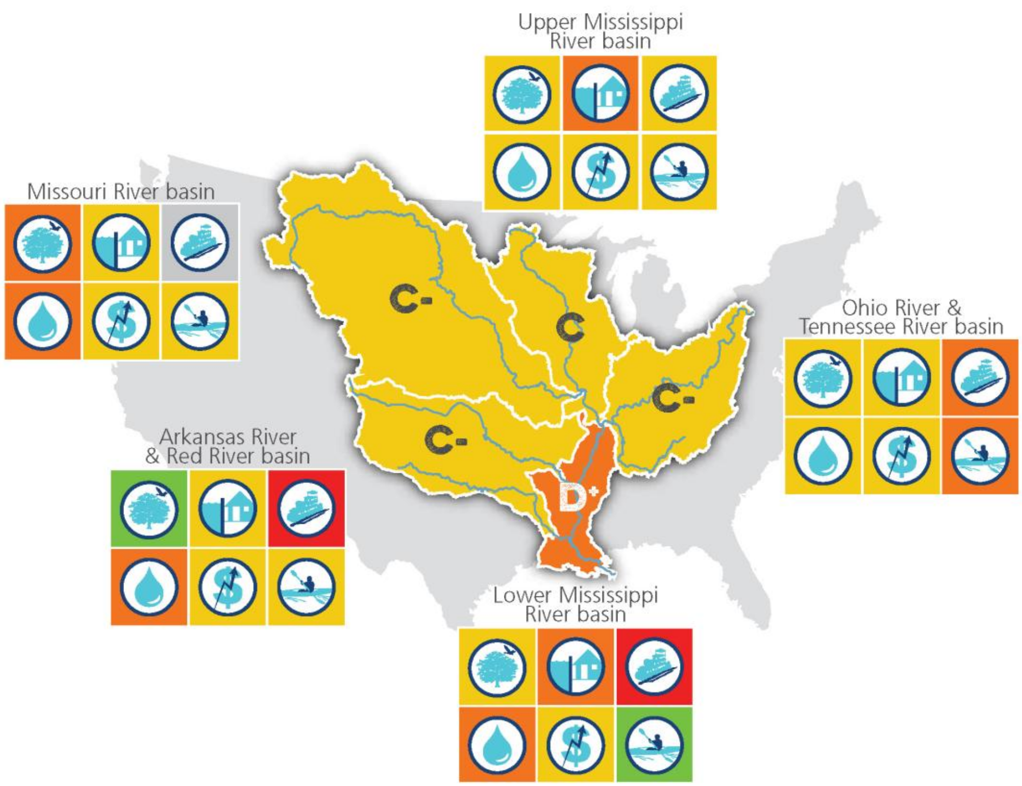
America's Watershed Initiative Report Card for the Mississippi River

Methods report on data sources, calculations, additional discussion



December 4, 2015

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Overview

This companion document to the report card contains information about data sources for all indicators, summary of analysis methods, and scoring details for each of the six America's Watershed Initiative goals, and for two watershed wide indicators. Additional information regarding the goals is included to provide greater detail and discussion than is possible in the report card document.

Who is America's Watershed Initiative

America's Watershed Initiative (AWI) is a collaboration including public and private-sector leaders from the 31 states comprising the Mississippi River Watershed, working together to find solutions for the challenges we face managing the Mississippi River; and the more than 250 rivers that eventually flow into it. The challenges facing the waters and lands in America's Watershed are large and growing; only by working together and seeking collaborative solutions will we make meaningful and sustained progress to meet these many challenges.

Steering Committee

The America's Watershed Initiative Steering Committee includes members from throughout the watershed and a diversity of sectors including conservation, navigation, agriculture, flood control and risk reduction, industry, academics, basin associations, local & state government and the U.S. Army Corps of Engineers/Mississippi River Commission.

Harald "Jordy" Jordahl, *Director, America's Watershed Initiative*

Dru Buntin, *Upper Mississippi River Basin Association*

Nancy Delong, *Dupont Pioneer*

Sean Duffy, Sr., *Big River Coalition*

Stephen Gambrell, *Mississippi River Commission, U.S. Army Corps of Engineers*

Teri Goodmann, *City of Dubuque, Ia*

Sue Lowry, *State of Wyoming Upper Missouri Basin*

Steve Mathies, *Lower Mississippi River Basin*

Daniel Mecklenborg, *Ingram Barge Company*

Rob Rash, *Mississippi Valley Flood Control Association*

Michael Reuter, *The Nature Conservancy*

Rainy Shorey, Phd, *Caterpillar, Inc*

Charles Somerville, *Ohio River Basin Alliance*

Max Starbuck, *National Corn Growers Association*

Goals for the Mississippi River Watershed

America's Watershed Initiative has identified six broad goals based on input from stakeholders and leaders throughout the watershed. These goals form a foundation for developing a shared vision for the future of the Mississippi River Watershed.

Table 1: Goals for the Mississippi River Watershed

Support and enhance healthy and productive ecosystems

Conserve, enhance and restore ecosystems within the Mississippi River Watershed to support natural habitats and the fish and wildlife resources that depend upon them.

Provide reliable flood control and risk reduction

Provide reliable flood protection and risk reduction through well managed and maintained infrastructure, including appropriate floodplain connections for water conveyance and ecosystem benefits, and management of surface and storm water runoff to better protect life, property and economies.

Serve as the nation's most valuable river transportation corridor

Provide for safe, efficient and dependable commercial navigation within the Mississippi River Watershed to ensure a competitive advantage for our goods in global markets.

Maintain supply of abundant clean water

Ensure the quality and quantity of water in the Mississippi River Basin is adequate to support the economic, social and environmental functions that are dependent on it.

Support local, state and national economies

Sustain a water use system to efficiently and effectively support agricultural, industrial and energy productivity.

Provide world-class recreation opportunities

Enrich the quality of life for people and recreation-based economies by maintaining and enhancing riverine, lake and wetland-associated recreation within the basin.

The goal for the report card is simple – provide decision makers, watershed leaders and the public with easy to understand information about the state of the watershed's health to aid them in developing a collaborative approach to managing America's Watershed. From the start, the groups working together to support America's Watershed Initiative had three key objectives for the report card project:

- Bring together key leaders, stakeholders and experts representing all of the basins and sectors to develop a single and shared document to measure the current status of six broad goals for the watershed;
- Build a report card supported by data that will help us to identify successes, opportunities for improvement, and areas needing additional research;
- Use this tool to identify opportunities for collaborations and a more shared vision for the watershed.

How Was the Report Card Developed?

The AWI Report Card was developed over two years with the help of hundreds of people from throughout the watershed and nation. The report card incorporates information and advice provided by leaders, stakeholders and experts from more than 400 businesses, organizations, agencies and academic institutions from every major river basin in the watershed and from key stakeholder groups. More than 700 diverse participants joined us in workshops, summits, webinars and meetings to gather data, provide feedback and give advice since we initiated this process.

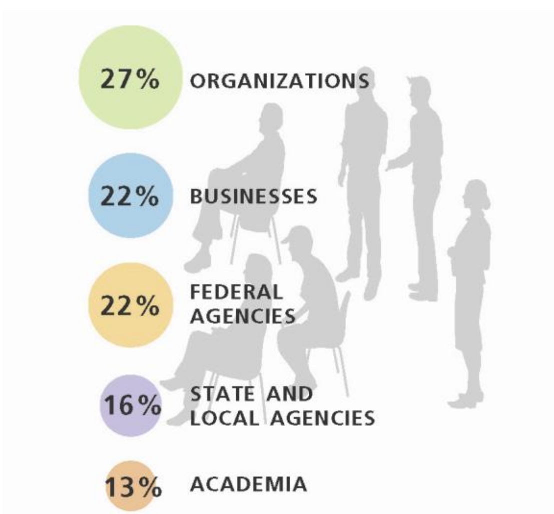


Figure 1: Participants in meetings and workshops represented a broad range of interests

The report card project was directed by the Report Card Working group, which included Harald "Jordy" Jordahl (Director, AWI); AWI Steering Committee members Dr. Charles Somerville (Marshall University/Ohio River Basin Alliance), Dr. Rainey Shorey (Caterpillar, Inc.); and Dr. Jonathan Higgins (The Nature Conservancy). Angela Freyermuth (US Army Corps of Engineers), Jay Harrod (The Nature Conservancy), and Barbara Allison (The Nature Conservancy) also played important roles developing the report card. Key leaders from the steering committee and partner organizations played critical roles in organizing the basin workshops in 2013 and 2014.

Production of the report card is the work of a team from the Integration and Application Network (IAN) at the University of Maryland Center for Environmental Science, led by Drs Heath Kelsey and Bill Dennison. The IAN team facilitated the information-gathering workshops and meetings, compiled and analyzed the data to calculate the report card grades, and designed and produced the preliminary and final report card documents and various interim and supporting communications products, including newsletters, posters, and this report. Over a dozen individuals contributed to the work of the IAN team. Dr. William Nuttle facilitated workshops, Science Communication was coordinated by Jane Thomas and was contributed to by Caroline Wicks, Brianne Walsh, and Jane Hawkey. Data tracking and analysis was supported by additional IAN staff.

Basin Workshops Poll Experts

The report card was developed in three stages. In the first stage, America's Watershed Initiative traveled to each basin to gather information about the basins and identify potential indicators in the six goal areas. In all, more than a dozen major workshops and meetings brought together diverse experts with broad perspectives to help develop the report card. Each workshop and meeting was different, but the importance of the rivers and waters in each basin and from every stakeholder group was clear. After each basin workshop, the project team produced a newsletter documenting the information gathered. These newsletters are available from the America's Watershed Initiative website.[1]

[Link to newsletters]

2014 Summit Reviews Preliminary Report Card

In the second stage, a preliminary report card was developed for review at the 2014 America's Watershed Summit. Indicators for the preliminary report card were chosen based on recommendations from the basin-level workshops. The report card team selected indicators for the preliminary report card based on relevance to measuring the goal, consistency with other basin indicators, data availability, and the ability to develop a relevant scoring method.

[1] http://americaswatershed.org/reportcard/; accessed 25 September 2015

The program for the Summit was designed specifically to solicit feedback and input from participants on the report card product and next steps for this initiative. We received more than 250 specific comments and recommendations.
[Link to Summit results]

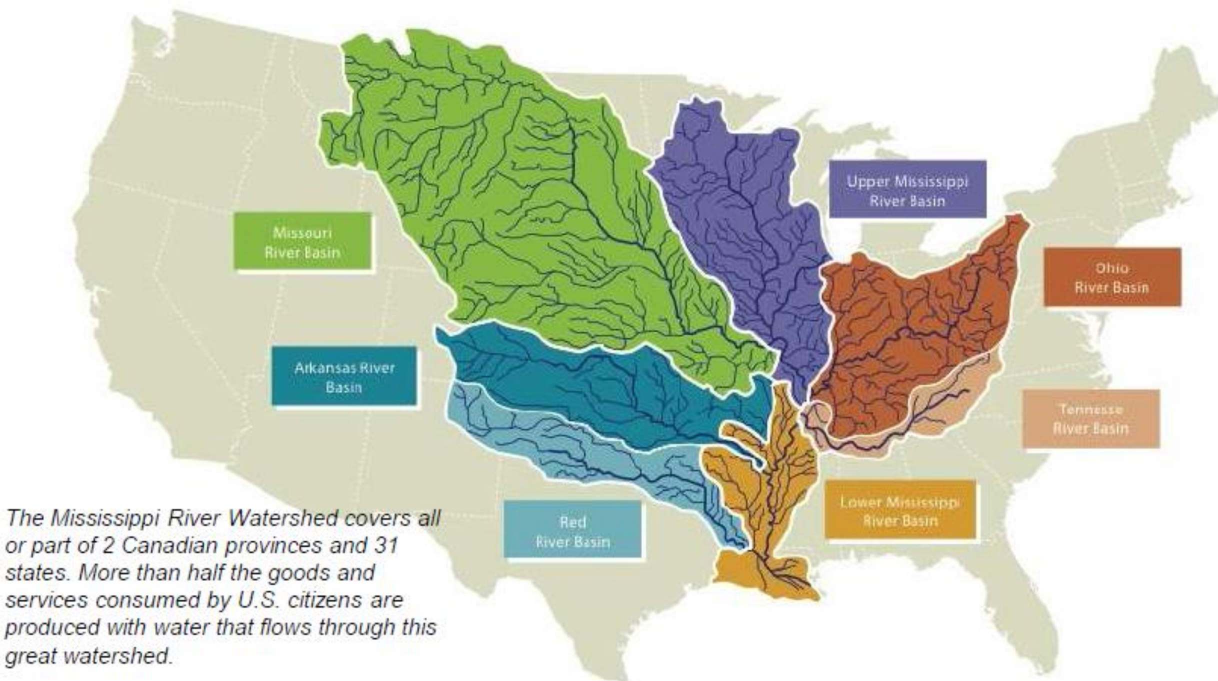


Figure 2: Mississippi River Watershed and basins used for the report card

Goal-area Working Groups Revise Indicators

In the third stage, we convened working groups of experts in each goal area to review the feedback and comments on the preliminary report card and to advise on refining the set of indicators used and how they are scored. An additional working group was formed to advise on selecting indicators that measured the overall condition of the watershed; this was a key recommendation from the 2014 Summit. Meeting with the working groups through the winter of 2015, the project team undertook a comprehensive revision of the report card indicators, data sources, analysis, and presentation. Some indicators included in the preliminary report card were dropped, new indicators were added, and all of the scores were recalculated. This report documents the results of this final step in the development of the Mississippi River Watershed report card.

Table 2: Participants in goal-area working groups

Ecosystems Review Team

Paulette Akers, *Kentucky Division of Water*
Georgiana Collins, *Ecology & Environment, Inc)*
Tim Joice, *Water Policy Director at Kentucky Waterways Alliance*
Jack Killgore, *Team Leader for environmental biology, USACE*
Keith McKnight, *Lower Mississippi Valley Joint Venture*
King Milling, *American Wetlands Foundation*
Olivia Dorothy, *American Rivers Association*
Michael Reuter, *The Nature Conservancy*
Chuck Somerville, *Ohio River Basin Alliance/Marshall University*

Flood Control Review Team

Mark Davis, *Tulane Institute on Water Resources Law and Policy*
Tonja Koob, *Gaea Engineering Consultants*
Mike Klingner, *Klingner & Associates*
Scott Arends, *Hanson Professional*
Larry Weber, *Iowa Flood Center*
Alan Lulloff, *Association of State Floodplain Managers*
Steve Mathies, *Environ International Corporation*

Recreation Review Team

Shelly Morgan, *Executive Director, Lake Texoma Association*
Paul Lepisto, *Izaak Walton League, Missouri River*
Amanda Payne, *Rahall Transport Institute, West Virginia*
Dru Buntin, *Upper Mississippi River Basin Association*
Sam Dinkins, *Ohio River Valley Sanitation Commission*

Watershed-wide Indicators Team

Charles "Chip" Groate, *President of the Water Institute*
Denise Reed, *Chief Scientist at the Water Institute*
Robert Twilley, *Director of Louisiana Sea Grant*
King Milling, *American's Wetland Foundation*
Nancy Rabalais, *Executive Director of Louisiana Universities Marine Consortium*

Transportation Review Team

James McKinney, *Navigation and Maintenance, USACE*
Jay Ruble, *Crounse Corporation – Continuous Improvement*
Dan Mecklenborg, *Ingram Barge Company*
Sheri Walz, *Wisconsin Dept. of Transportation*
Ernie Perry, *Mid-America Freight Coalition, Univ. of Wisconsin Madison*
Diedre Smith, *Oklahoma Dept. of Transportation*
Tom O'Hara, *CH2M Hill/USACE*
Jim Kruse, *Texas A&M Transportation Institute*
Paul Rohde, *Waterways Council, Inc*
Mike Toohey, *Waterways Council, Inc*
Sean Duffy, *Big River Coalition*

Water Supply Review Team

Paul Sloan, *Cumberland River Compact*
Margaret Fast, *Kansas Water Office*
Sue Lowry, *Wyoming State Engineer's Office*
Chuck Somerville, *Ohio River Basin Alliance/Marshall University*
Ryan Mueller, *Interstate Council on Water Policy*
Sam Dinkins, *Ohio River Valley Sanitation Commission*

Economy Review Team

Richard Brontoli, *Red River Valley Association*
Teri Goodmann, *City of Dubuque, Iowa*
Max Starbuck, *National Corn Growers Association*

How Are the Grades Calculated?

Results of the report card were calculated for the Upper Mississippi River, Ohio & Tennessee Rivers, Lower Mississippi River, Arkansas & Red Rivers, and Missouri River basins. Results from these five basins were summarized in an overall watershed score (Map, Results). In addition to the goals and basin results, we also include results for indicators on watershed wide issues including the size of the Gulf of Mexico hypoxic "dead zone" and the rate of coastal wetland loss in Louisiana.

This report documents the data sources, calculations for each indicator, interpretation, calculation and assignment of scores, and calculation of basin and watershed average scores.

