

North Fork John Day River Watershed Sediment and Physical Habitat Assessment



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Preface

Ecological systems are complicated; there are layers upon layers of complexity. Once one layer is understood, another layer is exposed and with it more questions. Science is our attempt to understand our world while removing bias and emotion, but it is our bias and emotions that drive us to ask questions. When interpreting this data remember why it was collected. It is important to remember not to get so bogged down in the details that we forget why we collected the data in the first place.*



Special thanks to the technical support team: Don Butcher of the ODEQ, Paul Boehne of the USFS, Caty Clifton of the USFS, Doug Drake of the ODEQ, Chuck Hawkins of Utah State University, Shannon Hubler of the ODEQ, Phil Kaufmann of the EPA, Brad Lovett of the USFS, Rosy Mazaika formerly of the BLM, Chester Novak of the BLM, Anna Smith of the BLM, and Karla Urbanowicz of the ODEQ. There are numerous others who provided input and support to this process, thank you!

*This preface is solely the opinion of the authors and in no way represents the BLM or their employees.

TMDL Context and 303(d) Sediment Listings

The following is a summary of the EPA guidance document titled, “Principles to Consider When Reviewing and Using Natural Condition Provisions”¹ [Summarized by Demeter Design; emphasis added]

All Clean Water Act (CWA) programs: are geographically specific; are scientifically defensible; are data driven and transparent; allow for public review and comment; and are accessible. Considerations fall into three categories: determining Water Quality Standards (WQS); 303(d) Listing and Delisting; and TMDLs and NPDES Permits. Include a “definition of a natural condition such as ‘the quality of surface water that exists in the absence of human-caused pollution or disturbance’; a provision that site-specific criteria may be set equal to a natural condition and a written procedure ...; [a] narrative [of] natural conditions criteria for [the metric] that allows the natural condition [metric] to become the criteria and supercede the numeric criteria when a natural condition determination is made on a case-by-case basis.” Decisions made using a natural condition provision **which allow a water body to be removed or not included on the list should be:** “based on existing and readily available data and information; supported by a site-specific, scientifically defensible rationale that ... explains why human activities in a watershed are not directly or indirectly the cause of the exceedance of WQS for the pollutant of concern, ***shows there has been virtually no human activity in the watershed that would affect the water quality parameter in question***, explains how natural processes alone are adequate to account for the observed exceedance of the water quality standard for the pollutant of concern OR, shows that the water quality in the watershed is similar to that measured in an undisturbed reference location.” TMDL development should consider the following questions: “***Does a suitable reference watershed or reference location (with similar size, elevation, geology, climate, fauna, flora, flow, etc.) exist***; Are there adequate data from the reference location; Is there an appropriate model that meets the project objectives; Is there available expertise to run the model; Are there adequate data to use as model input parameters; and What are the legal, resource and time constraints?” Finally, “natural condition is a term used to describe the quality of surface water untouched by human-caused pollution or disturbance... In some cases, a surface water may exceed the numeric criteria even though there have been no human disturbances in this water. As a result, states usually include a natural condition provision in their water quality standards... There is no single correct approach to calculating a natural condition... The report is not regulatory guidance... ***It also does not substitute for Clean Water Act requirements, EPA’s regulations, or the obligations imposed by consent decrees or enforcement orders...*** You are not required to use the report. EPA recognizes the need for flexibility to address unique circumstances associated with individual water bodies and state and Tribes, ***as long as water quality is protected...*** As the term is used in this report, ‘natural conditions’ are not present when: water quality has been or is altered by human activity or industry; irreversible human features, such as a dam, are present; or there have been influences from sources outside the watershed.”

The original 1998 North Fork John Day Watershed 303(d) listings for sediment were based on “declining redd counts” and cobble emeddedness data in the Wall Ecosystem Analysis, 1995. For a complete synopsis of the listings please refer to table ii and Map i. Table i provides historical data summaries and PACFISH and HABRATE targets for water quality and steelhead habitat respectively.

One of the most obvious concerns which resulted from this assessment in regards to the listing is the consideration of appropriate reference conditions. Although the Baldy and Granite Creek Watersheds are directly comparable to the reference populations, the Wall Creek Watershed, although similar to the Blue Mountain Ecoregion, is generally lower in elevation and therefore receives somewhat less precipitation. Two reference sites (on Cabin Creek) are geographically close and geologically similar to the Wall Creek Watershed. The LRBS values are similar in range and average to the WCW but the max %SAFN is 25% versus ~77% (for similar drainage areas). Additional EMAP and steelhead spawning and rearing data in the WCW and Cabin Creek Watershed may be useful. Additionally sediment in spawning habitat may be an issue in years where the mainstem of Wall Creek is too hot (refer to discussion).

1 USEPA Region 10, Office of Water and Watersheds, (January 2005). EPA Region 10 Natural Conditions Workgroup Report on Principles to Consider When Reviewing and Using Natural Conditions Provisions (50 pages).

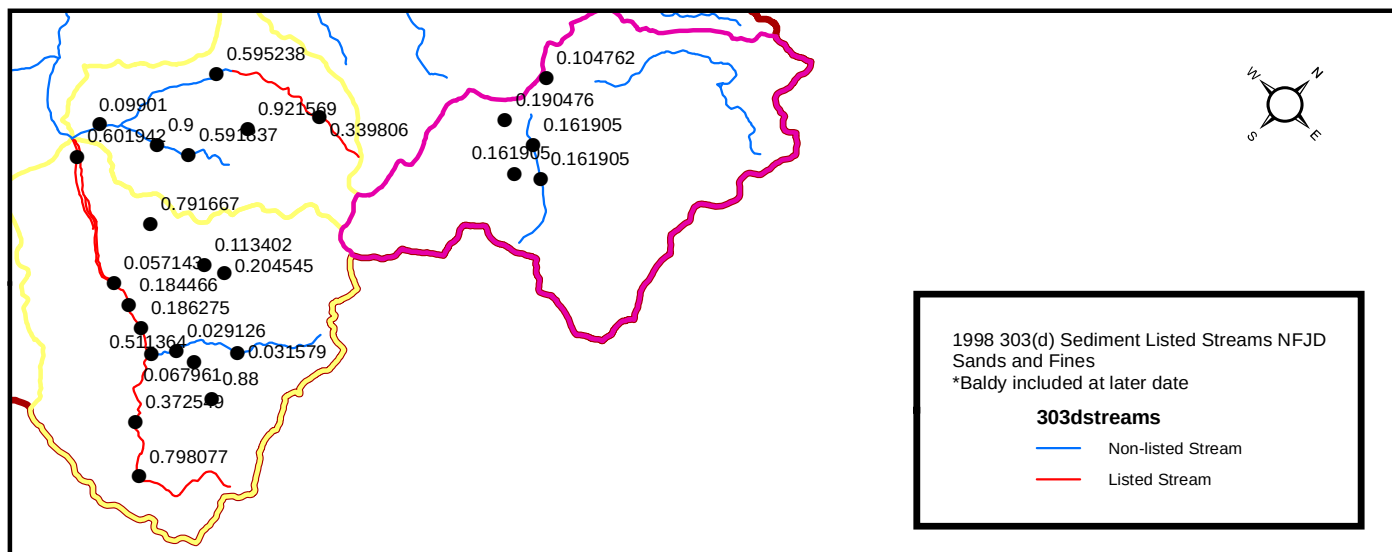
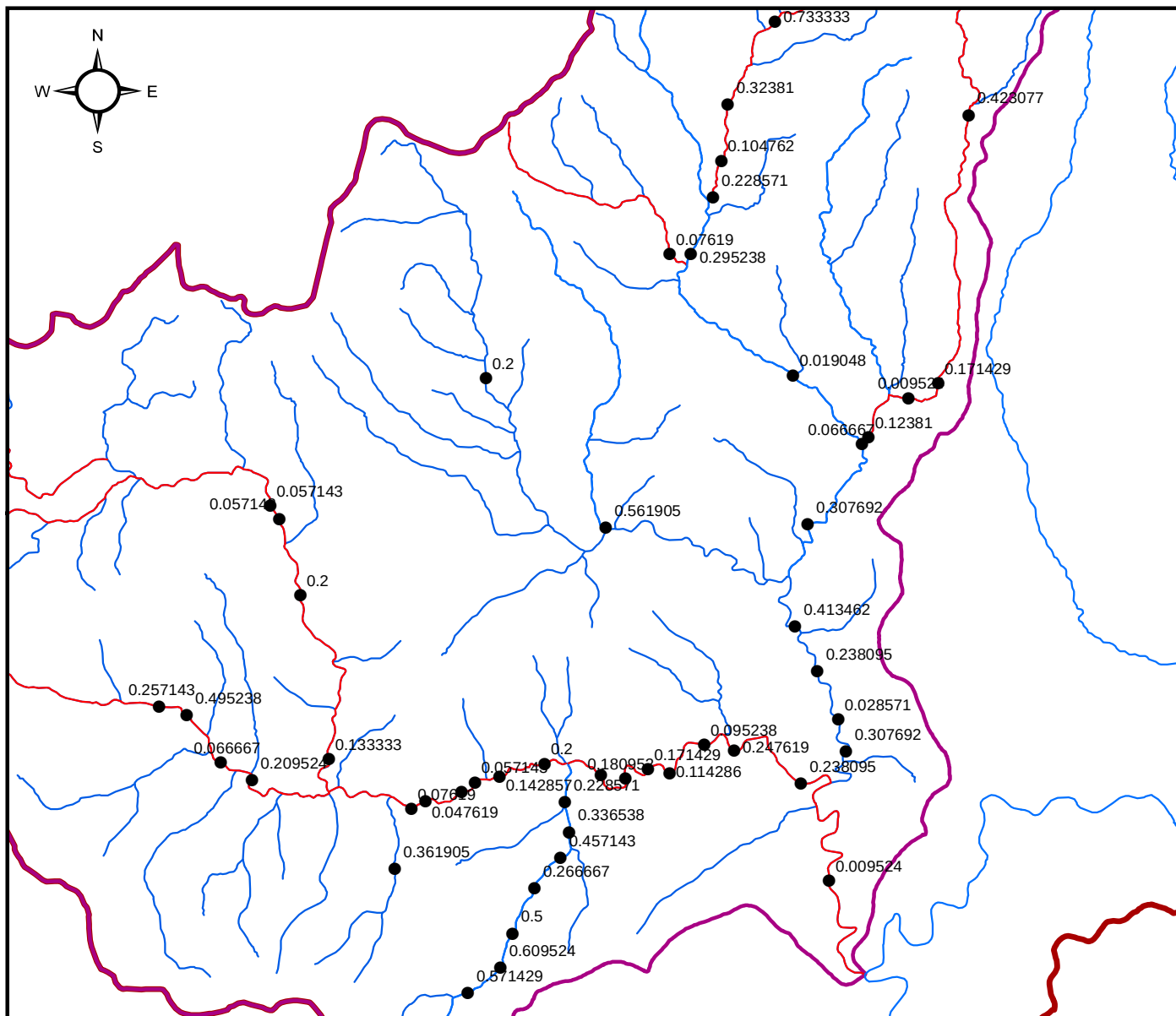
Table i - Historical Water Quality Data and Habitat Benchmarks (PACFISH and HABRATE)					
Stream Segment	%SAFN (Target < 20%)	LWD (PACFISH Target > 20/mile; HABRATE Target >20/100 meters)	Pools (PACFISH Target in (Pools/mile); HAB- RATE %Pools 40-60%*	Bank Stability (PACFISH Target >80%)	W:D!
Wilson 1	17	57/3.54	28.2 (6.7)	94	22.6
Wilson 2	7	10/0.62	29.9 (9.0)	94	18.2
Bull 1	76	10/0.62	1.2 (30)	88	2.2
Bull 2	66	19/1.18	nd	70	nd
Porter	26	1/0.06	26.7 (14.5)	73	15.3
Colvin 1	77	11/0.68	6.7 (39)	55	5.9
Colvin 2	82	35/2.17	nd	58	nd
Big Wall 3 - 97	11	13/0.81	28.2 (8.1)	98	18.2
Big Wall 4	nd	11.6/0.72	16.3 (15.7)	nd	8.3
Big Wall 5	nd	15.1/0.94	3.7 (23.8)	nd	21
Big Wall 1-97	21	1/0.06	18.9 (14.5)	93	26.7
Big Wall 2-97	8	8/0.5	19.4 (9.8)	91	29.6
Big Wall 1-92	nd	8.9/0.55	10 (10.6)	nd	24.4
Big Wall 2-92	nd	11/0.68	10 (10)	nd	22
Big Wall 3-92	nd	6.4/0.4	5.3 (11.3)	nd	28.1
Grassy Butte	100	3/0.19	5.5 (39)	75	8
Willow Springs	50	6/0.37	2.5 (39)	80	6.3
Alder 1	18	37/2.3	38.8 (16.1)	93	12
Alder 2	50	28/1.74	28.3 (24.6)	97	8.7
Alder 3	54	32/1.99	26.3 (39)	99	4.5
Alder 4	84	22/1.37	10.4 (39)	100	3.9
East Fork Alder	53	63/3.91	9.5 (39)	99	5.6
Hog 1	5	14/0.87	3.8 (15.6)	90	20
Hog	4	13/0.81	4.0 (17.8)	85	nd
Hog 3	18	10/0.62	11.8 (18.2)	91	3.5
Skookum 1	12	6.1/0.38	16.6 (13.5)	100	15.1
Skookum 2	19	10.4/0.65	19 (15.4)	99	13.9
Skookum 3	22	17.5/1.09	29.2 (39)	99	6.5
Swale 1	12	26.1/1.62	4.2 (17.4)	95	3.6
Swale 2	18.5	8.9/0.55	0.7 (28.4)	88	2.1
Swale 3	22	41.4/2.57	0.0 (39)	100	n/a
Little Bear	11	42.1/2.61	1.5 (39)	98	6.6
Bear	9	38/2.36	0.0 (39)	96	n/a
Dry Swale	12	13.5/0.84	1.0 (39)	94	9.3
Two Springs	16	21.1/1.31	1.5 (39)	96	5
* The HABRATE for pools is directly comparable to the EMAP data collected in 2008. ! 25th percentile of reference data is 6, average is between 10 and 12 Wildcat Vegetative Management Aquatics Report, March 26, 2007 and Biological Evaluation, Proposed, Engangered, Threatened, and Sensitivie (PETS) Fish and Aquatic Invertebrate Species and Habits, NFJD Ranger District, August 10, 2005)					

Table ii - Sediment Listing Justification of Streams on the 1998 303(d) List	
Stream	Basis for Listing
Alder Creek 0 to 5.5	Steelhead redds have shown declining trends over past few years, cobble embeddedness did not meet PACFISH objectives (Wall Ecosystem Analysis, 1995).
Baldy Creek 0 to 5	USFS Data shows large changes in erosion hazard between natural and current conditions.
Big Wall Creek 0 to 21.3	Steelhead redds have shown declining trends over past few years, cobble embeddedness did not meet PACFISH objectives (Wall Ecosystem Analysis, 1995).
Bull Run Creek 0 to 9.3	USFS Data shows large changes in erosion hazard between natural and current conditions. Degradation of stream habitat has reduced the potential for supporting fish.
Granite Creek 11.2 to 16.2	USFS Data shows large changes in erosion hazard between natural and current conditions. Degradation of stream habitat has reduced the potential for supporting fish.
Hog Creek 0 to 4.1	Steelhead redds have shown declining trends over past few years, cobble embeddedness did not meet PACFISH objectives (Wall Ecosystem Analysis, 1995).
Porter Creek 0 to 7.4	Steelhead redds have shown declining trends over past few years, cobble embeddedness did not meet PACFISH objectives (Wall Ecosystem Analysis, 1995).
Swale Creek 0 to 11.1	Steelhead redds have shown declining trends over past few years, cobble embeddedness did not meet PACFISH objectives (Wall Ecosystem Analysis, 1995).
Wilson Creek 0 to 10.7	Steelhead redds have shown declining trends over past few years, cobble embeddedness did not meet PACFISH objectives (Wall Ecosystem Analysis, 1995).
* All segments are listed for potential sediment impacts to Resident fish and aquatic life; Salmonid fish rearing; Salmonid fish spawning	
** Shaded streams are not in the Wall Creek Watershed	

Baldy Creek was identified as a reference watershed in ODEQ data provided by Dr. Chuck Hawkins. It is uncertain how the BCW was originally included as a reference watershed. One possibility raised was the potential for the designation was from Dr. Hawkins macroinvertebrate work conducted in the watershed. From what the ODEQ understood the ODEQ crews have never actually visited the BCW and the reference designation came from field observations which may not have included substrate but rather was focused on habitat. This allowed the ODEQ to include the sites in the macroinvertebrate models. Before the BCW is included in the pool of ODEQ reference watersheds the human disturbance index should be applied for consistency.¹ Baldy Creek is also listed as water quality limited for habitat modification and temperature in addition to sedimentation.² As defined by ODEQ Watershed Assessment section, reference conditions are based on levels of human activities (disturbances) in the watershed. Reference sites thus represent “least disturbed conditions” for any given region.³ There’s likely been little or no historic (nor recent) logging in the BCW. In 1997, the upper third of the watershed underwent an intense burn followed by a big storm cell, not unusual for the area. The granitic terrain naturally delivers abundant sand to slightly larger sized sediment. Mining activities were minimal. In the judgment of Paul Boehne and Brad Lovett at the Wallowa Whitman USFS office, the BCW has minimal human disturbance and is in good ecological condition.⁴ It was decided by the work group to include the BCW in the study population and not in the reference population to either confirm the BCW as a reference watershed or to confirm the listing.

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Karla Urbanowicz ODEQ Personal Communication
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1998 303(d) Sediment Listed Streams NFJD
Sands and Fines
*Baldy included at later date

303dstreams

- Non-listed Stream
- Listed Stream

Map i - Sites, Sands, and Listed Streams

Project Goals

The analysis is intended to meet multiple objectives of the BLM, USFS, EPA, and ODEQ. ODEQs interests related to methods for analyzing sediment impairment and water quality protection and restoration, using the TMDL process as mechanism for removing waters from the 303(d) list, and the utility of the method for addressing impairment and beneficial use analysis.

The results were intended to be evaluated for sufficiency in producing information for adequate for de-listing or yielding methods and targets suitable for defining sedimentation load allocations or surrogates. The following questions guided the development of this study:

- 1) Can we identify and/or characterize sedimentation concerns (in relation to the water quality standard) at relevant scales?
- 2) Do these concerns warrant a designation of impairment (adverse impact on beneficial use)?
- 3) Is sedimentation a limiting or controlling factor, with respect to impairment?
- 4) Are other types of impairment indicated?
- 5) As appropriate, given the proposed method of analysis and for the various sample/data types: are reference and sample data populations statistically similar?
- 6) Do the sample populations meet acceptable thresholds?

The ODEQ water quality standard for bedded instream sediments is currently in development. Previous benchmarks for sediment were based on population fine sediment averages and distributions in minimally disturbed watersheds within the study population ecoregion and lithological type. Additionally relative bed stability and other habitat metrics (averages and distributions) were considered when determining impairment. This weight of evidence approach will likely continue to be a dominant component of the future ODEQ sediment benchmark but the numerical criteria for RBS and fine sediments is going to change. The ODEQ is working through the Suspended and Bedded Sediments (SABS) process in order to develop numeric criteria for evaluating impairment by sedimentation.¹

The goals of the project were modified during the assessment to address the fluxuating benchmarks. Questions 1-3 and 6 were not analyzed given this fluxuation. This report focused on questions 4 and 5. The majority of the analysis addressed question 5. Brief analysis was dedicated to question 4 and was included in the discussion section.



Wall Creek Watershed Meadow

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Executive Summary

The Bureau of Land Management (BLM) contracted an assessment of 303(d) sediment listed streams within the North Fork John Day River (NF) in partnership with the United States Forest Service (USFS) and the Oregon Department of Environmental Quality (ODEQ) in 2008. This assessment was completed as part of a process to elucidate the current condition of the watersheds listed for sedimentation and to better understand the relationship between instream sediment and the biotic community. The Environmental Protection Agency's (EPA) Environmental Monitoring and Assessment Program (EMAP) physical habitat protocol was used to collect data at randomly seeded sites throughout the listed streams.

All 1st order (NHD 1:100k stream layer) streams within the Wall Creek Watershed (WCW) were dropped from the sample due to lack of flow during the summer in contrast with the 1st order streams in the Granite Creek Watershed (GCW), Baldy Creek (BCW), and Reference Watersheds. This is likely a result of the higher elevations. Low flows may interact with solar inputs to limit the quality of summer rearing habitat in the WCW especially in conjunction with downstream passage barriers. The confluence of Wall Creek with the mainstem NFJD was found to be dry, resulting in a flow dependent barrier to juvenile migration. Further smaller streams were found to be sandier overall suggesting that high summer temperatures which can force salmonids out of larger streams, may also cause steelhead to spawn in less successful areas.

Wall Creek Watershed Results

The WCW is a 5th field watershed dominated by a resistant lithology. For this reason comparisons to reference were conducted using the Blue Mountain Ecoregion resistant lithology reference population. Land managers within the watershed include the USFS, the BLM, and private owners. The hillslopes are managed for mixed use forestry, grazing, and recreation. Low intensity agriculture is common in the lower watershed.

Instream conditions within the WCW are similar to those found within minimally disturbed resistant reference watersheds. When compared to reference, the WCW is more stable (i.e. the WCW has lower LRBS values; WCW LRBS = -.28; Reference LRBS = -.97), has a similar W:D (WCW W:D = 12; Reference W:D = 11), exhibits a similar proportion of instream fine sediments (WCW Fines = 6%; Reference Fines = 7%), and a slightly higher proportion of instream sands and fines (WCW SAFN = 24%; Reference SAFN = 18%).

Baldy Creek Watershed Results

The BCW is underlain by glacial deposits similar to those which underlie the erodible reference sites. The hillslopes are dominated by plutonic (resistant) rocks and the stream network is dominated by surficial sediments. For this reason comparisons to reference were made using the entire Blue Mountain Ecoregion reference data population.

The BCW is more stable (BCW LRBS = -.45; Reference LRBS = -1.04) and exhibits a lower proportion of sands and fines (BCW %SAFN = 16%; Reference %SAFN = 21%) than reference. The historical reference site collected in 2001 had a %SAFN value of 40%. The proportion of sands and fines is nearly 50% less however in Baldy than in the erodible reference population. Pool volume is similar to reference (6.6 versus 7.2). Wood volume and width to depth ratios are also similar to reference (.035; 9.3 respectively).

Granite Creek Watershed Results

The lithology within the GCW is mixed resistant and erodible, for this reason comparisons to reference were made using the entire Blue Mountain Ecoregion reference data population. The GCW is almost entirely managed by the USFS (mixed use).

The GCW has the lowest LRBS value (both population averages and individual site data; GCW LRBS = -1.45; most unstable site LRBS = -3.7) and is the least stable stream network evaluated in this study. Additionally, the GCW has the highest proportion of sands and fines (GCW %SAFN = 41%; reference %SAFN = 21%) and fines (17% versus 8% respectively). Pool volume in the GCW is similar to that of the reference population (GCW RP100 = 6.7; Reference RP100 = 7.2). Wood volume in the GCW is similar to that of the reference population (GCW RW = .03; Reference RW = .03). Width to depth ratios within the GCW are half of reference (W:D = 4.9 versus 9.6 respectively).

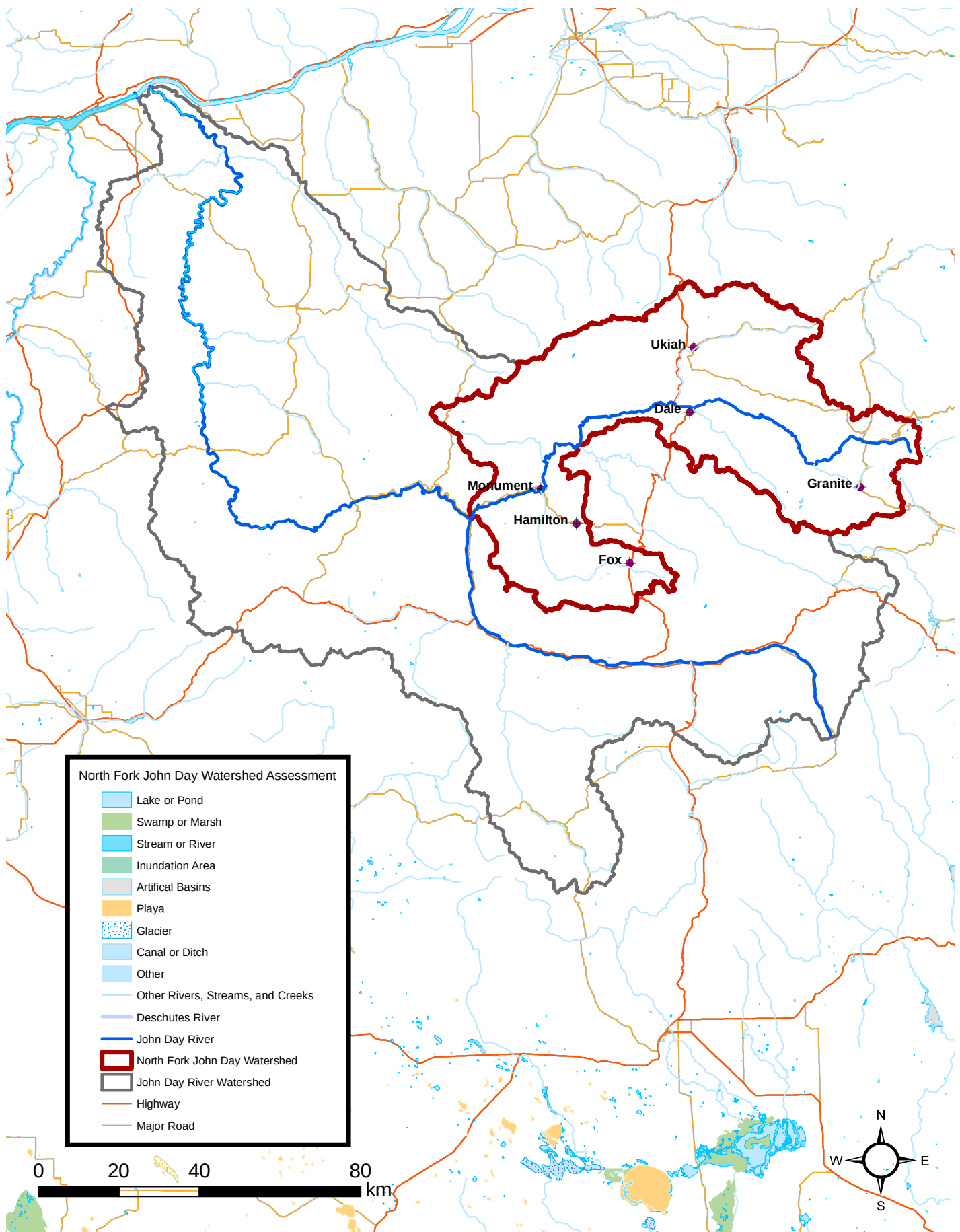
Introduction and Background

This assessment was conducted between 2008 and 2009 under contract to the BLM. The purpose of this assessment was to determine the condition of several watersheds within the NF (NF HUC # 170702). The watersheds evaluated during this assessment were the Wall Creek Watershed (WCW; 5th Field HUC# 17070202), the Granite Creek Watershed (GCW; 5th Field HUC# 1707020202; Bull Run 6th Field HUC #1707020202 and Upper Granite 6th Field HUC #170702020201), and the Baldy Creek Watershed (BCW; 6th Field HUC# 170702020101). The John Day River Basin is approximately 8100 square miles in drainage area, the 4th largest basin in the state. The area of the NF subbasin is approximately 1800 square miles. The NF is located in eastern-central Oregon in the Blue Mountains Ecoregion. The Mainstem John Day River is ~284 miles long. The John Day River is the longest, free-flowing river in the Oregon making it an important river for salmon. Although the mainstem John Day River is the second longest free-flowing river in the United States, low flows often serve as a barrier to fish passage in many tributary system despite the absence of dams and high temperatures serve as barriers to juvenile fish. Water withdraw occurs throughout the NF and many of its tributaries. Beneficial uses of water in the John Day basin are: public and private water supply; industrial water supply; irrigation; livestock watering; anadromous fish passage; salmonid fish rearing and spawning; resident fish and aquatic life; wildlife and hunting; fishing; boating; water contact recreation; and aesthetic quality.¹

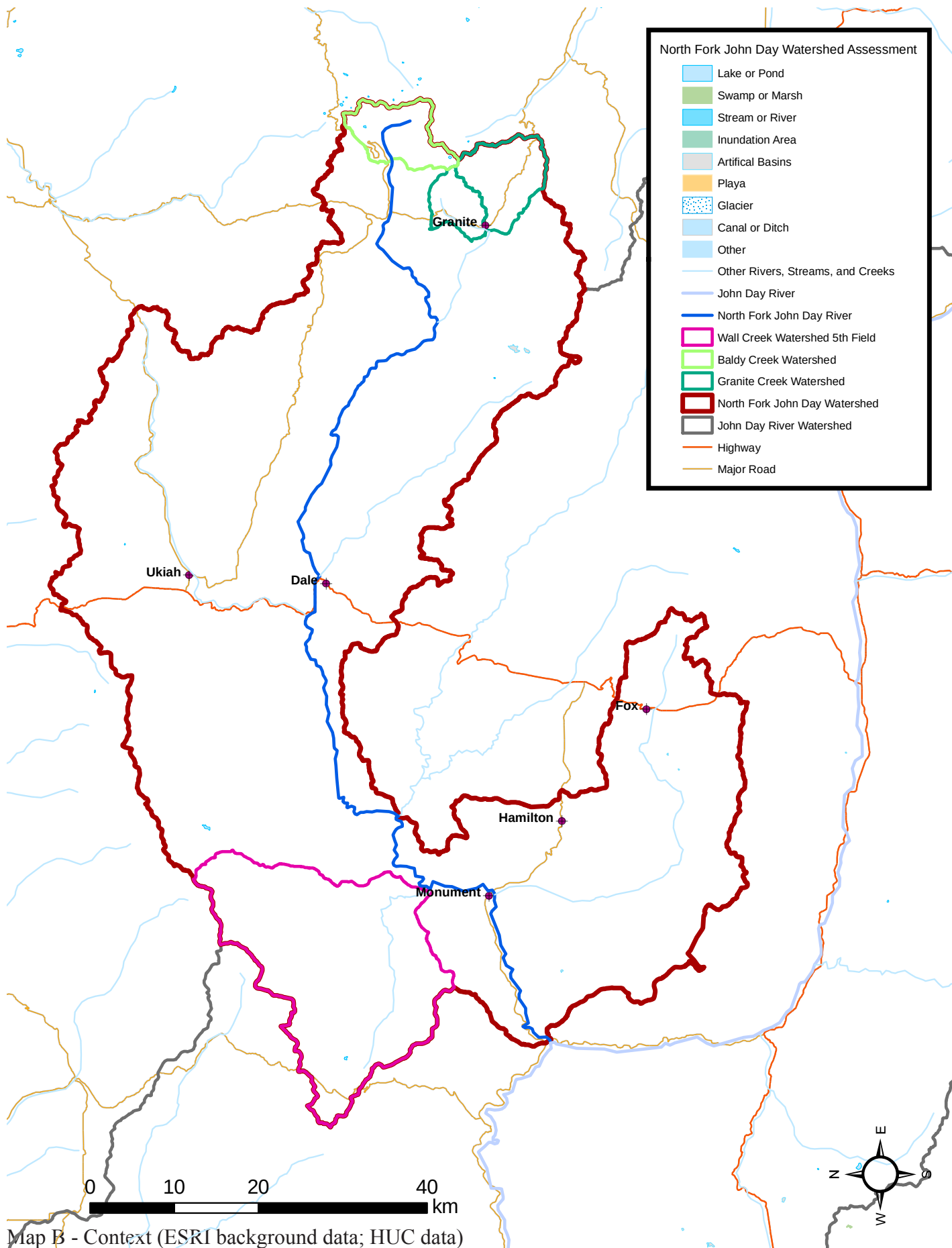
Approximately half of the NF is comprised of basalt and more than half is comprised of resistant materials. The WCW has a nearly identical proportion of basalt but is comprised of significantly more mixed rock types (~48%) which are classified in the Oregon Geologic Data Compilation data layer (OGDC; release 5) as primarily granite rock forms. The WCW is relatively simple in regards to geology. There are minimal rock types and ~98% of the rock types belong to one of two classes. This is in contrast to the GCW with only 13% basalt rock type and 33% fine grained sediments and another ~37% belonging to either intermediate or mixed lithologies. Baldy is ~66% intermediate composition lithologies, 10% fine grained sediments, and 20% mixed grain sediments with no basalt rock types.²

