Assessing Habitat Requirements for Brook Trout (Salvelinus fontinalis) in Low Order Streams

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Abstract

Two sets of data related to brook trout habitat and relative abundance were examined to determine which habitat variables had the most significant effects on the relative numerical abundance of this species. The first data set was obtained by Wood-Pawcatuck Watershed Association (WPWA) personnel during the summers of 2002 and 2003. Data from a total of 31 sites involving seven habitat variables were examined by two approaches. The first approach involved stepwise multiple regression and the second approach involved regression trees. The second data set was derived from a report published by the Connecticut Department of Environmental Protection (CTDEP) in 1995. This data set provided 116 samples sites with 11 habitat variables. The dependent variable for both data sets was the same, namely the proportion of brook trout relative to the total fish species found at the site. The results obtained from the WPWA samples indicated that the proximity of the sample site to dams was important in determining the relative proportion of brook trout in the sample. This was followed by stream depth as next in importance. The CTDEP data set did not contain data related to dam proximity. Instead the alkalinity of the water sample from the site was determined to be most important to brook trout with stream width and canopy cover being of secondary importance. Some management implications of these results are described.

Introduction

Among the many species of fish which are threatened due to habitat changes brought about by anthropogenic causes, the brook trout (Salvelinus fontinalis) is one of the more important and vulnerable species. Understanding and limiting human impacts on brook trout requires knowledge of the relationship between the species and its environment. A proper identification and evaluation of the conditions which define the habitat requirements of this species in a local environment is a primary goal of this study. However, it should be recognized that the concept of habitat requirements is usually not well defined. Herein, we consider habitat requirements as features of the environment which are thought to be important for the persistence of the species. Recently Rosenfeld (2003) provided an excellent review including an overview and explanation of various approaches to assessing stream fish habitat requirements. While the above review emphasizes the need for identification of the critical stream habitats necessary for persistence of the species, it also stresses the importance of identifying and predicting the processes which ultimately generate and maintain these features.

Although the relationship between the abundance of species and characteristics of habitats are important for management and theoretical purposes, the data on populations and habitats are often unsuitable for classical model based analyses. Rice (1999) has clearly pointed this out. He stated that populations and habitats are frequently unsuitable for conventional model based statistical analyses. The exact shape of the functional relation between habitat and abundance is rarely known, and noise in the data is often large relative to the signal. Rice therefore suggested nonparametric density estimation, specifically a nonparametric estimator based on the Cauchy distribution. We acknowledge that concerns about the assumptions of classical statistical methods are seldom met when analyses involve the relationship between fish habitat and abundance. Our approach includes a classic statistical procedure (multiple regression) as well as a nonparametric procedure. We utilize an alternative nonparametric approach which is believed to be useful for the purposes at hand. This approach involves classification and regression trees (CART). Although we have not used neural networks in this study, we realize that neural networks have also been utilized to provide models for explaining and predicting trout abundances. Examples of such studies include Lek et. al (1996) and Baran et. al (1996). Specifically, a comparison is made between the results from multiple regression versus regression trees, the latter being a robust nonlinear procedure. Our emphasis will be on the interpretation of regression tree results, because we believe these are more valid due to the limited assumptions required which are better satisfied than those of multiple regression.

Data and Methodology

The first data set used in this study was obtained during the summers of 2002 and 2003 from field work conducted in low order streams in the Wood-Pawcatuck watershed. A total of 31 sample sites were believed to be useful for further analysis. These sample sites were characterized by several habitat related variables of which seven were chosen for detailed study as independent variables. The dependent variable was relative abundance of brook trout as determined by electrofishing. We are aware of a recent study related to the efficiency of single pass versus multiple pass electrofishing as reported by Meador et. al (2003). Although we conducted a multiple pass survey (three successive passes over a portion of stream reach of known length which was defined by blocking seines of one-quarter inch mesh at the upper and lower limits), we have not attempted to estimate biomass or numerical abundance quantitatively. Instead, we have utilized the proportion of brook trout to the total number of all species as an indicator of relative brook trout abundance as our dependent variable. This was done to avoid adjusting for the relative efficiency of two different backpack electrofishing devices, as well as for not adequately meeting other population estimation model assumptions.

In addition to the above mentioned data collection carried out by WPWA personnel with limited funds and equipment, it was found that a similar but significantly more extensive sampling of low order streams as well as a few rivers had been carried out by personnel of the Connecticut Department of Environmental Protection (Hagstrom et. al, 1995). The data reported in this study were obtained mostly from southeastern Connecticut streams and it was determined that a total of 116 sample sites with 11 input (independent) variables were suitable for further analysis by the methods described for our data. These independent variables were similar but more extensive than the data collected by WPWA. However, an identical decision (dependent) variable was derived, which consisted of the proportion of brook trout relative to the total number of species. This was done in spite of the fact that numerical estimates of the absolute abundance had been developed in the Connecticut study because we wanted the dependent variable to be identical for comparison between the two studies. In a limited number of the 116 sites used it was necessary to estimate one or two missing variables. These were mostly alkalinity measurements for which the arithmetic mean was substituted for the blank in order to effectively use all the data in the regression models.

The computer programs used in this project included multiple regression as well as classification and regression trees (CART). Since multiple regression has been widely used and described no serious effort is made herein to provide details of the procedure and its assumptions. However, it should be kept in mind that multiple linear regression models require that all independent variables be continuous, and that multicolinearity and other sources of ill-conditioning should be taken into account. The above cautionary statement provides reasons why nonparametric approaches (such as CART) are well worth consideration for classification and prediction problems when there are several independent variables.

In general, classification trees include those models in which the dependent variable (the predicted variable) is categorical. Regression trees include those models in which the dependent variable is continuous. In our study we have treated the proportion of brook trout in the total sample as a continuous variable. Within both classification and regression trees the independent variables (predictors) may be categorical or continuous. Trees are directed graphs beginning with one node and branching to many. CART models are fit by binary recursive partitioning, whereby a data set is split successively into increasingly homogeneous subsets until it is no longer feasible to continue. Classification and regression trees are often used for predictive purposes. They are also becoming alternates to multiple regression, discriminate analysis and other procedures used in algebraic modeling. A good background for classification and regression tree analyses is found in Breimen et al (1998), and the reader is referred to this book for further enlightenment.

Results and Interpretation

WPWA Data:

The first data set which was subjected to analysis with both stepwise multiple regression and CART analysis is data collected by WPWA personnel during the summers of 2002 and 2003. For the purposes of this analysis the data utilized consisted of seven habitat condition attributes (independent variables) and one decision attribute (dependent variable). The independent variables were: 1. mean depth (ft.), 2. mean velocity of flow (cfs), 3. percent stream shelter (estimated), 4. percent stream canopy (estimated), 5. ratio of cobble to sand (estimated), 6. ratio of sand to silt (estimated), and 7. proximity to dam (estimated). The dependent variable (decision attribute) was the proportion of brook trout to the total number of all fish species caught by electrofishing. TABLE 1 illustrates the values of the variables utilized these analyses. Note that the first two columns have been scaled by multiplying the original values in the first column by 100 and the second by 10 in an effort to homogenize their variances. The lower panel of F 1 indicates the stream and location for each numbered site.

