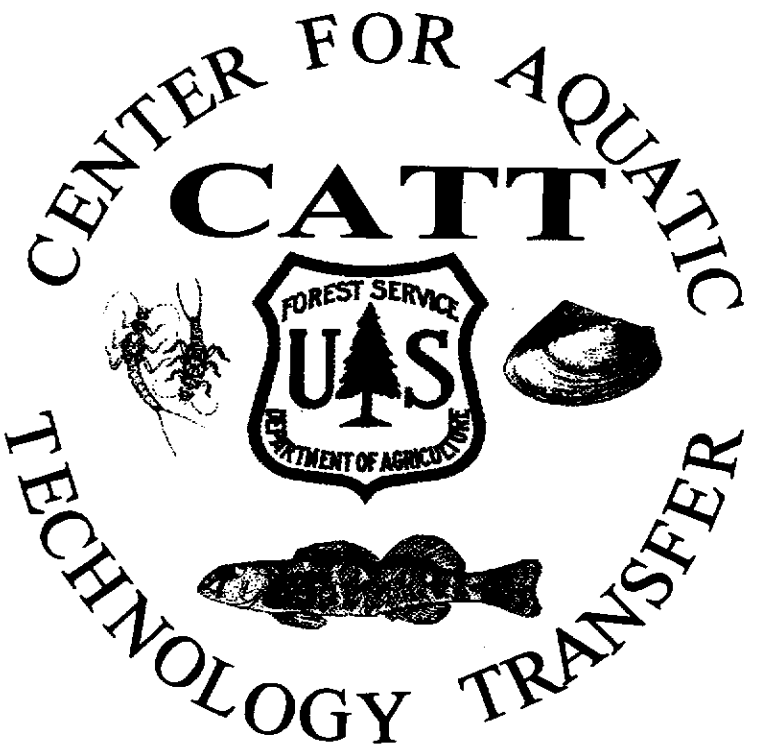
An Inventory of Stream Habitat and Tennessee Dace *Phoxinus tennesseensis* in Lynn Camp Creek and Lick Creek, George Washington - Jefferson National Forest, Virginia



United States Department of Agriculture Forest Service
Center for Aquatic Technology Transfer
Department of Fisheries and Wildlife Sciences
Virginia Tech, Blacksburg, VA 24061-0321

An Inventory of Stream Habitat and Tennessee Dace *Phoxinus tennesseensis* in Lynn Camp Creek and Lick Creek, George Washington - Jefferson National Forest, Virginia

United States Department of Agriculture
Forest Service
Center for Aquatic Technology Transfer

134 Cheatham Hall
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061-0321

Martin K. Underwood
Fisheries Biologist

and

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

Prepared By:

Martin K. Underwood and J. Keith Whalen

April 1999

Introduction

We used the basinwide visual estimation technique (BVET) (Hankin and Reeves 1988; Dolloff et al. 1993) to inventory habitat and fish in two North Fork Holston River tributaries, Virginia. The main focus of this study was to determine the distribution and abundance of the Tennessee dace *Phoxinus tennesseensis* (a state threatened fish species), in Lick Creek and Lynn Camp Creek. The majority of both streams are located in the Wythe - Blacksburg Ranger District of the George-Washington National Forest (GW-JNF), therefore both study sections were restricted within the boundaries of the National Forest.

Another of our goals was to begin linking knowledge of habitat use by the Tennessee dace to habitat use by its federally threatened sister species the blackside dace *Phoxinus cumberlandensis*. In Kentucky, the blackside dace prefers areas where large woody debris (LWD) is prevalent (Starnes, 1981), especially in small, cool water streams found on the Daniel Boone National Forest (DBNF). If there is a strong relationship between physical habitat and the well being of these species (barring numerous other biological factors) then management practices on both the DBNF and the GW-JNF can be modified or instituted to meet their specific needs.

Study Streams

We started our survey of Lynn Camp Creek, a small second order cool water tributary of Lick Creek, at the lower U.S. Forest Service boundary and ended over 5 kilometers upstream where the stream was deemed marginal to support fish. The upper 3 kilometers of the study section flowed adjacent to the U.S. Forest Service road 632 (Figure 1). We surveyed over 6 kilometers of the larger Lick Creek (averages over 5.5 meters wide) starting at the lower U.S. Forest Service boundary about one kilometer upstream from the confluence with Lynn Camp Creek (Figure 2). This survey was continuous up to the third private in-holding found on the Hutchinson Rock United States Geological Survey quadrangle. The survey was resumed starting at the upper private boundary and continued another kilometer through U.S. Forest Service land

where the survey ends at the next private land boundary.

Methods

Habitat

Habitat in all streams was stratified into similar groups based on naturally occurring habitat units including pools (areas in the stream with low water velocity, streambed gradient near zero, and a smooth water surface), and riffles (areas in the stream with relatively steep gradient, shallow water, relatively high velocity, and turbulent surface).

We used two-stage visual estimation techniques to quantify habitat in the study stream. During the first stage, all habitat units were classified and the surface area and maximum and average depth were estimated. Habitat was classified and inventoried by a two-person crew. One crew member identified each habitat unit by type, estimated wetted stream width, and classified the dominant and subdominant substrata particle size (Modified Wentworth scale). The remaining crew member classified and inventoried LWD within the active stream channel, estimated the maximum and average depth of each habitat unit, and measured depth at riffle crest for each riffle. LWD greater than 1 meter long and greater than 10 centimeters in diameter was divided into four classes: 1) less than 5 m long, less than 55 cm in diameter, 2) less than 5 m long, greater than 55 cm in diameter, 3) greater than 5 m long, less than 55 cm in diameter, and 4) greater than 5 m long, greater than 55 cm in diameter. Average depth of each habitat unit was estimated by taking depth measurements at various places across the channel profile with a graduated staff marked in 5 cm increments. The length (0.1 m) of each habitat unit was measured with a hip chain, and data were recorded on a Husky Hunter field data logger.

The first unit of each habitat type selected for intensive sampling (accurate measurement of surface area, second stage sampling and calibration) was determined randomly. Additional units were selected systematically (about one unit out of 5 for each habitat type).

BVET calculations were computed using a Statistical Analysis Systems (SAS) program. Data were summarized using a Corel Quattro Pro spreadsheet, Corel Presentations, SigmaPlot graphics software, and SigmaStat statistical software.

Fish

Underwater observation was used to estimate the distribution and relative abundance of Tennessee dace in each of the habitat units selected for intensive sampling in the Lynn Camp Creek study section. When a sample unit was encountered, a diver entered at the downstream end and proceeded slowly upstream to the head of the unit while searching for and counting all fish. When a fish was sighted, it was directed out of the line of travel by the diver's hand to prevent double counting. We selected about 17% of the total number of pools and 39% of the total number of riffles snorkeled in the Lynn Camp Creek study section for multiple-pass removal census (Zippen 1958), using a 700V AC backpack electrofisher, to verify species identification and diver counts.

Due to low visibility, only electrofishing was used to sample fish in the larger Lick Creek study section. The same multiple-pass depletion census that was performed on the Lynn Camp study section, was used to survey 15 pools and 10 riffles in the Lick Creek study section.

In both sections, all fish were counted and identified before being returned to their approximate location of capture. Tennessee dace were measured for fork length (FL; mm) and total length (TL; mm), and weighed (0.1 g). All fish captured were released immediately after handling.

Results

Habitat

Lynn Camp Creek -We identified 266 pools and 234 riffles in the 5.0-kilometer- long study section of Lynn Camp Creek. Visual estimates of habitat areas were paired with

measured habitat area for 51 (19%) pools, and 23 (10%) riffles. We estimated that the study section of Lynn Camp Creek contained 40.9% pool habitat (4,740.0 $\pm$ 142.8 m^2) and 51.9% riffle habitat (6,844.0 $\pm$ 316.0 m^2) (Figure 3). Total area was estimated for each habitat type using correction factors ($\hat{Q}$) that ranged from 1.00 to 1.03.

Maximum depth in the Lynn Camp Creek study section ranged from a mean of 13.0 cm in riffles to 29.4 cm in pools (Figure 4). Likewise, average depth ranged from a mean of 7.0 cm in riffles to 17.5 cm in pools (Figure 4). The mean average residual depth was 12.7 cm (Figure 4).

We identified cobble as the most common (modal) dominant and subdominant substratum for pools in the Lynn Camp Creek study section, but the remainder of pool stream bottom also contained a large percentage of gravel (Figure 5). In riffles, the most common (modal) dominant and subdominant substrata were cobble and boulder, respectively (Figure 6).

The total of 266 pieces of LWD per kilometer in the Lynn Camp Creek study section more than meets the desired future condition for stream habitat on the GW-JNF (Figures 7 and 8) This section contained over 180 pieces of the smallest size class, which is preferred by this and other *Phoxinus* species (Etnier and Starnes 1993; Jenkins and Burkhead 1994)(Figure 7).

Lick Creek -We identified 170 pools and 106 riffles in the 6.4-kilometer- long study section of Lick Creek. Visual estimates of habitat areas were paired with measured habitat area for 33 (19%) pools, and 8 (8%) riffles. We estimated that the study section of Lick Creek contained 75.9% pool habitat (30,692.0 $\pm$ 599.4 m^2) and 24.1% riffle habitat (9,767.0 $\pm$ 360.2 m^2) (Figure 9). Total area was estimated for each habitat type using correction factors ($\hat{Q}$) that ranged from 1.03 to 1.05.

Maximum depth in the Lick Creek study section ranged from a mean of 20.1 cm in riffles to 45.5 cm in pools (Figure 10). Likewise, average depth ranged from a mean of 13.7 cm in riffles to 30.3 cm in pools (Figure 10). The mean average residual depth was 19.7 cm (Figure 10).

We identified cobble as the most common (modal) dominant and subdominant

substratum for pools in the Lick Creek study section, but the remainder of pool stream bottom also contained a large percentage of gravel (Figure 11). In riffles, the most common (modal) dominant and subdominant substrata were cobble and large gravel, respectively (Figure 12).

Lick Creek contained about 92 pieces of LWD per kilometer (Figures 13 and 14). This section, however, only contained about 9 pieces per kilometer of the larger size classes, which are the most stable and most capable of forming instream habitat and providing cover for fishes (Figure 14).

Fish

Lynn Camp Creek - We captured 8 species of fish while sampling 11 pools and 9 riffles during the electrofishing survey of the Lynn Camp Creek study section (Table 1). Blacknose dace *Rhinichthys atratulus*, rosyside dace *Clinostomus funduloides*, and creek chub *Semotilus atromaculatus* were the most abundant species, while Tennessee dace made up only 3.4 % of the relative abundance (Figure 15).

A population estimate of 204.9 ($\pm$ 200.5) was calculated for Tennessee dace in Lynn Camp Creek pools only. Tennessee dace were not found in riffles during both the underwater observation and the electrofishing surveys. Tennessee dace were fairly common in the lower two kilometers while numbers dropped off considerably in the upper half of the study section (Figure 16). Densities ranged from 0.13 per m^2 to 1.53 per m^2 in pools where the species was found.

In an attempt to link Tennessee dace distribution and abundance to habitat variables we produced a correlation matrix composed of Tennessee dace numbers and densities versus various habitat data (Table 2). Although sample size was small (N = 14) Tennessee dace apparently prefer relatively deep large pools and large woody debris in the Lynn Camp Creek study section (Table 2).

