RIVER AND STREAM CONDITIONS IN WISCONSIN AND THE UNITED STATES

Findings of the U.S. Environmental Protection Agency's National Aquatic Resources Survey Program's Rivers and Streams Assessment

Figure 1. *WDNR crew members collecting algae and macroinvertebrate samples from Bacon Branch Creek, Grant Co., Wisconsin.*

Key Findings of the National Rivers and Streams Assessment 2018-2019:

- One third of U.S. and two thirds of Wisconsin stream and river miles had healthy fish populations.
- Over half of Wisconsin stream and river miles had excessively high concentrations of phosphorus, and over two thirds had high nitrogen concentrations. Concentration of both nutrients were significantly higher in Wisconsin than the nation as a whole.
- A quarter of stream and river miles in the US and Wisconsin had highly disturbed riparian (shoreline) habitats, while a little over half maintained healthy amounts and types of riparian vegetation.
- Enterococci, an indicator of fecal bacteria, was present at unsafe concentrations in 1/5 of U.S. and 1/6 of Wisconsin streams and rivers.
- *Microcystins*, toxins produced by cyanobacteria, were not found at unsafe concentrations in any U.S. or Wisconsin stream or river miles.

The National Aquatic Resources Survey (NARS) is a collaborative effort among state and federal agencies and tribes, led by the U.S. Environmental Protection Agency (EPA). The primary goal of NARS is to assess the physical, chemical, and biological conditions of the nation's lakes, rivers, streams, wetlands, and coastal waters on a reoccurring basis. The National Rivers and Streams Assessment (NRSA), from which 2018-2019 findings are reported here, is one component of NARS.

In 2018 and 2019, over 1,800 boatable river and wadeable stream sites representing nearly 1.2 million miles of flowing water in the continental United States were surveyed. This survey is being repeated both nationally and in Wisconsin in 2023 (streams) and 2024 (rivers).

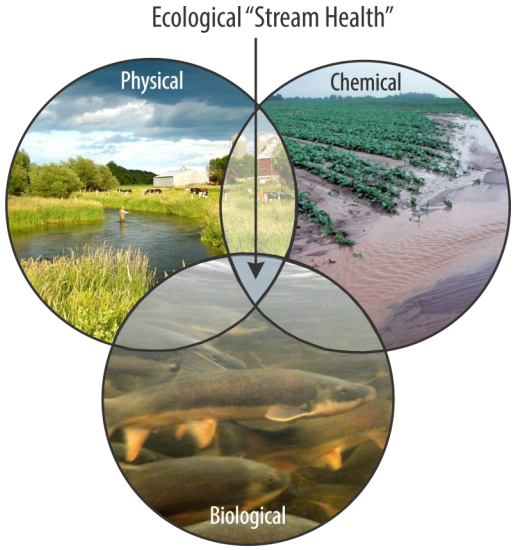


Figure 2. *NRSA assesses numerous physical, chemical, and biological attributes of stream and river conditions for a holistic evaluation of flowing waters.*

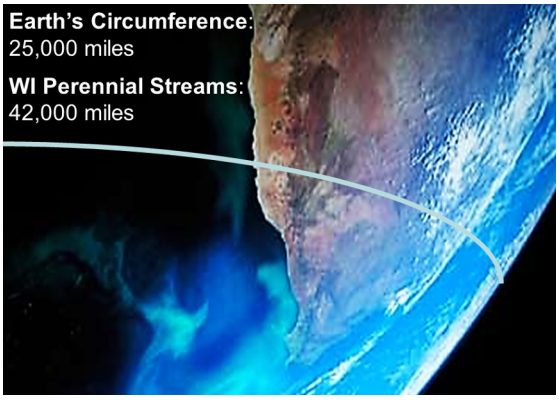


Figure 3. *Comparison of Earth's circumference and the total length of Wisconsin's perennial streams and rivers.*

Why NARS is Important

Clean water is essential for life. Knowing the conditions of our aquatic resources and what affects their quality is fundamentally important. The continental United States has nearly 4 million miles of flowing water. Wisconsin has over 40,000 miles of perennially-flowing streams and rivers, enough miles to encircle the planet over 1.7 times. To adequately sample each river and stream would take decades and would be prohibitively expensive. However, for science-based management of land and water resources, it is important to accurately assess the condition of the state's and nation's waters and understand what factors influence their quality.

Prior to NARS the federal government could not accurately assess the condition of the nation's water resources. In the 2000s, the General Accounting Office, National Research Council, The Heinz Center, EPA, and others, all reported that the federal government did not have the monitoring data needed to effectively manage water resources programs or to make scientifically-defensible statements about the condition of waters across the U.S.. In part, due to differences among states' assessment and evaluation methods and inadequacies of some states' monitoring programs. The NARS program offers a rigorous assessment of the nation's surface waters, providing data of known quality by using a statistically-valid sampling design and nationally-consistent field, lab, and data interpretation methods.

Analogous to a tree, there are many more small streams (branches) than larger rivers (limbs) in a watershed. From headwaters to a stream or river's mouth, there are continuous, predictable, natural changes in physical and chemical characteristics that result in biological changes. Streams and rivers also have natural geographic variability and are also strongly influenced by varying types of human disturbances across the landscape.

Figure 4. *Shaded relief map of Wisconsin land formations, and groundwater-dominated streams colored blue.*

Bedrock and surficial geology, and landscape formations influence groundwater recharge and subsequent discharge to streams. Darker shading in Figure 4 shows areas with greater topographic relief. The blue lines represent larger streams with greater proportions of groundwater inputs than surface water runoff. This "baseflow" influences stream water temperatures, flow volume stability, water chemistry characteristics, and can moderate the effects of runoff pollution and other types of human disturbance.

Urban and agricultural land uses can degrade streams[1,2]. Figure 5 shows the distribution of Wisconsin's human population. Taller red bars indicate areas with greater human density. Streams in urbanized watersheds often have altered flow regimes (higher storm-flows and lower baseflow), eroded streambanks, poorer in-stream habitat, degraded water quality, and as a result, significantly poorer biological conditions.