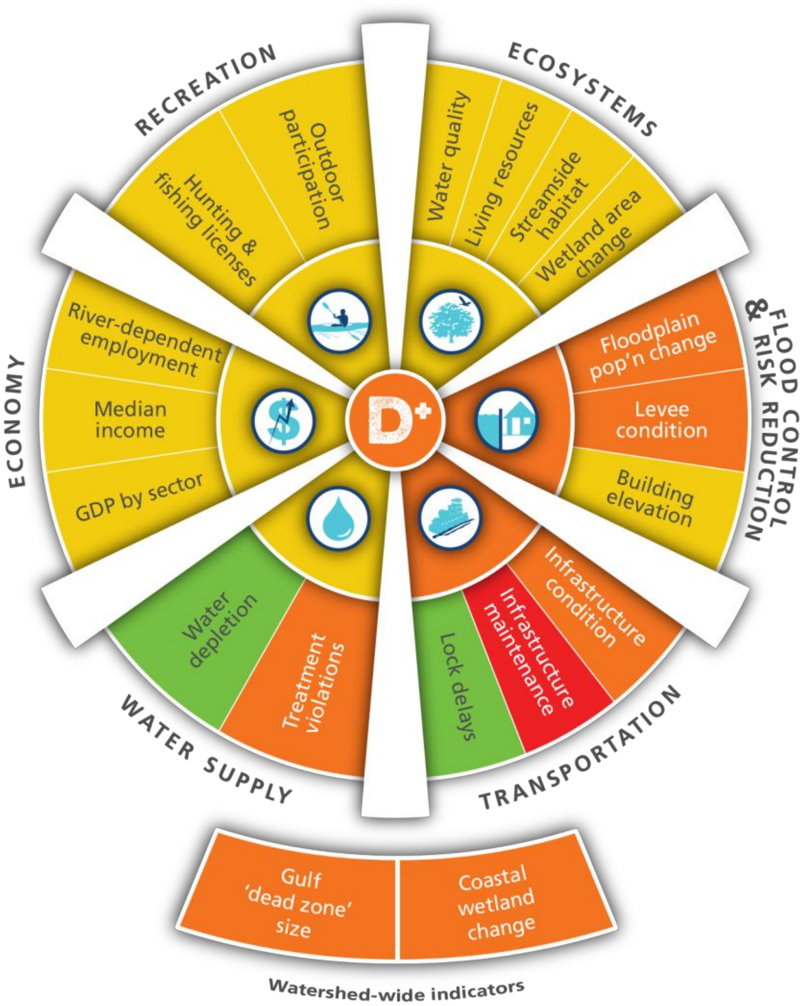


Figure 3: Report Card Results for the Mississippi River Watershed.

The Mississippi River Watershed contains the 5 major river basins used for the report card including the Upper Mississippi River basin, the Lower Mississippi River basin, the Missouri River basin, the Arkansas River and Red River basin, and the Ohio River and Tennessee River basin. The America's Watershed Initiative Report Card for the Mississippi River Watershed has been designed to measure the status and trends of the six goals throughout the 31 state watershed and five major river basins.

The methods and the results shown are the product of much effort and deliberation by partners in the 5 basins and the University of Maryland IAN team. Regional experts in each goal area suggested these indicators, which were further revised after the 2014 Summit, by the goal area review teams.

Scoring and Letter Grades

All measurements were standardized to a 0-100 scale to enable aggregation of individual indicator results to the goal score. Scores were distributed in even increments to enable ease of aggregation. It is important to note that the scoring scheme is not a reflection of a "curve" or a lenient grading system; the goal teams and expert advisors determined through data analysis what data values represented good and bad grades, and those were translated to the final scoring scheme distributed into the 0-100 scale in 20-point increments. Final scores were given a grade based on the simple grading scheme as below:

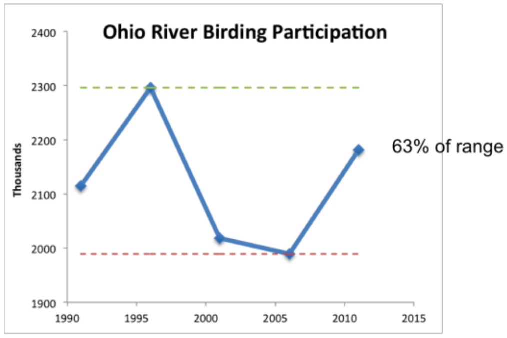
Score	Grade
80-100	A
60-80	B
40-60	C
20-40	D
0-20	F

Figure 4: Scoring scheme for the Mississippi River Report Card.

There were several potential scoring methods that were applied for report card indicators, including:

1. Pre-determined scoring. For some indicators, the data provider had already provided a rating of observations or results. These may have been measured against a regionally specific desired condition, or some other method. We use this method when the assessment methods were from an accepted source, using generally accepted practices. For example, the EPA National Rivers and Streams Assessment provided ratings for indicators in the ecosystems goal based on ecologically relevant thresholds for the ecoregion in which the measurements were taken.
2. Comparison to historical range of data. For several indicators, (in recreation, for instance), most recent data were compared to the historical range of data available. The

most desirable (for example, highest participation rate in birding) was the top score, and the least desirable value became the lowest possible score.



Source: National Survey of Fishing, Hunting, & Wildlife-Associated Recreation (FHWAR), US Census

Figure 5. Example of comparison to historic range of data.

3. Comparison to national average. Where adequate time series of data did not exist or where a comparison method was more relevant, data were compared to the national average. Unemployment for instance was aggregated for the states in the basin, and this value was compared to the national average. Scoring was accomplished by creating ranges bounded by the standard deviation of the data from the 50 states. If the basin average was within one standard deviation of the US average, the resulting score was a "C" for example.

Description	Standard Deviation	Grade
substantially above national average	1.5 - 2.5	A
above national average	0.5 - 1.5	B
near national average	-0.5 - 0.5	C
below national average	-1.5 - -0.5	D
substantially below national average	-2.5 - -1.5	F

Figure 6. Example scheme for comparison to the national average.

To calculate basin scores for each indicator, weighting schemes were assigned to reflect the nature of the data and the information it contained. Weighting was objective, and based on relevant data properties (Table 4). Weighting was necessary in many instances to account for the varied impact that some states or regions may have on the overall result. For instance, water supply results for a state with very little population in the basin should not count as highly in the basin water supply score as a state with much higher population in the basin. The weighting schemes were designed to account for these differences, and create a result that is reflective of the actual conditions in the basin. Table 4 presents the factors that were used for weighting each indicator to the basin result.

Table 4: Indicator summary – including weighting factors used in calculating watershed averages.

Indicators	Source of Data	Weighting Scheme
Water supply		
Water Treatment Violations	2013 Government Performance and Results Act (GPRA) of Total Water Systems.	Population served by community water systems
Water Depletion	2010 WaSSI model results for HUC8 watersheds	Population
Flood control and risk reduction		
Floodplain Population Change	US Census, and FEMA Special Flood Hazard Area,	Population in 500-yr floodplain
Levee condition	US Army Corps of Engineers 2013 National Levee Database	Total levee length in basin
Building Elevation Requirements	Association for State Floodplain Managers	Population in 500-yr floodplain
Economy		
River-Dependent Employment	Bureau of Labor Statistics 2013	Total employment in basin
GDP by Sector	Bureau of Labor Statistics 2013	Total GDP in basin
Median income	Bureau of Economic Analysis 2013	Population in basin
Ecosystems		
Living Resources Water Quality Habitat Index	EPA National Rivers and Streams Assessment 2008-2009.	Stream length
Wetland Area Change	Multi-Resolution Land Characteristics data	Wetland area in basin
Recreation		
Outdoor Participation	US Fish and Wildlife Service survey by US Census Bureau, and National Park Service	Participation totals in basin
Hunting and Fishing Licenses	US Fish and Wildlife Service	License totals in basin
Transportation		Annual tons moved in basin
Lock delays	US Army Corps of Engineers 2013	Annual tons moved per lock in basin
Infrastructure Condition	US Army Corps of Engineers 2010	Combined basin inspection results for the watershed
Infrastructure Maintenance	Office of Management and Budget, US Army Corps of Engineers, Congressional Research Service, and National Research Council, Committee on U.S. Army Corps of Engineers Water Resources Science, Engineering, and Planning	(scored for watershed)
Watershed-wide		
Gulf Dead Zone	Mississippi River/Gulf of Mexico Watershed Nutrient Task Force	(scored for watershed)
Coastal Wetland Change	US Geological Survey	(scored for watershed)

1 Ecosystems

Support and enhance healthy and productive ecosystems

People value the natural ecosystems of the Mississippi River Watershed for the abundant and diverse fish and wildlife resources they support, but this is only part of the reason why it is important to conserve and restore natural ecosystems. Maintaining the health of ecosystems in the watershed also contributes to achieving goals for water supply, flood protection, recreation, and the economy. Healthy and productive ecosystems provide a range of services such as cleaning water, reducing the risk of flooding, and providing recreational opportunities.

Indicators

The indicators selected for ecosystem health in the Mississippi River Watershed measure the overall condition of river and stream ecosystems in the watershed and the effectiveness of efforts to protect and restore wetlands throughout the watershed. Ecosystem condition is evaluated using detailed data from surveys conducted by EPA for the 2008-2009 National Rivers and Streams Assessment (NRSA)[2] to score indices for living resources, water quality and habitat. The effectiveness of ecosystem protection and restoration is evaluated using the measured change in wetland area within each basin between 2006 and 2011, in response to adoption of the "no net loss" policy for wetland protection. In the case of both ecosystem condition and change in wetland area, the ecosystem indicators assess conditions throughout each basin, beyond the immediate vicinity of the Mississippi River and its major tributaries.

[2] http://www2.epa.gov/national-aquatic-resource-surveys/national-rivers-and-streams-assessment; accessed 1 October 2015

Living Resources

The living resources index assesses the condition of aquatic animal communities living in river and stream ecosystems. The score is calculated based on EPA's assessment at each sampling location used for the 2008-2009 NRSA. The 2008-2009 assessment is the most recent available. Each "site" consisted of sampling at a number of locations to characterize conditions along a specific length of river or stream. At each site, researchers assessed existing conditions as "good," "fair," or "poor" against conditions at an undisturbed reference site within similar ecoregions.

Data source:

The index combines the NRSA scores for the Macro-invertebrate Multi-metric Index and the Fish Multi-metric Index. EPA provided synthesized results from 2008-2009 NRSA for each sub-basin, with the percent of stream lengths in good, fair, or poor condition for each index.
[LINK to DATA]

Calculation Method and Scoring:

The living resources index is scored based on the average of the scores for EPA's Macro-invertebrate Multi-metric Index and the Fish Multi-metric Index in each basin. We calculate a score for each basin by assigning a value to each assessment category (100 for "good", 50 for "fair", and 0 for "poor") and computing the average of the results for all NRSA sampling locations in a basin based on the percent stream length in each category. The score for the watershed is calculated using the same approach as for the basin scores based synthesized results provided by EPA for the entire watershed.

Table 1.1: Scoring results for each basin and the Mississippi River Watershed. The watershed score is based on the combined results for all basins weighted by stream length.

Living Resources OVERALL			
Sub-basin	**Score**	**Letter grade**	**Weighting factor**
Upper Mississippi	43	C-	24%
Ohio	36	D+	31%
Lower Mississippi	34	D	11%
Arkansas	49	C	10%
Missouri	52	C	24%
Mississippi River Watershed	**43**	**C-**	

Water Quality

The water quality index assesses nutrient levels in rivers and streams in the watershed. The score is calculated based on EPA's assessment at each sampling location used for the 2008-2009 NRSA. The 2008-2009 assessment is the most recent available to us. Each "site" consisted of sampling at a number of locations to characterize conditions along a specific length of river or stream. At each site, researchers assessed existing conditions as "good," "fair," or "poor" against conditions at an undisturbed reference site.

Data source:

The index combines the NRSA scores for total phosphorous and total nitrogen. EPA provided synthesized results from 2008-2009 EPA National Rivers and Streams Assessment for each sub-basin, with the percent of stream lengths in good, fair, or poor condition for each index. Natural variability in nutrient concentrations is reflected in the regional thresholds set by EPA for high, medium, and low levels, which are based on least-disturbed reference sites for each of the nine NRSA ecoregions.

[LINK to DATA]

Calculation Method and Scoring:

The water quality index is scored based on the average of the scores for EPA's nitrogen index and phosphorous index in each basin. We calculate a score for each basin by assigning a value to each assessment category (100 for "good", 50 for "fair", and 0 for "poor") and computing the average of the results for all NRSA sampling locations in a basin based on the percent stream length in each category. The score for the watershed is calculated using the same approach as for the basin scores based synthesized results provided by EPA for the entire watershed.

Table 1.2: Scoring results for each basin and the Mississippi River Watershed. The watershed score is based on the combined results for all basins weighted by stream length.

Water Quality OVERALL			
Sub-basin	**Score**	**Letter grade**	**Weighting factor**
Upper Mississippi	35	D+	24%
Ohio	37	D+	31%
Lower Mississippi	48	C	11%
Arkansas	40	C-	10%
Missouri	47	C	24%
Mississippi River Watershed	**41**	**C-**	

Habitat Index

The Habitat Index assesses the condition of stream and river habitat in the ecosystem. The score is calculated based on EPA's assessment at each sampling location used for the 2008-2009 NRSA. The 2008-2009 assessment is the most recent available to us. Each "site" consisted of sampling at a number of locations to characterize conditions along a specific length of river or stream. At each site, researchers assessed existing conditions as "good," "fair," or "poor" against conditions at an undisturbed reference site.

Data source:

The index combines the NRSA scores for the Riparian Vegetative Cover and Riparian Disturbance. EPA provided synthesized results from 2008-2009 EPA NRSA for each sub-basin, with the percent of stream lengths in good, fair, or poor condition for each index.
[LINK to DATA]

Calculation Method and Scoring:

The habitat index is scored based on the average of the scores for EPA's Riparian Vegetative Cover index and Riparian Disturbance index in each basin. We calculate a score for each basin by assigning a value to each assessment category (100 for "good", 50 for "fair", and 0 for "poor") and computing the average of the results for all NRSA sampling locations in a basin based on the percent stream length in each category. The score for the watershed is calculated using the same approach as for the basin scores based synthesized results provided by EPA for the entire watershed.

Table 1.3: Scoring results for each basin and the Mississippi River Watershed. The watershed score is based on a compilation of the statistics for each basin.

Habitat Index OVERALL			
Sub-basin	**Score**	**Letter grade**	**Weighting factor**
Upper Mississippi	63	B-	24%
Ohio	49	C	31%
Lower Mississippi	71	B	11%
Arkansas	55	C+	10%
Missouri	55	C+	24%
Mississippi River Watershed	**57**	**C+**	

Wetland Area Change

The index of wetland area change scores the percent change in wetland area in each basin by state.

Data source:

Calculations are based on data from the National Land Cover Database (NLCD).[3] NLCD uses multiple dates of Landsat satellite imagery and other ancillary datasets to produce nationally standardized land cover and land change information for the Nation. These products support a wide variety of Federal, State, local and nongovernmental applications that seek to assess ecosystem status and health, understand the spatial patterns of biodiversity, examine the effects of climate change, and help develop land management policy.

[LINK to DATA]

Calculation Method and Scoring:

The wetland area change index is scored based on the change in wetland area for each state between 2006 and 2011, the two most recent years in the database; data are compiled every five years. The change in wetland area is calculated as a percent of the total wetland area. Basin values for the area of wetlands and the change in wetland area is calculated from the state values based on the portion of the total basin area in each state. The score for each basin is calculated from the percent change in wetland area using the formula $y = 200x + 50$; where y is the score and x is the percent change in wetland area. The score for the watershed is calculated as the average of the basin scores weighted by the wetland area in each basin.

[3] http://www.mrlc.gov; accessed 25 September 2015
The National Land Cover Database (NLCD) products in this tool were derived by the Multi-Resolution Land Characteristics Consortium (MRLC), which is a partnership of Federal agencies led by the U.S. Geological Survey.

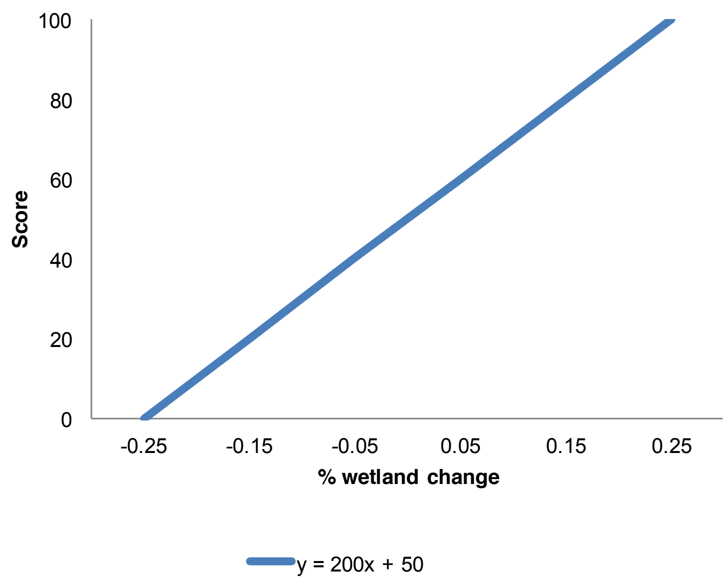


Figure 1.1: Scoring method for Wetland Area Change.

Table 1.4: Scoring results for each basin and the Mississippi River Watershed. The watershed score is an average of basin scores weighted by the area of wetlands in each basin.

Wetland Area Change OVERALL				
Sub-basin	**% loss**	**Score**	**Letter grade**	**Weighting factor**
Upper Mississippi	-0.11	29	D	29%
Ohio	0.25	99	A+	9%
Lower Mississippi	-0.05	41	C-	30%
Arkansas Red	0.30	100	A+	13%
Missouri	-2.84	0	F	19%
Mississippi River Watershed		**42**	**C-**	

Additional Discussion on Ecosystem Goal

Historically, human activities often have had the effect of disrupting natural ecosystems. Healthy ecosystems depend on natural dynamics of temperature, water level and flow, and the movement of sediments. Connectivity is also important, both along the channel and between the channel and upland areas, for regulating nutrients and sustaining populations of fish and other organisms. Impounding huge reservoirs behind dams alters the seasonal pattern of water discharge and interrupts the supply of sediment to the river. The system of locks and dams constructed for navigation has eliminated the nature riffle and pool morphology along the Ohio River, interrupting longitudinal connectivity. Flood control levees and navigation works along the Lower Mississippi interrupt the lateral connectivity between the river and bottom land swamps. Throughout the Mississippi River Watershed, drainage and improvements to convert land for agriculture has caused the loss of about half of the wetland area present in the 18th century.[4]

The challenge is to sustain healthy ecosystems while also maintaining the functions that human-built infrastructure is intended to provide related to flood control, water supply, transportation, and recreation. Both the natural ecosystems and human infrastructure are critical to sustaining a healthy economy in the watershed. For the past 40 years, since the adoption of the National Environmental Policy Act and the Clean Water Act, it has been national policy to protect and preserve the functioning of natural ecosystems for the benefit of future generations. Initial efforts focused on ecosystem protection through regulations that would limit the impact of human activities.

