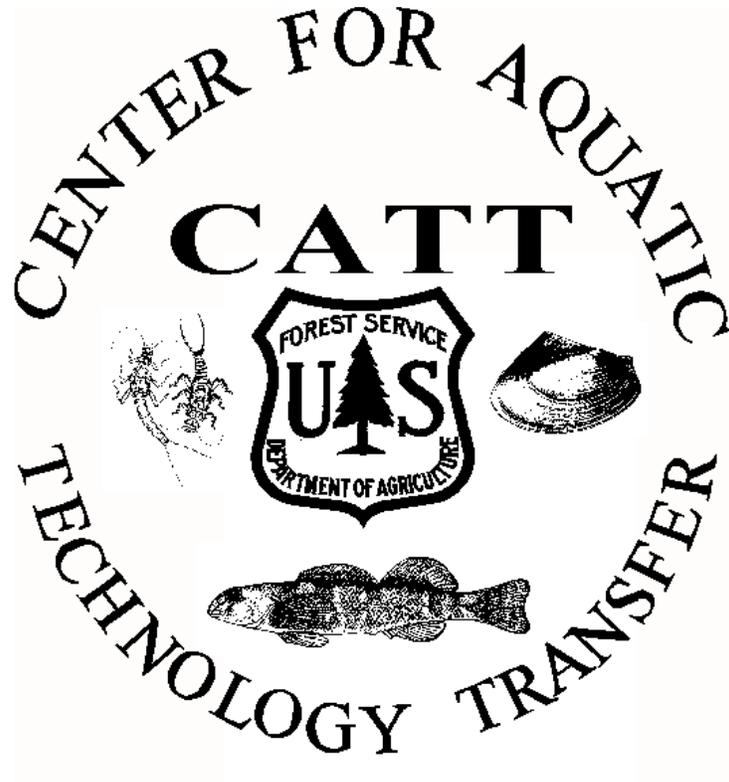


**Summary of Stream Inventories on the
Daniel Boone National Forest, 2005-2009**



**United States Department of Agriculture Forest Service
Southern Research Station
Center for Aquatic Technology Transfer
1710 Ramble Rd.
Blacksburg, VA 24060-6349**

C. Andrew Dolloff, Team Leader

**Report prepared by:
Colin Krause and Craig Roghair
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Table of Contents

Introduction..... 2
Methods 2
 Reach Selection 2
 Pebble Count Inventory 2
 Habitat Inventory 3
 Fish Inventory 3
Results..... 4
Data Availability 4
Literature Cited 15
Appendix A: Field Methods for Stream Inventory 16
Appendix B: Field Methods for Habitat Inventory 21

List of Tables

Table 1. Number of sample sites with inventories and the distance inventoried by year. 6
Table 2. Summary of parameters inventoried at stream sample locations in 2005..... 7
Table 3. Summary of parameters inventoried at stream sample locations in 2006..... 8
Table 4. Summary of parameters inventoried at stream sample locations in 2007..... 10
Table 5. Summary of parameters inventoried at stream sample locations in 2008..... 11
Table 6. Summary of parameters inventoried at stream sample locations in 2009..... 12
Table 7. Fish species captured on the DBNF, 2005-2009..... 13

List of Figures

Figure 1. Sample site locations (2005-2009) within the Daniel Boone National Forest, Kentucky. 5

Introduction

In March 2005, resource specialists from the Center for Aquatic Technology Transfer (CATT), Daniel Boone National Forest (DBNF), National Forests in North Carolina (NFNC), George Washington-Jefferson National Forest (GWJNF), and Southern Region Office (RO) met with Southern Research Station (SRS) scientists to develop the framework for a Southern Region stream monitoring program. All parties acknowledged that existing monitoring programs (e.g. Hixson et al. 2004, Walker and Bishop 1991) were not appropriate or sustainable for Forest-level stream monitoring in the Southern Region. The team outlined a sampling design and discussed specific sampling protocols.

Recommendations from the meeting were compiled into a field guide by the CATT (Appendix A). The DBNF volunteered to test the new strategy and initiated a pilot monitoring program. CATT field crews performed stream habitat and fish assemblage inventories on the DBNF each summer from 2005 – 2009 (Table 1).

Methods

Reach Selection

Random site selection is an important component of the monitoring program. The DBNF requested random sites from the Environmental Protection Agency (EPA), which has an existing random site selection program for the state of KY (Olsen, 2005). All sites had to meet two criteria: 1) watershed greater than 13 km²; 2) depth shallow enough for backpack electrofishing.

At each site we measured the wetted width of 1 – 2 fast water (riffle or run) habitat units and calculated the average wetted width. If the average wetted width was less than or equal to 3.0 m or greater than or equal to 7.5 m, the sample reach length was 120 m or 300 m, respectively (Appendix A). In all other cases sample reach length was 40-times the average wetted width.

Macroinvertebrate Inventory

We collected macroinvertebrates using riffle sample and multi-habitat sample methods described by Pratt (2002). Macroinvertebrates were collected at least one day before fish sampling. See Appendix A for detailed field methods.

Pebble Count Inventory

Fish sampling crews (see below) conducted pebble counts (Wolman heel-to-toe steps protocol; Wolman, 1954) in riffle habitat units to characterize the substrate in sample reaches. Crew members measured the intermediate axis of a minimum of 200 pebbles per riffle as described in Bunte and Abt (2001) and Kappesser (2002). In addition to pebble counts, bar counts were conducted by measuring the

intermediate axis of 30 dominant large particles residing on a bar or similar depositional feature within the sample reach. See Appendix A for detailed field methods.

