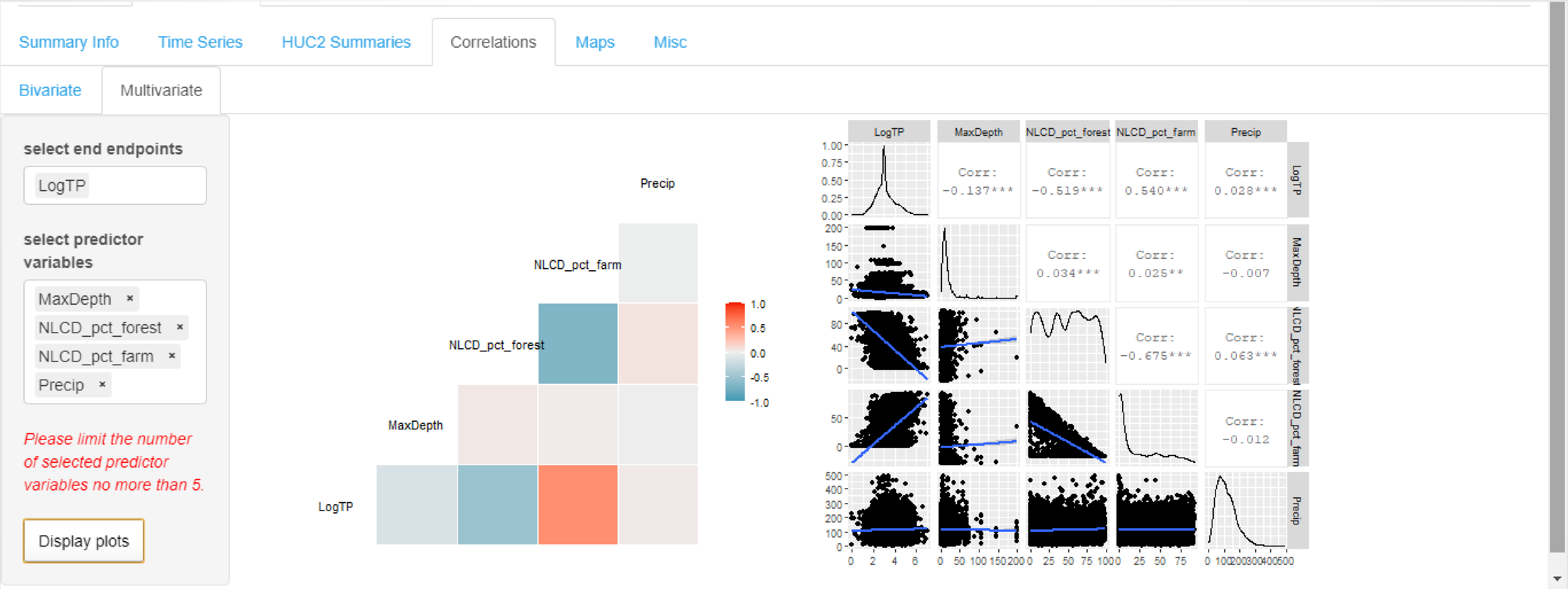
Explore Data: Predictor Variable HUC2 Summaries



