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DOES THE OHIO RIVER FLOW ALL THE WAY TO NEW ORLEANS?[1]

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ABSTRACT: Rivers were among the first geographical features in the United States (U.S.) to receive official names, often initially stemming from Native American heritage. Today river titles portray both cultural and physical origins. These naming conventions provide a descriptive connotation driven by social perceptions. At present, most people accept that the Mississippi River is the largest river and "mother river" in the U.S. Our investigation explored this river's prominence in the U.S. by identifying and comparing various hydrologic, biological, and cultural metrics. We used six variables to determine the magnitude of river importance: 30-year average discharge, length, drainage area, fish richness, fish endemism, and river-specific song lyrics. The Mississippi, Missouri, and Ohio River Basins were evaluated using data from nine selected U.S. Geological Survey gaging stations and ranked using the six metrics. Using an average for the rankings across the three rivers, the Ohio is ranked highest for three individual metrics (discharge, fish richness, and fish endemism), and highest across the average for all six metrics, and for an average of five metrics, including hydrology and biodiversity metrics. Thus, our results suggest that the Ohio River could be considered the most prominent river in the U.S. and that the river itself should have the same name (Ohio or Mississippi) from New Orleans to at least Pittsburgh, Pennsylvania.

(KEY TERMS: Ohio River; Mississippi River; river name; river discharge; environmental metrics.)

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INTRODUCTION

Commonly, topics of conversation during a hydrology conference or workshop can involve debates over soul-searching questions about major hydrologic principles, such as which river discharges more, is longer, or has more biodiversity than the next. Such a discussion occurred during the Moonlight on the Marsh Lecture Series in Naples, Florida, when Bill Mitsch, formerly of The Ohio State University, opined that perhaps the Ohio River delivered more discharge to the Mississippi watershed than the actual Mississippi (or Missouri) tributaries, so perhaps one of the largest river systems in the world was misnamed. The river system's prominent name appears to originate with terms from Native Americans, such as the Ojibwe's, "Messipi," which means big river, or from the Algonquin "Missi Sepe," or great river (http://www.mississippiriveradventures.com/mississippi_river.htm. Accessed December 26, 2017). Mitsch and his co-investigators in Louisiana began to call the Mississippi

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River Basin the Mississippi–Ohio–Missouri (MOM) River Basin (Day et al. 2005; Mitsch and Day 2006) in scientific presentations in the early 2000s because otherwise these large upstream rivers are dismissed as being unimportant to the lower Mississippi. But almost every time there was a massive flood in the upper Ohio River Basin in the 20th Century; the lower Mississippi and New Orleans experienced these floods a week or two later. When the Upper Mississippi River had disastrous floods, as it did in 1993, with discharges of about 30,000 m^3/s (1,000,000 ft^3/s) at St. Louis and Thebes; there was essentially little flooding downstream of its confluence with the Ohio and the "Mississippi River Delta" in Louisiana.

One can imagine a contentious debate would ensue over which major tributary contributes the most discharge into the Mississippi drainage systems among the East, Great Lakes, and Midwest regions should such a name change be proposed. The Ohio River Basin drains one-third of western Pennsylvania and a bit of southwestern New York from the Allegheny River, and two-thirds of Ohio and most of West Virginia from the Monongahela River. The Allegheny and "Mon" converge at "three rivers" in Pittsburgh, Pennsylvania, forming the Ohio River. The Ohio River scribes the boundary between the states of Ohio and Kentucky on its way to meet the Mississippi near Cairo, Illinois. If a formal academic debate was organized, the East could be represented in this instance by research universities such as the land grant institutions of The Pennsylvania State University, West Virginia University, Purdue University, and The Ohio State University. The Missouri River, reaching westward into Montana, brings a contingent from the Midwest, which could bring University of Missouri, University of Nebraska, South Dakota State University, and others to the debate. Of course, the Great Lakes states (except Indiana, Ohio, and eastward) might push hard to maintain the Mississippi River "title," with the University of Minnesota, University of Wisconsin, Iowa State University, University of Illinois, and many others weighing in. The southern states of Mississippi and Louisiana undoubtedly would prefer that the name remain the Mississippi River, but perhaps would not mind if the Mississippi River name extended up to Pittsburgh, Pennsylvania.

