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National Rivers and Streams Assessment 2013–2014:

A Collaborative Survey

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Acronyms and Abbreviations

ANC	Acid-neutralizing capacity
CWA	Clean Water Act
EPA	U.S. Environmental Protection Agency
MMI	Multimetric index
NARS	National Aquatic Resource Surveys
NHD	National Hydrography Dataset
NRSA	National Rivers and Streams Assessment
OW	Office of Water
PCB	Polychlorinated biphenyls
PFAS	Per- and polyfluoroalkyl substances
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
ppb	Parts per billion
qPCR	Quantitative polymerase chain reaction

Ecoregions

CPL	Coastal Plains ecoregion
NAP	Northern Appalachians ecoregion
NPL	Northern Plains ecoregion
SAP	Southern Appalachians ecoregion
SPL	Southern Plains ecoregion
TPL	Temperate Plains ecoregion
UMW	Upper Midwest ecoregion
WMT	Western Mountains ecoregion
XER	Xeric ecoregion

Executive Summary

Rivers and streams shape America's landscape. They support fish and other aquatic life and provide food and habitat for birds and wildlife. Rivers and streams provide us with water for drinking, irrigation, hydropower, navigation, waste management, industrial use, and recreation. Indeed, rivers and streams are vital to our country's history, culture, and economy.

The National Rivers and Streams Assessment (NRSA) is one of the four National Aquatic Resource Surveys (NARS) collectively designed to assess the quality of America's water resources. *The National Rivers and Streams Assessment 2013–2014: A Collaborative Survey* describes the results of a nationwide statistical survey that was conducted in the summers of 2013 and 2014 by EPA and its state, tribal, and federal partners. The report provides a snapshot of the quality of perennial rivers and streams across the U.S. during the sampling period. The report also includes information on the differences in river and stream condition relative to the previous NRSA survey in 2008–09.

For 2013–14, survey crews sampled 1,853 river and stream sites. These sites were part of a random sample selected to represent the quality of the larger population of perennial rivers and streams across the lower 48 states, from large rivers to small headwater streams. Water quality was assessed using physical, chemical, biological, and human health indicators. To determine water quality conditions, sampling results were compared to regional or national benchmarks.

When appropriate, EPA used the nationally applicable benchmarks, such as the human health screening value for mercury in fish tissue, to interpret survey results. Results were categorized as "exceeds benchmark" or "at or below benchmark" for most of these national benchmarks. Some of the water quality indicators vary naturally across the country. For these indicators, EPA developed regionally relevant benchmarks drawing from conditions represented by a set of least-disturbed (or reference) sites in each of the nine different ecoregions. The reference site distribution was used to establish categories of "good," "fair," or "poor," which were applied to the findings. Waters scoring "good" had indicator values as good as the best 75 percent of the distribution of reference sites in an ecoregion. Waters scoring "poor" had indicator values worse than 95 percent of the distribution of reference sites in an ecoregion. Waters scoring

"fair" had indicator values in between the "good" and "poor" categories. Note that these categories are relative to NRSA benchmarks, not individual state water quality standards. Therefore, the nationally representative snapshot of water quality provided by NRSA does not have regulatory implications; the NRSA categories are not replacements for the evaluation states and tribes conduct on the quality of rivers and streams relative to state water quality standards.

This report provides inferences about the quality of perennial rivers and streams at the national and ecoregion scales, as well as national differences in quality compared to 2008–09 survey data.[1] Additional information from the assessment, including regional results (e.g., for EPA regions and Mississippi River subwatersheds), regional differences in quality from 2008–09 to 2013–14, and differences in wadeable stream quality between 2013–14 and the initial Wadeable Streams Assessment in 2004, is available in an interactive dashboard online: https://riverstreamassessment.epa.gov/dashboard.

KEY FINDINGS

The results below represent the full population of river and stream miles assessed during the rivers and streams survey (i.e., 1.2 million perennial river and stream miles) for all indicators except contaminants in fish fillet tissue. Contaminants in fish fillet tissue were assessed in larger river systems (rivers that are 5th order or greater), and results are for this sampled population of river miles. For more information on benchmarks and indicators, see Chapters 2 through 4 and the NRSA 2013–14 Technical Support Document (EPA 2020a).

▶ Biological Indicators

The survey looked at two types of biological indicators: 1) benthic (bottom-dwelling) macroinvertebrates such as dragonfly and stonefly larvae, snails, worms, and beetles, and 2) fish. Of the nation's river and stream miles, 30% (365,850 miles) were rated good based on benthic macroinvertebrate scores relative to the least-disturbed reference distribution, and 26% (319, 899 miles) were rated good based on fish community scores relative to the least-disturbed reference distribution.

▶ Chemical Indicators

NRSA reports on four chemical stressors: total phosphorus, total nitrogen, salinity and acidification. Fifty-eight percent (706,754 miles) of the nation's rivers and streams were rated poor for phosphorus relative to the least-disturbed reference distribution, and 43% (522,796 miles) were rated poor for nitrogen relative to the least-disturbed reference distribution. The data collected for this report indicate that a finding of poor biological condition based on benthic macroinvertebrates was almost twice as likely in rivers and stream miles rated poor for nutrients.

▶ Physical Habitat Indicators

Four indicators of physical habitat were assessed for NRSA 2013–14. Three were compared to least-disturbed reference sites' in-stream fish habitat, streambed excess fine sediments, and riparian vegetative cover (vegetation in the land corridor surrounding the river or stream). Riparian disturbance (human activities near the river or stream) was scored based on number and proximity of features such as roads and buildings. Physical habitat indicator scores revealed that 64% (778,585 miles) of river and stream miles were rated good for in-stream fish habitat. In addition, 58% (701,763 miles) of river and stream miles had good ratings for riparian vegetation, and 52% (627,829 miles) scored good for streambed sediment levels. Benthic macroinvertebrate condition was almost twice as likely to be rated poor when sediment levels were rated poor than when they were rated fair or good.

▶ Human Health Indicators

The survey evaluated river and stream quality compared to three indicators that provide insight into potential risks to human health: enterococci (bacteria that indicate fecal contamination), microcystins (naturally occurring algal

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[1] Though the 2008–09 survey results were generated with the best available survey design and indicators at the time, EPA continued to make improvements in both design and indicators and implemented improvements for 2013–14. Thus, the results shown in the 2008–09 report cannot be directly compared to the results of this 2013–14 report. To accurately report differences between the two surveys, EPA reevaluated the data from the 2008–09 survey taking into account these improvements. See Chapters 3 and 4 for more information.

toxins), and contaminants in fish tissue. The results for enterococci were below the EPA criteria recommendations for pathogens in 69% (833,529 miles) of river and stream miles. Cyanobacteria can produce a variety of toxins; the rivers and streams survey measured levels of one of these — microcystins. Only a small proportion of miles — 0.1% — had microcystins concentrations exceeding the EPA recommended recreational swimming advisory level (see Appendix A). Mercury, polychlorinated biphenyls (PCBs) and certain per- and polyfluoroalkyl substances (PFAS) were present in fish tissue, with occurrence varying by contaminant. Mercury concentrations in fillet composite samples were above the EPA fish tissue-based water quality criterion recommendation for methylmercury in 24% (25,119 river miles) of the sampled population of river miles.[2] For PCBs, 40% (24,583 river miles) of the sampled population of river miles had fish fillet PCB concentrations above the EPA human health fish tissue benchmark. Concentrations of perfluorooctane sulfonate (PFOS), one of the most dominant PFAS in freshwater fish tissue, were above the EPA human health fish tissue benchmark in fish fillets in 3% (3,490 river miles) of the sampled population of river miles.

NEXT STEPS

Policy makers, resource managers and scientists can use the information from this survey to evaluate the overall effectiveness of restoration and protection efforts that took place between 2008 and 2014, place site-specific data into a broader context, and initiate additional exploration of certain patterns or changes.

NRSA results are available on an interactive web-based dashboard that presents findings for each indicator and for several regions or subpopulations at https://riverstreamassessment.epa.gov/dashboard. Dashboard users can compare ecoregion results to national results for each indicator or look at data for all the indicators within specific regions. Users may also download data files of the NRSA results used in creating each of the dashboard visualizations. EPA has posted the NRSA data used to generate the results presented in the report and data dashboard at https://www.epa.gov/national-aquatic-resource-surveys/data-national-aquatic-resource-surveys. For the fish fillet composite data, the public may access the data at https://www.epa.gov/fish-tech/2013-2014-national-rivers-and-streams-assessment-fish-tissue-study. To provide greater transparency and the ability for the public to review information, EPA is working toward providing the five-year results of NARS online. In the future, EPA will migrate from "traditional" reports to providing data, summaries, and additional information online.

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[2] EPA analyzes fish tissue samples for total mercury (using EPA method 1631 Revision E) since the major pathway for human exposure to methylmercury is consumption of contaminated fish and since practically all mercury in fish tissue is methylmercury. See USEPA (2001) and Bloom (1992).

1

Introduction

This report presents the findings of the National Rivers and Streams Assessment (NRSA) 2013–2014, the second in a series of statistical surveys of the quality of the nation's large and small perennially flowing waters (the first was conducted in 2008 and 2009 (USEPA 2016b)). The report describes the results of the nationwide statistical survey that was conducted in the summers of 2013 and 2014 by EPA and its state, tribal, and federal partners. The report provides a snapshot of the quality of perennial rivers and streams across the contiguous U.S. during the sampling period and may not reflect current water conditions. Clean Water Act (CWA) sections 104(a) and (b) collectively grant the EPA Administrator authority to investigate and report on water quality across the country. National Aquatic Resources Survey (NARS) data also inform and benefit the national water quality inventory report that EPA prepares for Congress pursuant to CWA section 305(b)(2).

THE NATION'S RIVERS AND STREAMS

Rivers and streams shape our landscape. They supply our drinking water, irrigate our crops, power our cities with hydroelectricity, provide highways for shipping, offer us recreational opportunities, and support our industries. They support fish and other aquatic life and provide shelter, food, and habitat for birds and wildlife. They are the land's vast and interconnected circulatory system, carrying water, sediment, and organic material from the mountains to the sea. Clean and healthy rivers and streams enhance the quality of our lives.

Over the centuries, many U.S. rivers and streams have been impacted or modified in ways that have altered their natural flow. Additionally, our rivers and streams are subject to influences such as seasonal, annual, and climatological variations in precipitation and temperature, as well as changing cycles of erosion and deposition (e.g., during flooding or dam releases). To effectively restore and maintain these rivers and streams, we must improve the information we have available to inform our decision-making.

THE NATIONAL AQUATIC RESOURCE SURVEYS

In the early 2000s, a number of organizations, including the U.S. Government Accountability Office, the National Research Council, and the National Academy of Public Administration (USGAO 2000, NRC 2001, NAPA 2002) commented that EPA and the states did not have a uniform, consistent approach to monitoring that supported water quality decision-making nationally. They called for more consistent and cost-effective ways to understand the magnitude and extent of water quality problems, the causes of these problems, and practical ways to address them.

In response, EPA and its partners completed sampling for the first statistical survey of the condition of the nation's small, perennial streams — the *Wadeable Streams Assessment: A Collaborative Survey of the Nation's Streams* — in 2004. The survey was intended to establish a baseline of information on the condition of wadeable streams and the extent of major environmental stressors that affect them. State environmental and natural resource agencies, federal agencies, universities, and other organizations collected data from 1,392 perennial stream locations across the conterminous U.S. These sites were chosen using a statistical design to ensure that results represented the condition of all U.S. wadeable streams. Following the Wadeable Streams Assessment and building on this effort, EPA, states, tribes, academics, and other federal agencies began collaborating on NARS, a series of statistically based surveys to provide the public and decision-makers with environmental information.[3]

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[3] The NARS program uses nationally consistent data collection and assessment protocols that in many cases differ from existing state water quality programs. In addition, the NARS program does not assess water bodies against state water quality standards. As a result, state water quality assessment determinations may reasonably differ from those of the NARS program.

NARS are designed to answer long- and short-term questions about the quality of our waters:

- What is the extent of waters that support healthy biological communities, recreation, and fish consumption?
- How widespread are major stressors that affect water quality?
- Are we investing wisely in water resource restoration and protection?
- Are our waters getting cleaner?[4]

States and tribes conduct monitoring to support CWA programs and implement their water quality management programs. CWA Section 305(b) directs states to report to EPA on the water quality of all navigable waters within their borders with appropriate supplemental descriptions as shall be required to take into account seasonal, tidal, and other variations correlated with the quality of the water. The methods states use to monitor and assess their waters vary from state to state and within individual states over time.

This report is not intended to focus on water quality at individual sites; rather, it combines data across a random sample of sites into regional and national indicators to provide unbiased estimates of the quality of the resource with statistical confidence. The survey results can help set priorities for water resource protection and restoration.

The assessments focus on the 48 contiguous states. The NARS program also works with Alaska, Hawaii, and U.S. territories to implement related statistical surveys, and some highlights of this work can be found at https://www.epa.gov/national-aquatic-resource-surveys.

Surveys in the NARS series are the following:

- The National Lakes Assessment (2007, 2012 and 2017).
- The National Rivers and Streams Assessment (2008–09, 2013–14 and 2018–19).
- The National Coastal Condition Assessment (2010, 2015 and 2020).
- The National Wetland Condition Assessment (2011 and 2016).

Reports on efforts from 2004 through 2012, including the data on which they are based, are available at https://www.epa.gov/national-aquatic-resource-surveys. EPA will post additional reports and data online as they become available.

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[4] Though the 2008–09 survey results were generated with the best available survey design and indicators at the time, EPA continued to make improvements in both design and indicators and implemented improvements for 2013–14. Thus, the results shown in the 2008–09 report cannot be directly compared to the results of this 2013–14 report. To accurately report differences between the two surveys, EPA reevaluated the data from the 2008–09 survey taking into account these improvements. See Chapters 3 and 4 for more information.

2

Design of the Survey

NRSA is a national assessment of the quality of perennial rivers and streams in the contiguous U.S., from the smallest headwater streams to the largest rivers, including those that are tidally influenced until the point at which they reach dilute seawater (i.e., 0.5 parts per thousand salinity). The results of NRSA are designed to be representative of the target population of rivers and streams. Very slow-moving segments of rivers created by dams — known as run-of-the-river reservoirs, ponds, and pools — were excluded from NRSA because they are more like lakes than flowing waters. These systems are included in the National Lakes Assessment.

For NRSA, as with the other surveys that make up NARS, EPA scientists selected sampling locations using a statistical survey design based on stratified random sampling. For more information on the survey design, see the NRSA 2013–14 Technical Support Document (USEPA 2020a). The strata (i.e., divisions or groups) used in the NRSA design included state, ecoregion, and river and stream size. The survey approach estimates the status of populations or resources of interest using a representative sample of comparatively few members or sites. NRSA was designed to be able to estimate the national quality of rivers and streams within a margin of error of ±5% with 95% confidence (i.e., a sufficient number of sites are sampled from the population that one can be 95% confident that the actual value for the entire population is within 5% above or below the estimated value). The margin of error depends primarily on the number of sites sampled; as more sites are sampled, the margin of error narrows, meaning there is more certainty around the results. NRSA can also report at smaller scales (e.g., the ecoregions shown in Chapter 5), but within a wider margin of error because there are fewer sites per region. The sample site selection process is described in more detail in the NRSA 2013–14 Technical Support Document (USEPA 2020a).

CHOOSING SAMPLING SITES

There are three key steps in the process of choosing sites to be sampled:

1. **Identifying all potential sites in the target population.** To identify the locations of U.S. perennial rivers and streams, the NRSA design team used the EPA-U.S. Geological Survey National Hydrography Dataset Plus (NHD-Plus), version 1 (https://www.epa.gov/waterdata/nhdplus-national-hydrography-dataset-plus). NHD-Plus is a comprehensive set of digital, spatial data on surface waters at the 1:100,000 scale; it shows topography, area, flow, location, and other attributes.[5]
2. **Choosing potential sites to sample.** Sampling sites were identified using a stratified random sampling design. In such a design, every river and stream in the target population has a known probability of being selected for sampling. This ensures that the results of the survey reflect the full range of character and variation present in flowing waters across the U.S. (i.e., across all river and stream sizes). Site selection was controlled for spatial distribution, to ensure that sample sites covered all areas of the country within the 48 contiguous states. The design also included some sites from NRSA 2008–09 to improve the analysis of change over time.
3. **Confirming site validity and availability.** After sites were selected for sampling, field crews conducted desktop evaluations and field reconnaissance to determine if the sites were part of the target population. Rivers or streams found to be intermittently flowing during the sampling season or determined to be inaccessible were dropped from the sampling effort. Each such site was replaced with another from the list of replacement sites generated as part of the survey design. For NRSA 2013–14, crews sampled 1,853 river and stream sites across the country, representing approximately 1.2 million miles of flowing waters (site locations are shown in Figure 2.1).

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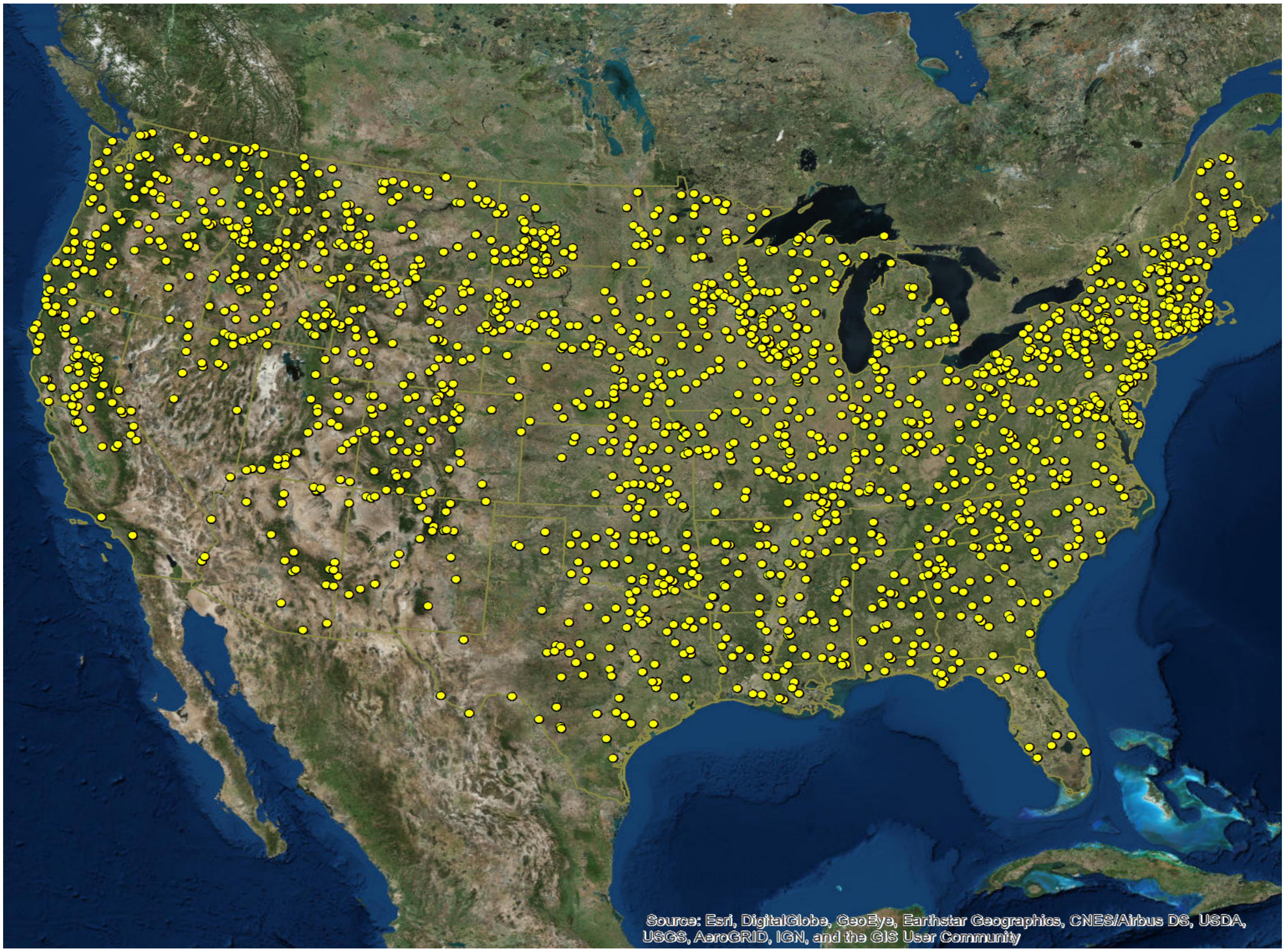
[5] As EPA and the Department of the Army recognize in the Navigable Waters Protection Rule, "NHD at High Resolution . . . may not accurately identify on-the ground flow conditions." 85 FR 22294 (April 21, 2020). NHD-Plus maps surface waters at a coarser resolution (1:100,000) compared to the scale of NHD at High Resolution (1:24,000). EPA evaluated 4,566 sites as part of NRSA 2013–14. Of those, a total of 1,853 were sampled. Of the evaluated sites, 1,328 sites were target sites but not sampled (landowner denial, otherwise inaccessible or other), and 1,385 sites were identified as non-target. Of the 1,385 non-target sites, 755 were identified as non-perennial. See the NRSA 2013–14 Technical Support Document for more information.

Figure 2.1 NRSA 2013–14 Sampled Sites


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

DETERMINING WHAT TO MEASURE

NRSA 2013–14 used 13 indicators (listed in Figure 2.2) to assess the condition of U.S. rivers and streams. The results for these indicators are discussed in Chapters 3 and 4. Chapter 3 presents physical, chemical, and biological indicators to reflect the extent to which water quality supports the CWA Section 101(a) goal of healthy biological communities. Chapter 4 presents indicators related to human health that reflect the CWA Section 101(a)(2) goal that water quality support recreation. As part of the NRSA effort, EPA publishes a website that provides public access to supporting documentation on the data collection, analysis, and interpretation protocols for the survey, as well as to the raw data collected in a series of files for each indicator. See the NRSA field operations and laboratory operations manuals for information on all samples and measurements from the survey (USEPA 2013, USEPA 2014), including basic analytes and measurements used for QA/QC (e.g., cations/anions) or basic stream measurements (temperature) that support data analysis but are not reported on as indicators. The data files include the following measurement results:

- In-situ measurements of dissolved oxygen, pH, temperature, and conductivity.
- Water chemistry: total phosphorus, total nitrogen, total ammonium, nitrate, basic anions, cations, total suspended solids, turbidity, acid-neutralizing capacity (ANC, alkalinity), dissolved organic carbon, and total organic carbon.
- Chlorophyll *a* (periphyton and water column samples).
- Benthic macroinvertebrates taxonomic identification.
- Fish assemblage taxonomic identification.

- Periphyton taxonomic identification and ash-free dry mass.
- Physical habitat: thalweg profile, large woody debris, substrate size, channel dimensions, channel and riparian measurements, canopy cover measurements, in-stream fish cover, algae and aquatic macrophytes, channel constraint, debris torrents, recent floods, discharge, visual riparian measurements, and human influence measurements.
- Fecal indicator enterococcus.
- Algal toxins (microcystins).
- Fish tissue plug mercury concentrations.
- Whole-fish composite fillet analysis: mercury, polychlorinated biphenyls (PCBs), and per- and polyfluoroalkyl substances (PFAS).

NRSA 2013–14 used two biological indicators: benthic macroinvertebrates (bottom-dwelling insects and other small animals such as snails and crayfish) and fish. Evaluating the number and type of organisms at a site provides a measurement of the biological integrity of rivers and streams (defined as their ability to support and maintain a balanced population of organisms comparable to those of rivers and streams in natural condition). EPA and its partners chose to use both benthic macroinvertebrates and fish as indicators because they are each sensitive to different disturbances that can result from human activities.

In addition to biological information, at each site field crews measured chemical and physical indicators. Examples of chemical indicators assessed as part of NRSA are nutrients (nitrogen and phosphorus) and acidification. Physical indicators include sedimentation and streamside trees and vegetation.

Figure 2.2 NRSA Indicators

NRSA used 13 indicators to assess the quality of rivers and streams. These parameters are grouped into four categories: biological, chemical, physical and human health.