Lick Creek - During the electrofishing survey of 15 pools and 10 riffles in the Lick Creek study section we captured over 2,200 fish, comprised of 22 species (Table 3). Most

species were relatively common throughout the study section while some, including Tennessee dace, were localized (Table 4, Figure 17).

Population estimates and 95% confidence intervals were calculated using Zippen (1958) for each unit where Tennessee dace were captured; estimates ranged from 2.0 ± 0.0 to 11.0 ± 0.4 (Figure 18). Tennessee dace were captured in 40% of the pools sampled and were not present in any of the riffles sampled during the Lick Creek electrofishing survey (Figure 19).

Discussion and Recommendations

Based on our results, Tennessee dace are more common in Lynn Camp Creek than Lick Creek. This could be partly due to this species preference for smaller, cool water streams. Lick Creek is significantly larger and is more susceptible to human influences such as roads and agriculture. There is very little access to Lynn Camp Creek and no obvious human impact except for a little used Forest Service road and the Appalachian Trail.

Even though the confidence intervals were high for the population estimate of Tennessee dace in the Lynn Camp Creek study section it still gives us relative estimate of how well this species is doing in this stream. Our estimates of abundance and distribution in Lynn Camp Creek can be used to design a new survey, concentrating effort on the known range of Tennessee dace.

We were not able to sample the lower two kilometers of Lynn Camp Creek flowing through private land to the confluence of Lick Creek. We think this section has the potential to support high densities of Tennessee dace because the concentration of this species was relatively high in the lower part of our study section. The only known access into the private section of Lynn Camp Creek is by wading at least a mile down Lick Creek from the U.S. Forest Service boundary. The status of ownership is unknown; if possible we would like to sample this section with assistance from the Virginia Department of Game and Inland Fisheries. This would give us a more complete understanding of the habitat relationships of Tennessee dace and may

significantly increase the distribution and abundance of this species within its range in Virginia.

Literature Cited

Etnier, D. and W. Starnes. 1993. Fishes of Tennessee. The University of Tennessee Press. Knoxville, Tennessee, USA. 618 pp.

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, Forest Service, Southeastern Forest Experimental Station. 25 pp.

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.

Jenkins, R. E., and N. M. Burkhead. 1994. Freshwater fishes of Virginia. American Fisheries Society. Bethesda, Maryland. 1079 pages.

Starnes, W. 1981. Listing package for the blackside dace *Phoxinus cumberlandensis.* Submitted to: U.S. Fish and Wildlife Service. Department of Zoology, The University of Tennessee, Knoxville, TN.

Zippen, C. 1958. The removal method of population estimation. Journal of Wildlife Management. 22:82-90.

Table 1. Fish species composition of Lynn Camp Creek, North Fork Holston River.

Scientific name	**Common Name**
Notropis leuciodus	Tennessee shiner
Campostoma anomalum	central stoneroller
Phoxinus tennesseensis	Tennessee dace
Semotilus atromaculatus	creek chub
Cottus spp.	sculpin **many possibilities
Etheostoma flabellare	fantail darter
Rhinichthys atratulus	blacknose dace
Clinostomus funduloides	rosyside dace

Table 2. Correlation Matrix for numbers and density of Tennessee dace versus habitat parameters where individuals were found in pools of Lynn Camp Creek. N = 14.

Habitat Parameter	Corrected Numbers	Density
Distance from Start	-0.31	-0.38
Number of LWD pieces	0.61	0.33
LWD Density	0.31	0.50
Maximum Depth	0.81	0.24
Average Depth	0.75	0.26
Avg. Residual Pool Depth	0.46	0.61
Wetted Width	0.87	0.14
Dominant Substrate	-0.43	-0.27
Subdominant Substrate	-0.02	-0.02

Table 3. Fish species composition of Lick Creek, North Fork Holston River.

Scientific name	Common Name
Notropis leuciodus	Tennessee shiner
Luxilus chrysocephalus	striped shiner
Luxilus coccogenis	warpaint shiner
Campostoma anomalum	central stoneroller
Phoxinus tennesseensis	Tennessee dace
Semotilus atromaculatus	creek chub
Nocomis micropogon	river chub
Cottus spp.	sculpin **many possibilities
Etheostoma flabellare	fantail darter
Etheostoma rufilineatum	redline darter
Etheostoma simoterum	snubnose darter
Lepomis auritus	redbreast sunfish
Micropterus dolomieu	smallmouth bass
Ambloplites rupestris	rock bass
Lepomis macrochirus	bluegill
Ichthyomyzon spp.	lamprey ammocoetes
Noturus insignis	margined madtom
Catostomus commersoni	white sucker
Moxostoma spp.	redhorse **field i.d. unsure of spp.
Hypentelium nigricans	northern hogsucker
Rhinichthys atratulus	blacknose dace
Clinostomus funduloides	rosyside dace

Table 4. Fish species distribution in Lick Creek.

Unit	No.	Distance (m)	Scientific Name	Common Name
Pool	5	130.0	*Ichthyomyzon spp.*	lamprey ammocoetes
			Campostoma anomalum	central stoneroller
			Luxilus coccogenis	warpaint shiner
			Nocomis micropogon	river chub
			Notropis leuciodus	Tennessee shiner
			Rhinichthys atratulus	blacknose dace
			Semotilus atromaculatus	creek chub
			Moxostoma spp.	redhorse
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
			E. simoterum	snubnose darter
			Ambloplites rupestris	rock bass
			Lepomis auritus	redbreast sunfish
			Lepomis macrochirus	bluegill
Pool	10	405.3	*Ichthyomyzon spp.*	lamprey ammocoetes
			Noturus insignis	margined madtom
			Campostoma anomalum	central stoneroller
			Luxilus coccogenis	warpaint shiner
			Nocomis micropogon	river chub
			Notropis leuciodus	Tennessee shiner
			Rhinichthys atratulus	blacknose dace
			Semotilus atromaculatus	creek chub
			Hypentelium nigricans	northern hogsucker
			Cottus spp.	sculpin
			Etheostoma simoterum	snubnose darter
Riffle	10	739.9	*Campostoma anomalum*	central stoneroller
			Nocomis micropogon	river chub

Table 4. Continued.

Unit	No.	Distance (m)	Scientific Name	Common Name
			Notropis leuciodus	Tennessee shiner
			Rhinichthys atratulus	blacknose dace
			Semotilus atromaculatus	creek chub
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
			E. rufiliniatum	redline darter
			Ambloplites rupestris	rock bass
Riffle	15	993.6	*Noturus insignis*	margined madtom
			Campostoma anomalum	central stoneroller
			Luxilus coccogenis	warpaint shiner
			Notropis leuciodus	Tennessee shiner
			Rhinichthys atratulus	blacknose dace
			Semotilus atromaculatus	creek chub
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
			E. rufiliniatum	redline darter
			E. simoterum	snubnose darter
Pool	25	1002.6	*Campostoma anomalum*	central stoneroller
			Clinostomus funduloides	rosyside dace
			Luxilus coccogenis	warpaint shiner
			Notropis leuciodus	Tennessee shiner
			Phoxinus tennesseensis	Tennessee dace
			Semotilus atromaculatus	creek chub
			Hypentelium nigricans	northern hogsucker
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
			E. rufiliniatum	redline darter

Table 4. Continued.

Unit	No.	Distance (m)	Scientific Name	Common Name
Pool	25	1002.6	*E. simoterum*	snubnose darter
			Ambloplites rupestris	rock bass
Riffle	20	1214.6	*Campostoma anomalum*	central stoneroller
			Notropis leuciodus	Tennessee shiner
			Rhinichthys atratulus	blacknose dace
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
			E. rufiliniatum	redline darter
			E. simoterum	snubnose darter
Pool	30	1222.1	*Noturus insignis*	margined madtom
			Campostoma anomalum	central stoneroller
			Clinostomus funduloides	rosyside dace
			Luxilus coccogenis	warpaint shiner
			Notropis leuciodus	Tennessee shiner
			Rhinichthys atratulus	blacknose dace
			Semotilus atromaculatus	creek chub
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
			E. simoterum	snubnose darter
Riffle	30	1951.0	*Ichthyomyzom spp.*	lamprey ammocoetes
			Notropis leuciodus	Tennessee shiner
			Rhinichthys atratulus	blacknose dace
			Cottus spp.	sculpin
Pool	45	1995.3	*Ichthyomyzom spp.*	lamprey ammocoetes
			Campostoma anomalum	central stoneroller
			Notropis leuciodus	Tennessee shiner
			Phoxinus tennesseensis	Tennessee dace

Table 4. Continued.

Unit	No.	Distance (m)	Scientific Name	Common Name
Pool	45	1995.3	*Rhinichthys atratulus*	blacknose dace
			Semotilus atromaculatus	creek chub
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
Pool	50	2203.6	*Campostoma anomalum*	central stoneroller
			Clinostomus funduloides	rosyside dace
			Luxilus coccogenis	warpaint shiner
			Nocomis micropogon	river chub
			Notropis leuciodus	Tennessee shiner
			Phoxinus tennesseensis	Tennessee dace
			Rhinichthys atratulus	blacknose dace
			Semotilus atromaculatus	creek chub
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
			E. simoterum	snubnose darter
			Ambloplites rupestris	rock bass
Riffle	40	2674.9	*Campostoma anomalum*	central stoneroller
			Clinostomus funduloides	rosyside dace
			Notropis leuciodus	Tennessee shiner
			Rhinichthys atratulus	blacknose dace
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
			E. rufiliniatum	redline darter
			E. simoterum	snubnose darter
Pool	65	2865.0	*Ichthyomyzon spp.*	lamprey ammocoetes
			Clinostomus funduloides	rosyside dace
			Luxilus chrysocephalus	striped shiner

Table 4. Continued.

Unit	No.	Distance (m)	Scientific Name	Common Name
Pool	65	2865.0	*Phoxinus tennesseensis*	Tennessee dace
			Rhinichthys atratulus	blacknose dace
			Semotilus atromaculatus	creek chub
			Catostomus commersoni	white sucker
			Hypentelium nigricans	northern hogsucker
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
			E. simoterum	snubnose darter
			Ambloplites rupestris	rock bass
Pool	70	3073.7	*Campostoma anomalum*	central stoneroller
			Clinostomus funduloides	rosyside dace
			Notropis leuciodus	Tennessee shiner
			Rhinichthys atratulus	blacknose dace
			Semotilus atromaculatus	creek chub
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
			E. simoterum	snubnose darter
Riffle	50	3421.4	*Campostoma anomalum*	central stoneroller
			Clinostomus funduloides	rosyside dace
			Notropis leuciodus	Tennessee shiner
			Rhinichthys atratulus	blacknose dace
			Semotilus atromaculatus	creek chub
			Hypentelium nigricans	northern hogsucker
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
			E. simoterum	snubnose darter
Pool	85	3602.6	*Ichthyomyzon spp.*	lamprey ammocoetes

Table 4. Continued.

Unit	No.	Distance (m)	Scientific Name	Common Name
Pool	85	3602.6	*Campostoma anomalum*	central stoneroller
			Clinostomus funduloides	rosyside dace
			Notropis leuciodus	Tennessee shiner
			Rhinichthys atratulus	blacknose dace
			Semotilus atromaculatus	creek chub
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
			E. simoterum	snubnose darter
			Ambloplites rupestris	rock bass
Pool	90	3721.6	*Ichthyomyzon spp.*	lamprey ammocoetes
			Campostoma anomalum	central stoneroller
			Clinostomus funduloides	rosyside dace
			Notropis leuciodus	Tennessee shiner
			Rhinichthys atratulus	blacknose dace
			Semotilus atromaculatus	creek chub
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
			E. simoterum	snubnose darter
Riffle	60	3858.6	*Notropis leuciodus*	Tennessee shiner
			Rhinichthys atratulus	blacknose dace
			Cottus spp.	sculpin
Pool	105	4345.3	*Ichthyomyzon spp.*	lamprey ammocoetes
			Campostoma anomalum	central stoneroller
			Clinostomus funduloides	rosyside dace
			Notropis leuciodus	Tennessee shiner
			Phoxinus tennesseensis	Tennessee dace
			Rhinichthys atratulus	blacknose dace

Table 4. Continued.

