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WATERSHED PRIORITIZATION TO REDUCE NUTRIENT EXPORT: A FRAMEWORK FOR THE STATE OF ARKANSAS BASED ON AMBIENT WATER QUALITY MONITORING DATA

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Watershed prioritization to reduce nutrient export: A framework for the State of Arkansas based on ambient water quality monitoring data

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EXECUTIVE SUMMARY

The annual formation of the Northern Gulf of Mexico hypoxic zone is driven by nutrient loading from the Mississippi-Atchafalaya River Basin (MARB). Member States of The Mississippi River/Gulf of Mexico Hypoxia Task have developed statewide strategies to identify priorities and opportunities for nutrient export reduction in the MARB. In 2014, the State of Arkansas joined the Task Force and initiated an Arkansas Nutrient Reduction Strategy (ANRS), which currently prioritizes ten Hydrologic Unit Code 8 (HUC-8) watersheds (ANRD, 2014). These priority watersheds were not selected based on measured in-stream nutrient concentrations or trends, which impedes quantitative assessment, goal setting, and linking investments to nutrient reduction progress. The ANRS is currently under revision to address these concerns, and the goal of this project was to develop a prioritization framework for the State of Arkansas based on robust statistical analysis of extensive, statewide ambient water quality monitoring data sets.

This study used available data sets to calculate HUC-8 75th percentiles of site median total nutrient (total nitrogen, or TN, and total phosphorus, or TP) concentrations (subsequently, screening levels) on an annual basis as inputs to HUC-level analyses of nutrient magnitude and trend. The magnitude assessment compared screening levels to screening thresholds that were based on ecological responses to nutrient gradients to identify nutrient reduction needs, identifying 21 HUC-8s for TN and 18 for TP. Trend analysis provided the context of directional change in screening levels over time, suggesting that total nutrient concentrations are widely decreasing and near total absence of increasing trends. Each HUC-8 was also characterized by level of data availability (insufficient, marginal, or sufficient) for each component of the overall analysis, with approximately 1/3 of Arkansas HUC-8s having insufficient data to qualify for any component. A four-Tier framework was developed based on synthesis of magnitude and trend results and data availability to assign all Arkansas HUC-8s to priority Tiers.

The prioritization framework identified seven HUC-8s for maximum focus in Tier 1 as the priority watershed candidates for the ANRS update:

- 08020205 – L’Anguille
- 08020402 – Bayou Meto
- 11010003 – Bull Shoals Lake
- 11010004 – Middle White
- 11110103 – Illinois
- 11110203 - Lake Conway-Point Remove
- 11110207 – Lower Arkansas-Maumelle

Tier 1 criteria targeted Arkansas HUC-8s with multiple lines of evidence (TN and TP) from the data analysis supporting prioritization, as well as sufficient data availability. Thus, these Tier 1 HUC-8 recommendations hone in on a select set of HUC-8s with the greatest demonstrated nutrient reduction need based on analysis of measured ambient nutrient concentrations in Arkansas waterbodies, paired with the level of data availability required to support a quantitative and goal-oriented ANRS.

The prioritization framework identified 23 Arkansas HUC-8s for focus status in Tier 2. Tier 2 criteria also targeted Arkansas HUC-8s with demonstrated nutrient reduction need, including equivalent lines of evidence to Tier 1, but without sufficient data for quantitative assessment and goal setting, as well as needs demonstrated by fewer lines of evidence, both with and without sufficient data. The HUC-8s with insufficient data for any component of the analysis, but that were partner priorities in programs with stated nutrient reduction goals also fell in Tier 2. All Arkansas HUC-8s that were not assigned to Tier 1 or Tier 2, were divided between Tier 3 (less focus) and in Tier 4 (least focus), depending on data availability. Tier 3 assignments acknowledge that HUC-8s with relatively less weight of evidence suggesting nutrient reduction need, but with data limitations, require a greater focus status, with the goal of investing in monitoring programs. Twenty-three data-limited HUC-8s were assigned to Tier 3, while five HUC-8s with sufficient data were assigned to Tier 4.

INTRODUCTION

Coastal and estuarine seasonal hypoxic zones are a global environmental challenge and have increased in size and scale over the last half century (Diaz and Rosenberg, 2008). Marine hypoxic zones are areas of low oxygen availability resulting from an interplay of natural density stratification due to salinity or temperature gradients and excessive algal growth due to nutrient enrichment (Rabalais et al., 2002). The largest marine hypoxic zone in the United States coastal waters is in the Northern Gulf of Mexico and is also one of the largest in the world. Though nutrient enrichment and oxygen minimum zones occur naturally through processes such as upwelling, the source of nutrient enrichment to the Gulf of Mexico is excessive nutrient loading from the Mississippi-Atchafalaya River Basin (MARB; Turner et al., 2006). The MARB drains approximately 40% of the contiguous United States, and nutrient loading to the Gulf of Mexico has increased over the last century or more (Turner and Rabalais, 1991; Justic et al., 1995).

The Gulf of Mexico hypoxia task force was formed to advance understanding of the drivers of hypoxic zone formation, as well as possible mitigations. The task force has set a goal of limiting the dead zone to a running 5-year average of 5000 km^2 (Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, 2008). Meeting this goal will hinge on nutrient load reduction to the Gulf of Mexico from the MARB in both total nitrogen (TN) and total phosphorus (TP), which both potentially limit the primary production fueling the eutrophication cycle in the Gulf of Mexico hypoxic zone, depending on temporally and spatially variable conditions (Dodds, 2006; Turner and Rabalais, 2013; Fennel and Laurent, 2017). Long-term data continues to support observations that nutrient load drives the extent of the Gulf of Mexico hypoxic zone (Rabalais et al., 2007), with estimated reductions in TN and TP loads of 48 ± 21% required to reach task force goals (Fennel and Laurent, 2017).

The task force also coordinates federal, state, and tribal agencies in developing plans to reduce nutrient export to the Gulf of Mexico from the

MARB. State Nutrient Reduction Strategies are considered the cornerstone in reducing nutrient loads to the Gulf of Mexico. The State of Arkansas joined the Task Force and initiated a Nutrient Reduction Strategy (ANRS) as part of the 2014 Water Plan update (ANRD, 2014). The goal of the ANRS is to improve overall aquatic health and viability in Arkansas waters for recreational, economic, environmental, and human health benefits. Identifying priority watersheds and waterbodies is a key component of the ANRS and is foundational for maximizing the impact of available resources. Currently, ten priority watersheds are identified under the ANRS. Designation as a priority watershed considered the priority areas of conservation and nutrient reduction programs in the state, waterbody impairments, interstate cooperative efforts, local conservation district goals, and nutrient export model estimates for the MARB (Spatially Referenced Regression on Watershed attributes, or SPARROW).

However, the prioritization of Arkansas watersheds under the ANRS was not based on measured in-stream nutrient concentrations or trends (i.e. directional change). This missing piece feeds into other concerns related to updating and advancing the ANRS, including no defined methods to evaluate progress or lack of progress, challenges to documenting clear links between resource expenditures and water quality improvement, and no clearly defined goal or water quality target. The ANRS is currently under revision to address these concerns, with emphasis on demonstrating a need for nutrient reduction using measured data and targeting watersheds where data are sufficient to allow quantitative assessment and goal setting.

The goal of this project was to develop a framework for the State of Arkansas to prioritize watersheds based on robust statistical analysis of extensive, statewide ambient water quality monitoring program datasets to identify trend and central tendency in nutrient concentrations. Project objectives were:

1. Develop a statewide water quality database using ADEQ ambient water quality monitoring program data from 1990 – 2019.
2. At the watershed (Hydrologic Unit Code, or HUC-8) scale, assess magnitude of 75th percentiles of TN and TP concentration annual site medians against screening thresholds for levels of ecological concern.
3. At the HUC-8 scale, assess 75th percentiles of TN and TP concentration annual site medians for trend over time.
4. Assign HUC-8s to prioritization categories based on synthesis of HUC-8 level trend and magnitude assessment results, data availability, and priorities of select Arkansas programs with a nutrient export reduction focus.
5. At the site-level, within priority category 1 HUC-8s, assess total nutrient concentrations for trend over time.

METHODS

Database development

The primary data source for this project was the Arkansas Department of Environmental Quality (ADEQ) ambient water quality monitoring database accessed via the water quality monitoring data portal (https://www.adeq.state.ar.us/techsvs/env_multi_lab/water_quality_station.aspx). All observations for focus nutrient parameters were downloaded for the time period January 1, 1990 – December 31, 2019. Focus parameters were Nitrite+nitrate-nitrogen (mg/L; NOx-N), Total Kjeldahl nitrogen (mg/L; TKN), Total Nitrogen (mg/L; TN), and Total Phosphorus (mg/L; TP). The parameters NOx-N and TKN were used to calculate TN for sites and time intervals with no direct TN measurements. Calculated TN and direct TN measurements were merged into a single TN dataset, with priority given to direct measurements of TN when available.

Datasets from the Arkansas Natural Resource Division's Section 319(h) Nonpoint Source Pollution Management Program (subsequently, 319) were added as a secondary data source after initial analyses showed limited coverage of HUC-8s in the Mississippi Alluvial Plain, a key agricultural region in Arkansas, by the ADEQ's ambient water quality monitoring network. Many Section 319(h) monitoring projects target these HUC-8s, and analyzed nutrient parameters were compatible between the data sources. Therefore, datasets from projects from across the state were compiled and organized for inclusion in HUC-8 level analyses of recent TN and TP concentration magnitudes to address the ADEQ data gap.

Prior to analysis, database formats were standardized for compatibility with statistical software using R 4.0.4 (R Core Team, 2021) and the packages tidyverse (Wickham et al. 2019) and lubridate (Grolemund and Wickham, 2011). Non-numeric information accompanying observation values was separated from numeric information and stored in supplemental information columns. Data were most commonly flagged because an analyte was not detected at concentrations above reporting limits. Non-detections were recorded as the value of the provided reporting limit and flagged as non-detections in a supplemental information column. Data were screened for potential outlier values or transcription errors and a subset of data were flagged in the final database as out of quality control compliance including 1) values that were an order of magnitude out of range of typical values for that parameter and HUC-8, 2) values flagged as non-detections that were out of range of typical reporting limits for that parameter, 3) values flagged with "?", and 4) zero or negative values. These observations were not included in analysis and were not used to calculate TN. The final water quality database was reviewed according to quality assurance and quality control protocols by checking 10% of database entries for accuracy against original data files following an approved secondary data quality assurance project plan.

Annual TN and TP concentration site medians were calculated for all monitoring stations in the ADEQ and 319 databases. For site years with only one observation, the median was equal to the single measured value. Where multiple values were recorded for a single day, values were averaged prior to median calculation. In cases of overlapping monitoring locations between data sources, sites were treated as separate and unique. Two iterations of frequency distributions of annual site medians were then calculated for each HUC-8 and year combination with at least three site medians. The first iteration included both ADEQ and 319 monitoring stations with a five-year focus period (2015 – 2019) in order to target current nutrient levels for assessing HUC-8 nutrient magnitudes. The second iteration included only ADEQ monitoring stations and analyzed data for the full study period (1990 – 2019) for the purpose of trend analysis. The 319 data were not included in percentiles for trend analysis because of limited monitoring duration (typically < 5 years) compared to ADEQ stations, which would introduce new sources of variability unevenly through time and potentially reduce the probability of detecting trends. The resulting frequency distribution data sets consisted of HUC-8 percentile estimates for each year in which data availability requirements were met (i.e., up to 5 years or up to 30 years for the first and second iterations of percentiles, respectively).

HUC-8 nutrient magnitude assessment

For the nutrient magnitude assessment, the average of 75th percentiles of site medians (ADEQ and 319 sites; 2015 – 2019) was selected as the measure (subsequently, screening level) of HUC-8 nutrient concentrations to be compared to screening thresholds. Screening thresholds in TN and TP concentrations were derived by calculating frequency distributions of nutrient thresholds for biological response compiled from a review of stressor-response studies in the scientific literature (see Table S1 and accompanying References in Supplementary Materials). The compiled nutrient thresholds were identified for responses in a wide range of algal, aquatic macroinvertebrate, and fish indicator species, functional groups, and communities. Response thresholds were grouped based on geospatial characteristics of the studied systems, including size (ex: wadeable or non-wadeable) and dominant watershed agricultural land use types (ex: row-crop or pasture). Frequency distributions of TN and TP thresholds were calculated for geospatial groupings based on these characteristics and across all studies. Many included studies analyzed statewide, regional, or even global datasets, representing spatial scales that could not be linked to a single dominant land use type. Thresholds from these studies were included in frequency distribution calculations for any relevant geospatial grouping.

For both TN and TP, two screening scenarios were developed, each selecting one or more concentrations as screening thresholds (Table 1). Multiple scenarios were used to identify a gradient in nutrient concentrations and allow flexibility in bringing together magnitude assessment results for TN and TP with trend results into a final priority categorization framework. The primary difference between scenarios was the degree to which the selected thresholds were tailored to HUC-8 characteristics that reflect Arkansas's diverse geography and land use (Figure 1A). Seven Omernik, 1987 Level III ecoregions are present in Arkansas: Arkansas Valley (ARV), Boston Mountains (BOSM), Mississippi Alluvial Plain (MAP), Mississippi Valley Loess Plains, Ouachita Mountains (OUAM), Ozark Highlands (OZKH), and South Central Plains (SCP). Each HUC-8 was assigned to a dominant ecoregion based on the location of the greatest percentage of monitoring sites in the database (Figure 1B). In most cases, a clear majority (i.e. >2/3 of sites) were located in a single ecoregion. However, sites in 11110207 – Lower Arkansas-Maumelle were split across four ecoregions, with only 42% of sites in the dominant ecoregion (OUAM), and sites in 08040102 – Upper Ouachita were near evenly divided between 2 ecoregions (56% in the OUAM and 44% in the SCP).

Table 1. Scenarios for screening HUC-8 total nutrient concentration magnitudes for levels of ecological concern.

Scenario	Parameter	Ecoregion	Screening Threshold (mg/L)	Explanation
1	TN	All ecoregions	1.0	Median all systems
2	TN	Miss. Alluvial Plain	0.81	Median row-crop, non-wadeable systems
		All other ecoregions	0.66	Median pasture, non-wadeable systems
1	TP	Miss. Alluvial Plain	0.14	Median row-crop non-wadeable systems
		All other ecoregions	0.10	Median pasture, non-wadeable systems
2	TP	Forested uplands	0.07	Median pasture, wadeable systems

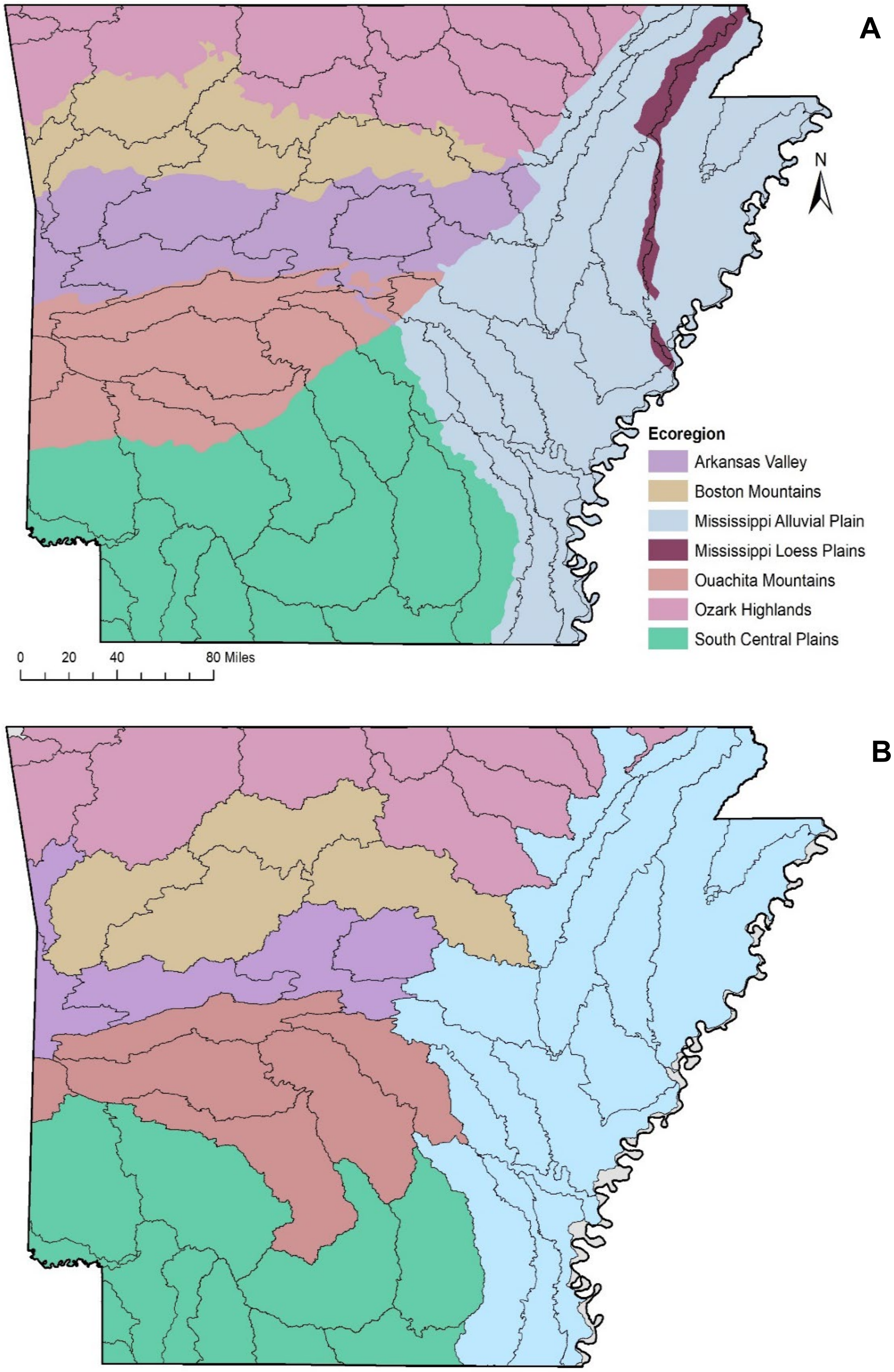


Figure 1. Omernik Level IIII ecoregions in Arkansas A) overlying Arkansas HUC-8s and B) as assigned to individual HUC-8s based on analysis of the ecoregion in which the greatest number of sites were located.

No monitoring sites were located in the Mississippi Valley Loess Plains.

Under TN scenario 1, a single screening threshold (TN = 1.0 mg/L) was selected for comparison with TN screening levels for all Arkansas HUC-8's and was approximately the median of all compiled TN stressor-response thresholds. For TN, scenario 2 set separate screen thresholds for the MAP, Arkansas's primary row-crop production region, and all other ecoregions, which were the medians of thresholds derived for non-wadeable systems with row-crop watershed influence (TN = 0.81 mg/L) and pasture watershed influence (TN = 0.66 mg/L), respectively. For TP, scenario 1 also set separate screen thresholds for the MAP and all other ecoregions, which were also equivalent to the median of thresholds derived for non-wadeable systems with row-crop watershed influence (TP = 0.14 mg/L) and pasture watershed influence (TP = 0.10 mg/L), respectively. For TP, scenario 2 set the median of thresholds derived for wadeable systems with pasture influence (TP = 0.070 mg/L) as the screening threshold for HUC-8s in Arkansas's three forested upland ecoregions (BOSM, OUAM, and OZKH). The scenario 1 screening thresholds were applied for all other ecoregions under scenario 2. The degree of geospatial specificity differed between TN and TP scenarios, reflecting that many compiled studies estimated thresholds for TP only and considerably less information was available for dividing and analyzing TN thresholds by geospatial groupings.

