

Summary of Stream Habitat Inventories on the Conasauga, Blue Ridge, and Chattooga River Districts of the Chattahoochee National Forest, Georgia 2017



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Introduction

Land management practices prior to the current era including forest clearing and road building, have left many streams on the Chattahoochee-Oconee National Forest (CONF), Georgia with a legacy of degraded habitat, including long shallow riffles, few pools, large deposits of sediment, and low 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. In streams where factors such as water temperature, water chemistry, sedimentation, and habitat complexity are not limiting, habitat restoration through recruitment or manual addition of large wood will increase the likelihood of trout persistence or recovery.

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). Trees (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, and 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 (Boyer et al. 2003, Jacobs 2004) and where recruitment or loading is judged insufficient, LW is intentionally added to stream channels (Reich et al. 2003). Large wood additions encourage pool formation and sediment scour, thereby increasing the amount of spawning and rearing habitat, particularly for trout (Ryan et al. 2014, Faustini and Jones 2003, Thompson 1995).

The rate at which large wood enters stream channels is controlled by a number of natural and human-caused factors. 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 dentata*) 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 insect from East Asia threatens another keystone species of eastern forests, eastern hemlock (*Tsuga canadensis*) 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 woolly adelgid, dead hemlock trees located in riparian areas are a temporary source of large wood for these streams. Dead or dying hemlocks may be allowed to recruit through natural processes, or may be intentionally added to stream channels.

Habitat assessments are needed to locate sites and optimize the effectiveness of habitat remediation projects. The CONF partnered with the USDA Forest Service, Southern Research Station, Center for Aquatic Technology Transfer (CATT) to complete stream habitat inventories in the Conasauga, Blue Ridge, and Chattooga River Districts of the CONF in 2014, 2015, and 2017 (Figure 1). Our goals were to: 1) quantify current stream habitat conditions; and 2) describe Hemlock abundance and condition within the riparian area. Results of our 2014 and 2015 inventories on the CONF are presented in Krause et al. (2015 and 2016). The CATT deployed a 6-person crew to the CONF in summer 2017 to inventory stream habitat and describe hemlock abundance and condition. Here we present the results of our 2017 inventories.

Methods

Site Selections and Reach Layout

Taylor Beard (CONF Forest Soil Scientist) and CONF District Biologists selected stream reaches for inventory. The CONF chose reaches within the Foothills Landscape project boundary because they could be the target of future stream habitat improvement work if our habitat inventories indicate such improvements are necessary and achievable.

Habitat Inventory

We performed basinwide visual estimation technique (BVET) habitat inventories on all 19 streams visited (Figure 1, Table 1, and Appendix A) (Dolloff et al. 1993). The BVET is a two-stage visual estimation technique used to quantify stream habitat. During the first stage, habitats are classified based on naturally occurring habitat features as pools (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), or riffles (fast water, turbulent, gradient <12%; shallow reaches characterized by water flowing over or around rough bed materials that break the surface during low flows). Glides (slow water, no surface turbulence, gradient <1%; shallow with little to no flow and flat bottom profile) were identified during the inventory, but were grouped with pools for some data analysis. Runs (fast water, non-turbulent, gradient <12%; deeper than riffles with little or no surface agitation or flow obstructions and a flat bottom profile) and cascades (fast water, turbulent, gradient >12%; highly turbulent series of

short falls and small scour basins, with very rapid water movement) 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 B). 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 B, 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 B) 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 B). All wood less than 1.0 m long and less than 10 cm in diameter were omitted from the inventory. Placed pieces of LW to build fish habitat improvement structures were included in 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 B).

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 B for detailed field methods.

Results

From June 20th-July 5th 2017 we inventoried 19 streams totaling 56.9 km of stream habitat on the CONF (Figure 1, Table 1, and Appendix A). 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 2 cm to 30 cm among the inventoried streams (Table 3). Most streams tended to have relatively similar maximum pool depths in both the downstream reaches and upstream reaches; the exception being Emery Creek due to its proximity to the headwaters (Figure 2). The average wetted width ranged from 2.0 and 1.9 m for Goldmine Branch to 11.8 and 13.8 m for Warwoman Creek for pools and riffles, respectively (Table 3).

Habitat Area

Slow water (pools + glides) habitat was lacking and made up <25% of a stream's habitat area for over half of the streams (10 of 19) (Figure 3, Table 4). Thus, the majority of the streams (16 of 19) had more fast water (riffle + run + cascade) than slow water habitat area (Figure 3, Table 4). Though the majority of the stream area is comprised of fast water habitat (due to larger unit size), the quantity (i.e. unit count) of slow water units to fast water units was similar (differed by less than ± 20 units) for all streams except Cane Creek, which had 26 less slow water than fast water units (Table 4). Warwoman, Sarahs, and Moss Creek had >50% slow water habitat area (54%, 55%, and 78% respectively), followed closely by Panther and Jones Creek (49% and 47% respectively) (Figure 3, Table 4). Fast water habitat area was >75% in Jigger Cr., Emery Cr., Bear Cr., N. Prong Sumac Cr., Mill Cr., Goldmine Br., West Cane Cr., Cane Cr., and Turninglathe Branch (Figure 3, Table 4). Cascade habitat area was highest for Emery Creek (11%), North Prong Sumac Creek (14%), and Turninglathe Creek (10%) (Figure 3, Table 4).

% Fines and Substrate

The average percent fines (percent of habitat unit's channel bottom covered by sand, silt, or clay) in pools of the inventoried streams ranged from 12% to 84%, and the majority of the streams had percentages >35% (13 of 19 streams) (Table 3). Average percent fines in riffles were <25% for all streams except Goldmine Branch, which had 67% fines (Goldmine Branch) (Table 3). There were no

apparent longitudinal trends in percent fines; the exception being Bear Creek which showed decreased percent fines moving upstream in both riffles and pools (Figure 4).

In pools, the dominant substrate was most frequently sand and bedrock; the substrate types organic matter, silt, small gravel, large gravel, cobble, and boulder were also present, but typically as a subdominant substrate (Table 5 and 6, Figure 5). In riffles, the dominant substrate was most frequently large gravel, cobble, and bedrock; the substrate types organic matter, silt, sand, small gravel, and boulder were also present, but most often as a subdominant substrate (Table 5 and 6, Figure 6).

Large Wood

The total pieces of large wood per kilometer (LW/km) ranged from 74 in Rock Creek to 405 in Goldmine Branch (Figure 7, Table 7). The majority of LW was small diameter size classes (LW1 and LW3; 10 to 55 cm diameter) (Figure 7, Table 7). Emery Creek had the largest amount (11 LW4/km) of size class 4 (>5 m length, >55 cm diameter), followed by Mill Creek (6 LW4/km) (Figure 7, Table 7). 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 8).

Hemlock Abundance and Condition

Hemlocks were present in the riparian area of all streams, except Sarahs Creek, and showed varying degrees of infestation with Hemlock Woolly Adelgid (Figure 9). The following streams had high (>50) hemlock abundance for the majority of the inventoried reach: Jigger, Emery, Bear, Holly, Mill, Warwoman, Stonewall, Panther, and Cane Creek (Figure 9). The following streams had long reaches where dead Hemlocks were present: Emery Creek, Bear Creek, Holly Creek, Goldmine Branch, Warwoman Creek, Stonewall Creek, Panther Creek, Bryant Creek, Moss Creek, Cane Creek, and Turninglathe Creek (Figure 9).

Discussion

Habitats in the inventoried streams show the typical degraded legacy of late 19th-early 20th century land use. Many have long and shallow riffles, shallow residual pool depths, high percent fines, and low amounts of LW in the most desirable large size classes. Many also contain fish habitat improvement structures designed 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). Habitat structures did not contribute substantially to LW count, pool count, or habitat area except in Sarahs Creek, where structures were numerous near its confluence with Warwoman Creek. Streams inventoried in 2014 (Krause et al. 2015), 2015, and 2017 had similar habitat conditions; stream area comprised mainly of fast

water habitat, high percent fines in slow water habitat, very little large diameter large wood, and hemlocks are predominantly infested and dead within the riparian area.

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 nearly all the inventoried streams contain hemlock trees infested with hemlock wooly adelgid. Over time some of these hemlocks will shed limbs and tops, while others will fall entirely into the stream channel, providing a variety of LW sizes. Hemlocks can also be deliberately felled into stream channels to strategically provide additional channel complexity in high-priority management areas. The majority of inventoried streams had between 150 and 300 LW/km and all were largely lacking in wood of the largest size class (LW4).

Given the high number of dead or dying hemlocks, these streams are prime targets for LW treatments, but how much wood is enough? Neighboring National Forests in South Carolina and North Carolina specify that the desired LW condition is 322 and 161 LW/Km, respectively (USDA 1994 and 2004b). The CONF does not specify a LW/Km target, but they do manage streams and riparian areas to maintain, enhance, and recruit LW (USDA 2004a). Researchers have not found an upper limit on the amount of large wood that is beneficial to fish so most often the upper limit will be determined by social factors rather than fish habitat objectives (Richards and Hollingsworth 2000), particularly in areas managed for multiple uses.

Sand was prevalent as both a dominant and subdominant substrate in many of the streams, as is evident by the high percent fines (sand and silt exceeding 35%) observed in most pools. Researchers have demonstrated that when fines exceed 35% trout reproduction is negatively impacted (Everest et al. 1987). Fines can be reduced in spawning gravel by salmonids building redds, flushing flows from storm events, and large wood improving stream habitat through pool creation and habitat complexity. Newly formed plunge pools from LW can help flush out fine sediments and expose additional patches of spawning gravel (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. In the long run, it may be cost-effective to manage riparian areas to provide a source of LW for natural recruitment. Efforts to enhance habitat by adding designed structures has resulted in improved habitat conditions, however many of these structures are reaching the end of their designed lifespan. 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 2017, 2015, and 2014 stream habitat data reside in a MS Access database, which is managed by the CATT, and a copy has been provided to Taylor Beard, CONF Forest Soil Scientist. We will work with the CONF to develop custom queries and reports for the MS Access database, as needed.

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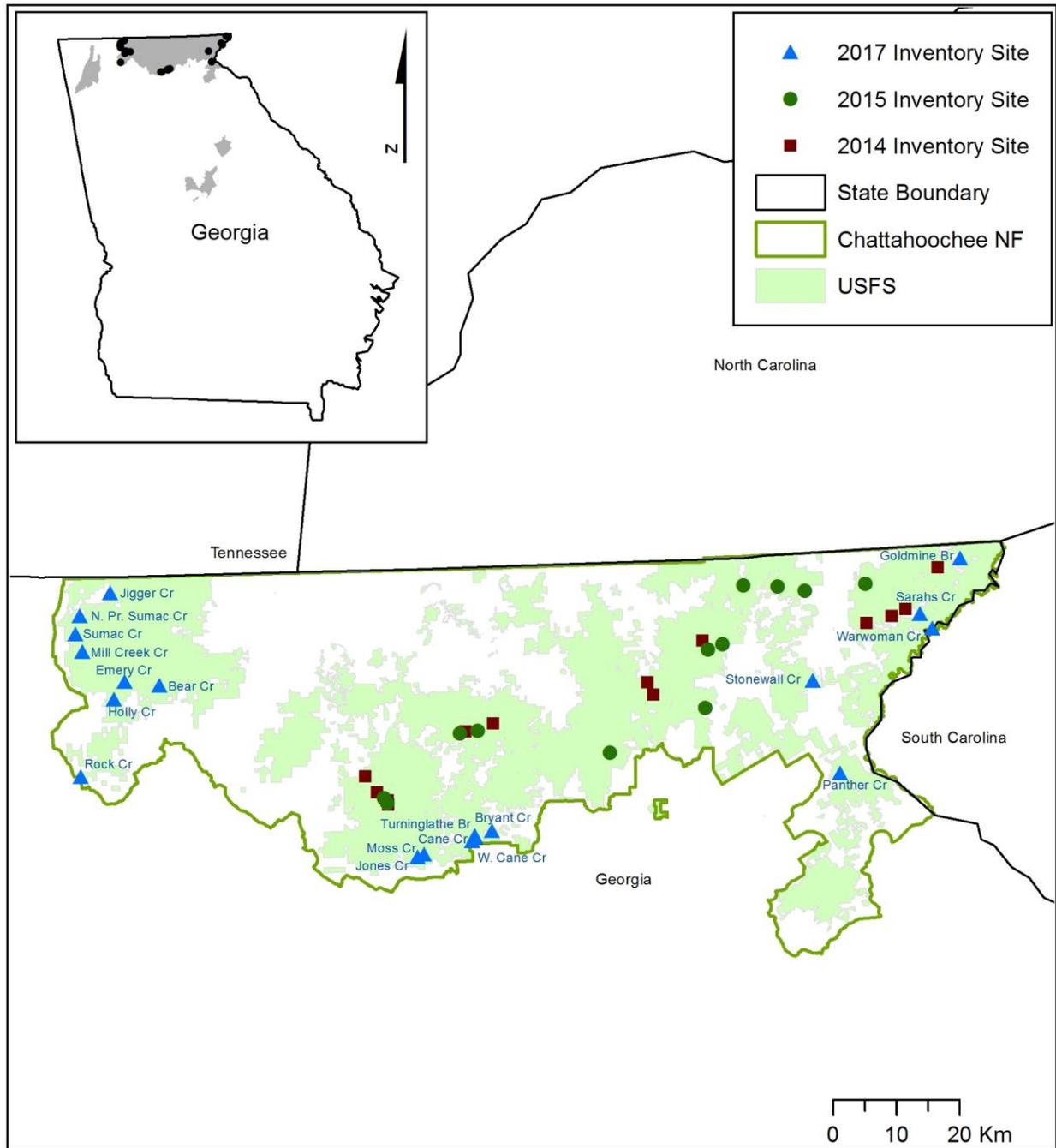


Figure 1. Streams visited on the Chattahoochee National Forest in 2017 as well as previously in 2014 and 2015 (Krause et al. 2015 and 2016).

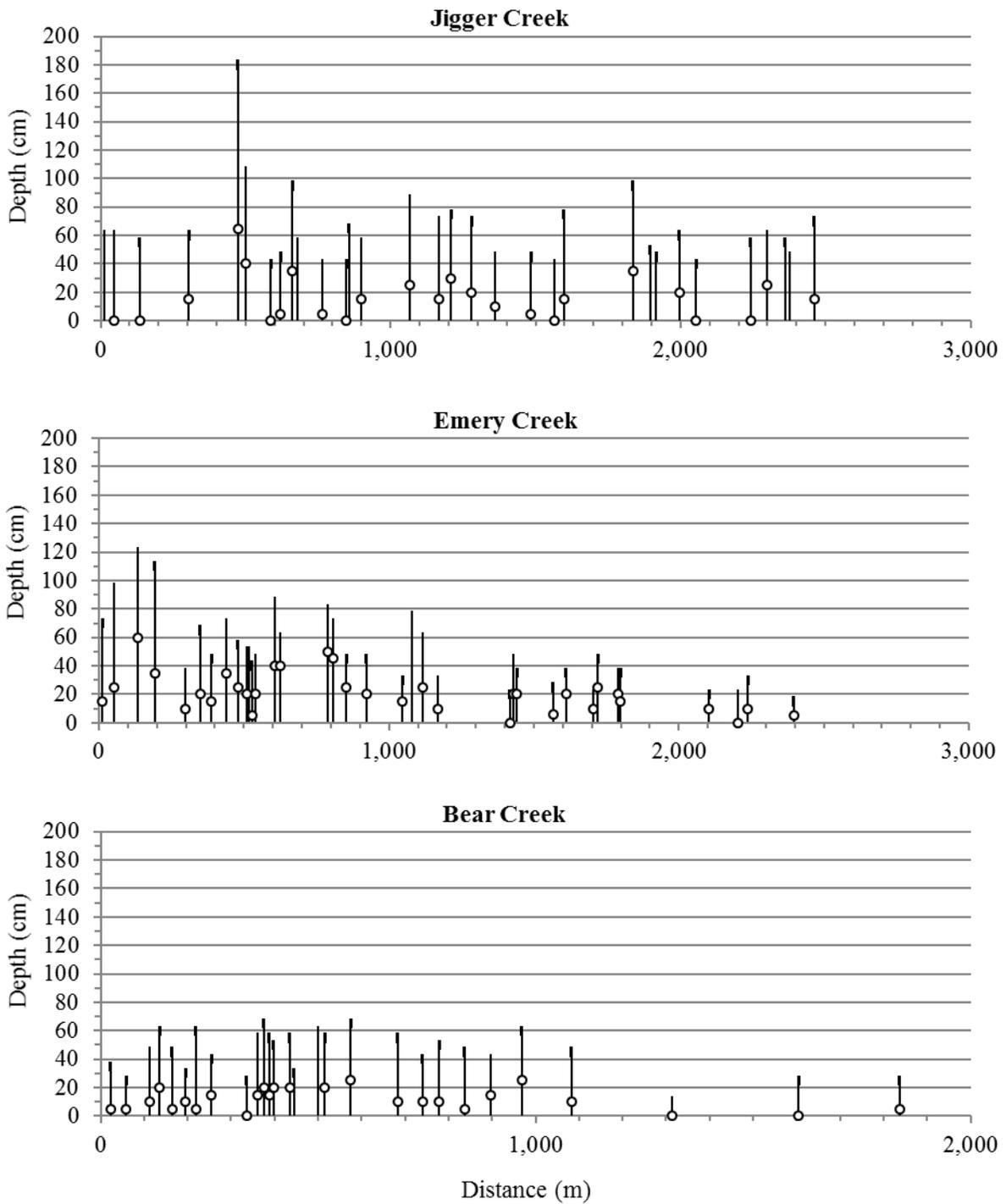


Figure 2. Maximum pool depth (bars) and residual pool depth (circles) shown longitudinally for each stream inventory.

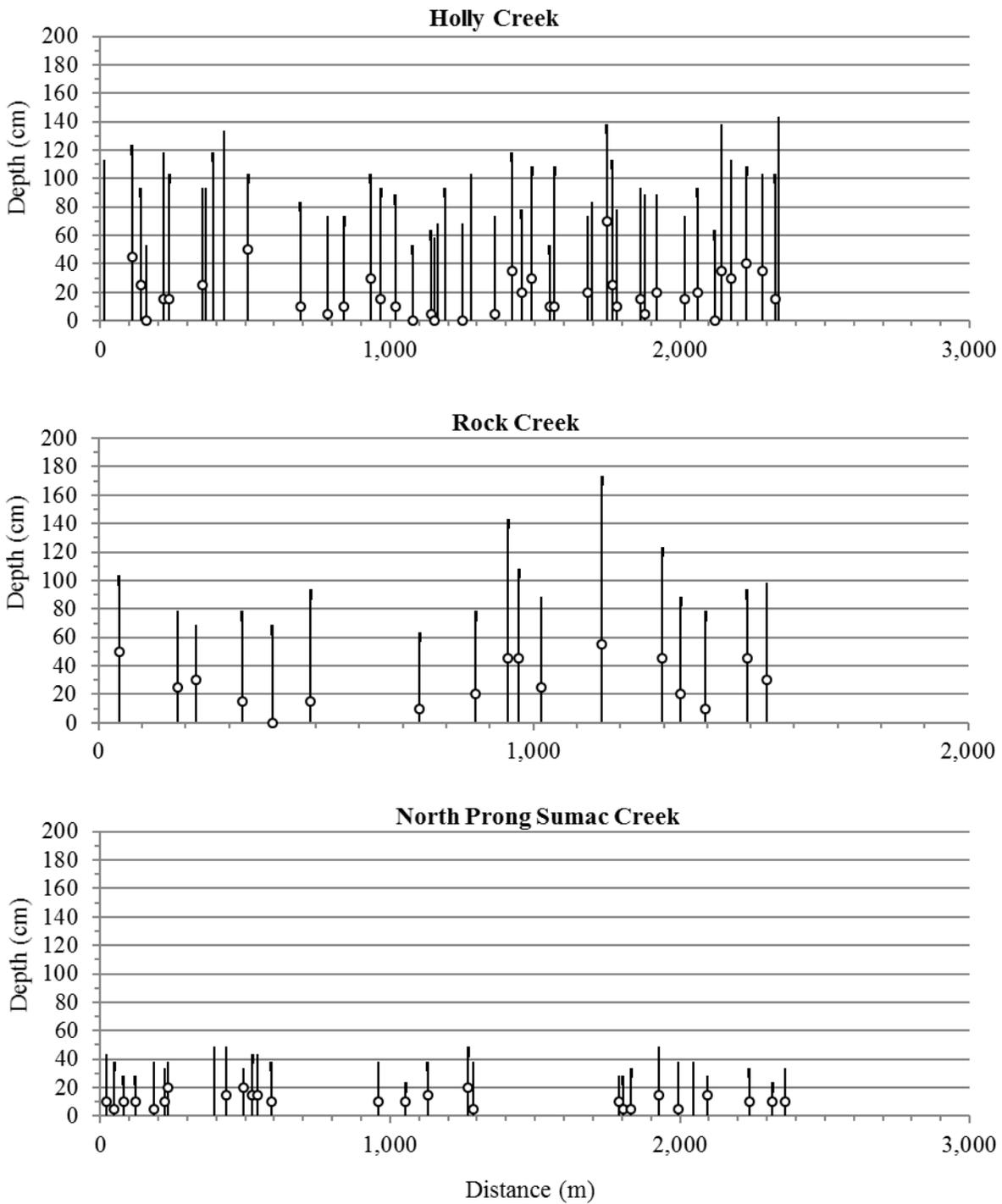


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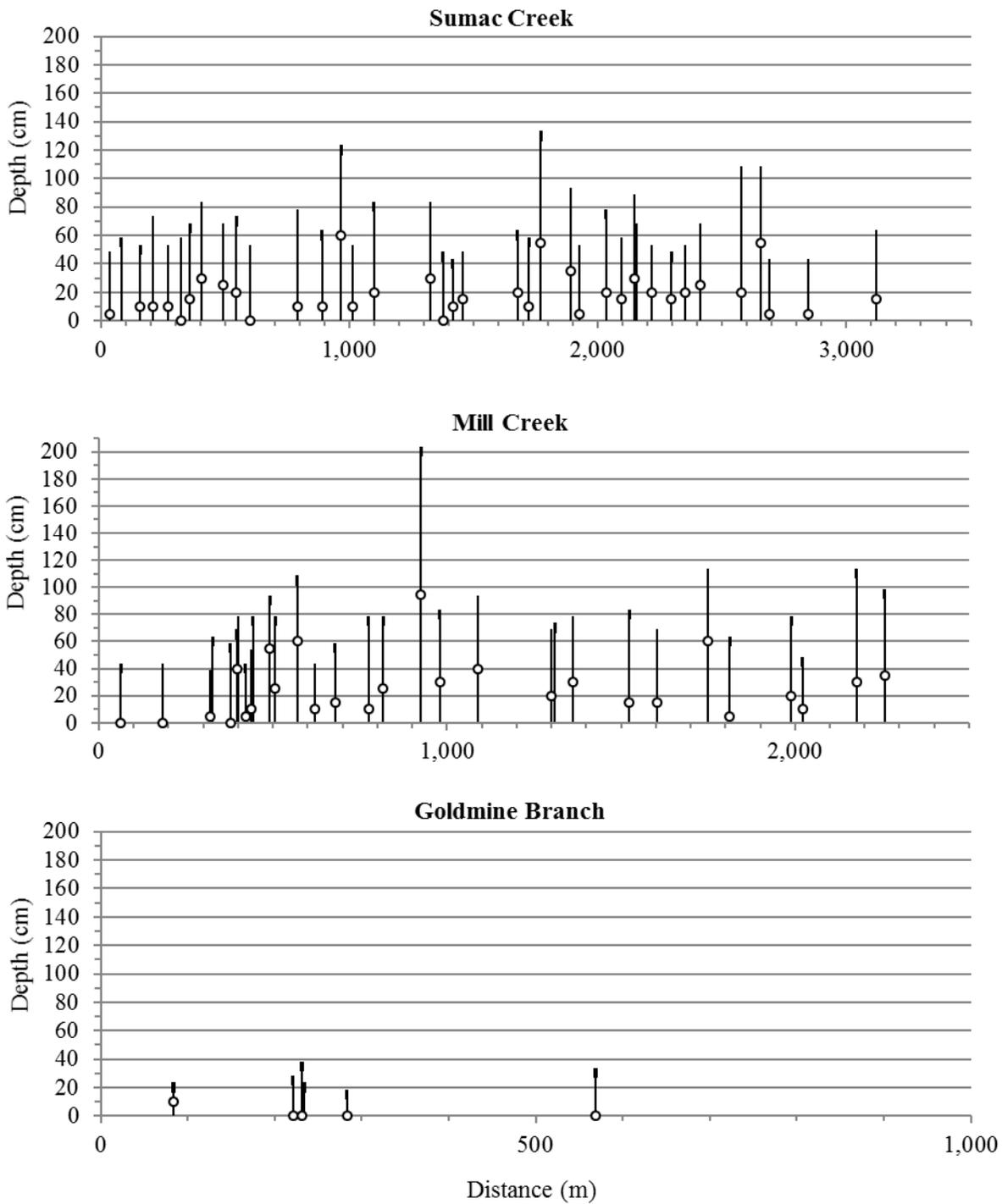


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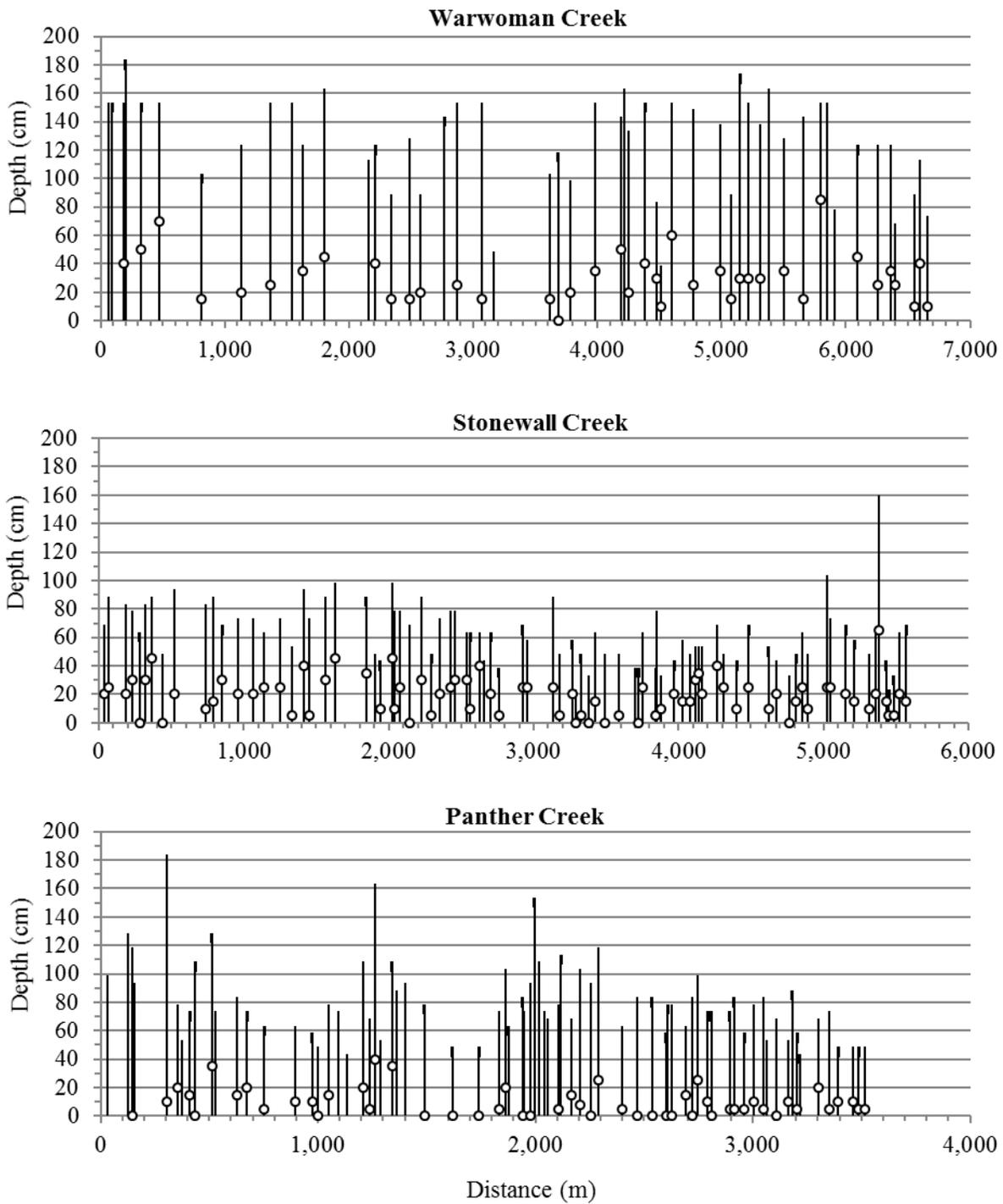


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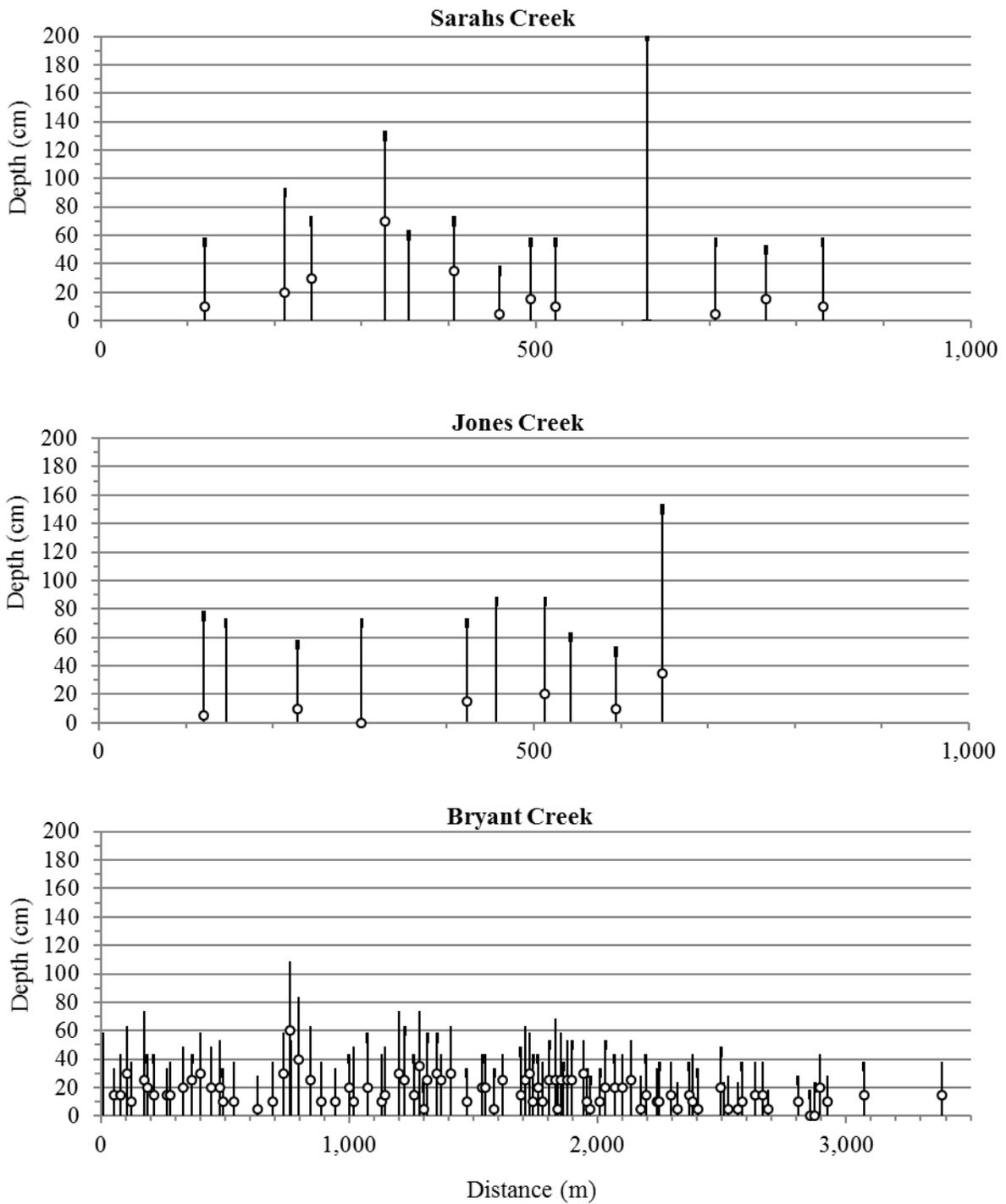


Figure 2 continued. Maximum pool depth (bars) and residual pool depth (circles) shown longitudinally for each stream inventory.