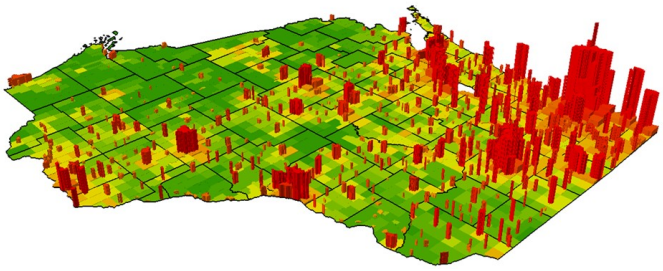


Figure 5. *Taller red bars indicate greater human population density.*

Over 35% of Wisconsin's land area is used for agriculture.[3] Darkening coloration in Figure 6 shows watersheds with increasingly higher proportions of row crop agriculture. Row cropping tends to deliver more sediment, nutrients, and agrochemicals to surface waters than most other types of agricultural land use.

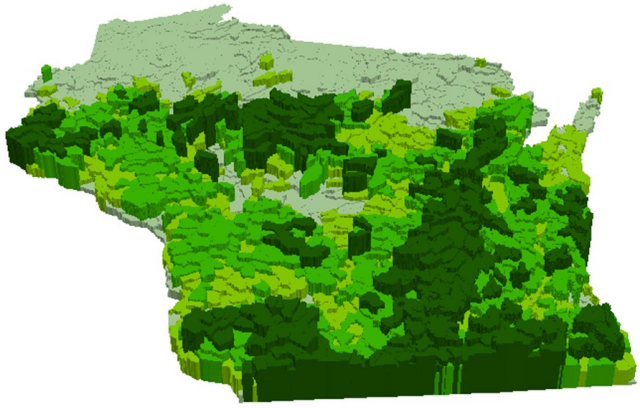


Figure 6. *Darker coloration indicates watersheds with higher proportions row cropping.*

A U.S. Geological Survey study done in Wisconsin estimated that 150 tons of soil and 653 pounds of phosphorus are lost from each square mile of land in agricultural watersheds each year.[4] This equates to approximately four dump trucks of soil and over 150 lbs. of phosphorus flowing out of a 100 mi.^{2} watershed each day.

Excess sediment smothers streambed habitat, scours aquatic plants and animals, reduces water clarity, and increases solar heating; all of these factors are stressful to aquatic organisms and degrade overall stream health. Excess nutrients, particularly phosphorus and nitrogen, promote algae growth, which alters aquatic food chains, and increases day-night fluctuations in dissolved oxygen concentrations.

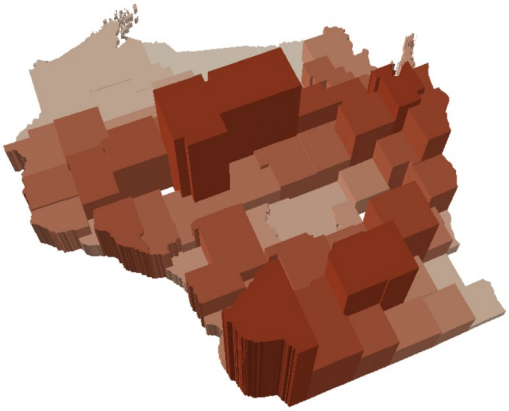


Figure 7. *Darker, taller, extrusions show Wisconsin counties with higher numbers of cattle.*

Wisconsin's millions of livestock produce a large amount of waste, that contains phosphorus, nitrogen and other nutrients, as well as bacteria, viruses, and pharmaceuticals. Figure 7 shows, Wisconsin county cattle densities.[5] On average, one dairy cow produces 115 pounds of manure each day.[6] Wisconsin's 1.2 million head of dairy cows alone, produce an estimated 54 billion pounds of manure each year; enough manure to a fill Camp Randall Stadium in Madison (Figure 8), every four months!

Figure 8. *Camp Randall Stadium Madison, Wisconsin.*

SURVEY DESIGN

NRSA uses a nationally-consistent assessment of all flowing waters, excluding reservoirs, brackish waters along ocean coastal areas, and streams that flow intermittently. A set number of candidate sampling sites are randomly selected from all sizes of streams and rivers within all major ecoregional areas in the U.S. This stratified-random sampling design reduces sampling biases and results in comprehensive survey data of known statistical quality. These data are then analyzed to objectively evaluate the conditions of the Nation's rivers and streams. The WDNR increases the number of sites surveyed in Wisconsin to provide a statistically-robust state-scale survey of both streams and rivers. While WDNR has water quality standards for some pollutants, and has various biological and habitat indexes to interpret field data, EPA indexes and thresholds[7] were used in this report to allow direct comparisons between Wisconsin and national survey findings.

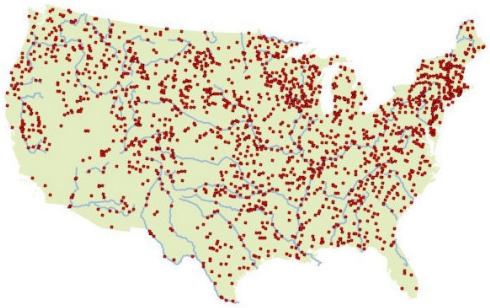


Figure 9. *Locations of NRSA 2018—2019 sampling sites.*

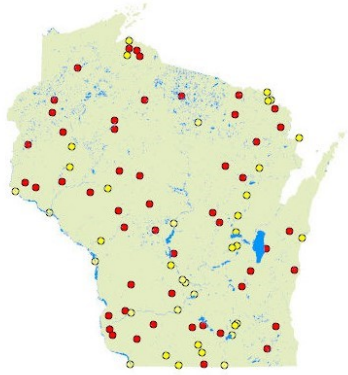


Figure 10. *NRSA sampling sites in Wisconsin, yellow dots show the locations of river sampling sites, red dots indicate the stream sites.*

Strahler's stream ordering system is used to account for the number of streams and rivers of different sizes. A headwater stream is designated as order "1", when two "1st order" streams join together, it becomes a "2nd order", when a 1st and 2nd order join, the downstream reach is 2nd order, etc. The lower reaches of the Chippewa River for example, is "8th" order, and the Mississippi River is 9th order at Prairie Du Chien, WI. The definitions for streams or rivers are somewhat arbitrary. For NRSA sampling sites selection, Strahler stream orders 1-2 are classified as small wadeable streams; orders 3-4 as large wadeable streams, and orders 5+ are designated as boatable rivers. Small streams are more numerous than large rivers, but small streams tend to be shorter in length than river segments (Figure 11). Each randomly selected stream or river sampling site in the NRSA sample population was assigned a "weight" to account for the total length of flowing waters the individual sample site represented in the overall study population. For example, survey results from a Strahler 2nd order (stream) site has a greater influence on the overall state and national resource condition estimates than a Strahler 7th order (river) sample site that represents a much smaller proportion of the overall number or length of flowing waters in Wisconsin or the U.S.