For each scenario, all HUC-8s with a TN or TP screening level that was greater than the relevant screening threshold were identified as having nutrient concentrations at levels of potential ecological concern. These HUC-8s were flagged as candidate HUC-8s in need of nutrient reduction based on the magnitude component of the overall categorization framework. A subset of HUC-8s was flagged as having marginal data availability in the magnitude assessment if 75th percentile estimates were available for fewer than three years of the five-year focus period or if the median number of site medians used to calculate a 75th percentile each year was less than four per year (2015 – 2019).

HUC-8 Trend Analysis

Trend analysis was conducted on the second iteration of HUC-8 75th percentiles of site median TN and TP concentrations (ADEQ sites only) after log-transformation using linear regression analysis (LR) and the Mann-Kendall test (MK) to detect monotonic change in concentrations over time. The analyses were carried out in R 4.0.4 using the rkt package for MK (Marchetto, 2017). Trend analysis data availability requirements were at least ten years of 75th percentile estimates, with at least 50% of years in a HUC-8's period of record represented. A subset of HUC-8s was assigned marginal data availability status if less than 2/3 of years in a HUC-8's period of record were represented, the total number of years with 75th percentiles was less than 15 years, or if the median number of site medians used to calculate a 75th percentile each year was less than four per year (1990 – 2019).

Results were typically in agreement between LR and MK, but MK results were used for determining statistical significance due to the limited sample size (i.e. maximum one 75th percentile per year, or $n_{max} = 30$). Statistical significance was interpreted as follows: for $p \geq 0.20$, trend was unlikely; for $0.10 \geq p < 0.20$, trend may exist; for $0.05 \geq p < 0.10$, trend was likely; and for $p < 0.05$, trend was very likely. Positive and negative Sen line slopes reflected increasing and decreasing trends, respectively; a slope with magnitude less than 0.01% in either direction was considered not changing, regardless of significance. The HUC-8s where increasing nutrient concentrations were detected were flagged as candidates in need of nutrient reduction based on the trend component of the overall categorization framework.

Site-level trend analysis

Trend analysis was also conducted on log-transformed TN and TP concentrations at qualifying ADEQ monitoring sites ($n \geq 50$) located in HUC-8s that were flagged as candidates in need of nutrient reduction based on magnitude or trend for at least one nutrient (scenarios 1 and 2). For site-level trends, a focus period of 2000 – 2019 was targeted, and the seasonal Kendall test (SKT) was used in addition to LR and MK. When results of the three analyses were not in agreement, added weight was given to SKT results, because SKT corrects for common sources of outside variability in ambient monitoring datasets, such as seasonality, missing data, and irregular sampling intervals. Further, the site-level trend analysis results shown in state maps and summary tables are SKT results. More selective thresholds for statistical significance were applied for site-level analyses since the number of observations was less limited. The statistical significance of site-level trend analysis results was interpreted, as follows: for $p \geq 0.10$, trend was unlikely; for $0.05 \geq p < 0.10$, trend was likely; and for $p < 0.05$, trend was very likely. Positive and negative Sen line slopes reflected increasing and decreasing trends, respectively; a slope with magnitude less than 0.01% in either direction was considered not changing regardless of significance.

HUC-8 priority categorization

The prioritization framework divided HUC-8s into four tiers: 1) maximum focus for nutrient reduction, with sufficient monitoring, 2) focus for nutrient reduction, with more monitoring needed, 3) less focus, with more monitoring needed, and 4) least focus, with sufficient monitoring. Tiered rankings correspond to the level of demonstrated nutrient reduction need in synthesis with assessment of available data. HUC-8s were considered data-limited if flagged for marginal data availability for any component of analysis, or if the HUC-8 did not qualify for one or both components. The framework also considered select substantiating prioritization layers (National Resources Conservation Service Mississippi River Basin Initiative, or MRBI, priority watersheds and Nutrient Surplus Areas, or NSA, under AR Code § 15-20-1104, 2019) as an approach to separate data-deficient HUC-8s into categories with more or less evidence of nutrient reduction need. Designations as MRBI priority watershed (Figure 2A) or NSA (Figure 2B) are not based directly on measured in-stream nutrient concentrations, but nutrient export reduction is a stated goal.

The framework was designed to capture a limited number of HUC-8s in Tier 1 in order to focus investment of limited resources in nutrient reduction strategies and maximize returns by targeting HUC-8s with both the most evidence for nutrient reduction need and sufficient baseline data for quantitative assessment and goal setting. Specific qualifying criteria for Tier 1 were identification as a nutrient reduction focus for both TN and TP (scenarios 1 and 2 qualify), with sufficient data to assess both trend and magnitude.

In contrast, Tier 2 was set up to focus on a number of identified concerns that were not eligible for prioritization in Tier 1 due to data limitations or because the observed evidence of nutrient reduction need did not cumulatively meet Tier 1 criteria, or both. The primary goal under the ANRS for Tier 2 was investment in evaluating and meeting monitoring needs to support assessment under future ANRS updates. Qualifying criteria for Tier 2 were 1) magnitude

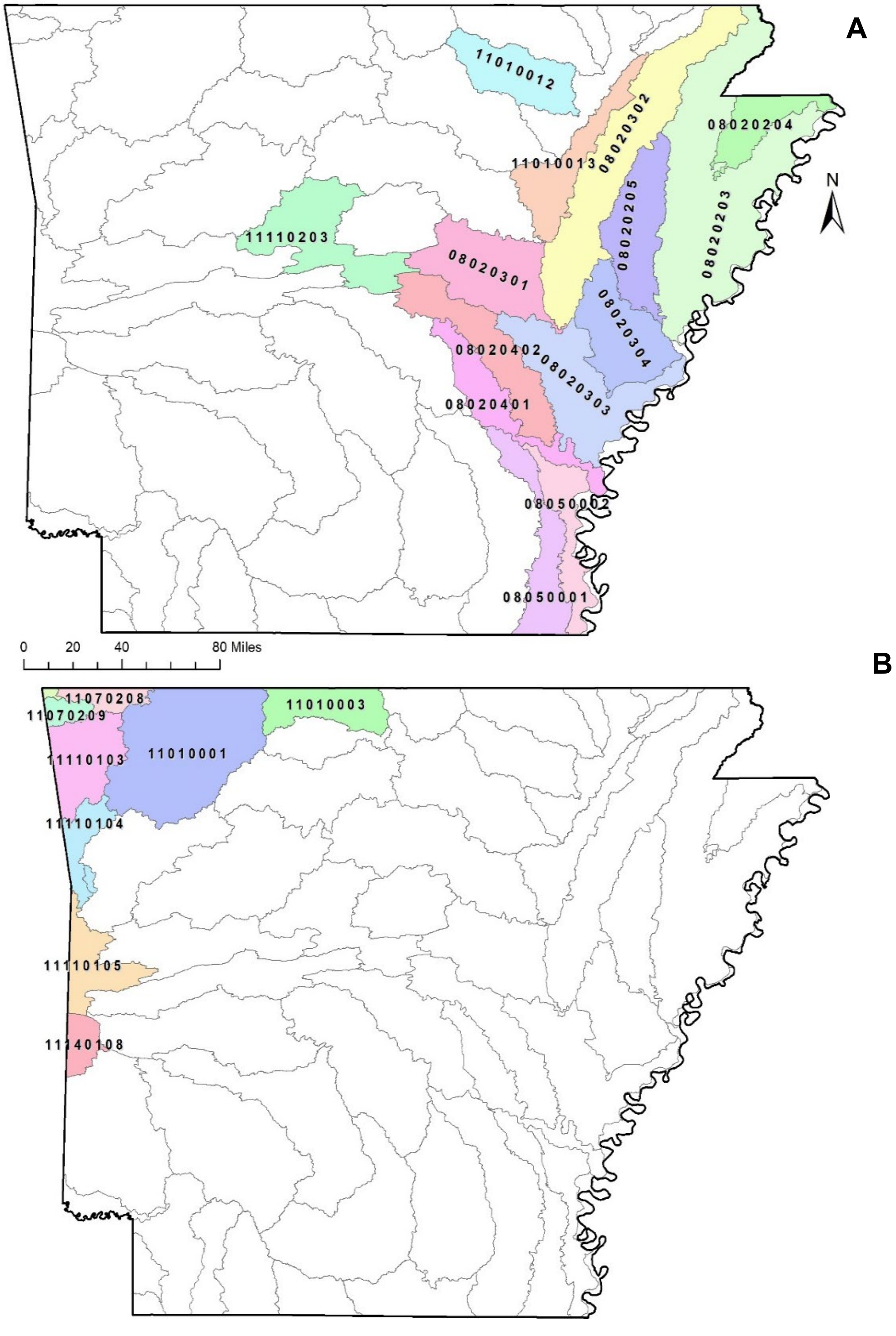


Figure 2. Arkansas HUC-8s designated as A) Mississippi River Basin Initiative (MRBI) priority watersheds and B) Nutrient Surplus Areas by AR Code § 15-20-1104, 2019.

greater than scenario 1 threshold for one nutrient with sufficient data to assess both trend and magnitude, 2) identification for increasing trend for one nutrient, 3) identification for two nutrients (scenario 1 and 2 qualify) with limited data to assess, 4) identification for one nutrient under scenario 1 with limited data to assess, and 5) insufficient data to assess, but MRBI or NSA.

Tier 3 and 4 were designed to encompass HUC-8's with the fewest lines of evidence suggesting nutrient reduction need, acknowledging that data-limited HUC-8s merit greater prioritization in Tier 3 from the perspective of investment in future data collection efforts. All HUC-8s that did not qualify for Tier 1 or 2 status were assigned to Tier 3 or 4 based on data availability, with data-limited HUC-8s assigned to Tier 3 and HUC-8s with sufficient data assigned to Tier 4.

RESULTS AND DISCUSSION

Nutrient magnitudes by Arkansas ecoregion

The TN and TP magnitude screening levels varied across the state (Figure 3A-B; Table S2-3). The HUC-8 TN screening levels were greatest in the OZKH, where the median level was greater than the scenario 1 screening threshold (TN = 1 mg/L). For HUC-8s in the ARV, MAP, and SCP, the upper quartile of screening levels was also greater than 1 mg/L. The median screening levels for MAP, ARV, and SCP HUC-8s were greater than the applicable scenario 2 screening threshold (TN = 0.81 mg/L for MAP; TN = 0.66 mg/L for all other ecoregions). The OUAM and BOSM HUC-8 TN screening levels were the lowest in central tendency and range. However, the upper quartile of OUAM HUC-8 TN screening levels was greater than 0.66 mg/L, while all Boston Mountain TN screening levels were less than the screening thresholds.

In contrast to TN, the greatest HUC-8 TP screening levels were observed in the MAP, with the median screening level ~2x greater than the scenario 1 screening threshold (TP = 0.14 mg/L).

The OZKH HUC-8 median TP screening level and upper quartile of screening levels for the ARV, BOSM, and SCP were greater than the applicable scenario 1 screening threshold (TP = 0.10 mg/L). For both ARV and SCP HUC-8s the median TP screening level was close in range with 0.10 mg/L. As with TN, the TP screening levels were lowest range in the BOSM and OUAM HUC-8s. However, the range in TP screening levels for BOSM HUC-8s was far greater for TP than for TN, with the 75th percentile screening level > 0.10 mg/L, but the median less than the scenario.

Magnitudes of HUC-8 nutrient 75th percentiles

The magnitude assessment identified a number of HUC-8s where nutrient screening levels were greater than screening thresholds, representing the HUC-8s with the greatest potential for nutrient reduction (Figure 4A-B). Twenty-one HUC-8s were flagged for TN reduction based on the magnitude component (13 under scenario 1; 8 under scenario 2); while 18 HUC-8s were flagged for TP (15 under scenario 1; 3 under scenario 2). The magnitude assessment results reflect the regional gradient (Figure 3A-B) in nutrient levels among qualifying Arkansas HUC-8 watersheds, with flagged HUC-8s clustered in the OZKM and MAP ecoregions. This pattern was especially apparent for HUC-8s that were flagged under the less restrictive scenario 1, which were the HUC-8s with the highest nutrient levels relative to the screening thresholds.

Approximately 2/3 of HUC-8s met data availability requirements for the magnitude assessment, but 19 were not included due to data limitations. Of qualifying HUC-8s, 11 were flagged for marginal data availability to assess

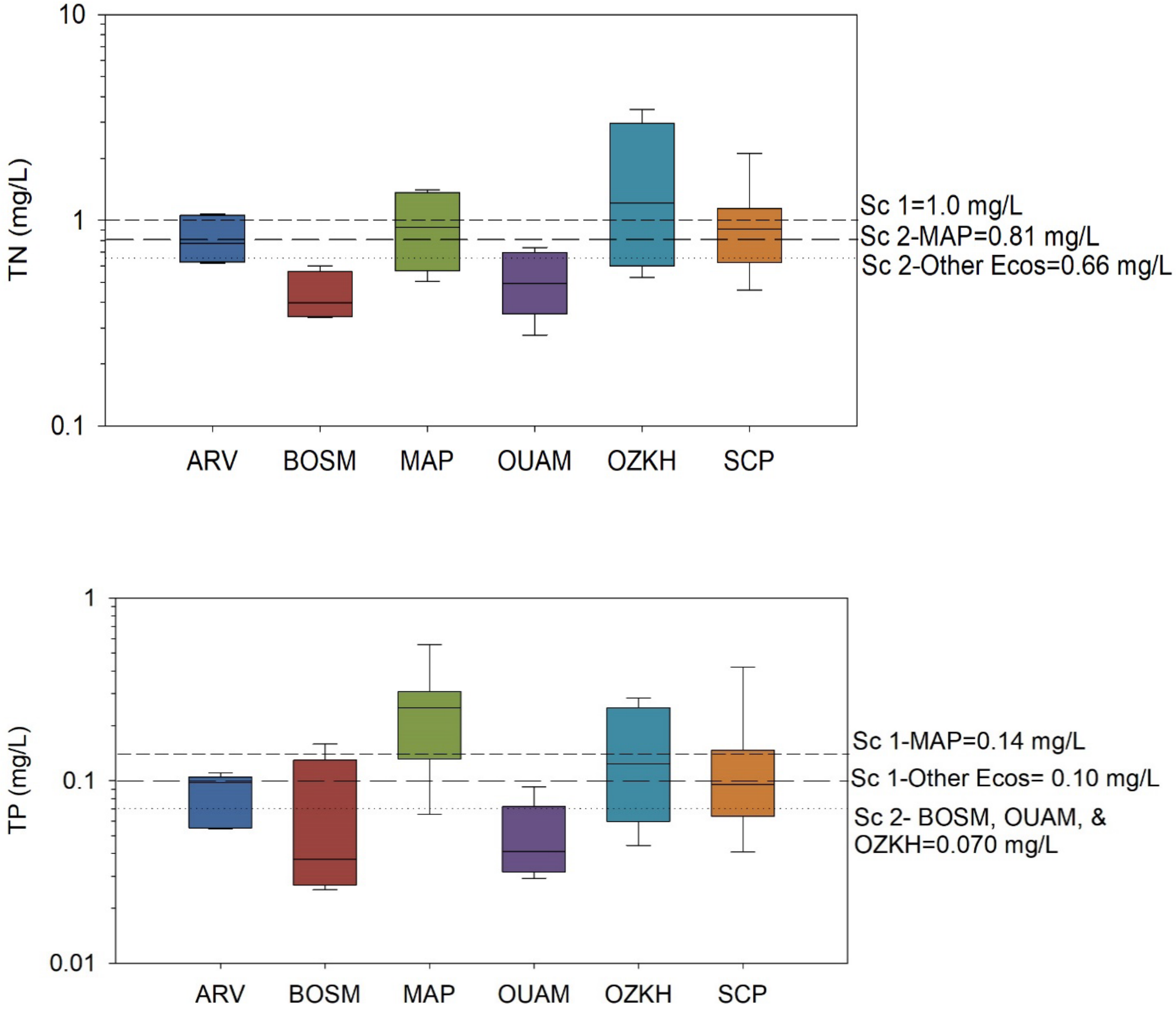


Figure 3. Boxplots showing the A) TN and B) TP concentration frequency distribution of the HUC-8 averages of 75th percentiles of site medians from 2015 - 2019 (i.e., HUC-8 screening levels) by ecoregion. screening level (TP = 0.070 mg/L). The upper quartile of OUAM HUC-8 TP screening levels was greater than 0.070 mg/L, but the median was ~2x less.

magnitude for either TN or TP, or both. The main limitation on data availability was spatial coverage, or having too few active monitoring sites (n<3) within a HUC during the focus period 2015 – 2019. However, some HUC-8s were flagged for marginal data availability based on limited temporal coverage, or having <3 years of 75th percentiles. These HUC-8s were 11110104 – Robert S. Kerr Reservoir, 11010009 – Lower Black, 11140205 – Bodcau Bayou, 11140302-Lower Sulpher, and 08020203 Lower St. Francis.

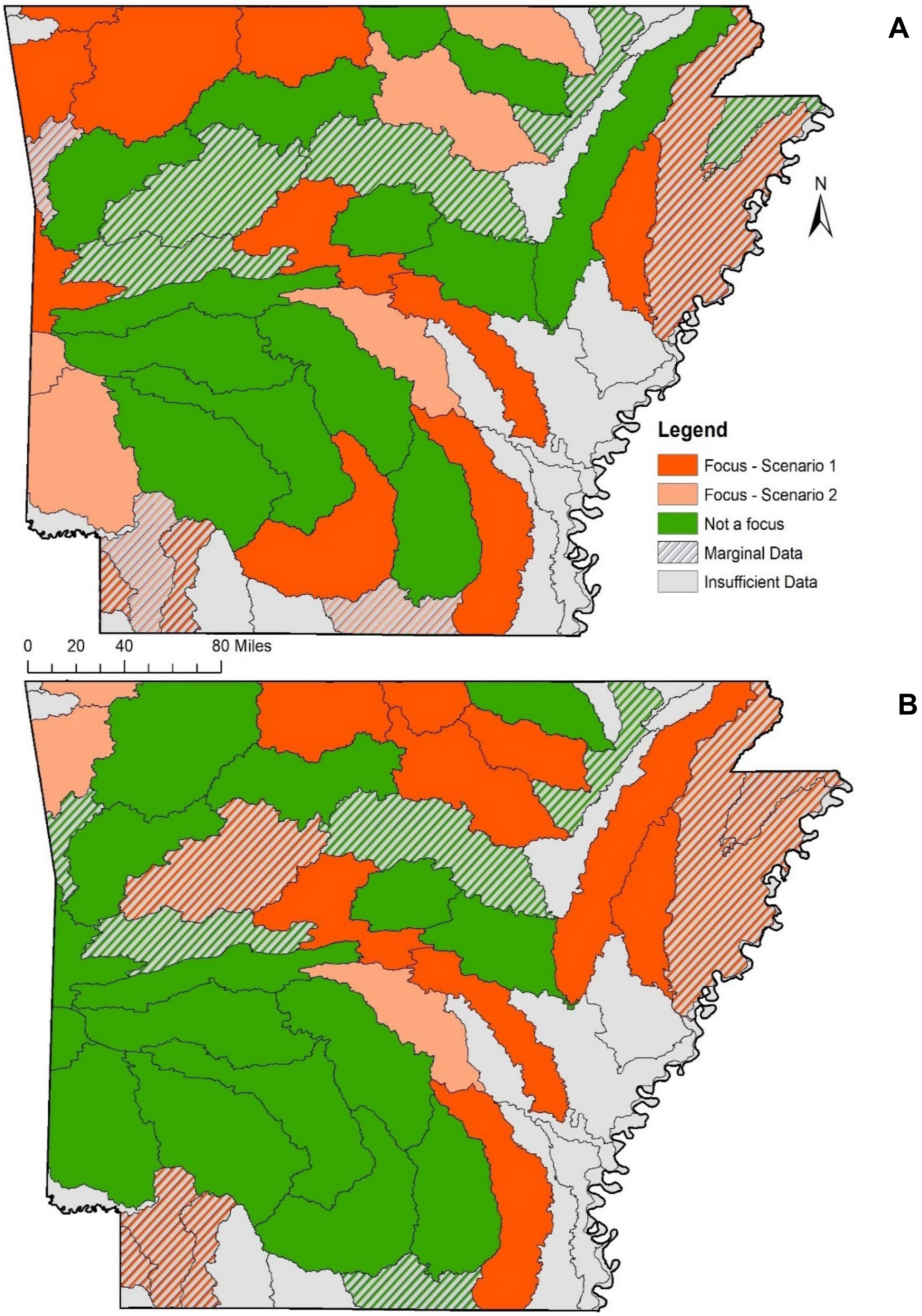


Figure 4. Results of HUC-8 magnitude assessment on A) total nitrogen and B) total phosphorus 75th percentile of site median concentrations for the period 2015 - 2019.

