Summary of Stream Habitat Inventories on the Blue Ridge and Chattooga River Districts of the Chattahoochee National Forest, Georgia 2014

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Introduction

Past land management practices including logging and road building, have left trout streams on the Chattahoochee-Oconee National Forest (CONF), Georgia with a legacy of degraded habitat, including long shallow riffles, lack of pool habitat, large deposits of sediment in pools, and decreased amounts of large wood (Waters 1995). Both native (Brook Trout, Salvelinus fontinalis) and naturalized (Brown Trout, Salmo trutta; Rainbow Trout, Oncorhynchus mykiss) trout populations on the CONF are impacted by these conditions. If other conditions (water temperature and chemistry, exploitation rates, etc.) remain the same or improve, the recovery and persistence of the trout resource could be supported by habitat restoration including the control of excess sediment inputs and the transport and addition of large wood.

Trout populations can be impeded by lack of deep pools, high amounts of fine sediment, and insufficient large wood to create complex habitat. Wood of all sizes is an important feature of streams flowing through forested areas. In particular, large wood (LW) and other obstructions such as boulders slow flow, trap sediments, and damp and delay flood peaks (Montgomery et al. 2003). Tree boles (i.e. tree trunks or rootwads) are major pool forming elements and wood contributes to aquatic habitat in diverse ways such as providing cover from predators, refuge from high velocity flow, as well as the LW being the substrate and organic matter for macroinvertebrates (Benke and Wallace 2003, Dolloff and Warren 2003). Large wood is considered so beneficial that riparian forests today are managed for LW inputs (Boy et al. 2003, Jacobs 2004) and where recruitment or loading is judged insufficient, LW is intentionally added to stream channels (Reich et al. 2003).

Wood naturally enters stream channels by various avenues including bank undermining or blowdown of individual trees or groups of trees and transport en masse in debris flows or landslides from upstream channels or adjacent riparian areas (Swanson 2003). Although logging was one of the more dramatic causes for the decline in large wood loading, other human influences such as the construction of roads and trails and land clearing in general have influenced both the rate and amount of large wood entering streams (Nakamura and Swanson 2003). Invasive species can also lead to variation in the rate of LW recruitment. Since the beginning of the 20th century a fungus, inadvertently brought to North America on nursery stock from Asia, has killed nearly all American chestnut (Castanea dentate) trees. American chestnut was a dominant tree throughout much of the eastern US where, except for areas of salvage, its demise resulted in higher than expected rates of large wood and large wood recruitment to streams and riparian areas. Today, hemlock wooly adelgid (Adelges tsugae), an aphid-like insect from Japan threatens another keystone species of eastern forests, eastern hemlock, with a similar fate. Eastern hemlock trees in the CONF watersheds are infested by the hemlock wooly adelgid resulting in a rapid decline of hemlock trees, a major component of streamside vegetation. With seedling hemlock trees unable to reach maturity in the presence of hemlock wooly adelgid, dead hemlock trees located in the
riparian area are a temporary source of large wood for these streams. Dead or dying hemlocks may be allowed to recruit to the stream channel through natural processes, or may be intentionally added to the stream channel.

Large wood additions will encourage pool formation and sediment scour, increasing the amount of suitable spawning habitat for trout (Ryan et al. 2014, Faustini and Jones 2003, Thompson 1995). Habitat assessments are needed to optimize the effectiveness of habitat remediation projects. In summer 2014, the CONF partnered with the USDA Forest Service, Southern Research Station, Center for Aquatic Technology Transfer (CATT) to complete stream habitat inventories in the Blue Ridge District and Chattooga River District of the CONF (Figure 1). Our goals were to: 1) quantify current stream habitat conditions; and 2) describe Hemlock abundance and condition within the riparian area. The CATT deployed a 6-person crew to the CONF from August 7-14, 2014 to inventory stream habitat and describe hemlock abundance and condition.

Methods

Site Selections and Reach Layout

The streams inventoried, and the inventoried reach extent on each stream, were selected by Mike Joyce, CONF Forest Fish Biologist.

Habitat Inventory

We performed a basinwide visual estimation technique (BVET) habitat inventory on 11 streams, two of which were split into a lower and upper section due to different crew members performing the data observations (Figure 1, Table 1) (Dolloff et al. 1993). The BVET is a two-stage visual estimation technique to quantify stream habitat. During the first stage, habitat was stratified into similar groups based on naturally occurring habitat units including pools (areas in the stream with concave bottom profile, gradient equal to zero, greater than average depth, and smooth water surface), and riffles (areas in the stream with convex bottom profile, greater than average gradient, less than average depth, and turbulent water surface). Glides (areas in the stream similar to pools, but with average depth and flat bottom profile) were identified during the inventory, but were grouped with pools for some data analysis. Runs (areas in the stream similar to riffles but with average depth, less turbulent flow, and flat bottom profile) and cascades (areas in the stream with > 12% gradient, high velocity, and exposed bedrock or boulders) were grouped with riffles for some data analysis.