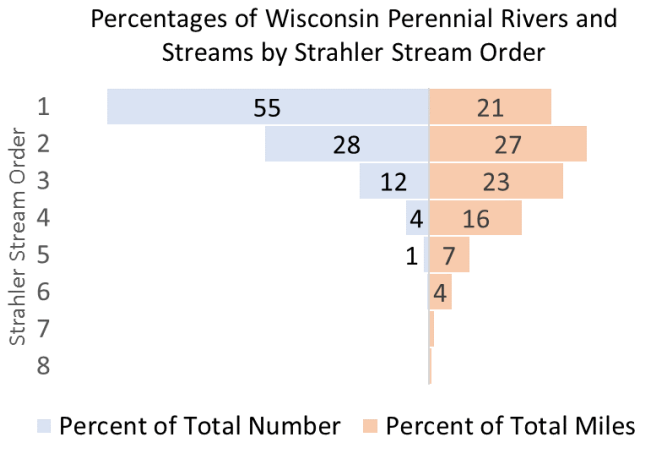


Figure 11. *Percent total number and percent total miles of streams and rivers in Wisconsin by Strahler stream order.*

BIOLOGICAL SURVEY FINDINGS

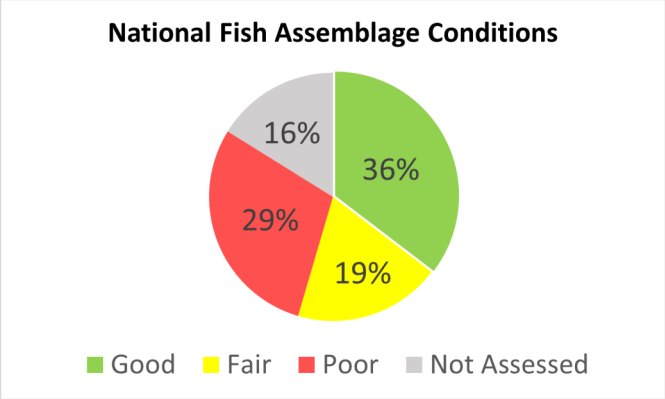
Fish are a key indicators of ecosystem health. 21,893 individual fish representing 105 species and 2 species hybrids were caught (and released) during the 2018-2019 NRSA survey in Wisconsin. A total of 57 different fish species or hybrids were captured in streams and 100 species or hybrids in rivers. The school of common fish names (Figure 13) shows the species captured during the state survey. Names with larger text size were species more numerous in the overall total catch. Names in blue represent species primarily (95% or more of that species' individuals) caught in rivers, green text represents species primarily caught in streams, black text represents species commonly caught in both streams and rivers, and red text indicates threatened, endangered, or species of special concern in Wisconsin. Survey results suggest many fish species inhabit either streams or rivers, and nearly 30% of the species captured were commonly found in all sizes of flowing water. Sampling efficiency can sometimes bias results; for example, small bottom-dwelling fish like darters may be common in larger rivers but are often out of reach of crews sampling from boats. Conversely, a fast swimming fish like northern pike may out-distance a sampling crew wading up a stream when electrofishing.

Figure 12. *Smallmouth bass (top) and white sucker are relatively common in Wisconsin streams and rivers.*

Smallmouth bass were found at nearly all (97%) of the river survey sites in Wisconsin, and white suckers were the most commonly encountered stream species, being found at 73% of the stream sampling sites.

Figure 13. *Fish species captured in Wisconsin streams and rivers during the NRSA 2018-2019 survey. Species most common in rivers (blue), stream species (green), species common to both streams and rivers (black), and endangered, threatened, or species of special concern in Wisconsin (red).*

Multi-metric stream and river condition indexes incorporate various ecological attributes of plant, animal, or physical habitat surveys into a single numeric score to assess environmental conditions. The fish survey results reported are a multi-metric fish index developed by EPA for the national survey. The condition estimates of streams and rivers are combined in the national and Wisconsin assessment pie charts on the following page (Figure 14), and the mirrored bar chart (Figure 15) shows fish assemblage conditions for Wisconsin streams and rivers reported separately. Waters "not assessed" indicate some survey sites had no or insufficient numbers of fish captured to calculate fish index scores.



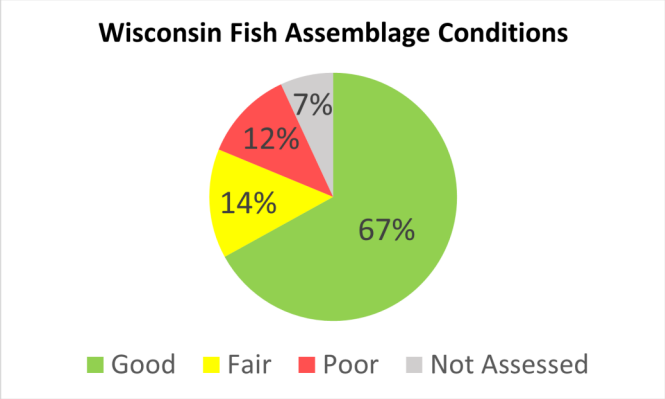


Figure 14. *Proportions of river and stream miles both nationally and in Wisconsin with "good", "fair" or "poor" fish index of biological integrity scores.*

Wisconsin had almost twice as many streams and river miles with healthy fish assemblages compared to the nation as a whole. Wisconsin survey results indicate that overall streams were healthier than the rivers in the state, based on the fish index results.

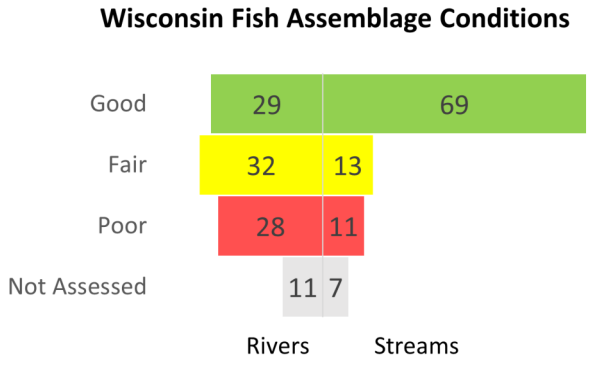


Figure 15. *Proportions of river or stream miles in Wisconsin with "good", "fair" or "poor" fish index scores.*

The bar chart below (Figure 16) shows the 30 fish species most commonly captured in Wisconsin streams and rivers during the NRSA 2018—2019 survey. A larger number of fish species occurred more frequently and more equitably among river sites than streams. Conversely, wadeable streams typically had a small number of frequently occurring species. Fish species most common to rivers were rarely common in streams and vice-versa, though exceptions include white suckers, common shiners, and bluntnose minnows, which were routinely captured in both streams and rivers.