Trend analysis on HUC-8 nutrient 75th percentiles

A notable study finding is that 75th percentiles of site median nutrient concentrations have widely declined or remained stable across Arkansas HUC-8s (Figure 5A-B; Table S4-5). This finding suggests that the State of Arkansas has seen a return on investment in nutrient reduction strategies made over the last 30 years. In fact, trend analysis results suggested increasing nutrient concentrations in only one HUC-8 (i.e. TN in 11010010 – Spring). For TP, increases in 75th percentiles of site medians were not detected in any HUC-8. No changes were detected for 5 HUC-8s for TN and for 7 HUC-8s for TP. For all other qualifying HUC-8s, trend analysis results suggested that 75th percentiles of site median total nutrient concentrations are decreasing.

However, data availability was insufficient for trend analysis for approximately half of Arkansas HUC-8s; therefore, it was not possible to determine if this finding applies statewide, including for the majority of MAP HUC-8s, a substantial number of which were flagged for nutrient levels greater than screening thresholds. The lack of increasing trends and inability to assess trends statewide with this approach had practical implications for the HUC-8 focus categorization process. Namely, the categorization process was largely based on the magnitude assessment.

Two HUC-8s were flagged for marginal data availability to assess trend in TN (11110205 – Cadron and 08020301 – Lower White-Bayou Des Arc). These same HUC-8s were also flagged for TP, as well as 08040205 – Bayou Bartholomew, which did not meet data qualifications for trend analysis for TN. For HUC-8s flagged for insufficient data availability, limited number of long-term monitoring sites (n<3) drove data limitations. However, HUC-8s flagged for marginal data availability all had monitoring periods that were truncated or had data gaps.

Data analysis focus categorization

The prioritization framework identified seven HUC-8s for maximum focus status in Tier 1 with sufficient monitoring data to guide investment in nutrient reduction strategies (Figure 6):

- 08020205 – L’Anguille
- 08020402 – Bayou Meto
- 11010003 – Bull Shoals Lake
- 11010004 – Middle White
- 11110103 – Illinois
- 11110203 – Lake Conway-Point Remove
- 11110207 – Lower Arkansas-Maumelle

Nutrient levels in these watersheds represent the greatest potential for reduction. Though total nutrient magnitudes were the primary driver, Tier 1 also encompasses several HUC-8s where trend analysis suggested that conditions were not improving, namely 11110103 – Illinois for TN, 08020402 – L’Anguille for TP, and 11010004 – Middle White and 11010003 – Bull Shoals Lake for both TN and TP.

Twenty-three HUC-8s were assigned to Tier 2 focus status, with emphasis under the ANRS on future monitoring program investments due to demonstrated nutrient reduction needs, data limitations, or both. Of HUC-8’s not assigned to Tier 1 or Tier 2 focus status, 23 were categorized as data-limited and assigned to Tier 3, while only five were categorized as data-sufficient and assigned to Tier 4. See Table 2 for Tier assignments for all Arkansas HUC-8s, including a weight of evidence summary of magnitude and trend results, partner priority status, and data availability.

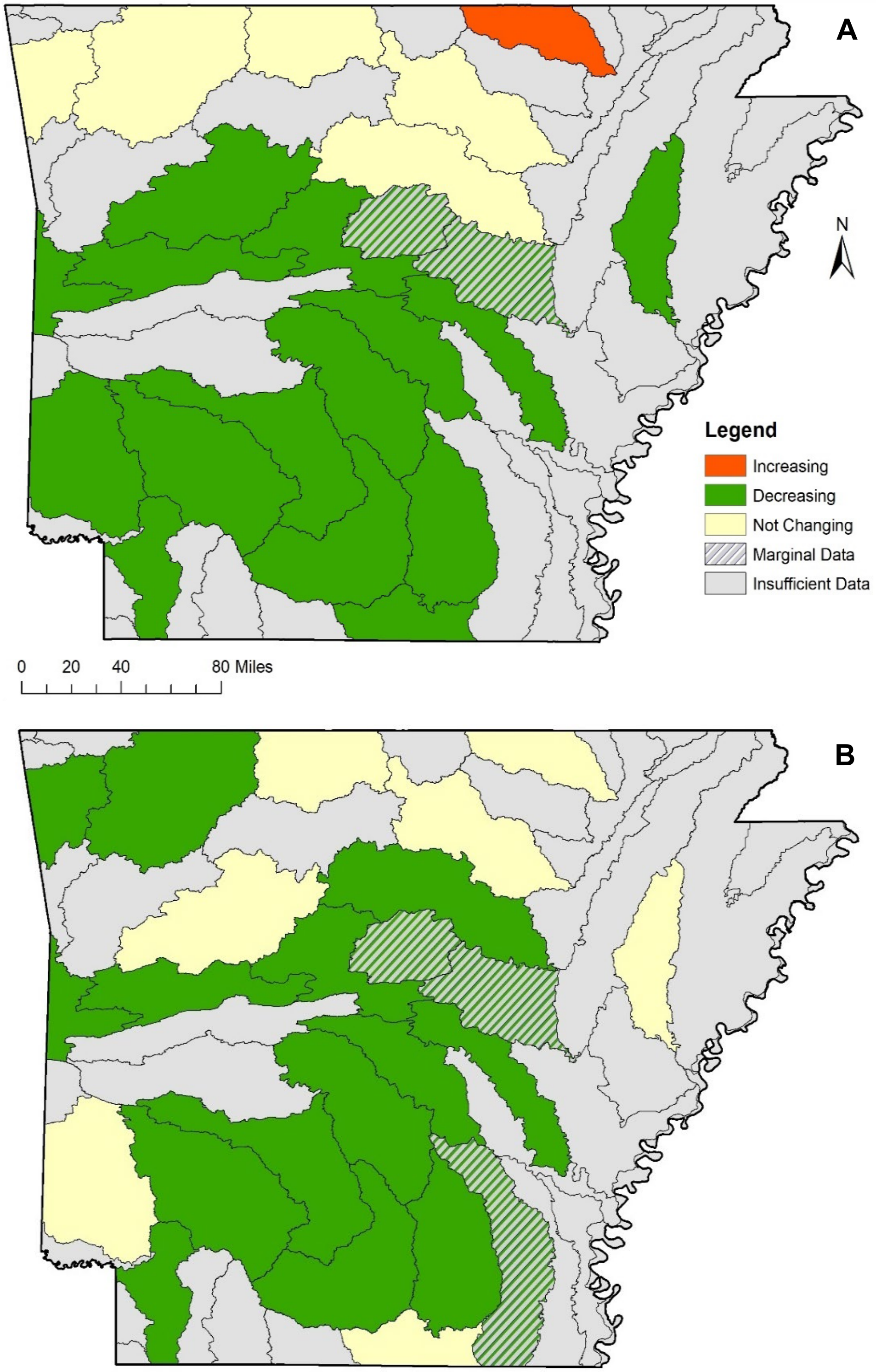


Figure 5. Results of HUC-8 level trend analysis on A) total nitrogen and B) total phosphorus 75th percentile of site median concentrations.

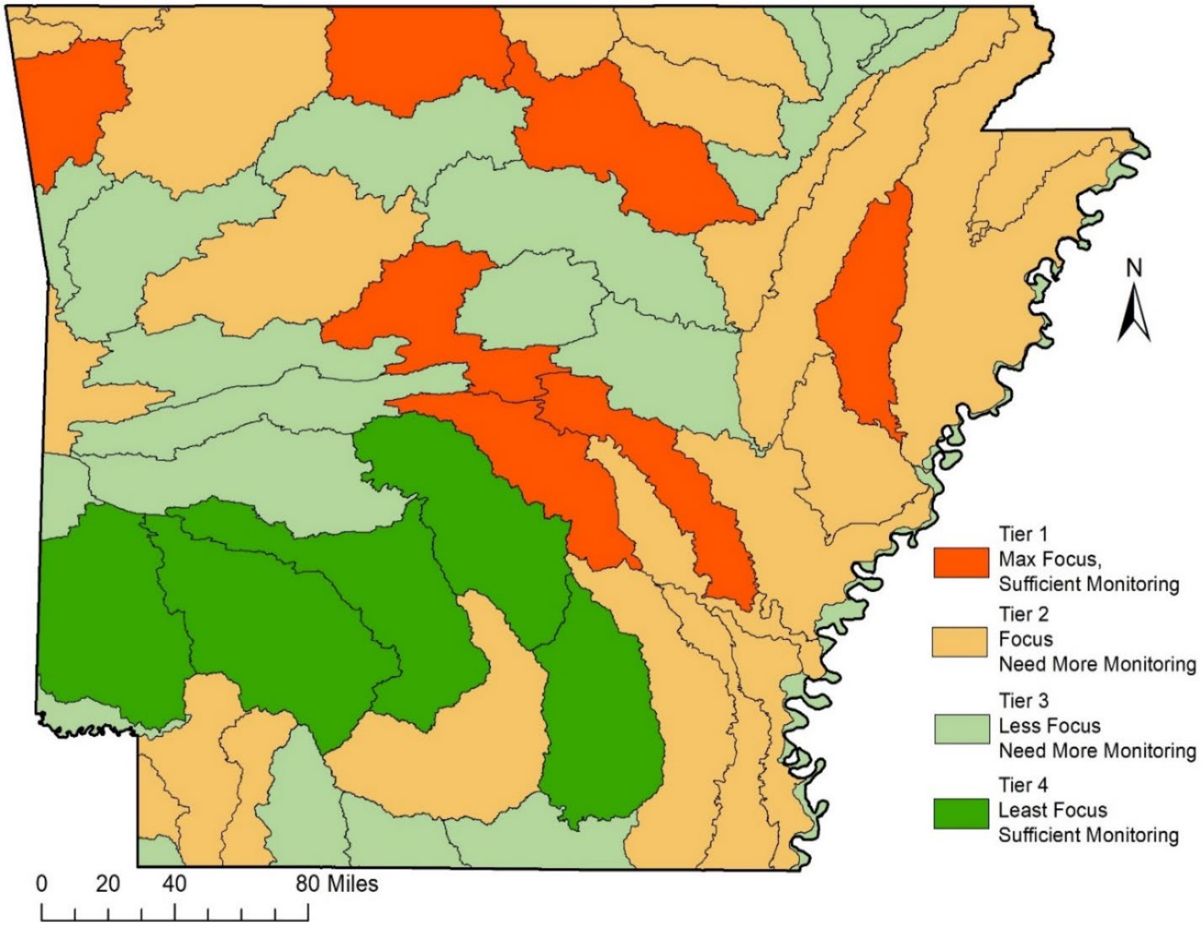


Figure 6. Categorization framework for HUC-8's under the ANRS update. Priority categories were 1) maximum focus for nutrient reduction activities, sufficient data; 2) Focus, but more data needed 3) less focus, but more data needed; and 4) least focus, with sufficient data.

Table 2. Priority tier assignments for all Arkansas HUC-8's, including summary of results for TN and TP magnitude assessment and trend analysis components of the data analysis, partner priority status, and data availability. Synthesis of these factors was the basis for priority tier assignments. Magnitude assessment scenarios (Sc) compared HUC-8 screening levels to a range of screening thresholds, as follows: Sc 1 TN threshold = 1.0 mg/L for all ecoregions; Sc2 TN threshold for Mississippi Alluvial Plain (MAP) = 0.81 mg/L; Sc2 TN threshold for other ecoregions = 0.66 mg/L; Sc1 TP threshold for MAP = 0.14 mg/L; Sc1 TP threshold for other ecoregions = 0.10 mg/L; Sc2 thresholds for Boston Mountains (BOSM), Ouachita Mountains (OUAM), and Ozark Highlands (OZKH) = 0.07 mg/L. For MAP, Arkansas River Valley (ARV) and South Central Plains (SCP), only a Sc1 threshold was used in the TP screening.

				Factors determining priority tier			Data availability	
HUC-8	Name	Ecoregion	Tier	TN Magnitude, Trend	TP Magnitude, Trend	Partner Priority	Magnitude	Trend
08010100	Lower Mississippi-Memphis	MAP	3	Not Assessed	Not assessed	-	Insufficient	Insufficient
08020100	Lower Mississippi-Helena	MAP	3	Not Assessed	Not Assessed	-	Insufficient	Insufficient
08020203	Lower St. Francis	MAP	2	Above Sc 1 threshold	Above Sc 1 threshold	MRBI	Marginal	Insufficient
08020204	Little River Ditches	MAP	2	Below Sc 1 threshold	Above Sc 1 threshold	MRBI	Marginal	Insufficient
08020205	L'Anguille	MAP	1	Above Sc 1 threshold, decreasing	Above Sc 1 threshold, not changing	MRBI	Sufficient	Sufficient
08020301	Lower White-Bayou Des Arc	MAP	3	Below Sc 1 threshold, decreasing	Below Sc 1 threshold, decreasing	MRBI	Sufficient	Marginal
08020302	Cache	MAP	2	Below Sc 1 threshold	Above Sc 1 threshold	MRBI	Sufficient	Insufficient
08020303	Lower White	MAP	2	Not Assessed	Not assessed	MRBI	Insufficient	Insufficient
08020304	Big	MAP	2	Not Assessed	Not assessed	MRBI	Insufficient	Insufficient
08020401	Lower Arkansas	MAP	2	Not Assessed	Not assessed	MRBI	Insufficient	Insufficient
08020402	Bayou Meto	MAP	1	Above Sc 1 threshold, decreasing	Above Sc 1 threshold, decreasing	MRBI	Sufficient	Sufficient
08030100	Lower Mississippi-Greenville	MAP	3	Not Assessed	Not Assessed	-	Insufficient	Insufficient
08040101	Ouachita Headwaters	OUAM	3	Below Sc 2 threshold	Below Sc 2 threshold	-	Sufficient	Insufficient
08040102	Upper Ouachita	OUAM	4	Below Sc 2 threshold, decreasing	Below Sc 2 threshold, decreasing	-	Sufficient	Sufficient

				Factors determining priority tier			Data availability	
HUC-8	Name	Ecoregion	Tier	TN Magnitude, Trend	TP Magnitude, Trend	Partner Priority	Magnitude	Trend
08040103	Little Missouri	SCP	4	Below Sc 2 threshold, decreasing	Below Sc 1 threshold, decreasing	-	Sufficient	Sufficient
08040201	Lower Ouachita-Smackover	SCP	2	Above Sc 1 threshold, decreasing	Below Sc 1 threshold, decreasing	-	Sufficient	Sufficient
08040202	Lower Ouachita-Bayou De Loutre	SCP	3	Above Sc 2 threshold, decreasing	Below Sc 1 threshold, not changing	-	Marginal	Sufficient
08040203	Upper Saline	OUAM	4	Below Sc 2 threshold, decreasing	Below Sc 2 threshold, decreasing	-	Sufficient	Sufficient
08040204	Lower Saline	SCP	4	Below Sc 1 threshold, decreasing	Below Sc 1 threshold, decreasing	-	Sufficient	Sufficient
08040205	Bayou Bartholomew	MAP	2	Above Sc 1 threshold	Above Sc 1 threshold, decreasing	MRBI	Sufficient	Marginal
08040206	Bayou D'Arbonne	SCP	3	Not Assessed	Not Assessed	-	Insufficient	Insufficient
08050001	Boeuf	MAP	2	Not Assessed	Not Assessed	MRBI	Insufficient	Insufficient
08050002	Bayou Macon	MAP	2	Not Assessed	Not assessed	MRBI	Insufficient	Insufficient
11010001	Beaver Reservoir	OZKH	2	Above Sc 1 threshold, not changing	Below Sc 2 threshold, decreasing	NSA	Sufficient	Sufficient
11010003	Bull Shoals Lake	OZKH	1	Above Sc 1 threshold, not changing	Above Sc 1 threshold, not changing	-	Sufficient	Sufficient
11010004	Middle White	OZKH	1	Above Sc 2 threshold, not changing	Above Sc 1 threshold, not changing	-	Sufficient	Sufficient
11010005	Buffalo	BOSM	3	Below Sc 2 threshold	Below Sc 2 thresholds	-	Sufficient	Insufficient
11010006	North Fork White	OZKH	2	Below Sc 2 threshold	Above Sc 1 threshold	-	Sufficient	Insufficient
11010007	Upper Black	MAP	3	Not Assessed	Not Assessed	-	Insufficient	Insufficient
11010008	Current	OZKH	3	Not Assessed	Not Assessed	-	Insufficient	Insufficient
11010009	Lower Black	MAP	3	Below Sc 1 threshold	Below Sc 1 threshold	-	Marginal	Insufficient
11010010	Spring	OZKH	2	Above Sc 2 threshold, increasing	Below Sc 2 threshold, not changing	-	Sufficient	Sufficient

