

Article

Streambed Median Grain Size (D50) across the Contiguous U.S.

Manoj K. Jha ^{1,*} , Dawit M. Asamen ¹, Peter M. Allen ², Jeffrey G. Arnold ³, Michael J. White ³ and Katrin Bieger ⁴¹ Department of Civil, Architectural and Environmental Engineering, North Carolina A&T State University, Greensboro, NC 27411, USA² Department of Geoscience, Baylor University, Waco, TX 76798, USA³ Grassland Soil and Water Research Laboratory USDA-ARS, Temple, TX 76502, USA⁴ Department of Ecoscience, Aarhus University, Vejlsovej 25, DK-8600 Silkeborg, Denmark

* Correspondence: mkjha@ncat.edu

Abstract: The streambed median grain size (D50) has been an integral part of many sediment transport and stream power equations seeking to characterize stream channel stability conditions. However, its previous usage is constrained by regional applicability, localization of datasets, and a limited number of data points. This study uses a large and geographically diverse data set ($n > 2400$), from five published sources, to present quantitative information and assess the distribution of D50 data across the contiguous U.S. Spatial distribution was analyzed based on the three regional frameworks: Physiographic Provinces, Level III Ecoregions, and Hydrologic Landscape Regions (HLRs). Gravel was found to be the dominant streambed material in most Physiographic Provinces. Regions with a humid climate, permeable soil, and plateaus exhibit a higher average D50 than regions with other climate, geologic texture, and landscape forms. Further analysis of all data across the U.S. using smoothed spatial maps showed the dominance of sand and fine gravel in streams located in the central and southern U.S., and the dominance of coarse gravel and cobbles in the northeastern U.S.

Keywords: median grain size (D50); regional assessment; Physiographic Provinces; Level III Ecoregions; Hydrologic Landscape Regions (HLR); contiguous U.S.



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1. Introduction

Streams are composed of active channels and floodplains, which play a vital role in the water cycle, ensuring the sustainability of the natural water balance. They are characterized by dynamic processes that maintain a state of equilibrium under variable sediment and water throughputs [1,2]. A stream can maintain its viability so long as it is under a stable equilibrium condition. [3] indicated a stable river can sustain sufficient transport capacity to convey the sediment and water flow coming from its watershed while preserving its channel pattern and dimension. However, natural and anthropogenic disturbances alter sediment and water flow [4], forcing streams and rivers to readjust their shape, size, and slope. Such perturbations result in reduced water storage capacity, diminished channel roughness, and shortened flow paths ensuring the prevalence of higher sediment transport and lower sediment storage capacity [5]. Consequently, the extra energy acquired through such modifications will be invested in scouring the streambed.

The resulting channel alterations can have a pronounced negative impact on nearby infrastructures [6,7], the benthic environment [8,9], and on the sediment transport [10]. The severity of these changes depends upon the landscape character and geological conditions [11], which mainly influence the magnitude of geomorphic driving and resisting forces [4]. This imbalance can be expressed by the stream power proportionality proposed by [1], which correlates to available stream power (the discharge-slope product) and the discharge of streambed material sediment. [12] employed parameters such as top width, average flow depth, flow velocity, longitudinal slope, and bankfull discharge to assess channel stability. The median grain size of mobile streambed sediments (D50) has been investigated as an indicator of channel stability [13–15].

D50 of streambed sediments is a valuable parameter in assessing watershed management strategies, analyzing and predicting stream behavior, and improving overall understanding of stream processes [16]. Previous studies recognized the influence of streambed material on channel stability and channel geometry [17,18]. The potential to assess channel stability and channel processes through median grain size data justifies its ubiquitous use in hydrological and geomorphological studies.

Golden and Springer [19] and Hack [20] used D50 in combination with drainage area to establish a regression relation for capturing the variation in the streambed slope. Grain-size data has also been used to predict the onset of scouring and streambed instability. Ref [16,21–23] used D50 as one of the inputs for estimating the critical specific stream power. Parker et al. [24] proposed a simplified expression of specific stream power using D50 as the sole dependent variable. Similarly, multiple authors [8,25,26] have used D50 as an integral parameter in developing formulas for critical shear stress and bedload. Kiel [27] developed a map of D50 using data collected from more than 400 sites to estimate the horizontal hydraulic conductivity of riverbanks. These studies demonstrated the extensive applicability of D50 in streambed stability analysis, but they also showed its limitations for its application in large regional scales.

This study developed a comprehensive database of D50 across the contiguous U.S. The data is presented in a stratified format using three regional frameworks: Physiographic Provinces, Level III Ecoregions, and Hydrologic Landscape Regions (HLRs). These frameworks use different sets of variables to define areas with similar hydrological processes. Many hydrological studies use these regional stratifications because they effectively characterize processes [28–32]. We prepared maps that depicted the distribution of streambed material over the contiguous U.S. Our dataset and analysis are applicable to diverse hydrological studies, but particularly those that address streambed stability.

2. Data

A large and geographically diverse data set ($n > 2400$) was collected for D50 from five different sources (Table 1). Some of the sources were comprehensive in terms of the hydrological parameters that were included within their dataset along with D50. The majority of the data points were obtained from the U.S. EPA [33]. Figure 1 shows the distribution of data per source over the contiguous U.S. An abundance of the data was found to be located in the Northeast, the Central U.S., and to some extent on the West Coast.

Table 1. D50 data sources with other hydrological parameters.

Data Source	Hydrological Parameter	No. of Data Points
[28] Bieger et al. (2015)	Q, D50, W, D, S, and DA	642
[33] USEPA (2016)	D50	1387
[34] Bledsoe et al. (2016)	Q, D50, and DA	103
[35] Hawley & Bledsoe (2013)	D50	66
[36] Slater & Singer (2013)	D50, W, D, S, and DA	255

Note: Q: bankfull discharge; D50: median grain size; W: bankfull width; D: bankfull depth; S: Slope; DA: Drainage area.

Preliminary data quality check revealed several duplicate and erroneous data points, which were removed from the analysis. Some data points had the same latitude and longitude but different D50 values. The USEPA dataset [33] contained 101 duplicate points, but the other four sources contained only 5 duplicates.

