2006 Preseason Stocked Trout Residency Study

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Executive Summary

General Statewide Observations

- A total of 135 stream sections less than 15 meters wide were electrofished in spring, 2006, at randomly selected stocking points ten to twenty days after stocking to determine the percentages of trout remaining within approximately 300 meters of the stocking points

- Trout recaptures were adjusted upward for measured capture efficiency (67.19%) to provide an estimate of the trout remaining at each sampling point expressed as a percentage of the total stocked at each location.

- Trout recaptures were significantly and positively correlated with the survey crews' confidence ratings that they were electrofishing where the trout had actually been stocked. More trout were recaptured at those sites with higher confidence ratings.

- A total of 259 sample sites were included in the analysis. They were classified into excellent (>90%), good (75%-89.9%), fair (40%-74.9%), poor (10%-39.9%) and very poor (<9.9%) adjusted recapture rates. There was no discernable pattern of trout recaptures (as rated) statewide. Excellent to very poor sites occurred throughout the state with a few exceptions. No samples were collected in sub-basins 14 and 15, the Genesee River and Lake Erie drainages.

- Seventy-two percent of the sites sampled had fair or better recaptures of stocked trout. Twenty-eight percent of the sites sampled had poor or very poor recaptures of stocked trout.

- There were no occurrences of very poor recaptures in sub-basins 2, 5, 6, 7, 11, 13, and 20.

- Sub-basins 8 and 9 in the middle and upper West Branch Susquehanna Basin appeared to be regions of fair to very poor trout residency rates. Out of 8 sample sites in sub-basin 8, two had a fair (40-75%) recaptures; the rest were below the 40% recapture rate. While 3 of the 9 sites in sub-basin 9 were excellent (>90%), two sites had fair (40-75%) recaptures, and the rest were poor to very poor (<40%). This could have been the result of infertile waters and the sub-basins' known vulnerability to acid precipitation as pH was observed to be one factor affecting residency, although the relationship was weak. Sampling during peak flow events between the time of stocking and sampling would be helpful in investigating this relationship further.

- A portion of sub-basin 4 in the upper "North Branch" Susquehanna Basin also had localized poor and very poor trout recaptures.

- Elapsed time within the ten to 20 day post-stocking period did not have any impact on trout residency. Whatever residency problems occurred in 2006 occurred within the first nine days after stocking. Some aspects of future research may need to focus on residency changes that occur during the first nine days post-stocking.

Habitat and Chemical Analysis

- Stream width, epifaunal substrate (high gradient streams only), and bank stability (high gradient only) illustrated significant differences (Kruskal-Wallis k-sample test) in percent recaptured trout among rating categories.

- There was a trend toward higher recaptures of trout occurring in waters with higher scores for epifaunal substrate – fallen logs, undercut banks, logs, and boulders. Epifaunal substrate is a measure of trout habitat, but appeared to be too generalized as a community measure to provide strong correlations with adult stocked trout recapture rates. Epifaunal substrate accounted for the most variation (only 5.5%) in trout recaptures of any variable measured.

- Generally, higher trout recaptures occurred when the bank was moderately stable to stable; that is, there were infrequent, small areas of erosion, no erosion, and there were possible undercut banks. Lowest trout recaptures occurred under poor bank conditions (e.g., unstable; raw and eroded). Bank stability was also a potential measure of overhanging vegetation that may have been acting as a stabilizer and as overhead cover.

- Stream pH, epifaunal substrate (high gradient streams only), velocity/depth regime (high gradient only), bank stability (high gradient only), vegetation protection (high gradient only), sediment deposition (low gradient only), and channel flow status (low gradient streams only) were significantly correlated (Spearman's rank correlation) to adjusted trout recapture rates. All significant variables were positively correlated with recaptured trout such that more trout were recaptured for larger values of a variable, but other than epifaunal substrate they contributed little (less than epifaunal substrate's 5.5%) to the variation in trout recaptures.

- Principal Components Analysis (PCA), inclusively of only high gradient sample sites, did not suggest any of the measured habitat/chemical gradients potentially influenced trout emigration. There were no discernable patterns of trout recaptures (ratings) plotted on the principal components.

Hatchery

- No significant difference was found between trout recaptures and either hauling time, the number of stops, or tank densities.

- Differences in water temperature, pH, specific conductance, and total alkalinity between hatcheries, truck tanks, streams on the days of stockings, and sample sites on the days of electrofishing were not significantly related to trout recapture numbers. The relationship(s) between trout recaptures and any hatchery influences were removed by 10-20 days during which environmental influences possibly became more of an influence on trout residency than residual hatchery influences.

- There were several sources of variability that potentially influenced any and all significant statistical tests. These included but were not limited to the quality of the initial stocked trout counts, the generalization of trout into a collective group rather than separating them by species, liberal inclusion of sampling sites, possible differences between electrofishing crews' efficacies, and fish length differences between brood and smaller trout.

Recommendations

- The PFBC through research and stocking program management, should continue to search for ways to improve the percentage of trout that remain in streams from the stocking date until the opening day of trout season.

- The PFBC Commissioners and administration should determine what is the economically and socially minimal acceptable percentage of preseason-stocked trout that remain in individual stocked stream sections by opening day of trout season. The Division of Fisheries Management should evaluate the relationship between residency and angler use/economic value to inform this policy decision.

- To achieve the goal of examining the performance of trout residency at stocking locations on a statewide level, future sampling should include streams (<15 m) that were not sampled in 2006 preseason stocking with the intent of eventually sampling all sections less than 15 m wide. Such evaluations should be standard practice when new stream sections are added to the catchable hatchery trout stocking program.

- Those stream sections (14) that were listed as very poor and/or poor with respect to trout recaptures in the 2006 analysis should be resampled in spring 2007 for confirmation that those waters are indeed poor/very poor performers. After two years of preseason sampling, those sections in which sampling site recapture rates remain poor/very poor should be either removed from the stocked trout program, stocked just before opening day, or relegated to the inseason only stocking program, provided that inseason angler usage justifies stocking.

- To better examine hatchery influences on trout residency, substantially more sample sites (minimally 5 sites per management area) should be electrofished within forty-eight hours of the stockings to minimize the time that trout are exposed to environmental influences of the sample sites.

- Reduce the controllable sources of variability. Accuracy and precision of species-specific stocking counts at individual stocking sites is critical. The traditional "bucket" count is known to have upwards of 15-20% variability, which is cumulative by the number of buckets planted at a site. Furthermore, more accurate counts would allow investigation into the residency of trout per species if perchance; different species are prone to immigration.

- Focus near-term trout residency evaluations on high gradient streams, which are much more numerous in the overall stocking program than low gradient streams.

- Habitat variables need further refinement toward a better classification of adult trout habitat preferences. Pool characteristics such as maximum pool depth, frequency of pools, and the length of the deepest portion of the pool need to be included as measured variables. The frequency of riffles and the length of riffles occupying the site length also need to be measured.

- The Rapid Bioassessment Protocols habitat variables need further refinement and/or deletion for use in classifying adult trout habitat. Those variables (epifaunal substrate, velocity regime, bank stability, and vegetation protection) that were of potential importance for trout residency at sample sites should be refined from a community generalization too a more specialized variable for scoring adult trout habitats. For example, the RBP variable epifaunal substrate should be broken into three separate variables – fallen logs/submerged logs, undercut banks, and boulder/cobble - that are scored on a 0-20 scale based on some measurable criteria.

- Some RBP variables (embeddedness, sediment deposition, channel flow status, channel alteration, riparian vegetation protection) that did not show any potential in explaining trout residency should be considered for exclusion in future sampling due to their lack of performance and their generalization of stream habitat for biotic community work.

- Some new, measurable variable(s) may need to be generated that allow(s) for the classification of overall adult trout habitat quality. This (these) may include a combination of physical and habitat variables. For example, one variable might be under cut banks that occur over deep pools of slow moving water in which well-established snags and submerged logs exist versus good under cut banks, submerged logs and pools but not occupying the same location within the site.

- Additional confidence evaluations may need to be included in future surveys that can provide a sampling crew's "gut" feeling (1-5; 5 best) for the sampling site with respect to the following: capture efficiency rating; overall trout habitat rating; and potential bird predation impacts.

- Future evaluations should include a comparison of trout residency within individual streams when trout are stocked directly into pools, directly into short riffles and runs, and directly into long stretches of riffles and runs. This refinement would require a sample frame of streams that generally have only one type of residency rating.

- The practicalities of continuing research into the trout residency problem with its multiple variables and possible multiple causes versus adapting to the problem as a program management concern should be evaluated. Consideration should be given to the possibility that it may be more cost-effective to determine which streams exhibit a residency problem and change their management than to determine the cause(s) of the problem. All above research recommendations should be evaluated in light of this issue.

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Introduction

In recent years concerns have arisen regarding adult stocked trout movement in some Pennsylvania streams between the time of preseason stocking and opening day. Research efforts conducted by the Pennsylvania Fish and Boat Commission's (PFBC's) Fisheries Management Division have confirmed the movement of stocked trout away from stocking points and sometimes out of stocked sections or entire streams. In 2003, a survey of preseason stocked trout in the East and West Branches of Dyberry Creek indicated that stocked trout had emigrated from initial stocking locations within two days of the stockings, which had occurred four days prior to opening day. Stocked trout had disappeared from most stocking points evaluated along the East Branch of Dyberry Creek and movement had occurred to a lesser extent in the West Branch of Dyberry Creek. There was no evidence of mortality.

In response to these concerns and observations, the Fisheries Management Area 4 staff conducted a more detailed stocked trout movement study in 2005 (Wnuk 2005). As part of this effort, a total of 4,600 trout were tagged with numbered floy tags prior to preseason stocking in early March on two northeastern Pennsylvania stream sections, Wysox Creek and the Tunkhannock Creek. In addition to the tags, radio transmitters were also placed in 25 trout to aid in tracking the movement of these fish after stocking. Radio telemetry indicated that most stocked rainbow trout moved away from stocking points within three days after stocking; most brown trout moved away within seven days; and most brook trout moved away within 10 days after stocking. Follow-up electrofishing work prior to opening day at five stocking points along each of the two stream sections captured only two stocked trout from each stream. Subsequently, an eight-week creel survey was conducted on one of the stream sections beginning with the opening day of regular trout season. The tagging study was well publicized, encouraging anglers to report tag returns from any of the tagged trout they caught. Despite the creel survey and substantial publicity, only six legitimate tag returns were reported from the total of 4,600 trout that had been stocked in these two waters.

Investigations of Pennsylvania's wild trout populations in streams illustrated the importance of the underlying geological formations within a stream's drainage in influencing species-specific trout residency. Kocovsky and Carline (2005) found that due to pH and slope gradients, wild brook trout predominated in higher elevation streams whereas wild brown trout resided in lower elevation streams. The authors noted that geological formations at the higher elevations tended to have limited or no buffering capacity due to the lack of calcareous materials, which often resulted in waters with pH values lower than brown trout preferred. Additionally, Kocovsky and Carline (2006) noted that streams with underlying Pottsville sandstone geology were the most problematic in retaining wild trout populations. This was due to the lack of buffering capacity from previous acidic episodes, the leaching of acidic materials, and the leaching of aluminum during precipitation events.

During 2005, Pennsylvania Fish and Boat Commission Waterways Conservation Officers were polled for lists of streams where they suspected similar problems with stocked trout movement were occurring between the times of preseason stocking and opening day. Based on their observations, trout residency problems were evident on a number of stocked trout streams in northeastern Pennsylvania. Problems were also noted from streams in other regions of the state, including agricultural Lancaster County, where habitat and heron predation were believed to be problems on some streams. In some cases, poor early season water quality in the forms of low pH and low total alkalinity appeared to be a factor contributing to the movement of stocked trout. On a number of waters, however, early season water quality did not appear to be a problem.

To determine the extent of this problem on a statewide basis the Fisheries Management Division initiated a pilot statewide survey of stocked trout streams prior to the beginning of the regular trout season in 2006. The principal objective of the survey was to determine the statewide frequency of stream sections less than 15 meters (49.5 ft.) in average width where preseason stocked trout residency was problematic. Secondary objectives included identifying potential physical, chemical, habitat, and or hatchery related influences on the residency of stocked trout at planting sites.

The pilot study investigated trout residency, not trout movement, at surveyed stocking locations. Residing stocked trout were defined as those trout stocked ten to twenty days earlier that were subsequently recaptured via electrofishing at preseason-planting sites. The study did not make any distinctions among origins of the stocked trout that were recaptured at a stocking location; the trout recaptured at a stocking location might have originated from stocking at that location or they might have immigrated from other stocking points along the stream. Inferences into trout migration habits were not an intended outcome of this pilot study.

Methods

Data Collection

Stocked trout were sampled throughout the state of Pennsylvania in all major river basins except the Genesee and Lake Erie drainages. The remaining four major river basins were sub-divided into 20 sub-basins and 101 sub-subbasins (Figure 1) from which stocked stream sections were randomly selected by fisheries management regions to be electrofished (Table 1). To provide broad coverage of waters, no more than three stream sections were sampled within a sub-subbasin and no more than one stocked section was sampled per stream. Sampling consisted of two randomly selected sampling sites examined per stream section. All sites were at point stop stocking locations. Only wadeable stream sections that averaged less than 15 meters (m) in mean width were studied (135 from a total of 824 statewide), due to anticipated depth and flow impacts on early spring electrofishing. Furthermore, stream segments that were float stocked or stocked with cooperative nursery trout prior to sampling were not included in the study.

Sampling by seven sampling crews statewide commenced on March 20 and continued through April 14, 2006, on stream sections that were stocked from 10 to 20 days in advance of the sampling. One stream was sampled nine days after stocking. Initially, 266 sampling sites were surveyed; however, due to obvious efficiency problems (e.g., water too deep for effective sampling), seven sampling sites were later excluded from all analyses based on the recommendations of sampling crews. The sites were on Hoffman Run, Canawacta Creek, East Branch Brandywine Creek, Ridley Creek, Little Schuylkill R (both sites), and Perkiomen Creek.

At the time of stocking, the total number of trout released at each stocking point, regardless of species, was enumerated by the hatchery truck drivers or volunteer help. An exception was that some hatchery truck drivers and Waterways Conservation Officers apparently assumed that the average stocking bucket contained 33.3 trout and recorded the number of trout stocked based upon the number of buckets distributed at each stocking point, with successive stocking points being reported as having received exactly the same number of trout.