Habitat Inventory

Two-person crews performed abbreviated stream habitat inventories (Roghair and Nuckols, 2005) based on the basinwide visual estimation technique (BVET) (Dolloff et al. 1993). For each habitat unit contained wholly or partially within the sample reach, the crew visually estimated or measured the following attributes:

All Habitat Units	Sub-Sample of Habitat Units
Type of habitat	Bankfull channel width
Length and width	Channel gradient
Maximum and average depth	Water temperature
Riffle crest depth	Photographs
Dominant and subdominant substrate	GPS coordinates
Rosgen channel type (Rosgen, 1996)	
Percent fines	
Large wood counts	

When possible, the crew sub-sampled at least 3 fast water and 3 slow water units within each reach.

In addition, the crew noted stream features including:

- Waterfalls
- Tributaries
- Side channels
- Braided channels
- Seeps (springs)
- Landslides
- Bridges
- Fords
- Dams
- Culverts

See Appendix A for detailed field methods.

Fish Inventory

A four-person crew using a DC backpack electrofisher collected fish from the same stream reach inventoried for stream habitat (see above). The crew attempted to apply standard effort of approximately 1 sec/m² of wetted stream habitat, and recorded the following data:

- Species name
- Counts of adult, age-0, and voucher specimens
- Sample reach length, electrofishing time (sec), and voltage
- GPS coordinates of start and end location

See Appendix A for detailed field methods.

Results

The CATT and DBNF personnel completed habitat inventories on a total of 81 sites (20.6 km) between 2005-2009 (Table 1-6). We did not sample fish at 10 sites due to the potential presence of blackside dace (*Phoxinus cumberlandensis*), a federally threatened species. We collected a total of 69 fish species on the DBNF between 2005-2009 (Table 7). These data can be used to describe stream condition on the DBNF and serve as a baseline for future comparisons. In addition, the data will be used to test the effectiveness of the new Southern Region stream monitoring program.

Data Availability

Summer 2005-2009 habitat, fish, and pebble data are ready for migration into the Natural Resource Information System water module (NRIS). We will format the data according to the Regional NRIS Water standards and migrate the data as the new NRIS water module comes online. As data are migrated into NRIS Water the CATT will coordinate development of custom query and reporting tools for the DBNF. In the interim, the CATT is available to assist with data analysis and report preparation. Jon Walker, DBNF Forest Hydrologist, received a copy of all data in electronic format.



Figure 1. Sample site locations (2005-2009) within the Daniel Boone National Forest, Kentucky.

Table 1. Number of sample sites with inventories and the distance inventoried by year.

Year	Dates	Crew Size	Inventory	
			Sites (#)	Distance (km)
2005	June 7-17	8	20	5.1
2006	July 18-27	9	34	8.7
2007	July 13-19	7	12	2.9
2008	July 15-19	6	5	1.3
2009	July 10-22	4	10	2.6
Total:			81	20.6

Table 2. Summary of parameters inventoried at stream sample locations in 2005.

Site	Stream Name	Macro-inverts		Pebble Count		B-VET		Efish		Mussels	Crayfish	Comments
		collected	--	RSI	D50 (mm)	habitat (m)	(sec)	2,747	none			
1	Rock Creek	collected	--	75	52	299	2,747	none	collected			
9	Marsh Creek	--	--	--	--	--	--	--	--		present	No survey, too large
14	Pine Creek	collected	--	86	42	226	1,408	none	present			
17	Rock Creek	collected	--	85	38	305	2,566	none	collected			
21	Roaring Paunch Creek	--	--	--	--	--	--	--	--			No survey, too large
33	Rock Creek	collected	--	73	58	311	3,356	collected	collected			
34	Bunches Creek	collected	--	19	680	218	--	--	present			No e fishing, blackside dace stream
38	Cane Creek	collected	--	58	92	305	3,877	none	collected			
41	Jellico Creek	collected	--	75	34	173	745	collected	collected			
42	Big Clifty Creek	collected	--	84	8	299	2,037	none	present			
45	Beaver Creek	collected	--	96	14	143	--	--	--			No e fishing, blackside dace stream
53	Laurel Creek	collected	--	90	70	253	1,638	none	present			Efish mistake, blackside dace stream
61	Beaver Creek	--	--	--	--	--	--	--	--			No survey, tick hazard
62	Horse Lick Creek	collected	--	75	54	297	1,620	collected	collected			
65	Rock Creek	collected	--	64	118	279	2,805	none	collected			
66	Beaver Creek	--	--	--	--	--	--	--	--			No survey, too large
75	Indian Creek	--	--	--	--	--	--	--	--			No survey, dry stream in karst area
78	Hawk Creek	collected	--	85	30	261	--	--	--			No e fishing, water too turbid
85	Roaring Paunch Creek	collected	--	69	82	325	3,000	collected	present			
90	Craig Creek	collected	NA*	NA*	1024	302	--	--	--			No e fishing, blackside dace stream
93	Middle Fork (Beaver Cr)	collected	--	68	14	200	--	none	present			No e fishing, blackside dace stream
97	Roaring Paunch Creek	--	--	--	--	--	--	--	--			No survey, too large
98	Dog Slaughter Creek	collected	NA*	NA*	1024	163	--	none	present			No e fishing, blackside dace stream
105	Capuchin Creek	collected	--	62	38	325	2,611	collected	collected			
109	Kilburn Fork	collected	--	69	34	141	--	--	--			No e fishing, blackside dace stream
117	Laurel Creek	collected	--	74	44	311	--	--	--			No e fishing, blackside dace stream
						Total	5,136					

*Riffle Stability Index (RSI) not available because no bars were present for bar count.