By the start of the 21st century it was clear that regulation alone was not enough, and people began taking additional steps to restore the lost functioning of natural ecosystems.[5] In one of the first such efforts, in 1988 the US federal government adopted a set of regulations and initiatives towards the goal of "no net loss" of wetlands. Today, more comprehensive, regional programs aimed at ecosystem restoration are underway in each of the basins of the Mississippi River Watershed.

Challenges

The grades for ecosystems indicators varied more across the basins than for any other goal, with some basins showing very positive results while others face significant challenges. The industrialized eastern portion of the watershed and the Lower Mississippi River showed the greatest threats to natural areas. Poor water quality is a result of many factors including, nutrient runoff from agriculture and industry, a major cause of nuisance algae bloom and low oxygen conditions within the watershed and in the waters of the northern Gulf of Mexico.

Indicators Not Selected

Several possible indicators were discussed during the regional workshops and during the working group meetings following the 2014 Summit. Although the project team was not able to implement these ideas in this version of the report card, they merit consideration for inclusion in a revised, future report card.

- ***Sediment Flux***
- ***Treatment plant operational modifications due to contaminant plumes***

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[4] GAO, 1991. Wetlands Overview: Federal and State Policies, Legislation, and Programs. US Government Accounting Office, RCED-92-79FS: Published: Nov 22, 1991. [online: http://www.gao.gov/products/RCED-92-79FS; accessed 15 April 2015]

[5] Allan, J.D. and M.A. Palmer, 2006. Restoring Rivers. Issues in Science and Technology, Winter 2006. [online: http://issues.org/22-2/palmer/; accessed 14 April 2015]

- ***Nutrient Flux***
- ***Waterfowl breeding surveys***
- ***Historical Wetland Loss***

2 Flood Control and Risk Reduction

Provide reliable flood control and risk reduction

The challenge for flood control and risk reduction is to maintain existing measures that have proven effective - both structural and nonstructural - while at the same time finding new strategies that respond to a changing climate, rising sea levels, coastal subsidence and erosion. Flood losses increase when watersheds lose their natural capacity to store water, communities and other permanent structures are developed in flood-prone areas, changes in the landscape increase runoff, and when infrastructure—such as levees and dams originally built to manage flood risk—begin to age or are not maintained. A variety of strategies can be used to reduce flooding, including storing water in reservoirs to reduce peak river discharge, constructing levees and flood walls to contain flood waters, and preserving wetlands to provide natural flood storage and redirect flood waters. The possibility that flooding will occur can never be reduced to zero; therefore, reducing risk also means constructing buildings and making plans in preparation to accommodate intense rainfall and high water levels when they do occur.

Indicators

The indicators selected for flood control and risk reduction in the Mississippi River Watershed assess the trend in the number of people at risk, the condition of flood protection infrastructure, and community preparedness. The trend in number of people at risk is evaluated based on the population within the 500-year floodplain. The condition of flood protection infrastructure is evaluated based on the results of levee inspections conducted regularly by the Corps of Engineers. Community preparedness is evaluated by the number of people living in communities that have adopted new, more protective elevation requirements for new structures. Evaluation of the number of people at risk and community preparedness is based on the proposed new federal flood protection standards.[6]

[6] https://www.whitehouse.gov/administration/eop/ceq/Press_Releases/January_30_2015; accessed 1 October 2015

Floodplain Population Change

The Floodplain Population Change indicator compares the change in number of people most at risk to flooding with the change in number of people living in a basin overall. The desired condition is that the number of people most at risk is decreasing, or at least increasing less quickly than the total population of the basin.

Data source:

We use the Federal Emergency Management Agency (FEMA) designated 500-year flood plain[7] to define areas most at risk to flooding, and we use US Census data[8] for 2000 and 2010 to calculate the change in number of people living in the flood plain and in the basins.
[LINK to Floodplain DATA] [LINK to Census DATA]

Calculation Method and Scoring:

The indicator score is calculated from the change in populations between the 2000 and 2010 censuses. The population of the floodplain was calculated by summing the populations of census blocks located within the boundary of the 500-year floodplain. In figuring the contribution from census blocks that lie across the floodplain boundary to the total, the population of the census block was pro rated by the portion of the census block area inside of the boundary. The same approach was used to calculate the basin populations.

The score is calculated for each basin based on the difference in the change in the population in the floodplain and change in the total population in the basin, expressed as a percent change. The score for each basin is calculated using the formula $y = 20x + 50$; where x is the difference in population change (measured as a percent) between floodplain and basin and y is the score. A positive difference indicates that population in the floodplain increased at a faster rate than in the sub-basin, while a negative difference indicates that population increased at a slower rate in the floodplain than in the sub-basin. The score for the Mississippi River Watershed is calculated as the average of the basin scores weighted by the populations in the floodplain, i.e. the number of people at risk in each basin.

[7] All flood data and analysis is derived from FEMA: http://msc.fema.gov/; accessed 25 September 2015 (Data layer: NFHL geodatabase by state. Example: NFHL_28_20131013.gdb)
[8] Source of geospatially processed census data: https://irma.nps.gov/App/Reference/Profile/2208959; accessed 5 June 2015

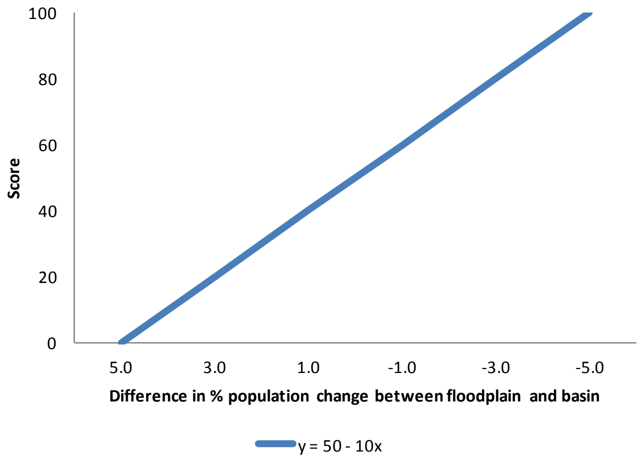

Figure 2.1: Scoring method for Floodplain Population Change.

Table 2.1: Scoring results for each basin and the Mississippi River Watershed. The watershed score is an average of basin scores weighted by the number of people living in the 500-year floodplain.

Floodplain Population Change OVERALL			
Sub-basin	**Score**	**Letter grade**	**Weighting factor**
Upper Mississippi	0	F	29%
Ohio	40	C-	19%
Lower Mississippi	32	D	21%
Arkansas	58	C+	18%
Missouri	43	C-	14%
Mississippi River Watershed	**30**	**D**	

Levee Condition

The Levee Condition indicator evaluates the status of levees inspected by the US Army Corps of Engineers (USACE).

Data source:

Results are based on inspection results reported in the USACE National Levee database[9] and dated 2013.

[LINK to DATA]

Calculation Method and Scoring:

Scores are assigned as follows based on inspection results as reported in the National Levee Database: Acceptable = 100, Minimally Acceptable = 50, and Unacceptable = 0. Basin scores are calculated as the average for all levees in the basin weighted by the length of each levee. The score for the Mississippi River Watershed is the average of the basin scores weighted by the miles of levees in each basin.

Table 2.2: Scoring results for each basin and the Mississippi River Watershed. The watershed score is an average of basin scores weighted by the miles of levee in each basin.

Levee Condition OVERALL			
Sub-basin	**Score**	**Letter grade**	**Weighting factor**
Upper Mississippi	50	C	25%
Ohio	50	C	4%
Lower Mississippi	25	D	30%
Arkansas	30	D	18%
Missouri	45	C	23%
Mississippi River Watershed	**38**	**D+**	

Building Elevation Requirements

The Building Elevation Requirements indicator assesses the degree to which communities have adopted requirements to elevate structures above mapped flood levels. The interval of elevation above flood levels is termed freeboard, and freeboard requirements are zero, 1, 2, and 3 feet.

[9] http://nld.usace.army.mil/egis/f?p=471:1 ; accessed 2 Jun 2015

Data source:

Scoring is based on the percent of population living in communities with state-mandated requirements to increased elevation for new construction above flood level. The data on freeboard requirements in the Mississippi River Watershed were compiled by David Conrad in conjunction with the Association for State Floodplain Managers (ASFPM) with input from other ASFPM members.[10] The data were developed primarily from 1) Community Rating System (CRS) higher standards data and 2) ASFPM publication.[11]

Calculation Method and Scoring:

Basin scores are calculated based on the population-weighted average freeboard requirement (x) using the following relationships: if x <1, then Score = 60x; else for Freeboard >=1, then Score = 20x + 40. The score for the watershed is calculated as the average of the basin scores weighted by the population in each basin living in the 500-year floodplain.

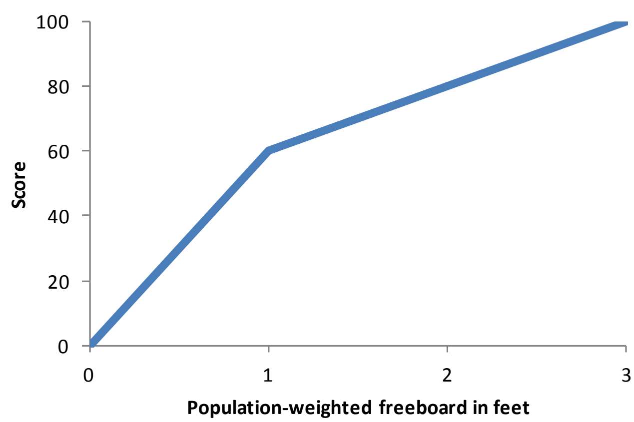

Figure 2.2: Scoring method for Building Elevation

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[10] The data were developed to inform ASFPM members about the potential implications of the recently issued Executive Order 13690 establishing a new flood risk management standard for federal investments and programs. While there are over 22,000 communities enrolled in the NFIP less than 1,300 communities are enrolled in CRS. This compilation provides a more comprehensive view of the most common higher standard implemented for flood risk management.

[11] Floodplain Management 2010: State and Local Programs. This report is a national summary of state and local floodplain management practices. The report updates and supplements previous reports issued in 1989, 1992, 1995, and 2003. Link: http://www.floods.org/index.asp?menuID=732

Table 2.3: Scoring results for each basin and the Mississippi River Watershed. The watershed score is an average of basin scores weighted by the population in the 500-year floodplain in each basin.

Building Elevation Requirements OVERALL			
Sub-basin	**Score**	**Letter grade**	**Weighting factor**
Upper Mississippi	63	B-	29%
Ohio	43	C-	19%
Lower Mississippi	22	D-	21%
Arkansas	42	C-	18%
Missouri	60	B-	14%
Mississippi River Watershed	**46**	**C**	

Additional Discussion on Flood Control Goal

The history of flooding shapes the relationship between the Mississippi River and communities in the watershed. The magnitude of life and property at risk to flooding is influenced by increased surface water runoff due to changes to the landscape, the loss of natural flood attenuation, the development of permanent structures and population centers in flood-prone areas, and the deterioration of infrastructure such as levees and floodways built to manage flood risk. Effective flood control and risk reduction uses a variety of strategies, each suited to the different types of flooding and the morphology of the surrounding landscape. In all cases, risks are reduced by being prepared to respond in advance of a flood event.

The chance of flooding can never be reduced to zero. Therefore, reducing risk also means constructing buildings and community infrastructure to accommodate intense rainfall and high water levels when they do occur. Risk from river flooding can be controlled by reducing building in low, flood-prone areas, or building above flood levels. Low elevations in the Louisiana coast, i.e. the Mississippi deltaic region, limit the opportunity to avoid flooding altogether; therefore reducing risks here must rely on elevating structures above anticipated flood levels.

In some cases the extent of flooding can be reduced. Hard structures, such as levees and flood walls, can contain flood waters within the river channel and protect critical infrastructure. River flooding can also be reduced by capturing water in reservoirs so that discharge and water levels are reduced downstream. Wetlands and other low areas along the river can be designated for flood storage or flow ways with the same effect.

Changing climate and rising sea level erode the protection provided by existing structures and policies no matter how diligently these are maintained. More intense rainfall combined with higher river discharge increases the probability of river flooding. Increased rainfall and river flow are expected to occur in the central and eastern portions of the Mississippi River Watershed. An analysis of historical data shows that the intensity of extreme rainfall events and flooding has increased significantly over the past 50 years.[12] Accelerated sea level rise, brought on by climate change, and high rates of subsidence in the Mississippi deltaic region expose coastal communities to an increased risk of flooding by storm surge. In response, the federal government has proposed new guidelines that will increase the protection for buildings and infrastructure from flooding.[13]

The challenge for flood control and risk reduction in the future will be to maintain existing measures, both structural and nonstructural, while at the same time responding to shifting levels of flood risk due to changes in where people live, changes in the economy and critical infrastructure and climate change, rising sea level, and coastal subsidence. This will require an approach to flood risk management that integrates information from throughout the Mississippi River Watershed, including its deltaic region, and adapts over time.

Challenges

The results for Flood Control & Risk Reduction are an example of the difficulty the Report Card had in fully capturing data on certain issues in the watershed. Watershed experts and stakeholders recommended that the report card only measure flood risks throughout the entire watershed—but not flood damage prevented—because comprehensive and complete data could not be collected. This explains the poor grade for the watershed only four years after the record 2011 Mississippi River flood, which resulted in minimal property damage and no loss of life.

Similar problems arise in attempting an assessment of levees and other flood protection and flood mitigation infrastructure. Due to lack of comprehensive and complete data, we were limited to basing the levee condition indicator solely on levees inspected by the USACE. This ignores a large number of levees and mitigation structures not owned or maintained by the USACE. For example, at the Arkansas/Red Rivers workshop we heard about a large number of dams constructed, mostly during the first half of the 20th century, to impound water and control

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[12] Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., 2014: Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2.

[13] https://www.fema.gov/federal-flood-risk-management-standard-ffrms

erosion of farmland. These dams play an important role in impeding runoff, but they are reaching the end of their useful lifetime and are prone to failure. Even the most basic information about these dams is lacking.

Indicators Not Selected

Several possible indicators were discussed during the regional workshops and during the working group meetings following the 2014 Summit. Although the project team was not able to implement these ideas in this version of the report card, they merit consideration for inclusion in a revised, future report card.

- ***Community resilience (community rating system class results)*** - This indicator was replaced by the building elevation indicator, which provides a more direct measure of preparedness.
- ***Implementation of watershed management plans*** - The role played by watershed management plans in managing flood risk varies widely. We could not identify a source of information on watershed planning with consistent information for all of the basins.
- ***Flood damage prevented by USACE works***
- ***Non-structural/green infrastructure***

3 Transportation

Serve as the nation's most valuable river transportation corridor

People value safe, secure, well-maintained, and future-oriented inland navigational infrastructure that is integrated with rail and highway transport to support cost effective movement of goods and materials. Commercial navigation is critical to the economic and social well-being of the United States and the world. The Mississippi River and its tributaries serve as the nation's most valuable river transportation corridor.

Indicators

The indicators selected for transportation in the Mississippi River watershed assess system performance, condition of navigation infrastructure, and sustainability of operations. System performance is assessed based on delays due to navigation locks taken out of service. The condition of navigation infrastructure is based on the assessed condition of critical components of the lock and dam facilities. Long-term sustainability is evaluated based on an assessment of the planning process that determines the resources allocated annually to operations and maintenance for the entire transportation system in the watershed.

System performance and the condition of essential components are evaluated based on data collected by the USACE for each lock and dam facility on the Mississippi River and its tributaries. The results are rolled up and scored for each basin in the watershed except the Missouri River basin. Navigation is restricted to the lower portion of the Missouri River, below Sioux City, and there are no navigation locks or dams on this section of the river. Therefore, the Missouri River basin does not receive a grade for navigation in this report card.

Note on Calculation of Watershed Score

The overall navigation score for the Mississippi River Watershed is calculated differently from the overall watershed scores in the other goal areas. A different approach is taken for transportation because the transportation indicators emphasize the lock and dam infrastructure components of the inland navigation system. This infrastructure is unevenly distributed among the basins; most of it is in the Upper Mississippi and Ohio basins. And also, the distribution of infrastructure is independent of the amount of traffic that moves through the system; navigation along the Lower Mississippi River, which has the highest volume of traffic, requires no locks or dams.

Therefore, the overall transportation score for the watershed is calculated as the average of the overall transportation scores for each basin, except the Missouri River basin which is not scored, weighted by the annual average tonnage moved in each basin. Note that the annual average tonnage moved in a basin is different that the tonnage recorded moving through the locks, which is used to calculate the watershed scores for lock delays.

Lock Delays

The index for lock delays compares the amount of time that locks in a basin were unavailable in 2013 with the unavailable time in the best performing year 2000 through 2012. Delay times for individual locks are weighted by the amount of traffic passing through the lock in scoring the indicator for the entire basin.

Data source:

Summary data reported by the US Army Corps of Engineers (USACE) on the use and performance of navigation locks includes the amount of time each lock was unavailable and the amount of cargo passing through each lock measured in tons.[14]
[LINK to DATA]

Calculation Method and Scoring:

For each basin, we calculated the average total time each lock was unavailable from all causes, weighted by the total tonnage that moved through the lock in a year. The tonnage-weighted average time unavailable was computed for each year 2000 through 2013. The basin score is calculated as the ratio, in percent, of the tonnage-weighted time unavailable in the best performing year divided by tonnage-weighted time unavailable in 2013. The score for the Mississippi River Watershed is the average of the basin scores weighted by the annual average tonnage moved per lock in each basin.

[14] http://www.navigationdatacenter.us/lpms/lpms.htm; accessed 1 June 2015.