Unit	No.	Distance (m)	Scientific Name	Common Name
Pool	105	4345.3	*Semotilus atromaculatus*	creek chub
			Catostomus commersoni	white sucker
			Hypentelium nigricans	northern hogsucker
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
			E. simoterum	snubnose darter
			Ambloplites rupestris	rock bass
Pool	110	4498.7	*Ichthyomyzon spp.*	lamprey ammocoetes
			Campostoma anomalum	central stoneroller
			Clinostomus funduloides	rosyside dace
			Luxilus coccogenis	warpaint shiner
			Notropis leuciodus	Tennessee shiner
			Rhinichthys atratulus	blacknose dace
			Semotilus atromaculatus	creek chub
			Catostomus commersoni	white sucker
			Hypentelium nigricans	northern hogsucker
			Cottus spp.	sculpin
			Etheostoma simoterum	snubnose darter
			Ambloplites rupestris	rock bass
Riffle	70	4514.2	*Campostoma anomalum*	central stoneroller
			Notropis leuciodus	Tennessee shiner
			Rhinichthys atratulus	blacknose dace
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
Pool	135	5453.9	*Campostoma anomalum*	central stoneroller
			Clinostomus funduloides	rosyside dace
			Notropis leuciodus	Tennessee shiner

Table 4. Continued.

Unit	No.	Distance (m)	Scientific Name	Common Name
Pool	135	5453.9	*Phoxinus tennesseensis*	Tennessee dace
			Rhinichthys atratulus	blacknose dace
			Semotilus atromaculatus	creek chub
			Hypentelium nigricans	northern hogsucker
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
			E. simoterum	snubnose darter
			Ambloplites rupestris	rock bass
Pool	140	5661.9	*Campostoma anomalum*	central stoneroller
			Clinostomus funduloides	rosyside dace
			Notropis leuciodus	Tennessee shiner
			Rhinichthys atratulus	blacknose dace
			Semotilus atromaculatus	creek chub
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
Riffle	90	5692.9	*Notropis leuciodus*	Tennessee shiner
			Rhinichthys atratulus	blacknose dace
			Semotilus atromaculatus	creek chub
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
Pool	145	5741.5	*Notropis leuciodus*	Tennessee shiner
			Rhinichthys atratulus	blacknose dace
			Hypentelium nigricans	northern hogsucker
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter
			E. simoterum	snubnose darter
Riffle	100	6057.6	*Notropis leuciodus*	Tennessee shiner

Table 4. Continued.

Unit	No.	Distance (m)	Scientific Name	Common Name
Riffle	100	6057.6	*Rhinichthys atratulus*	blacknose dace
			Cottus spp.	sculpin
			Etheostoma flabellare	fantail darter

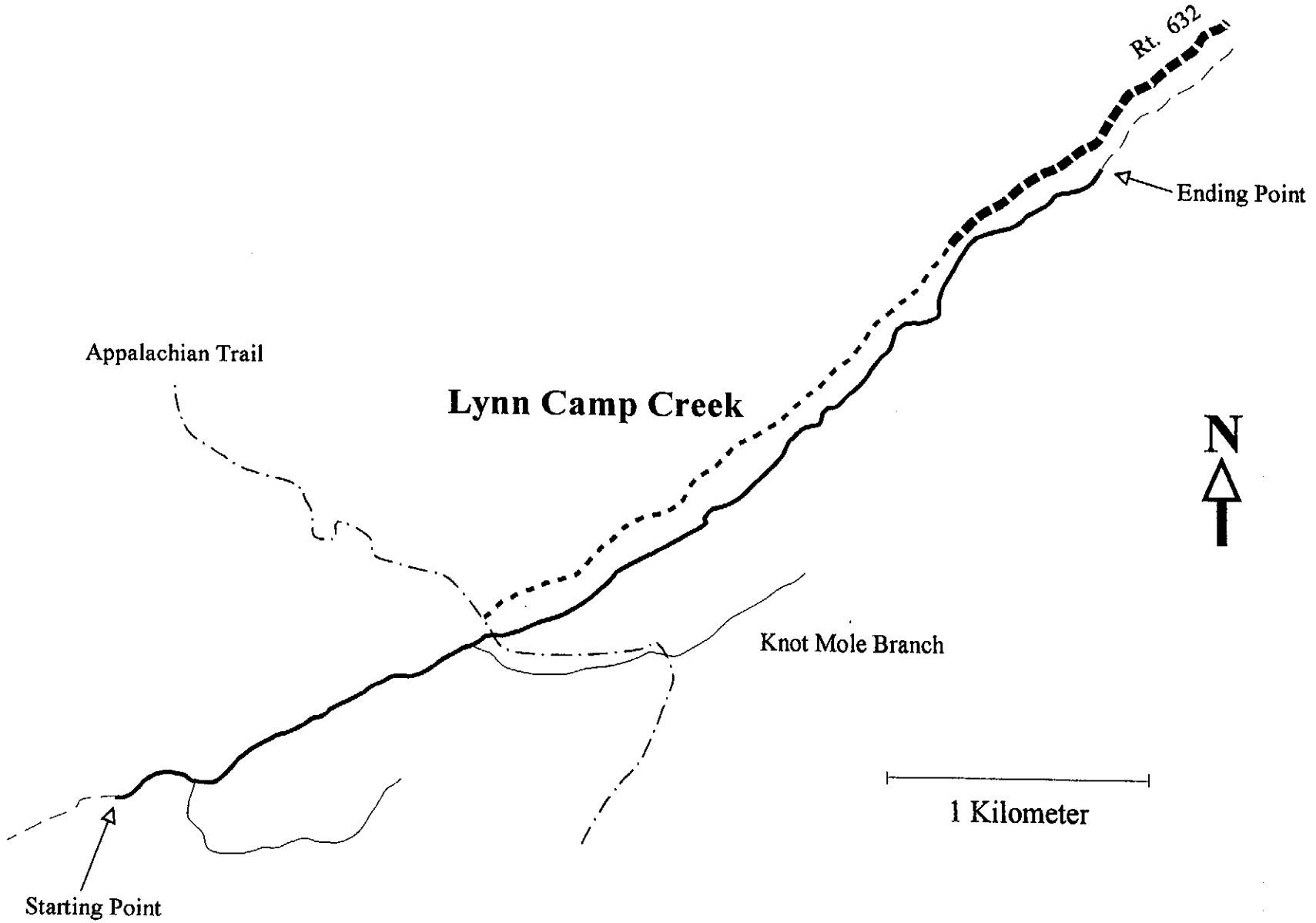


Figure 1. Map showing the Lynn Camp Creek Watershed. The bold line represents the section sampled in the survey.

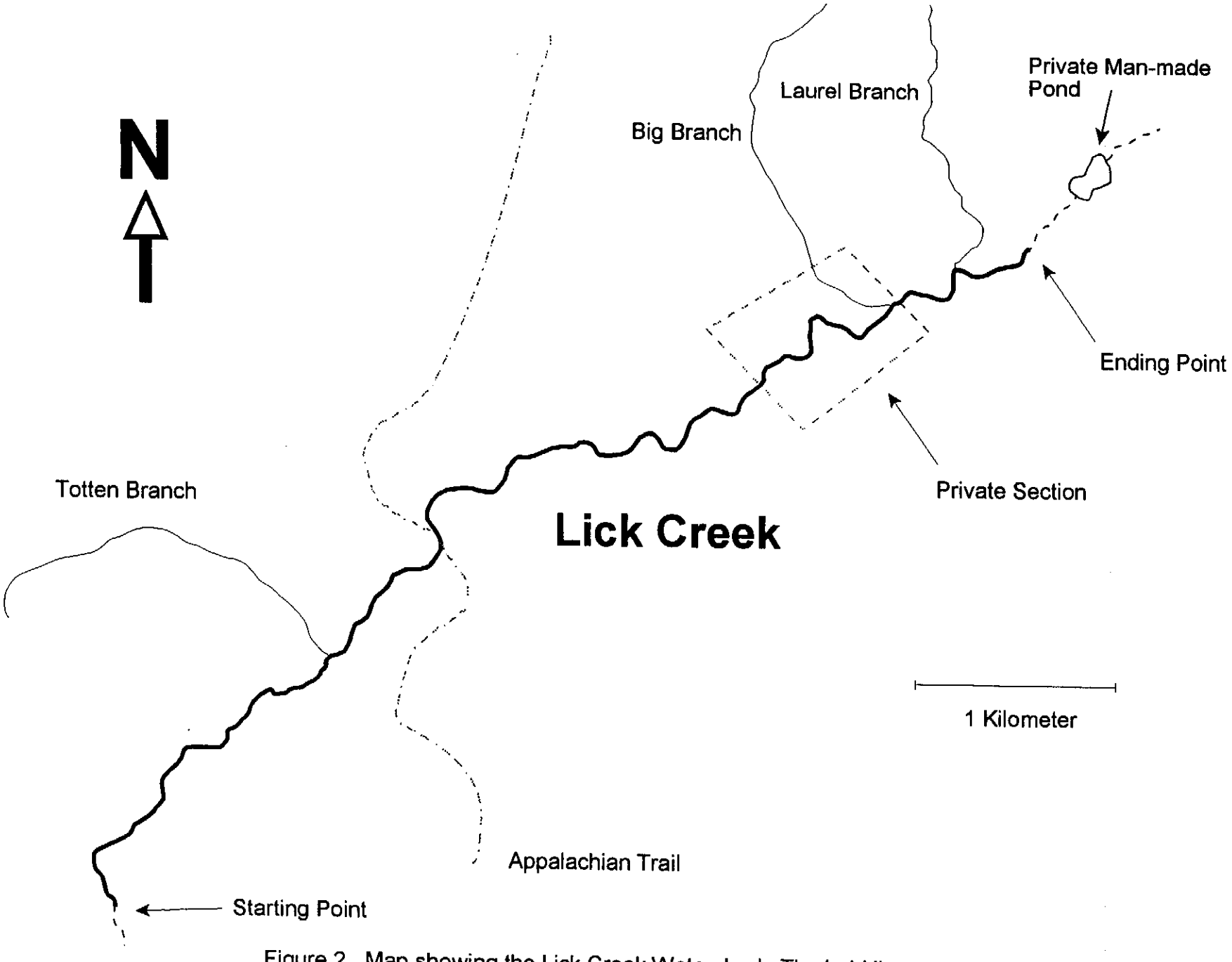


Figure 2. Map showing the Lick Creek Watershed. The bold line represents Lick Creek, and the gray lines represent tributaries not sampled. All of Lick Creek shown in bold, with the exception of the stream flowing through the private section, was sampled.