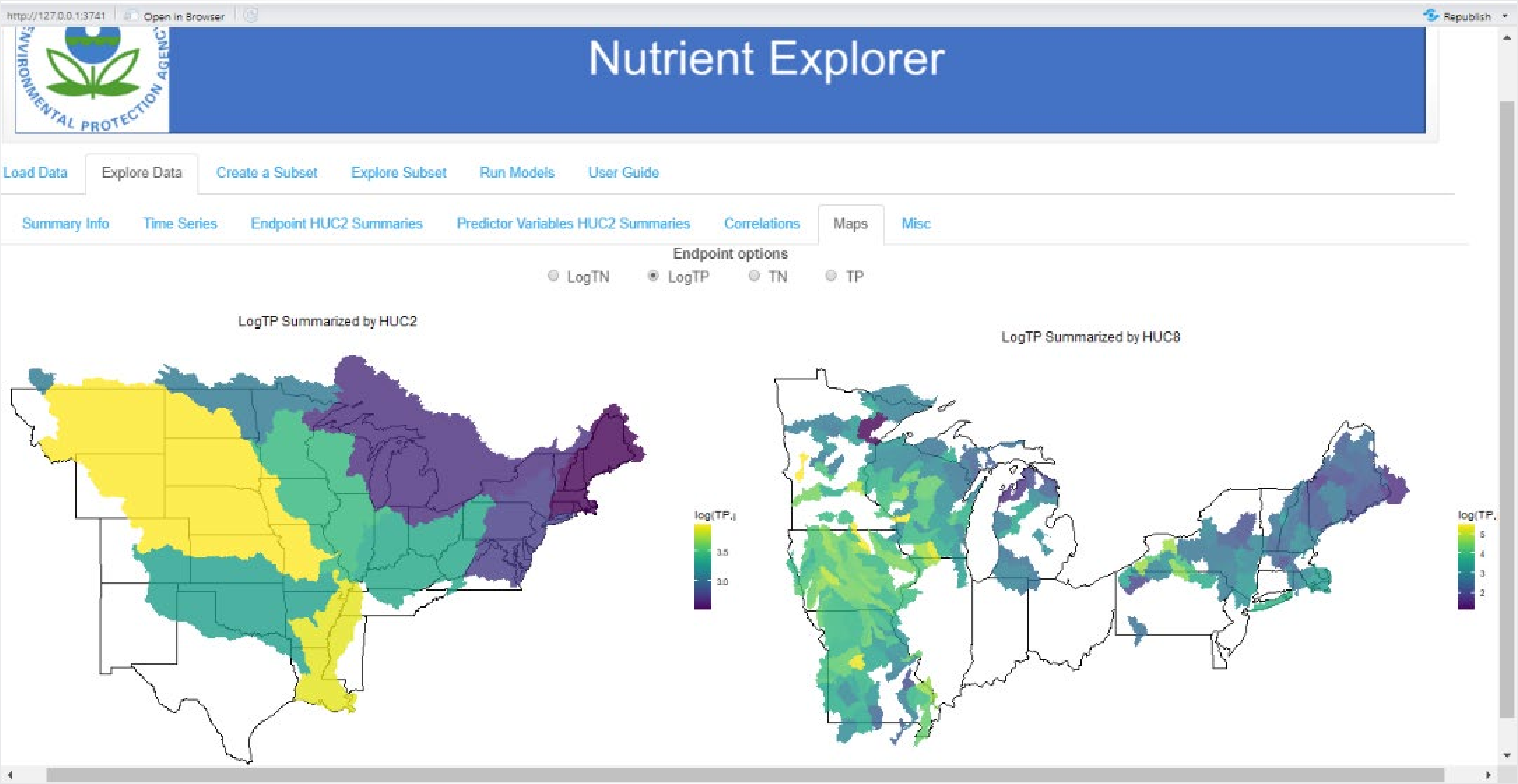
Explore Data: Correlations - Bivariate



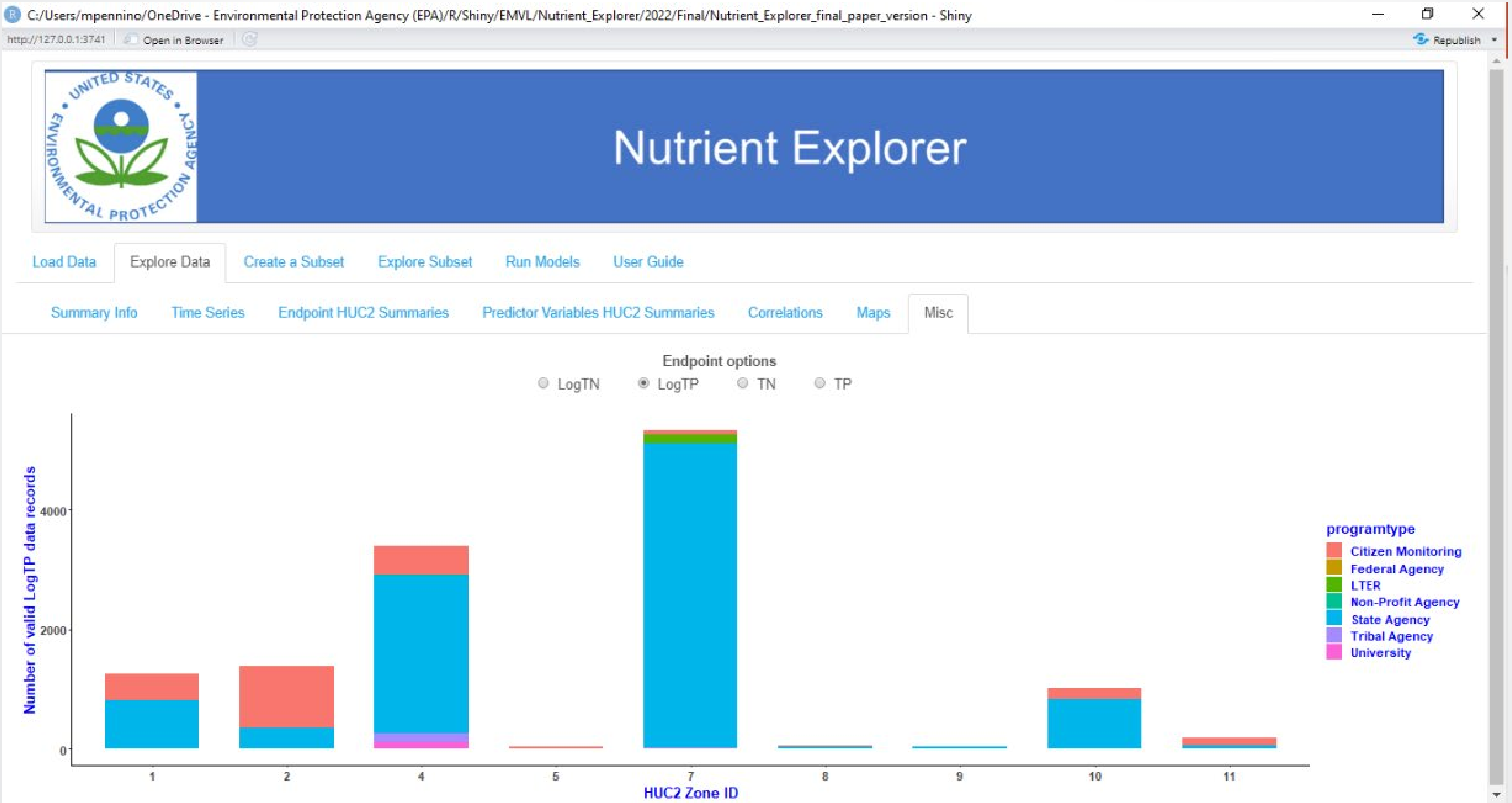
Explore Data: Correlations - Multivariate



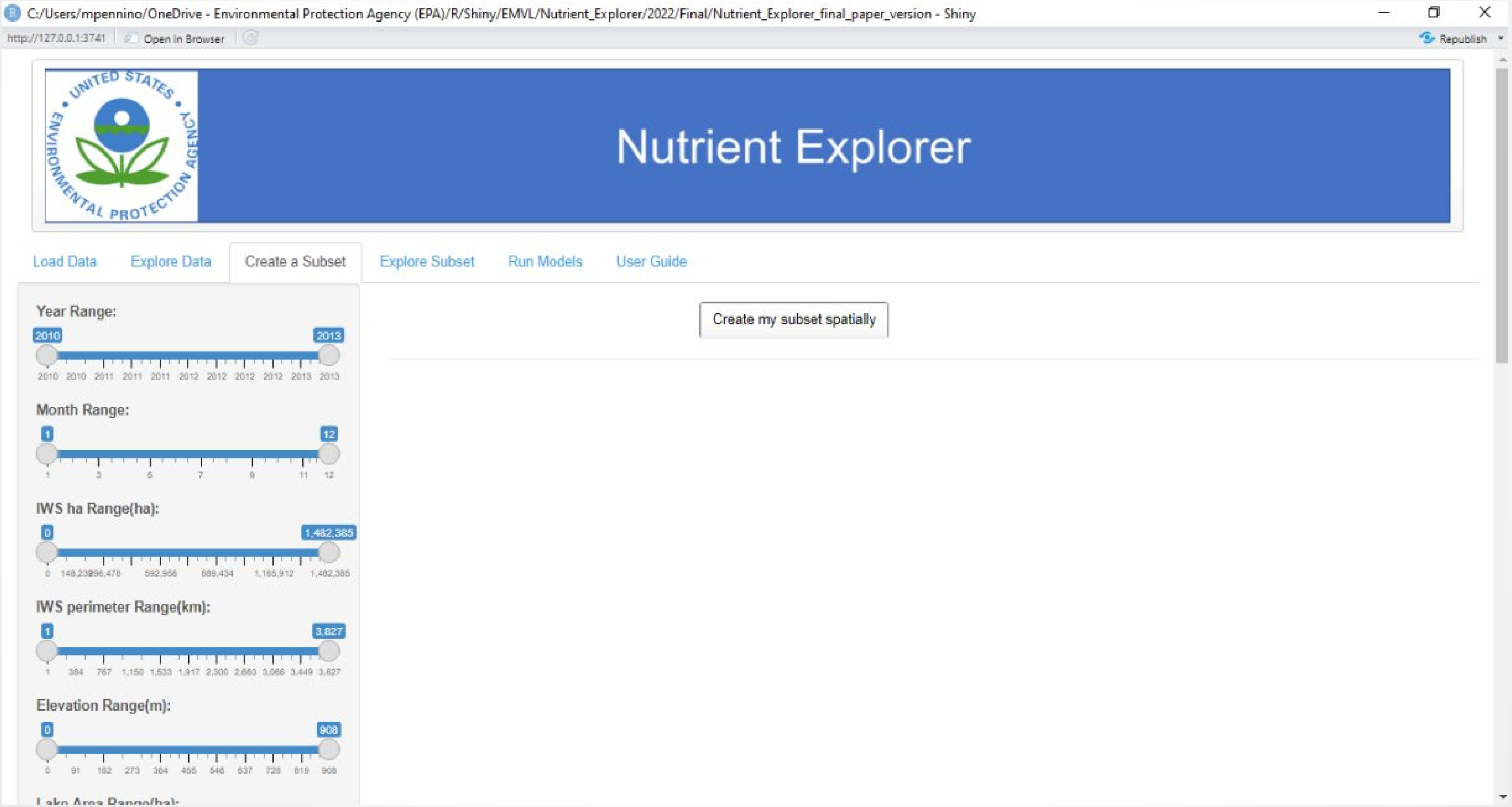
Explore Data: Maps



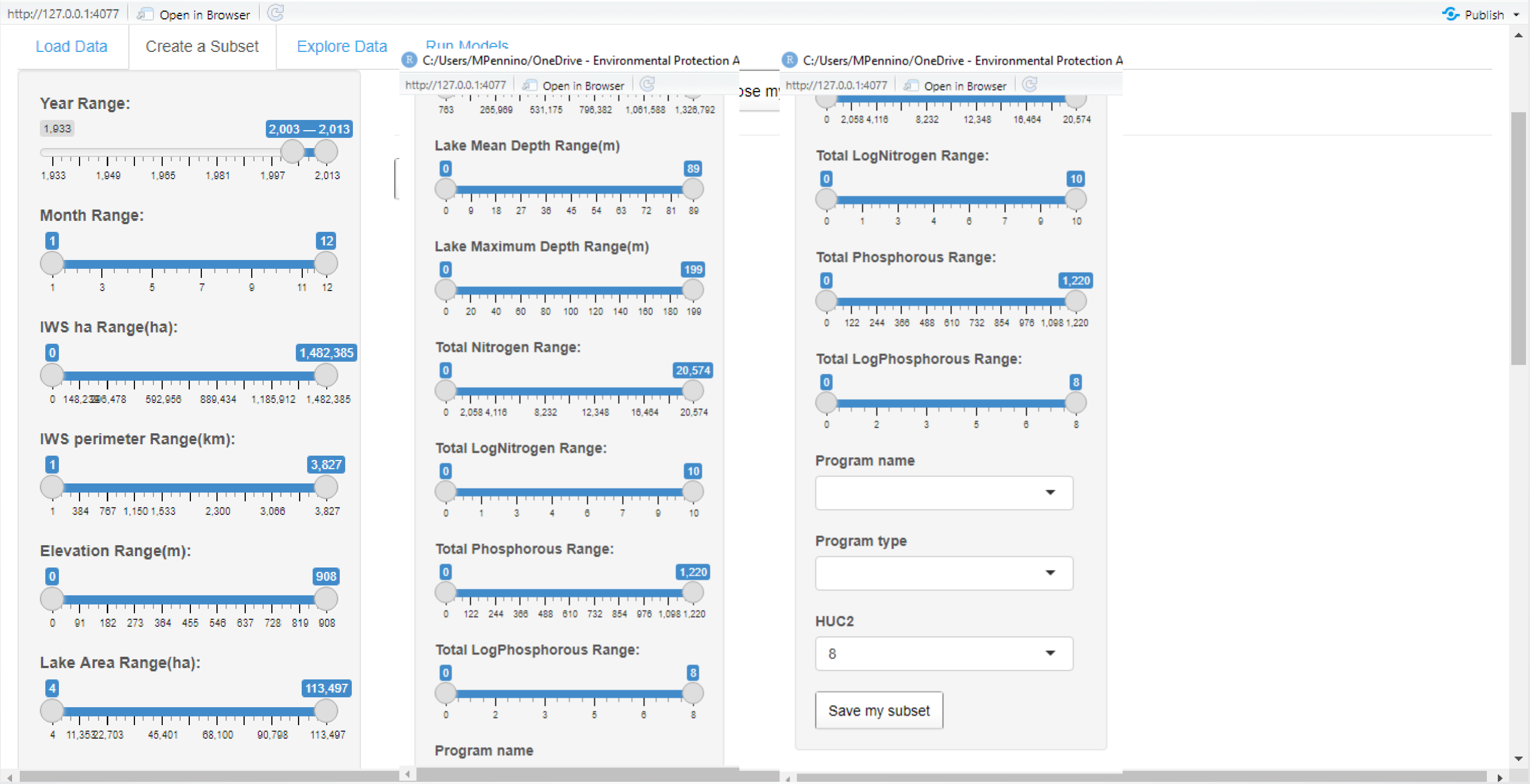
Explore Data: Misc.