Our study investigated whether or not the Upper Mississippi River discharges more water at and above its gage in Grafton, Illinois, compared to the gage located on the Ohio River near Smithland Dam in Kentucky. To be thorough, we included the Missouri River in this comparison, based on the gage at Hermann, Missouri near its confluence with the Mississippi River (Figure 1).

We believe that ranking a river's prominence by only a single hydrologic metric, that is, discharge, is restrictive, so we used three other common measures representing a river's hydrologic and watershed characteristics:

1. 30-year average discharge (cfs or m^3/s) at the gaging station nearest the mouth of each river,
2. length (km) of the main channel from mouth to most distant headwater tributary,
3. drainage area (km^2) above the selected gaging station.

To provide an example of how selecting metrics beyond the physical realm could influence results, we searched for biological and cultural metrics for which existing data were readily available across the major tributaries. We included two biological variables describing the biodiversity of fish populations in each river basin using measures of species richness and endemism. To provide a more holistic perspective, we included one cultural metric that incorporates both historic and the region's cultural dimensions. Song lyrics were used as a cultural metric because there were substantial quantitative data available such as the number of songs containing each river's name in the title and the number of times a river's name appeared at least once in a song's lyrics. We certainly realize that debates over the metrics alone can be contentious and time-consuming, as can appropriate weighting criteria. No weighting system was used, but there is the potential for one to exist. By choosing to add or delete metrics in the data we provide in the tables, one can see how the rank order of tributaries can change.

METHODS

We conducted a general survey of available hydrographic discharge data for the gages of interest (U.S. Geological Survey [USGS] Water Data Service 2016. "Discharge Data." Accessed February 16, 2016, https://waterdata.usgs.gov/nwis). Drainage areas for the major river basins were obtained (U.S. Army Corp of Engineers 2016. "Water Control." Accessed October 3, 2016. http://rivergages.mvr.usace.army.mil/WaterControl/new/layout.cfm). Fish biodiversity data were available to represent the biological contributions of each river basin (Mac et al. 1998; Steuck et al. 2010; NatureServe 2016. "Distribution of Native U.S. Fishes by Watershed." Accessed January 16, 2017, http://www.natureserve.org/getData/dataSets/watershedHucs/index.jsp; Ohio River Foundation 2016, "Ohio River Facts." Accessed October 3, 2016, http://www.ohioriverfdn.org/education/ohio_river_facts/). As a cultural metric, we chose songs about these