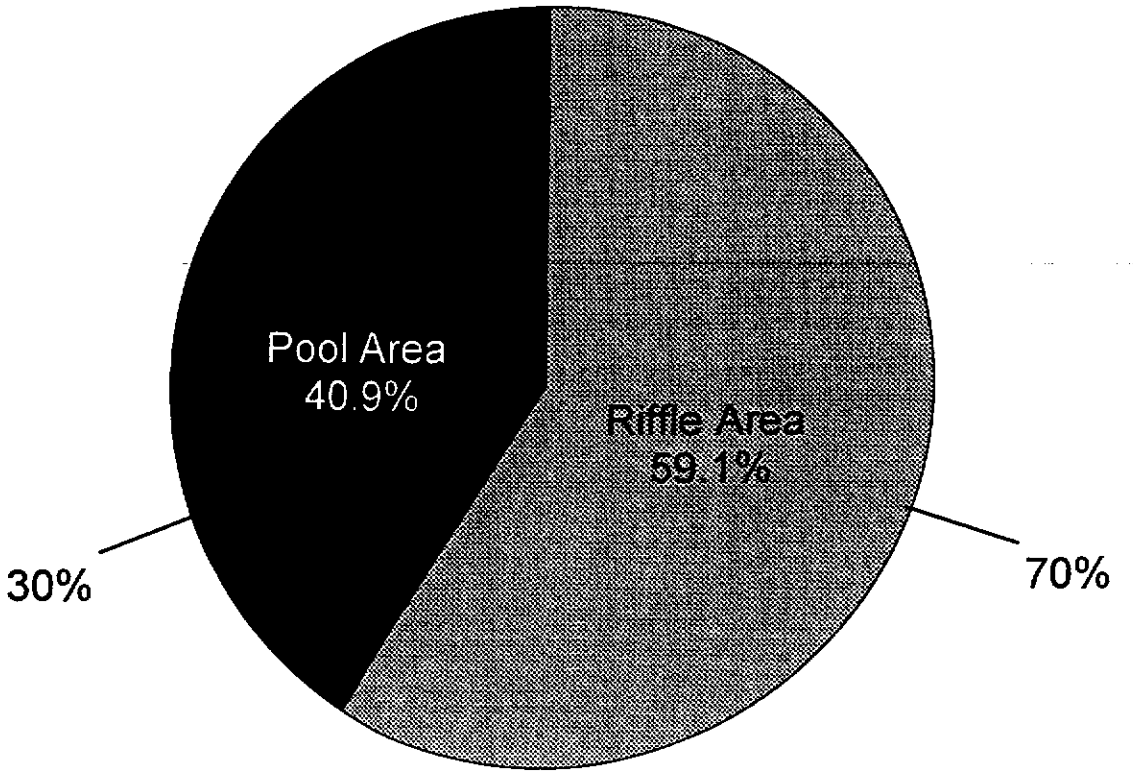


Figure 3. Percent pool and riffle surface area in the study section of Lynn Camp Creek.

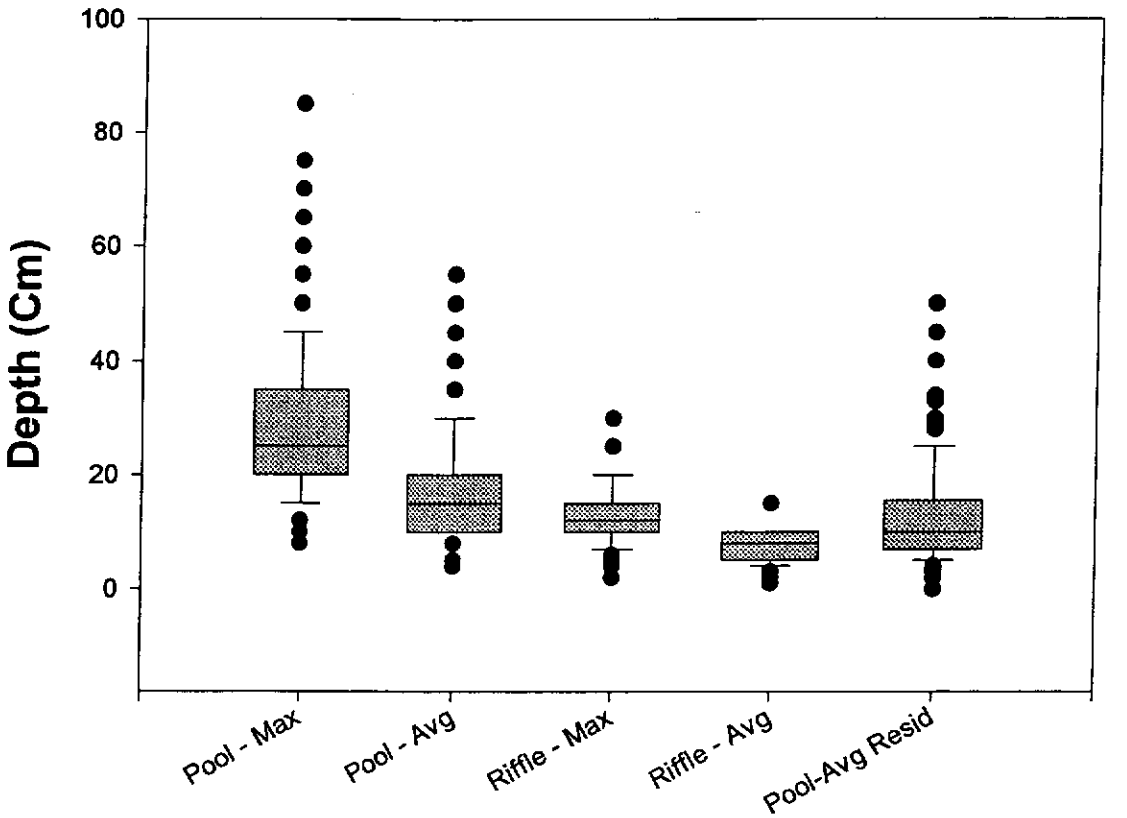


Figure 4. Box plots for habitat-unit maximum and average depths, and average residual pool depth in the study section of Lynn Camp Creek. The box encloses the middle 50% of the observations, the capped lines below and above the box represent the 10% and 90% quantiles, respectively, dots represent outliers, and the solid line in the box represents the median.

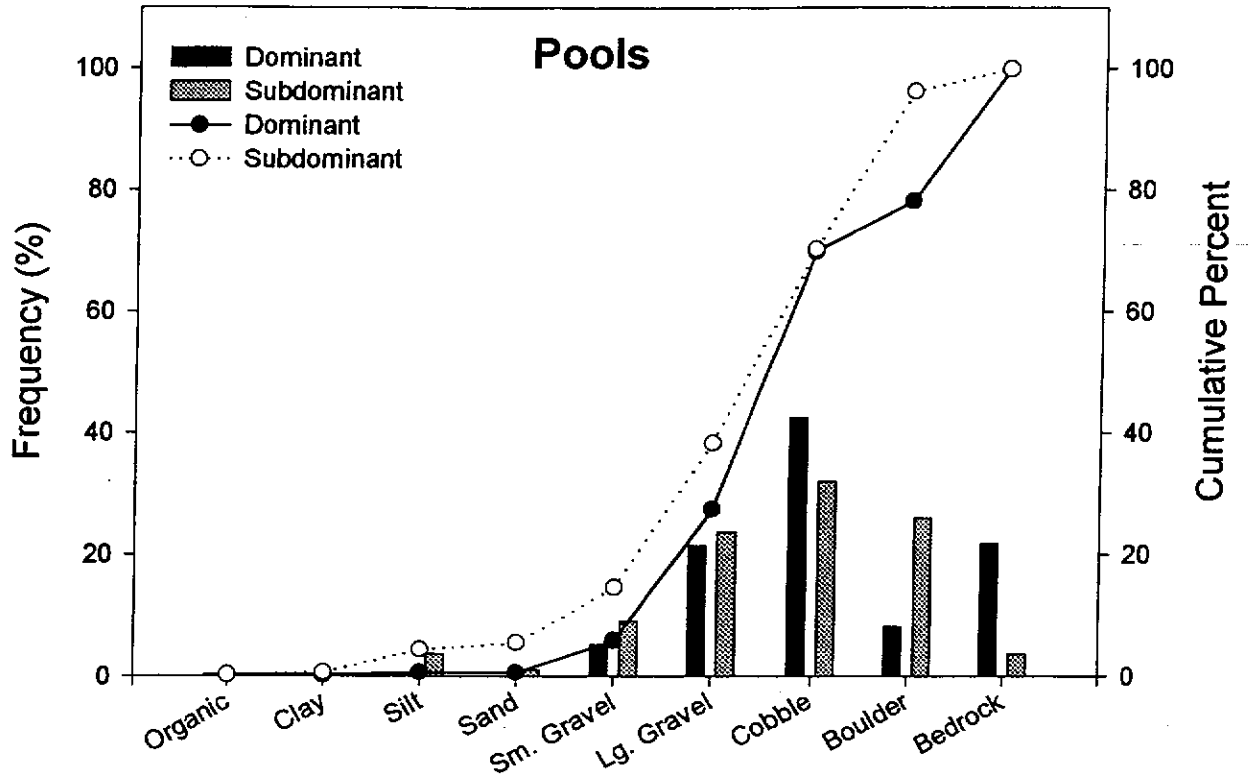


Figure 5. Frequency (percent) of dominant and subdominant substrate occurrence for pool type habitat in the study section of Lynn Camp Creek. Solid dots represent cumulative percent of dominant substrate and open dots represent cumulative percent of subdominant substrate.

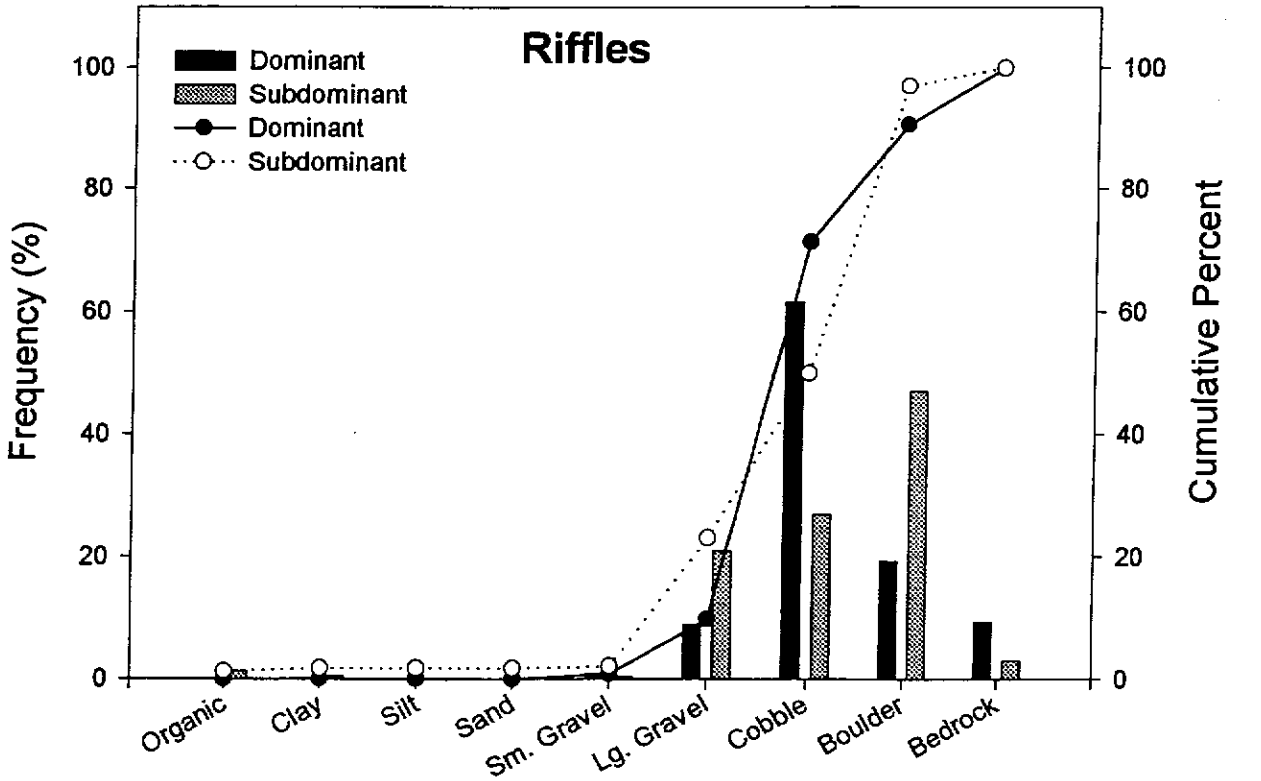


Figure 6. Frequency (percent) of dominant and subdominant substrate occurrence for riffle type habitat in the study section of Lynn Camp Creek. Solid dots represent cumulative percent of dominant substrate and open dots represent cumulative percent of subdominant substrate.

