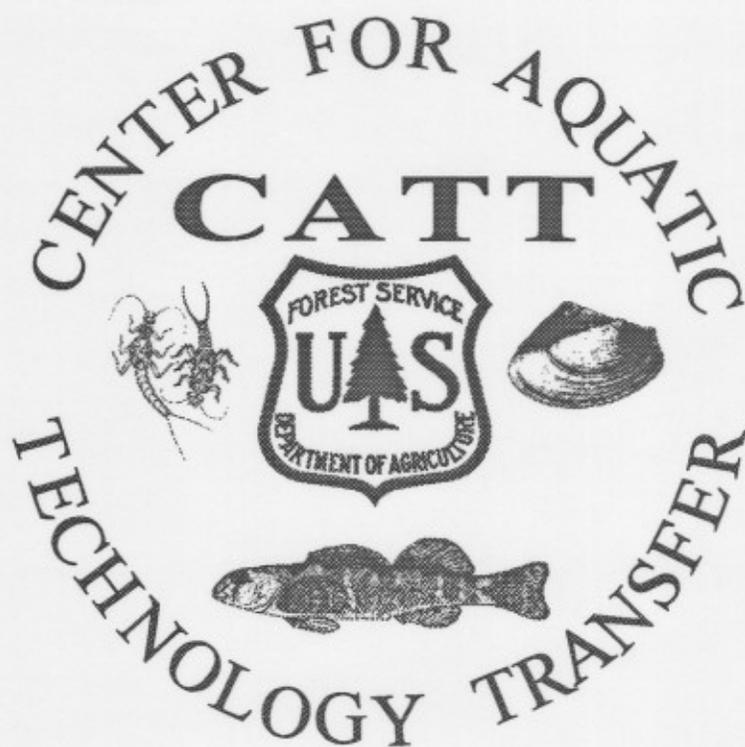


**Distribution and Abundance of Blackside Dace in Big Lick Branch, Ned
Branch, and Ryans Creek, Daniel Boone National Forest**



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

**Distribution and Abundance of Blackside Dace in Big Lick Branch, Ned
Branch, and Ryans Creek, Daniel Boone National Forest**

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

Kevin N. Leftwich
Lead Fisheries Biologist

Martin K. Underwood
Fisheries Biologist

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

Prepared for

Victoria R. Bishop
Fisheries Biologist
Daniel Boone National Forest

February 1997

Introduction

The Federally Threatened blackside dace *Phoxinus cumberlandensis* is endemic to the upper Cumberland River drainage of Kentucky and Tennessee (Etnier and Starnes 1993). Of the 30 streams reported to harbor blackside dace, about 50% flow through the Daniel Boone National Forest (DBNF)(USFWS 1988). Little is known about blackside dace population numbers, habitat requirements, and threats and distribution records are sketchy and incomplete.

A primary goal of the USDA Forest Service is to promote the recovery of listed species through habitat improvement, ecosystem restoration, and habitat protection by providing research to understand the impact of human activities and natural events on species and their habitat (Statement of the Chief of USDA Forest Service before the Committee of Resources, U.S. House of Representatives 17 April 1996). Each National Forest is responsible for determining the distribution, status, and trend of threatened, endangered, proposed, and sensitive species and their habitats on Forest lands (Forest Service Manual, FSN 2600, Chapter 2670.45, Paragraph 4).

The DBNF, Southern Research Station, and Center for Aquatic Technology Transfer are involved in an ongoing project designed to collect information on the distribution, status, and habitat requirements of blackside dace in the DBNF to help meet those goals and responsibilities. The purpose of this report was to describe the distribution and abundance of blackside dace in three DBNF streams.

Study Streams

In August 1996 we investigated the distribution and abundance of blackside dace in three DBNF streams: 1) Big Lick Branch, a tributary of the Cumberland River, located primarily on the Somerset Ranger District, 2) Ned Branch, a tributary of the Rockcastle River, located entirely within the London Ranger District, and 3) Ryans Creek, a tributary of Jellico Creek, located on the Stearns Ranger District but flowing mostly through private lands.

We surveyed 2.9 river kilometers (rkm)(1.8 miles) of Big Lick Branch from the full

pool boundary of Cumberland Lake, upstream to its confluence with an unnamed tributary near a private land boundary (Figure 1) and 1.4 rkm (0.9 miles) of Ned Branch from the inundated Rockcastle River upstream to the Ned Branch Trail crossing (Figure 1). On Ryans Creek, we surveyed about 2.0 rkm (1.3 miles) upstream of the USFS boundary. This study section includes 0.8 rkm of Riggs Branch (Figure 1). Brierfield Branch, a tributary of Ryans Creek, was not surveyed due to extreme low flows.

Methods

We used visual estimation techniques and a stratified random sampling design to estimate total surface area of selected habitat types and abundance of blackside dace and southern redbelly dace *P. erythrogaster* in the Big Lick Branch and Ned Branch study sections (Hankin and Reeves 1988; Dolloff et al 1993).

We identified all habitat in the study sections by unit type (pools and riffles). The first unit of each habitat type selected for estimates of surface area and sampling by divers was determined randomly. Additional sampling units in Big Lick Branch (44 pools and 32 riffles) and Ned Branch (23 pools and 17 riffles) were selected systematically. When a sample unit was encountered, divers entered at the downstream end and proceeded slowly upstream to the head of the unit while searching for and counting blackside dace and southern redbelly dace. When a fish was sighted, it was directed out of the line of travel by the diver's hand to prevent double counting. Hipchain measurements were used to locate each sample unit on 7.5 minute USGS topographic maps for each stream (Figures 2 and 3; Appendices A and B).

We used multiple-pass removal (Zippen 1958) electrofishing (one DC backpack electrofisher) to estimate the populations of all species by habitat unit and to obtain a more accurate estimate of the number of blackside dace and southern redbelly dace in a subset of habitat-units sampled by divers. Estimates from this subset were used to obtain a more accurate estimate of blackside dace and southern redbelly dace populations, with 95% confidence intervals, in the Big Lick Branch and Ned Branch study areas, respectively. All fish captured during the three-pass depletions were

identified but only blackside dace were weighed (g) and measured (mm). Ten units of each habitat type were systematically selected from among the diver-sampled units in Big Lick Branch and twelve pools and ten riffles were selected in Ned Branch. Surface areas of units selected for electrofishing were measured with a 15-m measuring tape and marked for the electrofishing survey with an identification flag at the upper and lower boundaries. Visual estimates of habitat-unit area were paired with the corresponding measured habitat area to calculate a calibration ratio (\hat{Q}). All estimates of pool area (both species were only found in pools) were multiplied by \hat{Q} (1.04 and 0.86, respectively for each stream) to more accurately depict the area of each habitat unit. Ryans Creek was sampled using three pass depletions (Zippin 1958) because low water clarity prevented divers from seeing fish. We systematically sampled 18 pools and 2 riffles (Figure 4).

We used the calibrated habitat-unit area and calibrated diver counts to estimate fish density (number of fish counted divided by the habitat unit area). Blackside dace and southern redbelly dace densities were estimated for each of the habitat units surveyed by underwater observation.

Results

Big Lick Branch

Blackside dace were relatively abundant and widely distributed in pools of Big Lick Branch (Figure 2). We estimated that there are 2,322 (95% CI \pm 284) blackside dace in Big Lick Branch.

We used linear regression to investigate changes in blackside dace densities from downstream to upstream in Big Lick Branch. We observed no significant relationship between blackside dace abundance and longitudinal position ($r = 0.188$, $p = 0.1$)(Figure 5). Blackside dace densities in Big Lick Branch are shown in Appendix A.

Ned Branch

We only observed seven blackside dace in three pools near the upper portion of

the Ned Branch study section (Figure 3). Although we captured nine blackside dace in those same three pools during the electrofishing survey, indicating that our underwater observations were reliable, we were unable to accurately calculate a population estimate and 95% confidence interval for the population of blackside dace in Ned Branch.

Southern redbelly dace were widely distributed and abundant in Ned Branch (Figures 3 and 6). We estimated 939 (95% CI \pm 249) southern redbelly dace in Ned Branch. We observed both blackside and southern redbelly dace in pool habitats only. Densities for both species in Ned Branch are shown in Appendix B.

Ryans Creek

Blackside dace were captured in the first pool that we electrofished (Pool 11) in Ryan's Creek; approximately one hundred meters upstream of the Forest Service boundary (Figure 4). The species was only captured in pools and was common for the first 1.2 rkm (.75 miles)(Figure 6). Creek chub *Semotilus atromaculatus*, was the only fish species captured in the remaining upstream section.