It is obvious from the stepwise multiple regression results shown in TABLE 2 that the most significant predictive variable of those tested is the DAMPROX variable, which roughly indicates site proximity to a dam. It is also evident that this multiple regression model explains somewhat less than one-half of the variability (R squared is only 0.446). The dam proximity variable clearly has a negative effect on relative abundance of brook trout. The other variable which was found to be of some importance is the water depth variable. The importance of this variable has been previously reported in the literature and it is believed that its relationship to the presence of pools is quite important to brook trout persistence and growth. We are not aware of prior reports which indicate adverse dam effects to brook trout from small low dams on the East coast in spite of the fact that in the western part of the United States large dams have severely and adversely affected Pacific salmon runs. We believe that dams not only obstruct seasonal movements but more importantly dams significantly increase suitable habitat for competitive warm-water fish species. The competition from these species may be severe in many instances resulting in reduced growth and survival of brook trout. It is also evident from studies of water temperature which are described in an accompanying report that water temperatures during summer months increase near outfalls of dams by several degrees.

Because these findings are considered important it was decided to test for habitat variable effects using a robust non parametric model, namely regression trees. TABLE 3 illustrates the results of the regression tree analysis. This procedure indicates that proximity to dams is the most important variable which is followed by water velocity and canopy cover. These results correspond quite well with the multiple regression model, except that canopy cover is given more importance in the regression tree.
There are some management implications from this study. Clearly, if some low dams can be breached or removed this would improve conditions for brook trout in the watershed area by permitting increased seasonal movement, reducing competition and reducing adverse summer temperature effects. The removal of dams will not eliminate all competition for the brook trout, but it will improve brook trout habitat quality and reduce competition to a more tolerable level. The maintenance of adequate canopy cover is also considered important as well as the presence of pools which provide protection and habitat diversity.

CTDEP Data:
TABLE 4 illustrates the CTDEP data set derived from the report by Hagstrom et. al (1995), which was utilized in this study. The 11 independent (predictor) variables are clearly defined in the above mentioned report and will not be repeated herein. It is evident that there is some overlap in these variables and those described in TABLE 1. Unfortunately, a measure of dam proximity is not available from the Connecticut data for direct comparison with the prior results described above. On the other hand, this data set includes more independent variables (11), and the sample size is considerably larger than that from the WPWA study. Utilization of these data seems justified due to the close proximity of these sample sites to the Wood-Pawcatuck watershed. Indeed, some sites are in the watershed. Note also that the dependent (response) variable is the same for both data sets. This is believed to be helpful for comparative purposes.

TABLE 5 illustrates the results of applying stepwise multiple regression to the data. The leverage term listed in this table is a diagnostic statistic for assessing model fit. Four samples (sites) are listed as having high values for leverage. A rule of thumb utilized in this study is that leverage values greater than 0.2 are somewhat risky to be included in the model. However, removal of these four sites did not improve the regression model, and they were therefore retained in the analysis which is described in the table. It is somewhat surprising that the model results indicate a low R squared value of 0.342 which is even lower than the value obtained with the WPWA data in spite of a larger sample size and a greater number of independent variables.

Examination of the t values in the next to last column of TABLE 5 indicates that alkalinity is the most important predictor variable which is followed by stream width. This analysis was followed be a regression tree analysis for reasons similar to those listed in the analysis of the smaller data set described above. The regression tree analysis for this data set (TABLE 6) again corresponded quite well to the multiple regression results of TABLE 5. Stream width and alkalinity were the most important variables and the pool-riffle ratio and canopy cover were of secondary importance.

A few words of introduction to the relationship between pH and alkalinity seem appropriate in view of the importance of alkalinity as a predictor of brook trout abundance from TABLE 4 data. Rhode Island and Connecticut's streams can vary somewhat in alkalinity and acidity due to natural causes as well as anthropogenic inputs. Extremely low pH values (substantially below 5.0) are harmful to aquatic organisms, and so the buffering capacity (alkalinity) of water is critical the persistence of aquatic life. The pH is a measure of the concentration of hydrogen ions. Thus it is a measure of the strength and amount of acid present. In natural streams, such as encountered in the WPWA and CTDEP surveys, carbonic acid is the main source of hydrogen ions. This results in a pH of about 5.7. Rainwater is normally acidic because of its carbon dioxide content and also due to its sulfate content. In catchments basins, such as in southern Rhode Island and Connecticut the rocks are generally hard (not very soluble),and there is little buffering capacity. Thus stream water will be acid even if there is no pollution in these areas. Organic acids (derived from swamps) also contribute to a low pH. Alkalinity relates to the quantity and kinds of compounds which shift pH to the alkaline range (7 or higher). Bicarbonates, carbonates and hydroxides are the primary sources of alkalinity. It is measured by titration with a strong acid to a known endpoint, and it is expressed as milliequivalents per liter. The procedure for estimating alkalinity is relatively simple. This finding about the relative importance of alkalinity is not new, and there have been numerous studies of brook trout physiological response to pH as well as changes in aluminum and calcium. Much of this work is described by Bergman and Mattice (1990) for early life stages of brook trout and by Bergman et al (1988) for adults. Additional information on early life history stage response of brook trout to pH, aluminum and calcium is found in Ingersoll et al (1990).

It is believed that the importance of stream width in this latter study was due to the relatively large range of stream sizes utilized in the Connecticut study. Gibson et. al (1987) has also indicated that there is a correlation between brook trout abundance and stream size. The importance of pool-riffle ratio and canopy cover have also been previously reported in the literature.

The possible management implications from this latter study are interesting and should be further explored. Increasing the buffering capacity and pH of low order streams seems feasible by adding limestone to highly acidic streams. The amount is a function of the stream acidity and the exchange capacity of the stream sediment. Some work has already been done as reported in the literature. It is suggested that efforts to improve the buffering capacity and pH of the more acidic streams in the Wood-Pawcatuck watershed could result in a considerable increment in the quality of brook trout habitat in these streams.

References

Baran,P., S. Lek, M. Delacoste and A. Beland. 1996. Stochastic models that predict trout population density or biomass on a mesohabitat scale. Hydrobiologia 337:1-9.

Bergman, H. L., and J. S. Mattice. 1990. Lake acidification and fisheries project: early life stage and juvenile brook trout (Salvelinus fontinalis). Canadian Journal of Fisheries and Aquatic Sciences. 47:1578-1579.

Bergman, H. L., J. S. Mattice and D. J. A. Brown. 1988. Lake acidification and fisheries project: adult brook trout (Salvelinus fontinalis). Canadian Journal of Fisheries and Aquatic Sciences. 45:1561-1562.

Breiman, L., J. H. Friedman, R. A. Olshen and C. J. Stone. 1998. Classification and Regression Trees. Chapman and Hall/CRC, Boca Raton, Florida

Gibson, R. J., T. R. Porter and K. G. Hillier. 1987. Juvenile salmonid production in the Highlands River, St. Georges Bay, Newfoundland. Canadian Technical Report of Fisheries and Aquatic Sciences 1538.

Hagstrom, N. T., M. Humpreys and N. A. Hyatt. 1995. A survey of Connecticut streams and rivers: lower Thames River, Pawcatuck River and eastern central drainages. Federal Aid in Sport Fish Restoration. F-66-R-6, Progress Report April 1,1993 and March 31, 1994.

Ingersoll, C. G., D. C. Mount, D. A. Gulley, T. W. La Point and H. L. Bergman. 1990. Effects of pH, aluminum, and calcium on survival and growth of eggs and fry of brook trout (Salvelinus fontinalis). Canadian Journal of Fisheries and Aquatic Sciences 47:1580-1592.

Lek, S., A. Beland, P. Baran, I. Dimopoulos and M. DeLacoste. 1996. Role of some environmental variables in trout abundance models using neural networks. Aquatic Living Resources 9:23-29.