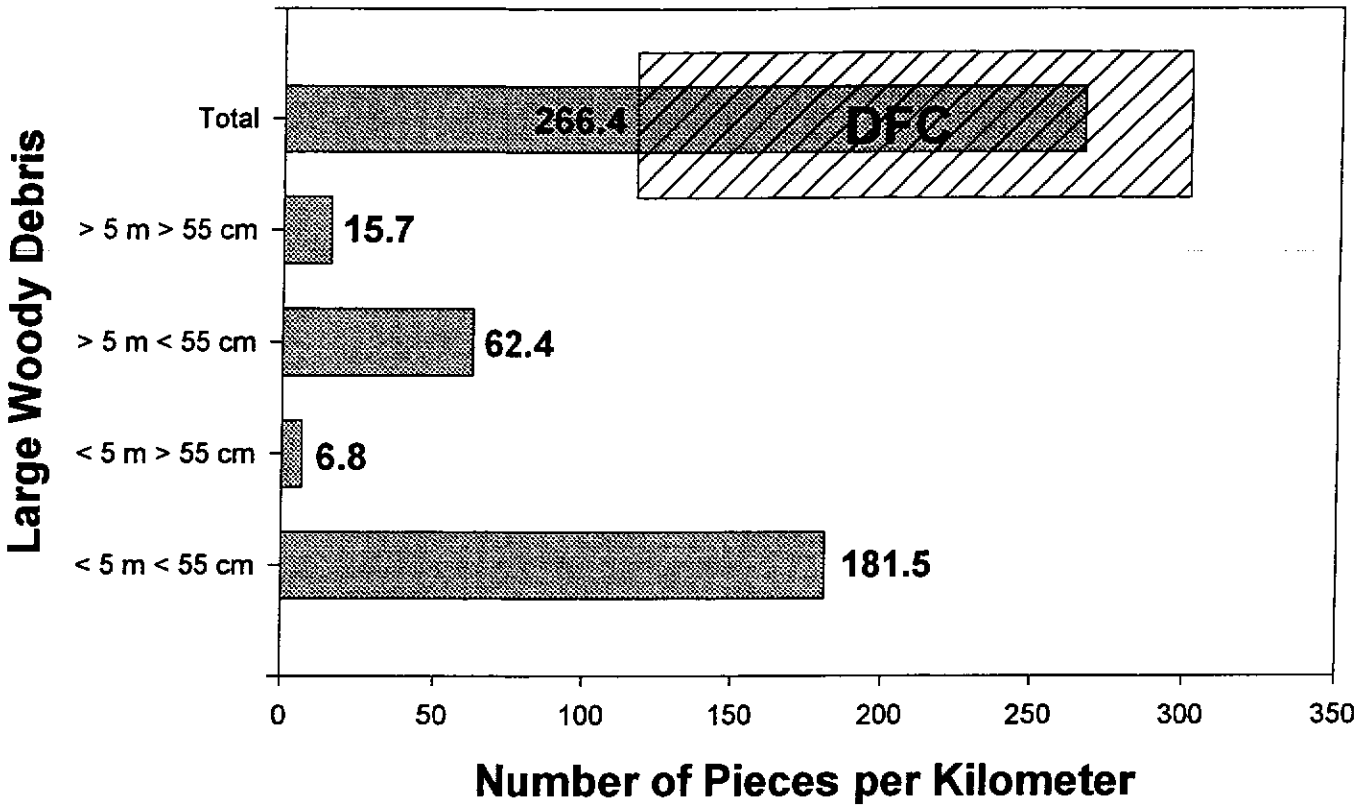


Figure 7. Pieces of large woody debris per kilometer in the study section of Lynn Camp Creek.

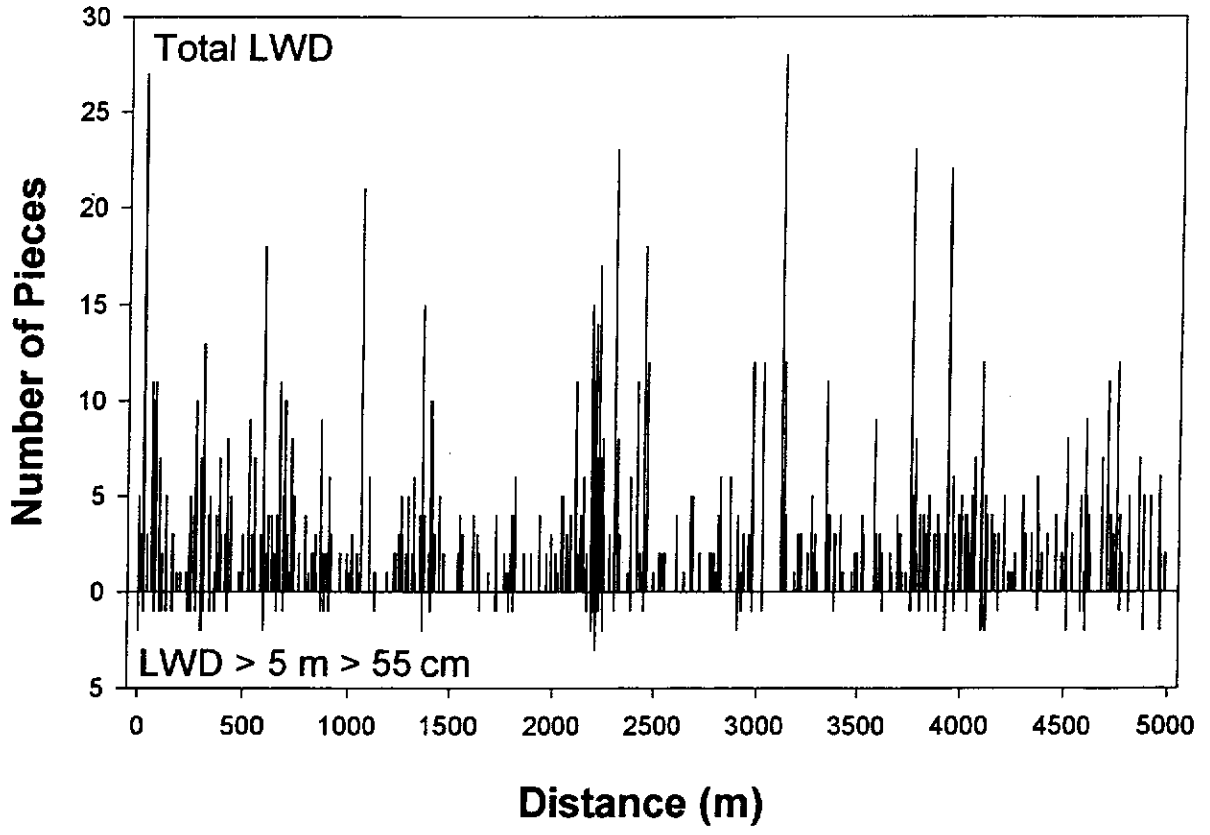


Figure 8. Distribution and total abundance of large woody debris in the study section of Lynn Camp Creek.

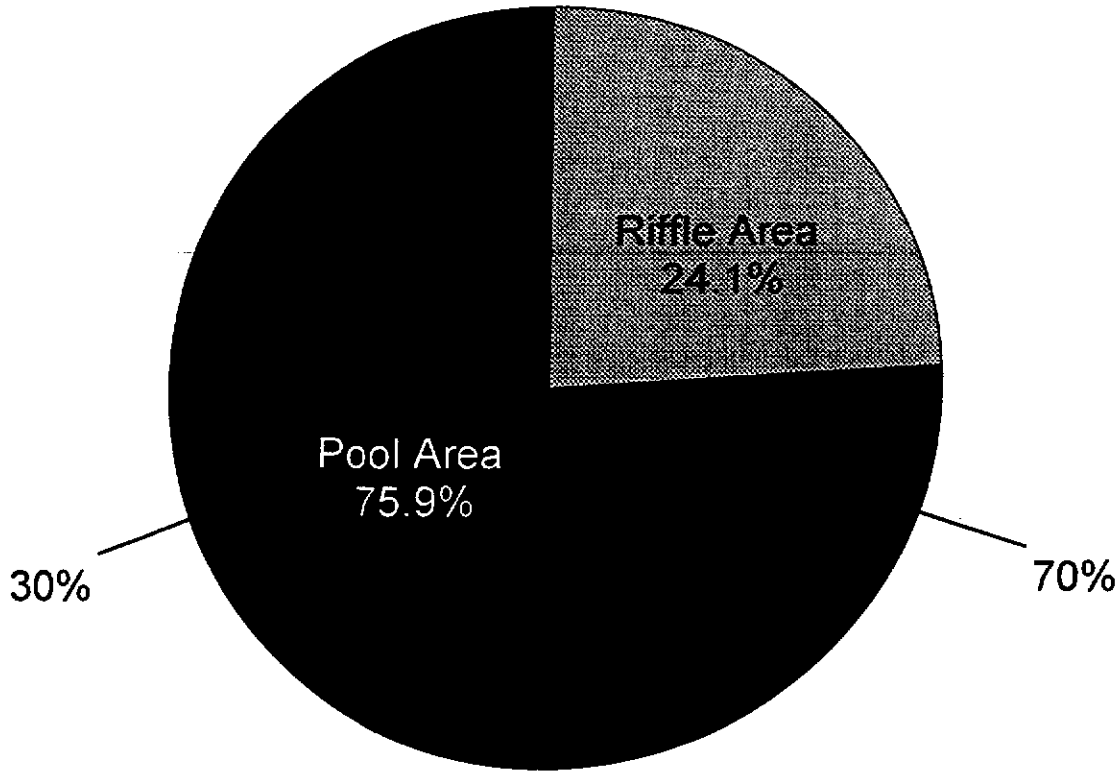


Figure 9. Percent pool and riffle surface area in the study section of Lick Creek.