Population estimates for three-pass depletions ranged from 0.0 to 13.3 blackside dace in Ryans Creek (Figure 7; Appendix C). Blackside dace densities ranged from 0.0 to 41.3 per 100 m² in Ryans Creek with an average density of 5.9 blackside dace per pool.

We measured lengths and weights of blackside dace captured during the electrofishing surveys. The length-weight relationship for both Big Lick Branch and Ryans Creek suggest that the blackside dace populations were composed of three year classes (Figures 8 and 9).

In addition to blackside dace and southern redbelly dace, 9 other fish species were identified in the three study sections (Table 1). We observed four species of fish in Big Lick Branch, seven species in Ned Branch, and six species in Ryans Creek. Three-pass depletions estimates with 95% confidence intervals for each species are given for individual habitat-units in each stream in Tables 2, 3, and 4.

Conclusions and Recommendations

We observed the highest densities of blackside dace in Big Lick Branch. Apparently, the population of blackside dace in Big Lick Branch has been healthy and stable since its description by Starnes (1981), who concluded that Big Lick Branch contained one of the healthiest known populations. Big Lick Branch appears to be an important refugia for blackside dace and we agree with Starnes' (1981) that this stream is of considerable importance in efforts to preserve the species.

Both the blackside dace population and land management practices should be closely monitored in the Big Lick Branch watershed. We also suggest a full basinwide habitat and fish survey be conducted in Big Lick Branch to investigate the relationships among species abundance, stream habitat, and watershed characteristics. This information can be used to develop a habitat template to aid in understanding the species distribution and abundance in other DBNF streams. Further, this information should provide insight into potential threats to blackside dace and suggest restoration and recovery strategies for streams in which the species has declined or disappeared.

Ned Branch supports a sympatric population of blackside dace and southern redbelly dace. Because we do not know if the low blackside dace population observed in Ned Branch is related to the high abundance of southern redbelly dace (i.e. competition) we recommend research on interactions between the two species. We believe the first step in understanding the distribution and abundance patterns of blackside dace is to investigate stream habitat associations of both species.

Blackside dace are relatively abundant and widely distributed in the mainstem of Ryans Creek, but diminish in Riggs Branch upstream of its confluence with Ryans Creek. Blackside dace in Riggs Branch may be limited by water flow during periods of little precipitation. Riggs Branch had relatively low water at the time of our survey compared to the mainstem and the pools were separated by dry sections and stagnant water.

Ryans Creek, Big Lick Branch, and Ned Branch are susceptible to human and

natural disturbances. All three streams have been and continue to be influenced by land use on private and Forest Service lands. For example, mining has had a devastating effect on blackside dace populations (Etnier and Starnes 1993), and siltation from roads, agriculture, and other sources is similarly damaging. Because of the potential threats of habitat degradation and the importance of each of these streams to the overall distribution of blackside dace, we recommend that these streams, and their blackside dace populations, be regularly monitored and that the potential impact of activities such as use of off-road recreational vehicles, road construction, and timber harvest be fully investigated. We also recommend further investigation and analysis of blackside dace population ecology and stream habitat relations to better understand the species habitat requirements and to link habitat use to current and future land use.

References

- Dolloff, C. A., D. G. Hankin, and G. H. Reeves. 1993. Basinwide estimation of habitat and fish populations in streams. U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. General Technical Report SE-83. Asheville, North Carolina.
- Etnier, D. and W. Starnes. 1993. Fishes of Tennessee. The University of Tennessee Press. Knoxville, Tennessee, USA. 618 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.
- 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.
- U.S. Fish and Wildlife Service. 1988. Blackside Dace Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 23 pp.
- Zippen, C. 1958. The removal method of population estimation. Journal of Wildlife Management. 22:82-90.

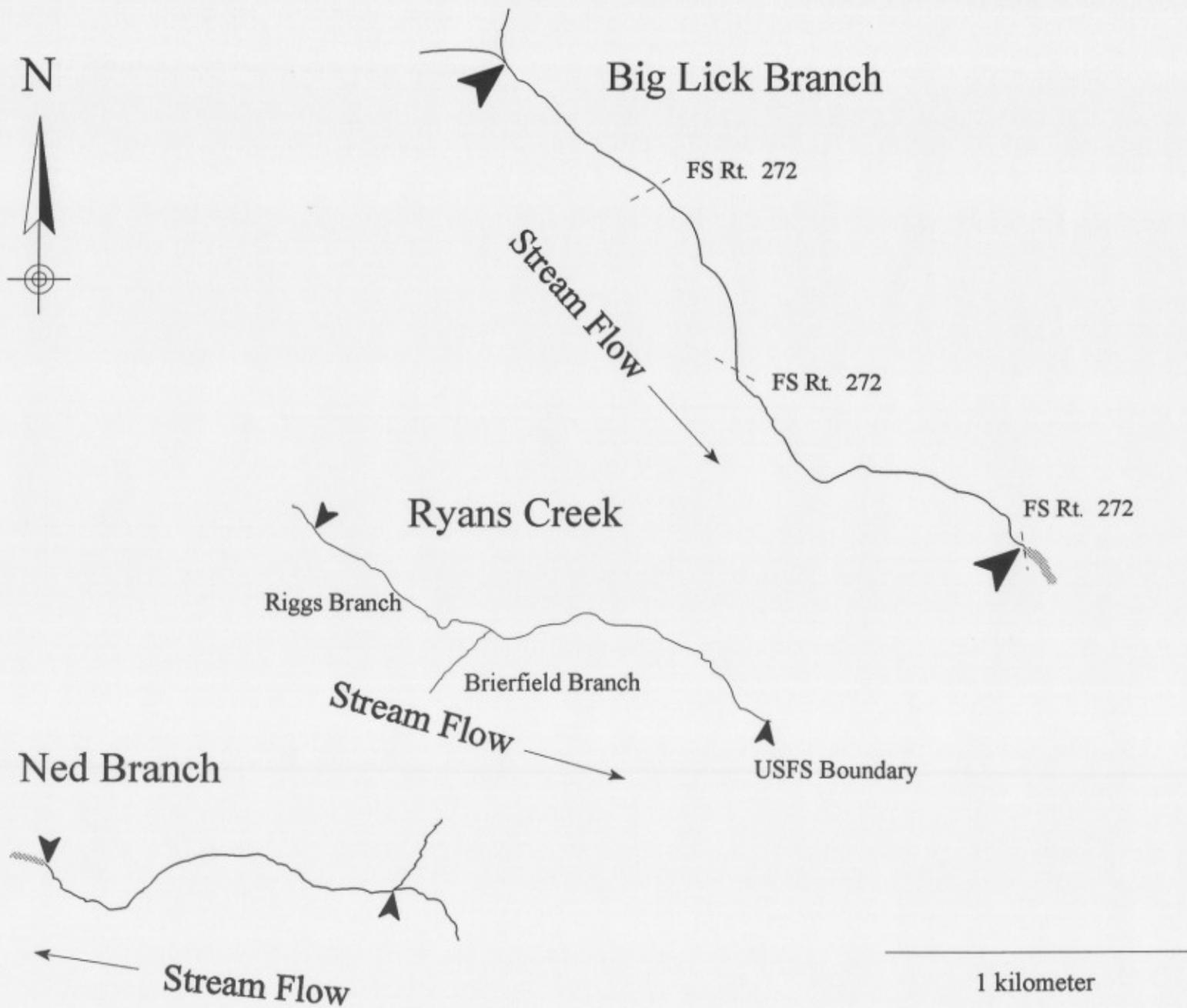


Figure 1. Big Lick Branch, Ryans Creek, and Ned Branch, DBNF, KY. Arrows represent starting and ending points of survey.