Table 3.1: Results for each basin and overall Mississippi River Watershed. Score for the overall watershed is a weighted average based on the annual average of tons of cargo moved in the basin.

Lock Delays OVERALL			
Sub-basin	**Score**	**Letter grade**	**Weighting factor**
Upper Mississippi	82	A-	30%
Ohio	73	B	49%
Lower Mississippi	26	D	9%
Arkansas	0	F	13%
Missouri	n/a	n/a	n/a
Mississippi River Watershed	**62**	**B-**	

Infrastructure Condition

Infrastructure condition is calculated based on the percentage of USACE critical components identified as in "inadequate" or "failed" condition. A "mission critical" component is one that if it fails will cause an unscheduled outage, or unavailability, that will last one day or longer in duration; that impedes our ability to (1) pass navigation traffic and/or (2) maintain the navigation pool to pass that traffic.

Data source:

The USACE assessed the condition of each lock or dam facility, and each component is graded based on the following scale:

A = adequate
B = probably adequate
C = probably inadequate
D = inadequate
F = failed.

Calculation Method and Scoring:

We obtained the grades for critical components[15] in each basin and calculated the percent of critical components assigned a grade of D or E (inadequate or failed) for components of locks and components of dams, separately. Infrastructure Condition for the basin is scored on the scale 0-100 based on the average of the percentages of critical components receiving graded D or F for the locks and dams. We selected 2.5% percent of critical components in inadequate or failed condition as the threshold between pass and fail, i.e. the threshold between receiving a D grade or F, based on the discussions about the importance of even a small percentage of critical infrastructure in nearly failing condition.

Basin scores are assigned using the following formula: $y = -40x + 120$, in which y is the score and x is the percent of critical components in each basin that the USACE assessment assigned a grade of D or F. The score for the watershed is assigned by, first, aggregating the basin-level critical component assessment results into a single data set, then calculating the percent of critical components assigned a grade of D or F in the aggregated data, and finally, using the same formula to calculate a score.

[15] Doug Ellsworth, USACE; personal communication

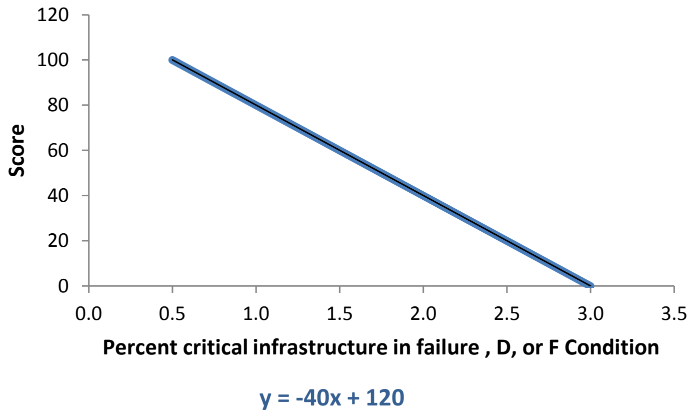

Figure 3.1: Scoring method for Infrastructure Condition

Table 3.2: Results for each basin and overall Mississippi River Watershed. Score for the overall watershed is calculated directly from the combined basin statistics

Infrastructure Condition OVERALL			
Sub-basin	**Score**	**Letter grade**	**Weighting factor**
Upper Mississippi	43	C-	n/a
Ohio	37	D+	n/a
Lower Mississippi	25	D	n/a
Arkansas	35	D	n/a
Missouri	n/a	n/a	n/a
Mississippi River Watershed	**35**	**D**	

Infrastructure Maintenance

The adequacy of maintenance for navigation infrastructure evaluates the adequacy of funding for operations and maintenance against the goals: (1) funding is provided at the level needed to maintain the current infrastructure in working order, and (2) continued funding is assured, so that maintenance can be scheduled and performed efficiently.

Data source:

To evaluate the level of funding, we compare estimated and actual expenses by the Civil Works program, reported by the Office of Management and Budget, and estimates by USACE of the annual amount of deferred maintenance related to the inland marine navigation system. To evaluate the level of assurance of funding for maintenance, we examine the long-term trend in annual allocations to the Civil Works program by Congress, and we review recent analysis of the sustainability of funding through the Inland Waterways Trust Fund, which is the principal source of funds for construction to rehabilitate ageing infrastructure.
[LINK to DATA]

Calculation Method and Scoring:

The adequacy of maintenance for navigation infrastructure is evaluated pass/fail based on weight of evidence. Factors that determine the adequacy of maintenance of navigation infrastructure in the Mississippi River Watershed affect equally the inland navigation system for the entire US. Therefore, the same score applies to the entire watershed.

Infrastructure Maintenance OVERALL		
Sub-basin	Score	Letter grade
Mississippi River Watershed	0	F

Additional Discussion on Transportation Goal

The commercial navigation industry in the Mississippi River Watershed annually transports $54 billion dollars of agricultural products representing 92% of the nation's farm exports, including more than 60% of the U.S. grain products for global consumption. Barge transport is a vital link in a transportation system that integrates rail, truck and international shipping systems to move goods and materials to where they are needed. It is a cost effective method to provide the agricultural, energy and manufacturing sectors with materials, and transport products to national and global markets. Sustaining and increasing this capacity through infrastructure maintenance, rehabilitation, updates and innovations is necessary in order to maintain a competitive economy that benefits an increasing number of people throughout the world.

Operation, maintenance, and rehabilitation of existing transportation infrastructure present the main challenge for navigation in the Mississippi River Watershed. Transportation by barge depends critically the system of locks and dams that maintain the depth of water required for navigation. The current system of locks and dams is extensive and complete but ageing, having been built mostly between about 1850 and 1950. The USACE has responsibility for operation and maintenance of the system. The USACE determines the specific needs and sets priorities for maintenance and rehabilitation of system components. However, the Congress and executive branch of the federal government influence the selection of what projects get done, and they determine the level of funding for operations and maintenance as part of the annual budgeting process for the whole country.[16]

Grading the transportation goal in the Missouri Basin was a challenge for the report card. The Missouri basin is an outlier because there are no locks used for navigation. Two of the three indicators for the transportation goal measure the condition of the physical infrastructure for navigation and the performance of lock facilities, based on input from stakeholders and significant feedback from experts. These indicators do not apply to the Missouri Basin, and for this reason, the report card does not assign a grade to the transportation goal specific to this basin. However, transportation in the basin is compromised by the lack of adequate funding for maintenance, because this affects the management of the entire inland waterway network.

The volume of transportation activity in the Missouri River basin is substantially smaller than in the other basins of the watershed. Recent years have seen a slight recovery in the volume of activity since it reached a low point around 2009; however, the volume of river born transportation on the Missouri River is still below levels sustained in the early 1980s.

Challenges

One point that was stressed in feedback by experts and at report card workshops throughout the watershed was the need to view and evaluate the navigational system as a unified system and not as a series of individual units. Disruption—such as a major infrastructure failure or accident—at a handful of single points in the system would significantly affect the performance of the entire system.

The current navigational *system* plays a critical role in efficiently moving goods throughout the Mississippi River Watershed and to world markets. Although the current Report Card results for lock delays led to a grade of C for the watershed, these delays are caused by a small number of components in poor or failing condition. The lack of funding for system maintenance is widely

[16] NRC, 2012. Corps of Engineers Water Resources Infrastructure: Deterioration, Investment, or Divestment? Committee on U.S. Army Corps of Engineers Water Resources Science, Engineering, and Planning; Water Science and Technology Board; Division on Earth and Life Studies; National Research Council. Washington, DC.

expected to increase the number of components that fail and will likely significantly increase lock delays and decrease overall system performance.

Indicators Not Selected

Several possible indicators were discussed during the regional workshops and during the working group meetings following the 2014 Summit. Although the project team was not able to implement these ideas in this version of the report card, they merit consideration for inclusion in a revised, future report card.

- ***Criticality of infrastructure*** – The project team recognizes the importance of having some way of evaluating the importance of different components of transportation infrastructure either within the inland transportation network or for the whole transportation system on a regional or national basis.
- ***Tonnage*** - We investigated several different ways, in addition to tonnage, of measuring the total amount of material moving through the inland navigation system as a measure of overall system performance. However, this approach is complicated by external factors that also affect the amount of material moved, such as year-to-year changes in the economic situation. (See also the discussion of deep-draft shipping under whole-watershed indicators.)

4 Water Supply

Maintain supply of abundant clean water

People value clean surface and ground water for multiple uses, including domestic uses, recreation, agricultural and industrial water uses. The term “water supply” relates to a broad range of uses that go beyond direct use of water for drinking and home use. It is critical to improve the capacity of the Mississippi River Watershed to provide water that is of sufficient quality and quantity for this range of uses and to support the heath of ecosystems and the services they provide.

Indicators

The indicators selected for water supply in the Mississippi River Watershed assess the safety of municipal water supplies and the quantity of surface water available to meet existing demands. The safety of municipal water supplies is evaluated using data on violations by community water treatment systems reported to EPA. The quantity of surface water available is evaluated using a water stress index developed for this report card.

Water Treatment Violations

This indicator measures drinking water quality and was discussed frequently at the basin workshops and in the expert review team meetings for revising the report card following the October 2014 Summit. Measured and reported violations of water treatment standards are considered to represent unsatisfactory operation of public water supply facilities.

Data source:

The data are from the Safe Drinking Water Information System - Federal (SDWIS/FED) drinking water data compiled by EPA and summarized by state.[17]
[LINK to DATA]

[17] http://water.epa.gov/scitech/datait/databases/drink/sdwisfed/pivottables.cfm; accessed 28 May 2015

Calculation Method and Scoring:

This indicator is calculated based on the percent of the population served by community water systems in each state that had no reported violations in 2013. Three categories of violations were counted: maximum contaminant level, maximum residual disinfectant level, and treatment technique violations. A state with 99% or more of it's population served by water supply systems without any of these violations was considered an "A" score and a state with 96% or less of its population served by water treatment facilities without treatment violations was considered failing. Basin scores are weighted averages of state scores based on percent of total basin population served by community water systems, and the overall watershed score is a weighted average of basin scores based on percent of total watershed population served.

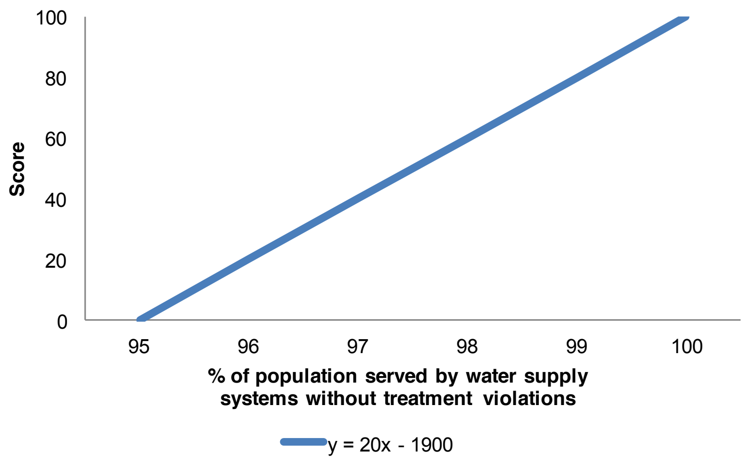

Figure 4.1: Scoring method for calculating scores for each state based on the percentage of population served by water supplies without treatment violations.

Table 4.1: Results for each state and overall Mississippi River. Score for the overall watershed score is a weighted average based on the population of each basin served by a community water system.

Water Treatment Violations OVERALL			
Sub-basin	**Score**	**Letter grade**	**Weighting factor**
Upper Mississippi	46	C	25%
Ohio	39	D+	25%
Lower Mississippi	2	F	10%
Arkansas	14	F	25%
Missouri	31	D-	15%
Mississippi River Watershed	**30**	**D-**	

Water Depletion

This indicator compares the available amount of surface water in a region with the net amount of water used by people. This indicator was developed for this report card based on discussions at the basin workshops and in subsequent revision meetings with sector experts. It assesses the degree to which the availability of water is limited relative to existing demand.

The scores for this indicator are based on a water depletion index, which measures the degree to which net water use depletes the amount of available surface water. Net water use is the amount of water consumed by people, and it is calculated as the difference between total water withdrawals from rivers, streams and lakes and the total amount discharged back into surface water bodies. Available surface water is the amount provided by precipitation and stream flow minus losses from natural evaporation; evaporation lost from irrigated agriculture is counted as part of the net water use.

The depletion index is calculated as the ratio of net water use by people in a region and the total amount of water naturally available. Values of the depletion index vary between zero and one. Values close to one indicate very dry conditions in which people are using very nearly all available surface water. The depletion index[18] approach to evaluating regional water scarcity was developed by Brian Richter, Director of Freshwater Strategies and Emily Powell, Global Water Analyst, in The Nature Conservancy's Global Freshwater program, who assisted us in this application.

Data Source

The depletion index is calculated using water fluxes compiled by the US Forest Service Water Supply Stress Index (WaSSi) model.[19] The WaSSi model calculates land-surface hydrology and ecosystem productivity based on historical climate data for the period 1960 through 2012. Consumptive use of water is estimated based on data on consumptive use (1995) and water withdrawals and return flows (2005) compiled by the US Geological Survey (USGS).

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[18] B.D. Richter, E.M. Powell, T. Lystash and M. Faggert, "Protection and Restoration of Freshwater Ecosystems", chapter 7 in "Western Water Policy and Planning in a Variable and Changing Climate" (Editor: K. Millert), soon to be published by Taylor & Francis Publishers, Boca Raton, FL

[19] The WaSSI model and documentation can be found here: http://www.wassiweb.sgcp.ncsu.edu/ (Accessed 29 May 2015).

Water budget calculations are performed on the HUC8-level drainage basins.[20] The HUC8 regions are defined by a system for classifying river systems developed by the US Geologic Survey. The Mississippi River Watershed contains 847 of the 2200 HUC8 regions defined for the contiguous 48 states of the US. These are distributed within the Mississippi River Watershed as follows: 152 in the Ohio River basin, 131 in the Upper Mississippi River basin, 82 in the Lower Mississippi River basin, 173 in the Arkansas/Red Rivers basin, and 309 in the Missouri River basin.

[LINK to WaSSI Model]

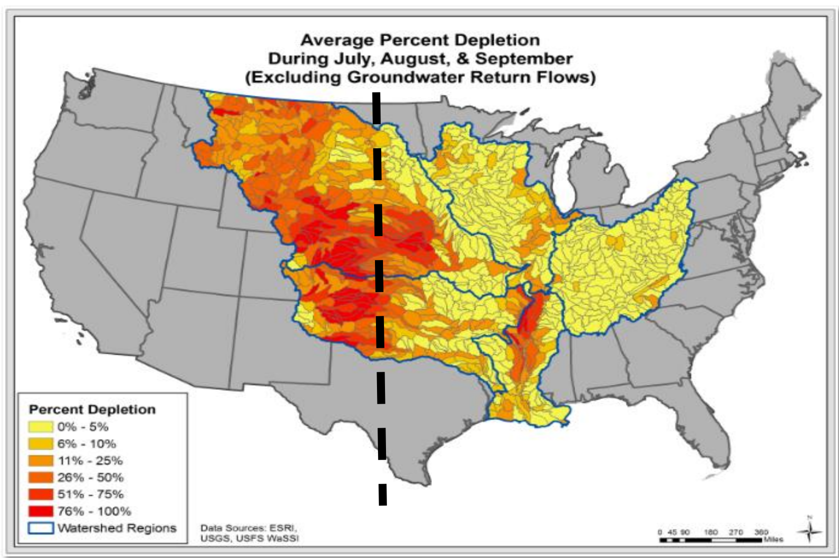

Figure 4.2: Values of the water depletion index used to score the water depletion indicator. High values indicate areas where human activities consume water at nearly the rate that supplies are renewed. The dashed line is the 100th meridian, which marks the transition between low precipitation to the west and wetter conditions in the east.

Calculation Method and Scoring

The water depletion in each HUC8 region is scored based on the average depletion index, calculated by the WaSSI model, for the months July, August, and September (JAS-average). Water depletion is scored on a scale 0-100 by comparing the JAS-average depletion index in each HUC8 region to the JAS-average depletion index for all HUC8 regions in the contiguous 48 states of the US. Scores are assigned based on the percentile rank of each HUC8 region in the distribution of all HUC8 basins, and ranks are assigned so that high values of the depletion index, indicating dry conditions, receive low scores.

[20] The United States Geological Survey created a hierarchical system of hydrologic units to catalog drainage basins in the US. There are 2200 HUC8 basins, so named because they are assigned an 8-digit numerical code, with an average area of 700 square miles.

Using the JAS-average values of the depletion index accounts for seasonal changes in water supply and water use. Conditions during the low-flow time period of July, August and September are the most pressing for evaluating water scarcity. Annual-averaged values of the depletion index would not accurately provide information about water scarcity in a low supply month. In the water budget calculations using the WaSSI model it is assumed that water supply in excess of demand during high flow months does not provide any benefit in the months when supply does not meet demand.

Scores for each basin in the Mississippi River Watershed are calculated as the average of the scores for the HUC8 basins weighted by the area of the HUC8 basins. The basin scores for water depletion provide a measure of water availability over the area of the basin. However, the score for the watershed is calculated as the average of the basin scores weighted by the basin population. Therefore, the average for the watershed provides a measure of water availability conditioned by where people live, by giving weight to the water-rich, smaller but more densely populated Upper Mississippi River basin and Ohio River basin over the dry Missouri River basin, which accounts for over 40% of the area of the watershed.