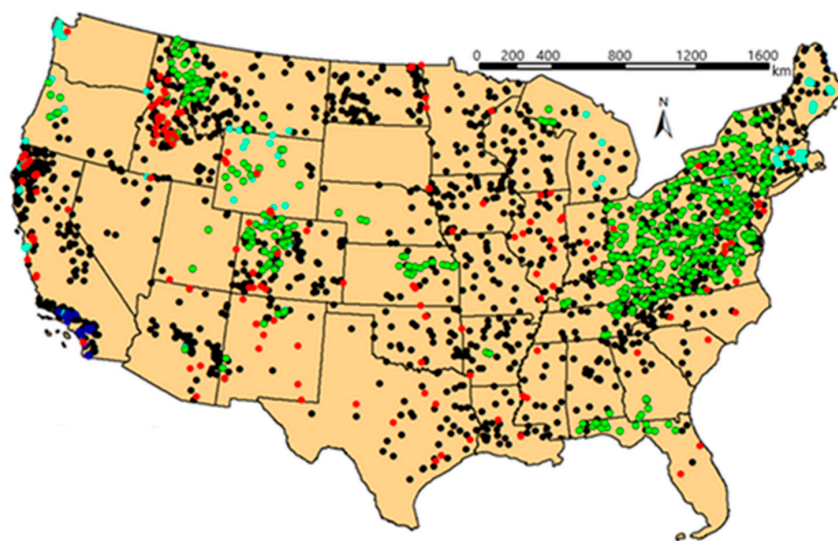


Figure 1. Distribution of D50 data points from five sources across the contiguous U.S. Dots with different colors in the figure represent different D50 data sources.

Box plot of D50 (Figure 2a) for each of the dataset revealed outliers that ranged from 6 to 84. The Interquartile range, defined as the difference between the 75th and 25th percentile of a dataset, was used as a measure of the statistical dispersion. Table 2 presents the descriptive statistics for each dataset after removing the outliers. According to [37], outliers can either be removed, used with weight adjustment, or be replaced with statistical estimators. We merely removed all outliers because there were relatively few of them. 139 data points were removed in total, which reduced the total number of points for further analyses to about 2300. Figure 2b shows the box plots after the removal of outlier. It shows the new outliers, but the interquartile range is much smaller and these remaining outliers will have minimal influence on the overall analysis. All D50 data and related information are provided in Tables S1 and S2 in the supplementary material of this paper.

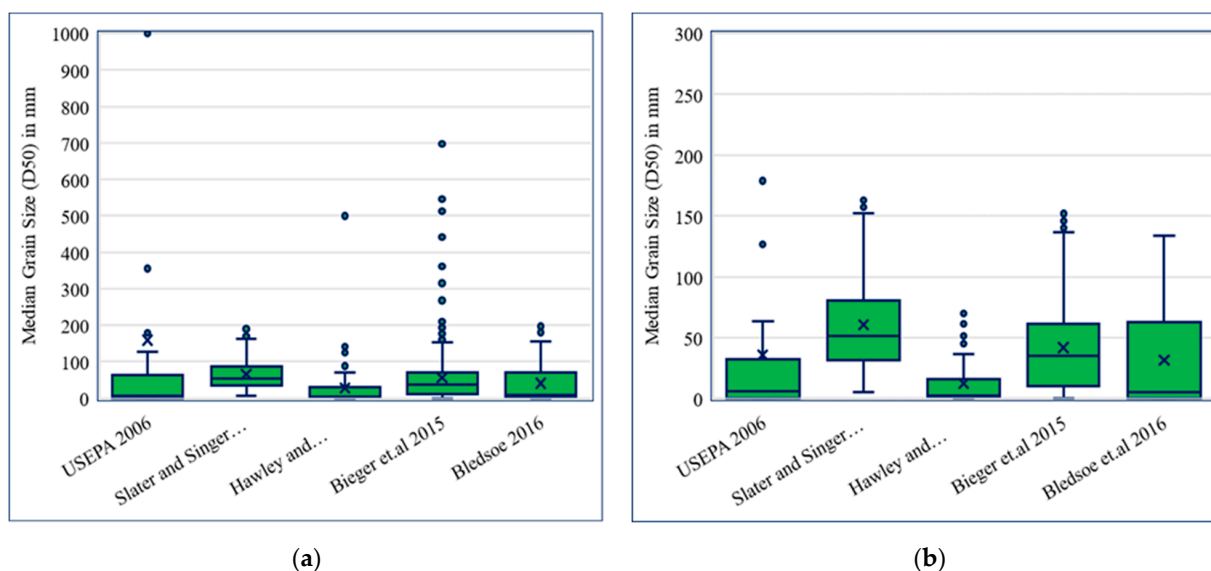


Figure 2. Box plots using D50 data values from five datasets: (a) original data, (b) after removing outliers. The outliers are designated by shaded circles, which are the values beyond the whiskers (lines extended up to 1.5 times the interquartile range) in both directions from the box. The box represents the range of 25th and 75th percentile. The horizontal line within the box and the 'x' sign represent median and average values respectively. Outliers are designated by shaded circles.

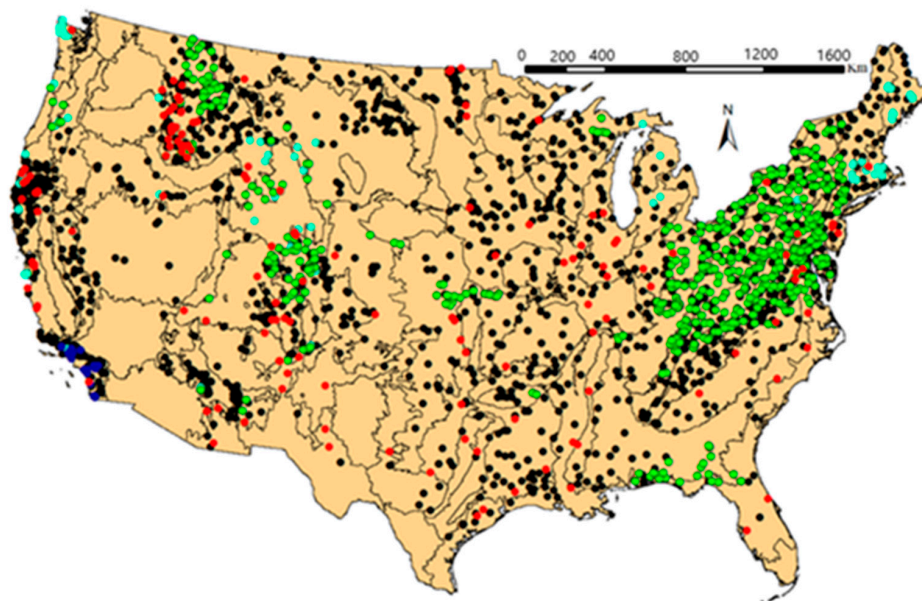
Table 2. Descriptive Statistics for the D50 data obtained from the five sources.