				Factors determining priority tier			Data availability	
HUC-8	Name	Ecoregion	Tier	TN Magnitude, Trend	TP Magnitude, Trend	Partner Priority	Magnitude	Trend
11010011	Eleven Point	OZKH	3	Not Assessed	Not Assessed	-	Insufficient	Insufficient
11010012	Strawberry	OZKH	2	Below Sc 2 threshold	Above Sc 1 threshold	MRBI	Sufficient	Insufficient
11010013	Upper White-Village	MAP	2	Not Assessed	Not assessed	MRBI	Insufficient	Insufficient
11010014	Little Red	BOSM	3	Below Sc 2 threshold, not changing	Below Sc 2 threshold, decreasing	-	Marginal	Sufficient
11070206	Lake O' The Cherokees	OZKH	2	Not Assessed	Not assessed	NSA	Insufficient	Insufficient
11070208	Elk	OZKH	2	Above Sc 1 threshold	Above Sc 2 threshold	NSA	Sufficient	Insufficient
11070209	Lower Neosho	OZKH	2	Not Assessed	Not assessed	NSA	Insufficient	Insufficient
11110103	Illinois	OZKH	1	Above Sc 1 threshold, not changing	Above Sc 2 threshold, decreasing	NSA	Sufficient	Sufficient
11110104	Robert S. Kerr Reservoir	ARV	3	Above Sc 2 threshold	Below Sc 2 threshold	NSA	Marginal	Insufficient
11110105	Poteau	ARV	2	Above Sc 1 threshold, decreasing	Below Sc 2 threshold	NSA	Sufficient	Sufficient
11110201	Frog-Mulberry	BOSM	3	Below Sc 2 threshold	Below Sc 2 threshold	-	Sufficient	Insufficient
11110202	Dardanelle Reservoir	BOSM	2	Below Sc 2 threshold, decreasing	Above Sc 1 threshold, not changing	-	Marginal	Sufficient
11110203	Lake Conway-Point Remove	ARV	1	Above Sc 1 threshold	Above Sc 1 threshold	MRBI	Sufficient	Sufficient
11110204	Petit Jean	ARV	3	Below Sc 2 threshold, decreasing	Below Sc 2 threshold, decreasing	-	Marginal	Sufficient
11110205	Cadron	ARV	3	Below Sc 1 threshold	Below Sc 1 & 2 thresholds, decreasing	-	Sufficient	Marginal
11110206	Fourche La Fave	OUAM	3	Below Sc 2 threshold	Below Sc 2 threshold	-	Sufficient	Insufficient
11110207	Lower Arkansas-Maumelle	OUAM	1	Above Sc 2 threshold, decreasing	Above Sc 2 threshold, decreasing	-	Sufficient	Sufficient
11140105	Kiamichi	OUAM	3	Not Assessed	Not assessed	-	Insufficient	Insufficient

				Factors determining priority tier			Data availability	
HUC-8	Name	Ecoregion	Tier	TN Magnitude, Trend	TP Magnitude, Trend	Partner Priority	Magnitude	Trend
11140106	Pecan-Waterhole	SCP	3	Not Assessed	Not Assessed	-	Insufficient	Insufficient
11140108	Mountain Fork	OUAM	3	Above Sc 2 threshold	Below Sc 2 threshold	NSA	Sufficient	Insufficient
11140109	Lower Little Arkansas, Oklahoma	SCP	4	Above Sc 2 threshold, decreasing	Below Sc 1 threshold, not changing	-	Sufficient	Sufficient
11140201	McKinney-Posten Bayous	SCP	2	Above Sc 2 threshold, decreasing	Above Sc 1 threshold, decreasing	-	Marginal	Sufficient
11140203	Loggy Bayou	SCP	3	Not Assessed	Not Assessed	-	Insufficient	Insufficient
11140205	Bodcau Bayou	SCP	2	Above Sc 1 threshold	Above Sc 1 threshold	-	Marginal	Insufficient
11140302	Lower Sulpher	SCP	2	Above Sc 1 threshold	Above Sc 1 threshold	-	Marginal	Marginal
11140304	Cross Bayou	SCP	3	Not Assessed	Not Assessed	-	Insufficient	Insufficient

Statewide prioritization framework challenges

Uneven coverage in the State's ambient water quality monitoring data sets was the primary challenge to a statewide HUC-8 prioritization framework. Approximately one third of Arkansas HUC-8s did not qualify for either component of the analysis. In many cases, data-deficient HUC-8s may not represent the appropriate scale for ANRS prioritization. Some are data limited because only a small area is located in Arkansas, most notably 11140105 – Kiamichi. In some cases, Arkansas contains only a small downstream portion of the HUC-8, such as 11140106 – Pecan Waterhole, 11010007 – Upper Black, 11010011 – Eleven Point, and 11010008 – Current. Additionally, the scale of some HUC-8s may be too large for ANRS prioritization, such as three Mississippi River mainstem HUC-8s located on Arkansas's eastern border. For all these HUC-8s, Arkansas's ability to effect or demonstrate nutrient reduction with a single-state strategy is unlikely.

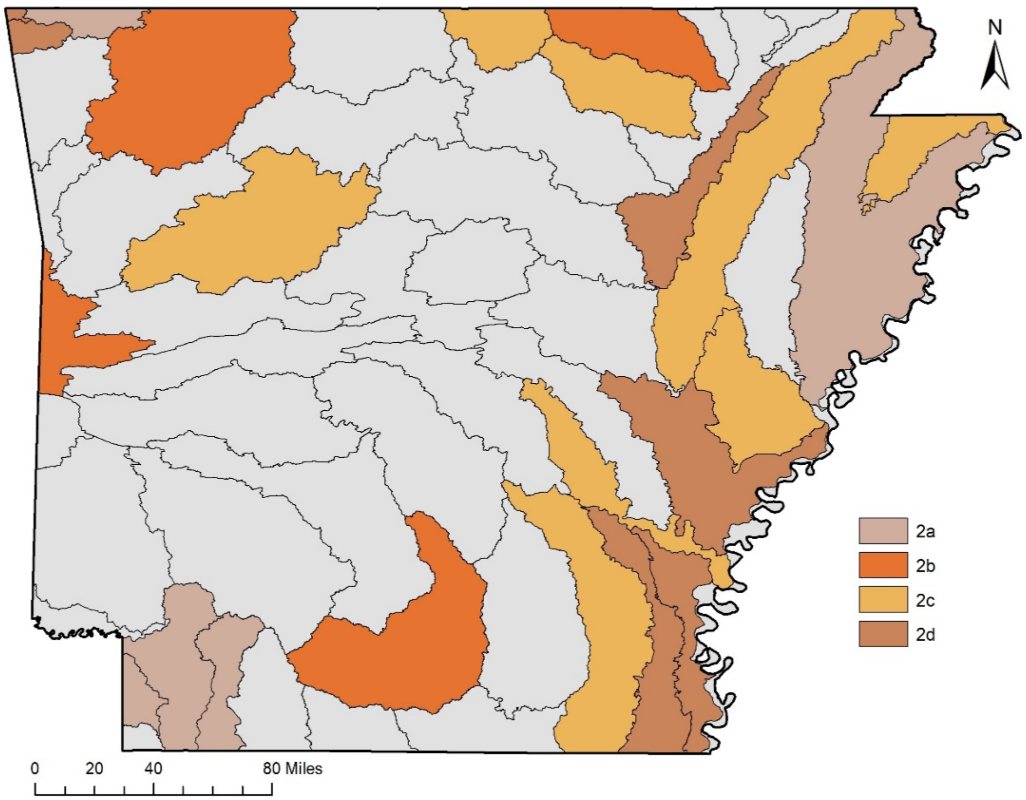
However, some data-deficient HUC-8s with limited area in Arkansas are known nutrient export hotspots, such as the Spavinaw Creek and Honey Creek sub-watersheds of 11070209 – Lower Neosho and 11070206 – Lake O' The Cherokees. Further, issues of scale largely do not apply for a cluster of Tier 2 HUC-8s located in the lower Mississippi River Alluvial Plain in Southeast Arkansas. The lack of a robust data record that includes multiple active monitoring locations and regular sample collection is an impediment to understanding how watersheds in these regions fit into a data-based prioritization framework for watershed prioritization under the ANRS.

A second challenge was related to the goal of maintaining a streamlined prioritization framework with a maximum of four tiers, with the first tier having a stated target number of only 5 – 8 HUC-8s. Gradients both in the weight of evidence for nutrient reduction need and data availability were observed across Arkansas HUC-8s, with a number of complex scenarios arising from synthesis of these factors that could not be accommodated uniquely with only four tiers. Thus, Tier 2 groups a broad range of scenarios, and sub-categories were needed that differentiate the HUC-8s with a common set of factors resulting in Tier 2 categorization, as well as the types of action and monitoring investments needed under the ANRS.

Subcategories describing these scenarios were: 2a) equivalent evidence for nutrient reduction need to Tier 1, but with insufficient data for quantitative assessment and goal setting; 2b) evidence of nutrient reduction need, but less than qualifying criteria for Tier 1, with sufficient data; 2c) evidence of nutrient reduction need, with limited data; and 2d) a partner priority (Mississippi River Basin Initiative or Nutrient Surplus Area) for nutrient reduction focus, but with insufficient data for assessment in any component of the data analysis (Figure 7).

Current ANRS priority watershed comparisons

The 2014 ANRS qualitatively identified ten priority HUC-8s: 08040205 - Bayou Bartholomew, 08020302 - Cache River, 11110203 - Lake Conway-Point Remove, 08040201 - Lower Ouachita-Smackover, 11010012 - Strawberry, 11010001 - Beaver Reservoir, 11110103 - Illinois, 08020205 - L'Anguille, 11110105 - Poteau, and 08040203 - Upper Saline. Three, or 43%, of tier 1 HUC-8s identified in this study, overlap the 2014 priority HUC-8s (11110203 – Lake Conway-Point Remove, 11110103 – Illinois, and 08020205 – L'Anguille). Three 2014 priority HUC-8s (HUC-8s were 08040205 – Bayou Bartholomew, 08020302 – Cache River, and 11010012 – Strawberry) were identified in the data analysis



2a – Max nutrient reduction need, enhanced data needed
- 08020203 – Lower St. Francis
- 08040205 – Bayou Bartholomew
- 11070208 – Elk
- 11140201 – McKinney-Posten Bayous
- 11140205 – Bodcau Bayou
- 11140302 – Lower Sulpher

2b – Nutrient reduction need, sufficient data
- 08040201- Lower Ouachita – Smackover
- 11010001 – Beaver Reservoir
- 11010010 - Spring
- 11110105 – Poteau

2c – Nutrient reduction need, enhanced data needed
- 08020204 – Little River Ditches
- 08020302 – Cache
- 11010006 – North Fork White
- 11010012 - Strawberry
- 11110202 – Dardanelle Reservoir

2d – Partner priority, baseline data needed
- 08020303 - Lower White
- 08020304 – Big
- 08020401 – Lower Arkansas
- 08050001 – Boeuf
- 08050002 – Bayou Macon
- 11010013 – Upper White-Village
- 11070206 – Lake O' The Cherokees
- 11070209 – Lower Neosho

Figure 7. Tier 2 HUC-8s grouped by four subcategories that summarize the level of nutrient reduction need suggested by the data analysis, data availability, and partner priority status

Table 3. Summary of trend analysis results, as percentage of sites with decreasing, increasing, or not changing TN and TP concentrations, for sites in HUC-8s that were flagged for a nutrient reduction focus for one or more component (trend or magnitude for TN or TP) of the overall categorization framework.

				Trend		
HUC-8	Name	Site count	Nutrient	Decreasing	Increasing	Not changing
08020205	L'Anguille	3	TN	67	0	33
			TP	0	33	67
08020402	Bayou Meto	4	TN	75	0	25
			TP	50	0	50
11010003	Bull Shoals Lake	7	TN	0	71	29
			TP	14	29	57
11010004	Middle White	4	TN	0	25	75
			TP	50	0	50
11110103	Illinois	9	TN	44	33	22
			TP	67	11	22
11110203	Lake Conway – Point Remove	9	TN	44	0	33
			TP	33	11	44
11110207	Lower Arkansas – Maumelle	7	TN	71	0	29
			TP	71	0	29

for nutrient reduction need, but were not eligible for Tier 1 based on data limitations. These HUC-8's were assigned to Tier 2 as priorities for monitoring program investments for future ANRS updates. Three 2014 priority HUC-8s (08040201 – Lower Ouachita-Smackover, 11010001 – Beaver Reservoir, and 11110105 – Poteau) were fully assessed in the data analysis and were assigned Tier 2 focus status based on nutrient reduction need, but short of criteria qualifying for Tier 1. In contrast, 08040203 – Upper Saline was assigned to Tier 4, least focus status. Neither TN nor TP screening levels in the Upper Saline were greater than screening thresholds, while trend analysis suggested that the 75th percentiles of site median concentrations were decreasing for both nutrients.

Trend analysis on sites in focus watersheds

Site-level TN and TP trend analysis results show that sites with increasing TN concentrations are clustered in a band across northern Arkansas, while increasing TP concentrations are more diversely spread across the state (Figure 8A-B; Table S6-7). Site-level results were largely in-line with HUC-level findings for trend in 75th percentiles of site median total nutrient concentrations (Table 3). Increasing nutrient concentrations, which were detected for only one nutrient-HUC combination in the HUC-level analysis, were also the least common result at the site-level, representing just 12 – 21% of 42 qualifying sites. Nutrient concentrations that were decreasing or not changing were far more commonly detected. For TN, decreasing trend was identified for 43% of sites; static concentrations for 31%. Trend results suggesting decreasing or static TP concentrations both comprised 43% of sites.

Agreement between site- and HUC-level analysis was also typical for individual HUC-8s, with limited exceptions. Most notably, trend analysis suggested TN concentrations were increasing at 71% of sites within 11010003 - Bull Shoals Lake, in contrast to the HUC-level finding that TN concentrations were not changing. For TP, no change was detected for 44% of sites in

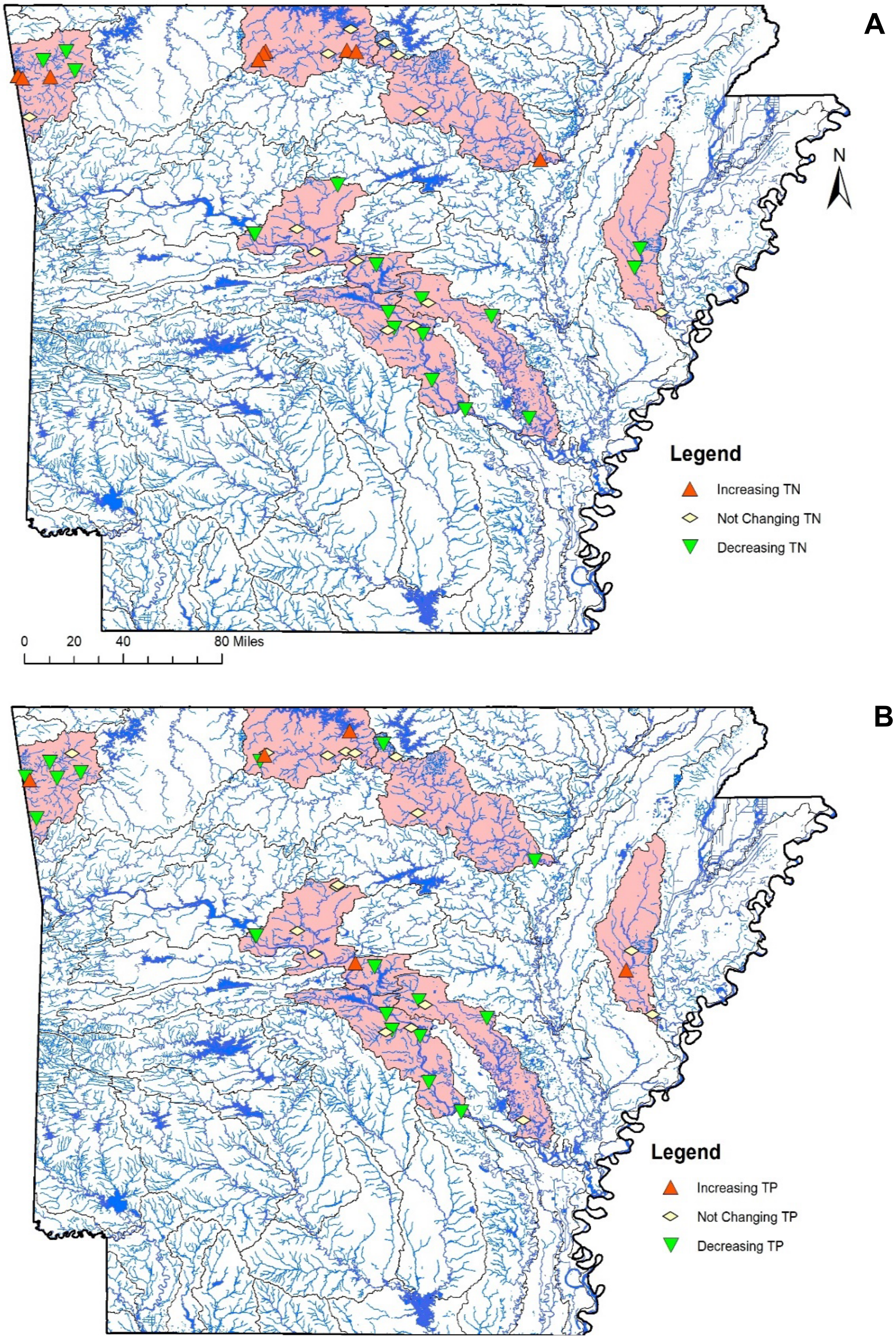


Figure 8. Site-level trend analysis results on A) TN and B) TP concentrations for qualifying sites located in HUC-8s flagged for a nutrient reduction focus for at least one component (trend or magnitude, TN or TP) of the overall prioritization framework.

11110203 - Lake Conway-Point Remove, but HUC-8 level analysis suggested decreasing TP concentrations. Conversely, HUC-level trend analysis suggested no change in 11110103 – Illinois TN concentrations, but the most frequent site-specific result suggested decreasing trends (44 – 100%).

CONCLUSIONS

This project presents an approach to identify watersheds with the greatest nutrient reduction need at a statewide scale. Key findings of component assessments of the overall framework included regional gradients in HUC-8 75th percentiles of site median total nutrient concentrations, broadly decreasing nutrient trends and near statewide absence of increasing trends, clustering of increasing TN concentrations at sites in northern Arkansas, and spatial gaps in the State's ambient water quality monitoring program that prevented approximately one-third of HUC-8s from qualifying for any component of the data analysis.

The prioritization framework targeted HUC-8s with the greatest nutrient reduction need demonstrated in the data analysis for maximum focus in Tier 1 under the ANRS. These criteria identified seven HUC-8s:

- 08020205 – L'Anguille
- 08020402 – Bayou Meto
- 11010003 – Bull Shoals Lake
- 11010004 – Middle White
- 11110103 – Illinois
- 11110203 - Lake Conway-Point Remove
- 11110207 – Lower Arkansas-Maumelle

Most of these watersheds had other substantiating factors for prioritization, including nutrient levels that were not changing at the HUC-8 level (11010004 - Middle White, 11010004 - Bull Shoals Lake, and 11110103 - Illinois), a majority of sites with increasing nutrients (11010004 - Bull Shoals Lake), MRBI priority watershed (08020205 - L'Anguille, 08020402 - Bayou Meto) or Nutrient Surplus Area (11010003 Bull Shoals Lake and 11110103 - Illinois) designation, or qualitative selection for prioritization under the 2014 ANRS (08020205 - L'Anguille, 11110103 – Illinois, 11110203 - Lake Conway-Point Remove).

The framework also honed in on HUC-8s with demonstrated nutrient reduction need based on less selective requirements, with data limitations, or both, for Tier 2. Twenty-three HUC-8s were assigned to Tier 2 focus status, with emphasis under the ANRS on future monitoring program investments to support assessment as part of future ANRS updates. Of HUC-8's not assigned to Tier 1 or Tier 2 focus status, 23 were categorized as data-limited and assigned to Tier 3, while only five were categorized as data-sufficient and assigned to Tier 4.

