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When does a stream become a river?

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Abstract

The distinction between a "stream" and "river" is imprecise and vague despite the popular usage of the terms across disciplines for describing flowing waterbodies. Based on an analysis of named flowing waterbodies in the continental United States, we suggest a bank-to-bank channel width of 15 m as a working threshold in defining smaller "streams" from larger "rivers."

KEYWORDS
channel width, river, river definition, river versus stream, stream, stream definition

What defines a *stream* as opposed to a *river*? The US Geological Survey's Manual of Hydrology defines a *stream* as "a general term for a body of flowing water" irrespective of size (Langbein & Iseri, 1995). The term *river*, along with other names for surface-water features, was explicitly excluded from their list of definitions because "hydrologists have not devised better definitions than are in the dictionaries" (Langbein & Iseri, 1995). Dictionary definitions of *stream* generally agree with the above definition, but often confound the definition with other terms that describe small flowing waterbodies, such as *creek* or *brook* (Merriam-Webster, 2023a; Oxford English Dictionary, 2023a). For example, the Oxford English Dictionary (2023a) defines a *stream* as "a course of water flowing continuously along a bed on the earth, forming a river, rivulet, or brook" and also "a rivulet or brook, as contrasted with a river." Merriam-Webster (2023a) defines a *stream* as "a body of running water (such as a river or creek) flowing on the earth." These definitions add confusion because they do not clearly delineate between *streams*, *rivers*, and other flowing waterbodies such as *creeks*, *brooks*, or many others.

Some definitions of *stream* versus *river* make a distinction between small flowing waterbodies as streams and large flowing waterbodies as rivers (National Geographic's Education Resource Library, 2023a; Oxford Advanced Learner's Dictionary, 2023). For example, Oxford Advanced Learner's Dictionary (2023) defines a *stream* as "a small, narrow river." National Geographic's Education Resource Library (2023a) defines a *stream* as "a body of water that flows on Earth's surface" and adds that "the word stream is often used interchangeably with river, though rivers usually describe larger streams." However, it is unknown quantitatively what defines a *stream* versus a *river* (Bukaveckas, 2009). The lack of a clear distinction between *streams* and *rivers* can lead to ambiguities and misunderstandings in applications that use the terms.

It is important to distinguish a *stream* from a *river* because *stream/river* scientists and managers do not have a clear distinction between the two words (Bukaveckas, 2009). Having multiple terms for the same feature limits effective communication in the science and management of *streams* and *rivers* (Fryirs & Brierley, 2018). Clear and practical definitions of widely used terminology is necessary to reduce inconsistent nomenclature across disciplines and facilitate interdisciplinary research (Bracken & Oughton, 2006). Furthermore, the names given to waterbodies can affect whether and how they are regulated

(Doyle & Bernhardt, 2011). Prior research has focused on developing consistent terminology for various fluvial geomorphic features (Buffington & Montgomery, 2022; Fryirs & Brierley, 2018; Rosgen, 1994; Wheaton et al., 2015) and for non-perennial *streams* and *rivers* (Busch et al., 2020), but has not quantitatively discussed the distinction between *streams* and *rivers* themselves.

Herein, we quantitatively answer what defines a *stream* versus a *river* based on bank-to-bank channel width, or bankfull width (Wolman & Miller, 1960), of named flowing waterbodies in the Geographic Names Information System (GNIS). "Bankfull" is the condition when water fills a stream channel to the top of its banks and is often considered the condition shaping channel form (Leopold et al., 1964; Lindroth et al., 2020; Parker et al., 2007; Phillips & Jerolmack, 2016). We use bankfull channel width because, unlike wetted width, it does not vary depending on short-term flow fluctuations, it can be a straightforward geomorphic parameter to measure from typical single-thread, alluvial channel cross sections, and it is a common parameter used in flowing waterbody classification (McManamay & DeRolph, 2019; Rosgen, 1994). However, we acknowledge that the term "bankfull" has a long history, with varying definitions, and can be difficult to assess in some environments (see Lindroth et al., 2020). The specific definition of "bankfull" used herein is from the underlying datasets in Bieger et al. (2015): where bankfull discharge "is defined as the highest flow a channel can convey before it starts to spill onto its floodplain (Leopold et al., 1964) and can be identified in the field using physical indicators (Mulvihill & Baldigo, 2012)."