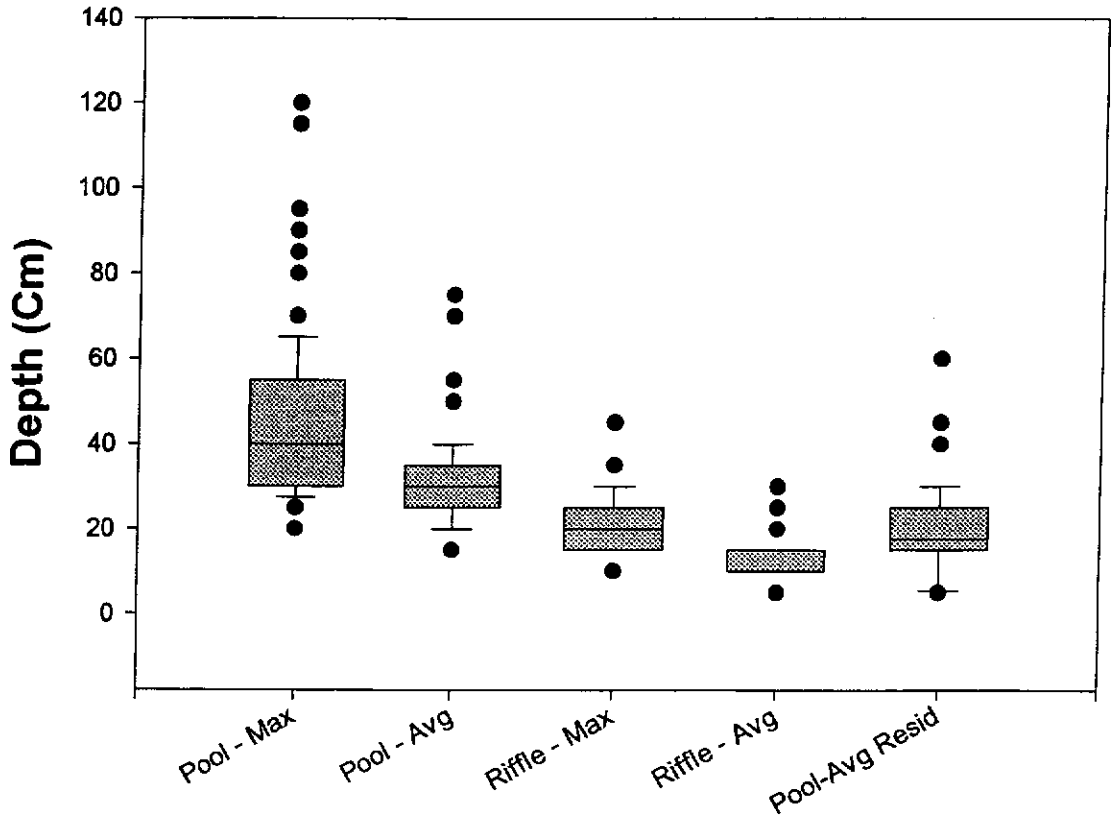


Figure 10. Box plots for habitat-unit maximum and average depths, and average residual pool depth in the study section of Lick Creek. The box encloses the middle 50% of the observations, the capped lines below and above the box represent the 10% and 90% quantiles, respectively, dots represent outliers, and the solid line in the box represents the median.

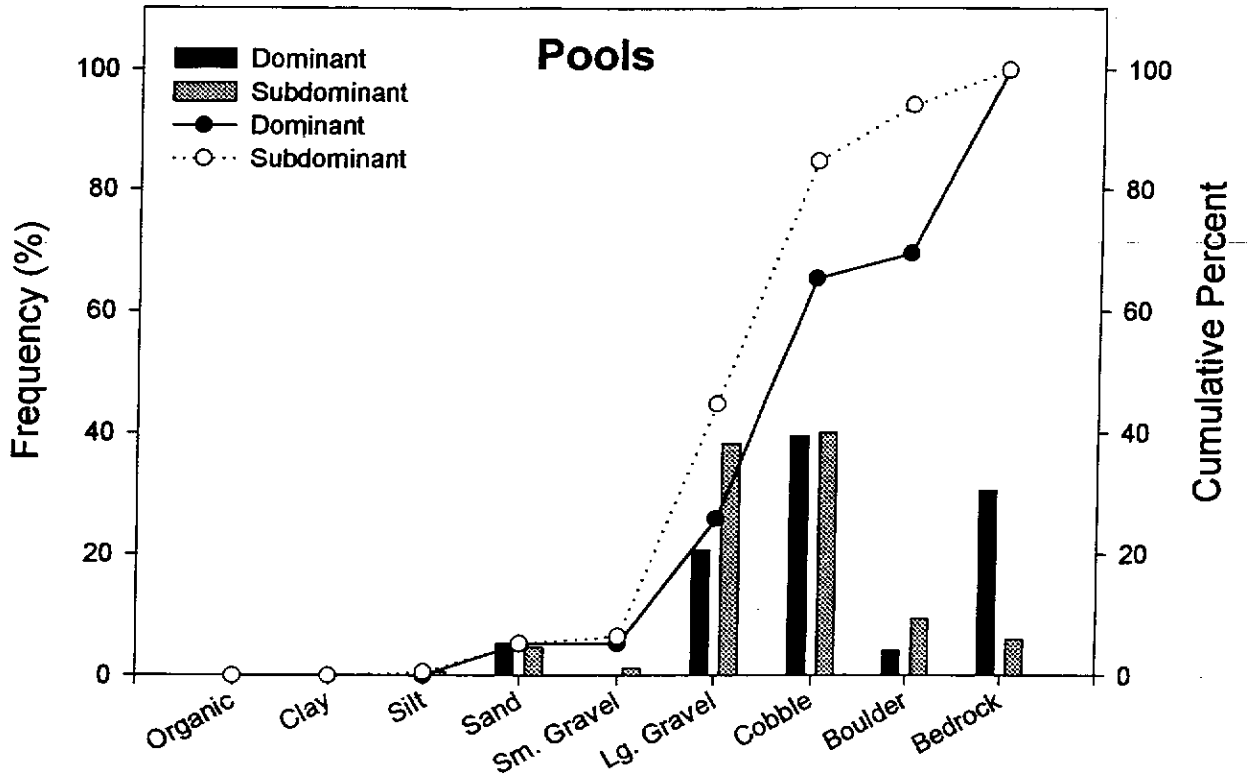


Figure 11. Frequency (percent) of dominant and subdominant substrate occurrence for pool type habitat in the study section of Lick Creek. Solid dots represent cumulative percent of dominant substrate and open dots represent cumulative percent of subdominant substrate.

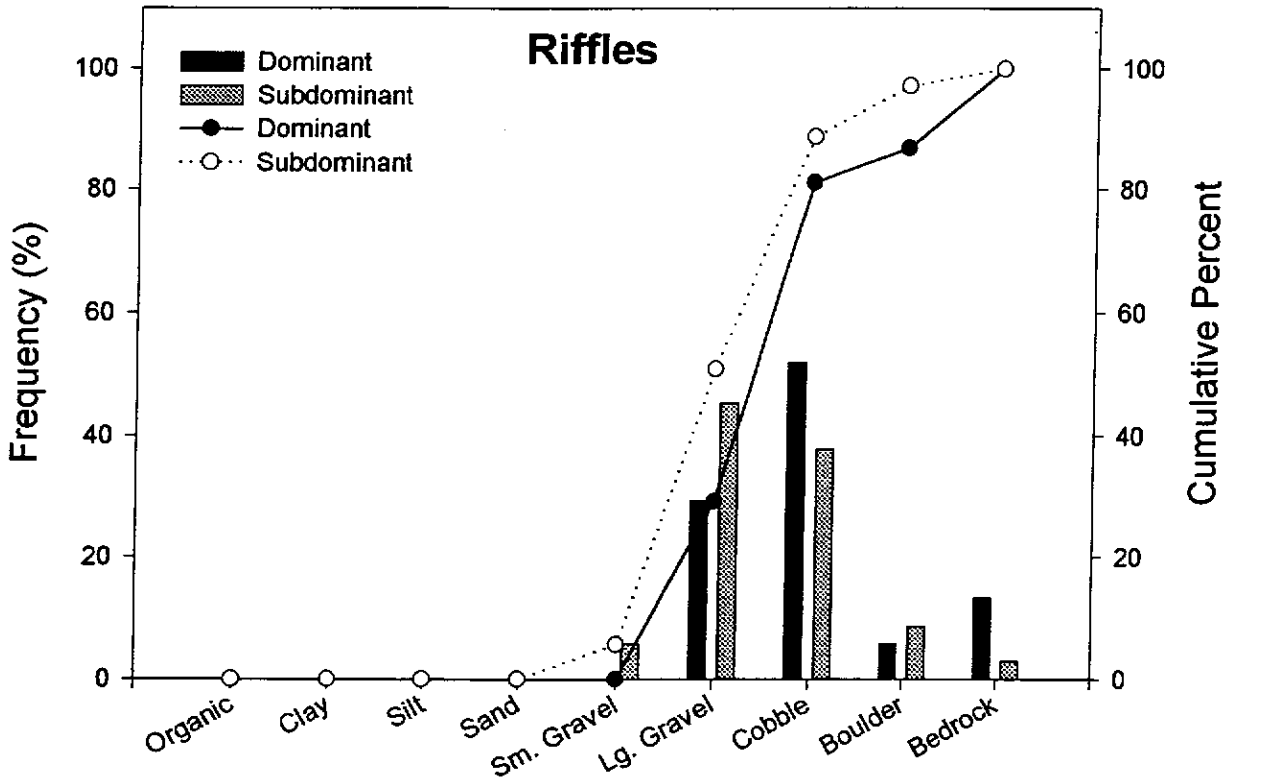


Figure 12. Frequency (percent) of dominant and subdominant substrate occurrence for riffle type habitat in the study section of Lick Creek. Solid dots represent cumulative percent of dominant substrate and open dots represent cumulative percent of subdominant substrate.

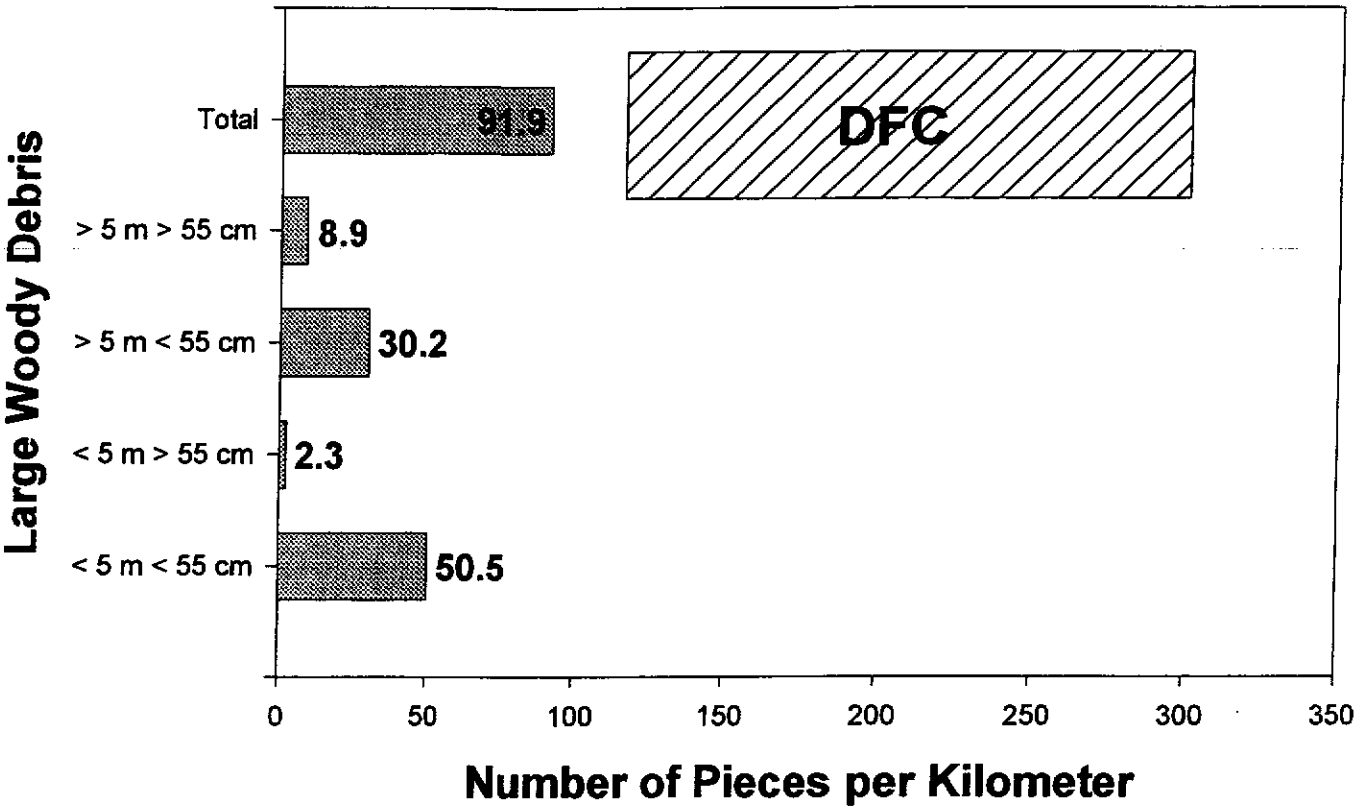


Figure 13. Pieces of large woody debris per kilometer in the study section of Lick Creek.