Biological Indicators	• Macroinvertebrates • Fish
Chemical Indicators	• Phosphorus • Nitrogen • Salinity • Acidification
Physical Indicators	• In-stream Fish Habitat • Riparian Disturbance • Riparian Vegetative Cover • Streambed Sediments
Human Health Indicators	• Enterococci • Microcystins • Contaminants in Fish Tissue

Appendix A provides general information about each of the NRSA indicators.

NRSA included indicators to evaluate the potential for concerns to human health from fish consumption and recreational exposure. Specifically, field crews sampled contaminant levels in fish tissue (mercury, PCBs, and PFAS), fecal indicator bacteria called enterococci, and cyanotoxins called microcystins.

NRSA included collection of some data for research purposes, such as periphyton (microscopic organisms such as algae and bacteria). Results for research indicators are not included in this report.

Field protocols used in NRSA were designed to collect data relevant to the biological condition of stream resources and the key stressors affecting them. A three- or four-person field crew — composed of state/tribal environmental agency, EPA and contract staff — sampled each site under normal flow conditions during the summer of 2013 or 2014. Crews laid out the stretch of river or stream to be sampled (the sample reach) and 11 transects to guide data collection (see Figure 2.3, What Happens on a Field Day?). At each site, crews collected water and fish tissue samples to send to laboratories for chemical analysis, collected macroinvertebrate samples to send to taxonomists for identification, and identified fish species found at the site. Crews also recorded visual observations on field forms, including data on the characteristics of each stream and its riparian area (the area on or adjacent to its banks). Data collected during a single visit provide a representative snapshot of each site for the purposes of the survey. EPA trained and audited each crew to ensure that standard protocols were followed, and 10% of the survey sites were revisited as part of the survey's quality assurance project plan.[6]

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[6] For more information on data collection and quality assurance in NRSA, see https://www.epa.gov/national-aquatic-resource-surveys/manuals-used-national-aquatic-resource-surveys#National Rivers & Streams Assessment and USEPA (2020a).

Figure 2.3 What Happens on a Field Day?

With site selection and evaluation complete, a field crew sets out for a day of sampling. A simplified description of the sampling that happens on a field day is shown below.

Step 1: Pack

First, the crew gathers all necessary items such as maps, equipment, and supplies.

Step 2: Travel

Once preparations are made, the field crew travels to the site. Remote sites require additional time and planning.

Step 3: Sample

The crew conducts sampling. General details on how a site is sampled can be found below.

Step 4: Report and Ship

At the end of the field day, the crew cleans all equipment used, packages samples for shipment to laboratories, and submits field forms.

HOW IS SAMPLING CARRIED OUT?

After locating the "index site" with GPS, the crew establishes a sampling reach that is 40 times the river's width. The crew then splits the reach into 11 transects (or cross-sections) labeled A to K. For boatable sites like the one represented below, Transect A is upstream of Transect K; the reverse is true for wadeable sites.

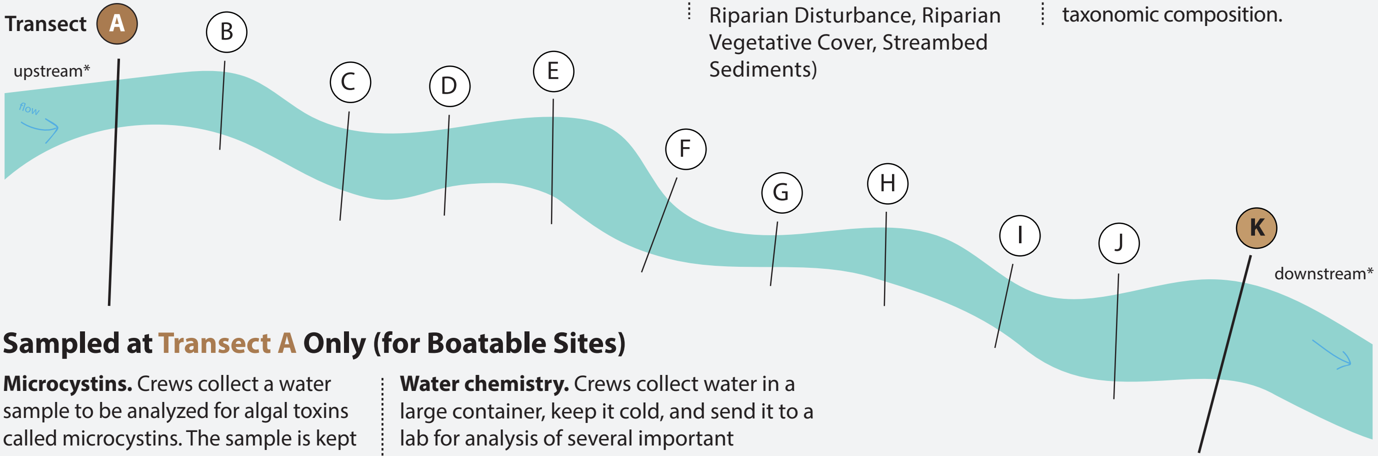
Sampled Throughout the Reach (for Boatable Sites)

Macroinvertebrates. At each transect, the bottom of the stream is agitated, and the crew collects organisms using a net. The samples taken from all transects are combined into a collective sample and analyzed. (Indicators supported: Macroinvertebrates)

Fish are sampled throughout the reach using methods like electrofishing, which temporarily stuns fish so they can be caught. Crews identify species and release most fish, keeping some to assess tissue contaminant levels. (Indicators supported: Fish, Contaminants in Fish Tissue)

Physical habitat characteristics are observed throughout the length of the site. These include the amount of woody debris present, the amount of vegetation overhanging the river, and signs of human disturbance. Crews record information on field forms and upload to a database. (Indicators supported: In-stream Fish Habitat, Riparian Disturbance, Riparian Vegetative Cover, Streambed Sediments)

Periphyton are microscopic organisms—such as algae and bacteria—that attach to rocks and other submerged surfaces. Crews collect small samples at each transect by either scrubbing (when hard surfaces are available) or collecting a small amount of sand or silt. These samples are combined into one sample. At the lab, analysts measure chlorophyll *a*, biomass, and taxonomic composition.



Sampled at Transect A Only (for Boatable Sites)

Microcystins. Crews collect a water sample to be analyzed for algal toxins called microcystins. The sample is kept cold and sent to a lab for testing. (Indicators supported: Microcystins)

Water chemistry. Crews collect water in a large container, keep it cold, and send it to a lab for analysis of several important parameters. (Indicators supported: Acidification, Nitrogen, Phosphorus, Salinity)

At Transect K Only

Enterococci, bacteria found in fecal matter, are sampled at the final transect to ensure filtration and freezing within 6 hours of collection, as required for lab analysis. (Indicators supported: Enterococci)

?

Is sampling the same for both rivers and streams? Yes and no. Data for the same indicators are collected at both rivers and streams, but some methods are different depending on whether crews can sample by wading or have to use a boat for access.

To access the field manual, visit https://www.epa.gov/national-aquatic-resource-surveys/national-rivers-streams-assessment-201314-field-operations-manual

*This diagram represents sampling for non-wadeable sites only. For wadeable streams sites, the labeling of transects is reversed.

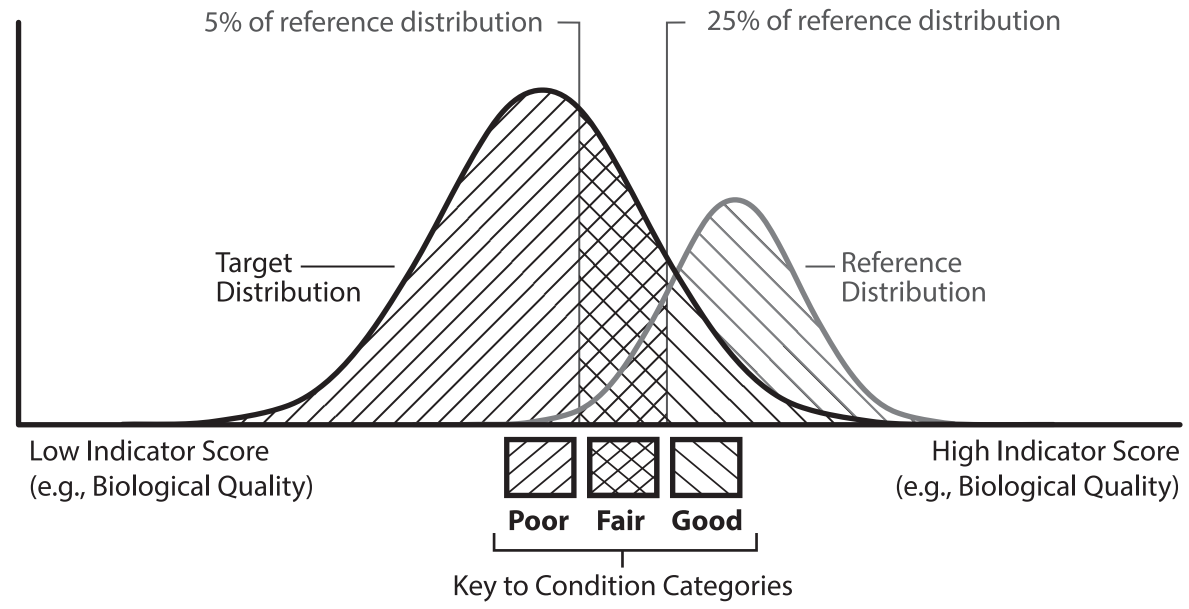
Setting the Benchmarks

Two types of assessment benchmarks — fixed and distribution-based — were used in NRSA depending on the indicator. Fixed benchmarks are based on accepted values from peer-reviewed, scientific literature and are typically well established and/or widely and consistently used by water quality agencies. For indicators related to human health, EPA used numeric benchmarks it developed (see Chapter 4 for specifics). An example of this is the human health fish tissue benchmark of 300 parts per billion (ppb) for mercury.

The second type of benchmark is based on the distribution of values for a particular indicator derived from least-disturbed reference site data. For environmental indicators that vary naturally across the country (e.g., biological community condition, physical habitat, and nutrient levels), EPA set regional benchmarks to reflect this variation, using nine major ecological regions. These ecological regions separate the country into zones of similar topography, climate and other ecological characteristics (see Chapter 5 for a description of the nine ecological regions). Data within each ecological region were screened independently to identify a set of reference sites that represent the least-disturbed conditions in that ecoregion. The conditions for the least-disturbed reference sites represent the best range of conditions that can be achieved by similar streams within a particular ecological region. EPA's guidance notes that in no instance should any notably degraded conditions be accepted as the reference for criteria development (USEPA 1996). The screening factors used for the reference sites include chemical parameters like conductivity, a dam influence index, and other landcover variables such as percent agriculture, population density, and road density, as described in the NRSA 2013–14 Technical Support Document (EPA 2020a).

The range of conditions found at reference sites for an ecoregion describes a distribution of values expected for least-disturbed condition. For each indicator, benchmarks were chosen using defined percentiles from the range of values (the distribution) across all of the reference sites in a region. Following established approaches, NRSA uses percentiles of the reference distribution to establish benchmarks (Arizona 2012, Hughs 1995, USEPA Case Studies, USEPA 1996, USEPA 2000b). Sites rate "good" when indicator scores are as good as the best 75% of the least-disturbed reference distribution. Sites rate "poor" when they score worse than the worst 5% of the least-disturbed reference distribution. This means that some river and stream miles in the poor category overlap with the conditions at 5% of the reference sites that are used to define the least-disturbed reference conditions. These 5% are the lowest quality among the least-disturbed reference sites. "Fair" sites have indicator scores that fall in between the good and poor benchmark values. As shown in Figure 2.4, this overlap means that there are some sites meeting the screening factors for "least-disturbed"

Figure 2.4 Illustrative Graphic of Percentiles Drawn from a Reference Distribution Curve for Good, Fair, and Poor Assessment



yet categorized by the NRSA design as being poor or fair. Because expectations vary naturally across ecoregions, the benchmarks reflect the least-disturbed conditions for each ecoregion. The ecoregional benchmarks used in NRSA 2013–14 are presented in Appendix B.

Using benchmarks from the two approaches, for each indicator, EPA categorized each river or stream site in the full set of statistical survey sites as good, fair, or poor; "at or below benchmark" or "exceeds benchmark"; or another category in some cases. In general, the ecosystem health indicators presented in Chapter 3 are reported as good, fair, or poor, and the human health indicators presented in Chapter 4 are reported as at or below benchmark or exceeds benchmark. More information on the benchmarks is available in Appendix A and B and in the NRSA 2013–14 Technical Support Document (EPA 2020a). To report on the quality of *all perennial* rivers and streams, EPA then used a weighted analysis of the randomly sampled sites (sites were weighted based on the extent of the river or stream miles they represent). This produced estimates of the percentage of river and stream miles in each condition category for each indicator, nationally and within each ecoregion, with 95% confidence.

The NRSA indicators are not replacements for the evaluation by states and tribes of the quality of rivers and streams relative to their water quality standards. Interested readers can find more detailed information about determining reference condition in the NRSA 2013–14 Technical Support Document (EPA 2020a), published online at https://www.epa.gov/national-aquatic-resource-surveys/nrsa.

ASSESSING THE RELATIONSHIP BETWEEN KEY STRESSORS AND BIOLOGICAL QUALITY

In addition to assessing rivers and streams for each of the individual indicators, NRSA analysts evaluated chemical and physical indicators in relation to biological quality. Results of these analyses are presented in Chapter 3 following the discussion of the individual indicators.

For NRSA, analysts applied three approaches to rank stressors as they applied to both biological indicators. The first approach, relative extent, presents how many river and stream miles are characterized as poor for selected chemical and physical measures, e.g., what percent of rivers and stream miles have phosphorus concentrations that fall within the poor category. The second, relative risk, examines the severity of the impact from an individual stressor when it is rated poor, e.g., how likely the biology is to be degraded when a stream's phosphorus levels are rated poor compared to when phosphorus levels are rated good or fair. The third approach involves attributable risk, which is a value derived by combining the first two risk values into a single number.

ANALYZING HUMAN HEALTH INDICATORS

For the human health indicators (enterococci, microcystins, and contaminants in fish tissue), EPA used the relevant water quality criteria recommendations and EPA human health fish tissue benchmarks. Enterococci samples measured by quantitative polymerase chain reaction (qPCR) (a method that detects and quantifies DNA) were compared to EPA's recreational water quality criteria recommendations for swimming. Microcystin samples were compared to EPA's recreational water swimming advisory recommendations. For fish tissue mercury analysis, EPA compared tissue levels to its recommended mercury fish tissue-based water quality criterion to protect human health. Fish fillet composite samples were compared to EPA's human health fish tissue benchmarks for PCBs and perfluorooctane sulfonate (PFOS) (the most commonly occurring PFAS).[7] See Chapter 4, Appendix A and the NRSA 2013–14 Technical Support Document (USEPA 2020a) for more information on the benchmarks for these contaminants.

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[7] For the NRSA 2013–14 survey, a composite sample was formed by combining fillet tissue from up to five adult fish of the same species and similar size from the same site. Use of composite sampling for screening studies is a cost-effective way to estimate average contaminant concentrations while also ensuring that there is sufficient fish tissue to analyze for all contaminants of concern. (Average concentrations from composite samples may represent an over- or underestimation of a contaminant as compared to the concentration in a single fish sample.)

3

Quality of the Nation's Rivers and Streams

This chapter discusses national findings for biological, chemical, and physical habitat indicators that, together, address the quality of the nation's perennial rivers and streams. The sections below present background information about each indicator and a summary of results from NRSA 2013–14. This chapter also includes data on differences between 2008–09 and 2013–14. It is important to note that the NRSA 2013–14 results should not be compared directly to the results presented in the 2008–09 report. Though the 2008–09 survey results were generated with the best available survey design and indicators at the time, EPA continued to make improvements in both design and indicator analysis and implemented improvements for 2013–14. To accurately report differences between the two surveys, EPA reevaluated the data from the 2008–09 survey taking into account these improvements. This yielded updated results for 2008–09 that allow a comparison to the 2013–14 survey results and calculation of differences in water quality between the two surveys. Please see Appendix C for a comparison of how the values changed. Figure 3.1 describes how to interpret the graphics in this chapter presenting the key findings for NRSA water quality indicators.

Figure 3.1 Interpreting NRSA Graphics (Using Fish Indicator As an Example)

This figure describes how to interpret the data graphics in this chapter, which provide detailed national results on the quality of rivers and streams for each indicator and difference over time.

2013–14 Quality

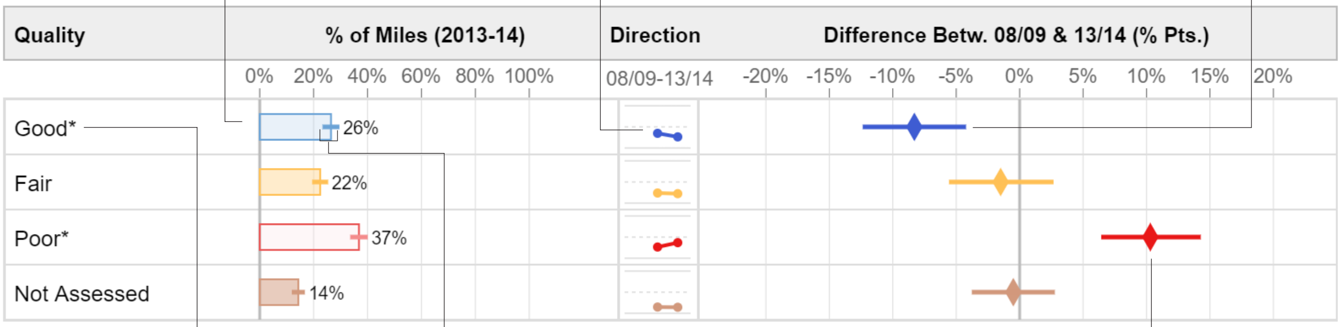
The bars represent EPA's 2013–14 estimate for the proportion of rivers and stream miles rated good, fair, or poor – here, 26% plus or minus 3% were rated good.

Direction of Difference

The slope graphs show the difference from 2008–09 to 2013–14, with the light gray line indicating 50%. Lines that appear nearly flat signal little difference. Here, the gentle slope indicates a difference of 8 percentage points (from 34% to 26%).

Magnitude of Difference

The diamond shows the difference estimate and the line conveys the range of uncertainty. Below, the percentage of river and stream miles in the good category decreased by 8 percentage points, with a confidence interval of -12 to -4.



Statistical Significance

Statistically significant difference within a category is indicated by an asterisk (*) and darker colors (e.g., red vs. pink) in the columns showing difference data. The proportion of miles rated good decreased from 2008–09 to 2013–14 at a 95% confidence limit.

Confidence Intervals

The darker line represents the confidence interval, which is the margin of error (here, plus or minus 3%) around the point estimate. In this case, EPA is 95% certain that, in 2013–14, between 23% and 29% of all miles in the target population were in the good category.

Good or Bad?

Falling to the left or right of the zero line means something different for each category. Above, the decrease in river and stream miles designated as good is undesirable, as is the increase in miles rated poor.

BIOLOGICAL INDICATORS

Ecologists evaluate the biology of river and streams by analyzing key characteristics of the communities of organisms or taxa living in them. NRSA focuses on two such communities: benthic macroinvertebrates and fish. Scientists evaluated both groups for a robust understanding of biological quality, as each of these groups has unique sensitivities to human disturbances.

Biological Indicators	• Macroinvertebrates • Fish

Macroinvertebrates

Benthic macroinvertebrates are small organisms, such as aquatic insects and snails, that live among the rocks and bottom sediments of rivers and streams. They are widely used as biological indicators because they are broadly distributed and often provide a source of food for fish and other aquatic animals. Benthic macroinvertebrates are relatively immobile; because they do not readily escape pollution, macroinvertebrate communities change in response to the cumulative effects of the stressors to which they are exposed over time.

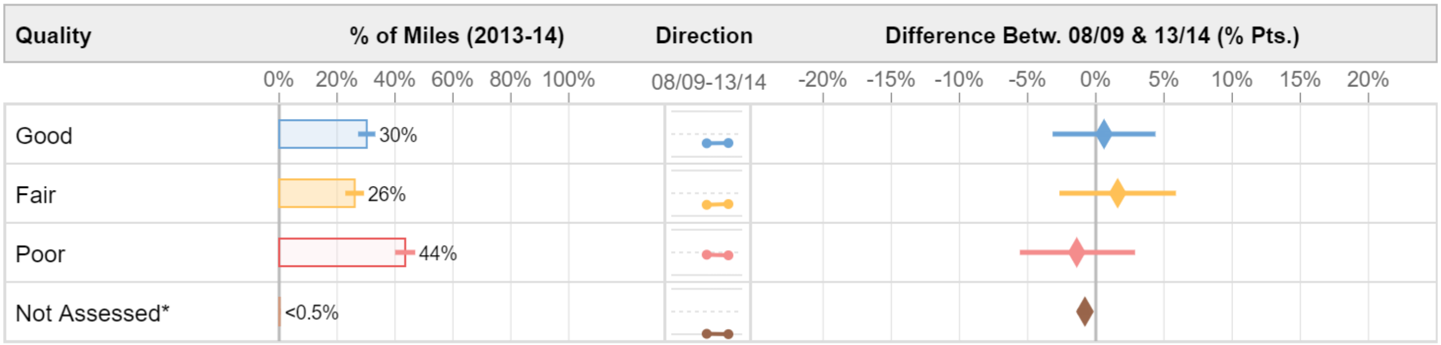
Taxa (plural of taxon) are groupings of living organisms, such as phyla, classes, orders, families, genera, or species. Biologists describe and organize organisms into taxa in order to better identify and understand them.

EPA used a robust multimetric index (MMI), which aggregates the observed values for a variety of individual metrics into a single score. During the 2008–09 analysis process, EPA ecologists developed MMIs for nine ecoregions using metrics indicative of different aspects of macroinvertebrate community structure: taxonomic richness, taxonomic composition, taxonomic diversity, feeding groups, habits/habitats, and pollution tolerance (see text box *Elements of the Macroinvertebrate Multimetric Index*).

Because it integrates a variety of informative macroinvertebrate metrics into one index, a macroinvertebrate MMI provides a particularly strong indicator of biological quality. This approach is widely used by state water quality agencies and other organizations to assess and report on the quality of perennial rivers and streams. The MMI scores are compared to benchmarks established using least-disturbed reference sites. More information is available in the NRSA 2013–14 Technical Support Document, including additional references.

As shown in Figure 3.2, based on the macroinvertebrate MMI results, 30% (365,850 miles) of the nation's river and stream miles were rated good, 26% (315,471 miles) were rated fair, and 44% (526,576 miles) were rated poor for biological quality. The extent of river and stream miles rated good, fair, or poor for macroinvertebrate communities was not statistically different between NRSA 2008–09 and NRSA 2013–14.

Figure 3.2 Macroinvertebrates: NRSA 2013–14 National Results



*Reflects a statistically significant change between 2008–09 and 2013–14 (95% confidence).

Elements of the Macroinvertebrate Multimetric Index

The macroinvertebrate multimetric index (MMI) is a total index score that is the sum of scores for a variety of individual measures (also known as metrics). To determine the macroinvertebrate MMI, ecologists selected six metrics indicative of different aspects of macroinvertebrate community structure:

- **Taxonomic richness** — the number of distinct families or genera within different taxonomic groups of organisms, within a sample. A sample with many different families or genera, particularly within those groups that are sensitive to pollution, indicates least-disturbed physical habitat and water quality and an environment that is not stressed.

- **Taxonomic composition** — the proportional abundance of certain taxonomic groups within a sample. Certain taxonomic groups are indicative of either highly disturbed or least-disturbed conditions, so their proportions within a sample serve as good indicators of condition.

- **Taxonomic diversity** — the distribution of the number of taxa and the number of organisms among all the taxonomic groups. Healthy rivers and streams have many organisms from many different taxa; unhealthy streams are often dominated by a high abundance of organisms in a small number of taxa.

- **Feeding groups** — the distribution of macroinvertebrates by the strategies they use to capture and process food from their aquatic environment (e.g., filtering, scraping, grazing or predation). As a river or stream degrades from its natural condition, the distribution of animals among the different feeding groups will change, reflecting changes in available food sources.

- **Habits/habitats** — the distribution of macroinvertebrates by how they move and where they live. A stream with a diversity of habitat types will support animals with diverse habits, such as burrowing under streambed sediments, clinging to rocks, swimming and crawling. Unhealthy systems, such as those laden with silt, will have fewer habitat types and macroinvertebrate taxa with less diverse habits (e.g., will be dominated by burrowers).