Trout were captured using PFBC standard single-pass backpack electrofishing procedures. In a few cases (n=4) a towboat or an additional backpack was employed to effectively sample the selected site. Where possible, electrofishing crews avoided sampling the last stocking point in each stream section, as quite often the number of trout stocked at the last stocking point varies from the number stocked at other stocking points. Sampling sites were a minimum of 300 m in total length with the first 200 m located downstream from the stocking location. Sixty sites were over 320 m long. Sites frequently extended somewhat beyond 300 m in order to reach shallow riffles or other natural impediments to trout moving ahead of electrofishing crews and out of the sampling sites. On the rare occasions when two stocking points were less than 300 m apart they were treated as a single stocking point and sampling extended from 200 m downstream from the downstream stocking point to 100 m upstream from the upper stocking point, producing electrofishing sites that were as much as 500 m long.

Sampling crews used their judgment regarding the electrofishing gear (backpack unit or towed boat) that was selected for sampling at each site. Judgment was also used to determine if a site could be worked effectively, as in some cases the number of deep pools precluded electrofishing. In cases where pools were determined to be too deep to effectively sample a site, the site was moved to another randomly selected stocking point within the stream section. High water events that precluded sampling were not encountered during the spring of 2006; statewide flows were generally normal to low and precipitation was much below average.

On streams where a backpack electrofishing unit was used for sampling, trout were dip netted and passed to a person carrying a belly board. This person recorded information on the number of trout captured by species and origin (hatchery or wild, with “wild” including carry over hatchery trout), fish species occurrence, and the time required to complete the electrofishing effort at the site. In cases where large numbers of trout were encountered, or where a third crew member was unavailable, trout were netted and information on species and origin was verbally relayed to the recorder. In these situations, trout were released well behind the electrofishing crew to avoid problems with double counting released fish that can quickly recover and swim ahead of the electrofishing crew. On streams where a towed boat electrofishing unit was used for sampling, procedures were the same except that all trout were netted and held in a tub until either enough fish were captured to require processing or the end of the site had been reached.

The number of hatchery trout captured at each sampling site by species was adjusted to account for an estimated mean electrofishing efficiency of 67.19 percent of the stocked trout captured per electrofishing run. This estimate was generated through a mid-March, 2006, pre-study in which six streams (12 sites) were electrofished across Pennsylvania within 24 hours (the next day) after a known number of representative hatchery trout had been stocked (Table 2). This pre-study assumed that there was no movement out of the electrofishing site within the period between stocking and sampling. Capture efficiencies varied from a minimum of 46.4% (Little Fishing Creek in Area 3) to a maximum of 100% (Princess Run in Area 5), with a mean of 67.19 % +/- 15.24 %. During the trout residency study the number of spring, 2006 stocked trout recovered at each site was divided by 0.6719 to estimate the number that remained within the site. The estimate was then converted to a percentage of the trout that had been stocked at the site.

A plethora of physical and water quality information was recorded at or about each sampling site. This included the length of the sampling site (m), the average width of the sampling site (n=5), water temperature, pH, total alkalinity, and specific conductance. Additionally, information was recorded on the total length of pools within the site and the average depth of pools, riffles, and runs within the site, all expressed in meters. This required measuring the pool lengths within each site and measuring depths from three points in each thalweg of two pools, two riffles, and two runs. In cases where there were less than two pools, riffles, or runs within the site, crews were instructed to record information based only on the available habitat types. For instance, records on one pool or no records from pools were acceptable. Site elevations and stream section gradients were recorded from USGS topographic maps.

In-stream and riparian habitat parameters were rated at each sampling site according to Rapid Bioassessment Protocols (RBP) (Barbour et al. 1999). The parameters rated in high gradient streams were epifaunal substrate/available cover, substrate embeddedness, velocity/depth regime, sediment deposition, channel flow status, channel alteration, riffle or bend frequency, bank stability, bank vegetative protection, and riparian vegetative zone width. A few different parameters were substituted in the RBP system for low gradient streams, but ultimately low gradient stream RBP ratings were rejected from the data analyses due to the small sample size (n=21 sampling sites). The aforementioned physical and chemical data were recorded on the day of electrofishing.

Information was also collected on conditions during the day of stocking. This included water temperature information on the hatchery water supply, in the distribution unit during transport, and in the receiving water. Information obtained from distribution records included the date of stocking, number of trout stocked by species, size and age of trout stocked, hauling time from hatchery to receiving water, trout density in the tanks during the trip, and the number of stocking points.

Hatchery raceway and truck transportation conditions were compiled from individual hatcheries specific to the trout planted in each stream. Hatchery raceway water quality information is not regularly collected at all trout production hatcheries; but for this study information on water temperature, pH, total alkalinity, and specific conductance was collected on a monthly basis at the hatcheries. Hatchery water chemistry data recorded nearest to the stocking date was used for the analysis. In addition, the hatchery managers also provided information on the strains of trout stocked by species. Transportation conditions that the trout were subjected to included tank densities, hauling time, and the number of stops per trip.

Analysis

Spatial distributions of percent recaptured trout were categorized and plotted in relation to the major river drainages and sub-basins. Percent recaptures were categorized as follows: >90% - excellent; 75-89.9% good; 40-74.9% fair; 10-39.9% poor; < 9.9% very poor.

Non-parametric statistical tests were used to explore potential relationships between the measured physical, chemical, habitat, and hatchery characteristics and the percentage of recaptured trout. Differences in percentages of recaptured trout were examined using a Kruskal-Wallis k-sample test for differences among categorical variables, including differences among optimal, sub-optimal, marginal, and poor categories in the RBP habitat assessments, differences among geological formations in which occurred at least one sampling site, differences among geological formations in which occurred at least three sampling sites, differences among dominant lithologies (dominant by volume), differences among dominant and secondary lithologies combined, differences among alkalinity-based stream types based upon two different classification schemes, differences among hatchery water temperatures, truck tank water temperatures, and stream temperatures on the stocking dates, and temperature differences among hatchery water, tank water, and streams on the electrofishing dates. To further illustrate between which classifications more trout were significantly recaptured a non-parametric *Post Hoc* test was calculated for the epifaunal substrate and bank stability variables (Zar 1996).

In cases where only two classifications or categories existed, a Mann-Whitney U test was employed instead. This test was utilized when examining the recapture differences between sections with calcareous and non-calcareous geologies, pH differences between the hatcheries and the stocked streams, total alkalinity differences between the hatcheries and the stocked stream, and specific conductivity differences between the hatcheries and the stocked streams.

A Spearman's rank correlation (r_s) was employed to determine any significant correlation between the percentages of recaptured trout and variables measured on a continuous scale. These included: stream width, elapsed days from the date of planting to the date of sampling, pool length as a percentage of the total sample site length, average pool depth, maximum pool depth, average riffle depth, average run depth, pH, total alkalinity, water temperature, specific conductance, RBP habitat variables, the difference and absolute difference between hatchery water temperatures and sample site water differences, the difference between truck tank water temperatures and stocking point water temperatures, sample site elevation, and section gradient. The total amount of variation (coefficient of determination: $– r^2$) explained by a change of magnitude of one variable in relation to the other was represented as the square of the r_s value.

Principal components analyses (PCA) were computed based on the measured physical, chemical, and habitat variables at sample sites. The analyses were used to describe potential variable gradients and identify distributions of recaptured trout along those gradients. Principal components loadings greater than 0.30 or less than –0.30 were considered to be significant; loadings greater than 0.40 or less than –0.40 were considered to be more important; and loadings greater than 0.50 or less than –0.50 were considered to be very significant. The loading sign (+/-) indicated the direction of the variable and component relationship.

All variables included in the PCA were treated as continuous variables and transformed as necessary to approximated normal distributions. Represented as a percentage, the "pool length" variable expressed as a percentage of the total site length was arcsine transformed. Some variables were $\log_e$+1 transformed (stream width, elapsed days, pool depth, maximum pool depth, run depth, riffle depth, specific conductance, stream width, and total alkalinity) to approximate normal distributions. The RBP habitat variables were not transformed since none of the common transformations appreciatively improved their distributions; therefore, their raw values were used.

The Kolmogorov-Smirnov test of departure from normality as well as the examination of normality plots indicated that all of the variables, whether transformed or not, were not normally distributed, except for specific conductivity and stream width. The examination of the normality plots, however, suggested that the departure from normality was not severe. Considering that these analyses were for exploratory purposes, the data's departure from normality was acceptable.

The influences of the measured physical, chemical, and habitat variables relative to the percentages of recaptured trout were interpreted by graphical representation of component scores for each sampling entity. The percentages of recaptured trout at each sampling site categorized as being excellent, good, fair, poor, or very poor, rather than the actual number of recaptured trout at each site were used for clarification of the graphical plots.

Sample sites that were identified as low gradient were not included in the examination of habitat and PCA analyses due the low number of individual sites (n=21).

All statistical analyses were conducted with Systat software (v.11.0).

Results/Discussion

Statewide Stocked Trout Residency

Data from 259 sampling sites were retained for analysis from the original 266 sites that had been sampled (Table 1). Of the retained sites, 238 were from high gradient streams and 21 were from low gradient streams. The total number of trout recaptured (unadjusted for capture efficiencies) varied from one to 388 fish at the retained sampling sites, with recaptured trout exceeding the number of trout stocked at eight sampling sites (Table 3). Following adjustment for capture efficiency, however, there were 51 sampling sites where the estimated trout numbers present exceeded the numbers of trout that had been stocked at the respective sites.

The majority (72%, n=187) of the sampling sites had adjusted recapture rates that were greater than or equal to 40 percent of the trout that had been stocked at the sites. This range of adjusted recapture rates included those that were subjectively classified as fair, good, and excellent. Adjusted recapture rates greater than or equal to 40% were well represented in all sub-basins throughout the state, except sub-basin 4, upper "North Branch" Susquehanna River, and sub-basin 8, upper West Branch Susquehanna River. At least three sampling sites with excellent (>90 percent) or good (75-90 percent) adjusted recapture rates occurred in each sub-basin except in the upper West Branch Susquehanna, where none occurred (Table 4; Figures 2, 3, 4).

Seventy-two sampling sites (28%) had adjusted recapture rates that were classified as being very poor or poor where adjusted recapture rates fell between zero and 39.9 percent. Forty-nine of these sampling sites were poor, with adjusted recapture rates in poor sites falling between ten and 39.9 percent. Twenty-three of the 72 sites were very poor, with adjusted recapture rates being less than ten percent. Poor and very poor adjusted recapture rates occurred throughout the state except in sub-basin 13, the Potomac River drainage (Table 4; Figure 5).

Poor and very poor adjusted recapture rates were particularly common in three sub-basins. They occurred in two-thirds and three quarters of the sampling sites in the upper "North Branch" Susquehanna River sub-basin (sub-basin 4) and in the upper West Branch Susquehanna River sub-basin (sub-basin 8), respectively. They were also common in the middle West Branch Susquehanna sub-basin (sub-basin 9), amounting to nearly half of the sites (Table 4). Those in the upper "North Branch" Susquehanna sub-basin were generally regionalized in the eastern portion of the sub-basin and included Gaylord Creek (4D), North Branch Wyalusing Creek (4D), South Branch Tunkhannock Creek (4F), and Martins Creek (4F). Those in the upper and middle West Branch Susquehanna sub-basins included Asaph Run (9A), Bailey Run (8A), Cush Creek (8B), Hicks Run (8A), Long Run (9A), Long Run (9C), and North Creek (8A). Sub-basins 8 and 9 are partially underlain by Pottsville and Allegheny geological formations, which are known problem formations with respect to poor buffering of acid precipitation (Dr. William Sharpe, pers. comm., 2006). However, the only study stream in sub-basins 8 and 9 that was underlain by one of these formations was Cush Creek (8B). Nevertheless, periodic low pH values could be a factor in explaining trout residency in some streams as pH was observed to be one factor affecting residency, although the relationship was weak (Figure 9). Sampling during peak flow events between the time of stocking and sampling would be helpful in investigating this relationship further.

Five sub-basins (10, 16, 17, 19 and 20) generally had a third of the sites sampled in each classified as having either poor or very poor adjusted trout recapture rates (Table 4). While the majority of waters within these sub-basins offered a fair (>40%) chance of finding stocked trout at a stocking location, these sub-basins may be regions of potentially common problematic trout residency. Four of the sub-basins (16, 17, 19, and 20) were located in the western portion of the state in the Ohio River drainage. The poor and very poor sampling sites in these four sub-basins were generally located in higher elevations of the Appalachian Plateau, which is characterized by acid precipitation and poor buffering capacity. Sub-basin 10 was in the lower section of the West Branch Susquehanna River basin. Measured total alkalinities at the four poor and very poor sampling sites within this sub-basin also suggested very limited buffering capacity against acid precipitation events.

Sampling sites with very poor adjusted recapture rates did not occur in seven sub-basins. Those sub-basins were sub-basin 2 (Lehigh River Basin), sub-basin 5 (lower "North Branch" Susquehanna/ Lackawanna River Basin), sub-basin 6 (middle Susquehanna River Basin), sub-basin 7 (lower Susquehanna River Basin), sub-basin 11 (upper Juniata River Basin), sub-basin 20 (Beaver/Ohio River Basin), and the previously mentioned Potomac River sub-basin 13.

Very poor recapture rates occurred inconsistently within stream sections. Eighteen stream sections had at least one sampling site of the pair with very poor adjusted recapture rates (Table 5). When the adjusted recapture rates at the second site within each of these sections were examined, ten of the sampling sites had adjusted recapture rates that were poor (n=6) or very poor (n=4), and the remaining eight had adjusted recapture rates that were fair (n=5), good (n=2), or excellent (n=1). The streams where both sites were poor or very poor were Dunbar Creek (19D), Elk Creek (10B), Gaylord Creek (4D), Havens Run (16C), Hicks Run (8A), Long Run (9A), North Creek (8A), Ross Run (16F), South Branch Tunkhannock Creek (4F), and

North Branch Wyalusing Creek (4D). In the remaining eight stream sections where very poor sites occurred in combination with fair, good, or excellent sites, half of the fair, good, and excellent adjusted recapture rate sites occurred upstream from the very poor sites and half occurred downstream from the very poor sites. This suggested that if movement was substantially depleting one site and adding fish to another, movement was possibly occurring in either direction. The eight streams where very poor sites occurred in combination with fair or better sites were Brush Creek (18D), West Branch Chester Creek (3G); Cowanshannock Creek (17E), Delaware Creek (12B), Fourmile Run (18C), Lake Creek (1E), Sartwell Creek (16C), and an unnamed tributary to Pine Creek (03B).