Table 3. Summary of parameters inventoried at stream sample locations in 2006.

Site	Stream Name	Macro-inverts		Pebble Count RSI D50 (mm)	BVT habitat (m)	Efish (sec)	Mussels	Crayfish	Comments
		collected	not collected						
7	South Fork Kentucky River	--	--	--	--	--	--	--	Not surveyed, too large
32	Yocum Creek	collected	90	78	304	2,108	none	present	
35	Red Bird River	--	--	--	--	--	--	--	Not surveyed, too large
40	Open Fork	--	--	--	--	--	--	--	Not surveyed, too large
48	North Fork Licking River	collected	94	72	276	2,824	collected	collected	
55	Bullskin Creek	collected	81	66	268	772	none	collected	
59	Cavanaugh Creek	collected	93	54	293	1,480	none	collected	
64	Minor Creek	collected	92	56	213	1,300	none	collected	
67	Rock Lick Creek	--	--	--	--	--	--	--	Not surveyed, private land
68	Chimney Top Creek	collected	99	38	218	764	none	present	
72	Beaver Creek	collected	97	24	415	1,842	none	present	
79	Sand Lick Fork	collected	97	50	193	953	none	present	
84	Swift Camp Creek	collected	74	88	322	2,479	none	present	
99	Upper Jacks Creek	collected	84	60	300	1,739	none	collected	
123	Ross Creek	collected	70	80	124	427	none	collected	
135	Red Bird River	--	--	--	--	--	--	--	Not surveyed, too large
136	Beaver Creek	collected	96	24	374	2,700	none	collected	
148	Red River	--	--	--	--	--	--	--	Not surveyed, too large
159	Middle Fork Red River	collected	82	60	215	1,000	none	collected	
160	Upper Lick Fork Creek	collected	93	54	129	336	none	collected	
175	Red River	--	--	--	--	--	--	--	Not surveyed, too large
176	Craney Creek	collected	89	8	377	2,252	none	collected	
179	Red Bird River	--	--	--	--	--	--	--	Not surveyed, too large
183	Leatherwood Creek	collected	52	112	230	998	none	present	
191	East Fork Indian Creek	collected	88	66	256	1,061	none	collected	

Table continued on next page.

Table 3 Continued. Summary of parameters inventoried at stream sample locations in 2006.

Site	Stream Name	Macro-inverts		Pebble Count		BVET		Efish		Mussels	Crayfish	Comments
		collected	RSI	D50 (mm)	habitat (m)	(sec)						
192	Clear Fork	collected	78	126	223	1,002		collected	none	collected		
195	Collins Fork	--	--	--	--	--		--	--	--		Not surveyed, too deep
196	Gladie Creek	collected	93	48	443	2,456		present	none	present		
199	Bowen Creek	collected	90	58	124	413		collected	none	collected		
200	Brushy Fork	collected	84	88	200	707		collected	none	collected		
207	Right Fork Buffalo Creek	collected	76	60	198	788		collected	none	collected		
224	North Fork Licking River	collected	98	40	357	2,403		none	collected	none		
239	Indian Creek	collected	93	50	251	1,398		collected	none	collected		
240	Slabcamp Creek	collected	99	40	213	751		collected	none	collected		
251	Big Sinking Creek	collected	77	160	320	1,796		collected	none	collected		
275	Phillips Fork	collected	59	96	277	1,165		collected	none	collected		
283	War Fork	collected	88	66	463	2,137		present	none	present		
288	Craney Creek	collected	99	20	322	2,965		collected	collected	Live Corbicula clams		
307	Hector Branch	collected	58	114	268	1,910		collected	none	collected		
NA	Gilberts Big Creek	collected	92	52	105	290		collected	none	collected	site # DBF04052007	
NA	Katies Creek	collected	75	58	195	823		collected	none	collected	site # DBF04051009	
NA	Sugar Creek	collected	92	46	109	362		collected	none	collected	site # DBF04052030	
NA	Upper Bear Creek	collected	45	210	158	654		collected	none	collected	site # DBF04052701	
Total										8,730		

Table 4. Summary of parameters inventoried at stream sample locations in 2007.

Site	Stream Name	Macro- inverts	Pebble Count RSI D50 (mm)	BVET habitat (m)	Efish (sec)	Mussels	Crayfish	Comments	
117	Laurel Creek	collected	54	106	190	956	none	collected	
133	Big Creek	collected	55	104	265	1,669	none	collected	
137	Barren Fork	collected	78	32	279	--	--	No e fishing, blackside dace stream	
178	Bark Camp Creek	collected	15	1024	225	1,392	none	collected	
201	Indian Creek	collected	69	80	277	--	none	-- No e fishing, blackside dace stream	
218	Lick Creek	collected	94	18	189	728	none	collected	
258	Mill Creek	collected	73	80	232	1,146	none	collected	
278	Cane Creek	collected	59	88	260	1,222	none	collected	
290	Bark Camp Creek	collected	42	380	252	1,542	none	collected	
293	Bridge Fork	collected	50	126	201	868	none	collected	
305	Wolf Creek	collected	54	108	181	738	none	collected	
314	Sinking Creek	collected	37	140	300	2,056	present	collected	
					Total	2,851			

Table 5. Summary of parameters inventoried at stream sample locations in 2008.