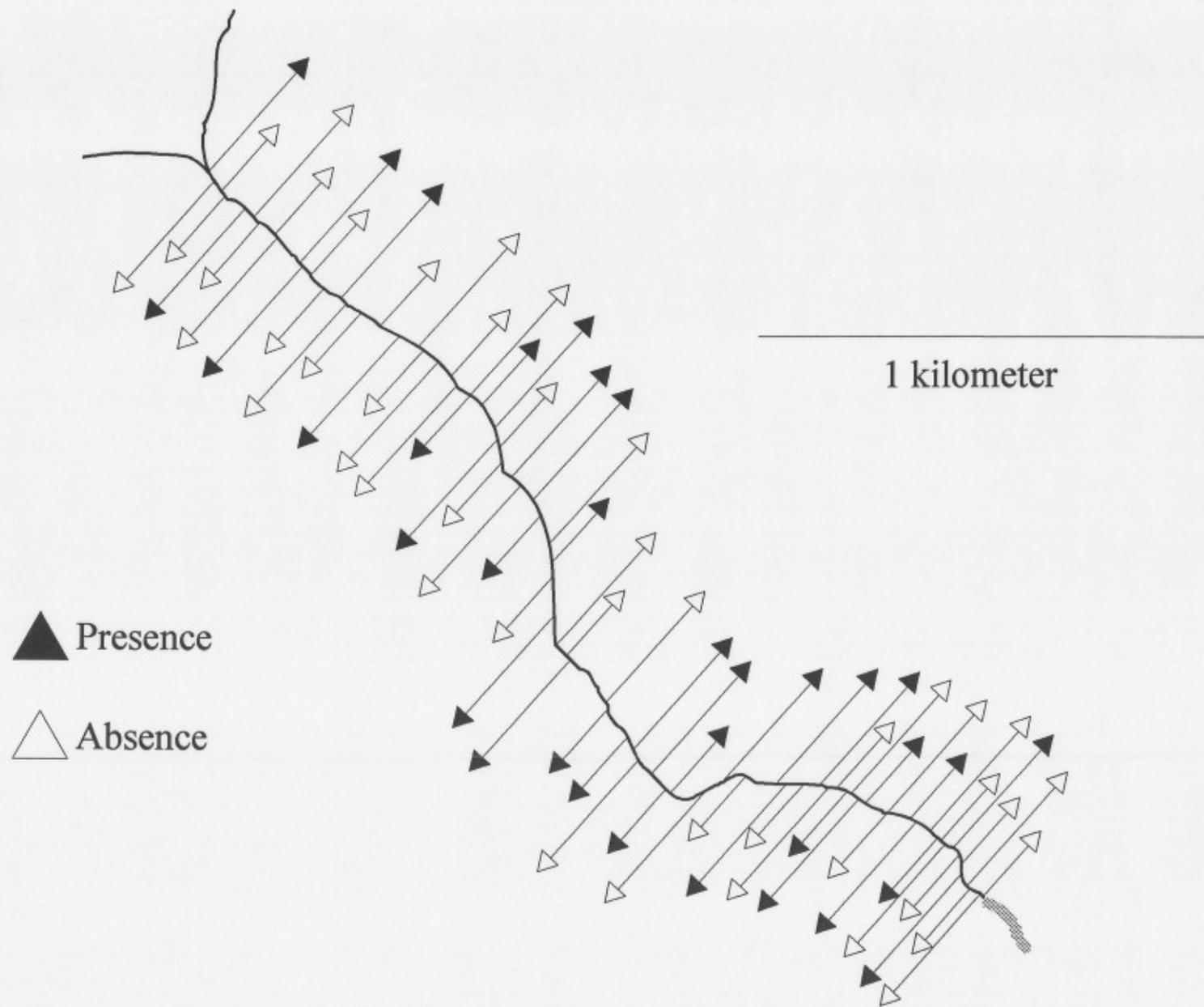
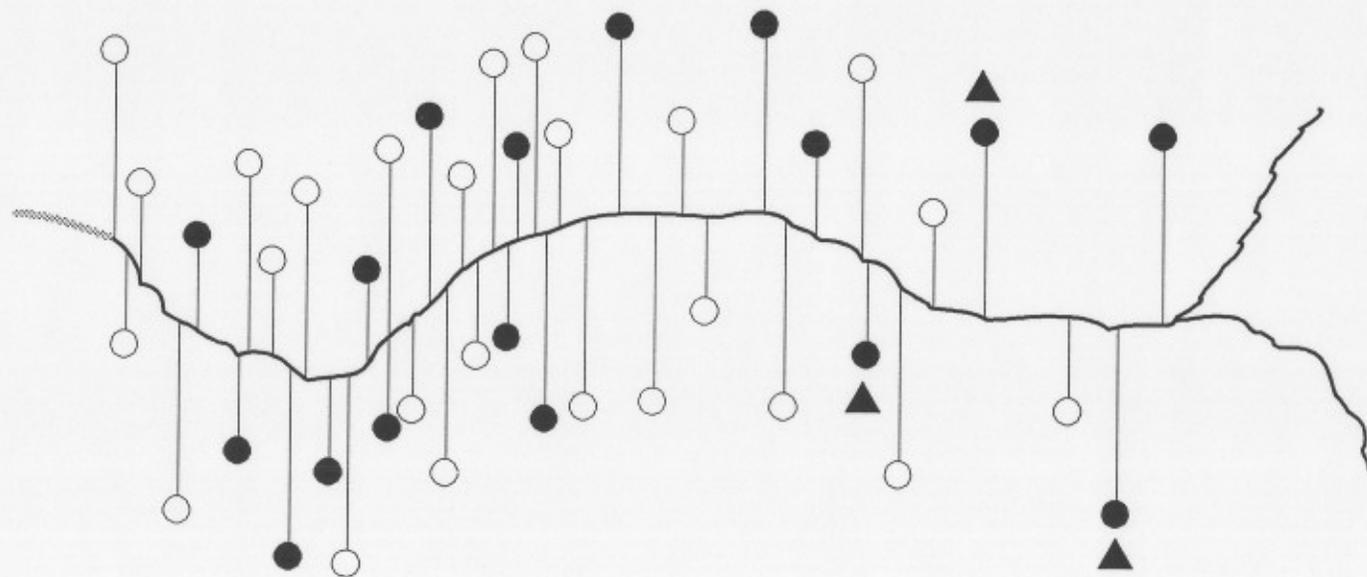


Figure 2. Distribution of blackside dace in the Big Lick Branch study area. Triangles indicate sample sites. Solid triangles represent sites where blackside dace are present.

- Presence
○ Absence ▲ Blackside Dace



1 kilometer

Figure 3. Distribution of southern redbelly dace and blackside dace in the Ned Branch study area. Circles indicate sample sites. Solid circles represent sites where southern redbelly dace are present. Solid triangles represent presence of blackside dace.

