Results and Assessment of Basinwide Visual Estimation Technique (BVET) Fish and Habitat Surveys for the Caribbean National Forest

Center for Aquatic Technology Transfer
1650 Ramble Road
Virginia Polytechnic Institute and State University
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Craig N. Roghair
Fisheries Biologist

J. Keith Whalen
Fisheries Technician

John D. Moran
Fisheries Technician

and

C. Andrew Dolloff
Project Leader
Coldwater Fisheries Research Unit
Southern Research Station

Prepared By:
Craig N. Roghair and J. Keith Whalen

Introduction

In the summer of 1996, we made a site visit to the Caribbean National Forest (CNF) to provide training and on-the-ground experience with BVET (Leftwich and Dolloff 1997). Personnel completed a weeklong training-survey, which provided both training and practical field experience surveying habitat and aquatic fauna in CNF streams. Results from the training-surveys were limited because multiple, inexperienced individuals performed the surveys on a relatively short reach of stream. We gathered enough information to conclude that the BVET habitat survey could successfully be used to inventory stream habitat in the CNF. Streams in the CNF were morphologically similar to streams in the Appalachian Mountains of the eastern United States where BVET habitat surveys have been successfully performed for years. We also concluded that traditional BVET fish survey techniques might not be adequate for assessing aquatic fauna in CNF streams. Major elements of the fauna, which is dominated by shrimp and crabs, were not as susceptible to electrofishing as fish species for which the BVET was originally developed.

In summer 2000, we returned to the CNF with a field crew experienced in performing BVET surveys. We performed BVET fish and habitat surveys on a typical CNF stream inhabited by species of shrimp and crabs. Our primary goal was to further assess BVET as a tool for inventorying aquatic fauna and habitat in the CNF. This report summarizes the summer 2000 BVET surveys in Rio Gurabo, a typical CNF stream, and discusses of the usefulness of BVET surveys for inventorying aquatic fauna and habitat in the CNF.

Methods

Study Area

Rio Gurabo originates within the CNF on the south facing slopes of El Toro and flows for approximately 3.5 km before exiting the CNF and flowing onto privately owned lands (Figure 1). Between August 28 and August 31, 2000, we performed BVET fish and habitat surveys on Rio Gurabo and several of its tributaries starting at the CNF boundary (highway 949) and ending 2.8 km upstream. The study section consisted of a high gradient, second order section of the mainstem flowing from an elevation of 800 m to 350 m and three first order tributaries. Note that the tributaries on the study site map (Figure 1) are not the tributaries that were surveyed. Several unmarked tributaries entered the mainstem of Rio Gurabo and we surveyed the first three tributaries that were encountered as we progressed upstream. The aquatic fauna in the study section consisted exclusively of two shrimp species (*Atya lanipes* and *Xiphocaris elongata*) and one crab species (*Epilobocera sinuatifrons*). The riparian area consisted of tropical rainforest with a dense understory. Several waterfalls were encountered throughout the study section.

Habitat

We used standard BVET habitat survey protocols to estimate pool and riffle surface area and the total surface area of the study section (Hankin and Reeves 1988, Dolloff et al. 1993). Habitat was stratified into similar groups based on naturally occurring habitat units including pools (areas in the stream with relatively low water velocity, streambed gradient near zero, relatively deep water, and a smooth water surface), and riffles (areas in the stream with relatively high water velocity, relatively steep gradient, shallow water, and a turbulent surface). Glides (areas in the stream morphologically similar to pools but with moderate water velocity) were identified during the survey but were grouped with pools for data analysis. Runs (areas in the stream with relatively steep gradient, with rapid, non-turbulent flow) and cascades (areas in the stream with > 12% gradient, high velocity, and exposed bedrock or boulders) were grouped with riffles for data analysis.

Habitat was classified and inventoried by a two-person crew using two-stage visual estimation techniques. One crew member identified all habitat units within the surveyed stream reach by type (pool, riffle, etc.), measured each unit's length to the nearest 0.1 m with a hip chain, and visually estimated each unit's width. The second crew member classified and inventoried the amount of large woody debris (LWD) within the active stream channel in each habitat unit and recorded data on a Husky Hunter data logger.

Width estimates were calibrated by measuring the widths of approximately 20% of the pools and riffles in the surveyed reach. The first unit of each habitat type selected for paired estimates and measurements of width was determined randomly. Additional paired sampling units were selected systematically (every 5^{th} habitat unit was selected). In habitat units selected for paired sampling we visually estimated and measured wetted stream width to the nearest 0.1 m. In addition we determined 1) habitat unit length (measured with a hip chain to the nearest 0.1 m), 2) bankfull channel width (measured to the nearest 0.1 m), 3) dominant and subdominant substrata particle size (modified Wentworth scale), 4) percentage canopy closure (visually estimated), 5) instream cover (estimated linear distance to the nearest 0.5 m of undercut banks, boulders, and LWD), and 6) average and maximum depth (measured to the nearest 0.01 m – average depth of each habitat unit was estimated by taking depth measurements at various places across the channel profile with a graduated staff) in each habitat unit selected for paired sampling. Percentage canopy closure estimates were calibrated by pairing approximately 20% of the estimates with spherical densiometer measurements.