Habitat in each section of stream was classified and inventoried by a 2 or 3 person crew. One crew member identified each habitat unit by type (as described above), estimated average wetted width, average and maximum depth, riffle crest depth (RCD), substrate composition, and percent fines. The
length of each habitat unit was measured with a hip chain. Average wetted width was visually estimated. Average and maximum depth of each habitat unit were estimated by taking depth measurements at various places across the channel profile with a graduated staff marked in 5 cm increments. The RCD was estimated by measuring water depth at the deepest point in the hydraulic control between riffles and pools. The RCD was subtracted from average pool depth to obtain an estimate of residual pool depth. Substrates were assigned to one of nine size classes (Appendix A). Dominant substrate (covered greatest amount of surface area in habitat unit) and subdominant substrate (covered 2nd greatest amount of surface area in habitat unit) were visually estimated. Percent fines is the percent surface area of the stream bed consisting of sand, silt, or clay substrate particles (particles < 2 mm diameter).

Where encountered, the distance at the upstream end of channel features, as well as additional attributes described in Appendix A, were recorded for waterfalls, tributaries, side-channels, braids, seeps, landslides, and ‘other’ miscellaneous features encountered (e.g. campsites, fish habitat structures, etc.). In addition, a photograph and GPS ID (as well as additional attributes described in Appendix A) were recorded for waterfalls and crossing features (bridges, fords, dams, and culverts).

The second crew member classified and inventoried large wood (LW) within the bankfull channel and recorded all data. LW was assigned to one of four size classes (Appendix A). All wood less than 1.0 m long and less than 10 cm in diameter were omitted from the inventory.

The first unit of each habitat type selected for intensive (second stage) sampling (e.g. accurate measurement of wetted width) was determined randomly. Additional units were selected systematically (every 10th habitat unit type for streams >1000 m and every 5th habitat unit type for streams <500 m). The wetted width of each systematically selected habitat unit was measured with a meter tape across at least three transects and averaged. For the reach between each second stage fast water habitat unit, we estimated the abundance and condition of Hemlock trees within the riparian area (Appendix A).

The ratio of measured to visually estimated area was used to calibrate all estimates, which enabled the calculation of total stream area by habitat type (Hankin and Reeves 1988). The BVET calculations were computed with a Microsoft Excel spreadsheet using formulas found in Dolloff et al. (1993). Data were summarized using Excel spreadsheets. See Appendix A for detailed field methods.

**Results**

From August 7-14th 2014 we inventoried 11 streams totaling 50.2 km of stream habitat on the CONF (Figure 1-5, Table 1). GPS coordinates for the start and end location of the inventories, are available in Table 2.
Depth and Width

Mean residual pool depth (the riffle crest depth was subtracted from average pool depth to obtain an estimate of residual pool depth which could occur during low flow conditions) ranged from 12 cm to 28 cm among the inventoried streams (Table 3). All streams tended to have somewhat deeper maximum pool depths in the downstream reaches than in reaches upstream that are higher in the watershed (Figure 6). The average wetted pool width ranged from 1.6 m for Board Camp Creek to 7.2 m for Chester Creek (lower), followed by 6.5 m for Holcomb Creek (Table 3). The average wetted riffle width ranged from 2.4 m for both Board Camp Creek and Chester Creek (upper) up to 8.6 m for High Shoals (upper), followed by 6.9 m for Chester Creek (lower) (Table 3).

Habitat Area

Only a few streams had >30% slow water (pools + glides) habitat; Walnut Fork, Holcomb Creek, and Chester Creek (lower) (Figure 7, Table 4). Fast water (riffle + run + cascade) habitat made up the majority, being >50% for all streams except Holcomb Creek (Figure 7, Table 4). Fast water habitat exceeded 90% in Chastain Creek and High Shoals Creek (upper) (Figure 7, Table 4). Though the majority of the habitat area is fast water habitat (a result of larger unit size), the quantity (i.e. unit count) of slow water units (pool and glide) to fast water units (riffle, run, cascade) was similar for most streams (Table 4). Holcomb Creek had the highest percentage of pool (32%), glide (16%), and run (10%) habitat (Figure 7, Table 4). The cascade habitat area was ≥5% for Tuckaluge Creek, Walnut Fork, Lovinggood Creek, and Martin Creek (Figure 7, Table 4).

% Fines and Substrate

The average percent fines (percent of habitat unit’s channel bottom covered by sand, silt, or clay) in pools was high (i.e. ≥35%) in all streams except High Shoals Creek (lower), which had 25% fines (Table 3). The percent fines in riffles were much lower, never exceeding an average of 20% in any of the streams (Table 3). Tuckaluge Creek and Lovinggood Creek had the most consistently high percent fines in pools (Figure 8).

In pools, the dominant substrate was most frequently sand, cobble, and bedrock; the substrate types small gravel, large gravel, and boulder were also present, but typically as a subdominant substrate (Table 5, Figure 9). In riffles, the dominant substrate was most frequently large gravel, cobble, boulder, and bedrock; the substrate types sand and small gravel were also present, but most often as a subdominant substrate (Table 5, Figure 10). In some streams there are noticeable changes in substrate type with distance upstream. In Lovinggood Creek riffles, boulder and bedrock substrate transitions to small gravel
and large gravel at ~3,300 m (Figure 10). In Bryant Creek, there is a change from bedrock to gravels at ~3,400 m in both pools and riffles (Figure 9 and 10).

**Large Wood**

The total pieces of large wood per kilometer (LW/km) ranged from 124 LW/km in High Shoals Creek (lower) to 245 LW/km in Tuckaluge Creek (Figure 11, Table 6). The majority of LW was in small diameter size classes (10-55 cm diameter) (Figure 11, Table 6). Bryant Creek had the largest amount (11 LW4/km) of size class 4 (>5 m length, >55 cm diameter) (Figure 11, Table 6). Large wood is distributed fairly evenly throughout the inventoried reaches; there are occurrences of log jams resulting in higher wood counts within an individual habitat unit (Figure 12).