Overall, there were 14 (10%) stream sections statewide in which both sampling sites had poor or very poor recapture ratings while in 31 (23%) stream sections both sites had either excellent or good recapture ratings. Based upon the results, in 2006, the projected number of stream sections less than 15 meters wide in which trout residency was poor or very poor was 91. The projected number of stream sections in which trout residency was excellent or good was 206. Given that sections 15 meters wide and wider were not sampled, these projection were most likely conservative for the trout stocking program as a whole.

Elapsed time within the range of ten to 20 days post-stocking did not have any impact on stocked trout residency. There was no correlation between the adjusted number of trout recaptured and the number of days within the range of ten to 20 days that the fish had been at large. Whatever measurable movement or mortality occurred at the stocking points took place in the first nine days after stocking (Figure 6). Cooper (1953) found that water temperature at the time of stocking was critical in stimulating downstream movement of stocked adult brook and rainbow trout. Very strong tendencies to move downstream at a rapid rate occurred when stream temperatures at the time of stocking were less than 50 deg. F. Some trout moved 1400 yds (1280 m) to 1600 (1463 m) in the first three hours after having been stocked. However, this was not apparent in the 2006 trout residency study where differences in water temperature among hatcheries, truck tanks, and streams on the day of stocking were not significantly ($P>0.05$) related to the percent of trout recaptured, and the correlation between stream temperature and percent of trout recaptured was not significant ($P>0.05$). Additionally, no significant difference (Mann-Whitney: U =3266.0, $P= 0.856$) was found when comparing trout recaptures between sample sites classified as either cold ($<50^{o}$F; n=230) or warm ($>50^{o}$F; n=39) waters, suggesting emigration of trout from the 2006 stocking locations was not related to colder waters temperatures ($<50^{o}$F) at the time of planting as proposed by Cooper (1953).

Stream Physical Characteristics and Habitat

Broad ranges of stream channel characteristics were encountered at sample sites across the state (Table 6). With the exception of average run depth, none of the measured physical characteristics including stream width, average riffle depth, pool length, average pool depth, maximum pool depth, and stream gradient independently impacted trout residency (Figure 6). Only average run depth illustrated a significant ($P<0.05$) correlation to adjusted recapture rates, such that more trout were recaptured at sites having shallower average run depths. While the correlation was significant, suggesting a possible inverse relationship between run depth at a site and the number of recaptured trout, it was a very weak relationship that only accounted for 1.5% of the total variation in the number of recaptured trout; therefore, its importance was minimal. It is possible that this relationship was an artifact of electrofishing techniques, in which trout are often herded out of pools toward shallow runs and shallow riffles where they are then easily caught. Deeper runs may not as effectively block trout movement during electrofishing.

Stream gradient was not correlated (*P*= 0.90) with the adjusted trout recapture rate Therefore, stream gradient and any related stream velocities, which would tend to increase with gradient, didn't significantly affect trout residency. Perhaps the velocities in runs didn't typically exceed those suitable for stocked trout, or there were adequate velocity breaks in runs to negate the influence of gradient.

Of the ten RBP habitat variables measured, only epifaunal substrate and bank stability independently illustrated any significant differences ($P<0.05$) in the adjusted trout recapture rates among the four habitat rankings of poor, marginal, sub-optimal, and optimal (Figure 7). Better trout residency occurred at sample sites with optimal epifaunal substrate than those with sub-optimal substrate; however, *post hoc* testing revealed that there were no differences among optimal, marginal, and poor substrates. This inconsistency suggested that there was a poorly defined relationship between trout residency and epifaunal substrate rankings. Results may have been clouded by the confounding of various habitat features – boulders, logs, undercut banks, and cobble – into one category called "epifaunal substrate" and by the use of a community based ranking system rather than a system specific to adult trout.

More trout were recaptured where stream banks were moderately stable to stable. Overhanging terrestrial vegetation associated with moderately stable to stable banks may provide overhead cover to which trout orient. Additionally, moderately stable banks may be undercut, providing an overhead cover type that stable banks may lack.

Epifaunal substrate, velocity/depth regime, bank stability, and vegetation protection, four of the RBP habitat variables, were significantly ($P<0.05$) correlated with the adjusted trout recapture rates; however, the amount of variation in adjusted recapture rates explained by these variables was very low, less than 5.5% for each variable (Figure 8). These correlations were positively related to trout recaptures. This suggested that greater number of trout were recaptured at sampling sites that were scored higher for having better habitat for adult trout, including snags, submerged logs, boulders, undercut banks, moderately stable banks, strongly vegetated shorelines, and multiple water velocity/depth combinations.

Given the generally accepted importance of good habitat being necessary to support large fish populations, the low variation in the recapture rates that was explained by habitat was surprising, and suggested that RBP habitat measurements were too general or coarse, applying more to aquatic communities as a whole than to adult trout in particular. Variations in other factors, often referred to as sampling error, may have overridden the impacts of habitat on the abundance of stocked trout at the sampling sites or habitat may truly not have been as important as some other variables. Sampling variations could have included, for example, differences in electrofishing team efficiencies, the apparent errors introduced by some counts of trout stocked at each site, and the possible occasional stocking of some trout beyond the sampling site limits.

Stream Water Chemistries

A broad range of water chemistries and water temperatures were encountered at sampling sites across the state (Table 7); however, water chemistries and temperatures, as measured at each sampling site on the day of electrofishing, did not illustrate strong relationships to the adjusted numbers of recaptured trout (Figure 9). Among the variables of pH, total alkalinity, specific conductivity, and water temperature, only pH was significantly correlated (P<0.05) to the adjusted number of recaptured trout. This was a weak correlation, however, as it only explained 1.7% of the recaptured (adjusted) trout variation among sample sites, where pH's ranged from pH 6.0 to pH 8.8. While pH on the day of electrofishing was not a strong influence, greater trout recaptures occurred at sample sites with higher pH values, conditions that were most ideal for aquatic life in general (Figure 9).

It is possible that stream pH had more of an effect on the adjusted number of recaptured trout at some sites than was revealed by the analysis. Prior to the stream electrofishing survey period, which started on March 20, a substantial rainfall event (March 11^{th}-14^{th}) occurred over the majority of the state. Precipitation data indicated that total amounts of rainfall in Pennsylvania varied by region (The Pennsylvania State Climatologist, 2006). The March 11^{th} – 14^{th} rainfall event produced 1.41 inches in western Pennsylvania (Washington), 1.33 inches in northwestern Pennsylvania (Bradford), 0.54 inches in northeastern Pennsylvania (Mt. Pocono), no rainfall in southeastern Pennsylvania (Bucksville), and 0.63 inches in south central Pennsylvania (South Mountain). In the West Branch of the Susquehanna basin (sub-basins 8 and 9) rainfall amounts of 1.19 inches at Clearfield were substantial enough to possibly impact the water quality of streams. The geology of these two sub-subbasins is known to be problematic in providing buffering capacity, thus streams located in these sub-subbasins could have experienced substantially acidified conditions from this rain event. Five streams selected for the study from sub-basins 8 and 9 were stocked prior to the rain event and three of these streams had sample sites with very poor (Long Run 09A; North Creek 08A) or poor trout recaptures (Asaph 09A; Long Run 09A; North Creek 08A). The recaptures of trout at these sites might have been unduly influenced by temporary rainfall and drainage conditions that forced trout to seek more tolerable water conditions. Three sample sites located in sub-basin 9 that were preseason stocked only 2 days (Upper Pine Bottom Run) or 6 days (Wallace Run) after the rainfall had excellent recaptures of trout. Statewide, stockings before and after the precipitation event probably added variability to the results of the overall study.

As surface elevation increased, adjusted trout recapture rates decreased (P <0.05). This occurrence was most likely related to the nearly uniformly lower pHs and alkalinities that occur at higher elevations in Pennsylvania (Figures 10, 11; Table 8).

No differences were found in adjusted trout recapture rates among the sampling sites when they were categorized by the 59 geological formations over which they were located (Figure 12). When sampling sites that occurred only once (n=17) or twice (n=17) in a particular geological formation were removed from the analysis, however, a significant difference (P=0.029) in adjusted trout recapture rates was found among the remaining 25 geological formations (Figure 13). Further classification of these geological formations into two categories, those that did and did not contain calcareous materials, revealed that sites with underlying calcareous materials had significantly higher (P= 0.010) adjusted trout recapture rates than those sites without underlying calcareous materials (Figure 14). This occurred despite the determination that limestone streams, moderately buffered streams, and freestone streams, as classified by total alkalinity values, did not differ among categories with respect to adjusted trout recapture rates (Figure 15). It is unknown why the total alkalinity relationship to trout residency did not parallel that of underlying calcareous/non-calcareous geological relationship, particularly under largely base flow conditions.

Hatchery and Transportation Factors

Water temperatures and water chemistries differed among and between the times and locations of measurement. Water temperatures were measured at the hatcheries by month, in the stocking trucks and in the streams during the day of stocking, and in the streams on the electrofishing dates. Chemistries (pH, total alkalinity, and specific conductance) were measured at the hatcheries and measured in the streams on the electrofishing dates. In all cases there were significant differences among or between locations. This was true for water temperatures even after stream temperatures on the electrofishing dates were removed from the analysis (Figure 16). While hatchery and stream temperatures as well as truck tank and stream temperatures were significantly different on stocking dates ($P<0.001$), these differences did not have an impact on the adjusted trout recapture rates despite the lack of tempering trout to stream water temperatures (Figure 17). Median water temperatures in the stocking trucks and in the streams on the days of stockings were 9.5^{o} C and 5.6^{o} C, respectively. Truck tank temperatures ranged from 3.3^{o} C to 17.8^{o} C and stream temperatures ranged from 0.6^{o} C to 15.0^{o} C on the stocking dates. Median pH values at the hatcheries and at the sampling sites were pH 7.2 and pH 7.1, respectively, but hatchery pH's ranged from pH 6.3 to pH 8.0 and electrofishing site pH's ranged from pH 6.0 to pH 8.8. Median specific conductance values were 251 micromhos in the hatcheries and 111 micromhos in the streams on the electrofishing dates. Hatchery water conductivities ranged from 45-381 micromhos and stream conductivities ranged from 22-763 micromhos.

Stream temperature changes from the stocking date to the electrofishing date, a period of ten to 20 days, did not influence trout residency rates at the stocking points. There was no correlation between the absolute value of the temperature difference that occurred from the stocking date to the electrofishing date and the adjusted trout recapture rates (Figure 18). The eight sampling sites with the largest differences between water temperatures ($>8^{o}$C) on the stocking dates and the electrofishing dates demonstrated the full range of adjusted recapture rates from very poor to excellent. Half had adjusted recapture rates that were fair or better, including one classified as being excellent (Wallace Run – 9A), with three remaining sites being poor and one being very poor (Fourmile Run – 18C).

The absolute values of pH, specific conductance, and total alkalinity differences between the hatchery water supplies and the streams on the electrofishing dates did not influence adjusted trout recapture rates. Two separate sets of correlations were calculated based on the elapsed time from stocking to sampling. The first set of correlations included all sampling sites that were electrofished ten to 20 days after stocking (n=259) and the second set of correlations included only those sampling sites (n=8) that were surveyed within twenty-four hours of stocking. Regarding the first set of correlations, there was a considerable delay (10-20 days) between planting and sampling during which trout experienced potentially stronger stream effects in comparison to any lingering hatchery effects prior to sites being sampled. The second correlation eliminated potential stream effects that trout experienced in the ten to 20 days between the time of planting and the time of sampling, but the sample size was very small.

Measured hatchery truck transportation factors did not influence the adjusted electrofishing recapture rates of trout. No correlations were identified between either the hauling times, number of stops, or average tank densities and the percentage of trout recaptured from the stocking points.

Species differences and genetic strain differences could have possibly had an influence on the residency of stocked trout. Measuring species differences was not within the scope of this study primarily due to manpower constraints. Additionally, species differences could not be gleaned from the available hatchery and electrofishing data due to variations in loading techniques among and within hatcheries. Strain differences could not be successfully evaluated due to the large number of strains being stocked and the mixture of strains within hatcheries. Strain-specific sample sizes would have been too small for proper evaluation.

Principal Components Analysis (PCA analysis)

The amount of stream habitat and chemical variability was poorly explained by the PCA analysis (Table 9 and Figure 19). The first three components, which were the most important, explained only 44% of the total variation. The first principal component was best described by three variables that had notable loadings or importance (absolute values >0.3), including the negatively loaded specific conductance, the positively loaded vegetation protection, and sediment deposition (Table 10). At negative axis values for this component, waters were characterized by having high specific conductance with heavy deposits of material on the bottom and obvious disrupted shore vegetation. At the positive end of the axis waters were characterized by low specific conductance values, minimal (<5%) sediment deposition, and excellent (<90%) vegetation along stream banks.

Loadings on the second principal component were predominated by maximum pool depth, average pool depth, average run depth, and average riffle depth, and stream width, all of which were positively loaded on the component. Collectively, these five variables described a gradient from small, shallow streams to larger, deeper streams, essentially a measure of the stream size at the sampling sites.

There were no discernable patterns of adjusted trout recaptures rates in relation to the first and second or the first and third principal components. In an attempt to clarify the distribution of trout recaptures, only those sample sites classified as excellent (>90%) and very poor (<10%) were plotted on the three principal components, again with no discernable pattern evident.

The gradients in habitat and chemistries described by the first two principal components did not appear to have any relationship to the adjusted trout recapture rates. Thus, the PCA did not provide good descriptors or a model that would suggest possible explanations of where/when to expect high trout recaptures.

Stream Flows

Unusual stream flow conditions were encountered during the sampling period for the spring 2006 preseason trout residency survey. Snowfall conditions during the 2005/06 winter were relatively light and all of the snow pack runoff throughout the state was generally absent prior to March 1, the first date of stockings. Additionally, normal springtime rainfalls had not yet begun with the exception of one somewhat substantial precipitation event that deposited approximately 0.5 to 1.5 inches of rain in all regions of Pennsylvania except southeastern

Pennsylvania. During the sampling period, which began on March 20, rainfall throughout the state was very light. For example, only 1.6 inches of rain fell in southeastern Pennsylvania during the one-month study. The end result was that riverine flow conditions encountered statewide were more representative of early summer flow rates than typical higher springtime flow conditions. Most of the streams filled their channels bank to bank, but some habitat that would have normally been available for adult trout in a typical spring (e.g. near-shore habitats including undercut banks, snags, exposed logs, etc.) was minimal or inaccessible due to the lower flows. Runs and riffles were generally shallower than in a normal spring, and substrate was even exposed in some riffles. Conversely, since snow pack melt was absent and rainfall was below normal, stream pH was slightly more neutral than would have been expected under traditional springtime conditions and episodic declines in pH associated with acid precipitation most likely occurred infrequently. Acidic waters, rapid pH declines, and the frequently associated dissolution of naturally occurring aluminum may tend to influence trout to redistribute farther downstream or upstream in favor of more neutral pH water. As a result, trout residency at the stocking locations in 2006 may not have been reflective of a typical springtime residency in other years due to unusually low snow melt and precipitation influencing stream flows.