Total surface area of pools and riffles was calculated using an Excel spreadsheet (Dolloff et al. 1993). Maximum and average depths, dominant and subdominant substrates, canopy closure, instream cover, and LWD data were summarized using Excel spreadsheets and Sigma Plot graphing software.

Aquatic Fauna

We inventoried aquatic fauna using standard BVET fish survey protocols (Hankin and Reeves 1988, Dolloff et al. 1993). Diver counts were performed in 20% of pools and riffles, the same habitat units that were used as paired samples during the habitat survey. Before any habitat parameters were measured a diver entered the downstream end of selected habitat units and proceeded slowly upstream to the head of the unit while searching for and counting all encountered species. Diver counts were used to examine the distribution of each species in the study section.

Calibrated diver counts can be used to estimate population abundances with confidence intervals (Hankin and Reeves 1988, Dolloff et al. 1993). We attempted to calibrate diver counts by performing three-pass removal electrofishing on 20% of the pools and riffles in which we had diver counts. A major assumption of three-pass removal estimates is that fewer fish are captured in each successive pass (Kwak 1991). Because the target species were not susceptible to electrofishing, we did not obtain usable depletions. We therefore could not calibrate our estimates of population abundance.

Results

Habitat

We surveyed habitat in 2.8 km of the mainstem of Rio Gurabo and approximately 1.0 km of tributary habitat. The tributary data was lost due to a data logger malfunction and data analysis was limited to the 2.8 km reach of the mainstem. For the remainder of this report, ‘study section’ refers to the 2.8 km reach on the mainstem of Rio Gurabo.

We identified 220 pools and 167 riffles in the 2.8 km study section. We also identified one glide, one cascade, and one run in the study section. Visual estimates of habitat area were paired with measured habitat area for 37 (17%) pools and 27 (16%) riffles. We estimated that the reach contained 47% pool habitat (6672±268 m^2) and 53% riffle habitat (7658±301 m^2) (Figure 2). Total area was estimated for pools and riffles using correction factors of 0.91 and 1.04, respectively.

Maximum pool depths ranged from 40 cm to 170 cm, with a mean of 93 cm and maximum riffle depths ranged from 15 cm to 70 cm, with a mean of 44 cm (Figure 3). Average pool depths ranged from 20 cm to 90 cm, with a mean of 47 cm and average riffle depths ranged from 10 cm to 35 cm, with a mean of 22 cm.

The most frequently encountered substrate types were boulder and cobble. Boulder was the dominant substrate in 61% of pools and 70% of riffles (Figure 4). Cobble was the subdominant substrate in 47% of pools and 59% of riffles. Although organic, clay, silt, and sand substrates were all present in the study section they were not the dominant or subdominant substrate type in any habitat units.

The study reach contained 169 pieces of LWD per km, of which the majority was <5 m long, < 50 cm in diameter (Figure 5). There was less than one piece per km of LWD >5 m in length, > 50 cm in diameter in the study reach. Pieces >5 m in length and >50 cm in diameter are the most persistent and most likely to form habitat units in the stream channel (Hilderbrand et al. 1998). LWD was found throughout the study reach, with the largest number of pieces per habitat unit located upstream of stream meter 2000 (Figure 6).

Rock was the dominant form of instream cover (Figure 7). We identified rock cover in every pool and riffle in which estimates were made. Undercut banks and LWD provided much less potential instream cover than rocks.

Canopy closure ranged from near zero to 100% (Figure 8). No increasing or decreasing trends in canopy closure were evident along the length of the study section.

Aquatic Fauna

We surveyed aquatic fauna in 2.8 km of the mainstem of Rio Gurabo and approximately 1.0 km of tributary habitat. As discussed in the 'Methods' section, we were unable to estimate population abundances for any of the crustacean species because electrofishing failed to produce valid depletions. However, we were able to examine distributional trends in the mainstem using our diver count data (Figure 9). *X. elongata* were the most commonly encountered and widely distributed species. They were rarely observed occupying riffle habitat. *A. lanipes* was less widely distributed than *X. elongata*. We first encountered *A. lanipes* 700 m upstream of highway 949. Individuals >100 mm in length (tip of rostrum to end of tail) were observed in several pools. *E. sinuatifrons* were most frequently encountered in the lower 1700 m of the study section. They were more frequently observed in riffles than *X. elongata* or *A. lanipes*. The tributary data was lost due to a data logger malfunction, however all three species were found throughout the entire length of two of the three tributaries that were surveyed. The remaining tributary had no species of shrimp or crab.