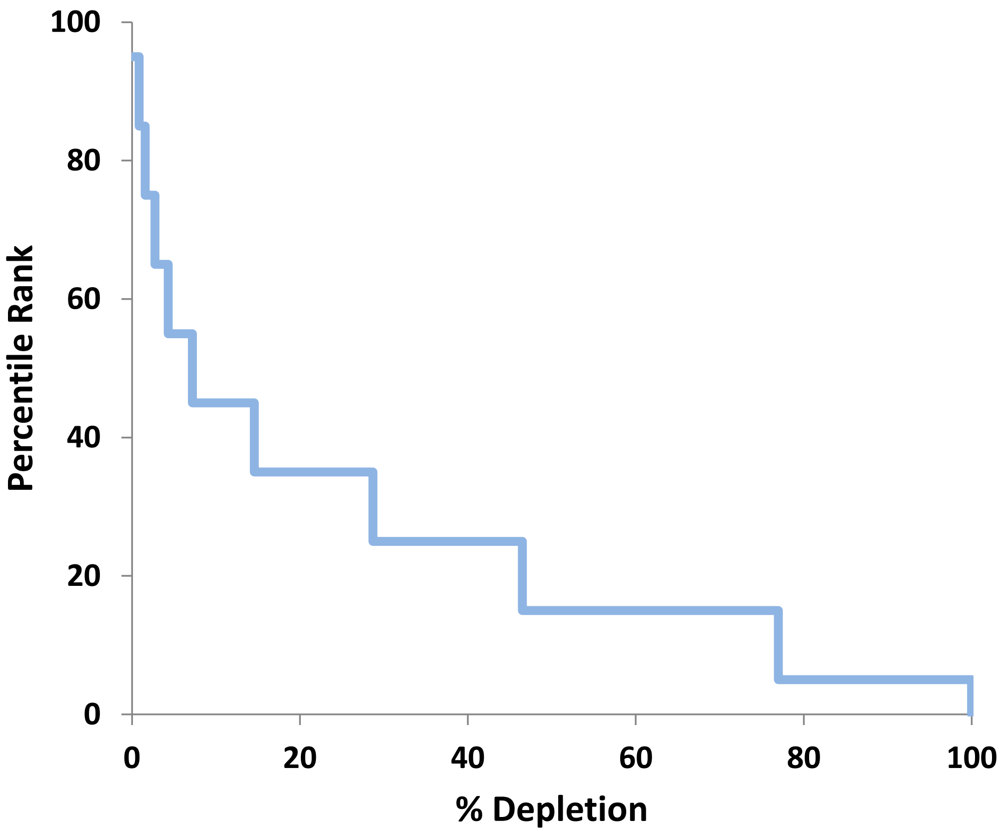

Figure 4.3: Scores for the Water Scarcity Index for each basin are calculated first by assigning a percentile rank value each HUC8 in the basin based on the distribution of the percent depletion index for all the HUC8 areas in the contiguous 48 states. The curve shown here was used to assign percentile rank values (95%, 85%, 75%,…15%, 5%, 0%) based on the percent depletion calculated by the WaSSI model. Higher values of percentile rank, and therefore Water Scarcity Index, correspond to lower values for percent depletion, and therefore wetter conditions.

Table 4.2: Scoring results for each basin and the Mississippi River Watershed. The watershed score is a population-weighted average of basin scores.

Water Depletion OVERALL			
Sub-basin	**Score**	**Letter grade**	**Weighting factor**
Upper Mississippi	68	B	29%
Ohio	78	B+	34%
Lower Mississippi	56	C	9%
Arkansas	43	C-	12%
Missouri	38	D+	15%
Mississippi River Watershed	**63**	**B-**	

Additional Discussion on Water Supply Goal

People and communities throughout the watershed value clean and abundant water for many uses, including drinking water, supplies for farms and industry, recreation and natural systems. The issues related to water quality and supply are complex, often controversial and vary among the different basins and regions of the watershed. Demand for surface and groundwater is growing as populations increase and more water is needed to grow crops and support industry. These growing demands combine with an aging water treatment and supply infrastructure to put unprecedented pressure on water resources. In the future, there must be an integrated management approach that assures that water supplies support society's needs and opportunities in a balanced manner throughout the watershed.

The 100th meridian bisects the Mississippi River Watershed and divides the low precipitation areas to the west from the higher precipitation conditions in the eastern parts of the watershed. In general, water supply issues and concerns relate to water quality in the relatively water-rich eastern portion of the watershed and to securing a sufficient quantity of water in the drier western portion. Since 1948, states in the industrialized Ohio River basin have cooperated to address water quality issues through membership in the Ohio River Valley Water Sanitation Commission (ORSANCO). In the drought-prone Arkansas/Red River basin, states have entered into interstate compact agreements to manage water reservoirs and apportion water equitably among users. However, in the Missouri River basin the management of reservoirs and apportionment of water is an ongoing source of discussion.

The challenges to supplying abundant clean water are increasing. In August 2014, a toxic plankton bloom shut down the municipal water supply serving half a million people in Toledo, Ohio, clearly showing that current efforts to protect water quality are inadequate. The underlying cause for the bloom, nutrient-rich runoff from farm fields, poses a similar threat to municipal water supplies and communities in the Ohio and Upper Mississippi basins. Groundwater is an important source of water that is being used increasingly by agriculture, but the current rate of water extraction from major aquifers is unsustainable.[21]

Challenges

Basic data needed for the management and protection of water supplies in the Mississippi River Watershed are missing or inaccurate. EPA and the states are required to compile and report this information under the Clean Water Act. Many of the experts we consulted recommended these data as the basis for an indicator related to the water supply goal. However, over the course of this project and in discussions with USEPA, it was determined that the information compiled to evaluate water quality in states and in the Mississippi River Basin is not adequate and provides misleading results.

Problems with data collection and reporting under the Clean Water Act are long-standing and have been the subject of investigations by the GAO[22] and the National Research Council.[23] Problems with the designated used data, i.e. the 303(d) list, arise from disparities among the states in determining a water body's designated use, the criteria for each use, and the methodology evaluating suitability for these uses. As a result, the information that is compiled is unreliable in the view of the analysts and experts who worked to develop this indicator, including those at EPA. The administration of the Clean Water Act, which relies on voluntary compliance by the states to a large degree, is complicated by the fact that the Mississippi River and its major tributaries constitute shared, inter-state waters over much of their length. The NRC 2008 report

[21] McGuire, V.L., 2014, Water-level changes and change in water in storage in the High Plains aquifer, predevelopment to 2013 and 2011–13: U.S. Geological Survey Scientific Investigations Report 2014–5218, 14 p., http://dx.doi.org/10.3133/sir20145218; and Konikow, L.F., 2013, Groundwater depletion in the United States (1900−2008): U.S. Geological Survey Scientific Investigations Report 2013−5079, 63 p., http://pubs.usgs.gov/sir/2013/5079. (Available only online.)

[22] GAO, 2012. NONPOINT SOURCE WATER POLLUTION: Greater Oversight And Additional Data Needed For Key EPA Water Program. US Government Accounting Office, GAO-12-335. May 2012; and GAO, 2005. Environmental Information: Status of Federal Data Programs That Support Ecological Indicators. US Government Accounting Office, GAO-05-376. September 2005.

[23] NRC, 2008. Mississippi River Water Quality and the Clean Water Act: Progress, Challenges, and Opportunities. Committee on the Mississippi River and the Clean Water Act, Water Science and Technology Board, Division on Earth and Life Studies, National Research Council. National Academies Press, Washington, DC.

concludes that the problems with monitoring and assessment arise from the EPA's reluctance to assume a strong leadership role, using authorities already available to it in existing legislation. However, the GAO 2012 report calls for Congress to address the issue of limited authority by revising the Clean Water Act.

Indicators Not Selected

Several possible indicators were discussed during the regional workshops and during the working group meetings following the 2014 Summit. Although the project team was not able to implement these ideas in this version of the report card, they merit consideration for inclusion in a revised, future report card.

- ***Water supply suitability*** - This indicator was recommended strongly throughout the report card development process. The Water Supply Suitability indicator was intended to measure the percent of rivers and streams attaining water quality criteria set by states for industrial, agricultural, and public water supply uses. Under the Clean Water Act, every two years each state must send to USEPA a 303(d) list of impaired waters, and the compiled results are available online.[24]
- ***Groundwater sustainability*** - Groundwater is also an important source of water. The US Geological Survey has compiled information on the sustainability of regional aquifers in some of the basins (see above), but information needed to assess groundwater supplies in all five basins does not yet exist.
- ***Treatment plant operational modifications due to contaminant plumes***
- ***National Integrated Drought Information System***
- ***American Society of Civil Engineers (ASCE) results on infrastructure and water supply***

[24] http://www.epa.gov/waters/ir/; accessed 30 May 2015.

5 Economy

Support local, state and national economies

Many sectors in local, state and national economies depend on reliable access to high-quality water in sufficient quantity. Many businesses rely on water supply for operations and production of goods. Water is used in power generation, agricultural irrigation, animal husbandry and industrial production. The total amount of water available for use is limited, and allocation decisions become increasingly difficult as demand increases and supplies become less reliable. Diminished water quality adds to this difficulty. As water stresses increase nationally, greater pressures will be placed on local water resources, with potentially harmful effects to the economy of the watershed.

Indicators

The indicators selected for economy in the Mississippi River Watershed assess the employment and productivity in river-related sectors of the economy and per capita income for each basin. Information is compiled from national economic statistics summarized by state, and the indicators are scored by state, by comparing with all other state in the country.

River-Dependent Employment

The number of people employed in river dependent sectors (farming, fishing, & forestry; production; transportation and material moving) in each state for 2013 is compared to the average employment in these industries for all states.

Data source:

The data are from the Bureau of Labor Statistics.[25]
[LINK to DATA]

Calculation Method and Scoring:

The score for river-dependent employment in each state is calculated from the difference between the state total and the average for all US states, standardized by the standard deviation of the state totals (number of standard deviations away from the national average). The formula y

[25] http://www.bls.gov/oes/current/oessrcst.htm; accessed 26 May 2015

= 20x + 50 is designed to convert the "Std Dev offset[26]" value to a value between 0-100, which then becomes the score for that state. The formula was calculated using -2.5 and 2.5 as the lower and upper bounds, corresponding to scores of 0 and 100, respectively. The state score is represented by "y" while the 'Std Dev offset' is represented by "x".

Basin scores are calculated as the average of the state scores weighted by the area of each state in the basin. The overall score for the Mississippi River Watershed is the average of the basin scores weighted by the total river-related employment in each basin.

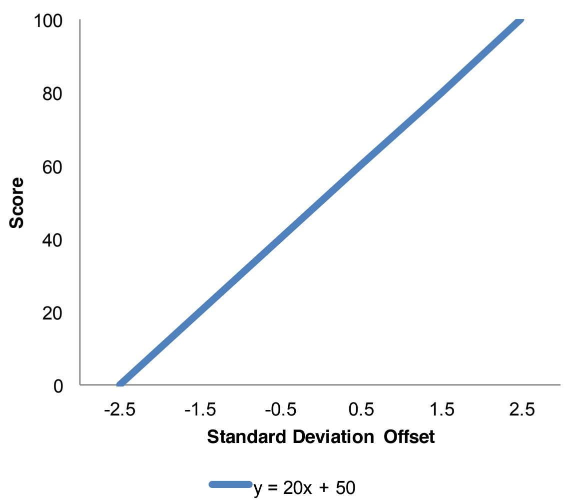

Figure 5.1: Scoring method for economy indicators.

Table 5.1: Scoring results for each basin and the Mississippi River Watershed. The watershed score is an average of basin scores weighted by the total river-related employment in each basin.

River-Dependent Employment OVERALL			
Sub-basin	**Score**	**Letter grade**	**Weighting factor**
Upper Mississippi	59	C+	28%
Ohio	60	B-	29%
Lower Mississippi	45	C	14%
Arkansas	53	C	23%
Missouri	37	D+	6%
Mississippi River Watershed	**54**	**C**	

[26] The "Std Dev offset" value represents how many (national) standard deviations that the state total differs from the national average.

GDP by Sector

This indicator uses data on gross domestic product (GDP) for selected industries in each state for 2013 and is compared to the average GDP in these industries for all US states.

Data source:

The data are from the Bureau of Economic Analysis[27] for the following river dependent industries are used:

Agriculture, forestry, fishing, and hunting
Arts, entertainment, recreation, accommodation, and food services
Manufacturing
Mining
Transportation and warehousing
Utilities

[LINK to DATA]

Calculation Method and Scoring:

The score for GDP in river-related industries for each state is calculated from the difference between the state total and the average for all US states, standardized by the standard deviation of the state totals (number of standard deviations away from the national average). The formula y = 20x + 50 is designed to convert the "Std Dev offset[28]" value to a value between 0-100, which then becomes the score for that state. The formula was calculated using -2.5 and 2.5 as the lower and upper bounds, corresponding to scores of 0 and 100, respectively. The state score is represented by "y" while the 'Std Dev offset' is represented by "x".

Basin scores are calculated as the average of the state scores weighted by the area of each state in the basin. The overall score for the Mississippi River Watershed is the average of the basin scores weighted by the GDP in river-related industries for each basin.

[27] 2013 Gross Domestic Product by State (millions of current dollars) http://www.bea.gov/regional/index.htm; accessed 1 September 2015

[28] The "Std Dev offset" value represents how many (national) standard deviations that the state total differs from the national average.

Table 5.2: Scoring results for each basin and the Mississippi River Watershed. The watershed score is an average of basin scores weighted by the GDP in river-related industries for each basin.

GDP by Sector OVERALL			
Sub-basin	**Score**	**Letter grade**	**Weighting factor**
Upper Mississippi	53	C	22%
Ohio	54	C	23%
Lower Mississippi	47	C	15%
Arkansas	55	C+	33%
Missouri	40	C-	7%
Mississippi River Watershed	**52**	**C**	

Median Income

The median per capita income in each state for 2013 is compared to the average employment in these industries for all US states.

Data source:

The data are from the Bureau of Economic Analysis.[29]
[LINK to DATA]

Calculation Method and Scoring:

The score for median per capita income for each state is calculated from the difference between the state total and the average for all US states, standardized by the standard deviation of the state totals (number of standard deviations away from the national average). The formula $y = 20x + 50$ is designed to convert the "Std Dev offset[30]" value to a value between 0-100, which then becomes the score for that state. The formula was calculated using -2.5 and 2.5 as the lower and upper bounds, corresponding to scores of 0 and 100, respectively. The state score is represented by "y" while the 'Std Dev offset' is represented by "x".

Basin scores are calculated as the average of the state scores weighted by the area of each state in the basin. The overall score for the Mississippi River Watershed is the average of the basin scores weighted by the population in each basin.

Table 5.3: Scoring results for each basin and the Mississippi River Watershed. The watershed score is an average of basin scores weighted by the population in each basin.

Median Income OVERALL			
Sub-basin	**Score**	**Letter grade**	**Weighting factor**
Upper Mississippi	52	C	29%
Ohio	38	D+	34%
Lower Mississippi	33	D	9%
Arkansas	42	C-	12%
Missouri	52	C	15%
Mississippi River Watershed	**44**	**C**	

[29] 2013 SA1-3 Personal income summary (millions of current dollars) http://www.bea.gov/regional/index.htm; accessed 1 September 2015

[30] The "Std Dev offset" value represents how many (national) standard deviations that the state total differs from the national average.

Additional Discussion on Economy Goal

The role of the Mississippi River and tributaries as an economic engine can be evaluated by tracking activities in river-related economic sectors. Economic profiles have been compiled for the Lower Mississippi River[31] and the Upper Mississippi River region[32] but not for other basins, so far as we could determine. These two profiles focus on nine key sectors: commercial navigation; commercial harvest of natural resources; water supply; recreation; tourism and cultural resources; mineral resources; agriculture; energy production; and manufacturing. River-related economic activities accounted for $151.7 billion in annual revenues in 2011, and employed just over 585,000 people in the Lower Mississippi River in 2011. River-related economic activities in the Upper Mississippi River region are larger, accounting for $145 billion in revenue and 870,000 people employed in 1999.

Challenges

The challenge is to develop a similarly detailed, up-to-date picture of the role of the river in supporting the economies in all five basins. The grades for the overall watershed and the five basins reflect general economic conditions nationwide, differing only slightly among the basins. Additional data is needed to better reflect how local economies directly tie to the management of the watershed and its rivers. Such data will be included in future Report Cards. Planning for the efficient use of water among a diversity of stakeholders is critical to sustaining our viable economies.

Indicators Not Selected

Several possible indicators were discussed during the regional workshops and during the working group meetings following the 2014 Summit. Although the project team was not able to implement these ideas in this version of the report card, they merit consideration for inclusion in a revised, future report card.

- ***Economic impacts of recreation, water supply, flood control, transportation***
- ***Benefit and value of water to regional economies***

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[31] Industrial Economics Inc. Economic Profile of the Lower Mississippi River: An Update. Prepared for Lower Mississippi River Conservation Committee, February 2014. [online: http://www.lmrcc.org/wp-content/uploads/2014/02/LMR_Economic_Profile_February2014.pdf; accessed 26 May 2015]

[32] Industrial Economics Inc. Economic Profile of the Upper Mississippi River Region: An Update. Prepared for Division of Economics, U.S. Fish and Wildlife Service and U.S. Department of the Interior, March 1999. [online: http://nctc.fws.gov/Pubs3/economicprofile_miss99.pdf; accessed 26 May 2015]

6 Recreation

Provide world-class recreational opportunities

People value access to diverse recreational opportunities including hiking, boating, fishing, etc. People also value the economic benefits of a vibrant tourist economy. Access to recreational areas and other opportunities for outdoor recreation enriches people's lives. Every year in all seasons, millions of people fish, boat, hike, watch birds and visit cultural sites along the rivers. These activities support a multi-billion dollar recreational economy that is vital to the communities and businesses that provide related equipment and services.

Indicators

The indicators selected for recreation in the Mississippi River Watershed measure the numbers of people participating in various recreational activities. Participation is evaluated both directly based on numbers of people engaged in recreational activities and indirectly based on sales of licenses and permits.

Outdoor Participation

Index of hunting, fishing, and birding activity and national park visitation compares the most recent numbers available for numbers of participants in hunting, fishing, and birding (2011, average by state) and visitors to national parks (2104) within each basin with their 20-year historical ranges.