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SUPPLEMENTARY MATERIALS

Table S1. Summary of compiled biological response thresholds in TN and TP concentration observed in the scientific literature for measures of benthic and sestonic algae, macroinvertebrates (Macros), and fish communities.

Community	Geo_unit	System size	Watershed LULC	Response	Method	TN (mg/L)	TP (mg/L)	Citation
Benthic Algae	Global	Range	Range	Mean chl-a	regression	0.540	0.043	Dodds et al., 2002, 2006
Benthic Algae	Global	Range	Range	Maximum chl-a	regression	0.600	0.062	Dodds et al., 2002, 2006
Benthic Algae	Global	Range	Range	Mean chl-a	2DKS	0.520	0.027	Dodds et al., 2002, 2006
Benthic Algae	Global	Range	Range	Maximum chl-a	2DKS	0.370	0.027	Dodds et al., 2002, 2006
Benthic Algae	Wisconsin	Wadeable	Range	chl-a	regression tree	0.920	0.039	Robertson et al., 2006
Benthic Algae	Wisconsin	Wadeable	Range	Diatom nutrient index	regression tree	1.200	0.057	Robertson et al., 2006
Benthic Algae	Wisconsin	Wadeable	Range	Diatom siltation index	regression tree	0.870	0.074	Robertson et al., 2006
Benthic Algae	Wisconsin	Wadeable	Range	Diatom biotic index	regression tree	1.200	0.072	Robertson et al., 2006
Benthic Algae	Mid-Atlantic Highlands	Wadeable	Range	Mean chl-a	nCPA	NA	0.0127	Stevenson et al., 2008
Benthic Algae	Mid-Atlantic Highlands	Wadeable	Range	Mean AFDM	nCPA	NA	0.0082	Stevenson et al., 2008
Benthic Algae	Mid-Atlantic Highlands	Wadeable	Range	Acid phosphatase activity	nCPA	NA	0.0065	Stevenson et al., 2008
Benthic Algae	Mid-Atlantic Highlands	Wadeable	Range	Alkaline phosphatase activity	nCPA	NA	0.0065	Stevenson et al., 2008
Benthic Algae	Mid-Atlantic Highlands	Wadeable	Range	Number of diatom taxa	nCPA	NA	0.0115	Stevenson et al., 2008
Benthic Algae	Mid-Atlantic Highlands	Wadeable	Range	Diatom evenness	nCPA	NA	0.0195	Stevenson et al., 2008
Benthic Algae	Mid-Atlantic Highlands	Wadeable	Range	Proportion of native diatom taxa	nCPA	NA	0.0115	Stevenson et al., 2008
Benthic Algae	Mid-Atlantic Highlands	Wadeable	Range	Proportion of low-P native taxa	nCPA	NA	0.0185	Stevenson et al., 2008

Community	Geo_unit	System size	Watershed LULC	Response	Method	TN (mg/L)	TP (mg/L)	Citation
Benthic Algae	Mid-Atlantic Highlands	Wadeable	Range	Diatom species similarity to reference	nCPA	NA	0.0265	Stevenson et al., 2008
Benthic Algae	Mid-Atlantic Highlands	Wadeable	Range	low-P diatom individuals, %	nCPA	NA	0.0185	Stevenson et al., 2008
Benthic Algae	Mid-Atlantic Highlands	Wadeable	Range	High-P diatom individuals, %	nCPA	NA	0.0115	Stevenson et al., 2008
Benthic Algae	Ohio	Wadeable	Range	Mean chl-a	nCPA	0.435	0.038	Miltner, 2010
Benthic Algae	Western US	Wadeable	Range	Abundance of pollution tolerant diatoms, %	regression	0.86	0.28	Black et al., 2011
Benthic Algae	Western US	Wadeable	Range	Alkalophilus diatom richness	regression	NS††	0.05	Black et al., 2011
Benthic Algae	Western US	Wadeable	Range	Abundance of pollution-sensitive diatoms, %	regression	NS	0.09	Black et al., 2011
Benthic Algae	Western US	Wadeable	Range	Abundance of high-TN diatoms, %	regression	0.61	0.06	Black et al., 2011
Benthic Algae	Western US	Wadeable	Range	Abundance of high-TP diatoms, %	regression	0.71	0.06	Black et al., 2011
Benthic Algae	Western US	Wadeable	Range	Abundance of N heterotrophs, %	regression	1.5	0.1	Black et al., 2011
Benthic Algae	Western US	Wadeable	Range	Abundance of motile algae, %	regression	0.27	0.06	Black et al., 2011
Benthic Algae	Western US	Wadeable	Range	Richness of motile algae, %	regression	1.49	0.09	Black et al., 2011
Benthic Algae	Western US	Wadeable	Range	Alkalophilus diatom richness	regression	1.25	0.03	Black et al., 2011
Benthic Algae	Western US	Wadeable	Range	Abundance of high TN diatoms, %	regression	1.45	0.07	Black et al., 2011
Benthic Algae	Western US	Wadeable	Range	Abundance of high-TP diatoms, %	regression	1.3	0.08	Black et al., 2011
Benthic Algae	Western US	Wadeable	Range	Abundance of N heterotrophs, %	regression	0.59	0.13	Black et al., 2011
Benthic Algae	Western US	Wadeable	Range	Abundance of motile algae, %	regression	NS	0.2	Black et al., 2011
Benthic Algae	Western US	Wadeable	Range	Richness motile algae, %	regression	1.79	0.07	Black et al., 2011

Community	Geo_unit	System size	Watershed LULC	Response	Method	TN (mg/L)	TP (mg/L)	Citation
Benthic algae	Texas Brazos River-Cross Timbers	Wadeable	Pasture	TITAN diatom sum(z-)	nCPA - threshold	NA	0.02	Taylor et al. 2017
Benthic algae	Texas Brazos River-Cross Timbers	Wadeable	Pasture	TITAN diatom sum(z+)	nCPA - threshold	NA	0.04	Taylor et al. 2017
Benthic algae	Texas Brazos River-Cross Timbers	Wadeable	Pasture	TITAN diatom sum(z-)	nCPA - threshold	NA	0.025	Taylor et al. 2017
Benthic algae	Texas Brazos River-Cross Timbers	Wadeable	Pasture	TITAN diatom sum(z+)	nCPA - threshold	NA	0.027	Taylor et al. 2017
Benthic algae	Texas Brazos River-Cross Timbers	Wadeable	Pasture	TITAN diatom sum(z-)	nCPA - 95%	NA	0.032	Taylor et al. 2017
Benthic algae	Texas Brazos River-Cross Timbers	Wadeable	Pasture	TITAN diatom assemblage sum(z+)	nCPA - 95%	NA	0.14	Taylor et al. 2017
Benthic algae	Texas Brazos River-Cross Timbers	Wadeable	Pasture	TITAN diatom assemblage sum(z-)	nCPA - 95%	NA	0.037	Taylor et al. 2017
Benthic algae	Texas Brazos River-Cross Timbers	Wadeable	Pasture	TITAN diatom assemblage sum(z+)	nCPA - 95%	NA	0.036	Taylor et al. 2017
Benthic Algae	Connecticut	Wadeable	Urban	TITAN sum(Z-) TP (sensitive species)	nCPA -threshold	NA	0.027	Smucker et al. 2013
Benthic Algae	Connecticut	Wadeable	Urban	%Z- IC (sensitive species)	nCPA -threshold	NA	0.034	Smucker et al. 2013
Benthic Algae	Connecticut	Wadeable	Urban	TITAN community	nCPA -threshold	NA	0.039	Smucker et al. 2013
Benthic Algae	Connecticut	Wadeable	Urban	NMS axis 1 score (community structure)	nCPA -threshold	NA	0.042	Smucker et al. 2013
Benthic Algae	Connecticut	Wadeable	Urban	% low P (sensitive species)	nCPA -threshold	NA	0.05	Smucker et al. 2013
Benthic Algae	Connecticut	Wadeable	Urban	TITAN sum(Z+)TP (tolerant species)	nCPA -threshold	NA	0.051	Smucker et al. 2013
Benthic Algae	Connecticut	Wadeable	Urban	Chlorophyll a	nCPA -threshold	NA	0.058	Smucker et al. 2013
Benthic Algae	Connecticut	Wadeable	Urban	%Z+ IC (tolerant species)	nCPA -threshold	NA	0.066	Smucker et al. 2013
Benthic Algae	Connecticut	Wadeable	Urban	%high P (tolerant species)	nCPA -threshold	NA	0.072	Smucker et al. 2013
Benthic Algae	Connecticut	Wadeable	Urban	TITAN sum(Z-) TP (sensitive species)	nCPA - 90%	NA	0.033	Smucker et al. 2013
Benthic Algae	Connecticut	Wadeable	Urban	%Z- IC (sensitive species)	nCPA - 90%	NA	0.039	Smucker et al. 2013

Community	Geo_unit	System size	Watershed LULC	Response	Method	TN (mg/L)	TP (mg/L)	Citation
Benthic Algae	Connecticut	Wadeable	Urban	TITAN community	nCPA - 90%	NA	0.058	Smucker et al. 2013
Benthic Algae	Connecticut	Wadeable	Urban	NDMS axis 1 score (community structure)	nCPA - 90%	NA	0.048	Smucker et al. 2013
Benthic Algae	Connecticut	Wadeable	Urban	% low P (sensitive species)	nCPA - 90%	NA	0.062	Smucker et al. 2013
Benthic Algae	Connecticut	Wadeable	Urban	TITAN sum(Z+)TP (tolerant species)	nCPA - 90%	NA	0.066	Smucker et al. 2013
Benthic Algae	Connecticut	Wadeable	Urban	Chlorophyll a	nCPA - 90%	NA	0.22	Smucker et al. 2013
Benthic Algae	Connecticut	Wadeable	Urban	%Z+ IC (tolerant species)	nCPA - 90%	NA	0.067	Smucker et al. 2013
Benthic Algae	Connecticut	Wadeable	Urban	%high P (tolerant species)	nCPA - 90%	NA	0.074	Smucker et al. 2013
Benthic Algae	Ohio	Wadeable	Row-crop	threshold ranges multiple analyses	multiple	NA	0.075	Smucker et al. 2020
Benthic Algae	Ohio	Wadeable	Row-crop	threshold ranges multiple analyses	multiple	NA	0.15	Smucker et al. 2020
Benthic Algae	Ohio	Wadeable	Row-crop	threshold ranges multiple analyses	multiple	NA	0.3	Smucker et al. 2020
Benthic Algae	Ohio	Wadeable	Row-crop	threshold ranges multiple analyses	multiple	0.28	NA	Smucker et al. 2020
Benthic Algae	Ohio	Wadeable	Row-crop	threshold ranges multiple analyses	multiple	0.53	NA	Smucker et al. 2020
Benthic Algae	Ohio	Wadeable	Row-crop	threshold ranges multiple analyses	multiple	0.85	NA	Smucker et al. 2020
Benthic algae	Minnesota	Wadeable	Row-crop	Chlorophyll a	AQUATOX	2.7	0.1	Carleton et al. 2009
Benthic algae	Central Texas	Wadeable	Pasture	TITAN sum(z-)	nCPA - threshold	1.9	0.021	Taylor et al. 2014
Benthic Algae	Central Texas	Wadeable	Pasture	TITAN sum(z-)	nCPA - 95%	2.3	0.048	Taylor et al. 2014
Benthic algae	Central Texas	Wadeable	Pasture	TITAN sum(z+)	nCPA - threshold	0.44	0.027	Taylor et al. 2014
Benthic algae	Central Texas	Wadeable	Pasture	TITAN sum(z+)	nCPA - 95%	2.4	0.03	Taylor et al. 2014
Benthic algae	Montana	Non-wadeable	Range	Chlorophyll a	nCPA	NA	0.024	Suplee et al. 2012
Benthic algae	Montana	Non-wadeable	Range	Chlorophyll a	QUAL2K	0.66	0.055	Suplee et al. 2015
Benthic algae	Montana	Non-wadeable	Range	Chlorophyll a	QUAL2K	0.82	0.095	Suplee et al. 2015

Community	Geo_unit	System size	Watershed LULC	Response	Method	TN (mg/L)	TP (mg/L)	Citation
Benthic algae	Mississippi (Alluvial Plain)	Wadeable	Row-crop	diatom assemblage	nCPA	NA	0.12	Hicks and Taylor 2018
Benthic algae	Ontario & Quebec	Wadeable	Row-crop	Chlorophyll a	Linear regression	1.8	0.046	Chambers et al. 2008
Benthic algae	Arkansas & Oklahoma	Wadeable	Pasture	Mean chl-a	nCPA - threshold	NA		King 2016
Benthic algae	Arkansas & Oklahoma	Wadeable	Pasture	Mean chl-a	nCPA - 95%	NA		King 2016
Benthic algae	Arkansas & Oklahoma	Wadeable	Pasture	Mean (24 mo) Cladophora biovolume	nCPA - threshold	NA	0.039	King 2016
Benthic algae	Arkansas & Oklahoma	Wadeable	Pasture	Mean (24 mo) Cladophora biovolume	nCPA - 95%	NA	0.047	King 2016
Benthic algae	Arkansas & Oklahoma	Wadeable	Pasture	Biovolume proportion of nuisance taxa	nCPA - threshold	NA	0.039	King 2016
Benthic algae	Arkansas & Oklahoma	Wadeable	Pasture	Biovolume proportion of nuisance taxa	nCPA - 95%	NA	0.059	King 2016
Benthic algae	Arkansas & Oklahoma	Wadeable	Pasture	TITAN community	nCPA - threshold	NA	0.033	King 2016
Benthic algae	Arkansas & Oklahoma	Wadeable	Pasture	TITAN community	nCPA - 95%	NA	0.04	King 2016
Benthic algae	Arkansas & Oklahoma	Wadeable	Pasture	TITAN sum z-	nCPA - threshold	NA	0.021	King 2016
Benthic algae	Arkansas & Oklahoma	Wadeable	Pasture	TITAN sum z-	nCPA - 95%	NA	0.025	King 2016
Benthic algae	Arkansas & Oklahoma	Wadeable	Pasture	TITAN sum z+	nCPA - threshold	NA	0.021	King 2016
Benthic algae	Arkansas & Oklahoma	Wadeable	Pasture	TITAN sum z+	nCPA - 95%	NA	0.037	King 2016
Benthic algae	Michigan, Indiana & Kentucky	Wadeable	Row-crop	%Cladophora cover	regression	1	0.03	Stevenson et al. 2006
Benthic algae	Montana	Non-wadeable	Range	Chlorophyll a	regression	0.35	0.03	Dodds et al. 1997

Community	Geo_unit	System size	Watershed LULC	Response	Method	TN (mg/L)	TP (mg/L)	Citation
Benthic algae	New Jersey	Range	Range	Biological Condition Gradient threshold	Impaired BCG threshold nutrient conc	1	0.05	Charles et al. 2019
Benthic algae	New Jersey	Range	Range	Biological Condition Gradient threshold	Concentrations protective of good condition	NA	0.045	Hausmann et al. 2016
Benthic algae	New Jersey	Range	Range	Biological Condition Gradient threshold	Concentrations protective of fair condition	NA	0.058	Hausmann et al. 2016
Benthic algae	Canada	Range	Range	Trophic Diatom Index	regression tree	NA	0.032	Chambers et al. 2012
Benthic algae	Canada	Range	Range	Diatom Shannon diversity	regression tree	0.59	NA	Chambers et al. 2012
Benthic algae	Canada	Range	Range	Mean chl-a	regression tree	1.2	0.046	Chambers et al. 2012
Benthic algae	New York (Ecoregions VIII/XI)	Wadeable	Upland pristine forested	NBI-P	nCPA - threshold	NA	0.016	Smith et al. 2013
Benthic algae	New York (Ecoregions VIII/XI)	Wadeable	Upland pristine forested	NBI-N	nCPA - threshold	0.41	NA	Smith et al. 2013
Benthic algae	New York (Ecoregions VIII/XI)	Wadeable	Upland pristine forested	TRI	nCPA - threshold	0.53	0.015	Smith et al. 2013
Benthic algae	New York (Ecoregions VIII/XI)	Wadeable	Upland pristine forested	HBI	nCPA - threshold	NA	NA	Smith et al. 2013
Benthic algae	New York (Ecoregions VII/XIV)	Wadeable	Nutrient enriched (pasture & row-crop)	NBI-P	nCPA - threshold	0.61	0.016	Smith et al. 2013
Benthic algae	New York (Ecoregions VII/XIV)	Wadeable	Nutrient enriched (pasture & row-crop)	NBI-N	nCPA - threshold	0.54	0.017	Smith et al. 2013
Benthic algae	New York (Ecoregions VII/XIV)	Wadeable	Nutrient enriched (pasture & row-crop)	TRI	nCPA - threshold	0.56	0.018	Smith et al. 2013
Benthic algae	New York (Ecoregions VII/XIV)	Wadeable	Nutrient enriched	HBI	nCPA - threshold	2.8	NA	Smith et al. 2013

Community	Geo_unit	System size	Watershed LULC (pasture & row-crop)	Response	Method	TN (mg/L)	TP (mg/L)	Citation
Chemical	British Columbia, Canada (Montane Cordillera)	Range	Range	Multiple methods		0.21	0.02	Chambers et al. 2012
Chemical	Alberta, Canada (Prairie)	Range	Range	Multiple methods		0.98	0.11	Chambers et al. 2012
Chemical	Manitoba, Canada (Prairies/Boreal Plains)	Range	Range	Multiple methods		0.39	0.1	Chambers et al. 2012
Chemical	Ontario, Canada (Mixedwood Plains)	Range	Range	Multiple methods		1	0.026	Chambers et al. 2012
Chemical	Quebec, Canada (Mixedwood Plains)	Range	Range	Multiple methods		1.2	0.042	Chambers et al. 2012
Chemical	New Brunswick, Canada (Atlantic Maritime)	Range	Range	Multiple methods		0.87	0.013	Chambers et al. 2012
Chemical	Prince Edward Island, Canada (Atlantic Maritime)	Range	Range	Multiple methods		1.2	0.048	Chambers et al. 2012
Fish	Wisconsin	Wadeable	Range	Percentage of carnivorous individuals	regression tree	1.22	0.09	Wang et al., 2007; Robertson et al. 2006
Fish	Wisconsin	Wadeable	Range	Index of biotic integrity	regression tree	1.36	0.07	Wang et al., 2007; Robertson et al. 2006
Fish	Wisconsin	Wadeable	Range	Salmonid individuals	regression tree	0.63	0.06	Wang et al., 2007
Fish	Wisconsin	Wadeable	Range	Percentage of intolerant individuals	regression tree	1.83	0.09	Wang et al., 2007; Robertson et al. 2006
Fish	Wisconsin	Wadeable	Range	Percentage of carnivorous individuals	2DKS§	0.54	0.06	Wang et al., 2007
Fish	Wisconsin	Wadeable	Range	Index of biotic integrity	2DKS	0.54	0.06	Wang et al., 2007
Fish	Wisconsin	Wadeable	Range	Salmonid individuals	2DKS	0.61	0.06	Wang et al., 2007
Fish	Wisconsin	Wadeable	Range	Percentage of intolerant individuals	2DKS	0.54	0.07	Wang et al., 2007
Fish	Wisconsin	Non-wadeable	Range	Index of biotic integrity	regression tree	0.634	0.139	Weigel and Robertson, 2007