Site	Stream Name	Macro-inverts	RSI	Pebble Count D50 (mm)	BVET habitat (m)	Efish (sec)	Mussels	Crayfish	Comments
4	Chimney Top Creek	collected	72	64	241	1,786	none	collected	
20	Swift Camp Creek	collected	70	60	258	1,735	none	none	
63	Indian Creek	collected	90	36	302	2,098	none	collected	
100	Gladie Creek	collected	82	52	270	1,850	none	collected	
255	East Fork Indian Creek	collected	84	50	205	1,063	none	collected	
					Total	1,276			

Table 6. Summary of parameters inventoried at stream sample locations in 2009.

Site	Stream Name	Macro-inverts	Pebble Count	RSI	D50 (mm)	BVET habitat (m)	Efish (sec)	Mussels	Crayfish	Comments
15	Big Sinking Creek	--	--	--	--	--	--	--	--	Stream dry
16	Middle Fork Red River	collected	69	80	210	1,120	none	collected		
34	McCammon Branch	collected	81	62	184	796	none	collected		
51	Hector Branch	collected	78	52	219	1,118	none	collected		
180	Red River	--	--	--	--	--	--	--	--	No access
235	War Fork	collected	88	46	305	2,526	none	collected		
244	Red River	collected	51	100	338	2,762	none	collected		
254	Laurel Fork	collected	80	38	303	2,929	none	collected		
277	Bridge Fork	collected	NA*	130	304	2,211	none	none		
289	White Oak Creek	collected	59	78	145	500	none	present		
301	Beaver Creek	collected	58	98	320	2,233	none	collected		
315	Big Sinking Creek	collected	66	70	305	2,473	none	collected		
						Total	2,633			

*Riffle Stability Index (RSI) not available because no bars were present for bar count.

Table 7. Fish species captured on the DBNF, 2005-2009.

Family	Scientific Name	Common Name
Atherinidae	<i>Labidesthes sicculus</i>	Brook silverside
Catostomidae	<i>Catostomus commersoni</i>	White sucker
Catostomidae	<i>Hypentelium nigricans</i>	Northern hog sucker
Catostomidae	<i>Moxostoma anisurum</i>	Silver redhorse
Catostomidae	<i>Moxostoma macrolepidotum</i>	Shorthead redhorse
Catostomidae	<i>Moxostoma poecilurum</i>	River redhorse
Centrarchidae	<i>Ambloplites rupestris</i>	Rock bass
Centrarchidae	<i>Lepomis auritus</i>	Redbreast sunfish
Centrarchidae	<i>Lepomis cyanellus</i>	Green sunfish
Centrarchidae	<i>Lepomis gibbosus</i>	Pumpkinseed
Centrarchidae	<i>Lepomis gulosus</i>	Warmouth
Centrarchidae	<i>Lepomis macrochirus</i>	Bluegill
Centrarchidae	<i>Lepomis megalotis</i>	Longear sunfish
Centrarchidae	<i>Micropterus dolomieu</i>	Smallmouth bass
Centrarchidae	<i>Micropterus punctulatus</i>	Spotted bass
Centrarchidae	<i>Micropterus salmoides</i>	Largemouth bass
Clupeidae	<i>Dorosoma cepedianum</i>	Gizzard shad
Cottidae	<i>Cottus bairdi</i>	Mottled sculpin
Cottidae	<i>Cottus carolinae</i>	Banded sculpin
Cyprinidae	<i>Campostoma anomalum</i>	Central stoneroller
Cyprinidae	<i>Clinostomus elongatus</i>	Redside dace
Cyprinidae	<i>Clinostomus funduloides</i>	Rosyside dace
Cyprinidae	<i>Cyprinella galactura</i>	Whitetail shiner
Cyprinidae	<i>Cyprinella whipplei</i>	Steelcolor shiner
Cyprinidae	<i>Cyprinus carpio</i>	Carp
Cyprinidae	<i>Ericymba buccata</i>	Silverjaw minnow
Cyprinidae	<i>Etheostoma baileyi</i>	Emerald shiner
Cyprinidae	<i>Hybopsis amblops</i>	Bigeye chub
Cyprinidae	<i>Luxilus chrysocephalus</i>	Striped shiner
Cyprinidae	<i>Lythrurus ardens</i>	Rosefin shiner
Cyprinidae	<i>Nocomis micropogon</i>	River chub
Cyprinidae	<i>Notemigonus crysoleucas</i>	Golden shiner
Cyprinidae	<i>Notropis boops</i>	Bigeye shiner
Cyprinidae	<i>Notropis photogenis</i>	Silver shiner
Cyprinidae	<i>Notropis rubellus</i>	Rosyface shiner
Cyprinidae	<i>Notropis spilopterus</i>	Spotfin shiner
Cyprinidae	<i>Notropis stramineus</i>	Sand shiner
Cyprinidae	<i>Notropis telescopus</i>	Telescope shiner
Cyprinidae	<i>Notropis volucellus</i>	Mimic shiner
Cyprinidae	<i>Phoxinus erythrogaster</i>	Southern redbelly dace
Cyprinidae	<i>Pimephales notatus</i>	Bluntnose minnow
Cyprinidae	<i>Rhinichthys atratulus</i>	Blacknose dace
Cyprinidae	<i>Semotilus atromaculatus</i>	Creek chub

Table continued on next page.