Discussion

The results of the present study in combination with those from Leftwich and Dolloff (1997) allow us to further discuss the use of BVET fish and habitat surveys in CNF streams. The results of the habitat survey were encouraging. We were able to survey nearly 3 km of stream and estimate several habitat parameters over a period of only four days. We believe that we could have surveyed a longer reach of stream given improved road or trail access to the site and less hostile terrain. The stream was in a remote location, was extremely steep, and was surrounded by dense rainforest vegetation. A considerable portion of our time was spent walking to/from our starting/ending point each day and maneuvering around obstacles such as waterfalls during the surveys. Surveying further than 3 km from any road access point would be difficult on any streams similar to Rio Gurabo.

Another factor to consider is the number of habitat parameters that were included in the survey. Many of the parameters in the present study are typically included in BVET surveys, however others were added at the request of the CNF. The usefulness of each parameter to CNF biologists and managers should be carefully considered before including it in a survey. A crew can move faster, and thus further, during a survey if they have fewer parameters to measure.

We were able to investigate species distribution but not population abundance using the BVET fish survey. The results of this and the earlier study (Leftwich and Dolloff 1997) suggest that shrimp and crab species are not as susceptible to electrofishing as the fish species for which the BVET was originally designed. Without valid depletions (i.e. obtaining fewer fish in each successive pass) we were unable to develop correction factors for diver counts and thus were unable to estimate population abundance. Despite its limitations, electrofishing has been used in both three-pass depletion and mark-recapture studies to estimate population abundance of stream-dwelling decapod crustaceans (Penczak and Rodriguez 1990, Fievet et al. 1996, Rabeni et al. 1997). Rabeni et al. (1997) suggested that mark-recapture estimates might be more precise than depletion estimates for estimating population abundance of crayfish.

Given the above factors and depending on the goals of CNF biologists and managers several options exist:

1) Accept the limitations of electrofishing and continue to estimate population abundance using standard BVET fish survey techniques. This is not a desirable option given our results thus far.

2) Modify BVET fish survey protocols and develop an alternative to electrofishing that will provide population abundance estimates with confidence intervals.

3) Develop alternative methods such as mark-recapture to provide population abundance estimates.

4) Use the BVET fish survey diver counts to assess distribution of species and abandon attempts to estimate population abundances.

We are eager to work with the CNF to further develop any of these or other options.

During our summer 2000 visit CNF personnel indicated that there is a lack of information available on CNF stream habitat and fauna. BVET surveys in combination with other techniques could provide a large amount of data for the CNF stream habitat and aquatic fauna monitoring plan. This data could be used to, for example, compare habitat conditions (substrate type, amount of LWD, etc.) between streams, examine for trends in species distribution within and between streams, examine for relationships between habitat types and population abundance, etc. Data needs to be collected on several more streams before comparisons between streams of different types or streams in different areas can be made. The limitations discussed above and the goals of the CNF stream habitat and aquatic fauna monitoring plan need to be considered carefully before further surveys are performed.

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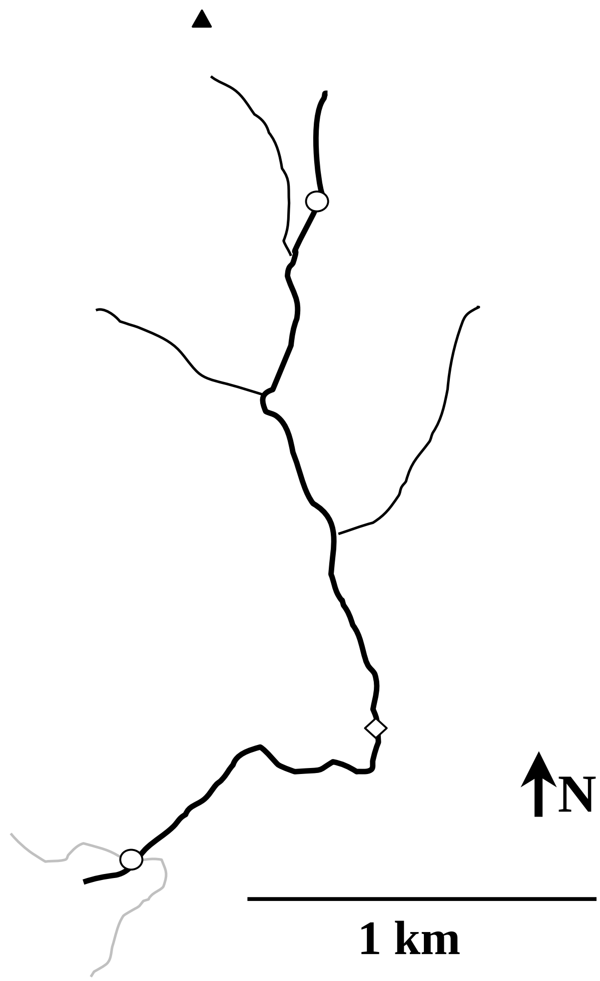

Figure 1. Study section of Rio Gurabo, CNF. The open circles represent the starting and ending points for BVET fish and habitat surveys performed during summer 2000. The open diamond indicates the location of a water intake structure. The closed triangle indicates the location of the peak of El Toro. Highway 949 (also marking the southern edge of the CNF boundary on Rio Gurabo) is represented by the gray line near the bottom of the map.