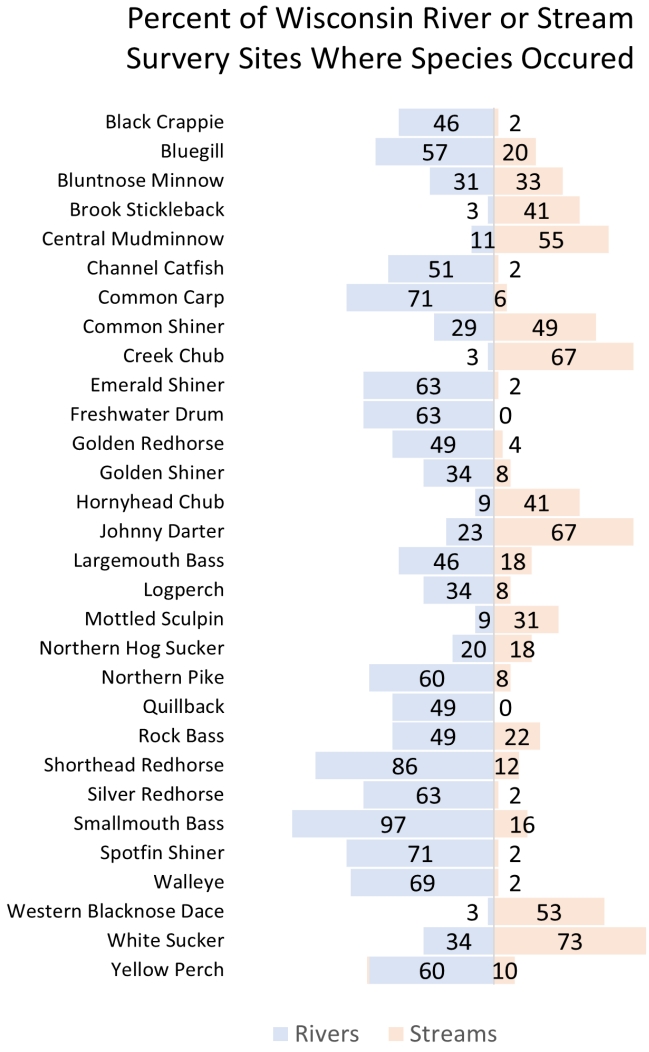


Figure 16. *Frequency of occurrence of most-common fish species captured in rivers or streams in Wisconsin during NRSA 2018-2019. Numbers inside of histogram bars are the percent of river or stream survey sites where the species was captured.*

Fish species composition and species densities at a survey site often varied by stream or river size. Rivers tended to be more species rich than streams. On average, 18 fish species were captured at river sites and 9 species were captured at stream sites (Figure 17). Figure 18 shows the relative densities of fish species captured at NRSA river or stream sites. Rivers tended to have numbers of fish more equitably distributed among species, while streams tended to be numerically-dominated by a few species. The Emerald Shiner was the most numerous river species captured in the total catch and the Creek Chub was the most numerous stream species.

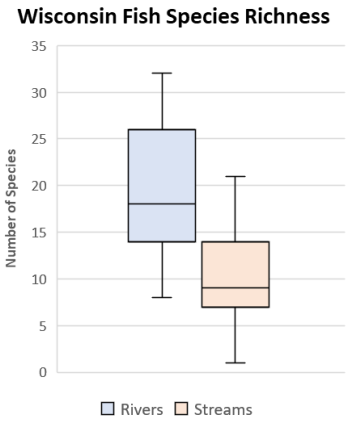
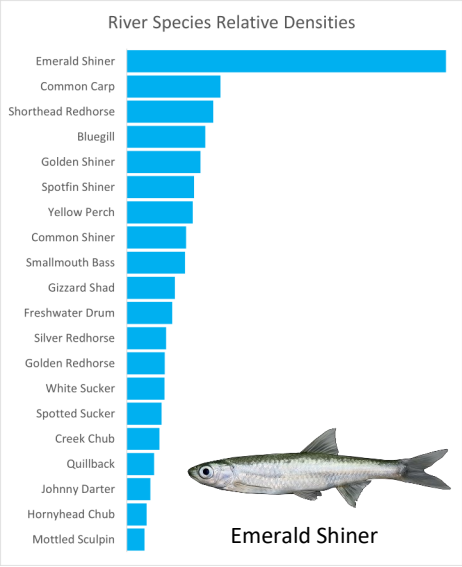


Figure 17. *Fish species richness in Wisconsin streams and rivers based on NRSA 2018—2019 findings.*



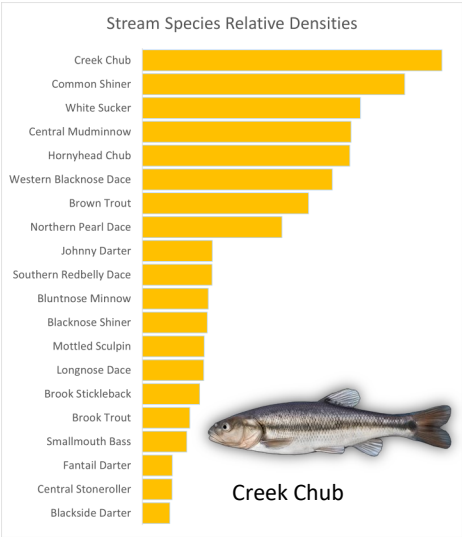


Figure 18. *Relative densities of fish species in Wisconsin rivers or streams during the NRSA survey 2018-2019.*

Aquatic macroinvertebrates (insects, crustaceans, aquatic worms, snails, leeches, etc.) are key links in aquatic and terrestrial food webs. They are primary consumers of plant matter and in-turn are important food sources for fish, amphibians, birds, and other invertebrates. Similar to fish, the types and numbers of macroinvertebrate found in streams and rivers can be key indicators of environmental conditions. Typically being less mobile than fish, aquatic macroinvertebrates are thought to be better biological indicators of local conditions of streams or rivers compared to wider-ranging fish.