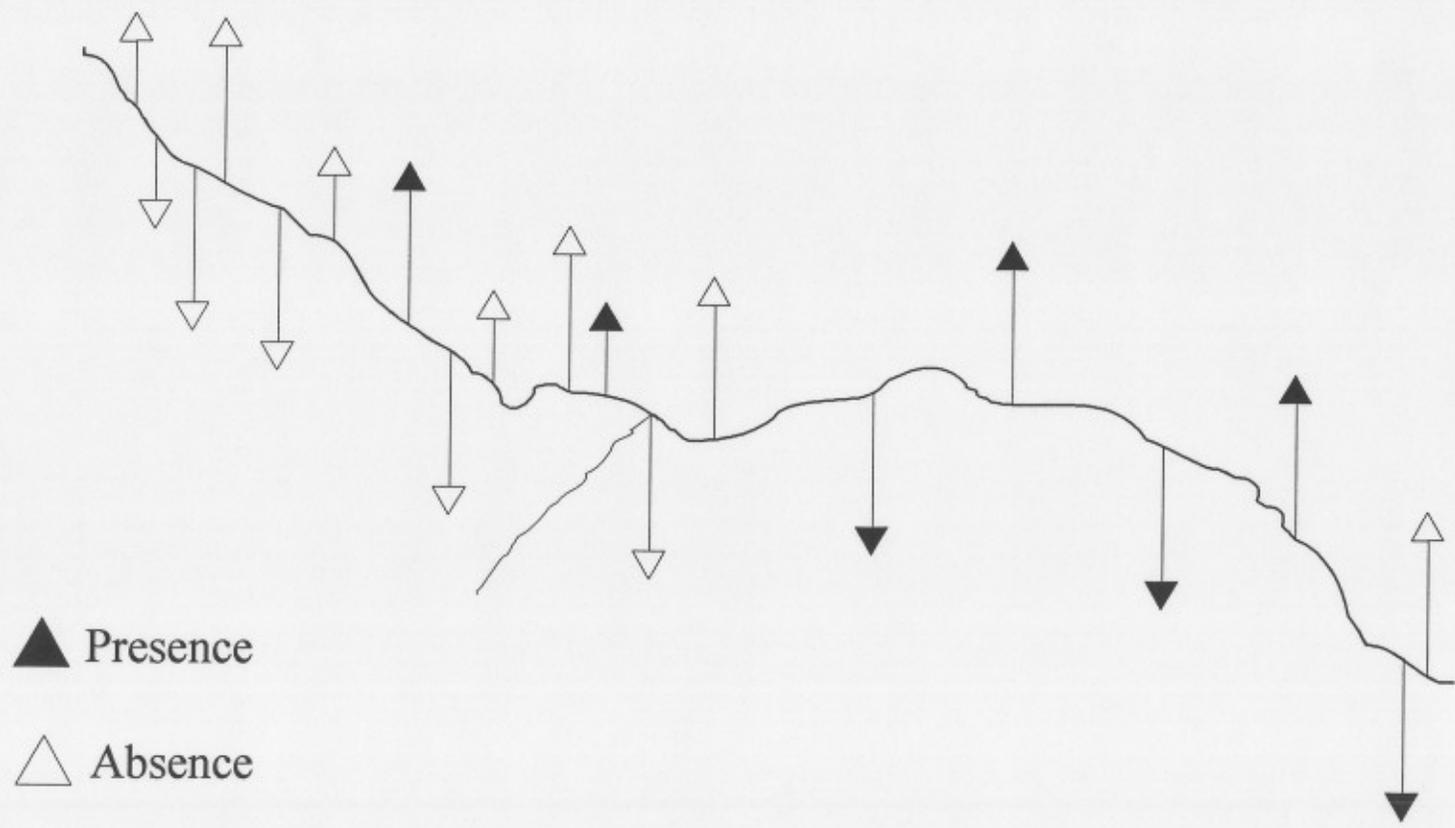


Figure 4. Distribution of blackside dace in the Ryans Creek study area. Triangles indicate sample sites. Solid triangles represent sites where blackside dace are present.

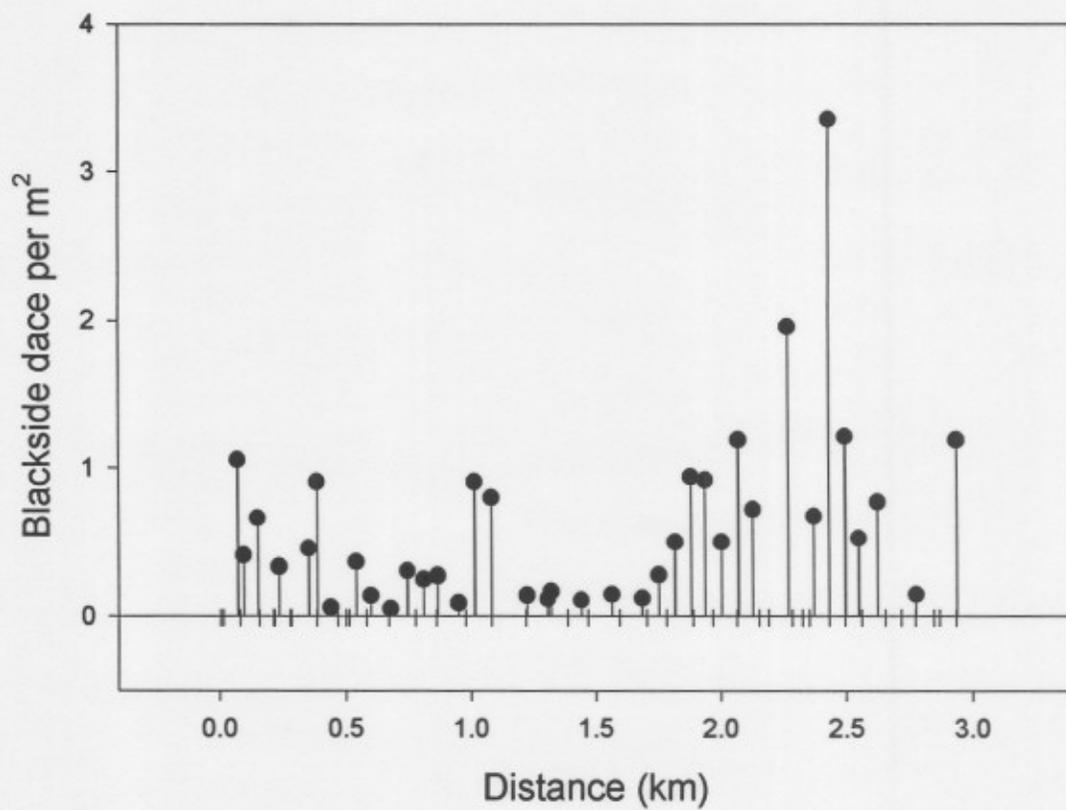


Figure 5. Density of blackside dace, by habitat-unit, in Big Lick Branch. Vertical marks on axis represent sampled habitat-units where fish were not present.

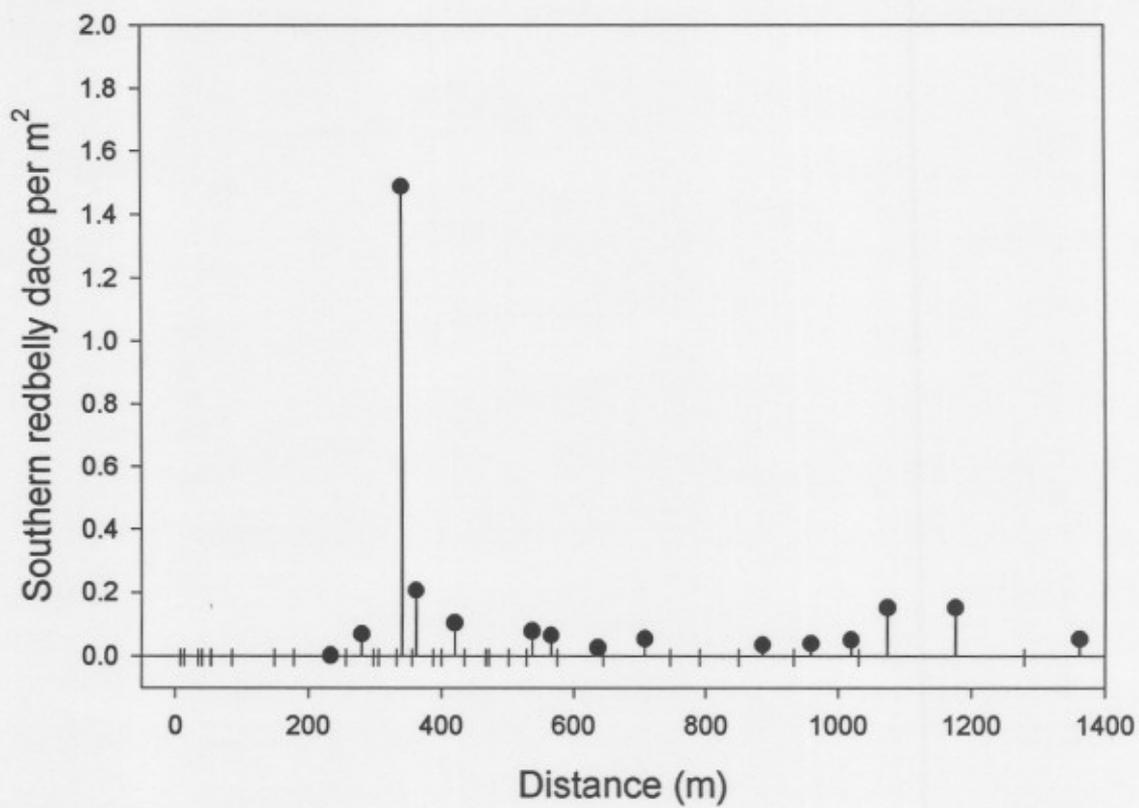


Figure 6. Density of southern redbelly dace, by habitat-unit, in Ned Branch. Vertical marks represent sampled habitat-units where fish were not present.