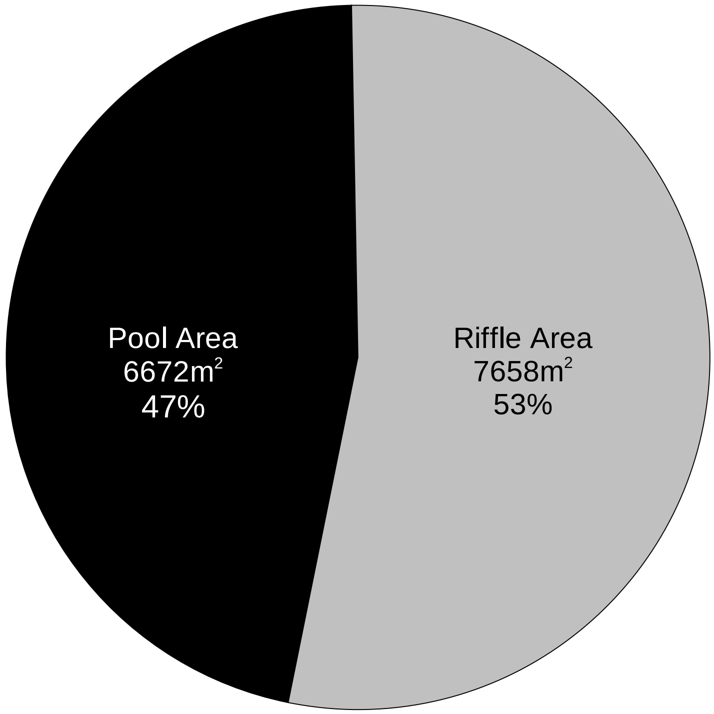

Figure 2. Total and percent pool and riffle surface area for all pools and riffles in the study section of Rio Gurabo.

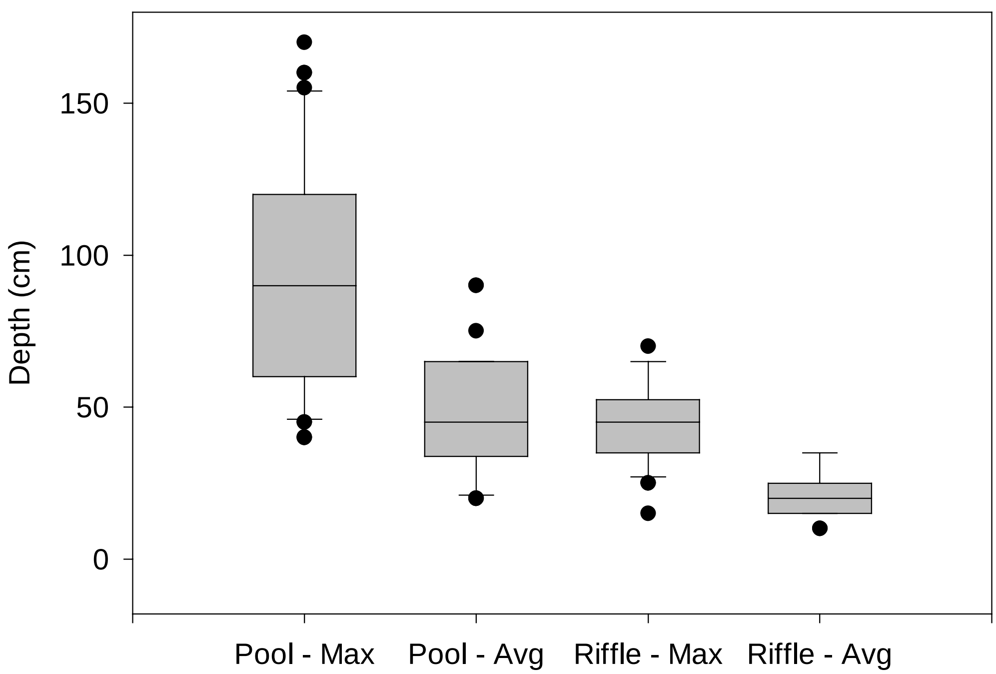

Figure 3. Box plots representing maximum and average depths for approximately 20% of pools and riffles in the study section of Rio Gurabo. The top and bottom of the boxes represent the 25^{th} and 75^{th} percentiles, the bar in the center of the box represents the median, whiskers represent the 10^{th} and 90^{th} percentiles, and closed circles represent the entire range of the data.