- **Pollution tolerance** — the distribution of macroinvertebrates by the specific range of contamination they can tolerate. Highly sensitive taxa, or those with a low tolerance to pollution, are found only in rivers and streams with good water quality. Waters with poor quality will support more pollution-tolerant species.

The specific metrics chosen for each of these characteristics varied among the nine ecoregions used in the analysis.

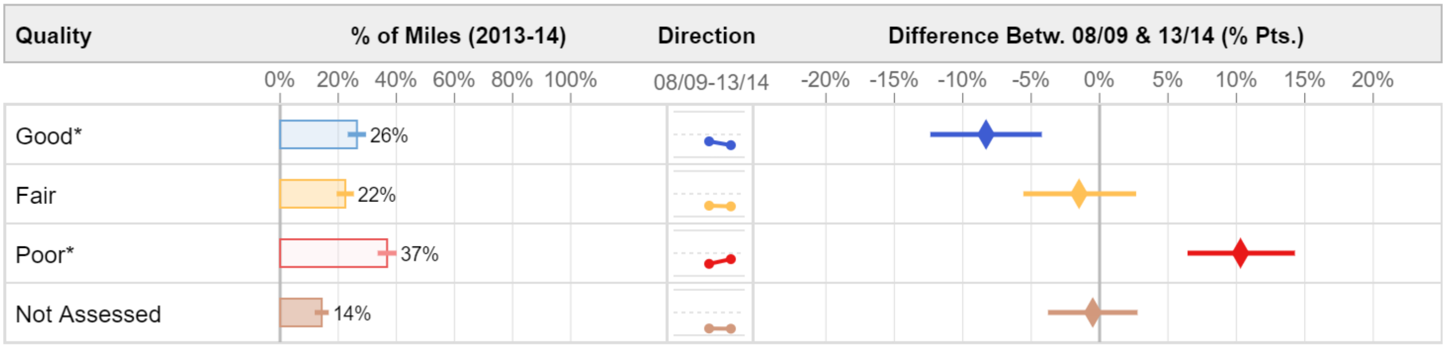
Fish

Evaluating the variety and abundance of fish species in rivers and streams is an important component of many water monitoring programs. Fish are sensitive indicators of physical habitat degradation, environmental contamination, migration barriers, and overall ecosystem productivity. They need plants, insects, and benthic macroinvertebrates to eat; in-stream and streambank cover for shelter; high-quality streambed substrate conditions for spawning; and overhanging vegetation to shade and cool the water in which they live.

During the 2013–14 analysis process, EPA biologists developed a new fish MMI using an approach similar to the one used to develop the benthic macroinvertebrate MMI. The index is based on a variety of metrics, including taxonomic richness, taxonomic composition, pollution tolerance, habitat and feeding groups, spawning habits, the number and percent of taxa that are migratory, and the percent of taxa that are native. A fish MMI was developed for each ecoregion to account for differences in natural fish community assemblages.

As shown in Figure 3.3, based on the NRSA fish MMI, 26% (319,899 miles) of river and stream miles were rated good, 22% (271,395 miles) were rated fair, 37% (445,622 miles) were rated poor, and 14% (173,310 miles) were not assessed. An analysis of the difference between the adjusted 2008–09 results and 2013–14 results found the percentage of river and stream miles rated good based on the fish MMI decreased by approximately 8 percentage points, while river and stream miles rated poor increased by approximately 10 percentage points.

Figure 3.3 Fish: NRSA 2013–14 National Results



Reflects a statistically significant change between 2008–09 and 2013–14 (95% confidence).

CHEMICAL INDICATORS

Four chemical indicators were assessed as part of NRSA: total phosphorus, total nitrogen, salinity, and acidification. These four indicators were selected because of national or regional interest in the extent to which they might be affecting the quality of the biological communities in rivers and streams. Additional water chemistry parameters that were collected during NRSA 2013–14 are described in the NRSA field and laboratory manuals.

Chemical Indicators

- Phosphorus
- Nitrogen
- Salinity
- Acidification

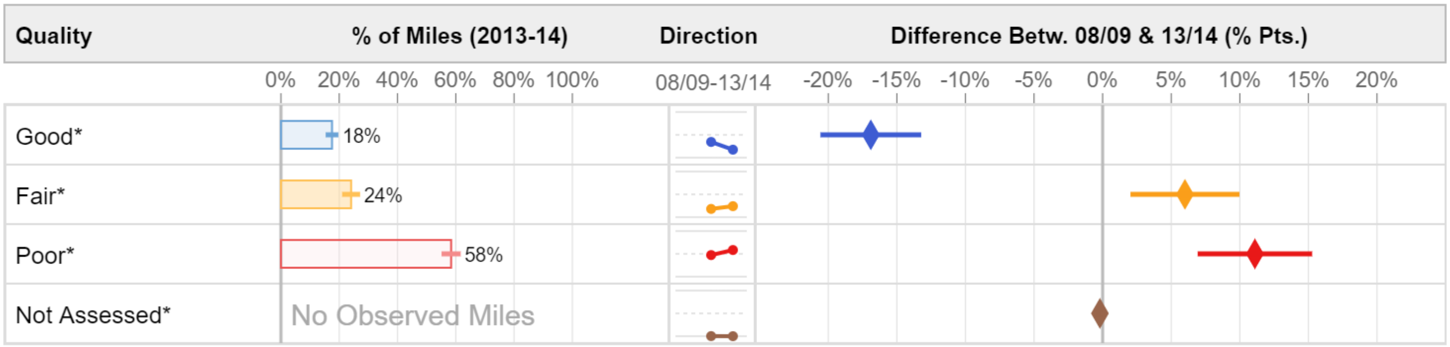
Phosphorus

Phosphorus is an essential nutrient in the environment. In rivers and streams, it is found naturally. Excess phosphorus, however, can adversely affect (or stress) water quality and biology. Agricultural and urban runoff, leaking septic systems, sewage discharges, eroded stream banks, and similar sources can increase the flow of nutrients and organic substances into rivers and streams.

Excess levels of phosphorus can lead to increased growth of algae and aquatic plants, which may reduce the aesthetic enjoyment of our waters and interfere with swimming. When algae and plants decay, dissolved oxygen levels decrease, causing additional stress to aquatic life. Excess phosphorus can also lead to cyanobacterial blooms that can produce toxins harmful to human and animal health (see discussion of microcystins in Chapter 4).

Natural variability in phosphorus concentrations is reflected in the regional benchmarks for good, fair, and poor, which are based on least-disturbed reference sites for each of the nine NRSA ecoregions. Based on total phosphorus levels measured for NRSA 2013–14, approximately 18% (212,086 miles) of river and stream miles were rated good, 24% (291,385 miles) were rated fair, and 58% (706,754 miles) were rated poor (Figure 3.4). Comparison of results between the 2008–09 and 2013–14 surveys showed a decline of 17 percentage points in the extent of river and stream miles rated good and an increase of 11 percentage points in the miles rated poor for phosphorus.

Figure 3.4 Phosphorus: NRSA 2013–14 National Results



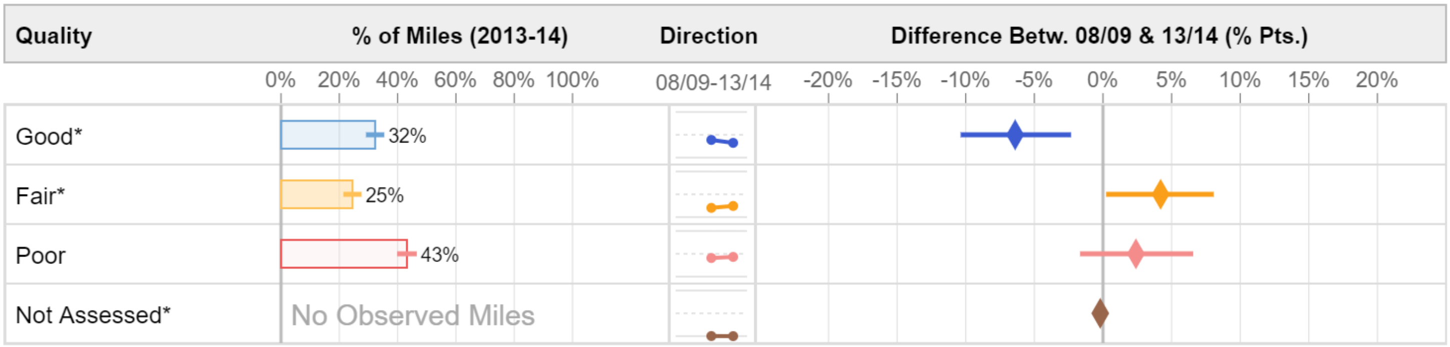
Reflects a statistically significant change between 2008–09 and 2013–14 (95% confidence).

Nitrogen

Nitrogen is an essential nutrient that at high concentrations can stimulate excess growth of algae, large aquatic plants, and cyanobacteria, which can result in algal blooms, low dissolved oxygen levels, and degraded conditions for benthic macroinvertebrates and other aquatic life. Common sources of nitrogen include fertilizer, wastewater, animal wastes, and atmospheric deposition.

Natural variability in nitrogen concentrations is reflected in the regional benchmarks for good, fair, and poor, which are based on least-disturbed reference sites for each of the nine NRSA ecoregions. As shown in Figure 3.5, NRSA 2013–14 found that 32% (390,743 miles) of river and stream miles were rated good, 25% (296,687 miles) were rated fair, and 43% (522,796 miles) were rated poor for nitrogen compared to regional benchmarks. Between the 2008–09 and 2013–14 surveys, the percentage of river and stream miles rated good for nitrogen decreased by 6 percentage points.

Figure 3.5 Nitrogen: NRSA 2013–14 National Results



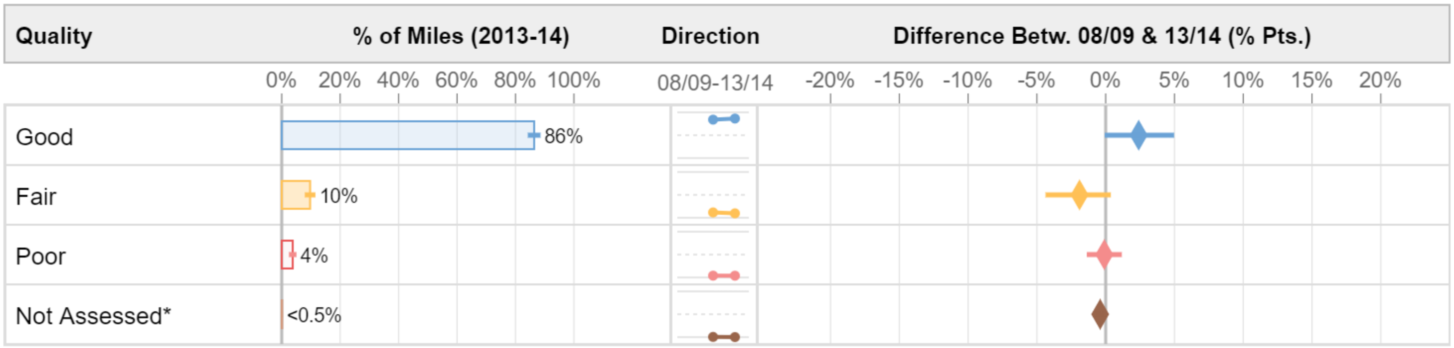
Reflects a statistically significant change between 2008–09 and 2013–14 (95% confidence).

Salinity

Excess salts can be toxic to freshwater plants and animals, and they can make water unsafe for drinking, irrigation, and watering livestock. Excess salinity can occur in areas where evaporation is high and water is repeatedly re-used for irrigation or water withdrawals; where road de-icing compounds are applied; and where mining, oil drilling, and wastewater discharges occur. Conductivity, a measure of water's ability to pass an electrical current, was used as a measure of salinity for NRSA. Findings for salinity (Figure 3.6) show the majority of the nation's river and stream miles

(86%) were classified as good (1,045,488 miles), 10% (117,561 miles) were rated fair, and 4% (45,514 miles) were rated poor. Analysis showed no statistically significant difference in salinity categories for rivers and streams between NRSA 2008–09 and NRSA 2013–14.

Figure 3.6 Salinity: NRSA 2013–14 National Results



Reflects a statistically significant change between 2008–09 and 2013–14 (95% confidence).

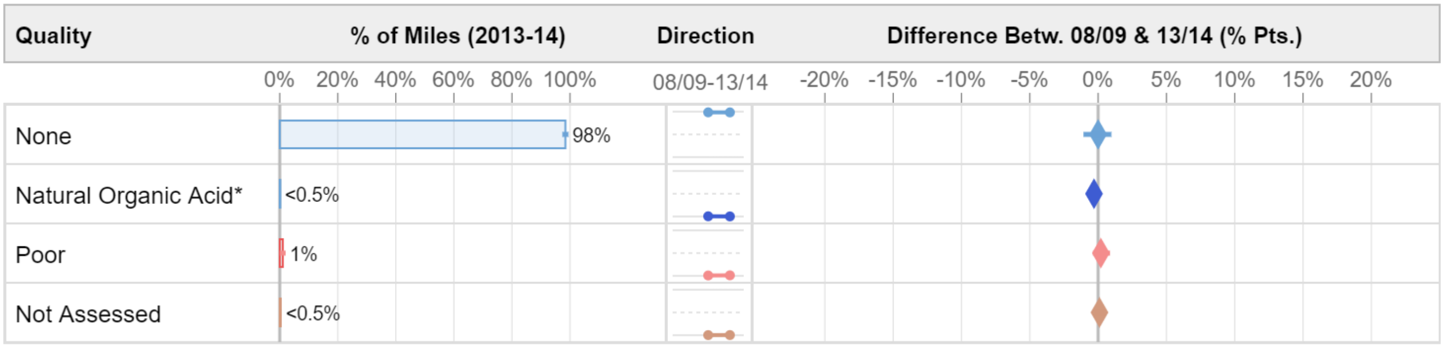
Acidification

A small proportion of rivers and streams are naturally acidic, but there are mechanisms by which human activity contributes to acidification. These include deposition of air pollution from smokestacks and auto emissions (acid rain), as well as the leaching of sulfur compounds into water as it flows through abandoned mines (acid mine drainage). Such acidification can harm aquatic animals both directly (through acidity itself) and indirectly (through reactions facilitated by acidity). Some fish and macroinvertebrates are acid-sensitive and can only tolerate small changes in acidity. Toxic metals such as aluminum released from soils into the water by acidification can also affect aquatic life. To assess the extent to which flowing waters are not acidic, are

What Is Acid-Neutralizing Capacity?

Acid-neutralizing capacity (ANC) is determined by the soil and underlying geology of the surrounding watershed. Rivers and streams with high levels of dissolved bicarbonate ions (e.g., in limestone watersheds) are able to neutralize acid depositions and buffer the effects of acid rain. Conversely, watersheds that are rich in granites and sandstones contain fewer acid-neutralizing ions and have low ANC; these systems have a predisposition to acidification. Most aquatic organisms function at the optimal pH range of 6.5 to 8.5. Sufficient ANC in surface waters will buffer acid rain and prevent pH levels from straying outside this range. In naturally acidic waters, the ANC may be quite low, but the presence of natural organic compounds in the form of dissolved organic carbon can mitigate the effects of pH fluctuations.

Figure 3.7 Acidification: NRSA 2013–14 National Results



Reflects a statistically significant change between 2008–09 and 2013–14 (95% confidence).

naturally acidic, or are acidic due to anthropogenic sources, NRSA measured the water's ability to neutralize inputs of acids, called acid-neutralizing capacity or ANC. Maintaining stable and sufficient ANC is important for aquatic life because ANC protects or buffers against pH changes in the water body. Data were compared to nationally consistent benchmarks derived during the National Acid Precipitation Assessment Program (Baker et al. 1990; Kaufmann et al. 1991). As shown in Figure 3.7, the great majority, 98% (1,191,242 miles), of the nation's river and stream miles were not acidified (either had no acidification or were affected by acidity from natural sources), and 1% were classified as poor for acidification. Poor consists of three categories of acidification that were reported separately in the NRSA 2008–09 report: acid mine drainage, episodic acidification, and acid deposition.

PHYSICAL INDICATORS

Among the many human activities that can stress the physical condition of rivers and streams — and, by extension, fish and other aquatic organisms — are construction, certain agricultural practices, removal of vegetation buffering rivers and streams, land development, and creation of impervious surfaces (e.g., roads and parking lots). NRSA used four indicators of physical habitat, described further below: in-stream fish habitat, riparian disturbance, riparian vegetation, and excess streambed sediments. More information about physical habitat protocols can be found in the NRSA 2013–14 field operations manual (USEPA 2013).

Physical Indicators

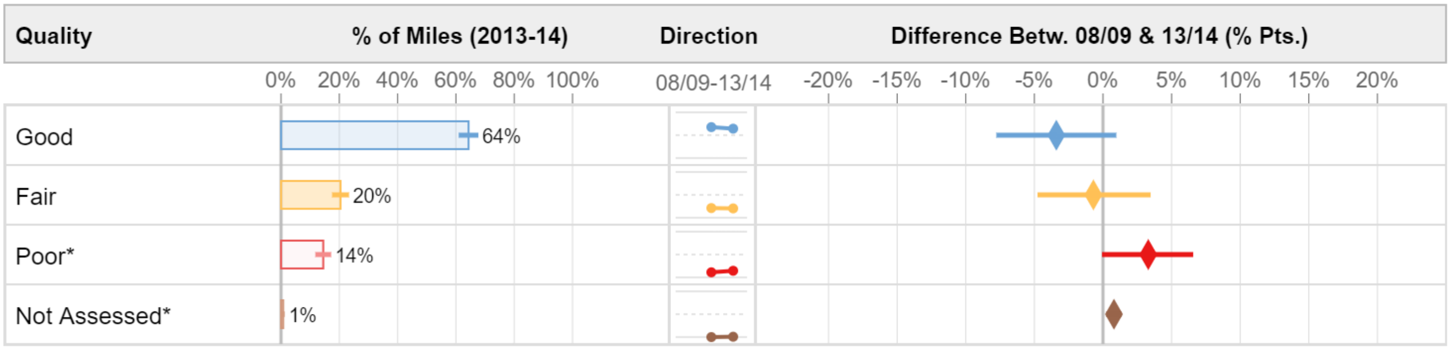
- In-stream Fish Habitat
- Riparian Disturbance
- Riparian Vegetative Cover
- Streambed Sediments

In-stream Fish Habitat

Healthy fish and macroinvertebrate communities are typically found in rivers and streams that have complex and varied forms of habitat, such as rocks and boulders, undercut banks, overhanging vegetation, brush, and tree roots and logs within the stream banks. NRSA used a habitat complexity measure that reflects the amount of such in-stream fish habitat and concealment features within the water body and its banks. The in-stream fish habitat scores are compared to benchmarks established using least-disturbed reference sites.

Figure 3.8 shows that 64% (778,585 miles) of river and stream miles were rated good, 20% (247,124 miles) were rated fair, and 14% (175,315 miles) were rated poor in NRSA 2013–14 for in-stream fish habitat. More miles were rated poor in the 2013–14 survey (an increase of 3 percentage points) compared to the 2008–09 survey.

Figure 3.8 In-stream Fish Habitat: NRSA 2013–14 National Results



Reflects a statistically significant change between 2008–09 and 2013–14 (95% confidence).

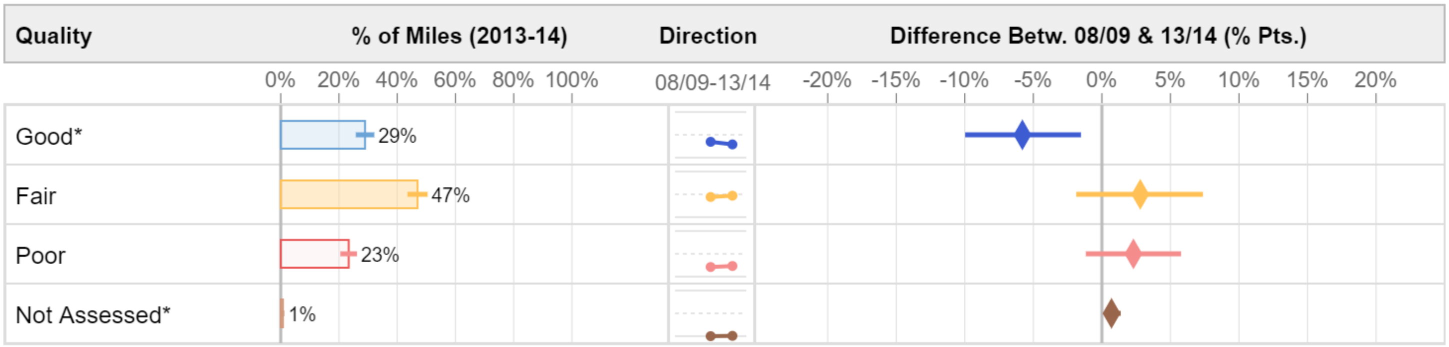
Riparian Disturbance

The riparian area is the land along a river or stream. For this indicator, NRSA used a direct measure of riparian human disturbance that tallies 11 specific types of human activities and their proximity to the water body in 22 riparian plots. Examples of human disturbance in the riparian area include roads, pavement and cleared lots, buildings, pipes, parks or maintained lawns, trash, pastures and rangeland, row crops, dams, and logging or mining operations. Activities such as these can contribute to excess sedimentation, excess nutrient loading, alteration of native plant communities, in-stream habitat degradation, and other disturbances.

A river or stream site was considered good if, on average, one type of human influence was observed in fewer than one-third of the riparian plots, fair if on average one type of human influence was noted in at least one-third of the riparian plots, and was considered poor if on average one or more types of disturbance were observed across all of the plots. The closer these activities are to a river or stream, the more impact they are likely to have.

For this indicator, Figure 3.9 shows that 29% (350,385 miles) of river and stream miles were rated good for riparian disturbance, 47% (568,482 miles) were classified as fair, and 23% (282,422 miles) were classified as poor using the approach described above. There were fewer river and stream miles with levels of riparian disturbance categorized as good in 2013–14 than in 2008–09; the decrease was 6 percentage points.

Figure 3.9 Riparian Disturbance: NRSA 2013–14 National Results



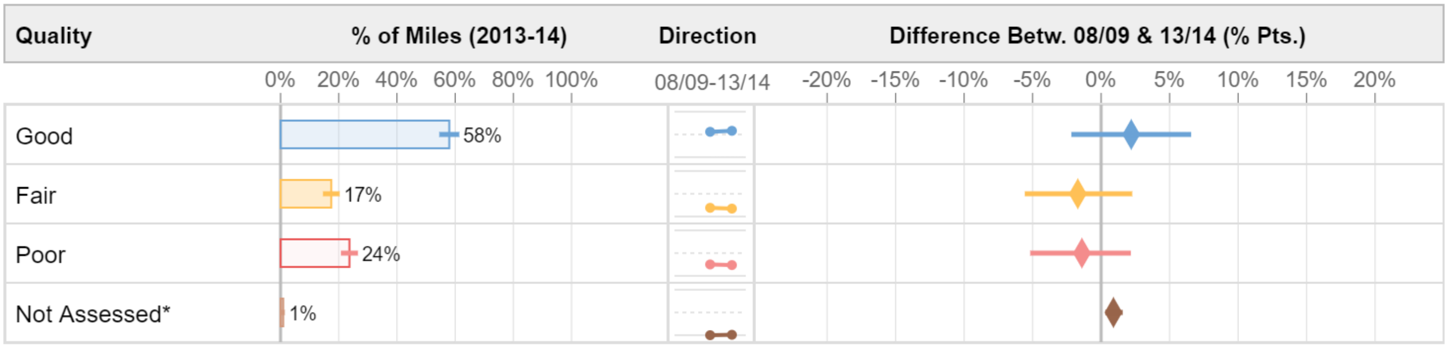
Reflects a statistically significant change between 2008–09 and 2013–14 (95% confidence).

Riparian Vegetative Cover

Healthy, multilayered vegetation in the riparian corridor can provide a buffer from the effects of human disturbance in several ways: by slowing runoff; filtering nutrients and sediments; reducing streambank erosion; providing shade, which keeps water cool and reduces algae growth; and supplying leaf litter, branches, and logs that serve as food, shelter, and habitat for fish and other aquatic organisms. Analysts assessed riparian vegetative cover by summing the amount of cover provided by three layers of vegetation: the ground layer, woody shrubs, and canopy trees. Results for riparian vegetative cover were compared to benchmarks established using least-disturbed reference sites.