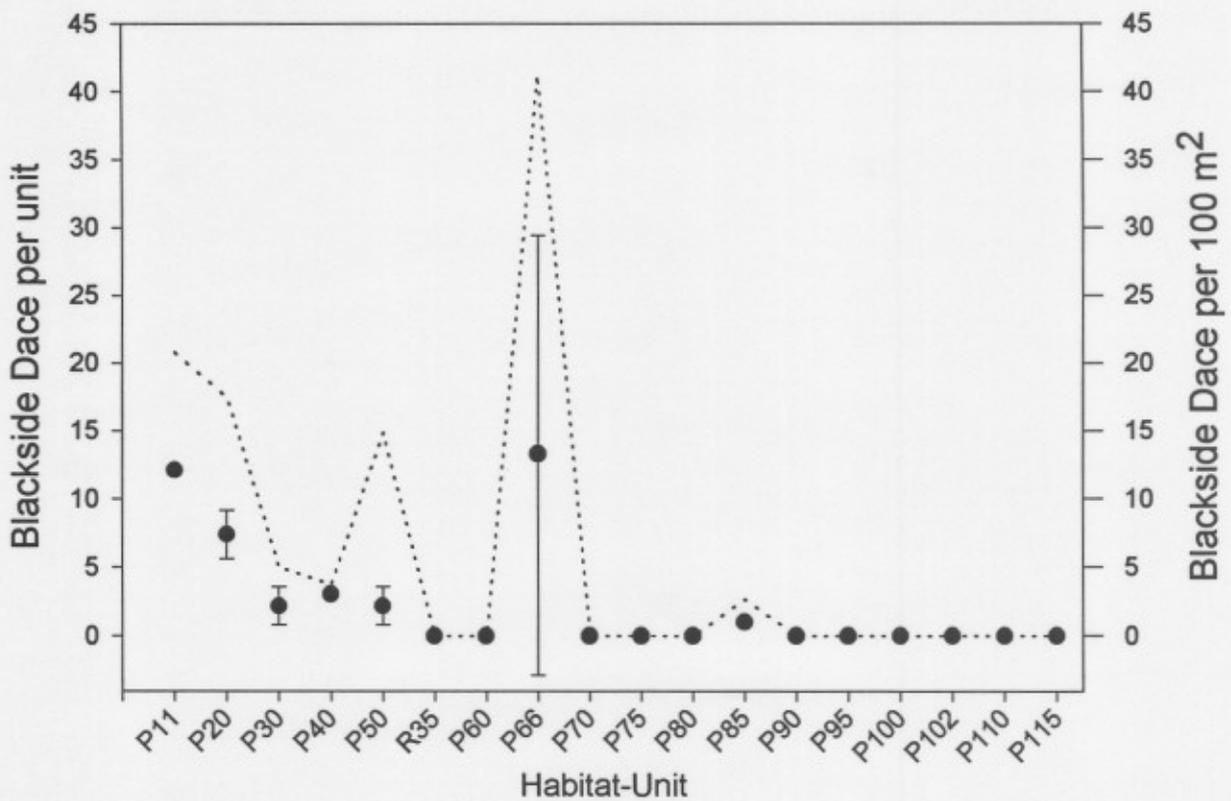


Figure 7. Population estimate of blackside dace in Ryans Creek. Solid circles represent three-pass depletion estimate for each habitat-unit surveyed and capped line above and below solid circles represent 95% confidence intervals. Dotted-line represents density estimates (number of blackside dace per 100m²) for each habitat-unit surveyed.

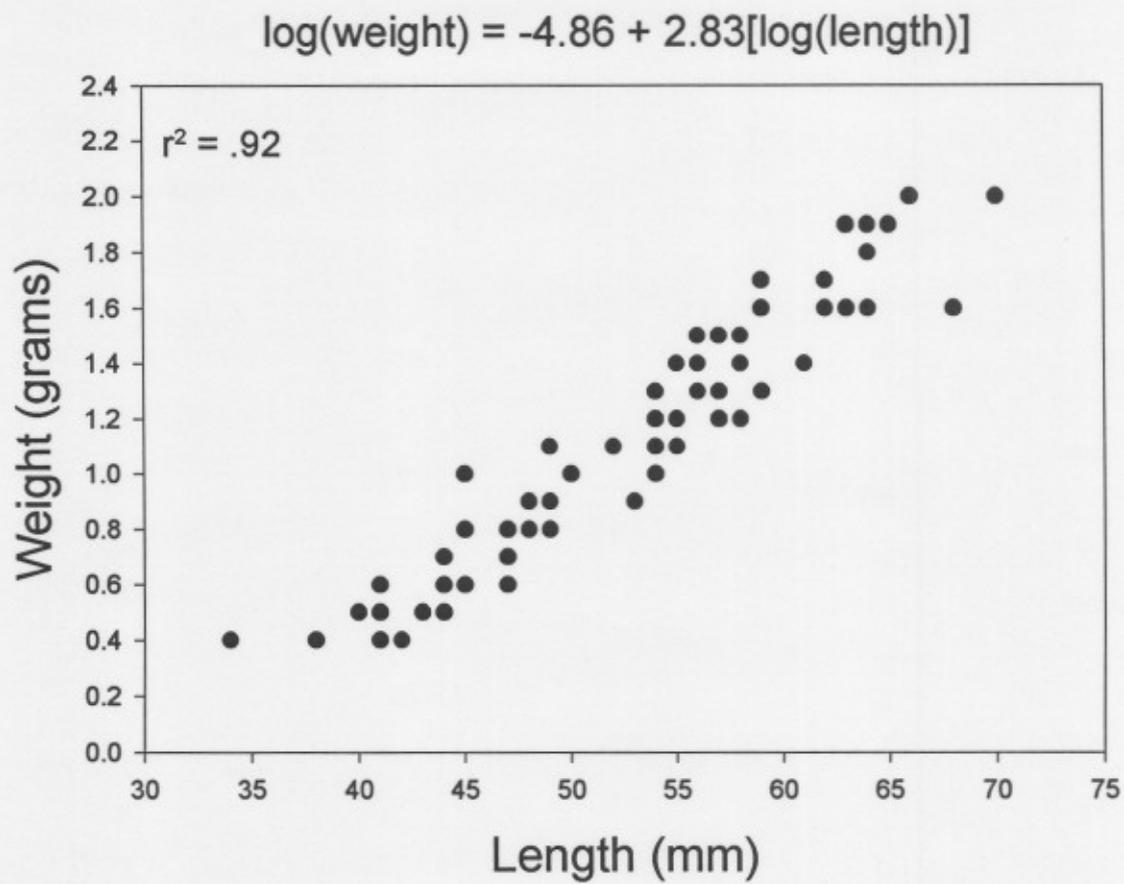


Figure 8. Length-weight relationship for blackside dace in Big Lick Branch.

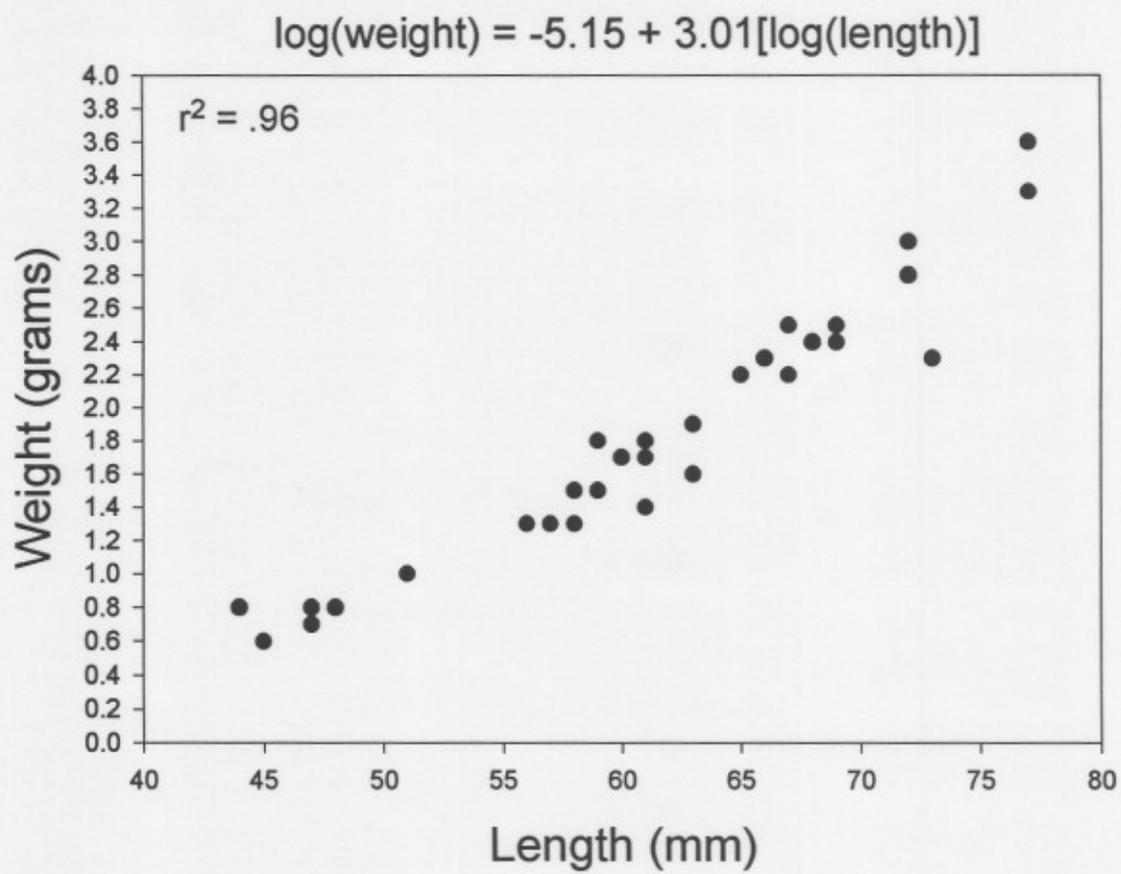


Figure 9. Length-weight relationship for blackside dace in Ryans Creek.