Table 7. Continued. Fish species captured on the DBNF, 2005-2009.

Family	Scientific Name	Common Name
Ictaluridae	<i>Ameiurus natalis</i>	Yellow bullhead
Ictaluridae	<i>Ameiurus nebulosus</i>	Brown bullhead
Ictaluridae	<i>Noturus flavus</i>	Stonecat
Ictaluridae	<i>Noturus miurus</i>	Brindled madtom
Percidae	<i>Etheostoma baileyi</i>	Emerald darter
Percidae	<i>Etheostoma blenniodes</i>	Greenside darter
Percidae	<i>Etheostoma caeruleum</i>	Rainbow darter
Percidae	<i>Etheostoma camurum</i>	Bluebreast darter
Percidae	<i>Etheostoma chlorosomum</i>	Bluntnose darter
Percidae	<i>Etheostoma flabellare</i>	Fantail darter
Percidae	<i>Etheostoma kennicotti</i>	Stripetail darter
Percidae	<i>Etheostoma nigrum</i>	Johnny darter
Percidae	<i>Etheostoma obeyense</i>	Barcheek darter
Percidae	<i>Etheostoma rufilineatum</i>	Redline darter
Percidae	<i>Etheostoma sagitta</i>	Arrow darter
Percidae	<i>Etheostoma spectabile</i>	Orangethroat darter
Percidae	<i>Etheostoma variatum</i>	Variegate darter
Percidae	<i>Etheostoma virgatum</i>	Striped darter
Percidae	<i>Etheostoma zonale</i>	Banded darter
Percidae	<i>Percina caprodes</i>	Logperch
Percidae	<i>Percina maculata</i>	Blackside darter
Percidae	<i>Percina sciera</i>	Dusky darter
Percidae	<i>Percina stictogaster</i>	Frecklebelly darter
Petromyzontidae	<i>Lampetra aepyptera</i>	Least brook lamprey
Petromyzontidae	<i>Lampetra appendix</i>	American brook lamprey
Salmonidae	<i>Oncorhynchus mykiss</i>	Rainbow trout

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Appendix A: Field Methods for Stream Inventory

Sampling Strategy

Day 1

- All crew to first site to learn site documentation, reach layout, and macroinvertebrate and habitat sampling methods
- Split into several crews to document sites, layout reaches, and sample macroinvertebrates and habitat

Day 2

- Two crew continue with site documentation, reach layout, and macroinvertebrate and habitat sampling methods
- Remainder of crew (6-8 persons) begin fish sampling at sites visited on day 1

Day 3

- Continue with approach from day 2, allowing at least 1 day between macroinvertebrate and fish sampling
- If fish sampling crew catches up with layout crew, then take a day to split into several layout crews as during day 1
- When layout crew finishes all sites they can rejoin fish sampling crew

This approach should maximize crew efficiency and prevent biases associated with sampling fish and macroinvertebrates within the same reach in the same day.

Site Documentation

Objective - Record location and description of site for reporting purposes

Methods

- Directions to site
 - Record roads taken to parking area
 - Record trails walked to site
 - Document route to site on quadrangle map
- GPS
 - Record GPS coordinates at middle of reach
 - Use Daniel Boone National Forest standard for coordinate system and map datum; example) CONUS, NAD27
- Photos
 - Take digital photo from downstream end looking up, upstream end looking down
 - Photograph any pertinent features within the reach that may influence habitat and fauna, example, road or trail crossings, erosion, etc.
- Written description
 - Record comments on land use in the reach area, for example private land with mowed lawns, all forested, pasture lands, etc.
 - Record comments on other features that may be influencing stream conditions

Fish Reach Layout

Objective - Use consistent method to lay out reach for fish and macroinvertebrate sampling

Methods

- Locate 1 – 2 riffles or runs and determine the average wetted width by making several measurements and computing the average. Measure width perpendicular to thalweg.
 - If the average wetted width is less than or equal to 3.0 m, then the reach length will be 120 m
 - If the average wetted width is greater than or equal to 7.5 m, then the reach length will be 300 m
 - If the average wetted width is between 3.0 and 7.5 m, then reach length is 40-times the average wetted width, example: average wetted width = 5 m; reach length = 5 x 40 = 200m
- Hang a double orange flag at the downstream end of the reach . Attach topofil from a hipchain and walk to the midpoint of the reach, hang a single orange flag, then continue to the end of the reach and hang another single orange flag
- Record the average wetted width and reach length on the datasheet
- Reaches will not be moved to avoid road or trail crossings – moving reaches violated the assumptions of the stratified random sample design and invalidates statistical analysis. Document these features fully with photos and written descriptions
- Always begin reaches at the downstream end of a defined habitat unit, end points should be at the exact distance as described above
- In large streams make sure the reach includes all of a fast water habitat unit and all of a slow water habitat unit

Macroinvertebrates Inventory

Objective - Collect assemblage sample

Methods

- Using D-frame nets and a seine collect macroinvertebrates using the riffle sample and multi-habitat sample methods described by Pratt (2002)
- Where possible, keep macroinvertebrate samples within designated reaches. If this is not possible be sure to indicate on datasheet.

Pratt, J. W. 2002. Methods for assessing biological integrity of surface waters. Kentucky Department for Environmental Protection. Division of Water, Ecological Support Division, Frankfort, KY.