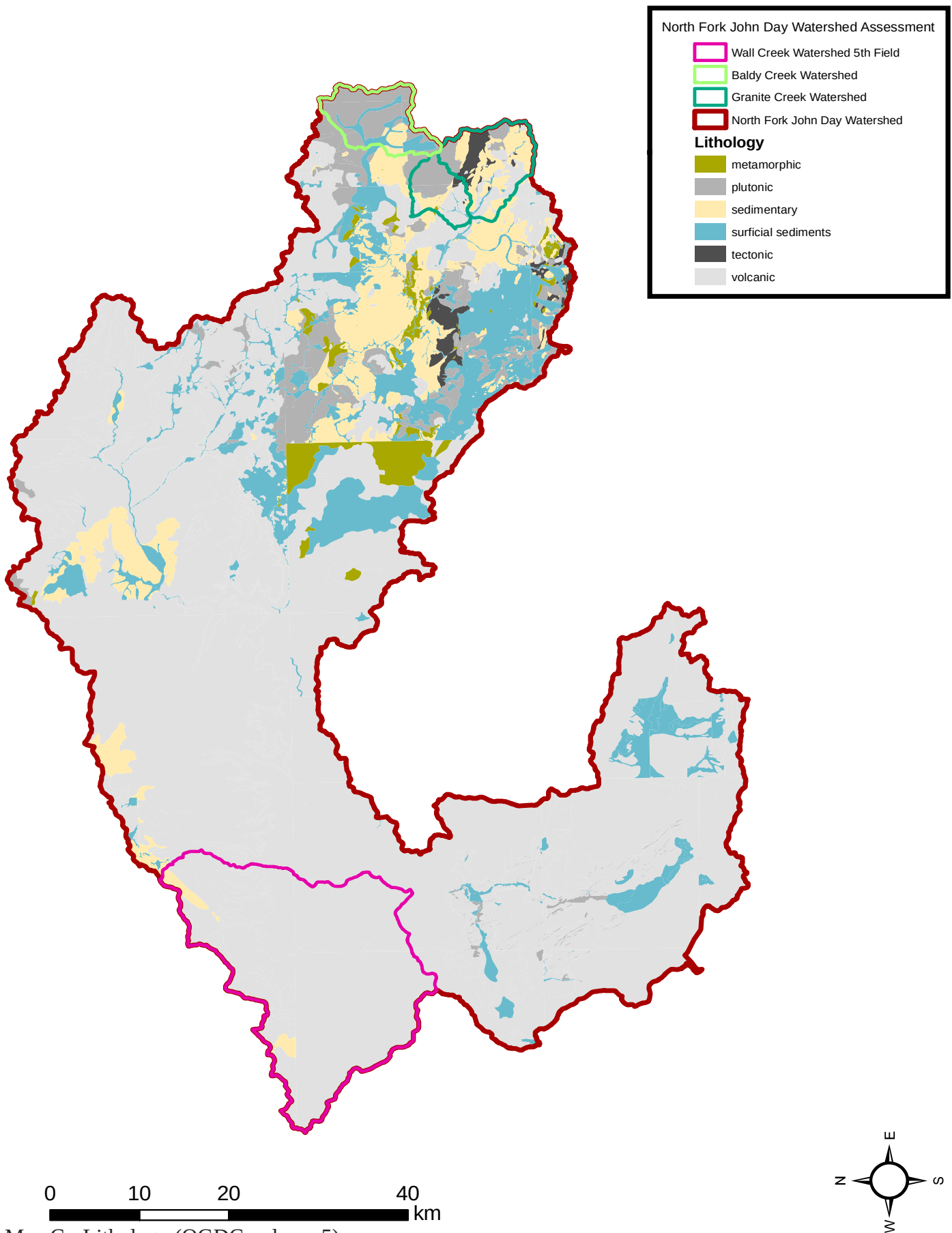
The NF provides nearly 120 miles of mainstem habitat but over 2400 miles of stream network. This distinction is important when considering the supply of sediments to critical salmonid spawning habitat. The NF contributes roughly 60% of the total flow to the John Day River. The NF is listed as a wild and scenic river from Camas Creek to the headwaters. There are significant human uses present within the watershed both historically and presently. Mining was very common historically and is still present to a smaller extent. Hydraulic mining was used to wash soil and gravel away to expose the gold ore. Dredges were used in the streams to dig up the deposited gravel and sift out the gold. The Oregon Department of Geology and Mineral Industries (DOGAMI) estimates that at least 13 million cubic yards of material was handled on the North Fork-Granite Creek-Clear Creek system. Forestry is another dominant landuse with the majority owner in many Blue Mountain watersheds being the USFS. Grazing on private and federal lands is much less prevalent today than between 1850 and 1900, but hay farming and other agricultural practices are still common in the area (lesser common crops include alfalfa, orchard fruits, and mint). Most hay produced is used to feed wintering cattle and although livestock production is less common than historically, cattle production accounts for over 70% of the agricultural income in the area. Range forage provides over 50% of the year-round cattle feed with hay and pasture providing the remainder. Approximately half of the cattle operations use BLM or USFS range on a permit basis. (North and Middle Forks John Day River Agricultural Water Quality Management Area Plan) Hunting is present throughout most of the Ecoregion on public lands. The NF has water rights, administered by the Oregon Water Resource Department (OWRD), for 536.0 cubic feet per second (cfs), mainly for irrigation (291.5 cfs) and mining (202.2 cfs). Annually, a total of 13,400 acres are irrigated, mostly by sprinklers, requiring 17,800 acres feet of water. Minimum stream flows were established in 1962 at Monument (55 cfs) and Dale (30 cfs). Some water may be diverted from the North Fork to the Umatilla basin (25-28 cfs) and the NF Burnt River (22 cfs) for irrigation. There are currently 15 instream water rights.³

1 <http://www.deq.state.or.us/WQ/standards/uses.htm>
2 Ma, L., Madin, I., Olson, K., Watzig, R.; Oregon Geologic Data Compilation (OGDC) Release 5; Oregon DOGAMI; 2009
3 Local Advisory Committee Members; North and Middle Forks John Day River Agricultural Water Quality Management Area Plan; 2002

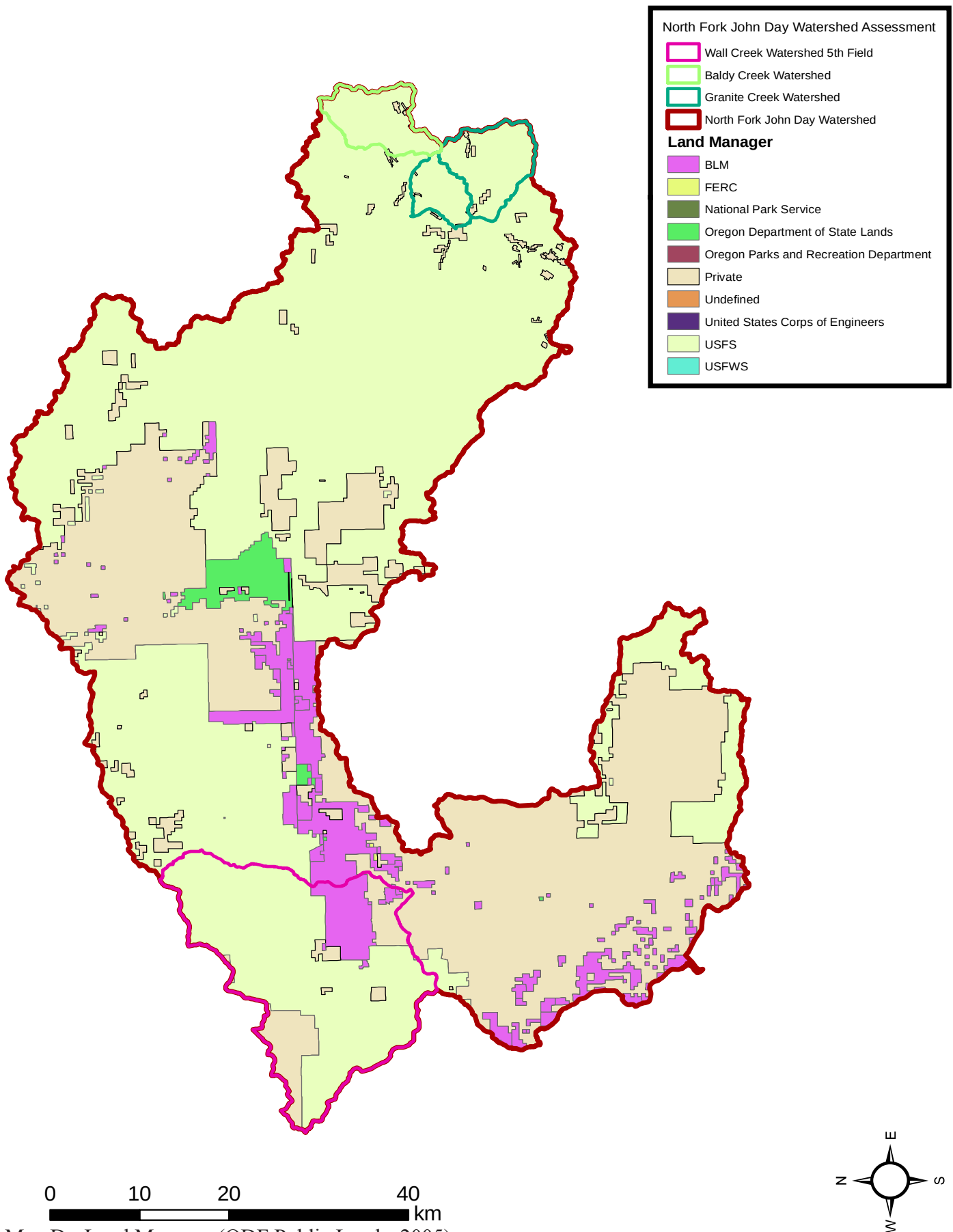


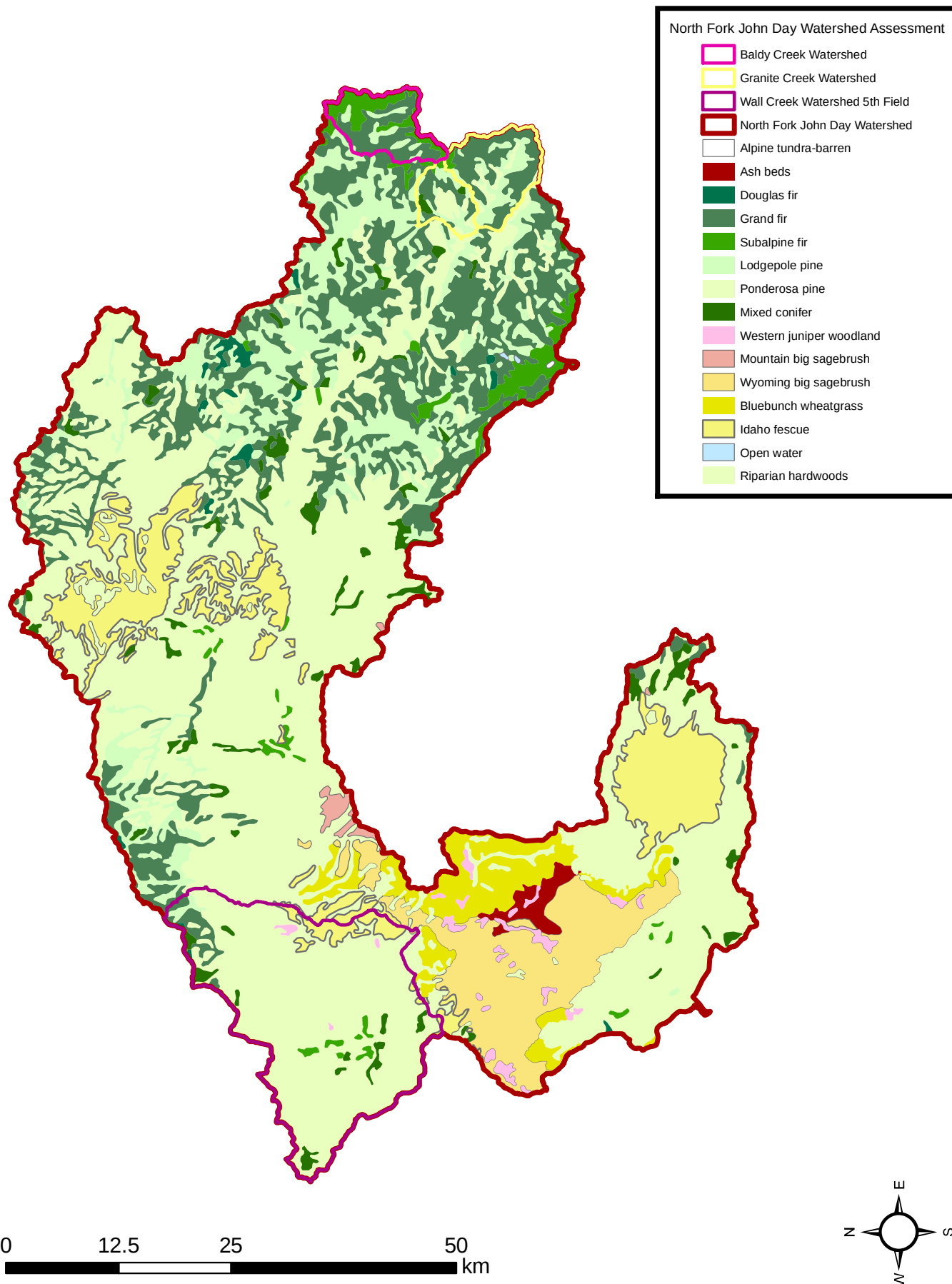
Map A - Context (ESRI background data; HUC data)





Map C - Lithology (OGDC; release 5)





Map E - Historical Vegetation (GAP Analysis)

The Wall Creek Watershed

The WCW is located in the northwest corner of the Assessment area while the GCW and BCW are both located on the south east boundary of the Assessment area. The mainstem of Wall Creek is ~14 miles in length and contains a total of 240 stream miles (NHD 1:100k Hydro Layer). The WCW contributes an estimated 8% total flow to the NF. The confluence of WC with the NF is near the city of Monument. Precipitation falls predominantly in the form of snow with rain ranging from 15 inches in the lower WCW up to 35 inches in the upper WCW¹. There is ~30 additional inches in snow water equivalent (extrapolated from Madison Butte data)². Peak flow events are often triggered by rain on snow or rain on melting snow between the months of April and July. Riparian habitat has been disrupted to the point that streams within the assessment area often do not access their associated floodplains. Beavers have nearly been extirpated throughout the assessment area. Grazing is a significant use in the WCW with several allotments in active use throughout the watershed. The USFS has fenced the riparian corridor along streams where active cattle grazing occurs. The ~128,287 acres within the WCW is predominantly managed by the United States Forest Service (USFS; 75%; 95,677 acres) followed by private landowners (15%; 20,247 acres) and the BLM (10%; 12,363 acres).

The Granite Creek Watershed

Granite Creek is adjacent to Baldy Creek in the upper NF. Granite Creek (the two 6th fields surveyed; 28,706 acres) provides 65 miles of stream network. Precipitation falls predominantly in the form of snow with rain ranging from 30 inches in the lower GCW up to 40 inches in the upper GCW³. There is ~60 additional inches in snow water equivalent (Gold Center data).⁴ The GCW is predominantly managed by the USFS (97%) while private landowners manage only 948 acres (3%). The entire Granite Creek Watershed includes 94,485 acres and 15 subwatersheds although only streams with a 303(d) listing for sediment were surveyed. Ownership patterns are similar for the larger 5th field with 95% USFS ownership and 5% private ownership. There are numerous mining claims (primarily gold and silver) in the GCW and a dense road network. A significant portion of the 5th field is designated as wilderness but none of the surveys were within that designation.

The Baldy Creek Watershed

Baldy Creek (a 6th field; 17,270 acres) provides ~30 miles of stream network. Precipitation falls predominantly in the form of snow with rain ranging from 35 inches in the lower GCW up to 40 inches in the upper GCW⁵. There is ~60 additional inches in snow water equivalent (Gold Center data).⁶ The BCW is also predominantly managed by the USFS with 16,844 acres (98%) followed by private ownership at 425 acres. The BCW lies mostly within a designated wilderness area.

Table 1 - Sedimentation 303(d) listed streams in the North Fork John Day	
Water Body (Stream/Lake)	River Miles
Alder Creek	0 to 5.5
Baldy Creek (BCW)	0 to 5
Big Wall Creek	0 to 21.3
Bull Run Creek (GCW)	0 to 9.3
Granite Creek (GCW)	11.2 to 16.2
Hog Creek	0 to 4.1
Porter Creek	0 to 7.4
Swale Creek	0 to 11.1
Wilson Creek	0 to 10.7

1
2
3
4
5
6

ESRI Climate Servers
John Day Basin SNOTEL Sites
ESRI Climate Servers
John Day Basin SNOTEL Sites
ESRI Climate Servers
John Day Basin SNOTEL Sites

Fish Usage¹

General

The John Day River Basin supports the largest remaining exclusively wild runs of spring Chinook and summer steelhead, of which the North Fork supports 70% and 43% of the adult population respectively.² The John Day Recovery Unit includes bull trout from three watersheds: the North Fork John Day River, the Middle Fork John Day River and a portion of the Upper Mainstem John Day River. The upper mainstem reaches are also occupied by bull trout. However, harvest of bull trout is prohibited because of their threatened status (ESA). Very little information regarding harvest rates of resident trout species is available. Catch of westslope cutthroat and redband is limited by ODFW angling regulations. Coho and chum are considered extinct in the Upper Columbia and Snake River Basins, at least 5 stocks have also gone extinct, and 60% of the remaining stock is listed as depressed, threatened, or endangered.

Westslope Cutthroat Trout

Westslope cutthroat trout in Oregon are found only in the John Day River Subbasin. Historically, westslope cutthroat trout were limited to the Upper John Day River and select tributaries. Today, however, they are found in the North Fork John Day River watershed as well. Westslope cutthroat were introduced into Clear and Desolation creeks (North Fork John Day River tributaries) from Deardorff Creek (Upper Mainstem John Day River tributary) in the early 1960s to reestablish a fishery after extensive spruce budworm spraying eliminated aquatic life in portions of those streams.

Bull Trout

Bull trout within the subbasin is limited to the resident form, particularly in the Middle Fork. Historically, bull trout exhibited more diverse life history patterns than at present. Larger historic populations of chinook salmon, steelhead, cutthroat and redband would have provided a large forage base for bull trout. A larger forage base would have favored the highly predatory, migratory (fluvial) form, which can grow as large as 20 to 25 inches in length. Another unique feature of bull trout is their tolerance for and growth rates in cold water. Optimum growth of bull trout fry occurs at 39 to 40° F. Historically, bull trout are estimated to have occupied about 60% of the Columbia River Basin. Presently bull trout occur in 45% of their estimated historical range. Juvenile bull trout utilize the interstitial space for cover making this species sensitive to changes in bed load structure and flow during incubation and rearing a potential hazard to survival. It is estimated that the NF could support ~2000 spawning pairs of bull trout were the habitat to recover.

Steelhead and Redband Trout

Prior to their listing as threatened steelhead, annual estimates of steelhead caught by anglers was 4700 wild fish and harvest rates estimated at 12% of escapement. After listing in 1996, steelhead fishing is limited to marked, hatchery fish straying into the John Day River from other Columbia River tributaries (consumptive) and catch-and-release for wild fish. Redband trout have adapted to relatively warmer water temperatures, with optimum growth at 55 to 64° Fahrenheit.

Chinook

Harvest of spring Chinook has not been allowed in the John Day River Subbasin since 1976. The Confederated Tribes of the Umatilla Indian Reservation is allowed to harvest no more than 5% of the estimated number of spring Chinook returning to the subbasin for subsistence. Recently, this harvest has occurred only in the NF and the GCW. An escapement goal of 7000 spring Chinook returning to the mouth of the John Day River was set as part of the settlement in U.S. versus. Oregon. This goal must be reached before any new take (either tribal or recreational) is allowed in the larger John Day Subbasin. The quality of the habitat used by spring Chinook in the upper John Day drainage has been stable to improving, except in the area used by the Granite Creek population. Chinook smolt production for the NF is estimated at 42,130, much higher than surrounding watersheds of similar size. ODFW has estimated the recent Chinook smolt production for the John Day River: 2001 – 92,900; 2002 – 103,100; 2003 – 83,950; 2004 – 91,400.

¹
²

(Unless noted, this information is summarized from the John Day Subbasin Plan, 2005).
North Fork John Day River Basin Anadromous Fish Enhancement Project; CTUIR; 2003

Fisheries Limitations

Current salmonid use of the North Fork John Day River is much lower than historical use. This is attributed to several causes: dams and other barriers to passage; low flows from withdraw and climate change; decreased dissolved oxygen from algal blooms associated with nutrient rich runoff and increases in stream temperature from riparian degradation; decreased habitat complexity from human uses; and increases in instream sedimentation from numerous sources. The following section summarizes the top three freshwater fisheries limitations within the John Day Subbasin: Dams and Barriers to Passage; Temperature; and Habitat Modifications (of which increased sedimentation and spawning habitat reduction is one).



Juvenile Trout in WCW - Stream at this site exhibits poor sorting and siltation of gravels

Dams, Barriers to Passage, and Hatchery Impacts

Columbia River dams serve as passage barriers to adult salmonids, cause mortality for adults and juveniles (~50%-75% of Chinook adults and ~93% of Chinook juveniles), and reduce individual vigor. Estimates of salmonid usage of the Columbia River suggest that prior to the 1850s ~88% of salmonid spawning occurred upstream of the Bonneville dam, this decreased to ~44% by 1980s. Prior to the damming of the area between the present day Bonneville dam and the confluence of the Snake River with the Columbia River, this region produced an estimated 340,000 chinook, coho, and steelhead. Anadromous fish are no longer found in the Metolius River, the Crooked River, or the Deschutes River upstream of the Pelton Dam. Given the number of dams on the Columbia River upstream of the confluence with the John Day River and the number of dams on most of the Columbia River tributaries excluding the John Day River, it seems plausible that the majority of the returning adults that spawn upstream of the Bonneville dam do so in the John Day River. The John Day dam, the third largest dam in the US, was built in 1968-1971 immediately downstream of the confluence of the John Day with the Columbia River. Before the dams construction the John Day River supported roughly 26,000 salmonids, the majority being Steelhead, and this number is thought to have been well below what the river could actually support given the impacts on fish from mining and agriculture, which were already extensive. Irrigation and riparian vegetation removal had altered flow and temperature so much so that Chinook populations (late summer and fall) were decimated by the early 20th century.

Multiple hatcheries were constructed post 1950s to mitigate the impact on native salmonid fisheries from dams, fishing, and other factors. In the early 1950s hatcheries received ~50% of the mitigation plans funding while habitat improvement received ~5%. Hatchery funding increased to 72% of the total mitigation budget by 1980 with the remaining funds going towards pollution abatement and other measures. There are no hatcheries in the John Day Subbasin. In 1966 ocean fishing had harvested ~27,000 Columbia River hatchery Chinook salmon or ~80% of the total hatchery production. The spring Chinook and summer steelhead populations in the John Day River have local as well as regional significance because they are not supplemented with hatchery fish. The John Day River is managed exclusively for wild fish production and may be the only large Columbia River tributary that has no hatchery stocking program for anadromous fish.

Temperature

Following dams as a major factor in the decline of salmonid populations in Oregon is the direct mortality from elevated instream temperature. Most of the North Fork John Day River Watershed is listed for elevated temperatures during rearing season exceeding not only the stress temperature limit but the mortality limit as well. This is exacerbated by water withdrawal (Flow is a limiting factor for summer steelhead and for spring Chinook impacting 40% of the geographic area of the John Day River watershed) and perhaps also by climate change¹, “The hydrologic curve has shifted from historic times, with peak flows greater than in the past and late season flows more diminished. It is suspected that these effects are due to greatly reduced rates of soil infiltration, reduced capacity for ground water/riparian storage, and diminished inchannel storage in beaver ponds.”² Temperature is a limiting factor for spring Chinook and summer steelhead in 40 to 50% of their range in the John Day River subbasin. The predominant cause of elevated instream temperatures within the North Fork John Day River watershed is a reduction of riparian vegetation from past logging in the riparian corridor, active grazing to the stream channel, and mining activities. Instream temperatures exceeded the state water quality standard for salmonid rearing of 64°F at all stations (7 day average maximum) as reported in the 1994 Wall Creek Ecosystem Analysis. Additionally temperature ranges were similar to recordings taken 30 years prior. The five hottest stations were Swale Creek Middle Reach (84.2°F), Lower Indian Creek (83.4°F), Wall Creek at the Forest Boundary (80.4°F), Wilson Creek up stream of Wall Creek (80.0°F), and Wall Creek at the mouth (77°F). Four out of five of these stations exceed the juvenile lethal temperature limit. Cutthroat and 1+ Steelhead rearing densities decrease as temperatures exceed 62.6 F.³ Refer to Table 2 for Coho Sensitivity by Life Stage temperature limits.

Table 2 - Temperature Tolerance of Coho Salmon* (Sensitivity by Life Stage)		
Juveniles UILT:	26° C	78.8 F
CTM :	24.4° C	75.92 F
Growth Stops	20.3° C/19.1° C/18 C°	68.54 F/66.38 F/64.4 F
Optimum Growth	12-14° C/10-15.6° C/9-13° C	53.6-57.2 F/50-60.1 F/48.2-55.4 F
Growth Occurs	5-17° C	41-62.6F
* Temperature tolerances are similar for salmonids with bull trout being the most sensitive. http://www.krisweb.com/stream/temperature.htm		

Habitat Modification

Habitat modification is also a limiting factor of salmonid production. The removal of large wood, riparian vegetation, and other habitat elements can disturb the salmonid spawning and rearing capacity of a stream network. Surficial fine sediments can cause direct mortality of spawned eggs by encasing or entombing developing eggs in a shell of clay or by reducing the total available dissolved oxygen (embedding the interstitial space with sands). Empirical evidence suggests that egg emergence is decreased when fines are at or above 20% embeddedness (volumetric not surface fines; maximum fining is set at ~24% fines in a volume).⁴ A lack of suitable spawning and rearing habitat was found to be a limitation for both steelhead and Chinook in the John Day River watershed. Instream sediment loading is a limiting factor for ~30% of the historical habitat area and 60% of steelhead habitat area. NOAA Fisheries monitoring suggested that the NFJD suffers from mass wasting and surface erosion to a greater degree than historically would be present.⁵

Decreases in habitat diversity was found to be a limitation in 70% of the geographic areas of spring Chinook and steelhead. It is estimated that there has been a loss of 60% of pool habitat between current and historic conditions for the region.

1 Graves, D.; A GIS Analysis of Climate Change and Snowpack on Columbia Basin Tribal Lands; The Columbia River Inter-Tribal Fish Commission; 2008
2 John Day Subbasin Assessment
3 <http://www.krisweb.com/stream/temperature.htm> (Sensitivity by Life Stage)
4 McCullough, Dale, M. Greene, “Monitoring Fine Sediment; Grande Ronde and John Day Rivers”, 2001-2003 Final Report, Project No. 199703400, 170 electronic pages, (BPA Report DOE/BP-00004272-2)
5 McCullough, Dale, M. Greene, “Monitoring Fine Sediment; Grande Ronde and John Day Rivers”, 2001-2003 Final Report, Project No. 199703400, 170 electronic pages, (BPA Report DOE/BP-00004272-2)

Habitat Improvement Goals, Strategies, and Actions

The USFS has constructed riparian fencing and removed mine tailings impacting roughly 72.5 miles of degraded stream reaches in the upper North Fork of the John Day Subbasin. Additionally the Oregon Department of Fish and Wildlife (ODFW) has conducted habitat improvement projects within the North Fork Subbasin such as fencing eleven miles of stream on Cottonwood and Fox Creeks, fencing two miles on Camas Creek (on private property), and fish ladder construction on Five Mile Creek which provided access to 25 miles of previously unavailable spawning habitat which was blocked by a waterfall. As the region is very remote it is difficult to conduct the landowner outreach needed to complete habitat restoration on private lands.

The John Day Subbasin Plan included several restoration goals for the John Day River Watershed:

Within 25 years:

1. Restore the freshwater productivity of steelhead and chinook populations to the 25-year levels;
2. Restore adult returns of steelhead and chinook populations to the 25-year levels;
3. Allow limited fisheries on the strongest populations;

Within 50 years:

4. Achieve the freshwater productivity of steelhead and chinook populations to the 50-year levels;
5. Achieve adult returns of steelhead and chinook populations to the 50-year levels;
6. Support annual fisheries on all populations;
7. Reestablish connectivity between existing populations to allow metapopulation interactions;
8. Some populations should be expanding beyond their baseline distributions.

The 10 restoration strategies are:

- Strategy A: Improve fish passage
- Strategy B: Install fish screens on water diversions
- Strategy C: Flow restoration
- Strategy D: In-stream activities
- Strategy E: Riparian habitat improvements
- Strategy F: Control pollution sources
- Strategy G: Protect existing high quality habitat areas
- Strategy H: Upland improvement projects
- Strategy I: Education/outreach
- Strategy J: Manage recreational/tribal fisheries

Priority Rankings

The plan identifies restoration priorities within three geographic areas of the John Day Subbasin:

- Lower and Middle Mainstem John Day River (below Kimberly)
 - Middle Fork and North Fork John Day River
 - Upper Mainstem and South Fork John Day River
- o First priority – Protection of existing habitat
 - o Second priority – Passage and riparian habitat improvements
 - o Third priority – Fish screens
 - o Fourth priority – Instream habitat improvements, upland restoration, and flow restoration.



Mainstem North Fork John Day River

Materials and Methods

Sampling Protocol

Site selection was based on protocols developed by the EPA to support EMAP surveys throughout the nation. Stratified random sampling was used to characterize the condition of the listed stream reaches and upstream tributaries. Sites were field verified for stream conditions and access issues and were adjusted as necessary. An estimated 33% of the stream network sample frame (NHD 1:100K) is considered perennial. This resulted in a dense sample of mainstem Wall Creek and its tributaries and a moderately dense sample of Granite and Baldy creeks. The EMAP protocol is considered a low flow survey which limited instream time to late July through early September (access limitations from snow became an issue in the higher elevation watersheds). Further, some sites were revisited after the initial survey were found to be dry towards the end of the survey window.

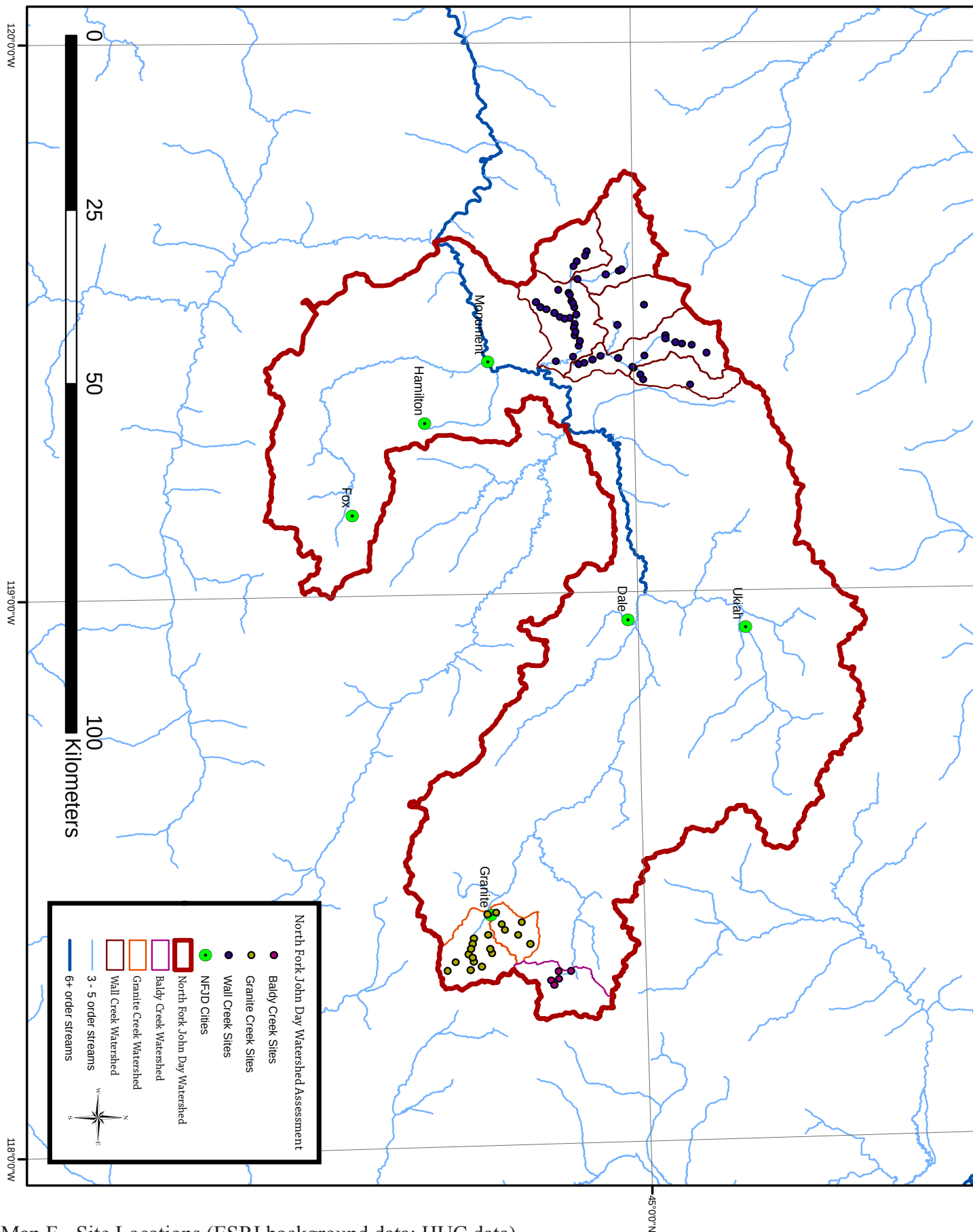
Baldy Creek is listed for sedimentation but also is considered an ODEQ reference watershed. The original 303(d) listing was based primarily on potential impacts of recent forest fires on soil erosion while the reference designation does not take fire into account, and is instead based upon GIS indicators of landuse, and is finalized with a field verification. BCW data was not included in the reference pool, rather it was evaluated as a unique sub-population. It is likely that the BCW data would serve as a more appropriate reference for the GCW than streams in the larger Blue Mountain Ecoregion (refer to discussion on reference).

Sites were selected from the “Master Sample” produced by the EPA research lab in Corvallis, Oregon. The Master Sample was developed in support of statewide efforts to coordinate monitoring efforts. It is a statewide panel of random sites drawn from the National Hydrography Database Plus (NHDPlus) using the General Random Tessellation Stratified (GRTS) algorithm.¹ It contains thousands of sites seeded at roughly 1 km intervals along the stream network. By utilizing a subsection of the Master Sample, the data collected in this study can now be easily integrated into regional assessments and future monitoring.

Sites were clipped from the statewide “Master Sample” using the four study area Hydrologic Unit Codes (HUC; WCW 5th Field HUC# 17070202; Bull Run 6th Field HUC #170702020201 and Upper Granite 6th Field HUC 170702020202; BCW 6th Field HUC# 170702020101). Reference sites were identified by extracting all Master Sites within reference watershed boundaries provided by ODEQ staff. All reference watersheds are within the Blue Mountain Level III Ecoregion. One data layer comprises the areas identified by ODEQ as meeting reference standards. A second data layer comprises areas identified by Chuck Hawkins during the development of the ODEQ’s macro invertebrate stressor model. It has been observed that 1st order streams on the NHD+ are generally 3rd or even 4th order based on the stream network defined using 1:24K hydro coverages. This should be considered when interpreting the results of the study. Sites were weighted during analysis to account for all changes in the sample frame and study design.

Table 3 - Sites Visited			
Watershed	HUC	Final Sites	Original SAP
Wall Creek 5th Field	17070202	52	40
Upper Granite 6th Field	170702020201	10	10
Bull Run 6th Field	170702020202	10	10
Baldy	170702020101	5	5
Additional NFJD Reference Sites	17070202	5	5
Blue Mountain Reference Sites Outside the NFJD	NA	14	20

1 Stevens, D. and Olsen, A.; Spatially Balanced Sampling of Natural Resources; Journal of the American Statistical Association V99(465) pp 262-278; 2004



Site sampling was proportional to the size of the watershed containing the listed segment. In other words the 5th field watershed contains a greater number of sites to get a more accurate result whereas the smallest 6th field only contains 5 sites as this will be adequate (given limited resources) to determine current condition. Further the Blue Mountain Ecoregion contained 30 sites of reference data, which with the additional 18 sites (23 is BCW is included) nearly doubles the existing reference pool. These sites were limited in their spatial balance (unbalanced across the entire Ecoregion but balanced within reference watersheds) as very few watersheds meet ODEQ reference standards.

