

**Summary of Stream Inventories on the Andrew Pickens Ranger District,
Sumter National Forest, South Carolina, 2020**



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Project Type

Stream fish and habitat inventory.

Goal

Provide stream biota and habitat information needed for project-level and Forest-level planning.

Objective

Complete stream fish and habitat inventory in March 2020.

Approach

Forest identifies streams with gaps in fish or habitat information. The CATT trains and deploys field teams to complete inventories. The CATT provides project database for incorporation into Forest datasets.

Accomplishments

Completed 17.3 km of habitat inventory on 5 streams using the basinwide visual estimation technique (BVET). Sampled fish in 5 streams at a total of 22 sites. Entered data into project database and provided to project partner.

Partners and Contacts

Forest Contact: Keith Whalen, Forest Fisheries Biologist

Project Summary

Periodic aquatic resource assessments provide the information National Forest managers need to effectively identify current status and trends, management options and impacts, and threats and impacts of fire, insects, disease, and other natural processes on aquatic resources. In 2020, Sumter National Forest partnered with the CATT to assess stream habitat and fish in high-priority management areas, the latest effort in a long history of inventory and monitoring partnerships on the Forest. Our current effort is intended to fill data gaps and update aquatic resource information needed for Forest- and project-level analyses.

Field Methods

Appendix

- Guide to Stream Habitat Characterization using the BVET Methodology, South Carolina

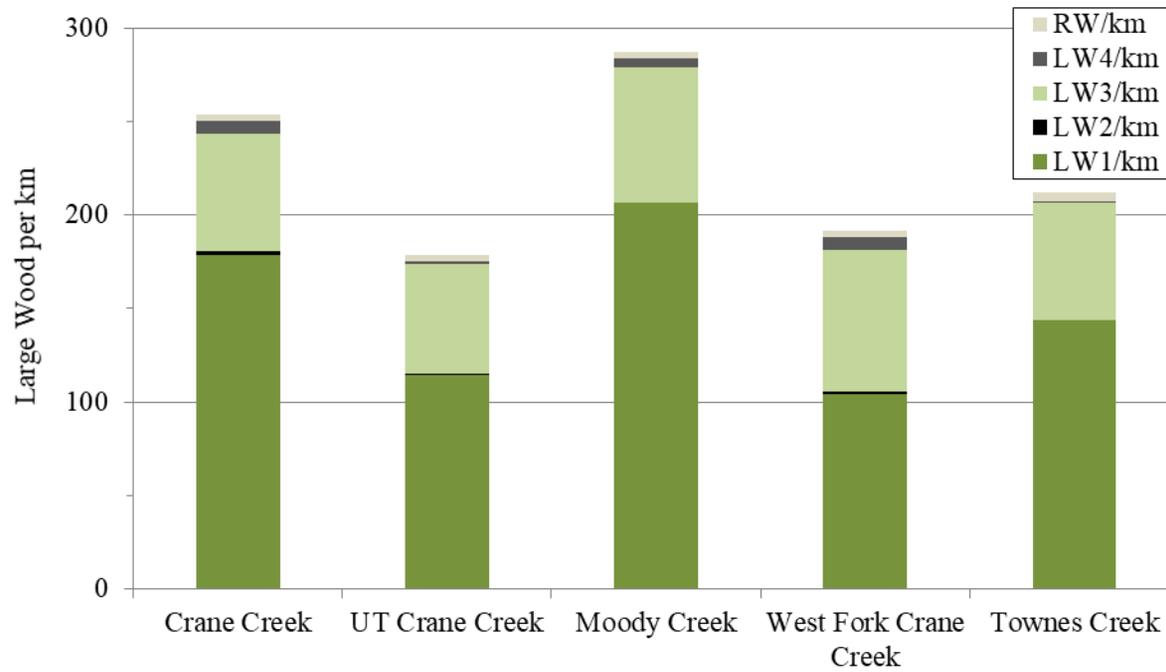


Figure 2. Quantity of large wood (LW; dead and down, any part within bankfull channel) per km. LW size classes: LW1 = 1-5 m length, 10-55 cm diameter; LW2 = 1-5 m length, >55 cm diameter; LW3 = >5 m length, 10-55 cm diameter; LW4 = >5 m length, >55 cm diameter; RW = rootwad.

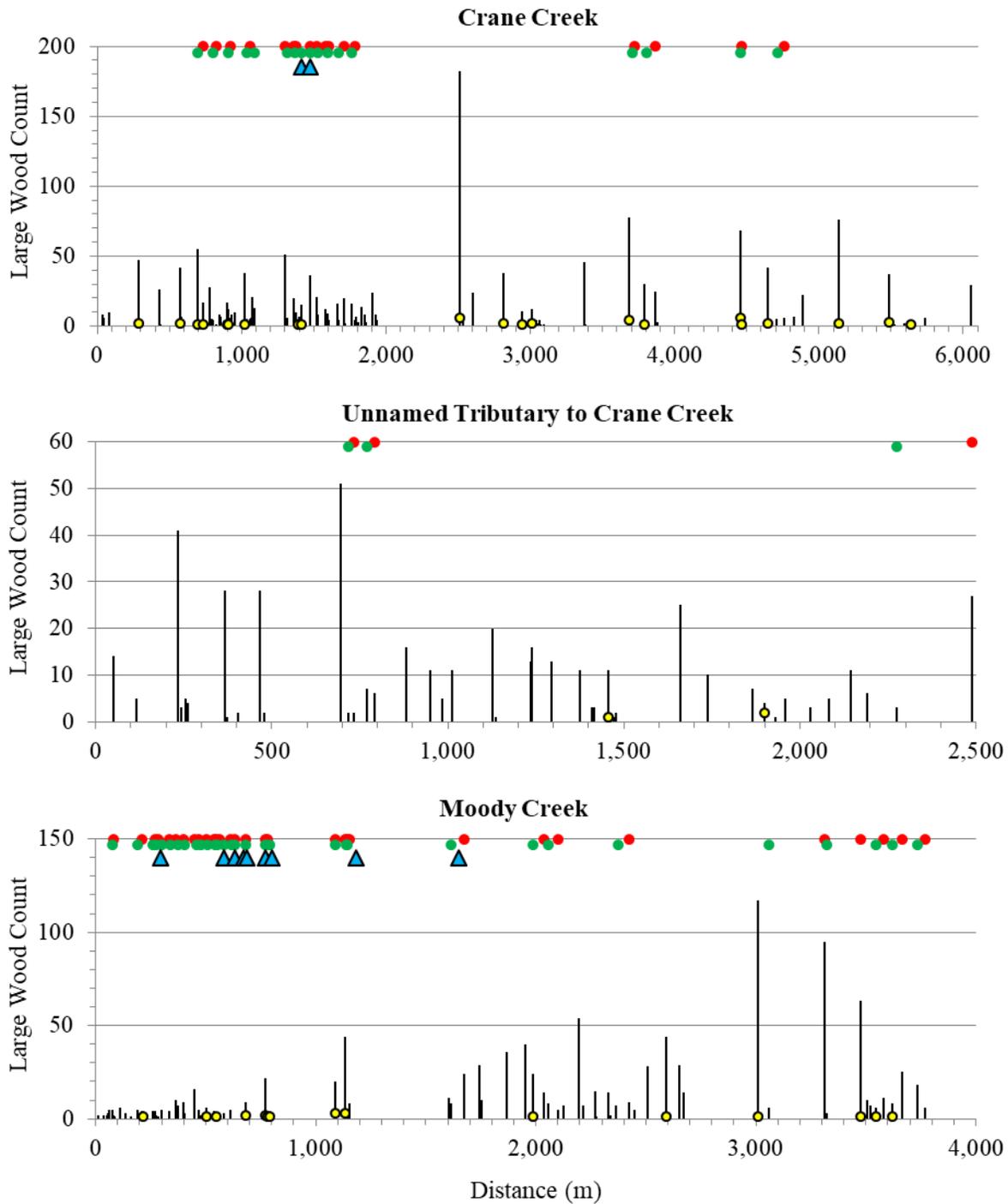


Figure 3. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; yellow circles = size 4 only). Counts of large wood occurred within pools, glides, riffles, runs, cascades, and underground sections. At the top of each graph are the location of waterfalls (blue triangles) and the beginning (green circle) and end (red circle) of each cascade habitat unit; large LW counts are typically the result of long habitat units.