(see pages 53 – 59 for macroinvertebrate sampling methods)

Pebble Count Inventory

Objective - Determine the riffle stability index (RSI), bar sample geometric mean, and median particle sizes.

Methods

- Pebble count data is collected using methods modified from those in Kappesser (2002) to characterize the substrate composition of sample reaches
- Pebble counts are performed in riffles designated for electrofishing by walking transects perpendicular to the flow within the bankfull channel (Harrelson et al. 1994)
- Walk the transect beginning at the edge of the bankfull channel on one side of the stream and walk heel-to-toe across the stream channel to the opposite bank
- At each step pick up the pebble at the tip of your toe and measure its intermediate axis with a ruler to the nearest millimeter
- For very large particles, the same particle is counted as many times it is encountered
- These procedures are repeated until at least 200 measurements are recorded; Transects are not terminated until the opposite bank is reached even if this results in more than 200 measurements
- Transects are distributed throughout the riffle; If detritus, LW, or other organic materials are encountered the rock substrate found directly below them is sampled
- For the bar sample, measure 30 freshly moved dominant large particles residing on a bar or similar depositional feature to estimate the largest particle size transported at flows of bankfull and above; Freshness is evaluated by lack of growing vegetation and lack of embeddedness of the particles
- The depositional feature must be in close proximity to the riffle being examined, and can include laterally attached bars, side bars, and central bars; The entire bar should be visually inspected to identify the dominant large size of particle present; If a bar deposit cannot be found, trained field personnel may select the large mobile particles from within the riffle; For each particle, measure the intermediate axis to the nearest millimeter

Bunte, K. and S. R. Abt. 2001. Sampling surface and subsurface particle-size distributions in wadable gravel- and cobble-bed streams for analyses in sediment transport, hydraulics, and streambed monitoring. General Technical Report RMRS-GTR-74. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Harrelson, Cheryl C., Rawlins, C. L., and Potyondy, John P. 1994. Stream channel reference sites: an illustrated guide to field technique. Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61p.

Kappesser, G. B. 2002. A riffle stability index to evaluate sediment loading to streams. *Journal of the American Water Resources Association*. 38:1069-1081.

Habitat Inventory

Objective – Characterize stream habitat attribute within the sample reach.

Methods

- Collect attribute as described in Section 2 of Roghair and Nuckols (2005) (Appendix B)
- Increase frequency of paired (sub-) samples to include at least 3 fast and 3 slow water units within each reach
 - Where less than 3 fast or slow occur, sub-sample all units
- Start and end data collection at habitat unit breaks
 - This may extend habitat data collection slightly beyond end of sample reach

Electrofishing Inventory

Objective - Determine relative abundance and determine catch-per-unit-effort (CPUE). Note: we are not attempting to estimate population size or density for individual species, only assessing the fish assemblage

Methods (based on sampling strategies discussed and approved by R8 and SRS personnel in 3/2005)

- Electrofishing starts in same location as habitat inventory
- Electrofishing ends at location designated in reach layout process
 - Habitat inventory may extend beyond end of designated reach
 - DO NOT extend electrofishing sample beyond end of designated reach
- Single-pass DC backpack electrofishing
- One shocker, 3 netters
- No blocknets
- Electrofishing effort will be equal to 1.0 seconds for each 1.0 m² of wetted area
 - note: this will standardize our effort and remove the potentially confounding effect of changes in wetted width relative to the bankfull channel width in wet or dry years
 - derived Warren et al. data on electrofishing effort in MS streams
- Fish will be counted and released at the site, except for a voucher specimen for each species; endangered species lists will be reviewed before sampling
- Record age-0 fish and all fish older than age-0 separately for each species
- Keep all relic mussel shells encountered
- Keep all crayfish captured, review endangered species lists before sampling

Appendix B: Field Methods for Habitat Inventory

Methods for Stream Habitat Characterization using the BVET Methodology in the Daniel Boone National Forest, KY



Prepared by:



Prepared by: Craig N. Roghair and Daniel R. Nuckols

2005

Table of Contents

Introduction.....	24
References cited in this manual:	25
Changes to BVET inventory in 2005.....	26
Outline of BVET Habitat Inventory.....	27
Section 1: Getting Started	28
Equipment List	28
Duties.....	28
Header Information.....	28
Random Numbers.....	29
Starting the Inventory	29
Section 2: Stream Attributes	30
Unit Type (see abbreviations).....	30
Unit Number (#)	31
Distance (m)	32
Estimated Width (m)	32
Maximum and Average Depth (cm).....	33
Riffle Crest Depth (cm).....	33
Dominant and Subdominant Substrate (1-9)	34
Rosgen Channel Type (A-G).....	35
Percent Fines (%).....	36
Large Wood (1-4 and rootwad)	36
Actual Width (m).....	37
Bankfull Channel Width (m)	37
Riparian Width (m).....	38
Gradient (%).....	39
Water Temperature (C).....	39
Photo (y or n).....	39
Features.....	40
Section 3: Wrapping Up.....	41
Section 4: Summary.....	42
Section 5: Field Guide, Random Numbers Table, Equipment Checklist.....	43

Introduction

The basinwide visual estimation technique (BVET) is a versatile tool used to assess streamwide habitat conditions in wadeable size streams and rivers. A crew 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 crew may inventory any number of other habitat attributes as they walk length of the stream. Experienced crews can inventory an average of 2.0 – 3.0 km per day, but this will vary depending on stream size and the number of stream attributes inventoried.

Before a crew 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 crew. 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.