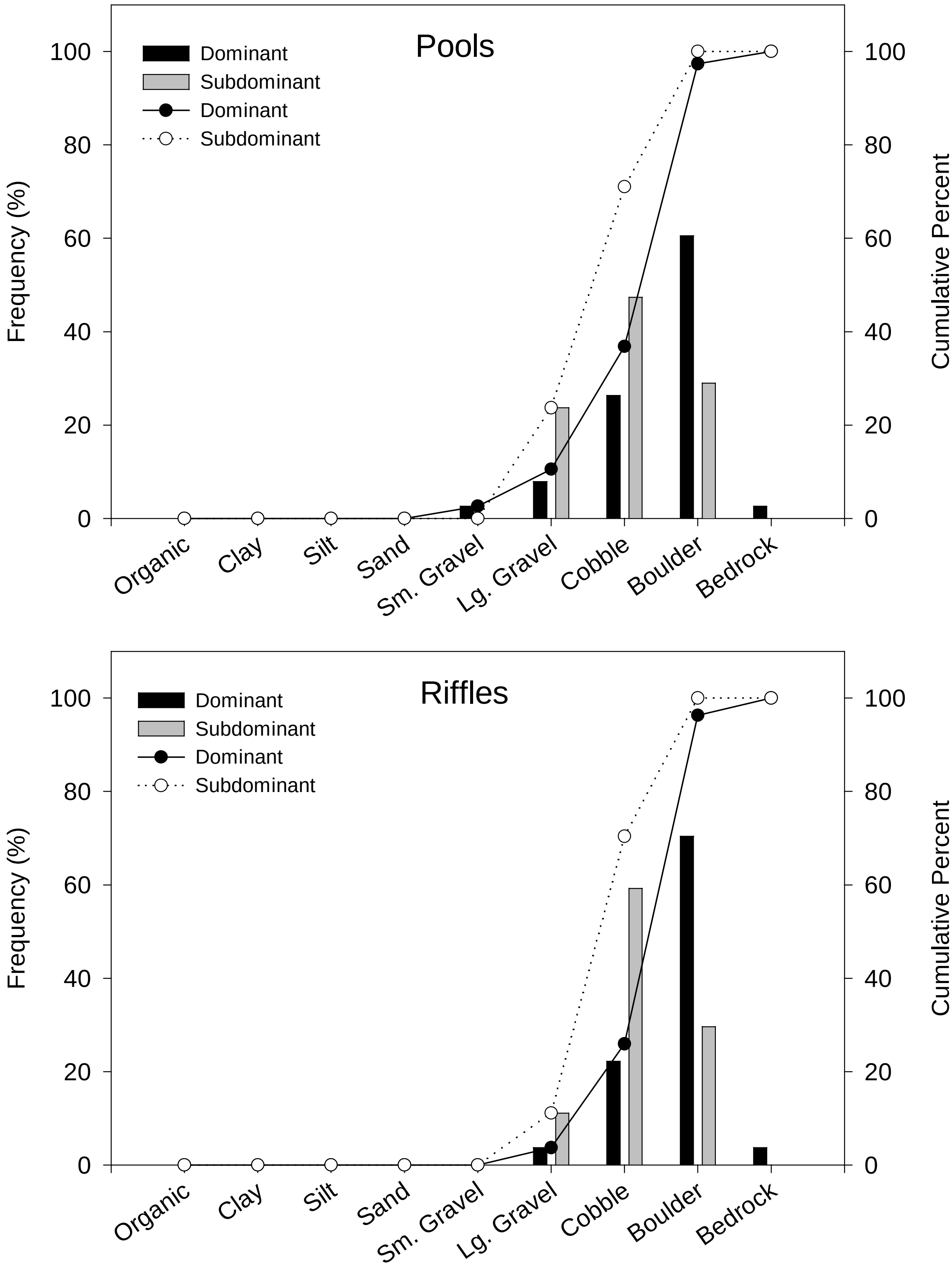

Figure 4. Frequency (percent) and cumulative percent of dominant and subdominant substrate occurrence for approximately 20% of pools and riffles in the study section of Rio Gurabo.