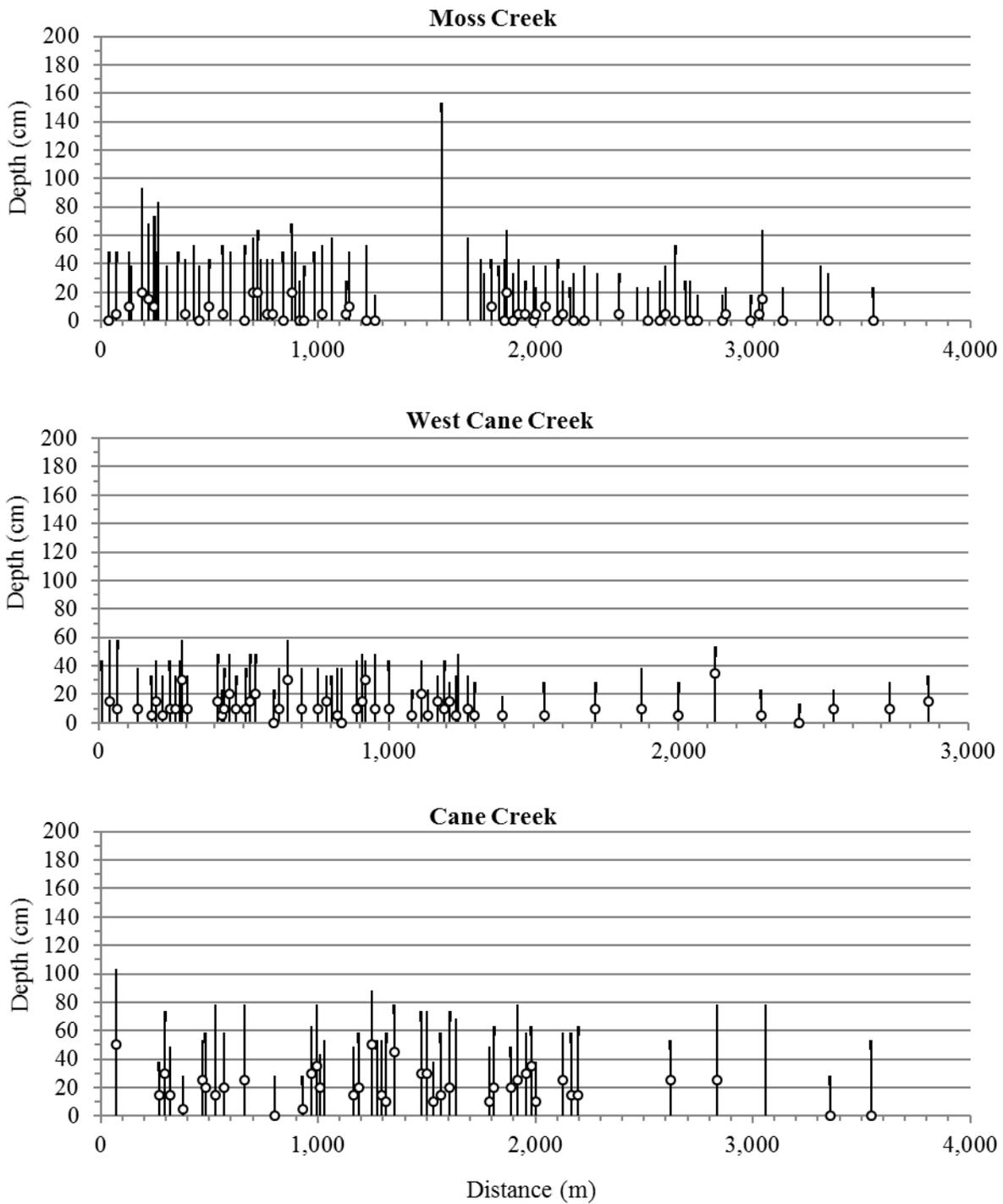


Figure 2 continued. Maximum pool depth (bars) and residual pool depth (circles) shown longitudinally for each stream inventory.

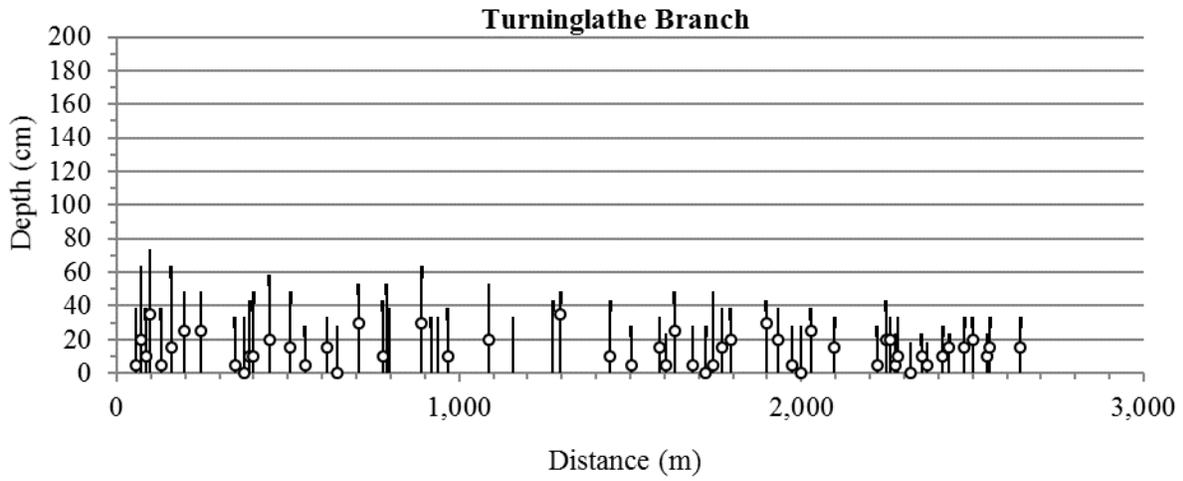


Figure 2 continued. Maximum pool depth (bars) and residual pool depth (circles) shown longitudinally for each stream inventory.

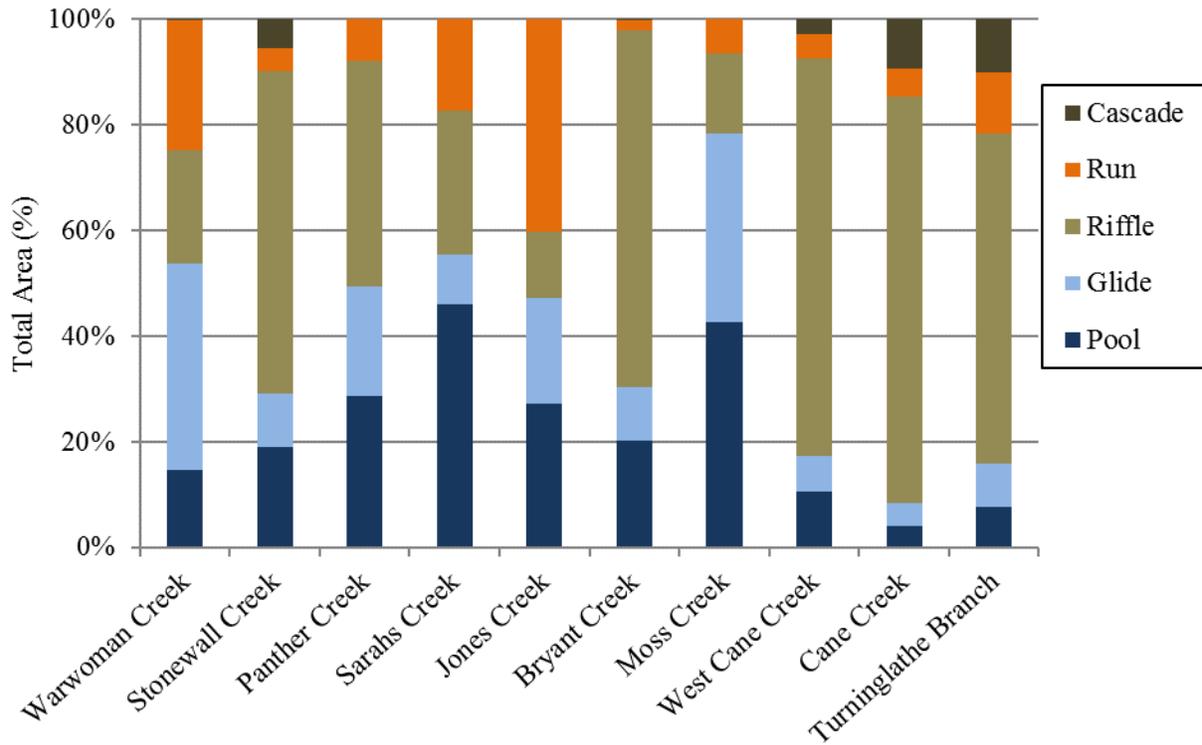
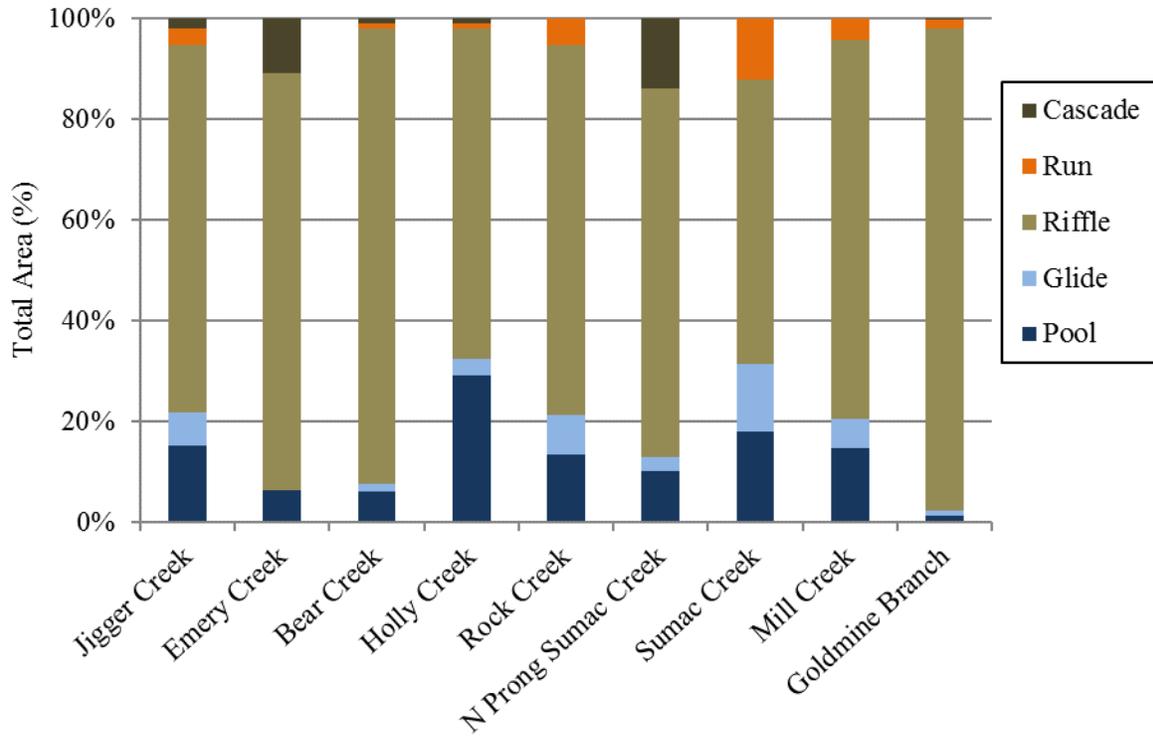


Figure 3. Percent pool, glide, riffle, run, and cascade habitat area.

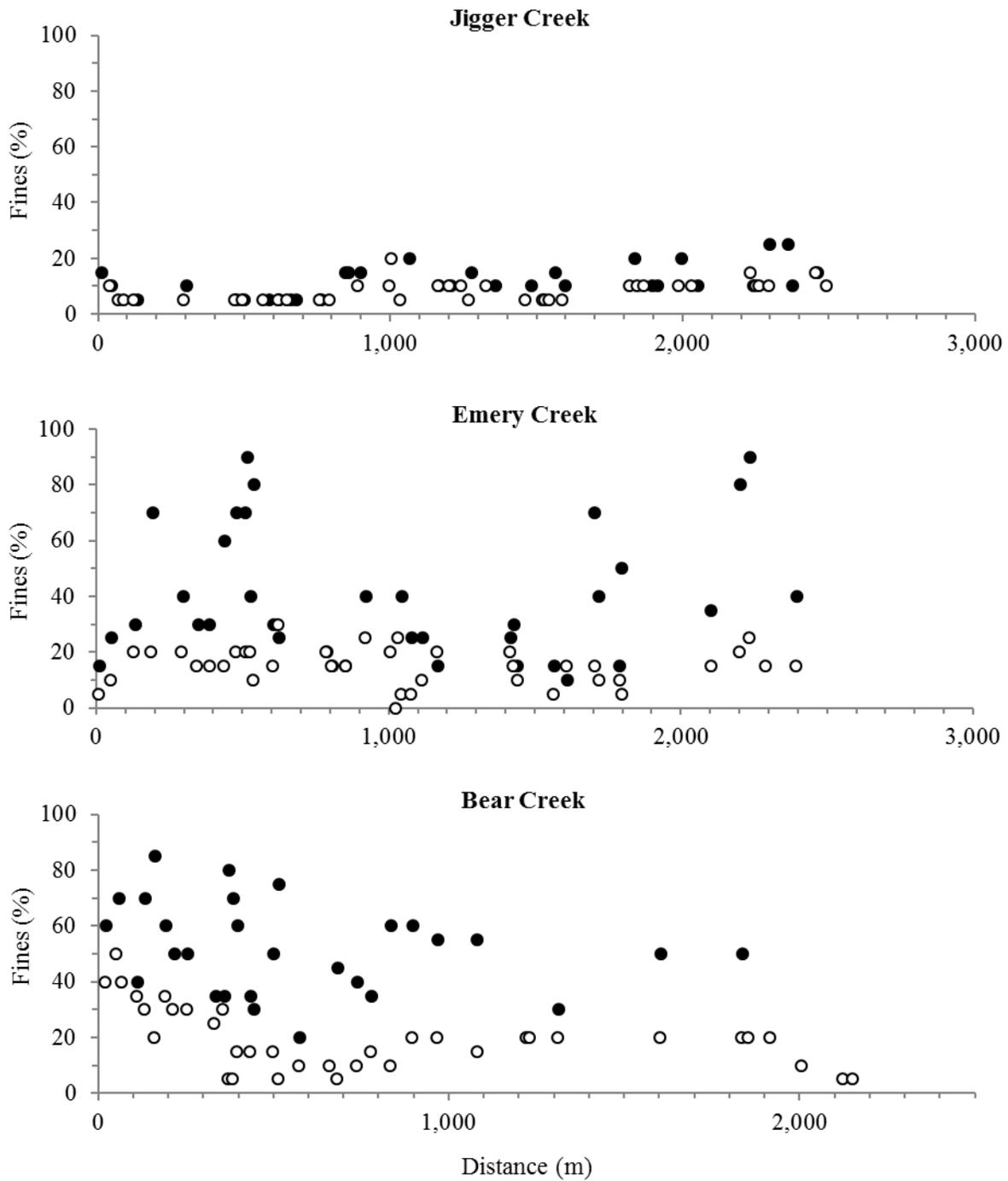


Figure 4. Percent of each pool (solid circles) and riffle (open circles) channel bottom comprised of fine sediment (sand, silt, and/or clay).

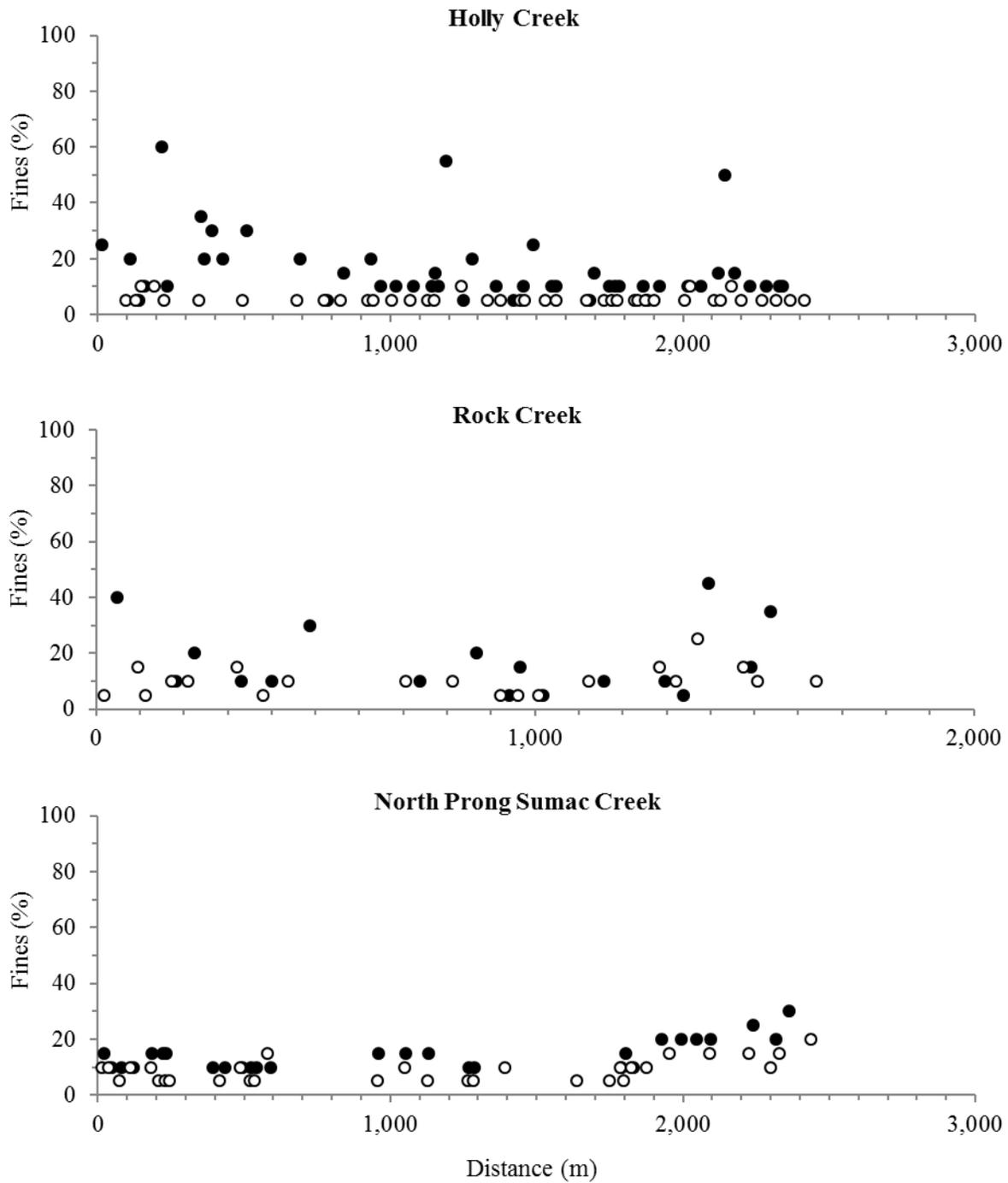


Figure 4 continued. Percent of each pool (solid circles) and riffle (open circles) channel bottom comprised of fine sediment (sand, silt, and/or clay).

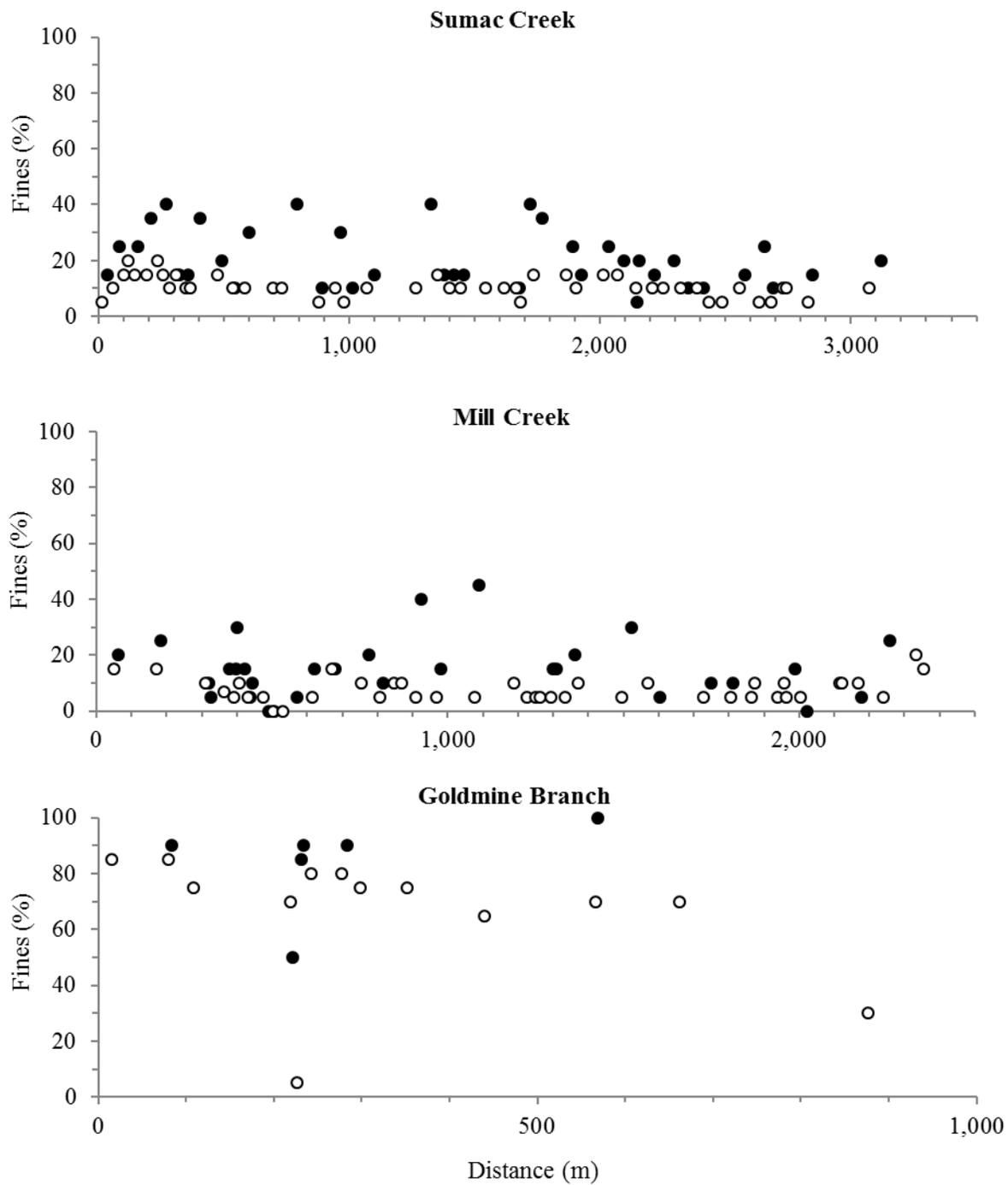


Figure 4 continued. Percent of each pool (solid circles) and riffle (open circles) channel bottom comprised of fine sediment (sand, silt, and/or clay).

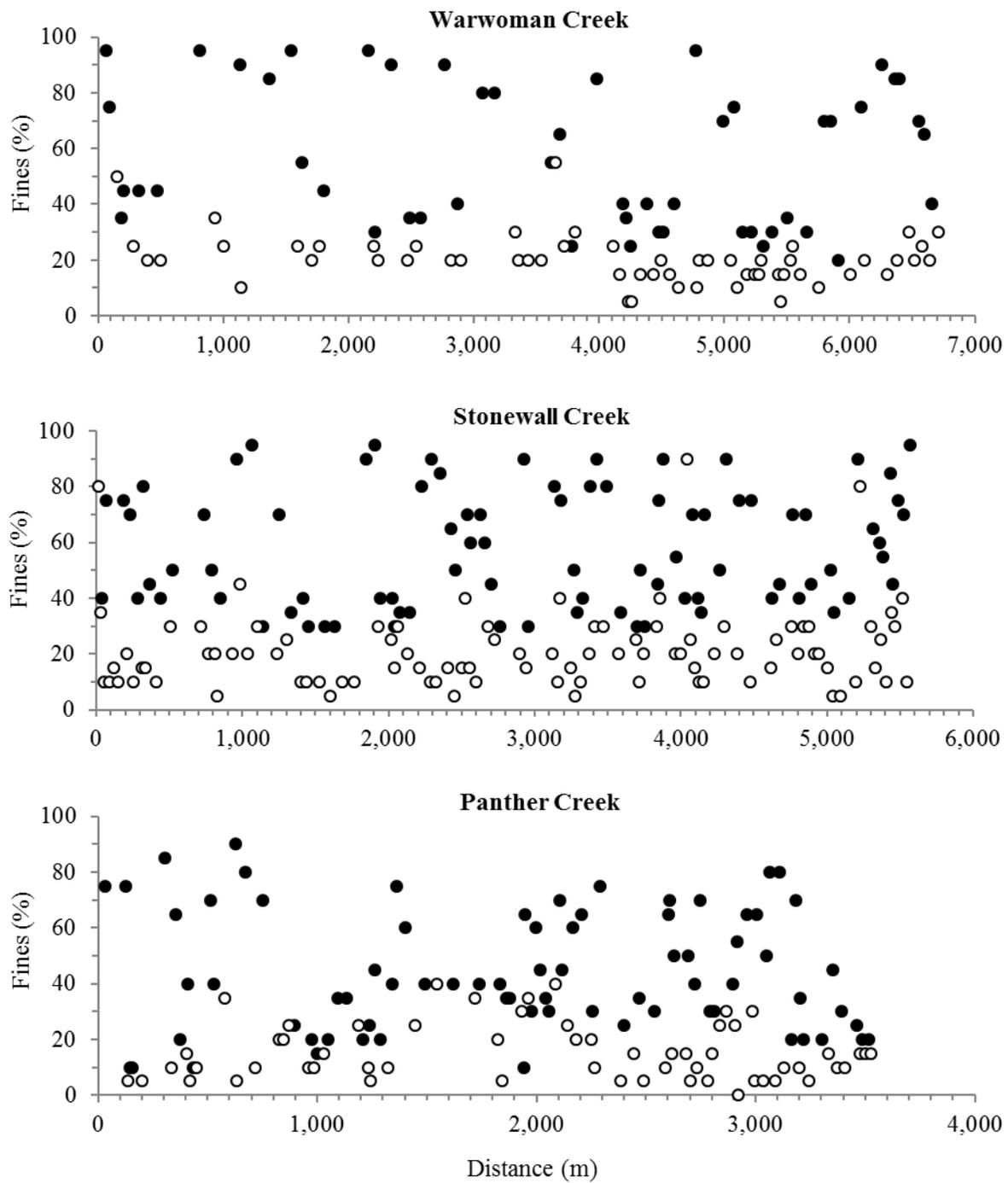


Figure 4 continued. Percent of each pool (solid circles) and riffle (open circles) channel bottom comprised of fine sediment (sand, silt, and/or clay).

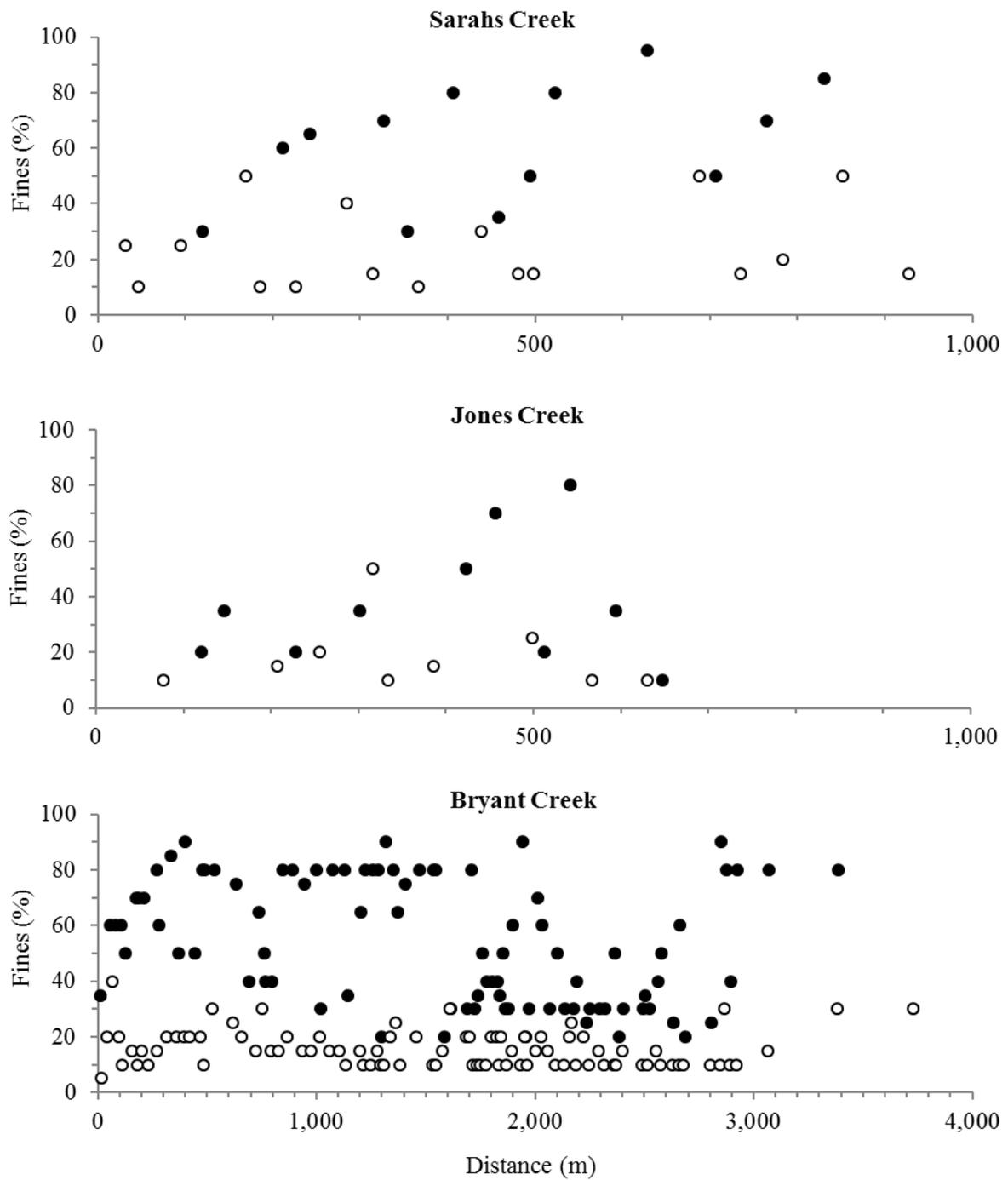


Figure 4 continued. Percent of each pool (solid circles) and riffle (open circles) channel bottom comprised of fine sediment (sand, silt, and/or clay).