As Figure 3.10 shows, 58% (701,763 miles) of river and stream miles were rated good, 17% (210,949 miles) were rated fair, and 24% (286,546 miles) were rated poor for riparian vegetative cover. Analysis showed no statistically significant difference in riparian vegetative cover categories for rivers and streams between the NRSA 2008–09 and NRSA 2013–14 surveys.

Figure 3.10 Riparian Vegetative Cover: NRSA 2013–14 National Results



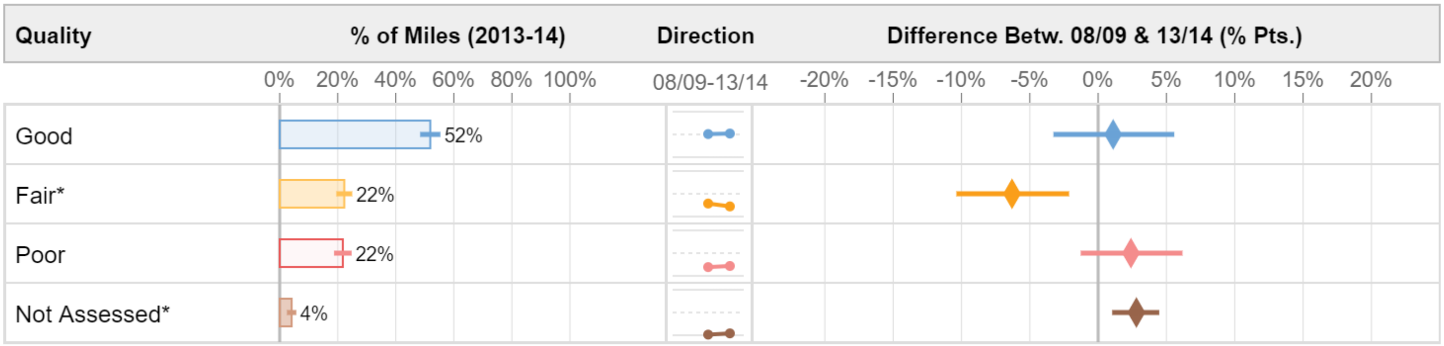
Reflects a statistically significant change between 2008–09 and 2013–14 (95% confidence).

Excess Streambed Sediments

The size of particles that make up the riverbed and streambed is important for maintenance of stable and healthy river and stream systems. Human activities that disturb land can interfere with river and stream sediment balance by increasing the amount of fine sediment entering river and stream channels. Human activities can also lead to increases in the magnitude or frequency of flooding. Typically, these hydrologic alterations increase the frequency of high-magnitude floods. Channels can respond by down-cutting (incising), eroding their banks, washing away important aquatic habitat (e.g., woody debris and other organic material), and depositing fine and less stable sediments (e.g., silt or clay). For example, the presence of paved surfaces such as roads and parking lots in a watershed prevents rainwater from soaking into the ground, and can increase the volume and velocity of water entering streams and the frequency of high-magnitude floods. Excess fine sediments can fill in the spaces between cobbles and rocks where many benthic macroinvertebrates live and breed.

NRSA scientists analyzed the extent to which excess fine sediments occurred in rivers and streams, focusing on conditions indicating lower-than-expected streambed stability and higher excess sedimentation. Results were compared to benchmarks established using least-disturbed reference sites. As shown in Figure 3.11, 52% (627,829 miles) of river and stream miles were rated good for streambed sediments, while 22% (269,326 miles) were rated fair, 22% (263,289 miles) were rated poor, and 4% (49,781 miles) were not assessed. Compared to NRSA 2008–09, there was a decrease of 6 percentage points in the river and stream miles rated fair.

Figure 3.11 Excess Streambed Sediments: NRSA 2013–14 National Results



Reflects a statistically significant change between 2008–09 and 2013–14 (95% confidence).

ASSOCIATIONS BETWEEN STRESSORS AND BIOLOGICAL QUALITY

An important function of NRSA is to provide data to support the protection and restoration of rivers and streams, including their ecological function. This includes estimating the benefits that might be derived if those stressors were reduced.

For NRSA, analysts used three approaches to assess the influence of stressors on the ecological condition of the nation's perennial rivers and streams: **relative extent, relative risk,** and **attributable risk**. Throughout this section, stressors are assessed and reported on independently and as such do not sum to 100%. Many rivers and streams are likely to experience multiple stressors simultaneously, which can result in cumulative or overlapping effects not accounted for in this analysis. An overview of these concepts is provided here. Further details on their calculation can be found in the NRSA 2013–14 Technical Support Document (USEPA 2020a).

These risk analysis tools are intended to help guide management priorities, not to establish a direct cause and effect connection. Figure 3.12 provides overall findings for estimated risk to benthic macroinvertebrates associated with the stressors assessed in NRSA. Information on the risk to fish community structure is available through the NRSA interactive dashboard (https://riverstreamassessment.epa.gov/dashboard).

Relative Extent: Water resource managers need to consider how extensive a stressor is when setting priority actions at national, regional, and state scales. Relative extent compares the percent of waters rated poor for each individual stressor; this number comes from the results for chemical and physical indicators shown earlier in this chapter. Most stressors can be found in all geographic areas, but those that are not pervasive do not have high relative extents. The first panel of Figure 3.12 presents a summary of relative extent for the chemical and physical indicators. For NRSA 2013–14, the most widespread stressors were phosphorus and nitrogen.

Taking Action

Reducing nutrient and sediments can improve the health of our rivers and streams. An estimated 25% of river and stream miles that are currently of poor biological quality could see improvements if phosphorus levels were reduced, 23% could experience improvements if nitrogen levels were reduced, and 16% could see improvements with reductions in sediments.

Relative Risk: Relative risk is a way to examine the severity of the impact of a stressor when it occurs. Relative risk is used frequently in the human health field. For example, a person who smokes is 15 to 30 times more likely to get lung cancer or die of lung cancer than a person who does not.[8] Similarly, scientists can examine the likelihood of finding poor biological conditions in a river or stream when phosphorus concentrations are higher, relative to the likelihood when phosphorus concentrations are lower. When these two likelihoods are quantified, their ratio is called the relative risk. A relative risk value of 1 means that poor biological conditions are just as likely when the stressor is rated poor as when it is rated good or fair — in essence, no demonstrable effect. A relative risk of 2, however, means poor biological conditions are twice as likely when a stressor is in poor condition. The middle panel of Figure 3.12 presents results of the relative risk analysis for benthic macroinvertebrates. At the national level, acidification, salinity, excess sediments, and nutrients were associated with poor biological condition based on the macroinvertebrate MMI, with relative risk ranges from 1.6 to 2. When these stressors are present in stream miles rated poor, benthic macroinvertebrate communities are more likely to be rated poor, too.

Attributable Risk: Attributable risk represents the magnitude or importance of a potential stressor and can be used to help rank and set priorities for policymakers and managers. Attributable risk is derived by combining relative extent and relative risk into a single number for ranking purposes. Conceptually, attributable risk provides an estimate of the proportion of poor biological conditions that could be reduced if high levels of a particular stressor were reduced. This number is presented in terms of the length in poor condition that could be improved — that is, moved from poor into either good or fair condition categories. The calculation of attributable risk looks at one stressor at a time and assumes that the stressor is the sole reason for the poor biology rating, the effects of the stressor can be reversed, and the stressor's impact on condition is independent of that caused by other stressors. Despite the limitations of these

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[8] Centers for Disease Control and Prevention (CDC). What Are the Risk Factors for Lung Cancer? https://www.cdc.gov/cancer/lung/basic_info/risk_factors.htm (accessed May 22, 2018)

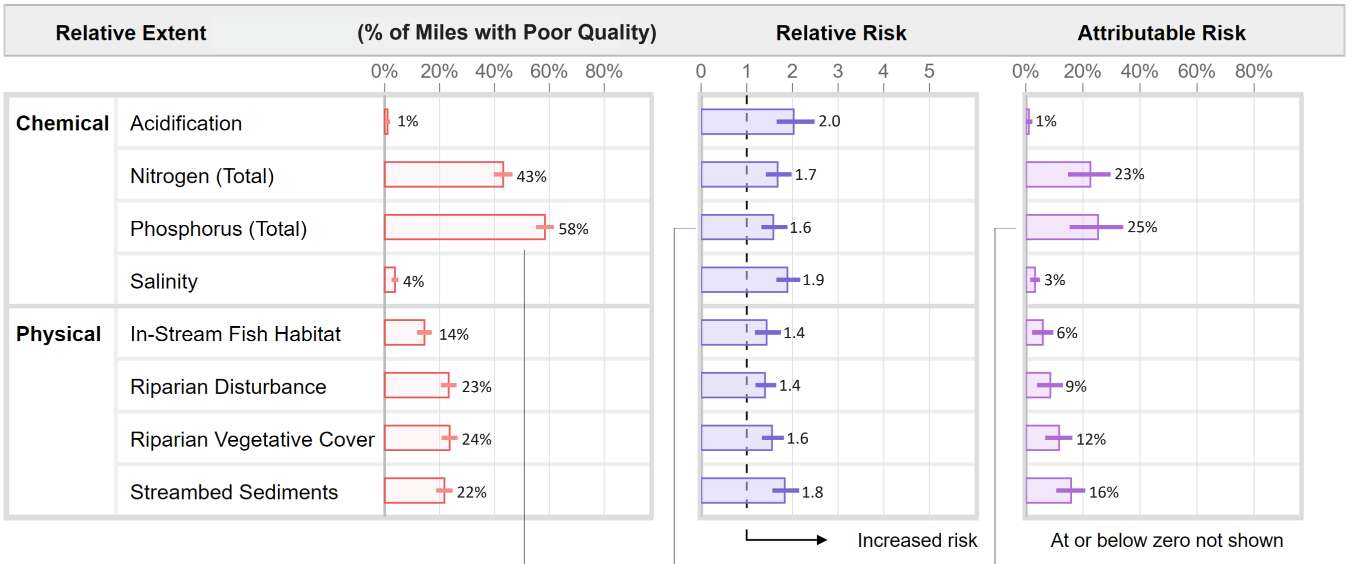
assumptions, estimates of attributable risk provide insight as to what stressors are affecting biology and to what degree, relative to the other stressors evaluated.

Attributable risk findings are presented in the right-hand panel of Figure 3.12. The stressors with the highest attributable risk values are phosphorus, nitrogen, and suspended sediments. The attributable risk analysis suggests that if high levels of phosphorus were reduced to levels representative of good or fair, macroinvertebrate quality would improve in 25% of river and stream miles currently of poor biological quality. In comparison, acidification has low attributable risk. Although its relative risk is the highest among the indicators evaluated, its relative extent (percent of miles rated poor) is small. Thus, acidification poses risk to biological integrity in the small percentage of waters rated poor for that stressor. Reducing acidification could improve the waters that are heavily impacted by this stressor, but this is a small percentage of waters nationally.

Attributable risk is not intended as an absolute "prediction" of the improvement in flowing waters but rather an estimate calculated in a consistent manner for all stressors so that they can be ranked relative to one another. Use of the attributable risk information can help policymakers and resource managers prioritize actions and the use of limited resources by stressor and geographic area (see the NRSA interactive dashboard for information on other geographic regions).

These attributable risk estimates underscore the importance of efforts to reduce the impact of excess nutrients and degraded habitat on the nation's rivers and streams. Further, although some stressors such as acidification might not be widespread, localized management actions targeting these stressors could improve impacted local waters.

Figure 3.12 Relative Extent, Relative Risk, and Attributable Risk to Macroinvertebrates: NRSA 2013–14 National Results



Relative Extent

Relative extent is the percentage of miles affected by each stressor. (This amount is equal to the percentage rated poor.) In 2013–14, EPA found that 58% of all national miles were designated as poor for phosphorus. The confidence interval for this estimate was 55% to 62%.

Relative Risk

Relative risk conveys the likelihood of having poor biological quality when a particular stressor is rated poor. In 2013–14, EPA found that, when phosphorus was rated poor, macroinvertebrates were 1.6 times more likely to be rated poor compared to when phosphorus was rated good or fair. The confidence interval for this estimate was 1.3 to 1.9.

Attributable Risk

Attributable risk represents the percentage of miles rated poor for a biological indicator that could be improved if a stressor were removed. In 2013–14, EPA found that the number of miles rated poor for macroinvertebrates could be reduced by approximately 25% if waters rated poor for phosphorus were improved to fair or good. The confidence interval associated with this estimate was 15% to 34%.

4

Human Health Indicators

In addition to physical, chemical, and biological indicators of the quality of the nation's rivers and streams, NRSA includes data collection for three human health indicators: the fecal contamination indicator enterococci, cyanobacterial toxins called microcystins, and contaminants in fish tissue. In this chapter, the results for these indicators are compared to EPA's recommended criterion for methylmercury, EPA's recommended swimming advisory levels for enterococci and microcystins, and human health fish tissue benchmarks that EPA derived for reporting results for PCBs and PFOS. This section also includes information on differences between 2008–09 and 2013–14 survey results, where applicable.

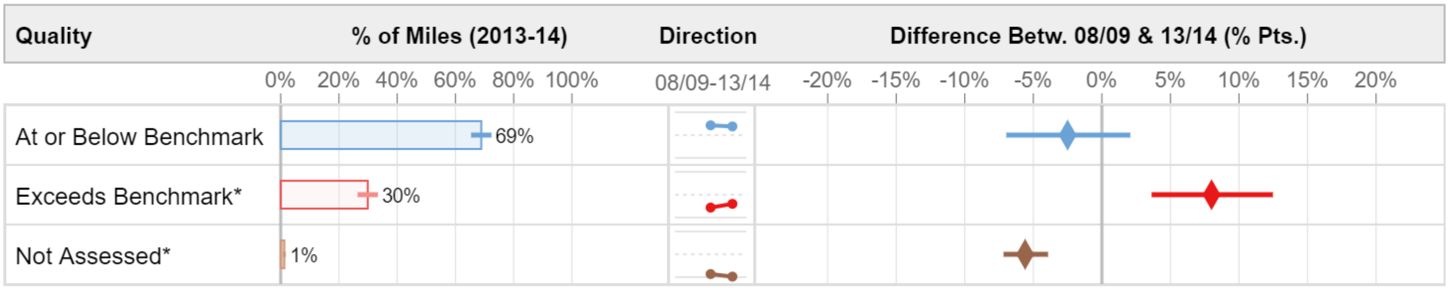
Human Health Indicators	• Enterococci • Microcystins • Contaminants in Fish Tissue

Enterococci

Enterococci are bacteria that live in the intestinal tracts of warm-blooded animals, including humans. While not considered harmful to humans, their presence in the environment indicates that disease-causing agents such as viruses, bacteria, and protozoa may be present. Enterococci are therefore used as indicators of possible fecal contamination from sources such as wastewater treatment plant discharges; leaking septic systems; stormwater runoff; animal waste; and runoff from pastures, feedlots, and manure storage areas.

For NRSA, water samples were analyzed using qPCR. Results were compared to an EPA recommended water quality criterion for protecting human health in ambient waters designated for swimming (1,280 calibrator cell equivalents/100 mL) (USEPA 2012).[9] Figure 4.1 shows that 69% (833,529 miles) of river and stream miles were at or below the recommended enterococci human health criterion, 30% (361,716 miles) were above the criterion and 1% were not assessed. The number of river and stream miles that exceeded the EPA recommended water quality criteria for recreation increased by 8 percentage points compared to the 2008–09 survey. It is important to note that for this indicator, the 2013–14 survey results show fewer river and stream miles in the "not assessed" category.

Figure 4.1 Enterococci: NRSA 2013–14 National Results



Reflects a statistically significant change between 2008–09 and 2013–14 (95% confidence).

Note: Benchmark for enterococci is the EPA recommended water quality criteria of 1,280 CCE/100 mL. At or Below Benchmark category includes results for which enterococci were not detected.

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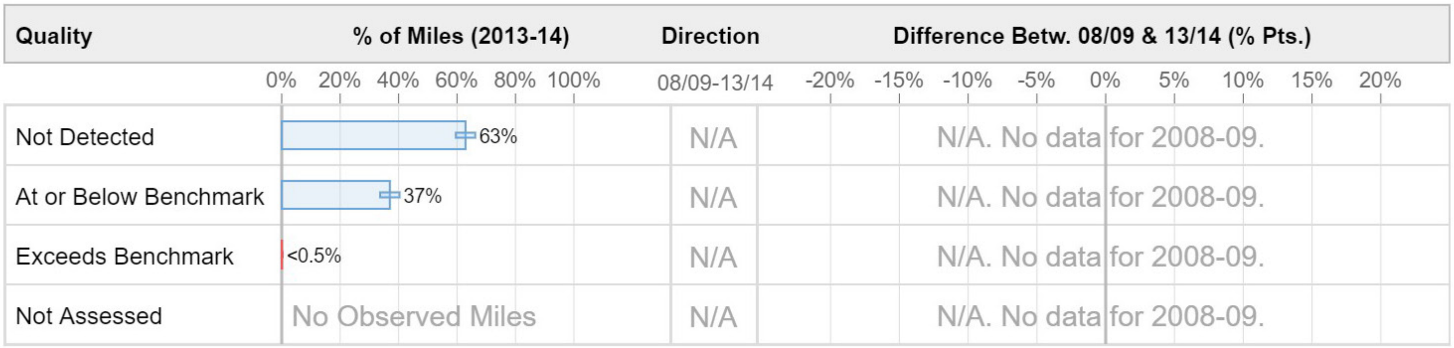
[9] The enterococci recommended water quality criterion is based on a DNA analysis using qPCR (EPA method 1609.1), which determines the abundance of enterococci DNA sequences relative to calibrator samples that contain a known quantity of enterococci.

Microcystins

Microcystins are a group of naturally occurring toxins produced by various cyanobacteria (sometimes also called blue-green algae, although they are not algae) that are common in surface waters. Under certain conditions, cyanobacteria in nutrient-rich, slow-moving water can form blooms that float on the surface in unsightly, thick mats or color the water green. Not all blooms are toxic, but at elevated levels, microcystins can be harmful to humans, pets, and wildlife, causing skin rashes, eye irritation, respiratory ailments, gastroenteritis, and even liver and kidney failure. For NRSA 2013–14, EPA focused on concerns from microcystins associated with recreational contact.

NRSA scientists analyzed the extent of detections and concentrations of microcystins in the nation's perennial rivers and streams. Figure 4.2 shows that microcystins were not detected in 63% (761,179 miles) of river and stream miles and detected but at levels below EPA's recommended swimming advisory level (8 µg/L; EPA 2019a) in 37% (447,821 miles) of river and stream miles. Microcystins were not sampled as part of NRSA 2008–09, so a difference analysis could not be conducted.

Figure 4.2 Microcystins: NRSA 2013–14 National Results



Quality	% of Miles (2013-14)	Direction 08/09-13/14	Difference Betw. 08/09 & 13/14 (% Pts.)
Not Detected	63%	N/A	N/A. No data for 2008-09.
At or Below Benchmark	37%	N/A	N/A. No data for 2008-09.
Exceeds Benchmark	<0.5%	N/A	N/A. No data for 2008-09.
Not Assessed	No Observed Miles	N/A	N/A. No data for 2008-09.

Note: Benchmark for microcystins is the EPA recommended swimming advisory level of 8 µg/L.

Contaminants in Fish Tissue

Consuming fish can be an important part of a balanced diet. Fish provide protein, are low in saturated fat, are rich in many micronutrients, and provide certain omega-3 fatty acids that the body cannot make and that are important for growth and development in fetuses, infants, and children. However, due to natural processes and human activity, contaminants enter the aquatic environment, where they can accumulate in fish and may reach levels of concern for people who eat fish.

For this study, composite samples of fish fillet tissue were analyzed for mercury, PCBs, and 13 PFAS. Additionally, fish tissue plugs were analyzed for mercury only.

The potential human health effects that can be associated with high levels of mercury in fish include problems with neurological development and an increased risk of cardiovascular disease (USEPA 2001). The range of potential health effects from exposure to PCBs in fish includes liver disease, reproductive impacts, neurological effects in infants and young children, and cancer. Studies indicate that low-level exposure to PCBs can increase the risk of cancer, while higher-level exposure may increase the potential for additional health impacts (USEPA 1980, ATSDR and USEPA 1998). Studies indicate that PFOS, a PFAS chemical, can cause reproductive and developmental, liver and kidney, and immunological effects in laboratory animals. The most consistent findings from human epidemiology studies are increased cholesterol levels among exposed populations, with more limited findings related to infant birth weights, effects on the immune system, and thyroid hormone disruption (USEPA 2016a).

EPA applied human health benchmarks to evaluate potential health concerns from human exposure to various chemicals through fish consumption. Each chemical-specific benchmark represents the chemical concentration in fish tissue that, if exceeded, may adversely impact human health. For mercury, this analysis used EPA's recommended fish tissue-based water quality criterion for methylmercury. This is the same value EPA used in the NRSA 2008–09 report. For PCBs and PFOS, EPA used fish tissue benchmarks it developed using the equations found in EPA's *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories* (USEPA 2000a). However, compared to the fish tissue benchmarks used in the NRSA 2008–09 report, EPA updated the body weight and fish consumption rate used in the equations. Additionally, for PFOS, this analysis used EPA's reference dose (USEPA 2016a) to calculate the human health fish tissue benchmark. In the NRSA 2008–09 report, EPA did not have an EPA reference dose available and used a fish tissue benchmark developed by the state of Minnesota. The development of the human health fish tissue benchmarks is described in more detail in the NRSA 2013–14 Technical Support Document (USEPA 2020a).

Two sampling approaches were used to examine levels of contaminants in fish tissue. The first approach involved collecting small tissue plugs from target fish species; these fish were then treated with antibiotic salve and released. Crews attempted to collect fish tissue plugs at all river and stream sites, regardless of stream order, as long as target fish of a minimum size suitable for human consumption were available for testing. Fish tissue plugs were only analyzed for mercury. The results for mercury in fish tissue plugs (Figure 4.3) apply to the full NRSA target population of rivers and streams (~1.2 million miles), the same population defined for the other indicators in this report (except the fish fillet indicator as noted below). Consistent with the other indicators (except the fish fillet indicator), the portion of the population that was unable to be assessed is shown in the results.

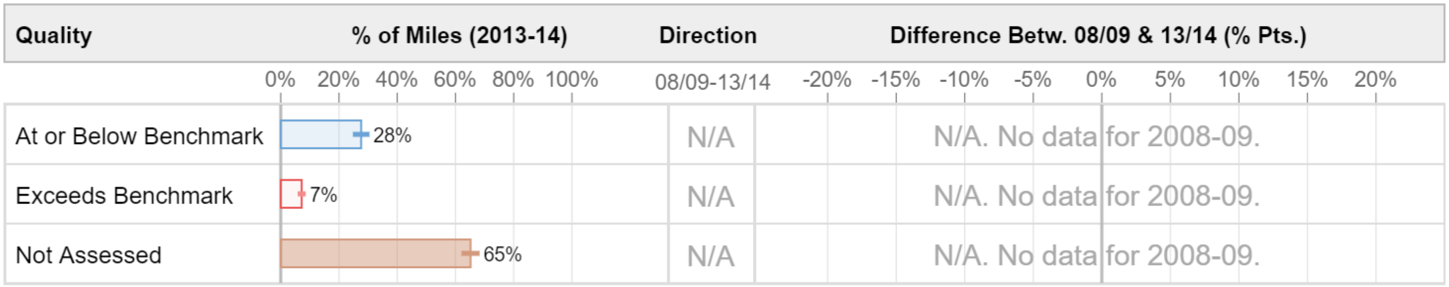
The second sampling approach, which was also used in NRSA 2008–09, involved collecting whole-fish samples for laboratory preparation and analysis of fillet composite samples (composed of muscle tissue from both sides of each fish in the composite sample that is ground before chemical analysis).[10] Ideally, a whole-fish composite sample consists of five adult fish of the same species (fish species typically sought for human consumption by recreational anglers) whose lengths are within 75% of the length of the largest fish in the composite sample. The number of fish in a composite sample may vary depending on the number of suitable fish that can be collected from a particular river site. Whole-fish composite samples were only collected from rivers defined as 5th order or greater for this study.