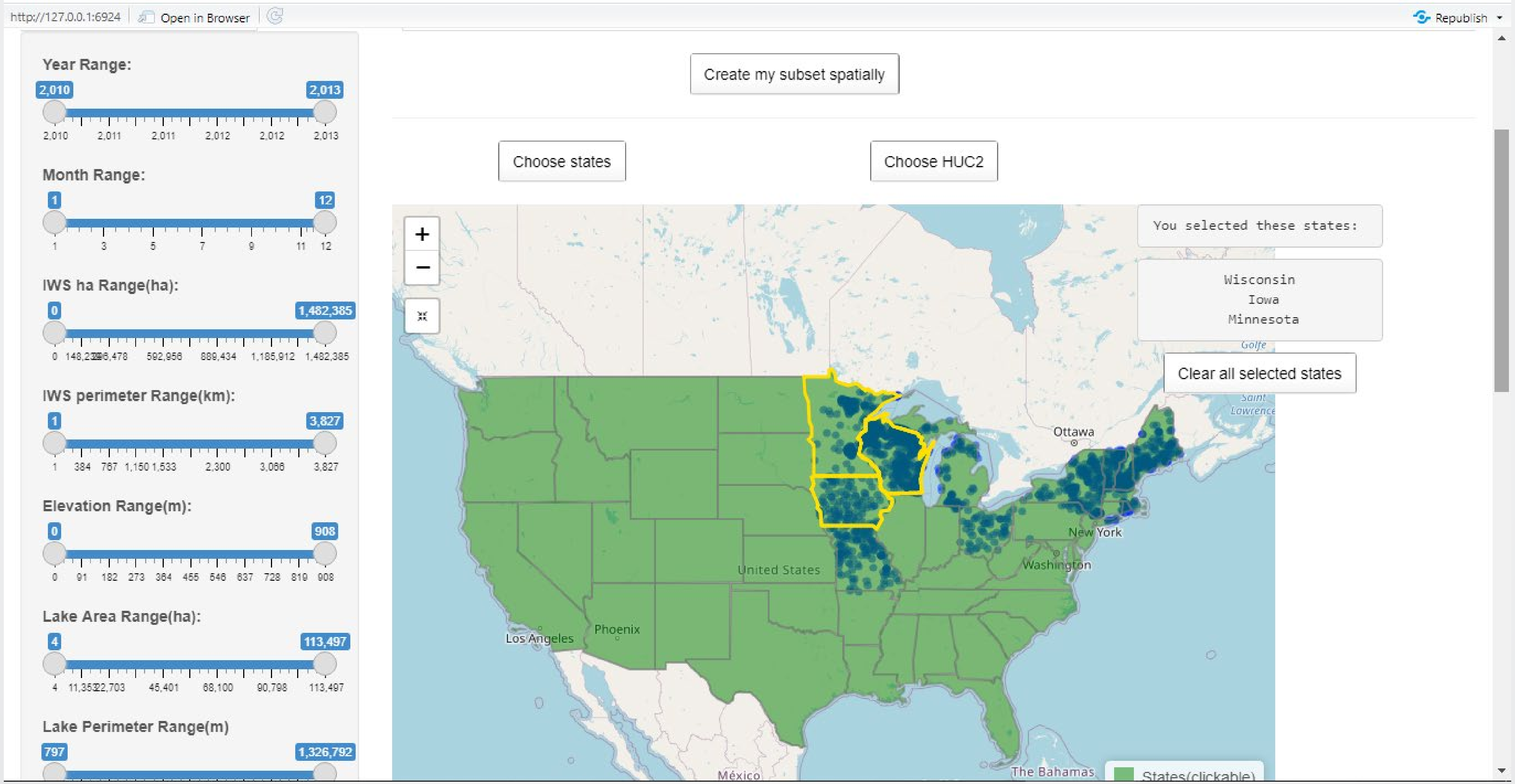
Create a Subset of the Data



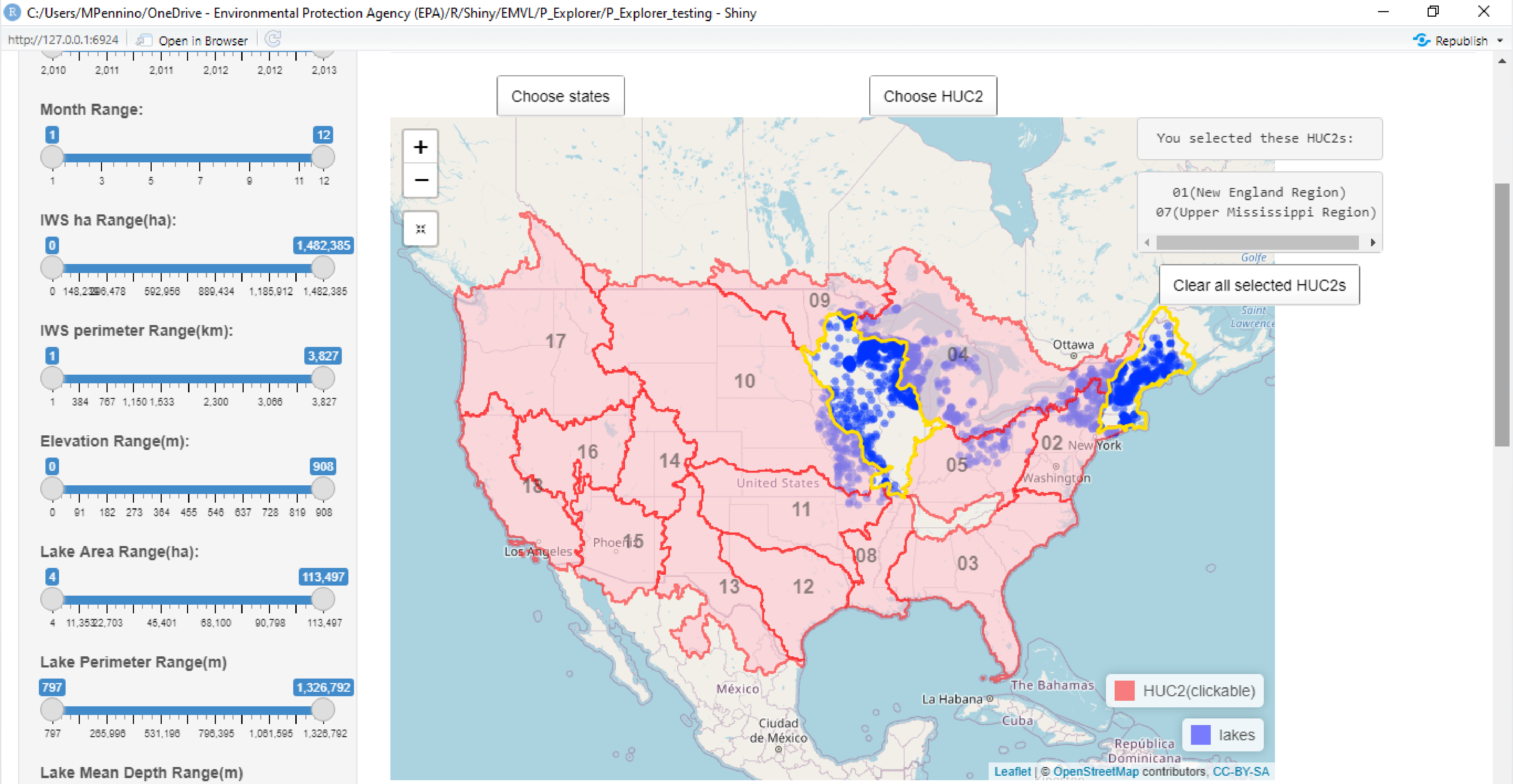
Create a Subset of the Data



Create a Subset Spatially



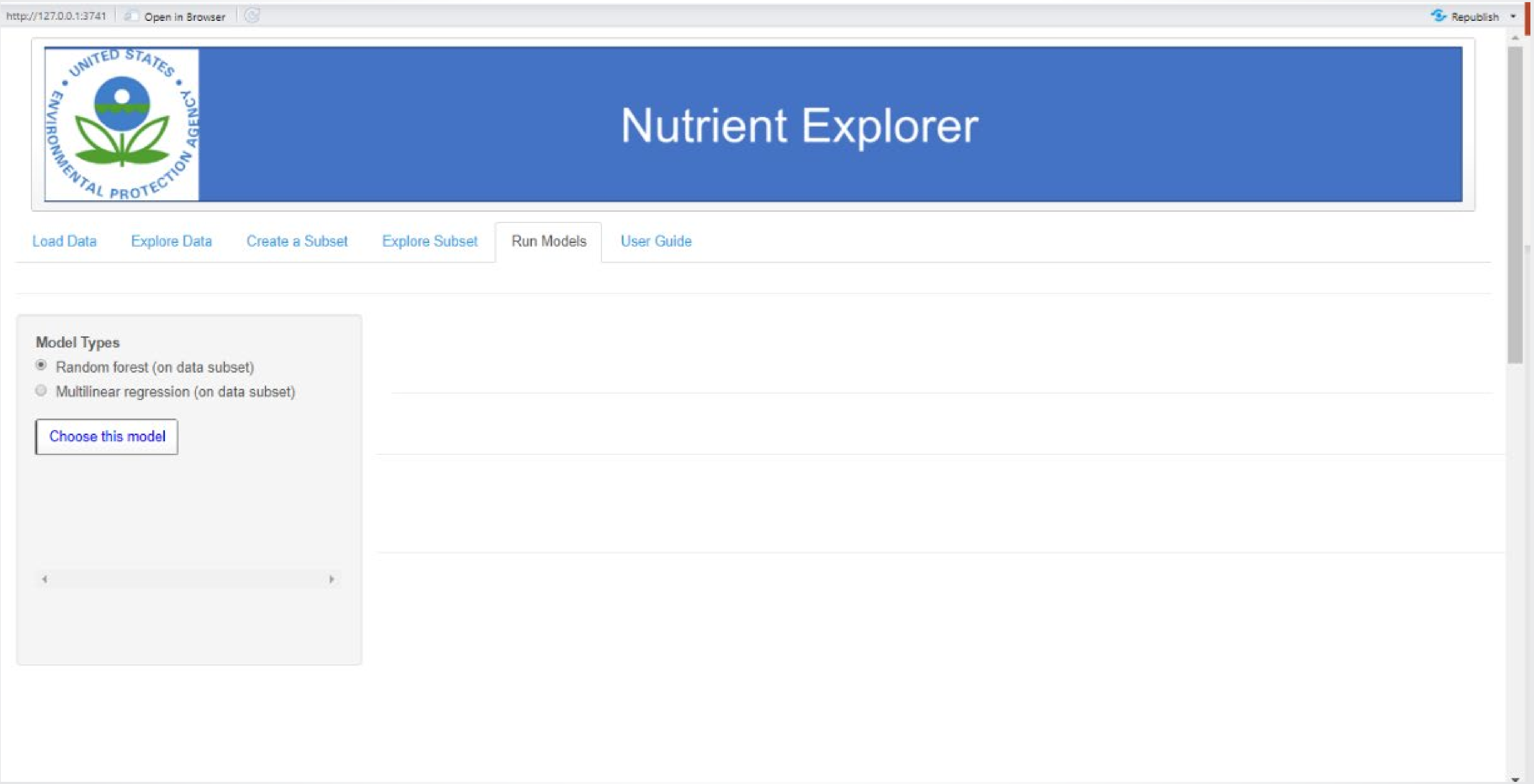
Create a Subset Spatially



Explore Subset

- This section produces the same figures as the Explore Data section, but specifically for the subsetted dataset

Run Models



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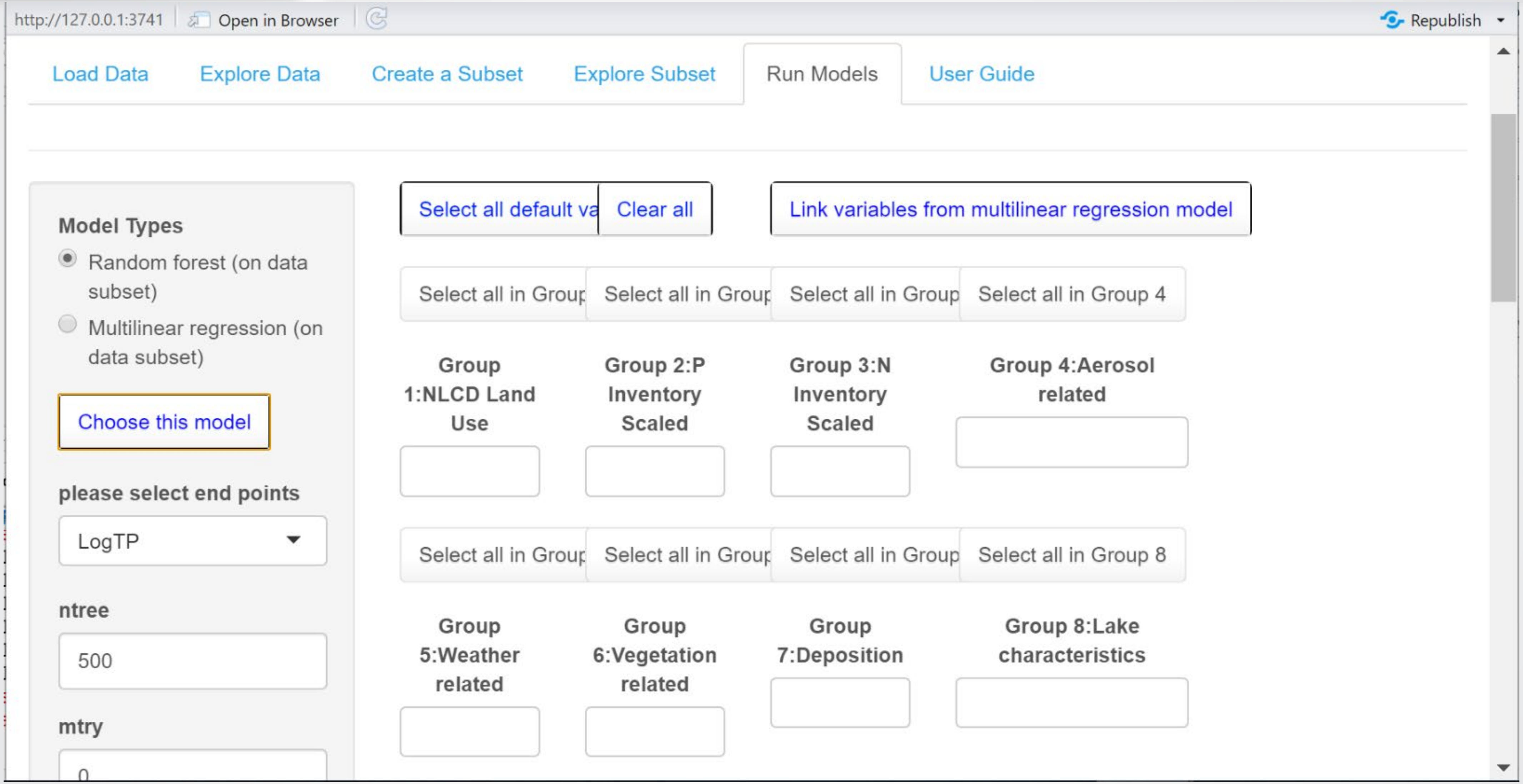
Republish
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Nutrient Explorer
Load Data
Explore Data
Create a Subset
Explore Subset
Run Models
User Guide
Model Types
Random forest (on data subset)
Multilinear regression (on data subset)
Choose this model

Random Forest (RF) Model

Random Forest Model



Random Forest Model

RF Model: Results

C:/Users/mpennino/OneDrive - Environmental Protection Agency (EPA)/R/Shiny/EMVL/Nutrient_Explorer/Science_Inventory_Version/Nutri...