Data Characteristics	[28] Bieger et al., 2015	[33] USEPA 2006	[34] Bledsoe et al., 2016	[35] Hawley & Bledsoe 2013	[36] Slater & Singer 2013
Total Number of Data	606	1202	96	59	245
Maximum (mm)	152	178.9	134	69.7	163.1
Minimum (mm))	0.06	0.008	0.06	0.125	5.24
Q1 (mm)	10.38	0.35	0.56	0.90	31.4
Median (mm)	35	5.66	5.215	2.60	51.6
Q3 (mm)	60.93	32	63	14.50	80.00
Mean (mm)	56.43	35.92	31.29	12.02	60.29
Range	151.94	178.88	133.94	69.58	157.83
Number of outliers	6	84	6	10	33

3. Distribution of D50 by Regions

The spatial and temporal changes of climatic, geographic, and ecological variables influence hydrological processes. Despite their diverse and complex nature, these variables share common features [38]. Conceptual and analytical frameworks are therefore developed on a regional basis where similarities in these factors are used to define consistent hydrological characteristics of the region [32]. In this study, the D50 data were stratified using three major regionalization scheme in the U.S.: Level III Ecoregions [39], Physiographic Provinces [40], and Hydrologic Landscape Regions (HLR) [38]. The spatial distribution of the D50 data varies based on the geographic regions.

Level III Ecoregions. Ecoregions are geographical divisions characterized by similar ecological systems, organisms and environments [41]. The contiguous U.S. has been divided into 85 Level III Ecoregions [39], which have already been employed to regionalize hydraulic geometry parameters [42]. Figure 3 shows the distribution of D50 data points across the Level III Ecoregions. Of the 85 regions, 13 contain no data points. Moreover, the number of data points also varied considerably among the other 72 ecoregions. For example, the Ridge and Valley ecoregion contained 151 points, but the Central California Valley ecoregion contained only two data points. The overall distribution of the data points was representative except for the spatial gaps observed in some parts of the U.S., especially the central and western regions. The details of data distribution per the ecoregion is provided in Appendix A Table A1.

**Figure 3.** Distribution of D50 data points over Level III Ecoregions. Dots with different colors in the figure represent different D50 data sources.

Figures 4 and 5 present the spatial distribution of all D50 data following the classification schemes suggested by [43,44] respectively. The former categorizes unconsolidated sediments into six classes: silt (<0.0625 mm), sand (0.0625 – 2 mm), fine gravel (2 – 16 mm), coarse gravel (16 – 64 mm), cobble (64 – 512 mm), and boulder (>512 mm). The spatial map (Figure 4) depicts the distribution of all classes across the U.S. with no geographical bias. The map classifies the streambed material based on their susceptibility to degradation and armoring: labile bed (<16 mm), intermediate bed (16 – 128 mm), and coarse or armored bed (>128 mm). The labile bed class has the least resistance to erosion, whereas the coarse or armored bed has the highest. A box plot analysis indicated that the interquartile range for all 72 ecoregions lies either within the intermediate or labile bed class. This interpretation is supported by the spatial map (Figure 5) which shows the dominance of those two streambed classes. The two maps illustrate the streambed material composition and erosion susceptibility of streams based on location across the contiguous U.S.

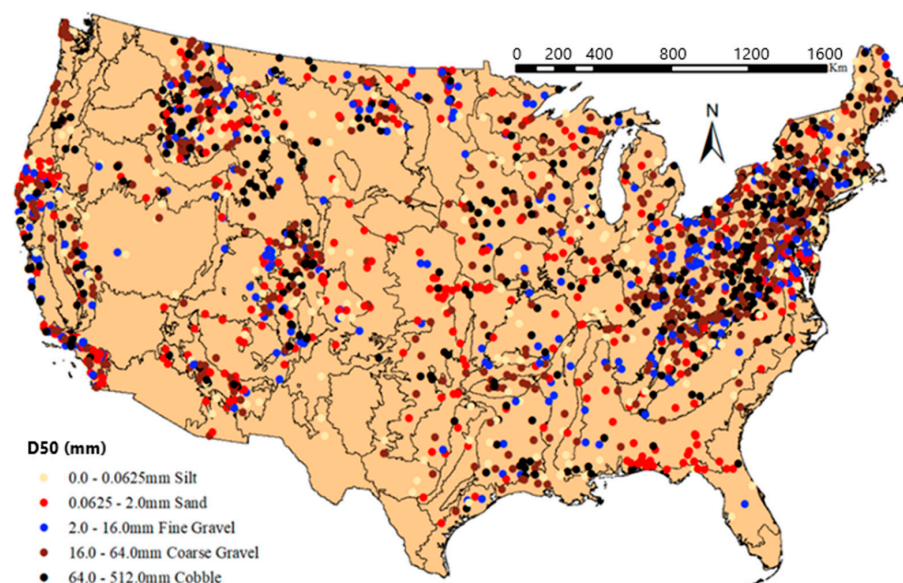


Figure 4. Distribution of D50 data points over Level III Ecoregions.

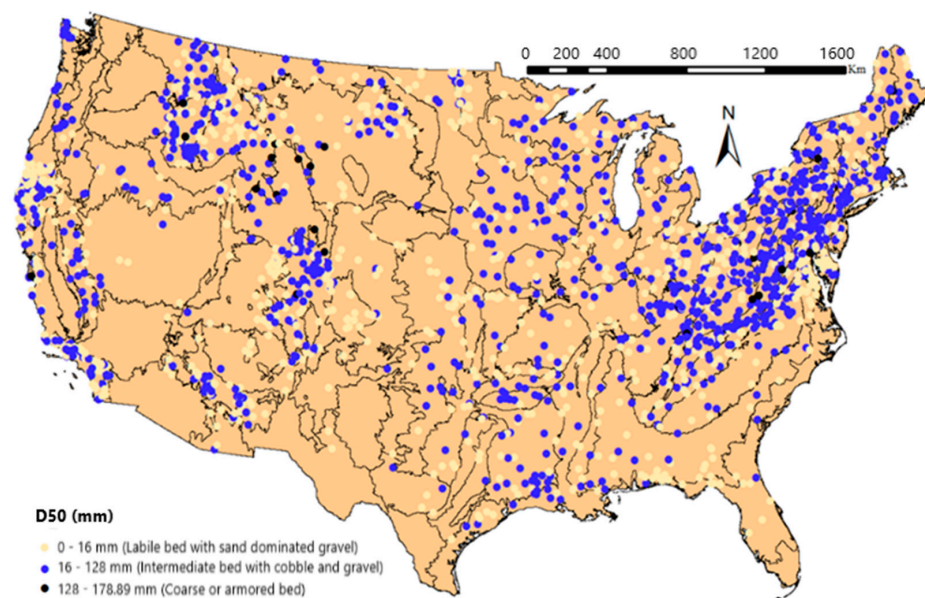


Figure 5. Streambed D50 values over Level III Ecoregions based on the channel susceptibility scheme.