**Hemlock Abundance and Condition**

Hemlocks were present in the riparian area of all streams and showed varying degrees of infestation with Hemlock Wooly Adelgid (Figure 13). The following streams had high hemlock abundance for the majority of the inventoried reach: Tuckaluge Creek, Lovinggood Creek, Holcomb Creek, and Chester Creek (lower & upper) (Figure 13). The following streams had long reaches where dead Hemlocks were present: Lovinggood Creek, Chastain Creek, Chester Creek (lower), and High Shoals Creek (upper) (Figure 13).

**Discussion**

The inventoried streams are characteristic of those impacted by early 20th century forestry practices. Many of them have long and shallow riffles, shallow residual pool depths, high percent fines, and low amounts of LW in the largest size classes. Many also contain log weir fish habitat structures such as K-dams, installed by the CONF and its partners to mitigate the impacts of those early forestry practices. While some of these structures are recent additions and others are reaching the end of their designed lifespan, they were all installed to increase habitat complexity by creating pool habitat and cover for fish, as well as to trap spawning gravel and flush out fine sediments (Seehorn 1992).

The large-scale loss of hemlocks from hemlock wooly adelgid infestations, though tragic, also presents a new opportunity as the CONF continues to address the impacts on the Forest from historical land use. The riparian areas of all the inventoried streams contain hemlock trees infested with hemlock wooly adelgid. Over time some of these hemlocks will naturally fall into the stream channel, or they can be manually felled and placed. Many of the inventoried streams have low amounts of LW/km (Walnut Fork, Frick Creek, Chastain Creek, Board Camp Creek, and High Shoals Creek lower all had <150 LW/km) and all were largely lacking in LW4/km, with the possible exception of Bryant Creek (>10%
Given the high number of dead or dying hemlocks, these streams are prime targets for LW treatments.

Sand was prevalent as both a dominant and subdominant substrate in many of the streams, as is evident by the high percent fines observed in most pools. In addition to large wood improving stream habitat though pool creation and habitat complexity, newly formed plunge pools could help flush out fine sediments and expose patches of spawning gravel for trout (Ryan et al. 2014, Faustini and Jones 2003, Thompson 1995).

Land management practices such as wholesale logging in the watershed in the early 1900’s are still impacting the number and size of trees available, as well as sediment inputs. Efforts to reverse or mitigate habitat degradation effects have been ongoing for decades and will continue into the foreseeable future. Clearly, decisions made by today’s land managers will impact large wood recruitment and retention, and sediment transport and deposition, for decades to come. New challenges may present new opportunities and we encourage the CONF and its partners to continue their work to improve stream habitat.

Data Availability

Summer 2014 stream habitat data reside in a MS Access database, which is managed by the CATT, and a copy has been provided to Mike Joyce, CONF Forest Fish Biologist. We will work with the CONF to develop custom queries and reports for the MS Access database, as needed.

Literature Cited


Seehorn, M. E. 1992. *Stream habitat improvement handbook*, Technical Publication R8-TP 16, USDA Forest Service, Southern Region, 1720 Peachtree Road, N. W., Atlanta, GA.


Figure 1. Streams inventoried on the Chattahoochee National Forest, Georgia.
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Figure 9. Dominant (solid circles) and subdominant (open circles) substrate category present in pools. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn’t hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.
Figure 9 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in pools. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn’t hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.
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Figure 10. Dominant (solid circles) and subdominant (open circles) substrate category present in riffles. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn’t hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.
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Figure 11. Quantity of large wood (LW; dead and down, any part within bankfull channel) per kilometer. 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 12. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units in each stream inventoried. Tuckaluge Cr. LW n=1,284 and habitat unit n=263, Walnut Fk. LW n=759 and habitat unit n=311, and Frick Cr. LW n=614 and habitat unit n=120.
Figure 12 continued. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units in each stream inventoried. Lovinggood Cr. LW n=1,272 and habitat unit n=346, Chastain Cr. LW n=147 and habitat unit n=24, and Holcomb Cr. LW n=1,569 and habitat unit n=342.
Figure 12 continued. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units in each stream inventoried. Bryant Cr. LW n=1,078 and habitat unit n=350, Board Camp Cr. LW n=266 and habitat unit n=96, and Martin Cr. LW n=428 and habitat unit n=145.
Figure 12 continued. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units in each stream inventoried. Chester Cr. (lower) LW n=568 and habitat unit n=150, and Chester Cr. (upper) LW n=347 and habitat unit n=72.
Figure 12 continued. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units in each stream inventoried. High Sholas Cr. (lower) LW n=279 and habitat unit n=95, and High Shoals Cr. (upper) LW n=489 and habitat unit n=53.
Figure 13. Hemlock abundance (0 = none; 1 = 1-10; 2 = 11-50, 3 = >50) and condition (0 = Healthy, 1 = Early Infestation, 2 = Late Infestation, 3 = Mortality, 4 = LW Recruiting) shown longitudinally for each stream inventory (see appendix A for detailed categories).
Figure 13 continued. Hemlock abundance (0 = none; 1 = 1-10; 2 = 11-50, 3 = >50) and condition (0 = Healthy, 1 = Early Infestation, 2 = Late Infestation, 3 = Mortality, 4 = LW Recruiting) shown longitudinally for each stream inventory (see appendix A for detailed categories).
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Table 1. Summary of streams inventoried on the Chattahoochee National Forest, 2014.