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2

testingset percentage

0.1

minimum node

5

set seed

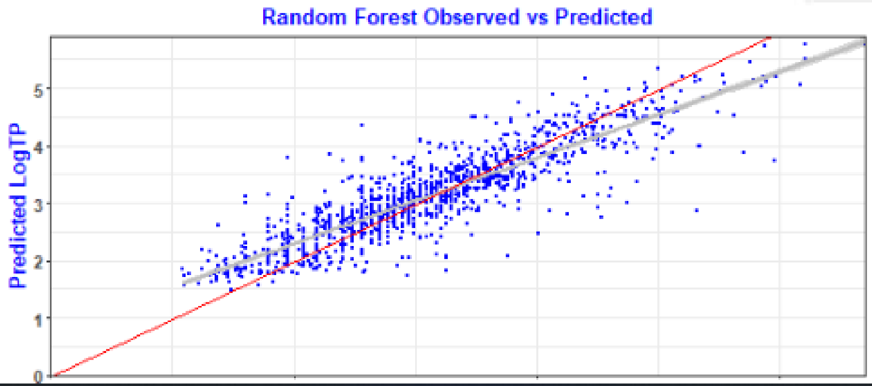
10

Run random forest

related | related

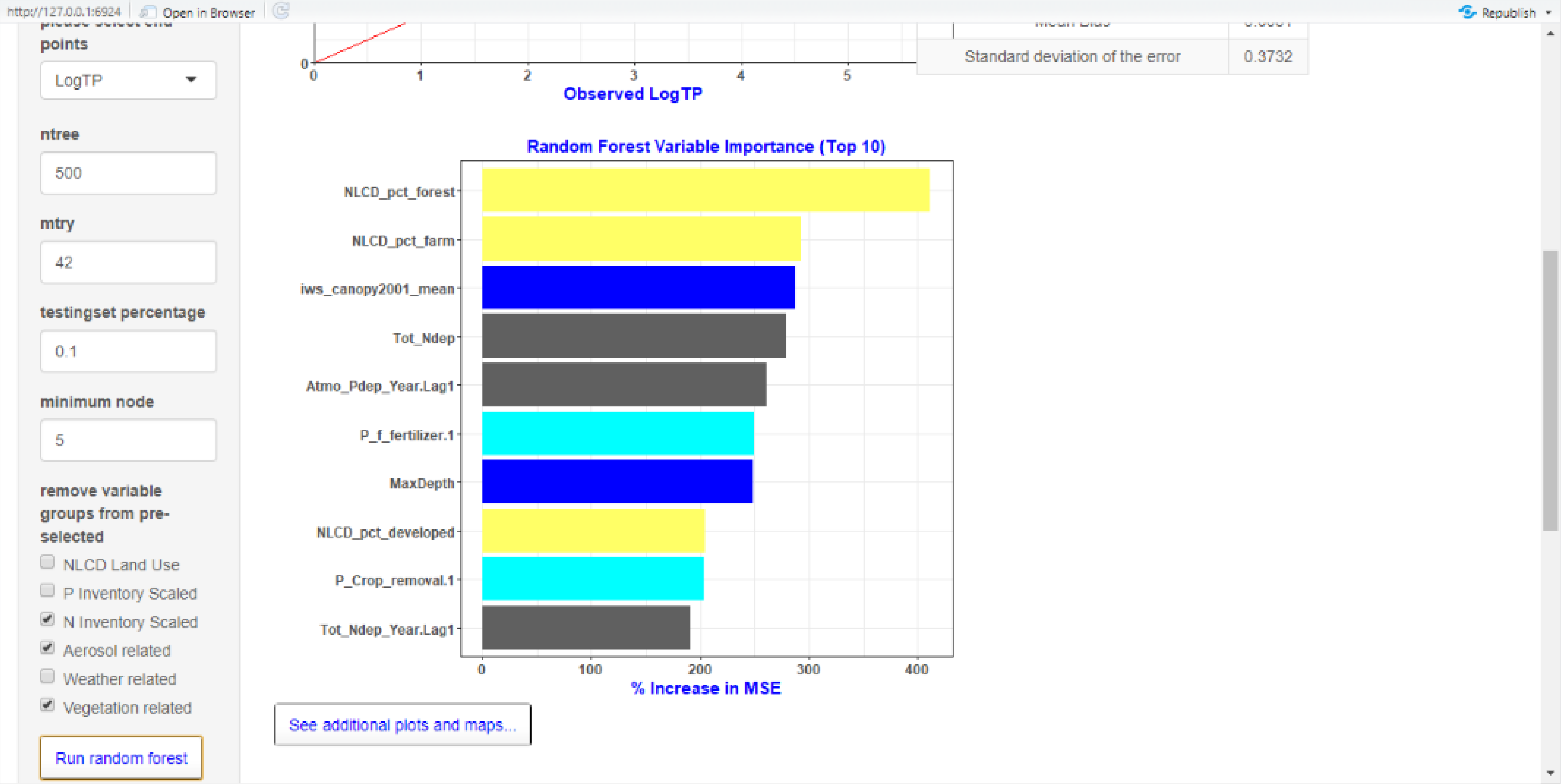
LST_Lag2

Model Uncertainty Metrics	Values
r.squared (reported by Ranger function)	0.7569
prediction.error (reported by Ranger function)	0.2149
R squared (testing set)	0.7840
R squared (training set)	0.8859
Root Mean Squared Error	0.4366
Mean Bias	0.0166
Standard deviation of the error	0.4365
Nash-Sutcliffe efficiency coefficient	0.7837

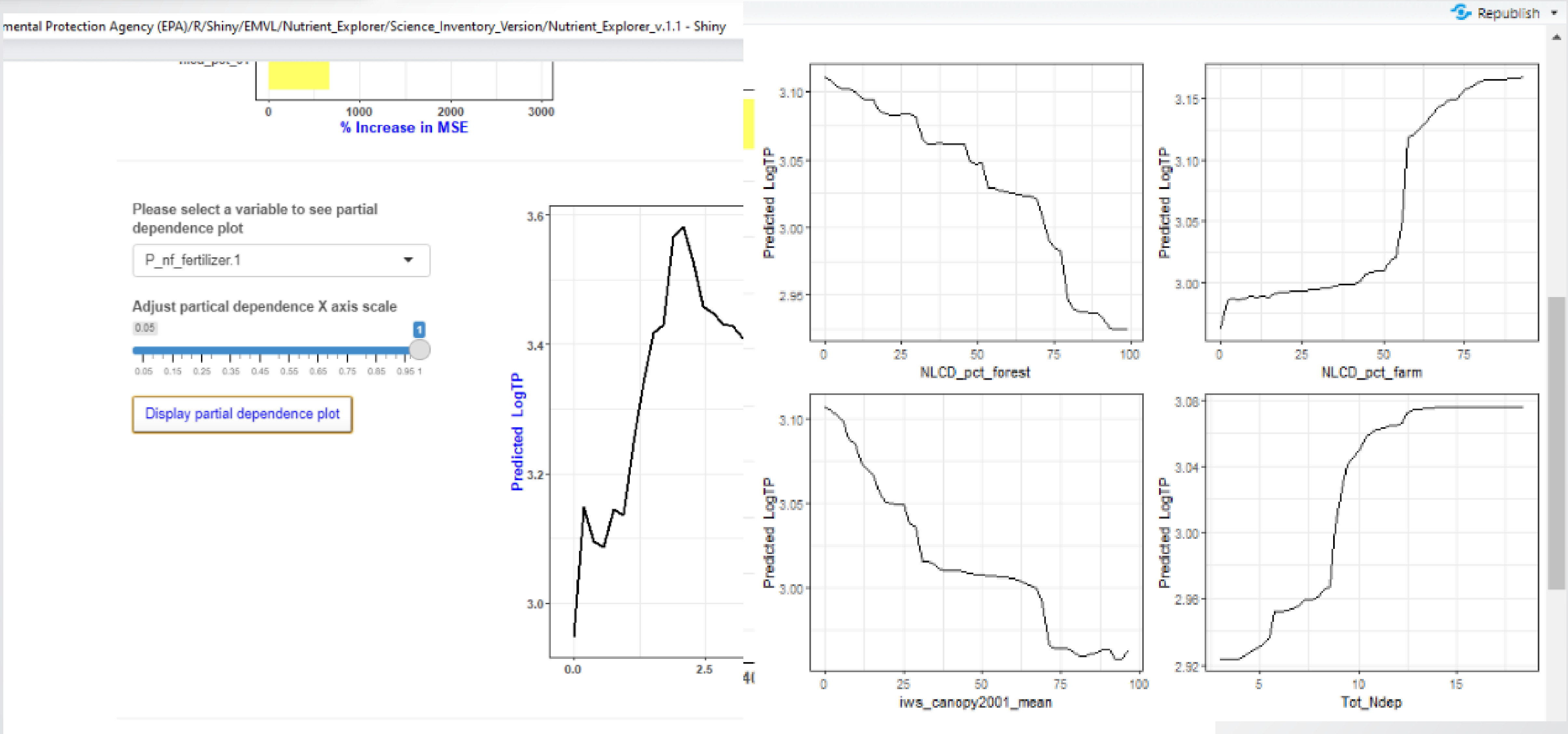


Model Uncertainty Metrics	Values
r.squared (reported by Ranger function)	0.7569
prediction.error (reported by Ranger function)	0.2149
R squared (testing set)	0.7840
R squared (training set)	0.8859
Root Mean Squared Error	0.4366
Mean Bias	0.0166
Standard deviation of the error	0.4365
Nash-Sutcliffe efficiency coefficient	0.7837