Physiographic Provinces. Fenneman and Johnson [40] devised a method that divides the contiguous U.S. into twenty-five Physiographic Provinces. These provinces assume overall simplicity in geologic and geomorphic conditions, creating an ideal platform for the gross characterization of stream reaches. Figure 6 shows the distribution of D50 over the Physiographic Provinces. The Central Lowland province contained the highest number of data points ($n = 312$) whereas the St. Lawrence Valley contained the lowest number ($n = 6$). The D50 data were further analyzed for streambed material composition using the sediment classification scheme suggested by [43]. The percentage of silt, sand, gravel, cobbles, and boulders was calculated based on the D50 data in each of the 25 Physiographic Provinces. Analysis of data presented in Table 3 and Figure 7 allowed the identification of dominant bed materials within the divisions. The analysis indicates that gravel comprises the highest percentage of streambeds in the majority of the provinces. The Appalachian Highlands and Rocky Mountains are dominated by gravel and cobble-bedded channels. Sand and gravel were found to be abundant in the beds of stream channels located in the Atlantic Plains, Intermontane Plateaus and Pacific Mountains. Furthermore, the Interior Highlands regions saw an abundance of gravel while the Interior plains exhibited a mixture of sand, gravel and cobble in the beds of their stream channels.

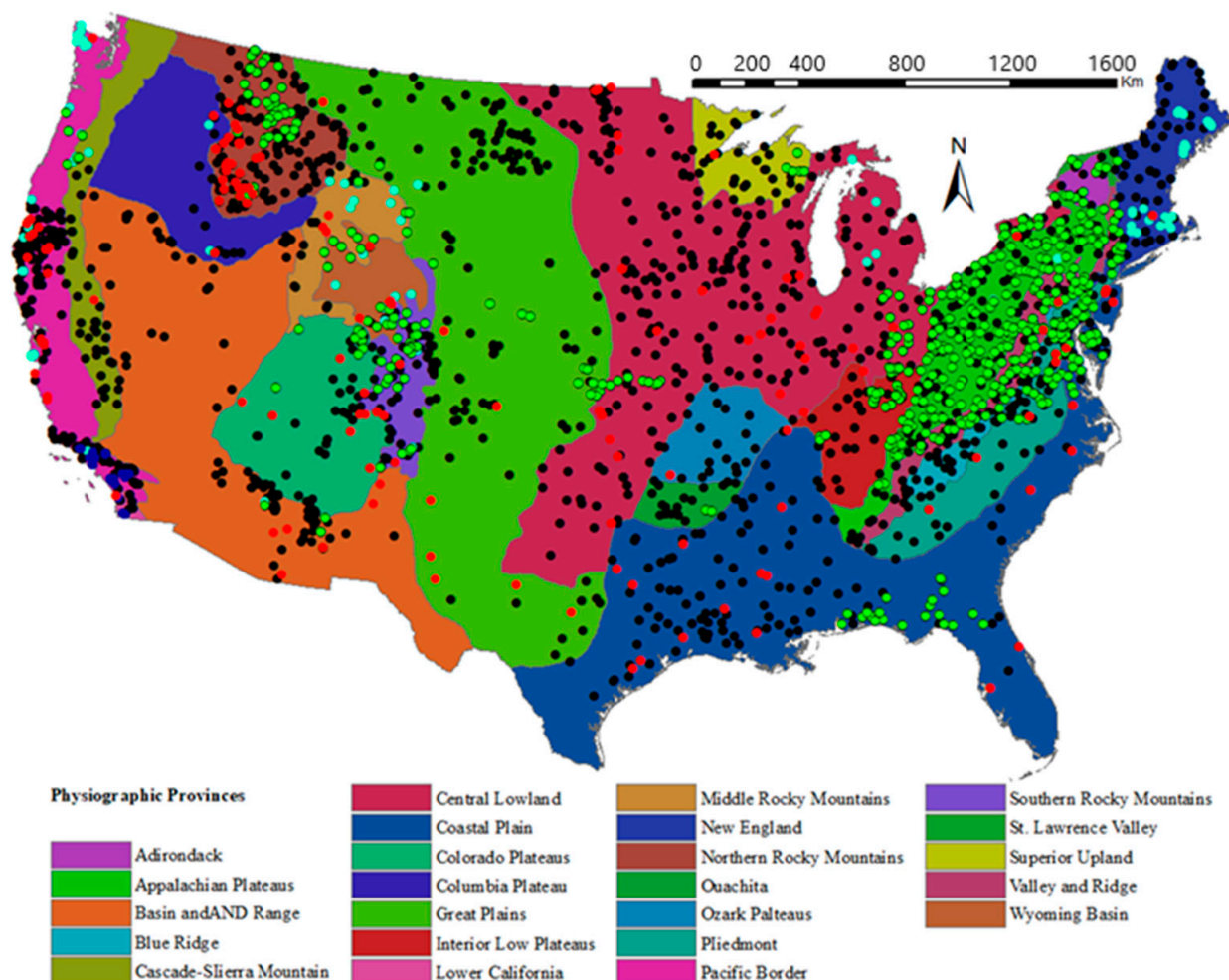
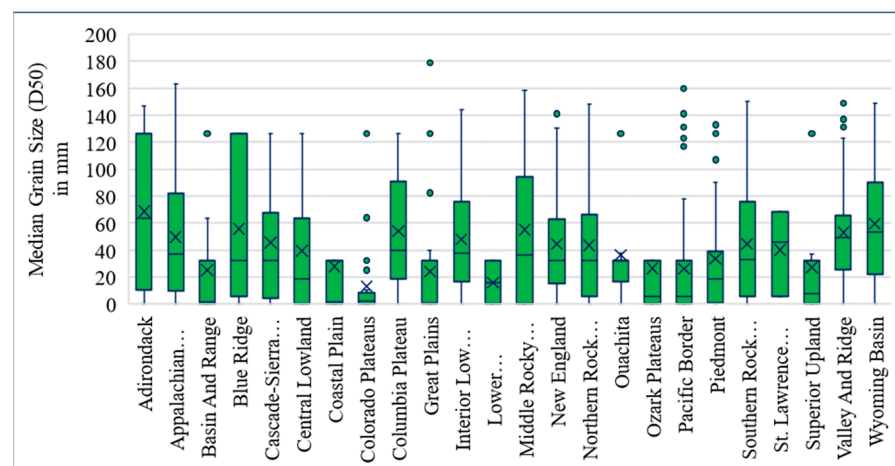


Figure 6. Distribution of D50 data points over Physiographic Provinces.

Table 3. Bed material percentage composition of physiographic provinces of the U.S.