Data source:

Participation numbers for fishing, hunting and birding are from the National Survey of Fishing, Hunting and Wildlife Associated Recreation (FHWAR), which is performed every 5 years by the US Fish and Wildlife Service and the US Census.[33] The survey tracks participation in fishing, hunting, and other wildlife-associated recreation, such as wildlife observation, photography, and feeding. The numbers of people visiting national parks were obtained from the NPS Visitor Use Statistics website.[34]

[LINK to FHWAR DATA] [LINK to NPS DATA]

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[33] http://www.census.gov/prod/www/fishing.html; accessed 25 September 2015

[34] https://irma.nps.gov/Stats/; accessed 1 September 2015

Calculation Method and Scoring:

The participation score in each basin is calculated as the average of the basin-level participation scores for each category of participation, i.e. hunting, fishing, birding and national park visitation. The basin-level scores within categories are calculated from the scores for each state weighted by the area of the basin in each state. Hunting, fishing and birding participation numbers for each state from the 2011 survey are scored relative to 20-year historical range of data (as a % of that range). The number of visitors to national parks within each basin is compared to the 20-year range (as a % of that range). Park visitation numbers are updated annually.

The score for the Mississippi River Watershed is calculated, first, as the weighted-average of the basin-level participation scores in each category, with the weights calculated based on the participation numbers in each basin. The overall score for the watershed is then calculated as the average of the category scores. We take this approach because the relative numbers of people participating in hunting, fishing and birding (taken together) and visiting national parks varies widely between the basins. For example, the Missouri River basin accounts for 9 percent of all participation in hunting, fishing, and birding in the watershed, but it accounts for 31 percent of all national park visitation in the watershed.

Table 6.1: Scoring results for each basin and the Mississippi River Watershed. The watershed score is an area-weighted average of basin scores.

Outdoor Participation OVERALL				
			Weighting factor	
Sub-basin	Score	Letter grade	Hunt/fish/bird	Park visits
Upper Mississippi	41	C-	27%	7%
Ohio	34	D	24%	47%
Lower Mississippi	53	C	17%	6%
Arkansas	42	C-	23%	10%
Missouri	45	C-	9%	31%
Mississippi River Watershed	**48**	**C**		

Hunting and Fishing Licenses

The index of sales of licenses, tags, stamps, and permits for hunting and fishing compares the 3-year (2011-2013) average hunting and fishing license sales with the 10-year (2004-2013) historical range of the license sales.

Data source:

Numbers of sales of licenses and permits are from the National Hunting License Report 2004-2013 and National Fishing License Report 2004-2013.[35]
[LINK to DATA]

Calculation Method and Scoring:

The 3-year (2011-2013) average of sales of tags, permits, licenses is compared with 10-year range (as a percent of that range). Basin scores are calculated as the average of the state-level scores weighted by the percent of the basin in each state. The score for the Mississippi River Watershed is calculated as the average of the basin scores weighted by the percent of the total license sales for the watershed in each basin.

Table 6.2: Scoring results for each basin and the Mississippi River Watershed. The watershed score is an average of basin scores weighted by the combined hunting and fishing license sales in each basin.

Hunting and Fishing Licenses OVERALL			
Sub-basin	Score	Letter grade	Weighting factor
Upper Mississippi	73	B	33%
Ohio	14	F	19%
Lower Mississippi	74	B	16%
Arkansas	54	C	19%
Missouri	63	B-	14%
Mississippi River Watershed	**57**	**C+**	

Additional Discussion on Recreation Goal

The diverse ecosystems in the Mississippi River Watershed support a broad range of recreational pursuits. Millions of people every year hunt, fish, boat, hike, watch birds, visit cultural sites

[35] http://wsfrprograms.fws.gov/Subpages/LicenseInfo/Hunting.htm; accessed 24 May 2015

along the rivers, and drive, bicycle and walk river trails, supporting a multi-billion dollar recreational economy. Society participates in the shared responsibility to protect and care for our unique natural and cultural heritage for future generations. Nature based recreation provides water resources, wildlife habitat, educational value, personal enrichment, and other benefits to society while providing economic benefits for local communities.

Challenges

The challenge going forward is to develop a more comprehensive understanding of recreational activities that people pursue in the watershed and to identify sources of data to improve the our ability to track progress toward the recreation goal. Much more needs to be done to support current and emerging recreational opportunities through effective management of natural resources that support recreation. Additional information is also needed to evaluate some recreational uses.

Indicators Not Selected

Several possible indicators were discussed during the regional workshops and during the working group meetings following the 2014 Summit. Although the project team was not able to implement these ideas in this version of the report card, they merit consideration for inclusion in a revised, future report card.

- ***Recreation Water Suitability -*** Feedback from watershed experts attending Report Card workshops encouraged inclusion of an indicator measuring the suitability of waters for recreational uses in the watershed based on data submitted to the U.S. Environmental Protection Agency (EPA) by the state governments under section 305(b) of the Clean Water Act. However, as the data was gathered and analyzed, it became clear that it was inconsistent among the states, currently making it impossible to compile accurate information for the entire watershed. (see discussion of the Water Supply indicators)
- ***Access -*** This indicator has been repeatedly suggested as a potential measure of recreation, and we are researching ways to access and interpret these data. Issues include the consistency of local, state, and federal sources of data and the relatively slow change in this indicator over time.
- ***Boating use*** - We could not find a source for consistent data across all basins related to boating use.
- ***State parks and other facilities use*** - We could not find a source for consistent data across all basins related to the use of state parks and other recreational facilities.
- ***Economic value of recreation*** - We could not find a source for consistent data across all basins related to the value of recreation to the regional economies.

7 Watershed-wide Indicators

Maintain a functioning, sustainable Mississippi River watershed

The influence of the Mississippi River's outflow extends over a large area of the coast along the northern Gulf of Mexico, and the influence of the river's plume has been detected in ocean water as far away as south Florida. The area directly affected by the river includes the Louisiana coastal zone, which contains the Mississippi's deltaic region and wetlands of the Chenier Plain that are influenced by the river, and shallow waters of the Gulf of Mexico along the coasts of Louisiana and eastern Texas. Communities and ecological resources in this area are linked to the integrated functioning of the Mississippi River Watershed through fluxes of freshwater, sediment, and nutrients carried by the river. The watershed-wide indicators assess conditions that are directly linked to the river and the watershed and that affect the sustainability of communities and ecosystems of the Louisiana coast.

Indicators

The watershed-wide indicators measure the health of the wetlands in the Mississippi River's deltaic region and the extent of low-oxygen water, also known as the "dead zone," that appears each summer in the Gulf of Mexico along the Louisiana coast.[36] The wetland indicator measures the change in wetland area, which is the net result of the dynamic deltaic processes of accretion of new land and the loss of existing wetlands due to subsidence and erosion. The "dead zone" indicator compares the annual extent of low-oxygen water along the Louisiana coast with the target set by the Mississippi River/Gulf of Mexico Watershed Nutrient (Hypoxia) Task Force. . Both phenomena are the direct result of processes occurring across the entire Mississippi River Watershed. Wetland accretion and loss in the delta depends on the availability of sediment delivered to the coast from the watershed, and the extent of the "dead zone" depends on the amount of nutrients delivered to coastal marine waters in the river's plume.

[36] Watershed-wide indicators were selected based on the advice of an expert panel of Louisiana scientists convened in the Board Room at the Water Institute of the Gulf in Baton Rouge, LA on 6 April 2015. This group included Charles "Chip" Groate, President of the Water Institute, Denise Reed, Chief Scientist at the Water Institute, Robert Twilley, Director of Louisiana Sea Grant, King Milling, Chair of American's Wetland Foundation, Nancy Rabalais, Executive Director of Louisiana Universities Marine Consortium (LUMCON).

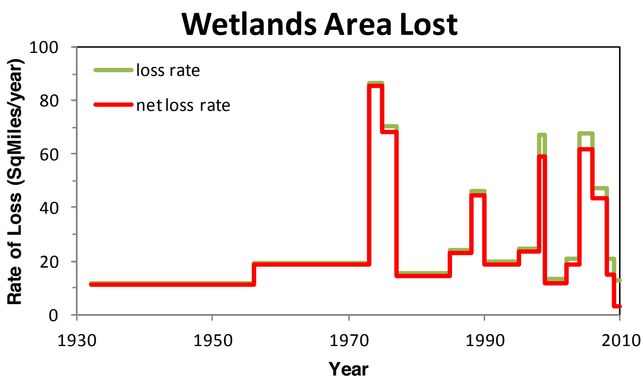
Coastal Wetland Change

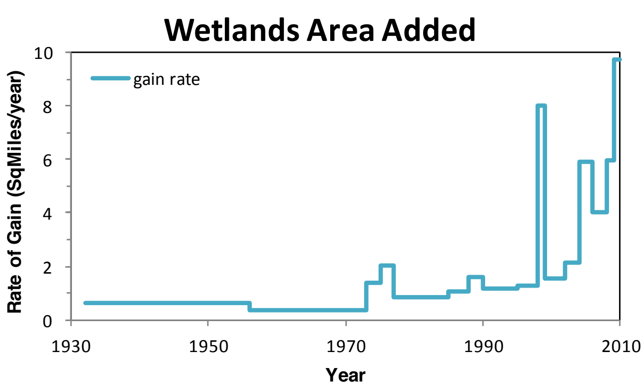
This indicator measures the net rate of wetland loss in coastal Louisiana, which includes the deltaic region of the Mississippi River and wetlands of the Chenier Plain that depend on water and sediment discharged by the river. The area of wetlands in coastal Louisiana has declined consistently since the 1930s. A net loss rate of zero (no net loss, but no recovery) would earn a C grade. Wetland area must show a net gain in wetland area to score higher than a C grade.

Data source:

The score is calculated based on the net rate of wetland loss averaged over the last 11 years compared to historical loss rates. Rates of land loss and gain are determined from detailed analysis of aerial images by the US Geological Survey.[37] The estimated rates of change apply the concept of "persistent" land loss or gain to account for the confounding effect of fluctuating water levels in delineating the area of land.

[LINK to DATA]





[37] Table 3 in Couvillion, B.R.; Barras, J.A.; Steyer, G.D.; Sleavin, William; Fischer, Michelle; Beck, Holly; Trahan, Nadine; Griffin, Brad; and Heckman, David, 2011, Land area change in coastal ouisiana from 1932 to 2010: U.S. Geological Survey Scientific Investigations Map 3164, scale 1:265,000, 12 p. pamphlet. [online: http://pubs.usgs.gov/sim/3164/downloads/SIM3164_Pamphlet.pdf; accessed 2 Jun 2015]

Figure 7.1: Rates of historical wetlands loss, wetlands gain and the net loss rate based on data in Couvillion et al. (2011).

Calculation Method and Scoring:

The indicator score is calculated from the net rate of loss and the cumulative wetlands loss since the 1930's. The net rate of loss is expressed as a negative number in square miles per year, based on the highest estimated rate of loss from 1973 – 1985 (~35 sq miles/year and the poorest score) and a no-net loss rate of 0, which would represent a C grade.

Net loss scores are calculated based on the following formula:

if loss <0, score = 1.41 * rate +50

if loss >= 0, score = 10 * rate + 50

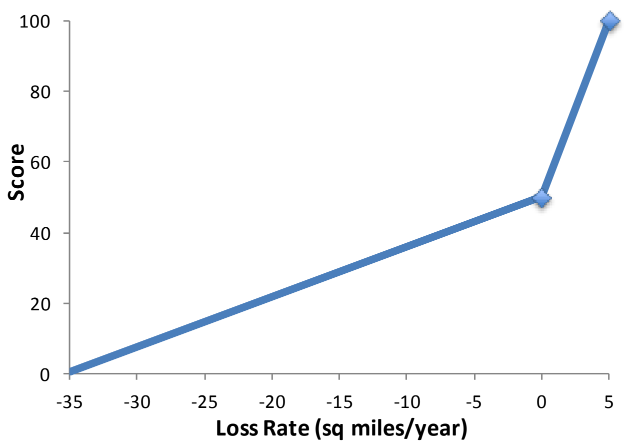


Figure 7.2: Relationship between net loss rate and the report card score.

Net loss in 2014 was approximately 3 square miles, which creates a score of 46.

Cumulative loss is expressed as a percentage of the historical loss, where 100% of the historical loss represents a 0 (poorest score), and half of the historical loss (meaning that approximately ½ of the wetlands had been recovered) would represent a 100 (highest score). As net change in coastal wetland area was negative in 2014 (wetlands are still being lost annually), the current score is a 0, the lowest possible score.

Table 7.1: Scoring result for the watershed-wide Coastal Wetland Change indicator.

Coastal Wetland Change		
Sub-basin	Score	Letter grade
Mississippi River Watershed	23	D-

Gulf of Mexico "Dead Zone"

This indicator assesses the impact of excess nutrients discharged from the Mississippi River Watershed on the coastal marine ecosystem in the northern Gulf of Mexico. Scoring is based on the annual maximum extent of the plume of low oxygen (hypoxic) water in the bottom waters of the northern Gulf, also called the "dead zone." The size of the area of low oxygen water reflects the amount of nutrients delivered to the Gulf by the Mississippi River in the preceding year.

Data source:

The Mississippi River/Gulf of Mexico Watershed Nutrient (Hypoxia) Task Force tracks and reports the annual hypoxia area.[38] The annual extent of the dead zone is defined as the area with dissolved oxygen less than 2.0 mg/l based on a mid-summer survey. The task force has set a remediation goal of 5,000 km^2 for the hypoxic area, based on a running five year average to account for inter-annual variability.

[LINK to DATA]

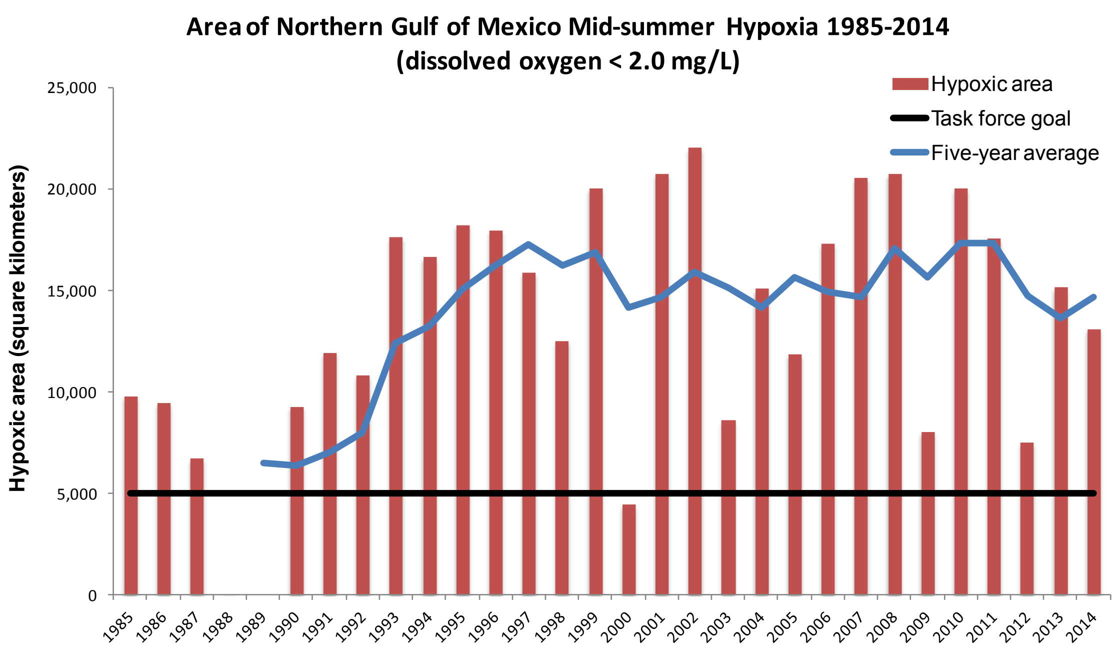


Figure 7.3: Annual extent of Gulf of Mexico "Dead Zone" and restoration goal set by the Hypoxia Task Force.

[38] http://www.gulfhypoxia.net/Research/Shelfwide%20Cruises/; accessed 2 Jun 2015

Calculation Method and Scoring:

The indicator score is calculated from Gulf of Mexico hypoxic zone area for 2014. Scoring is based on a set of thresholds recommended by the expert panel:

$<1,000\ km^2$ = A
$<5,000\ km^2$ = B
$<10,000\ km^2$ = C
$<15,000\ km^2$ = D
$>15,000\ km^2$ = F

The "dead zone" in 2014 was 13,000 square kilometers in area, two and half times higher than the target of 5,000 square kilometers, which earns a score of 28 and a D grade.

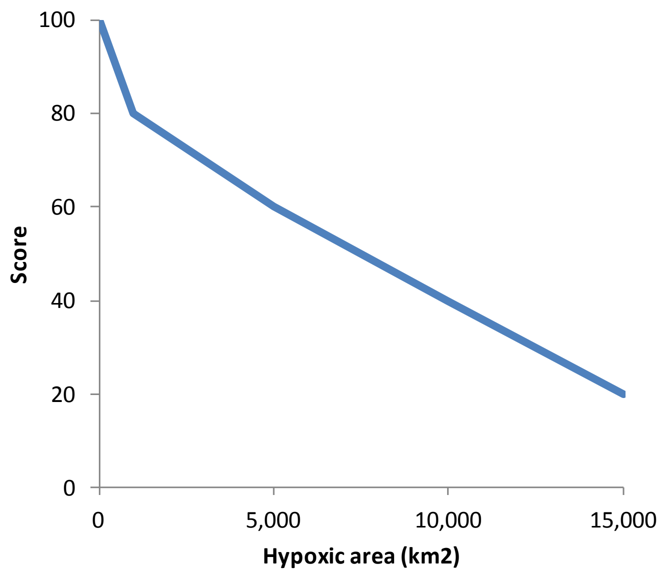


Figure 7.4: Scoring method for the Gulf of Mexico "Dead Zone" Indicator.