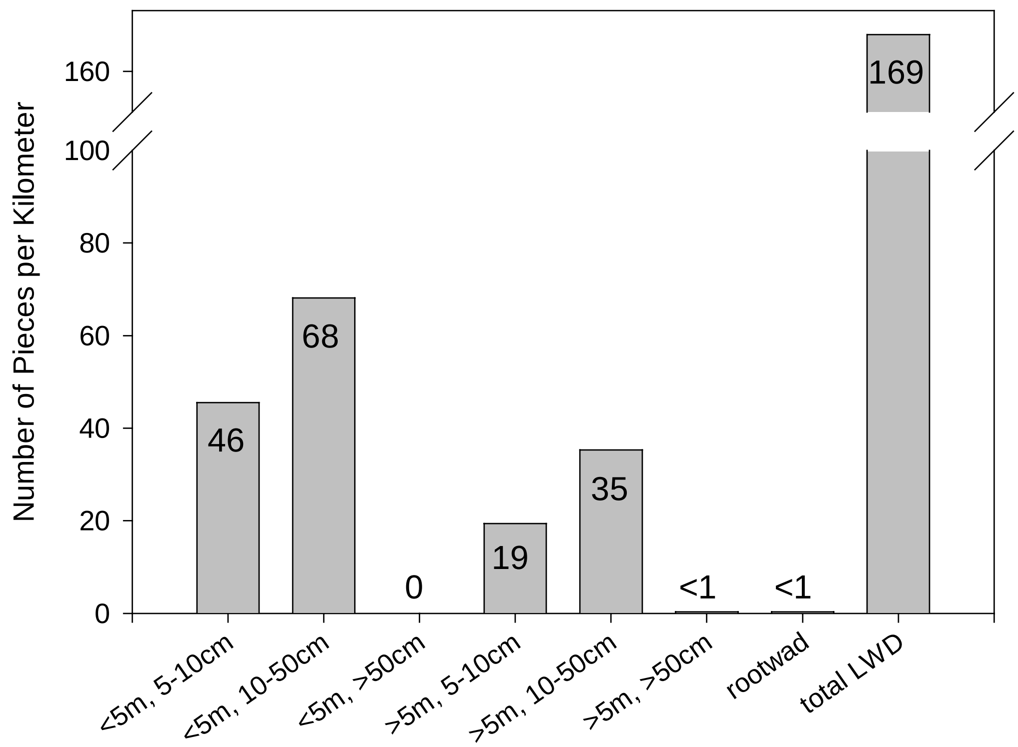

Figure 5. LWD per kilometer in the study reach of Rio Gurabo. X-axis labels represent LWD size classes with the first number indicating LWD length and the second number indicating LWD diameter.

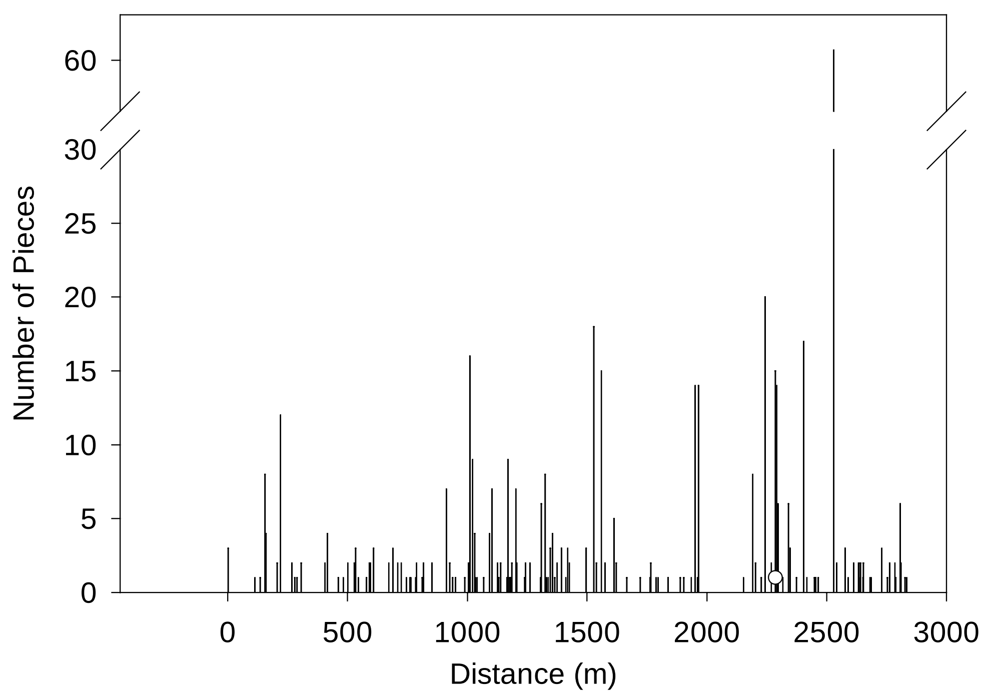

Figure 6. Distribution and abundance of LWD in every habitat unit in the study reach of Rio Gurabo. Open circles represent amount of the total LWD that was >5 m in length, >55 cm in diameter.