<table>
<thead>
<tr>
<th>Site #</th>
<th>Stream Name</th>
<th>Topo Quad</th>
<th>Date</th>
<th>BVET</th>
<th>habitat (km)</th>
<th>Start Location</th>
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<td>Tuckaluge Creek</td>
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<td>5.2</td>
<td>FS boundary</td>
<td>8/9/14</td>
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<td>Rabun Bald</td>
<td>8/8/14</td>
<td>8/10/14</td>
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<td>FS boundary</td>
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<td>Noontootla</td>
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<td>8/12/14</td>
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<td>8/10/14</td>
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<td>8/10/14</td>
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<td>2.3</td>
<td>750 m upstream of FS boundary</td>
</tr>
<tr>
<td>2014-10U</td>
<td>High Shoals Creek (upper)</td>
<td>Tray Mountain</td>
<td>8/14/14</td>
<td>8/14/14</td>
<td>2.4</td>
<td>1st trib on left, upstream of Maple Spring Br.</td>
</tr>
<tr>
<td>2014-13</td>
<td>Martin Creek</td>
<td>Rabun Bald</td>
<td>8/8/14</td>
<td>8/8/14</td>
<td>2.3</td>
<td>Rock Mountain Creek confluence</td>
</tr>
</tbody>
</table>

Total 50.2
Table 2. GPS coordinates recorded at the downstream (start) and upstream (end) extent of stream habitat inventories.

<table>
<thead>
<tr>
<th>Site #</th>
<th>Stream Name</th>
<th>Downstream Inventory Start</th>
<th>Upstream Inventory End</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014-01</td>
<td>Tuckaluge Creek</td>
<td>N34.89987 W83.29929</td>
<td>N34.92660 W83.33071</td>
</tr>
<tr>
<td>2014-02</td>
<td>Walnut Fork</td>
<td>N34.90861 W83.27467</td>
<td>N34.94530 W83.29630</td>
</tr>
<tr>
<td>2014-03</td>
<td>Frick Creek</td>
<td>N34.66033 W84.17898</td>
<td>N34.65480 W84.14505</td>
</tr>
<tr>
<td>2014-04</td>
<td>Lovinggood Creek</td>
<td>N34.69545 W84.21598</td>
<td>N34.66487 W84.21951</td>
</tr>
<tr>
<td>2014-05</td>
<td>Chastain Creek</td>
<td>N34.87409 W83.62648</td>
<td>N34.87915 W83.63451</td>
</tr>
<tr>
<td>2014-06</td>
<td>Holcomb Creek</td>
<td>N34.96630 W83.21609</td>
<td>N34.98224 W83.29099</td>
</tr>
<tr>
<td>2014-07</td>
<td>Bryant Creek</td>
<td>N34.75498 W84.04173</td>
<td>N34.78210 W84.01450</td>
</tr>
<tr>
<td>2014-08</td>
<td>Board Camp Creek</td>
<td>N34.76522 W83.99317</td>
<td>N34.76630 W83.97594</td>
</tr>
<tr>
<td>2014-09L</td>
<td>Chester Creek (lower)</td>
<td>N34.67238 W84.19704</td>
<td>N34.65422 W84.17827</td>
</tr>
<tr>
<td>2014-09U</td>
<td>Chester Creek (upper)</td>
<td>N34.65422 W84.17827</td>
<td>N34.64201 W84.17008</td>
</tr>
<tr>
<td>2014-10L</td>
<td>High Shoals Creek (lower)</td>
<td>N34.81719 W83.72419</td>
<td>N34.79956 W83.71537</td>
</tr>
<tr>
<td>2014-10U</td>
<td>High Shoals Creek (upper)</td>
<td>N34.79969 W83.71526</td>
<td>N34.80080 W83.69744</td>
</tr>
<tr>
<td>2014-13</td>
<td>Martin Creek</td>
<td>N34.89125 W83.34288</td>
<td>N34.90201 W83.35909</td>
</tr>
</tbody>
</table>
Table 3. Summary of BVET stream habitat attribute averages collected.