Community	Geo_unit	System size	Watershed LULC	Response	Method	TN (mg/L)	TP (mg/L)	Citation
Fish	Wisconsin	Non-wadeable	Range	Percent biomass of round suckers	regression tree	0.634	0.091	Weigel and Robertson, 2007
Fish	Nebraska	Range	Row-crop	Pollution tolerance index	threshold 95% of streams good or excellent	NA	0.6	Heatherley 2014
Fish	Central Texas	Wadeable	Pasture	TITAN sum(z-)	nCPA - threshold	NA	0.034	Taylor et al. 2014
Fish	Central Texas	Wadeable	Pasture	TITAN sum(z-)	nCPA - 95%	NA	0.6	Taylor et al. 2014
Fish	Central Texas	Wadeable	Pasture	TITAN sum(z+)	nCPA - threshold	0.24	0.034	Taylor et al. 2014
Fish	Central Texas	Wadeable	Pasture	TITAN sum(z+)	nCPA - 95%	0.49	0.052	Taylor et al. 2014
Fish	Georgia	Wadeable	Urban	Nitrate tolerance score	Segmented regression	NA	NA	Meador 2013
Fish	Indiana & Ohio	Wadeable	Row-crop	Nitrate tolerance score	Segmented regression	NA	NA	Meador 2013
Fish	Wisconsin	Wadeable	Range	IBI	Nonparametric deviance reduction	NA	0.39	Brenden et al. 2008
Fish	Wisconsin	Wadeable	Range	IBI	Piecewise regression	NA	0.07	Brenden et al. 2008
Fish	Wisconsin	Wadeable	Range	IBI	Bayesian changepoint	NA	0.03	Brenden et al. 2008
Fish	Wisconsin	Wadeable	Range	IBI	Quantile piecewise constant (90th percentile)	NA	0.04	Brenden et al. 2008
Fish	Wisconsin	Wadeable	Range	IBI	Quantile piecewise constant (99th percentile)	NA	0.06	Brenden et al. 2008
Fish	Wisconsin	Wadeable	Range	IBI	QPL 90%	NA	0.04	Brenden et al. 2008
Fish	Wisconsin	Wadeable	Range	IBI	QPL 99%	NA	0.07	Brenden et al. 2008
Fish	Wisconsin	Wadeable	Range	Percent intolerant individuals	Nonparametric deviance reduction	NA	0.16	Brenden et al. 2008
Fish	Wisconsin	Wadeable	Range	Percent intolerant individuals	Piecewise regression	NA	0.1	Brenden et al. 2008
Fish	Wisconsin	Wadeable	Range	Percent intolerant individuals	Bayesian changepoint	NA	0.08	Brenden et al. 2008

Community	Geo_unit	System size	Watershed LULC	Response	Method	TN (mg/L)	TP (mg/L)	Citation
Fish	Wisconsin	Wadeable	Range	Percent intolerant individuals	Quantile piecewise constant (90th percentile)	NA	0.11	Brenden et al. 2008
Fish	Wisconsin	Wadeable	Range	Percent intolerant individuals	Quantile piecewise constant (99th percentile)	NA	0.06	Brenden et al. 2008
Fish	Wisconsin	Wadeable	Range	Percent intolerant individuals	QPL 90%	NA	0.11	Brenden et al. 2008
Fish	Wisconsin	Wadeable	Range	Percent intolerant individuals	QPL 99%	NA	0.06	Brenden et al. 2008
Fish	Wisconsin	Wadeable	Range	Number of salonidae fish	Nonparametric deviance reduction	NA	0.14	Brenden et al. 2008
Fish	Wisconsin	Wadeable	Range	Number of salonidae fish	Piecewise regression	NA	0.09	Brenden et al. 2008
Fish	Wisconsin	Wadeable	Range	Number of salonidae fish	Bayesian changepoint	NA	0.12	Brenden et al. 2008
Fish	Wisconsin	Wadeable	Range	Number of salonidae fish	Quantile piecewise constant (90th percentile)	NA	0.09	Brenden et al. 2008
Fish	Wisconsin	Wadeable	Range	Number of salonidae fish	Quantile piecewise constant (99th percentile)	NA	0.07	Brenden et al. 2008
Fish	Wisconsin	Wadeable	Range	Number of salonidae fish	QPL 90%	NA	0.09	Brenden et al. 2008
Fish	Wisconsin	Wadeable	Range	Number of salonidae fish	QPL 99%	NA	0.13	Brenden et al. 2008
Fish	Statewide Minnesota	Range	Range	%Sensitive	regression tree	NA	0.042	Heiskary et al. 2013
Fish	Statewide Minnesota	Range	Range	%Darter	regression tree	NA	0.103	Heiskary et al. 2013
Fish	Statewide Minnesota	Range	Range	%Simple Lithophils	regression tree	NA	0.136	Heiskary et al. 2013
Fish	Statewide Minnesota	Range	Range	%Tolerant	regression tree	NA	0.199	Heiskary et al. 2013
Fish	Statewide Minnesota	Range	Range	%Piscivores	regression tree	NA	0.081	Heiskary et al. 2013
Fish	Statewide Minnesota	Range	Range	%Intolerant	regression tree	NA	0.081	Heiskary et al. 2013
Fish	Statewide Minnesota	Range	Range	%Sensitive	regression	NA	0.152	Heiskary et al. 2013

Community	Geo_unit	System size	Watershed LULC	Response	Method	TN (mg/L)	TP (mg/L)	Citation
Fish	Statewide Minnesota	Range	Range	%Darter	regression	NA	0.094	Heiskary et al. 2013
Fish	Statewide Minnesota	Range	Range	%Simple Lithophils	regression	NA	0.121	Heiskary et al. 2013
Fish	Statewide Minnesota	Range	Range	%Tolerant	regression	NA	0.192	Heiskary et al. 2013
Fish	Statewide Minnesota	Range	Range	%Intolerant	regression	NA	0.106	Heiskary et al. 2013
Fish	North Minnesota	Range	Range	%Sensitive	regression	NA	0.043	Heiskary et al. 2013
Fish	North Minnesota	Range	Range	%Darter	regression	NA	0.036	Heiskary et al. 2013
Fish	North Minnesota	Range	Range	%Tolerant	regression	NA	0.046	Heiskary et al. 2013
Fish	North Minnesota	Range	Range	%Insectivores	regression	NA	0.075	Heiskary et al. 2013
Fish	North Minnesota	Range	Range	%Piscivores	regression	NA	0.121	Heiskary et al. 2013
Fish	North Minnesota	Range	Range	Taxa Richness	regression	NA	0.154	Heiskary et al. 2013
Fish	North Minnesota	Range	Range	%Intolerant	regression	NA	0.048	Heiskary et al. 2013
Fish	Central Minnesota	Range	Range	%Sensitive	regression	NA	0.081	Heiskary et al. 2013
Fish	Central Minnesota	Range	Range	%Darter	regression	NA	0.158	Heiskary et al. 2013
Fish	Central Minnesota	Range	Range	%Simple Lithophils	regression	NA	0.118	Heiskary et al. 2013
Fish	Central Minnesota	Range	Range	%Tolerant	regression	NA	0.188	Heiskary et al. 2013
Fish	Central Minnesota	Range	Range	Taxa Richness	regression	NA	0.209	Heiskary et al. 2013
Fish	Central Minnesota	Range	Range	%Intolerant	regression	NA	0.105	Heiskary et al. 2013
Fish	South Minnesota	Range	Range	%Sensitive	regression	NA	0.095	Heiskary et al. 2013
Fish	South Minnesota	Range	Range	%Simple Lithophils	regression	NA	0.106	Heiskary et al. 2013
Fish	South Minnesota	Range	Range	%Tolerant	regression	NA	0.383	Heiskary et al. 2013
Fish	South Minnesota	Range	Range	Taxa Richness	regression	NA	0.373	Heiskary et al. 2013
Fish	North Minnesota	Range	Range	%Sensitive	regression tree	NA	0.033	Heiskary et al. 2013
Fish	North Minnesota	Range	Range	%Darter	regression tree	NA	0.057	Heiskary et al. 2013
Fish	North Minnesota	Range	Range	%Simple Lithophils	regression tree	NA	0.039	Heiskary et al. 2013
Fish	North Minnesota	Range	Range	%Tolerant	regression tree	NA	0.034	Heiskary et al. 2013
Fish	North Minnesota	Range	Range	%Insectivores	regression tree	NA	0.053	Heiskary et al. 2013
Fish	North Minnesota	Range	Range	%Piscivores	regression tree	NA	0.033	Heiskary et al. 2013
Fish	North Minnesota	Range	Range	Taxa Richness	regression tree	NA	0.042	Heiskary et al. 2013

Community	Geo_unit	System size	Watershed LULC	Response	Method	TN (mg/L)	TP (mg/L)	Citation
Fish	North Minnesota	Range	Range	%Intolerant	regression tree	NA	0.066	Heiskary et al. 2013
Fish	Central Minnesota	Range	Range	%Sensitive	regression tree	NA	0.124	Heiskary et al. 2013
Fish	Central Minnesota	Range	Range	%Darter	regression tree	NA	0.201	Heiskary et al. 2013
Fish	Central Minnesota	Range	Range	%Simple Lithophils	regression tree	NA	0.16	Heiskary et al. 2013
Fish	Central Minnesota	Range	Range	%Tolerant	regression tree	NA	0.174	Heiskary et al. 2013
Fish	Central Minnesota	Range	Range	%Piscivores	regression tree	NA	0.085	Heiskary et al. 2013
Fish	Central Minnesota	Range	Range	Taxa Richness	regression tree	NA	0.187	Heiskary et al. 2013
Fish	Central Minnesota	Range	Range	%Intolerant	regression tree	NA	0.086	Heiskary et al. 2013
Fish	South Minnesota	Range	Range	%Sensitive	regression tree	NA	0.066	Heiskary et al. 2013
Fish	South Minnesota	Range	Range	%Darter	regression tree	NA	0.086	Heiskary et al. 2013
Fish	South Minnesota	Range	Range	%Simple Lithophils	regression tree	NA	0.146	Heiskary et al. 2013
Fish	South Minnesota	Range	Range	%Tolerant	regression tree	NA	0.31	Heiskary et al. 2013
Fish	South Minnesota	Range	Range	Taxa Richness	regression tree	NA	0.395	Heiskary et al. 2013
Fish	Central Minnesota	NonWadeable	Range	%Sensitive	regression	NA	0.116	Heiskary et al. 2013
Fish	Central Minnesota	NonWadeable	Range	%Simple Lithophils	regression	NA	0.123	Heiskary et al. 2013
Fish	Central Minnesota	NonWadeable	Range	%Tolerant	regression	NA	0.11	Heiskary et al. 2013
Fish	Central Minnesota	NonWadeable	Range	%Piscivores	regression	NA	0.099	Heiskary et al. 2013
Fish	Central Minnesota	NonWadeable	Range	%Intolerant	regression	NA	0.131	Heiskary et al. 2013
Fish	South Minnesota	NonWadeable	Range	%Insectivores	regression	NA	0.131	Heiskary et al. 2013
Fish	North Minnesota	NonWadeable	Range	%Sensitive	regression tree	NA	0.027	Heiskary et al. 2013
Fish	North Minnesota	NonWadeable	Range	%Piscivores	regression tree	NA	0.029	Heiskary et al. 2013
Fish	Central Minnesota	NonWadeable	Range	%Sensitive	regression tree	NA	0.086	Heiskary et al. 2013
Fish	Central Minnesota	NonWadeable	Range	%Simple Lithophils	regression tree	NA	0.075	Heiskary et al. 2013
Fish	Central Minnesota	NonWadeable	Range	%Tolerant	regression tree	NA	0.086	Heiskary et al. 2013
Fish	Central Minnesota	NonWadeable	Range	%Intolerant	regression tree	NA	0.086	Heiskary et al. 2013
Fish	South Minnesota	NonWadeable	Range	%Insectivores	regression tree	NA	0.199	Heiskary et al. 2013
Fish	North Minnesota	Wadeable	Range	%Sensitive	regression	NA	0.043	Heiskary et al. 2013
Fish	North Minnesota	Wadeable	Range	%Darter	regression	NA	0.1	Heiskary et al. 2013

Community	Geo_unit	System size	Watershed LULC	Response	Method	TN (mg/L)	TP (mg/L)	Citation
Fish	North Minnesota	Wadeable	Range	%Tolerant	regression	NA	0.049	Heiskary et al. 2013
Fish	North Minnesota	Wadeable	Range	%Insectivores	regression	NA	0.075	Heiskary et al. 2013
Fish	North Minnesota	Wadeable	Range	%Piscivores	regression	NA	0.052	Heiskary et al. 2013
Fish	North Minnesota	Wadeable	Range	%Intolerant	regression	NA	0.048	Heiskary et al. 2013
Fish	Central Minnesota	Wadeable	Range	%Sensitive	regression	NA	0.081	Heiskary et al. 2013
Fish	Central Minnesota	Wadeable	Range	%Darter	regression	NA	0.202	Heiskary et al. 2013
Fish	Central Minnesota	Wadeable	Range	%Simple Lithophils	regression	NA	0.118	Heiskary et al. 2013
Fish	Central Minnesota	Wadeable	Range	%Tolerant	regression	NA	0.154	Heiskary et al. 2013
Fish	Central Minnesota	Wadeable	Range	Taxa Richness	regression	NA	0.188	Heiskary et al. 2013
Fish	Central Minnesota	Wadeable	Range	%Intolerant	regression	NA	0.081	Heiskary et al. 2013
Fish	South Minnesota	Wadeable	Range	%Sensitive	regression	NA	0.05	Heiskary et al. 2013
Fish	South Minnesota	Wadeable	Range	%Darter	regression	NA	0.076	Heiskary et al. 2013
Fish	South Minnesota	Wadeable	Range	%Simple Lithophils	regression	NA	0.105	Heiskary et al. 2013
Fish	South Minnesota	Wadeable	Range	Taxa Richness	regression	NA	0.339	Heiskary et al. 2013
Fish	North Minnesota	Wadeable	Range	%Sensitive	regression tree	NA	0.034	Heiskary et al. 2013
Fish	North Minnesota	Wadeable	Range	%Darter	regression tree	NA	0.057	Heiskary et al. 2013
Fish	North Minnesota	Wadeable	Range	%Tolerant	regression tree	NA	0.034	Heiskary et al. 2013
Fish	North Minnesota	Wadeable	Range	%Insectivores	regression tree	NA	0.053	Heiskary et al. 2013
Fish	North Minnesota	Wadeable	Range	%Piscivores	regression tree	NA	0.033	Heiskary et al. 2013
Fish	North Minnesota	Wadeable	Range	Taxa Richness	regression tree	NA	0.084	Heiskary et al. 2013
Fish	North Minnesota	Wadeable	Range	%Intolerant	regression tree	NA	0.034	Heiskary et al. 2013
Fish	Central Minnesota	Wadeable	Range	%Sensitive	regression tree	NA	0.122	Heiskary et al. 2013
Fish	Central Minnesota	Wadeable	Range	%Darter	regression tree	NA	0.201	Heiskary et al. 2013
Fish	Central Minnesota	Wadeable	Range	%Simple Lithophils	regression tree	NA	0.174	Heiskary et al. 2013
Fish	Central Minnesota	Wadeable	Range	%Tolerant	regression tree	NA	0.169	Heiskary et al. 2013

Community	Geo_unit	System size	Watershed LULC	Response	Method	TN (mg/L)	TP (mg/L)	Citation
Fish	Central Minnesota	Wadeable	Range	Taxa Richness	regression tree	NA	0.159	Heiskary et al. 2013
Fish	Central Minnesota	Wadeable	Range	%Intolerant	regression tree	NA	0.093	Heiskary et al. 2013
Fish	South Minnesota	Wadeable	Range	%Sensitive	regression tree	NA	0.066	Heiskary et al. 2013
Fish	South Minnesota	Wadeable	Range	%Darter	regression tree	NA	0.086	Heiskary et al. 2013
Fish	South Minnesota	Wadeable	Range	%Simple Lithophils	regression tree	NA	0.145	Heiskary et al. 2013
Fish	South Minnesota	Wadeable	Range	%Tolerant	regression tree	NA	0.287	Heiskary et al. 2013
Fish	South Minnesota	Wadeable	Range	Taxa Richness	regression tree	NA	0.287	Heiskary et al. 2013
Macros	Wisconsin	Wadeable	Range	Percentage of EPT individuals	regression tree	1.68	0.08	Wang et al., 2007; Robertson et al. 2006
Macros	Wisconsin	Wadeable	Range	Percentage of EPT taxa	regression tree	1.3	0.09	Wang et al., 2007; Robertson et al. 2006
Macros	Wisconsin	Wadeable	Range	Hilsenhoff Biotic Index	regression tree	1.14	0.09	Wang et al., 2007; Robertson et al. 2006
Macros	Wisconsin	Wadeable	Range	Taxa richness	regression tree	0.87	0.04	Wang et al., 2007
Macros	Wisconsin	Wadeable	Range	Percentage of EPT¶ individuals	2DKS	0.98	0.09	Wang et al., 2007
Macros	Wisconsin	Wadeable	Range	Percentage of EPT taxa	2DKS	1.11	0.09	Wang et al., 2007
Macros	Wisconsin	Wadeable	Range	Hilsenhoff Biotic Index	2DKS	0.61	0.09	Wang et al., 2007
Macros	Wisconsin	Wadeable	Range	Taxa richness	2DKS	0.85	0.04	Wang et al., 2007
Macros	Wisconsin	Non-wadeable	Range	Taxa richness	regression tree	1.925	0.15	Weigel and Robertson, 2007
Macros	Wisconsin	Non-wadeable	Range	Mean pollution tolerance value	regression tree	0.634	0.064	Weigel and Robertson, 2007
Macros	Central Plains US	Wadeable	Range	Taxa richness	nCPA - threshold	1.04	0.05	Evans-White et al., 2009
Macros	Central Plains US	Wadeable	Range	Taxa richness	nCPA - 95%	2.00	0.09	Evans-White et al., 2009
Macros	Central Plains US	Wadeable	Range	Primary consumer richness	nCPA - threshold	1.14	0.05	Evans-White et al., 2009
Macros	Central Plains US	Wadeable	Range	Primary consumer richness	nCPA - 95%	2.00	0.09	Evans-White et al., 2009