Meador, M. R., J. P. McIntyre and K. H. Pollock. 2002. Assessing the efficiency of single-pass backpack electrofishing to characterize community structure. Transactions of the American Fisheries Society 132:39-46.

Rice, J. C. 1993. Forecasting abundance from habitat measures using nonparametric density estimation methods. Canadian Journal of Fisheries and Aquatic Sciences 50:1690-1698.

Rosenfeld, J. 2003. Assessing the habitat requirements of stream fishes: an overview and evaluation of different approaches. Transactions of the American Fisheries Society 132:953-968.

TABLES

TABLE 1. Data from WPWA surveys used in developing habitat variable predictions. (Note that some columns have been scaled in order to achieve a more homogeneous data set for analysis.)

TABLE 2. Results from applying a stepwise multiple regression model to the data of *TABLE 1*.

TABLE 3. Results obtained from applying a regression tree model to the data of *TABLE 1*.

TABLE 4. Data from the CTDEP report used in developing habitat variable predictions. (Note that all sites described in the report are not utilized. Selection was made for completeness and for proximity to the WPWA sites.)

TABLE 5. Results obtained from applying a stepwise multiple regression model to the data of *TABLE 4*.

TABLE 6. Results obtained from applying a regression tree analysis to the data of *TABLE 4*.

TABLE 7. Fish Assemblage Chart 2002

TABLE 8. Fish Assemblage Chart 2003

TABLE 1

SITE	DEPTH	VEL	SHELTER	CANOPY	COBGRAV	SANDSILT	DAMPROX	BROOK TROUT
1	40	26.2	30	95	40	45	2	92
2	30	26.6	15	70	80	10	2	19
3	90	6	10	90	25	75	1	0
4	60	13	15	30	15	85	1	44
5	50	25	10	80	30	45	2	33
6	150	20	10	50	70	10	2	8
7	100	20	25	90	50	5	2	33
8	125	25	40	60	20	80	2	4
9	100	30	40	75	80	20	2	88
10	64	1.4	25	10	35	45	2	0
11	40	16	15	95	70	5	1	94
12	50	15	20	90	60	20	1	0
13	20	19.6	75	80	35	65	1	3
14	60	24.4	10	50	5	95	2	3
15	10	6	20	85	20	80	1	3
16	50	6	30	90	50	50	2	3
17	40	34.9	30	80	30	70	2	100
18	40	28.7	10	10	85	15	2	100
19	85	54.5	15	85	45	5	2	100
20	60	30	10	70	40	10	1	0
21	70	23	20	80	30	40	1	0
22	75	23	15	40	65	30	1	0
23	50	23	15	85	40	50	2	100
24	60	27	10	95	65	10	1	0
25	60	17	20	100	0	100	1	0
26	35	50	25	90	60	10	2	100
27	26.5	19	15	80	10	90	2	50
28	10	69	12	80	60	0	2	54
29	20	67.1	20	90	60	0	2	100
30	70	66	15	85	75	20	1	0
31	110	40.9	15	90	65	20	1	0

1 Brushy Brook, Saw Mill Rd, Hopkinton, RI
2 Locke Brook, Mail Road, Exeter, RI
3 Queen River, Brownell Site, Exeter, RI
4 Queen River, Mail Rd, Exeter, RI
5 Fisherville Brook, Wm. Henry Road, Exeter, RI
6 Falls River, near Austin Farm Road, Exeter, RI
7 Falls River, near Falls River Road, Exeter, RI
8 Beaver River, Beaver River Road, Richmond, RI
9 Beaver River, Punch Bowl Trail, Richmond, RI
10 Breakheart Brk, Frosty Hollow Rd, W. Greenwich RI
11 Breakheart Brk, Frosty Hollow Pond, W. Greenwich, RI
12 Moscow Brook, Saw Mill Road, Hopkinton, RI
13 Canonchet Brook, Palmer prop., Hopkinton, RI
14 Canochet Brk, Canochet Brk Road, Hopkinton, RI
15 Meadow Brk, Pine Hill Rd, Richmond, RI
16 Meadow Brk, Switch Rd, Richmond, RI
17 Blitzkreig Brk, Blitzkreig Rd, Hopkinton, RI
18 Sherman Brk, Dugway Bridge Rd, Exeter, RI
19 Queen River, Stony Lane, Exeter, RI
20 Tomaquag Brk, Collins Rd, Hopkinton, RI
21 Acid Factory Brk, Eisenhower Lake, W. Greenwich, RI
22 Acid Factory Brk, below Butler Pond dam, Plain Mtg. House Rd, W. Greenwich, RI
23 Acid Factory Brk, above dam, Plain Mtg. House Rd, W. Greenwich, RI
24 Roaring Brk, Summit Rd, W. Greenwich, RI
25 Cedar Swamp Brk, Kings Factory Rd, Charlestown, RI
26 Roaring Brk, Arcadia Rd, Exeter, RI
27 Perry Healy Brk, Klondike Rd, Charlestown, RI
28 Kelly Brk, Falls River Rd, W. Greenwich, RI
29 Glen Rock Brk, Glen Rock Rd, Exeter, RI
30 Chickasheen Brk, Miskanani Rd, S. Kingston, RI
31 Assekonk Brk, Rt. 2, N. Stonington, CT

TABLE 2A

```
Step # 0 R =  0.668 R-Square =  0.446

Effect            Coefficient   Std Error  Std Coef    Tol.  df       F     'P'

In
___
  1 Constant
  2 DEPTH               -0.342       0.205    -0.268 0.93706   1   2.786   0.109
  3 VEL                  0.432       0.468     0.179 0.63933   1   0.855   0.365
  4 SHELTER             -0.018       0.533    -0.006 0.88079   1   0.001   0.973
  5 CANOPY               0.163       0.307     0.092 0.79992   1   0.280   0.602
  6 COBGRAV              0.283       0.587     0.158 0.22491   1   0.232   0.635
  7 SANDSILT            -0.002       0.467    -0.001 0.19137   1   0.000   0.997
  8 DAMPROX             40.984      13.937     0.486 0.88328   1   8.648   0.007

Out               Part. Corr.   none
___
-------------------------------------------------------------------------------



Dependent Variable BRTROUT
Minimum tolerance for entry into model = 0.010000
Backward stepwise with Alpha-to-Enter=0.150 and Alpha-to-Remove=0.150

Step # 1 R =  0.668 R-Square =  0.446
Term removed: SANDSILT

Effect            Coefficient   Std Error  Std Coef    Tol.  df       F     'P'

In
___
  1 Constant
  2 DEPTH               -0.342       0.200    -0.268 0.94173   1   2.921   0.100
  3 VEL                  0.433       0.436     0.180 0.70453   1   0.986   0.331
  4 SHELTER             -0.019       0.503    -0.006 0.94869   1   0.001   0.971
  5 CANOPY               0.163       0.293     0.092 0.84284   1   0.309   0.584
  6 COBGRAV              0.285       0.303     0.159 0.81174   1   0.885   0.356
  8 DAMPROX             40.988      13.593     0.486 0.88983   1   9.093   0.006

Out               Part. Corr.
___
  7 SANDSILT            -0.001        .         .    0.19137   1   0.000   0.997
-------------------------------------------------------------------------------
```