Table 7.2: Scoring result for the watershed-wide Gulf of Mexico "Dead Zone" Indicator.

Gulf of Mexico "Dead Zone"		
Sub-basin	**Score**	**Letter grade**
Mississippi River Watershed	28	D

Additional Discussion on Watershed-Wide Indicators

The Mississippi River and its tributaries drain 41 percent of the continental United States; the river system has 12,000 miles of navigable channel with depths of 9 feet or more and transits 600 million tons of cargo annually. The cost effectiveness of marine transportation of the Mississippi River system and the vast acreage available for agricultural production provides the U.S. an economic advantage in food exports not found anywhere else in the world. By any standard of measurement, the Mississippi River and Tributaries Project (MR&T) has been enormously successful from both navigation and flood risk reduction objectives.

The development of the US to superpower status was made possible by the expansion of grain production in the Midwest following the development of reliable navigation and flood control on the Lower Mississippi River. This was made possible by the MR&T planned and executed by the U.S. Army Corps of Engineers at the direction of the United States Congress. The flood of 1927 inundated 16.8 million acres in the Mississippi River Watershed and killed at least 250 people. The record flood of 2011 inundated 6.35 million acres, many of which were designed to be flooded during major flood events as a part of the MR&T and its' "Room for the River" approach to flood damage reduction, and no lives were lost.

However, these great economic benefits have come at the expense of sacrificing the function and sustainability of the deltaic landscape that comprises coastal Louisiana. Historic annual overflows and typical natural riverine functioning of the Mississippi River resulted in the robust system of coastal wetlands that is coastal Louisiana. Man's attempt to manageme the river for navigation and flood control purposes has resulted in the devastating land loss crisis that characterizes the coast of Louisiana today.

The 19th-century proponents of what would evolve into the MR&T project anticipated that the changes that they were making would have consequences for the sustainability and ecological functioning in the deltaic region. As reported in an 1897 article in National Geographic magazine, proponents argued that the near-term economic benefit would "greatly outweigh" the damages to coastal Louisiana. And, since the devastating impacts would occur "two to three generations" after the project would be implemented, there would be time to address and/or avoid the inevitable damages to the coast.

Sediments Sustain Coastal Wetlands

Inputs of sediment allow existing coastal wetlands to maintain elevation relative to sea level rise and create new wetland areas to balance losses from erosion. The construction of reservoirs along the Mississippi River and its tributaries during the 20th century has reduced the amount of sediment carried by the river below what it was historically. Channelizing the river and constructing levees to control flooding along the Lower Mississippi River drastically reduces the amount of the remaining sediment that is delivered to coastal wetlands. Currently, most of the sediment carried to the Gulf of Mexico through the Lower Mississippi River is carried out through its mouth in the Bird's-foot Delta and deposited in deep water, where it is no longer available to nourish coastal wetlands. This situation is a direct result of engineering the river to maintain high flow water velocities through the mouth, which reduces the dredging needed to maintain a navigable channel.

The rate at which wetland area is being lost each year has decreased from historically high rates, but the net loss of wetlands continues. The rate at which new wetland area is being added is increasing; wetland area is being added at the outlet of the Atchafalaya River, a distributary of the Mississippi that delivers sediment to shallow, inshore waters. Other efforts to recycle materials dredged from the shipping channel to create wetland areas have also proven successful. If these trends continue, the balance soon could shift to a net increase in wetland area. However, expected increases in the rate of global sea level rise and continuing land subsidence (natural and historic land elevation decline) threaten to increase the rate of loss of wetland area.

Additionally, the rate at which new coastal wetland area is being added is increasing; wetland area is being added at the outlet of the Atchafalaya River, a distributary of the Mississippi that delivers sediment to shallow, inshore waters. Other efforts to recycle materials dredged from the shipping channel to create wetland areas have also proven successful. If these trends continue, the overall balance soon could shift to a net increase in wetland area.

Excessive Nutrients Fuel Growth of the "Dead Zone"

Nutrients (primarily nitrogen) from farms, urban areas, and wastewater enter streams and rivers through storm water runoff. Fertilizers that are applied to crops and lawns, and treated and un-treated wastewater are common sources of nitrogen. Nitrogen delivered to estuarine and coastal waters fuels the growth of algae. Oxygen dissolved in the water is depleted when the algae die and decompose, and this creates a large area of low oxygen (hypoxic) water. This area is popularly referred to as a "dead zone" because the lack of oxygen in the water prevents most animals from living there. The annual extent of hypoxic bottom water tracks the amount of nutrients that enter the Mississippi River and its tributaries and are carried into the Gulf of Mexico. Reducing nutrients in runoff and wastewater on the watershed will reduce the size of the algae bloom and the subsequent area of the dead zone.

Challenges

The challenge today is to implement new river management approaches that preserve and restore this vitally important coastal landscape, while preserving the navigation and flood risk reduction functions of the MR&T. Three generations have now passed since large-scale engineering of the river began, and the coast of Louisiana is experiencing the greatest ecosystem collapse in modern history. Delivery of needed sediment and freshwater to sustain and rebuild these critical coastal landscapes must be part of the future management of the Mississippi River Watershed.

Indicators Not Selected

Several possible indicators were discussed during the regional workshops and during the working group meetings following the 2014 Summit. Although the project team was not able to implement these ideas in this version of the report card, they merit consideration for inclusion in a revised, future report card.

- ***Economic impact of deep draft shipping*** - The issue of the five deep draft ports in the lower Mississippi River (Baton Rouge, New Orleans, South Louisiana, St. Bernard, Plaquemines) which are not covered in the current transportation metrics used in the report card was raised. The barge traffic is being assessed as part of the transportation goal for each of the five basins, but the ocean going ships that import and export goods connecting the Mississippi River with the rest of the world have not been assessed. It is proposed that the value of deep draft shipping be included as an indicator of watershed wide economic vitality. It appears that two year increments of tonnage are available and hopefully these tonnages can be converted into economic terms.
- ***Economic impact of coastal commercial fisheries*** - The Louisiana delta serves as a major fishery resource and is second only to Alaska in commercial fisheries landings. The valuation of the commercial fisheries can be obtained from the annually produced NOAA Office of Science and Technology commercial fisheries statistics. Two year increments are proposed that correspond to the Economic Impact of Deep Draft Shipping indicator.

Appendices

A: Participation Memo

Building the America's Watershed Initiative Report Card: Summary of Participation

For 18 months, with financial support from The Nature Conservancy and facilitation by the University of Maryland, more than 600 participants from over 400 organizations, businesses and agencies have engaged in shaping America's Watershed Initiative Report card for the Mississippi River Watershed. Diverse experts and stakeholders came together in workshops, meetings and webinars to identify information about six broad goals and create a report card to support collective action toward sustaining the economic and natural vitality of the river system.

Data and information will measure and report on progress against six goals – flood control and risk reduction, recreation, ecosystems, transportation, economies and water supply. Each workshop and meeting was different, but the importance of the rivers and waters to every sector and in each basin was clear.

From the start, the groups working together to support America's Watershed Initiative had three key goals for the report card project:

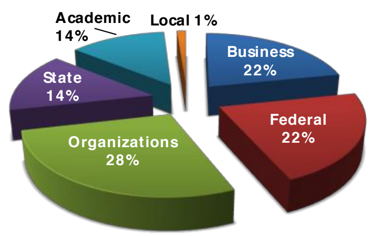
1. Bring together key leaders, stakeholders and experts representing all of the basins and sectors to develop a single and shared document to measure the current status of six broad goals for the watershed;

2. Build a report card supported by data that will help us to identify successes, opportunities for improvement, and areas needing additional research;

3. Use this tool to identify opportunities for collaborations and a more shared vision for the watershed.

The report card is not a goal into itself – it's a tool to bring together leaders from around the watershed to develop a shared vision for the future and create awareness among key constituencies of the opportunities and challenges that face our states and nation. This shared vision can be used to identify and form partnerships to pursue shared solutions to these critical water management challenges.

Knowing what's important and how to measure it is the foundation to taking collaborative action to improve the watershed. The AWI report card will be finalized and shared with key leaders and the public in 2015.



672 Participants
413 businesses and organizations
37 states + Canada and Korea

143 Business Organizations
144 Federal Agencies
183 Organizations & Basin Groups
95 State Government Agencies
85 Academic Institutions
8 Local Governments

For more information contact
Harald (Jordy) Jordahl by phone at (608) 445-8543
or by email at hjordahl@tnc.org

V. 23MAR2015

AmericasWatershed.org

Link to complete document: http://americaswatershed.org/reportcard/

B: National Rivers and Streams Assessment

The National Rivers and Streams Assessment 2008–2009: A Collaborative Survey[39] (NRSA) reports the results of a nation-wide field study conducted by the U.S. Environmental Protection Agency and its state and tribal partners. The purpose of the study was to assess the condition of river and stream ecosystems on a national and regional scale as a benchmark to document environment change over time. The assessment is based on data collected at 1,924 river and stream sites using standardized methods. Sites were selected using a random sampling technique to ensure that the results reflect the full variety of river and stream types and sizes across the U.S. Ecological conditions were assessed using a suite of indicators, and the indicators were evaluated based on comparison with conditions at least-disturbed (or reference) sites in different ecological regions.

The Mississippi River Watershed report card uses results of the NRSA sampling and evaluation at the 900-945 river and stream sites located in the Mississippi River Watershed, Figure B.1 (total number of sampling site varied slightly by indicator). Results for each site are compiled based on sampling a number of transects along a segment of a river or stream. At each site, the NRSA assesses the ecological condition using a set of indicators; conditions associate with each indicator are evaluated as "good", "fair", or "poor" relative to conditions at reference sites chosen to represent undisturbed natural conditions. The report card uses a subset of the NRSA indicators to define a set of three indices: living resources, water quality, and habitat, Table B.1. We convert the NRSA narrative evaluations into a score for each basin by assigning a value of 100 for "good", 50 for "fair", and 0 for "poor" and computing the average of the results for all NRSA sampling locations in the basin weighted by the length of the stream or river segment sampled.

Scores for the individual indicators obtained for the Mississippi River Watershed are comparable to scores calculated from the NRSA national results, reported for the 48 contiguous states, Table B.1. The largest difference is seen in the scores for the nitrogen indicator. This is unsurprising, given that the watershed's nitrogen discharge is a recognized problem.

[39] EPA, 2013. National Rivers and Streams Assessment 2008–2009: A Collaborative Survey. Draft report EPA/841/D-13/001, Office of Research and Development, U.S. Environmental Protection Agency, Washington, DC. February 28, 2013 [online: http://water.epa.gov/type/rsl/monitoring/riverssurvey/; accessed 19 May 2015]

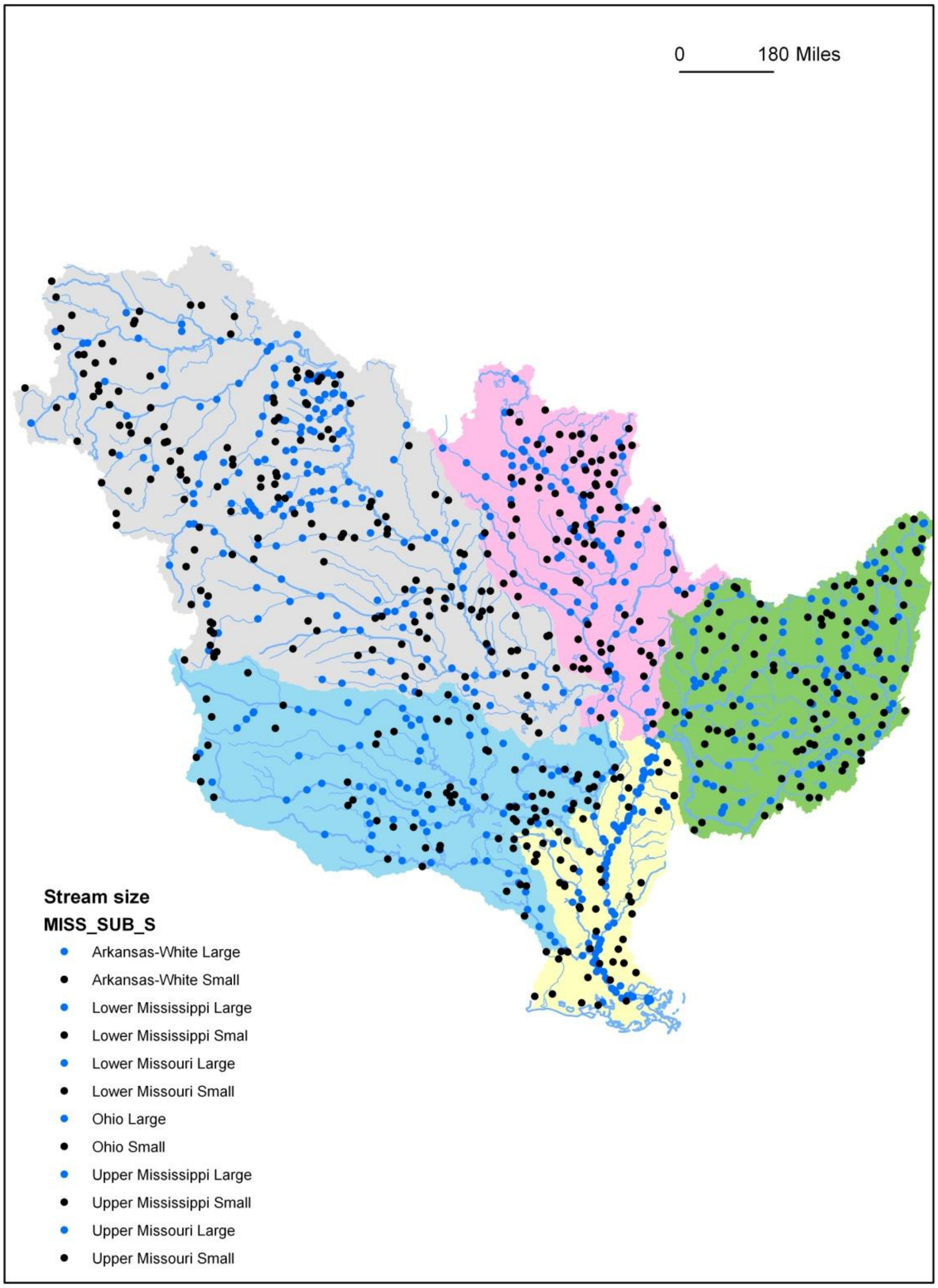


Figure B.1: Locations sampled to evaluate the NRSA indicators

Table B.1: Comparison of AWI scores for the Mississippi River Watershed and for NRSA sites in the 48 contiguous states

Indicator	Scores	
	AWI Miss. Riv.	EPA National
Living Resources		
Benthic MMI	41	33
Fish MMI	47	51
Water quality		
Nitrogen	39	64
Phosphorus	42	47
Habitat		
Insteam habitat	74	79
Riparian vegetation	61	66
Riparian disturbance	52	57
Streambed stability	71	70

Living Resources Index

The Living Resources Index assesses the condition of aquatic animal communities living in the ecosystem. The index combines the NRSA scores for the Macro-invertebrate Multi-metric Index and the Fish Multi-metric Index. EPA provided synthesized results from 2008-2009 EPA National Rivers and Streams Assessment for each sub-basin, with the percent of stream lengths in good, fair, or poor condition for each index. We calculate a score for each basin by assigning a value of 100 for "good", 50 for "fair", and 0 for "poor" and computing the average of the results for all NRSA sampling locations in the basin weighted by the length of the stream or river segment sampled. The Living Resources Index is computed as the average of the scores for Macro-invertebrate Multi-metric Index and the Fish Multi-metric Index in each basin.

From the NRSA report:
"[S]cientists developed a Fish MMI using an approach that estimates expected condition at individual sites. Separate indices were developed for each of the three major climatic regions. These indices were based on a variety of metrics including taxa richness, taxonomic composition, pollution tolerance, habitat and feeding groups, spawning habits (specifically, the percent of individuals that deposit eggs on or within the substrate in shallow waters), the number and percent of taxa that are migratory, and the percent of taxa that are native."

From the NRSA report:
"[To] determine the [Benthic] Macro-invertebrate MMI, ecologists selected six metrics indicative of different aspects of macro-invertebrate community structure:

Taxonomic richness — the number of distinct taxa (family or genus) 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 taxa groups. Healthy rivers and streams have many organisms from many different taxa groups; unhealthy streams are often dominated by a high abundance of organisms in a small number of taxa.

Feeding groups — the distribution of macro-invertebrates by the strategies they use to capture and process food from their aquatic environment, such as 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 macro-invertebrates 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 macro-invertebrate taxa with less diverse habits (e.g., will be dominated by burrowers).

Pollution tolerance — the distribution of macro-invertebrates 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."

Water Quality Index

The Water Quality Index assesses nutrient levels in rivers and streams in the watershed. The index combines the NRSA scores for total phosphorous and total nitrogen. EPA provided synthesized results from 2008-2009 EPA National Rivers and Streams Assessment for each sub-basin, with the percent of stream lengths in good, fair, or poor condition for each index. Natural variability in nutrient concentrations is reflected in the regional thresholds set by EPA for high, medium, and low levels, which are based on least-disturbed reference sites for each of the nine NRSA ecoregions. We calculate a score for each basin by assigning a value of 100 for "good", 50 for “fair”, and 0 for “poor” and computing the average of the results for all NRSA sampling locations in the basin weighted by the length of the stream or river segment sampled. The Water Quality Index is computed as the average of the total phosphorous and total nitrogen scores in each basin.

Habitat Index

The Habitat Index assesses the condition of stream and river habitat in the ecosystem. The index combines the NRSA scores for the Riparian Vegetative Cover and Riparian Disturbance indices. EPA provided synthesized results from 2008-2009 EPA National Rivers and Streams Assessment for each sub-basin, with the percent of stream lengths in good, fair, or poor condition for each index. We calculate a score for each basin by assigning a value of 100 for “good”, 50 for “fair”, and 0 for “poor” and computing the average of the results for all NRSA sampling locations in the basin weighted by the length of the stream or river segment sampled. The Habitat Index is computed as the average of the scores for the four component indices in each basin.