The target population for the fillet indicator consists of 129,445 river miles. A portion of this river target population could not be assessed for a variety of reasons, including denial of access to sites on private lands, inability to obtain permits, lack of suitable fish, and physical barriers (e.g., high bluffs). The amount of fillet tissue available from each composite sample limited the number of samples that could be analyzed for each contaminant. These limitations affected the extent of rivers represented in each set of results, which is referred to as the sampled population. The sampled population is the subset of the target population for which fish fillet indicator samples were successfully collected and analyzed. The fish fillet composite samples were analyzed for mercury, PCBs, and 13 PFAS. Figure 4.4 presents the fish fillet composite results for mercury, PCBs, and PFOS (see the NRSA 2013–14 Technical Support Document (USEPA 2020a) for results related to all 13 PFAS chemicals analyzed) for the sampled population of river miles that applies for each contaminant.[11]

Mercury

Mercury enters the environment via both anthropogenic and natural sources. When released into the atmosphere, it can be transported for long distances before it is deposited in water or on land; thus, it may occur even in relatively undisturbed rivers and streams. Aquatic ecosystems are particularly sensitive and vulnerable to mercury

Figure 4.3 Mercury in Fish Tissue (Plugs): NRSA 2013–14 National Results



Note: Benchmark for mercury is the EPA's recommended criterion for methylmercury of 300 ppb.

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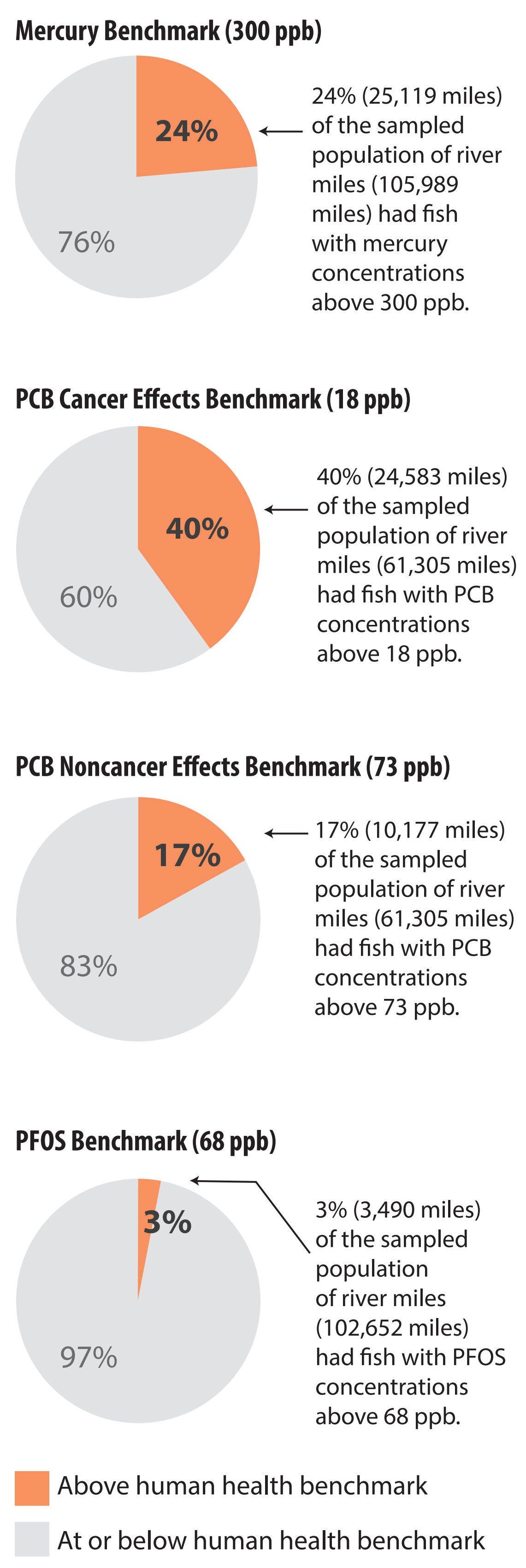
[10] For the NRSA 2013–14 survey, a composite sample was formed by combining fillet tissue from up to five adult fish of the same species and similar size from the same site. Use of composite sampling for screening studies is a cost-effective way to estimate average contaminant concentrations while also ensuring that there is sufficient fish tissue to analyze for all contaminants of concern. (Average concentrations from composite samples may represent an over- or underestimation of a contaminant as compared to the concentration in a single fish sample.)

[11] PFOS and perfluorooctanoic acid (PFOA) are the two PFAS chemicals for which EPA has developed chronic reference doses. Reference doses are needed to derive a human health fish tissue benchmark. However, because PFOA was only detected in 4% of fish fillet composite samples, the Agency did not develop a human health fish tissue benchmark for PFOA for use in evaluating results for this report.

Figure 4.4. Percentage of River Miles with Fillet Composite Concentrations Above Human Health Fish Tissue Benchmarks



contamination. Once elemental mercury is deposited in water, bacteria convert it into methylmercury, a toxic compound that accumulates in fish, shellfish, and animals that eat fish. Nearly all fish contain quantifiable levels of mercury, and the amount of mercury measured in fish tissue usually increases with fish age and size. It also varies among fish species — those that prey on other fish typically accumulate higher concentrations of mercury than those that eat insects or other aquatic organisms. Mercury can build up in large predator fish to levels as much as 10 million times higher than levels in water (i.e., through biomagnification), so fish consumption can be a main source of human exposure to mercury (Fitzgerald et al. 1998, Wiener et al. 2003). States and tribes issue consumption advisories for specific fish species and water bodies when state or local sampling results indicate elevated mercury concentrations. More information on fishing advisories is available from local health agencies and at https://www.epa.gov/fish-tech.

The mercury levels in fish tissue plugs and fillet composite samples were compared to EPA's recommended fish tissue-based water quality criterion for mercury of 0.3 milligrams of methylmercury per kilogram of tissue (wet weight), or 300 ppb (USEPA 2001). This fish tissue benchmark represents the concentration that, if exceeded, can be harmful to human health.

For mercury in fish plugs, Figure 4.3 shows that fish in 7% (87,031 miles) of river and stream miles had concentrations above the 300 ppb mercury criterion recommendation, while 28% (334,271 miles) did not. Additionally, 65% (788,924 miles) of river and stream miles were not assessed for a variety of reasons, including the absence of fish, the lack of habitat to support fish that met the minimum size requirement, inability to obtain permits, inclement weather, and site access denial. [Note: As described earlier in this section, the target population for the fish fillet composite is a subset of the target population for the fish plug indicator. Therefore, the percentage of miles that had exceedances above the mercury benchmark for fish plugs is not directly comparable to the percentage for fish fillet composite samples.] Fish plugs were not collected in 2008–09, so a difference analysis could not be conducted.

Mercury was detected in 100% of the fish fillet composite samples from the 353 river sites that were assessed for mercury. Mercury concentrations in the fillet composite samples were above the EPA recommended fish tissue-based water quality criterion for methylmercury of 300 ppb in 24% of the sampled population of 105,989 river miles assessed for mercury (or 25,119 river miles had mercury levels above the benchmark) (see Figure 4.4). Comparisons of fillet composite results for mercury between NRSA 2008–09 and NRSA 2013–14 did not reveal statistically significant differences.

PCBs

PCBs are industrial chemicals that were once used as coolants in electrical insulators and as a component in the manufacture of carbonless copy paper. EPA banned manufacture and phased out most uses of PCBs about 40 years ago, but they are still widely distributed and extremely persistent in the environment. PCBs remain chemicals of concern due to their stability, potential for atmospheric transportation, and tendency to attach onto organic particles that deposit in river and lake sediments. As with mercury, many PCBs biomagnify in the food web. Levels in aquatic organisms can be as much as one million times greater than levels in water (ATSDR 2000). In humans, some of the highest exposures to PCBs come from eating contaminated fish (ATSDR 2000). The potential adverse health effects from PCBs vary based on levels of exposure through consumption of PCB-contaminated fish and are described earlier in this section.

All whole-fish samples collected from 223 river sites and the corresponding fillet composite samples analyzed for PCBs during NRSA 2013–14 contained detectable levels of PCBs. PCB results were compared to EPA's human health fish tissue benchmarks of 18 ppb for cancer effects and 73 ppb for noncancer effects (e.g., reproductive effects in women and liver disease). Fish had fillet composite total PCB concentrations above the 18 ppb benchmark for cancer effects in 40% (24,583 river miles) of the sampled population of river miles and above the 73 ppb benchmark for noncancer effects in 17% (10,177 river miles) of this sampled population (see Figure 4.4). Estimates of PCB fish fillet results from NRSA 2008–09 are not comparable to the results from NRSA 2013–14 due to differences in chemical methods used during the two surveys (21 PCB congeners analyzed in 2008–09 and 209 congeners in 2013–14).

PFAS

PFAS are a very large group of synthetic chemicals that have been produced for decades to make products resistant to heat, oil, stains, and water. PFAS are used in many industrial applications and are found in stain-resistant fabrics, nonstick cookware, and some types of food packaging. Due to their widespread use and persistence in the environment, most people in the U.S. have been exposed to PFAS. There is evidence that continued exposure above specific levels to certain PFAS may lead to adverse health effects (USEPA 2019b).

This section presents the results for the most commonly detected PFAS in freshwater fish tissue, PFOS, which can accumulate through the food web to levels of concern in fish. PFOS concentrations in fish fillets can be thousands of times higher than PFOS levels in surface water (Sinclair et al. 2006). See the NRSA 2013–14 Technical Support Document (USEPA 2020a) for summary statistics (e.g., detection frequency, detection limits, measured concentration range, etc.) related to the 13 PFAS chemicals analyzed in fish tissue.

PFOS results were compared to a human health fish tissue benchmark of 68 ppb that is based on toxicity information presented in EPA's *Health Effects Support Document for PFOS* and a fish consumption rate of 22 grams per day (USEPA 2000a, 2016a).[12] PFOS and perfluorooctanoic acid (PFOA) are the two PFAS chemicals for which EPA has developed chronic reference doses. Reference doses are needed to derive a human health fish tissue benchmark. However, because PFOA was only detected in 4% of fish fillet composite samples, the Agency did not develop a human health fish tissue benchmark for PFOA for use in evaluating results for this report. Fish had fillet composite PFOS concentrations above the 68 ppb human health benchmark for PFOS in 3% (3,490 river miles) of the sampled population of 102,652 river miles assessed for PFAS (see Figure 4.4). Fish fillet composite samples from 99% of the 349 river sites assessed for PFAS during NRSA 2013–14 contained detectable levels of PFOS. Comparisons of fillet composite results for PFOS between NRSA 2008–09 and NRSA 2013–14, which involved urban river sampling locations only, did not reveal statistically significant differences.[13]

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[12] Human health fish tissue benchmarks are used in the fish consumption advisory program, while health advisories are used in the drinking water program.

[13] In the NRSA 2008-–09 study, fish tissue fillet composite sampling was limited to urban water sites only. Therefore, difference estimates are calculated by comparing the NRSA 2008–09 urban river sites to NRSA 2013–14 urban river sites.

5

Comparing Results Across Ecoregions

The design of NRSA allows one to examine indicators across ecological regions (ecoregions) as well as across the nation. This chapter presents information and graphics that can be used to answer questions about rivers and streams at the ecoregional scale.

Ecoregions are geographic areas that display similar environmental characteristics, such as climate, vegetation, type of soil, and geology. EPA has defined ecoregions at various scales, from a continental scale (Level I) to fine scales that divide the land into smaller ecosystem units (Levels III or IV). This chapter will focus on NRSA results for the nine U.S. Level III ecoregions aggregated for use in NARS. These nine ecoregions, shown in Figure 5.1, are:

- Northern Appalachians
- Southern Appalachians
- Coastal Plains
- Upper Midwest
- Temperate Plains
- Southern Plains
- Northern Plains
- Western Mountains
- Xeric

Figure 5.1. NARS Aggregated Ecoregions

Ecoregions are used to conduct environmental assessments, to set water quality and biological criteria, and to set management goals for pollution control. It is important to assess water bodies in their own ecological setting. For example, the rivers in the mountainous, cold-to-temperate Northern Appalachians will have many similar characteristics; they run through steep, rocky channels over glacial sediments and are influenced by annual precipitation totals of 35 to 60 inches. These rivers will differ significantly from those in the dry plains, tablelands, and low mountains of the Xeric ecoregion, which drain erodible sedimentary rock and are subject to flash floods in a climate where precipitation ranges from 2 to 40 inches and average temperatures are much higher.

The following sections describe each ecoregion in more detail, providing background information and describing NRSA 2013–14 results for the length of rivers and streams throughout the ecoregion. (See Ch. 2 to review the methodology for developing ecoregion-specific benchmarks using the distribution of values from least-disturbed reference sites. See Chs. 3 and 4 for more on fixed benchmarks used for riparian disturbance and for human health indicators.) These results should not be extrapolated to an individual state or water body within the ecoregion because the study was not designed to characterize quality at these finer scales.

NORTHERN APPALACHIANS

Setting

The Northern Appalachians ecoregion covers all of the New England states, most of New York, the northern half of Pennsylvania, and northeastern Ohio. The ecoregion covers some 139,424 square miles of land (4.6% of the conterminous U.S.), with about 4,722 square miles of land under federal ownership. Included in the ecoregion are New York's Adirondack and Catskill Mountains and Pennsylvania's Allegheny National Forest. Major river systems include the St. Lawrence, Allegheny, Penobscot, Connecticut, and Hudson. The total river and stream length represented in NRSA 2013–14 for the Northern Appalachians ecoregion is 138,082 miles.

Forests in this ecoregion were extensively cleared in the 18th and 19th centuries. Current fish stocks are lower than at the time of European contact, but the coastal rivers of the Northern Appalachians ecoregion still have a wide variety of fish — including shad, alewife, salmon, and sturgeon — that are hatched in fresh water, move to the sea for most of their lives, and then return to fresh water to spawn. Major manufacturing and chemical, steel, and power production occur in the large metropolitan areas around New York City, Connecticut, and Massachusetts. It is common for treated wastewater effluent to account for much of the stream flow downstream from major urban areas.

This ecoregion is generally hilly, with some intermixed plains and mountain ranges. River channels in the glaciated uplands of the northern parts of the ecoregion are steep and rocky, and they flow over glacial sediments. The climate is cold to temperate, with mean annual temperatures ranging from 39°F to 48°F. Annual precipitation totals range from 35 to 60 inches.

Results Summary

A total of 252 NRSA sites were sampled to characterize the quality of rivers and streams in the Northern Appalachians ecoregion. Figure 5.2 shows an overview of the findings.

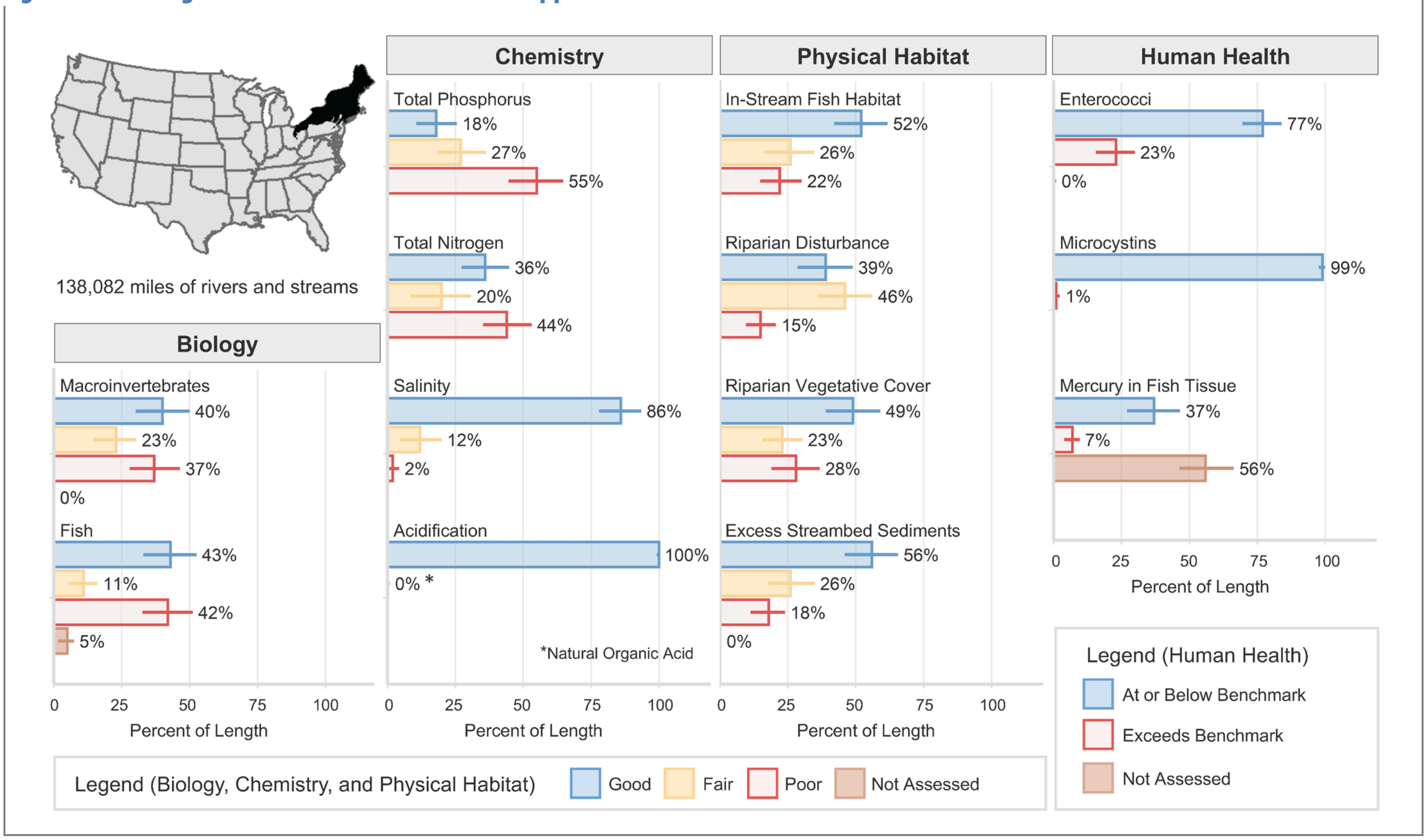
Biological Indicators

The macroinvertebrate MMI showed that 40% of the river and stream length in the Northern Appalachians ecoregion was of good quality (based on the least-disturbed reference distribution). The fish MMI showed that 43% of river and stream length in this ecoregion was of good quality. Five percent of river and stream length was not assessed or, for various reasons, had insufficient data to calculate the fish MMI.

Chemical and Physical Habitat Indicators

The percentage of miles rated good for chemical and physical habitat indicators varied widely within the Northern Appalachians ecoregion. Phosphorus and nitrogen tended to have a lower percentage of river and stream miles with good quality, 18% and 36% respectively, compared to physical habitat measures such as in-stream fish habitat, excess streambed sediments, and riparian vegetation cover, which had 52%, 56%, and 49%, respectively.

Figure 5.2. Ecoregional Results for the Northern Appalachians



Human Health Indicators

Human health indicators measured within the Northern Appalachians showed that most of the river and stream miles were below levels of concern. Enterococci were at or below the national benchmark for 77% of river and stream length. Microcystins were at or below the national benchmark for 99% of river and stream length. Mercury in fish tissue plugs was at or below the national benchmark for 37% of river and stream length, with 56% unassessed for a variety of reasons, including the absence of fish, the lack of habitat to support fish that met the minimum size requirement, inability to obtain permits, inclement weather, and site access denial.

SOUTHERN APPALACHIANS

Setting

The Southern Appalachians ecoregion stretches over ten states, from northeastern Alabama to central Pennsylvania, and includes the interior highlands of the Ozark Plateau and the Ouachita Mountains in Arkansas, Missouri, and Oklahoma. The topography of this ecoregion is mostly hills and low mountains, with some wide valleys and irregular plains. Its land area covers about 321,900 square miles (11% of the conterminous U.S.), with about 42,210 square miles in federal ownership. Many significant public lands, including Great Smoky Mountains National Park, George Washington and Monongahela National Forests, and Shenandoah National Park, are located within this ecoregion.

The Southern Appalachians ecoregion has some of the greatest aquatic animal diversity of any area of North America, especially for species of amphibians, fishes, mollusks, aquatic insects, and crayfishes. Some areas, such as Great Smoky Mountains National Park, continue to protect exceptional stands of old-growth forest riparian systems. Nevertheless, the effects of habitat fragmentation, urbanization, agriculture, channelization, diversion, mining, and impoundments have altered many rivers and streams in this ecoregion.

Rivers in this ecoregion flow mostly over bedrock and other resistant rock types, with steep channels and short meander lengths. A number of major rivers originate here, including the Susquehanna, James, and Potomac, along with feeders into the Ohio and Mississippi River systems, such as the Greenbrier River in West Virginia. The total river and stream length represented in NRSA 2013–14 for the Southern Appalachians ecoregion is 289,341 miles. It is considered temperate wet, with annual precipitation of 40 to 80 inches and mean annual temperature ranging from 55°F to 65°F.

Results Summary

A total of 251 NRSA sites were sampled to characterize the quality of rivers and streams in the Southern Appalachians ecoregion. An overview of the findings is shown in Figure 5.3.

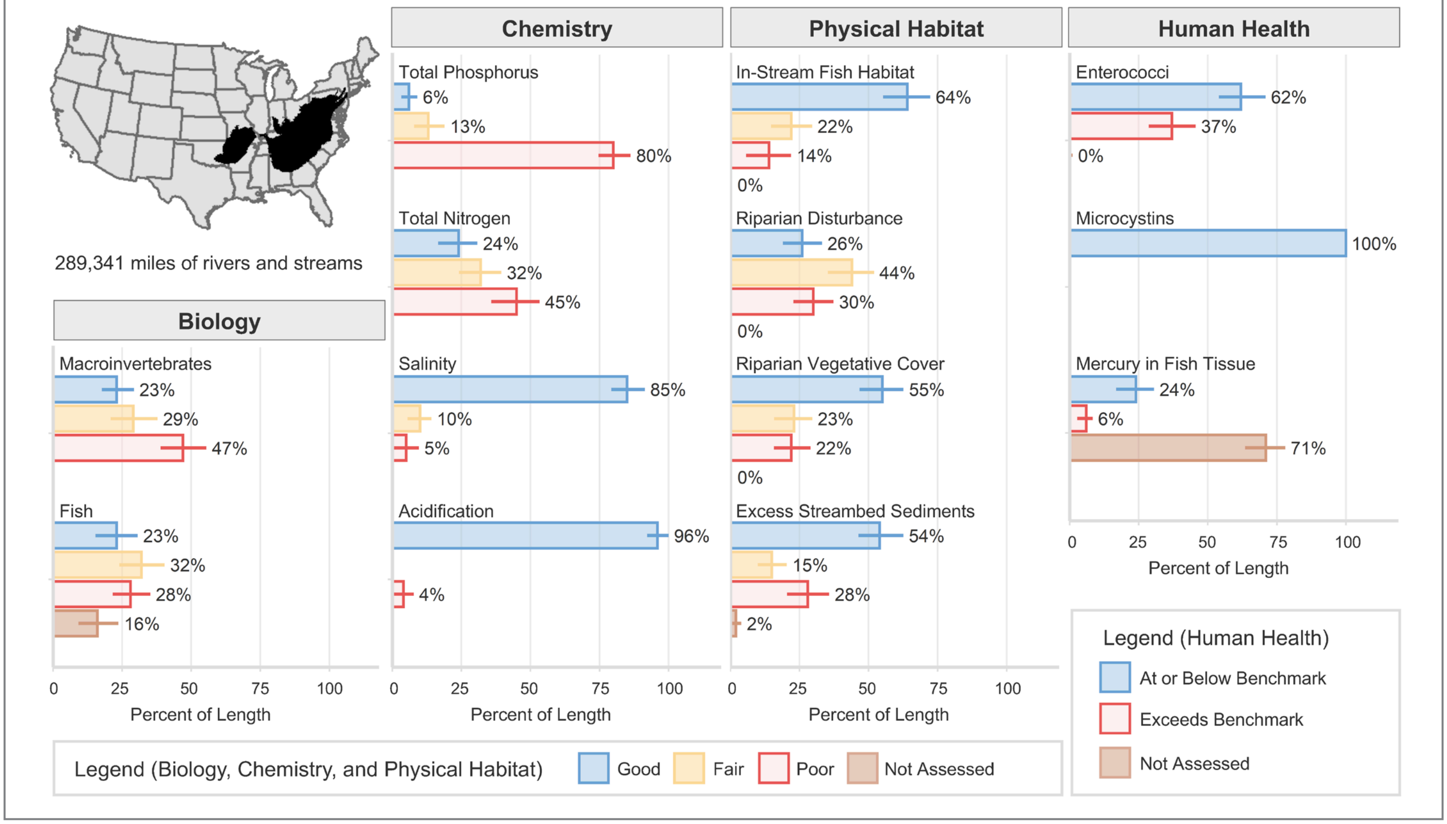
Biological Indicators

The macroinvertebrate MMI showed that 23% of the river and stream length in the Southern Appalachians ecoregion was of good quality (based on the least-disturbed reference distribution). The fish MMI showed that 23% of river and stream length was of good quality. Sixteen percent of river and stream length was not assessed or, for various reasons, had insufficient data to calculate the fish MMI.