The Oregon Geologic Data Compilation release 4 (obtained from DOGAMI following consultation with DOGAMI staff) was evaluated to determine if stratifying by lithology was necessary. Release 5 was used for mapping and analysis purposes and to reassess the validity of the original SAP. All rock types were divided into erodible and resistant categories. Sedimentary and surficial types were classified as erodible, and all volcanic or plutonic rock types were classified as resistant. Some rock types, such as ‘Mixed Terrane’ could not be classified either way. Based on this analysis, stratification by geology was deemed unnecessary. The Wall Creek Watershed is dominated by a resistant lithology while the Baldy Creek Watershed is mixed with the stream network underlain by glacial surficial deposits and the hillslopes in the study area dominated by an erodible lithology, obviating the need for stratification. However, for a conservative comparison, the BCW was compared to the entire reference population. The geology of the two Granite Creek subwatersheds assessed was so complex that stratification by geology was not practical.

Field Protocols

This project entailed gathering the field data required to complete the RBS calculations and additional parameters. The RBS calculation used is that described in Kaufmann et al. 2008¹. The field methodology used is that described in the EMAP manual.²

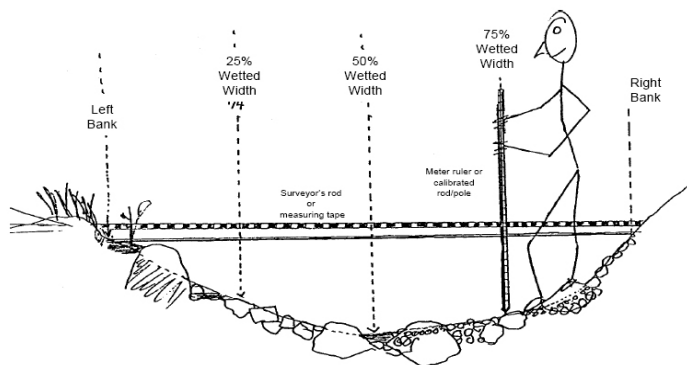
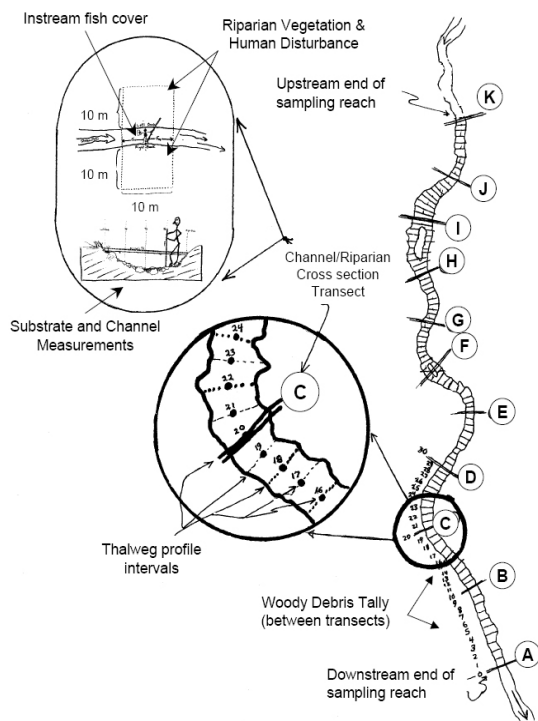
Collection of EMAP Physical Habitat Characteristics requires access to a reach of stream 40 times the wetted width and wading 11 transects to collect depth and substrate characteristics. The onset of the low-flow season is the best opportunity to evaluate the stream condition for sedimentation. Some streams may require access by inflatable raft, particularly in deep pool areas and larger streams. Site access limitations may require a modified, limited reach and transect number.

Measurements collected included:

- Bankfull width & height
- Thalweg depth profile
- Pebble count
- Slope
- Habitat units
- Large woody debris volume
- Bank condition
- Wetted width

1 Kaufmann, P., Faustini, J., Larsen, D., and Shirazi, M.; A Roughness-corrected Index of Relative Bed Stability for Regional Stream Surveys; Geomorphology V99 pp 150-170; 2008

2 Peck, D., Lazorchak, J., and Klemm, D.; Environmental Monitoring Assessment Program - Surface Waters: Western Pilot Study Field Operations Manual for Wadeable Streams; US EPA 2001



Figures from EMAP manual

Analytical Methods

The primary focus of the analysis was to evaluate population and subpopulation characteristics. The following key metrics were analyzed during this study:

- Relative Bed Stability (LRBS)
- Percentage of Sands and Fines (%SAFN)
- Residual Pool Depth (RP100)
- Large Woody Debris Volume (RW)
- Width to Depth Ratio (W:D)
- Bank Condition
- Spawning Gravel Inventory

An attempt was made to discover the relationship between instream sediment conditions and the following information: forest fire events; road conditions; landuse (limited); and salmonid spawning and smolting. Forest fire impact on instream sediments was evaluated by visually estimating the percent of the watershed burned and relating the burn extent with the percentage of instream fine sediments sequentially following the fires. Road conditions is being analyzed by the USFS Umatilla District Hydrologist using the Geomorphic Road Analysis and Inventory Protocol (GRAIP). A limited landuse assessment was completed by evaluating fire regimes, vegetation change, and grazing practices. Finally, the limited rearing and spawning data available was correlated with percent instream fine sediments for the stream and watershed.

Reference Conditions

EMAP data within the study area were compared to ODEQ gathered reference data within the Blue Mountain Level III Ecoregion. The watershed assessment division of the ODEQ has collected data from hundreds of minimally disturbed sites across the state using the EMAP protocol. This includes the 30 previously collected sites within the Blue Mountain Ecoregion III and 18 additional sites collected during this Assessment. To collect reference data a sample is generated which ideally covers all of the gradients in each ecoregion such as elevation and vegetation type. All reference sites are required to have minimal anthropogenic disturbance in the riparian zone and upland areas. The ODEQ's approach explicitly includes natural disturbance regimes as it is assumed that the biota of an area evolved in conjunction with these regimes. The metric values found in sites with minimal anthropogenic disturbance are used to judge the quality of physical habitat in the areas assessed. This approach is described in detail in ODEQ Technical Report S04-002.¹

Significance Testing

Significance testing is a common approach to statistical analysis but it is not the only one possible. While it is a useful component of the analytical process, over reliance on significance testing may yield misleading or erroneous results. First, a major weakness is the pervasive use of the arbitrarily chosen value of 5% to indicate significance. This begs the question of whether a p value of 4% is meaningful and a value of 6% is not. A stronger approach is to report the p value directly, as is done in this paper. Second, significance testing over emphasizes the probability of error (i.e. the p value) over the size of the effect. In most cases, including biology and ecology, it is the size of the effect that is most important. Third, any difference can be made significant with a large enough sample. The practical ramification of this is that significance can be purchased, which puts a burden on smaller organizations that do not have funding for a large study. Finally, numerous authors have elaborated on the shortcomings of significance testing. An excellent summary of the issues can be found in the following paper, "The Insignificance of Statistical Significance Testing" by Douglas Johnson. Hypothesis testing was used in this study as one component of a holistic approach to analyzing and understanding the data.

Estimates of Mean and Variability

Data was analyzed using custom built spreadsheets for data entry and metric calculation. All subsequent data analysis was carried out using the R statistical program. All data analyzed in this way was weighted according to the fraction of the stream network which it represents. Weighted averages were calculated for this Assessment. Variances for the Assessment were calculated using the Neighborhood Based Variance (NBV) estimator developed by the EPA.² NBV is a more precise estimate of variance when there is a spatial pattern to data, thus capitalizing on the spatial balance of the GRTS sample. The practical effect of utilizing the NBV is to decrease the variance. Modeling conducted by the EPA has shown that standard statistical procedures may result in substantial over estimates of variance when there is a spatial pattern to the data.

EMAP data provides estimates of physical habitat condition which change over time. In addition to natural changes errors occur during data collection. Unfortunately the two metrics which have the biggest influence on relative bed stability are the two metrics which are most likely to be incorrectly measured; slope and bankfull height. Caution was taken during this study to carefully calibrate each survey team to correctly measure bankfull heights.

1 Drake, D.; Selecting Reference Condition Sites: An Approach for Biological Criteria and Watershed Assessment; ODEQ WAS04-002 2004
2 Stevens, D. and Olsen, A.; Variance Estimation for Spatially Balanced Samples of Environmental Resources; Environmetrics V44 pp 593-610; 2003

Sediment Indicators

The Relative Bed Stability (RBS) metric was developed specifically to address the effects of bedded sediments on wadeable stream channels. RBS is defined as the ratio of the observed mean substrate diameter to the predicted competence of the channel at bankfull. Channel competence is calculated from field measurements of slope, hydraulic radius, and channel roughness. RBS is a unitless ratio of values, and is commonly expressed as log RBS or LRBS to compress the values and to normalize the variance. When the observed mean particle diameter is equal to the predicted diameter of the largest particle the system can move at bankfull (D_{CBF}), the RBS ratio is equal to 1 and LRBS is equal to 0. The observed mean particle diameter and the D_{CBF} are primarily dependent on disturbance regimes, channel morphology, geology, and climate. For example, small channels with low gradients are expected to have a small mean particle diameter and are not expected to have enough stream power to move larger particles during a bankfull event. The expected RBS score in these circumstances would be similar to a channel with large sediments and steep gradients. In other words, RBS controls for stream power at a coarse level. By logging the RBS value, the data is normalized so that parametric statistical methods can be applied. Previous studies have shown that increases in sediment input result in a fining of the streambed by overwhelming the capacity of the water column to move sediments. Decreases in the RBS score are often correlated with an increased sediment supply. Therefore RBS is a useful measure of current sediment input as well as instream conditions. Extremely low values indicate over-sedimentation (an example would be -2) whereas large values indicate armoring of the stream bed (an extreme example would be +2.) However, this is not always the case. For instance some systems have naturally high RBS scores. Within the Mid-Atlantic highlands, RBS scores are commonly greater than 0. In the coastal reference data, a few sites had LRBS scores between -1 and -3. Evaluation of the system as a whole, including past disturbances, is necessary in order to understand the significance of the LRBS score. An additional strength of RBS is that it is a composite metric calculated from numerous independent observations. This significantly increases the signal to noise ratio and reduces interobserver bias. One caveat to using the RBS metric is that streams can adjust to elevated sediment inputs over long periods of time (e.g. decades) resulting in stable beds that nonetheless contain unnaturally large quantities of fine sediments. RBS is most useful as an indicator of sediment impacts due to current rather than past anthropogenic disturbance.

Habitat Complexity

Quantitative indicators of habitat complexity are generated as part of the RBS calculation. Three indicators were used in this study to assess habitat complexity; residual pool depth (RP100), width to depth ratio (W:D), and wood radius (RW). The aquatic habitat of many streams is degraded due to a lack of large woody debris (LWD) and channelized as a result of historic logging practices or active stream cleaning. These modifications serve to decrease the hydraulic roughness of the channel. Roughness elements trap fine sediments and decrease the competence of the channel to move sediments. It is theoretically possible to mask an increase in sediment input with an increased competence due to lack of hydraulic roughness. In this scenario fine sediment would not be considered a primary stressor, but elements critical to maintaining healthy aquatic ecosystems would be lacking. If those elements were restored, fine sediment could become a local stressor if the elevated sediment input was not corrected first. It is critical that hydraulic roughness be evaluated when interpreting data on sediment impairment.

W:D – The width to depth ratio changes as a function of disturbance. In some instances it will increase with disturbance due to sustained bank erosion and elevated sediment inputs. Generally, this is related to decreased bedform complexity and degraded riparian vegetation. As a consequence, streams with a width to depth ratio greater than reference conditions could result in increased peak temperatures. In other instances, the width to depth ratio will decrease substantially as the channel down-cuts due to channel confinement. Geology is a controlling factor on channel responses to disturbance. A decreased width to depth ratio could potentially indicate loss of over-wintering fish habitat, increased downstream flood potential, and loss of floodplain connectivity. The metric used in this study was the bankfull width divided by the bankfull height.

RW – The benefits and importance of LWD are well established in the field of restoration biology. Under the protocol used in this study, all wood inside the bankfull channel with a diameter greater than 10 centimeters and a length greater than 1.5 meters was tallied and assigned to a size class. These measurements were then converted to a statistic representing the total volume of wood inside the channel at bankfull height. This volume was divided by the surface area of the stream reach to give an estimate of wood volume per square meter. This controls for the absolute difference in wood volume between large and small channels.

RP100 – Residual pool depth can be conceptualized as what would be left over in a stream reach if all flow stopped. It is a measure of reach-scale bedform complexity and is directly proportional to pool frequency. Qualitative classifications of reaches into habitat units such as riffle, glide, or pool are flow and observer dependent. In contrast, residual pool depth is a flow-invariant metric and is a quantitative measure. It is therefore more suitable for use in sediment transport and regression analyses.



Juvenile Great Basin Fence Lizard (*Sceloporus occidentalis longipes*) - Missing Tail; Found in Wall Creek Watershed ~3500 feet.

Results

Please refer to the discussion section for information regarding the applicability of the data. The following tables summarize the LRBS, %SAFN, RP100, W:D, and RW results for the primary populations. Not all metrics measured within the study population have been collected within the reference population or has not been released to the public by the ODEQ. More detailed results are found in the section which follows. Finally substrate percentages have been listed as proportions.

Table 4 - All Blue Mountain Reference Data				
Metric	Mean	N	Lower 95% CB	Upper 95% CB
Log Relative Bed Stability (LRBS)	-1.0444	32	-1.2262	-0.8626
Proportion Sands & Fines (%SAFN)	0.2124	32	0.1732	0.2515
Wood Volume per Meter of Bankfull Surface Area (RW)	0.0346	32	0.0212	0.0480
Residual Pool Depth (RP100)	7.1890	32	5.9009	8.4772
Width to Depth Ratio (W:D)	9.6196	32	7.7747	11.4645

Table 5 - All Resistant Blue Mountain Reference Data				
Metric	Mean	N	Lower 95% CB	Upper 95% CB
Log Relative Bed Stability (LRBS)	-0.9651	22	-1.2021	-0.7282
Proportion Sands & Fines (%SAFN)	0.1816	22	0.1310	0.2322
Wood Volume per Meter of Bankfull Surface Area (RW)	0.0344	22	0.0154	0.0534
Residual Pool Depth (RP100)	6.4510	22	4.7176	8.1844
Width to Depth Ratio (W:D)	10.5799	22	8.0356	13.1241

Table 6 - All Wall Creek Data (Compared to Resistant Reference Population)				
Metric	Mean	N	Lower 95% CB	Upper 95% CB
Log Relative Bed Stability (LRBS)	-0.2805	49	-0.4303	-0.1307
Proportion Sands & Fines (%SAFN)	0.2410	49	0.1970	0.2851
Wood Volume per Meter of Bankfull Surface Area (RW)	0.0145	49	0.0098	0.0192
Residual Pool Depth (RP100)	7.5360	49	6.4146	8.6574
Width to Depth Ratio (W:D)	12.1221	49	11.3348	12.9095

Table 7 - All Granite Creek Data (Compared to All Reference Data)				
Metric	Mean	N	Lower 95% CB	Upper 95% CB
Log Relative Bed Stability (LRBS)	-1.4284	20	-1.7396	-1.1172
Proportion Sands & Fines (%SAFN)	0.4139	20	0.2997	0.5280
Wood Volume per Meter of Bankfull Surface Area (RW)	0.0337	20	0.0189	0.0485
Residual Pool Depth (RP100)	6.6856	20	4.8766	8.4947
Width to Depth Ratio (W:D)	4.8967	20	4.2852	5.5083

Table 8 - All Baldy Creek Stream Data (Compared to All Reference Data)				
Metric	Mean	N	Lower 95% CB	Upper 95% CB
Log Relative Bed Stability (LRBS)	-0.4573	5	-0.5693	-0.3452
Proportion Sands & Fines (%SAFN)	0.1562	5	0.1325	0.1799
Wood Volume per Meter of Bankfull Surface Area (RW)	0.0352	5	0.0240	0.0464
Residual Pool Depth (RP100)	6.5984	5	4.8185	8.3782
Width to Depth Ratio (W:D)	9.3671	5	8.4068	10.3274

Reference Data - Key Findings

- Few sedimentary reference watersheds are available for the Blue Mountain Ecoregion.
- Reference sites on average have a high proportion of both sands and fines, and are relatively unstable.
- There is a marked difference in metric values between 3rd and 4th order streams in the reference population. Three of the 4 4th order streams are relatively closely spaced on the mainstem Minam River. In contrast, the 4 3rd order sites are well spaced throughout the ecoregion.
- Erodible reference sites are less stable and have a higher proportion of sands and fines than resistant.
- There is a distinct pattern of increasing stability and decreasing fine sediments as stream order increases. This is consistent with the idea that smaller streams act as sediment sources and mid-sized streams act as transport reaches.

Table 9 - All Blue Mountain Reference Data				
Metric	Mean	N	Lower 95% CB	Upper 95% CB
Log Relative Bed Stability (LRBS)	-1.0444	32	-1.2262	-0.8626
Percent Sands & Fines (%SAFN)	0.2124	32	0.1732	0.2515
Percent Fines	0.0833	32	0.0530	0.1135
Percent Bedrock	0.0230	32	0.0088	0.0372
Wood Volume per Square Meter Surface Area (RW)	0.0346	32	0.0212	0.0480
Key Piece Wood Volume (per sq. meters)	0.0166	32	0.0050	0.0282
Residual Pool Depth (RP100)	7.1890	32	5.9009	8.4772
Width to Depth Ratio W:D	9.6196	32	7.7747	11.4645

Table 10 - All Resistant Blue Mountain Reference Data				
Metric	Mean	N	Lower 95% CB	Upper 95% CB
Log Relative Bed Stability (LRBS)	-0.9651	22	-1.2021	-0.7282
Percent Sands & Fines (%SAFN)	0.1816	22	0.1310	0.2322
Percent Fines	0.0689	22	0.0271	0.1108
Percent Bedrock	0.0325	22	0.0124	0.0527
Wood Volume per Square Meter Surface Area (RW)	0.0344	22	0.0154	0.0534
Key Piece Wood Volume (per sq. m)	0.0185	22	0.0021	0.0348
Residual Pool Depth (RP100)	6.4510	22	4.7176	8.1844
Width to Depth Ratio W:D	10.5799	22	8.0356	13.1241

Table 11 - All Erodible Blue Mountain Reference Data				
Metric	Mean	N	Lower 95% CB	Upper 95% CB
Log Relative Bed Stability (LRBS)	-1.2188	10	-1.5291	-0.9085
Percent Sands & Fines (%SAFN)	0.2800	10	0.2151	0.3448
Percent Fines	0.1148	10	0.0818	0.1478
Percent Bedrock	0.0019	10	-0.0013	0.0051
Wood Volume per Square Meter Surface Area (RW)	0.0351	10	0.0256	0.0446
Key Piece Wood Volume (per sq. m)	0.0125	10	0.0031	0.0218
Residual Pool Depth (RP100)	8.8127	10	6.6909	10.9345
Width to Depth Ratio W:D	7.5070	10	5.3137	9.7004

Table 12 - All 1st Order Blue Mountain Reference Data				
Metric	Mean	N	Lower 95% CB	Upper 95% CB
Log Relative Bed Stability (LRBS)	-1.5193	10	-1.7997	-1.2390
Percent Sands & Fines (%SAFN)	0.2544	10	0.1783	0.3305
Percent Fines	0.1301	10	0.0447	0.2154
Percent Bedrock	0.0174	10	-0.0131	0.0479
Wood Volume per Square Meter Surface Area (RW)	0.0569	10	0.0282	0.0856
Key Piece Wood Volume (per sq. m)	0.0283	10	-0.0021	0.0587
Residual Pool Depth (RP100)	3.9915	10	1.9537	6.0293
Width to Depth Ratio W:D	6.2264	10	4.8061	7.6467

Table 13 - All 2nd Order Blue Mountain Reference Data				
Metric	Mean	N	Lower 95% CB	Upper 95% CB
Log Relative Bed Stability (LRBS)	-1.0441	13	-1.2291	-0.8590
Percent Sands & Fines (%SAFN)	0.2177	13	0.1756	0.2598
Percent Fines	0.0760	13	0.0545	0.0974
Percent Bedrock	0.0391	13	0.0123	0.0659
Wood Volume per Square Meter Surface Area (RW)	0.0303	13	0.0147	0.0460
Key Piece Wood Volume (per sq. m)	0.0135	13	0.0042	0.0228
Residual Pool Depth (RP100)	7.8779	13	5.7722	9.9835
Width to Depth Ratio W:D	6.7237	13	5.6567	7.7907

Table 14 - All 3rd Order Blue Mountain Reference Data				
Metric	Mean	N	Lower 95% CB	Upper 95% CB
Log Relative Bed Stability (LRBS)	-0.3614	5	-0.6929	-0.0299
Percent Sands & Fines (%SAFN)	0.1435	5	0.0244	0.2626
Percent Fines	0.0562	5	0.0148	0.0975
Percent Bedrock	0.0000	5	0.0000	0.0000
Wood Volume per Square Meter Surface Area (RW)	0.0270	5	0.0088	0.0452
Key Piece Wood Volume (per sq. m)	0.0130	5	-0.0022	0.0283
Residual Pool Depth (RP100)	9.7761	5	7.1369	12.4152
Width to Depth Ratio W:D	11.9938	5	10.0217	13.9660

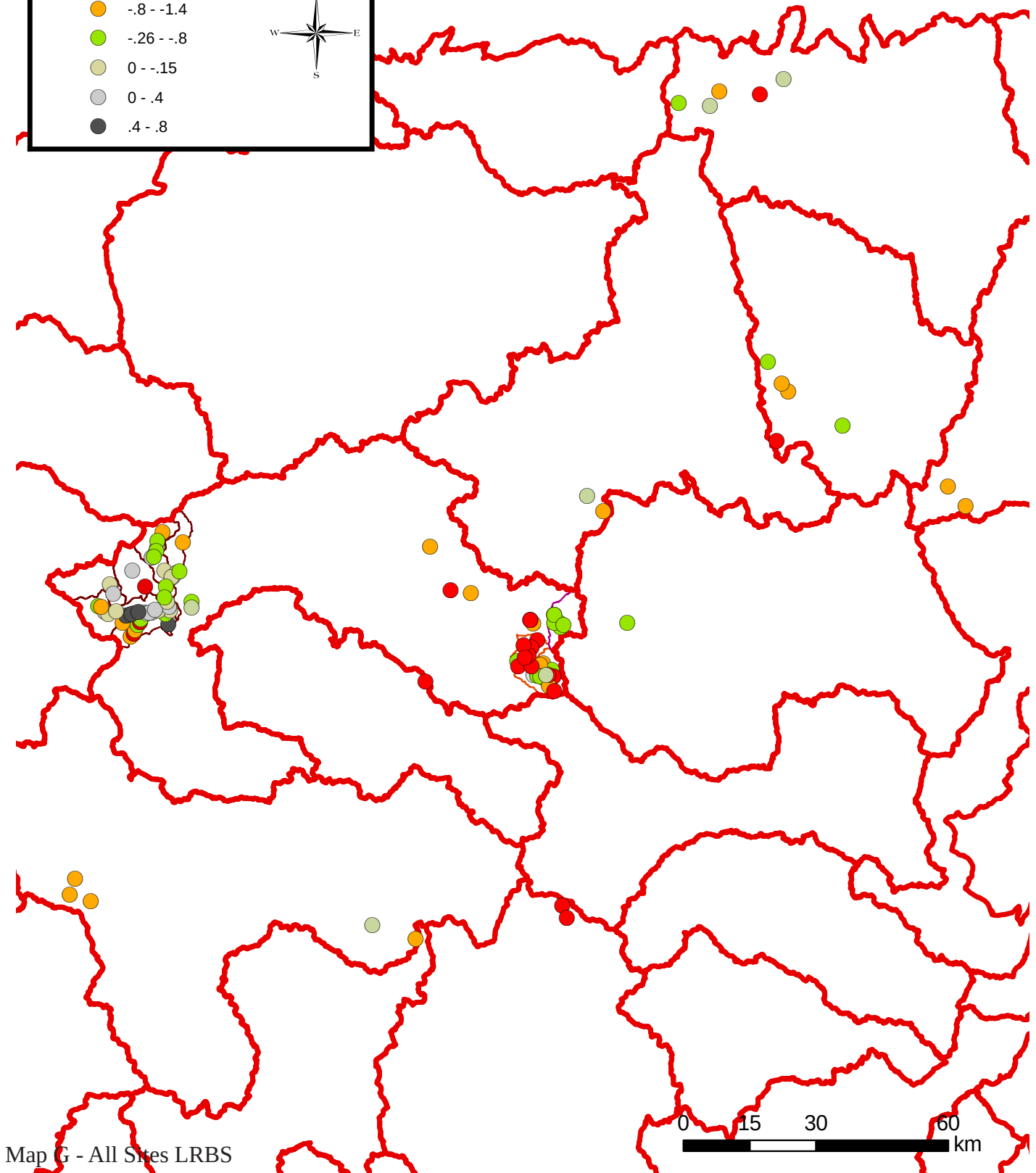
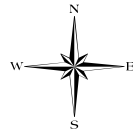
Table 15 - All 4th Order Blue Mountain Reference Data				
Metric	Mean	N	Lower 95% CB	Upper 95% CB
Log Relative Bed Stability (LRBS)	-0.7119	4	-1.1021	-0.3216
Percent Sands & Fines (%SAFN)	0.1760	4	0.0715	0.2805
Percent Fines	0.0238	4	-0.0159	0.0635
Percent Bedrock	0.0132	4	-0.0004	0.0268
Wood Volume per Square Meter Surface Area (RW)	0.0025	4	0.0002	0.0048
Key Piece Wood Volume (per sq. m)	0.0017	4	0.0001	0.0033
Residual Pool Depth (RP100)	9.7104	4	6.5136	12.9072
Width to Depth Ratio W:D	24.5466	4	17.9259	31.1673

North Fork John Day Watershed Assessment

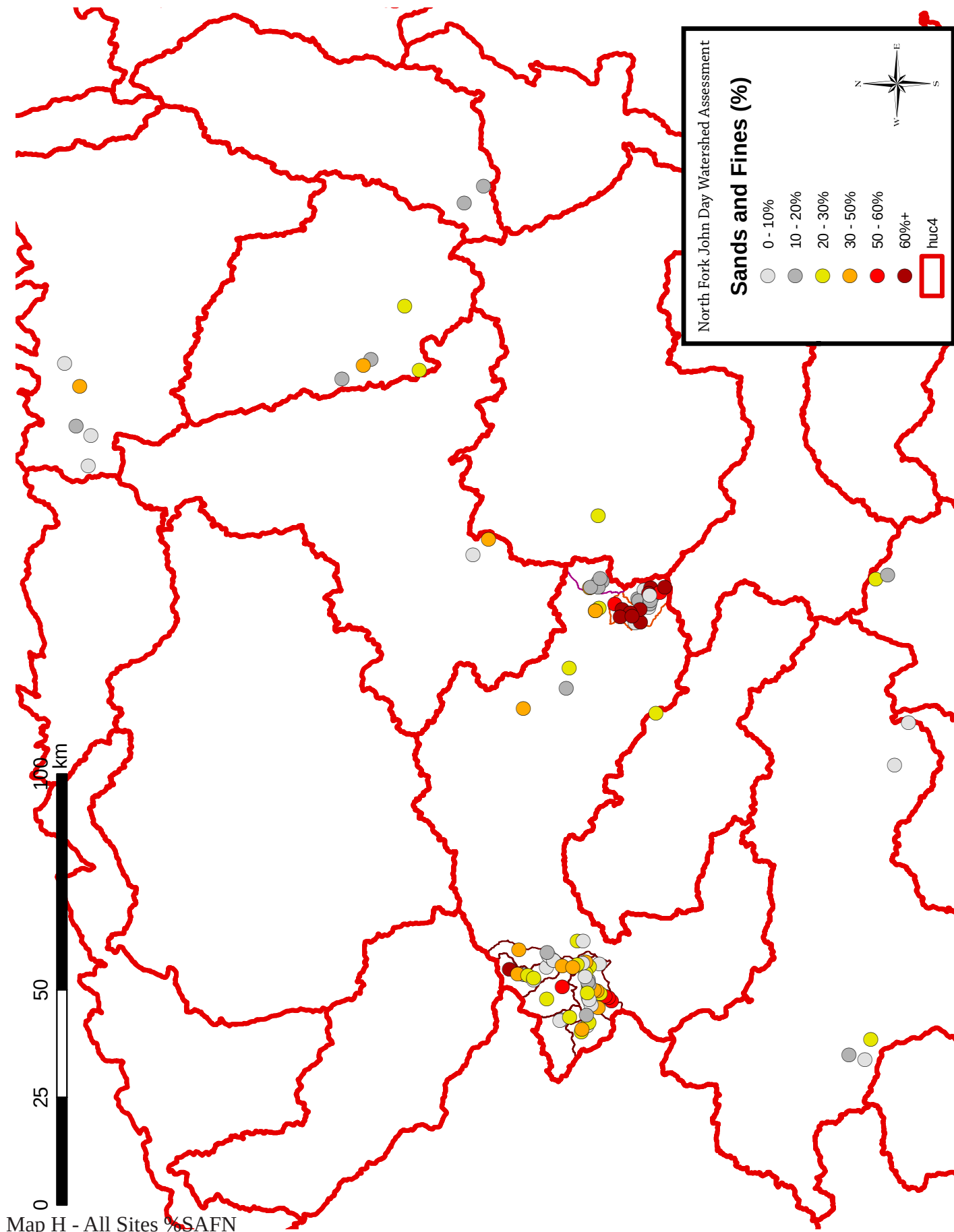
4th Field HUC Watersheds

Relative Bed Stability

- -1.4 - -3.7
- -.8 - -1.4
- -.26 - -.8
- 0 - -.15
- 0 - .4
- .4 - .8



Map G - All Sites LRBS



Wall Creek Watershed (WCW) Results

Instream conditions within the WCW are similar to reference conditions. When compared to reference, the WCW is more stable (i.e. the WCW has lower LRBS values; WCW LRBS = -.28; Reference LRBS = -.97), has a similar W:D (WCW W:D = 12; Reference W:D = 11), exhibits a similar proportion of instream fine sediments (WCW Fines = 6%; Reference Fines = 7%), and a slightly higher proportion of instream sands and fines (WCW SAFN = 24%; Reference SAFN = 18%). Gravel proportions (similar between 2nd and 3rd + order streams) were not compared to reference due to inaccessibility.

All 1st order (NHD 1:100k stream layer) streams were dropped from the sample due to lack of flow during the summer. This is likely a result of the aspect and elevation of the Granite and Baldy watersheds which receive more precipitation and greater snow-pack. Reference watersheds too were commonly higher in elevation. Low summer flows strongly limit the available rearing habitat for juvenile salmonids. Low flows may interact with solar inputs to limit the quality of summer rearing habitat. In conjunction with downstream passage barriers, these factors are hypothesized to constitute the dominant factor limiting salmonid populations in the watershed. The confluence of Wall Creek with the mainstem NFJD was found to be dry, resulting in a flow dependent barrier to juvenile migration.

Relative Bed Stability

Larger streams in the WCW are very stable (WCW 3rd + order streams LRBS = .09; Reference 3rd order streams LRBS = -.36) and exhibit a mean particle size greater than the estimated channel competence. Small streams were less stable than 3rd + order streams and more stable than reference streams of the same size. An access road runs along the mainstem for its lower length. This limits floodplain connectivity and may increase the magnitude of peak flows. As in reference, there is a distinct pattern of increasing stability and decreasing fine sediments as stream order increases. The differences in LRBS values between 2nd and 3rd + order streams in WCW is driven by an increase in particle size from 2nd to 3rd + and a decrease in channel competence from an increased residual pool depth.

Residual Pool Depth

Residual pool depth is higher in the WCW than in reference (WCW RP100 = 7.5; Reference RP100 = 6.5). The resistant lithology reference population was generally confined to smaller streams as larger streams had more alluvial deposits which were defined as erodible. Pool volume is more than twice as high in 3rd + order (RP100 = 10) streams than in 2nd order (RP100 = 5) streams. It is likely that a significant number of the pools observed were the result of active stream channel restoration projects.¹

Wood Radius

RW in the WCW is .01 while it is higher in reference at .03. Wood volume is nearly 0 in 3rd + order streams at and closer to reference in smaller streams at .02. It is hypothesized that historically, roughness was largely supplied by beaver activity. Beaver populations have been significantly reduced in almost every watershed in Oregon. Additionally fire suppression occurred within the watershed for many decades following European settlement. The lack of fires (both stand maintaining and stand replacing fires) may have decreased the supply of large woody debris. Field observations support this hypothesis: in the BCW more dead conifers were present on the stream banks from a recent fire as compared with few stream side conifers (living or dead) in the WCW.

Width to Depth Ratio

Bankfull width to depth ratios were higher in 3rd + order streams (W:D = 13) than in 2nd order streams (W:D = 11). This is consistent with the pattern observed in the reference population.

Substrate

The proportion of sands and fines in the WCW was slightly higher than in the resistant reference population (WCW %SAFN = 24%; Reference %SAFN = 18%) while the proportion of fines was similar (6% vs. 7% respectively). The percentage of instream gravels was 38%, cobbles 25%, small boulders 7%, large boulders 1%, (no comparison to reference) and bedrock was 3% in both test and reference populations.