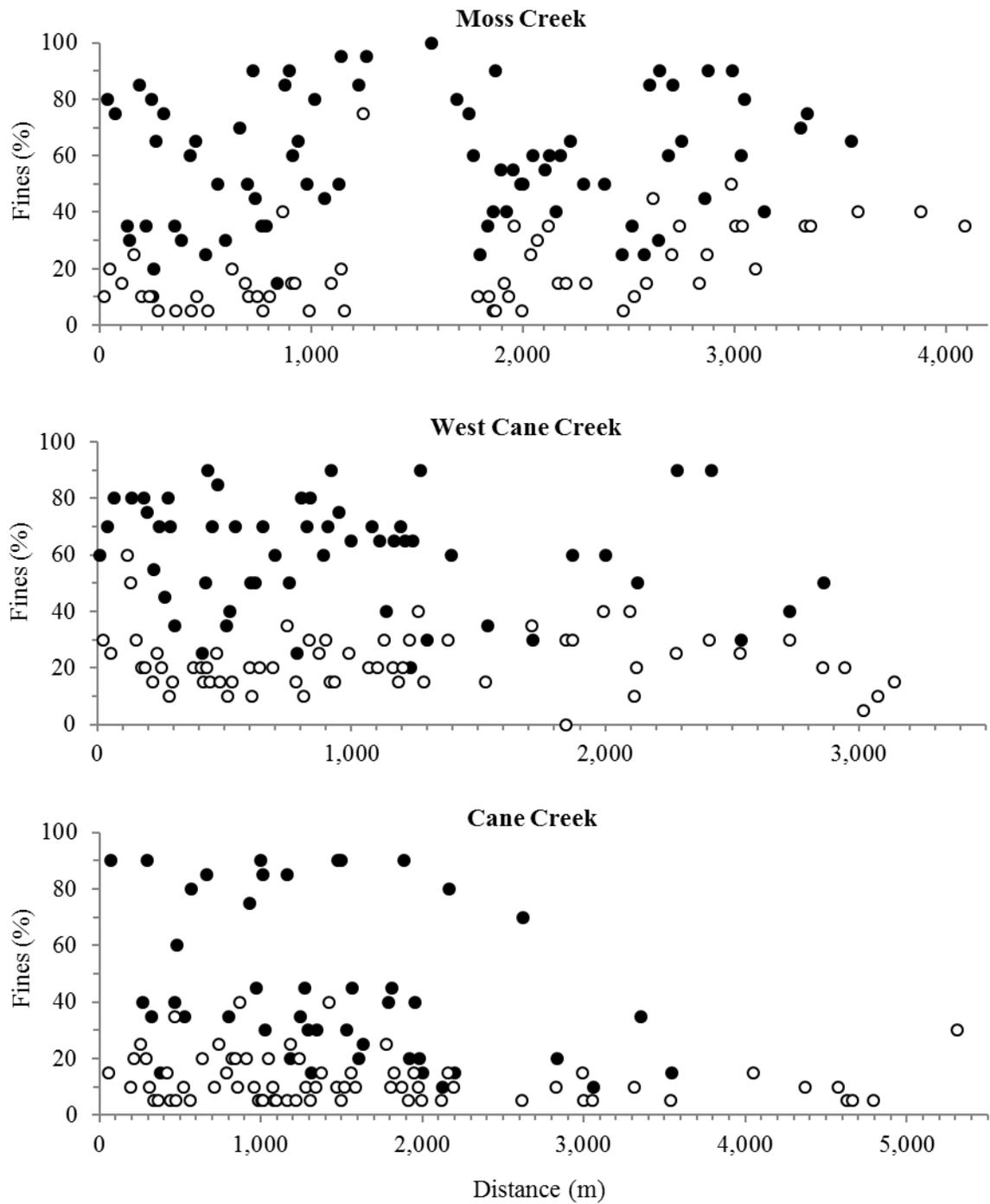


Figure 4 continued. Percent of each pool (solid circles) and riffle (open circles) channel bottom comprised of fine sediment (sand, silt, and/or clay).

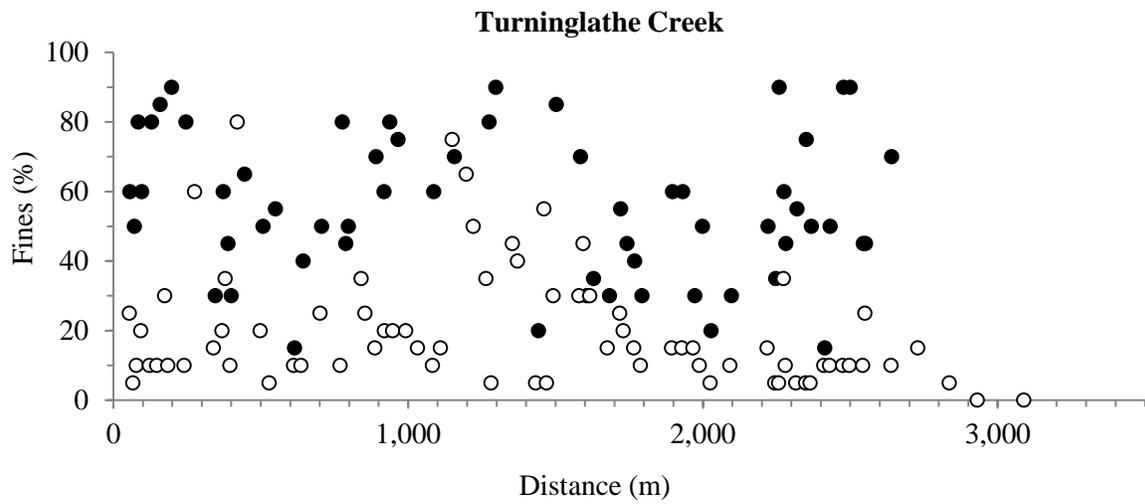


Figure 4 continued. Percent of each pool (solid circles) and riffle (open circles) channel bottom comprised of fine sediment (sand, silt, and/or clay).

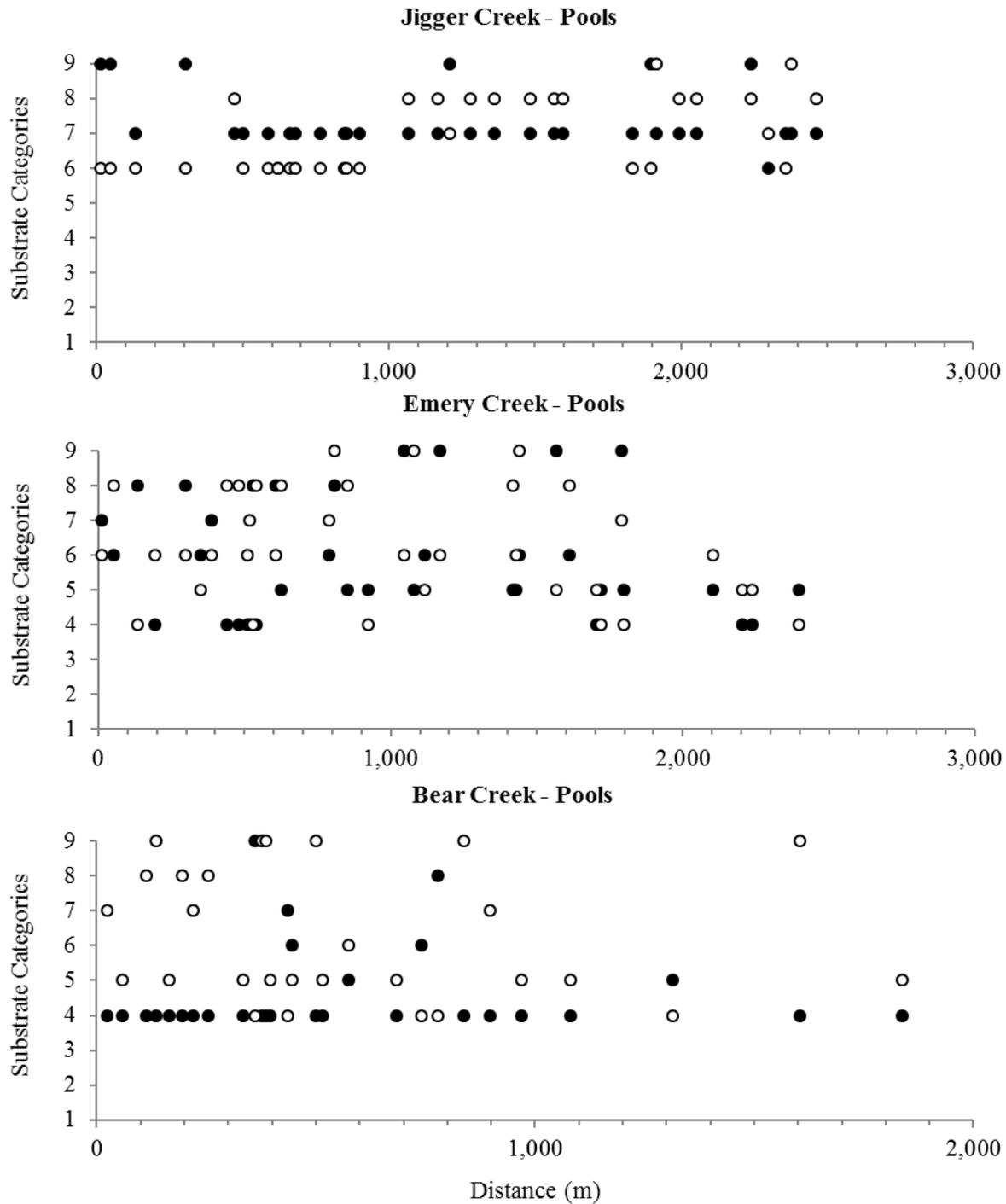


Figure 5. Dominant (solid circles) and subdominant (open circles) substrate category present in pools. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

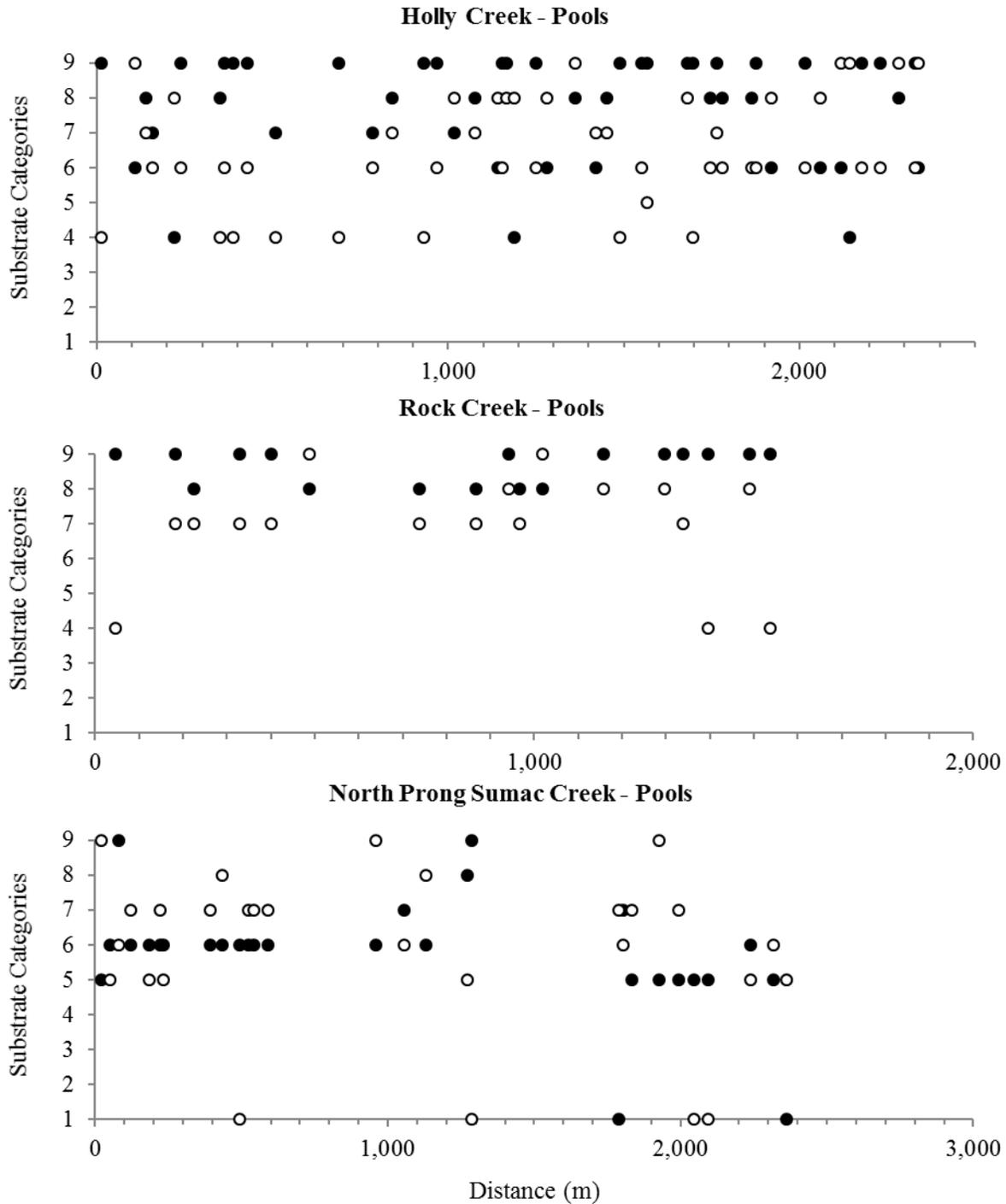


Figure 5 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in pools. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

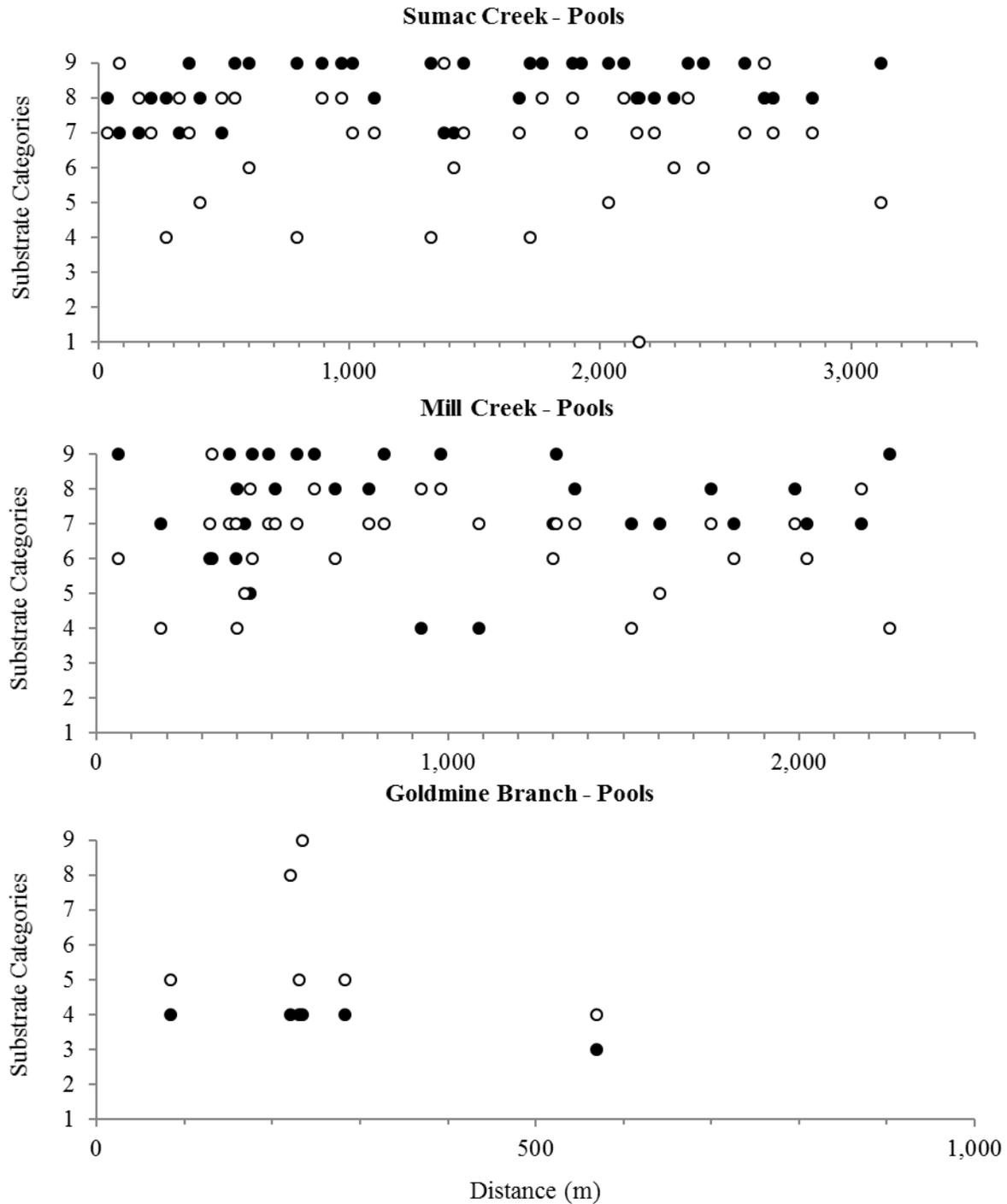


Figure 5 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in pools. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

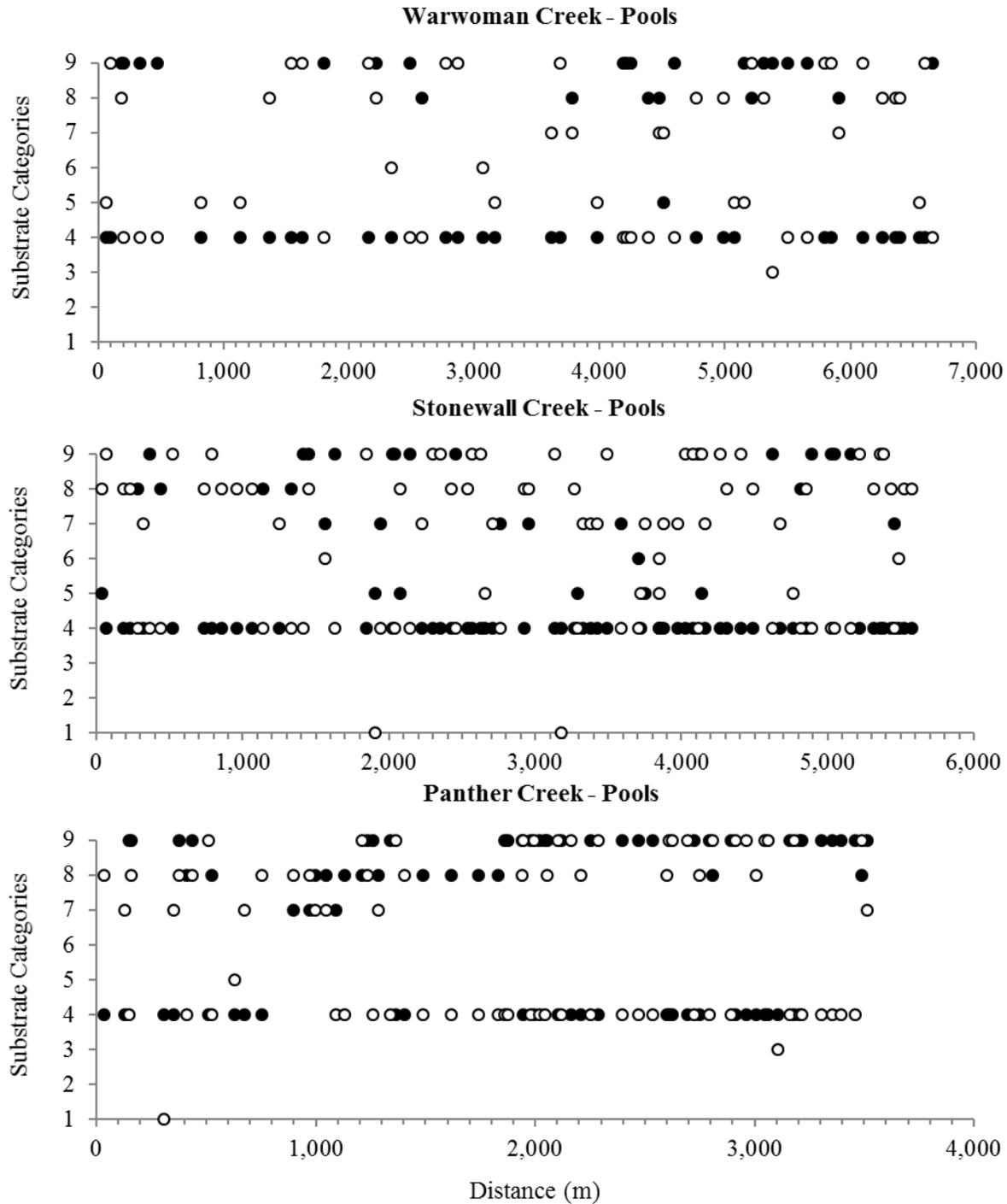


Figure 5 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in pools. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

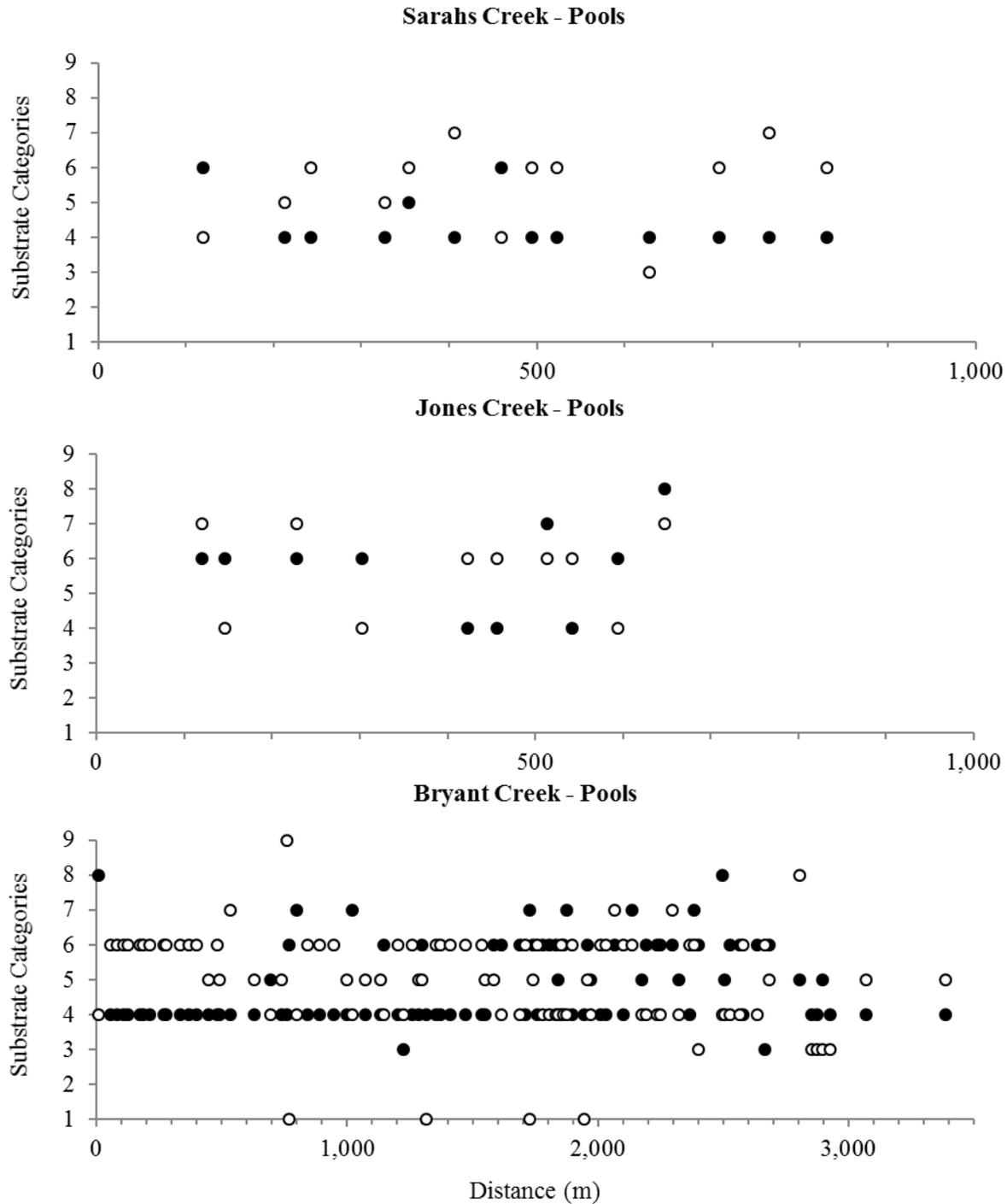


Figure 5 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in pools. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

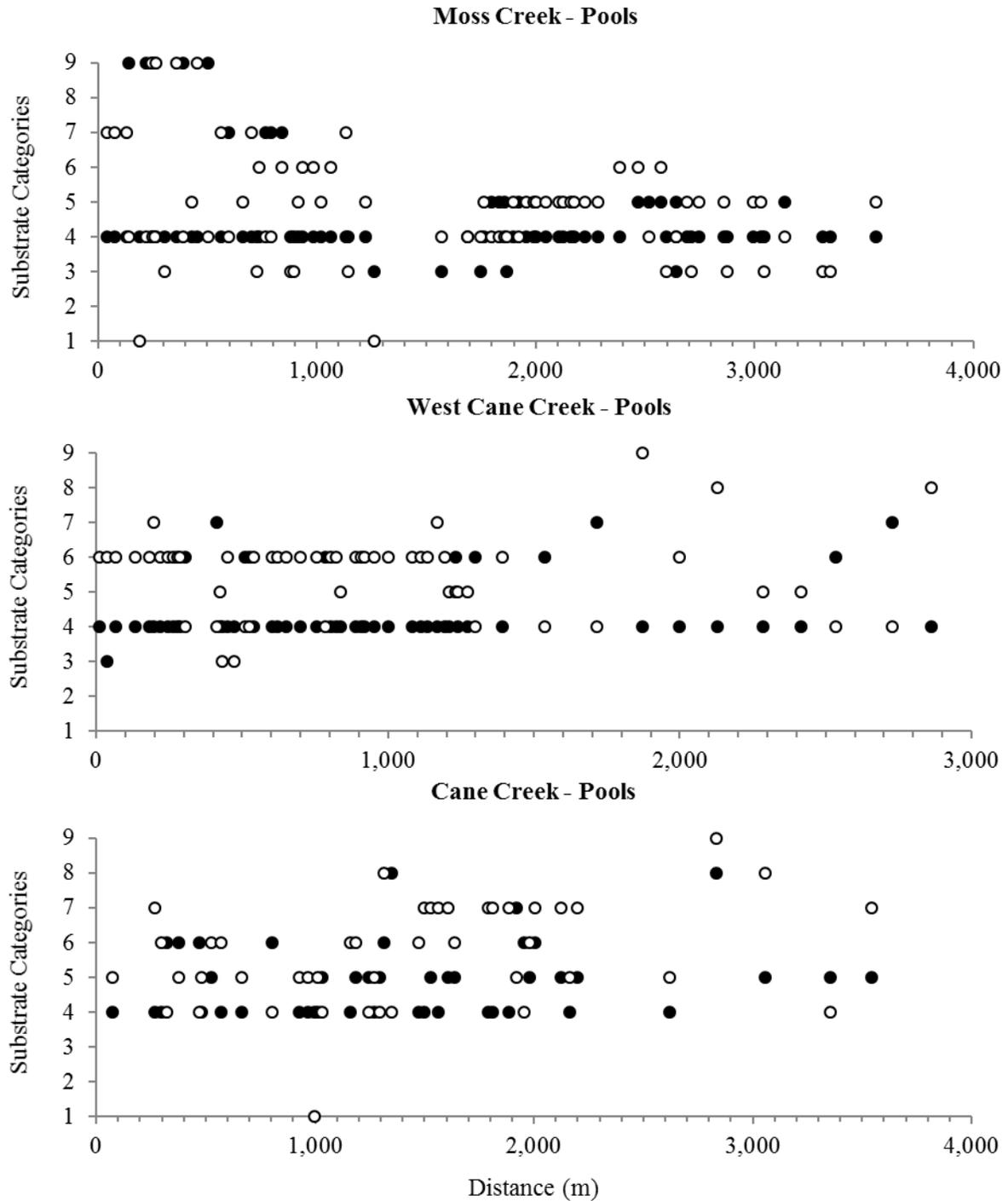


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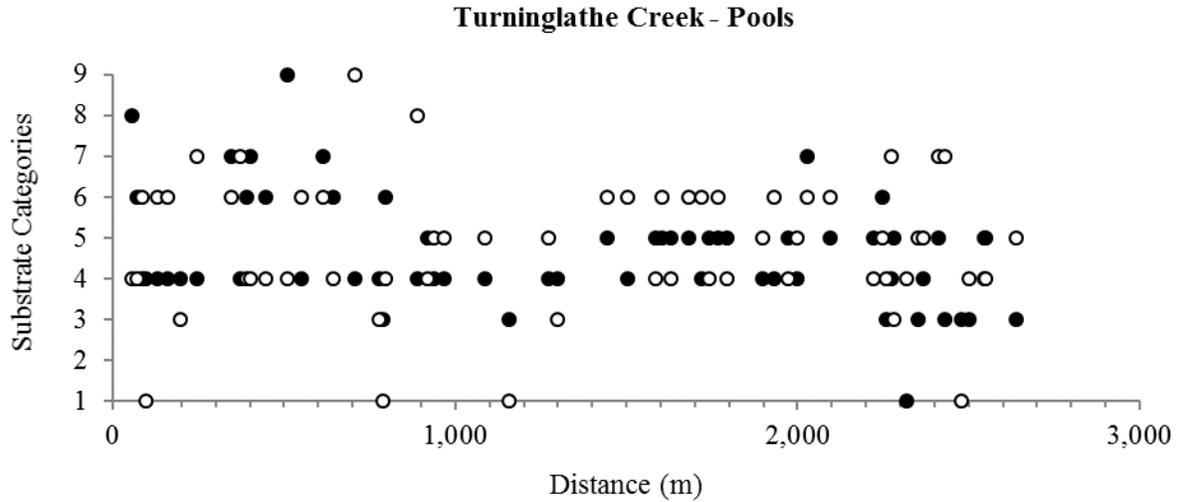


Figure 5 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in pools. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

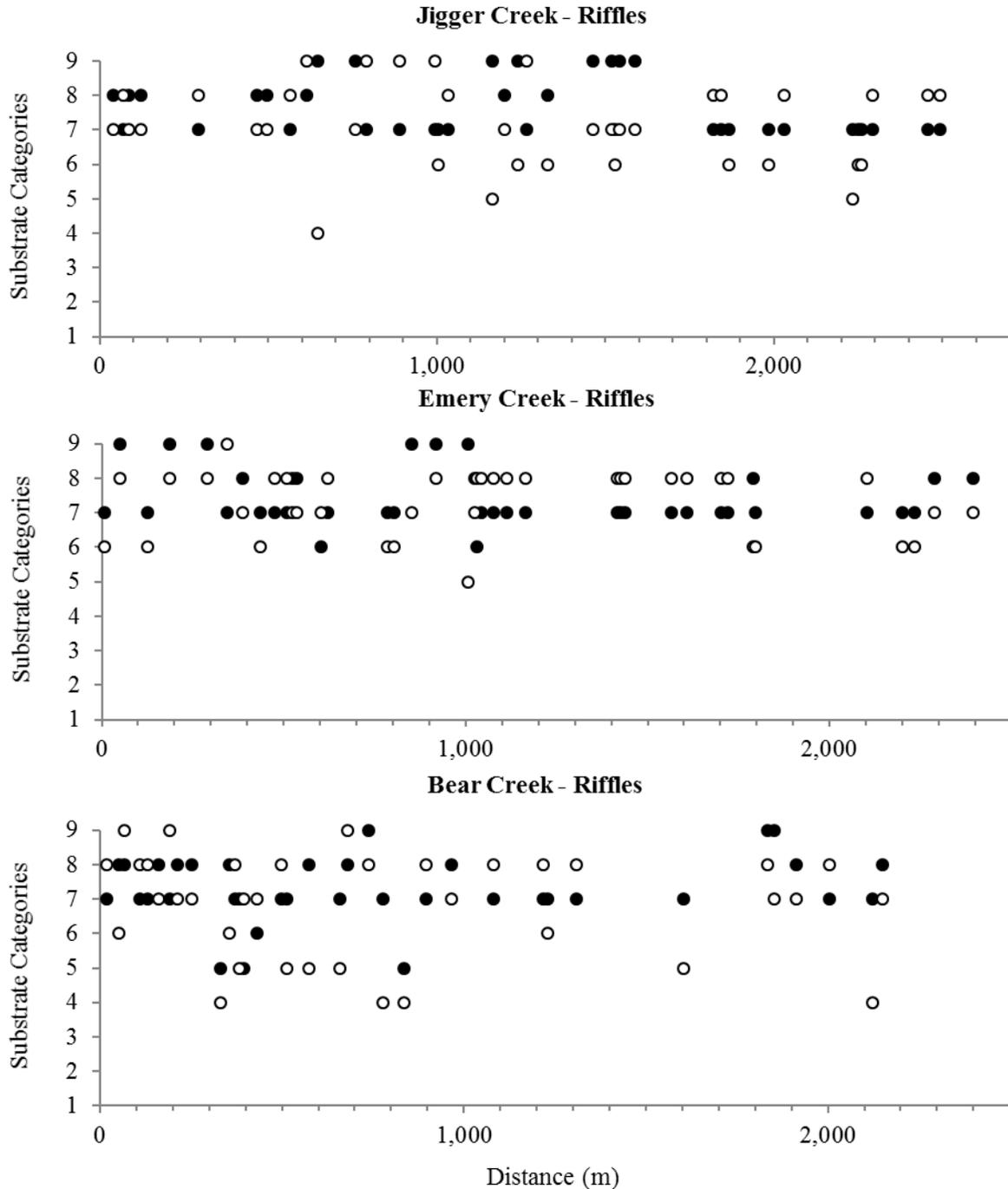


Figure 6. Dominant (solid circles) and subdominant (open circles) substrate category present in riffles. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