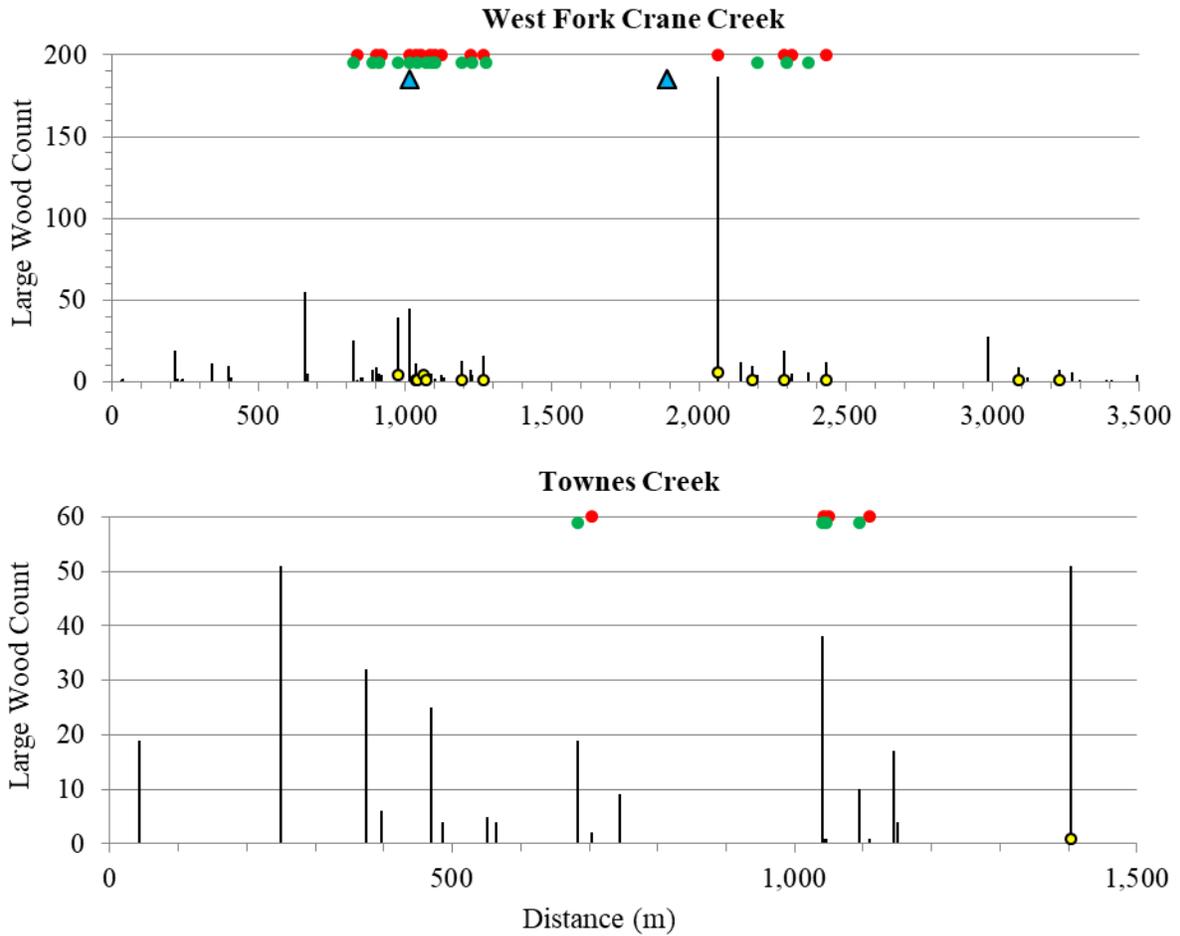


Figure 3 continued. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; yellow circles = size 4 only). Counts of large wood occurred within pools, glides, riffles, runs, cascades, and underground sections. At the top of each graph are the location of waterfalls (blue triangles) and the beginning (green circle) and end (red circle) of each cascade habitat unit; large LW counts are typically the result of long habitat units.

Table 1. Summary of BVET inventories completed on the Andrew Pickens Ranger District, Sumter National Forest, SC, 2020.

Stream	Start Date	End Date	Inventory Dist. (km)	Inventory Start		Inventory End	
				Latitude	Longitude	Latitude	Longitude
Crane Creek	3/3/20	3/9/20	6.1	34.92180	-83.07764	34.95698	-83.09769
UT Crane Creek	3/9/20	3/10/20	2.5	34.94219	-83.09448	34.95729	-83.09035
Moody Creek	3/3/20	3/9/20	3.8	34.94033	-83.07424	34.96377	-83.07657
West Fork Crane Creek	3/10/20	3/11/20	3.5	34.92188	-83.07745	34.94430	-83.08656
Townes Creek	3/11/20	3/11/20	1.4	34.91508	-83.06939	34.92183	-83.07750

Table 2. Waterfalls encountered during BVET inventories on the Andrew Pickens Ranger District, Sumter National Forest, SC, 2020.

Stream	Inventory Dist. (km)	Waterfall Coordinates		Approx. Waterfall	Photo ID
		Latitude	Longitude	Height (m)	
Crane Creek	1,413	34.92695	-83.08976	20	Photo-20200304-145128.jpg
	1,472	34.92750	-83.09027	10	Photo-20200304-161046.jpg
Moody Creek	296	34.94200	-83.07623	2	Photo-20200304-153803.jpg
	582	34.94330	-83.07813	3	Photo-20200304-181109.jpg
	630	34.94346	-83.07839	<1	Photo-20200304-184412.jpg
	674	34.94389	-83.07839	1	Photo-20200304-185502.jpg
	689	34.94403	-83.07843	1	Photo-20200304-190554.jpg
	773	34.94452	-83.07886	2	Photo-20200304-193059.jpg
	799	34.94475	-83.07897	1	Photo-20200304-195247.jpg
	1,181	34.94804	-83.08090	4	Photo-20200305-161630.jpg
1,648	34.94936	-83.08097	1	Photo-20200305-165602.jpg	
West Fork Crane Creek	1,016	34.92794	-83.08121	3	Photo-20200310-161808.jpg
	1,893	34.93290	-83.08564	25	Photo-20200311-145216.jpg

Table 3. Stream area in pools (i.e. slow water units = pools and glides) and riffles (i.e. fast water units = riffles, runs, and cascades) observed during BVET habitat inventories on the Andrew Pickens Ranger District, Sumter National Forest, SC, 2020.

Stream	Habitat Area (m ²)			Percent Area	
	Pool	Riffle	Total	Pool	Riffle
Crane Creek	1,698	17,362	19,060	9%	91%
UT Crane Creek	228	5,222	5,450	4%	96%
Moody Creek	1,199	12,789	13,989	9%	91%
West Fork Crane Creek	544	12,637	13,181	4%	96%
Townes Creek	476	7,460	7,936	6%	94%

Table 4. Large wood (LW) per kilometer observed during BVET habitat inventories. LW size classes: LW1 = 1-5 m length, 10-55 cm diameter; LW2 = 1-5 m length, >55 cm diameter; LW3 = >5 m length, 10-55 cm diameter; LW4 = >5 m length, >55 cm diameter; RW = rootwad.