1

Table 16 - All Wall Creek Data				
Metric	Mean	N	Lower 95% CB	Upper 95% CB
Log Relative Bed Stability (LRBS)	-0.2805	49	-0.4303	-0.1307
Log Relative Bed Stability, No Bedrock	-0.3213	49	-0.4508	-0.1919
Residual Pool Depth cm (RP100)	7.5360	49	6.4146	8.6574
Wood Volume per Square Meter Surface Area (RW)	0.0145	49	0.0098	0.0192
Key Piece Wood Volume per Square Meter Surface Area	0.0077	49	0.0050	0.0104
Width to Depth Ratio (W:D)	12.1221	49	11.3348	12.9095
Percent Fines	0.0581	49	0.0353	0.0808
Percent Sands & Fines (%SAFN)	0.2410	49	0.1970	0.2851
Percent Gravels	0.3878	49	0.3640	0.4117
Percent Cobbles	0.2532	49	0.2307	0.2757
Percent Small Boulders	0.0745	49	0.0638	0.0851
Percent Large Boulders	0.0155	49	0.0109	0.0200
Percent Bedrock	0.0281	49	0.0130	0.0431
Bank Condition (1-5)	1.6356	49	1.4491	1.8220
Slope	0.0248	49	0.0216	0.0279
Bankfull Radius	0.2241	49	0.2082	0.2401
Estimated Bankfull Competence (m)	0.0293	49	0.0259	0.0327
Geometric Mean Particle Size (m)	24.9983	49	18.8996	31.0970
Geometric Mean Particle Size, no bedrock (mm)	20.0726	49	15.5154	24.6297

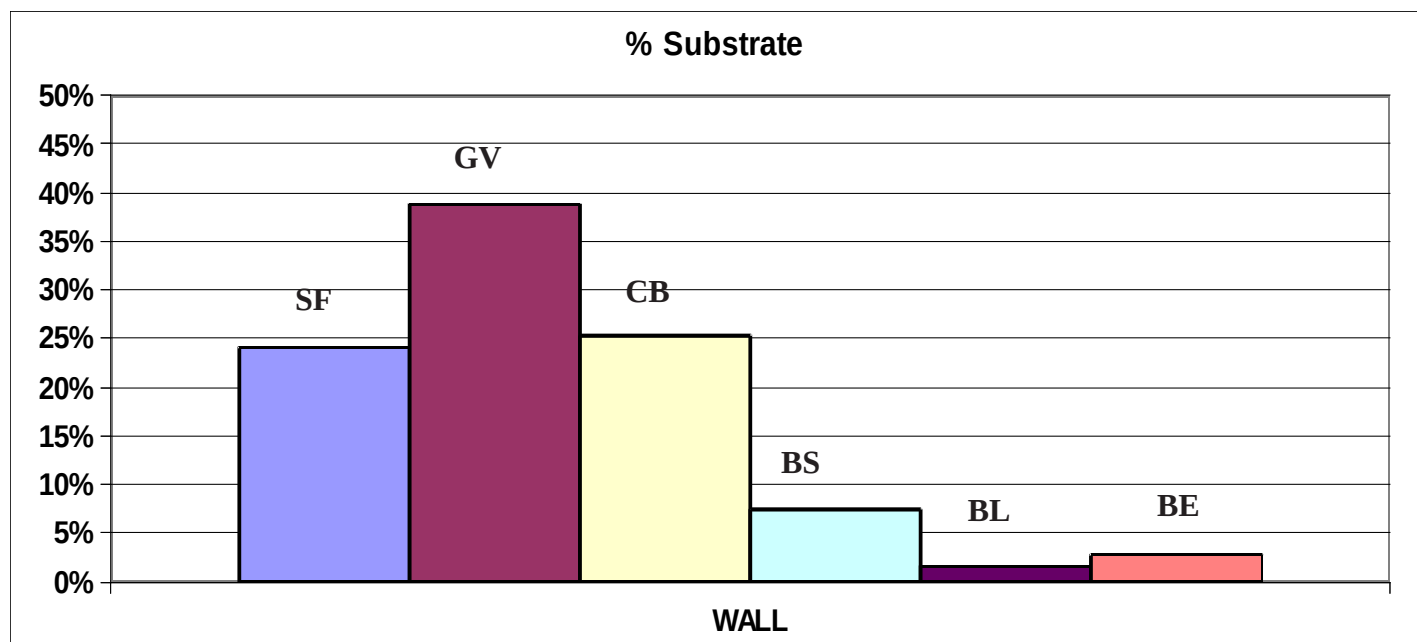


Table 17 - All Wall Creek 2nd Order Data				
Metric	Mean	N	Lower 95% CB	Upper 95% CB
Log Relative Bed Stability (LRBS)	-0.5947	13	-0.8722	-0.3172
Log Relative Bed Stability, No Bedrock	-0.6164	13	-0.8458	-0.3869
Residual Pool Depth cm (RP100)	4.5612	13	3.6087	5.5137
Wood Volume per Square Meter Surface Area (RW)	0.0205	13	0.0113	0.0297
Key Piece Wood Volume per Square Meter Surface Area	0.0100	13	0.0052	0.0148
Width to Depth Ratio (W:D)	11.3134	13	10.0335	12.5934
Percent Fines	0.0631	13	0.0140	0.1122
Percent Sands & Fines (%SAFN)	0.3131	13	0.2248	0.4015
Percent Gravels	0.3944	13	0.3474	0.4414
Percent Cobbles	0.2082	13	0.1661	0.2502
Percent Small Boulders	0.0462	13	0.0346	0.0578
Percent Large Boulders	0.0125	13	0.0049	0.0200
Percent Bedrock	0.0256	13	0.0018	0.0495
Bank Condition (1-5)	1.8713	13	1.5221	2.2205
Slope	0.0332	13	0.0274	0.0390
Bankfull Radius	0.1813	13	0.1655	0.1971
Estimated Bankfull Competence (m)	0.0345	13	0.0277	0.0413
Geometric Mean Particle Size (m)	19.4699	13	8.9191	30.0206
Geometric Mean Particle Size, no bedrock (mm)	15.0741	13	7.0765	23.0717

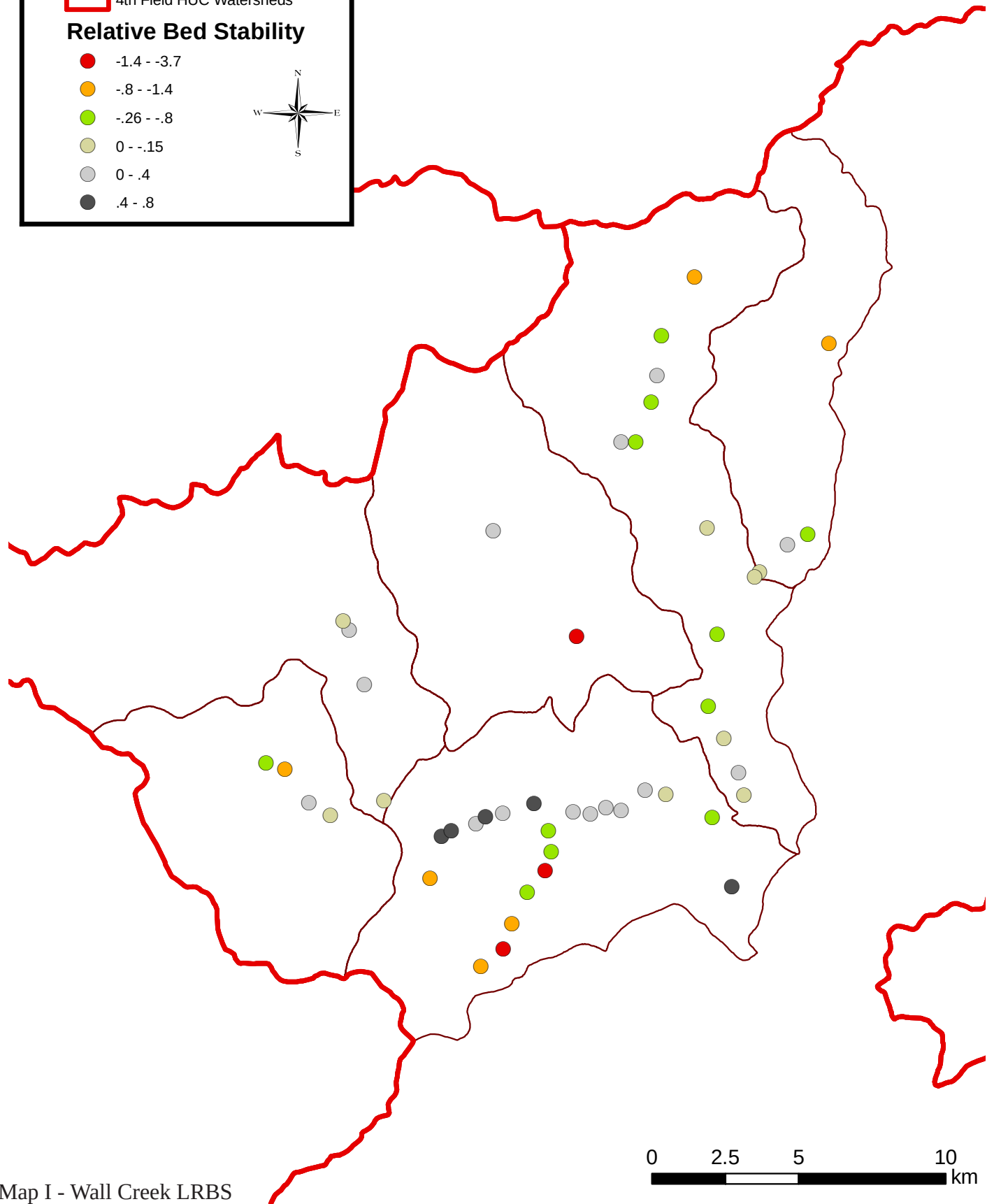
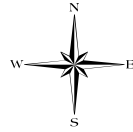
Table 18 - All Wall Creek 3rd and Greater Order Data				
Metric	Mean	N	Lower 95% CB	Upper 95% CB
Log Relative Bed Stability (LRBS)	0.0865	30	-0.0008	0.1738
Log Relative Bed Stability, No Bedrock	0.0180	30	-0.0787	0.1147
Residual Pool Depth cm (RP100)	10.7251	30	9.1045	12.3456
Wood Volume per Square Meter Surface Area (RW)	0.0065	30	0.0032	0.0097
Key Piece Wood Volume per Square Meter Surface Area	0.0043	30	0.0017	0.0069
Width to Depth Ratio (W:D)	13.2441	30	12.2309	14.2574
Percent Fines	0.0471	30	0.0339	0.0602
Percent Sands & Fines (%SAFN)	0.1544	30	0.1233	0.1855
Percent Gravels	0.3814	30	0.3541	0.4086
Percent Cobbles	0.3057	30	0.2795	0.3319
Percent Small Boulders	0.1058	30	0.0904	0.1213
Percent Large Boulders	0.0197	30	0.0136	0.0258
Percent Bedrock	0.0330	30	0.0124	0.0537
Bank Condition (1-5)	1.3652	30	1.2067	1.5236
Slope	0.0164	30	0.0150	0.0179
Bankfull Radius	0.2703	30	0.2490	0.2915
Estimated Bankfull Competence (m)	0.0246	30	0.0215	0.0276
Geometric Mean Particle Size (m)	32.1506	30	25.8045	38.4967
Geometric Mean Particle Size, no bedrock (mm)	26.2117	30	21.3308	31.0926

North Fork John Day Watershed Assessment

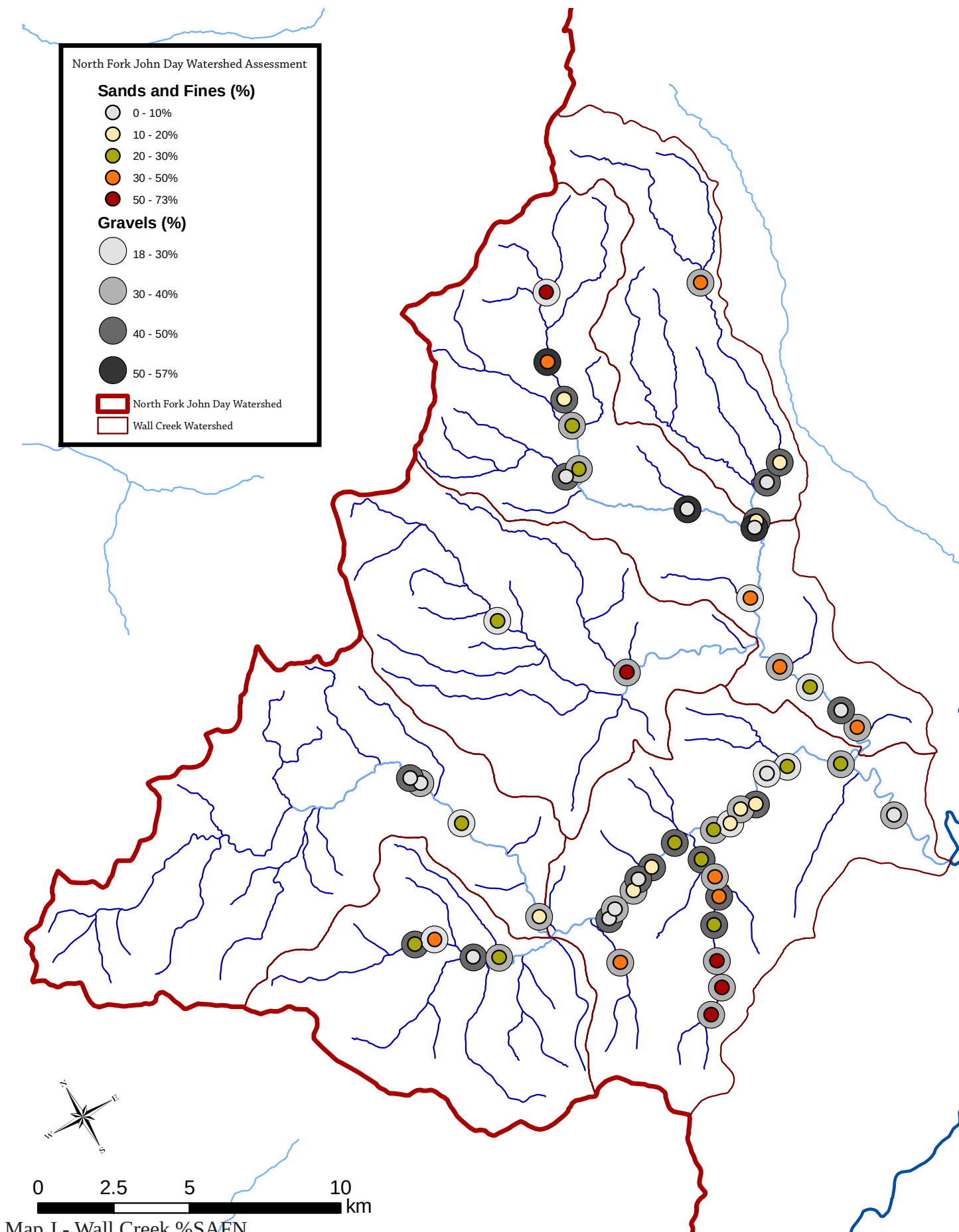
4th Field HUC Watersheds

Relative Bed Stability

- -1.4 - -3.7
- -.8 - -1.4
- -.26 - -.8
- 0 - -.15
- 0 - .4
- .4 - .8



Map I - Wall Creek LRBS



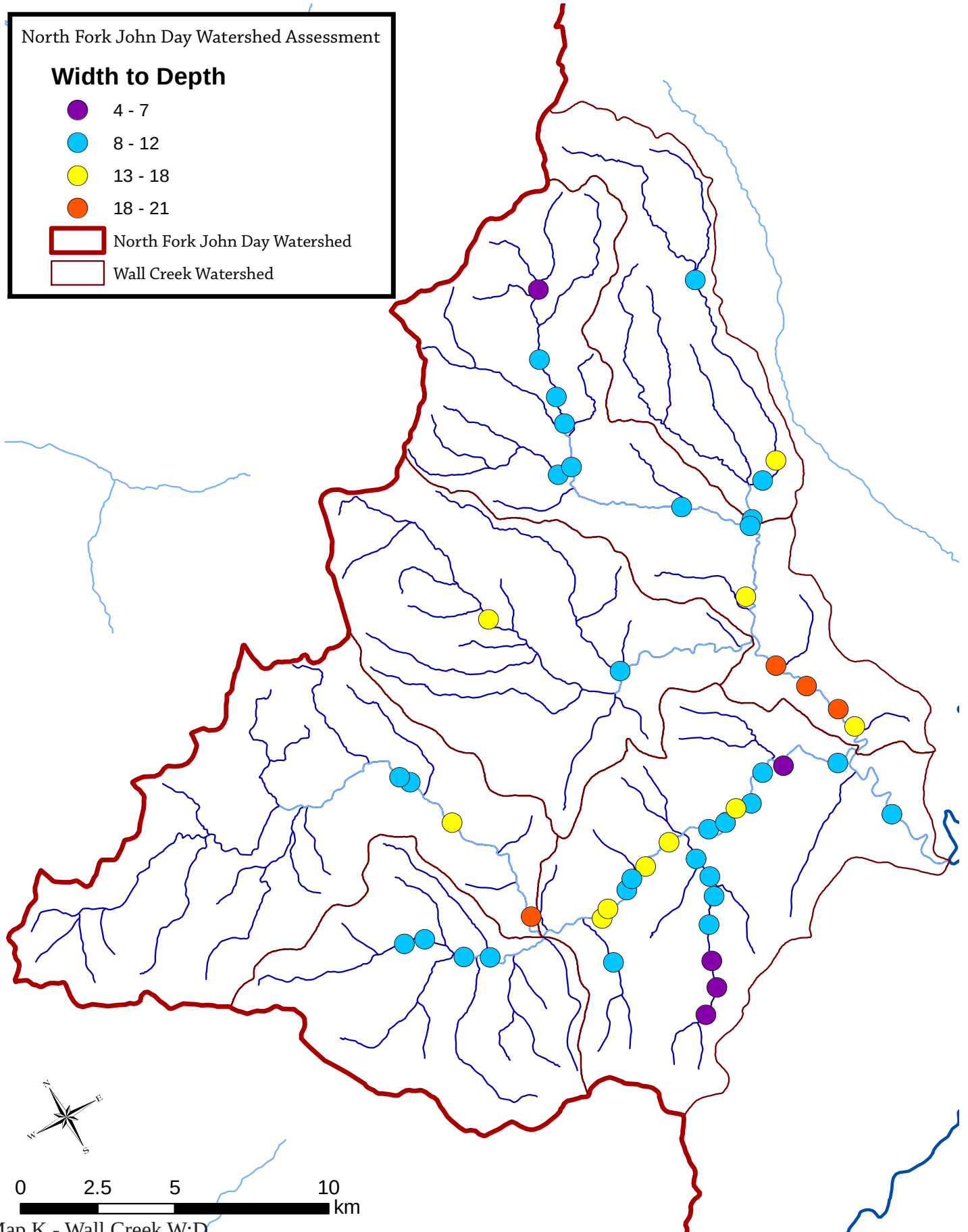
Map J - Wall Creek %SAFN

North Fork John Day Watershed Assessment

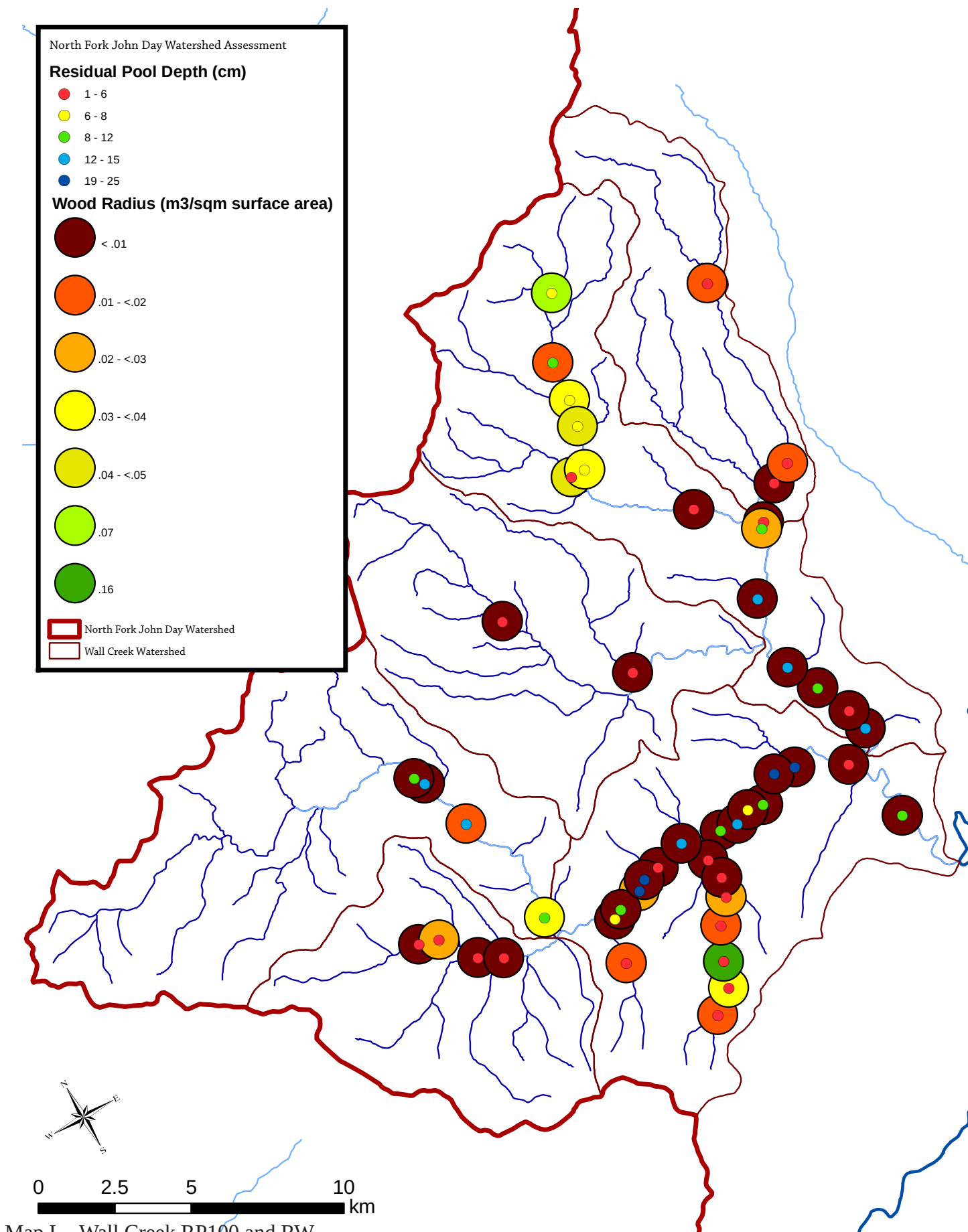
Width to Depth

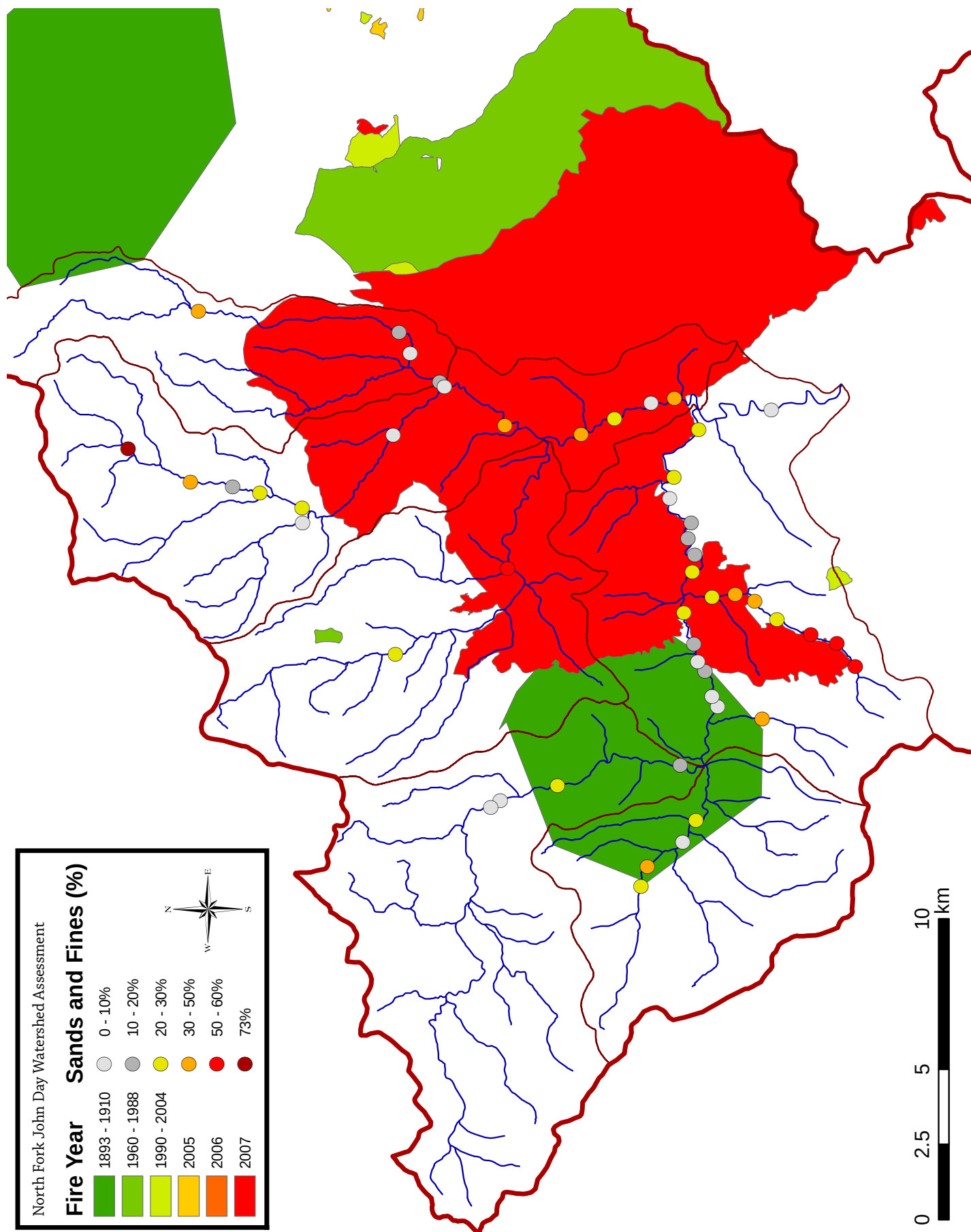
- 4 - 7
- 8 - 12
- 13 - 18
- 18 - 21

- ▭ North Fork John Day Watershed
- ▭ Wall Creek Watershed



Map K - Wall Creek W:D





Granite Creek Watershed (GCW) Results

The Granite Creek Watershed (GCW; 5th Field HUC# 1707020202; Bull Run 6th Field HUC #170702020202 and Upper Granite 6th Field HUC #170702020201) has a mixed and complex lithology and ownership. Common landuses include forestry, mining, agriculture, and rural residential. The GCW is almost entirely managed by the USFS with the remainder in private ownership. Approximately 30% of the 5th field watershed is managed for wilderness although no wilderness is located within the two 6th field study areas. Given the complexity of the lithology the GCW results were compared to the general reference population.

The GCW has the lowest LRBS value (both population averages and individual site data; GCW LRBS = -1.45; most unstable site LRBS = - 3.7) and is the least stable stream network evaluated in this study. Additionally, the GCW has the highest proportion of sands and fines (GCW %SAFN = 41%; reference %SAFN = 21%) and fines (17% versus 8% respectively). Pool volume in the GCW is similar to that of the reference population (GCW RP100 = 6.7; Reference RP100 = 7.1). Wood volume in the GCW is similar to that of the reference population (GCW RW = .03; Reference RW = .03). Width to depth ratios within the GCW are half of reference (W:D = 4.9 versus. 9.6 respectively). This indicates channel entrenchment given that the W:D ratios do not increase much with stream size (GCW 2nd order streams W:D = 4.47; 3rd + order streams W:D = 6.5).

Relative Bed Stability

Larger streams in the GCW are more somewhat stable than reference (GCW 3rd order streams LRBS = -.59; Reference 3rd order streams LRBS = -.36). Small streams were less stable than 3rd order streams and reference streams of the same size (GCW 1st order streams LRBS = -2.12; Reference 1st order streams LRBS = -1.51).

Residual Pool Depth

Residual pool depth is lower in the GCW than in reference (GCW RP100 = 6.8; Reference RP100 = 7.2). Pool volume did not vary much between stream sizes.

Wood Radius

RW in the GCW is .03 and is the same as reference values. The wood volume is predominantly driven by 1st order streams which have a wood volume of .05. Wood volume is very low in 3rd order streams at <.01. It is hypothesized that the wood volume in the smaller streams of the GCW are supplied by extremely unstable slopes.

Width to Depth Ratio

Bankfull width to depth ratios were similar in 3rd order streams (W:D = 6.5) and smaller streams (1st and 2nd order streams W:D = 4.2 - 4.5 respectively) indicating entrenchment.

Substrate

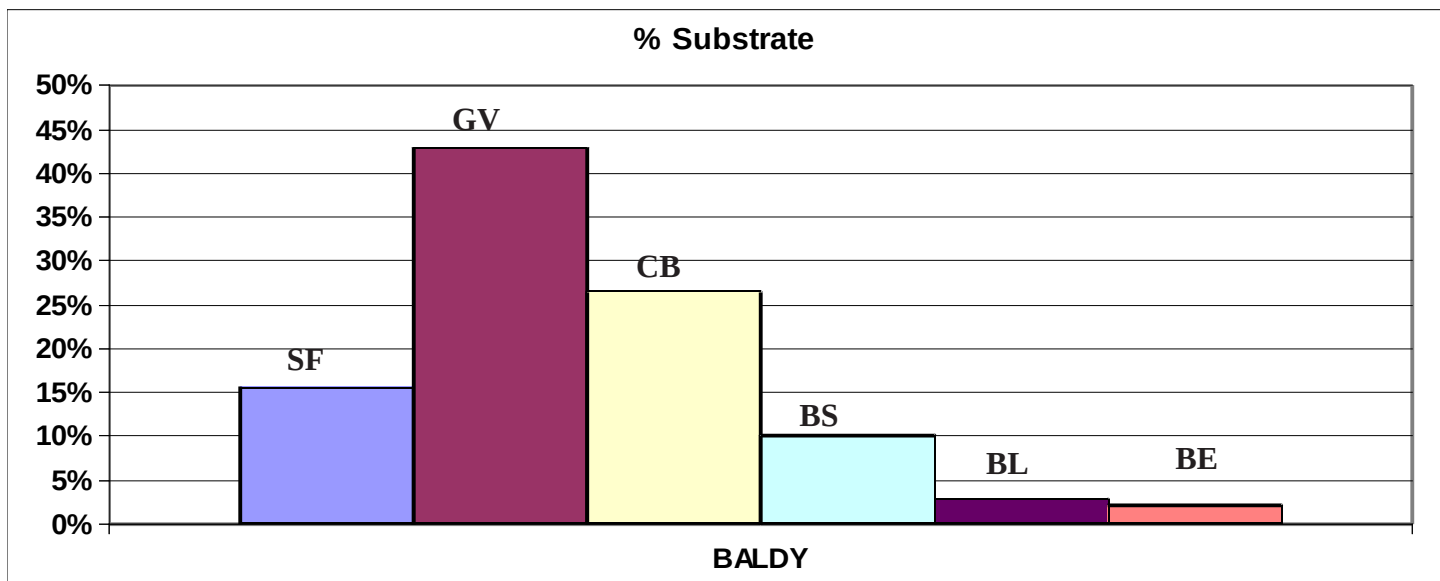
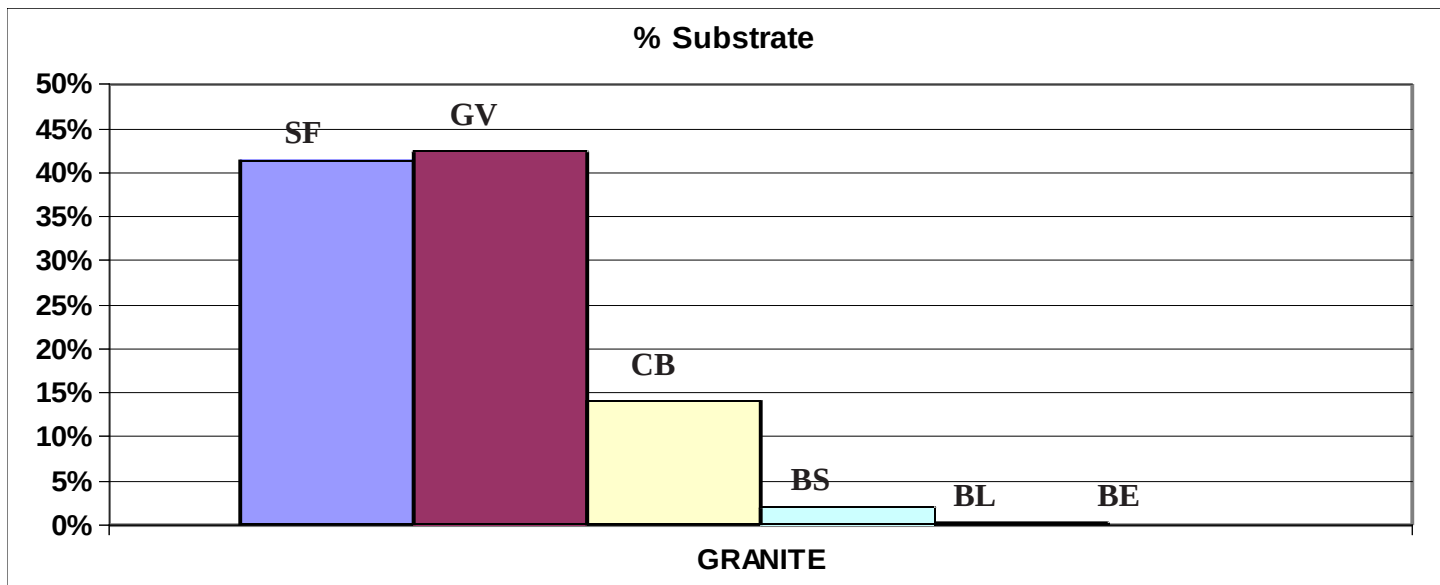
The proportion of sands and fines in the GCW was much higher than in the resistant reference population (GCW %SAFN = 41%; Reference %SAFN = 21%) as was the proportion of fines (17% vs. 8% respectively). The percentage of instream gravels was 30%, cobbles 6%, small boulders <1%, large boulders <1%, (no comparison to reference) and bedrock was lower at 0% in the GCW and 2% in reference populations. Although 1st and 2nd order streams are well above reference in terms of sediment metrics (61% and 35% respectively), 3rd order streams are much closer to reference conditions (GCW 3rd + order streams %SAFN = 23%; reference %SAFN = 21%). When evaluating the mobility of these fine sediments from source (1st order streams; 6.5% slope) to transport (2nd order streams; 3.5% slope), to depositional streams (3rd order streams; 1.5% slope) it is possible to conclude that the GCW is a significant source of fine sediments to the larger North Fork John Day Watershed.