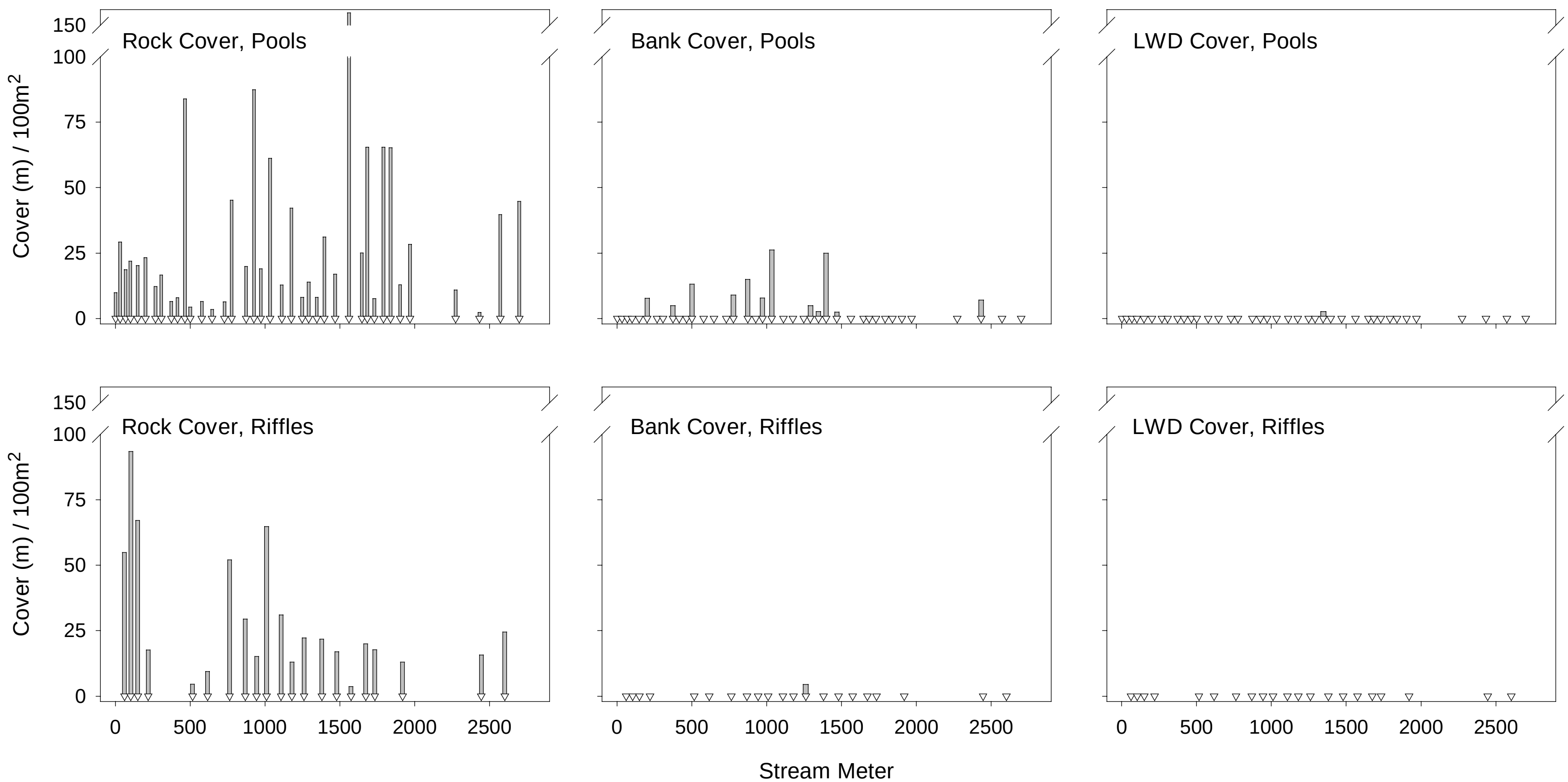

Figure 7. Linear meters of rock, undercut bank, and LWD cover per 100 m^2 of surface area for approximately 20% of pools and riffles in the study reach of Rio Gurabo. Open triangles represent locations where estimates of cover were made. X-axis indicates meters upstream from highway 949. X-axis and y-axis scales are the same for all figures.

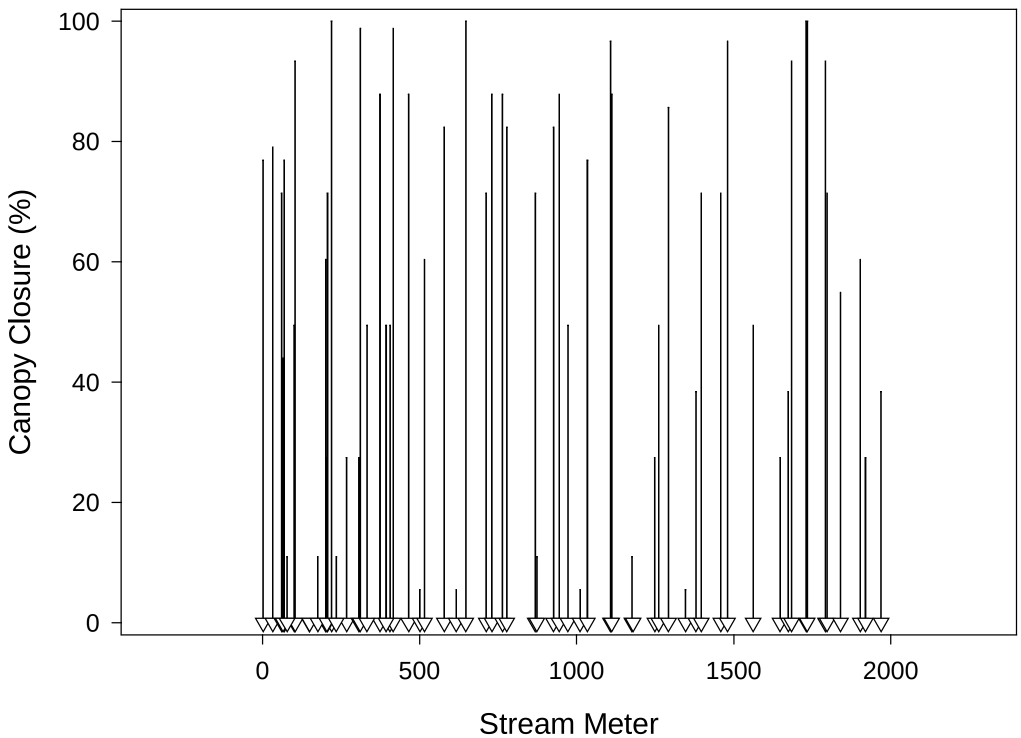

Figure 8. Percent canopy closure over approximately 20% of the habitat units in the study section of Rio Gurabo. Open triangles indicate locations where estimates were performed. Stream meter indicates distance upstream from highway 949.