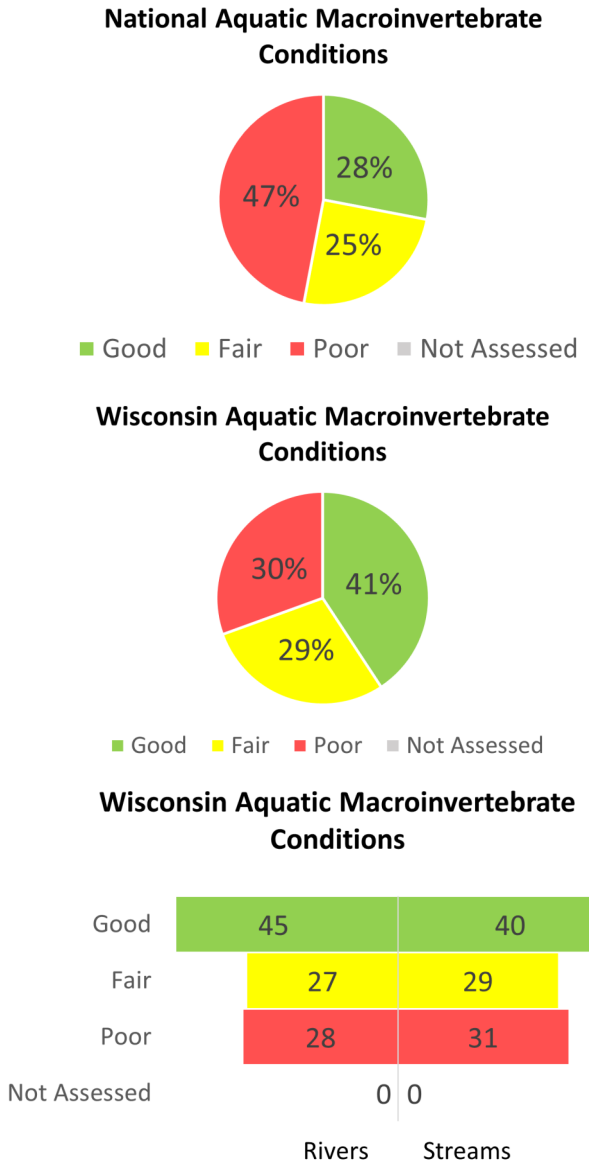


Figure 19. *Proportions of river and stream miles nationally and in Wisconsin with "good", "fair"' or "poor" ecological conditions based on aquatic macroinvertebrate index scores.*

CHEMISTRY FINDINGS

Median water column concentrations of various physical, chemical, and biological parameters for Wisconsin streams and rivers are reported in Table 1. Many of the values differed between streams and rivers as expected, and were within the ranges of values typically reported in the literature for flowing waters. The median value for total phosphorus and total nitrogen in Wisconsin streams and rivers exceeded EPA water quality standards (0.049 mg/L for phosphorus, and 1.024 mg/L for nitrogen, respectively) for streams and rivers in the Upper Midwest Ecoregion. None of the other median water column parameters exceeded state or federal water quality standards.

Wisconsin Water Column Parameter Median Values		
Analyte	River	Stream
Ammonia mg/L	**0.029**	0.027
Calcium mg/L	30.7	**33.5**
Chloride mg/L	**11.1**	9.23
Chlorophyll µg/L	2.32	**2.78**
Color PCU	**40**	30
Conductivity µS/cm	267	**315**
Dissolved Organic Carbon mg/L	**8.77**	4.28
Dissolved Oxygen mg/L	8.46	**9.15**
Enterococci CCE/100mL	**560**	474
Magnesium mg/L	15.0	**15.7**
Nitrate mg/L	0.61	**2.62**
Nitrite mg/L	**0.015**	0.009
Periphyton Biomass mg/L	NA	**0.54**
Periphyton Chlorophyll µg/cm^2	**1.98**	1.24
pH	7.5	**7.9**
Potassium mg/L	**2.08**	1.54
Silica mg/L	10.5	12.9
Sodium mg/L	**7.12**	5.13
Sulfate mg/L	7.92	**9.57**
Temperature °C	**20.6**	16.0
Total Nitrogen mg/L	1.36	**1.84**
Total Phosphorus mg/L	**0.093**	0.065
Total Suspended Solids mg/L	**10.8**	6.0
Turbidity NTU	**7.4**	4.0

Table 1. *Wisconsin rivers and streams water column parameter median values for NRSA 2018—2019. Bolded values are the highest values between the pairs.*

Excess nutrients in streams and rivers can promote filamentous algae growth, which is a poor food source for many aquatic invertebrate grazers.

Microscopic plants (benthic algae) cover nearly every surface in a stream or river that has sufficient sunlight. Excess phosphorus, and in some instances nitrogen, increase algae and rooted aquatic plant (macrophyte) growth and causes changes in benthic and planktonic algal types, including increased filamentous algae growth. Filamentous algae is a poor food source for many of the invertebrate grazers that are the base of stream food webs.

Algae and aquatic macrophytes produce oxygen during daylight (photosynthesis) and use dissolved oxygen at night (respiration). Excess algal and macrophyte growth can increase day-night fluctuations in dissolved oxygen concentrations, that can be stressful to aquatic invertebrates and fish.

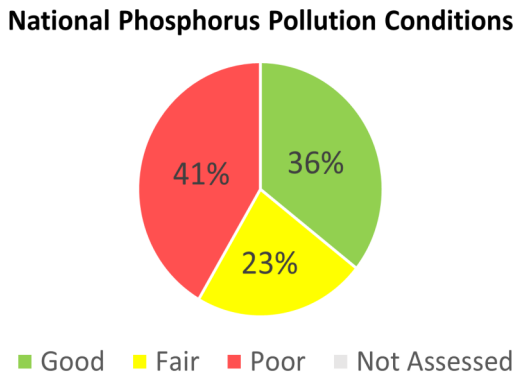


Figure 20. *Proportions of river and stream miles nationally with "good", "fair"' or "poor" total phosphorus concentrations.*