We obtained flowlines for the continental United States from the National Hydrography Dataset Plus Version 2 (NHDPlusV2; US Environmental Protection Agency [USEPA], 2023), which includes names from the GNIS and drainage area. We applied hydraulic geometry relations for bankfull width based on drainage area (Bieger et al., 2015) and then we extracted features based on different terms for natural flowing waterbodies. The NHDPlusV2 is a polyline shapefile format such that individual reaches are defined as the segment connecting two nodes, where nodes are either channel network endpoints or tributary junctions. Thus, our reported bankfull channel widths should be considered a spatial average of channel widths over a node-to-node segment of the flowing waterbody. We report only the terms (24 in total) that corresponded to natural flowing waterbody features with a cumulative total length of at least 400 km. Although this distinction is

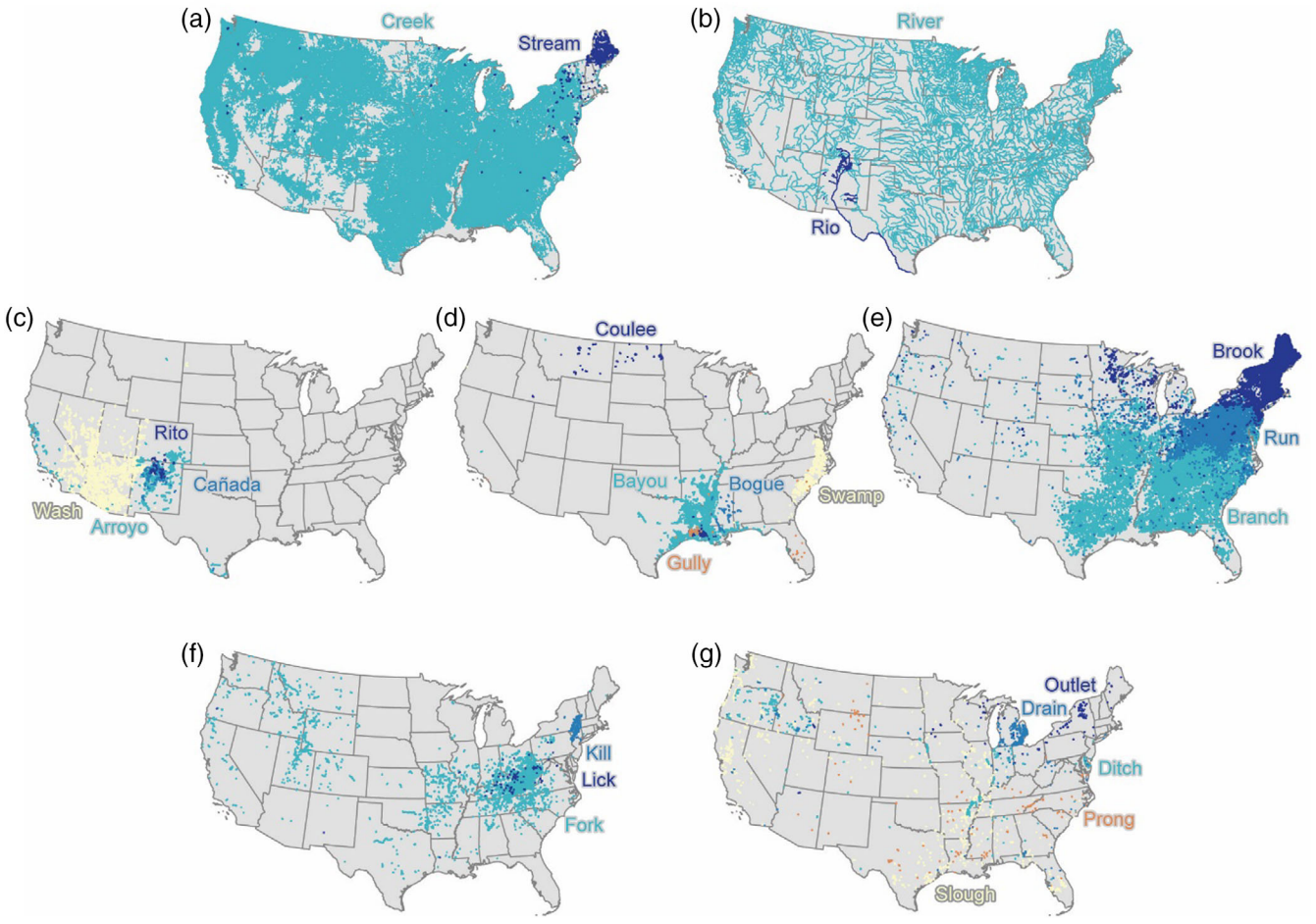

FIGURE 1 Spatial distribution across the continental United States of the 24 most common proper names for flowing waterbodies in the Geographic Names Information System (Campbell, 1991; USEPA, 2023): (a) *creek* and *stream*; (b) *river* and *rio*; (c) *rito*, *cañada*, *wash*, and *arroyo*; (d) *coulee*, *bayou*, *bogue*, *swamp*, and *gully*; (e) *brook*, *run*, and *branch*; (f) *kill*, *lick*, and *fork*; and (g) *outlet*, *drain*, *ditch*, *prong*, and *slough*. [Color figure can be viewed at wileyonlinelibrary.com]

arbitrary, it is a compromise that captures the most dominant and widespread terms and also shows a sufficient diversity of terms (from the more than 50 terms).