Table 19 - All Granite Creek Data				
Metric	Mean	N	Lower 95% CB	Upper 95% CB
Log Relative Bed Stability (LRBS)	-1.4284	20	-1.7396	-1.1172
Log Relative Bed Stability, No Bedrock	-1.4284	20	-1.7396	-1.1172
Residual Pool Depth cm (RP100)	6.6856	20	4.8766	8.4947
Wood Volume per Square Meter Surface Area (RW)	0.0337	20	0.0189	0.0485
Key Piece Wood Volume per Square Meter Surface Area	0.0120	20	0.0003	0.0237
Width to Depth Ratio (W:D)	4.8967	20	4.2852	5.5083
Percent Fines	0.1724	20	0.1140	0.2309
Percent Sands & Fines (%SAFN)	0.4139	20	0.2997	0.5280
Percent Gravels	0.4242	20	0.3436	0.5047
Percent Cobbles	0.1405	20	0.0948	0.1862
Percent Small Boulders	0.0195	20	0.0117	0.0274
Percent Large Boulders	0.0019	20	-0.0006	0.0045
Percent Bedrock	0.0000	20	0.0000	0.0000
Bank Condition (1-5)	2.3484	20	2.1896	2.5071
Slope	0.0396	20	0.0251	0.0541
Bankfull Radius	0.3220	20	0.2929	0.3511
Estimated Bankfull Competence (m)	0.1285	20	0.0728	0.1841
Geometric Mean Particle Size (m)	11.3769	20	6.6262	16.1276
Geometric Mean Particle Size, no bedrock (mm)	11.3769	20	6.6262	16.1276

Table 20 - Granite Creek 1st Order Stream Data				
Metric	Mean	N	Upper 95% CB	Lower 95% CB
Log Relative Bed Stability (LRBS)	-2.1241	7	-2.8018	-1.4463
Log Relative Bed Stability, No Bedrock	-2.1241	7	-2.8018	-1.4463
Residual Pool Depth cm (RP100)	6.1458	7	1.2947	10.9968
Wood Volume per Square Meter Surface Area (RW)	0.0502	7	0.0137	0.0866
Key Piece Wood Volume per Square Meter Surface Area	0.0206	7	-0.0125	0.0538
Width to Depth Ratio (W:D)	4.1958	7	2.8651	5.5266
Percent Fines	0.2332	7	0.1225	0.3439
Percent Sands & Fines (%SAFN)	0.6102	7	0.3872	0.8333
Percent Gravels	0.3086	7	0.1630	0.4542
Percent Cobbles	0.0673	7	-0.0176	0.1523
Percent Small Boulders	0.0097	7	-0.0036	0.0230
Percent Large Boulders	0.0042	7	-0.0025	0.0109
Percent Bedrock	0.0000	7	0.0000	0.0000
Bank Condition (1-5)	2.3045	7	1.9396	2.6694
Slope	0.0645	7	0.0312	0.0978
Bankfull Radius	0.2908	7	0.2382	0.3434
Estimated Bankfull Competence (m)	0.2151	7	0.0762	0.3539
Geometric Mean Particle Size (m)	5.7485	7	-2.7674	14.2643
Geometric Mean Particle Size, no bedrock (mm)	5.7485	7	-2.7674	14.2643

Table 21 - Granite Creek 2nd Order Stream Data				
Metric	Mean	N	Upper 95% CB	Lower 95% CB
Log Relative Bed Stability (LRBS)	-1.3410	8	-1.5720	-1.1099
Log Relative Bed Stability, No Bedrock	-1.3410	8	-1.5720	-1.1099
Residual Pool Depth cm (RP100)	6.7812	8	4.7626	8.7998
Wood Volume per Square Meter Surface Area (RW)	0.0387	8	0.0256	0.0517
Key Piece Wood Volume per Square Meter Surface Area	0.0120	8	0.0063	0.0176
Width to Depth Ratio (W:D)	4.4760	8	3.7855	5.1665
Percent Fines	0.1444	8	0.0594	0.2293
Percent Sands & Fines (%SAFN)	0.3596	8	0.2401	0.4792
Percent Gravels	0.4823	8	0.3788	0.5858
Percent Cobbles	0.1358	8	0.1004	0.1713
Percent Small Boulders	0.0210	8	0.0129	0.0291
Percent Large Boulders	0.0012	8	-0.0009	0.0033
Percent Bedrock	0.0000	8	0.0000	0.0000
Bank Condition (1-5)	2.3773	8	2.1840	2.5706
Slope	0.0323	8	0.0208	0.0437
Bankfull Radius	0.3529	8	0.3157	0.3900
Estimated Bankfull Competence (m)	0.1045	8	0.0525	0.1565
Geometric Mean Particle Size (m)	11.4381	8	5.9005	16.9758
Geometric Mean Particle Size, no bedrock (mm)	11.4381	8	5.9005	16.9758

Table 22 - Granite Creek 3rd Order Stream Data				
Metric	Mean	N	Lower 95% CB	Upper 95% CB
Log Relative Bed Stability (LRBS)	-0.5943	5	-1.0369	-0.1517
Log Relative Bed Stability, No Bedrock	-0.5943	5	-1.0369	-0.1517
Residual Pool Depth cm (RP100)	7.2885	5	5.4240	9.1530
Wood Volume per Square Meter Surface Area (RW)	0.0026	5	0.0004	0.0047
Key Piece Wood Volume per Square Meter Surface Area	0.0000	5	0.0000	0.0000
Width to Depth Ratio (W:D)	6.5511	5	6.2469	6.8553
Percent Fines	0.1322	5	-0.0272	0.2917
Percent Sands & Fines (%SAFN)	0.2258	5	0.0574	0.3942
Percent Gravels	0.4930	5	0.3892	0.5968
Percent Cobbles	0.2503	5	0.1315	0.3692
Percent Small Boulders	0.0309	5	0.0115	0.0504
Percent Large Boulders	0.0000	5	0.0000	0.0000
Percent Bedrock	0.0000	5	0.0000	0.0000
Bank Condition (1-5)	2.3636	5	2.0201	2.7072
Slope	0.0163	5	0.0100	0.0226
Bankfull Radius	0.3164	5	0.2592	0.3736
Estimated Bankfull Competence (m)	0.0455	5	0.0207	0.0702
Geometric Mean Particle Size (m)	19.1586	5	6.3587	31.9586
Geometric Mean Particle Size, no bedrock (mm)	19.1586	5	6.3587	31.9586



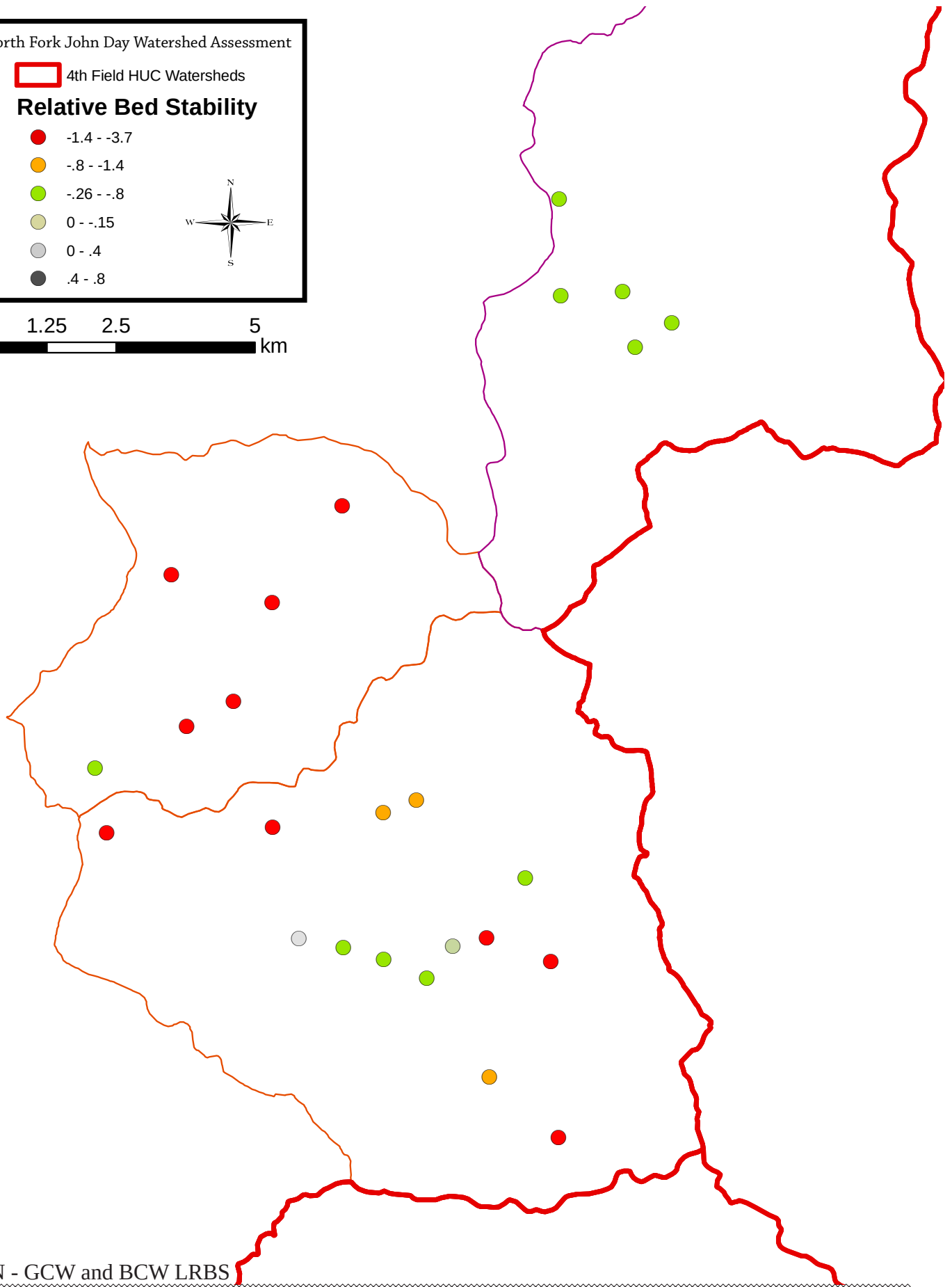
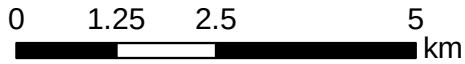
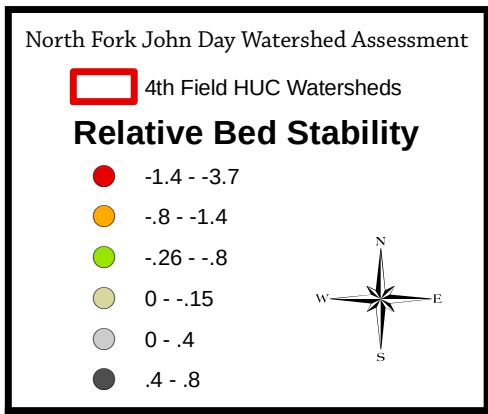
Baldy Creek Watershed (BCW) Results

The BCW is located immediately north of the GCW and is managed predominantly by the USFS almost entirely for Wilderness. The BCW is identified by the ODEQ as both a reference watershed and a 303(d) listed stream. The 303(d) listing was based on predicted potential for soil erosion as a result of fire activity. BCW data collected in 2008 for this Assessment was not included in the reference pool at the request of ODEQ staff, however one site collected in 2001 was included in the reference population. The North Fork John Day Wilderness Baldy Creek Unit is ~14,300 acres in area and was designated as Wilderness in 1984 primarily to provide headwater protection for tributaries of the North Fork John Day River. A large fire (the Sloans Ridge Fire of 1996) burned 7300 acres of the Baldy, Bull, and North Fork John Day drainages within the Wilderness.

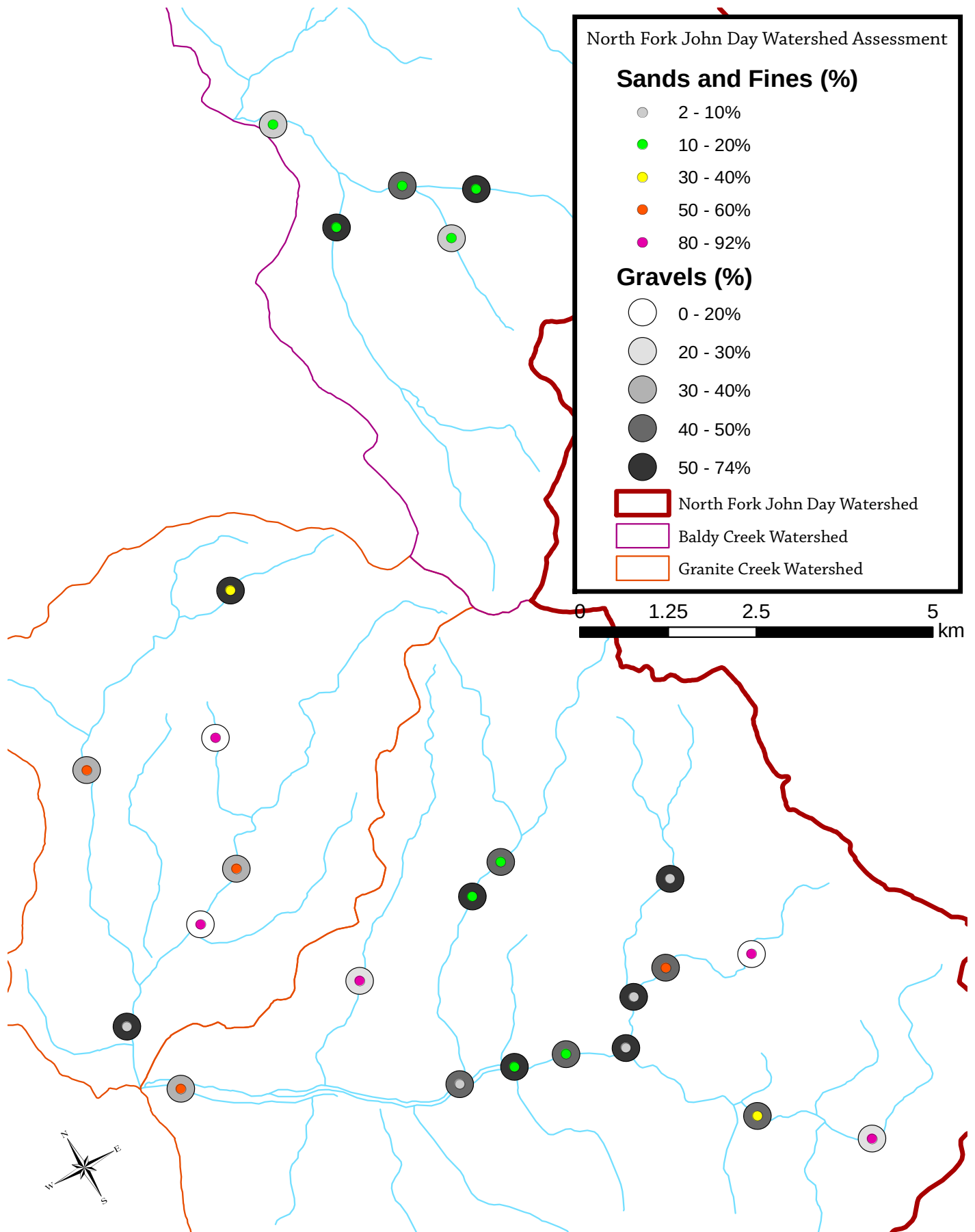
The BCW is more stable (BCW LRBS = -.45; Reference LRBS = -1.04) and exhibits a lower proportion of sands and fines (BCW %SAFN = 16%; Reference %SAFN = 21%) than reference. The historical reference site collected in 2001 had a %SAFN value of 40%. One hypothesis is that this site exhibits an above average (when compared to both the five 2008/09 sites collected in the BCW and to the first site immediately upstream) SAFN naturally as a result of the extensive burns. The large burn that occurred five years prior to the survey of the 2001 site burned the majority of the headwaters of the BCW. In combination with the larger width to depth ratios and pool volume this site is likely to accumulate fine sediments supplied from the remainder of the stream network. A related hypothesis is that large and intense fires destabilized the stream network and initiated a flush of sediments from the system. As this sediment moved through the system and no new watershed-scale disturbances occurred a new, lower baseline %SAFN was established. In other words the fires resulted in a long-term decrease in the average %SAFN within the watershed despite the short-term increase in %SAFN.

The Baldy Creek stream network is underlain by glacial deposits similar to those which underlie the erodible reference sites. The proportion of sands and fines is nearly 50% less however in the BCW than in the erodible reference population. Pool volume is low in the BCW, possibly limiting the quality of rearing habitat. Wood volume is nearly identical between the BCW and similarly sized reference streams. Width to depth ratios are similar between the BCW and the reference population. Overall, the stable beds and relatively low levels of sands and fines support the conclusion that the BCW should remain a reference watershed.

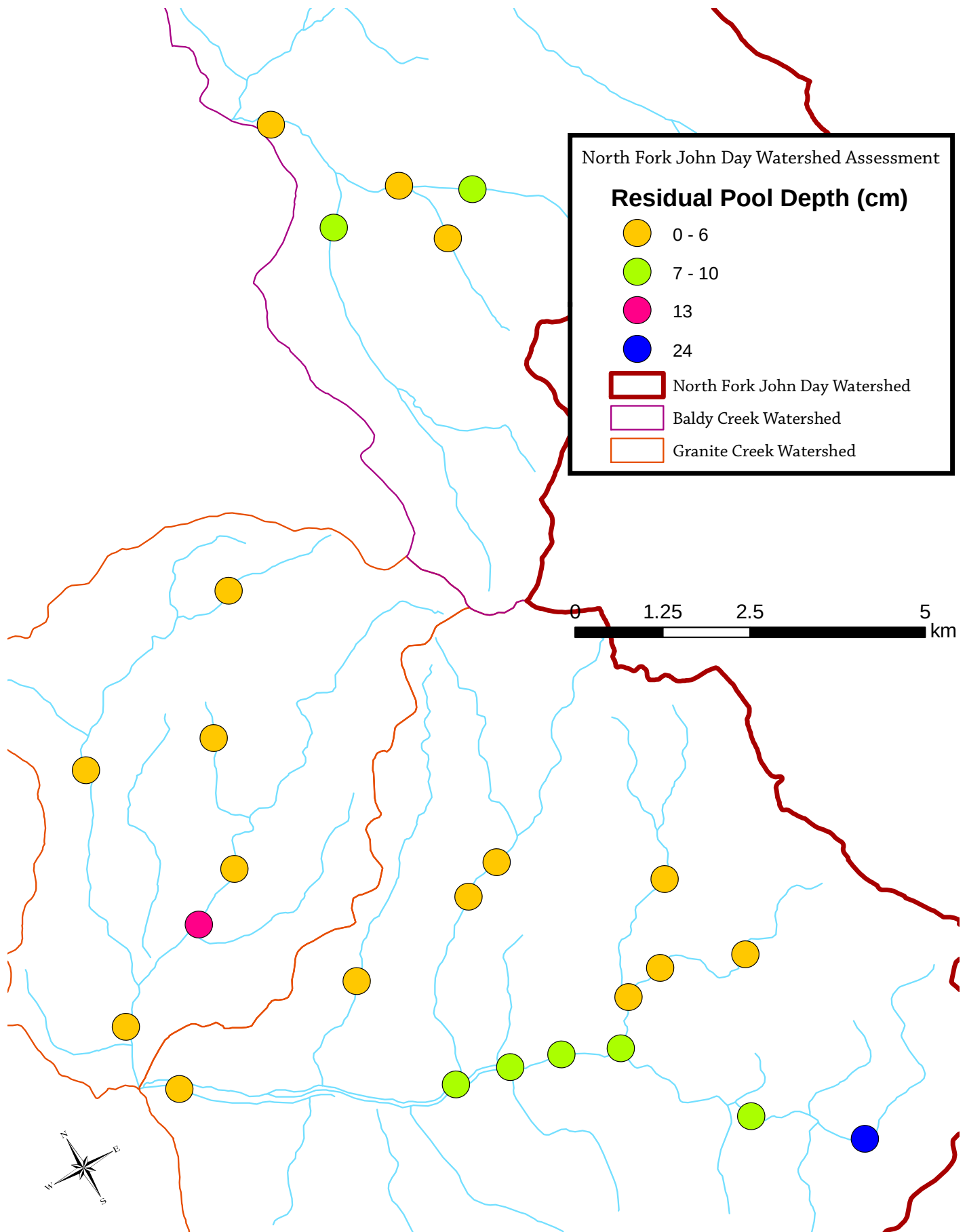
Table 23 - All Baldy Creek Stream Data				
Metric	Mean	N	Lower 95% CB	Upper 95% CB
Log Relative Bed Stability (LRBS)	-0.4573	5	-0.5693	-0.3452
Log Relative Bed Stability, No Bedrock	-0.4855	5	-0.6198	-0.3513
Residual Pool Depth cm (RP100)	6.5984	5	4.8185	8.3782
Wood Volume per Square Meter Surface Area (RW)	0.0352	5	0.0240	0.0464
Key Piece Wood Volume per Square Meter Surface Area	0.0142	5	0.0063	0.0221
Width to Depth Ratio (W:D)	9.3671	5	8.4068	10.3274
Percent Fines	0.0171	5	-0.0006	0.0348
Percent Sands & Fines (%SAFN)	0.1562	5	0.1325	0.1799
Percent Gravels	0.4286	5	0.2976	0.5596
Percent Cobbles	0.2648	5	0.1961	0.3334
Percent Small Boulders	0.1010	5	0.0211	0.1808
Percent Large Boulders	0.0286	5	0.0057	0.0514
Percent Bedrock	0.0210	5	-0.0149	0.0568
Bank Condition (1-5)	2.0764	5	1.7374	2.4153
Slope	0.0494	5	0.0154	0.0833
Bankfull Radius	0.2758	5	0.2458	0.3057
Estimated Bankfull Competence (m)	0.0813	5	0.0415	0.1210
Geometric Mean Particle Size (m)	29.6869	5	15.6929	43.6809
Geometric Mean Particle Size, no bedrock (mm)	27.2045	5	14.8327	39.5762

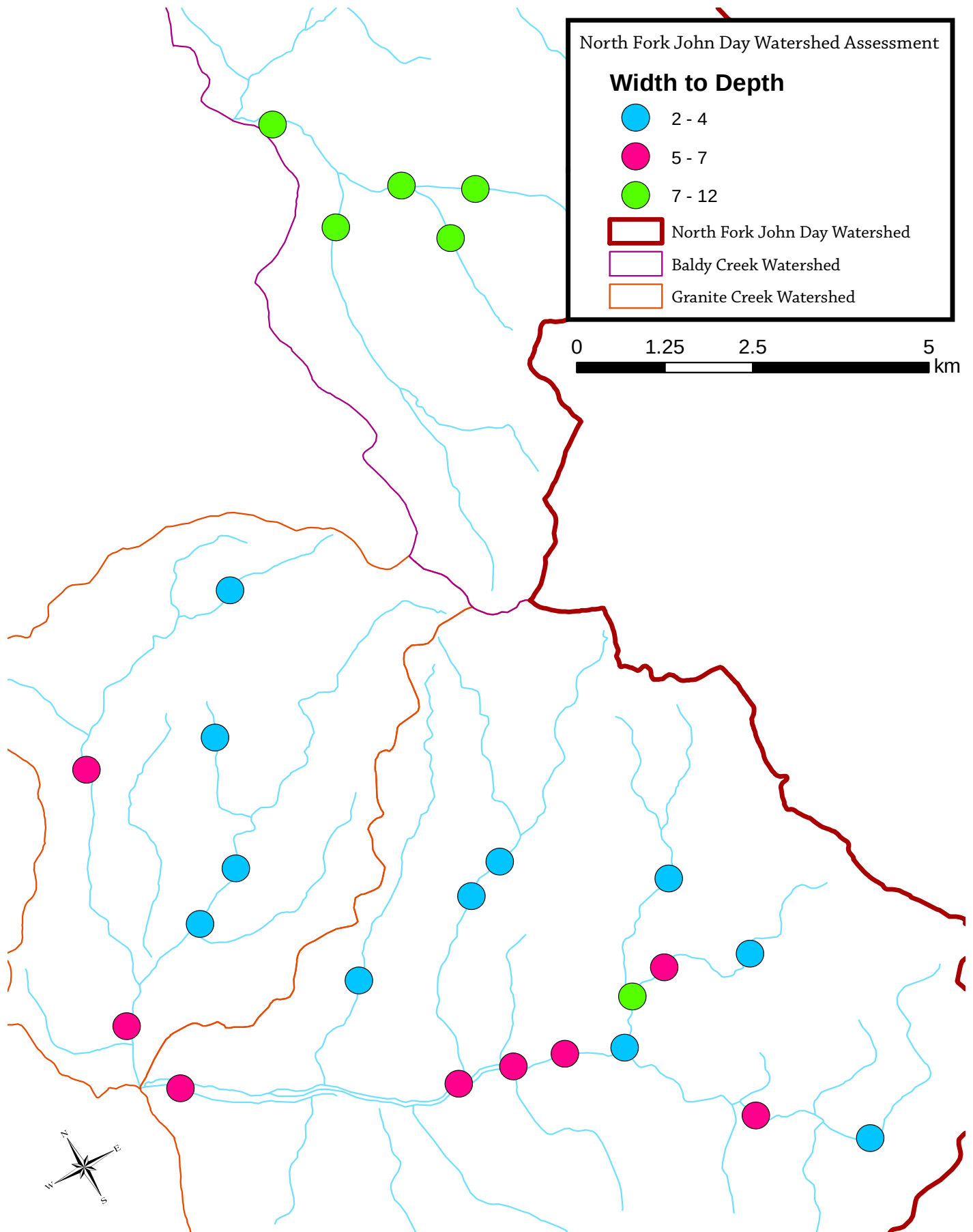


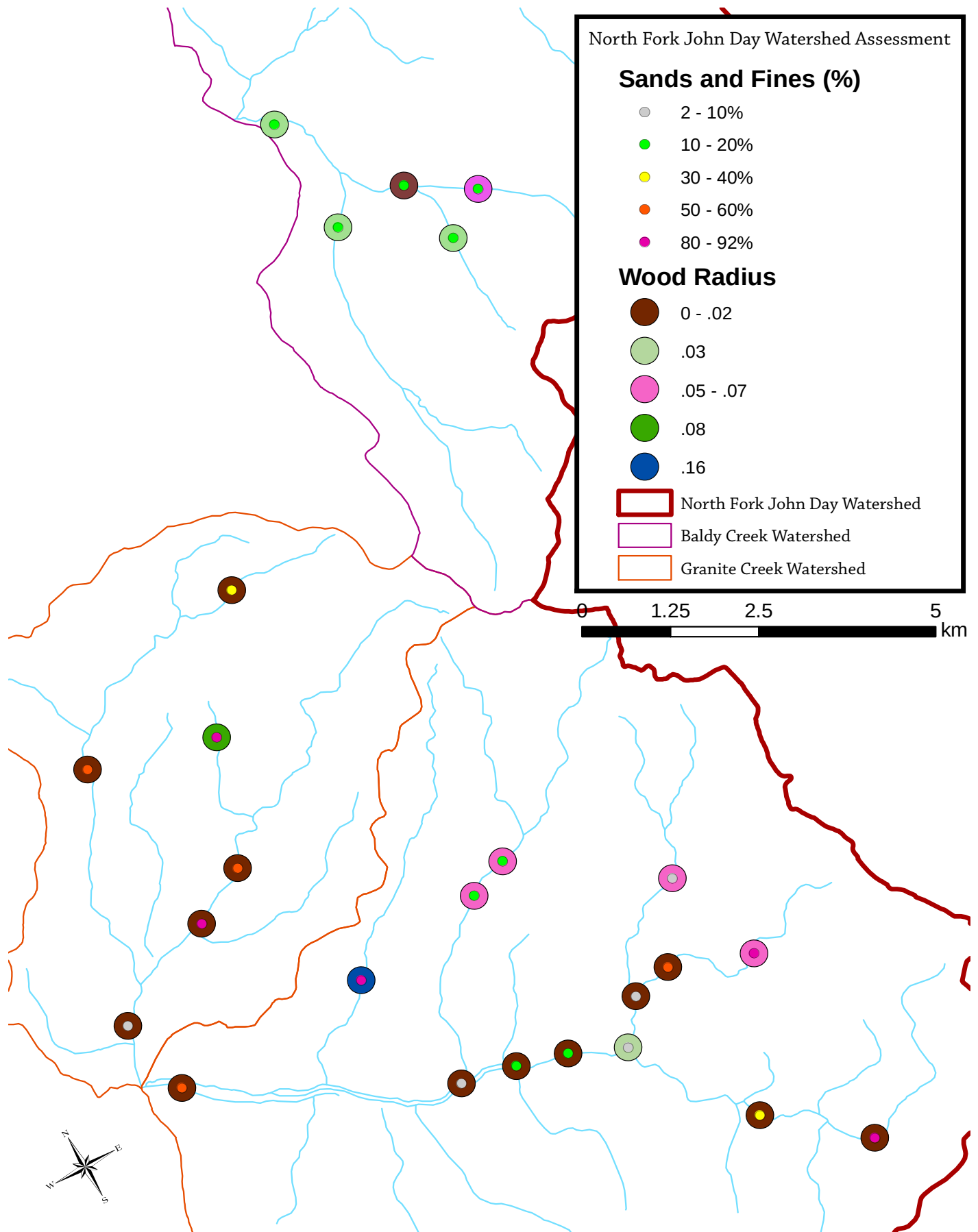
Map N - GCW and BCW LRBS



Map O - GCW and BCW %SAFN and %Gravels







Historical EMAP Data Results North Fork John Day River Watershed

Twenty sites were surveyed between 1997 and 2002 within the North Fork John Day using the EMAP protocol (does not include reference data or study areas). This data was analyzed during this study and the results reported below. This sub-population (NFJDW) was found to have a relative bed stability value closer to reference populations than either the WCW or the BCW (NFJDW LRBS ~ -.79 vs. Reference ~ -1.04; WCW LRBS ~ -.28). Sands and fines proportions were similar with the NFJDW exhibiting a lower %SAFN (~14.4%) than Blue Mountain reference watersheds (~21%). Wood Volume is almost double that of reference watersheds (.062 vs. .034). Width to depth ratios are similar to reference (10.6 vs. 9.6 respectively) although residual pool depth is lower than reference (5.6 vs. 7.2 respectively).

Table 24 - NFJD Sites Out of Study Area				
Metric	Mean	N	Lower 95% CB	Lower 95% CB
Log Relative Bed Stability (LRBS)	-0.7914	20	-0.9599	-0.6229
Percent Sands & Fines (%SAFN)	0.1439	20	0.1050	0.1829
Percent Fines	0.0728	20	0.0502	0.0953
Wood Volume per Square Meter of Surface Area (RW)	0.0626	20	0.0300	0.0952
Residual Pool Depth (RP100)	5.5729	20	4.5201	6.6257
Width to Depth Ratio (W:D)	10.6117	20	9.0563	12.1671



North Fork John Day

Discussion -The following sections address the data in regards to Question 4 - Are other types of impairment indicated; and Question 5 - As appropriate, given the proposed method of analysis and for the various sample/ data types: are reference and sample data populations statistically similar.

Part 1 - Study Design: Goals and Limitations

A series of questions were developed by the technical guidance team formed for this project. Some of these questions were answered with confidence during this study. The six primary questions raised to guide this assessment and the associated answers are:

1) Can we identify and/or characterize sedimentation concerns (in relation to the water quality standard) at relevant scales?

Not relevant at this time given the absence of a formal sediment legal standard. Were a legal standard to be set, the study design is robust enough to utilize this data to make that determination. No assessment was made at the listed stream scale as stream listings are applicable for the watershed upstream of the lowest listed segment which includes the entire WCW, the two 6th fields in the GCW, and the BCW.

2) Do these concerns warrant a designation of impairment (adverse impact on beneficial use)?

Not relevant at this time given the absence of a formal sediment legal standard. Additionally the data available for biotic usage is spatially limited and therefore difficult to compare to the physical habitat data.

3) Is sedimentation a limiting or controlling factor, with respect to impairment?

Not relevant at this time given the absence of a formal sediment legal standard. Additionally biotic data is limited. In order to address this question (with respect to a limiting factor for salmonid production) winter and summer juvenile salmonid rearing data would need to be collected and a complete spawning gravel inventory would need to be conducted. This would form the basis of a watershed salmonid production model which could then be used to identify limitations on salmonid production. Given the almost complete absence of spawning gravels, lack of complex habitat, and temperature issues, it is difficult to conceive that the limitation or controlling factor on salmonid production is fine sediment.

4) Are other types of impairment indicated?

Yes. Spawning habitat is limited from a lack of well sorted gravels and high temperatures. Large wood, although present (large wood present was also likely placed during historical restoration projects), is not evenly distributed throughout the WCW and is likely limiting gravel sorting, pool development, and channel migration.

Summer rearing habitat is limited from high summer temperatures, low channel complexity and cover, and low pool volumes. Canopy cover is low in many parts of the WCW. Only one instance of cattle grazing was encountered during the assessment suggesting that the fencing work conducted by the USFS is largely successful. Additionally the riparian canopy present almost always consisted of willows and other shrubs and there were very few conifers. In conjunction with low flows and limited pool habitat, a low canopy cover can lead to poor summer rearing. Almost no undercut banks were observed in the WCW. Flow is also potentially impacting beneficial uses. Several mainstem reaches of the WCW went dry during the summer. One beaver pond was observed in the WCW. It is theorized that beavers play a large role in flow regulation in the WCW in regards to summer discharge.

5) As appropriate, given the proposed method of analysis and for the various sample/data types: are reference and sample data populations statistically similar?

This question was answered and addressed in detail in the results section. Generally, sands and fines proportions are similar between the WCW and the reference population but the WCW has somewhat lower wood volumes and is more stable. The GCW has a higher sands and fines proportions than reference and is more unstable. The BCW is similar to reference.

6) Do the sample populations meet acceptable thresholds?

Not relevant at this time given the absence of a formal sediment legal standard.

Part 2 - The Primary Metrics and their Significance

Relative Bed Stability (RBS) – In order to understand the functioning condition of a watershed in relation to RBS, it is necessary to understand what RBS is and is not; how the metric is treated and analyzed; and what changes in RBS mean in a field situation. RBS is logged (LRBS) to normalize the data and allow for parametric statistical tests to be performed. LRBS is a multi-metric indicator and accounts for stream power (bankfull depth and height; gradient) and roughness (bedform and particle roughness; wood and pool volume; bedded sediments). LRBS is sensitive to changes in stream slope (meaning that a minor change in slope can change the LRBS score a great deal) but is less sensitive to small changes in substrate.

Large changes to substrate proportions do affect LRBS however. For instance if a stream experiences a large scour event as the result of a 100 year flood or a debris slide LRBS will likely increase (become more positive). However, this same event can deposit fine grained sediments downstream of this scour. The LRBS value at this point would likely indicate a decrease in stability (assuming all other metrics remained the same). The LRBS value for this example population may not change significantly even though there were significant changes in the sediment regime in the example watershed.