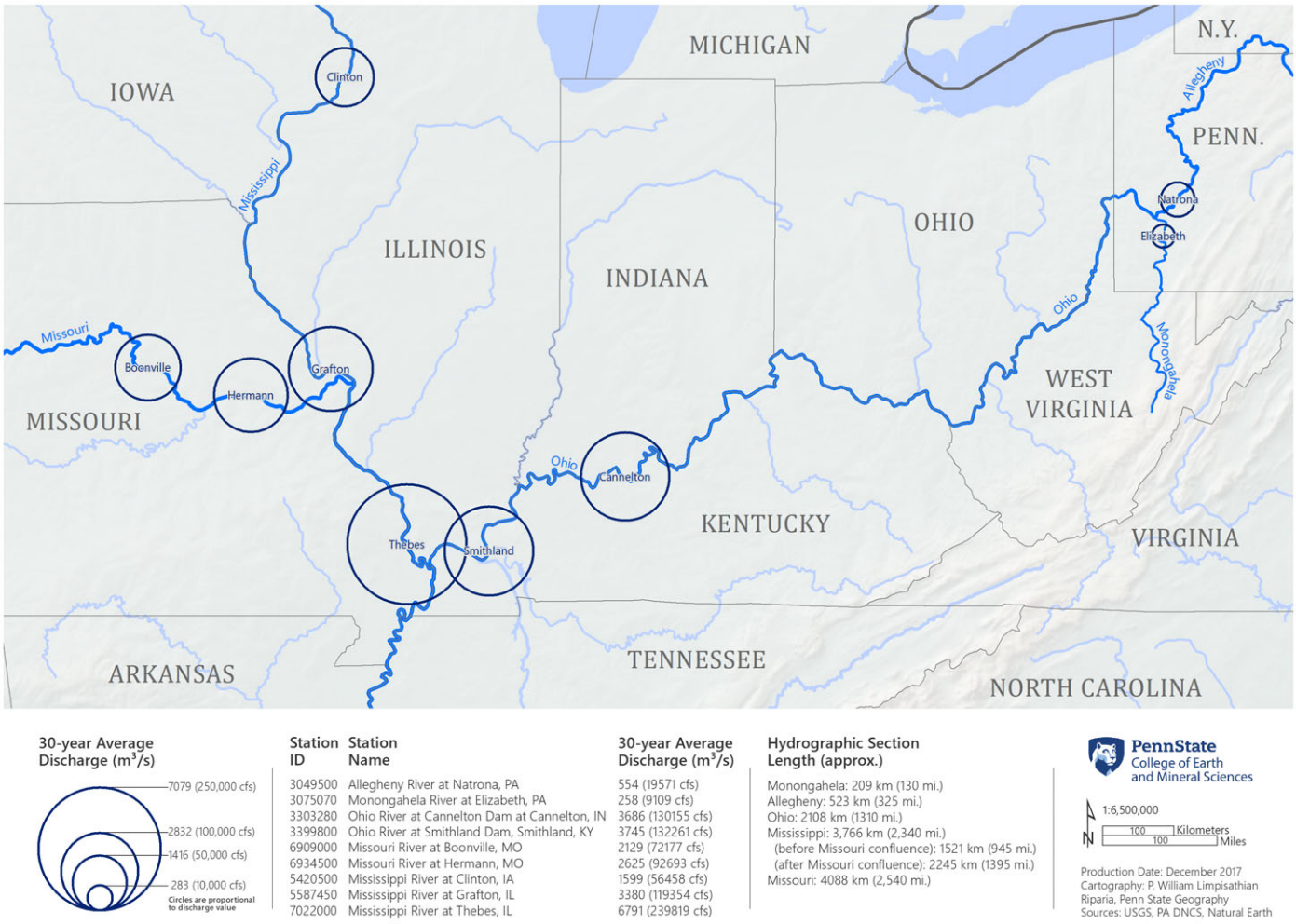

FIGURE 1. Proportional representation of discharge and length at key gages is portrayed within the Mississippi, Missouri, and Ohio River Basins. N.Y., New York; PENN., Pennsylvania.

rivers. After a brief Google search, we created a metric of how many song titles or lyrics contained the river names (Wright 1928; Songfacts 2017. "Songs with U.S. States in the Title." Accessed October 4, 2016. http://www.songfacts.com/category-songs_with_u.s._states_in_the_title.php; Stands4 LLC 2016. "Mississippi River Lyrics, Artists, and Albums." Accessed October 3, 2016. http://www.lyrics.com/lyrics/mississippi%20river).

The USGS Water Data service provides a centralized source of hydrographic data from U.S. river gaging stations, which were chosen based on their proximity to confluences of major tributaries in question, and their consistency in recording annual discharge. Annual discharge rates were extracted from the database and averaged over a 30-year period from 1985 to 2015. Approximate station locations were subsequently mapped using ArcMap 10.4 (Esri, Redlands, California). Corresponding 30-year averages were mapped as proportional symbols (Figure 1). River line widths were mapped based on its hydrographic scale rank classification. Basemap data were obtained from Natural Earth (2016. Accessed January 16, 2016, http://www.naturalearthdata.com/downloads/), and river length was computed to the nearest kilometer. Cartographic design for the project prioritized the discharge averages and the corresponding rivers.

We investigated the rankings across the three river basins for individual metrics and for combinations of those six metrics, including average rankings across multiple metrics.

RESULTS

The resulting map (Figure 1) shows that the 30-year average discharge from the Ohio River before

the confluence of the Mississippi River at Smithland, Kentucky is greater than the discharge from the Missouri River at Hermann, Missouri by 43% and greater than the Upper Mississippi River at Grafton, Illinois by 10% (Figure 1). Conversely, the 30-year average discharge from the Ohio River just before the confluence of the Mississippi River at Smithland is 45% less than the discharge of the Mississippi at Thebes, Illinois only because the Missouri River joins the Mississippi about 100 river km before the Mississippi and Ohio meet. The discharge from the Missouri at Hermann, Missouri is less than the discharge of the Upper Mississippi at Grafton, Illinois, and hence, less than the discharge of the Ohio at Smithland (Table 1).