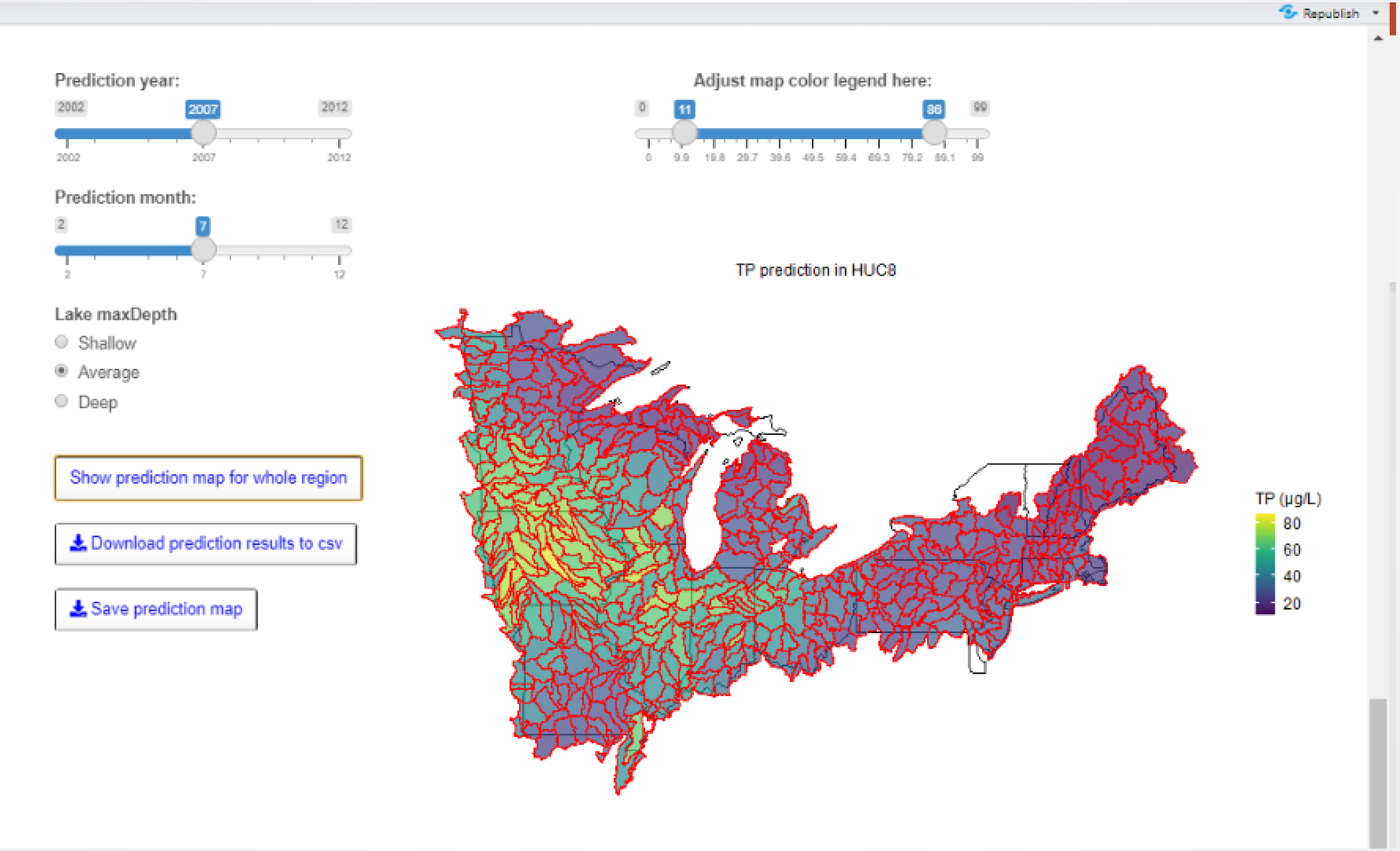
RF Model: Variable Importance Plot



RF Model: Partial Dependence Plots



RF Model Predictions



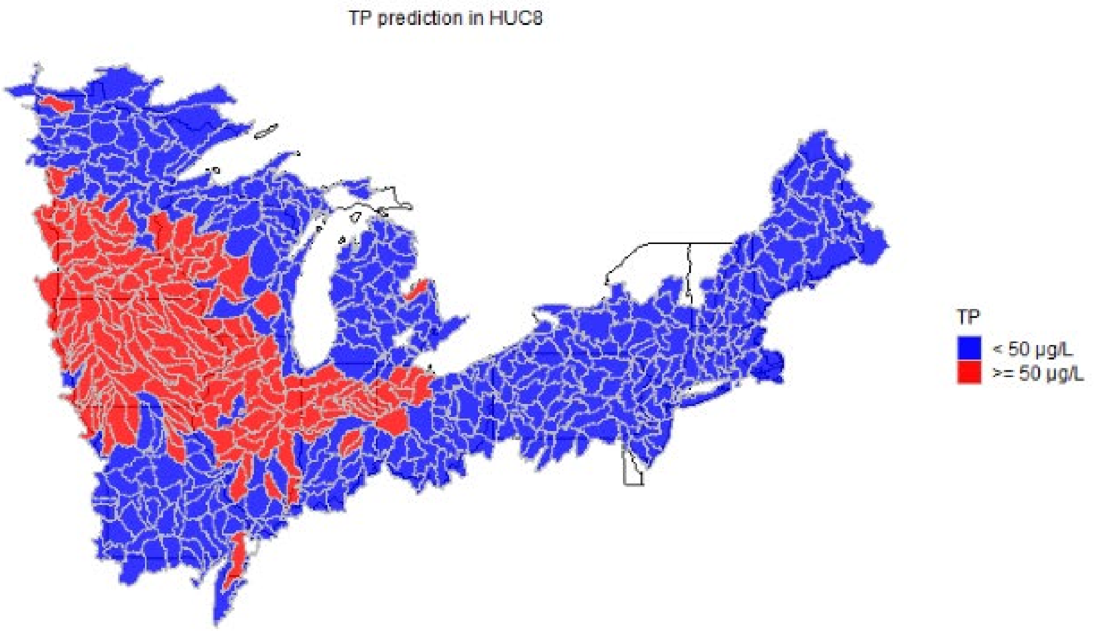
RF Prediction Map for specified Threshold