Chemical and Physical Indicators

The percentage of miles rated good for chemical and physical habitat indicators varied widely within the Southern Appalachians ecoregion. Phosphorus and nitrogen tended to have a lower percentage of river and stream miles with good quality, 6% and 24% respectively, compared to physical habitat measures such as riparian vegetation cover, in-stream fish habitat, and excess streambed sediments, which had 55%, 64%, and 54%, respectively.

Figure 5.3. Ecoregional Results for the Southern Appalachians



Human Health Indicators

Human health indicators measured within the Southern Appalachians showed that most of the river and stream miles were below levels of concern. Enterococci were at or below the national benchmark for 62% of river and stream length. Microcystins were at or below the national benchmark for 100% of river and stream length. Mercury in fish tissue plugs was at or below the national benchmark for 24% of river and stream length, with 71% unassessed for a variety of reasons, including the absence of fish, the lack of habitat to support fish that met the minimum size requirement, inability to obtain permits, inclement weather, and site access denial.

COASTAL PLAINS

Setting

The Coastal Plains ecoregion covers all of Florida, eastern Texas, and the Atlantic seaboard from Florida to New Jersey. It includes the Mississippi Delta and Gulf Coast, and it extends north along the Mississippi River to the Mississippi's confluence with the Ohio River. The total land area of this ecoregion is about 395,000 square miles, or 13% of the conterminous U.S. Of this area, 25,890 square miles, or 7%, is in federal ownership. River systems within or intersecting the Coastal Plains ecoregion include the Mississippi, Suwannee, Savannah, Potomac, Delaware, Susquehanna, James, Sabine, Brazos, and Guadalupe.

River habitats in the Coastal Plains ecoregion have high species richness and the greatest number of endemic species of aquatic organisms in North America. These organisms include fish, aquatic insects, and mollusks, as well as unique species such as paddlefish, American alligators, and giant aquatic salamanders. It is estimated that about 18% of the aquatic species in this ecoregion are threatened or endangered. Historically, this ecoregion had extensive bottomlands that flooded for several months each year; these areas are now widely channelized and confined by levees. Acid mine drainage, urban runoff, air pollution, sedimentation, and the introduction of invasive (i.e., non-native) species have affected riparian habitats and native aquatic fauna.

In general, rivers in the Coastal Plains meander broadly across flat plains created by river deposition and form complex wetland topographies, with natural levees, back swamps, and oxbow lakes. Typically, they drain densely vegetated

watersheds; well-developed soils and moderate rains and subsurface flows keep suspended sediment levels in the rivers relatively low. An exception is the Mississippi River, which carries large sediment loads from dry lands in the central and western portion of its drainage area. The total river and stream length represented in NRSA 2013–14 for the Coastal Plains ecoregion is 198,824 miles.

The topography of this ecoregion is mostly flat plains, barrier islands, many wetlands and about 50 important estuary systems that lie along its coastal margins. The climate is temperate wet to subtropical, with average annual temperatures ranging from 50°F to 80°F and annual precipitation ranging from 30 to 79 inches.

Results Summary

A total of 218 NRSA sites were sampled to characterize the quality of rivers and streams in the Coastal Plains ecoregion. An overview of the findings is shown in Figure 5.4.

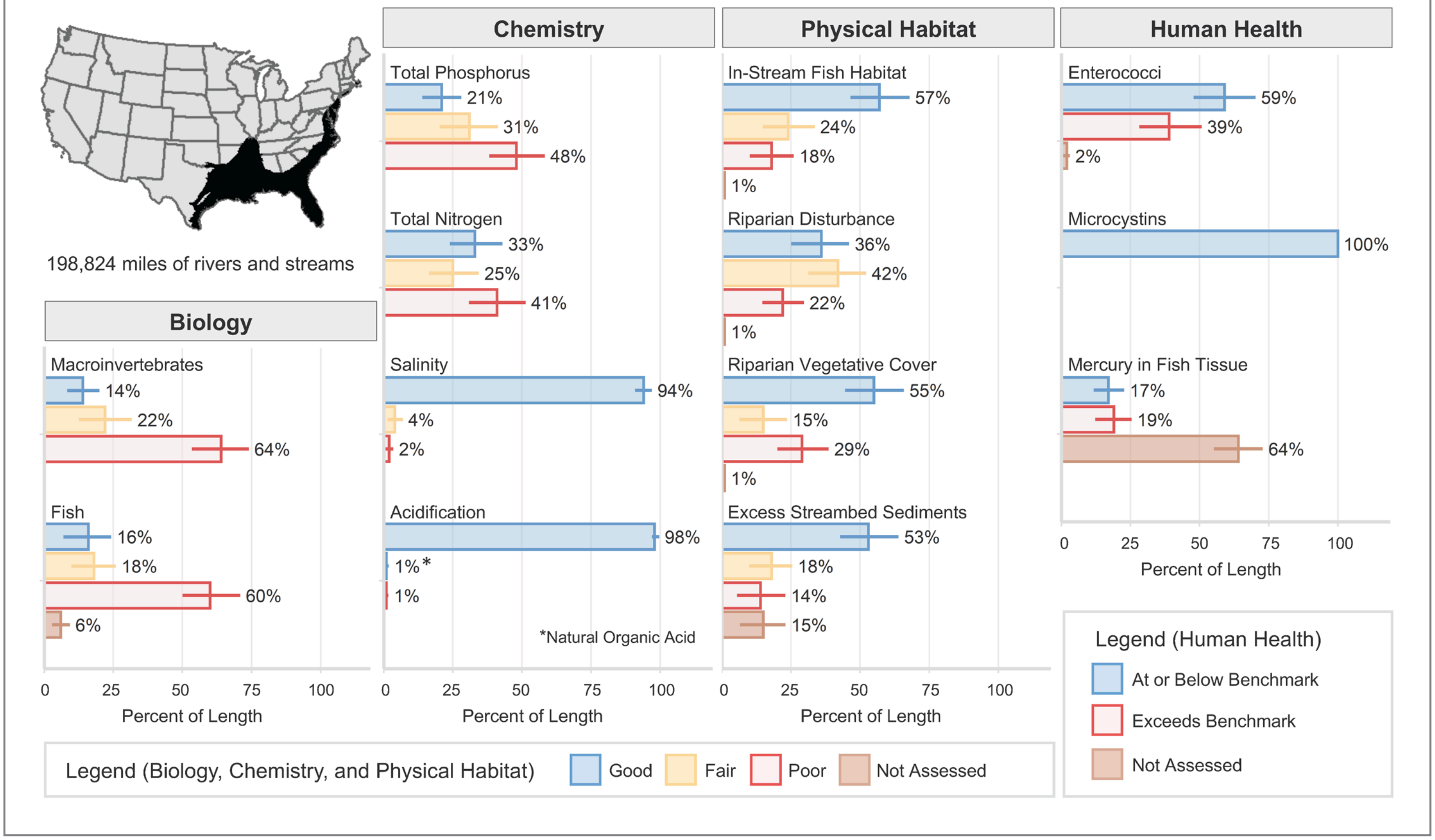
Biological Indicators

The macroinvertebrate MMI showed that 14% of river and stream length in the Coastal Plains ecoregion was of good quality (based on the least-disturbed reference distribution). The fish MMI showed that 16% of river and stream length was of good quality. Six percent of river and stream length was not assessed or, for various reasons, had insufficient data to calculate the fish MMI.

Chemical and Physical Habitat Indicators

The percentage of miles rated good for chemical and physical habitat indicators varied widely within the Coastal Plains ecoregion. Phosphorus and nitrogen tended to have a lower percentage of river and stream miles with good quality, 21% and 33%, respectively, compared to physical habitat measures such as riparian vegetation cover, in-stream fish habitat, and excess streambed sediments, which had 55%, 57%, and 53%, respectively.

Figure 5.4. Ecoregional Results for the Coastal Plains



Human Health Indicators

Human health indicators measured within the Coastal Plains ecoregion showed that most of the river and stream miles were below levels of concern. Enterococci were at or below the national benchmark for 59% of river and stream length. Microcystins were at or below the national benchmark for 100% of river and stream length. Mercury in fish tissue plugs was at or below the national benchmark for 17% of river and stream length, with 64% unassessed for a variety of reasons, including the absence of fish, the lack of habitat to support fish that met the minimum size requirement, inability to obtain permits, inclement weather, and site access denial.

UPPER MIDWEST

Setting

The Upper Midwest ecoregion covers most of Minnesota's northern half and southeastern area, two-thirds of Wisconsin and almost all of Michigan, an area of 160,374 square miles, or 5% of the conterminous U.S. National and state forests and federal lands account for approximately 25,000 square miles, or 16%, of the ecoregion. The river systems in this ecoregion empty into portions of the Great Lakes regional watershed and the upper Mississippi River watershed. Major river systems include the upper Mississippi River in Minnesota and Wisconsin; the Wisconsin, Chippewa, and St. Croix rivers in Wisconsin; and the Menominee and Escanaba rivers in Michigan. Other important water bodies include Lakes Superior, Michigan, Huron, and Erie.

Virtually all of the virgin forest in this ecoregion was cleared in the 19th and early 20th centuries, and rivers and streams were greatly affected by logging. The Great Lakes aquatic systems are subject to increasing impact from invasive animal and plant species, including the zebra mussel, round goby, river ruffe, spiny water flea, and Eurasian watermilfoil. Major manufacturing and chemical, steel, and power production occur in the large metropolitan areas of the Upper Midwest ecoregion.

Streams in the Upper Midwest ecoregion typically drain relatively small catchments and empty directly into the Great Lakes or upper Mississippi River. These streams generally have steep gradients, but the region's topography and soils tend to slow runoff and sustain flow throughout the year. The total river and stream length represented in NRSA 2013–14 for the Upper Midwest ecoregion is 101,648 miles.

The glaciated terrain of this ecoregion typically consists of plains with some hills. Lakes, rivers, and wetlands predominate in most areas. The climate is characterized by cold winters and relatively short summers, with mean annual temperatures ranging from 34°F to 54°F and annual precipitation ranging from 20 to 47 inches.

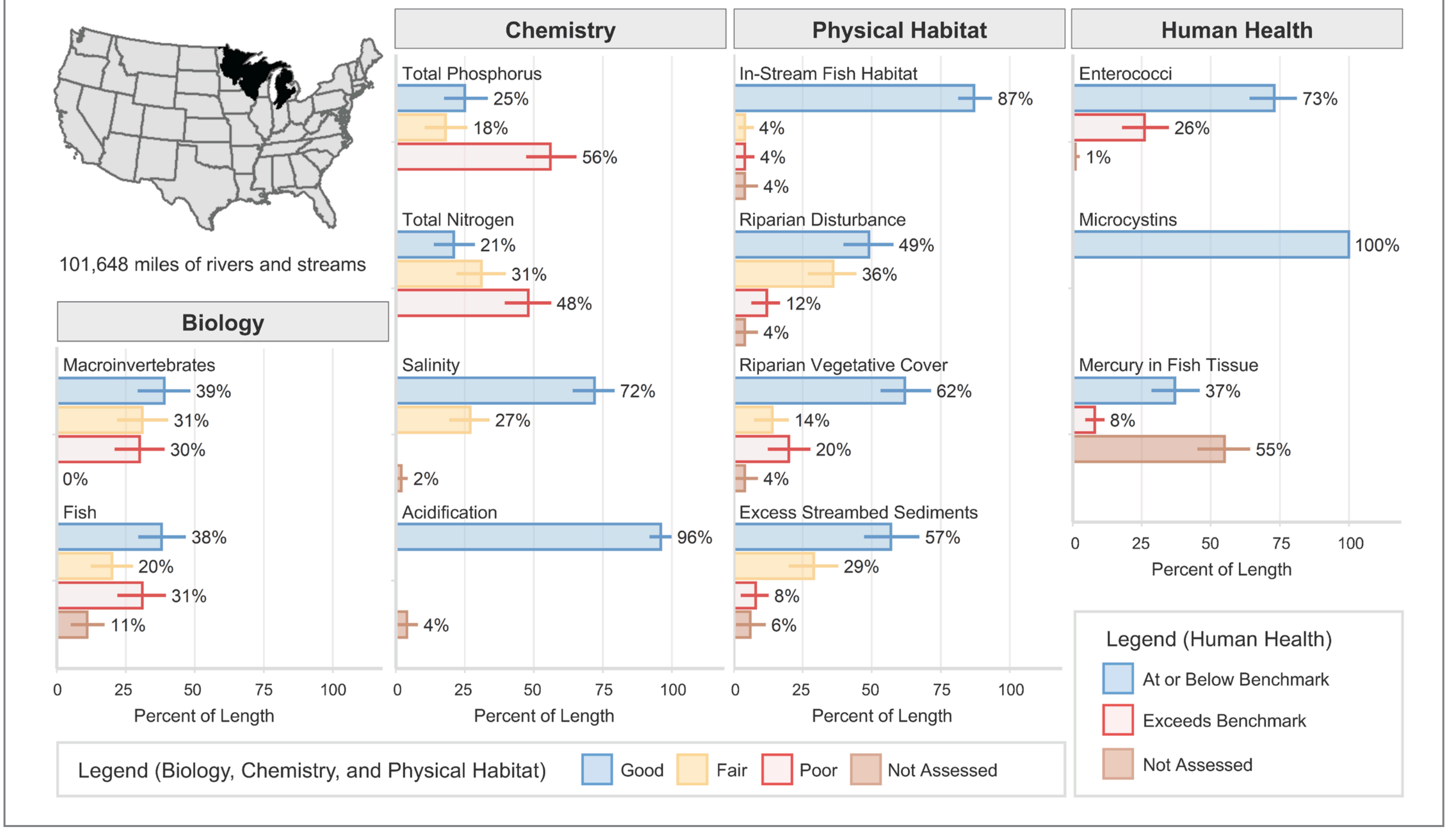
Results Summary

A total of 159 NRSA sites were sampled to characterize the quality of rivers and streams in the Upper Midwest ecoregion. An overview of the findings is shown in Figure 5.5.

Biological Indicators

The macroinvertebrate MMI showed that 39% of river and stream length in the Upper Midwest ecoregion was of good quality (based on the least-disturbed reference distribution). The fish MMI showed that 38% of river and stream length was of good quality. Eleven percent of river and stream length was not assessed or, for various reasons, had insufficient data to calculate the fish MMI.

Figure 5.5. Ecoregional Results for the Upper Midwest



Chemical and Physical Habitat Indicators

The percentage of miles rated good for chemical and physical habitat indicators varied widely within the Upper Midwest ecoregion. Phosphorus and nitrogen tended to have a lower percentage of river and stream miles with good quality, 25% and 21% respectively, compared to physical habitat measures such as in-stream fish habitat, excess streambed sediments, and riparian vegetation cover, which had 87%, 57%, and 62%, respectively.

Human Health Indicators

Human health indicators measured within the Upper Midwest ecoregion showed that most of the river and stream miles were below levels of concern. Enterococci were at or below the national benchmark for 73% of river and stream length. Microcystins were at or below the national benchmark for 100% of river and stream length. Mercury in fish tissue plugs was at or below the national benchmark for 37% of river and stream length, with 55% unassessed for a variety of reasons, including the absence of fish, the lack of habitat to support fish that met the minimum size requirement, inability to obtain permits, inclement weather, and site access denial.

TEMPERATE PLAINS

Setting

The Temperate Plains ecoregion includes Iowa; the eastern Dakotas; western Minnesota; portions of Missouri, Kansas, and Nebraska; and the flatlands of western Ohio, central Indiana, Illinois, and southeastern Wisconsin. This ecoregion covers about 342,200 square miles, or 11%, of the conterminous U.S., with approximately 7,900 square miles under federal ownership. Many of the rivers in this ecoregion drain into the upper Mississippi River, Ohio River, and Great Lakes watersheds.

Much of this ecoregion is now primarily agricultural land, including land used for field crop production (e.g., corn, wheat, and alfalfa) and hog and cattle production. Crops and grazing have reduced natural riparian vegetative cover, increased sediment yield, and introduced pesticides and herbicides. Rivers have many species of fish, including minnows, darters, killifishes, catfishes, suckers, sunfishes, and black bass.

Rivers and streams in the tallgrass prairie start from prairie potholes and springs, and they may be ephemeral (flowing for a short time only after snowmelt or rainfall). Rivers carry large volumes of fine sediments and tend to be turbid, wide, and shallow. The total river and stream length represented in NRSA 2013–14 for the Temperate Plains ecoregion is 185,850 miles.

The terrain of this ecoregion consists of smooth plains and many small lakes and wetlands. The climate is temperate, with cold winters, hot and humid summers, and mean temperatures ranging from 36°F to 55°F. Annual precipitation ranges from 16 to 43 inches.

Results Summary

A total of 219 NRSA sites were sampled to characterize the quality of rivers and streams in the Temperate Plains ecoregion. An overview of the findings is shown in Figure 5.6.

Biological Indicators

The macroinvertebrate MMI showed that 24% of river and stream length in the Temperate Plains ecoregion was of good quality (based on the least-disturbed reference distribution). The fish MMI showed that 28% of river and stream length was of good quality. Six percent of river and stream length was not assessed or, for various reasons, had insufficient data to calculate the fish MMI.

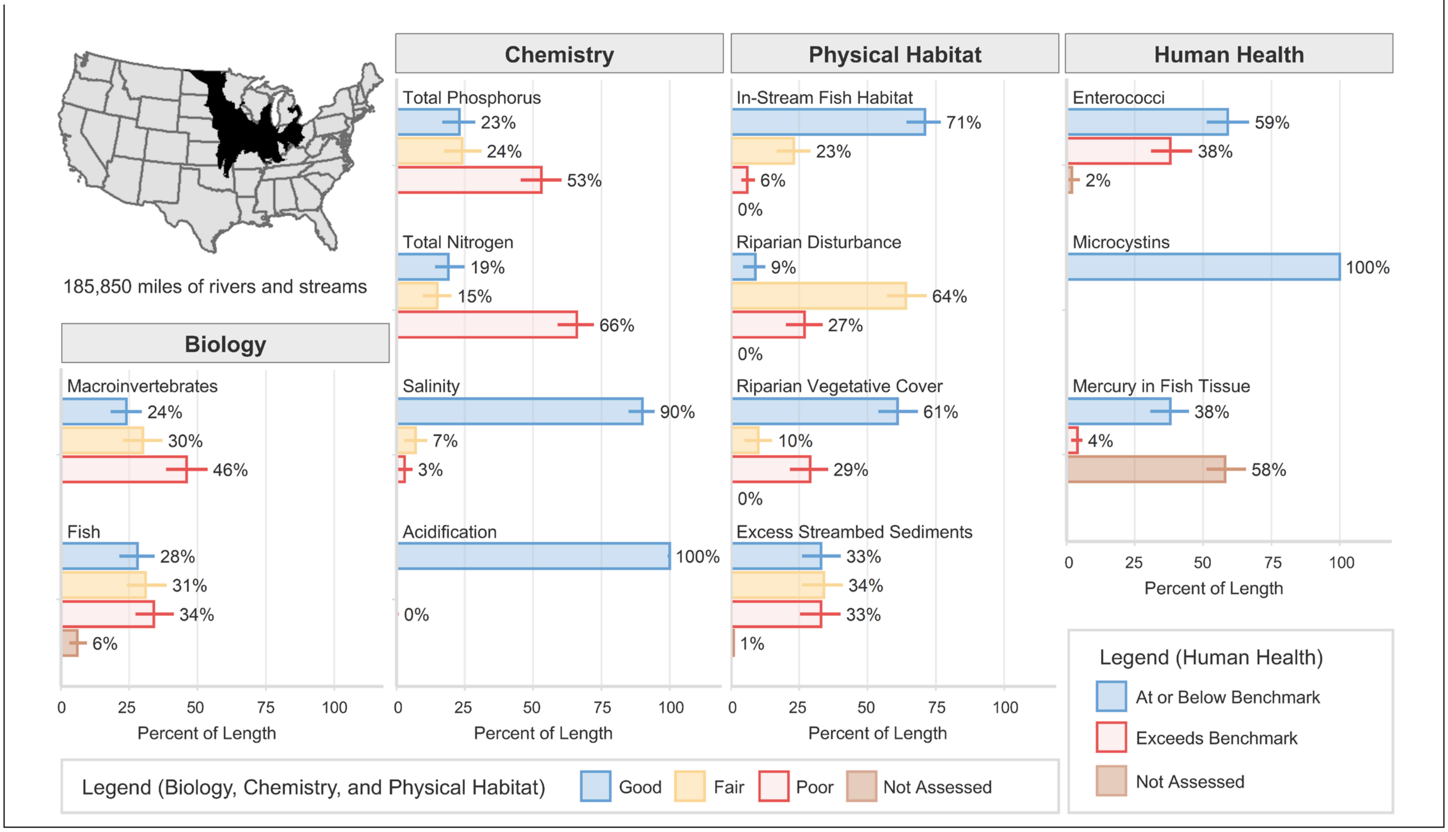
Chemical and Physical Habitat Indicators

The percentage of miles rated good for chemical and physical habitat indicators varied widely within the Temperate Plains ecoregion. Phosphorus and nitrogen tended to have a lower percentage of river and stream miles with good quality, 23% and 19% respectively, compared to physical habitat measures such as in-stream fish habitat, riparian vegetation cover, and excess streambed sediments, which had 71%, 61%, and 33%, respectively.

Human Health Indicators

Human health indicators measured within the Temperate Plains ecoregion showed that most of the river and stream miles were below levels of concern. Enterococci were at or below the national benchmark for 59% of river and stream length. Microcystins were at or below the national benchmark for 100% of river and stream length. Mercury in fish tissue plugs was at or below the national benchmark for 38% of river and stream length, with 58% unassessed for a variety of reasons, including the absence of fish, the lack of habitat to support fish that met the minimum size requirement, inability to obtain permits, inclement weather, and site access denial.

Figure 5.6. Ecoregional Results for the Temperate Plains



SOUTHERN PLAINS

Setting

The Southern Plains ecoregion covers about 405,000 square miles (14% of the conterminous U.S.) and includes central and northern Texas; most of western Kansas and Oklahoma; and portions of Nebraska, Colorado, and New Mexico. The Arkansas, Platte, White, Red, and Rio Grande rivers flow through this ecoregion, and most of the Ogallala aquifer (one of the world's largest groundwater aquifers, which supplies irrigation and drinking water to eight states) lies underneath it. Federal land ownership in this ecoregion totals about 11,980 square miles, or about 3% of the total.