<table>
<thead>
<tr>
<th>Site #</th>
<th>Stream Name</th>
<th>Mean Avg. Depth (cm)</th>
<th>Mean Max. Depth (cm)</th>
<th>Mean Residual Pool Depth (cm)*</th>
<th>Avg. Wetted Width (m)</th>
<th>Avg. % Fines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pools Riffles</td>
<td>Pools Riffles</td>
<td>Pools Riffles</td>
<td>Pools Riffles</td>
<td>Pools Riffles</td>
<td>Pools Riffles</td>
</tr>
<tr>
<td>2014-01</td>
<td>Tuckaluge Creek</td>
<td>40 15</td>
<td>63 34</td>
<td>28</td>
<td>4.8 4.2</td>
<td>74 20</td>
</tr>
<tr>
<td>2014-02</td>
<td>Walnut Fork</td>
<td>38 17</td>
<td>55 29</td>
<td>26</td>
<td>3.7 3.7</td>
<td>44 16</td>
</tr>
<tr>
<td>2014-03</td>
<td>Frick Creek</td>
<td>32 17</td>
<td>52 40</td>
<td>17</td>
<td>3.5 3.6</td>
<td>58 18</td>
</tr>
<tr>
<td>2014-04</td>
<td>Lovinggood Creek</td>
<td>35 21</td>
<td>54 35</td>
<td>16</td>
<td>4.2 3.8</td>
<td>60 20</td>
</tr>
<tr>
<td>2014-05</td>
<td>Chastain Creek</td>
<td>28 18</td>
<td>43 36</td>
<td>12</td>
<td>3.7 3.5</td>
<td>57 17</td>
</tr>
<tr>
<td>2014-06</td>
<td>Holcomb Creek</td>
<td>50 29</td>
<td>77 50</td>
<td>28</td>
<td>6.5 5.7</td>
<td>48 20</td>
</tr>
<tr>
<td>2014-07</td>
<td>Bryant Creek</td>
<td>34 17</td>
<td>44 27</td>
<td>20</td>
<td>3.7 4.3</td>
<td>40 14</td>
</tr>
<tr>
<td>2014-08</td>
<td>Board Camp Creek</td>
<td>30 14</td>
<td>39 23</td>
<td>20</td>
<td>1.6 2.4</td>
<td>35 12</td>
</tr>
<tr>
<td>2014-09L</td>
<td>Chester Creek (lower)</td>
<td>47 28</td>
<td>67 49</td>
<td>22</td>
<td>7.2 6.9</td>
<td>44 14</td>
</tr>
<tr>
<td>2014-09U</td>
<td>Chester Creek (upper)</td>
<td>28 11</td>
<td>43 28</td>
<td>20</td>
<td>3.5 2.4</td>
<td>51 13</td>
</tr>
<tr>
<td>2014-10L</td>
<td>High Shoals Creek (lower)</td>
<td>37 17</td>
<td>47 29</td>
<td>23</td>
<td>4.1 3.9</td>
<td>25 10</td>
</tr>
<tr>
<td>2014-10U</td>
<td>High Shoals Creek (upper)</td>
<td>28 10</td>
<td>42 26</td>
<td>20</td>
<td>2.6 8.6</td>
<td>36 8</td>
</tr>
<tr>
<td>2014-13</td>
<td>Martin Creek</td>
<td>32 17</td>
<td>43 30</td>
<td>17</td>
<td>3.2 3.8</td>
<td>49 12</td>
</tr>
</tbody>
</table>

*Residual pool depth = average pool depth – riffle crest depth
Table 4. Stream area and unit count of pool, glide, riffle, run, and cascade habitat as observed during BVET habitat inventories.

<table>
<thead>
<tr>
<th>Site #</th>
<th>Stream Name</th>
<th>Habitat Area (m²)</th>
<th>Percent Area</th>
<th>Unit Count</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pool</td>
<td>Glide</td>
<td>Riffle</td>
</tr>
<tr>
<td>2014-01</td>
<td>Tuckaluge Creek</td>
<td>5,465</td>
<td>540</td>
<td>14,289</td>
</tr>
<tr>
<td>2014-02</td>
<td>Walnut Fork</td>
<td>4,010</td>
<td>2,537</td>
<td>13,287</td>
</tr>
<tr>
<td>2014-03</td>
<td>Frick Creek</td>
<td>1,310</td>
<td>128</td>
<td>12,290</td>
</tr>
<tr>
<td>2014-04</td>
<td>Lovinggood Creek</td>
<td>4,823</td>
<td>1,343</td>
<td>13,540</td>
</tr>
<tr>
<td>2014-05</td>
<td>Chastain Creek</td>
<td>240</td>
<td>49</td>
<td>2,978</td>
</tr>
<tr>
<td>2014-06</td>
<td>Holcomb Creek</td>
<td>19,238</td>
<td>9,770</td>
<td>22,989</td>
</tr>
<tr>
<td>2014-07</td>
<td>Bryant Creek</td>
<td>3,911</td>
<td>1,605</td>
<td>15,962</td>
</tr>
<tr>
<td>2014-08</td>
<td>Board Camp Creek</td>
<td>449</td>
<td>80</td>
<td>3,594</td>
</tr>
<tr>
<td>2014-09L</td>
<td>Chester Creek (lower)</td>
<td>6,158</td>
<td>2,261</td>
<td>17,038</td>
</tr>
<tr>
<td>2014-09U</td>
<td>Chester Creek (upper)</td>
<td>598</td>
<td>261</td>
<td>3,604</td>
</tr>
<tr>
<td>2014-10L</td>
<td>High Shoals Cr. (lower)</td>
<td>1,531</td>
<td>185</td>
<td>7,485</td>
</tr>
<tr>
<td>2014-10U</td>
<td>High Shoals Cr. (upper)</td>
<td>256</td>
<td>9</td>
<td>19,425</td>
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<tr>
<td>2014-13</td>
<td>Martin Creek</td>
<td>751</td>
<td>699</td>
<td>5,937</td>
</tr>
</tbody>
</table>
Table 5. Percent occurrence of dominant and subdominant substrate size categories in pools (includes glides) and riffles (includes cascades and runs) in each stream inventoried. See appendix A for substrate size categories.