Stream	Large Wood per Kilometer						Large Wood Count (n)						Inventory
	LW1	LW2	LW3	LW4	RW	Total	LW1	LW2	LW3	LW4	RW	Total	Distance (km)
Crane Creek	179	2	63	7	3	254	1,090	13	383	42	21	1,549	6.1
UT Crane Creek	115	0	59	1	4	179	285	1	146	3	10	445	2.5
Moody Creek	206	1	72	5	3	287	777	2	271	19	12	1,081	3.8
West Fork Crane Creek	104	1	75	7	4	192	364	5	263	24	13	669	3.5
Townes Creek	144	0	62	1	5	212	203	0	88	1	7	299	1.4

Table 5. Summary of electrofishing inventories completed on the Andrew Pickens Ranger District, Sumter National Forest, SC, 2020.

Stream	Date	Unit Type	Inventory Dist. (m)	Unit Length (m)	Unit Width (m)	Unit Area (m ²)	Efish Time (sec)	# Backpack Efishers Used	Water Temp. (C)	Crayfish Observed	Coordinates	
											Latitude	Longitude
Crane Creek	3/8/20	Riffle	900	43	4.2	182	492	1	12	Yes	34.92486	-83.08443
	3/8/20	Pool	1,065	4	7.0	28	88	1	NA	Yes	34.92496	-83.08604
	3/8/20	Run	1,907	45	3.5	158	654	1	11	Yes	34.92948	-83.09325
	3/6/20	Pool	3,696	11	3.9	43	168	1	NA	No	34.94079	-83.09360
	3/12/20	Riffle	4,885	57	3.0	173	244	1	11	Yes	34.94799	-83.09733
UT Crane Creek	3/12/20	Riffle	480	14	2.7	37	66	1	13	Yes	34.94500	-83.09373
	3/12/20	Glide	1,417	8	2.1	17	29	1	NA	Yes	34.95032	-83.09359
	3/12/20	Run	1,866	127	2.4	305	551	1	11	Yes	34.95182	-83.09135
	3/12/20	Glide	1,931	19	1.9	35	49	1	NA	No	34.95303	-83.09117
Moody Creek	3/6/20	Pool	139	3	5.2	16	90	1	NA	No	34.94097	-83.07543
	3/6/20	Cascade	211	18	3.0	54	289	1	11	No	34.94143	-83.07584
	3/6/20	Cascade	1,142	2	4.2	8	259	1	11	Yes	34.94763	-83.08060
	3/6/20	Pool	1,754	9	3.5	31	245	1	NA	No	34.95030	-83.08105
	3/6/20	Riffle	2,270	54	3.8	207	688	1	11	Yes	34.95386	-83.08142
West Fork Crane Creek	3/12/20	Riffle	399	56	3.5	196	480	1	11	Yes	34.92428	-83.07726
	3/12/20	Pool	404	5	3.9	20	83	1	NA	Yes	34.92469	-83.07702
	3/12/20	Riffle	2,144	80	3.3	261	482	1	12	Yes	34.93473	-83.08662
Townes Creek	3/12/20	Riffle	375	125	5.4	675	2,073	2	12	Yes	34.91529	-83.07300
	3/12/20	Riffle	551	65	4.8	312	1,119	2	13	Yes	34.91555	-83.07418
	3/12/20	Pool	564	13	4.8	63	232	2	NA	Yes	34.91539	-83.07427
	3/12/20	Pool	1,057	7	5.5	39	398	2	NA	No	34.91892	-83.07637
	3/12/20	Cascade	1,109	15	9.6	144	291	2	13	Yes	34.91916	-83.07653

Table 6. Quantity of fish by species and stream sampled on the Andrew Pickens Ranger District, Sumter National Forest, SC, 2020.

Stream	Unit Type	Inventory Dist. (m)	Family	Scientific Name	Common Name	Adult Count	Age-0 Count
Crane Creek	Riffle	900		NO FISH		0	0
	Pool	1,065		NO FISH		0	0
	Run	1,907	Salmonidae	Salvelinus fontinalis	Brook Trout	2	2
	Pool	3,696	Salmonidae	Salvelinus fontinalis	Brook Trout	2	0
	Riffle	4,885		NO FISH		0	0
UT Crane Creek	Riffle	480		NO FISH		0	0
	Glide	1,417		NO FISH		0	0
	Run	1,866	Salmonidae	Salvelinus fontinalis	Brook Trout	2	0
	Glide	1,931		NO FISH		0	0
Moody Creek	Pool	139		NO FISH		0	0
	Cascade	211		NO FISH		0	0
	Cascade	1,142		NO FISH		0	0
	Pool	1,754		NO FISH		0	0
	Riffle	2,270	Salmonidae	Salvelinus fontinalis	Brook Trout	2	0
West Fork Crane Creek	Riffle	399	Cyprinidae	Clinostomus funduloides	Rosyside Dace	3	0
			Cyprinidae	Nocomis leptocephalus	Bluehead Chub	2	0
			Cyprinidae	Semotilus atromaculatus	Creek Chub	1	0
	Pool	404	Cyprinidae	Clinostomus funduloides	Rosyside Dace	1	0
	Riffle	2,144		NO FISH		0	0

Table 6 continued. Quantity of fish by species and stream sampled on the Andrew Pickens Ranger District, Sumter National Forest, SC, 2020.

Stream	Unit Type	Inventory Dist. (m)	Family	Scientific Name	Common Name	Adult Count	Age-0 Count
Townes Creek	Riffle	375	Centrarchidae	<i>Lepomis cyanellus</i>	Green Sunfish	1	0
			Cyprinidae	<i>Nocomis leptcephalus</i>	Bluehead Chub	1	0
			Percidae	<i>Etheostoma olmstedii</i>	Tessellated Darter	3	0
	Riffle	551	Centrarchidae	<i>Lepomis auritus</i>	Redbreast Sunfish	0	2
			Cyprinidae	<i>Clinostomus funduloides</i>	Rosyside Dace	1	0
			Cyprinidae	<i>Nocomis leptcephalus</i>	Bluehead Chub	1	0
			Percidae	<i>Etheostoma inscriptum</i>	Turquoise Darter	5	0
	Pool	564	NO FISH			0	0
	Pool	1,057	Cyprinidae	<i>Clinostomus funduloides</i>	Rosyside Dace	6	1
			Cyprinidae	<i>Nocomis leptcephalus</i>	Bluehead Chub	1	0
Cascade	1,109	NO FISH			0	0	

Appendix:

Guide to Stream Habitat Characterization using the BVET Methodology, South Carolina

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Introduction

The Basinwide Visual Estimation Technique (BVET) is a versatile tool used to assess streamwide habitat conditions in wadeable size streams and rivers. A team of two individuals performs the inventory using two-stage visual estimation techniques described in Hankin and Reeves (1988) and Dolloff et al. (1993). In its most basic form the BVET combines visual estimates with actual measurements to provide a calibrated estimate of stream area with confidence intervals, however the team may inventory any number of other habitat attributes as they walk the length of the stream. Experienced teams can inventory an average of 2-3 km per day, but this will vary depending on stream size and the number of stream attributes inventoried.

Before a team begins a BVET inventory they must receive adequate training, both in the classroom and in the field. Estimating and measuring a large number of habitat attributes can confuse and overwhelm an inexperienced team. Individuals must have an understanding of the basic concepts behind the BVET and be familiar with habitat attributes before they can effectively and efficiently perform an inventory.

This document was developed to serve as a guide for classroom and field instructions specific to the Francis Marion Sumter National Forest (FMSNF) BVET habitat inventory and to provide a post-training reference for field teams. It includes an overview of the BVET inventory, defines habitat attributes, instructs how and when to measure attributes, and provides reference sheets for use in the field. Each trainee should receive a copy of this manual and is encouraged to take notes in the spaces provided.

References cited in this manual:

Armantrout, N. B., compiler. 1998. Glossary of aquatic habitat inventory terminology. American Fisheries Society, Bethesda, Maryland.