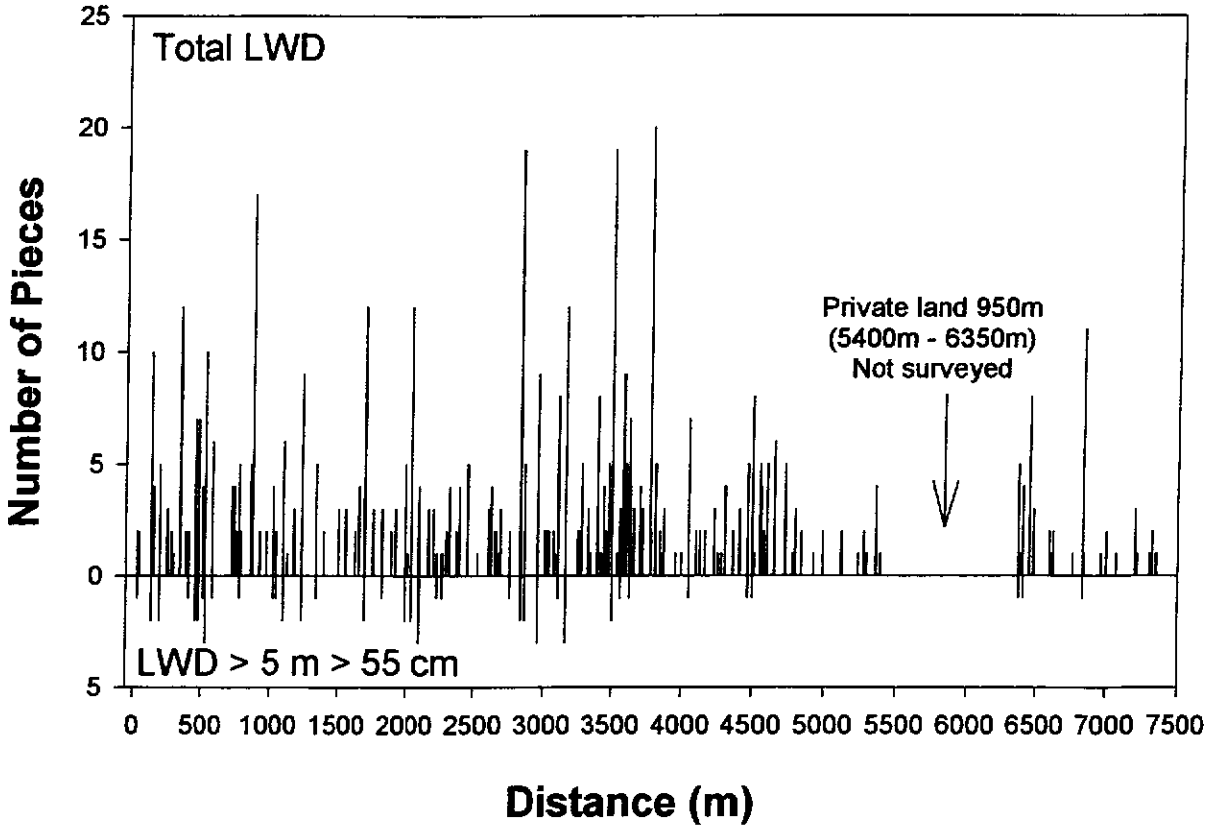


Figure 14. Distribution and total abundance of large woody debris in the study section of Lick Creek.

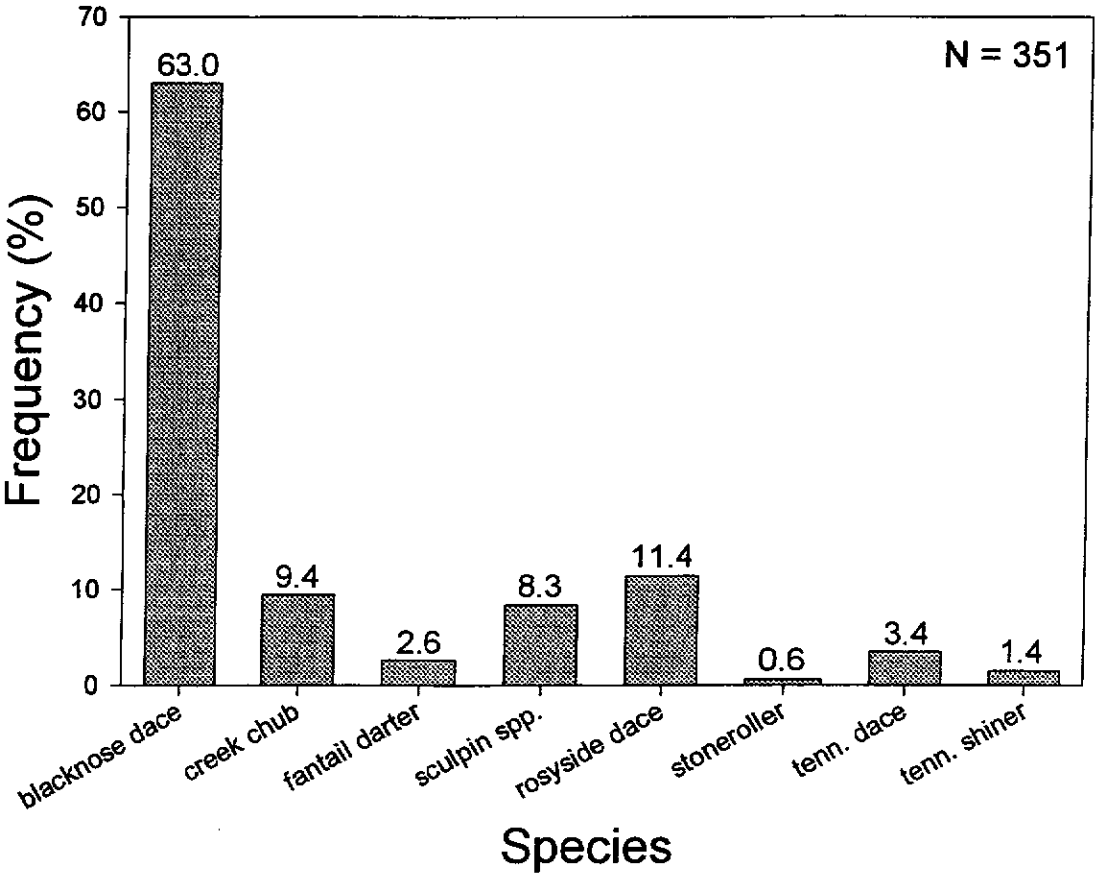


Figure 15. Vertical bar chart showing the relative abundance of each species captured in the Lynn Camp Creek study section, based on the total catch (N = 351).

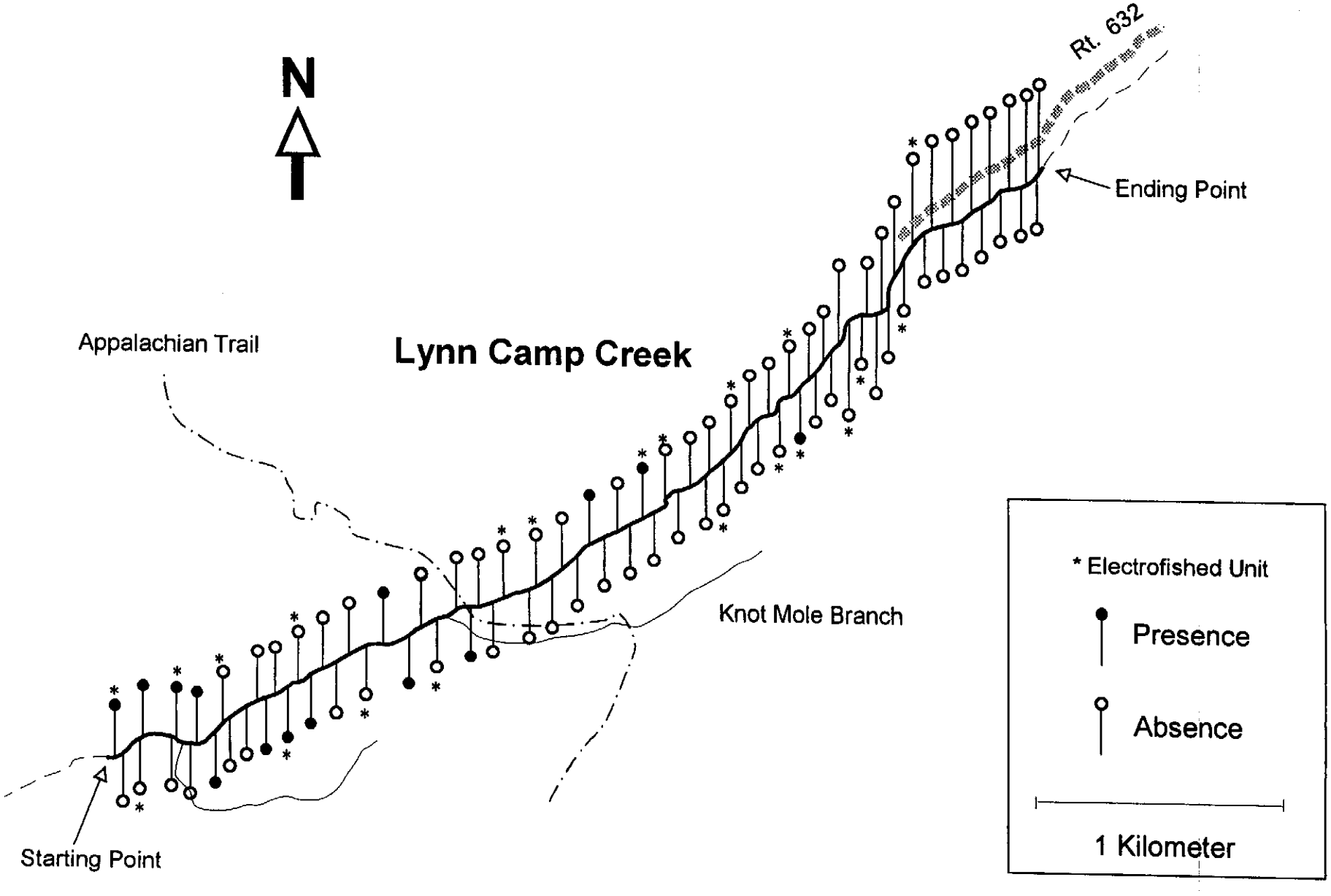


Figure 16. Distribution of Tennessee dace in the Lynn Camp Creek study section. Circles indicate sample sites. Solid circles represent sites where Tennessee dace were present. Asterisks represent units sampled with three-pass depletion electrofishing.