Using the WCW as an example, sands and fines are near reference averages but RBS indicates significant stability. Additionally wood in the WCW is below reference with most sites exhibiting no wood. If wood volumes returned to reference levels this might result in a change in RBS. Although an increase in wood volume could increase the stability of the watershed (resulting in a more positive RBS value), wood can also trap more fine sediments and lead to channel migration and slope modifications. This *may* lead to a change in RBS as a result of fine sediment and gravel aggradation and slope modifications (depending upon the size of the wood and the manner in which the wood settles in the channel).

Substrate Proportions (%SAFN, % Cobbles, et cetera) – The %SAFN is a fairly straight forward metric and is the proportion of the stream bed (as measured at 105 points; 11 transects, 10 additional pebble counts, 5 points across the stream) which exhibits sands and fines. Sediment transport is a complicated science. Although extremely low bed stability values (LRBS = -2.5) are often correlated with high proportions of sands and fines, high proportions of sands and fines are not always associated with unstable systems. For instance in a low gradient, low flow, and small stream with a high volume of wood in a watershed dominated by an erodible lithology, bed stability may be positive. Additionally, bed stability in a system with 50% sands and fines may exhibit a positive LRBS value if the other 50% substrate is bedrock. As stated previously, although sands and fines in the WCW are near reference values the bed stability indicates possible scour. This might indicate that the system has resulted in an equilibrium where fine sediment input levels are similar to reference but other physical parameters are dissimilar to minimally disturbed conditions (either from landuse or from naturally occurring differences).

Additionally the manner in which sediments are distributed throughout a watershed is critical for salmonid survival. Well sorted gravel flats between .5-2.5% slope at a pool crest tail-out are necessary for salmonid spawning. Very few of these were encountered in the WCW although fish were observed in June and in August of 2008 (juvenile steelhead and redband trout/1+steelhead). It is hypothesized that fine sediment is not limiting salmonid spawning by choking developing eggs but poor gravel sorting is limiting spawning.

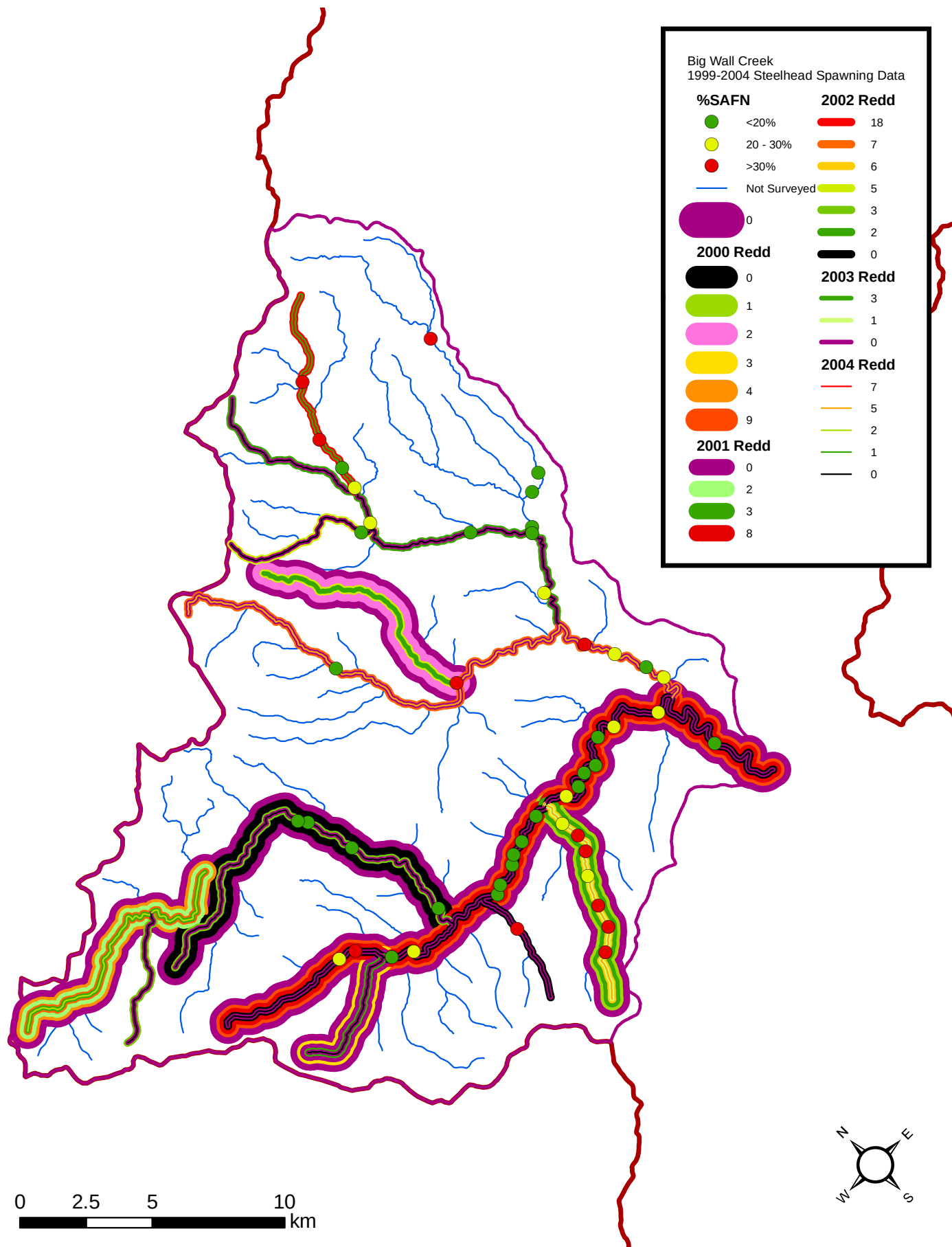
In the WCW areas with high sand proportions do overlap with beneficial uses. The mainstem dominates potential spawning habitat in total length but appears to be used in only the best of years (it is possible that temperature is too high for spawning in the mainstem by late spring/early summer). When the mainstem is unsuitable for spawning habitat the tributaries are utilized to a greater degree. The caveat to this is that the spawning data is only spatially explicit to the stream, not to a point on the stream. In general though it appears that sands in spawning habitat may be more of an issue during years that exceed the temperature standard during spawning season in the spawning habitat (as opposed to a watershed temperature average) than when it does not. In the 2003 spawning season (May 20 - June 15) the seven day maximum average within Wall Creek was 22.4°C. Every day within this time frame exceeded the spawning criteria of 55°F.

This correlated with extremely low spawning in the watershed and no spawning in the mainstem. An alternative hypothesis is that flow exceeded the maximum preferred range for spawning and spawners sought out smaller tributaries for this reason. In both cases sands and fines in these tributaries are an issue because the spawners are forced into areas where egg to emergence survival rates might be lower from embeddedness of fine sediments. In other words sediment may be negatively impacting beneficial uses *because* of high temperatures during spawning season. If summer temperatures were not an issue salmonids would have more choice in where spawning occurred, as it is now they are driven to areas with higher sands and fines (on average). Refer to Map S - Wall Creek Spawning Data and Sands and Fines.

Residual Pool Volume (RP100) – RP100 is can be imagined as the remaining water left in a stream if all flow ceased. It is a control on bed stability in that the amount of energy needed to move a particle from the bottom of a pool is greater than the energy needed to move a particle from a bedrock chute (assuming all other metrics remain the same). Pool volume is an important metric of consideration within the WCW in regards to salmonid rearing. Almost all deep pools observed were in conjunction with historical restoration (either wood and/or boulder placement). Pools are very important in the WCW given the flow regime (the mainstem of Wall Creek at the confluence with the North Fork John Day flows subsurface for a span of ~15-30 meters).

Width to Depth Ratio (W:D) – W:D is the ratio of the bankfull width to the bankfull depth. Width to depth can indicate the temporal trajectory of a stream channel. For instance when a stream experiences a prolonged disturbance (such as large wood removal, large wood input reduction, or channelization) it often undergoes a series of morphological changes. First down-cutting occurs as stream power increases. Then as high waters can no longer access their floodplains bank destabilization occurs followed by channel migration and a widening of the channel (an increased W:D can indicate that a stream is in this morphological state). Finally fine sediments are deposited on the channel margins rebuilding the trapazoidal shape and creating a new floodplain. The historical floodplains then are characterized as terraces. This is a gross generalization found to be true in many cases. Additionally stream size needs to be considered when interpreting W:D. Smaller streams (1st order for example or streams with small drainage areas) often have smaller pool depths (and are generally shallower over all) than larger streams. A low W:D can indicate entrenchment on a large stream or can simply be indicative of a small stream. This is one of the primary reasons for stratification by stream order. High W:D along with low sands and fines appear to explain the stability of the mainstem.

Wood Radius (RW) – This is defined as the cubic meters of wood per square meter of stream surface area over the length of a survey. Most of the WCW has 0 wood, the wood that is present is often confined to headwaters where the volumes are inflated as a result of the small stream size. RW is often (even in reference streams) not higher than .06 however some streams exhibit wood volumes of .86 or more. Additionally a population RW is non-normal meaning that most sites have extremely low values while a few sites have RW values greater than 1. There are several issues associated with this occurrence. The first is that a few sites with extreme wood volumes (10% of population with RW of 1) can dominate the RW score of a population with very low wood volumes overall (90% of population with RW of .01). The second is that it is difficult to understand what reference wood volumes mean. Although the ODEQ has a vigorous criteria for selecting reference sites these watersheds represent the most minimally disturbed areas within Oregon. Given the history of instream wood removal, stream cleaning, and riparian harvest within Oregon it is unlikely that these watersheds represent anything close to pre-disturbance conditions. Given that wood volumes influence so many physical characteristics of channel morphology the importance of understanding what historical wood volumes were is of critical import regarding setting as legal standard for sedimentation.



Map S - Wall Creek Spawning Data and Sands and Fines.

Part 3 – Data Interpretations and Limitations

Stream Order – Morphological differences between stream order are present as has been shown in previous literature. Generally high gradient streams have a greater sediment transport capacity than low-gradient streams. This has been extensively discussed in the following: Channel-reach Morphology in Mountain Drainage Basins by Montgomery and Buffington.¹ When interpreting this data, it is appropriate to compare results within the stream order classification schema. Further it was noted during this assessment that there were significant differences in flow between 1st order streams in the WCW and the BCW and the GCW. It may be appropriate to control for elevation and precipitation when comparing these populations.

Elevation - Elevation was a dominant factor in stream power. First order streams (NHD 1:100K stream layer) were dropped from the sample after it was found that most 1st order streams within the WCW were dry during the low flow season. The 1st order streams within the GCW and the BCW were not dry during the same time period however. Generally the reference population sites were located at elevations between 3000' and 6000'. It is possible that 1st order streams higher in elevation may provide more stream power and supply more fine sediments than those lower in elevation.

Lithology - All volcanics are considered resistant. The limited work relating EMAP/RBS has been successful at relating channel metrics to geology at a gross scale, but not a fine-detail one. It is important to consider lithology when interpreting EMAP physical habitat data. First lithology almost always drives the proportion of instream sands and fines present. Second lithology determines how long before gravels are abraded into finer grained sediments. This gives some indication of sediment sources. For example if a stream exhibits 50% sand and is found within an erodible watershed dominated by low gradient streams, it is likely that a significant proportion of the sands are coming either from instream gravel abrasion or from localized channel migration. In contrast if this stream were located in a resistant watershed these sands might be coming from a source farther away. There was a higher proportion of erodible material in both the GCW and BCW study areas. It is possible that bank erosion and gravel abrasion is a significant source of the sands observed in the GCW study area. This study did not test this hypothesis.

The Wall Creek Watershed (WCW) – The WCW is dominated by a resistant lithology (~94% resistant as defined by the OGDC data layer). For this reason stratification by geology was deemed unnecessary. The WCW exhibits a higher mean %SAFN than the resistant reference population (WCW %SAFN ~24% vs. Resistant Reference %SAFN ~18%; Resistant Reference Population N = 22). Relative bed stability (LRBS) within the WCW is higher than the resistant reference population (-.28 versus -.97 respectively) indicating that the WCW is more stable than the resistant reference population. These two metrics (%SAFN and LRBS) can be interpreted together to better understand the current condition of the watershed. It is possible that a decrease in bed stability (which would bring the WCW closer to the Blue Mountain Ecoregion resistant reference population) might lead to an increase in the percentage of sands and fines. Generally as sands and fines become more abundant LRBS decreases. LRBS in the WCW mainstem is largely driven by width.

No correlation was observed between fire occurrence and the %SAFN in the WCW. Three hypotheses were generated from this result: the most recent fire had no influence on the sediment transport regime of the system; the most recent fire did increase instream sands and fines but these were flushed quickly from the system; an increase of instream sands and fines will occur in the following decade. The final hypothesis is loosely supported by the limited data correlating elevated sands and fines in the Baldy Creek Watershed following the 1996 fire.

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(GSA Bulletin; May 1997; v. 109; no. 5; p. 596-611; DOI: 10.1130/0016-7606; 1997)

The Granite Creek Watershed (GCW) – The GCW has a mixed lithology. For this reason no stratification by lithology was conducted and the GCW population data was compared to the entire Blue Mountain Ecoregion (BME) reference population. Relative bed stability within the GCW is greater than the BME reference population (GCW LRBS= -1.45; BME Reference LRBS= -1.04). This is equivalent to roughly a 3 times decrease in relative bed stability. Further 1st order streams within the BME reference population exhibit more bed stability than in the GCW (GCW 1st order LRBS ~ -2.12; BME reference population 1st order LRBS ~ -1.51). Additionally, although roughly one-third of the GCW population is comprised of 1st order streams, the mean LRBS value of the GCW population is similar to the mean of the entire 1st order BME reference population. In other words the over all mean relative bed stability within the GCW is much higher than the BME reference population because of the extreme instability of the 1st (and to a lesser extent 2nd) order streams.

The Baldy Creek Wilderness (BCW) – The BCW stream network is dominated by glacially deposited surficial sediments. The hillslope lithology is a mix of sedimentary and plutonic sediments. For this reason, the BCW was compared to the entire BME reference population. Relative bed stability in the BCW is higher than the reference population (BCW LRBS = -.45; BME Reference LRBS = -1.044). This is equivalent to roughly a 4 times increase in stability from reference to the BCW population. The BCW population has a lower proportion of fine sediments than the reference population (BCW %SAFN = 15.6%; BCW %Fines = 1.7%; BME Reference %SAFN = 21.4%; BME Reference %Fines = 8.3%). The relatively low proportion of fine sediments is in part responsible for the stable beds observed in the BCW population. The high %SAFN (40%) value at the single historical site available for the BCW suggests that the stream network may be flushing fine sediments generated during the 1996 fire.

Part 4 – Data Applicability and Interpretation within this Project

Stratification – Stratification is conducted to compare a unique (either known or hypothesized; refer to discussion of significance testing) sub-population to a control population. For instance two watersheds are different in location but they may have a similar proportion of instream fine sediments. Stratification in this case would be conducted at multiple levels to determine why these two different populations have similar or dissimilar fine sediment proportions. One stratification could include a sub-population defined as resistant and erodible lithologies, another might include sub-populations defined by landownership, gradient, et cetera. With this study the major stratification which occurred was by watershed. Although it is known that the watersheds are different (in physical location, elevation, average stream size, lithology, et cetera) it was unknown how these differences influenced fine sediments. Other stratifications were conducted by analyzing the reference data in its entirety, by lithology, and by stream order. The most appropriate reference sub-population was then compared to the test population (for instance 1st order sites were compared to 1st order sites, resistant watersheds were compared to resistant watersheds). As the WCW was not similar in lithology or elevation to the majority of the reference data or the BCW and the GCW it was deemed unnecessary to analyze the entire test population to the entire reference population.

Hypothesis Testing – Hypothesis testing was not conducted during this assessment for a variety of reasons (please refer to the North Fork Siuslaw Physical Habitat and Sediment Assessment document for a complete discussion). Briefly, hypothesis testing only elucidates the statistical power of a test and says nothing about effect size. In most ecological studies, it is not a lack of power that limits the study, rather the issues associated with interpretation. Hypothesis testing does not elucidate differences, rather it only determines if there are differences. In ecological studies, it is already known that the populations are different. In other words, a stream network may have more unstable beds and a higher proportion of sands and fines than another, but a hypothesis test does not explain how that impacts beneficial uses, it only states whether or not a study has enough sites to state to some degree of certainty that the populations are different.

Questions for Future Study

- What is the spawning and rearing capacity of the WCW, the GCW, and the BCW?
- What is the seasonal habitat limitation: spawning, summer rearing, or winter rearing?
- Are steelhead driven to sites with lower spawning potential as a result of high stream temperatures?
- In what way do beaver ponds regulate summer flow and sediment transport/storage regimes?
- Is riparian vegetation limited by wild ungulate grazing?
- How dissimilar are the reference wood volumes from pre-settlement conditions?
- What role does wood serve in the WCW in regards to sediment trapping and sorting?
- If wood were returned to reference levels will fine sediment become an issue in the WCW?

Suggested Reading

Bell, M.C. 1973. *Fisheries handbook of engineering requirements and biological criteria*. US Army Corps of Engineers. Fish Passage Development and Evaluation Program, North Pacific Division, Portland, Oregon. Contract DACW57-68-0086.

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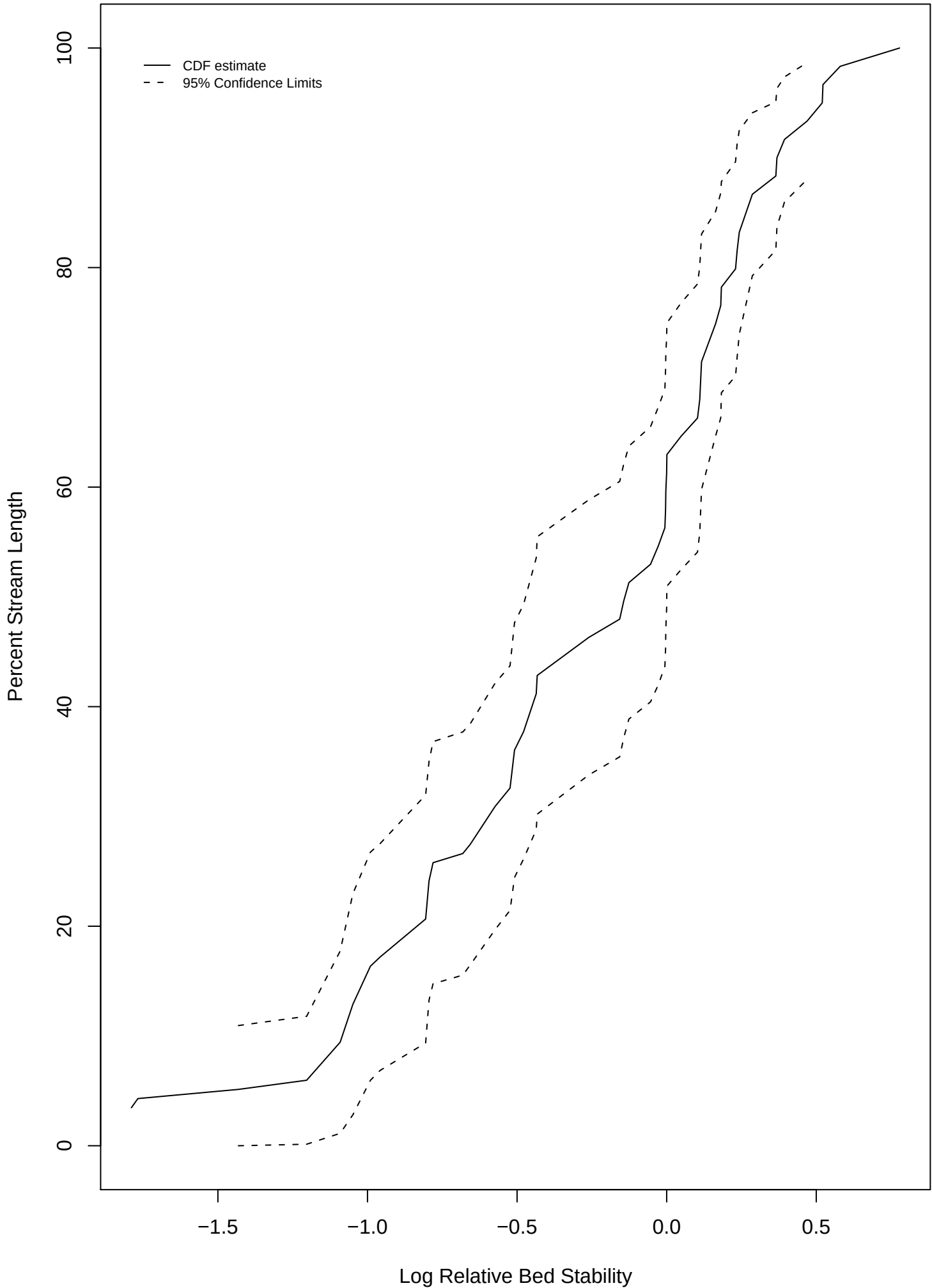
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USFS (1995) *Wall Ecosystem Analysis*