Table 1. Total fish species identified in Big Lick Branch, Ned Branch, and Ryans Creek.

| Common Name | Scientific Name |
|------------------------|---------------------------------|
| Blackside dace | <i>Phoxinus cumberlandensis</i> |
| Southern redbelly dace | <i>P. erythrogaster</i> |
| Creek chub | <i>Semotilus atromaculatus</i> |
| Striped darter | <i>Etheostoma virgatum</i> |
| Rainbow darter | <i>E. caeruleum</i> |
| Arrow darter | <i>E. sagitta</i> |
| Fantail darter | <i>E. flabellare</i> |
| Ohio logperch | <i>Percina caprodes</i> |
| Black bass | <i>Micropterus spp.</i> |
| Sculpin | <i>Cottus spp.</i> |
| White sucker | <i>Catostomus commersoni</i> |

Table 2. Population estimates, determined by three-pass depletions (Zippen 1958), by individual habitat units in Big Lick Branch. Habitat-unit surface area (P = pool,R = riffle) and locations are given in Appendix A.

| Unit | Blackside Dace | Creek Chub | Arrow Darter | Rainbow Darter |
|------|-------------------|------------|--------------|-------------------|
| R1 | 0 | 3 | 0 | 1 |
| P9 | 9 | 19 | 1 | 2 |
| P25 | 0 | 22 | 0 | 12 |
| R20 | 0 | 3 | 0 | 0 |
| P51 | 0 | 22 | 2 | 0 |
| R40 | 0 | 2 | 0 | 0 |
| P75 | 1 | 12 | 0 | 0 |
| R60 | 0 | 1 | 0 | 0 |
| P100 | 6 | 22 | 0 | 0 |
| R80 | 0 | 0 | 0 | 0 |
| P220 | 5 | 20 | 0 | 0 |
| R215 | 0 | 0 | 0 | 0 |
| P240 | 11 | 13 | 0 | 0 |
| R230 | 0 | 1 | 0 | 0 |
| P260 | 15 | 7 | 0 | 0 |
| R245 | 0 | 1 | 0 | 0 |
| R260 | 0 | 0 | 0 | 0 |
| P300 | 4 | 9 | 0 | 0 |
| R275 | 0 | 0 | 0 | 0 |
| P320 | 21 | 15 | 0 | 0 |

Table 3. Population estimates, determined by three-pass depletions (Zippen 1958), by individual habitat units in Ned Branch. Habitat-unit surface area (P = pool,R = riffle) and locations are given in Appendix B.

| Unit | Blackside Dace | Southern Redbelly | Creek Chub | Striped Darter | Rainbow Darter | Sculpin | Black Bass |
|------|-------------------|----------------------|---------------|-------------------|-------------------|---------|---------------|
| P6 | 0 | 0 | 4 | 0 | 4 | 1 | 0 |
| R9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| P12 | 0 | 5 | 35 | 18 | 1 | 0 | 1 |
| R15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| P18 | 0 | 0 | 9 | 1 | 2 | 0 | 0 |
| R21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| P24 | 0 | 2 | 26 | 0 | 1 | 0 | 0 |
| P30 | 0 | 5 | 11 | 1 | 1 | 0 | 0 |
| R30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| P37 | 0 | 0 | 5 | 1 | 2 | 0 | 0 |
| R33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| P43 | 0 | 0 | 6 | 1 | 6 | 0 | 0 |
| R36 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| R39 | 0 | 0 | 6 | 0 | 0 | 0 | 0 |
| R45 | 0 | 0 | 4 | 0 | 1 | 0 | 0 |
| P55 | 0 | 0 | 8 | 1 | 0 | 0 | 0 |
| R50 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| P60 | 4 | 13 | 42 | 1 | 3 | 0 | 0 |
| P70 | 0 | 4 | 10 | 0 | 1 | 0 | 0 |
| P75 | 4 | 33 | 15 | 0 | 3 | 0 | 0 |
| P80 | 1 | 4 | 13 | 0 | 3 | 0 | 0 |

Table 4. Population estimates, determined by three-pass depletions (Zippen 1958), by individual habitat units in Ryans Creek. Habitat-unit surface area (P = pool,R = riffle) and locations are given in Appendix C.

| Unit | Blackside Dace | Creek | Striped Darter | White Sucker | Fantail Darter | Arrow Darter |
|------|-------------------|-------|-------------------|-----------------|-------------------|-----------------|
| R6 | 0 | 1 | 0 | 0 | 0 | 0 |
| P11 | 12 | 26 | 2 | 6 | 1 | 3 |
| P20 | 7 | 30 | 0 | 0 | 1 | 2 |
| P30 | 1 | 44 | 0 | 1 | 1 | 0 |
| P40 | 3 | 40 | 0 | 3 | 3 | 1 |
| P50 | 2 | 4 | 0 | 2 | 0 | 0 |
| R35 | 0 | 0 | 0 | 0 | 0 | 0 |
| P60 | 0 | 6 | 0 | 0 | 0 | 0 |
| P66 | 13 | 34 | 0 | 0 | 0 | 3 |
| P70 | 0 | 7 | 0 | 0 | 0 | 0 |
| P75 | 0 | 4 | 0 | 0 | 0 | 0 |
| P80 | 0 | 14 | 0 | 0 | 0 | 0 |
| P85 | 0 | 12 | 0 | 0 | 0 | 0 |
| P90 | 0 | 2 | 0 | 0 | 0 | 0 |
| P95 | 0 | 6 | 0 | 0 | 0 | 0 |
| P100 | 0 | 2 | 0 | 0 | 0 | 0 |
| P102 | 0 | 27 | 0 | 0 | 0 | 0 |
| P110 | 0 | 42 | 0 | 0 | 0 | 0 |
| P115 | 0 | 10 | 0 | 0 | 0 | 0 |

Appendix A. Location of each sample unit in relation to starting point in feet (ft) and meters (m), corrected area of each sample unit in square feet (ft²) and square meters (m²), and density of blackside dace (BSD) in Big Lick Branch.