In summer 2004, resource managers on the Daniel Boone National Forest (DBNF) requested that the USFS Center for Aquatic Technology Transfer (CATT) implement modified BVET inventories to inventory stream reaches previously inventoried in the 1990's. The 1990's inventories followed methods detailed in the 'Daniel Boone National Forest Stream Inventory Work Plan and Sampling Techniques Manual', which were similar in nature to the BVET habitat inventory. After discussion with resource managers from the DBNF, we scaled down the original protocol, eliminating several attributes and modifying others to maximize inventory efficiency during our limited time on the Forest. In summer 2005 the DBNF opted to use identical BVET methods as National Forests in Virginia and North Carolina, which are only slightly different from methods used in Kentucky in 2004.

This document was developed to serve as a guide for classroom and field instruction for the DBNF BVET habitat inventory and to provide a post-training reference for field crews. 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.

We used an abbreviated version of the BVET to sample habitat within sample reaches only. Paired samples were collected more frequently than described here because reaches were short. Stream attributes were collected as described in Section 2.

References cited in this manual:

- Armantrout, N. B., compiler. 1998. Glossary of aquatic habitat inventory terminology. American Fisheries Society, Bethesda, Maryland.
- Bunte, K., and S. R. Abt. 2001. Sampling surface and subsurface particle-size distributions in wadable gravel- and cobble-bed streams for analyses in sediment transport, hydraulics, and streambed monitoring. General Technical Report RMRS-GTR-74. Fort Collins, Colorado: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
- 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.
- Rosgen, D.L., and L. Silvey. 1998 *Field Guide for Stream Classification*, Wildland Hydrology Books, Pagosa Springs, Colorado.

Changes to BVET inventory in 2005

Attribute	Action	Reason
Substrate	Modified	Substrate categories changed from those in Daniel Boone National Forest Stream Inventory Work Plan and Sampling Techniques Manual to those used during BVET inventories in National Forests in North Carolina and Virginia

Other minor changes, mostly modifications in terminology and definitions to provide increased clarity, are found throughout the manual.

Outline of BVET Habitat Inventory

The inventory is comprised of the following steps:

- 1) Enter 'header' information in the data sheet
 - 'Header' information includes date, stream, start location, crew, etc. and is **vitaly** 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
 - If the random number '3' were chosen, the crew would stop after making estimates in the 3rd pool (and 3rd riffle) and perform the necessary measurements
- 5) Progress upstream estimating attributes for every unit until the next paired sample unit is reached, then repeat step 4
 - In the above example, if the interval were 10 units, the crew 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 crew 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.

Repeat steps 4 and 5 until the end of the stream is reached.

The following sections describe the BVET habitat inventory in detail:

Section 1: Getting Started – equipment lists, header information, 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

Appendix: field guide, random number tables, equipment checklist

Section 1: Getting Started

Equipment List

Hipchain	camera
extra string for hipchain	backpack
wading rod	pencils
50 m tape measure	flagging
Clinometer	markers
Datalogger	waterproof backup datasheets
Thermometer	clipboard
GPS unit	BVET manual and field guide
topographic map	felt bottom wading boots or waders

Other useful equipment: lunch, water, water filter, 1st aid kit, toilet paper, rain gear, radio/cell phone

The crew 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	Record data
Measure distance	Determine paired sample location
Estimate width	Classify and count LW
Estimate depths	Photo-documentation
Classify substrates	Document features
Estimate Rosgen channel type	
Estimate percent fines	

Both crew members are needed to measure actual widths, channel widths, riparian areas, gradient, and water temperature at designated units. Although the crew 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 NAD27 CONUS, UTM
Location	Detailed written description of start point, include landmarks, road #, etc.
Notes	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 10 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 crew 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. The more paired samples, the tighter the confidence intervals for stream area estimates.

After the crew 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 crew would make measurements on the 3rd pool and 3rd riffle and then every 5th pool and riffle thereafter (8, 13, 18, 23, etc).

Starting the Inventory

After the crew 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, Rosgen channel type, and percent fines. When they reach the upstream end of the habitat unit they stop, report the distance, then turn to face the unit and report the unit type, estimated width, maximum and average depth, riffle crest depth (where appropriate), dominant and subdominant substrate classes, Rosgen channel type, and percent fines 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 crew 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)

Definitions:*

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

*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 the 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 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 crew has counted six slow water (pool/glide) units and seven fast water (riffle/run/cascade) units.

If '3' were chosen as the random number and the measuring interval was every 10th unit, the crew would estimate and then measure habitat data for Pool 3 and Cascade 3 (i.e. Pool 3 and Cascade 3 are 'paired sample' units). When the crew reaches pool or glide 13 and riffle, run, or cascade 13, they would repeat procedures followed in the 3rd units.

When to record: every habitat unit; not recorded for features such as falls, tributaries, side channels, culverts, etc.

Distance (m)

Definition:

Number of meters 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, 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

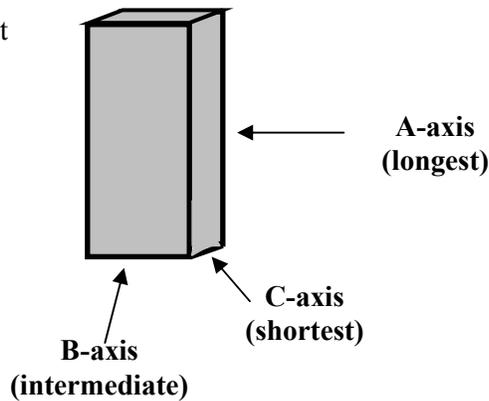
As the observer walks through the unit they scan the substrate. When they reach the upstream end of the unit they stop, turn to face the unit, and determine the dominant and subdominant substrate classes.