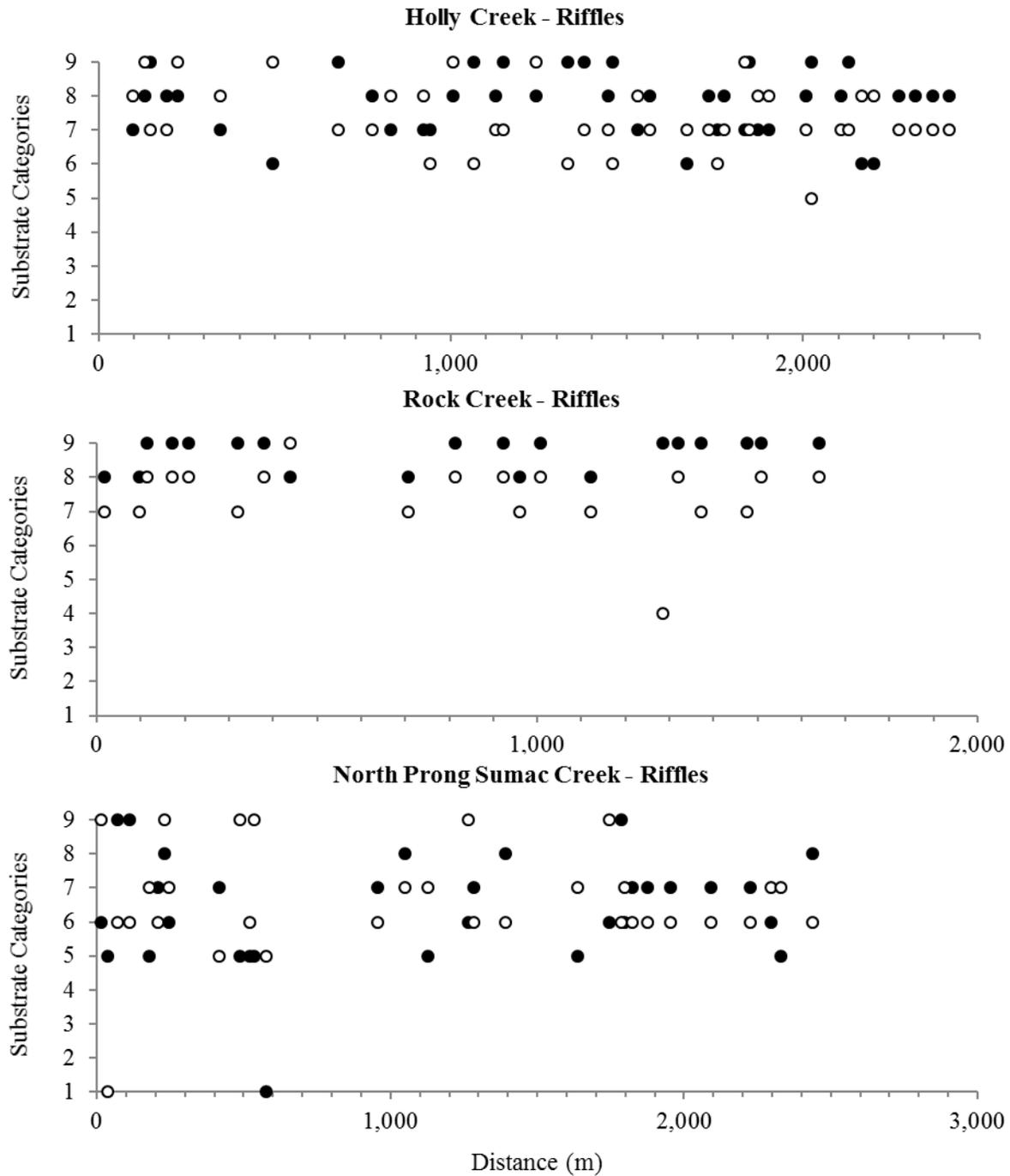


Figure 6 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in riffles. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

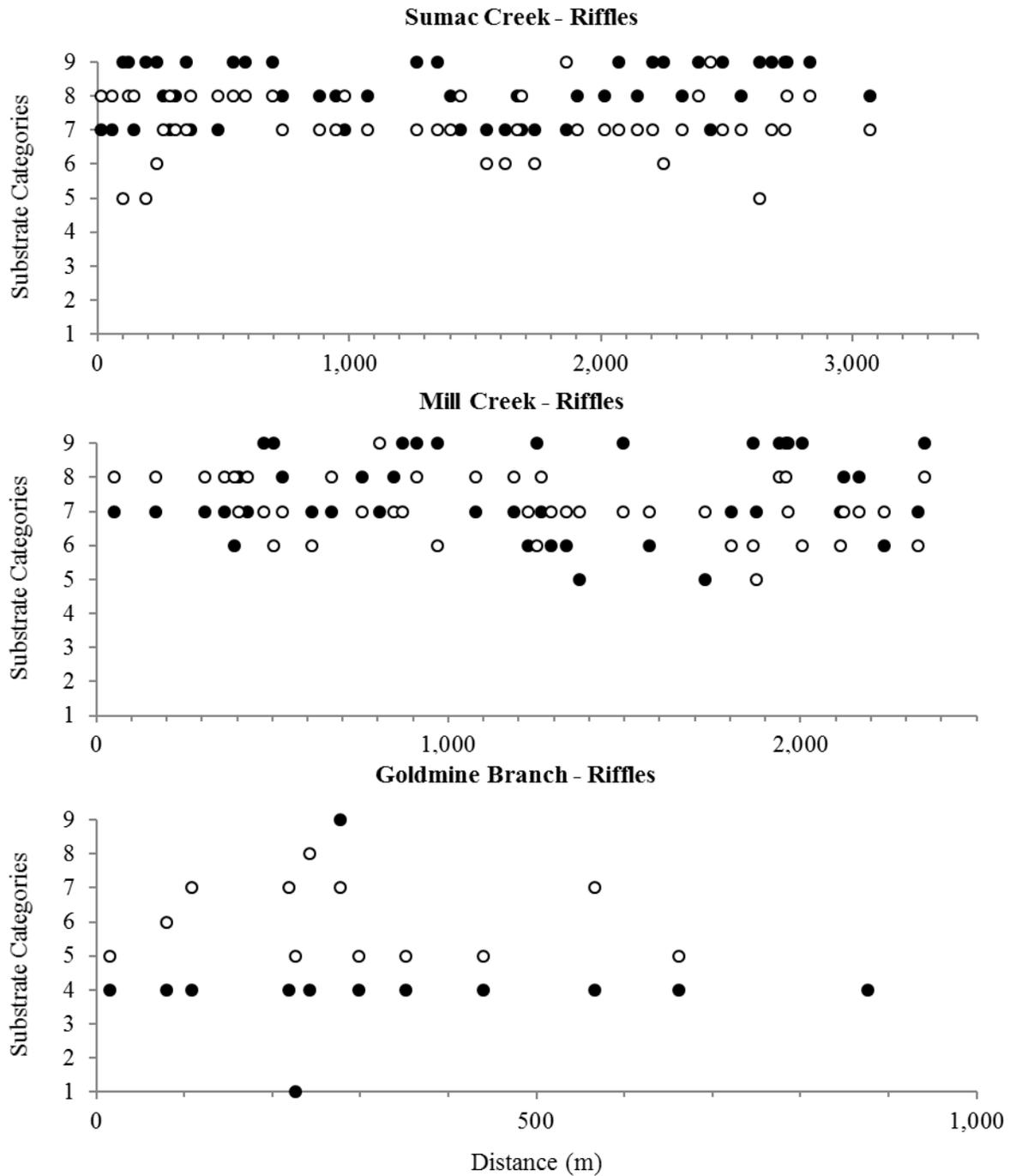


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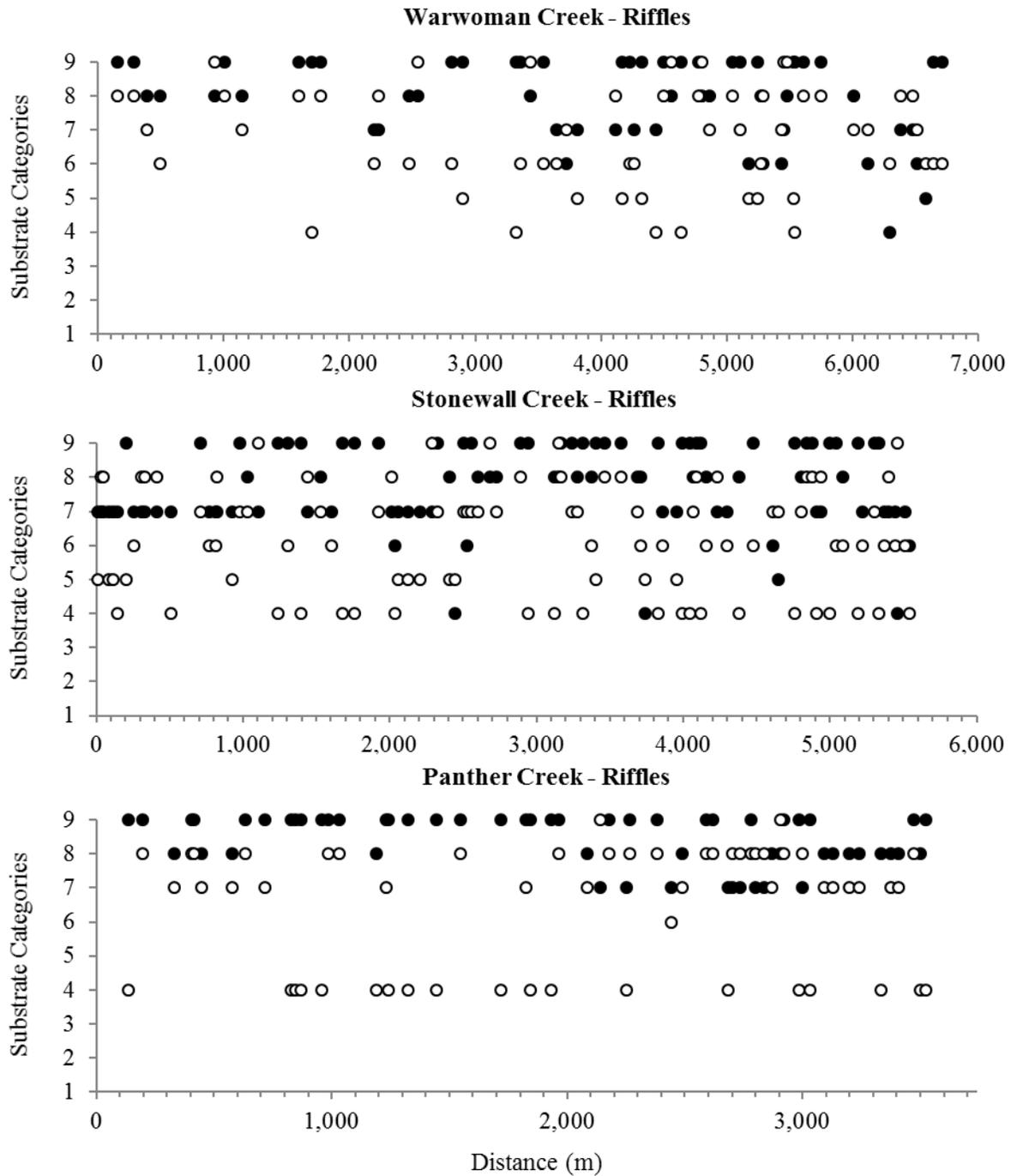


Figure 6 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in riffles. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

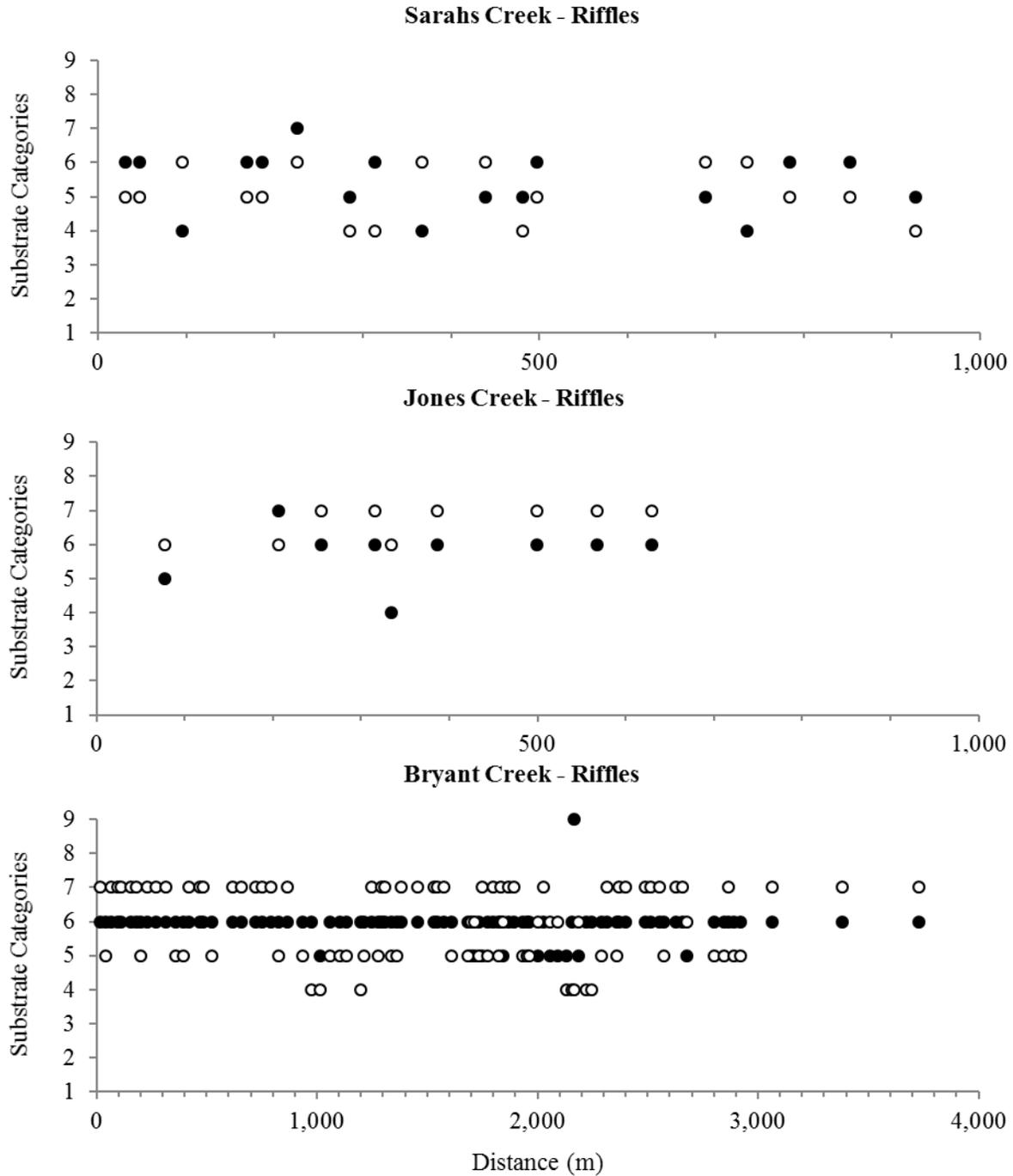


Figure 6 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in riffles. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

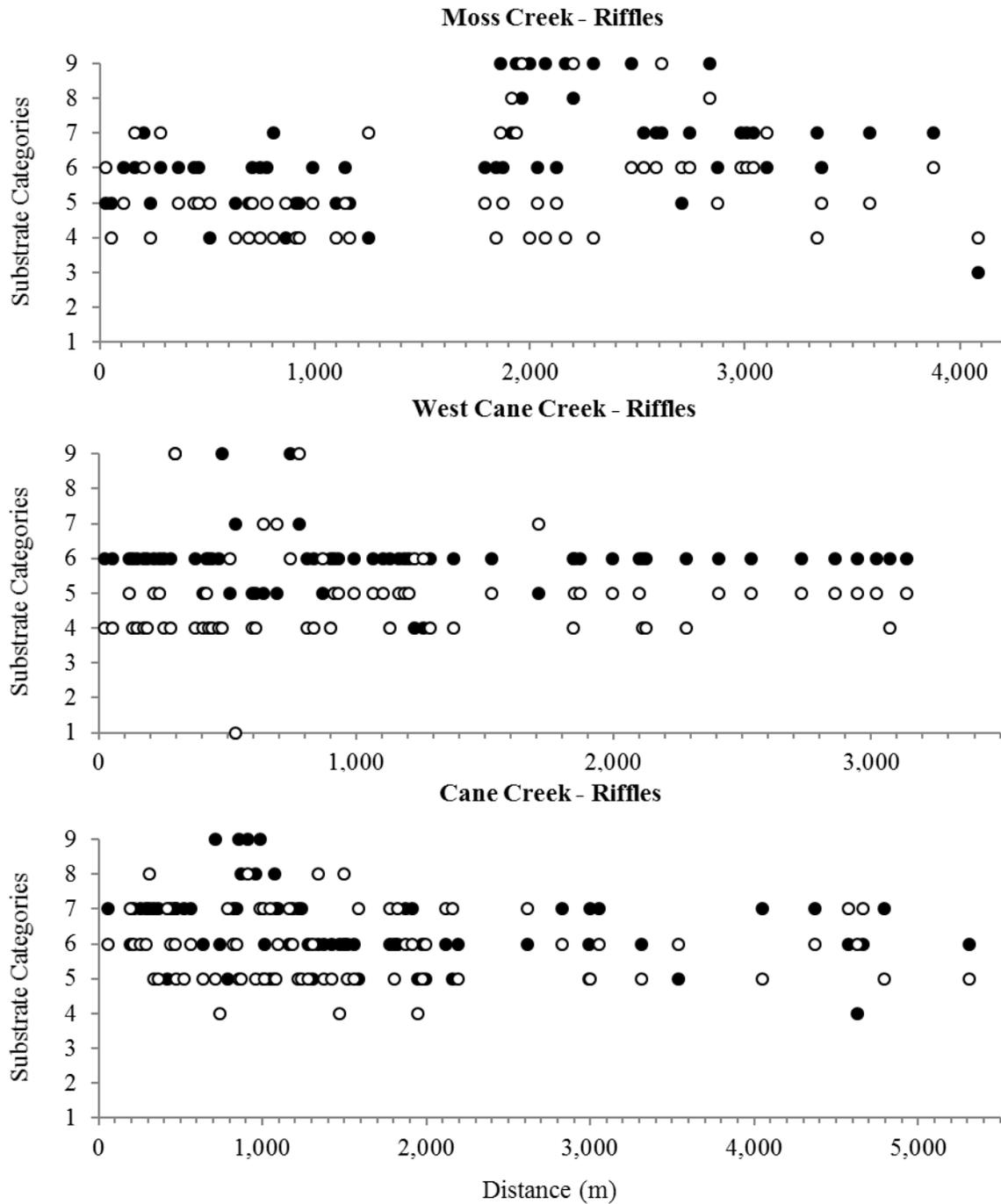


Figure 6 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in riffles. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

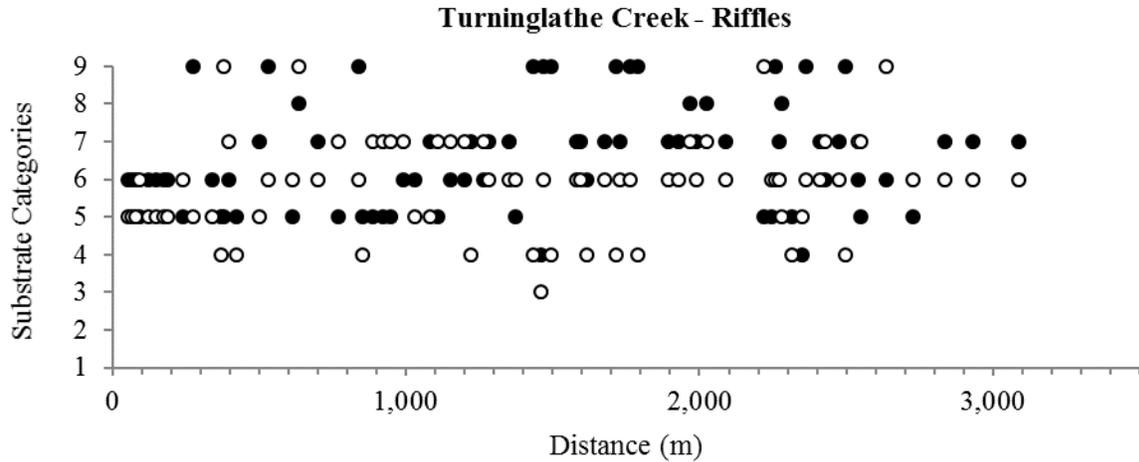


Figure 6 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in riffles. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

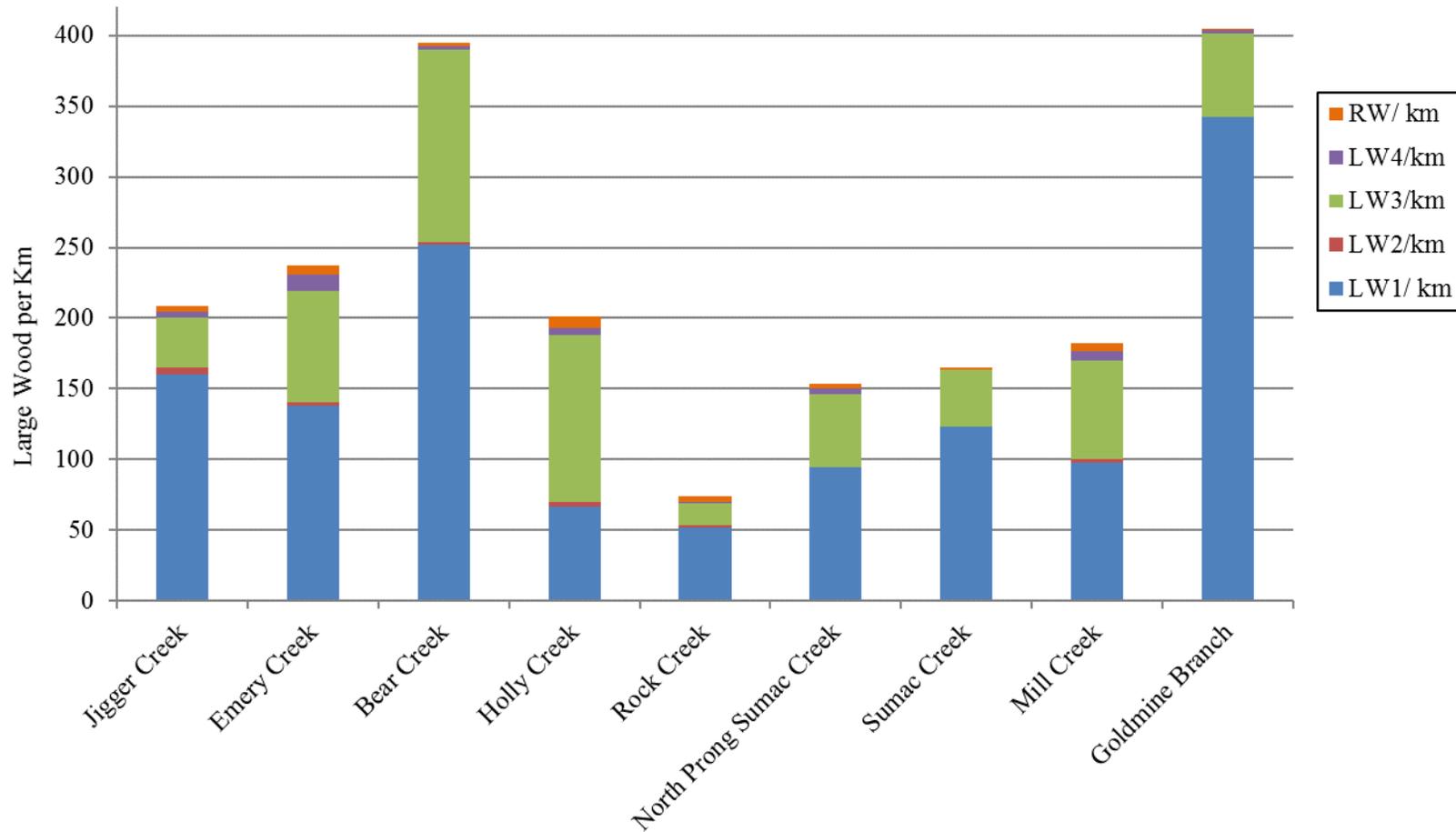


Figure 7. Quantity of large wood (LW; dead and down, any part within bankfull channel) per kilometer. LW size classes: LW1 = 1-5 m length, 10-55 cm diameter; LW2 = 1-5 m length, >55 cm diameter; LW3 = >5 m length, 10-55 cm diameter; LW4 = >5 m length, >55 cm diameter; RW = rootwad.

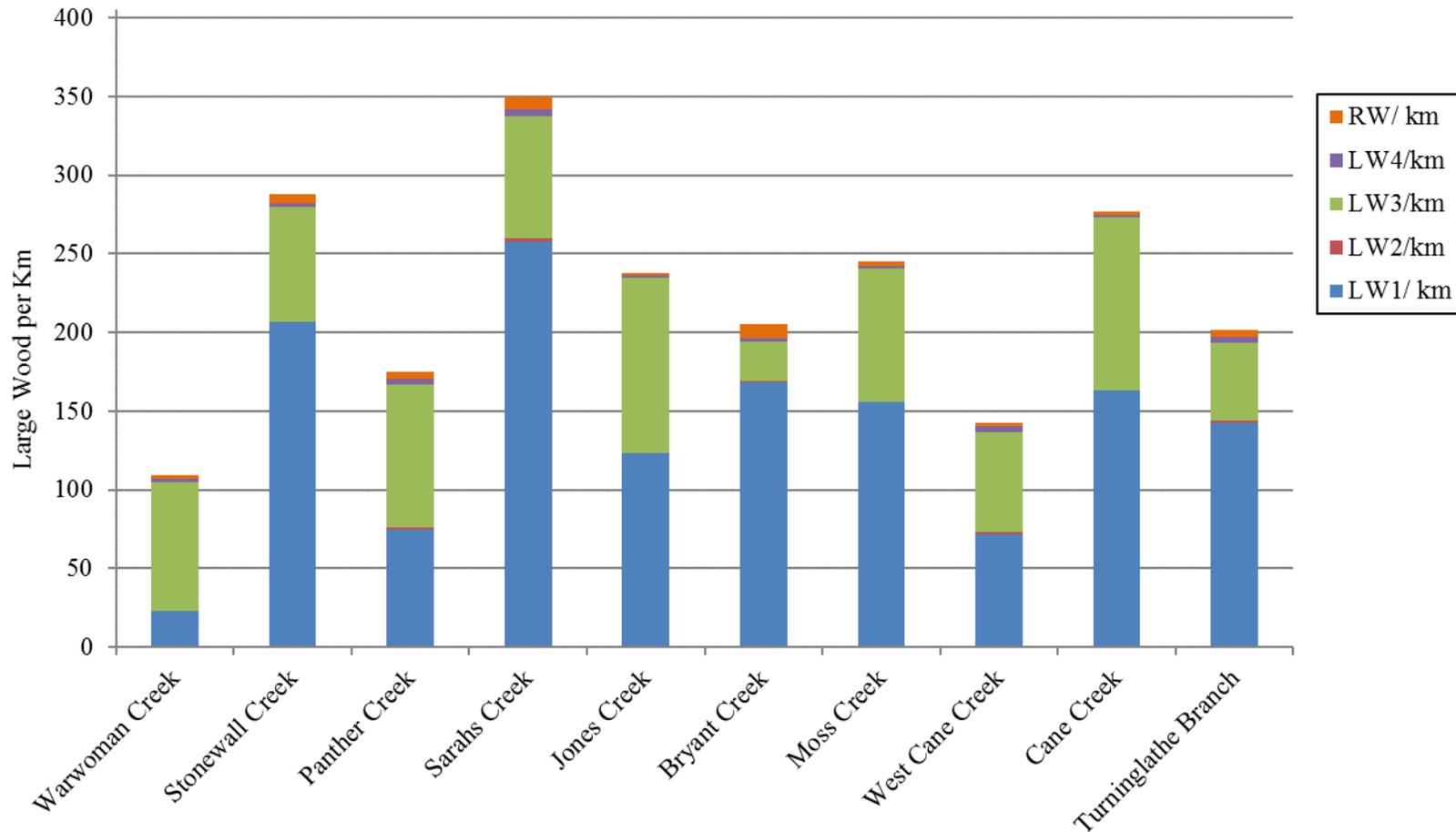


Figure 7 continued. Quantity of large wood (LW; dead and down, any part within bankfull channel) per kilometer. LW size classes: LW1 = 1-5 m length, 10-55 cm diameter; LW2 = 1-5 m length, >55 cm diameter; LW3 = >5 m length, 10-55 cm diameter; LW4 = >5 m length, >55 cm diameter; RW = rootwad.

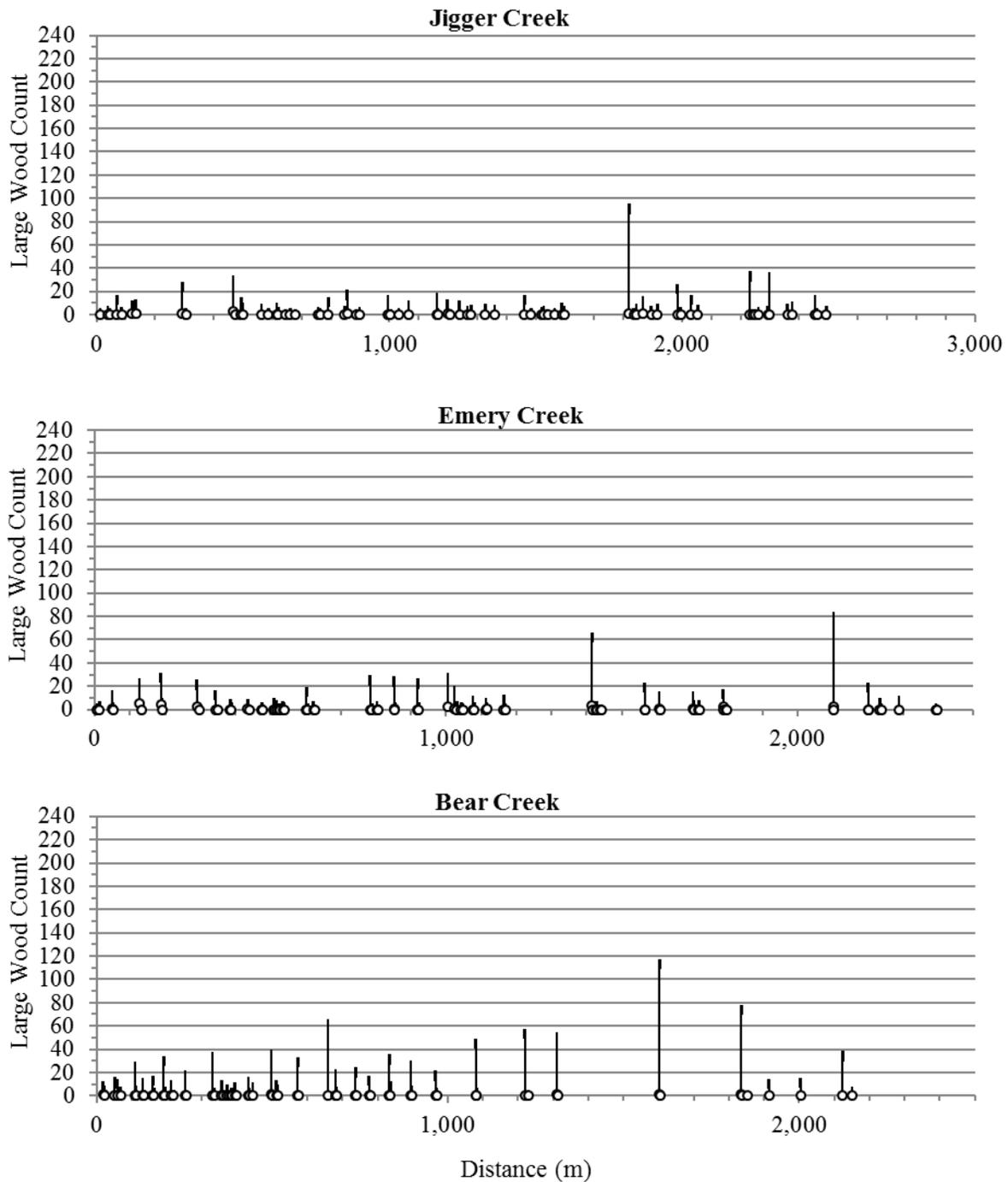


Figure 8. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units in each stream inventoried. Jigger Cr. LW n=521 and habitat unit n=69, Emery Cr. LW n=568 and habitat unit n=75, and Bear Cr. LW n=988 and habitat unit n=64.