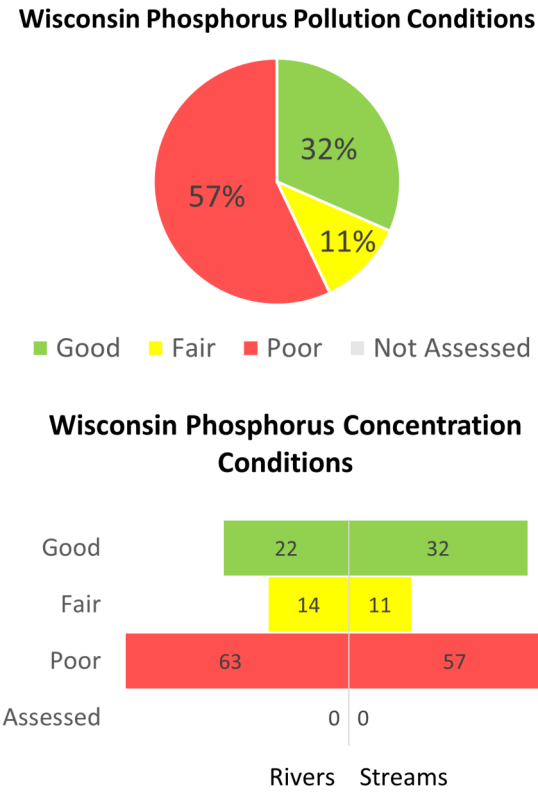


Figure 21. *Proportions of river and stream miles in Wisconsin with "good", "fair"' or "poor" total phosphorus concentrations.*

Wisconsin had a greater proportion of streams and rivers miles with excess amounts of phosphorus compared to the nation as a whole.

Nitrogen is found in numerous forms in water including ammonia, which is highly toxic to mollusks, other aquatic invertebrates, and fish. Nitrogen can also be a limiting factor for plant growth, second only to phosphorus in this role in freshwater ecosystems. Total nitrogen concentration water quality thresholds developed for NRSA were used in the following stream and river condition estimates.

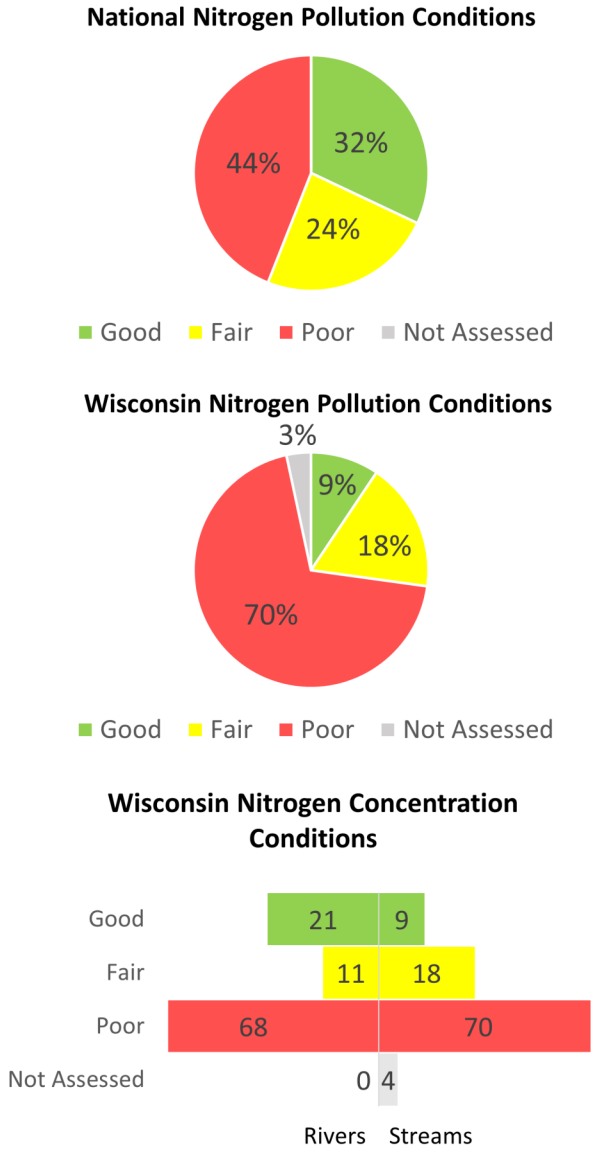


Figure 22. *Proportions of river and streams miles nationally and in Wisconsin with "good", "fair"' or "poor" total nitrogen concentrations.*

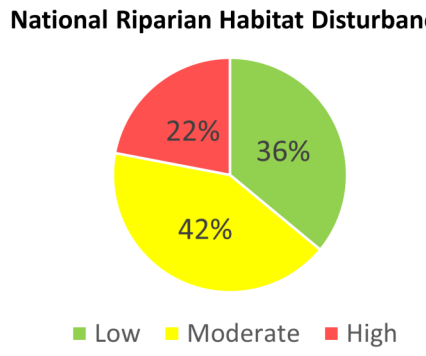
Wisconsin had a significantly greater proportion of stream and river miles with excess nitrogen than the nation as a whole, largely due to annual inputs of agricultural fertilizers and spreading of livestock manure.

RIPARIAN HABITAT FINDINGS

The land-water interface is a vital habitat for many plant and animal species.

Land cover and land use at the land-water interface (ecotone) is critically important to the functioning of aquatic and terrestrial ecosystems. Riparian areas are key habitat for many aquatic, amphibious, and terrestrial species, and can buffer streams and rivers from the effects of many upland human disturbances.

Visual estimates were used to assess riparian habitat conditions at NRSA survey sites. Roadways, urban development, cropland, rip-rap, and storm drains, are examples of disturbance factors noted. Disturbances were weighted by their areal-extent and proximity to the shoreline.



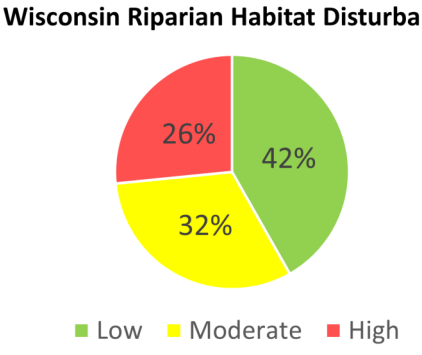


Figure 23. *Proportions of river and stream miles nationally and in Wisconsin with "good", "fair" or "poor" riparian habitat quality index scores.*

Wisconsin has a greater proportion of stream and river miles with high amounts of riparian disturbance than the nation as a whole, but also a greater amount of miles with low amounts of disturbance.