Sources of Variability

There were known sources of variability that may need to be addressed in future studies of this type and considered in relation to their potential influences on the conclusions drawn from this pilot study. First and foremost was the accuracy of the trout counts recorded at each stocking point on the stocking date. It appeared that the stocked trout counts varied across the state depending upon personnel conducting the stockings. Protocol called for trout to be counted as they were placed in the buckets for distribution, but it appeared from the frequency of whole number counts, such as 100 per stocking point, that traditional bucket estimates were used in some cases. Traditional bucket estimates of 33.3 trout per bucket used by hatchery truck drivers and Waterways Conservation Officers had previously been measured with the cooperation of two truck drivers as having had a four to 18 percent error on average from the actual number of trout within the buckets, depending upon individuals loading the buckets. The occurrence of brood fish in the buckets likely exacerbated the problem. Thus, comparisons of the recaptured trout to the initial number of trout stocked could have possibly exceeded the probability of accepting/rejecting test hypotheses, potentially resulting in type I or type II errors, if inaccurate counts of fish that were being stocked substantially influenced the study's results.

A second consideration is that the residencies of trout were not investigated on a species-specific basis. There was no species-specific enumeration of trout during stocking. In Pennsylvania, it is strongly suspected that rainbow trout tend to move farther than brook or brown trout based upon radio telemetry work (Wnuk 2005), but all fish migrated from the streams by the tenth day. In contrast, research in Michigan indicated that brook trout moved farther than rainbow trout, and that brown trout tended to remain near the planting site (Cooper 1953). In the 2006 study, depending on the initial stocked species ratio, species behavioral differences with respect to movement may have overridden any impacts of variables that were being measured.

Third, survey crew confidence ratings as to whether or not they were sampling at the exact stocking point described by the Waterways Conservation Officers were significantly (P<0.05) positively correlated with percent trout recaptures, suggesting that trout recapture rates increased as survey crew confidence in the stocking point locations increased. Survey crews rated their confidence at most sites as being excellent (n=198, 77.6%) or good (n=39, 15.3%). The remaining confidence ratings were fair (n=16, 6.3%) and poor (n=2, 0.8%). Regarding the two sites that had poor confidence, one sample site collection had an excellent (>90%) trout recapture rate and the other sample site collection had a poor (10-39.9%) trout recapture rate, suggesting that at least one of the sites encompassed the original stocking location or at least an environmental characteristic that was effectively holding stocked trout. Since the majority of sample sites had excellent and good confidences ratings in this study, variations in recapture rates of trout caused by inaccuracies in locating stocking points should have been minor, but they could have been problematic on a few streams.

Fourth, electrofishing crew efficiency may have varied from the initial tests that occurred within 24 hours after stocking depending upon the variety of waters sampled, the habitats sampled, and the skills of the crews. Sixty-seven percent of the trout were recaptured and the standard deviation in those initial tests was 15 percent. Sampling more than 12 sites would likely have lowered the standard deviation and possibly provided a somewhat different mean. Efficiency concerns were mitigated to some extent, however, by eliminating samples from the study about which sampling crews expressed doubts concerning sampling effectiveness.

Fifth, another source of potential variability that may need to be addressed in future work is the size differences among stocked trout. Smaller fish may be forced out of a stocking location if larger fish occupy the available habitat or, conversely, larger trout may move if the habitat is better suited to smaller fish. Size-specific behavioral differences might, in these cases, override other variables.Finally, three sources of variability over which there was no possible control were frequent predation, particularly by great blue herons in southeastern Pennsylvania, and poaching, which was a rarely identified problem (1 sampling site), and the planting of trout beyond our sample site limits (100 m upstream, 200 m downstream) by volunteer help at the time of stocking.

Recommendations

- The PFBC through research and stocking program management, should continue to search for ways to improve the percentage of trout that remain in streams from the stocking date until the opening day of trout season.

- The PFBC Commissioners and administration should determine what is the economically and socially minimal acceptable percentage of preseason stocked trout that remain in individual stocked stream sections by opening day of trout season. The Division of Fisheries Management should evaluate the relationship between residency and angler use/economic value to inform this policy decision.

- To achieve the goal of examining the performance of trout residency at stocking locations on a statewide level, future sampling should include streams (<15 m) that were not sampled in 2006 preseason stocking with the intent of eventually sampling all sections less than 15 m wide. Such evaluations should be standard practice when new stream sections are added to the catchable hatchery trout stocking program.

- Those stream sections (14) that were listed as very poor and/or poor with respect to trout recaptures in the 2006 analysis should be resampled in spring 2007 for confirmation that those waters are indeed poor/very poor performers. After two years of preseason sampling, those sections in which sampling site recapture rates remain poor/very poor should be either removed from the stocked trout program, stocked just before opening day, or relegated to the inseason only stocking program, provided that inseason angler usage justifies stocking.

- To better examine hatchery influences on trout residency, substantially more sample sites (minimally 5 sites per management area) should be electrofished within forty-eight hours of the stockings to minimize the time that trout are exposed to environmental influences of the sample sites.

- Reduce the controllable sources of variability. Accuracy and precision of species-specific stocking counts at individual stocking sites is critical. The traditional “bucket” count is known to have upwards of 15-20% variability, which is cumulative by the number of buckets planted at a site. Furthermore, more accurate counts would allow investigation into the residency of trout per species if perchance; different species are prone to immigration.

- Focus near-term trout residency evaluations on high gradient streams, which are much more numerous in the overall stocking program than low gradient streams.

- Habitat variables need further refinement toward a better classification of adult trout habitat preferences. Pool characteristics such as maximum pool depth, frequency of pools, and the length of the deepest portion of the pool need to be included as measured variables. The frequency of riffles and the length of riffles occupying the site length also need to be measured.

- The Rapid Bioassessment Protocols habitat variables need further refinement and/or deletion for use in classifying adult trout habitat. Those variables (epifaunal substrate, velocity regime, bank stability, and vegetation protection) that were of potential importance for trout residency at sample sites should be refined from a community generalization too a more specialized variable for scoring adult trout habitats. For example, the RBP variable epifaunal substrate should be broken into three separate variables – fallen logs/submerged logs, undercut banks, and boulder/cobble - that are scored on a 0-20 scale based on some measurable criteria.

- Some RBP variables (embeddedness, sediment deposition, channel flow status, channel alteration, riparian vegetation protection) that did not show any potential in explaining trout residency should be considered for exclusion in future sampling due to their lack of performance and their generalization of stream habitat for biotic community work.

- Some new, measurable variable(s) may need to be generated that allow(s) for the classification of overall adult trout habitat quality. This (these) may include a combination of physical and habitat variables. For example, one variable might be under cut banks that occur over deep pools of slow moving water in which well-established snags and submerged logs exist versus good under cut banks, submerged logs and pools but not occupying the same location within the site.

- Additional confidence evaluations may need to be included in future surveys that can provide a sampling crew's "gut" feeling (1-5; 5 best) for the sampling site with respect to the following: capture efficiency rating; overall trout habitat rating; and potential bird predation impacts.

- Future evaluations should include a comparison of trout residency within individual streams when trout are stocked directly into pools, directly into short riffles and runs, and directly into long stretches of riffles and runs. This refinement would require a sample frame of streams that generally have only one type of residency rating.

- The practicalities of continuing research into the trout residency problem with its multiple variables and possible multiple causes versus adapting to the problem as a program management concern should be evaluated. Consideration should be given to the possibility that it may be more cost-effective to determine which streams exhibit a residency problem and change their management than to determine the cause(s) of the problem. All above research recommendations should be evaluated in light of this issue.

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Table 1. Listing of all stream sampled for estimating the percent residency of trout recaptured after preseason stocking. Total stocked is the total number of trout stocked at the sample site as determined by the Conservation officer. The recaptures column represents the raw number of trout recaptured at a site (brook + brown + rainbow + golden). The efficiency column represents the number of trout adjusted for capture efficiencies; The percent column represents the total trout computed as the percent of the trout stocked at the sample site. The rating column represents a sample site's classification based on the percent of the trout recaptured. Excellent – are the number of sites that had percent trout recaptures >90%; Good – are the number of sites that had percent trout recaptures 75-90%; Fair - – are the number of sites that had percent trout recaptures 40-74.9%; Poor – are the number of sites that had percent trout recaptures 10-39.9%; Very poor – are the number of sites that had percent trout recaptures <10% of the total number of trout stocked at individual sites.

Water Name	Sub-basin	Section	River Mile	Total Stocked	Recaptured Trout	Efficiency	Percent (adjusted)	Recapture Rating
ANTIETAM CK	3C	4	3.99	225	162	241	107	Excellent
ANTIETAM CK	3C	4	2.33	225	111	165	73	Fair
ASAPH RN	9A	1	0.02	163	24	36	22	Poor
ASAPH RN	9A	1	2.65	163	48	71	44	Fair
AUGHWICK LTL N BR	12C	2	2.31	149	53	79	53	Fair
AUGHWICK LTL N BR	12C	2	2.94	199	82	122	61	Fair
BAILEY RN	8A	2	1.28	100	27	40	40	Fair
BAILEY RN	8A	2	1	100	16	24	24	Poor
BALD EAGLE CK	7I	2	2.2	98	31	46	47	Fair
BALD EAGLE CK	7I	2	1.05	100	50	74	74	Fair
BENS CK S FK	18E	2	6.31	100	10	15	15	Poor
BENS CK S FK	18E	2	5.6	100	67	100	100	Excellent
BERMUDIAN CK	7F	2	17.24	100	26	39	39	Poor
BERMUDIAN CK	7F	2	16.68	100	46	68	68	Fair
BIG RN	17D	1	3.65	111	20	30	27	Poor
BIG RN	17D	1	3.33	68	29	43	63	Fair
BIG RN	20A	2	1.13	225	141	210	93	Excellent
BIG RN	20A	2	2.35	225	101	150	67	Fair
BLAIR GAP RN	11A	2	4.74	95	89	132	139	Excellent
BLAIR GAP RN	11A	2	2.65	95	52	77	81	Good
BRANDYWINE CK E BR	3H	2	18.1	400	167	249	62	Fair
BRIAR CK W BR	5D	2	0.76	75	56	83	111	Excellent
BRIAR CK W BR	5D	2	0.07	125	74	110	88	Good
BRUSH CK	18D	2	4.7	150	52	77	51	Fair
BRUSH CK	18D	2	4.12	150	2	3	2	Very Poor
BUCKWHA CK	2B	4	2.13	105	30	45	43	Fair
BUCKWHA CK	2B	4	0.81	132	54	80	61	Fair
BUFFALO CK	18F	2	26.81	300	41	61	20	Poor
BUFFALO CK	10C	2	20.8	120	107	159	133	Excellent
BUFFALO CK	10C	2	18.11	120	87	129	108	Excellent
BUFFALO CK N BR	10C	2	5.38	175	94	140	80	Good
BUFFALO CK N BR	10C	2	1.14	175	91	135	77	Good
BUFFALO RN LTL	18F	2	0.18	250	98	146	58	Fair
BULL CK	18A	4	0.63	250	64	95	38	Poor
BULL CK	18A	4	2.14	170	76	113	66	Fair
BUSHKILL CK	1F	2	18.23	242	73	109	45	Fair
BUSHKILL CK	1F	2	17.36	180	145	216	120	Excellent
BUSHKILL CK	1D	2	23.54	330	109	162	49	Fair

Table 1. Continued.

BUSHKILL CK	1D	2	25.49	360	234	348	97	Excellent
BUSHKILL CK LTL	1F	3	5.75	91	52	77	85	Good
BUSHKILL CK LTL	1F	2	6.15	98	90	134	137	Excellent
CANAWACTA CK	4E	1	1.9	100	108	161	161	Excellent
CANOE CK	11A	2	12.71	147	104	155	105	Excellent
CANOE CK	11A	2	13.07	138	55	82	59	Fair
CHARTIERS CK LTL	20F	2	4	400	86	128	32	Poor
CHARTIERS CK LTL	20F	2	4.87	400	88	131	33	Poor
CHESTER CK W BR	3G	2	3.73	335	15	22	7	Very Poor
CHESTER CK W BR	3G	2	3.05	335	99	147	44	Fair
CLARION R W BR	17A	2	12.38	148	35	52	35	Poor
CLARION R W BR	17A	2	14.66	148	69	103	70	Fair
CLEAR CK	11C	2	3.23	204	99	147	72	Fair
CLEAR CK	11C	2	2.62	204	87	129	63	Fair
COCALICO CK LTL	7J	2	3.33	203	134	199	98	Excellent
COCALICO CK LTL	7J	2	2.09	134	24	36	27	Poor
COVE CK	13B	2	11.3	233	86	128	55	Fair
COVE CK	13B	2	7.3	150	128	191	127	Excellent
COWANSHANNOCK CK	17E	3	8.53	200	3	4	2	Very Poor
COWANSHANNOCK CK	17E	3	10.91	200	61	91	46	Fair
CUSH CK	8B	2	2.73	200	53	79	40	Fair
CUSH CK	8B	2	1.21	150	27	40	27	Poor
DECKER BK	1B	3	2.91	100	12	18	18	Poor
DECKER BK	1B	3	1.67	100	32	48	48	Fair
DEEP CK	6C	4	1.74	87	44	65	75	Good
DEEP CK	6C	4	1.36	91	7	10	11	Poor
DEER CK	7I	2	47.98	100	51	76	76	Good
DEER CK	7I	2	47.69	100	8	12	12	Poor
DELAWARE CK	12B	2	2.46	75	5	7	9	Very Poor
DELAWARE CK	12B	2	2.05	75	36	54	72	Fair
DOUBLE RN	10B	2	1.64	60	5	7	12	Poor
DOUBLE RN	10B	2	0.31	60	19	28	47	Fair
DUNBAR CK	19D	3	4.4	160	6	9	6	Very Poor
DUNBAR CK	19D	3	3.46	160	15	22	14	Poor
ELK CK	10B	2	4.04	300	3	4	1	Very Poor
ELK CK	10B	2	2.79	100	6	9	9	Very Poor
ELK LICK CK	19F	2	1.8	100	112	167	167	Excellent
ELK LICK CK	19F	2	0.8	50	19	28	56	Fair
FALLING SPRING BR	13C	5	0.53	166	97	144	87	Good
FALLING SPRING BR	13C	5	0.19	166	132	196	118	Excellent
FISHING CK LTL	5C	2	13.07	149	158	235	158	Excellent
FISHING CK LTL	5C	2	12.34	146	75	112	77	Good
FOURMILE RN	18C	3	8.29	175	92	137	78	Good
FOURMILE RN	18C	3	5.89	166	6	9	5	Very Poor
GAYLORD CK	4D	2	5.82	100	2	3	3	Very Poor
GAYLORD CK	4D	2	3.29	100	5	7	7	Very Poor
HARES VALLEY CK	12C	2	0.83	124	66	98	79	Good
HARES VALLEY CK	12C	2	0.38	99	41	61	62	Fair
HARVEY CK	5B	2	10.67	155	93	138	89	Good

Table 1. Continued.