TABLE 2B

Step # 2 R = 0.668 R-Square = 0.446
Term removed: SHELTER

Effect	Coefficient	Std Error	Std Coef	Tol.	df	F	'P'
In							
1 Constant							
2 DEPTH	-0.342	0.196	-0.267	0.94685	1	3.049	0.093
3 VEL	0.435	0.422	0.181	0.72145	1	1.064	0.312
5 CANOPY	0.161	0.284	0.091	0.86208	1	0.322	0.575
6 COBGRAV	0.285	0.296	0.159	0.81223	1	0.924	0.346
8 DAMPROX	40.937	13.250	0.485	0.89901	1	9.545	0.005
Out	Part. Corr.						
4 SHELTER	-0.008	.	.	0.94869	1	0.001	0.971
7 SANDSILT	-0.003	.	.	0.20613	1	0.000	0.989

Step # 3 R = 0.663 R-Square = 0.439
Term removed: CANOPY

Effect	Coefficient	Std Error	Std Coef	Tol.	df	F	'P'
In							
1 Constant							
2 DEPTH	-0.354	0.192	-0.277	0.95918	1	3.410	0.076
3 VEL	0.505	0.399	0.210	0.78768	1	1.603	0.217
6 COBGRAV	0.264	0.290	0.147	0.82504	1	0.827	0.371
8 DAMPROX	39.110	12.685	0.463	0.95536	1	9.506	0.005
Out	Part. Corr.						
4 SHELTER	0.009	.	.	0.97034	1	0.002	0.963
5 CANOPY	0.113	.	.	0.86208	1	0.322	0.575
7 SANDSILT	-0.023	.	.	0.21321	1	0.014	0.908

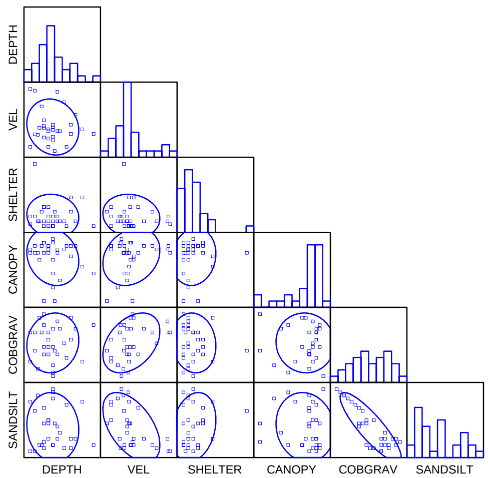
Step # 4 R = 0.649 R-Square = 0.421
Term removed: COBGRAV

Effect	Coefficient	Std Error	Std Coef	Tol.	df	F	'P'
In							
1 Constant							
2 DEPTH	-0.327	0.189	-0.256	0.98334	1	2.996	0.095
3 VEL	0.651	0.364	0.270	0.94029	1	3.202	0.085
8 DAMPROX	39.028	12.644	0.462	0.95540	1	9.527	0.005
Out	Part. Corr.						
4 SHELTER	0.002	.	.	0.97215	1	0.000	0.993
5 CANOPY	0.088	.	.	0.87567	1	0.205	0.655
6 COBGRAV	0.176	.	.	0.82504	1	0.827	0.371
7 SANDSILT	-0.159	.	.	0.71001	1	0.678	0.418

TABLE 3A

Pearson correlation matrix

	DEPTH	VEL	SHELTER	CANOPY	COBGRAV	SANDSILT
DEPTH	1.000					
VEL	-0.126	1.000				
SHELTER	-0.079	-0.121	1.000			
CANOPY	-0.161	0.230	0.111	1.000		
COBGRAV	0.093	0.393	-0.100	-0.033	1.000	
SANDSILT	-0.076	-0.519	0.212	-0.097	-0.865	1.000



Number of observations: 31

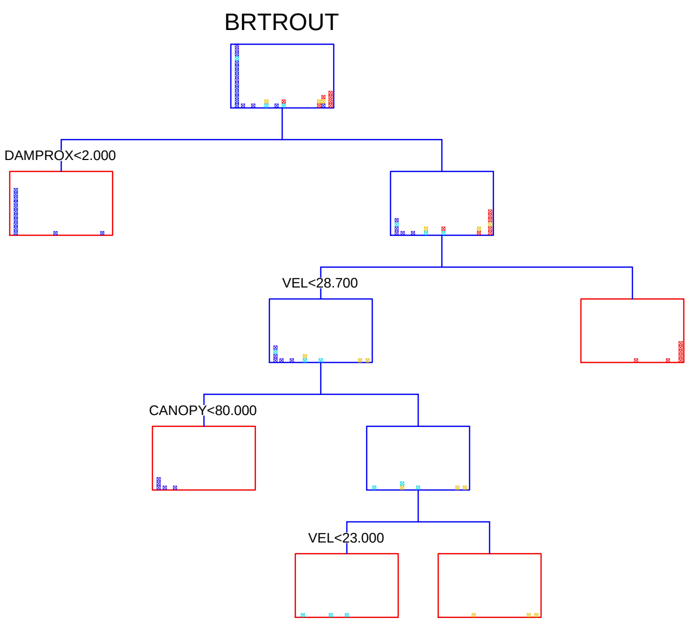
TABLE 3B

WPWA DATA

Split	Variable	PRE	Improvement
1	DAMPROX	0.269	0.269
2	VEL	0.558	0.290
3	CANOPY	0.661	0.103
4	VEL	0.721	0.060

Fitting Method: Least Squares
Predicted variable: BRTROUT
Minimum split index value: 0.050
Minimum improvement in PRE: 0.050
Maximum number of nodes allowed: 22
Minimum count allowed in each node: 3
The final tree contains 5 terminal nodes
Proportional reduction in error: 0.721

Node	from	Count	Mean	SD	Split Var	Cut Value	Fit
1	0	31	36.484	42.343	DAMPROX	2.000	0.269
2	1	13	11.077	27.681			
3	1	18	54.833	42.107	VEL	28.700	0.517
4	3	11	31.364	35.750	CANOPY	80.000	0.433
5	3	7	91.714	17.221			
6	4	5	6.800	7.396			
7	4	6	51.833	37.499	VEL	23.000	0.458
8	7	3	28.667	23.798			
9	7	3	75.000	36.592			



31 cases and 9 variables processed and saved.