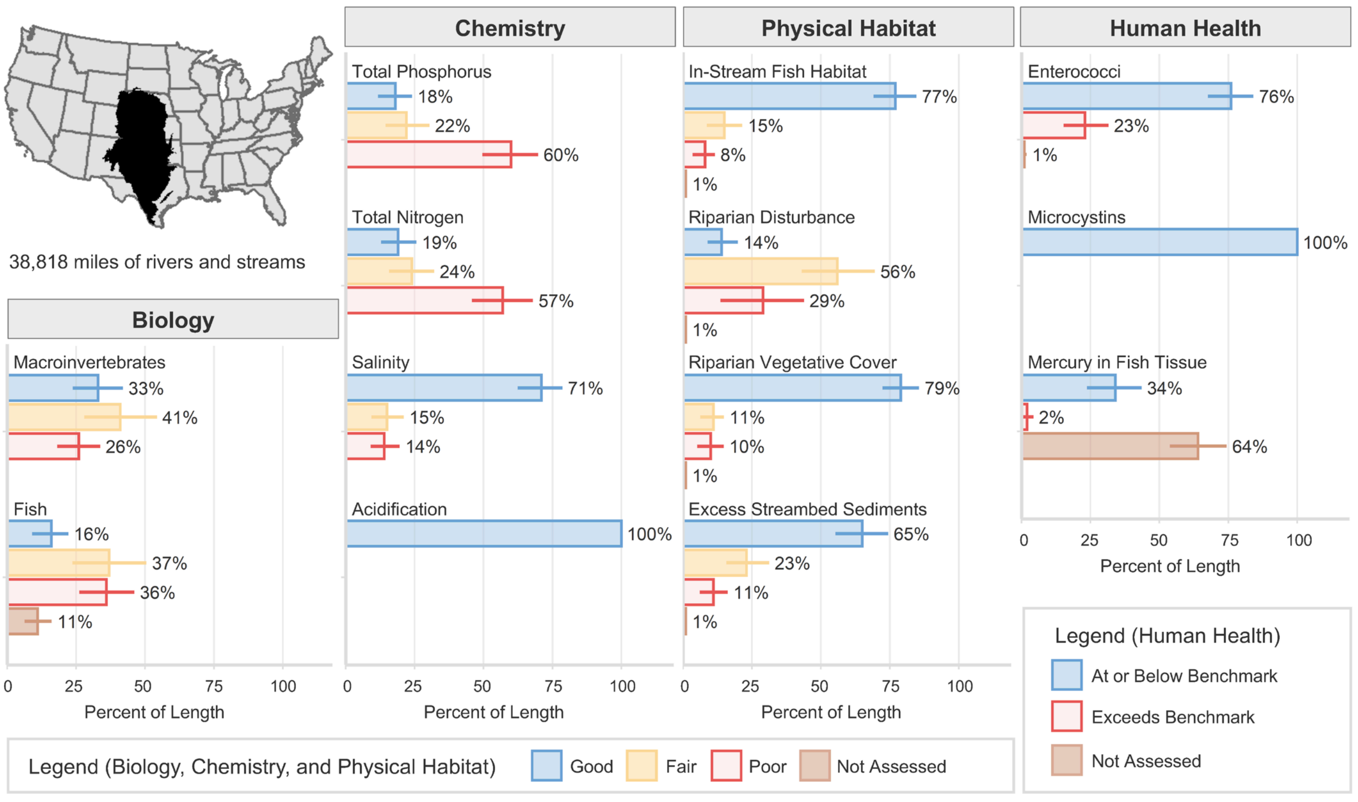
The terrain is a mix of smooth and irregular plains interspersed with tablelands and low hills. The Great Prairie grasslands, which once covered much of the Southern Plains ecoregion, are the most altered and endangered large ecosystem in the U.S. About 90% of the original tallgrass prairie has been replaced by other vegetation; agriculture and livestock grazing and production are prevalent. Agriculture is an important economic activity in this ecoregion, and it includes sorghum, wheat, corn, sunflower, bean and cotton production. Livestock production and processing is also prevalent. This ecoregion also contains a sizable portion of U.S. petroleum and natural gas production in Oklahoma, Kansas and Texas. The total river and stream length represented in NRSA 2013–14 for the Southern Plains ecoregion is 38,818 miles.

The climate in this ecoregion is dry temperate, with mean annual temperatures ranging from 45°F to 79°F. Annual precipitation is between 10 and 30 inches.

Results Summary

A total of 133 NRSA sites were sampled to characterize the quality of rivers and streams in the Southern Plains ecoregion. An overview of the findings is shown in Figure 5.7.

Figure 5.7. Ecoregional Results for the Southern Plains



Biological Indicators

The macroinvertebrate MMI showed that 33% of river and stream length in the Southern Plains ecoregion was of good quality (based on the least-disturbed reference distribution). The fish MMI showed that 16% of river and stream length was of good quality. Eleven percent of river and stream length was not assessed or, for various reasons, had insufficient data to calculate the fish MMI.

Chemical and Physical Habitat Indicators

The percentage of miles rated good for chemical and physical habitat indicators varied widely within the Southern Plains ecoregion. Phosphorus and nitrogen tended to have a lower percentage of river and stream miles with good quality, 18% and 19% respectively, compared to physical habitat measures such as in-stream fish habitat, riparian vegetation cover, and excess streambed sediments, which had 77%, 79%, and 65%, respectively.

Human Health Indicators

Human health indicators measured within the Southern Plains ecoregion showed that most of the river and stream miles were below levels of concern. Enterococci were at or below the national benchmark for 76% of river and stream length. Microcystins were at or below the national benchmark for 100% of river and stream length. Mercury in fish tissue plugs was at or below the national benchmark for 34% of river and stream length, with 64% unassessed for a variety of reasons, including the absence of fish, the lack of habitat to support fish that met the minimum size requirement, inability to obtain permits, inclement weather, and site access denial.

NORTHERN PLAINS

Setting

The Northern Plains ecoregion covers approximately 205,084 square miles, or 7% of the conterminous U.S. It includes the western Dakotas, Montana east of the Rocky Mountains, northeast Wyoming, and a small section of northern Nebraska. This ecoregion is the heart of the Missouri River system and is almost exclusively within the Missouri River's watershed. Federal lands account for 52,660 square miles, or nearly 26% of the total area.

Human economic activity in this ecoregion is primarily agriculture, including crop production and cattle and sheep grazing. Coal mining occurs in the portions of North Dakota, Montana, and Wyoming that are within the ecoregion, and petroleum and natural gas production are growing.

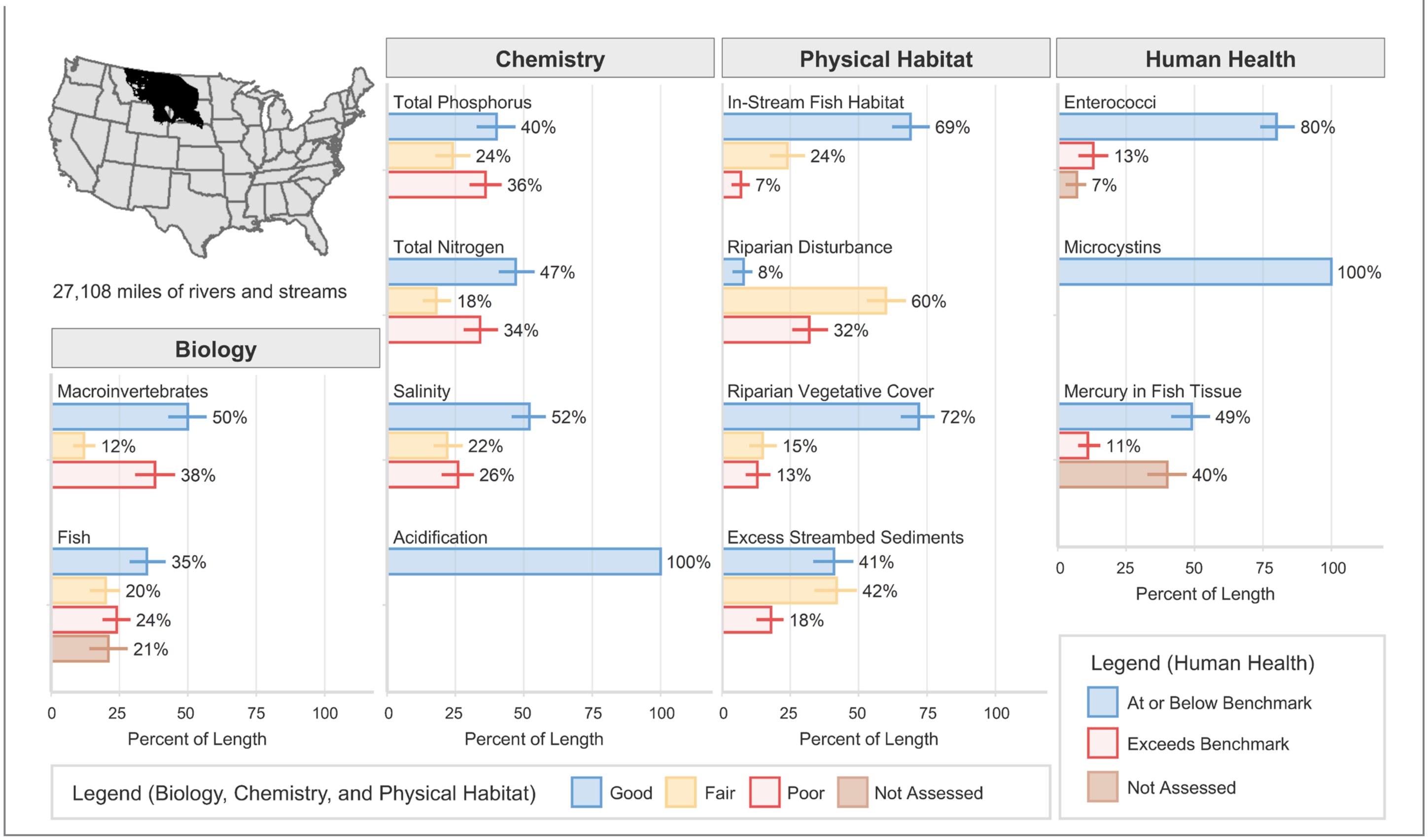
This ecoregion's terrain consists of irregular plains interspersed with tablelands and low hills. The Great Prairie grasslands were once an important feature of this ecoregion, but they have largely been replaced by other vegetation or land uses, particularly cropland. The total river and stream length represented in NRSA 2013–14 for the Northern Plains ecoregion is 27,108 miles.

The climate in this ecoregion is dry and characterized by short, hot summers and long, cold winters. Temperatures average 36°F to 46°F, and annual precipitation totals range from 10 to 25 inches. High winds are an important climatic factor in this ecoregion, which is also subject to periodic intense droughts and frosts.

Results Summary

A total of 172 NRSA sites were sampled to characterize the quality of rivers and streams in the Northern Plains ecoregion. An overview of the findings is shown in Figure 5.8.

Figure 5.8. Ecoregional Results for the Northern Plains



Biological Indicators

The macroinvertebrate MMI showed that 50% of river and stream length in the Northern Plains ecoregion was of good quality (based on the least-disturbed reference distribution). The fish MMI showed that 35% of river and stream length was of good quality. Twenty-one percent of river and stream length was not assessed or, for various reasons, had insufficient data to calculate the fish MMI.

Chemical and Physical Habitat Indicators

The percentage of miles rated good for chemical and physical habitat indicators varied widely within the Northern Plains ecoregion. Phosphorus and nitrogen tended to have a higher percentage of river and stream miles with good quality, 40% and 47% respectively, compared to other ecoregions; but unlike other ecoregions, salinity had a higher percentage of rivers and streams rated poor. Physical habitat measures such as riparian vegetation cover and in-stream fish habitat showed high percentages of river and stream miles with good quality, 72% and 69% respectively.

Human Health Indicators

Human health indicators measured within the Northern Plains ecoregion showed that most of the river and stream miles were below levels of concern. Enterococci were at or below the national benchmark for 80% of river and stream length. Microcystins were at or below the national benchmark for 100% of river and stream length. Mercury in fish tissue plugs was at or below the national benchmark for 49% of river and stream length, with 40% unassessed for a variety of reasons, including the absence of fish, the lack of habitat to support fish that met the minimum size requirement, inability to obtain permits, inclement weather, and site access denial.

WESTERN MOUNTAINS

Setting

The Western Mountains ecoregion includes the Cascade, Sierra Nevada, and Pacific Coast ranges in the coastal states; the Gila Mountains in the southwestern states; and the Bitterroot and Rocky mountain ranges in the northern and central mountain states. The headwaters and upper reaches of the Columbia, Sacramento, Missouri, and Colorado river systems all occur in this ecoregion. This ecoregion covers about 397,832 square miles, with about 297,900 square miles, or 75% of the land, classified as federal land.

The terrain of the Western Mountains ecoregion is characterized by extensive mountains and plateaus separated by wide valleys and lowlands. Coastal mountains are transected by many fjords and glacial valleys, are bordered by coastal plains, and include important estuaries along the margins of the ocean. Soils are mainly nutrient-poor forest soils. Rivers drain dense forested catchments and contain much woody debris that provides habitat diversity and stability. Rivers reaching the Pacific Ocean historically had large runs of salmon and trout; however, many of these populations have been reduced by the effects of dams, flow regulation, overfishing, and invasive species. Smaller rivers generally start as steep mountain streams with staircase-like channels, steps, and plunge pools, with riffles and pools appearing as the slope decreases. Upper river reaches experience debris flows and landslides when shallow soils become saturated by rainfall or snowmelt. The total river and stream length represented in NRSA 2013–14 for the Western Mountains ecoregion is 186,538 miles.

The climate is sub-arid to arid and mild in southern lower valleys; it is humid and cold at higher elevations. The wettest climates of North America occur in the marine coastal rainforests of this ecoregion. Mean annual temperatures range from 32°F to 55°F, and annual precipitation ranges from 16 to 240 inches.

Results Summary

A total of 266 NRSA sites were sampled to characterize the quality of rivers and streams in the Western Mountains ecoregion. An overview of the findings is shown in Figure 5.9.

Biological Indicators

The macroinvertebrate MMI showed that 51% of river and stream length in the Western Mountains ecoregion was of good quality (based on the least-disturbed reference distribution). The fish MMI showed that 26% of river and stream length was of good quality. Thirty-two percent of river and stream length was not assessed or, for various reasons, had insufficient data to calculate the fish MMI.

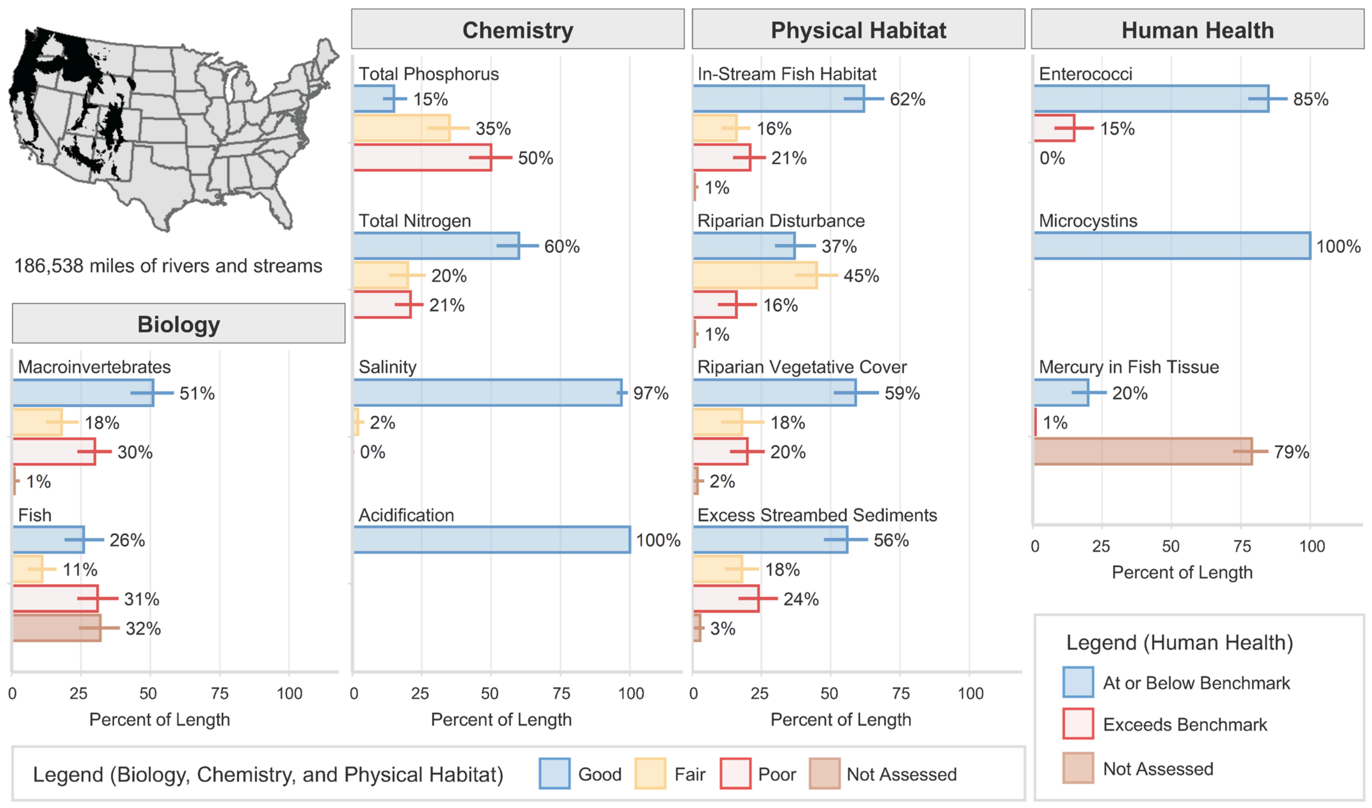
Chemical and Physical Habitat Indicators

The percentage of miles rated good for chemical and physical habitat indicators varied widely within the Western Mountains ecoregion. Phosphorus had a low percentage (15%) of river and stream miles in good condition, whereas nitrogen had the highest percentage (60%) of river and stream miles with good quality, as compared to other ecoregions. Physical habitat measures such as in-stream fish habitat, riparian vegetation cover, and excess streambed sediments showed high percentages of rivers and stream miles rated good, 62%, 59%, and 56%, respectively.

Human Health Indicators

Human health indicators measured within the Western Mountains ecoregion showed that most of the river and stream miles were below levels of concern. Enterococci were at or below the national benchmark for 85% of river and stream length. Microcystins were at or below the national benchmark for 100% of river and stream length. Mercury in fish tissue plugs was at or below the national benchmark for 20% of river and stream length, with 79% unassessed for a variety of reasons, including the absence of fish, the lack of habitat to support fish that met the minimum size requirement, inability to obtain permits, inclement weather, and site access denial.

Figure 5.9. Ecoregional Results for the Western Mountains



XERIC

Setting

The Xeric ecoregion covers the largest area of all NRSA aggregate ecoregions and includes the most total land under federal ownership. It covers portions of 11 western states and all of Nevada, for a total of approximately 636,583 square miles, or 21% of the conterminous U.S. Approximately 453,000 square miles, or 71% of the land, are classified as federal lands, including Grand Canyon National Park, Big Bend National Park, and Hanford Nuclear Reservation.

The terrain of the Xeric ecoregion is composed of a mix of physiographic features, including plains with hills and low mountains, high-relief tablelands, piedmont, high mountains, and intermountain basins and valleys. The ecoregion includes the flat to rolling topography of the Columbia/Snake River Plateau; the Great Basin; Death Valley; and the canyons, cliffs, buttes, and mesas of the Colorado Plateau. Its relatively limited surface water supply contributes to the Upper and Lower Colorado, Great Basin, California, Rio Grande, and Pacific Northwest regional watersheds. Large rivers flow all year, are supplied by snowmelt, and peak in early summer. Small rivers are mostly ephemeral. Rivers are often subject to rapid change due to flash floods and debris flows. In southern areas of the ecoregion, internal drainages often end in saline lakes or desert basins without reaching the ocean (e.g., Utah's Great Salt Lake).

Rivers in this ecoregion create a riparian habitat oasis for plants and animals. Many fish are endemic and have evolved to cope with warm, turbid waters. The total river and stream length represented in NRSA 2013–14 for the Xeric ecoregion is 44,017 miles.

The climate in this ecoregion varies widely from warm and dry to temperate, with mean annual temperatures ranging from 32°F to 75°F and annual precipitation ranging from 2 to 40 inches.

Results Summary

A total of 183 NRSA sites were sampled to characterize the quality of rivers and streams in the Xeric ecoregion. An overview of the findings is shown in Figure 5.10.

Biological Indicators

The macroinvertebrate MMI showed that 22% of river and stream length in the Xeric ecoregion was of good quality (based on the least-disturbed reference distribution). The fish MMI showed that 19% of river and stream length was of good quality. Thirty-five percent of river and stream length was not assessed or, for various reasons, had insufficient data to calculate the fish MMI.

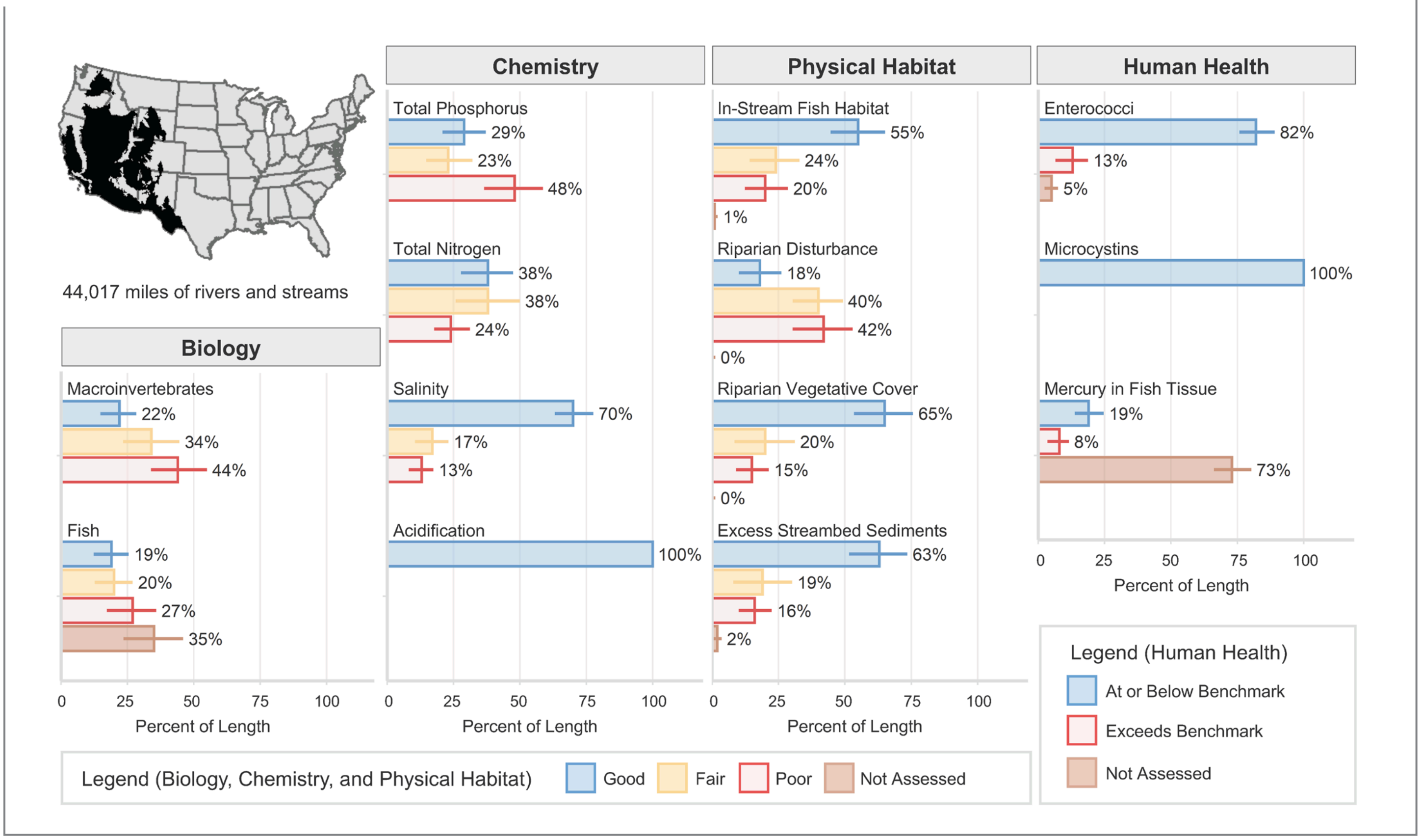
Chemical and Physical Habitat Indicators

The percentage of miles rated good for chemical and physical habitat indicators varied widely within the Xeric ecoregion. Phosphorus and nitrogen tended to have a lower percentage of river and stream miles with good quality, 29% and 38% respectively; however, the percentage of river and stream miles with poor quality for nitrogen was half as much as that for phosphorus, 24% and 48% respectively. Physical habitat measures such as in-stream fish habitat, riparian vegetation cover, and excess streambed sediments showed high percentages of rivers and stream miles rated good, 55%, 65%, and 63%, respectively.