<table>
<thead>
<tr>
<th></th>
<th>Pool Dominant Substrate</th>
<th>Riffle Dominant Substrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuckaluge Creek</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Walnut Fork</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Frick Creek</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Lovinggood Creek</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Chastain Creek</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Holcomb Creek</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Bryant Creek</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Board Camp Creek</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Chester Creek (lower)</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Chester Creek (upper)</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>High Shoals Creek (lower)</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>High Shoals Creek (upper)</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Martin Creek</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Pool Subdominant Substrate

<table>
<thead>
<tr>
<th></th>
<th>Pool Subdominant Substrate</th>
<th>Riffle Subdominant Substrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuckaluge Creek</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Walnut Fork</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Frick Creek</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Lovinggood Creek</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Chastain Creek</td>
<td>9%</td>
<td>0%</td>
</tr>
<tr>
<td>Holcomb Creek</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Bryant Creek</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Board Camp Creek</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Chester Creek (lower)</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Chester Creek (upper)</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>High Shoals Creek (lower)</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>High Shoals Creek (upper)</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Martin Creek</td>
<td>2%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Table 6. 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.

<table>
<thead>
<tr>
<th>Site #</th>
<th>Stream Name</th>
<th>Large Wood per Km</th>
<th>Large Wood Count in Sample Reach</th>
<th>Inventory Distance (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>LW1/ km</td>
<td>LW2/ km</td>
<td>LW3/ km</td>
</tr>
<tr>
<td>2014-01</td>
<td>Tuckaluge Creek</td>
<td>113</td>
<td>2</td>
<td>121</td>
</tr>
<tr>
<td>2014-02</td>
<td>Walnut Fork</td>
<td>106</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td>2014-03</td>
<td>Frick Creek</td>
<td>80</td>
<td>1</td>
<td>62</td>
</tr>
<tr>
<td>2014-04</td>
<td>Lovinggood Creek</td>
<td>123</td>
<td>0</td>
<td>113</td>
</tr>
<tr>
<td>2014-05</td>
<td>Chastain Creek</td>
<td>73</td>
<td>0</td>
<td>65</td>
</tr>
<tr>
<td>2014-06</td>
<td>Holcomb Creek</td>
<td>79</td>
<td>1</td>
<td>84</td>
</tr>
<tr>
<td>2014-07</td>
<td>Bryant Creek</td>
<td>112</td>
<td>4</td>
<td>68</td>
</tr>
<tr>
<td>2014-08</td>
<td>Board Camp Creek</td>
<td>76</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td>2014-09L</td>
<td>Chester Creek (lower)</td>
<td>76</td>
<td>0</td>
<td>76</td>
</tr>
<tr>
<td>2014-09U</td>
<td>Chester Creek (upper)</td>
<td>100</td>
<td>1</td>
<td>84</td>
</tr>
<tr>
<td>2014-10L</td>
<td>High Shoals Creek (lower)</td>
<td>56</td>
<td>0</td>
<td>61</td>
</tr>
<tr>
<td>2014-10U</td>
<td>High Shoals Creek (upper)</td>
<td>112</td>
<td>0</td>
<td>85</td>
</tr>
<tr>
<td>2014-13</td>
<td>Martin Creek</td>
<td>135</td>
<td>1</td>
<td>37</td>
</tr>
</tbody>
</table>
Appendix A: Field Methods for Stream Habitat Inventory
Guide to Stream Habitat Characterization using the BVET Methodology in the Chattahoochee National Forest, GA

Prepared by:

United States Department of Agriculture Forest Service
Southern Research Station
Center for Aquatic Technology Transfer (CATT)
1710 Research Center Dr.
Blacksburg, VA 24060-6349

C. Andrew Dolloff, Team Leader

July 2014
Appendix: Field Guide, Equipment Checklist

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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 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 the length of the stream. Experienced crews 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 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.

This document was developed to serve as a guide for classroom and field instructions specific to the Chattahoochee National Forest 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.
References cited in this manual:


Outline of BVET Habitat Inventory

1. Enter ‘Header’ information on the data sheet: ‘Header’ information includes date, stream, start location, crew, etc. and is vitally important to record for future reference.

2. 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.

3. At the paired sample units perform visual estimates, and then perform measurements. Pair a minimum of 3 fast and 3 slow-water units; pair more if possible. Typically inventories longer than 1 km can pair every 10th fast and slow water habitat unit; inventories shorter than 1 km pair every 5th.

4. Progress upstream estimating attributes for every unit until the next paired sample unit is reached, then repeat step 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. 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
- Camera
- Extra string for hipchain
- Backpack
- Wading rod
- Pencils
- 50 m tape measure
- Flagging
- Clinometer
- Markers
- iPad
- Waterproof backup datasheets
- Thermometer
- Clipboard
- Handheld GPS unit
- BVET field guide on waterproof paper
- Topographic maps
- Non-slip wading boots or waders
- Cell Phone
- Water
- First Aid Kit
- Water Filter
- Rain Gear (optional)
- Toilet Paper

The BVET 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

<table>
<thead>
<tr>
<th>Observer</th>
<th>Recorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designate habitat units</td>
<td>Track location on quad map</td>
</tr>
<tr>
<td>Measure distance</td>
<td>Record data</td>
</tr>
<tr>
<td>Estimate width</td>
<td>Determine paired sample location</td>
</tr>
<tr>
<td>Estimate depths</td>
<td>Classify and count Large Wood (LW)</td>
</tr>
<tr>
<td>Classify substrates</td>
<td>Photo-documentation</td>
</tr>
<tr>
<td>Locate features</td>
<td>Document features</td>
</tr>
<tr>
<td>Estimate percent fines</td>
<td>GPS-documentation</td>
</tr>
</tbody>
</table>

Both crew members are needed to measure actual widths 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 **vitally important** for future reference. Take the time to record all categories completely and accurately.