TABLE 4A												
	VOLUME	**DISCHARGE**	**WIDTH**	**DEPTH**	**DOM SUB**	**TYPE3SUB**	**EMBED3**	**CANOPY**	**INSTREAMSH**	**ALKALINITY**	**POOLRIF**	**POPSIZE**
1	0.073	0.016	3.87	17.38	1	16	39	30	18.9	7.7	6.14	0.43
2	0.184	0.282	8.66	17.75	3	76	24.91	54	193.4	8.6	2.52	0.06
3	0.1169	0.333	6.75	29.08	4	46	40.69	74	175.6	10.5	29	0.075
4	0.244	0.258	8.53	17.38	4	34	38.46	79	163.1	17	1.52	0.029
5	0.074	0.282	4.31	9.7	4	19	27.14	93	20.3	11.5	2	0
6	0.029	0.0635	4.75	24.75	3	47	35.79	83	181.7	19.2	5.3	0.076
7	0.073	0.135	3.34	5.45	3	75	8.81	83	0.3	17.2	0.56	0.062
8	0.025	0.013	4.27	12.55	4	25	23.33	98	85.3	15.2	4	0.307
9	0.126	0.075	5.84	12.55	3	51	12.88	72	139.4	17.7	0.97	0.017
10	0.15	0.1988	6.46	13.9	4	45	21.54	86	10.1	7.6	0.69	0.207
11	0.1667	0.518	2.85	10.88	3	45	50.5	63	45.2	13.2	0.9	0.738
12	0.028	0.038	5.53	14.1	4	28	30.77	94	19.3	13.6	2.75	0.116
13	0.153	0.794	4.15	13.43	4	0	30.77	100	13.2	11.5	4.41	0.145
14	0.124	0.15	1.73	6.85	4	0	30.77	86	1.7	17	1.22	0.388
15	0.048	0.087	4.39	15.3	1	13	70	22	97.4	18	4.17	0
16	0.041	0.065	2.27	6.55	4	35	21.67	89	0.3	7.1	4.56	0
17	0.097	0.638	3.23	20.33	6	3	50	93	50.5	25.9	2.05	0
18	0.122	0.373	3.94	7.8	3	79	8.08	71	8.8	19.5	0.85	0.178
19	0.03	0.012	5.63	22.02	4	16	45	90	45	30.3	11.86	0
20	0.054	0.0636	7.03	27.9	4	3	2.5	75	148	18	1.88	0
21	0.075	0.463	7.06	8.27	4	13	38.75	96	10.6	27.9	2.08	0
22	0.1154	0.677	5.09	11.6	4	5	20	71	31.8	18	1.37	0
23	0.074	0.425	7.94	9.38	3	31	37.37	95	34.2	19.2	2.61	0.042
24	0.159	1.923	5.77	21.33	4	4	15	96	50	18	1.24	0
25	0.1067	0.18	7.86	23.83	6	4	13.33	75	66.4	18	1.24	0
26	0.132	1.19	5.24	16.13	5	9	12.5	98	20.1	4	0.61	0.227
27	0.069	0.305	3.42	12.18	3	43	44.17	99	50	4.3	0.3	0.484
28	0.0636	0.0869	2.36	5.55	4	18	23.33	99	0.03	24.4	0.79	0.046
29	0.0705	0.0154	3.93	13.93	4	27	38.89	89	10.8	25.3	3.69	0.068
30	0.1	0.495	5.14	10.4	4	2	50	94	12.2	15.5	1.08	0.006
31	0.0845	0.684	8.69	9.7	4	19	24.67	92	51.7	26.1	1.21	0.01
32	0.052	0.689	6.38	18.65	1	0	24.67	100	123.2	42.9	2.13	0.003
33	0.1697	0.741	5.04	9.23	4	25	13.64	98	5.9	20.7	0.72	0
34	0.206	1.769	6.31	14.68	4	32	42.78	92	39.8	18	0.39	0.003
35	0.127	0.12	7.51	14.68	3	76	19.02	92	54.7	21.7	1.54	0.004
36	0.0748	0.1366	7.77	22.8	3	54	44.32	73	82.9	18	4.17	0.02
37	0.118	0.275	12.46	43.78	3	54	4.59	53	441.7	23.7	49	0
38	0.0259	0.107	13.08	20.8	4	9	80	89	114.1	18	11.38	0

39	0.0389	0.102	3.87	6.43	4	0	80	99	5.1	18	0.22	0.064
TABLE 4B												
	VOLUME	**DISCHARGE**	**WIDTH**	**DEPTH**	**DOM SUB**	**TYPE3SUB**	**EMBED3**	**CANOPY**	**INSTREAMSH**	**ALKALINITY**	**POOLRIF**	**POPSIZE**
40	0.0139	0.0103	5.19	15.38	1	16	38.57	75	44.3	18	8.12	0
41	0.0487	0.115	3.16	7.6	4	29	0	99	1.3	18	0.56	0
42	0.0119	0.0128	6.09	21.42	3	49	34.26	77	150.3	18	4.3	0.032
43	0.057	0.198	3.97	8.82	5	3	0	96	17.5	18	0.7	0.007
44	0.0273	0.011	5.55	24.48	4	37	66.67	90	162.9	18	5.52	0.005
45	0.091	0.253	2.5	11.43	4	6	10	76	15.6	29.5	1.81	0.417
46	0.0602	0.989	2.63	6.25	3	58	33.64	100	2.6	11.3	1.5	0.018
47	0.071	0.023	4.21	10.43	2	11	30	98	15.1	18	0.69	0.959
48	0.035	0.243	6.55	10.13	4	2	0	96	13	18	0.58	0.002
49	0.0153	0.0168	1.62	6.45	4	31	0	100	1.9	19.1	4.5	0.52
50	0.028	0.006	2.57	18.15	4	33	8.57	100	13.3	18	5.87	0.08
51	0.116	0.305	2.02	9.98	5	0	8.57	100	0.2	14.8	2.06	0.135
52	0.1251	0.097	1.45	5.1	2	20	50	96	0.7	21	1.08	0.88
53	0.141	0.285	1.72	11.32	3	83	24.5	85	2.3	12.7	0.19	0.019
54	0.036	0.057	3.15	5.18	4	4	0	90	3.6	21.3	0.67	0.99
55	0.0587	0.018	3.42	14.95	1	11	33.3	90	59.6	18.8	13.29	0.009
56	0.0357	0.012	1.03	2.95	1	0	33.33	96	15	18	0.22	0.67
57	0.1239	1.821	11.39	13.32	4	8	11.25	98	16.9	6.1	0.69	0.033
58	0.104	0.0771	6.03	6.77	2	12	56.67	77	3.5	27.3	10.54	0.33
59	0.0762	0.591	4.3	17.4	4	8	20	97	51.9	7.7	1.57	0.171
60	0.046	0.0079	2.78	14.9	4	4	50	83	25.1	22.8	6.38	0.43
61	0.105	0.114	5.76	2.35	3	38	12.75	74	29.5	7.9	0.99	0.175
62	0.008	0.0038	4.39	11.15	4	44	13.13	66	72.1	12.5	49	0.466
63	0.0556	0.124	2.5	9.4	4	0	25.71	97	1	16.4	0.61	0.946
64	0.0965	0.0361	3.39	9.2	4	20	33.3	79	14.9	15.1	1.88	0.431
65	0.1358	0.893	6.07	11.07	4	15	9.38	94	8.7	18	0.9	0.08
66	0.045	0.0055	2.55	4.47	4	38	17.5	33	0.2	22.9	0.47	0.154
67	0.0245	0.048	2.73	7.65	4	17	30	80	2.8	4.4	0.96	0.779
68	0.0109	0.0069	4.81	39.32	4	13	20	0	598.1	24.8	49	0.082
69	0.0954	0.2	2.43	8.65	4	28	16	40	4.3	7.8	0.85	0.005
70	0.161	0.0944	3.49	30.7	1	11	80	47	307.3	22.5	49	0.019
71	0.0284	0.061	3.3	6.95	4	11	16.67	91	0.9	3.6	0.28	0.282
72	0.04	0.072	1.6	10.38	4	0	16.67	86	0.7	10	49	0.227
73	0.0851	0.113	2.19	5.93	3	53	16.67	97	6.9	18	1.94	0.105
74	0.1351	1.375	6.36	16.3	4	0	16.67	52	107.8	35.5	1.59	0.022
75	0.043	0.02	4.79	19.33	3	38	38.75	77	87.6	18	12.5	0.179
76	0.127	0.049	3.67	20.7	2	13	52.5	92	38.8	19.4	10.67	0