Community	Geo_unit	System size	Watershed LULC	Response	Method	TN (mg/L)	TP (mg/L)	Citation
Macros	Central Plains US	Wadeable	Range	Gathering consumer richness	nCPA - threshold	0.93	0.06	Evans-White et al., 2009
Macros	Central Plains US	Wadeable	Range	Gathering consumer richness	nCPA - 95%	1.70	0.08	Evans-White et al., 2009
Macros	Central Plains US	Wadeable	Range	Scraping consumer richness	nCPA - threshold	NS	0.05	Evans-White et al., 2009
Macros	Central Plains US	Wadeable	Range	Scraping consumer richness	nCPA - 95%	NS	0.10	Evans-White et al., 2009
Macros	Central Plains US	Wadeable	Range	Shredding consumer richness	nCPA - threshold	NS	0.05	Evans-White et al., 2009
Macros	Central Plains US	Wadeable	Range	Shredding consumer richness	nCPA - 95%	NS	0.06	Evans-White et al., 2009
Macros	New York	Non-wadeable	Range	Biological Assessment Profile Score	nCPA - threshold	NA	0.07	Smith and Tran 2010
Macros	New York	Non-wadeable	Range	Nutrient Biotic Index-P	nCPA - threshold	0.51	0.011	Smith and Tran 2010
Macros	New York	Non-wadeable	Range	%mesotrophic individual	nCPA - threshold	0.41	0.009	Smith and Tran 2010
Macros	New York	Non-wadeable	Range	%eutrophic individuals	nCPA - threshold	0.5	0.02	Smith and Tran 2010
Macros	New York	Non-wadeable	Range	Hilsenhoff biotic index	nCPA - threshold	NA	0.03	Smith and Tran 2010
Macros	New York	Non-wadeable	Range	Pollution tolerance index	nCPA - threshold	1.2	NA	Smith and Tran 2010
Macros	New York	Non-wadeable	Range	Biological Assessment Profile Score	nCPA - 95%	NA	0.14	Smith and Tran 2010
Macros	New York	Non-wadeable	Range	Nutrient Biotic Index-P	nCPA - 95%	0.76	0.036	Smith and Tran 2010
Macros	New York	Non-wadeable	Range	%mesotrophic individual	nCPA - 95%	0.48	0.013	Smith and Tran 2010
Macros	New York	Non-wadeable	Range	%eutrophic individuals	nCPA - 95%	1.1	0.077	Smith and Tran 2010
Macros	New York	Non-wadeable	Range	Hilsenhoff biotic index	nCPA - 95%	NA	0.14	Smith and Tran 2010
Macros	New York	Non-wadeable	Range	Pollution tolerance index	nCPA - 95%	1.3	NA	Smith and Tran 2010
Macros	Statewide Minnesota	Range	Range	Taxa Richness	regression tree	1.4	0.153	Heiskary et al. 2013
Macros	Statewide Minnesota	Range	Range	#Collector-Gatherer	regression tree	NA	0.182	Heiskary et al. 2013

Community	Geo_unit	System size	Watershed LULC	Response	Method	TN (mg/L)	TP (mg/L)	Citation
Macros	Statewide Minnesota	Range	Range	#Collector-Filterer	regression tree	3.6	NA	Heiskary et al. 2013
Macros	Statewide Minnesota	Range	Range	Taxa Richness	regression	NA	0.154	Heiskary et al. 2013
Macros	Statewide Minnesota	Range	Range	#Collector-Gatherer	regression	NA	0.233	Heiskary et al. 2013
Macros	North Minnesota	Range	Range	Taxa Richness	regression	NA	0.126	Heiskary et al. 2013
Macros	North Minnesota	Range	Range	#Collector-Filterer	regression	NA	0.087	Heiskary et al. 2013
Macros	North Minnesota	Range	Range	#Collector-Gatherer	regression	NA	0.112	Heiskary et al. 2013
Macros	North Minnesota	Range	Range	#EPT	regression	NA	0.058	Heiskary et al. 2013
Macros	North Minnesota	Range	Range	#Intolerant	regression	NA	0.087	Heiskary et al. 2013
Macros	Central Minnesota	Range	Range	Taxa Richness	regression	NA	0.107	Heiskary et al. 2013
Macros	Central Minnesota	Range	Range	#Collector-Filterer	regression	NA	0.128	Heiskary et al. 2013
Macros	Central Minnesota	Range	Range	#Collector-Gatherer	regression	NA	0.118	Heiskary et al. 2013
Macros	Central Minnesota	Range	Range	#EPT	regression	NA	0.111	Heiskary et al. 2013
Macros	Central Minnesota	Range	Range	#Intolerant	regression	NA	0.092	Heiskary et al. 2013
Macros	South Minnesota	Range	Range	Taxa Richness	regression	NA	0.234	Heiskary et al. 2013
Macros	South Minnesota	Range	Range	#Collector-Gatherer	regression	NA	0.234	Heiskary et al. 2013
Macros	North Minnesota	Range	Range	Taxa Richness	regression tree	NA	0.098	Heiskary et al. 2013
Macros	North Minnesota	Range	Range	#Collector-Filterer	regression tree	NA	0.074	Heiskary et al. 2013
Macros	North Minnesota	Range	Range	#Collector-Gatherer	regression tree	NA	0.102	Heiskary et al. 2013
Macros	North Minnesota	Range	Range	#EPT	regression tree	NA	0.091	Heiskary et al. 2013
Macros	North Minnesota	Range	Range	#Intolerant	regression tree	NA	0.091	Heiskary et al. 2013
Macros	North Minnesota	Range	Range	%Tolerant	regression tree	NA	0.071	Heiskary et al. 2013
Macros	Central Minnesota	Range	Range	Taxa Richness	regression tree	NA	0.149	Heiskary et al. 2013
Macros	Central Minnesota	Range	Range	#Collector-Filterer	regression tree	NA	0.142	Heiskary et al. 2013
Macros	Central Minnesota	Range	Range	#Collector-Gatherer	regression tree	NA	0.149	Heiskary et al. 2013
Macros	Central Minnesota	Range	Range	#EPT	regression tree	NA	0.148	Heiskary et al. 2013
Macros	Central Minnesota	Range	Range	#Intolerant	regression tree	NA	0.142	Heiskary et al. 2013
Macros	Central Minnesota	Range	Range	%Tolerant	regression tree	NA	0.204	Heiskary et al. 2013
Macros	South Minnesota	Range	Range	Taxa Richness	regression tree	NA	0.337	Heiskary et al. 2013

Community	Geo_unit	System size	Watershed LULC	Response	Method	TN (mg/L)	TP (mg/L)	Citation
Macros	South Minnesota	Range	Range	#Collector-Filterer	regression tree	NA	0.145	Heiskary et al. 2013
Macros	South Minnesota	Range	Range	#Collector-Gatherer	regression tree	NA	0.329	Heiskary et al. 2013
Macros	South Minnesota	Range	Range	#EPT	regression tree	NA	0.329	Heiskary et al. 2013
Macros	South Minnesota	Range	Range	#Intolerant	regression tree	NA	0.411	Heiskary et al. 2013
Macros	South Minnesota	Range	Range	%Tolerant	regression tree	NA	0.411	Heiskary et al. 2013
Macros	Central Minnesota	NonWadeable	Range	Taxa Richness	regression	NA	0.123	Heiskary et al. 2013
Macros	Central Minnesota	NonWadeable	Range	#Collector-Gatherer	regression	NA	0.084	Heiskary et al. 2013
Macros	Central Minnesota	NonWadeable	Range	#EPT	regression	NA	0.144	Heiskary et al. 2013
Macros	North Minnesota	NonWadeable	Range	Taxa Richness	regression tree	NA	0.029	Heiskary et al. 2013
Macros	Central Minnesota	NonWadeable	Range	Taxa Richness	regression tree	NA	0.102	Heiskary et al. 2013
Macros	Central Minnesota	NonWadeable	Range	#Collector-Gatherer	regression tree	NA	0.102	Heiskary et al. 2013
Macros	North Minnesota	Wadeable	Range	Taxa Richness	regression	NA	0.126	Heiskary et al. 2013
Macros	North Minnesota	Wadeable	Range	#Collector-Filterer	regression	NA	0.087	Heiskary et al. 2013
Macros	North Minnesota	Wadeable	Range	#EPT	regression	NA	0.057	Heiskary et al. 2013
Macros	Central Minnesota	Wadeable	Range	#Collector-Filterer	regression	NA	0.127	Heiskary et al. 2013
Macros	Central Minnesota	Wadeable	Range	#Collector-Gatherer	regression	NA	0.103	Heiskary et al. 2013
Macros	Central Minnesota	Wadeable	Range	#EPT	regression	NA	0.092	Heiskary et al. 2013
Macros	Central Minnesota	Wadeable	Range	#Intolerant	regression	NA	0.089	Heiskary et al. 2013
Macros	Central Minnesota	Wadeable	Range	%Tolerant	regression	NA	0.29	Heiskary et al. 2013
Macros	South Minnesota	Wadeable	Range	Taxa Richness	regression	NA	0.277	Heiskary et al. 2013
Macros	South Minnesota	Wadeable	Range	#Collector-Gatherer	regression	NA	0.277	Heiskary et al. 2013
Macros	South Minnesota	Wadeable	Range	#Intolerant	regression	NA	0.199	Heiskary et al. 2013
Macros	North Minnesota	Wadeable	Range	Taxa Richness	regression tree	NA	0.098	Heiskary et al. 2013
Macros	North Minnesota	Wadeable	Range	#Collector-Filterer	regression tree	NA	0.074	Heiskary et al. 2013
Macros	North Minnesota	Wadeable	Range	#Collector-Gatherer	regression tree	NA	0.102	Heiskary et al. 2013
Macros	North Minnesota	Wadeable	Range	#EPT	regression tree	NA	0.073	Heiskary et al. 2013
Macros	North Minnesota	Wadeable	Range	#Intolerant	regression tree	NA	0.075	Heiskary et al. 2013

Community	Geo_unit	System size	Watershed LULC	Response	Method	TN (mg/L)	TP (mg/L)	Citation
Macros	North Minnesota	Wadeable	Range	%Tolerant	regression tree	NA	0.071	Heiskary et al. 2013
Macros	Central Minnesota	Wadeable	Range	Taxa Richness	regression tree	NA	0.149	Heiskary et al. 2013
Macros	Central Minnesota	Wadeable	Range	#Collector-Filterer	regression tree	NA	0.113	Heiskary et al. 2013
Macros	Central Minnesota	Wadeable	Range	#Collector-Gatherer	regression tree	NA	0.149	Heiskary et al. 2013
Macros	Central Minnesota	Wadeable	Range	#EPT	regression tree	NA	0.148	Heiskary et al. 2013
Macros	Central Minnesota	Wadeable	Range	#Intolerant	regression tree	NA	0.142	Heiskary et al. 2013
Macros	Central Minnesota	Wadeable	Range	%Tolerant	regression tree	NA	0.152	Heiskary et al. 2013
Macros	South Minnesota	Wadeable	Range	Taxa Richness	regression tree	NA	0.411	Heiskary et al. 2013
Macros	South Minnesota	Wadeable	Range	#Collector-Filterer	regression tree	NA	0.156	Heiskary et al. 2013
Macros	South Minnesota	Wadeable	Range	#Collector-Gatherer	regression tree	NA	0.269	Heiskary et al. 2013
Macros	South Minnesota	Wadeable	Range	#EPT	regression tree	NA	0.329	Heiskary et al. 2013
Macros	South Minnesota	Wadeable	Range	#Intolerant	regression tree	NA	0.35	Heiskary et al. 2013
Macros	South Minnesota	Wadeable	Range	%Tolerant	regression tree	NA	0.35	Heiskary et al. 2013
Macros	Canada	Range	Range	EPT relative abundance	regression tree	0.59	0.024	Chambers et al. 2012
Macros	Canada	Range	Range	EPT taxonomic richness	regression tree	2.8	0.022	Chambers et al. 2012
Macros	Canada	Range	Range	Modified Family Biotic Index	regression tree	2.1	0.021	Chambers et al. 2012
Macros	Canada	Range	Range	Diptera + noninsect relative abundance	regression tree	2.1	0.063	Chambers et al. 2012
NA	New York	Wadeable	Range	1o contact usability, public perception	median "slightly impacted"	0.71	0.026	Smith et al. 2015
NA	New York	Wadeable	Range	2o contact usability, public perception	median "slightly impacted"	0.71	0.029	Smith et al. 2015
NA	New York	Wadeable	Range	1o contact usability, public perception	median "substantially reduced"	0.97	0.036	Smith et al. 2015
NA	New York	Wadeable	Range	2o contact usability, public perception	median "substantially reduced"	1.04	0.05	Smith et al. 2015

Community	Geo_unit	System size	Watershed LULC	Response	Method	TN (mg/L)	TP (mg/L)	Citation
Sestonic algae	Wisconsin	Wadeable	Range	chl-a	regression tree	1.200	0.070	Robertson et al., 2006
Sestonic algae	Illinois	Non-wadeable	Row-crop	Chlorophyll a	Estimated threshold	NA	0.07	Royer et al. 2008
Sestonic algae	Ontario & Quebec	Wadeable	Row-crop	Chlorophyll a	Linear regression	0.95	0.021	Chambers et al. 2008
Sestonic algae	Canada	Range	Range	Mean Chl-a	regression tree	NA	0.014	Chambers et al. 2012
Sestonic algae	Texas & Oklahoma	Range	Range	Chl a	regression	1.6	0.15	Haggard et al. 2013
Sestonic algae	Texas & Oklahoma	Range	Range	Chl a	regression tree	0.75	0.14	Haggard et al. 2013
Sestonic algae	Texas & Oklahoma	Range	Range	Chl a	regression	NA	0.16	Haggard et al. 2013
Sestonic algae	Texas & Oklahoma	Range	Range	Chl a	regression	1.4	0.22	Haggard et al. 2013
Sestonic algae	Texas & Oklahoma	Range	Range	Chl a	regression	1.7	0.11	Haggard et al. 2013
Sestonic algae	Texas & Oklahoma	Range	Range	Chl a	regression	0.87	0.23	Haggard et al. 2013

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Table S2. Summary of TN screening levels by Arkansas HUC-8, which were the average of 75th percentiles of TN concentration site medians (2015 – 2019) and were compared to screening thresholds for biological response to TN concentration compiled from the scientific literature.

HUC-8	Name	Ecoregion	# Years	Median # Annual Medians	Screening Level (mg/L)
08010100	Lower Mississippi-Memphis	Mississippi Alluvial Plain	-	-	-
08020100	Lower Mississippi-Helena	Mississippi Alluvial Plain	-	-	-
08020203	Lower St. Francis	Mississippi Alluvial Plain	2	3	1.11
08020204	Little River Ditches	Mississippi Alluvial Plain	4	3	0.71
08020205	L'Anguille	Mississippi Alluvial Plain	5	13	1.40
08020301	Lower White-Bayou Des Arc	Mississippi Alluvial Plain	5	4	0.74
08020302	Cache	Mississippi Alluvial Plain	5	24	0.52
08020303	Lower White	Mississippi Alluvial Plain	-	-	-
08020304	Big	Mississippi Alluvial Plain	-	-	-
08020401	Lower Arkansas	Mississippi Alluvial Plain	-	-	-
08020402	Bayou Meto	Mississippi Alluvial Plain	5	4	1.26
08030100	Lower Mississippi-Greenville	Mississippi Alluvial Plain	-	-	-
08040101	Ouachita Headwaters	Ouachita Mountains	4	15.5	0.45
08040102	Upper Ouachita	Ouachita Mountains	5	20	0.28
08040103	Little Missouri	South Central Plains	5	5	0.46
08040201	Lower Ouachita-Smackover	South Central Plains	5	16	1.05
08040202	Lower Ouachita-Bayou De Loutre	South Central Plains	5	3	0.70
08040203	Upper Saline	Ouachita Mountains	5	21	0.54
08040204	Lower Saline	South Central Plains	5	4	0.60
08040205	Bayou Bartholomew	Mississippi Alluvial Plain	5	12	1.41
08040206	Bayou D'Arbonne	South Central Plains	-	-	-
08050001	Boeuf	Mississippi Alluvial Plain	-	-	-
08050002	Bayou Macon	Mississippi Alluvial Plain	-	-	-
11010001	Beaver Reservoir	Ozark Highlands	5	22	1.55
11010003	Bull Shoals Lake	Ozark Highlands	5	13	1.60
11010004	Middle White	Ozark Highlands	5	9	0.77
11010005	Buffalo	Boston Mountains	5	33	0.45
11010006	North Fork White	Ozark Highlands	3	5	0.53
11010007	Upper Black	Mississippi Alluvial Plain	-	-	-
11010008	Current	Ozark Highlands	-	-	-
11010009	Lower Black	Mississippi Alluvial Plain	2	4.5	0.51
11010010	Spring	Ozark Highlands	5	6	0.88
11010011	Eleven Point	Ozark Highlands	-	-	-
11010012	Strawberry	Ozark Highlands	5	9	0.55
11010013	Upper White-Village	Mississippi Alluvial Plain	-	-	-

HUC-8	Name	Ecoregion	# Years	Median # Annual Medians	Screening Level (mg/L)
11010014	Little Red	Boston Mountains	5	3	0.34
11070206	Lake O' The Cherokees	Ozark Highlands	-	-	-
11070208	Elk	Ozark Highlands	3	5	3.42
11070209	Lower Neosho	Ozark Highlands	-	-	-
11110103	Illinois	Ozark Highlands	5	21	3.47
11110104	Robert S. Kerr Reservoir	Arkansas Valley	2	6.5	0.78
11110105	Poteau	Arkansas Valley	5	19	1.04
11110201	Frog-Mulberry	Boston Mountains	3	7	0.35
11110202	Dardanelle Reservoir	Boston Mountains	5	3	0.60
11110203	Lake Conway-Point Remove	Arkansas Valley	5	19	1.08
11110204	Petit Jean	Arkansas Valley	5	3	0.62
11110205	Cadron	Arkansas Valley	5	7	0.63
11110206	Fourche La Fave	Ouachita Mountains	4	7	0.38
11110207	Lower Arkansas-Maumelle	Ouachita Mountains	5	16	0.74
11140105	Kiamichi	Ouachita Mountains	-	-	-
11140106	Pecan-Waterhole	South Central Plains	-	-	-
11140108	Mountain Fork	Ouachita Mountains	3	4	0.68
11140109	Lower Little Arkansas, Oklahoma	South Central Plains	5	21	0.97
11140201	McKinney-Posten Bayous	South Central Plains	5	3	0.84
11140203	Loggy Bayou	South Central Plains	-	-	-
11140205	Bodcau Bayou	South Central Plains	1	3	1.17
11140302	Lower Sulpher	South Central Plains	1	4	2.12
11140304	Cross Bayou	South Central Plains	-	-	-

Table S3. Summary of TP screening levels by Arkansas HUC-8, which were the average of 75th percentiles of TP concentration site medians (2015 – 2019) and were compared to screening thresholds for biological response to TP concentration compiled from the scientific literature.