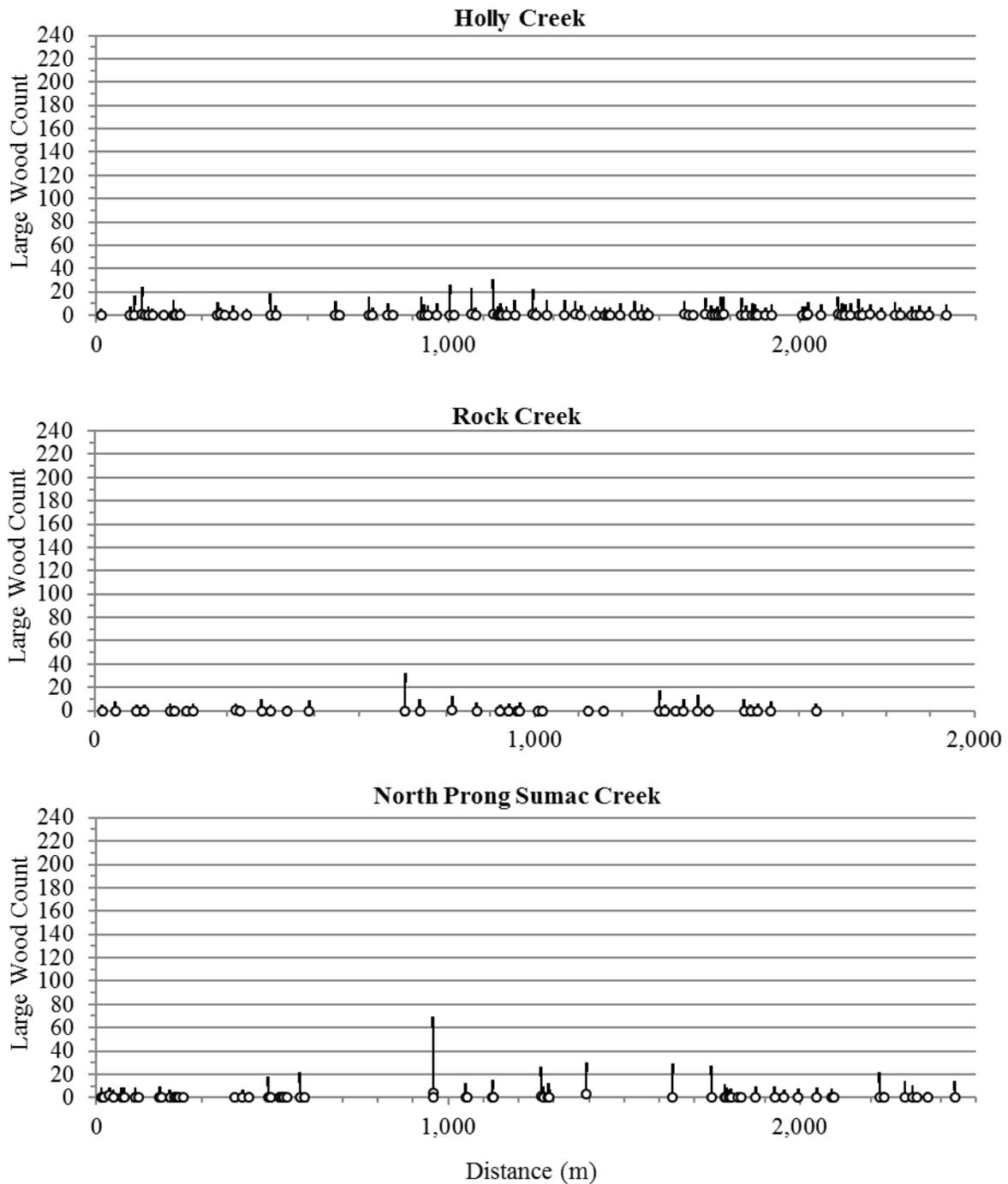


Figure 8 continued. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units in each stream inventoried. Holly Cr. LW n=486 and habitat unit n=88, Rock Cr. LW n=121 and habitat unit n=37, and North Prong Sumac Cr. LW n=375 and habitat unit n=59.

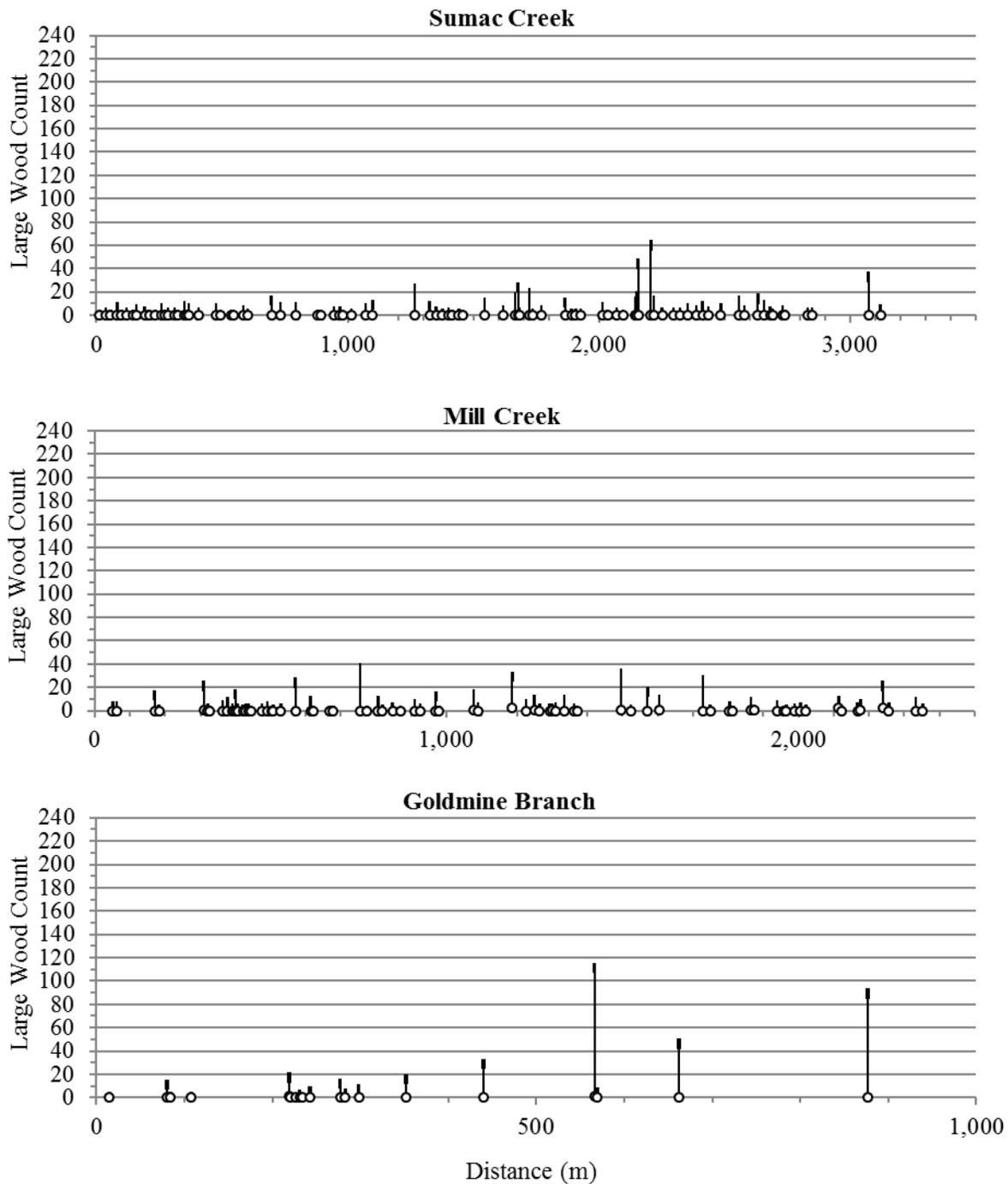


Figure 8 continued. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units in each stream inventoried. Sumac Cr. LW n=514 and habitat unit n=85, Mill Cr. LW n=429 and habitat unit n=74, and Goldmine Br. LW n=355 and habitat unit n=19.

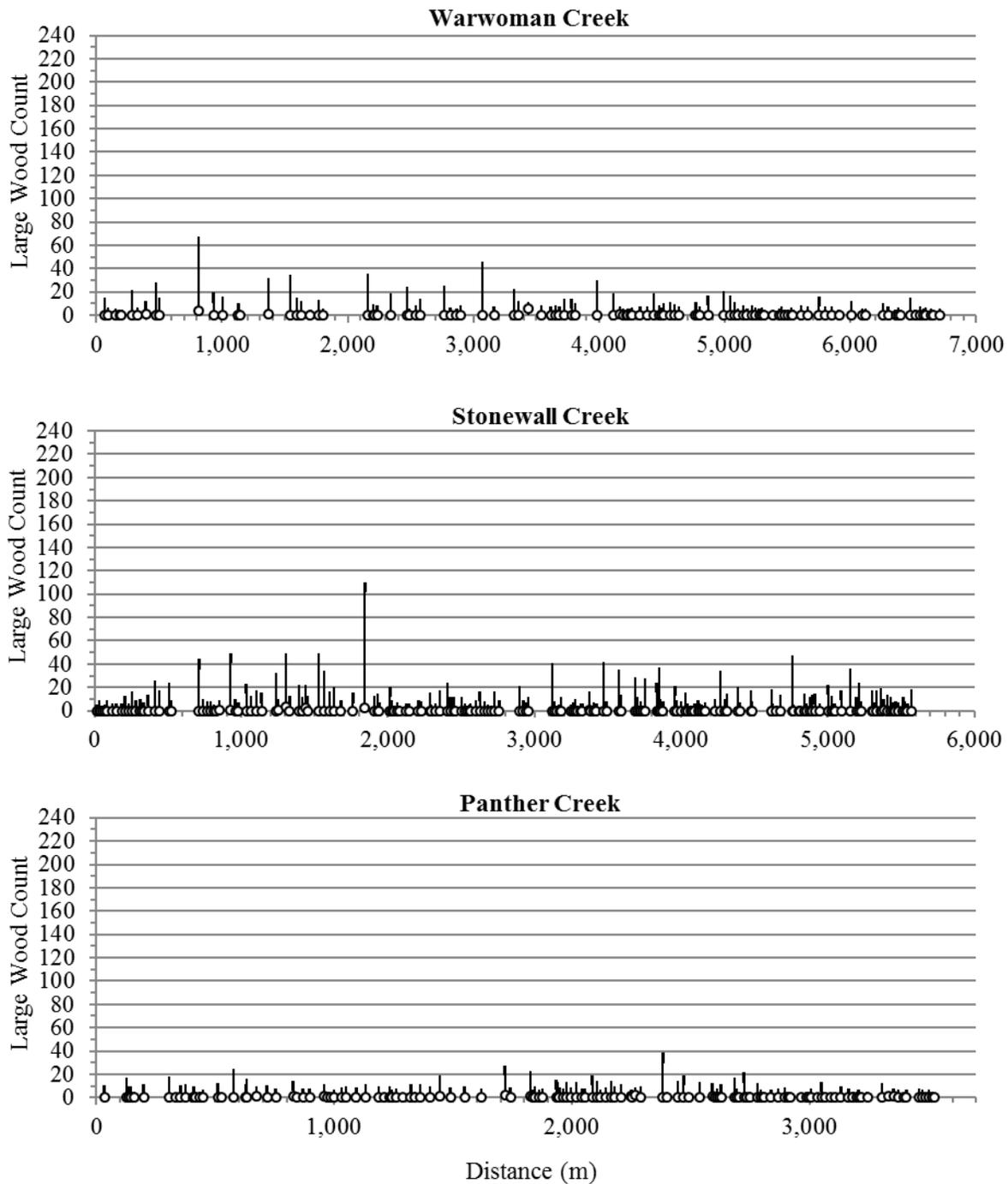


Figure 8 continued. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units in each stream inventoried. Warwoman Cr. LW n=734 and habitat unit n=114, Stonewall Cr. LW n=1604 and habitat unit n=170, and Panther Cr. LW n=616 and habitat unit n=132.

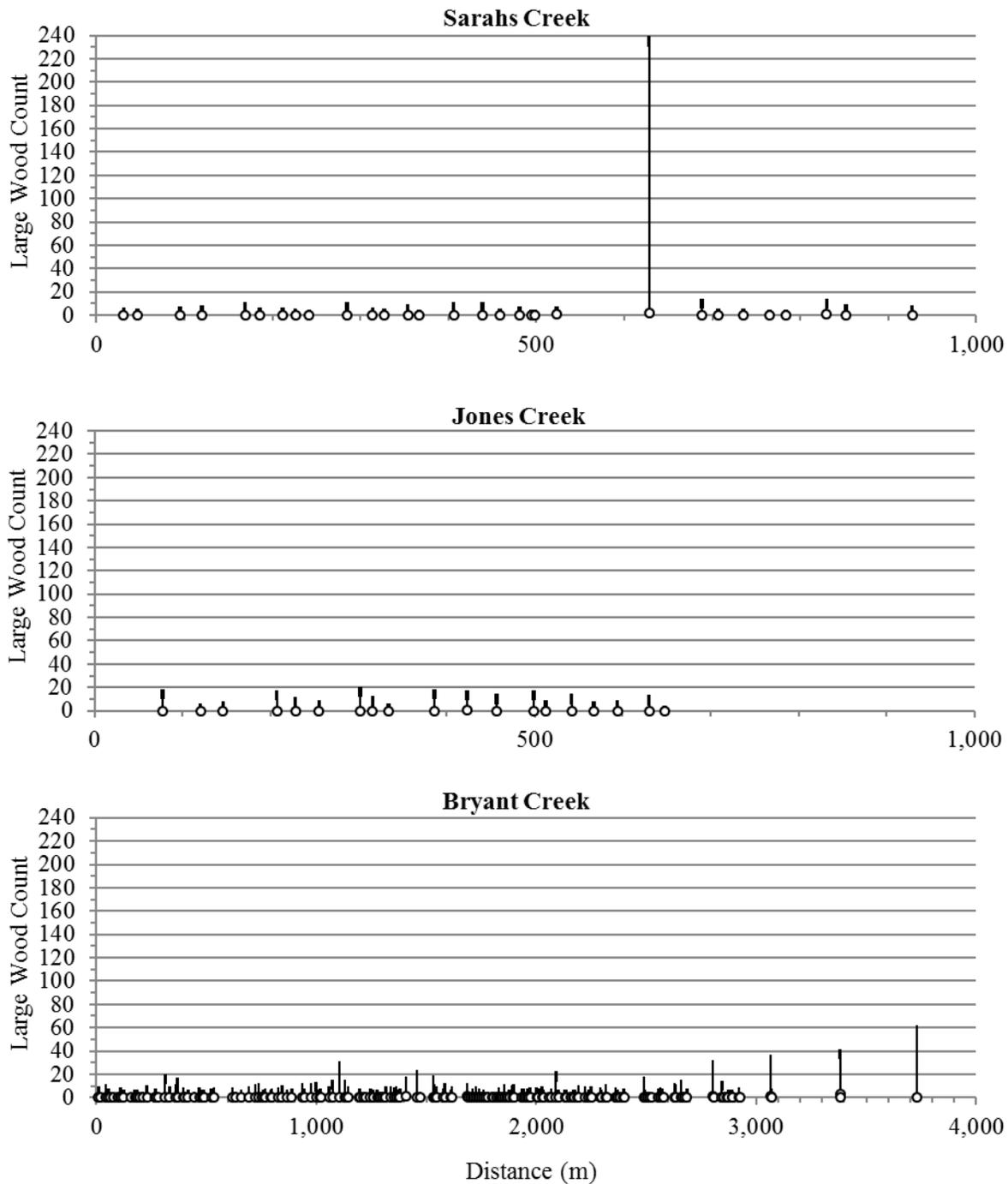


Figure 8 continued. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units in each stream inventoried. Sarahs Cr. LW n=324 and habitat unit n=30, Jones Cr. LW n=154 and habitat unit n=19, and Bryant Cr. LW n=765 and habitat unit n=179.

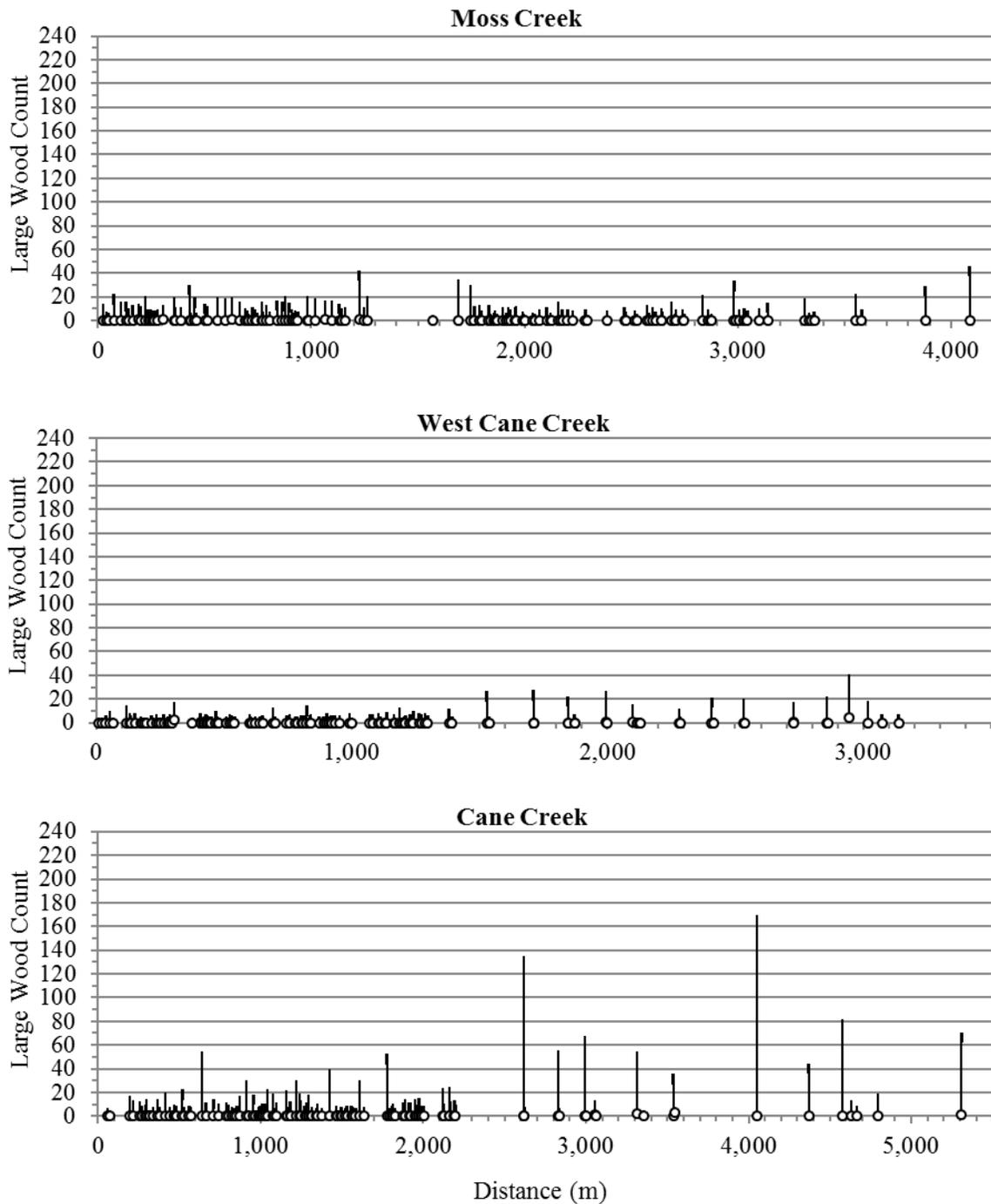


Figure 8 continued. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units in each stream inventoried. Moss Cr. LW n=1003 and habitat unit n=131, West Cane Cr. LW n=450 and habitat unit n=117, and Cane Cr. LW n=1470 and habitat unit n=114

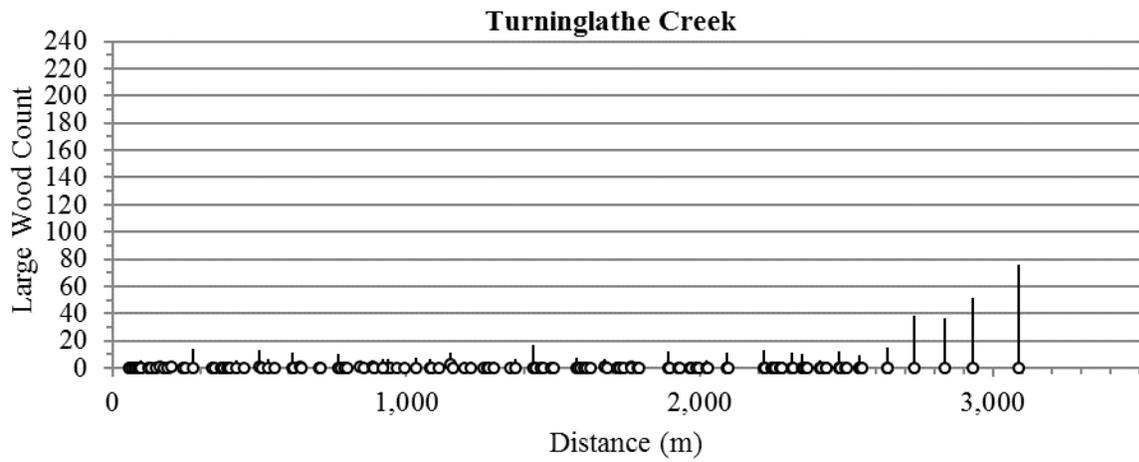


Figure 8 continued. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units in each stream inventoried. Turninglathe Cr. LW n=639 and habitat unit n=134.

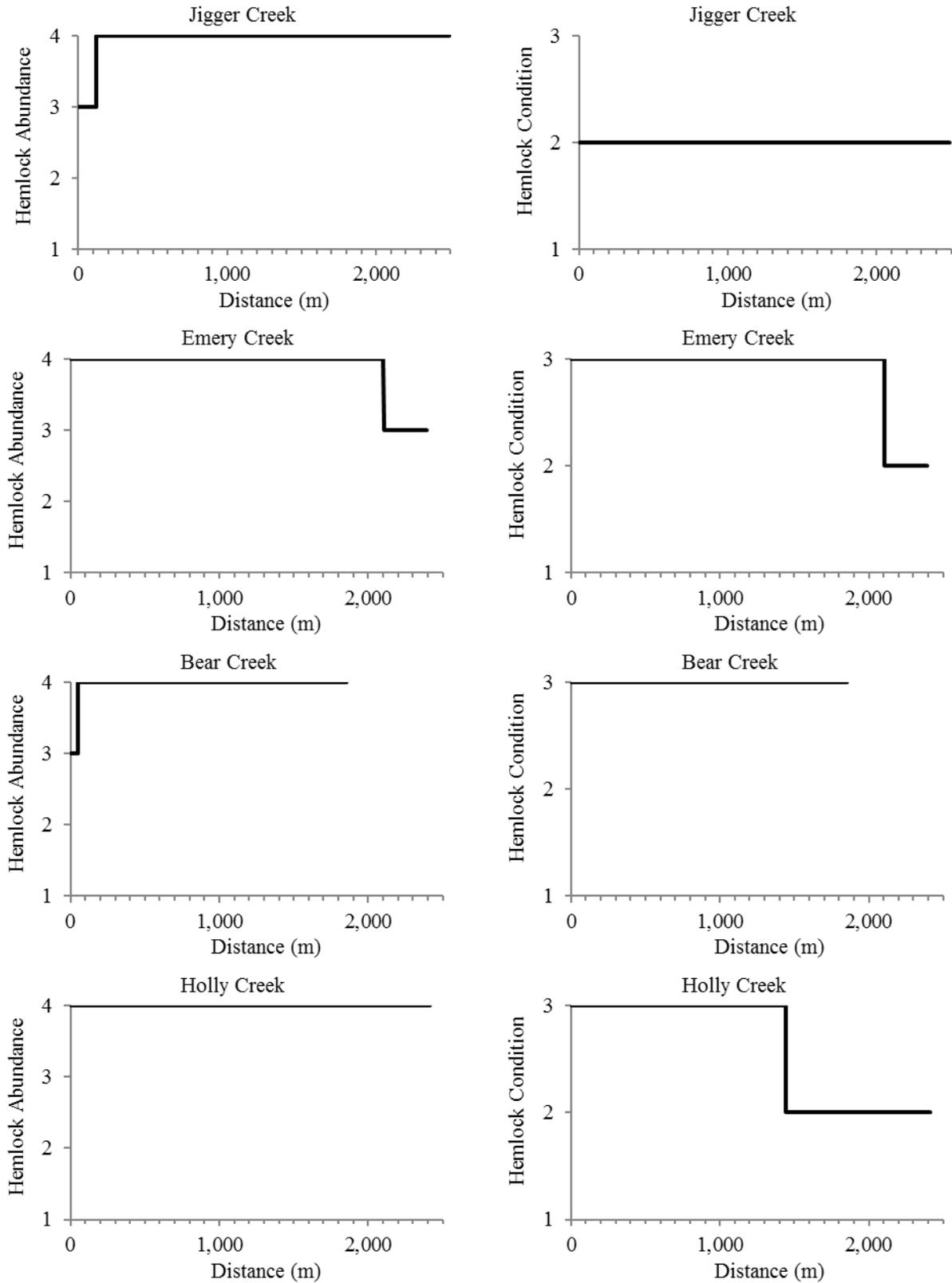


Figure 9. Hemlock abundance (1 = none; 2 = 1-10; 3 = 11-50, 4 = >50) and condition (1 = Healthy/Light Infestation, 2 = Infested, 3 = Dead) shown longitudinally for each stream inventory (see appendix B for detailed categories).

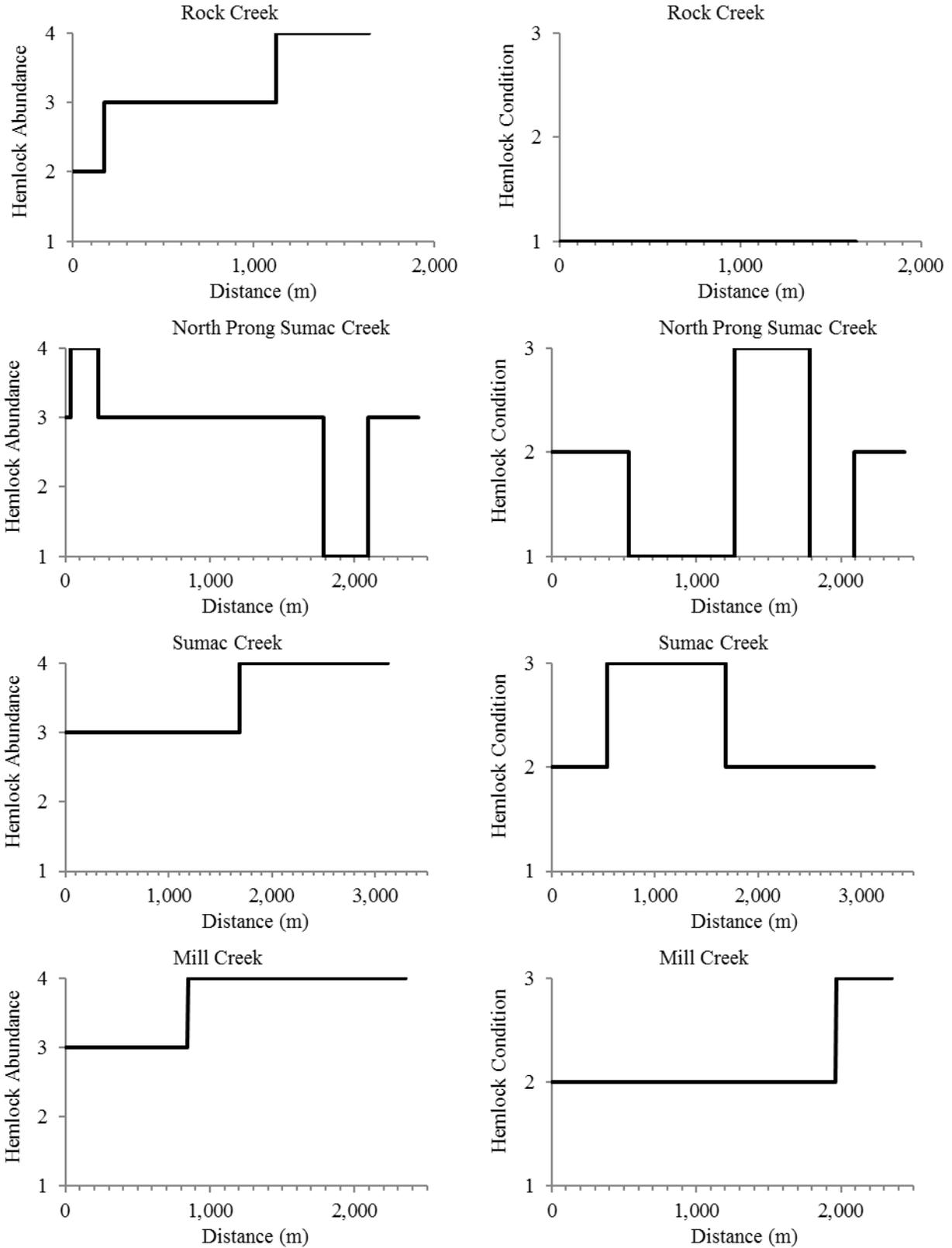


Figure 9 continued. Hemlock abundance (1 = none; 2 = 1-10; 3 = 11-50, 4 = >50) and condition (1 = Healthy/Light Infestation, 2 = Infested, 3 = Dead) shown longitudinally for each stream inventory (see appendix B for detailed categories).

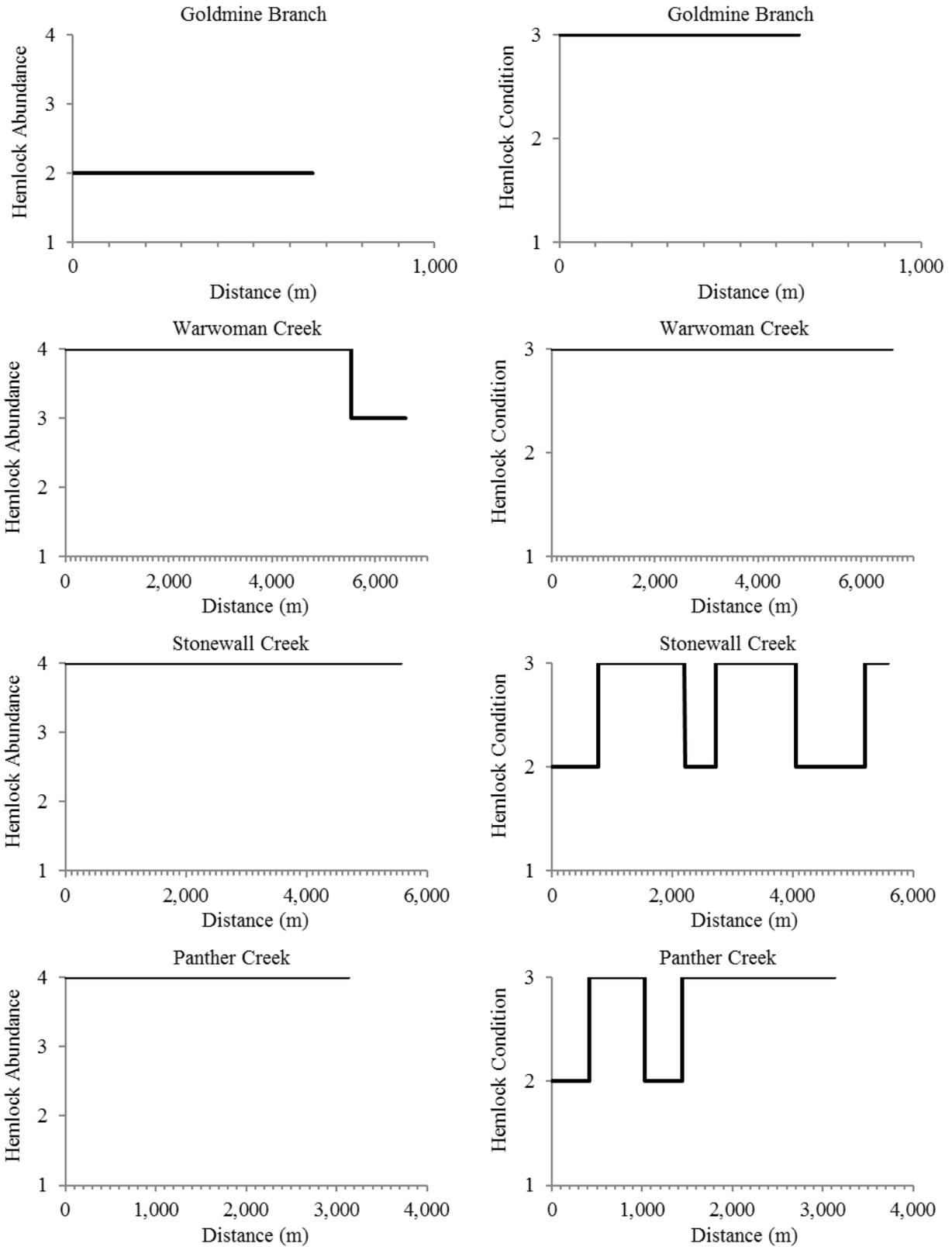


Figure 9 continued. Hemlock abundance (1 = none; 2 = 1-10; 3 = 11-50, 4 = >50) and condition (1 = Healthy/Light Infestation, 2 = Infested, 3 = Dead) shown longitudinally for each stream inventory (see appendix B for detailed categories).