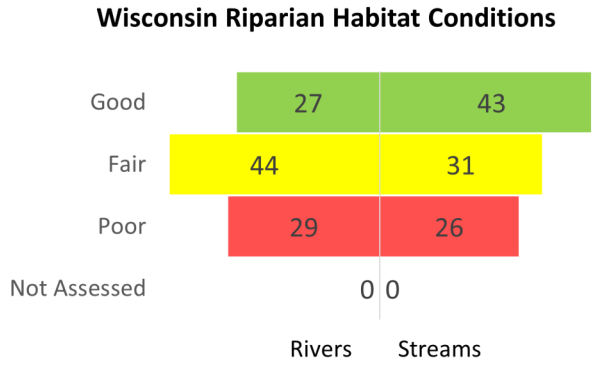
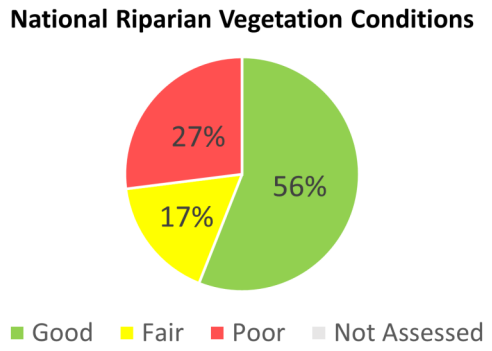


Figure 24. *Proportions of river or stream miles in Wisconsin with "good", "fair"' or "poor" riparian habitat conditions.*

Riparian vegetation complexity influences riparian habitat quality and its ability to buffer upland human land use disturbances. Terrestrial vegetation also provides important energy inputs to streams and can moderate the influences of solar heating and ambient air temperatures. The majority of stream and river miles nationally and in Wisconsin have riparian vegetation in good condition, with rivers in Wisconsin having better vegetation condition than streams and rivers combined.



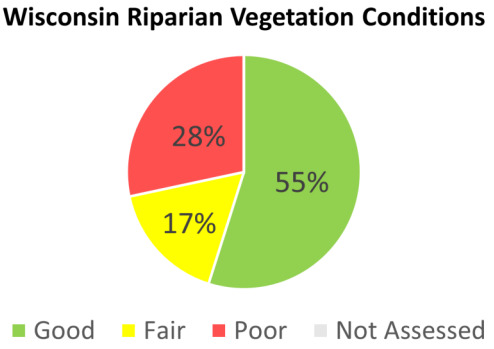


Figure 25. *Proportions of river and stream miles nationally and in Wisconsin with "good", "fair" or "poor" riparian vegetation condition scores.*

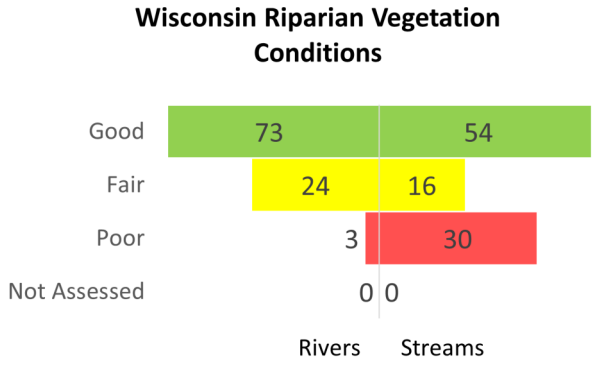
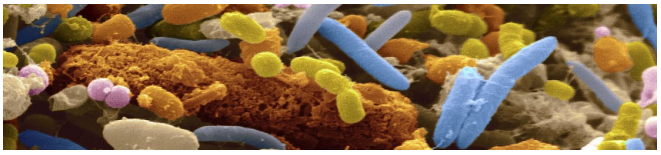


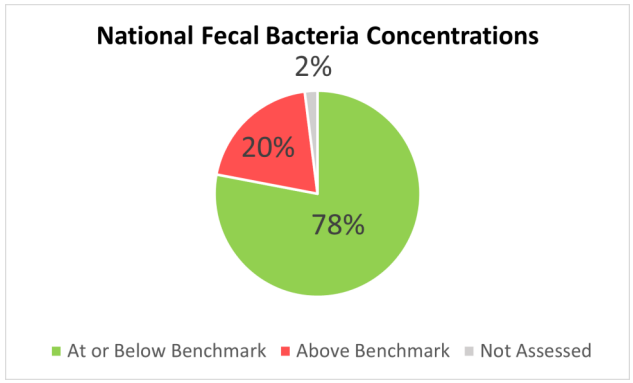
Figure 26. *Proportions of rivers and streams both nationally and in Wisconsin with "good", "fair"' or "poor" riparian vegetation condition scores.*

The majority of stream and river miles nationally and in Wisconsin have riparian vegetation in good condition, with rivers in Wisconsin having better vegetation condition than streams in the state.



Elevated bacteria concentrations in surface waters pose risks to humans, fish, and wildlife.

Bacteria concentrations in streams and rivers from livestock manure, failing septic systems, land-spread sewage sludge, storm sewers and wastewater discharges, limit the public's ability to safely recreate. Enterococci are a type of bacteria found in the intestinal tracts of warm-blooded animals (including humans), and is a good environmental marker of disease-causing agents found in fecal waste. Bacteria concentration findings for the nation and Wisconsin were quite similar.



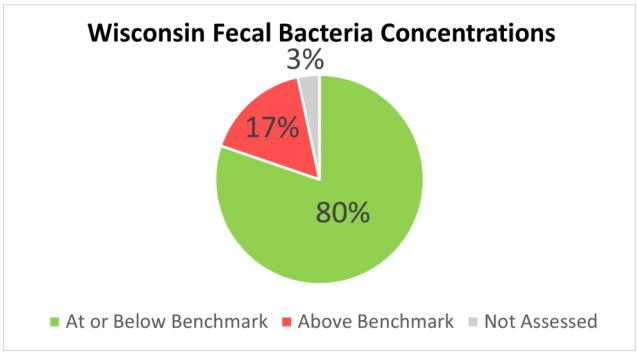


Figure 27. *Proportions of river and stream miles both nationally and in Wisconsin with enterococci bacteria concentrations above U.S. EPA's recreational water quality criterion.*

The large majority of stream and rivers miles in Wisconsin and Nationally have enterococci concentrations below the EPA's safe benchmark for recreation. However, one sixth of miles in Wisconsin are over the benchmark, so contact WDNR if you have concerns about a fecal contamination in a body of water.

While rare, toxic algal blooms pose risks, to humans, fish, and wildlife.

Cyanobacteria are photosynthetic bacteria commonly referred to as blue-green algae. Certain cyanobacteria can produce chemicals (cyanotoxins) that are irritants or toxins to aquatic and terrestrial animals. Blue green algae are most prominent in lake and river systems with excess nutrients. During certain environmental conditions, cyanobacteria numbers expand rapidly into harmful algal blooms. Microcystins are one of the more common cyanotoxins produced by these bacteria that is toxic to animals.