Human Health Indicators

Human health indicators measured within the Xeric ecoregion showed that most of the river and stream miles were below levels of concern. Enterococci were at or below the national benchmark for 82% of river and stream length. Microcystins were at or below the national benchmark for 100% of river and stream length. Mercury in fish tissue plugs was at or below the national benchmark for 19% of river and stream length, with 73% unassessed for a variety of reasons, including the absence of fish, the lack of habitat to support fish that met the minimum size requirement, inability to obtain permits, inclement weather, and site access denial.

Figure 5.10. Ecoregional Results for the Xeric Ecoregion



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Summary and Next Steps

The second NRSA provided an opportunity to assess the quality of our nation's perennial rivers and streams in 2013–14, to report consistently across jurisdictional boundaries, and to evaluate differences compared to data collected by prior surveys. This accomplishment resulted from the extraordinary effort and cooperation among state, tribal, and federal partners throughout its design and implementation. The results and underlying data from this national survey include important insights on biological and recreational quality of perennial rivers and streams, stressors associated with degraded biological quality, and the potential improvement that might arise from efforts to reduce those stressors. Additionally, NRSA provided valuable information on differences in river and stream water quality between 2008–09 and 2013–14 nationally and at other spatial scales (available to view in the NRSA data dashboard at https://riverstreamassessment.epa.gov/dashboard). Fish fillet composite results are available at https://www.epa.gov/fish-tech/2013-2014-national-rivers-and-streams-assessment-fish-tissue-study.

NEXT STEPS

As this report was being completed, NRSA 2018–19 was underway. During this next two-year survey, crews from states, tribes, EPA and other federal agencies, and contractors sampled more than 2,000 sites across the contiguous U.S. In preparation, the NRSA team applied a variety of lessons learned from NRSA 2013–14 as well as other national surveys. The planning team refined manuals and training materials to increase clarity for partners and facilitate consistency between surveys for future trends analysis. NRSA 2018–19 incorporated the use of tablet devices to replace paper forms and streamline submission of field-collected data.

Moving forward, EPA will continue to work on new analytical approaches to multiple aspects of the NARS program, as well as on refining the process for establishing benchmarks. For example, EPA completed a stressor-response model for nutrients in lakes and proposed water quality criteria recommendations for nutrients in lakes to assist states and tribes (USEPA 2020b).

Additionally, EPA will be improving the accessibility and transparency of future NRSA and other NARS reports by continuing to move to a web platform that will enable the public to more fully understand and use the data and information from the program.

Sources and References

Arizona Department of Environmental Quality. 2012. Implementation procedures for the narrative biocriteria standard, Final draft July 2012, http://www.azdeq.gov/environ/water/standards/download/draft_bio.pdf

Agency for Toxic Substances and Disease Registry (ATSDR) and USEPA. 1998. Public health implications of exposure to polychlorinated biphenyls (PCBs). US Department of Health and Human Services. Atlanta, GA.

ATSDR. 2000. Toxicological profile for polychlorinated biphenyls. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, GA.

Bailey, R.C., R.H. Norris, and T.B. Reynoldson. 2004. *Bioassessment of freshwater ecosystems: using the reference condition approach*. Kluwer Academic Publishers, New York.

Baker, L.A., P.R. Kaufmann, A.T. Herlihy, and J.M. Eilers. 1990. Current status of surface water acid-base chemistry. State of Science/Technology Report 9. National Acid Precipitation Assessment Program, Washington, D.C., 650 pp.

Barbour, M.T., J.B. Stribling, J. Gerritsen, and J.R. Karr. 1996. Biocriteria technical guidance for streams and small rivers. EPA 822-B-96-001. U.S. Environmental Protection Agency.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish, second edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water. Washington, D.C.

Bloom, N.S. 1992. On the chemical form of mercury in edible fish and marine invertebrate tissue. *Canadian Journal of Fisheries and Aquatic Sciences* 49(5), 1010-1017.

Carter, J.L., and V.H. Resh. 2013. Analytical approaches used in stream benthic macroinvertebrate biomonitoring programs of state agencies in the United States: U.S. Geological Survey Open-File Report 2013-1129, 50 p., http://pubs.usgs.gov/of/2013/1129/

Fitzgerald, W.F., D.R. Engstrom, R.P. Mason, and E.A. Nater. 1998. The case for atmospheric mercury contamination in remote areas. *Environmental Science and Technology* 32, 1-7.

Hughes, R.M. 1995. Defining acceptable biological status by comparing with reference conditions. Chapter 4 in *Biological assessment and criteria: tools for water resource planning and decision making*, W.S. Davis and T.P. Simon, eds. (pp. 31 – 47). CRC Press, Boca Raton.

Kaufmann, P.R., A.T. Herlihy, M.E. Mitch, J.J. Messer, and W.S. Overton. 1991. Chemical characteristics of streams in the Eastern United States: I. Synoptic survey design, acid-base status and regional chemical patterns. *Water Resources Research* 27:611-627.

Laroe, E.T., G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac, eds. 1995. Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. U.S. Department of the Interior, National Biological Service, Washington, DC.

NAPA (National Academy of Public Administration). 2002. Understanding what states need to protect water quality. Academy project number 2001-001. Prepared by the National Academy of Public Administration, Washington, D.C., for the U.S. Environmental Protection Agency, Washington, DC.

NRC (National Research Council). 2001. Assessing the TMDL approach to water quality management. Prepared by the Committee to Assess the Scientific Basis of the Total Maximum Daily Load Approach to Water Pollution Reduction, Water Science and Technology Board, Division of Earth and Life Studies, National Research Council, National Academy Press, Washington, DC.

Reynoldson, TB., R.H. Norris, V.H. Resh, K.E. Day, and D.M. Rosenberg. 1997. The reference condition: a comparison of multimetric and multivariate approaches to assess water-quality impairment using benthic macroinvertebrates. *Journal of the North American Benthological Society* 16:833–852.

Sinclair E., D. Mayack, K. Roblee, N. Yamashita, and K. Kannan. 2006. Occurrence of perfluoroalkyl surfactants in water, fish, and birds from New York State. *Archives of Environmental Contamination and Toxicology* 50:398–410.

Stoddard, J.L., D.P. Larsen, C.P. Hawkins, R.K. Johnson, and R.H. Norris. 2006. Setting expectations for the ecological condition of streams: The concept of reference condition. *Ecological Applications* 16:1267-1276.

Stoddard, J.L., J. Van Sickle, A.T. Herlihy, J. Brahney, S. Paulsen, D.V. Peck, R. Mitchell, and A.I. Pollard. 2016. Continental-scale increase in lake and stream phosphorus: Are oligotrophic systems disappearing in the United States? *Environmental Science and Technology* 50(7):3409-3415. doi:10.1021/acs.est.5b05950

USEPA. *Case studies — setting ecologically-based water quality goals ohio's tiered aquatic life use designations turn 20 years old* (website). U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology. https://www.epa.gov/wqc/ohios-tiered-aquatic-life-use-designations-turn-20-years-old

USEPA. 1980. Ambient water quality criteria for polychlorinated biphenyls. EPA 440/5-80-068. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 1996. Biological criteria technical guidance for streams and small rivers. EPA 822-B-96-001. U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Washington, DC.

USEPA. 2000a. Guidance for assessing chemical contaminant data for use in fish advisories. Volume 2. Risk assessment and fish consumption limits. Third edition. EPA 823-B-00-008. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 2000b. Nutrient criteria technical guidance manual: Rivers and streams. EPA-822-B-00-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC. USEPA. 2001. Water quality criterion for the protection of human health: Methylmercury. EPA-823-R-01-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 2006. Wadeable streams assessment: A collaborative survey of the nation's streams. EPA-841-B-06-002. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.

USEPA. 2011. A primer on using biological assessments to support water quality management. EPA 810-R-11-01. U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Washington, DC.

USEPA. 2012. Recreational water quality criteria. EPA 820-F-12-058. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 2013. National rivers and streams assessment: Field operations manual. EPA-841-B-12-009a and EPA-841-B-12-009b. Washington, DC.

USEPA. 2014. National rivers and streams assessment: Laboratory operations methods manual. EPA 841-B-12-010. Washington, DC.

USEPA. 2016a. Health effects support document for perfluorooctane sulfonate (PFOS). EPA 822-R-16-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 2016b. National rivers and streams assessment 2008–2009: A collaborative survey. EPA 841-R-16-007. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.

USEPA. 2019a. Recommended human health recreational ambient water quality criteria or swimming advisories for microcystins and cylindrospermopsin. EPA 822-R-19-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 2019b. EPA's per- and polyfluoroalkyl substances (PFAS) action plan. EPA 823R18004. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 2020a. National rivers and streams assessment 2013–2014: Technical support document. EPA 843-R-19-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 2020b. Draft ambient water quality criteria recommendations for lakes and reservoirs of the conterminous United States: Information supporting the development of numeric nutrient criteria. EPA 820-P-20-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

Wiener, J. G., D.P. Krabbenhoft, G.H. Heinz, and A.M. Scheuhammer. 2003. Ecotoxicology of mercury. In: Hoffman, D. J., B.A. Rattner, G.A. Burton, and J. Cairns, eds., *Handbook of ecotoxicology, 2nd ed.* CRC Press, Boca Raton, FL, USA, 409–463.

Appendix A

Indicator Table and List of Measurements

Category	Indicator	Benchmark approach	Was difference assessed?	General assessment notes
Biological	Macroinvertebrates	NRSA-derived, regionally specific benchmark	Yes	Collected from the bottom of the stream or river at 11 transects throughout the sampled reach. Organisms were typically identified to genus and a multimetric index was developed based on life history characteristics and tolerance to environmental conditions.
	Fish	NRSA-derived, regionally specific benchmark	Yes	Collected throughout the reach. Fish were typically identified to species by crews in the field and a multimetric index was developed based on life history characteristics and tolerance to environmental conditions.
Chemical	Phosphorus	NRSA-derived, regionally specific benchmark	Yes	Collected from the water column at Transect A (Non-Wadeable) or at the X-site (Wadeable). Measured concentrations were compared to benchmarks.
	Nitrogen	NRSA-derived, regionally specific benchmark	Yes	Collected from the water column at Transect A (Non-Wadeable) or at the X-site (Wadeable). Measured concentrations were compared to benchmarks.
	Salinity	NRSA-derived, regionally specific benchmark	Yes	Collected from the water column at Transect A (Non-Wadeable) or at the X-site (Wadeable). Measured concentrations were compared to benchmarks.
	Acidification	Nationally consistent, literature-based benchmark	Yes	Collected from the water column at Transect A (Non-Wadeable) or at the X-site (Wadeable). Measured concentrations were compared to benchmarks developed during the National Acid Precipitation Assessment Program.

Category	Indicator	Benchmark approach	Was difference assessed?	General assessment notes
Physical	In-stream Fish Habitat	NRSA-derived, regionally specific benchmark	Yes	Observations were recorded throughout the sampled reach. Metrics and indicators were developed and compared to regionally specific benchmarks.
	Riparian Disturbance	Nationally consistent, literature-based benchmark	Yes	Observations were recorded throughout the sampled reach. Metrics and indicators were developed and compared to national benchmarks.
	Riparian Vegetative Cover	NRSA-derived, regionally specific benchmark	Yes	Observations were recorded throughout the sampled reach. Metrics and indicators were developed and compared to regionally specific benchmarks.
	Streambed Sediments	NRSA-derived, regionally specific benchmark	Yes	Observations were recorded throughout the sampled reach. Metrics and indicators were developed and compared to regionally specific benchmarks.
Human Health	Enterococci	Nationally consistent, EPA-derived benchmark	Yes	Collected from the water column at K transect and measured using quantitative polymerase chain reaction. Concentrations were compared to the USEPA recommended recreational water quality criteria statistical threshold value of 1,280 CCE (cell calibrator equivalents)/100 mL (USEPA 2012).
	Contaminants in Fish Tissue	Nationally consistent, EPA-derived benchmarks	No	Collected throughout the reach. A small plug of fish tissue was collected for analysis at all sites for mercury; whole-fish composite samples were collected at sites with a stream order ≥ 5 for analysis of fillet composite samples for mercury, PCBs and PFAS. Concentrations were compared to EPA's recommended fish tissue-based water quality criterion for methylmercury (300 ppb; USEPA 2001), human health fish tissue benchmarks for PCBs (18 ppb based on cancer effects and 73 ppb based on noncancer effects), and a 68 ppb human health fish tissue benchmark for PFOS (USEPA 2016a).
	Microcystins	Nationally consistent, EPA-derived benchmark	No	Collected from the water column at Transect A (Non-Wadeable) or at the X-site (Wadeable). Concentrations were compared to the EPA recommended swimming advisory level for microcystins of 8 µg/L (USEPA 2019a).

Appendix B

Ecoregion-Specific Benchmarks Used in NRSA 2013–14

Ecoregion	Benthic Macroinvertebrate MMI		Fish MMI		Total Nitrogen (µg/L)		Total Phosphorus (µg/L)		Salinity as Conductivity (µS/cm)	
	Good (≥)	Poor (≤)	Good (≥)	Poor (≤)	Good (≤)	Poor (≥)	Good (≤)	Poor (≥)	Good (≤)	Poor (≥)
CPL	54.9	40.7	57.3	46.8	624	1081	55.9	103.0	500	1000
NAP	55.0	40.9	57.6	47.1	345	482	17.1	32.6	500	1000
SAP	45.0	30.8	60.3	49.8	240	456	14.8	24.4	500	1000
UMW	36.9	22.7	39.8	29.3	583	1024	36.3	49.9	500	1000
TPL	40.3	26.2	58.0	47.5	700	1274	88.6	143.0	1000	2000
NPL	56.8	42.6	46.3	35.8	575	937	64.0	107.0	1000	2000
SPL	35.5	21.3	50.2	39.7	581	1069	55.8	127.0	1000	2000
WMT	50.1	35.9	75.9	65.4	139	249	17.7	41.0	500	1000
XER	57.0	42.8	76.8	63.7	285	529	52.0	95.9	500	1000

See the NRSA 2013–14 Technical Support Document for ecoregional category assignments for in-stream fish habitat, riparian vegetation cover, and streambed sediment. See Appendix A for indicators that are assessed with nationally consistent benchmarks.

For an accessible version of this table, visit https://www.epa.gov/sites/production/files/2020-12/documents/nrsa_2013-14_appendix_B_C_accessible.pdf.

Appendix C

Percentage of Stream Miles in Each Category: 2008–09 Estimates (Original and Recalculated), 2013–14 Estimates, and Difference Between 2008–09 Recalculated and 2013–14 Estimates

Indicator	Original estimate from 2008–09 report (percent)	2008–09 estimate recalculated for consistency with 2013–14 report (percent)	2013–14 estimate (percent)	Difference (with confidence intervals) between recalculated 2008–09 estimate and 2013–14 estimate (percentage points)	Reason for difference between original 2008–09 estimate and 2008–09 recalculated estimate used in difference analysis
Benthic MMI					
Good	28	29.6	30.2	0.6 (-3.1 to 4.3)	1) To ensure known stream and river lengths were equivalent for difference analysis, the statistical analysis method was updated and applied to data from both NRSA 2008–09 and 2013–14.
Fair	25	24.5	26.1	1.6 (-2.6 to 5.8)	
Poor	46	44.9	43.5	-1.4 (-5.5 to 2.8)	
Not Assessed	1	1	0.2	-0.8 (-1.3 to -0.4)	
Fish MMI					
Good	36	34.8	26.4	-8 (-12 to -4)	1) To ensure known stream and river lengths were equivalent for difference analysis, the statistical analysis method was updated and applied to data from both NRSA 2008–09 and 2013–14. 2) Analytical approach for developing the fish MMI changed from a random-forest model to a more traditional approach similar to the one used for the benthic MMI. 3) A larger set of reference sites was used in 2013–14 to establish benchmarks than in 2008–09.
Fair	19	23.9	22.4	-1.5 (-6 to 3)	
Poor	32	26.5	36.8	10 (6 to 14)	
Not Assessed	13	14.8	14.3	-0.5 (-3 to 3)	

For an accessible version of this table, visit https://www.epa.gov/sites/production/files/2020-12/documents/nrsa_2013-14_appendix_B_C_accessible.pdf

Indicator	Original estimate from 2008–09 report (percent)	2008–09 estimate recalculated for consistency with 2013–14 report (percent)	2013–14 estimate (percent)	Difference (with confidence intervals) between recalculated 2008–09 estimate and 2013–14 estimate (percentage points)	Reason for difference between original 2008–09 estimate and 2008–09 recalculated estimate used in difference analysis
Phosphorus					
Good	35	34.4	17.5	-17 (-21 to -13)	1) To ensure known stream and river lengths were equivalent for difference analysis, the statistical analysis method was updated and applied to data from both NRSA 2008–09 and 2013–14.
Fair	19	18.1	24.1	6 (2 to 10)	
Poor	46	47.3	58.4	11 (7 to 15)	
Not Assessed	0.2	0.3	0	- 0.3 (-0.5 to -0.1)	
Nitrogen					
Good	38	38.7	32.3	-6.4 (-10.3 to -2.4)	1) To ensure known stream and river lengths were equivalent for difference analysis, the statistical analysis method was updated and applied to data from both NRSA 2008–09 and 2013–14.
Fair	20	20.3	24.5	4.2 (0.32 to 8.1)	
Poor	41	40.8	43.2	2.4 (-1.6 to 6.5)	
Not Assessed	0.2	0.3	0	-0.3 (-0.5 to -0.04)	
Salinity					
Good	85	84	86.4	2.4 (-0.01 to 4.9)	1) To ensure known stream and river lengths were equivalent for difference analysis, the statistical analysis method was updated and applied to data from both NRSA 2008–09 and 2013–14.
Fair	12	11.7	9.7	-2.0(-4.3 to 0.4)	
Poor	3	3.9	3.8	-0.12 (-1.3 to 1.1)	
Not Assessed	0.3	0.5	0.1	-0.4 (-0.7 to -0.1)	

For an accessible version of this table, visit https://www.epa.gov/sites/production/files/2020-12/documents/nrsa_2013-14_appendix_B_C_accessible.pdf.

Indicator	Original estimate from 2008–09 report (percent)	2008–09 estimate recalculated for consistency with 2013–14 report (percent)	2013–14 estimate (percent)	Difference (with confidence intervals) between recalculated 2008–09 estimate and 2013–14 estimate (percentage points)	Reason for difference between original 2008–09 estimate and 2008–09 recalculated estimate used in difference analysis
Acidification					
None	99	98.5	98.4	0.0 (-1 to 0.9)	1) To ensure known stream and river lengths were equivalent for difference analysis, the statistical analysis method was updated and applied to data from both NRSA 2008–09 and 2013–14. 2) Acid mine drainage, episodic acidification, and acid deposition were reported as separate categories in 2008–09 but are grouped together as "poor" in 2013–14.
ACID-organic	0.4	0.5	0.2	-0.3 (-0.6 to 0.0)	
Poor (ACID-AMD, Episodic, or ACID-aciddep)	0.5	0.8	1.1	0.2 (-0.3 to 0.7)	
Not Assessed	0.2	0.2	0.3	0.1 (-0.3 to 0.5)	
In-stream Fish Habitat					
Good	68	67.7	64.3	-3.4 (-7.7 to 0.9)	1) To ensure known stream and river lengths were equivalent for difference analysis, the statistical analysis method was updated and applied to data from both NRSA 2008–09 and 2013–14.
Fair	20	21.1	20.4	-0.7 (-4.7 to 3.4)	
Poor	11	11.2	14.4	3.3 (0.04 to 6.6)	
Not Assessed	0	0	0.8	0.8 (0.3 to 1.2)	
Riparian Disturbance					
Good	34	34.7	29	-5.8 (-9.9 to -1.6)	1) To ensure known stream and river lengths were equivalent for difference analysis, the statistical analysis method was updated and applied to data from both NRSA 2008–09 and 2013–14.
Fair	46	44.2	47	2.8 (-1.8 to 7.3)	
Poor	20	21.1	23.3	2.3 (-1.1 to 5.7)	
Not Assessed	0	0	0.7	0.7 (0.3 to 1.2)	

For an accessible version of this table, visit https://www.epa.gov/sites/production/files/2020-12/documents/nrsa_2013-14_appendix_B_C_accessible.pdf.

Indicator	Original estimate from 2008–09 report (percent)	2008–09 estimate recalculated for consistency with 2013–14 report (percent)	2013–14 estimate (percent)	Difference (with confidence intervals) between recalculated 2008–09 estimate and 2013–14 estimate (percentage points)	Reason for difference between original 2008–09 estimate and 2008–09 recalculated estimate used in difference analysis
Riparian Vegetation					
Good	56	55.8	58	2.2 (-2.1 to 6.5)	1) To ensure known stream and river lengths were equivalent for difference analysis, the statistical analysis method was updated and applied to data from both NRSA 2008–09 and 2013–14 2) A larger set of reference sites was used in 2013–14 than in 2008–09.
Fair	20	19.1	17.4	-1.7 (-5.5 to 2.2)	
Poor	24	25.1	23.7	-1.4 (-5.1 to 2.2)	
Not Assessed	0	0	0.9	0.9 (0.4 to 1.5)	
Streambed Sediment					
Good	55	50.8	51.9	1.1 (-3.2 to 5.4)	1) To ensure known stream and river lengths were equivalent for difference analysis, the statistical analysis method was updated and applied to data from both NRSA 2008–09 and 2013–14 2) A larger set of reference sites was used in 2013–14 than in 2008–09.
Fair	29	28.6	22.3	-6.3 (-10.3 to -2.3)	
Poor	15	19.3	21.8	2.5 (-1.2 to 6.1)	
Not Assessed	1	1.4	4.1	2.8 (1.1 to 4.4)	
Enterococci					
Above Human Health Benchmark	23	21.8	29.9	8.0 (3.7 to 12.4)	1) To ensure known stream and river lengths were equivalent for difference analysis, the statistical analysis method was updated and applied to data from both NRSA 2008–09 and 2013–14.
At or Below Human Health Benchmark	70	71.3	68.9	-2.5 (-6.9 to 2.0)	
Not Assessed	6	6.8	1.2	-5.6 (-7.1 to -4.1)	

For an accessible version of this table, visit https://www.epa.gov/sites/production/files/2020-12/documents/nrsa_2013-14_appendix_B_C_accessible.pdf.

Appendix D

Photo Citations

Page number	Photograph
Cover (left)	New Mexico[1]
Cover (2nd from left)	Olympic National Park, WA[1]
Cover (2nd from right)	Cattaraugus Creek, NY[1]
Cover (right)	West Virginia[1]
7	Minnesota[2]
9	Weber River, UT; *photo courtesy of Utah Department of Environmental Quality*
14 (left)	Rock Creek, Washington, DC[1]
14 (right)	Rock Creek, Washington, DC[1]
15	Young cutthroat trout swimming in shallow water, Yellowstone National Park, WY, *National Park Service, Jay Fleming*
21 (left)	New Mexico[1]
21 (2nd from left)	Rock Creek, Washington, DC[1]
21 (right)	Little White Oak Creek, TX; *photo courtesy of Environmental Institute of Houston, University of Houston-Clear Lake*
27	New Mexico[1]
34	Sandies Creek, TX; *photo courtesy of Environmental Institute of Houston, University of Houston-Clear Lake*
36	Wadsworth Falls on the Coginchaug River in Wadsworth Falls State Park, CT, *Jllm06*, Wikipedia, cropped, CC BY-SA 4.0
38	Potomac and Shenandoah Rivers, View from Maryland Heights Overlook, July 4, 2014, *National Park Service,* Wikimedia Commons
40	Key Bridge and Rosslyn, Potomac River, *Nathan Winter,* Flickr, cropped, CC BY-NC 2.0
42	Minnesota
44	Kansas
47	South Dakota
49	Family recreation on the Owyhee River, OR, *Larry Moore, Bureau of Land Management,* Flickr, cropped, CC by 2.0
50	Colorado
52	Rio Puerco, NM
54	Sand to Snow National Monument, CA, *Bob Wick, Bureau of Land Management*, Flickr, public domain
57	Vernal Falls, Yosemite Valley, CA; *Denys Nevozhai, Unsplash*

[1] Photo provided by USEPA. [2] Photo provided by USGS.