77	0.013	0.034	2.69	9.32	3	32	85	100	11.9	9.3	11.5	0.004

TABLE 4C

	VOLUME	DISCHARGE	WIDTH	DEPTH	DOM SUB	TYPE3 SUB	EMBED3	CANOPY	INSTREAMSH	ALKA LINITY	POOL RIF	POPSIZE
78	0.0939	0.239	2.2	10.23	3	65	27.27	100	10.9	11.5	3.55	0.65
79	0.058	0.0169	4.49	28.58	1	22	61.25	96	230.5	5.2	29	0.573
80	0.054	0.195	3.82	8.8	4	3	20	100	0.9	9.9	0.95	0.381
81	0.048	0.036	2.23	2.3	5	5	0	95	40	16.7	0.45	0.979
82	0.0577	0.279	4.02	12.88	4	6	50	74	1.9	9.5	0.89	0.152
83	0.075	0.389	4.53	11.77	4	8	6.67	94	11.5	16	1.56	0.706
84	0.1431	0.731	3.16	16.65	3	56	69.64	95	10.2	13.7	4	0
85	0.0267	0.096	3.55	10.1	4	7	10	90	8.1	20.4	1.74	0.006
86	0.073	0.368	4.04	12.38	4	17	25	75	16.1	22.6	2.33	0.032
87	0.0305	0.06	1.77	10.55	1	0	25	34	18.4	23	49	0.067
88	0.0397	0.088	1.74	12.82	1	0	25	30	3.3	40.2	11.5	0
89	0.016	0.037	4.17	5.55	4	17	89.17	0	0	13.4	49	0
90	0.07	0.166	2.68	9.81	4	11	75	97	6.8	16.1	1.78	0.333
91	0.096	0.263	3.14	8.5	4	33	6.25	99	1.7	25	1.08	0.117
92	0.17	0.55	3.06	9.43	4	40	17	90	3.7	18	0.43	0.004
93	0.028	0.066	1.89	12.23	1	8	10	100	3.3	23.2	24	0.5
94	0.2498	0.483	3.17	6.32	4	48	12.31	94	5	22.1	0.39	0
95	0.01	0.002	2.69	9.36	3	58	11.82	60	6.9	12.8	1.86	0.225
96	0.215	0.046	0.65	3.33	1	10	80	74	0	35.4	0.09	0
97	0.136	0.276	2.85	7.55	4	5	100	94	8.5	19.9	0.31	0
98	0.146	0.554	2.89	13.48	3	43	60	96	4.9	18	1.4	0.127
99	0.0908	0.17	2.55	7.25	4	14	0	100	0.6	26.3	0.47	0.003
100	0.0697	1.103	12.14	13.35	5	1	0	88	50.8	8.3	0.2	0.02
101	0.0887	0.476	4.34	8.15	7	0	0	100	4.8	10.4	0.36	0
102	0.02	0.014	1.3	5.6	4	0	0	100	0.5	10.4	0.67	0.514
103	0.0638	0.037	0.81	6.57	1	0	40	100	0.4	8.7	2.92	0.667
104	0.082	0.29	2.14	14.45	2	27	27.5	79	8	14.7	0.74	0.578
105	0.089	0.079	1.85	4.78	3	79	4.55	0	18	2	0.16	0.303
106	0.0335	0.035	0.87	10.93	1	0	50	0	7.921	21.1	5.71	0.106
107	0.018	0.0026	1.19	6.5	2	20	10	100	0.2	7.3	1.94	0.923
108	0.0847	0.104	1.18	10.25	3	70	12.86	57	7.9	22.7	1.16	0.936
109	0.0645	0.044	1.4	4.58	4	0	12.86	100	0.7	10.5	0.25	1
110	0.05	0.118	2.68	9.32	4	5	50	97	0.7	0.8	0.62	1
111	0.0625	0.062	1.6	4.97	4	18	35	68	1.2	44.5	1.08	0.026
112	0.0288	0.0247	4.87	17.92	3	41	50.83	94	57.2	21	5.19	0.392
113	0.1495	0.216	2.46	5.8	3	67	50	97	0.09	11.1	0.22	0.778
114	0.083	0.095	1.78	6.45	1	15	10	100	0.8	20.8	1.38	0.003

115	0.085	0.069	1.44	5.7	4	20	30	36	1.8	23.4	1.5	0.29
116	0.381	0.014	3.44	12.77	7	13	25	30	39.4	18	2.74	0.014

TABLE 5A

Dep Var: POPSIZE   N: 116   Multiple R: 0.584   Squared multiple R: 0.342

Adjusted squared multiple R: 0.272   Standard error of estimate: 0.255

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	0.749	0.160	0.000	.	4.668	0.000
VOLUME	-0.181	0.481	-0.036	0.704	-0.375	0.708
DISCHARGE	-0.112	0.081	-0.141	0.615	-1.388	0.168
WIDTH	-0.037	0.013	-0.301	0.555	-2.813	0.006
DEPTH	-0.010	0.006	-0.229	0.274	-1.505	0.135
DOMSUB	-0.037	0.022	-0.152	0.765	-1.671	0.098
TYPE3SUB	-0.002	0.001	-0.130	0.829	-1.482	0.141
EMBED3	-0.001	0.001	-0.105	0.846	-1.210	0.229
CANOPY	0.002	0.001	0.171	0.755	1.871	0.064
INSTREAMSH	0.001	0.001	0.267	0.257	1.703	0.092
ALKALINITY	-0.012	0.003	-0.312	0.900	-3.722	0.000
POOLRIF	-0.002	0.003	-0.084	0.567	-0.793	0.429

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	3.497	11	0.318	4.904	0.000
Residual	6.741	104	0.065		

*** WARNING ***

Case	37 has large leverage	(Leverage =	0.293)
Case	68 has large leverage	(Leverage =	0.575)
Case	89 has large leverage	(Leverage =	0.377)
Case	116 has large leverage	(Leverage =	0.431)

Durbin-Watson D Statistic 1.986
First Order Autocorrelation 0.006

Step # 0 R = 0.584   R-Square = 0.342

Effect	Coefficient	Std Error	Std Coef	Tol	df	F	'P'
In							
1 CONSTANT							
2 POOLRIF	-0.002	0.003	-0.084	0.567	1	0.629	0.429
3 ALKALINITY	-0.012	0.003	-0.312	0.900	1	13.853	0.000
4 INSTREAMSH	0.001	0.001	0.267	0.257	1	2.899	0.092
5 CANOPY	0.002	0.001	0.171	0.755	1	3.500	0.064
6 EMBED3	-0.001	0.001	-0.105	0.846	1	1.464	0.229
7 TYPE3SUB	-0.002	0.001	-0.130	0.829	1	2.198	0.141
8 DOMSUB	-0.037	0.022	-0.152	0.765	1	2.792	0.098
9 DEPTH	-0.010	0.006	-0.229	0.274	1	2.266	0.135
10 WIDTH	-0.037	0.013	-0.301	0.555	1	7.914	0.006
11 DISCHARGE	-0.112	0.081	-0.141	0.615	1	1.926	0.168
12 VOLUME	-0.181	0.481	-0.036	0.704	1	0.141	0.708

Out   Part. Corr.   none

TABLE 5B

Dependent Variable POPSIZE
Minimum tolerance for entry into model = 0.010000
Backward stepwise with Alpha-to-Enter=0.150 and Alpha-to-Remove=0.150