All six metrics selected to measure river prominence are shown in Table 2. Using an average for the rankings across the three rivers, the Ohio is ranked highest for three individual metrics (discharge, fish richness, and fish endemism), and highest across the average for all six metrics, and for an average of five metrics, including hydrology and biodiversity metrics. The Missouri is ranked highest for two individual hydrologic metrics (length and watershed area), and when using an average rank order of the three hydrology metrics; it is in second place when all six metrics are averaged. The Mississippi is highest only for number of song titles and lyrics, and has the lowest average rank across all six metrics (Table 3).

TABLE 1. Thirty-year average discharge rates for the three major river basins in the United States (U.S.) investigated in this study.

USGS gaging station ID	Station name	30-Year average discharge rate m^3/s (cfs)
3049500	Allegheny River at Natrona, Pennsylvania	554 (19,571)
3075070	Monongahela River at Elizabeth, Pennsylvania	258 (9,109)
3303280	Ohio River at Cannelton Dam at Cannelton, Indiana	3,686 (130,155)
3399800	Ohio River at Smithland Dam, Smithland, Indiana	3,745 (132,261)
6909000	Missouri River at Boonville, Missouri	2,129 (72,177)
6934500	Missouri River at Hermann, Missouri	2,625 (92,693)
5420500	Upper Mississippi River at Clinton, Iowa	1,599 (56,458)
5587450	Upper Mississippi River at Grafton, Illinois	3,380 (119,354)
7022000	Mississippi River at Thebes, Illinois	6,791 (239,819)

Note: USGS, U.S. Geological Survey.

TABLE 2. Metrics used to determine the dominance of a river basin.

River basin	30-Year average discharge, m^3/s (cfs)	Length, km (mi)	Drainage area, km^2 (mi^2)	Fish diversity: range of species for[1]		Song titles and lyrics (no. of times a river's name appears once)
				Richness	Endemism	
Mississippi	3,380 (119,354)	1,521 (945)	443,665 (171,300)	126–175	20–39	**665**
Missouri	2,625 (92,693)	**4,088 (2,540)**	**1,357,672 (524,200)**	71–125	10–19	45
Ohio	**3,745 (132,261)**	2,108 (1,310)	295,259 (114,000)	**176–232**	**40–67**	70
Mississippi–Missouri	6,791 (239,819)	6,333 (3,935)	1,847,180 (713,200)	NA	NA	NA

Note: Bold type is used to designate the river with the largest value for each metric. The combined Mississippi–Missouri totals are provided for comparative purposes only.

[1]Measures and estimates of fish biodiversity vary in the literature and by reach of watershed. For consistency, we used category ranking by Adell et al. (2000) who ranked major watersheds into six categories of abundance for fish richness and fish endemism.

TABLE 3. Rankings of the three river basins from 1 (highest) to 3 (lowest) for each metric (combined Mississippi–Missouri not included).

River basin with average rank order		Discharge, m^3/s (cfs)	Length, km	Drainage area, km^2	Fish diversity		Song titles and lyrics (no. of times a river's name appears at least once)
					Richness	Endemism	
Mississippi	2.0	2	3	2	2	2	1
Missouri	2.3	3	1	1	3	3	3
Ohio	1.7	1	2	3	1	1	2

Note: Average rank order across the six metrics is shown adjacent to the river basin name in the first column.

CONCLUSIONS

Using six hydrologic, biological, and cultural metrics to conduct a semiquantitative analysis, our results strongly support the Ohio River as the most prominent major tributary in the Mississippi River Basin, as currently named. The Ohio is more prominent than either the Upper Mississippi River or the Missouri River. This realization brings to light several intriguing quandaries. What's in a name? With a nod to William Shakespeare's Romeo and Juliet, "That which we call a river by any other name would flow as freely." Should a river basin of international renown be named based on its hydrologic dimensions, its volume of discharge, its river length, or its watershed area? Or, as we have shown, are factors of biodiversity and cultural impact also relevant to naming conventions?

More generally, we conclude that metric selection can be key in determining scoring, ranking, or prioritizing phenomena characterized by a set of indicators. The choice of environmental indicators, their metrics, and the weighting of those metrics for a given assessment should be tied to the specific questions investigators are trying to answer. Of course, any model is a simplification of reality, but if the choice set of metrics is too narrow, then the multiple dimensions of a phenomena are not appropriately assessed. Conversely, if a metric set is voluminous, then the assessment results may become cumbersome, create a highly collated set of metrics, or produce a set of results that are difficult to interpret. We look forward to further debate on use of naming conventions and use of metrics for aquatic systems when we see you at the next hydrologic event.

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