HUC-8	Name	Ecoregion	# Years	Median # Annual Medians	Screening Level (mg/L)
08010100	Lower Mississippi-Memphis	Ozark Highlands	-	-	-
08020100	Lower Mississippi-Helena	Mississippi Alluvial Plain	-	-	-
08020203	Lower St. Francis	Mississippi Alluvial Plain	2	3	0.22
08020204	Little River Ditches	Mississippi Alluvial Plain	4	3	0.56
08020205	L'Anguille	Mississippi Alluvial Plain	5	13	0.25
08020301	Lower White-Bayou Des Arc	Mississippi Alluvial Plain	5	4	0.10
08020302	Cache	Mississippi Alluvial Plain	5	24	0.28
08020303	Lower White	Mississippi Alluvial Plain	-	-	-
08020304	Big	Mississippi Alluvial Plain	-	-	-
08020401	Lower Arkansas	Mississippi Alluvial Plain	-	-	-
08020402	Bayou Meto	Mississippi Alluvial Plain	5	4	0.26
08030100	Lower Mississippi-Greenville	Mississippi Alluvial Plain	-	-	-
08040101	Ouachita Headwaters	Ouachita Mountains	4	15.5	0.05
08040102	Upper Ouachita	Ouachita Mountains	5	20	0.03
08040103	Little Missouri	South Central Plains	5	5	0.04
08040201	Lower Ouachita-Smackover	South Central Plains	5	16	0.10
08040202	Lower Ouachita-Bayou De Loutre	South Central Plains	5	3	0.07
08040203	Upper Saline	Ouachita Mountains	5	21	0.04
08040204	Lower Saline	South Central Plains	5	4	0.06
08040205	Bayou Bartholomew	Mississippi Alluvial Plain	5	12	0.32
08040206	Bayou D'Arbonne	South Central Plains	-	-	-
08050001	Boeuf	Mississippi Alluvial Plain	-	-	-
08050002	Bayou Macon	Mississippi Alluvial Plain	-	-	-
11010001	Beaver Reservoir	Ozark Highlands	5	22	0.05
11010003	Bull Shoals Lake	Ozark Highlands	5	13	0.15
11010004	Middle White	Ozark Highlands	5	9	0.28
11010005	Buffalo	Boston Mountains	5	33	0.03
11010006	North Fork White	Ozark Highlands	3	5	0.20
11010007	Upper Black	Mississippi Alluvial Plain	-	-	-
11010008	Current	Ozark Highlands	-	-	-
11010009	Lower Black	Mississippi Alluvial Plain	2	4.5	0.07
11010010	Spring	Ozark Highlands	5	6	0.04
11010011	Eleven Point	Ozark Highlands	-	-	-
11010012	Strawberry	Ozark Highlands	5	9	0.27
11010013	Upper White-Village	Mississippi Alluvial Plain	-	-	-

HUC-8	Name	Ecoregion	# Years	Median # Annual Medians	Screening Level (mg/L)
11010014	Little Red	Boston Mountains	5	3	0.03
11070206	Lake O' The Cherokees	Ozark Highlands	-	-	-
11070208	Elk	Ozark Highlands	3	5	0.09
11070209	Lower Neosho	Ozark Highlands	-	-	-
11110103	Illinois	Ozark Highlands	5	21	0.08
11110104	Robert S. Kerr Reservoir	Arkansas Valley	2	6.5	0.10
11110105	Poteau	Arkansas Valley	5	19	0.10
11110201	Frog-Mulberry	Boston Mountains	3	7	0.04
11110202	Dardanelle Reservoir	Boston Mountains	5	3	0.16
11110203	Lake Conway-Point Remove	Arkansas Valley	5	19	0.11
11110204	Petit Jean	Arkansas Valley	5	3	0.06
11110205	Cadron	Arkansas Valley	5	7	0.05
11110206	Fourche La Fave	Ouachita Mountains	4	7	0.03
11110207	Lower Arkansas-Maumelle	Ouachita Mountains	5	16	0.09
11140105	Kiamichi	Ouachita Mountains	-	-	-
11140106	Pecan-Waterhole	South Central Plains	-	-	-
11140108	Mountain Fork	Ouachita Mountains	3	4	0.07
11140109	Lower Little Arkansas, Oklahoma	South Central Plains	5	21	0.09
11140201	McKinney-Posten Bayous	South Central Plains	5	3	0.14
11140203	Loggy Bayou	South Central Plains	-	-	-
11140205	Bodcau Bayou	South Central Plains	1	3	0.42
11140302	Lower Sulpher	South Central Plains	1	4	0.15
11140304	Cross Bayou	South Central Plains	-	-	-

Table S4. Summary of trend analysis results on log-transformed annual 75th percentiles of TN concentration site medians for all qualifying Arkansas HUC-8s using linear regression (LR) and the Mann Kendall test (MK). Results of MK were considered a very likely change for p<0.05, a likely change for p<0.10, and may be changing for p<0.20. Rates of annual change represent increases when positive, and decreases when negative. For HUC-8s with p≥0.20, or if the estimated rate of annual change was less than 0.01%, TN concentrations were not changing.

					LR		MK	
HUC-8	Name	# Years	Data Range	Average # Annual Medians	p	TN Annual Change (%)	p	TN Annual Change (%)
08020205	L anguille	19	2001 - 2019	4	<0.0001	-1.1	0.033	-0.96
08020301	Lower White-Bayou Des Arc	12	2002 - 2019	6	<0.0001	-2.9	0.064	-3.1
08020402	Bayou Meto	23	1997 - 2019	4	<0.0001	-1.1	0.042	-1.3
08040102	Upper Ouachita	23	1997 - 2019	14	<0.0001	-4.7	<0.0001	-5.2
08040103	Little Missouri	23	1997 - 2019	5	<0.0001	-1.3	0.13	-1.5
08040201	Lower Ouachita-Smackover	23	1997 - 2019	5	<0.0001	-2.5	0.073	-1.9
08040202	Lower Ouachita-Bayou De Loutre	23	1997 - 2019	3	<0.0001	-3.1	<0.0001	-3.7
08040203	Upper Saline	30	1990 - 2019	10	<0.0001	-3.2	<0.0001	-3.4
08040204	Lower Saline	22	1998 - 2019	4	<0.0001	-1.8	0.00013	-1.7
11010001	Beaver Reservoir	30	1990 - 2019	12	0.31	-	0.84	-
11010003	Bull Shoals Lake	23	1997 - 2019	6	<0.0001	-0.5	0.32	-
11010004	Middle White	23	1997 - 2019	7	0.012	-0.58	0.32	-
11010010	Spring	23	1997 - 2019	7	<0.0001	0.42	0.13	0.56
11010014	Little Red	18	1998 - 2019	9	0.035	-0.49	0.45	-
11110103	Illinois	23	1994 - 2019	9	0.13	-	0.53	-
11110105	Poteau	22	1998 - 2019	4	<0.0001	-3.1	0.08	-1.8
11110202	Dardanelle Reservoir	23	1997 - 2019	6	<0.0001	-4.3	0.17	-3.4
11110203	Lake Conway-Point Remove	30	1990 - 2019	7	<0.0001	-8.7	<0.0001	-8
11110204	Petit Jean	23	1997 - 2019	4	<0.0001	-3.9	<0.0001	-3
11110205	Cadron	14	1998 - 2019	7	<0.0001	-4.6	0.016	-3.8
11110207	Lower Arkansas-Maumelle	30	1990 - 2019	10	<0.0001	-1.5	<0.0001	-1.6
11140109	Lower Little	30	1990 - 2019	13	<0.0001	-2.5	0.0024	-2.6
11140201	Mckinney-Posten Bayous	23	1997 - 2019	4	<0.0001	-0.92	0.02	-1.1

Table S5. Summary of trend analysis results on log-transformed annual 75th percentiles of TP concentration site medians for all qualifying Arkansas HUC-8s using linear regression (LR) and the Mann Kendall test (MK). Results of MK were considered a very likely change for $p<0.05$, a likely change for $p<0.10$, and may be changing for $p<0.20$. Rates of annual change represent increases when positive, and decreases when negative. For HUC-8s with $p\geq0.20$, or if the estimated rate of annual change was less than 0.01%, TP concentrations were not changing.

					LR		MK	
HUC-8	Name	# Years	Data Range	Average # Annual Medians	p	TP Annual Change (%)	p	TP Annual Change (%)
08020205	L anguille	22	1994 - 2019	4	<0.0001	0.66	0.45	-
08020301	Lower White-Bayou Des Arc	15	1994 - 2019	6	<0.0001	-1.5	0.048	-1.5
08020402	Bayou Meto	30	1990 - 2019	4	<0.0001	-1.2	0.1	-1.1
08040102	Upper Ouachita	30	1990 - 2019	12	<0.0001	-1.3	0.027	-1.3
08040103	Little Missouri	30	1990 - 2019	5	<0.0001	-1.5	0.12	-1.7
08040201	Lower Ouachita-Smackover	30	1990 - 2019	6	<0.0001	-3.1	0.046	-3.3
08040202	Lower Ouachita-Bayou De Loutre	27	1993 - 2019	3	0.00036	-0.52	0.33	-
08040203	Upper Saline	30	1990 - 2019	12	<0.0001	-2.3	0.0024	-2.4
08040204	Lower Saline	29	1991 - 2019	5	<0.0001	-1	0.045	-0.85
08040205	Bayou Bartholomew	12	1994 - 2014	12	<0.0001	-1.4	0.11	-1.2
11010001	Beaver Reservoir	30	1990 - 2019	16	<0.0001	-2.1	0.077	-2.5
11010003	Bull Shoals Lake	30	1990 - 2019	6	<0.0001	-1.2	0.69	-
11010004	Middle White	30	1990 - 2019	6	0.34	-	0.84	-
11010005	Buffalo	15	1990 - 2019	18	<0.0001	-2.9	0.73	-
11010010	Spring	30	1990 - 2019	7	0.041	-0.16	0.89	-
11010014	Little Red	25	1990 - 2019	8	<0.0001	-2.6	0.00034	-2.6
11110103	Illinois	30	1990 - 2019	10	<0.0001	-6	<0.0001	-5.8
11110105	Poteau	30	1990 - 2019	4	<0.0001	-7.3	<0.0001	-8.6
11110201	Frog-Mulberry	12	1994 - 2018	5	<0.0001	-2.4	0.054	-4.5
11110202	Dardanelle Reservoir	30	1990 - 2019	6	0.17	-0.41	0.63	-
11110203	Lake Conway-Point Remove	30	1990 - 2019	8	<0.0001	-9	0.0016	-7.7
11110204	Petit Jean	30	1990 - 2019	4	<0.0001	-0.52	0.13	-0.57
11110205	Cadron	17	1994 - 2019	7	<0.0001	-2.4	0.077	-1.7
11110206	Fourche La Fave	14	1991 - 2019	8	<0.0001	-0.5	0.17	-0.37
11110207	Lower Arkansas-Maumelle	30	1990 - 2019	10	<0.0001	-0.96	0.012	-0.92
11140109	Lower Little	30	1990 - 2019	15	0.12	-0.43	0.52	-
11140201	Mckinney-Posten Bayous	26	1994 - 2019	4	<0.0001	-2.1	0.098	-1.2

Table S6. Summary of trend analysis results on log-transformed TN concentration at qualifying sites located in Tier 1 HUC-8s using linear regression (LR), the Mann Kendall test (MK), and the seasonal Kendall test (SKT). Results of SKT were considered a very likely change for p<0.05 or a likely change for p<0.10. Rates of annual change represent increases when positive, and decreases when negative. For HUC-8s with p≥0.10, or if the estimated rate of annual change was less than 0.01%, TN concentrations were not changing.

				LR		MK		SKT	
HUC-8	Site	Lat	Long	p	TN Annual Change (%)	p	TN Annual Change (%)	p	TN Annual Change (%)
08020205	UWLGR01	35.145	-90.8783	0.0081	-1.3	0.0024	-1.2	0.0021	-1.1
08020205	FRA0012	35.0389	-90.9111	0.016	-0.86	0.024	-0.86	0.011	-0.92
08020205	FRA0010	34.79037	-90.7519	0.97	-	0.87	-	0.86	-
08020402	ARK0097	34.7694	-91.7514	<0.0001	-2.5	<0.0001	-2.5	<0.0001	-2.6
08020402	ARK0023	34.2019	-91.5306	<0.0001	-1.3	<0.0001	-1.4	<0.0001	-1.1
08020402	ARK0060	34.86631	-92.1624	0.0042	-1.8	<0.0001	-2.3	<0.0001	-2.3
08020402	ARK0050	34.8442	-92.1221	0.85	-	0.64	-	0.45	-
11010003	WHI0067	36.2329	-93.0914	0.0067	0.74	0.004	0.48	0.0061	0.48
11010003	WHI0048B	36.251	-92.6001	0.013	2	0.027	1.8	0.0097	1.7
11010003	WHI0048C	36.2433	-92.5461	0.23	-	0.092	1.5	0.025	1.9
11010003	WHI0200	36.19813	-93.1208	0.060	2.1	0.044	1.8	0.053	1.9
11010003	WHI0066	36.2443	-93.0777	0.060	0.69	0.077	0.65	0.084	0.54
11010003	WHI0193	36.22925	-92.7106	0.46	-	0.63	-	0.24	-
11010003	WHI0047	36.366	-92.577	0.84	-	0.78	-	0.52	-
11010004	WHI0029	35.6433	-91.4617	0.013	0.93	0.018	0.75	0.017	0.75
11010004	WHI0046	36.223	-92.299	0.14	-	0.21	-	0.34	-
11010004	WHI0011	35.91031	-92.1659	0.30	-	0.67	-	0.38	-
11010004	WHI0065	36.2922	-92.3758	0.90	-	1	-	0.61	-
11110203	ARK0032	35.22592	-93.1488	<0.0001	-1.6	<0.0001	-1.6	<0.0001	-1.6
11110203	ARK0051	35.05453	-92.4291	<0.0001	-14	<0.0001	-12	<0.0001	-12
11110203	ARK0067	35.22632	-93.1424	0.0016	-2.4	0.0005	-2.6	0.0002	-3.2
11110203	ARK0167	35.49965	-92.6559	0.0006	-6.6	0.0021	-5.7	0.0009	-6.5
11110203	ARK0030B	35.07764	-92.5436	0.074	-0.67	0.1	-	0.19	-
11110203	ARK0031B	35.12708	-92.7881	0.11	-	0.11	-	0.28	-
11110203	ARK0053	35.25475	-92.8942	0.42	-	0.92	-	0.91	-
11110207	ARK0029	34.7908	-92.3589	<0.0001	-1.9	<0.0001	-1.9	<0.0001	-1.7
11110207	ARK0046	34.6686	-92.155	<0.0001	-1.5	<0.0001	-1.4	<0.0001	-1.3
11110207	ARK0048	34.2488	-91.9061	<0.0001	-1.8	<0.0001	-1.7	<0.0001	-1.5
11110207	ARK0049	34.4133	-92.1019	<0.0001	-1.8	<0.0001	-1.7	<0.0001	-1.6
11110207	ARK0147C	34.70246	-92.3248	0.15	-	0.080	-0.94	0.066	-0.82
11110207	ARK0131	34.71684	-92.2066	0.0023	-1.5	0.024	-1.1	0.15	-
11110207	ARK0147H	34.69194	-92.3614	0.67	-	0.61	-	0.33	-

Table S7. Summary of trend analysis results on log-transformed TP concentration at qualifying sites located in Tier 1 HUC-8s using linear regression (LR), the Mann Kendall test (MK), and the seasonal Kendall test (SKT). Results of SKT were considered a very likely change for p<0.05 or a likely change for p<0.10. Rates of annual change represent increases when positive, and decreases when negative. For HUC-8s with p≥0.10, or if the estimated rate of annual change was less than 0.01%, TP concentrations were not changing.

				LR		MK		SKT	
HUC-8	Site	Lat	Long	p	TP Annual Change (%)	p	TP Annual Change (%)	p	TP Annual Change (%)
08020205	FRA0010	34.79037	-90.751938	0.52	-	0.26	-	0.26	-
08020205	FRA0012	35.0389	-90.9111	0.026	1.1	0.014	1.2	0.018	1.2
08020205	UWLGR01	35.145	-90.878304	0.57	-	0.42	-	0.19	-
08020402	ARK0023	34.2019	-91.530602	0.12	-	0.12	-	0.27	-
08020402	ARK0050	34.8442	-92.122101	0.47	-	0.43	-	0.15	-
08020402	ARK0060	34.86631	-92.162376	0.089	-1.3	0.0007	-1.9	<0.0001	-1.8
08020402	ARK0097	34.7694	-91.751404	0.0003	-3.1	0.0007	-2.2	<0.0001	-2.6
11010003	WHI0047	36.366	-92.577003	<0.0001	7.7	<0.0001	6.0	<0.0001	6.2
11010003	WHI0048B	36.251	-92.600098	0.040	2.6	0.14	-	0.60	-
11010003	WHI0048C	36.2433	-92.546097	0.11	-	0.24	-	0.28	-
11010003	WHI0066	36.2443	-93.077698	0.51	-	0.43	-	0.45	-
11010003	WHI0067	36.2329	-93.0914	0.0002	2.9	0.0002	2.3	0.0021	2.2
11010003	WHI0193	36.22925	-92.710648	0.96	-	0.55	-	0.20	-
11010003	WHI0200	36.19813	-93.120811	0.014	-8.4	0.075	-4.8	0.061	-4.1
11010004	WHI0011	35.91031	-92.165855	0.17	-	0.057	1.0	0.19	-
11010004	WHI0029	35.6433	-91.4617	0.14	-	0.023	-1.1	0.061	-1.1
11010004	WHI0046	36.223	-92.299004	0.99	-	0.92	-	1.00	-
11010004	WHI0065	36.2922	-92.375801	0.22	-	0.15	-	0.048	-2.1
11110103	ARK0004A	36.21716	-94.602409	0.75	-	0.66	-	0.56	-
11110103	ARK0005	36.19893	-94.583565	<0.0001	-11.0	<0.0001	-11.0	<0.0001	-11.0
11110103	ARK0006	36.10941	-94.534454	<0.0001	-8.0	<0.0001	-7.8	<0.0001	-7.8
11110103	ARK0007A	35.87679	-94.468338	<0.0001	-3.4	<0.0001	-3.9	<0.0001	-3.8
11110103	ARK0010C	36.1344	-94.2022	<0.0001	-5.7	<0.0001	-5.5	<0.0001	-5.9
11110103	ARK0040	36.10306	-94.344223	0.0060	-2.0	0.0044	-1.8	0.0021	-1.9
11110103	ARK0082	36.1914	-94.387497	<0.0001	-3.9	<0.0001	-3.6	<0.0001	-3.6
11110103	ARK0141	36.0939	-94.508904	0.0049	1.5	0.0007	1.5	<0.0001	1.7
11110103	OSC0004	36.2406	-94.253098	0.97	-	0.65	-	0.54	-
11110203	ARK0030B	35.07764	-92.54361	0.26	-	0.26	-	0.071	0.8
11110203	ARK0031B	35.12708	-92.788139	0.81	-	0.66	-	0.92	-
11110203	ARK0032	35.22592	-93.148811	0.041	-0.7	0.033	-0.8	0.0070	-1.0
11110203	ARK0051	35.05453	-92.429077	<0.0001	-16.0	<0.0001	-13.0	<0.0001	-13.0
11110203	ARK0053	35.25475	-92.894188	0.068	1.5	0.38	-	0.53	-
11110203	ARK0067	35.22632	-93.14241	<0.0001	-6.5	<0.0001	-6.6	<0.0001	-6.1
11110203	ARK0167	35.49965	-92.655907	0.97	-	0.66	-	0.90	-
11110203	ARK0168	35.51048	-92.648933	0.72	-	0.38	-	0.29	-

				LR		MK		SKT	
HUC-8	Site	Lat	Long	p	TP Annual Change (%)	p	TP Annual Change (%)	p	TP Annual Change (%)
11110207	ARK0029	34.7908	-92.358902	0.019	-1.2	0.022	-1.0	0.0062	-1.0
11110207	ARK0046	34.6686	-92.154999	0.016	-1.1	0.011	-0.9	0.0020	-1.0
11110207	ARK0048	34.2488	-91.906097	0.0003	-1.8	0.0008	-1.6	0.0008	-1.4
11110207	ARK0049	34.4133	-92.101898	0.0074	-1.2	0.028	-0.9	0.021	-0.9
11110207	ARK0131	34.71684	-92.206581	0.0047	-2.3	0.070	-1.4	0.44	-
11110207	ARK0147C	34.70246	-92.324783	0.028	-1.5	0.021	-1.5	0.060	-1.0
11110207	ARK0147H	34.69194	-92.361389	0.14	-	0.089	-1.3	0.51	-