| Type | No. | Dist(ft) | Dist(m) | Area(ft ²) | Area(m ²) | BSD | BSD/ft ² | BSD/m ² |
|--------|-----|----------|---------|------------------------|-----------------------|-----|---------------------|--------------------|
| Riffle | 1 | 0.0 | 0.0 | 178.9 | 16.1 | 0 | 0.000 | 0.000 |
| Pool | 1 | 46.0 | 12.8 | 255.6 | 23.0 | 0 | 0.000 | 0.000 |
| Pool | 5 | 235.0 | 71.6 | 76.7 | 6.9 | 7 | 0.095 | 1.055 |
| Riffle | 5 | 262.0 | 79.9 | 51.1 | 4.6 | 0 | 0.000 | 0.000 |
| Pool | 9 | 312.0 | 95.1 | 255.6 | 23.0 | 9 | 0.037 | 0.407 |
| Pool | 15 | 495.0 | 150.9 | 140.6 | 12.7 | 8 | 0.059 | 0.658 |
| Riffle | 10 | 515.0 | 157.0 | 153.3 | 13.8 | 0 | 0.000 | 0.000 |
| Pool | 20 | 690.0 | 210.4 | 319.4 | 28.8 | 0 | 0.000 | 0.000 |
| Riffle | 15 | 710.0 | 216.5 | 25.6 | 2.3 | 0 | 0.000 | 0.000 |
| Pool | 25 | 774.0 | 236.0 | 383.3 | 34.5 | 11 | 0.030 | 0.332 |
| Pool | 30 | 914.0 | 278.7 | 63.9 | 5.8 | 0 | 0.000 | 0.000 |
| Riffle | 20 | 924.0 | 281.7 | 89.4 | 8.1 | 0 | 0.000 | 0.000 |
| Pool | 35 | 1157.0 | 352.7 | 76.7 | 6.9 | 3 | 0.041 | 0.452 |
| Riffle | 25 | 1262.0 | 384.8 | 25.6 | 2.3 | 0 | 0.000 | 0.000 |
| Pool | 40 | 1267.0 | 386.3 | 102.2 | 9.2 | 8 | 0.081 | 0.904 |
| Pool | 45 | 1444.0 | 440.2 | 191.7 | 17.3 | 1 | 0.005 | 0.060 |
| Riffle | 30 | 1537.0 | 468.6 | 51.1 | 4.6 | 0 | 0.000 | 0.000 |
| Pool | 51 | 1637.0 | 499.1 | 268.3 | 24.2 | 0 | 0.000 | 0.000 |
| Riffle | 35 | 1685.0 | 513.7 | 166.1 | 15.0 | 0 | 0.000 | 0.000 |
| Pool | 55 | 1775.0 | 541.2 | 127.8 | 11.5 | 4 | 0.033 | 0.362 |
| Riffle | 40 | 1910.0 | 582.3 | 63.9 | 5.8 | 0 | 0.000 | 0.000 |
| Pool | 60 | 1967.0 | 599.7 | 166.1 | 15.0 | 2 | 0.013 | 0.139 |
| Riffle | 45 | 2193.0 | 668.6 | 230.0 | 20.7 | 0 | 0.000 | 0.000 |
| Pool | 65 | 2226.0 | 678.7 | 447.2 | 40.3 | 2 | 0.005 | 0.052 |
| Pool | 70 | 2447.0 | 746.0 | 76.7 | 6.9 | 2 | 0.027 | 0.301 |
| Riffle | 50 | 2546.0 | 776.2 | 89.4 | 8.1 | 0 | 0.000 | 0.000 |
| Pool | 75 | 2659.0 | 810.7 | 140.6 | 12.7 | 3 | 0.022 | 0.247 |
| Riffle | 55 | 2819.0 | 859.5 | 115.0 | 10.4 | 0 | 0.000 | 0.000 |
| Pool | 80 | 2841.0 | 866.2 | 127.8 | 11.5 | 3 | 0.024 | 0.271 |
| Pool | 85 | 3116.0 | 950.0 | 383.3 | 34.5 | 3 | 0.008 | 0.090 |
| Riffle | 60 | 3206.0 | 977.4 | 115.0 | 10.4 | 0 | 0.000 | 0.000 |
| Pool | 90 | 3327.0 | 1014.3 | 178.9 | 16.1 | 14 | 0.081 | 0.904 |
| Riffle | 65 | 3542.0 | 1079.9 | 38.3 | 3.5 | 0 | 0.000 | 0.000 |
| Pool | 95 | 3548.0 | 1081.7 | 1086.1 | 97.8 | 75 | 0.072 | 0.798 |
| Riffle | 70 | 3990.0 | 1216.5 | 115.0 | 10.4 | 0 | 0.000 | 0.000 |
| Pool | 100 | 4013.0 | 1223.5 | 408.9 | 36.8 | 5 | 0.013 | 0.141 |
| Riffle | 75 | 4280.0 | 1304.9 | 191.7 | 17.3 | 2 | 0.011 | 0.121 |
| Pool | 105 | 4329.0 | 1319.8 | 485.6 | 43.7 | 7 | 0.015 | 0.167 |
| Pool | 110 | 4724.0 | 1440.2 | 319.4 | 28.8 | 3 | 0.010 | 0.109 |
| Riffle | 80 | 4809.0 | 1466.2 | 25.6 | 2.3 | 0 | 0.000 | 0.000 |
| Pool | 115 | 5127.2 | 1563.2 | 155.0 | 14.0 | 2 | 0.013 | 0.149 |
| Riffle | 85 | 5226.9 | 1593.6 | 103.3 | 9.3 | 0 | 0.000 | 0.000 |

Appendix A. Continued

| Type | No. | Dist(ft) | Dist(m) | Area(ft ²) | Area(m ²) | BSD | BSD/ft ² | BSD/m ² |
|--------|-----|----------|---------|------------------------|-----------------------|-----|---------------------|--------------------|
| Pool | 120 | 5228.9 | 1594.2 | 129.2 | 11.6 | 0 | 0.000 | 0.000 |
| Pool | 125 | 5523.4 | 1684 | 189.4 | 17.1 | 2 | 0.011 | 0.122 |
| Riffle | 90 | 5580.5 | 1701.4 | 86.1 | 7.8 | 0 | 0.000 | 0.000 |
| Pool | 130 | 5744.8 | 1751.5 | 292.8 | 26.4 | 7 | 0.025 | 0.276 |
| Riffle | 95 | 5844.5 | 1781.9 | 51.7 | 4.7 | 0 | 0.000 | 0.000 |
| Pool | 135 | 5957.0 | 1816.2 | 396.1 | 35.7 | 17 | 0.045 | 0.496 |
| Pool | 140 | 6167.3 | 1880.3 | 86.1 | 7.8 | 7 | 0.085 | 0.939 |
| Riffle | 100 | 6186.6 | 1886.2 | 17.2 | 1.6 | 0 | 0.000 | 0.000 |
| Pool | 145 | 6352.6 | 1936.8 | 516.7 | 46.5 | 41 | 0.083 | 0.917 |
| Riffle | 105 | 6443.8 | 1964.6 | 43.1 | 3.9 | 0 | 0.000 | 0.000 |
| Pool | 150 | 6564.2 | 2001.3 | 163.6 | 14.7 | 7 | 0.045 | 0.494 |
| Riffle | 110 | 6762.9 | 2061.9 | 137.8 | 12.4 | 0 | 0.000 | 0.000 |
| Pool | 155 | 6787.2 | 2069.3 | 77.5 | 7.0 | 8 | 0.107 | 1.193 |
| Pool | 160 | 6976.1 | 2126.9 | 499.4 | 45.0 | 31 | 0.065 | 0.717 |
| Riffle | 115 | 7052.2 | 2150.1 | 68.9 | 6.2 | 0 | 0.000 | 0.000 |
| Pool | 165 | 7182.4 | 2189.8 | 327.2 | 29.5 | 0 | 0.000 | 0.000 |
| Pool | 170 | 7439.9 | 2268.3 | 111.9 | 10.1 | 19 | 0.177 | 1.961 |
| Riffle | 120 | 7488.8 | 2283.2 | 60.3 | 5.4 | 0 | 0.000 | 0.000 |
| Pool | 175 | 7622.0 | 2323.8 | 25.8 | 2.3 | 0 | 0.000 | 0.000 |
| Riffle | 125 | 7712.5 | 2351.4 | 103.3 | 9.3 | 0 | 0.000 | 0.000 |
| Pool | 180 | 7774.2 | 2370.2 | 51.7 | 4.7 | 3 | 0.060 | 0.671 |
| Riffle | 130 | 7966.4 | 2428.8 | 17.2 | 1.6 | 0 | 0.000 | 0.000 |
| Pool | 185 | 7971.3 | 2430.3 | 103.3 | 9.3 | 30 | 0.302 | 3.355 |
| Riffle | 135 | 8172.0 | 2491.5 | 68.9 | 6.2 | 0 | 0.000 | 0.000 |
| Pool | 190 | 8182.8 | 2494.8 | 361.7 | 32.6 | 38 | 0.109 | 1.214 |
| Pool | 195 | 8357.0 | 2547.9 | 155.0 | 14.0 | 7 | 0.047 | 0.522 |
| Riffle | 140 | 8389.5 | 2557.8 | 292.8 | 26.4 | 0 | 0.000 | 0.000 |
| Pool | 200 | 8604.7 | 2623.4 | 482.2 | 43.4 | 32 | 0.069 | 0.767 |
| Riffle | 145 | 8700.8 | 2652.7 | 516.7 | 46.5 | 0 | 0.000 | 0.000 |
| Pool | 205 | 8908.7 | 2716.1 | 103.3 | 9.3 | 0 | 0.000 | 0.000 |
| Riffle | 150 | 9090.1 | 2771.4 | 111.9 | 10.1 | 0 | 0.000 | 0.000 |
| Pool | 210 | 9100.6 | 2774.6 | 387.5 | 34.9 | 5 | 0.013 | 0.149 |
| Riffle | 155 | 9327.2 | 2843.7 | 103.3 | 9.3 | 0 | 0.000 | 0.000 |
| Pool | 215 | 9408.9 | 2868.6 | 292.8 | 26.4 | 0 | 0.000 | 0.000 |
| Riffle | 160 | 9623.8 | 2934.1 | 43.1 | 3.9 | 0 | 0.000 | 0.000 |
| Pool | 220 | 9630.6 | 2936.2 | 155.0 | 14.0 | 16 | 0.107 | 1.193 |