Step # 1 R = 0.584 R-Square = 0.341
Term removed: VOLUME

Effect	Coefficient	Std Error	Std Coef	Tol	df	F	'P'
In							
1 CONSTANT							
2 POOLRIF	-0.002	0.003	-0.077	0.582	1	0.556	0.458
3 ALKALINITY	-0.012	0.003	-0.316	0.913	1	14.500	0.000
4 INSTREAMSH	0.001	0.001	0.262	0.259	1	2.832	0.095
5 CANOPY	0.002	0.001	0.176	0.768	1	3.778	0.055
6 EMBED3	-0.001	0.001	-0.111	0.876	1	1.710	0.194
7 TYPE3SUB	-0.002	0.001	-0.138	0.887	1	2.688	0.104
8 DOMSUB	-0.038	0.021	-0.159	0.793	1	3.178	0.078
9 DEPTH	-0.009	0.006	-0.227	0.274	1	2.246	0.137
10 WIDTH	-0.036	0.013	-0.297	0.560	1	7.850	0.006
11 DISCHARGE	-0.125	0.073	-0.157	0.744	1	1.908	0.091
Out	Part. Corr.						
12 VOLUME	-0.037			0.704	1	0.141	0.708

Step # 2 R = 0.581 R-Square = 0.337
Term removed: POOLRIF

Effect	Coefficient	Std Error	Std Coef	Tol	df	F	'P'
In							
1 CONSTANT							
3 ALKALINITY	-0.012	0.003	-0.310	0.922	1	14.137	0.000
4 INSTREAMSH	0.001	0.001	0.233	0.276	1	2.400	0.124
5 CANOPY	0.002	0.001	0.193	0.818	1	4.854	0.030
6 EMBED3	-0.002	0.001	-0.114	0.879	1	1.830	0.179
7 TYPE3SUB	-0.002	0.001	-0.127	0.916	1	2.357	0.128
8 DOMSUB	-0.036	0.021	-0.150	0.805	1	2.917	0.091
9 DEPTH	-0.010	0.006	-0.241	0.278	1	2.581	0.111
10 WIDTH	-0.035	0.013	-0.290	0.564	1	7.569	0.007
11 DISCHARGE	-0.118	0.072	-0.149	0.755	1	2.664	0.106
Out	Part. Corr.						
2 POOLRIF	-0.073	0.003	-0.077	0.582	1	0.556	0.458
12 VOLUME	-0.024			0.704	1	0.063	0.802

Step # 3 R = 0.571 R-Square = 0.326
Term removed: EMBED3

Effect	Coefficient	Std Error	Std Coef	Tol	df	F	'P'
In							
1 CONSTANT							
3 ALKALINITY	-0.012	0.003	-0.307	0.922	1	13.826	0.000
4 INSTREAMSH	0.001	0.001	0.257	0.280	1	2.935	0.090
5 CANOPY	0.002	0.001	0.200	0.821	1	5.190	0.025
7 TYPE3SUB	-0.002	0.001	-0.116	0.924	1	1.987	0.162
8 DOMSUB	-0.029	0.021	-0.120	0.862	1	1.966	0.164
9 DEPTH	-0.011	0.006	-0.274	0.286	1	3.417	0.067
10 WIDTH	-0.036	0.013	-0.292	0.564	1	7.642	0.007
11 DISCHARGE	-0.110	0.072	-0.138	0.761	1	2.293	0.133
Out	Part. Corr.						
2 POOLRIF	-0.079			0.582	1	0.664	0.417
6 EMBED3	-0.130			0.879	1	1.830	0.179
12 VOLUME	-0.047			0.704	1	0.232	0.631

TABLE 5C

Step # 4 R = 0.560 R-Square = 0.313
Term removed: DOMSUB

Effect	Coefficient	Std Error	Std Coef	Tol	df	F	'P'
In							
1 CONSTANT							
3 ALKALINITY	-0.011	0.003	-0.291	0.942	1	12.510	0.000
4 INSTREAMSH	0.001	0.001	0.261	0.280	1	3.007	0.086
5 CANOPY	0.002	0.001	0.191	0.825	1	4.724	0.032
7 TYPE3SUB	-0.001	0.001	-0.102	0.939	1	1.524	0.220
9 DEPTH	-0.011	0.006	-0.259	0.288	1	3.045	0.084
10 WIDTH	-0.039	0.013	-0.321	0.587	1	9.542	0.003
11 DISCHARGE	-0.122	0.072	-0.153	0.771	1	2.835	0.095
Out	Part. Corr.						
2 POOLRIF	-0.059			0.595	1	0.368	0.545
6 EMBED3	-0.090			0.941	1	1.879	0.351
8 DOMSUB	-0.134			0.862	1	1.966	0.164
12 VOLUME	-0.068			0.767	1	0.501	0.481

Step # 5 R = 0.551 R-Square = 0.304
Term removed: TYPE3SUB

Effect	Coefficient	Std Error	Std Coef	Tol	df	F	'P'
'P'							
In							
1 CONSTANT							
3 ALKALINITY	-0.010	0.003	-0.272	0.976	1	11.270	0.001
4 INSTREAMSH	0.001	0.001	0.246	0.281	1	2.664	0.106
5 CANOPY	0.002	0.001	0.199	0.830	1	5.156	0.035
9 DEPTH	-0.010	0.006	-0.259	0.289	1	2.800	0.097
10 WIDTH	-0.040	0.013	-0.328	0.589	1	9.948	0.003
11 DISCHARGE	-0.122	0.072	-0.145	0.774	1	2.561	0.112
Out	Part. Corr.						
2 POOLRIF	-0.059			0.595	1	0.156	0.693
6 EMBED3	-0.090			0.941	1	0.742	0.391
7 TYPE3SUB	-0.001			0.939	1	1.524	0.220
8 DOMSUB	-0.134			0.862	1	1.503	0.223
12 VOLUME	-0.068			0.767	1	0.972	0.326

TABLE 6

CTDEP DATA

Split	Variable	PRE	Improvement
1	WIDTH	0.181	0.181
2	ALKALINITY	0.254	0.073
3	POOLRIF	0.358	0.104
4	CANOPY	0.431	0.073

Fitting Method: Least Squares
Predicted variable: POPSIZE
Minimum split index value: 0.050
Minimum improvement in PRE: 0.050
Maximum number of nodes allowed: 22
Minimum count allowed in each node: 5
The final tree contains 5 terminal nodes
Proportional reduction in error: 0.431

Node	from	Count	Mean	SD	Split Var	Cut Value	Fit
1	0	116	0.223	0.298	WIDTH	3.1600	0.181
2	1	47	0.276	0.358	ALKALINITY	22.900	0.128
3	1	69	0.119	0.192	POOLRIF	1.220	0.220
4	2	36	0.446	0.371	CANOPY	95.000	0.298
5	2	11	0.147	0.177			
6	4	18	0.618	0.384			
7	4	18	0.275	0.271			
8	6	10	0.435	0.414			
9	6	8	0.846	0.17			