No.	Physiographic Province	Bed Composition Based on D50 Data (%)					No. of D50 Points
		Silt	Sand	Gravel	Cobble	Boulder	
1	Superior Upland	8.6	22.9	40.0	11.4	17.1	35
2	Coastal Plain	10.7	34.8	33.1	18.0	3.4	171
3	Piedmont	5.6	19.0	54.8	17.5	3.2	121
4	Blue Ridge province	7.7	15.4	38.5	34.6	3.8	26
5	Valley and Ridge province	3.2	3.8	57.6	30.4	5.1	159
6	St. Lawrence Valley	16.7	0.0	50.0	33.3	0.0	6
7	Appalachian Plateaus province	5.1	5.8	50.0	34.3	4.7	275
8	New England Province	8.9	3.0	63.0	25.2	0.0	134
9	Adirondack province	7.7	15.4	30.8	46.2	0.0	14
10	Interior Low Plateaus	4.2	5.6	61.1	27.8	1.4	72
11	Central Lowland	9.7	22.8	37.8	23.4	6.3	312
12	Great Plains	18.6	31.0	31.7	14.5	4.1	138
13	Ozark Plateaus	20.0	15.0	45.0	15.0	5.0	20
14	Ouachita province	5.6	5.6	72.2	11.1	5.6	18
15	Southern Rocky Mountains	7.8	15.6	46.7	27.8	2.2	90
16	Wyoming Basin	6.9	3.4	48.3	41.4	0.0	31
17	Middle Rocky Mountains	20.7	6.9	24.1	44.8	3.4	20
18	Northern Rocky Mountains	9.3	11.7	49.2	27.8	2.0	248
19	Columbia Plateau	12.5	0.0	37.5	31.3	18.8	16
20	Colorado Plateaus	7.5	40.3	43.3	7.5	1.5	70
21	Basin and Range Province	15.2	35.4	31.3	11.1	7.1	97
22	Cascade-Sierra Mountains	15.6	13.3	42.2	26.7	2.2	45
23	Pacific Border province	9.8	28.7	44.4	14.2	2.9	272
24	Lower California province	15.0	35.0	50.0	0.0	0.0	20
25	Continental shelf	-	-	-	-	-	-

**Figure 7.** Box Plot showing the range of D50 data over Physiographic Provinces of the U.S.

Hydrologic Landscape Region (HLR). Using an integrated GIS technique and statistical tool, [35] subdivided the contiguous U.S. into twenty non-contiguous HLRs. This categorization was based on similarities in land-surface form, geologic texture, and climate characteristics. Unlike the two other regional frameworks, a single HLR can exist in different parts of the U.S. [45]. Figure 8 shows the distribution of D50 over the HLRs. All twenty HLRs are represented in the dataset. HLR 18, semiarid mountains with permeable soils and impermeable bedrock, contained the highest number of data points with a total of 352 points, whereas HLR 5 and HLR 10 contained the lowest, only 30 data points each. Box plot (Figure 9) analysis indicated HLRs with humid climate conditions (HLR 2, 4, 7, 9, 11 and 16) have higher average D50 values compared to regions with arid and sub-humid conditions. Additionally, HLRs with permeable soil conditions have higher average D50 values than those with impermeable soil.

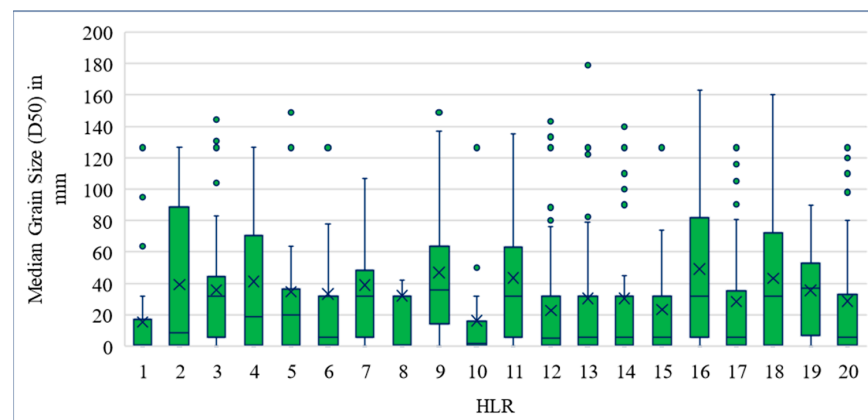


Figure 8. Box Plot showing the range of D50 data over Hydrologic Landscape Regions of the U.S. Boxes indicate data range falling between the first and third quartile. Note: Horizontal lines within the boxes indicate median values whereas the 'X' sign designates averages.

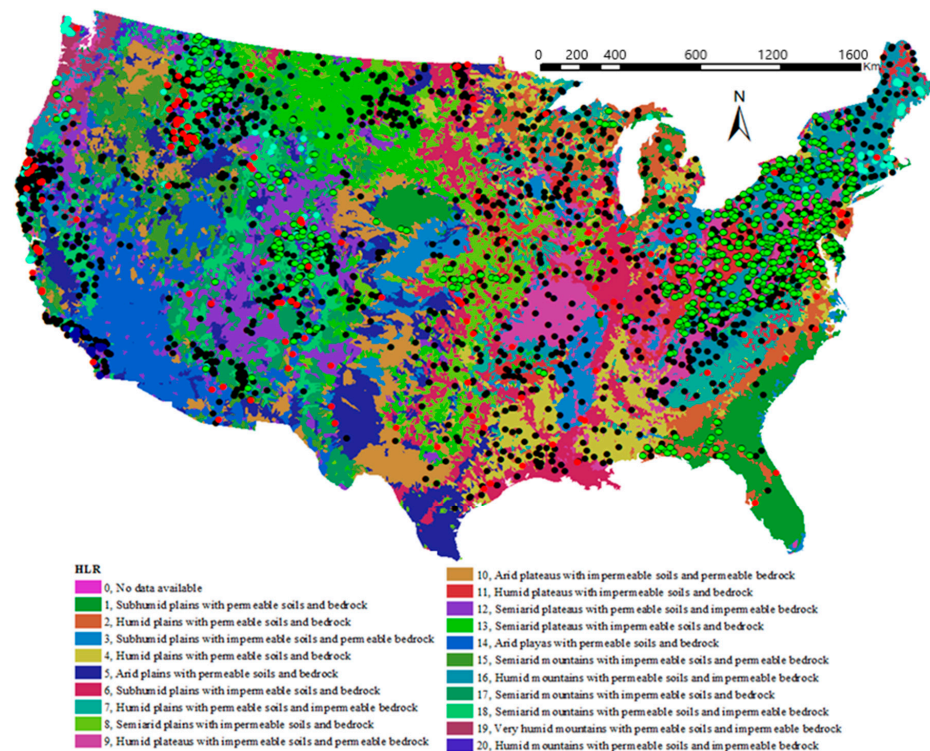


Figure 9. Distribution of D50 data points over HLR. Colors on the background map represent HLRs.