Endpoint concentration criteria

50

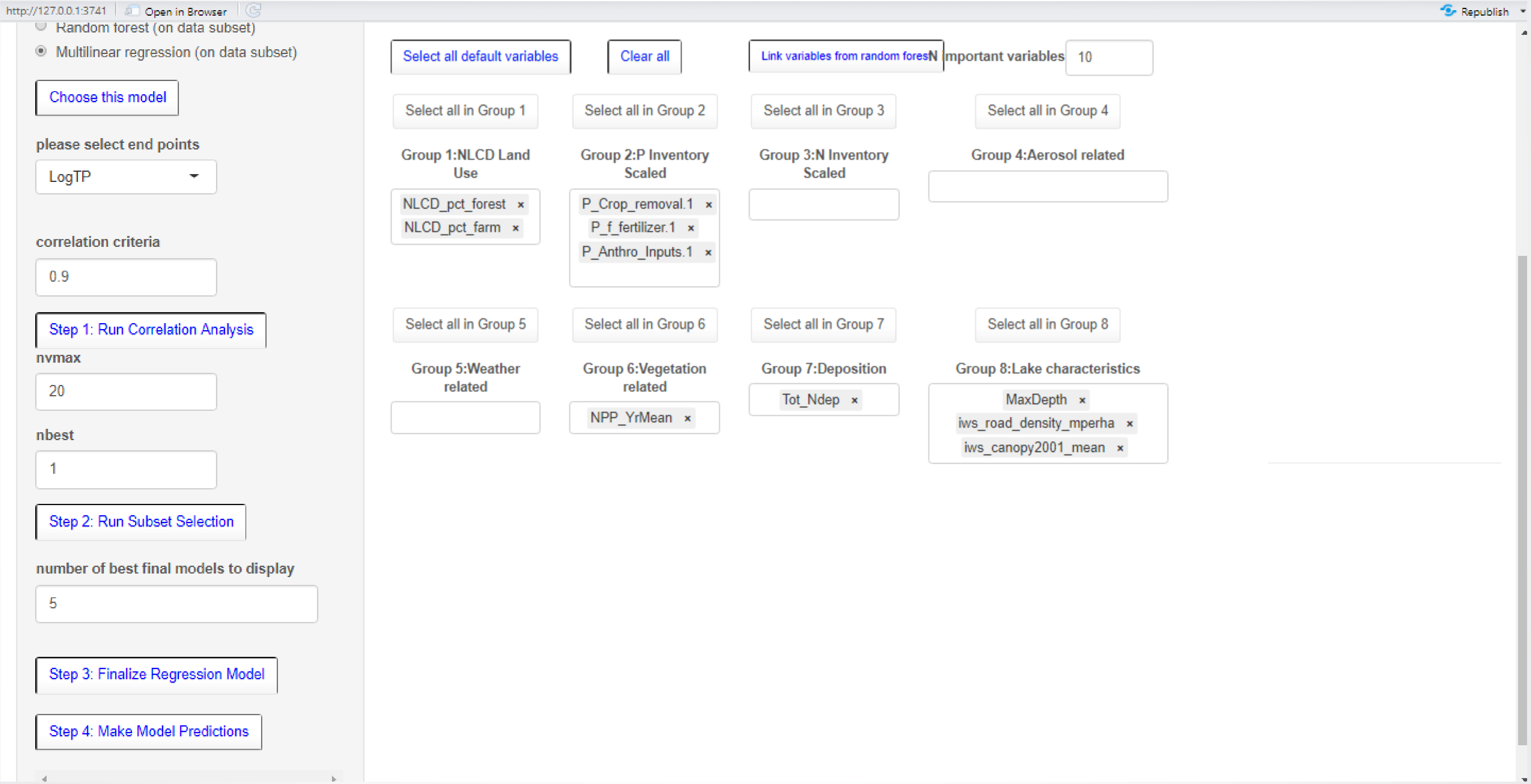
Show prediction map in bicolor

Save prediction map in bicolor



Multi-Linear Regression (MLR)

MLR Steps



http://127.0.0.1:3741
Open in Browser
Republish
Random forest (on data subset)
Multilinear regression (on data subset)
Choose this model
please select end points
LogTP
correlation criteria
0.9
Step 1: Run Correlation Analysis
nvmax
20
nbest
1
Step 2: Run Subset Selection
number of best final models to display
5
Step 3: Finalize Regression Model
Step 4: Make Model Predictions
Select all default variables
Clear all
Link variables from random fores
N important variables
10
Select all in Group 1
Select all in Group 2
Select all in Group 3
Select all in Group 4
Group 1:NLCD Land Use
NLCD_pct_forest
NLCD_pct_farm
Group 2:P Inventory Scaled
P_Crop_removal.1
P_f_fertilizer.1
P_Anthro_Inputs.1
Group 3:N Inventory Scaled
Group 4:Aerosol related
Select all in Group 5
Select all in Group 6
Select all in Group 7
Select all in Group 8
Group 5:Weather related
Group 6:Vegetation related
NPP_YrMean
Group 7:Deposition
Tot_Ndep
Group 8:Lake characteristics
MaxDepth
iws_road_density_mperha
iws_canopy2001_mean

MLR: Correlation Analysis

C:/Users/mpennino/OneDrive - Environmental Protection Agency (EPA)/R/Shiny/EMVL/Nutrient_Explorer/2022/Final/Nutrient_Explorer_final_paper_version - Shiny

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0.9

Step 1: Run Correlation Analysis

nvmax

20

nbest

1

Step 2: Run Subset Selection

number of best final models to display

5

Step 3: Finalize Regression Model

Step 4: Make Model Predictions

Select all in Group 5	Select all in Group 6	Select all in Group 7	Select all in Group 8
Group 5:Weather related	Group 6:Vegetation related	Group 7:Deposition	Group 8:Lake characteristics
	NPP_YrMean ×	Tot_Ndep ×	MaxDepth × iws_road_density_mperha × iws_canopy2001_mean ×

Copy | Print | Download

Search:

	NLCD_pct_forest	NLCD_pct_farm	P_Crop_removal.1	P_f_fertilizer.1	P_Anthro_Inputs.1	NPP_YrMean	Tot_
NLCD_pct_forest							
NLCD_pct_farm	-0.68						
P_Crop_removal.1	-0.33	0.39					
P_f_fertilizer.1	-0.34	0.41	0.98				
P_Anthro_Inputs.1	-0.42	0.55	0.94	0.94			
NPP_YrMean	0.73	-0.67	-0.31	-0.34	-0.42		
Tot_Ndep	-0.68	0.47	0.22	0.26	0.3	-0.77	
MaxDepth	0.03	0.03	-0.03	-0.05	-0.02	0	-
iws_road_density_mperha	-0.42	-0.1	-0.03	-0.04	-0.05	-0.25	(
iws_canopy2001_mean	0.92	-0.8	-0.37	-0.39	-0.49	0.81	-

Showing 1 to 10 of 10 entries

Previous 1 Next

only show cells with high correlation

MLR: Subset Selection

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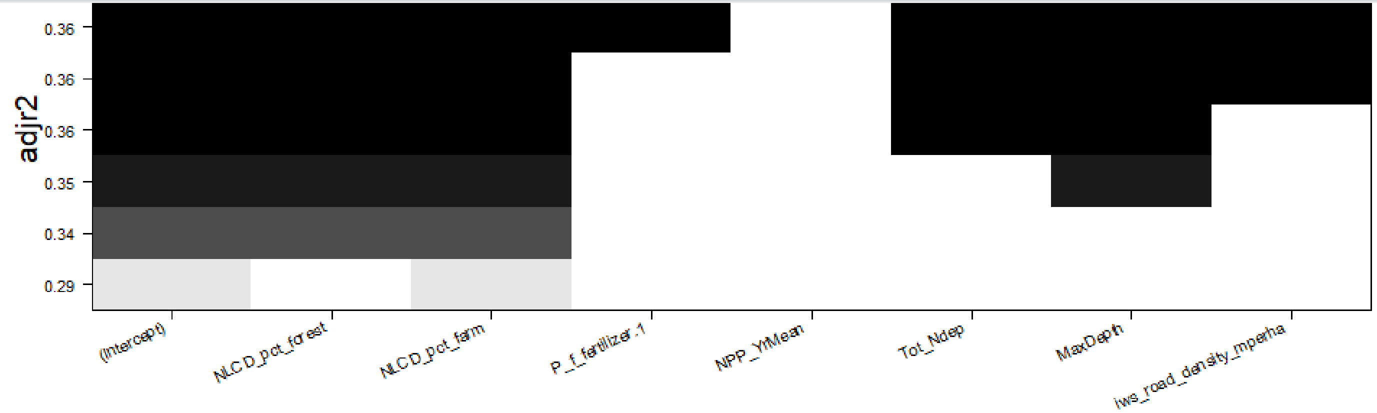
http://127.0.0.1:3741 | Open in Browser | Republish