There are few flowing waterbodies in the continental United States whose proper name ends with *stream* and this occurrence is limited mostly to Maine (roughly 7000 km in total length; median bankfull width of 14 m; Figures 1a and 2). Instead, *creek* is by far the dominant term in proper names accounting for over 1.3 million km in total length (median bankfull width of 8 m). However, many regional variations for describing small flowing waterbodies exist (Campbell, 1991; Figures 1 and 2). There is an identity crisis in terms of what names are used to describe small flowing waterbodies (ordered from most to least common): *creek*, *branch*, *run*, *brook*, *fork*, *wash*, *bayou*, *arroyo*, *slough*, *swamp*, *stream*, *drain*, *ditch*, *kill*, *cañada*, *prong*, *coulee*, *bogue*, *outlet*, *rito*, *gully*, *lick*, among many other less common terms. Each of these terms corresponded to bankfull width distributions that were statistically different ($p < 0.01$, *z*-test of log-transformed data and Wilcoxon rank sum test) from that of *creek*, but they all were within the range in bankfull width of *creek* (Figure 2b).

There is less variety in the terms used to describe a large flowing waterbody, which is almost always called a *river* (or *rio*, along the Rio Grande in Texas and New Mexico), with a median bankfull width of 33 m (Figure 2). This is consistent with definitions that commonly distinguish rivers as large flowing waterbodies (Merriam-Webster, 2023b; National Geographic's Education Resource Library, 2023b; Oxford English Dictionary, 2023b).