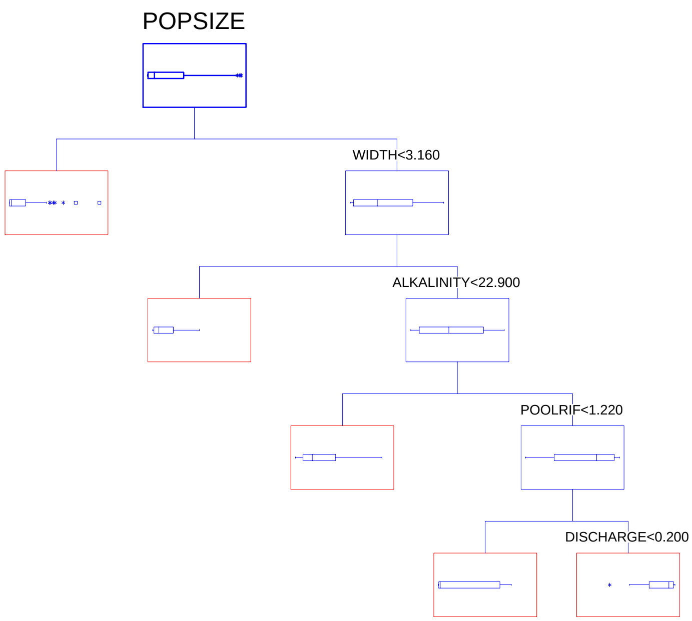


TABLE 7

Wood-Pawcatuck Watershed Association

Fish Assemblage Chart

2002

Date Sampled		*7/9/02*	*7/29/02*	*8/2/02*	*8/2/02*	*8/5/02*	*8/6/02*	*8/21/02*	*8/21/02*	*8/28/02*	*8/28/02*	*9/5/02*	*9/5/02*	*9/20/02*	*9/20/02*	*10/01/02*	*10/09/02*			
Common Name(s)	**Species**	**Queen River, Wm. Reynold Rd.**	**Fisher-ville Brook**	**Queen River, Mail Rd.**	**Locke Brook**	**Falls River (lower)**	**Falls River (upper)**	**Beaver River, play-ground)**	**Beaver River, Punch Bowl Tr.**	**Break-heart Brk, Frosty Hollow Pond**	**Break-heart Brook, foot-bridge**	**Moscow Brook**	**Brushy Brook, Saw Mill Rd.**	**Canonchet Brook, Palmer Property**	**Canonchet Brook, below golf course**	**Meadow Brook, Switch Rd.**	**Meadow Brook, Pine Hill Rd.**	**Total**	***Macro-Habitat***	***Pollution Tolerance***
American Eel (3)	*Anguilla rostrata*	2	4	4		1	1	3	4					5	2		1	**27**	*MG*	*T*
Atlantic Salmon (2)	*Salmo salar*		3		29	1				6								**39**	*FS*	*I*
Banded Sunfish (**)	*Enneacanthus obesus*															1		**1**	*MG*	*M*
Blacknose Dace(**)	*Rhinichthys atratulus*					1	1			3				1				**6**	*FS*	*I*
Bluegill (4)	*Lepomis macrochirus*											4						**4**	*MG*	*I*
Brook Trout (5)	*Salvelinus fontinalis*		4	7	7	1	1	5	17		35		24	1	1	1	4	**108**	*FS*	*I*
Brown Bullhead/ Catfish (**)	*Ameiuras nebulosus*											7	1			22		**30**	*MG*	*T*
Brown Trout (4)	*Salmo trutta*							1										**1**	*FD*	*M*
Common Shiner (**)	*Luxilus cornutus*	29												5	15			**49**	*MG*	*T*
Fallfish (**)	*Semotilus corporalis*													29	2			**31**	*FS*	*M*
Golden Shiner (**)	*Notemigonus crysoleucas*															3		**3**	*MG*	*T*
Largemouth Bass (4)	*Micropterus salmoides*											2		1		1		**4**	*MG*	*M*
Pumpkinseed/ Common Sunfish (**)	*Lepomis gibbosus*															7		**7**	*MG*	*M*
Redfin Pickerel/Grass Pickerel (**)	*Esox americanus*		1	3					1					8	8	1	3	**25**	*MG*	*M*
Tesselated Darter (**)	*Etheostoma olmstedi*					1		1						15	40	1	3	**61**	*FS*	*I*
White / Common Sucker (**)	*Catostomus commersoni*	2		2	1	6	12	3	2	18				22	5		2	**75**	*FD*	*T*
	Total	**33**	**12**	**16**	**37**	**11**	**15**	**13**	**24**	**27**	**35**	**13**	**25**	**87**	**73**	**37**	**13**	**471**		

(**) ***native primary freshwater species;*** **(2)** ***anadromous;*** **(3)** ***catadromous;*** **(4)** ***introduced;***
(5) ***primarily resident, but also has anadromous populations***

Macrohabitat*: FD= Fluvial Dependant; FS= Fluvial Specialist; MG= Microhabitat Generalist*
Pollution Tolerance: ***I= Intolerant; M= Intermediate; T= Tolerant***

TABLE 8

Wood-Pawcatuck Watershed Association
Fish Assemblage Study
2003

Date Sampled		***7/1/03***	***7/7/03***	***7/10/03***	***7/15/03***	***7/16/03***	***7/23/03***	***7/30/03***	***8/5/03***	***8/6/03***	***8/12/03***	***8/13/03***	***8/20/03***	***8/27/03***	***9/9/03***			
Common Name	**Species**	**Sherman Brook**	**Queen River, Stoney Lane**	**Tomaquag Brook, Collins Rd.**	**Acid Factory (Below Eisenhower Dam)**	**Acid Factory (Below Butler Pond)**	**Roaring Brook, Arcadia Hatchery**	**Cedar Swamp Brook (Old Mill Rd.)**	**Roaring Brook (Above pond)**	**Perry Healy Brook**	**Parris Brook**	**Kelley Brook, Falls River Rd.**	**Glen Rock Brook**	**Chicka-sheen Brook**	**Assekonk Brook, Rt. 2**	**Total**	***Macro-Habitat***	***Pollution Tolerance***
American Eel (3)	*Anguilla rostrata*			2	11					2		2			2	**19**	*MG*	*T*
Atlantic Salmon (2)	*Salmo salar*											1				**1**	*FS*	*I*
Longnose/Black-nose Dace(**)	*Rhinichthys atratulus*				50		1					9			1	**61**	*FS*	*I*
Bluegill (4)	*Lepomis macrochirus*			6	6		5	8		2				1	2	**30**	*MG*	*T*
Brook Trout (5)	*Salvelinus fontinalis*	18	9						48	7	2	14	57			**155**	*FS*	*I*
Brown Bullhead/ Catfish (**)	*Ameiuras nebulosus*													6		**6**	*MG*	*T*
Common Shiner (**)	*Luxilus cornutus*						1									**1**	*MG*	*T*
Fallfish (**)	*Semotilus corporalis*										2					**2**	*FS*	*M*
Golden Shiner (**)	*Notemigonus crysoleucas*			3			1								1	**5**	*MG*	*T*
Largemouth Bass (4)	*Micropterus salmoides*							3			1					**4**	*MG*	*M*
Pumpkinseed/ Common Sunfish (**)	*Lepomis gibbosus*			3	4	6	20								7	**40**	*MG*	*M*
Chain Pickerel/Grass Pickerel (**)	*Esox americanus*			1		3		2		1	2			3	8	**20**	*MG*	*M*
Tesselated Darter (**)	*Etheostoma olmstedi*				1					2	2				1	**6**	*FS*	*I*
Common Sucker (**)	*Catostomus commersoni*														1	**1**	*FD*	*T*
	Total	**18**	**9**	**15**	**72**	**9**	**28**	**13**	**48**	**14**	**9**	**26**	**57**	**10**	**23**	**351**		

(**) ***native primary freshwater species;*** **(2)** ***anadromous;*** **(3)** ***catadromous;*** **(4)** ***introduced;***
(5) ***primarily resident, but also has anadromous populations***

Macrohabitat***: FD= Fluvial Dependant; FS= Fluvial Specialist; MG= Microhabitat Generalist***

Pollution Tolerance***: I= Intolerant; M= Intermediate; T= Tolerant***