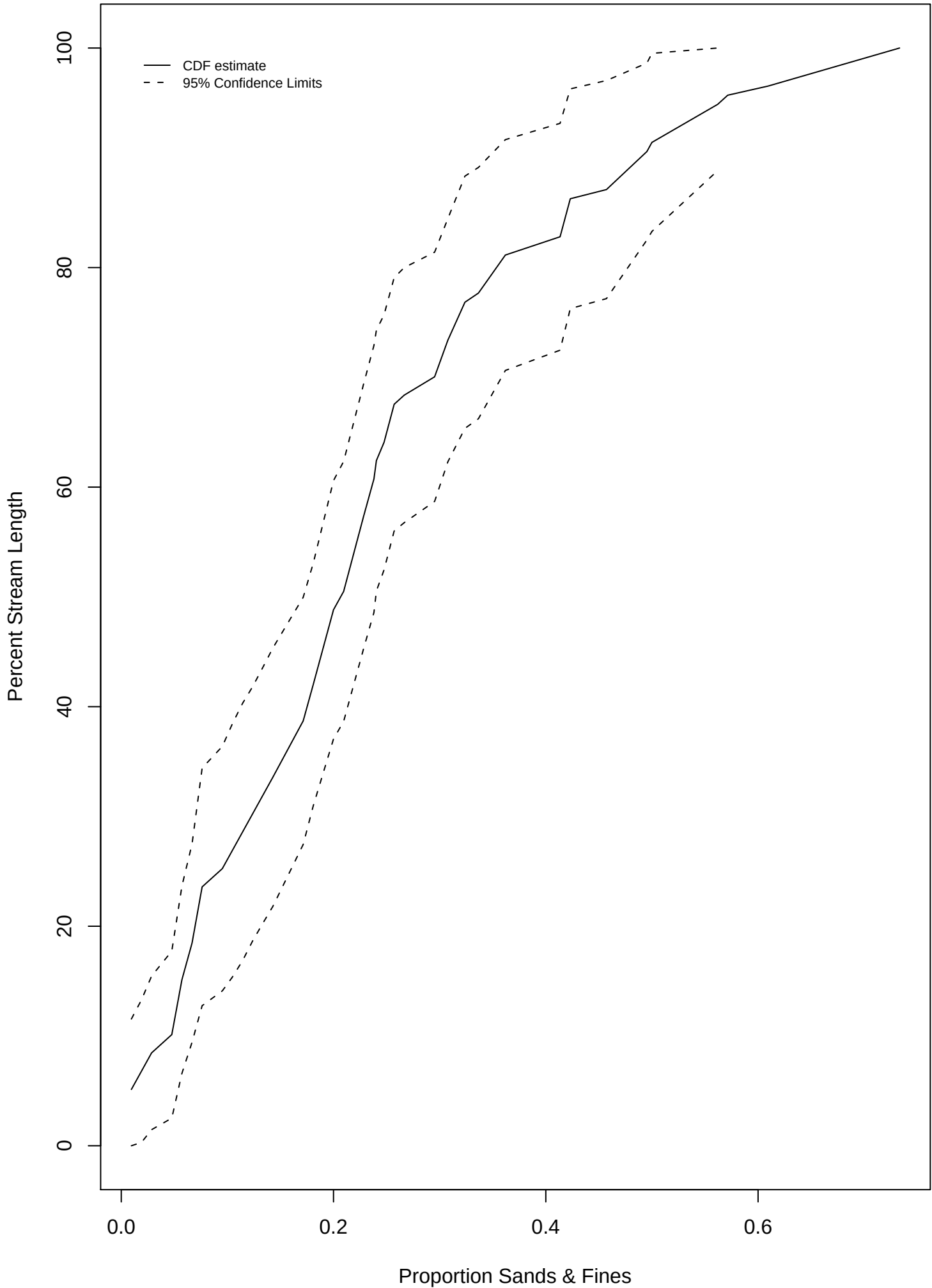


North Fork John Day at Night

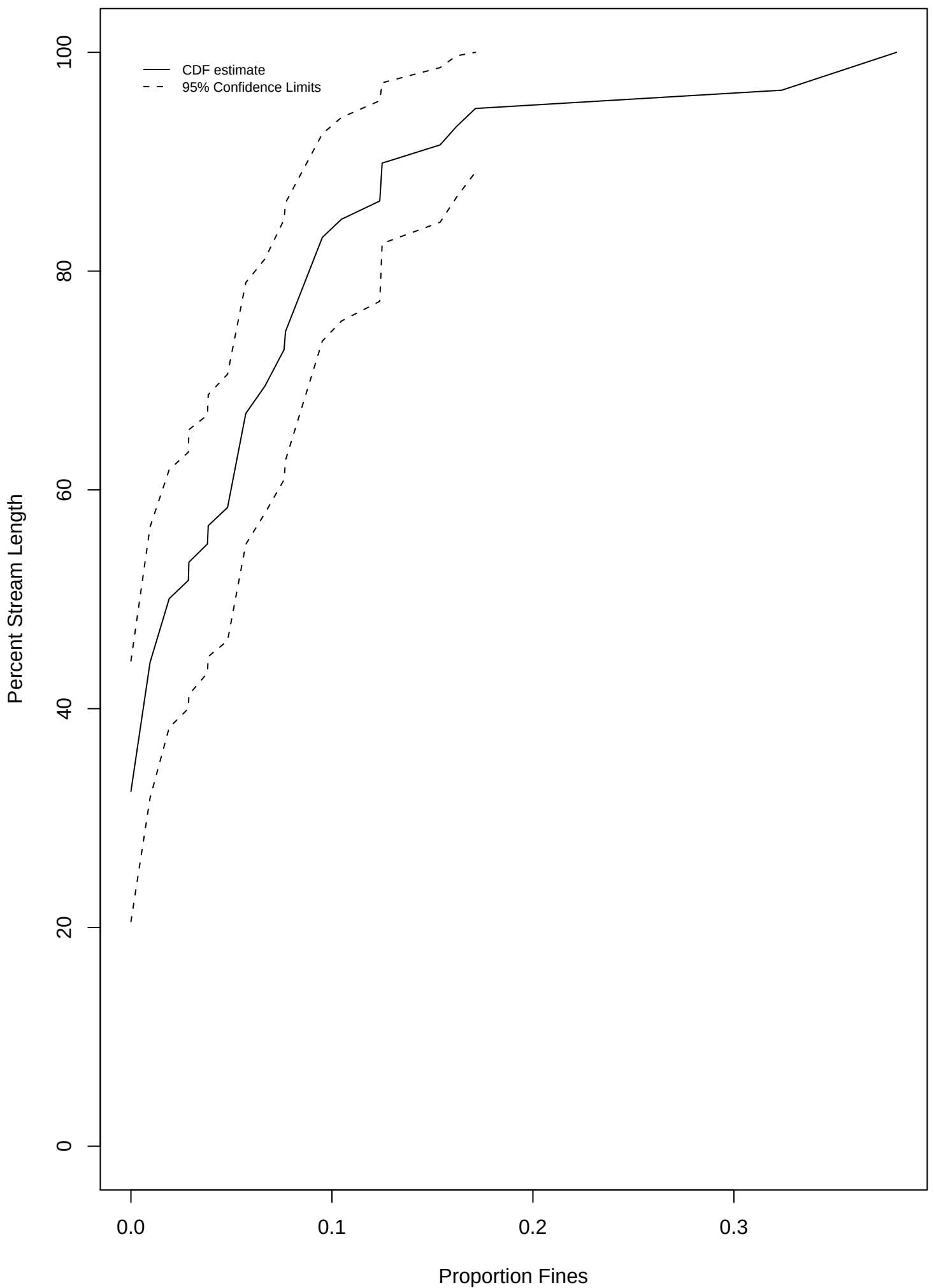
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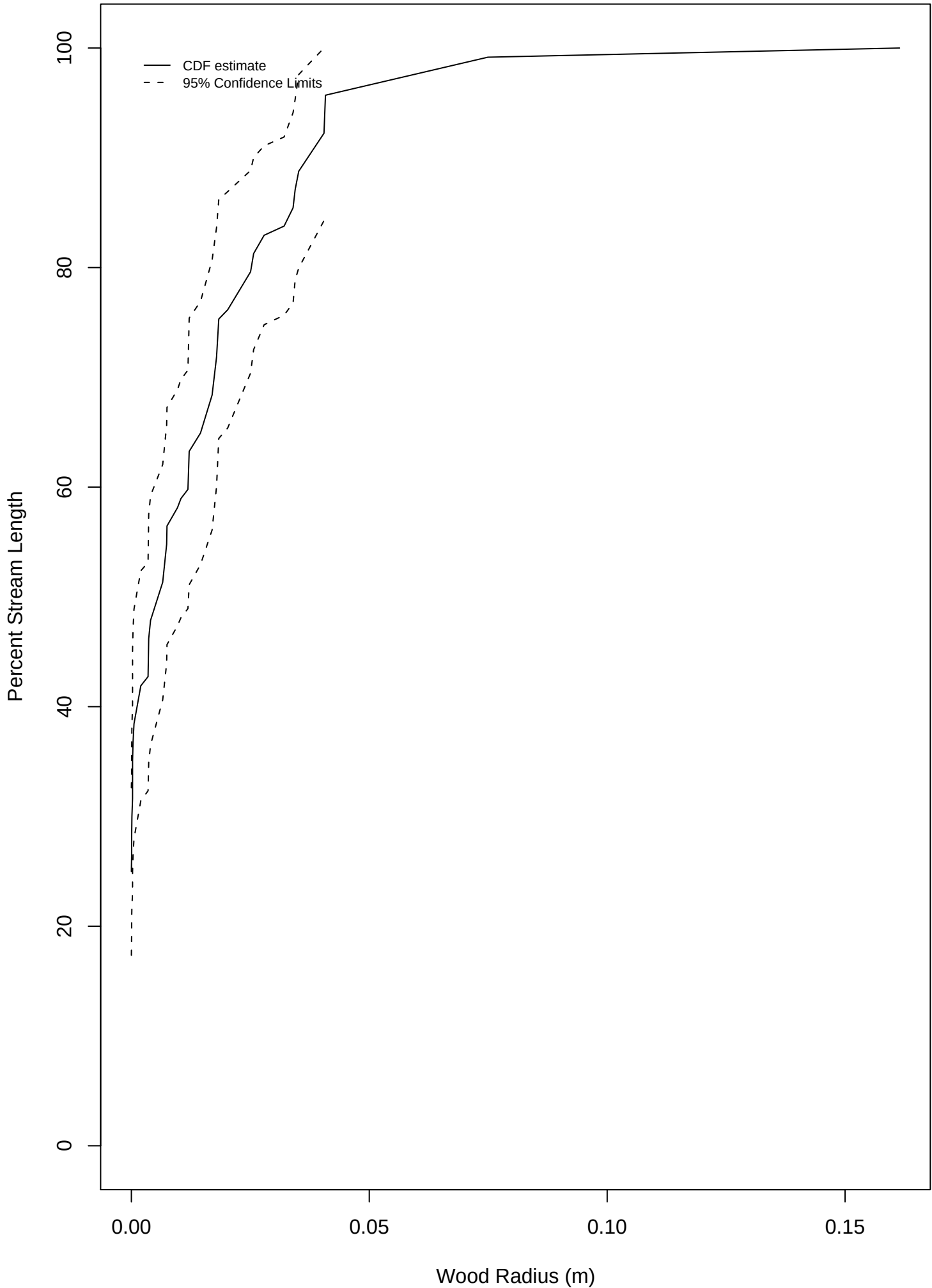
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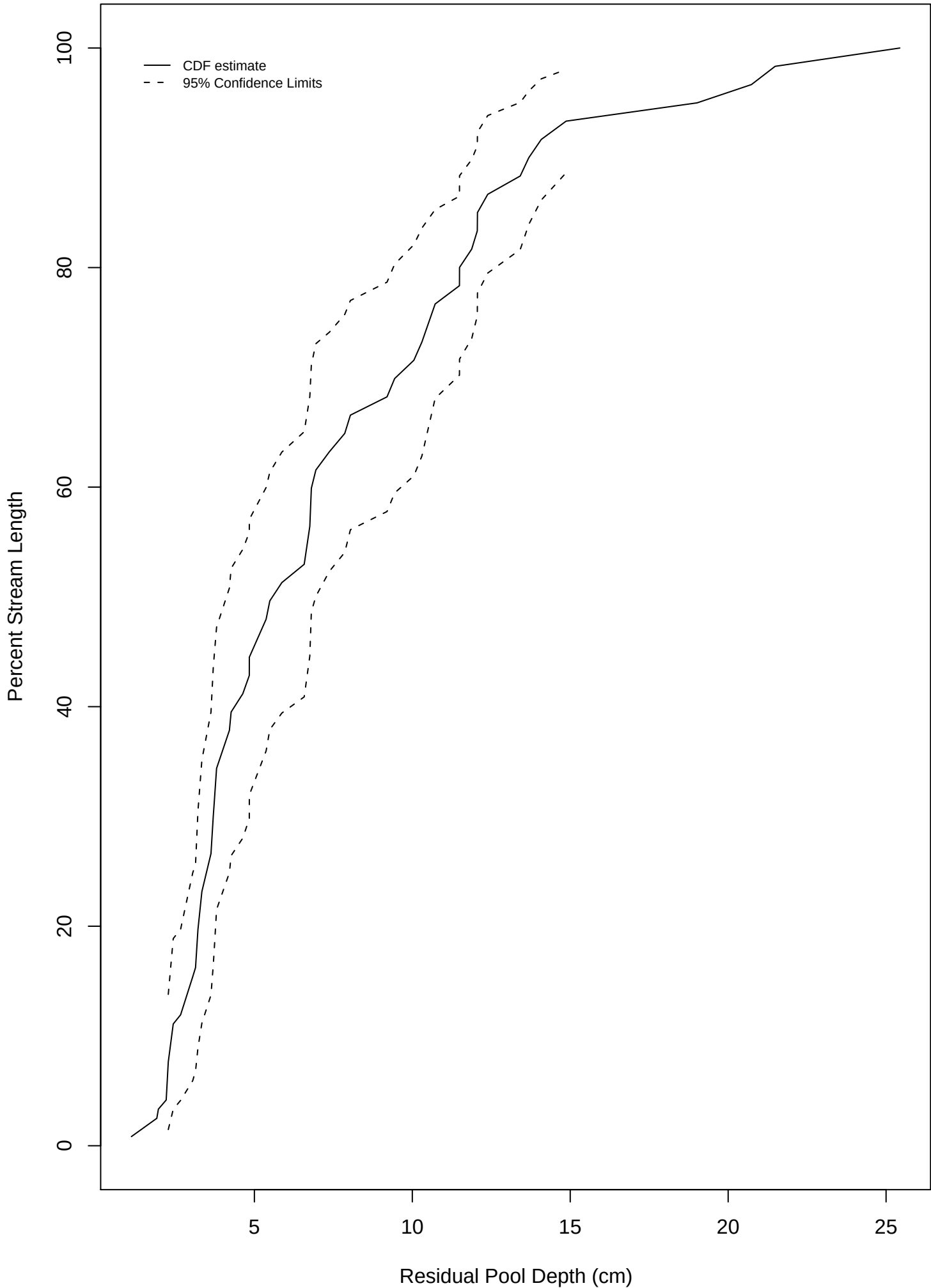
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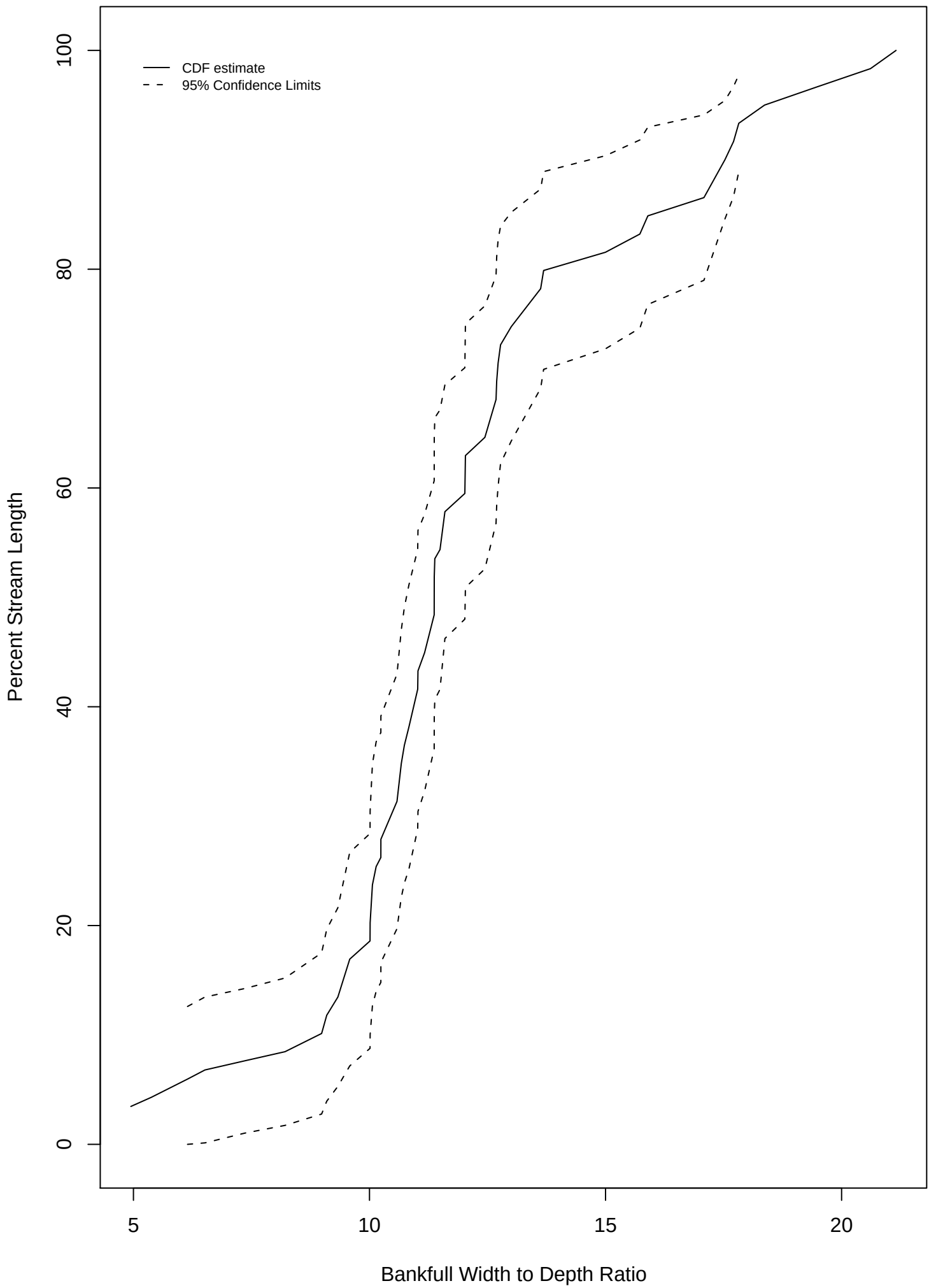
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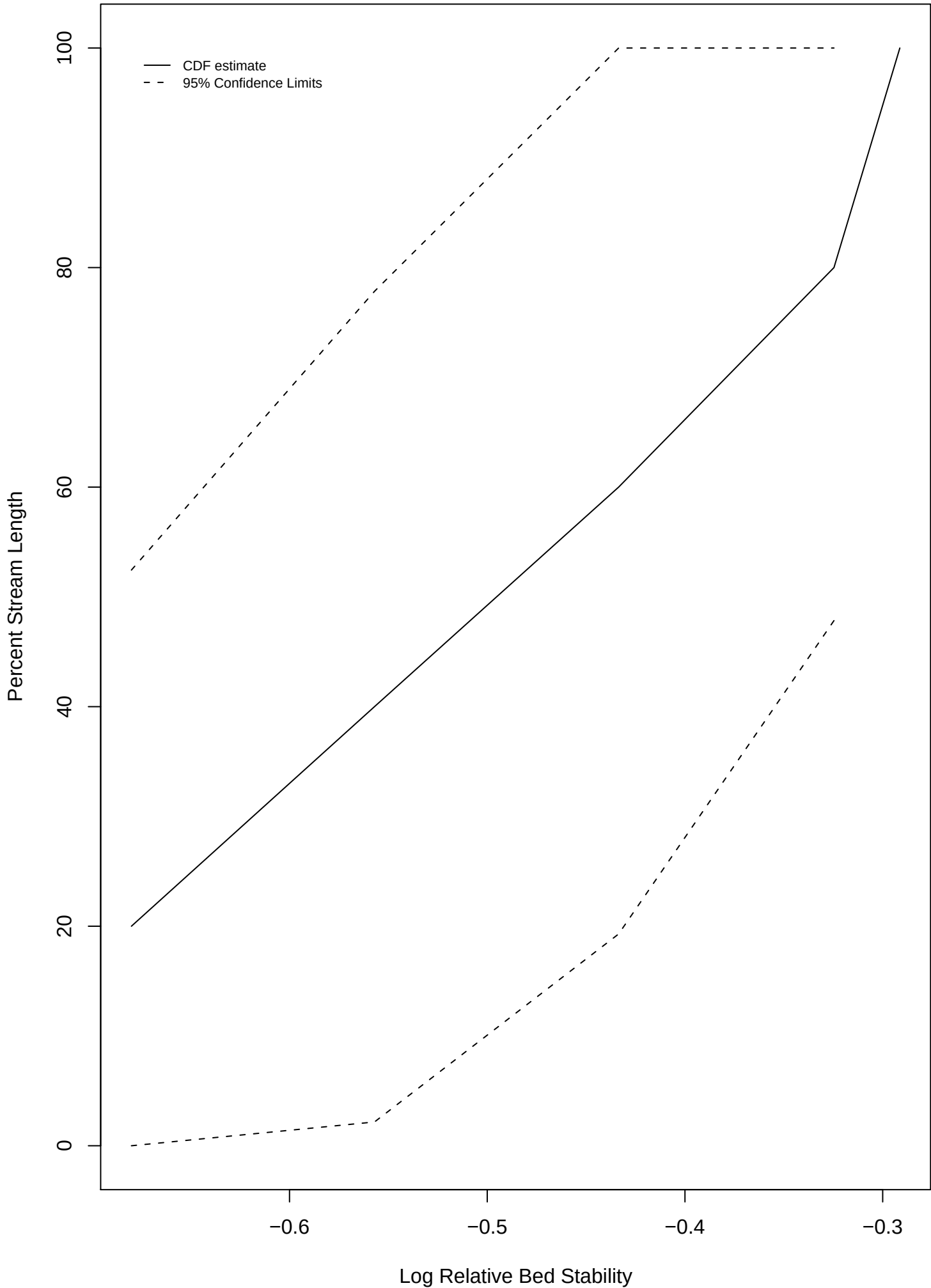
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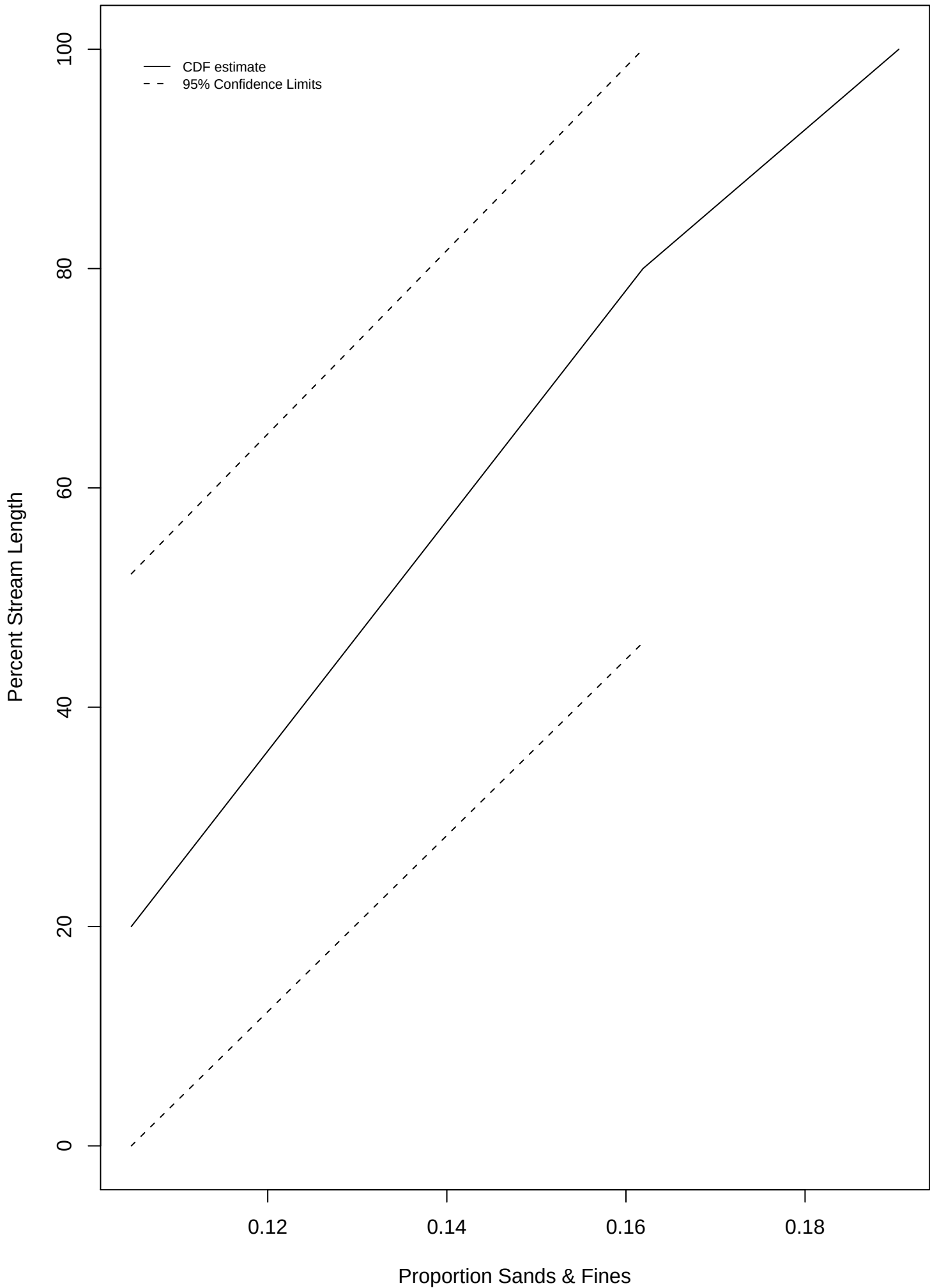
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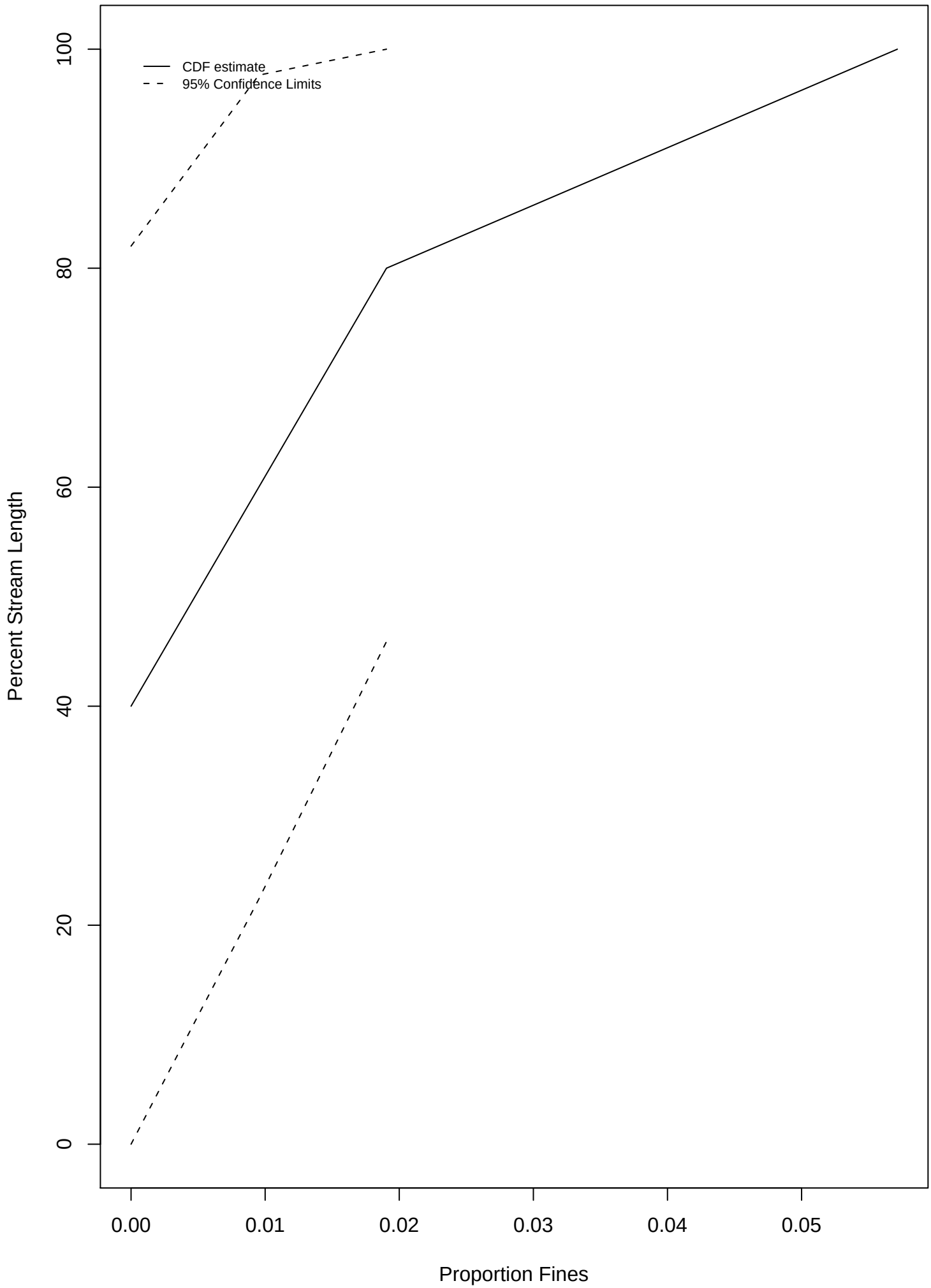
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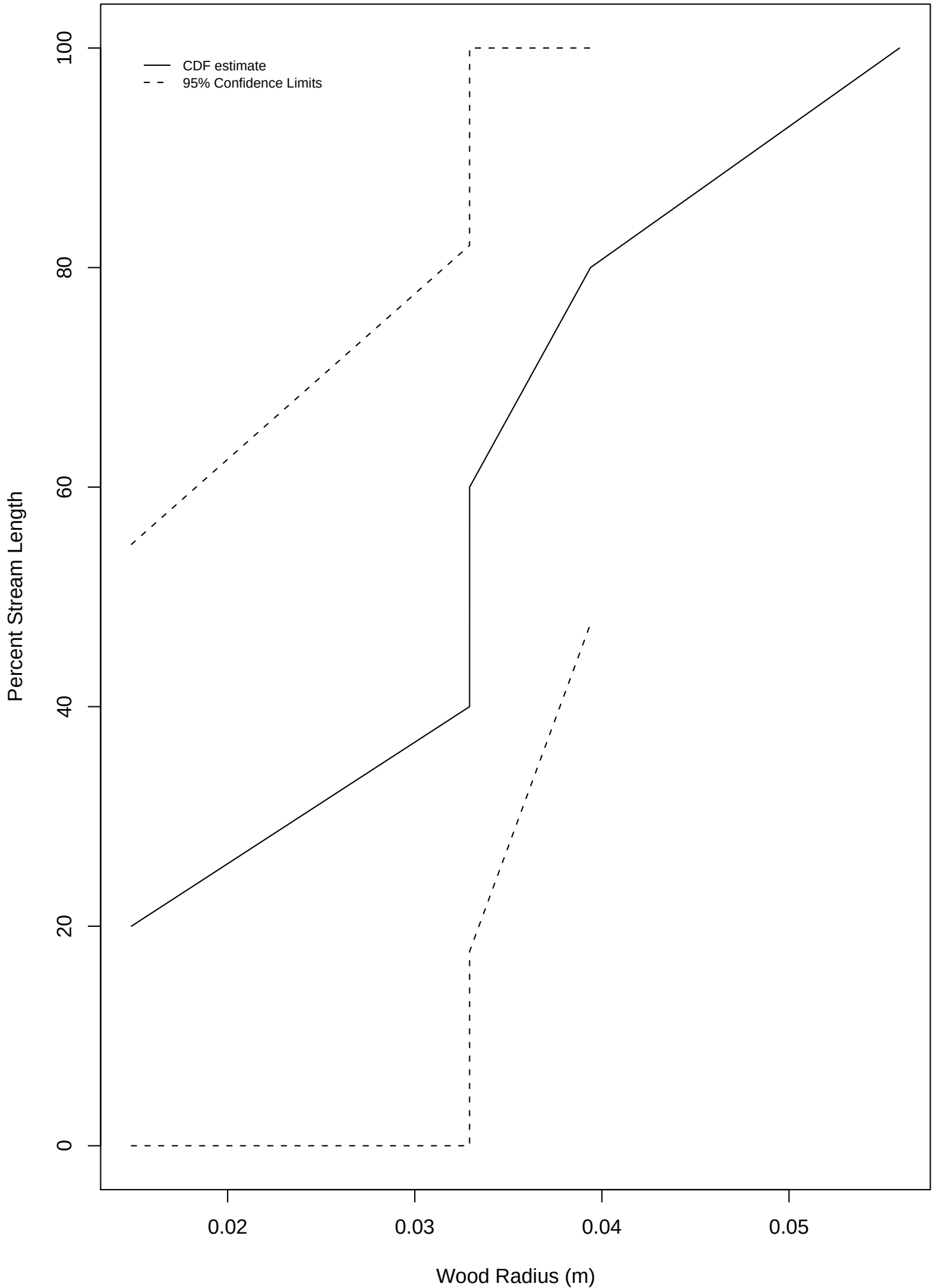
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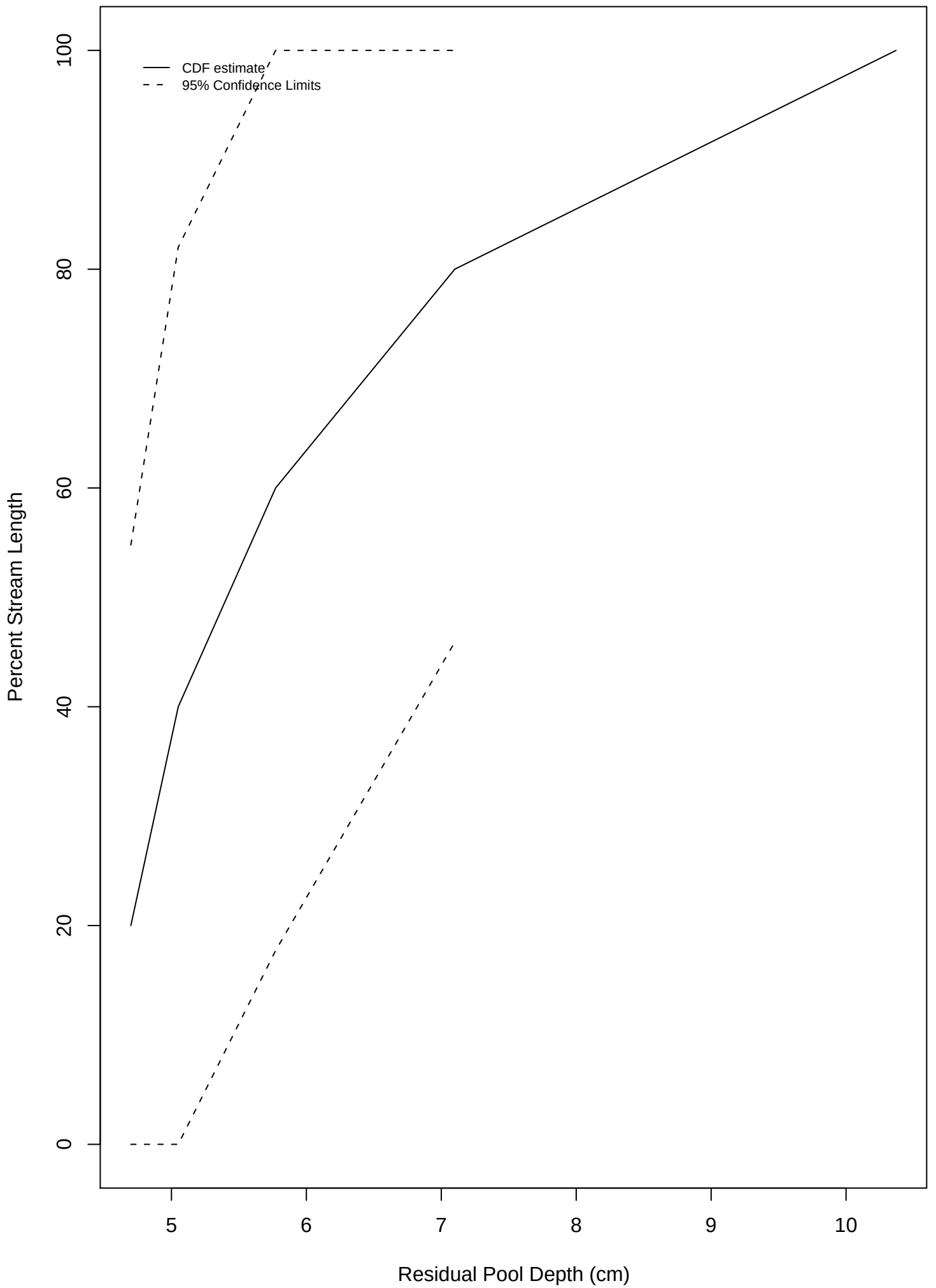
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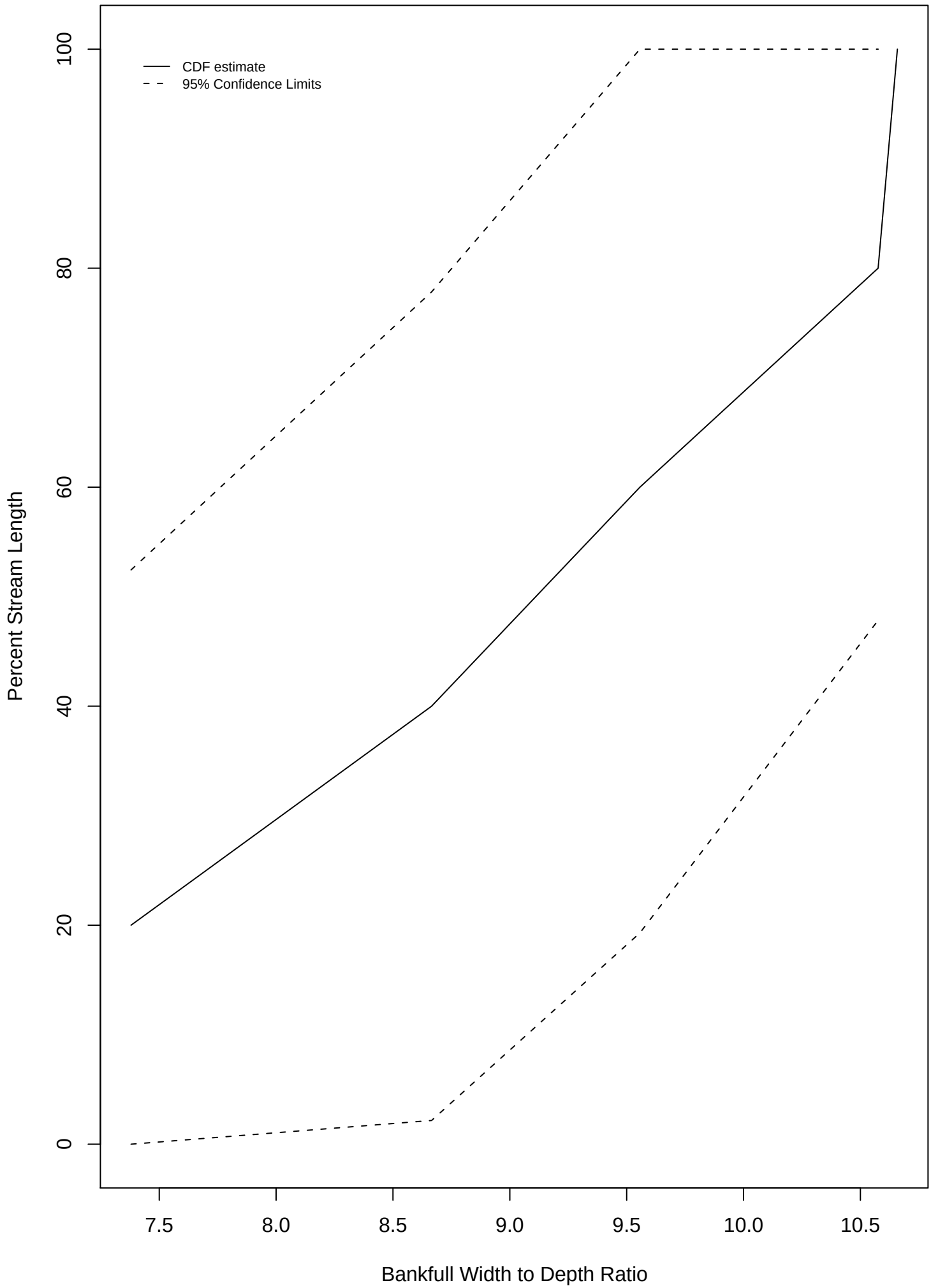
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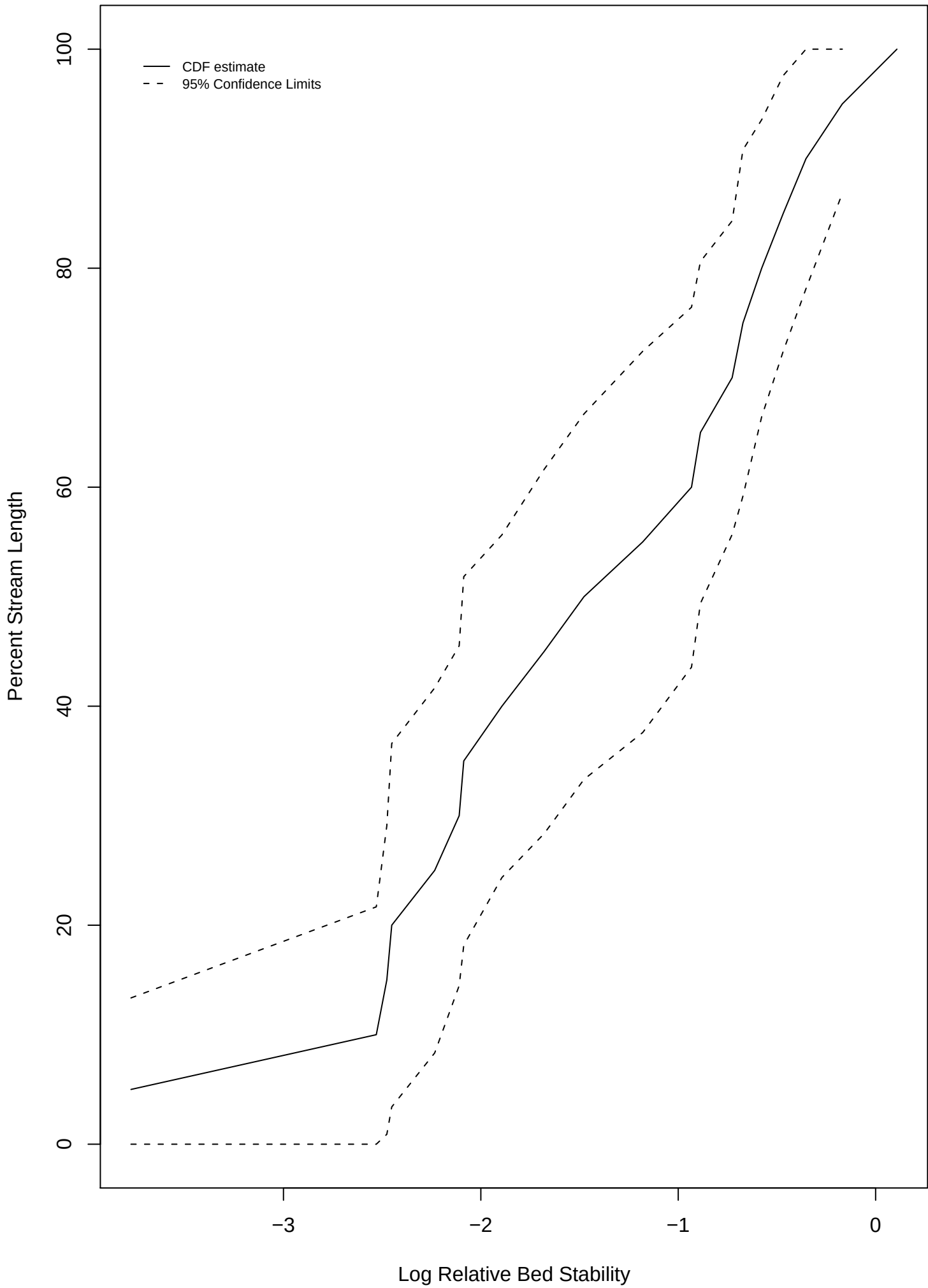