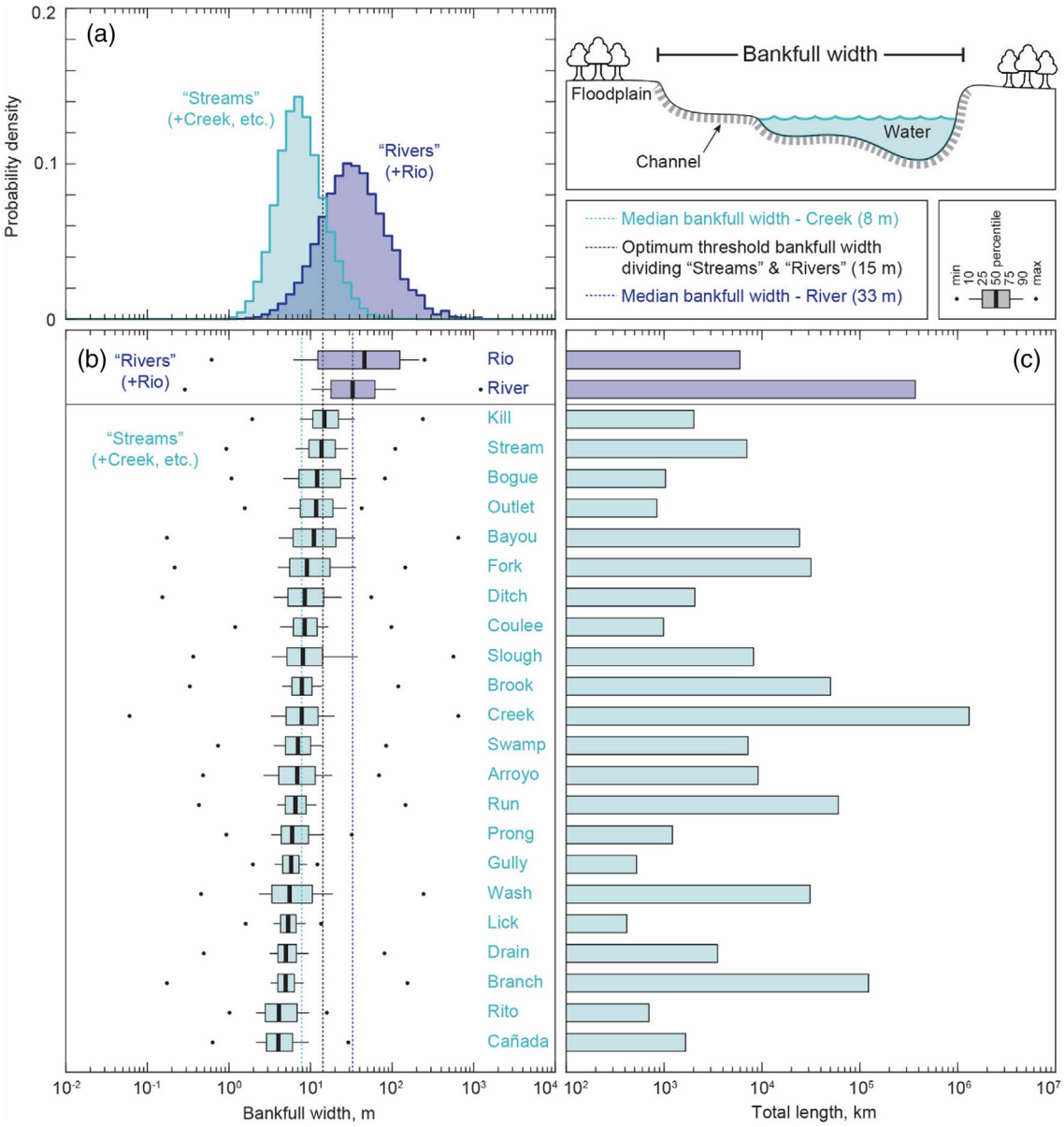

FIGURE 2 Bankfull width of the 24 most common proper names in the continental United States for flowing waterbodies in the Geographic Names Information System (Bieger et al., 2015; USEPA, 2023). (a) Probability density functions of bankfull width by total length of the flowing waterbody. (b) Boxplots of bankfull width arranged by increasing median (50 percentile) width. (c) Total length of the flowing waterbody. Note the log *x*-axes. [Color figure can be viewed at wileyonlinelibrary.com]

Although *creek* is the most common proper name for flowing waterbodies in the continental United States, its use is relatively uncommon in the international, English-language published literature. A search of the Web of Science Citation Database (2023) for each of the 24 terms shown in Figure 2 (except *cañada*), filtered by "water" to remove unrelated journal articles, returns more than 500,000 citations from 1970 to 2020. Of these, only 2.6% contain the word *creek*. Conversely, the search terms *river* (46%) and *stream* (17%) return the largest number of citations and are prevalent across a range of disciplines including Environmental Sciences, Water Resources, and Geosciences. Although there is a lot of disciplinary overlap, *river* is used more commonly in Geosciences and Environmental Engineering, whereas *stream* is used more commonly in Ecology. Based on usage, *stream* is a preferred term for small flowing waterbodies over *creek*.

Grouping all *rivers* and *rios* together as "rivers" and everything else as "streams," we determined an optimum threshold value between the two bankfull width distributions that maximize the flowing waterbodies in each broad category (i.e., the local minimum between the two distributions). We determined that this optimum threshold value for bankfull width dividing "streams" from "rivers" was 15 m (black dotted line, Figure 2a). That is, a bankfull channel width <15 m is a "stream" and ≥15 m is a "river." This distinction includes 86% of all named *streams* (and *creeks*, etc.) as "streams" and 80% of all named *rivers* as "rivers." This threshold is certainly fuzzy (Fisher & Wood, 1998), and expectedly so, because assigning proper names to flowing waterbodies is necessarily a socio-political, crowd-sourced act (Campbell, 1991). There is also uncertainty in the hydraulic geometry relations applied to the NHDPlusV2-derived drainage areas. Furthermore, our "stream" width distributions are likely biased wide because this analysis excludes the very large set of (typically smaller) flowing waterbodies without names (including ephemeral streams; Benstead & Leigh, 2012) that would otherwise be considered "streams."

In light of our findings, we offer the updated definition of, and distinction between, *streams* and *rivers* in the United States: a *stream* is a general term for a body of flowing water with a bankfull channel width less than 15 m (about 50 ft), whereas a *river* has a bankfull channel width equal to or greater than 15 m. Interestingly, this definition is consistent with the social connectivity threshold for the type of social interaction people can have on opposite banks of a channel: along a channel up to 15 m wide, people can communicate with someone on the other side, but as the channel becomes wider, the range of social interaction becomes difficult (Kondolf & Pinto, 2017). That is, people on opposite banks of a *stream* can easily communicate, but on opposite banks of a *river* their ability to communicate is more limited, with implications for human geography and socioeconomic development.

We have highlighted the imprecise nature of the terms *stream* and *river*, quantified the distribution of bankfull width for 24 of the most common terms in proper names for flowing waterbodies in the United States, and suggest a distinction of 15 m as a working threshold for bankfull channel width in classifying smaller "streams" from larger "rivers." Analysis of physical and functional flowing waterbody characteristics could be used in the future to further refine a more substantive classification of flowing waterbody terms, akin to lakes and ponds (Richardson et al., 2022). We acknowledge that flowing waterbodies are highly dynamic features of the landscape and thus our approach is a simplification of a more complex system. We welcome further conversation on establishing a quantitative and functional classification system for flowing waterbody terminology (Tadaki et al., 2014) and how these definitions may or may not apply to other regions of the world.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available in the National Hydrography Dataset Plus Version 2 (NHDPlusV2) at https://www.epa.gov/waterdata/get-nhdplus-national-hydrography-dataset-plus-data.

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