HARVEY CK	5B	2	9.97	169	128	191	113	Excellent
HAVENS RN	16C	2	1.43	150	2	3	2	Very Poor
HAVENS RN	16C	2	1.67	100	4	6	6	Very Poor
HAY CK	3C	3	2.11	320	199	296	93	Excellent
HAY CK	3C	3	0.5	136	86	128	94	Excellent
HICKS RN	8A	1	2.01	243	23	34	14	Poor
HICKS RN	8A	1	0.2	243	7	10	4	Very Poor
HOAGLAND RN	10A	2	4.82	133	32	48	36	Poor
HOAGLAND RN	10A	2	2.1	266	134	199	75	Good
HOFFMAN RN	17A	2	1.26	100	67	100	100	Excellent
HOKENDAUQUA CK	2C	2	8.35	192	165	246	128	Excellent
HOKENDAUQUA CK	2C	2	14.02	144	87	129	90	Excellent
HONEY CK	20B	2	0	225	55	82	36	Poor
HONEY CK	20B	2	1.25	150	53	79	53	Fair
HULING RN	17C	2	3.08	140	55	82	59	Fair
HULING RN	17C	2	3.71	100	25	37	37	Poor
JACKSON RN	16B	2	1.35	250	150	223	89	Good
JACKSON RN	16B	2	2.65	250	70	104	42	Fair
LABORDE BR	17C	2	4.26	132	40	60	45	Fair
LABORDE BR	17C	2	4.92	132	74	110	83	Good
LACKAWAXEN R W BR	1B	4	18.96	317	173	257	81	Good
LACKAWAXEN R W BR	1B	4	18.69	218	20	30	14	Poor
LAKE CK	1E	2	2.27	400	252	375	94	Excellent
LAKE CK	1E	2	0.94	300	19	28	9	Very Poor
LAUREL RN	18E	2	2.15	230	66	98	43	Fair
LAUREL RN	18E	2	0.65	200	207	308	154	Excellent
LAUREL RN	18D	2	0.75	100	48	71	71	Fair
LAUREL RN	18D	2	0.19	100	78	116	116	Excellent
LIZARD CK	2B	4	6.98	132	39	58	44	Fair
LONG RN	9A	2	2.77	207	11	16	8	Very Poor
LONG RN	9A	2	2.18	207	17	25	12	Poor
LONG RN	9C	1	5.5	100	16	24	24	Poor
LOST CK	12A	3	6.62	300	199	296	99	Excellent
LOST CK	12A	3	8.29	128	67	100	78	Good
MAHONING CK	5E	2	5.12	160	93	138	86	Good
MAHONING CK	5E	2	3.87	160	109	162	101	Excellent
MAPLE RN	11D	2	0.38	100	37	55	55	Fair
MAPLE RN	11D	2	0.11	100	47	70	70	Fair
MARSH CK LTL	13D	3	4.5	150	73	109	73	Fair
MARSH CK LTL	13D	3	3.2	120	59	88	73	Fair
MARTINS CK	1F	3	2.53	163	92	137	84	Good
MARTINS CK	1F	3	2.28	217	82	122	56	Fair
MARTINS CK	4F	3	6.24	200	3	4	2	Very Poor
MASTHOPE CK	1A	2	4.11	200	149	222	111	Excellent
MASTHOPE CK	1A	2	3.69	200	101	150	75	Good
MAUCH CHUNK CK	2B	2	2.24	200	129	192	96	Excellent
MAUCH CHUNK CK	2B	2	1.86	133	28	42	32	Poor
MAUSES CK	5E	2	1.81	50	41	61	122	Excellent
MAUSES CK	5E	2	0.19	50	55	82	164	Excellent

Table 1. Continued.

MCCABE RN	7A	2	2.95	60	49	73	122	Excellent
MCCABE RN	7A	2	1.67	75	45	67	89	Good
MEADOW CK	12A	2	1.55	200	108	161	81	Good
MEADOW CK	12A	2	1.14	50	58	86	172	Excellent
MEADOW RN	19E	5	2.55	300	207	308	103	Excellent
MEADOW RN	19E	5	2.18	225	84	125	56	Fair
MESHOPPEN CK W BR	4G	2	6.73	150	28	42	28	Poor
MESHOPPEN CK W BR	4G	2	5.42	150	135	201	134	Excellent
MIDDLE CK	6A	2	28.72	89	49	73	82	Good
MIDDLE CK	6A	2	27.97	89	61	91	102	Excellent
MIDDLE CK S BR	6A	2	3.72	133	61	91	68	Fair
MIDDLE CK S BR	6A	2	2.89	133	46	68	51	Fair
MILL CK	3F	2	1.43	120	73	109	91	Excellent
MILL CK	3F	2	0.85	120	63	94	78	Good
MILL CK	3B	2	1.34	100	41	61	61	Fair
MILL CK	3B	2	4.24	100	84	125	125	Excellent
MILL RN	19E	2	3.27	125	56	83	66	Fair
MILL RN	19E	2	1.75	100	96	143	143	Excellent
MINGO CK	19C	2	7.18	300	140	208	69	Fair
MINGO CK	19C	2	4.31	400	388	577	144	Excellent
MUDDY CK LTL	7J	2	6.64	65	37	55	85	Good
MUDDY CK LTL	7J	2	5.87	268	144	214	80	Good
MUDDY RN	7J	2	1.26	124	24	36	29	Poor
MUDDY RN	7J	2	1.88	152	49	73	48	Fair
MUGSER RN	5E	2	3.01	50	46	68	136	Excellent
MUGSER RN	5E	2	0.15	50	55	82	164	Excellent
MUNCY CK	10D	2	31.66	100	63	94	94	Excellent
MUNCY CK	10D	2	30.55	100	9	13	13	Poor
MUNCY CK LTL	10D	2	17.95	130	72	107	82	Good
MUNCY CK LTL	10D	2	14.58	130	18	27	21	Poor
NESCOPECK CK	5D	3	23.5	240	17	25	10	Poor
NESCOPECK CK	5D	3	21.94	420	265	394	94	Excellent
NORTH CK	8A	2	0.21	110	16	24	22	Poor
NORTH CK	8A	2	2.72	110	1	1	1	Very Poor
OCTORARO CK W BR	7K	1	14.64	264	46	68	26	Poor
OCTORARO CK W BR	7K	1	14.28	396	106	158	40	Fair
OIL CK E BR	16E	1	9.86	160	100	149	93	Excellent
OIL CK E BR	16E	1	11.01	144	85	127	88	Good
OTTER CK	7I	3	3.85	75	40	60	80	Good
OTTER CK	7I	3	2.5	100	77	115	115	Excellent
PAINT CK LTL	18E	2	4.81	130	83	124	95	Excellent
PAINT CK LTL	18E	2	3.48	180	104	155	86	Good
PERKIOMEN CK	3E	3	30.58	200	112	167	84	Good
PICKERING CK	3D	2	5.76	132	96	143	108	Excellent
PICKERING CK	3D	2	5.32	208	113	168	81	Good
PIKE RN	19C	2	3.76	300	168	250	83	Good
PIKE RN	19C	2	4.23	300	68	101	34	Poor
PINE BOTTOM RN UP	9A	2	2.3	100	99	147	147	Excellent
PINE BOTTOM RN UP	9A	2	1.66	100	121	180	180	Excellent

Table 1. Continued.

PINE CK	3A	2	1.69	112	57	85	76	Good
PINE CK	3A	2	0.7	109	79	118	108	Excellent
PINE RN	20A	2	0.26	130	20	30	23	Poor
PINE RN	20A	2	2.37	125	20	30	24	Poor
PINEY CK	17B	4	14.03	150	108	161	107	Excellent
PINEY CK	17B	4	14.3	150	64	95	63	Fair
PINEY CK LTL	19F	2	1.57	59	18	27	46	Fair
PINEY CK LTL	19F	2	0.68	53	26	39	74	Fair
POPLAR RN	11A	2	2.5	88	37	55	63	Fair
POPLAR RN	11A	2	2.84	111	74	110	99	Excellent
RAPID RN	10C	2	8.42	115	80	119	103	Excellent
RAPID RN	10C	2	10.36	115	87	129	112	Excellent
RIDLEY CK	3G	2	10.88	333	305	454	136	Excellent
RILEY CK	4G	2	1	100	12	18	18	Poor
ROSS RN	16F	2	0.35	150	9	13	9	Very Poor
ROSS RN	16F	2	2.48	150	1	1	1	Very Poor
SADDLER CK	12C	2	0.95	76	14	21	28	Poor
SADDLER CK	12C	2	5.75	38	24	36	95	Excellent
SALT LICK CK	4E	2	6.08	100	30	45	45	Fair
SALT LICK CK	4E	2	4.29	100	27	40	40	Fair
SARTWELL CK	16C	2	0.49	100	34	51	51	Fair
SARTWELL CK	16C	2	2.7	100	2	3	3	Very Poor
SAUCON CK S BR	2C	2	2.59	152	65	97	64	Fair
SAUCON CK S BR	2C	2	2.22	155	71	106	68	Fair
SHERMAN VALLEY RN	11D	2	1.9	75	25	37	49	Fair
SHERMAN VALLEY RN	11D	2	4.51	75	13	19	25	Poor
SHULTZ CK	7A	2	3.23	100	98	146	146	Excellent
SHULTZ CK	7A	2	3.65	50	24	36	72	Fair
SINKING CK	6A	2	7.37	150	82	122	81	Good
SINKING CK	6A	2	11.71	120	102	152	127	Excellent
SIXMILE RN	16F	2	0.75	102	95	141	138	Excellent
SIXMILE RN	16F	2	1.32	96	78	116	121	Excellent
SNAKE CK	4E	2	11.2	300	155	231	77	Good
SNAKE CK	4E	2	10.18	200	23	34	17	Poor
SNITZ CK	7D	2	3.45	165	119	177	107	Excellent
SNITZ CK	7D	2	1.51	180	93	138	77	Good
SPRING CK	3C	2	5.01	133	55	82	62	Fair
SPRING CK	3C	2	4.29	91	15	22	24	Poor
SUGAR CK	16D	2	14.98	200	79	118	59	Fair
SUGAR CK	16D	2	15.85	204	104	155	76	Good
SWABIA CK	2C	2	3.08	218	151	225	103	Excellent
SWABIA CK	2C	2	2.35	190	131	195	103	Excellent
THORN CK	20C	2	6.4	300	212	316	105	Excellent
THORN CK	20C	2	4.85	300	92	137	46	Fair
TIOGA R	4A	2	48.5	200	58	86	43	Fair
TIOGA R	4A	2	48.24	200	52	77	39	Poor
TOWANDA CK S BR	4C	2	5.96	200	24	36	18	Poor
TOWANDA CK S BR	4C	2	4.03	100	40	60	60	Fair
TUNKHANNOCK CK S B	4F	2	17.01	198	24	36	18	Poor

Table 1. Continued.

TUNKHANNOCK CK S B	4F	2	19.16	198	4	6	3	Very Poor
TUSCARORA CK	4D	2	4.92	150	29	43	29	Poor
TUSCARORA CK	4D	2	4.74	150	133	198	132	Excellent
TWO MILE RN LW	16G	2	0.73	75	61	91	121	Excellent
TWO MILE RN LW	16G	2	3.25	50	23	34	68	Fair
UNT PINE CK (ECKVILLE)	3B	2	0.58	157	1	1	1	Very Poor
UNT PINE CK (ECKVILLE)	3B	2	0.08	103	61	91	88	Good
VAN AUKEN CK	1B	2	0.95	146	93	138	95	Excellent
VAN AUKEN CK	1B	2	2.27	146	94	140	96	Excellent
WALLACE RN	9C	3	2.88	60	19	28	47	Fair
WALLACE RN	9C	3	2.16	50	33	49	98	Excellent
WALLENPAUPACK W BR	1C	2	8.27	200	157	234	117	Excellent
WALLENPAUPACK W BR	1C	2	7.28	200	58	86	43	Fair
WEST CK	5C	2	4.15	152	102	152	100	Excellent
WEST CK	5C	2	3.08	178	30	45	25	Poor
WHITELEY CK	19G	2	14.83	175	16	24	14	Poor
WHITELEY CK	19G	2	14.46	200	23	34	17	Poor
WILLOW CK	16B	2	4.14	250	36	54	22	Poor
WILLOW CK	16B	2	6.03	150	71	106	71	Fair
WLNG CK DN FK N FK	20E	3	0.3	235	100	149	63	Fair
WLNG CK DN FK N FK	20E	3	0.02	115	66	98	85	Good
WYALUSING CK N BR	4D	3	2.58	100	5	7	7	Very Poor
WYALUSING CK N BR	4D	3	2.33	100	15	22	22	Poor
YELLOW CK	18D	2	15.42	200	86	128	64	Fair
YELLOW CK	18D	2	14.06	100	56	83	83	Good

Table 2. Capture efficiency estimates made from samples collected within twenty-four hours after the initial stocking, 2006.

Water Name	Site Width	Width Class	BROOK	BROWN	GOLDEN	RAINBOW	Trout	Total Stocked	Efficiency
SUGAR CK LTL	17	2	0	6	1	140	147	300	49.00
SUGAR CK LTL	9.5	3	0	7	2	104	113	200	56.50
FISHING CK LTL	7.3	3	0	13	0	38	51	110	46.36
FISHING CK LTL	5.7	3	0	8	0	60	68	104	65.38
WAPWALLOPEN CK BG	7	3	30	4	0	142	176	300	58.67
WAPWALLOPEN CK BG	8.5	3	40	2	0	260	302	390	77.44
PRINCESS RUN	5.2	3	42	56	0	3	101	101	100.00
PRINCESS RUN	5	3	18	25	0	2	45	70	64.29
MARSH CK LTL	7.18	3	54	0	0	1	55	75	73.33
MARSH CK LTL	6.83	3	54	1	0	0	55	64	85.94
KOOSER RN	6.5	3	92	7	0	1	100	150	66.67
KOOSER RN	6.9	3	##	1	0	1	141	225	62.67

Table 3. Listing of those sites at which more hatchery trout were recaptured than were originally stocked at that particular site.