Appendix B. Location of each sample unit in relation to starting point in feet (ft) and meters (m), corrected area of each sample unit in square feet (ft²) and square meters (m²), density of southern redbelly dace (SRD), and density of blackside dace (BSD) in Ned Branch. Asterisk indicates missing data.

| Type | No. | Dist(ft) | Dist(m) | Area(ft ²) | Area(m ²) | SRD | SRD/ft ² | SRD/m ² | BSD | BSD/ft ² | BSD/m ² |
|---------|-----|----------|---------|------------------------|-----------------------|-----|---------------------|--------------------|-----|---------------------|--------------------|
| Pool | 3 | 172.20 | 52.5 | 551.1 | 49.6 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Riffles | 3 | 176.14 | 53.7 | 13.3 | 1.2 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Pool | 6 | 277.16 | 84.5 | 38.9 | 3.5 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Pool | 9 | 486.42 | 148.3 | 177.8 | 16 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Riffles | 9 | 583.51 | 177.9 | 65.6 | 5.9 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Pool | 12 | 765.55 | 233.4 | 897.2 | 80.8 | 2 | 0.021 | 0.002 | 0 | 0.000 | 0.000 |
| Riffles | 12 | 839.68 | 256 | 22.2 | 2 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Pool | 16 | 919.38 | 280.3 | 966.7 | 87 | 77 | 0.765 | 0.069 | 0 | 0.000 | 0.000 |
| Riffles | 15 | 975.80 | 297.5 | 266.7 | 24 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Pool | 18 | 1000.40 | 305 | 222.2 | 20 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Riffles | 18 | 1088.30 | 331.8 | 166.7 | 15 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Pool | 21 | 1119.14 | 341.2 | 261.1 | 23.5 | 35 | 0.134 | 1.489 | 0 | 0.000 | 0.000 |
| Riffles | 21 | 1167.02 | 355.8 | 60.0 | 5.4 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Pool | 24 | 1186.70 | 361.8 | 66.7 | 6 | 4 | 2.304 | 0.207 | 0 | 0.000 | 0.000 |
| Pool | 27 | 1270.67 | 387.4 | 28.9 | 2.6 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Riffles | 24 | 1311.34 | 399.8 | 11.1 | 1 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Pool | 30 | 1379.24 | 420.5 | 63.3 | 5.7 | 2 | 1.152 | 0.104 | 0 | 0.000 | 0.000 |
| Riffles | 27 | 1426.47 | 434.9 | 34.4 | 3.1 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Pool | 34 | 1531.43 | 466.9 | 119.4 | 10.8 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Riffles | 30 | 1546.19 | 471.4 | 75.0 | 6.8 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Pool | 37 | 1645.90 | 501.8 | 105.6 | 9.5 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Riffles | 33 | 1732.17 | 528.1 | 100.0 | 9 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Pool | 40 | 1763.66 | 537.7 | 133.3 | 12 | 12 | 0.864 | 0.078 | 0 | 0.000 | 0.000 |
| Pool | 43 | 1855.50 | 565.7 | 122.2 | 11 | 9 | 0.707 | 0.064 | 0 | 0.000 | 0.000 |
| Riffles | 36 | 1885.34 | 574.8 | 66.7 | 6 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Pool | 46 | 2089.69 | 637.1 | 100.0 | 9 | 3 | 0.288 | 0.026 | 0 | 0.000 | 0.000 |
| Riffles | 39 | 2113.30 | 644.3 | 200.0 | 18 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Pool | 50 | 2322.57 | 708.1 | 222.2 | 20 | 14 | 0.605 | 0.054 | 0 | 0.000 | 0.000 |
| Riffles | 45 | 2449.18 | 746.7 | 177.8 | 16 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Pool | 55 | 2593.17 | 790.6 | 44.4 | 4 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Riffles | 50 | 2788.33 | 850.1 | 111.1 | 10 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Pool | 60 | 2906.74 | 886.2 | 355.6 | 32 | 14 | 0.378 | 0.034 | 3 | 0.094 | 0.013 |
| Riffles | 55 | 3060.24 | 933 | 144.4 | 13 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Pool | 66 | 3145.85 | 959.1 | 177.8 | 16 | 8 | 0.432 | 0.039 | 0 | 0.000 | 0.000 |
| Pool | 70 | 3343.96 | 1019.5 | 122.2 | 11 | 7 | 0.550 | 0.049 | 0 | 0.000 | 0.000 |
| Riffles | 60 | 3379.71 | 1030.4 | 155.6 | 14 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Pool | 75 | 3523.38 | 1074.2 | 255.6 | 23 | 45 | 1.690 | 0.152 | 2 | 0.087 | 0.012 |
| Riffles | 65 | 3811.36 | 1162 | * | * | 0 | * | * | 0 | 0.000 | 0.000 |
| Pool | 80 | 3858.59 | 1176.4 | 200.0 | 18 | 35 | 1.680 | 0.151 | 1 | 0.056 | 0.008 |
| Riffles | 70 | 4195.12 | 1279 | 177.8 | 16 | 0 | 0.000 | 0.000 | 0 | 0.000 | 0.000 |
| Pool | 85 | 4245.96 | 1294.5 | * | * | 22 | * | * | 0 | 0.000 | 0.000 |
| Pool | 89 | 4468.02 | 1362.2 | 233.3 | 21 | 14 | 0.576 | 0.052 | 0 | 0.000 | 0.000 |

Appendix C. Location of each sample site, corrected area of each sample unit in square meters(m²) and square feet(ft²), number of blackside dace(BSD) captured, population of blackside dace, 95% confidence interval, and density of blackside dace in Ryans Creek.

| Type | No. | Area(ft ²) | Area(m ²) | BSD No. | BSD Est. | 95% CI | BSD/ft ² | BSD/m ² |
|--------|-----|------------------------|-----------------------|---------|----------|--------|---------------------|--------------------|
| Riffle | 6 | 133.3 | 12.0 | 0 | 0 | ± 0.0 | 0.00 | 0.00 |
| Pool | 11 | 646.7 | 58.2 | 12 | 12.1 | ± 0.0 | 1.87 | 20.80 |
| Pool | 20 | 468.9 | 42.2 | 7 | 7.4 | ± 1.8 | 1.58 | 17.50 |
| Pool | 30 | 483.3 | 43.5 | 2 | 2.2 | ± 1.4 | 0.46 | 5.00 |
| Pool | 40 | 893.3 | 80.4 | 3 | 3 | ± 0.0 | 0.34 | 3.80 |
| Pool | 50 | 162.2 | 14.6 | 2 | 2.2 | ± 1.4 | 1.36 | 14.90 |
| Riffle | 35 | 60.0 | 5.4 | 0 | 0 | ± 0.0 | 0.00 | 0.00 |
| Pool | 60 | 147.8 | 13.3 | 0 | 0 | ± 0.0 | 0.00 | 0.00 |
| Pool | 66 | 357.8 | 32.2 | 13 | 13.3 | ±16.1 | 3.72 | 41.30 |
| Pool | 70 | 36.7 | 3.3 | 0 | 0 | ± 0.0 | 0.00 | 0.00 |
| Pool | 75 | 12.2 | 1.1 | 0 | 0 | ± 0.0 | 0.00 | 0.00 |
| Pool | 80 | 118.9 | 10.7 | 0 | 0 | ± 0.0 | 0.00 | 0.00 |
| Pool | 85 | 415.6 | 37.4 | 1 | 1 | ± 0.0 | 0.24 | 2.68 |
| Pool | 90 | 22.2 | 2 | 0 | 0 | ± 0.0 | 0.00 | 0.00 |
| Pool | 95 | 60.0 | 5.4 | 0 | 0 | ± 0.0 | 0.00 | 0.00 |
| Pool | 100 | 41.1 | 3.7 | 0 | 0 | ± 0.0 | 0.00 | 0.00 |
| Pool | 102 | 117.8 | 10.6 | 0 | 0 | ± 0.0 | 0.00 | 0.00 |
| Pool | 110 | 206.7 | 18.6 | 0 | 0 | ± 0.0 | 0.00 | 0.00 |
| Pool | 115 | 110.0 | 9.9 | 0 | 0 | ± 0.0 | 0.00 | 0.00 |