4. Analysis of D50 Data over the Contiguous U.S.

Based on the D50 data distribution across the Contiguous U.S., a series of spatial maps of D50 were developed. Figure 10 shows an interpolated map of D50 values in mm, which was achieved through the implementation of a function in ArcMap using the technique of inverse distance weighted interpolation. This method calculates the raster value for the map by taking the average of nearby weighted observations where the weight is dependent on the distance between the observation and the raster cell. Since the D50 data over such a large geographic region exhibits a broad spatial variation, the D50 values were converted into logarithmic values ($\log_{10}D50$) for the spatial interpolation, which reduced the impact of large variations between the values. The logarithmic values were then converted back to mm for interpretation and visualization.

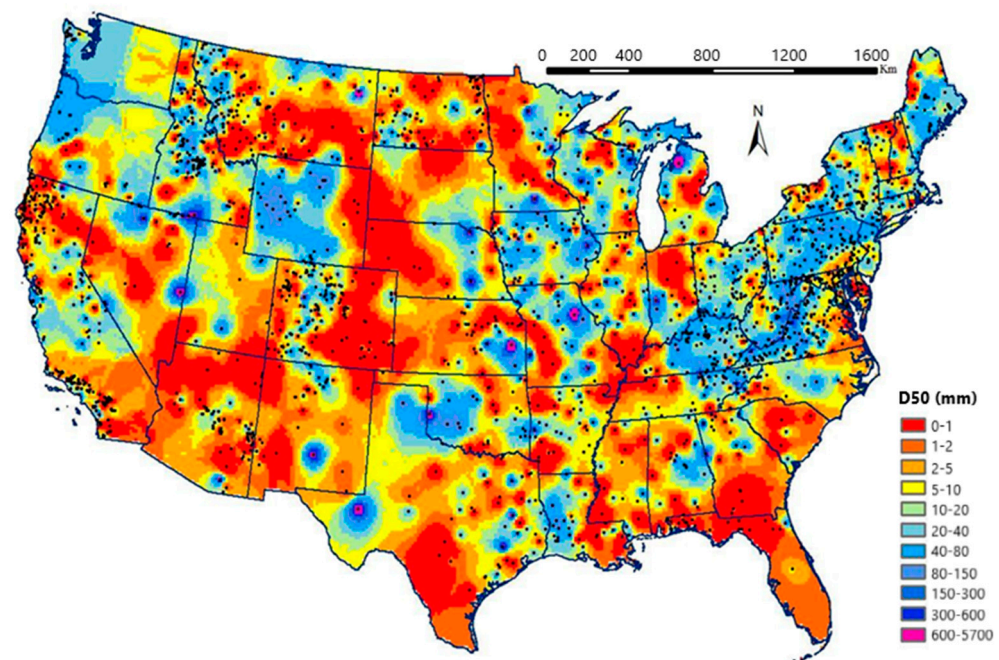


Figure 10. Map of interpolated D50 over the Contiguous U.S. Note: The map was prepared using the log value of more than 2200 D50 data points collected from five sources; black dots on the map show the locations of D50 data points.

As can be inferred from the map, streams located in the central and southern parts of the U.S. are dominated by bed material composed of sand and fine gravel. On the other hand, the northeastern part of the U.S. is dominated by coarse gravel and cobble. The map shows some degree of resemblance with the smoothed D50 map developed by Kiel [27], which used 400 D50 data points in his analysis of river shaping factors and their effect on groundwater quality. Both maps depicted the coarse nature of streambeds located in the northeastern part, but there are also some differences between the two maps. A coarse material majorly represented the southeastern part of the U.S. on the smoothed map developed by [27]; contrastingly, the region was designated by fine materials on the map shown in Figure 10. Part of the Midwest U.S. that was depicted as coarse bedded in Figure 10 was largely portrayed as being fine bedded on the map developed by [27]. These discrepancies could be attributed to the number of data points used in the map development. Though there still are spatial gaps in our database of over 2200 data points, the map developed here presents a more comprehensive and reliable representation of the streambed material compositions of streams located in the U.S.

We employed a simplified method of [46] to develop a map (Figure 11) that delineates the sediment types. The interpolated $\log_{10}D50$ value was converted back to “mm” and classified into the three streambed groups. The majority of the U.S. falls into the first class, labile bed width sand-dominated gravel. In accordance with Figure 10, this map also

captures the coarse nature of stream channels located in the northeastern part of the U.S. The map depicts a more simplified representation of streambed material distribution that serves to identify the erosion susceptibility of stream channels in different geographical regions. Similarly, Figure 12 presented the interpolated D50 map overlaid by Physiographic Provinces and Level III Ecoregions of the U.S.

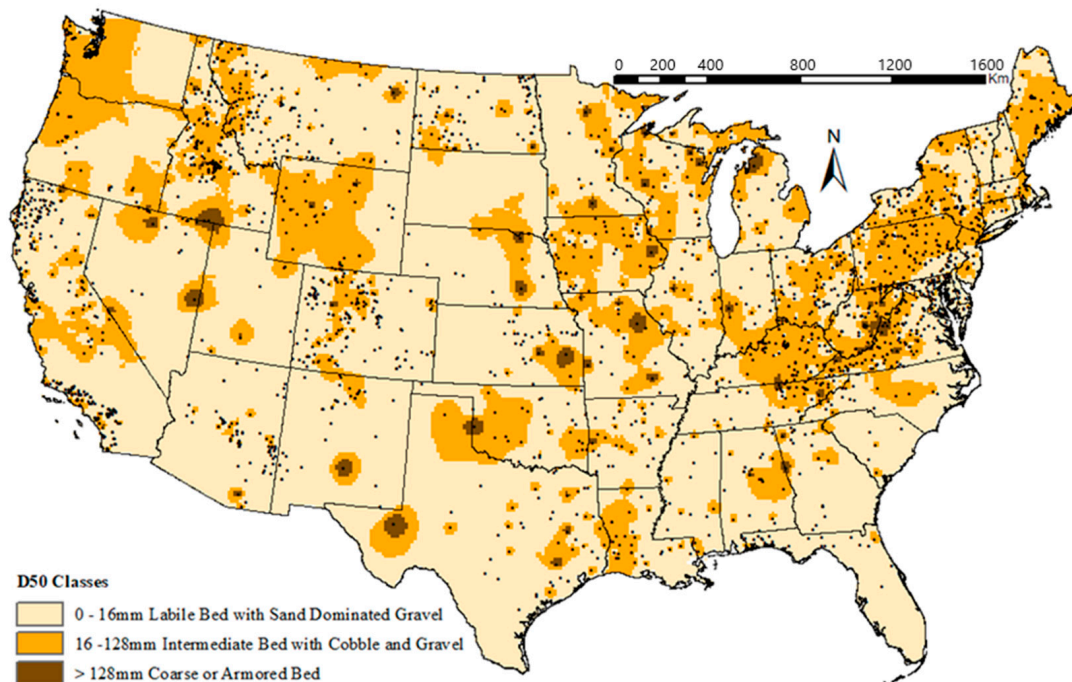


Figure 11. Map of interpolated D50 over the Contiguous U.S. using broad categories of streambed material. Note: The map was prepared using the log value of more than 2200 D50 data points collected from five sources; black dots on the map show the locations of D50 data points.