Water Name	Basin	Sec. No.	River Mile	Total Hatchery Trout	Adjusted Hatchery Trout	Percent Recaptured Hatchery (adjusted)	Total Stocked	Days Past Stocking
PINE BOTTOM RN UP	09A	2	1.66	121	204	204	100	12
MEADOW CK	12A	2	1.14	58	98	196	50	18
ELK LICK CK	19F	2	1.8	112	189	189	100	13
MAUSES CK	05E	2	0.19	55	93	186	50	10
MUGSER RN	05E	2	0.15	55	93	186	50	16
CANAWACTA CK	04E	1	1.9	108	182	182	100	10
FISHING CK LTL	05C	2	13.07	158	267	179.19	149	15
LAUREL RN	18E	2	0.65	207	349	174.5	200	13

Table 4. Frequency distribution of trout recapture ratings by sub-basin. Excellent (>90%), Good (75 to 90%), Fair (40 to 74.9%), Poor (10 to 39.9%), and Very Poor (< 10%).

Subbasin	Excellent	Good	Fair	Poor	Very Poor	Total
1	8	4	5	2	1	20
2	5		5	1		11
3	8	5	5	1	2	21
4	3	1	4	8	5	21
5	10	4		2		16
6	2	3	2	1		8
7	5	6	6	5		22
8			2	4	2	8
9	3		2	3	1	9
10	5	4	1	4	2	16
11	3	1	7	1		12
12	3	3	4	1	1	12
13	2	1	3			6
16	4	3	5	1	5	18
17	2	1	6	3	1	13
18	4	3	6	3	2	18
19	4	1	6	4	1	16
20	2	1	4	5		12
Total	73	41	73	49	23	259

Table 5. Comparison of sample sites within a stream section for those sites that had very poor recapture returns. The river mile that a site occurred at within a section is listed under the appropriate heading for classifying the site's recaptures. Excellent – are the number of sites that had percent trout recaptures >90%; Good – are the number of sites that had percent trout recaptures 75-90%; Fair - – are the number of sites that had percent trout recaptures 40-74.9%; Poor – are the number of sites that had percent trout recaptures 10-39.9%; Very poor – are the number of sites that had percent trout recaptures <10% of the total number of trout stocked at individual sites.

Water Name	Sec No.	Sub-basin	Excellent	Good	Fair	Poor	Very Poor
BRUSH CK	2	18D			4.7		4.12
CHESTER CK W BR	2	3G			3.05		3.73
COWANSHANNOCK CK	3	17E			10.91		8.53
DELAWARE CK	2	12B			2.06		2.46
DUNBAR CK	3	19D				3.46	4.4
ELK CK	2	10B					(2.79 & 4.04)
FOURMILE RN	3	18C		8.29			5.89
GAYLORD CK	2	4D					(3.29 & 5.82)
HAVENS RN	2	16C					(1.43 & 1.67)
HICKS RN	1	8A				2.01	0.2
LAKE CK	2	1E	2.27				0.94
LONG RN	2	9A				2.18	2.77
NORTH CK	2	8A				0.21	2.72
ROSS RN	2	16F					(0.35 & 2.48)
SARTWELL CK	2	16C			0.49		2.7
TUNKHANNOCK CK S B	2	4F				17.01	19.16
UNT PINE CK (ECKVILLE)	2	3B		0.08			0.58
WYALUSING CK N BR	3	4D				2.33	2.58

Table 6. Descriptive statistics for stream physical characteristics and the number of days from stocking to when sites were surveyed in the preseason stocked trout survey.

	Site width	Days	Pool length	Pool depth	Max pool depth	Riffle depth	Run depth
N	259	259	255	255	259	255	256
Mean	8.4	14.8	37.8	0.6	0.9	0.2	0.3
Std	2.58	2.82	19.71	0.20	0.30	0.07	0.10
Min	2.6	7	2.9	0.3	0.0	0.1	0.1
25th quartile	6.6	13	21.1	0.5	0.7	0.2	0.3
Median	7.98	14	36.3	0.6	0.8	0.2	0.3
75th quartile	9.8	17	51.8	0.8	1.1	0.2	0.4
Max	17.3	21	87.8	1.5	1.9	0.5	0.8

Table 7. Descriptive statistics for physicochemical parameters recorded at sites surveyed in the preseason stocked trout survey.

	pH	Total alkalinity	Water temp.	Specific cond.
n	257	257	259	254
mean	7.2	40.8	7.2	162.2
std	0.57	48.98	3.11	140.43
min	6	3	0.4	22
25th quartile	6.8	12	5	70
median	7.1	22	7.2	111
75th quartile	7.4	47	9.4	202.75
max	8.8	248	16	763

Table 8. Spearman's Rank correlations (r_s) and associated probabilities for the relationships between stream chemical and physical parameters (n=169).

	TA	pH	Elevation	Slope
PH				
r_s	0.867	1.0		
P	<0.001			
Elevation				
r_s	-0.451	-0.516	1.0	
P	<0.001	<0.001		
Slope				
r_s	-0.322	-0.265	0.069	1.0
P	<0.001	0.001	0.373	

Table 9. Principal components (PC) and associated eigenvalues for all high gradient sample sites. Principal components were derived from the sample site's physical, chemical, and habitat characteristics.

PC	Eigenvalue	Difference	Proportion	Cumulative
1	4.893	2.398	0.23300	0.23300
2	2.495	0.515	0.11881	0.35181
3	1.980	0.408	0.09429	0.44610
4	1.572	0.195	0.07486	0.52095
5	1.377	0.128	0.06557	0.58652
6	1.249	0.062	0.05948	0.64600
7	1.187	0.248	0.05652	0.70252
8	0.939	0.101	0.04471	0.74724
9	0.838	0.085	0.03990	0.78714
10	0.753	0.049	0.03586	0.82300
11	0.704	0.106	0.03352	0.85652
12	0.598	0.142	0.02848	0.88500
13	0.456	0.088	0.02171	0.90671
14	0.368	0.029	0.01752	0.92424
15	0.339	0.004	0.01614	0.94038
16	0.335	0.076	0.01595	0.95633
17	0.259	0.027	0.01233	0.96867
18	0.232	0.038	0.01105	0.97971
19	0.194	0.077	0.00924	0.98895
20	0.117	0.002	0.00557	0.99452
21	0.115			100

Table 10. Principal components (PC) loadings of variables for the first three components for all variables included in the analysis of high gradient sample sites.

Variable	PC 1	PC 2	PC 3
Stream width	-0.048	-0.389	0.154
Elapsed days	0.143	0.057	0.055
Pool length	-0.218	0.037	0.257
Average pool depth	-0.067	-0.535	-0.045
Maximum pool depth	-0.064	-0.454	-0.060
Average riffle depth	0.126	-0.349	0.092
Average run depth	0.070	-0.452	0.152
Epifaunal substrate	0.197	-0.021	0.194
Embeddedness	0.252	0.020	-0.049
Velocity regime	0.047	0.039	0.227
Sediment deposition	0.340	-0.013	0.053
Channel flow status	0.117	0.042	0.257
Channel alteration	0.212	-0.035	0.281
Frequency of riffles	0.259	0.046	0.102
Bank stability	0.281	0.057	0.205
Vegetation protection	0.346	0.049	0.248
Riparian zone protection	0.294	-0.010	0.216
pH	-0.277	0.085	0.364
Specific conductance	-0.314	0.015	0.357
Total alkalinity	-0.298	0.048	0.423
Water temperature	-0.072	0.053	0.176

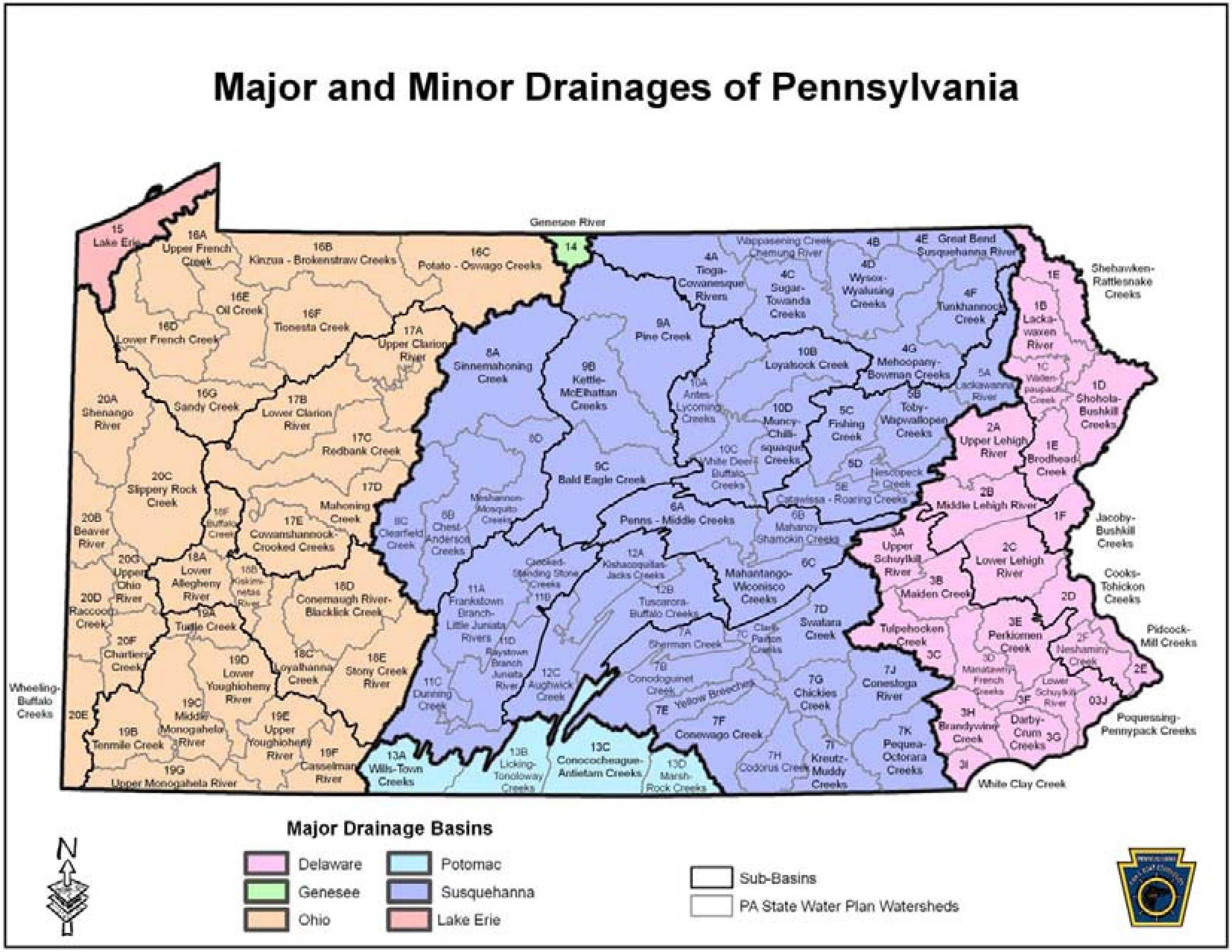

Figure 1. Pennsylvania's major and minor drainage basins.

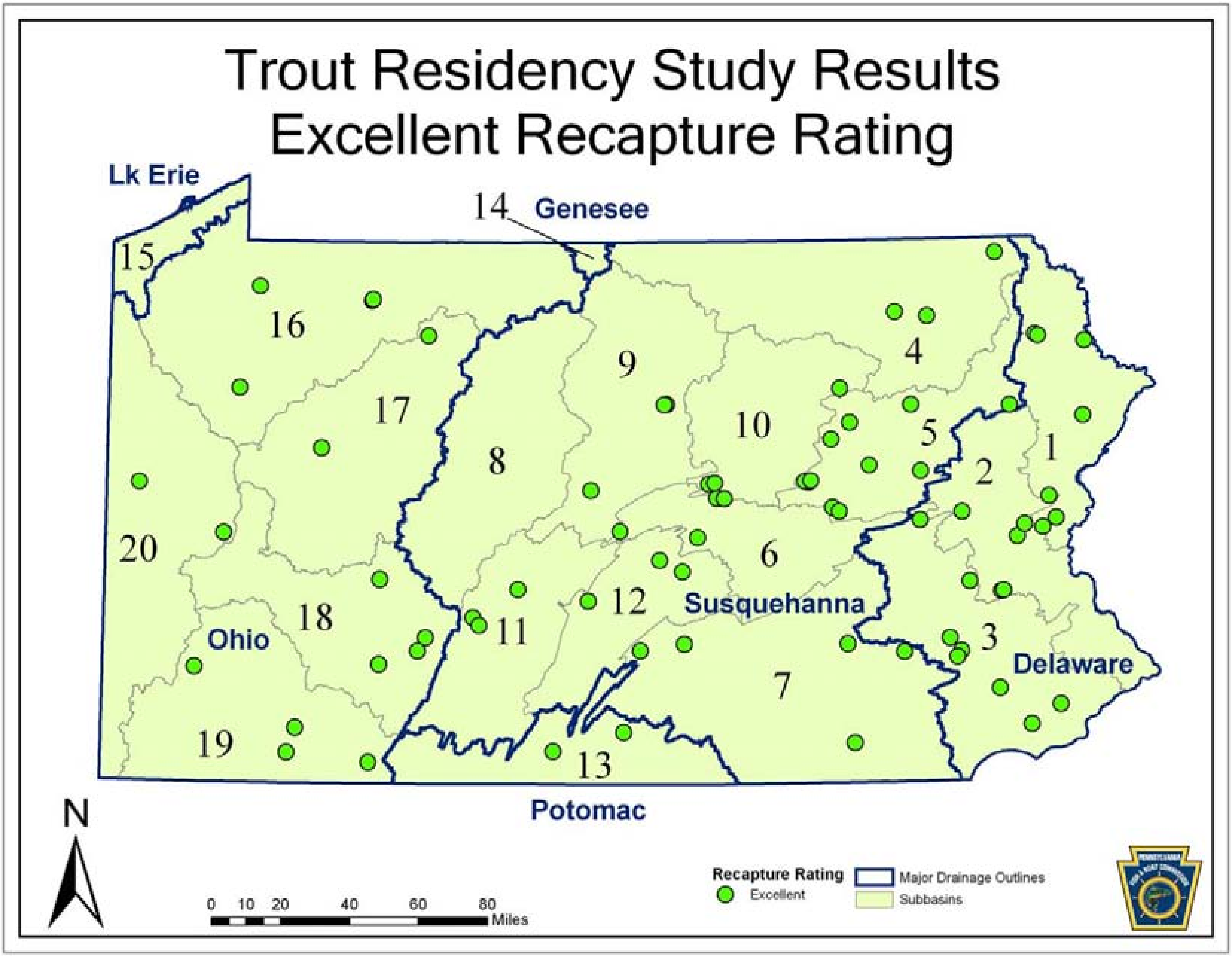

Figure 2. Distribution of trout residency study sites exhibiting an excellent recapture rating.