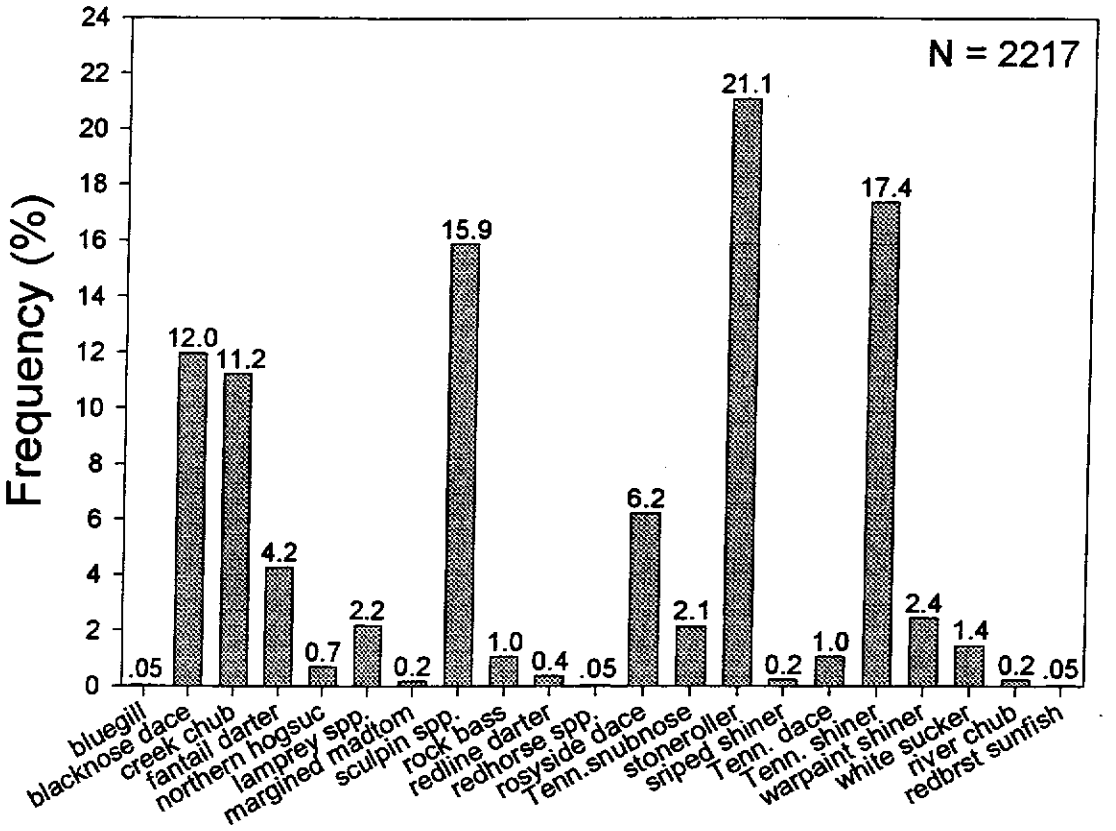


Figure 17. Vertical bar chart showing the relative abundance of each species captured in the Lick Creek study section, based on the total catch (N = 2217).

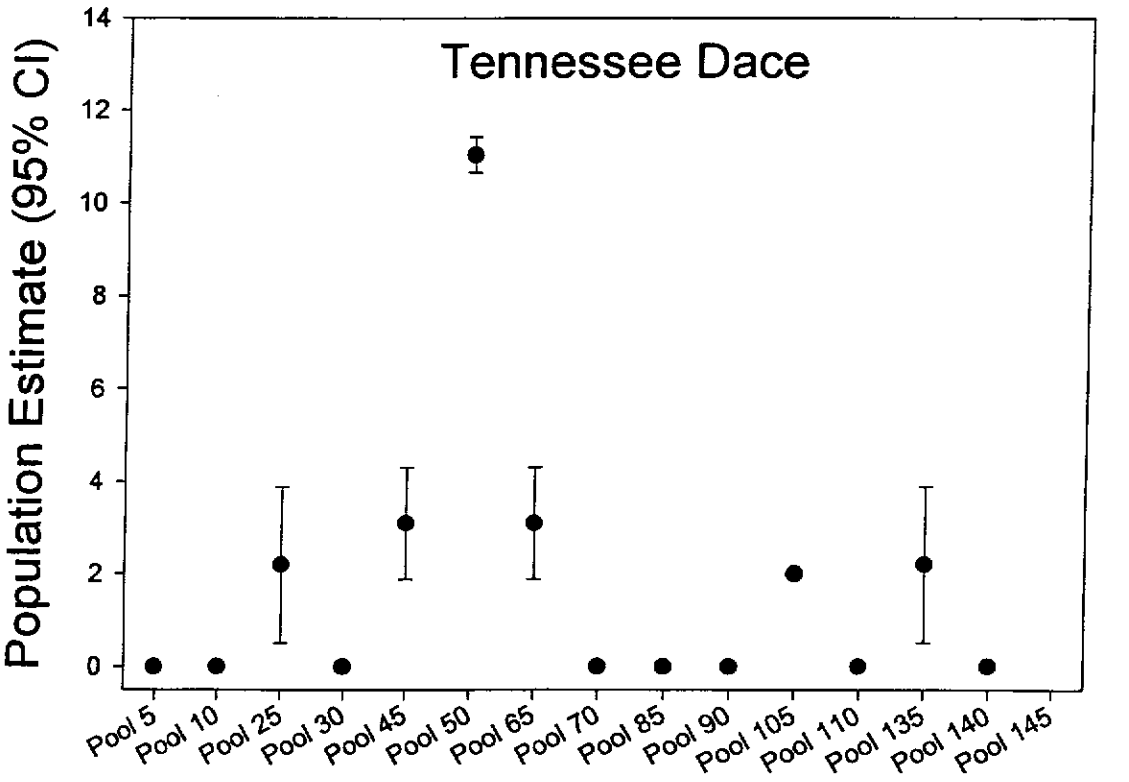


Figure 18. Scatter plot of population estimates for individual units electrofished in the Lick Creek study section based on Zippen three-pass depletion. Capped lines represent ranges of 95% confidence intervals.

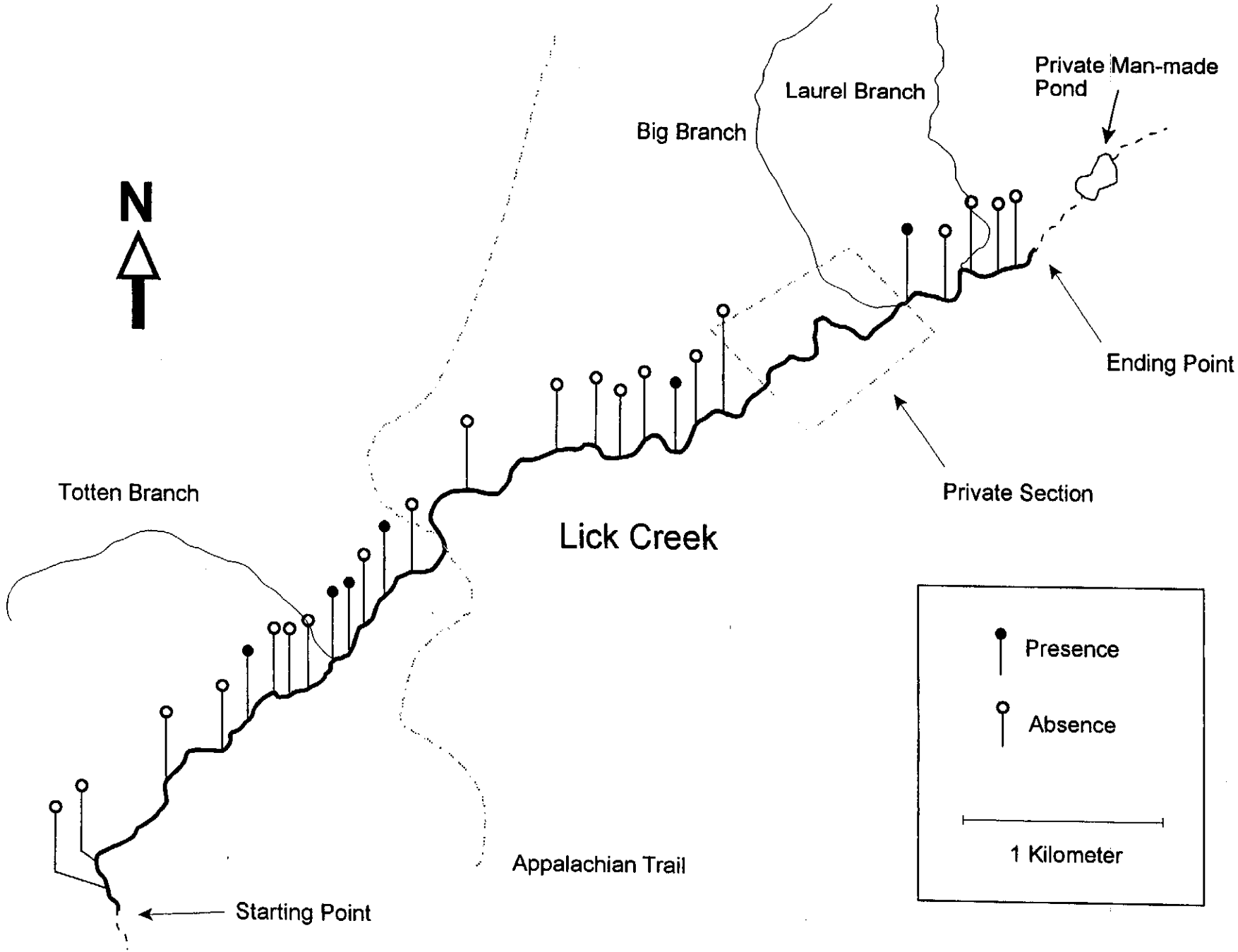


Figure 19. Distribution of Tennessee dace in the Lick Creek study section. Circles indicate sites sampled using three-pass depletion electrofishing. Solid circles represent sites where Tennessee dace were present.

Appendix 1a. Substrate classification criteria.

SUBSTRATE CLASSES

1		organic debris
2		clay
3		silt
4	silt- 2mm	sand
5	2-10mm	small gravel
6	1-10cm	large gravel
7	11-30cm	cobble
8	30cm	boulder
9		bedrock

Appendix 1b. Large woody debris (LWD) classification criteria.

LWD SIZE CLASSES

1 < 5 m (length) and < 55 cm (diameter)
2 < 5 m (length) and > 55 cm (diameter)
3 > 5 m (length) and < 55 cm (diameter)
4 > 5 m (length) and > 55 cm (diameter)