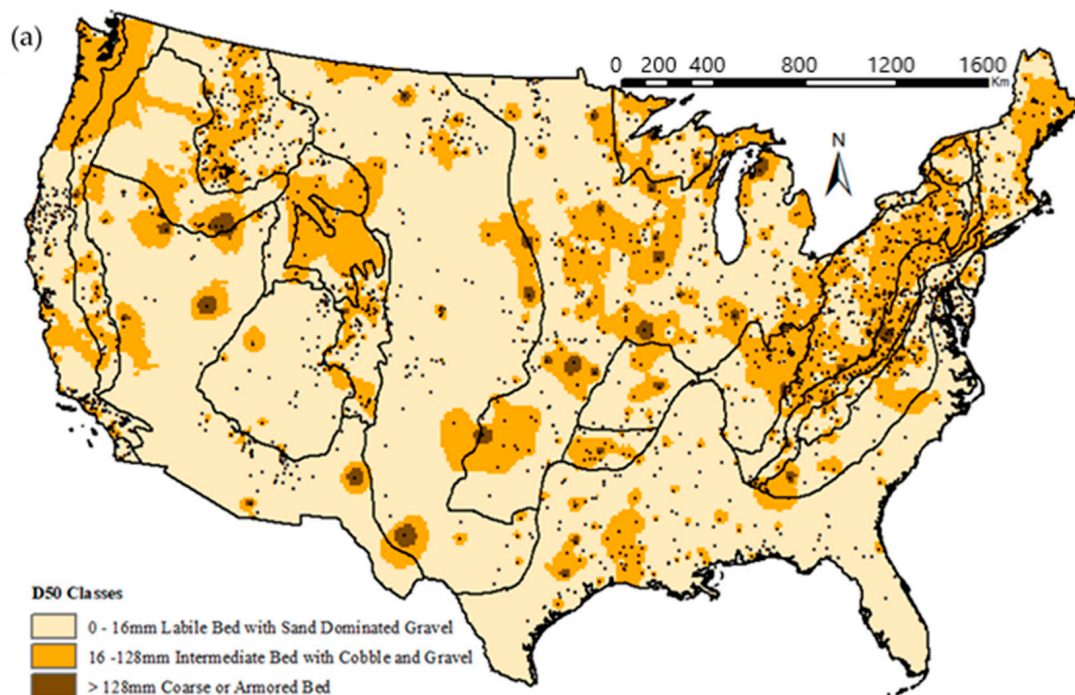


Figure 12. *Cont.*

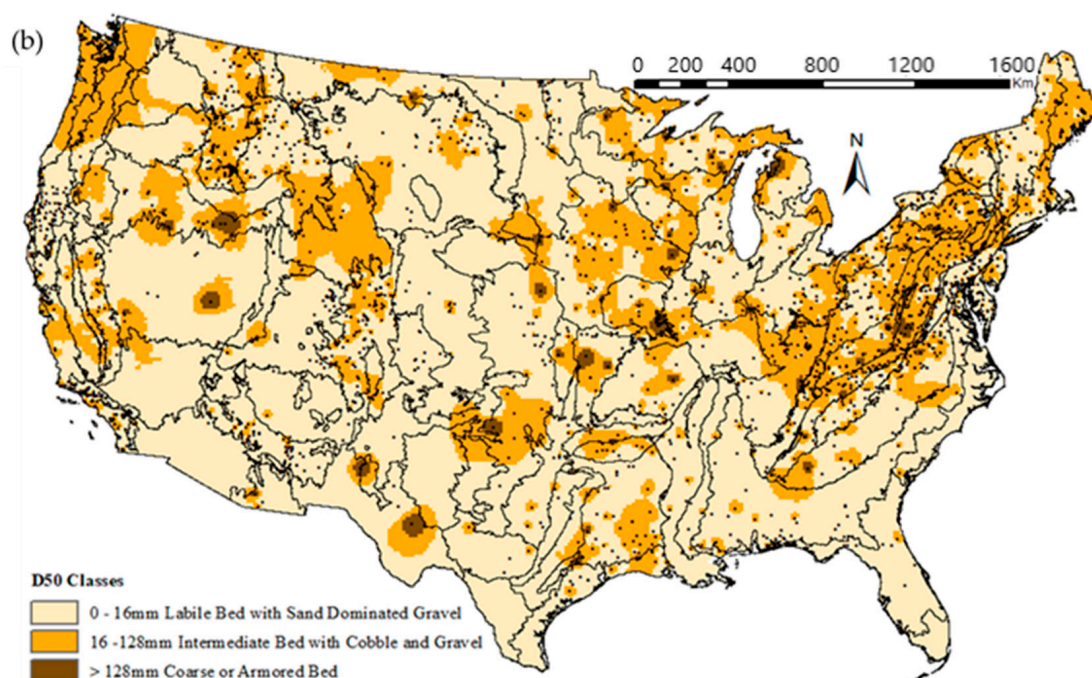


Figure 12. Map of interpolated D50 over the Contiguous U.S. with three streambed classes (a) overlaid with a map of physiographic provinces (b) overlaid with a map of level III Ecoregions. The black dots on the map show the locations of D50 data points.