Riparian Vegetative Cover, from the NRSA report:
“The NRSA uses a measure of riparian vegetative cover that sums the amount of cover provided by three layers of riparian vegetation: the ground layer, woody shrubs, and canopy trees. Because the amount and complexity of riparian vegetation differs naturally within and among ecoregions, lower-than-expected riparian vegetative cover was assessed by comparison with expected values at least-disturbed sites estimated within ecoregions."

Riparian Disturbance, from the NRSA report:
“The NRSA uses a direct measure of riparian human disturbance that tallies 11 specific forms of human activities and their proximity to the river or stream in 22 riparian plots along the waterbody. The same disturbance criteria were applied to define high, medium, and low riparian disturbance in streams and rivers nationwide. For example, a river or stream scored medium if one type of human influence was noted in at least one-third of the riparian plots, and scored high if one or more types of disturbance were observed at all of the plots.”

C: Transportation

Lock delays

The scores are based on the locks located in the basins as the basins are defined for this report card. This differs from the way in which navigation structures are grouped by the Corps of Engineers. For example, some of the locks that the Corps includes in the navigation system for the Arkansas and Red rivers are physically located in the Lower Mississippi River basin. There are no locks located in the Missouri River basin.

Time that a lock is unavailable does not translate directly into a delay to shipping. Scheduled closures provide shippers the opportunity to find alternative times or routes, and some locks facilities have twinned, parallel sets of locks, so that shipping is able to continue to move even if one set of locks is closed. Improvement in performance in recent years in the Upper Mississippi and Ohio basins follows a peak in spending on operations & maintenance (O&M) following the 2009 recession. However, a reason for the apparent worsening performance in the Arkansas/Red Rivers basin is not known.

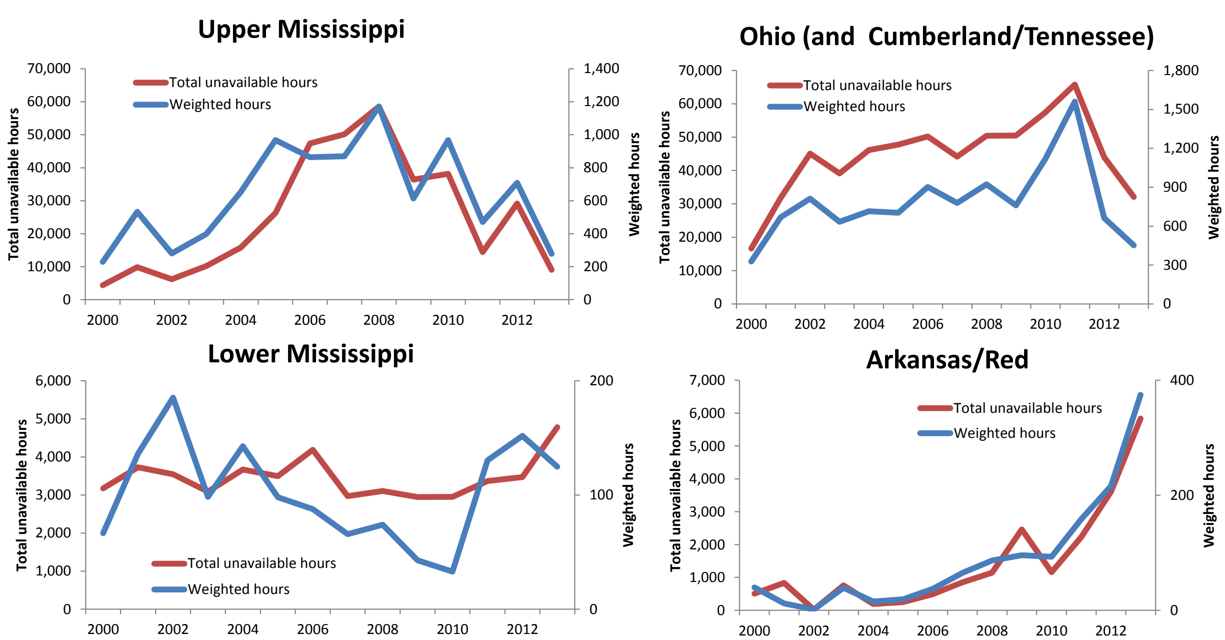


Figure C.1: Total and tonnage-weighted unavailable hours for navigation locks

Infrastructure condition

The process used by the Corps of Engineers to assess infrastructure condition begins by dividing each facility into subunits, rating the condition of each of the subunits and then, through field inspections, measuring the facility condition.[40] A partial list of subcomponents for a lock illustrates the hierarchical approach used:

Lock (Feature)
Lock Gates and Operating Machinery (System)
Lock Gate Operating Equipment (Sub-System)
Ohio River Type Assembly (Hydraulic) (Component)
Sub-components:
CHECK VALVE
CONNECTION PIN
GUDGEON PIN
HYD. CYLINDER SUPPORT
HYD. CYLINDER_CERAMIC
HYD. CYLINDER_CHROME / STAINLESS and so on…

A "mission critical" component is one that if it fails it will cause an unscheduled outage, or unavailability, that will last one day or longer in duration that impedes the ability to (1) pass navigation traffic and/or (2) maintain the navigation pool to pass that traffic. Examples of non-critical components would be most buildings, roads, fences, etc.…USACE inventory and assess condition of everything at their sites as there are also safety and legal issues that must be captured. And at multi-purpose sites a building that is also a visitors center may be critical to the recreation mission.

Infrastructure maintenance

Budget persistently underestimates need for maintenance

Although the Corps of Engineers bears responsibility for running the inland navigation system, the level of funding for operations and maintenance is determined in the annual budgeting process conducted by Congress and the executive branch of the federal government. Annual budget summaries prepared by the Office of Management and Budget[41] are consulted to compile information about how much was budgeted and what was spent on O&M for inland navigation. Although the numbers compiled from this source are for the entire US civil works program, the navigation system in along the Mississippi River and its tributaries accounts for the largest part.

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[40] Harrald, J.R., I. Renda-Tanali, G.L. Shaw, C.B. Rubin, and S. Yeletaysi. 2004. Review Of Risk Based Prioritization/Decision Making Methodologies For Dams. Institute for Crisis, Disaster, and Risk Management, The George Washington University, Washington, DC. April 29, 2004.

[41] Annual budget summaries are accessible online from this URL: http://www.gpo.gov/fdsys/browse/collectionGPO.action?collectionCode=BUDGET (accessed 31 May 2015). The Corps of Engineers – Civil Works budget summary is included in the Appendix documents to each year's budget.

O&M covers only routine maintenance; costs for the replacement of major pieces of equipment, renovations and major upgrades are budgeted as construction.

The comparison of the total amounts budgeted for O&M (two years in advance) with actual expenditures indicates that the budget process consistently underestimates the amount needed to keep inland navigation infrastructure operating. The difference between the amount budgeted and the O&M expense needed to keep the system running is developed on an ad hoc basis either from reallocation of funds from elsewhere in budget or from emergency funds requested from and allocated by Congress outside the budget process. Exceptions occurred during budget years 2010 and 2011, when the federal government increased spending in response to the deep recession in 2009.

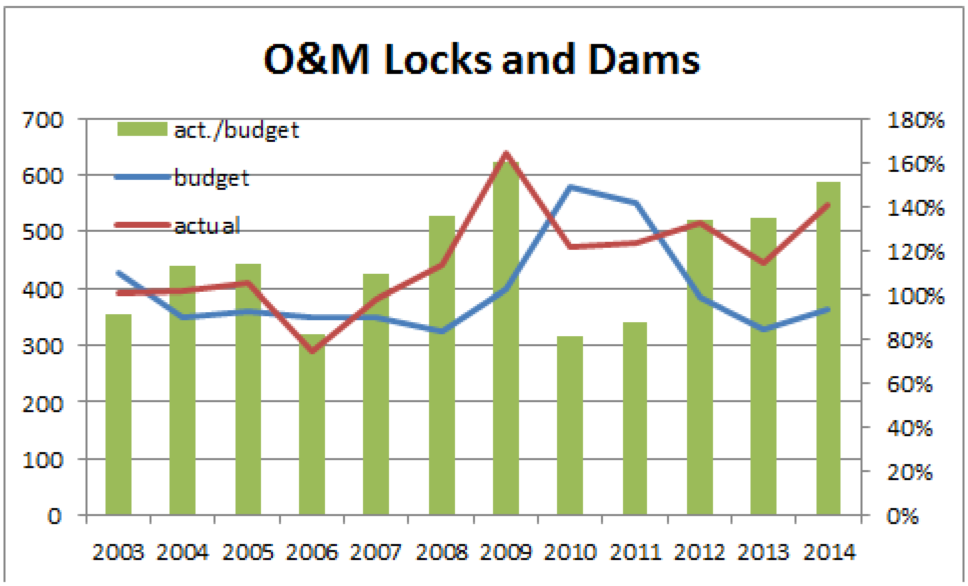

Figure C.2: Estimated vs actual cost data (its bad, except for 2010, 2011, which is related to emergency increase in federal spending during the recession)

Deferred maintenance is increasing

The Corps of Engineers tracks the amount of deferred maintenance on civil works, and the trend is toward increasing amount of deferred maintenance across the entire Civil Works program. Deferred maintenance and repair is defined as maintenance and repairs not performed when it should have been or was scheduled to be but delayed for a future period. The O&M needs are based on inspections of project features, engineering analyses and historical experience. Deferred maintenance increases the risk of unscheduled delays.

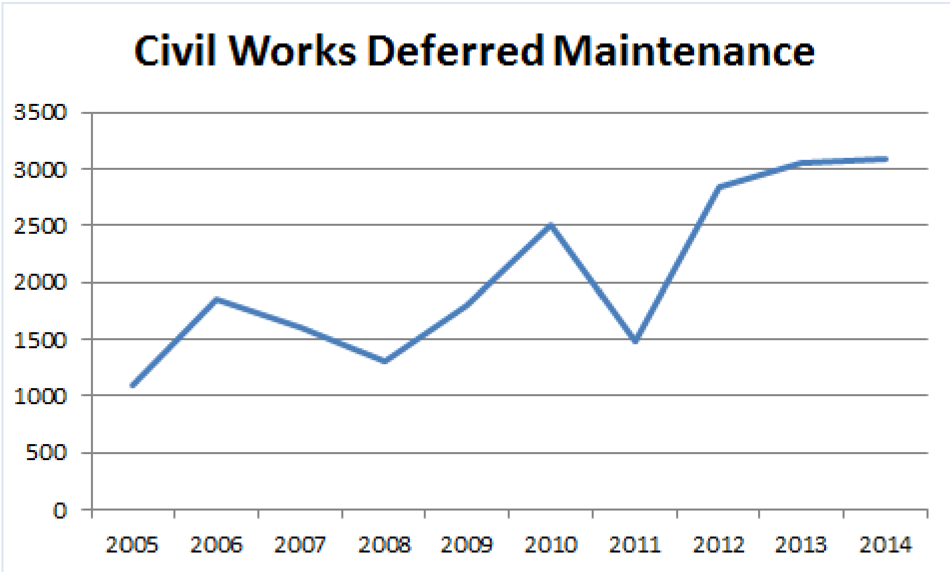

Figure C.3: Deferred maintenance on civil works is increasing across the entire Civil Works program. Navigation infrastructure accounts for about 73% of total; amount is in $ millions. (Source: USACE Civil Works Program Annual Financial Statements)

Politics complicates planning

The influence of national politics in the budgeting process complicates planning and maintenance.[42] The history of funding for the civil works program shows one instance of its susceptibility to the influence of national political objectives. Annual appropriations for O&M were level for decades up until 2009 when Congress increased spending in response to a deep recession. The annual appropriation for O&M jumped by about a factor of three for that one year, and it has since returned to previous levels. Other decisions that have complicated the planning process include the decision by Congress to eliminate the practice of earmarking. This disrupted the long-established practice used by Congress and the Corps to plan and direct the Civil Works program. Failure of the budgeting process in Congress precipitated across-the-board cuts, known as the sequestration, which reduced funding to all programs without regard to areas of critical need.

[42] NRC, 2012. Corps of Engineers Water Resources Infrastructure: Deterioration, Investment, or Divestment? Committee on U.S. Army Corps of Engineers Water Resources Science, Engineering, and Planning; Water Science and Technology Board; Division on Earth and Life Studies; National Research Council. Washington, DC.

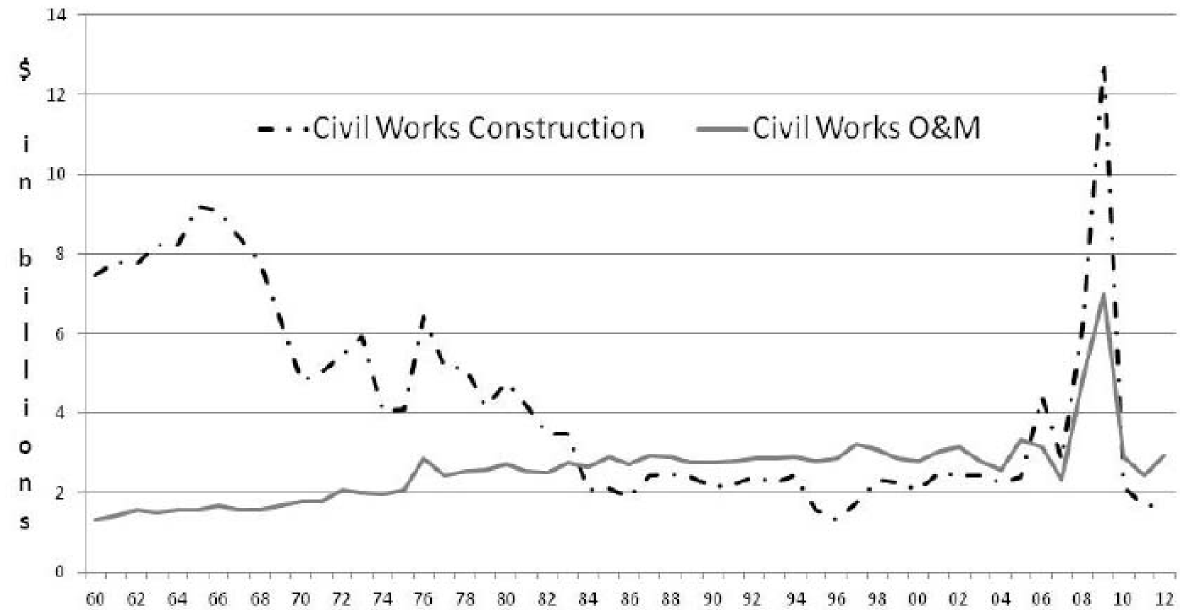

Figure C.4: The spike in appropriations for the Civil Works in 2009 reflects Congress' response to the deep recession in 2009

Sustainability of future funding is uncertain

The Inland Waterways Trust Fund was established by law in 1986 as a mechanism to fund construction of navigation infrastructure, including major renovations and upgrades, and share costs with the navigation industry. The trust fund is supported by income from a tax on fuel used in navigation. At current levels of funding, the trust fund is not able to meet the needs.[43] A single project, the Olmstead Lock upgrade, will consume the entire resources from the fund for ten years. Congress has refused requests to increase revenue into the fund based on a policy of no tax increases.

[43] Stern, C.V., 2013. Inland Waterways: Recent Proposals and Issues for Congress. Congressional Research Service, May 3, 2013.

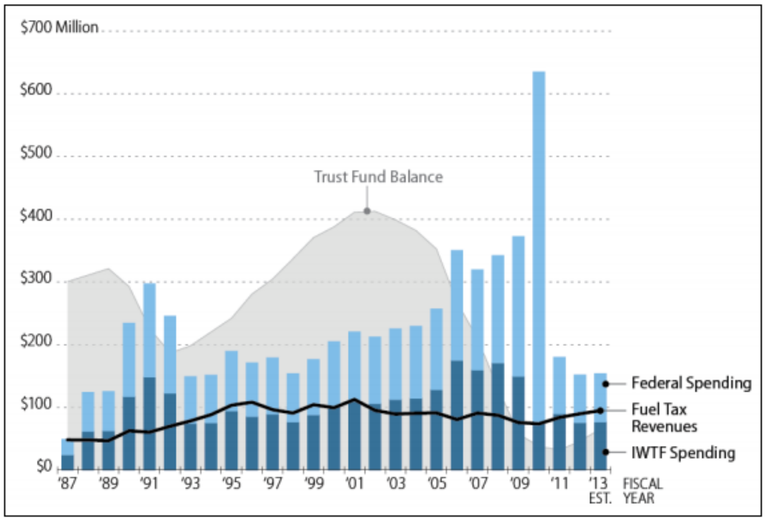

Figure C.5: Funding available from Inland Waterway Trust Fund is limited by fuel tax revenues.

D: Water Stress Index Model

The model calculates monthly outflow from each HUC8 basin based on the balance of inputs, withdrawals, and changes in storage as snow pack and soil moisture. Calculation of the depletion index requires two model runs; one in which water withdrawals for human use are set to zero to calculate the set of "natural" outflows and a run including water withdrawals and return flows to calculate the set of "depleted" outflows. The depletion index is calculated in each HUC8 basin for each month using the formula: 1 – (depleted flow/natural flow).

Calculations with the WaSSi model do not take into account fully the effects of groundwater withdrawals and the operation of reservoirs to capture and store water. These activities provide water for human use at times and locations where precipitation is low. As a result, the depletion index is not an indicator of the availability of water to supply human use. However, water available from reservoirs and groundwater, to a large extent, are not inexhaustible new sources of water; they merely store water that must be recharged from precipitation. Therefore, the depletion index reflects the match between human water use and the renewable supply of water from precipitation.

To partially compensate for the lack of reservoir storage in the water budget calculations, we base the water shortage score on a three-month average of the depletion index. We use the average for the summer months of July, August and September, because generally this is the time of year when human consumptive use is highest and surface water supplies are lowest.