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stream Name</td>
<td>Full name of stream</td>
</tr>
<tr>
<td>District</td>
<td>National Forest District name</td>
</tr>
<tr>
<td>Quad</td>
<td>USGS 1:24,000 quadrangle name</td>
</tr>
<tr>
<td>Date</td>
<td>Record date(s) of inventory</td>
</tr>
<tr>
<td>Recorder</td>
<td>Full name of recorder</td>
</tr>
<tr>
<td>Observer</td>
<td>Full name of observer</td>
</tr>
<tr>
<td>GPS</td>
<td>Record at start and end locations, always use NAD83, Decimal degrees</td>
</tr>
<tr>
<td>Location</td>
<td><strong>Detailed</strong> written description of start point, include landmarks, road #, etc.</td>
</tr>
<tr>
<td>Comments</td>
<td>Record signs of activity in area, water conditions, other pertinent information</td>
</tr>
</tbody>
</table>

**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, 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 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)

<table>
<thead>
<tr>
<th>Unit Type</th>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riffle</td>
<td>R</td>
<td>Fast water, turbulent, gradient &lt;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 &lt;12%</td>
</tr>
<tr>
<td>Cascade</td>
<td>C</td>
<td>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%</td>
</tr>
<tr>
<td>Run</td>
<td>RN</td>
<td>Fast water, non-turbulent, gradient &lt;12%; deeper than riffles with little or no surface agitation or flow obstructions and a flat bottom profile</td>
</tr>
<tr>
<td>Pool</td>
<td>P</td>
<td>Slow water, surface turbulence may or may not be present, gradient &lt;1%; generally deeper and wider than habitat immediately upstream and downstream, concave bottom profile; includes dammed pools, scour pools, and plunge pools</td>
</tr>
<tr>
<td>Glide</td>
<td>G</td>
<td>Slow water, no surface turbulence, gradient &lt;1%; shallow with little to no flow and flat bottom profile</td>
</tr>
<tr>
<td>Underground</td>
<td>UNGR</td>
<td>Stream channel is dry or not containing enough water to form distinguishable habitat units</td>
</tr>
</tbody>
</table>

*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 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:


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

<table>
<thead>
<tr>
<th>Unit Type</th>
<th>Unit Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>1</td>
</tr>
<tr>
<td>R</td>
<td>1</td>
</tr>
<tr>
<td>P</td>
<td>2</td>
</tr>
<tr>
<td>P</td>
<td>3</td>
</tr>
<tr>
<td>R</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
</tr>
<tr>
<td>R</td>
<td>4</td>
</tr>
<tr>
<td>G</td>
<td>4</td>
</tr>
<tr>
<td>R</td>
<td>5</td>
</tr>
<tr>
<td>P</td>
<td>5</td>
</tr>
<tr>
<td>RN</td>
<td>6</td>
</tr>
<tr>
<td>P</td>
<td>6</td>
</tr>
<tr>
<td>R</td>
<td>7</td>
</tr>
</tbody>
</table>

In the above example, the crew 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.

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

* 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
**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:

<table>
<thead>
<tr>
<th>Category</th>
<th>Length (m)</th>
<th>Diameter (cm)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-5</td>
<td>10-55</td>
<td>short, skinny</td>
</tr>
<tr>
<td>2</td>
<td>1-5</td>
<td>&gt;55</td>
<td>short, fat</td>
</tr>
<tr>
<td>3</td>
<td>&gt;5</td>
<td>10-55</td>
<td>long, skinny</td>
</tr>
<tr>
<td>4</td>
<td>&gt;5</td>
<td>&gt;55</td>
<td>long, fat</td>
</tr>
<tr>
<td>RW</td>
<td>rootwad</td>
<td>rootwad</td>
<td>roots on dead and down tree</td>
</tr>
</tbody>
</table>

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

*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

Hemlock Condition (0 - 4)

Definition:
Visual estimate of the condition of riparian hemlocks in the stream reach since the previous paired sample. For the first paired sample, condition of riparian hemlocks since the start of the inventory.

How to measure:
Observe the general condition of hemlocks in the riparian area as you walk between paired sample units. Select from one of the following categories for hemlock condition:

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Wooly needles</th>
<th>Needle loss</th>
<th>Limb loss</th>
<th>Hemlocks falling</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Healthy</td>
<td>No</td>
<td>None</td>
<td>Rare</td>
<td>&lt; 5 whole hemlocks recruited as LW</td>
</tr>
<tr>
<td>1</td>
<td>Early infestation</td>
<td>Yes</td>
<td>0 – 25%</td>
<td>Some small branches</td>
<td>&lt; 5 whole hemlocks recruited as LW</td>
</tr>
<tr>
<td>2</td>
<td>Late infestation</td>
<td>Yes</td>
<td>25 – 75%</td>
<td>Small, medium branches</td>
<td>&lt; 5 whole hemlocks recruited as LW</td>
</tr>
<tr>
<td>3</td>
<td>Mortality</td>
<td>NA</td>
<td>&gt; 75%</td>
<td>Small, medium, large branches and tree tops</td>
<td>&lt; 5 whole hemlocks recruited as LW</td>
</tr>
<tr>
<td>4</td>
<td>LW recruiting</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>5 or more whole hemlocks recruited as LW</td>
</tr>
</tbody>
</table>

Where to measure: assess throughout reach, but record only at paired sample habitat units

Hemlock Abundance (0 - 3)

Definition:
Category describing the total number of hemlocks encountered since the last paired sample unit.