Dolloff, C. A., D. G. Hankin, and G. H. Reeves. 1993. Basinwide estimation of habitat and fish populations in streams. General Technical Report SE-83. Asheville, North Carolina: U.S. Department of Agriculture, Southeastern Forest Experimental Station.

Hankin, D. G., and G. H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences 45:834-844.

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology Books, Pagosa Springs, Colorado.

Outline of BVET Habitat Inventory

1. Enter 'Header' information on the data sheet: --- 'Header' information includes date, stream, start location, team, etc. and is **vital**ly important to record for future reference.
2. Select an appropriate measurement interval and a random number: --- In streams < 1.0 km measure every 5th unit (random number 1-5), in streams > 1.0 km measure every 10th unit (random number 1-10). The random number designates the first habitat unit (i.e. the paired sample unit) in which the crew will perform measurements.
3. Enter downstream of the starting point, then move upstream and begin the inventory. Tie off the hipchain, proceed upstream to the starting point, reset the hipchain to zero, and proceed upstream estimating parameters and recording data in every habitat unit.
4. At the paired sample unit perform visual estimates, then perform measurements. Example: If the random number '3' was chosen, the crew would stop after making estimates in the 3rd pool (and 3rd riffle) and perform the necessary measurements. Pair a minimum of 3 fast and 3 slow-water units; pair more if possible.
5. Hang flags at every 2nd paired sample unit (downstream and upstream end of unit); label flags with habitat unit type and number (ex. R4)
6. Progress upstream estimating attributes for every unit until the next paired sample unit is reached, then repeat step 4.

In the above example with a random number '3', if the interval were 10 units, the team would stop at the 13th, 23rd, 33rd, etc. pool (and 13th, 23rd, 33rd, etc. riffle) and repeat measurements done in pool 3 and riffle 3.

The team should also take care to record roads, trails, tributaries, dams, waterfalls, road crossing types, riparian features (wildlife openings, trails, campsites, roads, timber harvest, etc.), and other pertinent stream features as they progress upstream. Be sure to record hipchain distances when noting such features. Some features may also require a picture number to be associated with them.

The following sections describe the BVET habitat inventory in detail:

- Section 1:** Getting Started – equipment, header info, random numbers, starting the inventory
- Section 2:** Habitat Attributes – definitions, how to estimate or measure, when to record
- Section 3:** Wrapping Up – what to do when the inventory is completed
- Section 4:** Summary
- Section 5:** GPS Instructions
- Appendix:** field guide, random number tables, equipment checklist

Section 1: Getting Started

Equipment List

- Hipchain
- Extra string for hipchain
- Wading rod
- 50 m tape measure
- Clinometer
- Datalogger
- Thermometer
- GPS unit
- Topographic map w/NHD_ID
- Cell Phone
- First Aid Kit
- Rain Gear (optional)
- Camera
- Backpack
- Pencils
- Flagging
- Markers
- Waterproof backup datasheets
- Clipboard
- BVET field guide on waterproof paper
- Felt bottom wading boots or waders
- Water
- Water Filter
- Toilet Paper

The BVET team consists of two individuals, the ‘observer’ and the ‘recorder’. The observer wears the hipchain and carries the wading rod. The recorder wears the data logger and carries other equipment in the backpack. The duties of each individual are listed below.

Duties

Observer	Recorder
Designate habitat units	Locate changes in NHD_ID
Measure distance	Record data
Estimate width	Determine paired sample location
Estimate depths	Classify and count Large Wood (LW)
Classify substrates	Photo-documentation
Locate features	Document features
Estimate percent fines	GPS-documentation

Both team members are needed to measure actual widths, channel widths, riparian areas, gradient, and water temperature at designated units. Although the team has assigned duties, they should not hesitate to consult with each other if they have questions or feel that a mistake may have been made. Working as a team will provide the best possible results.

Header Information

Header information is **vitaly important** for future reference. Take the time to record all categories completely and accurately.

Stream Name	Full name of stream
District	National Forest District name
Quad	USGS 1:24,000 quadrangle name
Date	Record date(s) of inventory
Recorder	Full name of recorder
Observer	Full name of observer
GPS	Record at start and end locations, always use datum NAD83 CONUS, UTM
Location	Detailed written description of start point, include landmarks, road #, etc.
Comments	Record signs of activity in area, water conditions, other pertinent information

Random Numbers

Before beginning the inventory, select a number from a random numbers table (see Appendix) to determine the first habitat unit at which to make measurements. For long inventories (> 1.0 km) select a random number between 1 and 10th (i.e. measure every 10th unit), for shorter streams use a number between 1 and 5 (i.e. measure every 5th unit). See the appendix for random numbers tables.

The team needs to measure units more frequently during shorter inventories to provide enough ‘paired samples’ for data analysis. ‘Paired samples’ are habitat units in which both visual estimates and actual measurements are made. Actual measurements are used to calibrate the observer’s visual estimates. The more paired samples, the tighter the confidence intervals for stream area estimates.

After the team records a paired sample they continue upstream making visual estimates and stopping to make additional measurements at the pre-determined interval. For example, if the random number was 3 and the crew was measuring every 5th unit, the team would make measurements on the 3rd pool and 3rd riffle and then every 5th pool and riffle thereafter (8, 13, 18, 23, etc).

If the inventory may not get 3 paired fast-water units and 3 paired slow-water units following the random number protocol, then make sure to add in additional paired units as necessary.

Starting the Inventory

After the team has organized their gear, determined their measurement interval, selected a random number, and recorded all the header information they are ready to begin the habitat inventory.

The observer should enter the stream slightly downstream of the starting point, tie off the hipchain, progress upstream to the starting point, reset the hipchain to zero and begin walking upstream through the first habitat unit. As the observer moves upstream they use the wading rod to measure depth at several locations in the habitat unit and make observations of unit type, width, substrates, and percent fines. When they reach the upstream end of the habitat unit they stop, turn to face the unit and report the unit type, maximum and average depth, riffle crest depth (where appropriate), dominant and subdominant substrate classes, percent fines, estimated width, and hipchain distance to the recorder.

As the observer moves upstream through the unit, the recorder follows behind, recording the amount of LW in the habitat unit. The recorder also assigns a number to the habitat unit. The recorder tells the observer if a unit is designated for measurements (i.e. if it is a 'paired sample' unit) only after they have recorded visual estimates.

The team continues upstream making estimates in every habitat unit and making estimates and measurements in every paired sample unit until the inventory endpoint is reached.

Definitions of habitat attributes, how to measure and when to record them, and what to do when the inventory is complete are covered in the following sections.

Section 2: Stream Attributes

Unit Type (see abbreviations)

Unit Type	Abbreviation	Definition
Riffle	R	Fast water, turbulent, gradient <12% ; shallow reaches characterized by water flowing over or around rough bed materials that break the surface during low flows; also include rapids (turbulent with intermittent whitewater, breaking waves, and exposed boulders), chutes (rapidly flowing water within narrow, steep slots of bedrock), and sheets (shallow water flowing over bedrock) if gradient <12%
Cascade	C	Fast water, turbulent, gradient ≥12% ; highly turbulent series of short falls and small scour basins, with very rapid water movement; also include sheets (shallow water flowing over bedrock) and chutes (rapidly flowing water within narrow, steep slots of bedrock) if gradient ≥12%
Run	RN	Fast water, non-turbulent, gradient <12% ; deeper than riffles with little or no surface agitation or flow obstructions and a flat bottom profile
Pool	P	Slow water, surface turbulence may or may not be present, gradient <1%; generally deeper and wider than habitat immediately upstream and downstream, concave bottom profile; includes dammed pools, scour pools, and plunge pools
Glide	G	Slow water, no surface turbulence, gradient <1% ; shallow with little to no flow and flat bottom profile
Underground	UNGR	Stream channel is dry or not containing enough water to form distinguishable habitat units (LW counts are the only data collected in underground reaches)

*modified from Armantrout (1998)

How to estimate:

Habitat units are separated by ‘breaks’. Breaks can be obvious physical barriers, such as a debris dam separating two pools or a small waterfall separating a pool and riffle, or may be less obvious transitional areas. Questions often arise as to whether a break is substantial enough to split two habitat units and where the exact location of the break occurs. When in doubt, the observer should consult with the recorder and the team should ‘think like a fish’. To determine if a break should be made, consider whether a fish would have to make an effort to move across the break and into the next habitat unit. If not, then it is probably a single habitat unit.