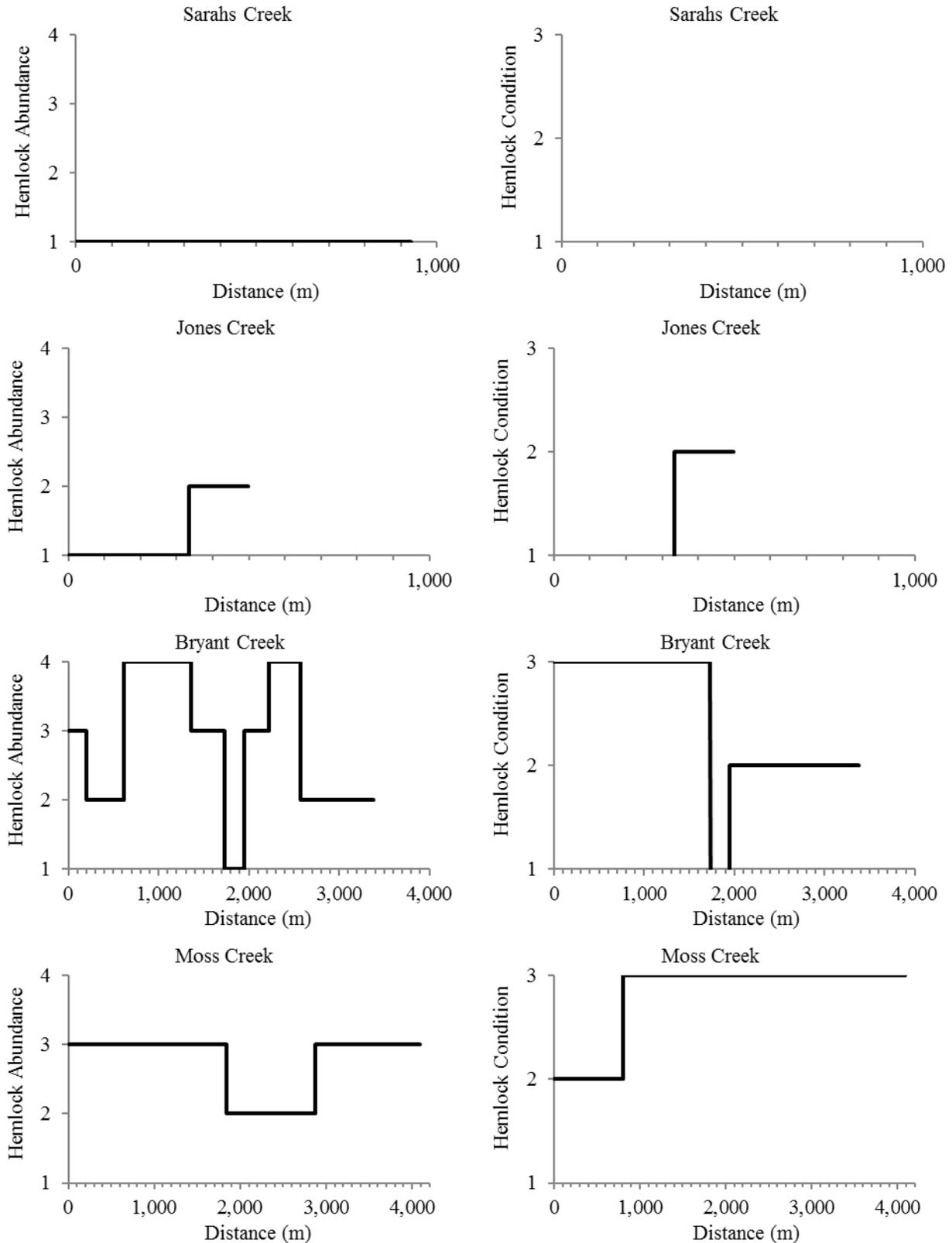


Figure 9 continued. Hemlock abundance (1 = none; 2 = 1-10; 3 = 11-50, 4 = >50) and condition (1 = Healthy/Light Infestation, 2 = Infested, 3 = Dead) shown longitudinally for each stream inventory (see appendix B for detailed categories).

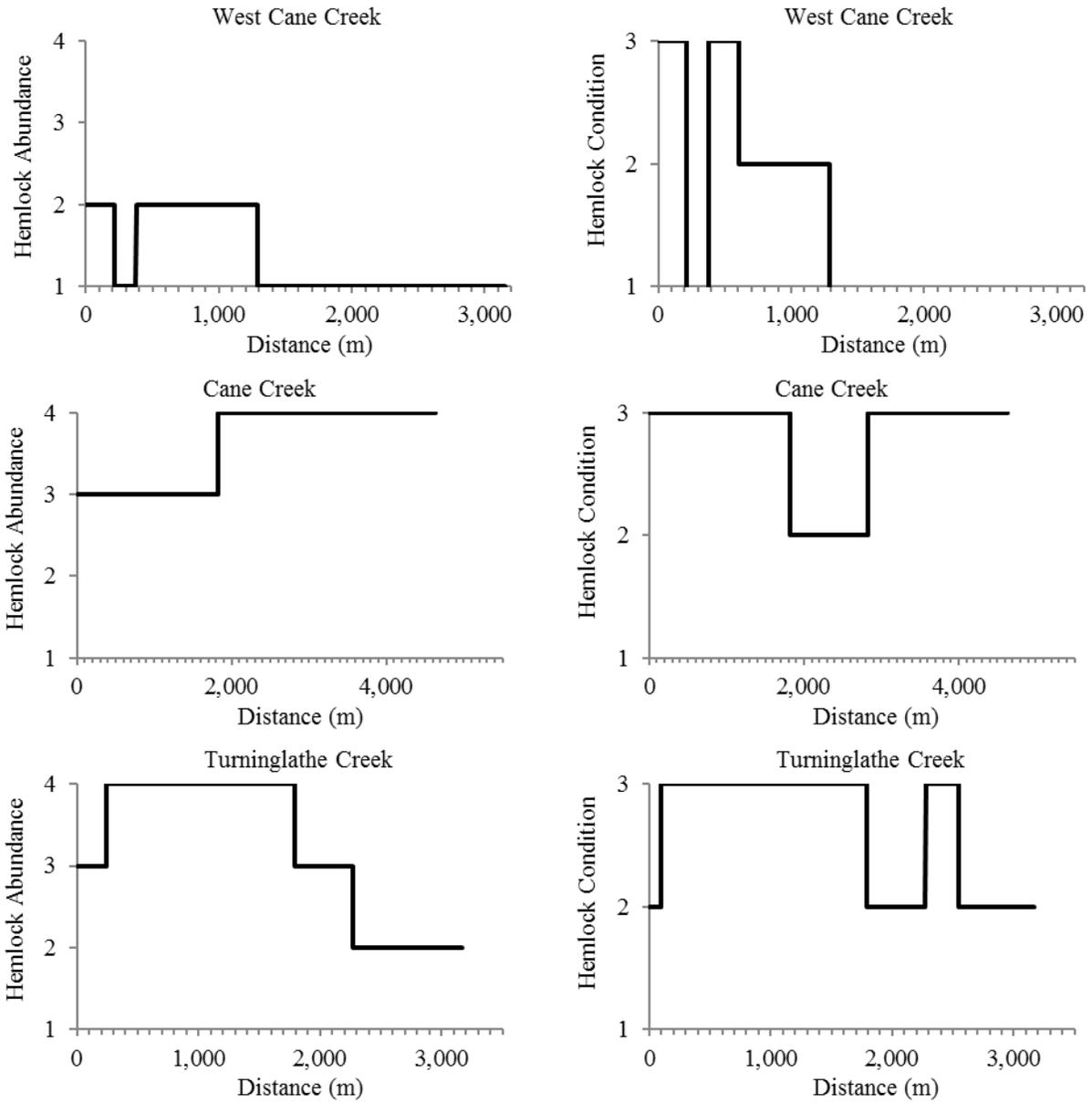


Figure 9 continued. Hemlock abundance (1 = none; 2 = 1-10; 3 = 11-50, 4 = >50) and condition (1 = Healthy/Light Infestation, 2 = Infested, 3 = Dead) shown longitudinally for each stream inventory (see appendix B for detailed categories).

Table 1. Summary of streams inventoried on the Chattahoochee National Forest, 2017.

Site #	Stream Name	Topo Quad	Date		BVET habitat (km)	Start Location/Comment	
			Start	End			
Conasauga District							
2017-A1	Jigger Creek	Tennga	6/20/17	6/20/17	2.5	80 m downstream of private property sign	
2017-A2	Emery Creek	Crandall and Dyer Gap	6/22/17	6/22/17	2.4		
2017-A3	Bear Creek	Dyer Gap	6/23/17	6/25/17	2.5	Approx 2 km on Bear Cr. Trail, trail on left	
2017-A4	Holly Creek	Crandall	6/20/17	6/21/17	2.4		
2017-A5	Rock Creek	Ramhurst	6/23/17	6/23/17	1.6	1 mile upstream from Dennis Mill Rd.	
2017-A6	North Prong Sumac Cr.	Tennga	6/21/17	6/22/17	2.4	Road on left looking upstream	
2017-A7	Sumac Creek	Tennga	6/25/17	6/25/17	3.1	150 m down mtn. from Rd. 17A	
2017-A8	Mill Creek	Tennga	6/21/17	6/22/17	2.3	80 m upstream of culvert on FS 630D	
Chattooga River District							
2017-B1	Goldmine Branch	Satolah	6/26/17	6/27/17	0.9	Confluence with Little Creek	
2017-B2	Warwoman Creek	Satolah and Rabun Bald	6/27/17	6/28/17	6.7	Confluence with Chattooga River	
2017-B3	Stonewall Creek	Tiger	6/27/17	6/28/17	5.6		
2017-B4	Panther Creek	Tallulah Falls	6/28/17	6/29/17	3.5	Off FS184, walk Wee Vogan Rd. for 200m	
2017-B5	Sarahs Creek	Satolah and Rabun Bald	6/26/17	6/26/17	0.9	Confluence with Warwoman Creek	
Blue Ridge District							
2017-C1	Jones Creek	Nimblewill	7/3/17	7/3/17	0.6	Beside "Artificial Lures Only" sign	
2017-C2	Bryant Creek	Dahlonega, Campbell Mtn, Suches	6/29/17	6/29/17	3.7	Off Byrant Creek trail ~150 m	
2017-C3	Moss Creek	Campbell Mtn	7/2/17	7/3/17	4.1	Walked 500 m via old road access	
2017-C4	West Cane Creek	Campbell Mtn	7/5/17	7/5/17	3.2	60 m upstream of cabin	
2017-C5	Cane Creek	Campbell Mtn and Suches	7/2/17	7/3/17	5.3	Old road on left bank, fence corner on right	
2017-C6	Turninglathe Branch	Campbell Mtn and Suches	7/3/17	7/5/17	3.2	Confluence with Cane Creek	
					Total	56.9	

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

Site #	Stream Name	GPS (NAD83)	
		Downstream Inventory Start	Upstream Inventory End
2017-A1	Jigger Creek	N34.96651 W84.64864	N34.96250 W84.62999
2017-A2	Emery Creek	N34.83932 W84.62707	N34.85687 W84.62462
2017-A3	Bear Creek	N34.83240 W84.56753	N34.84355 W84.58661
2017-A4	Holly Creek	N34.81431 W84.64653	N34.80487 W84.63132
2017-A5	Rock Creek	N34.70518 W84.70694	N34.71234 W84.70311
2017-A6	North Prong Sumac Creek	N34.93427 W84.70198	N34.93603 W84.68134
2017-A7	Sumac Creek	N34.90891 W84.70987	N34.91934 W84.69876
2017-A8	Mill Creek	N34.88299 W84.69906	N34.89190 W84.68912
2017-B1	Goldmine Branch	N34.97815 W83.17714	N34.97166 W83.17624
2017-B2	Warwoman Creek	N34.88010 W83.22957	N34.90202 W83.25414
2017-B3	Stonewall Creek	N34.81175 W83.43876	N34.83518 W83.47053
2017-B4	Panther Creek	N34.67841 W83.39746	N34.69552 W83.41649
2017-B5	Sarabs Creek	N34.90174 W83.25024	N34.90863 W83.24967
2017-C1	Jones Creek	N34.57781 W84.12937	N34.58168 W84.12931
2017-C2	Bryant Creek	N34.61254 W84.00085	N34.63447 W84.02061
2017-C3	Moss Creek	N34.58161 W84.11868	N34.60933 W84.11705
2017-C4	West Cane Creek	N34.59936 W84.03449	N34.61973 W84.04611
2017-C5	Cane Creek	N34.60308 W84.02919	N34.64049 W84.04198
2017-C6	Turninglathe Branch	N34.60665 W84.03002	N34.62725 W84.02354

Table 3. Summary of BVET stream habitat attribute averages collected in pools (includes glides) and riffles (include runs and cascades).

Site #	Stream Name	Mean Avg. Depth (cm)		Mean Max. Depth (cm)		Mean Residual Pool Depth (cm)*	Avg. Wetted Width (m)		Avg. % Fines	
		Pools	Riffles	Pools	Riffles		Pools	Riffles	Pools	Riffles
2017-A1	Jigger Creek	35	20	64	46	16	6.7	7.2	12	8
2017-A2	Emery Creek	33	15	50	29	21	4.2	3.9	39	15
2017-A3	Bear Creek	28	15	44	33	13	3.1	2.4	52	19
2017-A4	Holly Creek	50	29	90	59	19	9.4	8.7	16	6
2017-A5	Rock Creek	56	38	92	67	29	8.1	9.3	17	10
2017-A6	North Prong Sumac Creek	18	9	33	23	11	2.4	2.6	14	9
2017-A7	Sumac Creek	42	24	65	47	18	6.5	6.0	21	11
2017-A8	Mill Creek	54	33	73	58	25	7.0	6.0	15	8
2017-B1	Goldmine Branch	12	7	24	15	2	2.0	1.9	84	67
2017-B2	Warwoman Creek	71	42	125	83	30	11.8	13.8	58	20
2017-B3	Stonewall Creek	39	23	60	42	19	5.8	6.1	58	21
2017-B4	Panther Creek	43	23	77	48	9	7.0	8.2	44	15
2017-B5	Sarabs Creek	43	22	75	42	20	7.3	6.2	62	24
2017-C1	Jones Creek	46	31	77	53	14	7.5	7.4	38	18
2017-C2	Bryant Creek	27	9	41	22	17	4.1	3.0	54	16
2017-C3	Moss Creek	21	12	40	22	5	3.8	3.0	58	20
2017-C4	West Cane Creek	20	9	34	20	11	2.1	2.1	61	22
2017-C5	Cane Creek	36	19	56	37	21	3.8	4.7	46	13
2017-C6	Turninglathe Branch	26	15	35	29	14	2.0	2.2	56	20

*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.

Site #	Stream Name	Habitat Area (m ²)						Percent Area					Unit Count				
		Pool	Glide	Riffle	Run	Cas- cade	Total	Pool	Glide	Riffle	Run	Cas- cade	Pool	Glide	Riffle	Run	Cas- cade
2017-A1	Jigger Creek	2,492	1,075	11,918	552	320	16,356	15%	7%	73%	3%	2%	26	6	29	5	3
2017-A2	Emery Creek	585	7	7,813	0	1,030	9,435	6%	0%	83%	0%	11%	35	1	31	0	8
2017-A3	Bear Creek	268	64	3,945	43	42	4,361	6%	1%	90%	1%	1%	24	4	32	2	2
2017-A4	Holly Creek	6,449	758	14,555	223	210	22,196	29%	3%	66%	1%	1%	42	5	37	3	1
2017-A5	Rock Creek	2,080	1,201	11,404	838	0	15,523	13%	8%	73%	5%	0%	13	4	17	3	0
2017-A6	N Prong Sumac Cr.	631	164	4,523	0	867	6,184	10%	3%	73%	0%	14%	24	4	29	0	2
2017-A7	Sumac Creek	3,451	2,583	10,918	2,341	0	19,292	18%	13%	57%	12%	0%	19	18	37	11	0
2017-A8	Mill Creek	2,386	943	12,234	692	0	16,256	15%	6%	75%	4%	0%	23	8	34	8	1
2017-B1	Goldmine Branch	22	18	1,766	31	5	1,841	1%	1%	96%	2%	0%	4	2	10	2	1
2017-B2	Warwoman Creek	12,618	33,628	18,406	21,257	161	86,071	15%	39%	21%	25%	0%	26	25	31	25	7
2017-B3	Stonewall Creek	6,335	3,421	20,423	1,420	1,830	33,428	19%	10%	61%	4%	5%	54	30	75	11	0
2017-B4	Panther Creek	7,675	5,556	11,424	2,117	0	26,772	29%	21%	43%	8%	0%	44	30	48	10	0
2017-B5	Sarabs Creek	3,367	675	2,001	1,265	0	7,308	46%	9%	27%	17%	0%	9	4	11	6	0
2017-C1	Jones Creek	1,305	958	594	1,926	0	4,784	27%	20%	12%	40%	0%	6	4	2	7	0
2017-C2	Bryant Creek	2,225	1,145	7,461	221	16	11,068	20%	10%	67%	2%	0%	60	30	85	3	1
2017-C3	Moss Creek	6,980	5,848	2,465	1,072	0	16,366	43%	36%	15%	7%	0%	14	61	47	9	0
2017-C4	West Cane Creek	627	397	4,450	275	168	5,917	11%	7%	75%	5%	3%	39	16	54	5	3
2017-C5	Cane Creek	874	945	16,876	1,156	2,074	21,925	4%	4%	77%	5%	9%	29	15	52	14	4
2017-C6	Turninglathe Branch	493	540	4,071	759	649	6,513	8%	8%	63%	12%	10%	37	23	60	10	4

Table 5. Percent occurrence of dominant substrate size categories in pools (includes glides) and riffles (includes cascades and runs) in each stream inventoried. See appendix B for substrate size categories.

Site #	Stream Name	Pool Dominant Substrate									Riffle Dominant Substrate								
		Organic Matter	Clay	Silt	Sand	Small Gravel	Large Gravel	Cobble	Boulder	Bedrock	Organic Matter	Clay	Silt	Sand	Small Gravel	Large Gravel	Cobble	Boulder	Bedrock
2017-A1	Jigger Creek	0%	0%	0%	0%	0%	6%	75%	0%	19%	0%	0%	0%	0%	0%	0%	57%	22%	22%
2017-A2	Emery Creek	0%	0%	0%	25%	28%	17%	6%	14%	11%	0%	0%	0%	0%	0%	5%	62%	18%	15%
2017-A3	Bear Creek	0%	0%	0%	75%	7%	7%	4%	4%	4%	0%	0%	0%	0%	8%	3%	50%	31%	8%
2017-A4	Holly Creek	0%	0%	0%	6%	0%	17%	9%	21%	47%	0%	0%	0%	0%	0%	10%	24%	41%	24%
2017-A5	Rock Creek	0%	0%	0%	0%	0%	0%	0%	35%	65%	0%	0%	0%	0%	0%	0%	0%	30%	70%
2017-A6	North Prong Sumac Creek	7%	0%	0%	0%	25%	50%	7%	4%	7%	3%	0%	0%	0%	26%	19%	29%	13%	10%
2017-A7	Sumac Creek	0%	0%	0%	0%	0%	0%	16%	34%	50%	0%	0%	0%	0%	0%	0%	29%	29%	42%
2017-A8	Mill Creek	0%	0%	0%	6%	3%	10%	26%	23%	32%	0%	0%	0%	0%	5%	14%	36%	14%	31%
2017-B1	Goldmine Branch	0%	0%	17%	83%	0%	0%	0%	0%	0%	8%	0%	0%	85%	0%	0%	0%	0%	8%
2017-B2	Warwoman Creek	0%	0%	0%	53%	2%	0%	0%	12%	33%	0%	0%	0%	2%	2%	11%	18%	23%	46%
2017-B3	Stonewall Creek	0%	0%	0%	62%	7%	1%	7%	6%	17%	0%	0%	0%	3%	1%	4%	37%	18%	37%
2017-B4	Panther Creek	0%	0%	0%	38%	0%	0%	4%	18%	41%	0%	0%	0%	0%	0%	0%	16%	28%	57%
2017-B5	Sarabs Creek	0%	0%	0%	77%	8%	15%	0%	0%	0%	0%	0%	0%	18%	29%	47%	6%	0%	0%
2017-C1	Jones Creek	0%	0%	0%	30%	0%	50%	10%	10%	0%	0%	0%	0%	11%	11%	67%	11%	0%	0%
2017-C2	Bryant Creek	0%	0%	2%	56%	9%	24%	7%	2%	0%	0%	0%	0%	0%	12%	87%	0%	0%	1%
2017-C3	Moss Creek	0%	0%	7%	68%	12%	0%	5%	0%	8%	0%	0%	2%	5%	18%	34%	23%	4%	14%
2017-C4	West Cane Creek	0%	0%	2%	78%	0%	15%	5%	0%	0%	0%	0%	0%	3%	13%	76%	3%	0%	5%
2017-C5	Cane Creek	0%	0%	0%	45%	32%	16%	2%	5%	0%	0%	0%	0%	1%	14%	36%	39%	4%	6%
2017-C6	Turninglathe Branch	2%	0%	13%	38%	27%	10%	7%	2%	2%	0%	0%	0%	3%	24%	24%	27%	5%	16%
Average		0%	0%	2%	39%	8%	13%	10%	10%	18%	1%	0%	0%	7%	9%	23%	24%	15%	22%

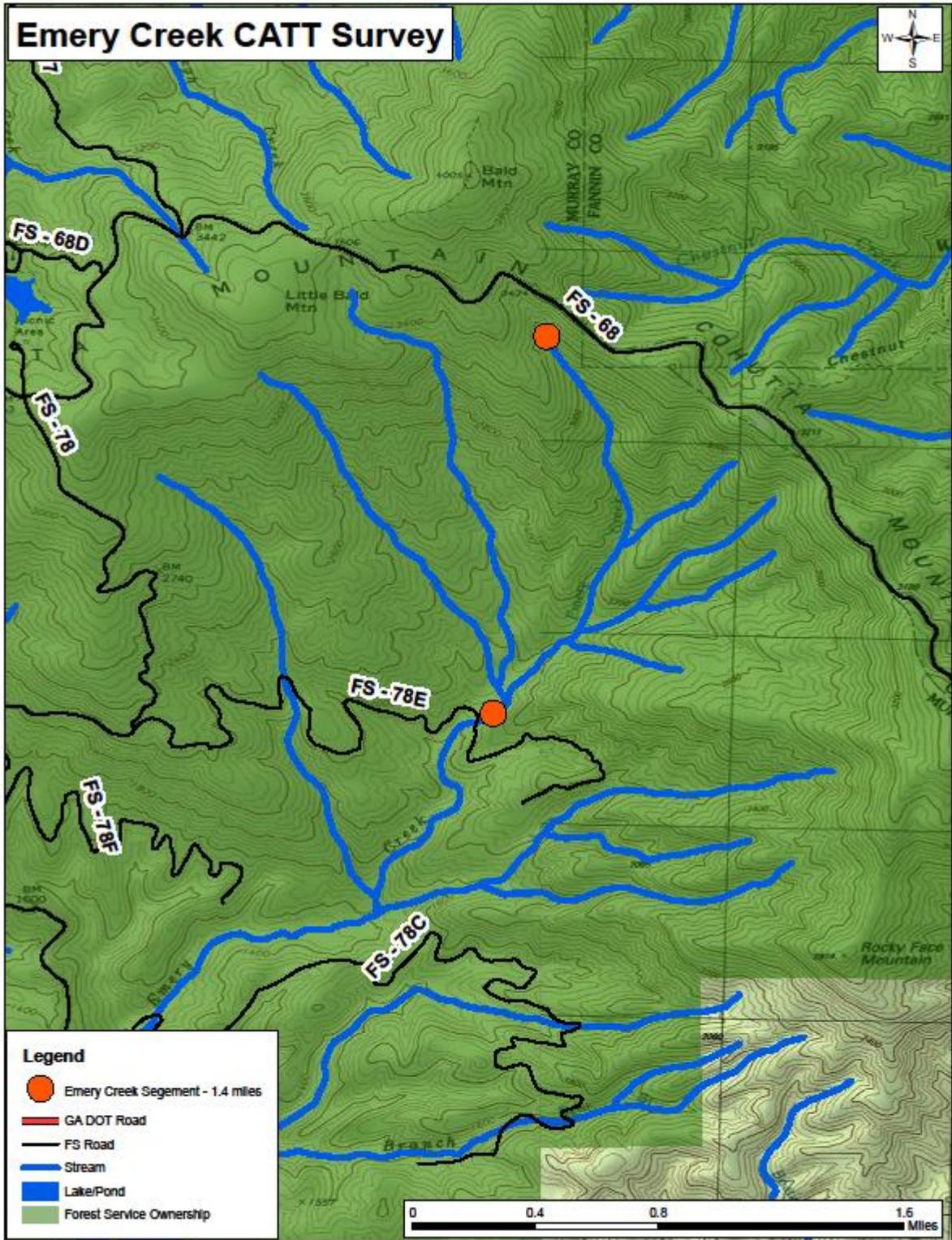
Table 6. Percent occurrence of subdominant substrate size categories in pools (includes glides) and riffles (includes cascades and runs) in each stream inventoried. See appendix B for substrate size categories.

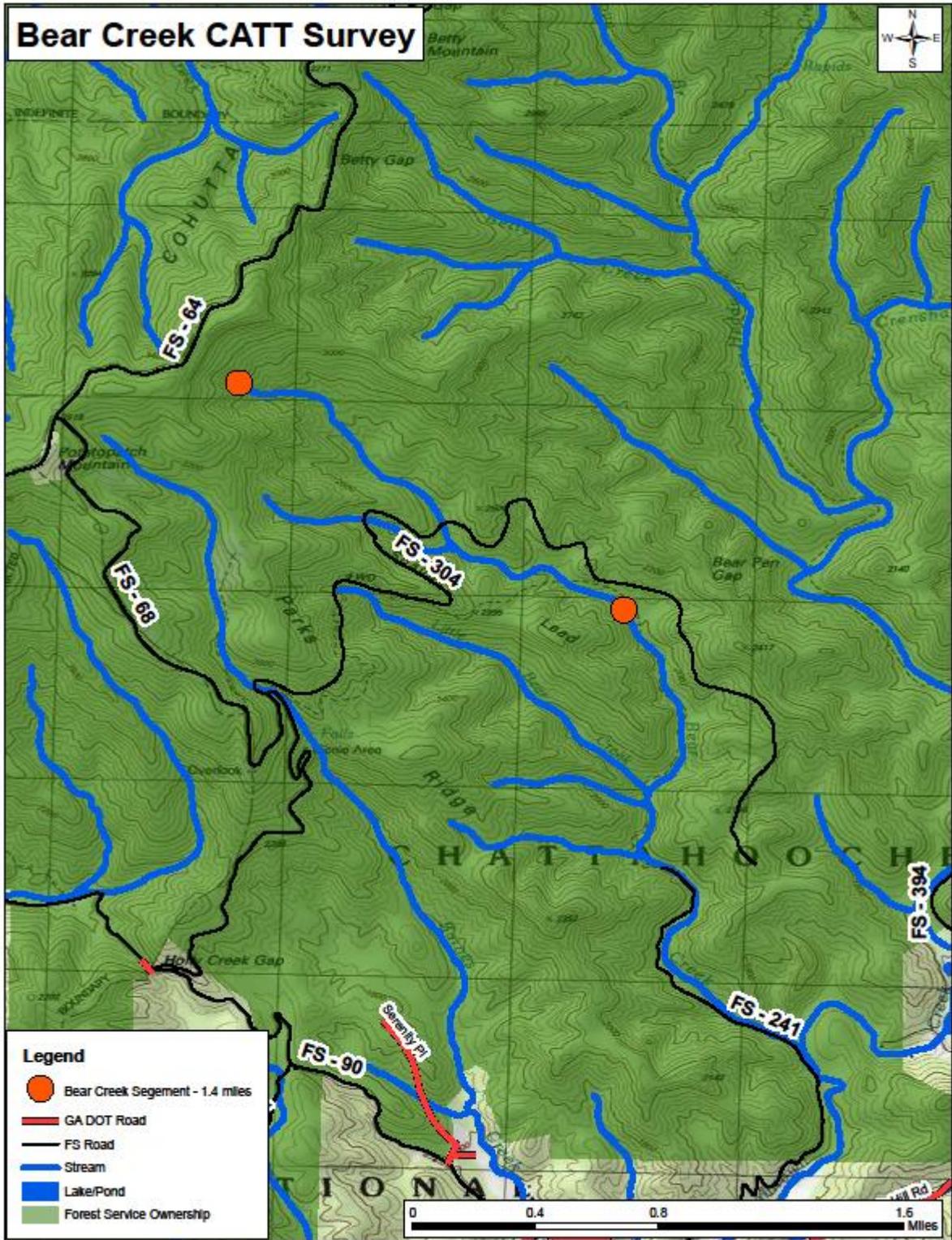
Site #	Stream Name	Pool Subdominant Substrate									Riffle Subdominant Substrate								
		Organic Matter	Clay	Silt	Sand	Small Gravel	Large Gravel	Cobble	Boulder	Bedrock	Organic Matter	Clay	Silt	Sand	Small Gravel	Large Gravel	Cobble	Boulder	Bedrock
2017-A1	Jigger Creek	0%	0%	0%	0%	0%	50%	6%	38%	6%	0%	0%	0%	3%	5%	22%	30%	27%	14%
2017-A2	Emery Creek	0%	0%	0%	17%	17%	28%	8%	22%	8%	0%	0%	0%	0%	3%	23%	21%	51%	3%
2017-A3	Bear Creek	0%	0%	0%	18%	36%	4%	11%	11%	21%	0%	0%	0%	11%	14%	8%	25%	33%	8%
2017-A4	Holly Creek	0%	0%	0%	17%	2%	36%	13%	19%	13%	0%	0%	0%	0%	2%	12%	49%	22%	15%
2017-A5	Rock Creek	0%	0%	0%	18%	0%	0%	47%	24%	12%	0%	0%	0%	5%	0%	0%	40%	50%	5%
2017-A6	North Prong Sumac Creek	14%	0%	0%	0%	21%	14%	32%	7%	11%	3%	0%	0%	0%	6%	45%	26%	0%	19%
2017-A7	Sumac Creek	3%	0%	0%	11%	8%	11%	34%	26%	8%	0%	0%	0%	0%	6%	10%	46%	33%	4%
2017-A8	Mill Creek	0%	0%	0%	13%	6%	19%	42%	16%	3%	0%	0%	0%	0%	2%	21%	40%	33%	2%
2017-B1	Goldmine Branch	0%	0%	0%	17%	50%	0%	0%	17%	17%	0%	0%	0%	0%	46%	15%	31%	8%	0%
2017-B2	Warwoman Creek	0%	0%	2%	27%	16%	4%	10%	18%	24%	0%	0%	0%	9%	12%	25%	16%	26%	12%
2017-B3	Stonewall Creek	2%	0%	0%	29%	5%	4%	14%	25%	21%	0%	0%	0%	23%	14%	18%	20%	19%	5%
2017-B4	Panther Creek	1%	0%	1%	42%	1%	0%	9%	20%	24%	0%	0%	0%	33%	0%	2%	26%	36%	3%
2017-B5	Sarabs Creek	0%	0%	8%	15%	15%	46%	15%	0%	0%	0%	0%	0%	24%	41%	35%	0%	0%	0%
2017-C1	Jones Creek	0%	0%	0%	30%	0%	40%	30%	0%	0%	0%	0%	0%	0%	0%	33%	67%	0%	0%
2017-C2	Bryant Creek	4%	0%	6%	28%	18%	39%	3%	1%	1%	0%	0%	0%	9%	33%	9%	49%	0%	0%
2017-C3	Moss Creek	3%	0%	15%	28%	31%	11%	8%	0%	5%	0%	0%	0%	30%	30%	20%	11%	4%	5%
2017-C4	West Cane Creek	0%	0%	4%	18%	15%	55%	4%	4%	2%	2%	0%	0%	44%	39%	8%	5%	0%	3%
2017-C5	Cane Creek	2%	0%	0%	20%	25%	18%	27%	5%	2%	0%	0%	0%	4%	40%	29%	21%	6%	0%
2017-C6	Turninglathe Branch	7%	0%	7%	33%	17%	25%	8%	2%	2%	0%	0%	1%	15%	19%	39%	20%	0%	5%
Average		2%	0%	2%	20%	15%	21%	17%	13%	10%	0%	0%	0%	11%	17%	20%	29%	18%	6%

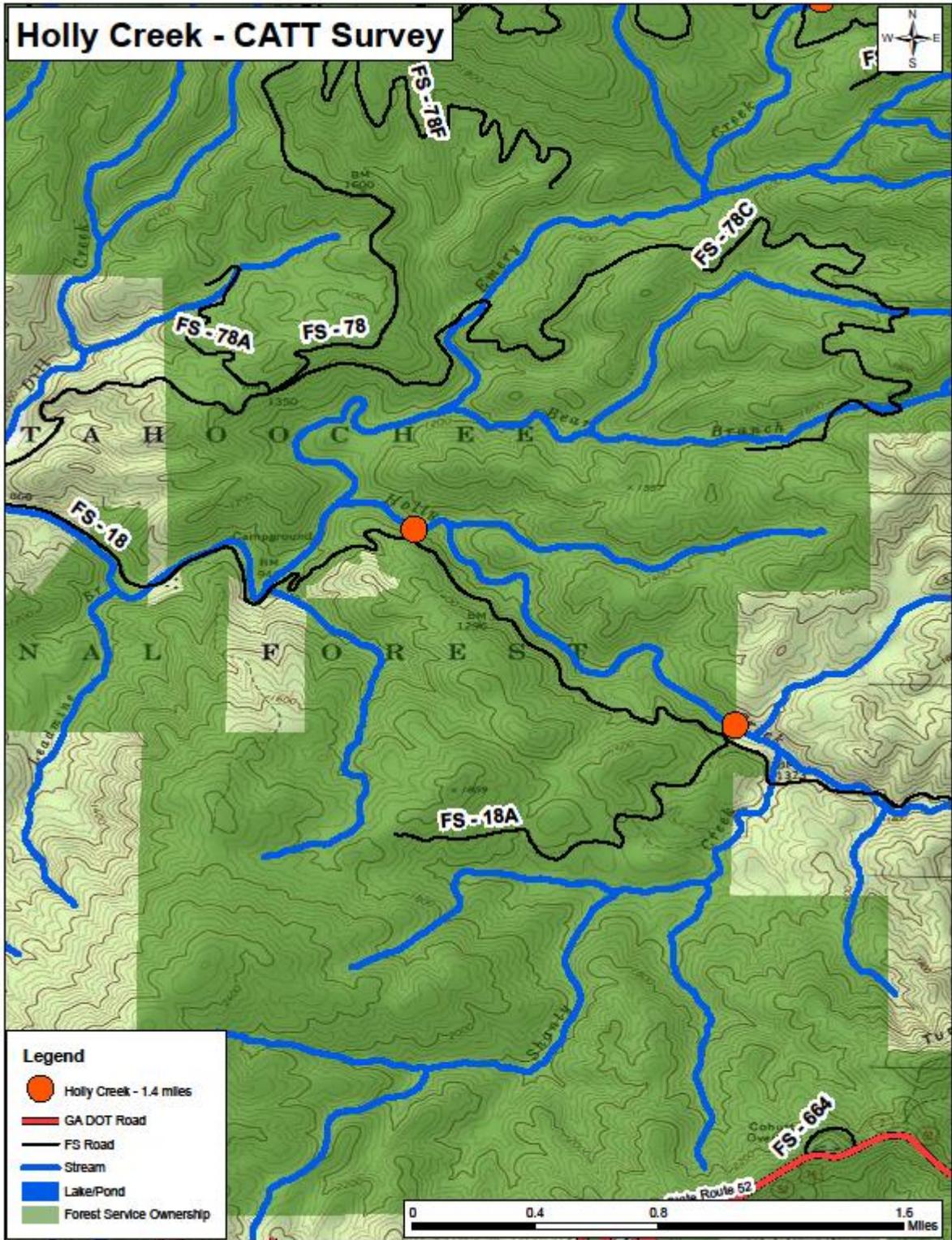
Table 7. Large wood (LW) per kilometer observed during BVET habitat inventories. LW size classes: LW1 = 1-5 m length, 10-55 cm diameter; LW2 = 1-5 m length, >55 cm diameter; LW3 = >5 m length, 10-55 cm diameter; LW4 = >5 m length, >55 cm diameter; RW = rootwad.