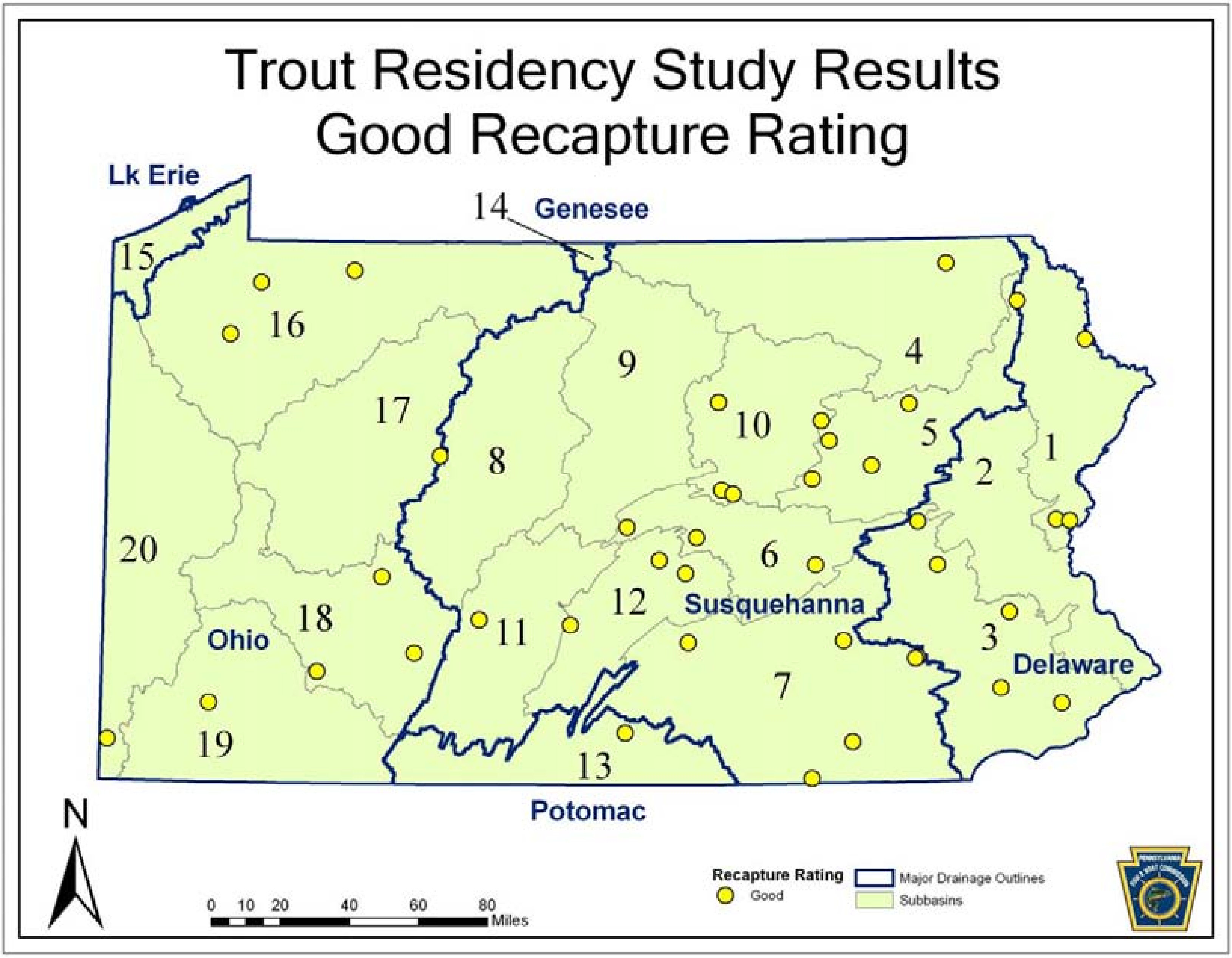

Figure 3. Distribution of trout residency study sites exhibiting a good recapture rating.

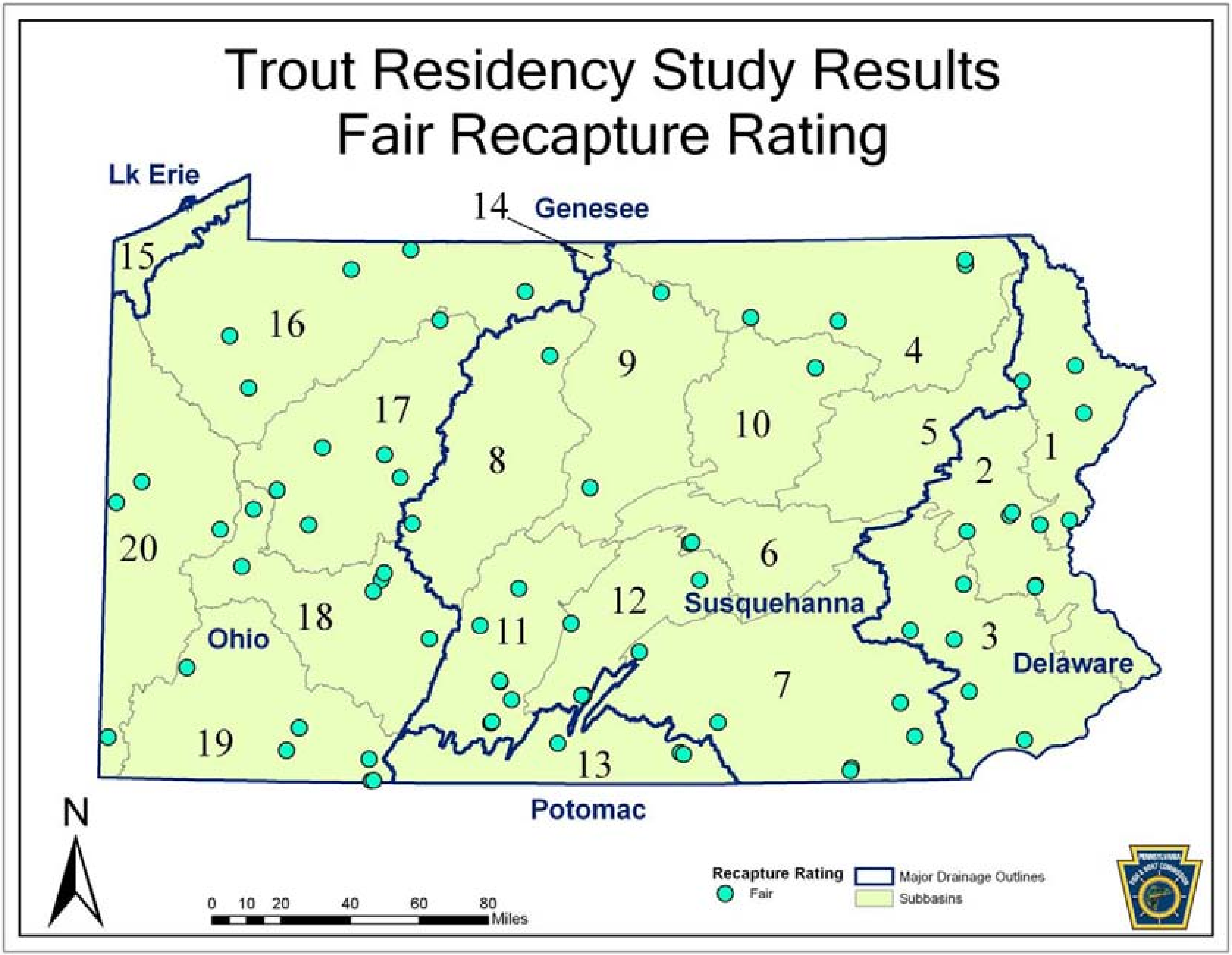

Figure 4. Distribution of trout residency study sites exhibiting a fair recapture rating.

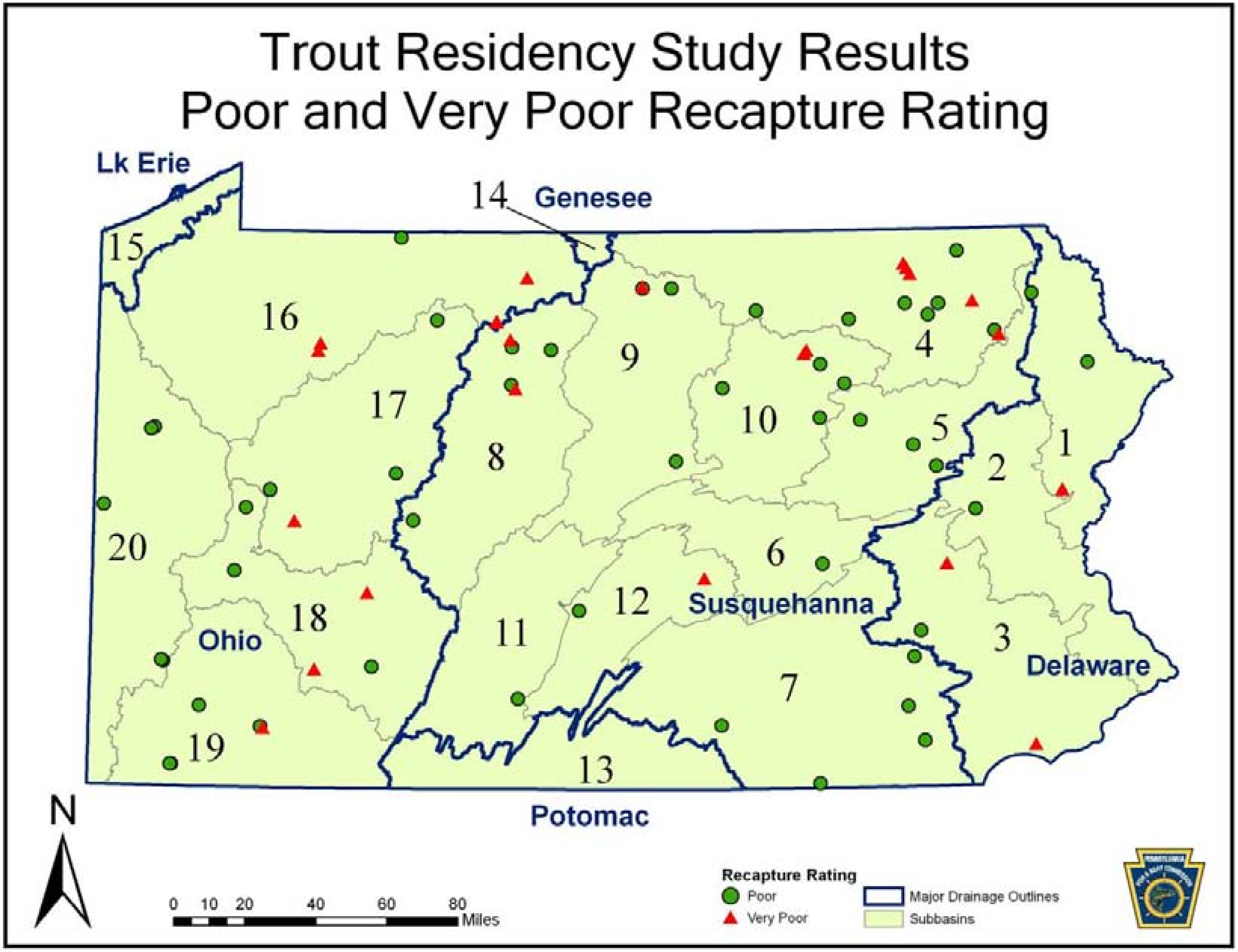

Figure 5. Distributions of trout residency study sites exhibiting a poor or very poor recapture rating.

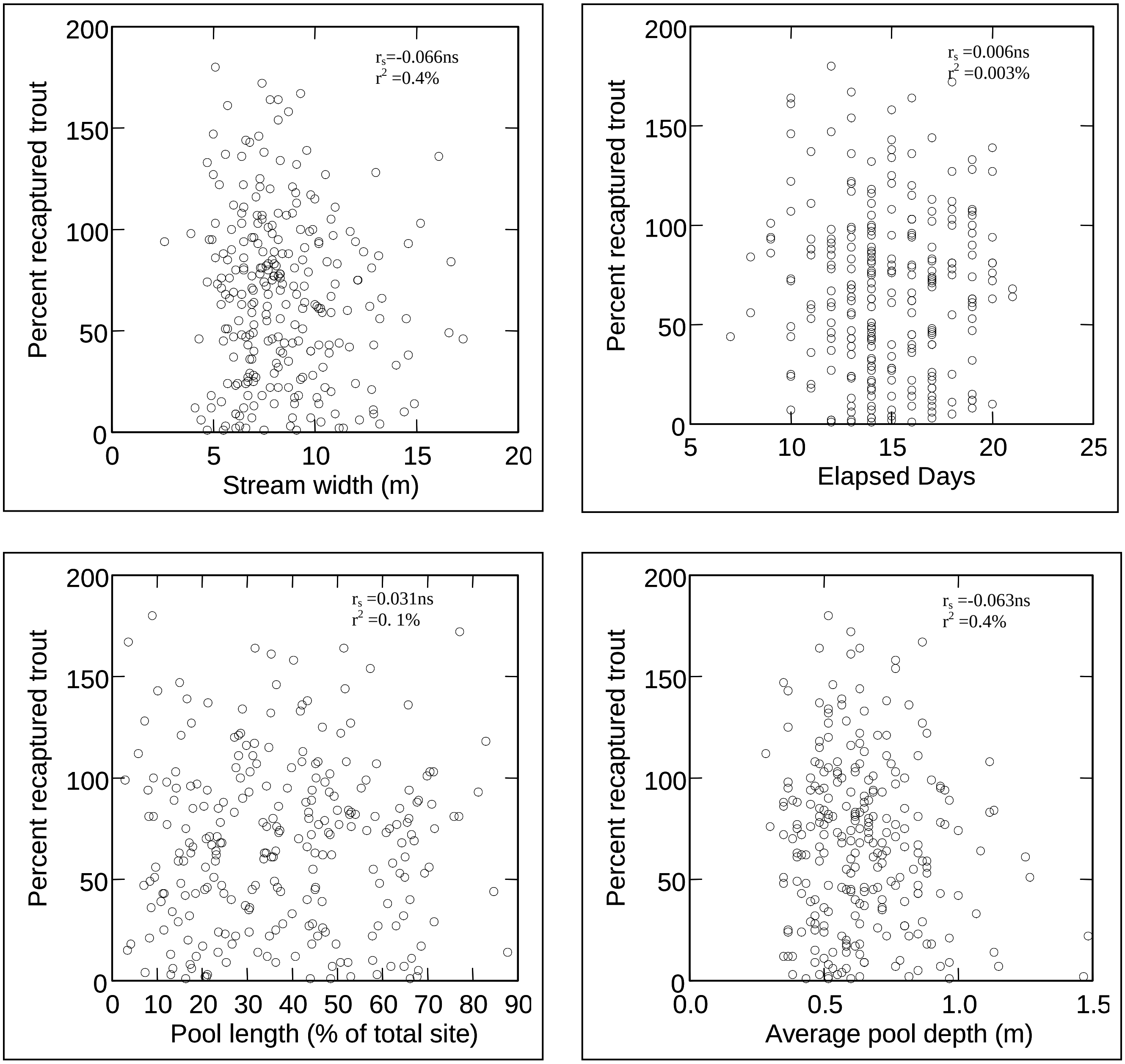

Figure 6. Scatter plots of the percent trout recaptured compared to temporal or stream physical characteristics measured at each site. The Spearman's Rank correlation (r_s) and coefficient of determination (r^2) values for each correlation are listed in the upper right corner of each plot. ns= no significant difference was found; * = $P < 0.05$ (significant); ** = $P < 0.01$ (highly significant); *** = $P < 0.001$ (very high significant), continued.