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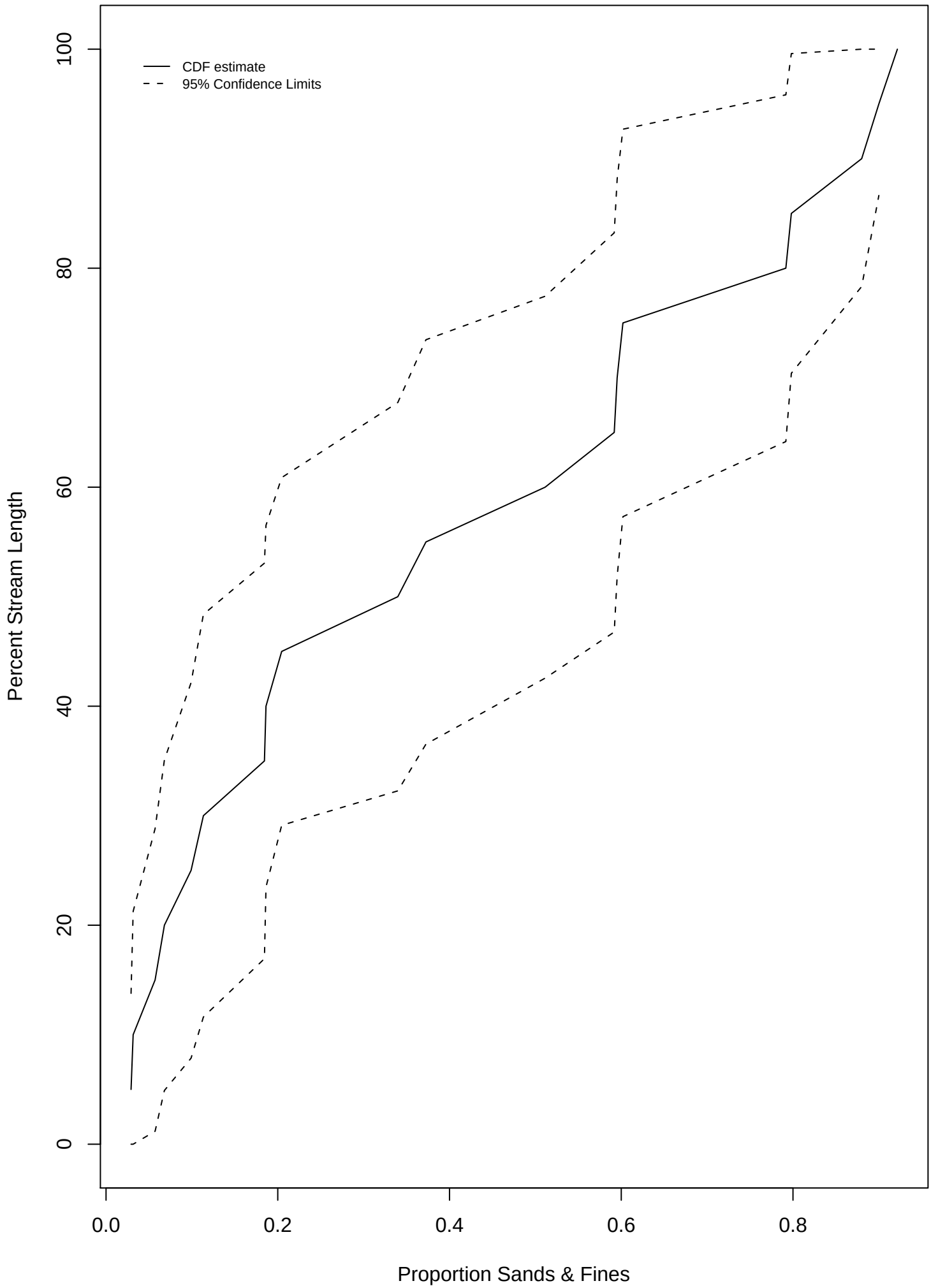
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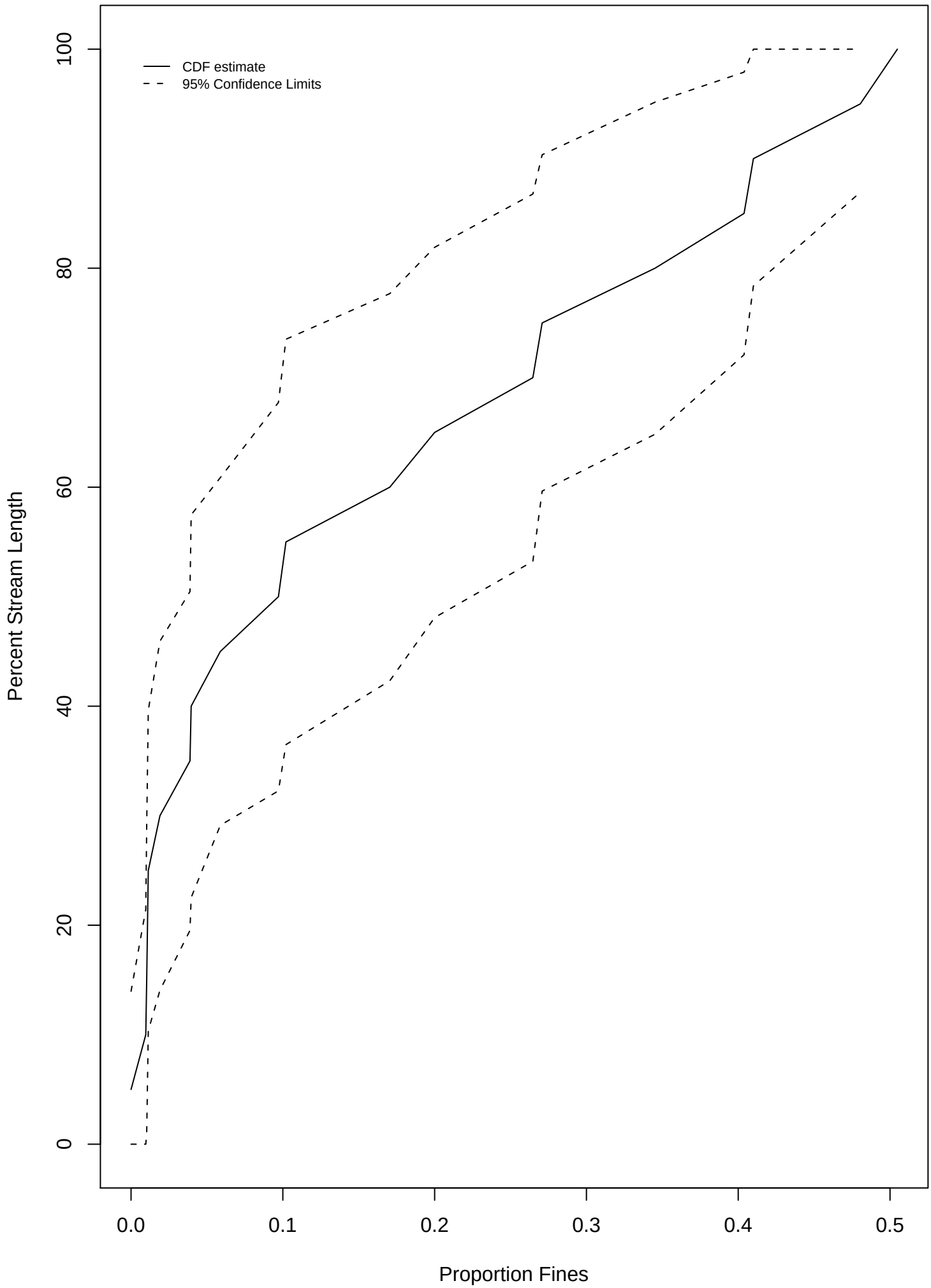
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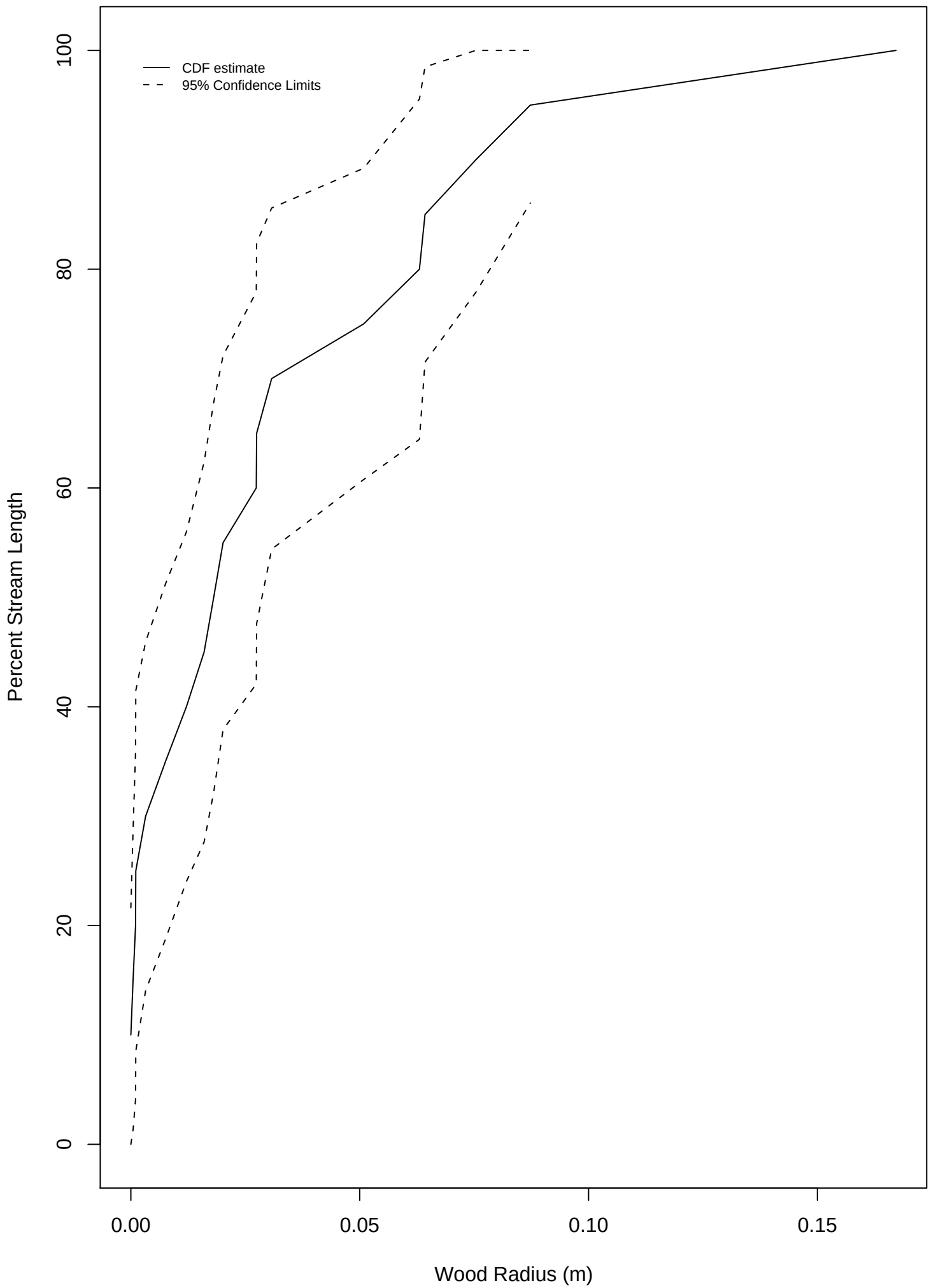
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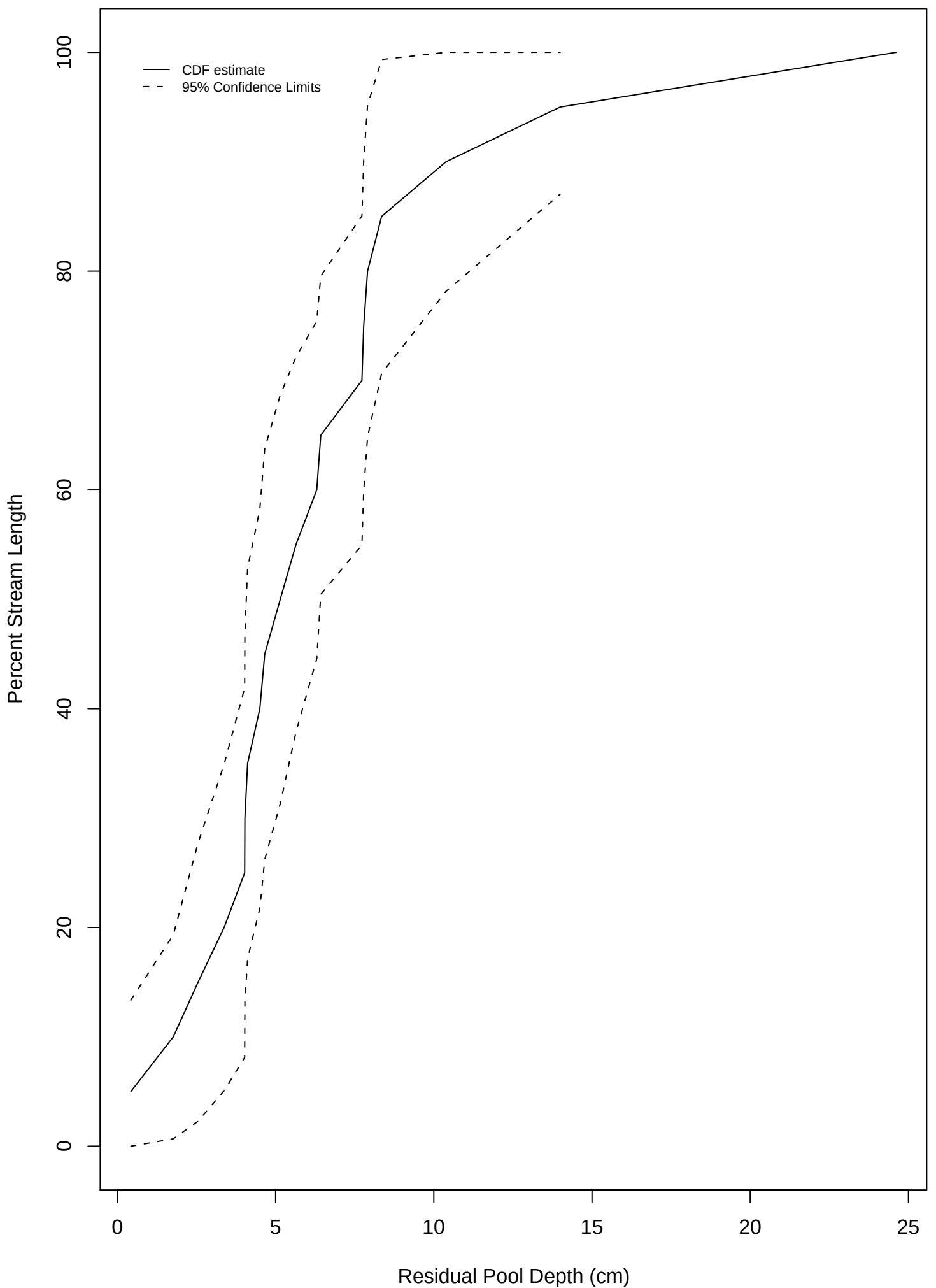
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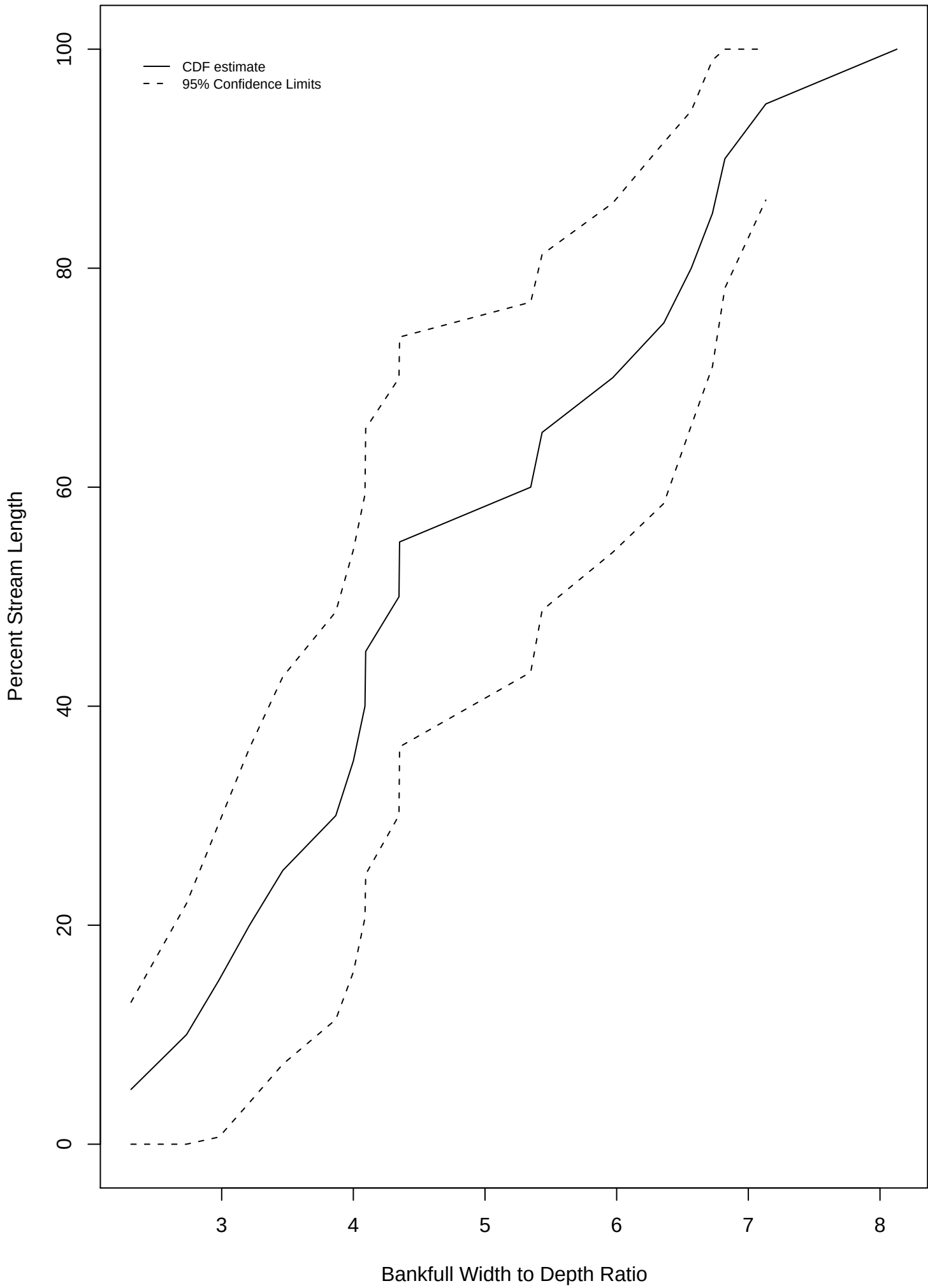
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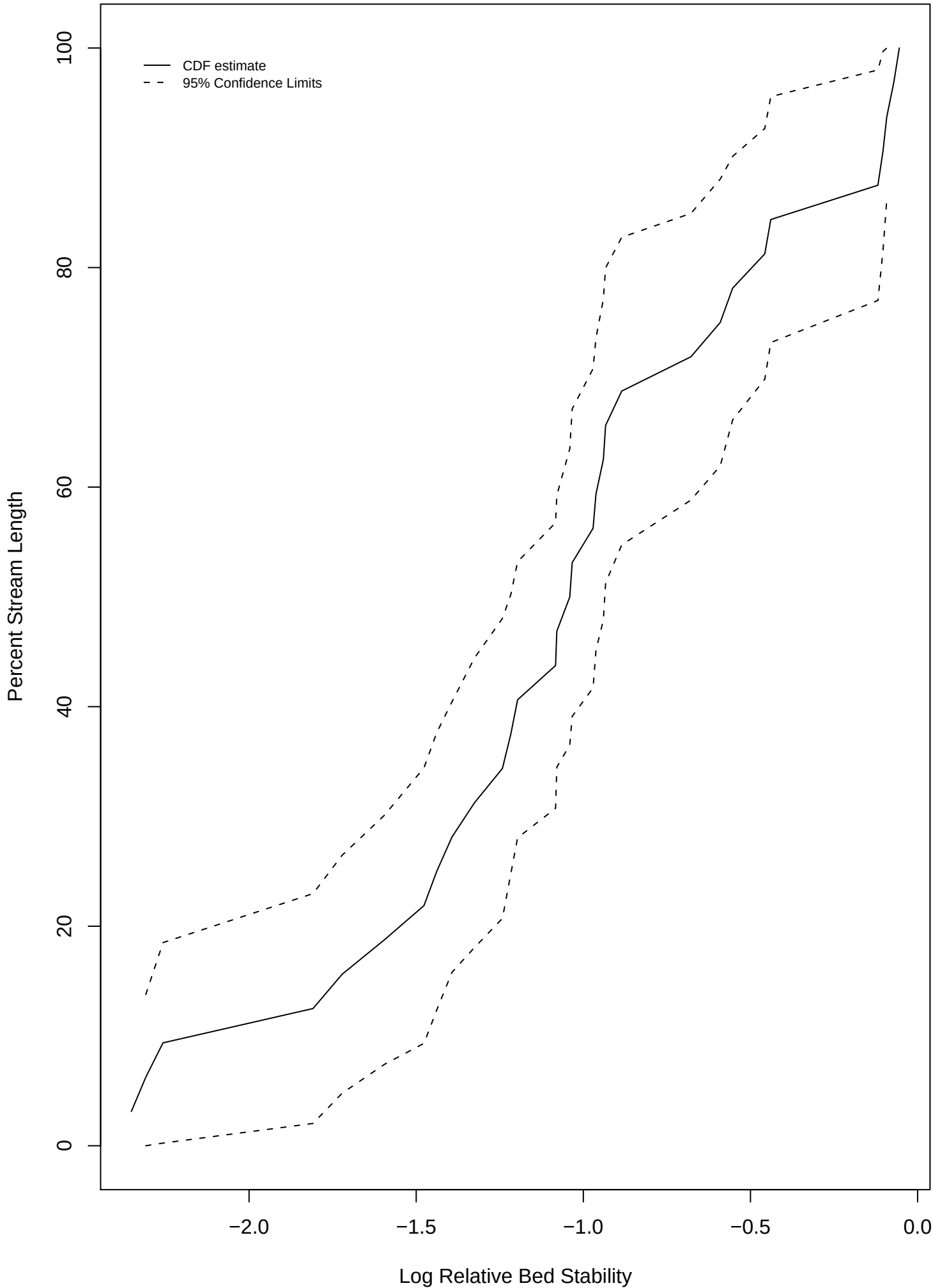
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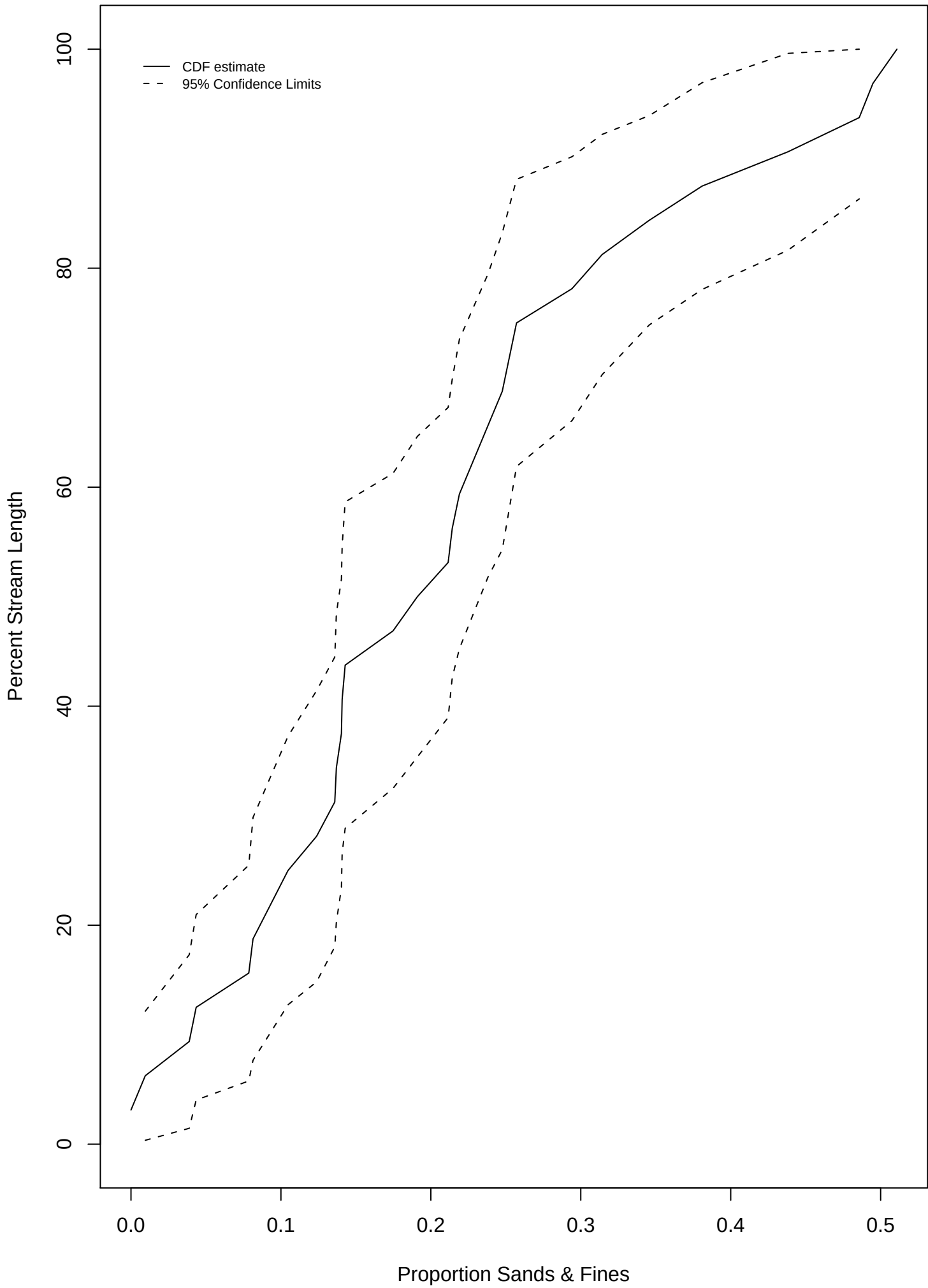
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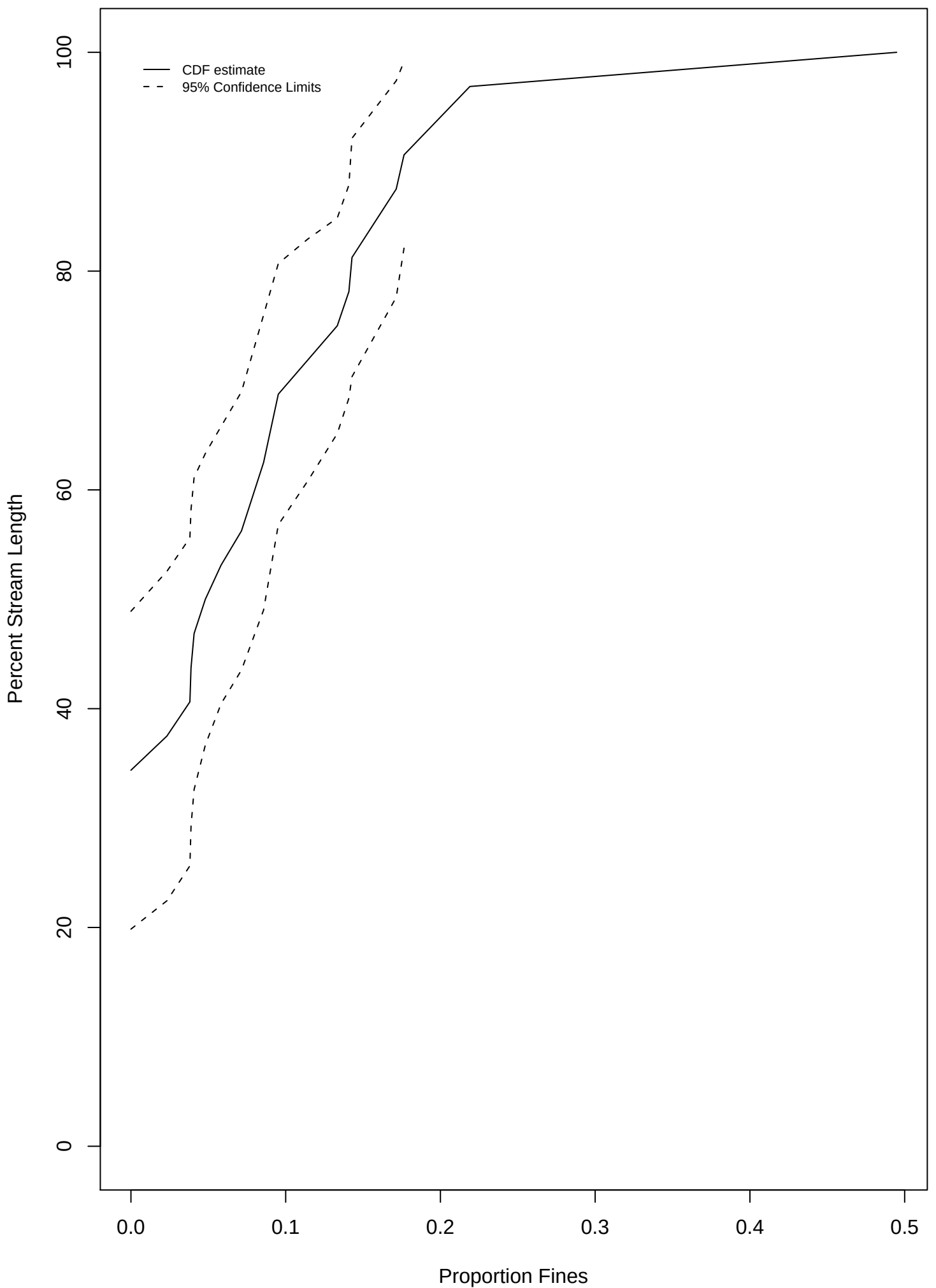
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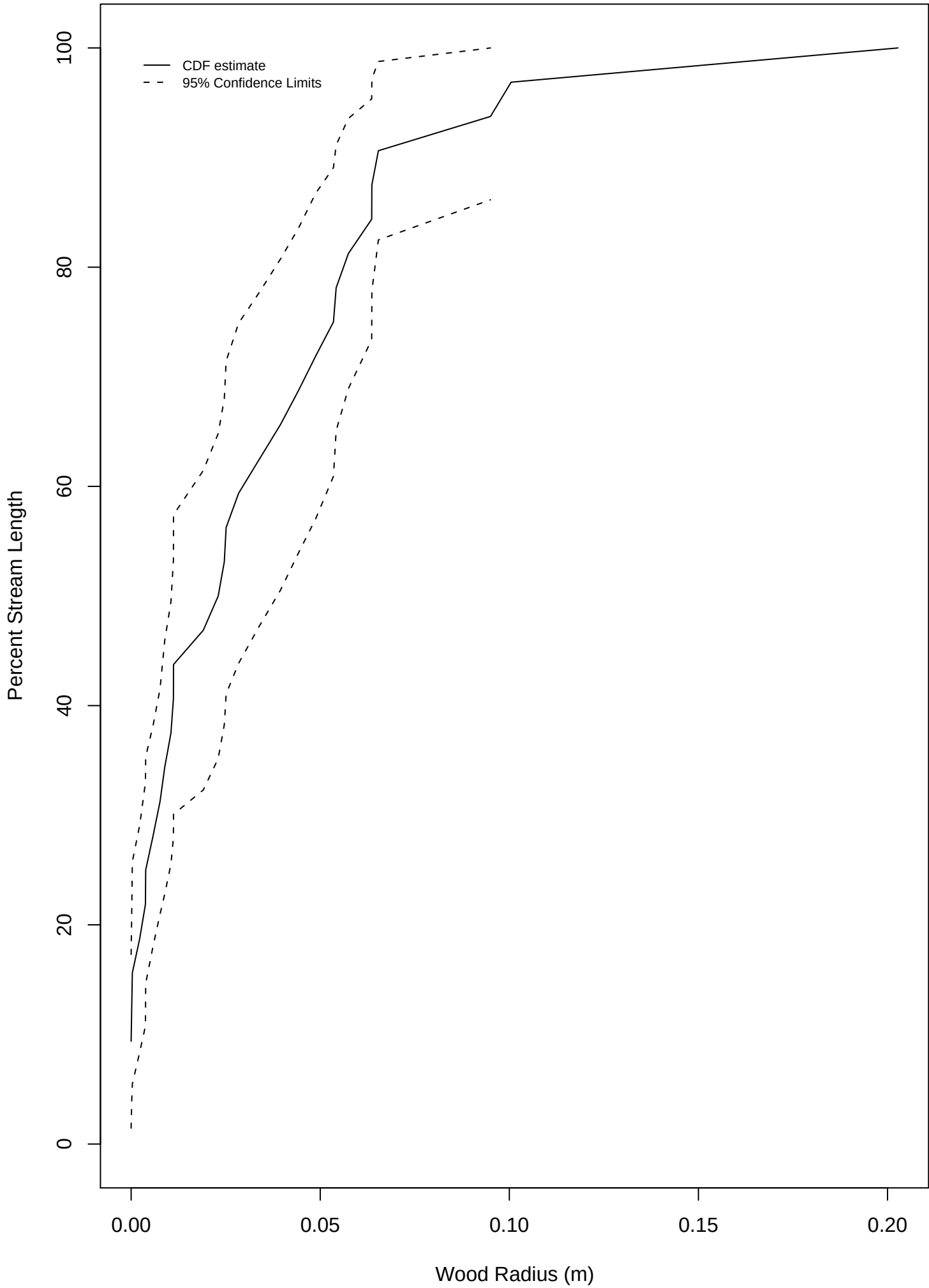
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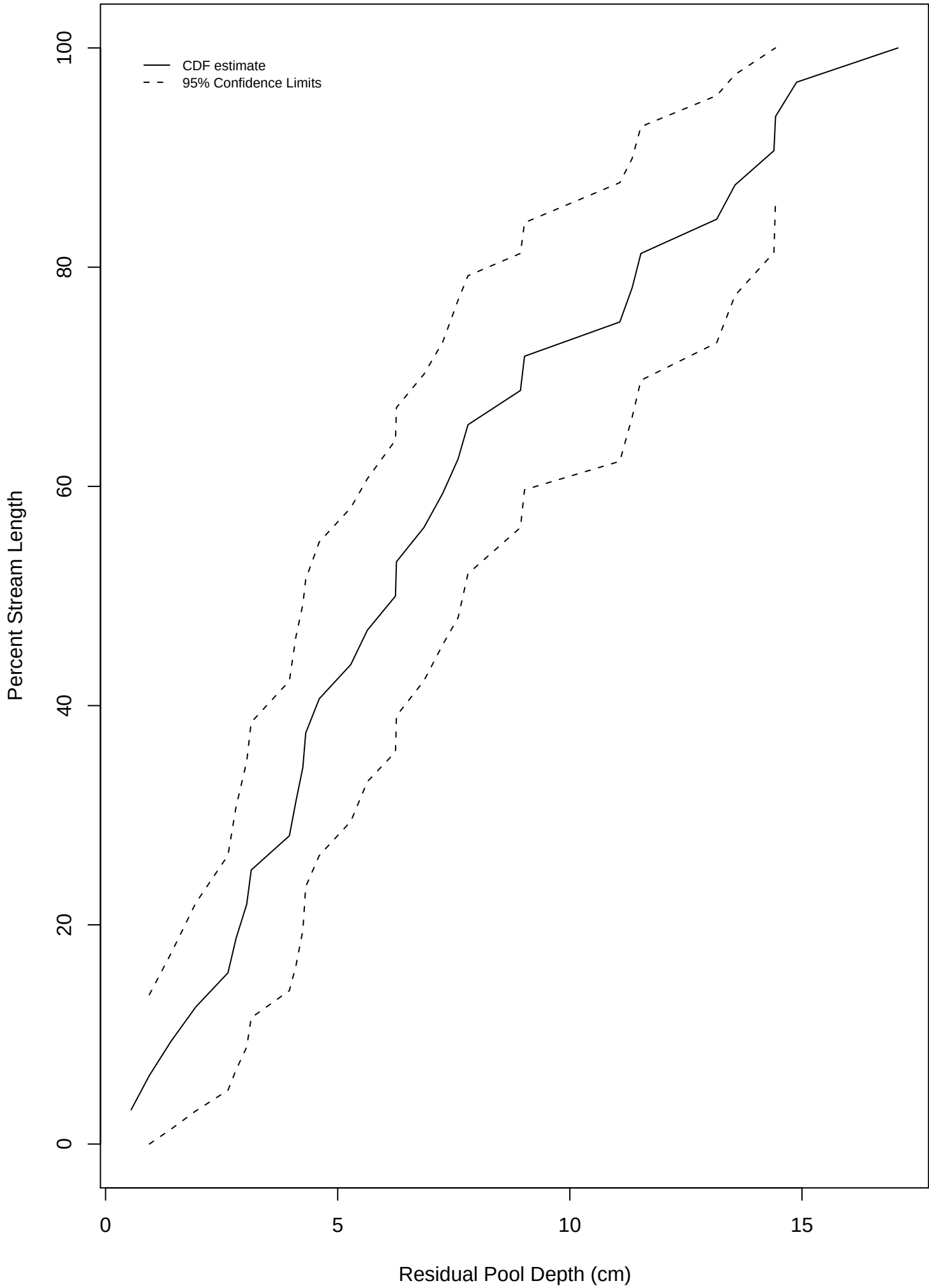
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Reference RW Distribution



Reference RP100 Distribution



Reference W:D Distribution