How to measure:
Estimate the number of hemlocks as you walk between paired sample units. Observe hemlocks within the riparian area of the surveyed stream. Select from one of the following categories for hemlock abundance: 0 = no hemlocks; 1 = 1-10 hemlocks; 2 = 11 – 50 hemlocks; 3 = more than 50 hemlocks

Where to measure: do counts throughout reach but record only at paired sample habitat units
**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 or waterfalls encountered

---

**GPS (ID)**

*Definition:* Name of the point recorded to mark a waterfall, crossing feature or other location in the GPS unit.

*How to measure:* Stand as close to the feature as possible and allow the GPS to have a clear view of the sky. Mark a waypoint on the GPS, then edit the waypoint name as follows:

- **S##** Start location of BVET survey
- **P##** Pause location of BVET survey if survey is not completed that day
- **E##** End location of BVET survey when survey is completed
- **W##b** Waterfall
- **B##b** Bridge
- **Fd##b** Ford
- **D##b** Dam
- **V##b** Culvert
- **O##b** Other, enter a brief description into the note section for the waypoint

## = stream priority number – see stream list or map
b = use b, c, d, etc to create unique labels when more than 1 of a feature type are encountered on a stream; for example if 3 waterfalls are found on stream priority number 5 the first waterfall would be W5, the second would be W5b, the third W5c

*Where to measure:* all waterfalls, all crossing features, any other notable features encountered during the survey that we may want to locate in the future or that could serve as landmarks

**See Section 5 below for additional information on GPS use.**
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. Record the GPS ID for all waterfalls and crossing features.

Where to record: wherever found

<table>
<thead>
<tr>
<th>Channel Feature</th>
<th>Abbreviation</th>
<th>What to Record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waterfall¹</td>
<td>FALL</td>
<td>Distance, estimated height, photos</td>
</tr>
<tr>
<td>Tributary</td>
<td>TRIB</td>
<td>Distance, average wetted width, into main channel on left or right (as facing upstream)</td>
</tr>
<tr>
<td>Side channel²</td>
<td>SCH</td>
<td>Distance, average wetted width, whether it is flowing into or out of main channel on left or right (as facing upstream)</td>
</tr>
<tr>
<td>Braid³</td>
<td>BRD</td>
<td>Distance at start and distance at end; continue with normal inventory up channel with greatest discharge</td>
</tr>
<tr>
<td>Seep (Spring)</td>
<td>SEEP</td>
<td>Distance, left or right bank (as facing upstream), size, coloration</td>
</tr>
<tr>
<td>Landslide</td>
<td>SLID</td>
<td>Distance, left or right bank (as facing upstream), estimated size</td>
</tr>
<tr>
<td>Other</td>
<td>OTR</td>
<td>Distance, description of feature, example: 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.</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Crossing Feature</th>
<th>Abbreviation</th>
<th>What to Record*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge</td>
<td>BRG</td>
<td>Distance, width, height, road or trail name and type (gravel, paved, dirt, horse, ATV, etc.), photo</td>
</tr>
<tr>
<td>Ford</td>
<td>FORD</td>
<td>Distance, road or trail name and type (gravel, paved, dirt, etc.), photo</td>
</tr>
<tr>
<td>Dam</td>
<td>DAM</td>
<td>Distance, type, condition, estimated height, dam use, name of road or trail, if applicable; include beaver dams, photo</td>
</tr>
<tr>
<td>Culvert</td>
<td>V</td>
<td>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</td>
</tr>
</tbody>
</table>

* 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 and GPS of all crossing features and waterfalls!
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:
- 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

Record for every paired sample riffle:
- Measured Width
- Hemlock Condition
- Photograph

Record features and full feature descriptions wherever they are encountered.

Photograph all crossings!
Section 5: GPS Instructions

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 golf flag.
- At the bottom of the next screen touch the ABC pyramid button.
- 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.
  - Note: Touch the left and right arrows at the bottom of the screen to move from letters to numbers to symbols. Touch the down arrow on the letters to get lowercase and up arrow to get back to uppercase.
- 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.
Garmin GPS Oregon 400T Cheatsheet

Turn On
- Press Power key, wait for GPS to boot

Turn Off
- Press and hold Power key

Backlight Strength
- Press and quickly release Power key, adjust with touchscreen options

Create New Waypoint
1. To create a waypoint of your current position touch “Mark Waypoint”
2. Touch “Save and Edit”, touch “Change Name”, type desired label, touch “Green Check Icon” to save

Calibrate compass
1. Whenever batteries are removed you must calibrate the compass so the map orients correctly
2. Touch “Setup”, touch “Heading”, touch “Press to Begin Compass Calibration”
3. Touch “Start”, hold GPS level and rotate it twice on your palm

Data Fields
1. To change the data fields on the map page touch “Map”
2. Touch a data field at the top of the map, then select your desired data field

Calibrating the Touchscreen
1. If the touchscreen buttons are not responding properly, recalibrate the touchscreen
2. While the GPS is turned off, press and hold the power key for ~30 seconds
3. Follow instructions on the screen until calibration is complete
Appendix: Field Guide, 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
- **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
- **Hemlock Condition (0-4)** – visual estimate of hemlock wooly adelgid infestation
- **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

- **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

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
Equipment Checklist

☐ hipchain
☐ extra string for hipchain
☐ wading rod
☐ 50 m tape measure
☐ clinometer
☐ thermometer
☐ iPad
☐ handheld 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
☐ non-slip wading boots
☐ raingear