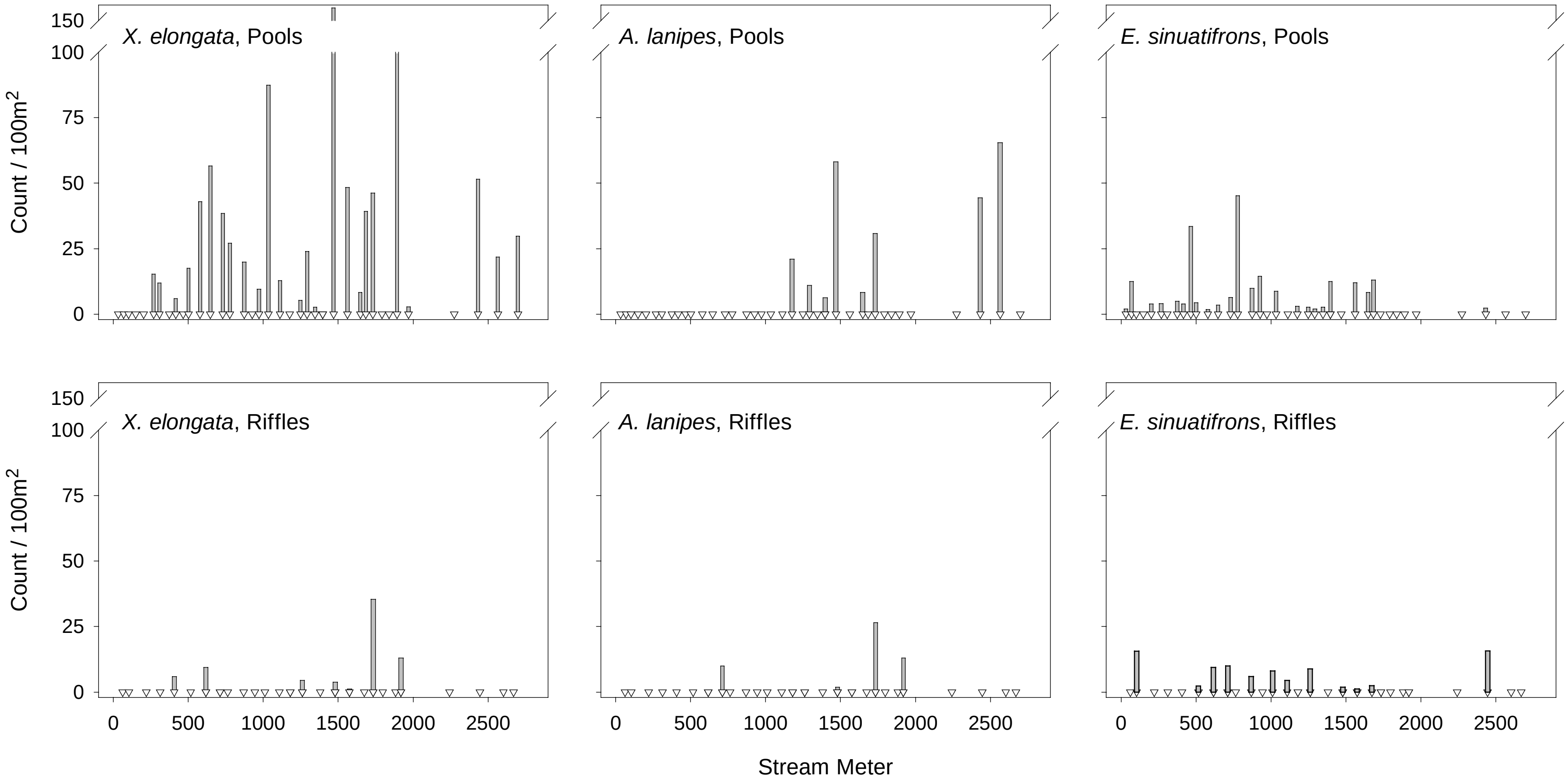

Figure 9. Diver counts of *X. elongata*, *A. lanipes*, and *E. sinuatifrons* per 100 m^2 of surface area for approximately 20% of pools and riffles in the study section of Rio Gurabo. Open trianges represent locations where diver counts were made. X-axis indicates meters upstream from highway 949. X-axis and y-axis scales are the same for all figures.