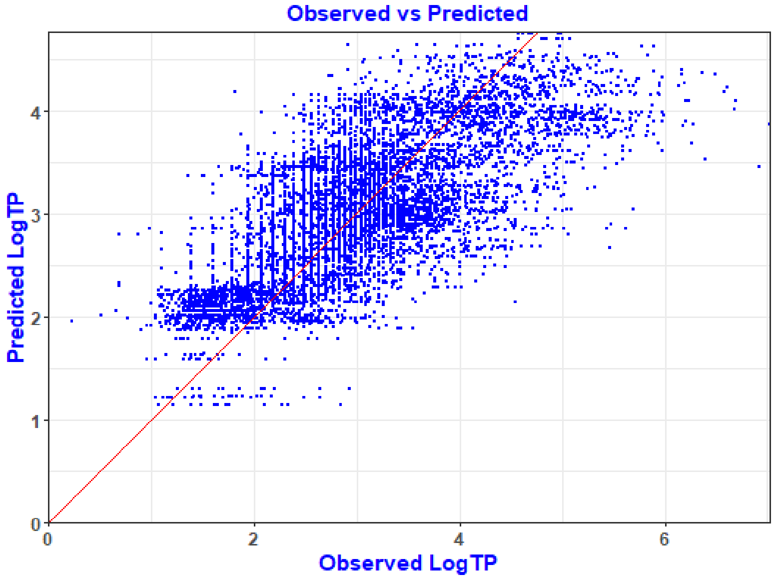


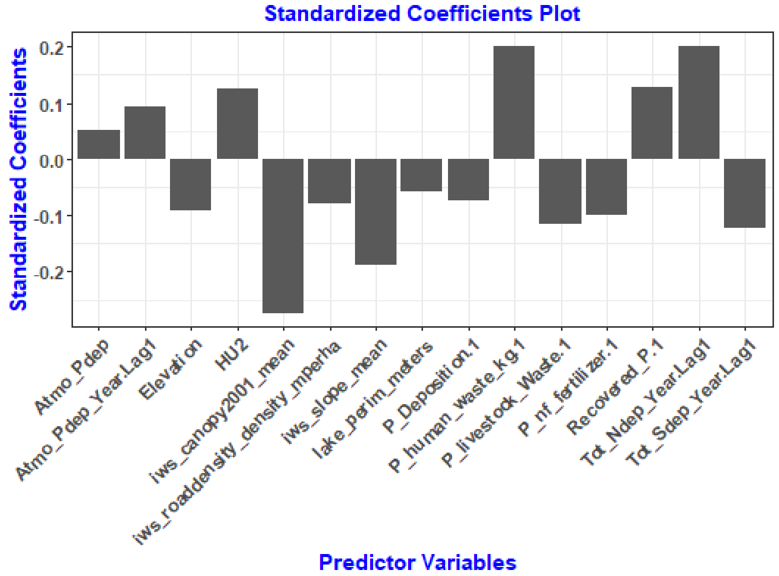
n	P_f_fertilizer.1	NPP_YrMean	Tot_Ndep	MaxDepth	iws_road_density_mperha	regs_adjr2	regs_cp	regs_bic	bic_delta
	*		*	*	*	0.364	9.590	-6,603.136	0.000
	*	*	*	*	*	0.364	8.000	-6,597.129	6.007
			*	*	*	0.361	76.020	-6,544.442	58.695
			*	*		0.356	182.006	-6,446.912	156.225
				*		0.354	235.728	-6,401.534	201.602

```
This table displays the 5 best model subsets for multi-linear regression model.
They are sorted from lowest to highest according to BIC (Bayesian Information Criterion) values.
If you want to see more/less models displayed, please increase/decrease the number under 'number of best final models to d
isplay' in the left sidebar layout.
Please click on one row in the above table to select the final model subset, we recommend to select the row with the lowe
st delta BIC('bic_delta').
Then click on 'Step 3: Finalize Regression Model'to proceed to the next step.
```

MLR: Finalize Regression Model

http://127.0.0.1:4889 Open in Browser Republish





	Estimate	Std..Error	t.value	Pr...t..	std.Beta	VIF
Atmo_Pdep	0.032260	0.009526	3.386571	0.000710852778370727	0.052513	4.272007
Atmo_Pdep_Year.Lag1	0.047697	0.008955	5.326549	1.02597525095346e-7	0.094113	5.546679
Elevation	-0.000550	0.000063	-8.794254	1.7157902653858e-18	-0.090479	1.880740
HU2	0.046731	0.005404	8.647773	6.18735566021186e-18	0.125179	3.722895
iws_canopy2001_mean	-0.009341	0.000462	-20.210369	8.47625757585889e-89	-0.275243	3.295421
iws_roaddensity_density_mperha	0.003255	0.000415	7.840196	5.02921916721534e-15	0.078493	1.780879

MLR: Finalize Regression Model

http://127.0.0.1:6510 Open in Browser Publish

Atmo_Pdep	0.129590	0.004296	30.163190	5.36391533447769e-194	0.247000	1.206854
nlcd_pct_52	-0.011738	0.001306	-8.989966	2.76929100920758e-19	-0.068041	1.030959
NPP	-0.018336	0.003940	-4.653443	0.00000329279617213373	-0.037126	1.145584
P_human_waste_kg						
P_livestock_Waste						

```
The cells marke
ted in the mode
Please pick one
predictor varia
Then rerun the
If there is no
p 4: Make Model
```


Model Uncertair
Multiple R-s
Adjusted R-s
Residual stand
Root Mean Squ
Mean Bi
Standard deviatior
Nash-Sutcliffe efficie

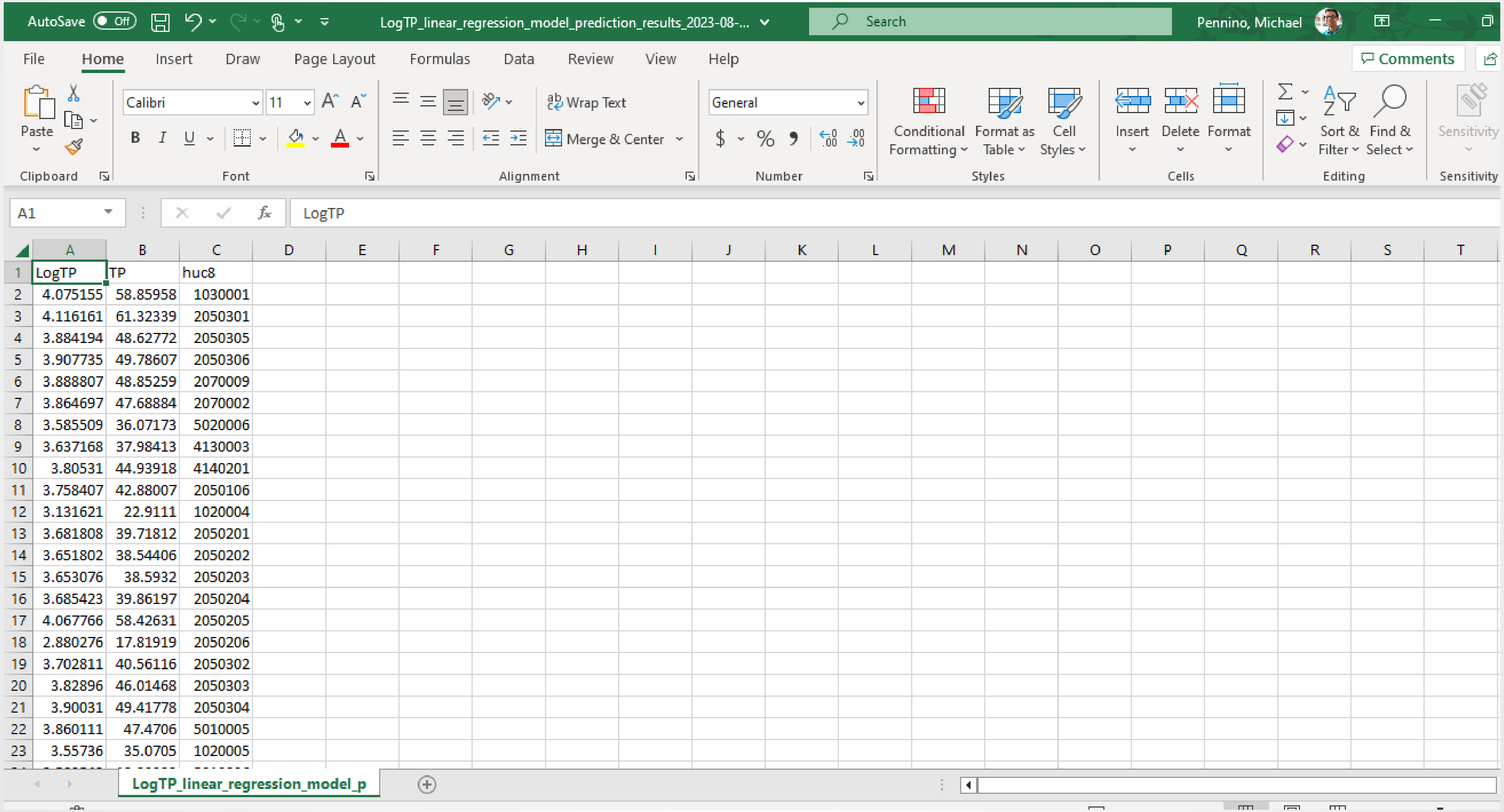
Model Uncertainty Metrics	Values
Multiple R-squared	0.4550
Adjusted R-squared	0.4543
Residual standard error	0.6405
Root Mean Squared Error	0.6401
Mean Bias	0.0000
Standard deviation of the error	0.6401
Nash-Sutcliffe efficiency coefficient	0.4550

Prediction year:

Show LR prediction map for whole region (if using default dataset only!!!)

MLR: Make Model Predictions

Download Dataset



LogTP	TP	huc8
4.075155	58.85958	1030001
4.116161	61.32339	2050301
3.884194	48.62772	2050305
3.907735	49.78607	2050306
3.888807	48.85259	2070009
3.864697	47.68884	2070002
3.585509	36.07173	5020006
3.637168	37.98413	4130003
3.80531	44.93918	4140201
3.758407	42.88007	2050106
3.131621	22.9111	1020004
3.681808	39.71812	2050201
3.651802	38.54406	2050202
3.653076	38.5932	2050203
3.685423	39.86197	2050204
4.067766	58.42631	2050205
2.880276	17.81919	2050206
3.702811	40.56116	2050302
3.82896	46.01468	2050303
3.90031	49.41778	2050304
3.860111	47.4706	5010005
3.55736	35.0705	1020005

MLR: Prediction Map for specified Threshold

Endpoint concentration criteria

50

Show prediction map in bicolor

Save prediction map in bicolor