The channel may have both pool and riffle type habitat in the same cross-sectional area. Determine predominate habitat type and record it as the unit type. For example if an area contains both pool and riffle, but the majority of the flow is into and out of the pool habitat, then call the unit a pool.

Questions also often arise as to the minimum size of individual habitat units. Generally, if a habitat unit is not at least as long as the wetted channel is wide, then do not count it as a separate habitat unit. This rule may need to be adjusted for streams wider than 5 m. Use best professional judgment in such cases.

See the section 2.1 for a list of features that should also be recorded while performing the inventory.

When to record: every habitat unit

Unit Number (#)

Definition:

Count of habitat units of similar types, used to determine location of paired sample units

How to estimate:

When counting habitat units, group pools and glides (slow water) together, and group riffles, runs, and cascades (fast water) together. For example, consider the following sequence of habitat units:

Pool – Riffle – Pool – Pool – Riffle - Cascade – Riffle - Glide – Riffle – Pool – Run – Pool – Riffle

Habitat units in this sequence would be counted in the following manner (similar types are shaded same color):

Unit Type	Unit Number
P	1
R	1
P	2
P	3
R	2
C	3
R	4
G	4
R	5
P	5
RN	6
P	6
R	7

In the above example, the team has counted six slow water (pool/glide) units and seven fast water (riffle/run/cascade) units.

When to record: every habitat unit; not recorded for features

Distance (m)*Definition:*

Number of meters (rounded to the whole meter) from the start of the inventory to the upstream end of the habitat unit or distance from the start of the inventory to upstream end of a feature, used as spatial reference for data analysis and to locate features in the future.

How to estimate:

The observer walks upstream in the middle of the stream channel with a hipchain measuring device. When they reach the upstream break between habitat units or the upstream end of a feature they stop and report the distance to the recorder.

Care should be taken to keep the hipchain string in the middle of the stream, especially around bends and meanders. If the hipchain should break, retreat to the location where the break occurred, tie off the hipchain, and continue. If the hipchain is reset for any reason be sure to note it in the comments.

When to record: every habitat unit and feature

Estimated Width (m)*Definition:*

Average wetted width of the habitat unit as estimated visually (typically to half-meter accuracy), used to calculate stream area. Wetted width is the distance from the edge of the water on one side of the main channel to the edge of the water on the opposite side of the main channel.

How to estimate:

The observer notes the general shape and width of the unit while walking to the upstream end. When they reach the upstream end of the unit the observer stops, turns to face the unit, and estimates the average wetted width. Measure the wetted width of the stream before starting each day to calibrate yourself.

When to record: every habitat unit

Maximum and Average Depth (cm)

Definitions:

Maximum Depth – vertical distance from substrate to water surface at deepest point in habitat unit

Average Depth – average vertical distance from substrate to water surface in habitat unit

How to estimate:

The observer uses a wading rod marked in 5 cm increments to measure water depth as they walk upstream through the habitat unit. Water depth in deepest spot is recorded as the maximum depth. Average depth is the average of several depth measurements taken throughout the habitat unit.

When to record: every habitat unit

Riffle Crest Depth (cm)

Definition:

Vertical distance from the substrate to the water surface at the deepest point in the riffle crest. The riffle crest is the shallowest continuous line (usually not straight) across the channel where the water surface becomes continuously riffled in the transition area between a riffle (or a run or cascade) and a pool (or glide) (Armantrout 1998); think of it as the last place water would flow out of the pool if the riffle ran dry.

How to estimate:

When the observer reaches the upstream end of a riffle (or a run or cascade) leading into a pool (or glide), they use the wading rod to measure the deepest point in the riffle crest. Record the depth in the RCD column for the riffle habitat row.

When to record: at the upstream end of any riffle, run, or cascade leading into a pool or glide

Dominant and Subdominant Substrate (1-9)

Definitions:

Dominant Substrate – size class of stream bed material that covers the greatest amount of surface area within the wetted channel of the habitat unit.

Subdominant Substrate – size class of stream bed material that covers the 2nd greatest amount of surface area within the wetted channel of the habitat unit.

How to estimate:

The following size classes are used to categorize substrates*. The substrate ‘Number’ is entered into the dominant and subdominant substrate columns on the datasheet.

Type	Number	Size (mm)	Description
Organic Matter	1		dead leaves, detritus, etc. – not live plants
Clay	2		sticky, holds form when rolled into a ball
Silt	3		slippery, does not hold form when rolled into a ball
Sand	4	silt – 2	grainy, does not hold form when rolled into ball
Small Gravel	5	3-16	sand to thumbnail
Large Gravel	6	17-64	thumbnail to fist
Cobble	7	65-256	fist to head
Boulder	8	>256	larger than head
Bedrock	9		solid rock, parent material, may extend into bank

* these size classes are based on the modified Wentworth scale

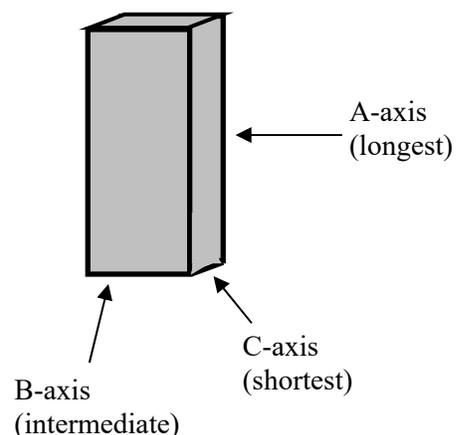
As the observer walks through the unit they scan the substrate. When they reach the upstream end of the unit they stop, turn to face the unit, and determine the dominant and subdominant substrate classes.

Estimate substrate size along the intermediate axis (b-axis). The b-axis is not the longest or shortest axis, but the intermediate length axis (see below). It is the axis that determines what size sieve the particle could pass through. Remember that your eyes are naturally drawn to larger size substrates. Be careful not to bias your estimate by focusing on the large size substrate.

Some units will contain a mixture of particle sizes. Consult with the recorder and use your best professional judgment to choose the dominant and subdominant sizes.

In units where the substrate is covered in moss, algae, or macrophytes classify the underlying substrate and make note of the plant growth in the comments. Only call organic substrate where there is dead and down leaves or other detritus covering the bottom of the unit.

When to record: every habitat unit



Rosgen Channel Type (A-G)

Definitions:

Stream channel classification system described in Rosgen (1996) based on entrenchment, width/depth ratio, sinuosity, and percent slope

How to Measure:

Before the team begins the inventory they should make the measurements described below to determine the channel type. Channel types are based on the following channel characteristics:

	A	B	C	D	E	F	G
Entrenchment	< 1.4	1.4 – 2.2	> 2.2	n/a	> 2.2	< 1.4	< 1.4
W/D Ratio	< 12	> 12	> 12	> 40	< 12	> 12	< 12
Sinuosity	1 – 1.2	> 1.2	>1.2	n/a	> 1.5	> 1.2	> 1.2
Slope (%)	4 – 9.9	2 – 3.9	< 2	< 4	< 2	< 2	2 – 3.9

Although we record channel type for every unit, it was designed to describe a reach of stream. Our main objective here is to locate changes between channel types, which could either be abrupt (such as change from a B to a G near a road crossing) or less obvious transitional areas (such as a natural transition from a B to an A channel as you move upstream). If you think channel type may have changed take the time to make the calculations listed below to determine the channel type for the reach you are entering.