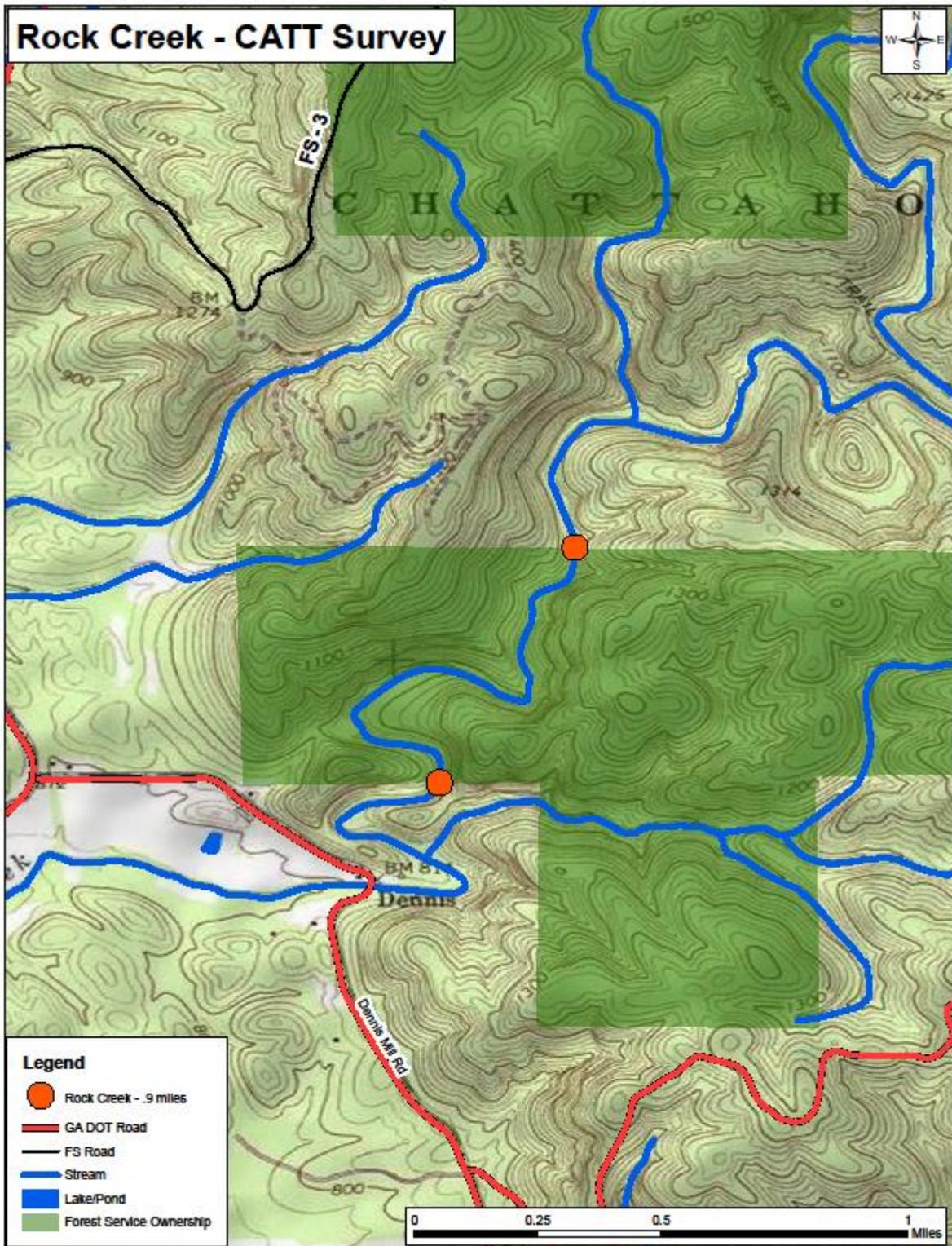
Site #	Stream Name	Large Wood per Km						Large Wood Count in Sample Reach						Inventory Distance (km)
		LW1/ km	LW2/ km	LW3/ km	LW4/ km	RW/ km	Total LW/km	LW1 n	LW2 n	LW3 n	LW4 n	RW n	Total LW n	
2017-A1	Jigger Creek	160	4	36	4	4	209	400	11	89	10	11	521	2.5
2017-A2	Emery Creek	138	3	78	11	7	237	331	6	188	27	16	568	2.4
2017-A3	Bear Creek	252	2	136	2	3	395	630	5	340	6	7	988	2.5
2017-A4	Holly Creek	67	3	118	5	8	201	161	8	286	12	19	486	2.4
2017-A5	Rock Creek	52	2	15	1	4	74	85	3	25	2	6	121	1.6
2017-A6	North Prong Sumac Creek	94	0	51	4	4	154	230	1	125	10	9	375	2.4
2017-A7	Sumac Creek	123	0	40	0	1	165	384	0	126	0	4	514	3.1
2017-A8	Mill Creek	98	2	70	6	6	182	231	5	164	15	14	429	2.4
2017-B1	Goldmine Branch	342	0	59	2	1	405	300	0	52	2	1	355	0.9
2017-B2	Warwoman Creek	23	0	82	2	2	109	154	2	550	13	15	734	6.7
2017-B3	Stonewall Creek	206	1	73	2	6	288	1150	3	407	12	32	1604	5.6
2017-B4	Panther Creek	74	2	91	4	4	175	262	7	320	13	14	616	3.5
2017-B5	Sarahs Creek	258	2	78	4	8	350	239	2	72	4	7	324	0.9
2017-C1	Jones Creek	123	0	111	2	2	238	80	0	72	1	1	154	0.6
2017-C2	Bryant Creek	168	1	25	2	9	205	627	5	93	7	33	765	3.7
2017-C3	Moss Creek	156	0	85	1	3	245	636	1	347	5	14	1003	4.1
2017-C4	West Cane Creek	72	2	64	3	3	143	226	5	201	10	8	450	3.2
2017-C5	Cane Creek	163	0	110	1	2	277	867	0	583	7	13	1470	5.3
2017-C6	Turninglathe Branch	143	1	50	3	4	202	452	4	158	11	14	639	3.2

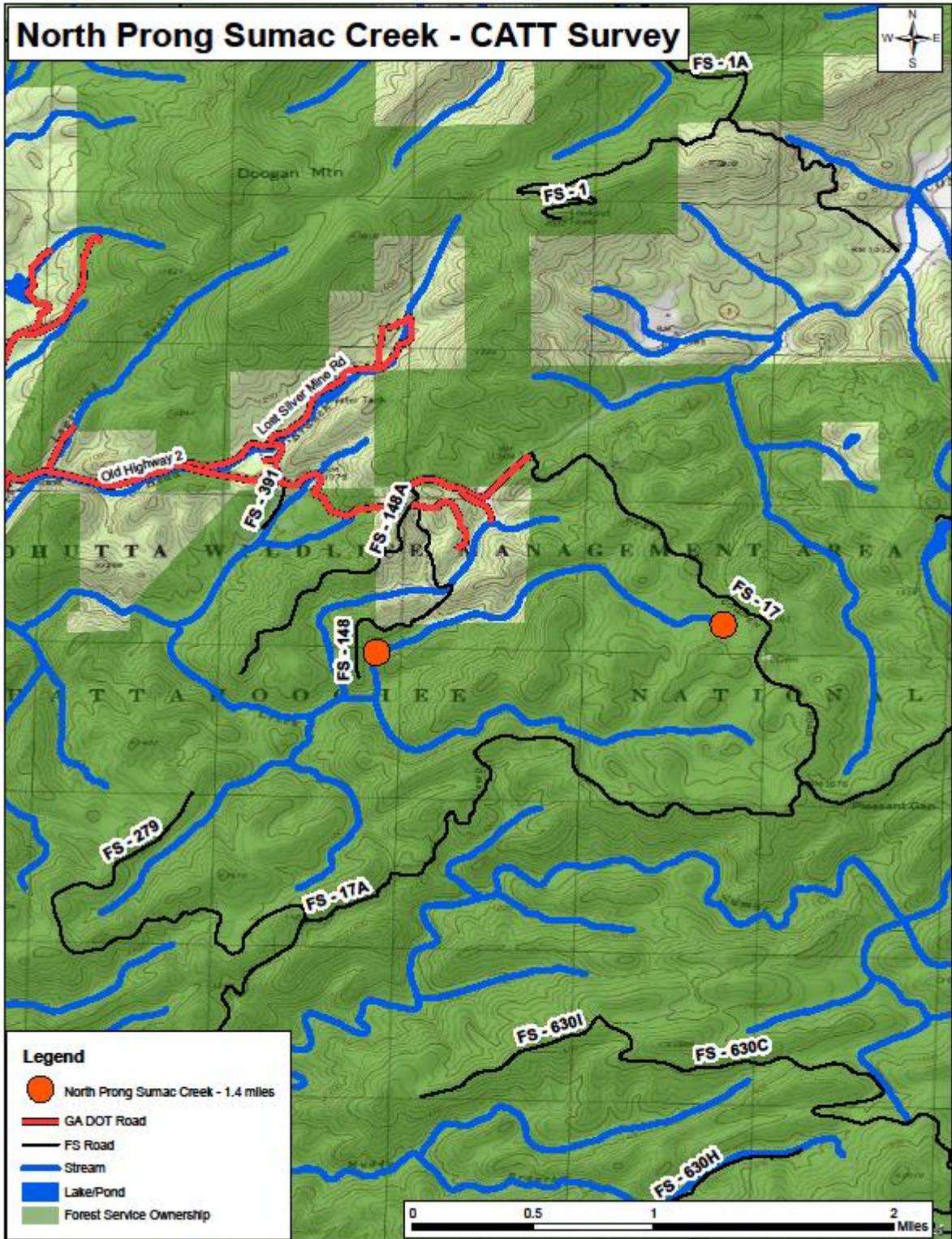
Appendix A: Maps Showing BVET Inventory Start and End Locations