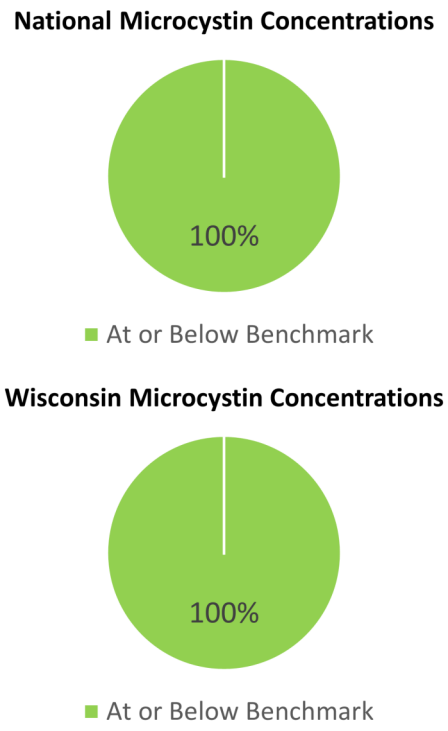


Figure 28. *Proportions of river and stream miles both nationally and in Wisconsin with microcystin concentrations above the World Health Organization's[6] algal toxin benchmarks for recreation.*

None of the stream and river miles nationally or in Wisconsin had microcystin concentrations over the World Health Organization's benchmark for safe recreation. It is still possible for specific rivers or streams to have dangerous levels of cyanobacteria growth, so it is important to contact WDNR if you have concerns about blue-green algae in a body of water.

Aquatic invasive species (AIS) assessments have been integrated into the National Aquatic Resource Surveys to assess AIS spread in Wisconsin. The first AIS survey was conducted during the National Rivers and Streams Assessments in 2018. The NRSA field crew were trained to identify common AIS, and were provided identification guides with distributions of less common species as well a species not yet present but proximal to the state.

The crew surveyed for AIS at 42 sites in 2018 and less than 50% of streams surveyed contained AIS. This was expected since many of these streams and their headwaters are not easily accessible. Of the 20 sites with AIS, rusty crayfish, curly leaf pondweed, and reed canary grass were the most common AIS observed, all of which have been present in the state for decades.

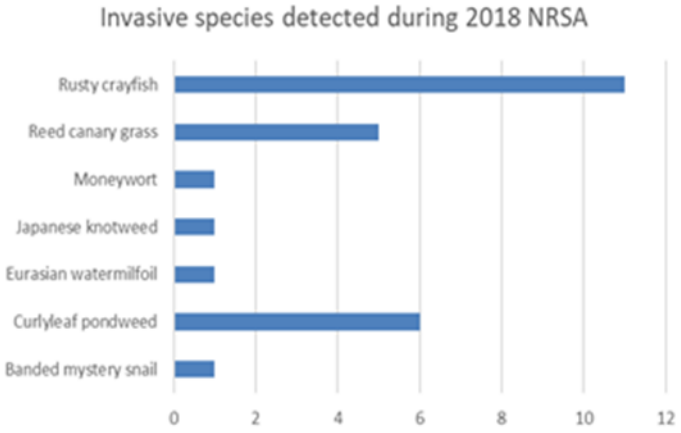


Figure 29*. Frequency of occurrence of invasive species in streams detected during the 2018 National Rivers and Streams Assessment.*

ADDITIONAL NATIONAL FINDINGS

Relative risk compares the proportion of survey sites with poor environmental conditions for a specific stressor (e.g. excessive streambed sediment) to the portion of these "stressed" sites that also have poor biological conditions. If for example, a majority of sites with excess sediment also have poor biology, it is evidence this specific stressor may strongly influences stream or river biota. Relative risk scores above 1.0 indicate the particular stressor influences aquatic organisms. Only stressors that significantly influenced macroinvertebrates are shown in Figure 32. Stressors with higher scores suggest the stressors is more detrimental to aquatic life than stressors with lower scores. Only national findings are reported. Few Wisconsin stream or river sites had anomalously-low pH, but at the national level some regions were prone to "acidification." Similarly, high salinity was prevalent in some regions of the U.S. but was less a frequent problem in Wisconsin.

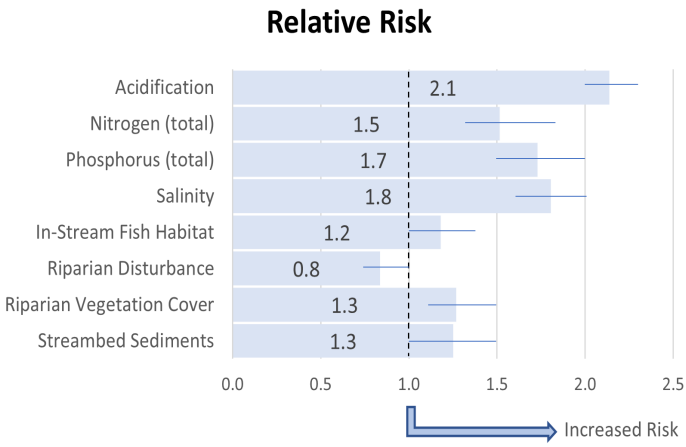


Figure 30. *Relative risk of various stressors impacting stream and river macroinvertebrate assemblages across the U.S. Higher scores indicate stressors with greater impact on aquatic life.*

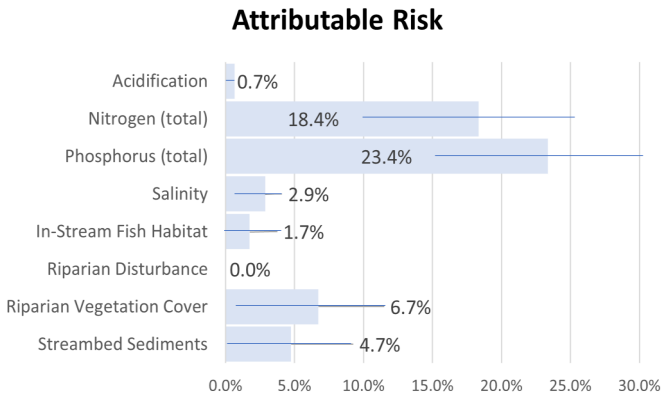


Figure 31. *Attributable risk estimates of the percent of stream and river miles in the U.S. that would have improved biological conditions, if the stressors listed above were reduced from most disturbed condition to moderately-disturbed or least-disturbed conditions.*

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Have questions about the National Rivers and Streams Assessment or national or Wisconsin findings?

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