Full channel type descriptions and how to measure each of the channel characteristics in the table above can be found in Rosgen (1998). Never perform measurements in a pool, always attempt to find a run or deep riffle with well-defined bankfull indicators to perform measurements. A summary of each is listed below:

Entrenchment (page 31 & 32 in Rosgen field guide):

- locate suitable riffle or run area for bankfull measurement (page 24-25 in Rosgen field guide)
- measure the bankfull width the maximum bankfull depth
- stretch a tape across the channel at 2x the maximum bankfull depth (this is the flood prone area)
- divide the flood prone area width by the bankfull width to determine entrenchment ratio

Width to Depth Ratio (page 32 in Rosgen field guide):

- locate suitable riffle or run area for bankfull measurement (page 24-25 in Rosgen field guide)
- measure the bankfull width and the maximum bankfull depth
- divide bankfull width by depth to determine width to depth ratio

Sinuosity (need aerial photo to determine)

Slope (page 37 in Rosgen field guide):

- Measure riffle to riffle gradient using clinometer

When to measure: every paired fastwater habitat unit*

* record for every fastwater paired unit, but remember this is describing a site characteristic – see above

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology Books, Pagosa Springs, Colorado.

Rosgen, D.L., and L. Silvey. 1998 Field Guide for Stream Classification, Wildland Hydrology Books, Pagosa Springs, Colorado.

Percent Fines (%)

Definition:

Percent of the total surface area of the stream bed in the wetted area of the habitat unit that consists of sand, silt, or clay substrate particles (i.e. particles < 2 mm diameter).

How to estimate:

As the observer walks through the habitat unit they note the amount of sand, silt, and clay in the habitat unit. When they reach the upstream end of the unit, they stop, turn to face the unit and estimate the amount of the total surface area within the wetted channel that consists of sand, silt, or clay.

Where to estimate: every habitat unit

Large Wood (1-4 and rootwad)

Definition:

Count of dead and down wood within the bankfull channel of a habitat unit

How to estimate:

The recorder classifies and counts LW as they walk through the habitat unit (including underground). LW counts are grouped by the size classes listed below:

Category	Length (m)	Diameter (cm)	Description
1	1-5	10-55	short, skinny
2	1-5	>55	short, fat
3	>5	10-55	long, skinny
4	>5	>55	long, fat
RW	rootwad	rootwad	roots on dead and down tree

Only count wood that is:

- 1 m in length and > 10.0 cm in diameter
- Within the bankfull channel
- Fallen, not standing dead

Additionally:

- Count rootwads separately from attached pieces of LW
- Estimate the diameter of LW at the widest end of the piece
- A piece that is forked, but is still joined counts as only one piece of LW
- Only count each piece one time, do not count a piece that is in two habitat units twice
- Enter the total count for each size category into the appropriate column on the datasheet
- Count LW in underground reaches

Where to estimate: every habitat unit

Actual Width (m)

Definition:

Average wetted width of the habitat unit as measured with 50 m tape, used to calculate stream area. Wetted width is the distance from the edge of the water on one side of the main channel to the edge of the water on the opposite side of the main channel.

How to measure:

Use a meter tape to measure the wetted width of the stream in at least three locations. Average the measurements to obtain the average wetted width.

Where to measure: paired sample habitat units

Bankfull Channel Width (m)

Definition:

Actual width of channel at bankfull elevation as measured with meter tape. Depending on channel type, bankfull may or may not be represented by the top of the banks. Use bankfull indicators to locate the top of the bankfull channel (Rosgen 1996).

How to measure:

Determine the location of bankfull water depth on both banks of the habitat unit and measure across the channel perpendicular to flow from bankfull to bankfull.

Where to measure: paired sample riffles, runs, or cascades

Riparian Width (m)

Definition:

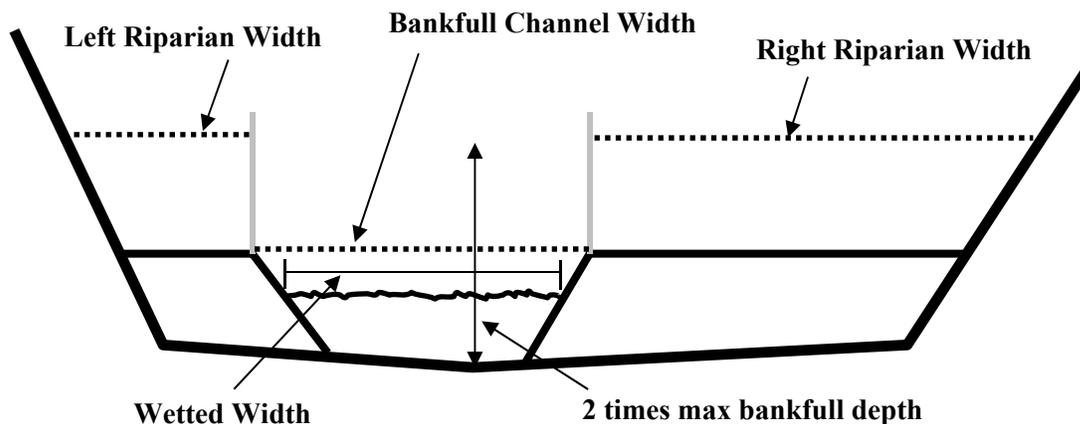
Width of the riparian area at an elevation of two times the maximum bankfull depth, measured for both left and right banks (left and right as oriented facing upstream). Maximum bankfull depth is the greatest vertical distance from the substrate to the top of the bankfull channel across a bankfull transect.

How to measure:

- Stretch a measuring tape across the top of the bankfull channel – this is your bankfull transect
- Use a wading rod to find the maximum bankfull depth
- Place the clinometer against the wading rod at two-times the maximum bankfull depth
- Using the clinometer to maintain a slope of zero degrees, site perpendicular to the channel to the intersection with the nearest landform. It may be necessary to site to an intermediate point, move the wading and clinometer, and site again if the tape measure is too short or the view is obstructed
- Measure the distance from the edge of the bankfull channel to the landform – do this separately for the left and right (as facing upstream) riparian areas

Note: if riparian width is more than 50 m, record 51 as the riparian width and note in ‘Comments’ that riparian width was longer than meter tape

Where to measure: paired sample riffles, runs, or cascades



Gradient (%)

Definition:

Change in vertical elevation per unit of horizontal distance of the water surface (Armantrout 1998)

How to measure:

Gradient is measured in riffles with a clinometer using the following steps:

- Observer stands at upstream end of riffle, recorder stands at downstream end of riffle
- Recorder sites upstream to the height of their eye on the observer using clinometer
- Record the **percent** slope, **not the degrees** (tip the clinometer all the way back to determine which side of the scale is percent)

The recorder should determine the height of their eye on the observer at the beginning of the inventory. Be certain that the observer and recorder are standing with their feet in the same position (preferably with feet at top of water surface) within the stream channel. If the observer is standing on top of a boulder and the recorder is standing in a depression, the measured gradient will be incorrect.

Where to measure: paired sample riffles, runs, or cascades

Water Temperature (C)

Definition:

Temperature of the water in degrees Celsius.

How to measure:

Place the thermometer in moving water in an area not exposed to direct sunlight. Leave the thermometer sit for at least three minutes, then record the water temperature in degrees Celsius.

Where to measure: paired sample riffles, runs, or cascades

Photo (ID#)

Definition:

Photograph of habitat unit or crossing feature.

How to measure:

Take photo facing upstream with observer holding wading rod in picture. Be sure to get entire width (and length if possible) of habitat unit or crossing feature in the photo.

Where to measure: paired sample riffles, runs, or cascades and any crossing features encountered

Flag (y or n)

Definition:

Marks the location of electrofishing units. Located at every 2nd paired sample unit for both fast and slow water habitat unit types.