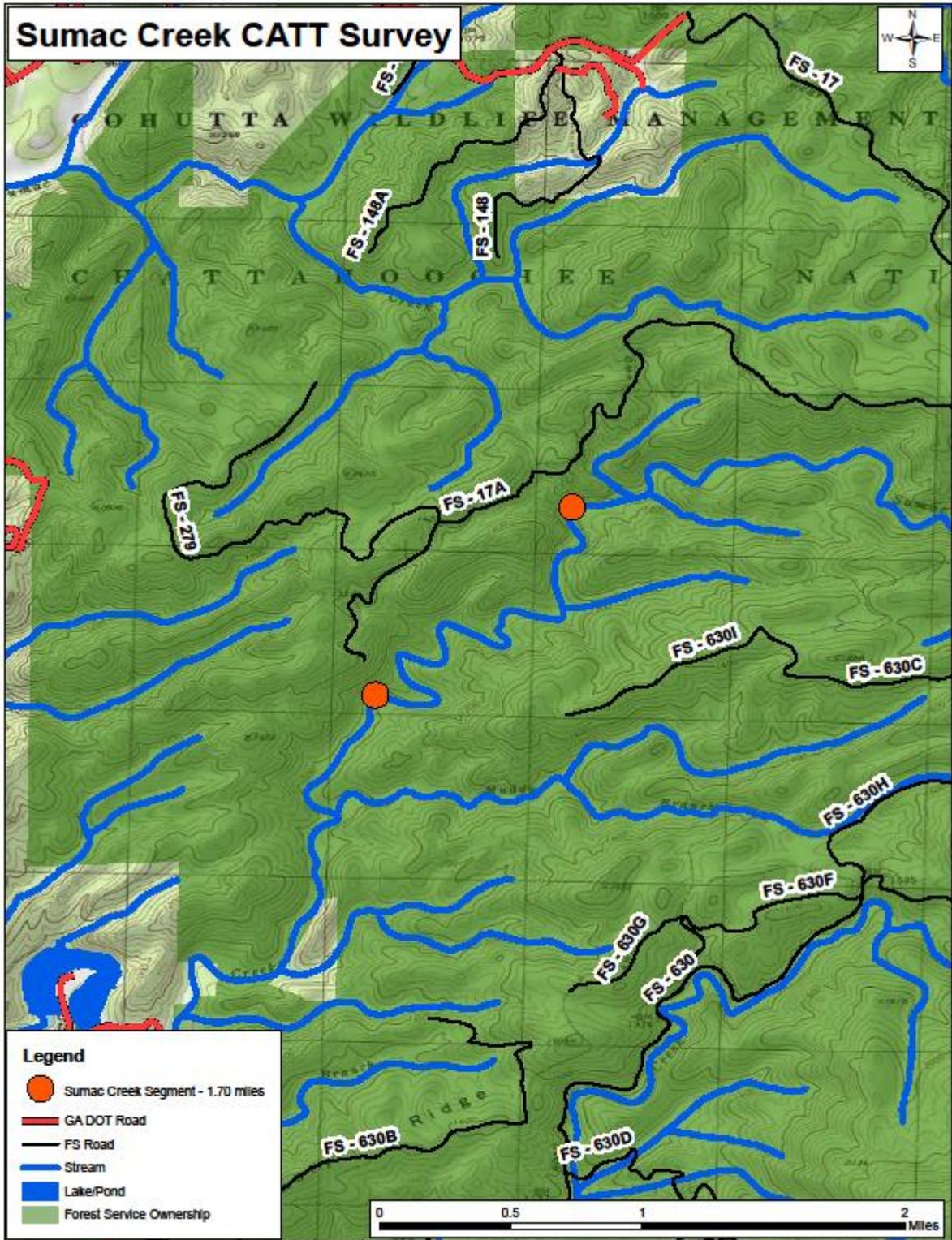


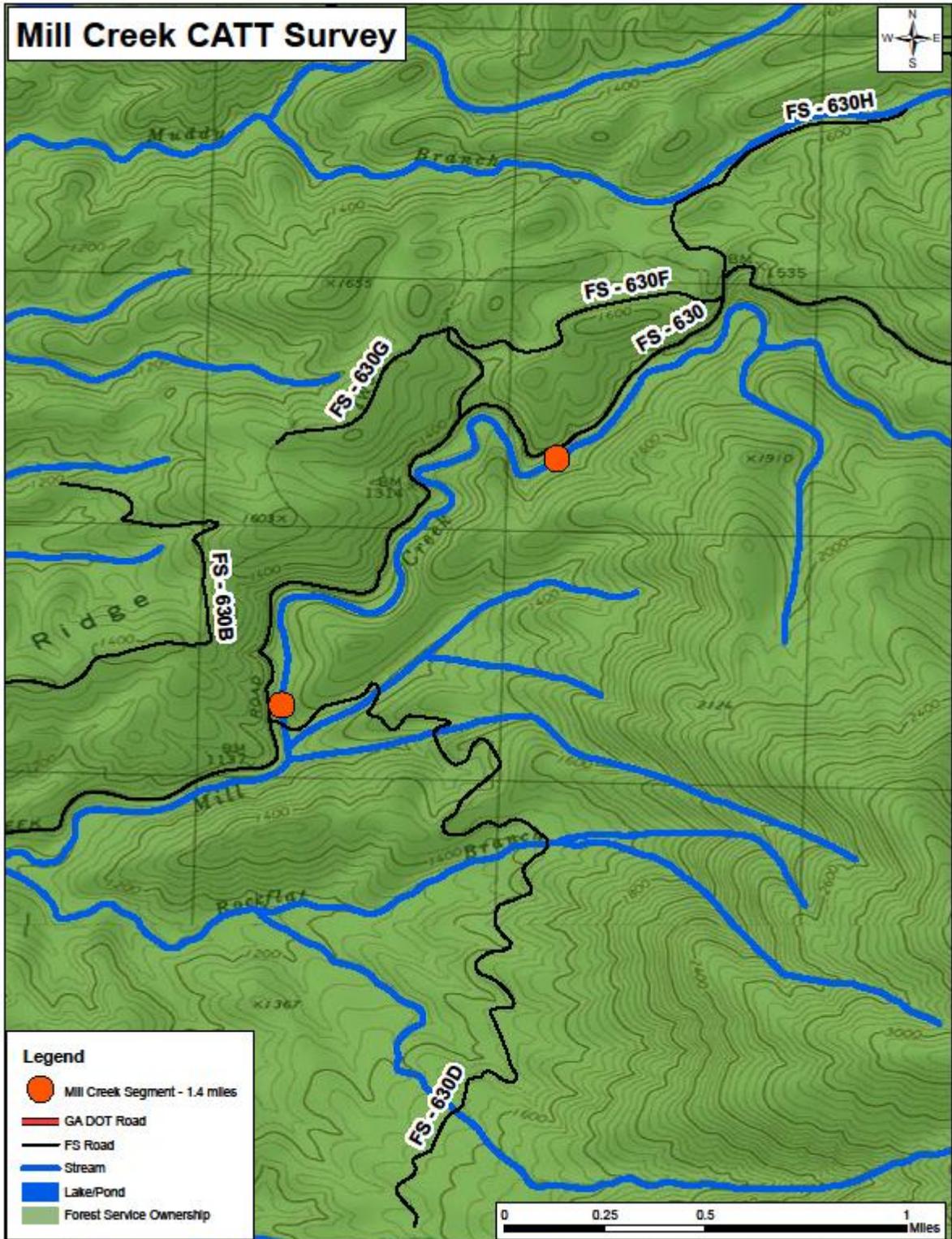




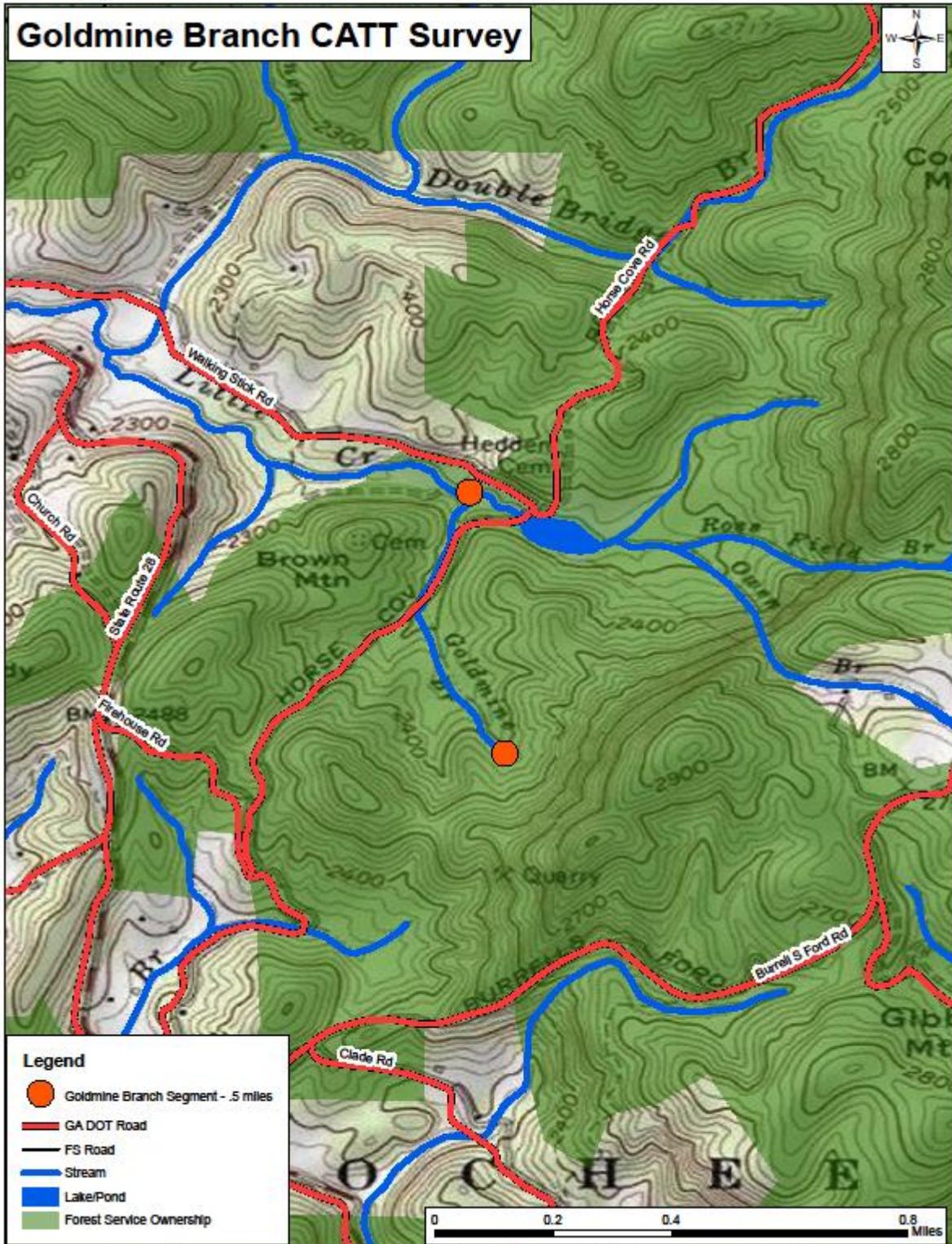


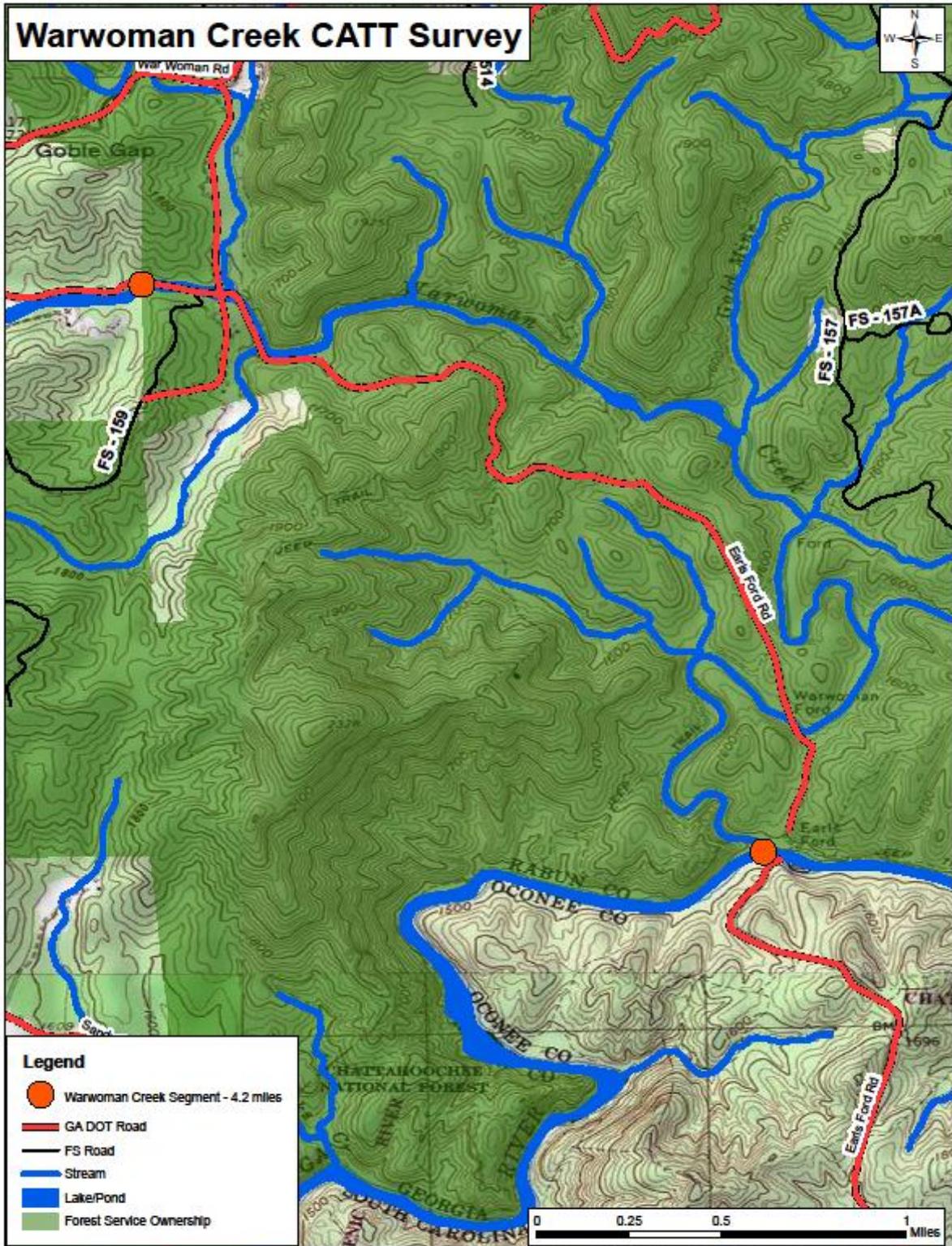


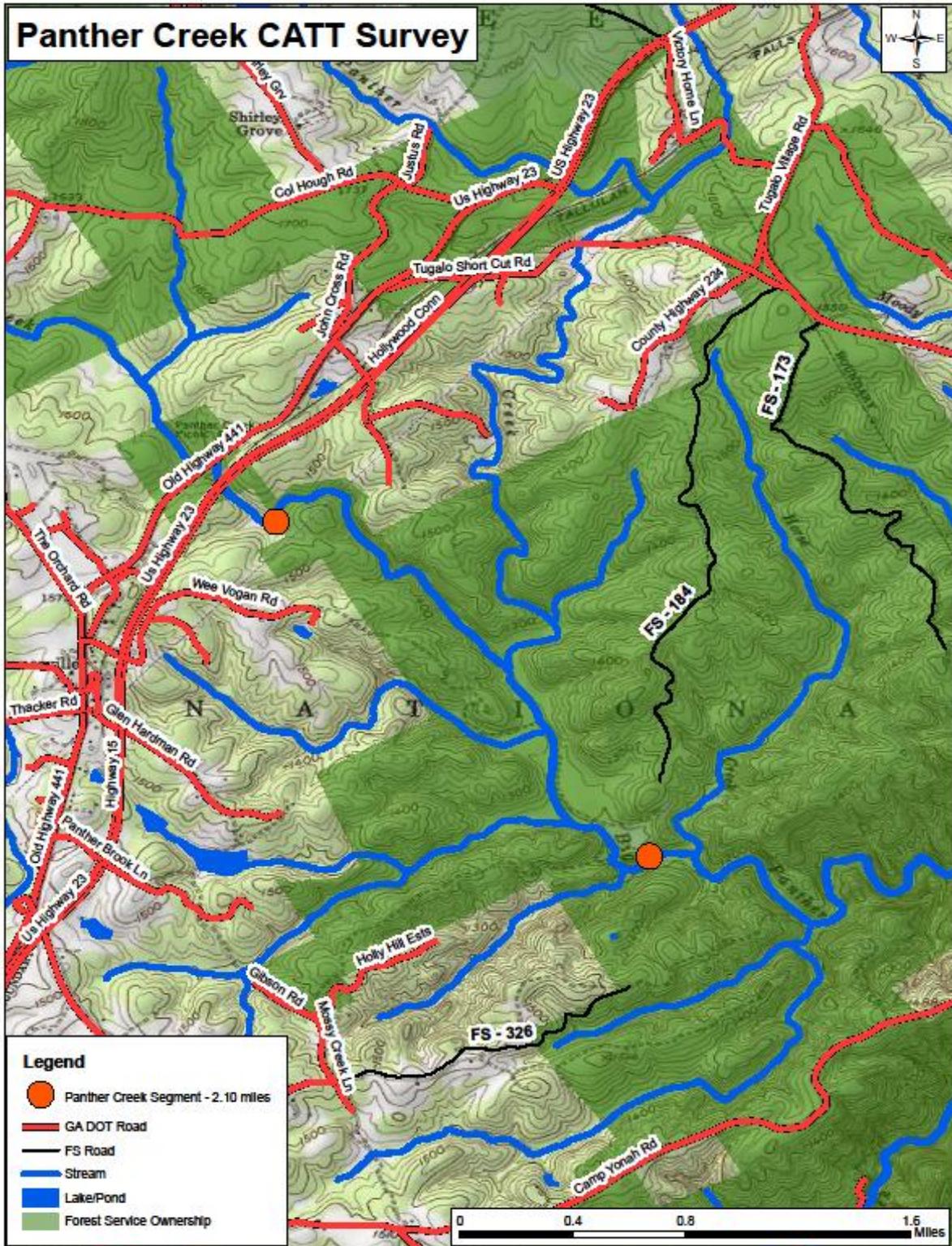


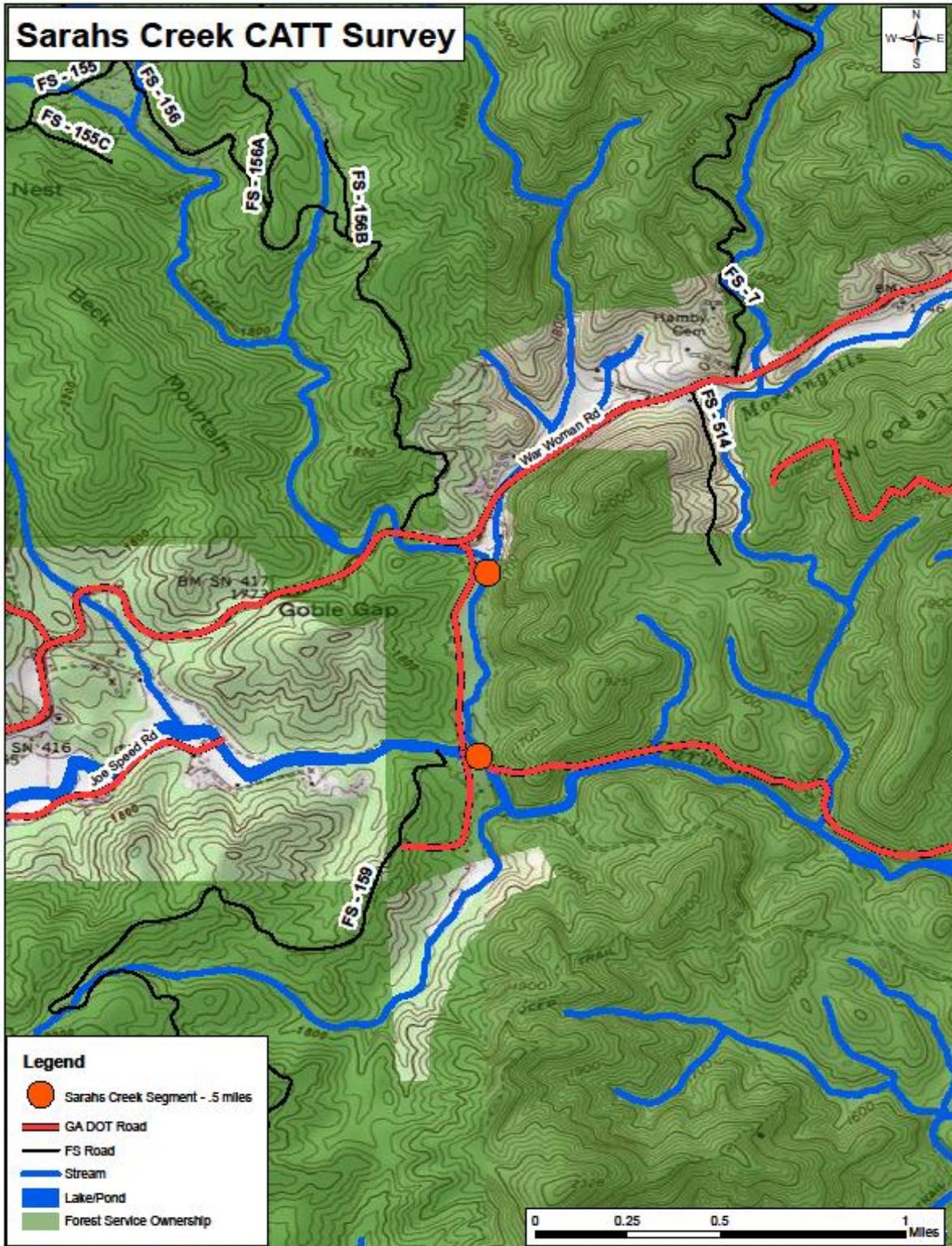


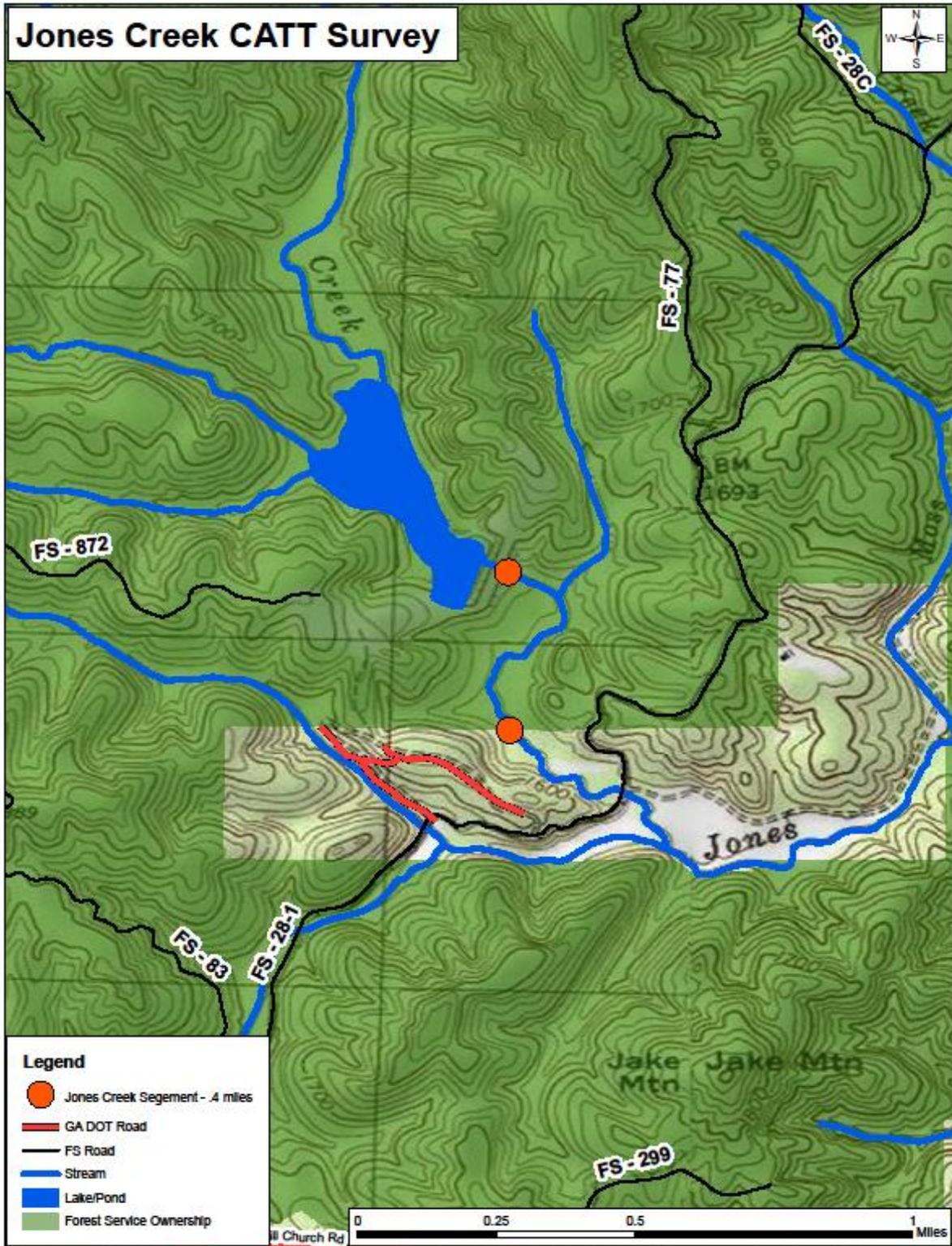
Goldmine Branch CATT Survey



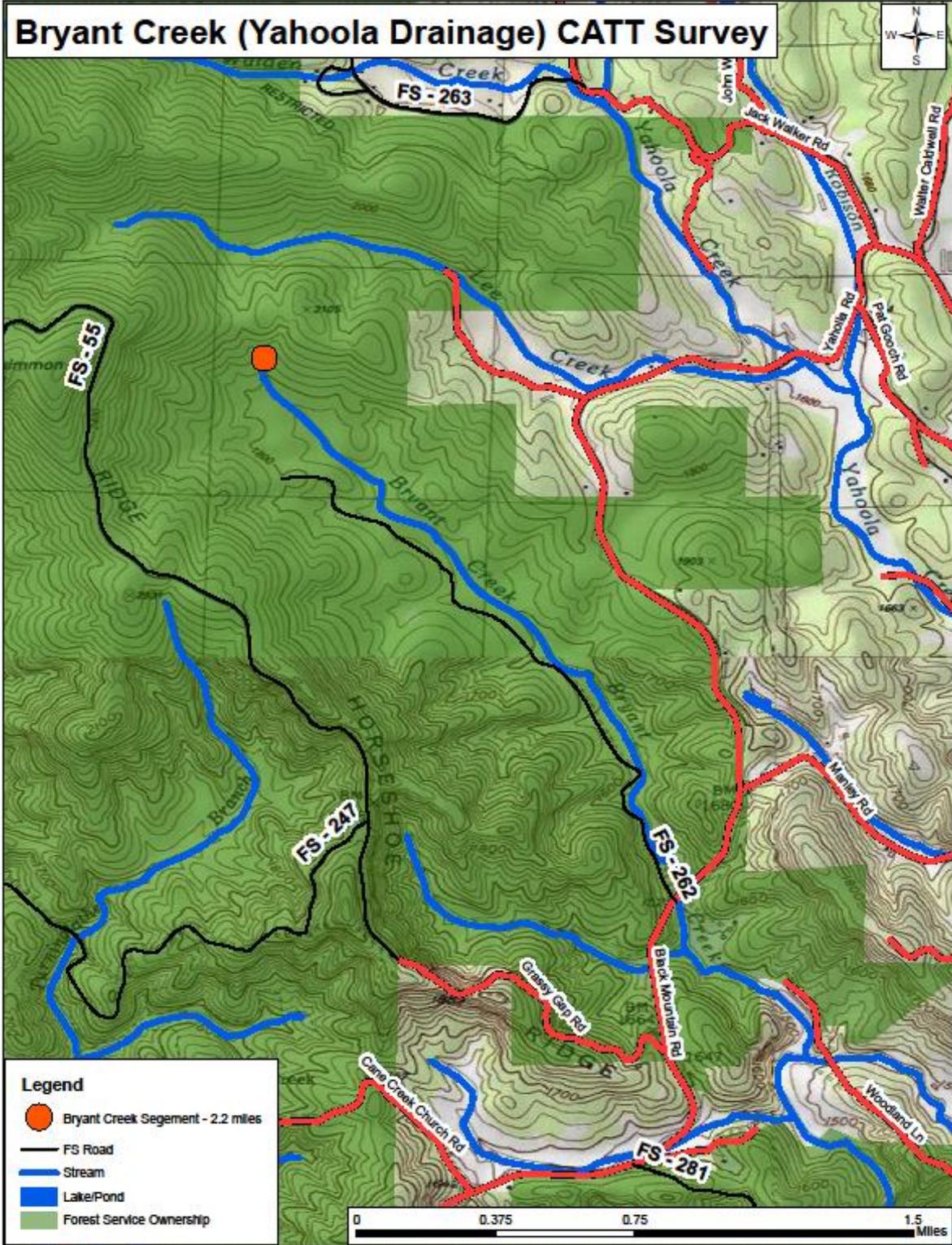


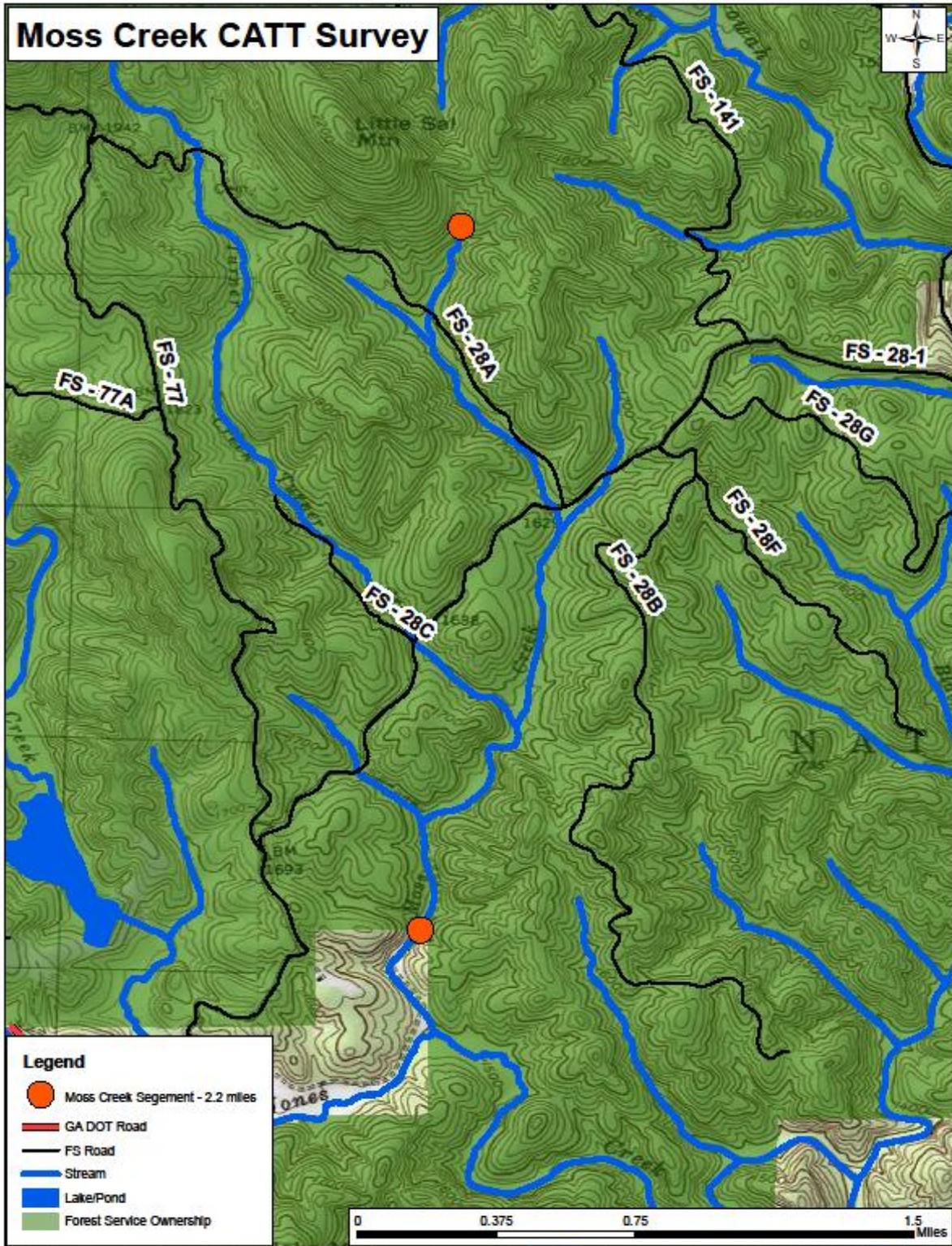


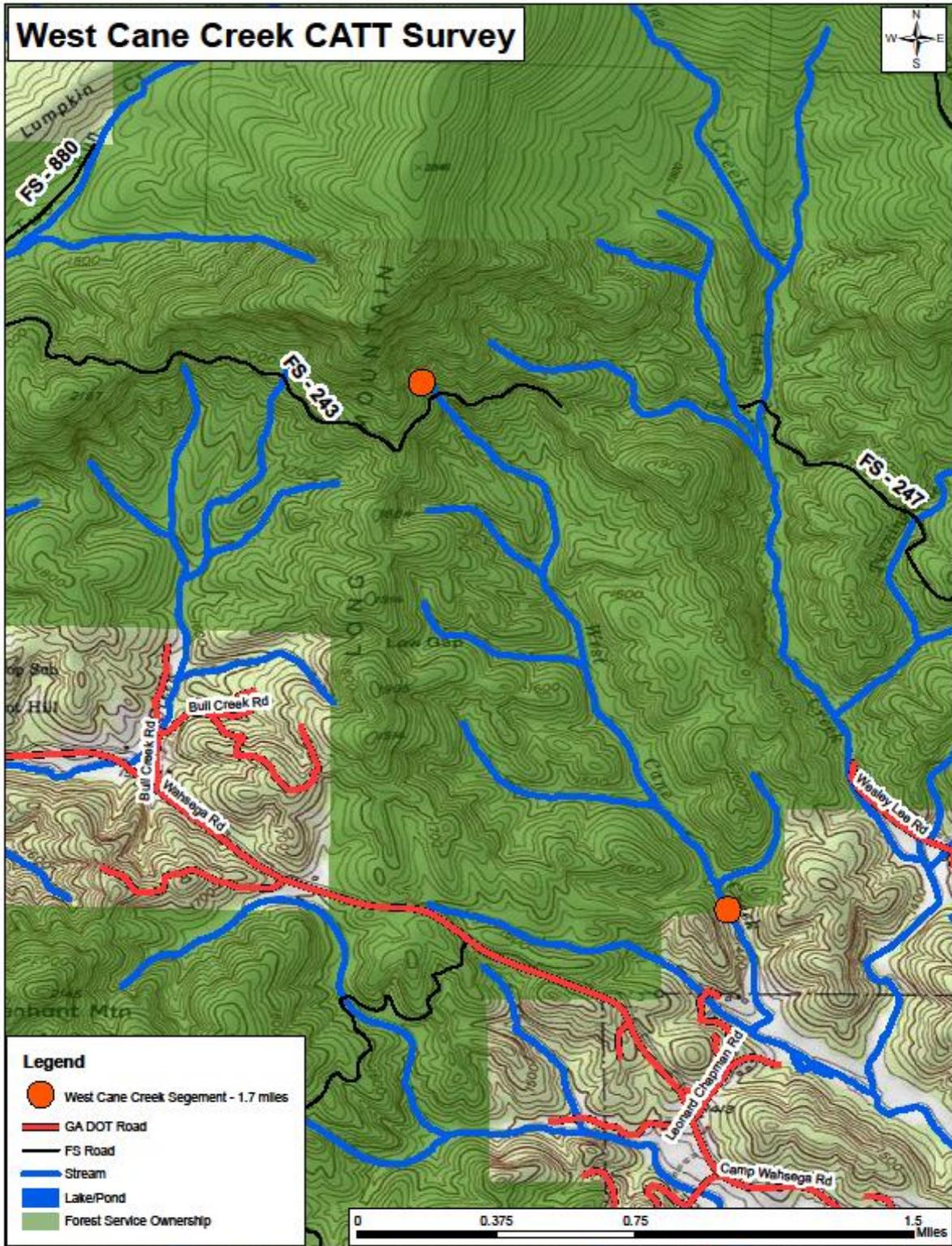


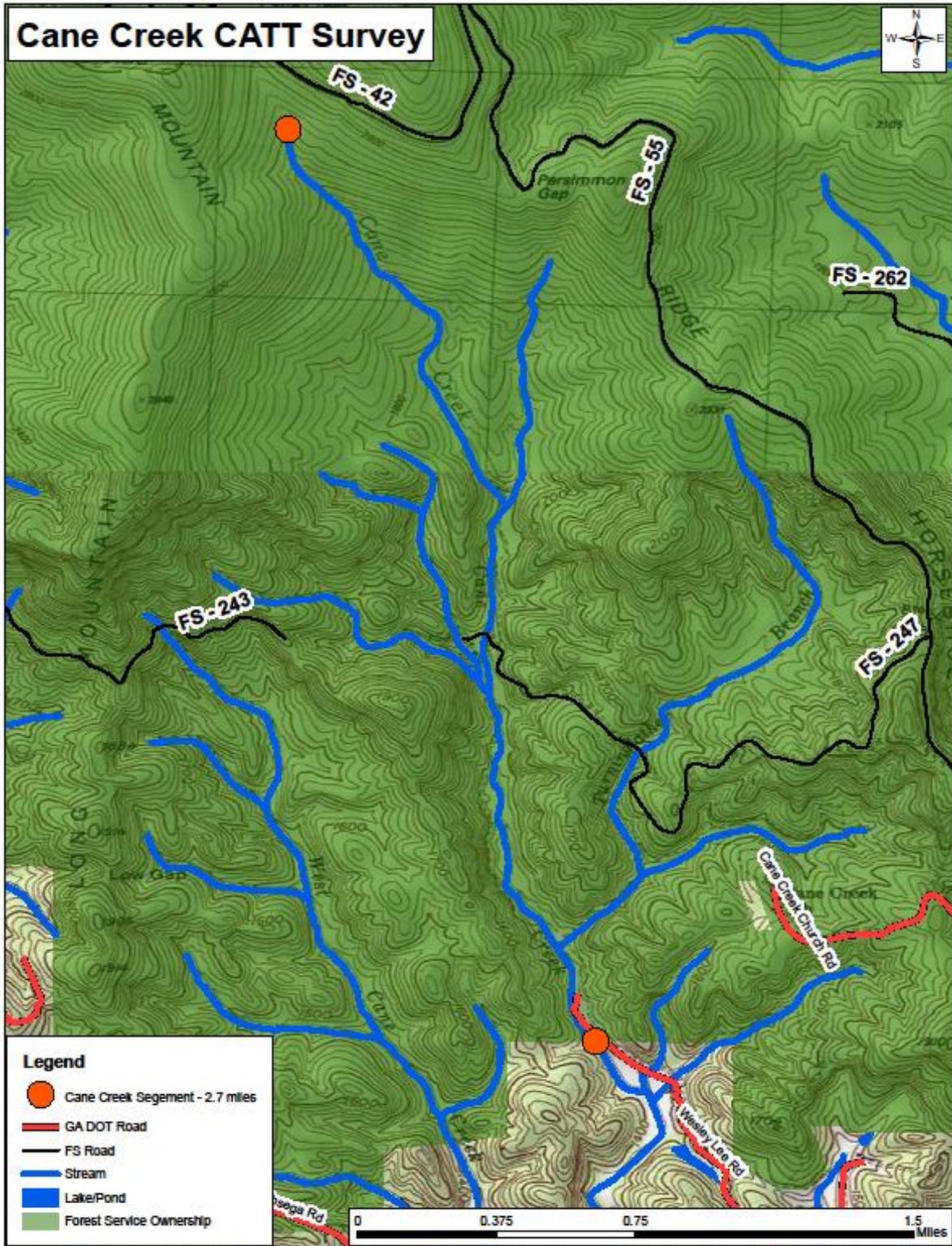


Bryant Creek (Yahoola Drainage) CATT Survey

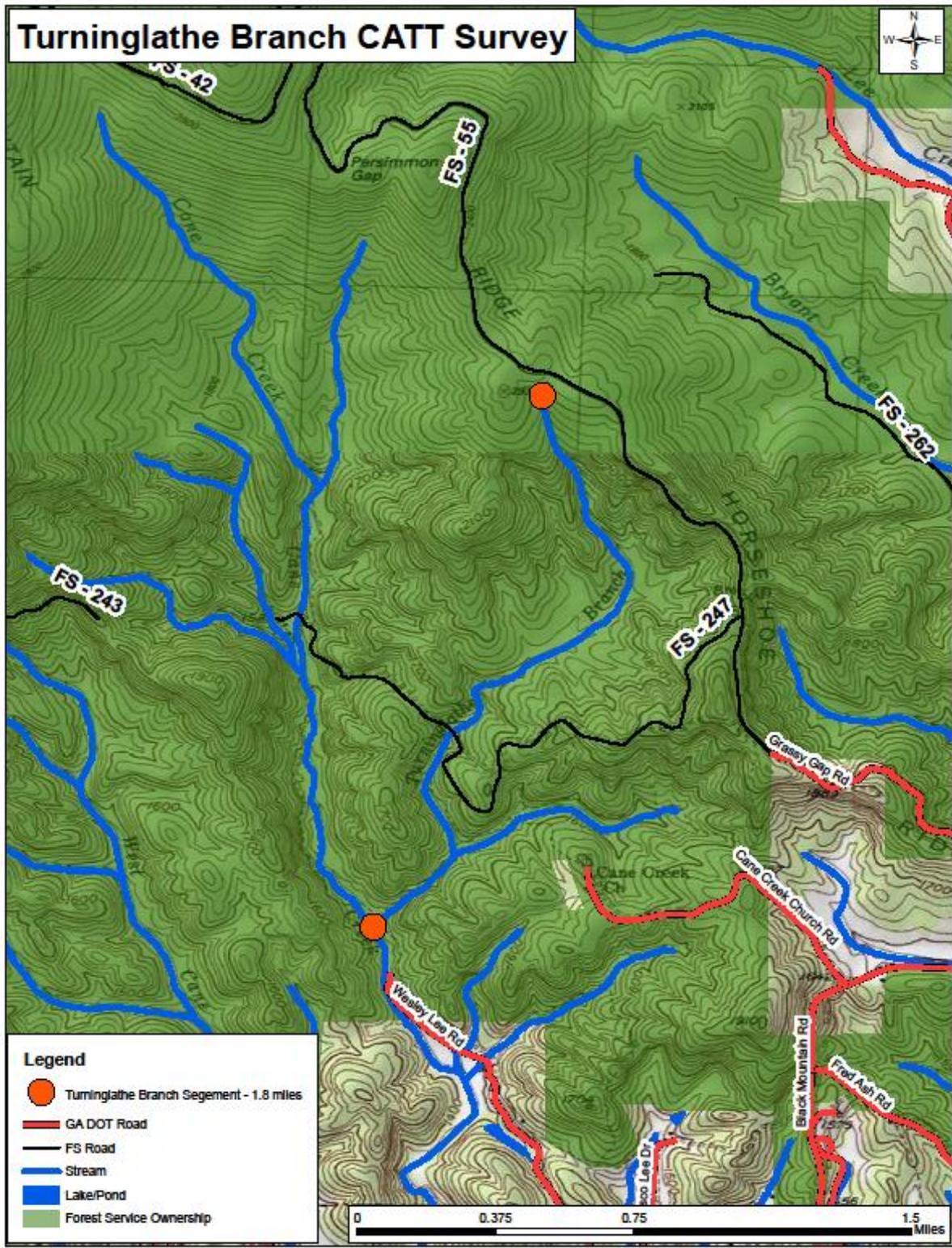








Turninglathe Branch CATT Survey



Appendix B: Field Methods for Stream Habitat Inventory

Guide to Stream Habitat Characterization using the BVET Methodology in the Chattahoochee National Forest, GA



Prepared by:



Prepared by: Colin Krause and Craig N. Roghair

2017

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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:

- Armantrout, N. B., compiler. 1998. Glossary of aquatic habitat inventory terminology. American Fisheries Society, Bethesda, Maryland.
- Dolloff, C. A., D. G. Hankin, and G. H. Reeves. 1993. Basinwide estimation of habitat and fish populations in streams. General Technical Report SE-83. Asheville, North Carolina: U.S. Department of Agriculture, Southeastern Forest Experimental Station.
- Hankin, D. G., and G. H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. *Canadian Journal of Fisheries and Aquatic Sciences* 45:834-844.
- Rosgen, D.L. 1996. *Applied River Morphology*. Wildland Hydrology Books, Pagosa Springs, Colorado.
- Rosgen, D.L., and L. Silvey. 1998 *Field Guide for Stream Classification*, Wildland Hydrology Books, Pagosa Springs, Colorado.

Changes to BVET inventory in 2015

Attribute	Action	Reason
Hemlock LW	added	Quantify hemlock LW in bankfull channel
Hemlock Condition	changed	Combined categories 0 & 1; combined categories 4&5 from 2014 methods; now using 3 categories instead of 5
Hemlock Abundance	changed	Using same categories, but shifting category labels from 0-3 to 1-4 for consistency with BVET methods used in other National Forests

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 **vital** 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 inventory reach.

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 & extra string	Backpack
wading rod	Pencils
50 m tape measure	Flagging
Datalogger	Markers
GPS unit	waterproof backup datasheets
topographic map	BVET manual and field guide
camera	felt bottom wading boots or waders
Clinometer (for cascades)	Water Filter
Thermometer	1 st Aid Kit & toilet paper

Other useful equipment: lunch, water, 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	Hemlock LW, abundance, condition
Classify substrates	Photo-documentation
Estimate percent fines	Document features

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, recorded all the header information, and determined the start location 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, 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, 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	<i>Abbreviation</i>	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; also record RCD where short riffles break pools

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

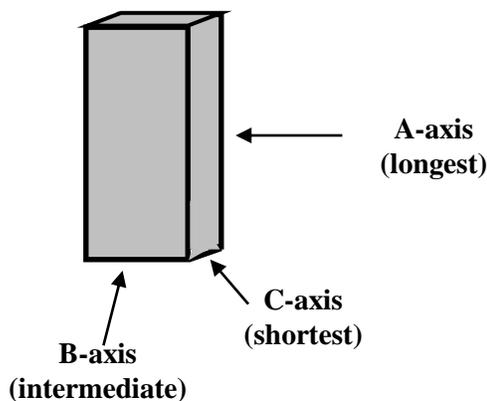
As the observer walks through the unit they scan the substrate. When they reach the upstream end of the unit they stop, turn to face the unit, and determine the dominant and subdominant substrate classes.

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



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 large 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
 - LW within fish habitat improvement structures is included in the inventory

Where to estimate: every habitat unit

Hemlock Large Wood

Definition:

Count of dead and down wood within the bankfull channel of a habitat unit that is identifiable as hemlock (Hemlock LW is already counted in LW Data; this is a separate count of only Hemlock LW, all size classes combined).

How to estimate:

The recorder counts a total tally of all LW that is identifiable as hemlock as they walk through the habitat unit. Only count hemlock large wood that is > 1.0 m in length and > 10.0 cm in diameter, within the bankfull channel, and fallen, not standing dead.

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

Definition:

Visual estimate of the condition of standing hemlock trees (DBH >10 cm) in the riparian zone (water's edge to 30 m up the streambank; visually estimated) as you walk between paired fast-water units. For the first paired sample, the condition of riparian hemlocks is 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:

Category	Description	Wooly needles	Needle loss	Limb loss
Healthy/Light Infestation (1)	Healthy or early stages of infestation	None to some	0-25%	Rare
Infested (2)	Late stages of infestation	Yes	25 – 75%	Small, medium branches
Dead (3)	Mortality; majority of hemlocks are dead	Yes for the few remaining needles	> 75%	Small, medium, large branches and tree tops

Where to measure: assess throughout reach, but record only at paired fast-water units

Hemlock Abundance

Definition:

Category describing the total number of hemlocks encountered since the last paired fast-water unit.

How to measure:

Estimate the number of standing hemlock trees (live or dead with DBH >10 cm) in the riparian zone (water's edge to 30 m up the streambank; visually estimated) as you walk between paired fast-water units.

Select from one of the following categories for hemlock abundance:

None (1) = no hemlocks; **Few (2)** = 1-10; **Some (3)** = 11-50; **Many (4)** = >50 hemlocks

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

Photo

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. Record photo number shown on digital camera.

Where to measure: paired sample riffles, runs, or cascades and any crossing features 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
T##	Tributary with name shown on quad map
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 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, fish habitat improvement structure , 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

	Abbreviation	What to Record*
<i>Crossing Feature</i>		
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 and waterfalls!
Take GPS of all waterfalls!**

Section 3: Wrapping Up

End the inventory where previous inventory ended or:

- 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 and Hemlock LW

Record for every riffle, run, or cascade (including breaks) 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 and Abundance
- Photograph
- Water Temperature

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 flag
- At the bottom of the next screen touch the 3 horizontal lines icon; then select spell search
- Start typing in the name of the desired waypoint; once the waypoint name is identified by the GPS it will list the waypoints associated with that waypoint name.
- Touch the waypoint name you were looking for when the list pops up
- To navigate to this location touch the big green **Go** button

Changing Waypoints:

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

Garmin GPS Cheatsheet

Turn On

- Press Power button, wait for GPS to boot

Turn Off

- Press and hold Power button

Create New Waypoint

1. To create a waypoint of your current position press the waypoint button (larger button below the power button)
2. Touch the waypoint label's field, type desired label, touch checkmark, touch save

Calibrate compass

1. Touch Compass icon, touch 3 horizontal lines icon, touch calibrate compass
2. Touch Start, follow onscreen instructions

Data Fields

1. To change the data fields on the map page touch the Map icon
2. Touch the 3 horizontal lines icon, then unlock data fields, touch the data field you want to change, select new data field category, select data field, then relock data fields

Appendix: 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
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
Hemlock Large Wood: count of dead and down Hemlock 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

- Measured Width:** (m) measurement of average wetted width
Hemlock Abun.: 1 None, 2 Few =1-10, 3 Some=1-50, 4 Many=>50
Hemlock Condition: 1 Healthy, 2 Infested, 3 Dead
Water Temperature: C, place thermometer in shaded area
Photo # : picture of habitat unit or crossing feature

Record for paired sample riffles:**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, GPS
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

- 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

- <5m long, 10-55cm diameter
 - <5m long, >55cm diameter
 - >5m long, 10-55cm diameter
 - >5m long, >55cm diameter
- RW: rootwad – count separately from attached LW, record in comments
do not record woody debris <10cm diameter, <1m length

End inventory

Where stream is less than 1.0 m wide for > 500 m, or channel runs dry for > 500 m, 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
- 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

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

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