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 crew 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 habitat unit*

* record for every unit, but remember this is describing a reach 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. 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:

- > 1.0 m in length and > 10.0 cm in diameter
 - within the bankfull channel
 - fallen, not standing dead
-
- 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

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:*

Average 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. Make at least three measurements across the bankfull channel.

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

Riparian Width (m)

Definition:

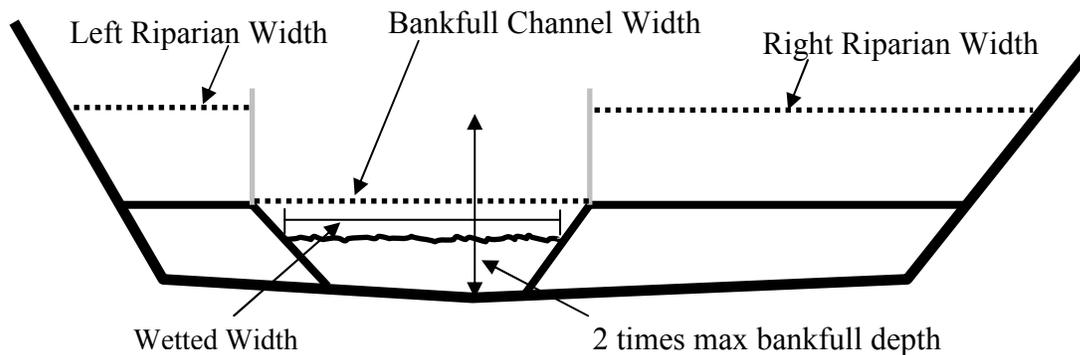
Width of the riparian area at an elevation of two times the maximum bankfull depth, measured for both left and right banks (left and right as oriented facing upstream). Maximum bankfull depth is the greatest vertical distance from the substrate to the top of the bankfull channel across a bankfull transect.

How to measure:

1. Stretch a measuring tape across the top of the bankfull channel – this is your bankfull transect
2. Use a wading rod to find the maximum bankfull depth
3. Place the clinometer against the wading rod at two-times the maximum bankfull depth
4. 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
5. 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:

- 1) observer stands at upstream end of riffle, recorder stands at downstream end of riffle
- 2) recorder sites upstream to the height of their eye on the observer using clinometer
- 3) 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 (y or n)

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

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 a feature; record distance of **all features** (both stream and crossing features) in the regular habitat datasheet; also record additional measurements for crossing features in the crossing datasheet and take a photograph of all crossing features.

Where to record: wherever found

Channel Feature	Abbreviation	What to Record
Waterfall¹	FALL	Distance, estimated height
Tributary	TRIB	Distance, average wetted width, into main channel on left or right (as facing upstream)
Side channel²	SCH	Distance, average wetted width, whether it is flowing into or out of main channel on left or right (as facing upstream)
Braid³	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 1000 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
- Note in all files if more than one file was used during the inventory
- 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
- Record on master list that inventory is complete, with data and names of crewmembers

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
- Rosgen Channel Type
- 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

Record for every paired sample riffle:

- Measured Width
- Channel Width
- Riparian Width (left and right)
- Gradient
- Water temperature
- Photograph

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: Field Guide, Random Numbers Table, Equipment Checklist

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
- Rosgen Channel Type:** (A-G) see table of channel characteristics below or refer to Rosgen book
- 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

Record for paired sample riffles:

- Measured Width:** (m) measurement of average wetted width
- Channel Width:** (m) measurement of bankfull channel width
- Riparian Width:** (L&R) (m) measurement of floodplain
- Gradient:** (%) clinometer measurement of riffle slope
- Water Temperature:** (C) temperature of water in Celsius
- Photo (y or n):** picture of habitat unit or crossing feature

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 – don't forget to photograph!

- 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 (top of water to culvert) road or trail name

Substrates

1. **Organic Matter**, dead leaves detritus, etc., not living plants
2. **Clay**, sticky, holds form when balled
3. **Silt**, slick, does not hold form when balled
4. **Sand**, >silt-2mm, gritty, doesn't hold form
5. **Small Gravel**, 3-16mm, sand to thumbnail
6. **Large Gravel**, 17-64mm, thumbnail to fist
7. **Cobble**, 65-256mm, fist to head
8. **Boulder**, >256, > head
9. **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	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 (nth riffle, run, cascade 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 is more than 50 m, record 51 as the riparian width and in ‘Comments’ note that riparian was > 50 m wide

End inventory

Where stream is less than 1.0 m wide for > 500 m, or channel runs dry for > 1.0 km, or where boundary is reached. Comment on why inventory was ended. Record time of day, detailed description of location, and GPS coordinates at endpoint, and be sure all header info is filled in on datasheets.

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
backup battery for datalogger
GPS unit
camera
backpack
pencils
flagging
markers
waterproof backup datasheets
clipboard
BVET manual
BVET field guide on waterproof paper
topographic maps
water
water filter
lunch
first aid kit
hardhats
high-viz vests
radio/cell phone
toilet paper
felt bottom wading boots
raingear

Remember the following for the start of each new stream or reach:

- Determine measuring interval
- Select a random number
- Fill in header information completely