How to measure:

At every 2nd paired sample unit hang a long piece of flagging tape at the exact location of the downstream and upstream end of the unit. Flags should be tied at eye level. Write the habitat unit type and number on each flag and indicate whether it is the downstream or upstream end of the habitat unit. Put a 'y' in the datasheet where flags are hung.

Where to measure:

Every 2nd paired sample fast and slow water unit; for example if the interval is every 5th unit and the random number is three, flags would be hung for pool 8, pool 18, pool 28, etc. and riffle 8, riffle 18, riffle 28, etc.

Features

Definition: Points on a stream that could potentially serve as landmarks, may be natural or manmade.

How to measure: Record the distance to the upstream end of all features and take a photograph of all crossing features.

Where to record: wherever found

Channel Feature	Abbreviation	What to Record
Waterfall ¹	FALL	Distance, estimated height
Tributary	TRIB	Distance, average wetted width (record 0 m if dry), into main channel on left or right (as facing upstream)
Side channel ²	SCH	Distance, average wetted width (record 0 m if dry), whether it is flowing into or out of main channel on left or right (as facing upstream)
Braid ³	BRD	Distance at start and distance at end; continue with normal inventory up channel with greatest discharge
Seep (Spring)	SEEP	Distance, left or right bank (as facing upstream), size, coloration
Landslide	SLID	Distance, left or right bank (as facing upstream), estimated size
Other	OTR	Distance, description of feature, <i>example:</i> found water intake pipe going to house here; old burned out shack on side of stream; Big Gap campground on left; alligator slide here, etc.

¹ must be vertical with water falling through air to be a waterfall and not a cascade, do not record unless >1m high

² two channels, continue with normal inventory up channel with most volume

³ three or more channels intertwined, continue with normal inventory up channel with most volume

Crossing Feature	Abbreviation	What to Record*
Bridge	BRG	Distance, width, height, road or trail name and type (gravel, paved, dirt, horse, ATV, etc.), photo
Ford	FORD	Distance, road or trail name and type (gravel, paved, dirt, etc.), photo
Dam	DAM	Distance, type, condition, estimated height, dam use, name of road or trail, if applicable; include beaver dams, photo
Culvert	V	Distance, road or trail name, type, # of outlets, diameter/width, height, material, perch (distance from top of water to bottom lip of culvert, natural substrate (present or absent through length)), photo

* photograph all crossing features with person and wading rod for scale, record 'Y' in 'Photo' column

We cannot stress enough the importance of fully and accurately describing features. This means getting out a quadrangle map and finding road, trail, and tributary names and recording them in 'Comments' and taking the time to describe the location of features in relation to landmarks found on quadrangle maps.

Take photos of all crossing features!

Section 3: Wrapping Up

End the inventory where:

- Forest Service property ends
- Stream is dry for more than 500 m
- Stream channel is < 1.0 m wide for more than 500 m

Record the following in the Comments:

- Time and date
- Reason for ending the inventory
- Detailed written description of location using landmarks for reference
- **Be sure the header information is completed – GPS, etc**

When you return to home base:

- Immediately download the data and check file to be sure all data downloaded
- Check header information to be sure it is complete
- Save to the computer and create a backup copy
- Document any photographs
- If using paper, make a photocopy of the data and store in secure location

Section 4: Summary

Before starting:

- determine interval
- select random number
- fill in header information

Record for every habitat unit:

- Unit Type
- Unit Number
- Distance
- Estimated Width
- Maximum Depth
- Average Depth
- Dominant Substrate
- Subdominant Substrate
- Percent Fines
- Large Wood

Record for every riffle, run, or cascade leading into a pool or glide:

- Riffle Crest Depth

Record for every paired sample pool:

- Measured Width
- Flag (y or n)

Record for every paired sample riffle:

- Measured Width
- Bankfull Channel Width
- Riparian Width (left and right)
- Gradient
- Rosgen Channel Type
- Water temperature
- Photograph
- Flag (y or n)

Record features and full feature descriptions wherever they are encountered.

Photograph all crossings!

When end of inventory is reached, record reason for ending, date, and time, be sure data is saved in safe location, and record inventory start and end points on master maps.

Section 5: GPS Instructions

Garmin BVET Waypoint Labels:

1. Named Stream
 - a. Use named stream's name
 - b. Example; **Horn**

2. Unnamed Stream flowing into a named stream
 - a. Use UT + Named stream's name
 - b. Example; **UTHorn**

3. Unnamed Stream flowing into a unnamed stream
 - a. Use UT + UT + Named stream's name
 - b. Example; **UTUTHorn**

Add the following letters to the end of the waypoint

S	Start location of BVET survey
P	Pause location of BVET survey if survey is not completed that day
F	Flagged habitat unit to be efished
T	Tributary with name shown on quad map
E	End location of BVET survey when survey is completed
W	Waterfall
B	Bridge
Fd	Ford
D	Dam
V	Culvert
O	Other

To create unique waypoint labels use 1, 2, 3, etc. at the end of the label when more than 1 of a feature type are encountered on a stream; for example if 3 habitat units are flagged for efishing on Horn Creek the first waterfall would be HornF1, the second would be HornF2, , the third HomeF3

How to Find a Waypoint on GPS:

- Turn Power On.
- On the main menu screen touch the **Where To?** icon with the magnifying glass.
- Touch the **Waypoints** icon with the red flag.
- At the bottom right of the next screen touch the **3-lines** button, then **Spell Search**.
- Start typing in the name of the desired waypoint. Once the waypoint name is identified by the GPS it will list the waypoints associated with that waypoint name.
- Touch the waypoint name you were looking for when the list pops up.
- To navigate to this location touch the big green **Go** button.

Changing Waypoints:

- To switch waypoints close the map screen by touching the **X** close button in the lower left corner of the screen.
- On the main menu screen touch the **Where To?** icon with the magnifying glass.
- Touch the Stop Navigation button and repeat the top process to get to a new waypoint.

Appendix: Field Guide, Equipment Checklist, Rosgen Worksheet

Record for every habitat unit:

- **Unit Type** – pool, riffle, run, cascade, glide, feature (see below)
- **Unit Number** – group pools & glides; group riffles, runs, cascades
- **Distance (m)** – at upstream end of unit
- **Estimated Width (m)** – visual estimate of average wetted width
- **Maximum Depth (cm)** – deepest spot in unit
- **Average Depth (cm)** – average depth of unit
- **Dominant Substrate (1-9)** – covers greatest amount of surface area in unit
- **Subdominant Substrate (1-9)** – covers 2nd most surface area in unit
- **Percent Fines (%)** – percent of bottom consisting of sand, silt, or clay
- **Large Wood (1-4, RW)** – count of dead and down wood in the bankfull channel

Record for every riffle, run, or cascade leading into a pool or glide:

- **Riffle Crest Depth (cm)** – deepest spot in hydraulic control between riffle type habitat and pool type habitat

Record for paired sample pools:

- **Measured Width (m)** – measurement of average wetted width
- **Flag (y or n)** – yes if electrofishing flag hung, no if not hung; hang flags at every 2nd paired sample unit

Record for paired sample riffles:

- **Measured Width (m)** – measurement of average wetted width
- **Channel Width (m)** – measurement of bankfull channel width
- **Riparian Width (m)** – L&R, measurement of floodplain
- **Gradient (%)** – clinometer measurement of riffle slope
- **Water Temperature (C)** – temperature of water in Celsius
- **Rosgen** – channel type classification
- **Photo (y or n)** – picture of habitat unit or crossing feature
- **Flag (y or n)** – yes if electrofishing flag hung, no if not hung; hang flags at every 2nd paired sample unit