5. Summary and Conclusions

This study presents a comprehensive dataset that contains information on the median grain size (D50) of the streambed and other hydrological parameters. The data were collected from five publications and spanned the contiguous U.S. Regional frameworks (Physiographic Provinces, Level III Ecoregions, and HLRs) that were used in this study to stratify the data and identify underlying trends exhibited by the streambed material. We found that Gravel is the dominant streambed material in most Physiographic Provinces. HLRs with a humid climate, permeable soil, and plateaus exhibited higher average D50 values than regions with other climates, geologic structures, and dominant landforms. Interpolated maps of D50 indicated that the central and southern parts of the U.S. are dominated by streambed material composed of sand and fine gravel, whereas the northeastern part of the U.S. is dominated by coarse gravel and cobbles. The data presented in this study can serve as a guide for future hydrological studies that rely on D50 and encompass large study areas. For application in localized scales, caution should be taken as local variations in channel slope, geology, dams, and tributary input could create site-specific conditions that deviate widely from the D50 spatial maps presented in this study. In parameterizing the streambed for a hydraulic or hydrologic model, these findings provide the user with an expectation of the regional conditions, but actual parametrization would likely be more accurately achieved with a method that accounts for the local channel slope [47].

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/w14213378/s1>. Table S1. Sources of D50 data. Table S2. D50 data with information on latitude, longitude, and value for each.

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Data Availability Statement: The data used in this study are available in the supplementary materials.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. D50 data distribution per Level III Ecoregions.

Level III Ecoregion	No. of Points	Min	Q1	Median	Q3	Max
Acadian Plains and Hills	37	5.24062	18.77	39.39	50.82	87.90
Arizona/New Mexico Mountains	46	0.00775	0.35	0.35	32.00	126.49
Arizona/New Mexico Plateau	16	0.00775	0.35	0.35	12.66	32.00
Arkansas Valley	4	0.34641	24.09	32.00	32.00	32.00
Atlantic Coastal Pine Barrens	6	5.65690	32.00	32.00	126.49	126.49
Blue Mountains	5	0.34641	24.09	43.00	72.12	126.49
Blue Ridge	22	0.00775	5.66	32.00	126.49	126.49
Boston Mountains	6	0.00775	1.42	5.66	5.66	32.00
Canadian Rockies	11	0.00775	3.00	5.66	62.00	126.49
Cascades	7	0.00775	0.35	16.17	70.50	90.00
Central Appalachians	50	0.00775	29.00	67.20	115.82	216.41
Central Basin and Range	15	0.00775	0.01	5.66	32.00	126.49
Central California Valley	2	32.00	55.62	79.25	102.87	126.49
Central Corn Belt Plains	19	0.00775	3.00	32.00	79.25	126.49
Central Great Plains	30	0.13000	0.96	32.00	126.49	126.49
Central Irregular Plains	18	0.00775	0.50	5.66	79.25	126.49
Coast Range	71	0.00775	1.67	32.00	53.30	200.00
Colorado Plateaus	35	0.00775	0.48	2.13	5.85	165.00
Driftless Area	13	0.00775	5.66	32.00	32.00	126.49
Eastern Cascades Slopes and Foothills	4	32.00	32.00	79.25	126.49	126.49
Eastern Corn Belt Plains	33	0.00775	7.37	22.80	40.66	126.49
Erie Drift Plains	29	0.00775	10.12	28.04	52.30	126.49
Huron/Erie Lake Plains	6	0.00775	0.28	4.80	32.00	126.49
Idaho Batholith	95	0.00775	8.33	37.50	91.00	190.00
Interior Plateau	60	0.00775	28.75	37.97	78.53	194.00
Lake Agassiz Plain	25	0.00775	0.35	0.87	5.66	126.49
Madrean Archipelago	7	0.00775	0.35	3.00	25.41	32.00
Middle Atlantic Coastal Plain	19	0.00775	0.33	1.00	21.50	126.49
Middle Rockies	85	0.00775	0.35	19.00	40.00	268.00
Mississippi Alluvial Plain	16	0.00775	1.67	18.83	32.00	126.49
North Central Appalachians	24	0.00775	43.40	81.90	119.00	133.00
North Central Hardwood Forests	11	0.00775	5.66	32.00	126.49	126.49
Northeastern Coastal Zone	25	0.00775	10.73	32.00	86.26	171.00
Northeastern Highlands	91	0.00775	5.66	32.00	84.96	179.45
Northern Allegheny Plateau	42	0.65	20.70	51.30	68.20	116.00
Northern Basin and Range	21	0.00775	0.35	32.00	34.00	126.49
Northern Glaciated Plains	15	0.00775	0.35	0.35	32.00	126.49
Northern Lakes and Forests	38	0.00775	0.35	32.00	32.95	126.49
Northern Piedmont	67	0.00775	1.13	14.00	32.00	132.81
Northern Rockies	41	0.00775	5.33	32.00	87.50	315.00
Northwestern Glaciated Plains	11	0.00775	5.66	32.00	126.49	126.49
Northwestern Great Plains	62	0.00775	0.35	5.66	32.00	178.89

Table A1. Cont.

Level III Ecoregion	No. of Points	Min	Q1	Median	Q3	Max
Ouachita Mountains	10	0.00775	32.00	32.00	36.20	126.49
Ozark Highlands	15	0.00775	0.35	5.66	32.00	126.49
Piedmont	57	0.00775	5.66	32.00	126.49	126.49
Ridge and Valley	151	0.00775	32.00	50.60	91.44	222.00
S. Michigan/N. Indiana Drift Plains	11	0.00775	0.35	32.00	126.49	126.49
Sierra Nevada	22	0.00775	0.35	32.00	126.49	126.49
Sonoran Basin and Range	6	0.34641	0.35	16.17	55.62	126.49
South Central Plains	34	0.00775	5.66	32.00	126.49	126.49
Southeastern Plains	58	0.00775	0.35	1.11	9.98	126.49
Southeastern Wisconsin Till Plains	9	0.00775	0.18	32.00	126.49	126.49
Southern and Central California						
Chaparral and Oak	32	0.00775	0.35	5.66	126.49	126.49
Southern California Mountains	47	0.00775	0.35	0.35	32.00	126.49
Southern California/Northern Baja Coast	57	0.12500	0.90	3.30	32.93	151.80
Southern Coastal Plain	15	0.00775	0.59	0.71	5.66	126.49
Southern Rockies	99	0.00775	5.66	32.00	76.00	190.00
Southwestern Appalachians	23	0.00775	5.66	28.00	46.30	135.00
Southwestern Tablelands	26	0.00775	0.01	0.35	1.67	126.49
Wasatch And Uinta Mountains	6	0.00775	0.93	8.08	27.36	126.49
Western Allegheny Plateau	62	0.00775	5.66	31.23	54.12	131.06
Western Corn Belt Plains	44	0.00775	5.66	32.00	126.49	126.49
Western Gulf Coastal Plain	12	0.00775	1.14	18.83	55.62	126.49
Western High Plains	12	0.00775	0.35	3.00	32.00	32.00
Willamette Valley	6	45.00	48.00	54.00	60.00	66.00
Wyoming Basin	24	0.00775	34.00	68.55	102.88	210.00

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