Unit Types

- **Riffle (R)** – fast water, turbulent, gradient <12%; includes rapids, chutes, and sheets if gradient <12%
- **Cascade (C)** – fast water, turbulent, gradient ≥12%, includes sheets and chutes if gradient ≥12%
- **Run (RN)** – fast water, little to no turbulence, gradient <12%, flat bottom profile, deeper than riffles
- **Pool (P)** – slow water, may or may not be turbulent, gradient <1%, includes dammed, scour, and plunge pools
- **Glide (G)** – slow water, no surface turbulence, gradient <1%, shallow with little flow and flat bottom profile
- **Underground (UNGR)** – distance at upstream end, why dry

Features

- **Waterfall (FALL)** – distance, height
- **Tributary (TRIB)** – distance, width, in on L or R
- **Side Channel (SCH)** – distance, width, in or out on L or R
- **Braid (BRD)** – distance at downstream and upstream ends
- **Seep or Spring (SEEP)** – distance, on left or right, amount of flow
- **Landslide (SLID)** – distance, L or R, est. size and cause
- **Other (OTR)** – record distance, describe feature in comments
- **Crossing Features** – photograph and record the following:
 - **Bridge (BRG)** – distance, height, width, road or trail name & type
 - **Dam (DAM)** – distance, type, est. height, road or trail name & type
 - **Ford (FORD)** – distance, road or trail name & type
 - **Culvert (V)** – distance, type (pipe, box, open box, arch, open arch), size, material, natural substrate, perch, road or trail name

Substrates

- **Organic Matter** – dead leaves detritus, etc., not living plants
- **Clay** – sticky, holds form when balled
- **Silt** – slick, does not hold form when balled
- **Sand** – >silt-2mm, gritty, doesn't hold form
- **Small Gravel** – 3-16mm, sand to thumbnail
- **Large Gravel** – 17-64mm, thumbnail to fist
- **Cobble** – 65-256mm, fist to head
- **Boulder** – >256, > head
- **Bedrock** – solid parent material

Large Wood

- **#1** <5m long, 10-55cm diameter
- **#2** <5m long, >55cm diameter
- **#3** >5m long, 10-55cm diameter
- **#4** >5m long, >55cm diameter
- **RW** – rootwad, count separately from attached LW, record in comments, do not record wood <10cm diameter, <1m length

Rosgen Channel Types

Rosgen Channel Types	A	B	C	D	E	F	G
Entrenchment	< 1.4	1.4 – 2.2	> 2.2	n/a	> 2.2	< 1.4	< 1.4
W/D Ratio	< 12	> 12	> 12	> 40	< 12	> 12	< 12
Slope (%)	4 – 9.9	2 – 3.9	< 2	< 4	< 2	< 2	2 – 3.9

Measuring Riparian Width (paired fast-water units only)

- Place clinometer against the wading rod at two times max bankfull depth
- Use the clinometer as a level – keep the slope at 0.0 – and site to the nearest landform perpendicular to the channel
- Measure the distance from the edge of the bankfull channel to the intersection with the landform
- Do this for both the left and right banks
- If riparian width in more than 50 m, record 51 as the riparian width and in 'Comments' note that riparian was > 50 m wide

Random Number Table

Random numbers for measuring every 5th unit

4	3	5	1	5	1	2	5	2	3
2	5	2	5	2	2	1	5	4	1
3	2	5	1	2	1	3	1	5	3
5	4	1	5	1	3	5	4	2	5
4	2	2	5	2	2	5	5	2	1
4	2	5	2	2	4	5	5	5	2
3	5	4	1	5	1	4	1	3	3
1	4	2	2	1	4	3	1	5	3
5	4	3	3	2	4	1	2	5	1
4	4	1	1	3	5	1	5	5	4

Random numbers for measuring every 10th unit

3	7	10	5	1	2	2	7	10	6
4	2	3	8	9	2	4	4	6	9
3	3	8	4	3	9	9	7	5	5
1	3	5	5	2	6	5	2	2	6
3	7	8	6	3	8	8	5	2	10
10	9	6	9	4	3	10	7	2	10
6	10	5	4	8	10	4	1	4	10
4	3	4	3	2	3	4	4	3	7
5	1	7	9	7	3	10	7	10	3
9	6	8	6	2	2	1	9	10	5

- Choose a new random number at the beginning of each stream inventory
- Use the number for the entire stream
- Use the first table for streams < 1.0 km long, the second table for streams >1.0 km long

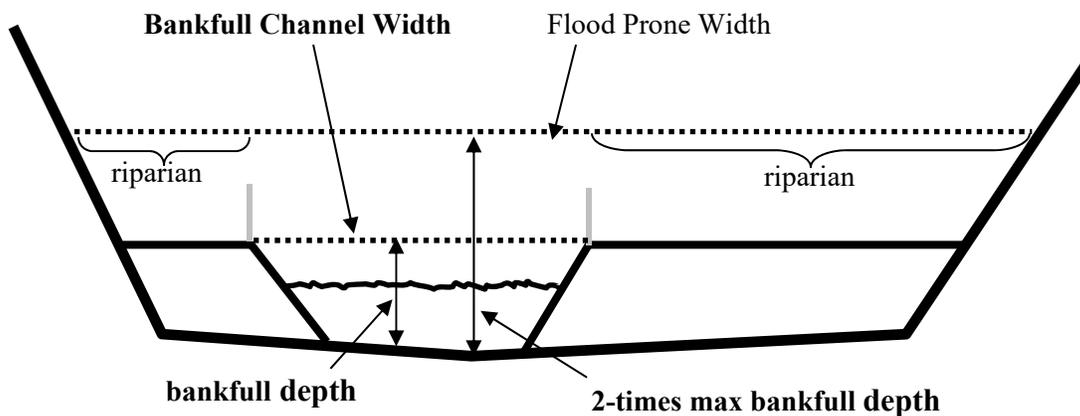
Equipment Checklist

- hipchain
- extra string for hipchain
- wading rod
- 50 m tape measure
- clinometer
- thermometer
- datalogger
- GPS unit
- camera
- backpack
- pencils
- flagging
- markers
- waterproof backup datasheets
- clipboard
- BVET field guide on waterproof paper
- topographic maps
- water
- water filter
- lunch
- first aid kit
- radio/cell phone
- toilet paper
- felt bottom wading boots
- raingear

Rosgen Measurements

All measurements should be made across a transect in an area of uniform flow, specifically riffle or run sections with few irregularities in cross-sectional shape. **Avoid** areas influenced by culverts, bridges, tributaries, side-channels, etc.

- What is the **entrenchment ratio**?
 - Entrenchment ratio = flood prone width / bankfull width
 - Floodprone width = width at two-times maximum bankfull depth
- What is the **width/depth ratio**?
 - Width/depth ratio = bankfull width / average bankfull depth
 - Be sure to use same units of measure (centimeters) for width and depth
 - Measure *bankfull* depth (**not** water depth) at several locations across transect to obtain average bankfull depth
- What is the **gradient**?
 - Measure riffle to riffle slope (%) with clinometer



Rosgen Worksheet

- A. Bankfull Channel Width (m) _____
- B. Maximum Bankfull Depth (cm) _____ *2 = _____
- C. Average Bankfull Depth (cm) _____
- D. Right Riparian Width (m) _____
- E. Left Riparian Width (m) _____
- F. Gradient (%) _____

Entrenchment Ratio = (A+D+E)/A

(_____ + _____ + _____) / _____ = _____

Width Depth Ratio = (100*A)/C

(100* _____) / _____ = _____

	A	B	C	D	E	F	G
Entrench. ratio	< 1.4	1.4 – 2.2	> 2.2	n/a	> 2.2	< 1.4	< 1.4
W/D ratio	< 12	> 12	> 12	> 40	< 12	> 12	< 12
Gradient (%)	4 – 9.9	2 – 3.9	< 2	< 4	< 2	< 2	2 – 3.9

*these are the dominant ranges, values may be slightly outside these ranges