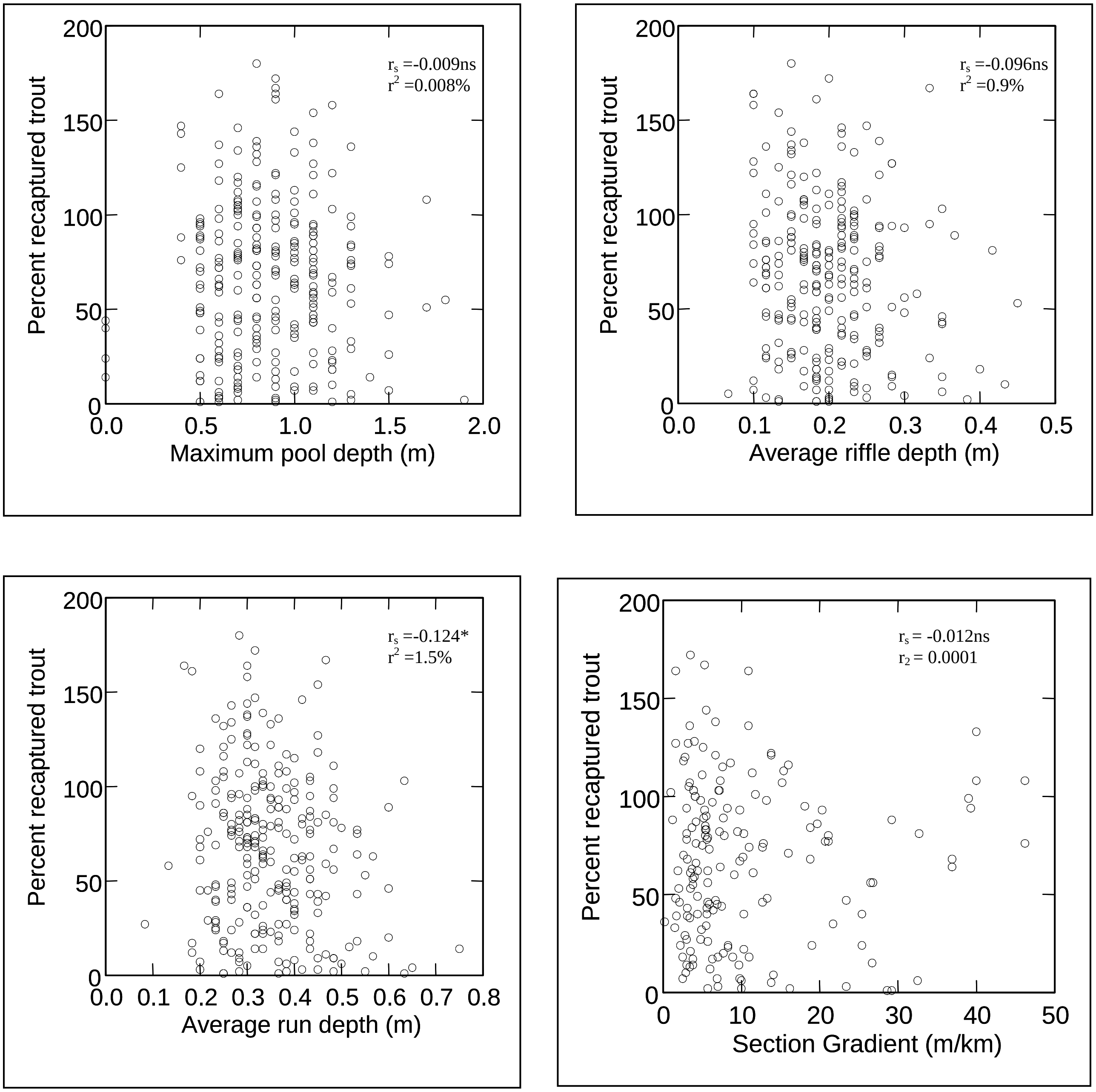

Figure 6. Continued scatter plots of the percent trout recaptured compared to stream physical characteristics measured at each site. The Spearman's Rank correlation (rs) and coefficient of determination (r2) values for each correlation are listed in the upper right corner of each plot. ns= no significant difference was found; * = P < 0.05 (significant); ** = P < 0.01 (highly significant); *** = *P* < 0.001 (very high significant).

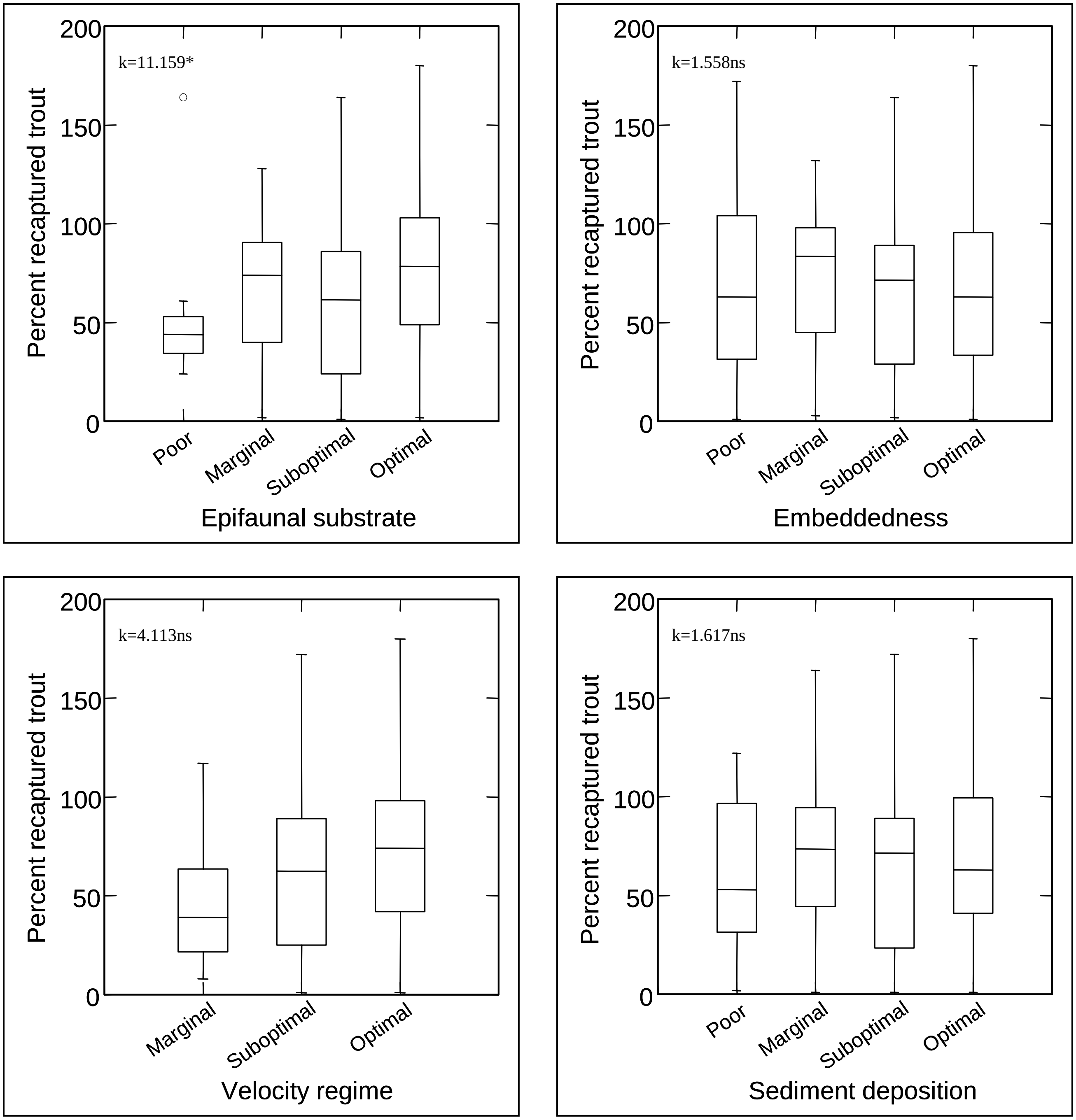

Figure 7. Box plots of the percent trout recaptured to stream habitat characteristics for high gradient streams. Habitat characteristics were classified into one of four categories; poor, marginal, sub optimal, and optimal. Kruskal-Wallis k-sample test values are listed in the upper left corner of each plot. Ns= no significant difference was found; * = $P < 0.05$ (significant); ** = $P < 0.01$ (highly significant); *** = $P < 0.001$ (very high significant), continued.

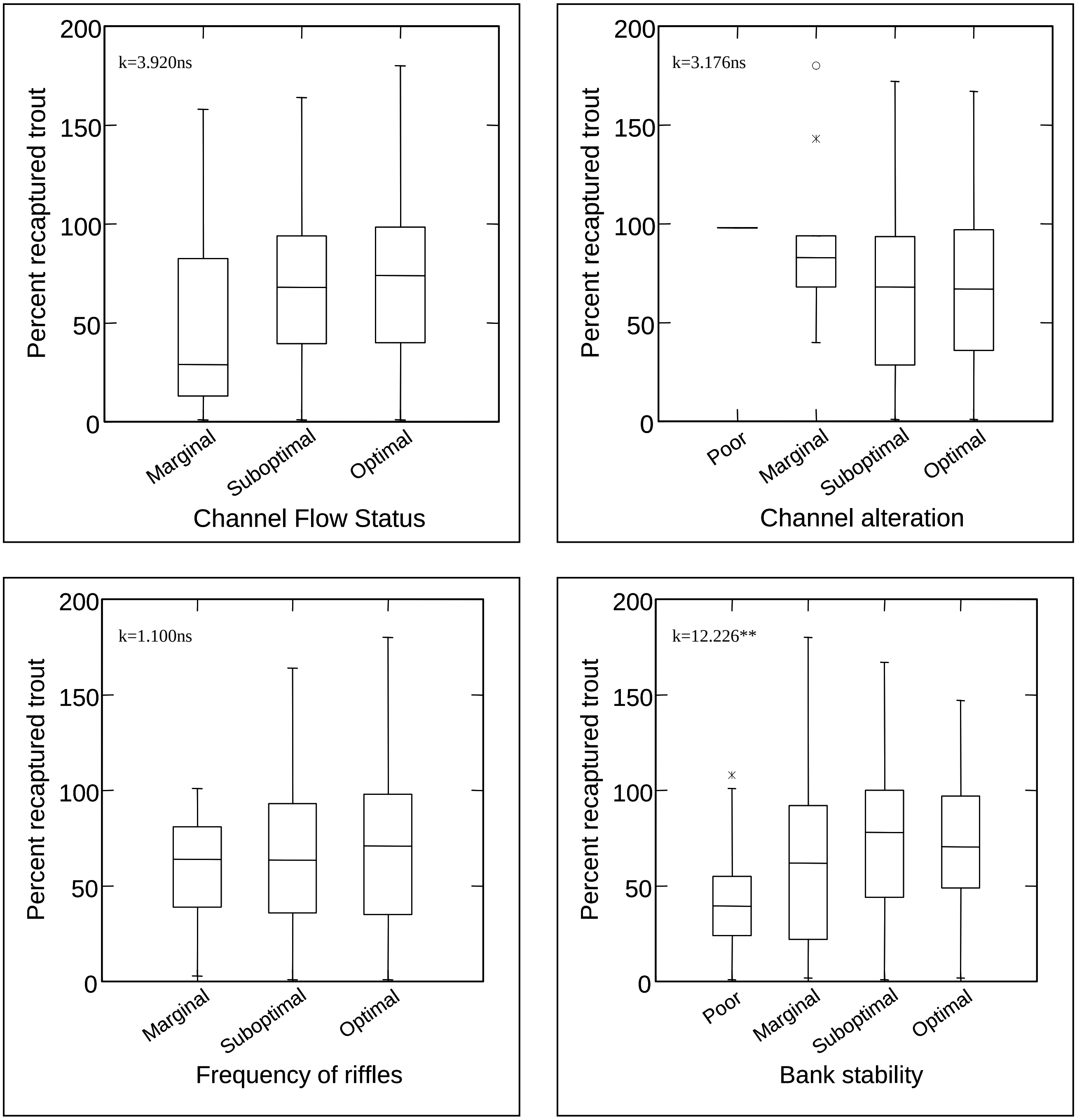

Figure 7. Continued box plots of the percent trout recaptured to habitat characteristics for high gradient streams. Habitat characteristics were classified into one of four categories; poor, marginal, sub optimal, and optimal. Kruskal-Wallis k-sample test values are listed in the upper left corner of each plot. Ns= no significant difference was found; * = *P* < 0.05 (significant); ** = *P* < 0.01 (highly significant); *** = *P* < 0.001 (very high significant).

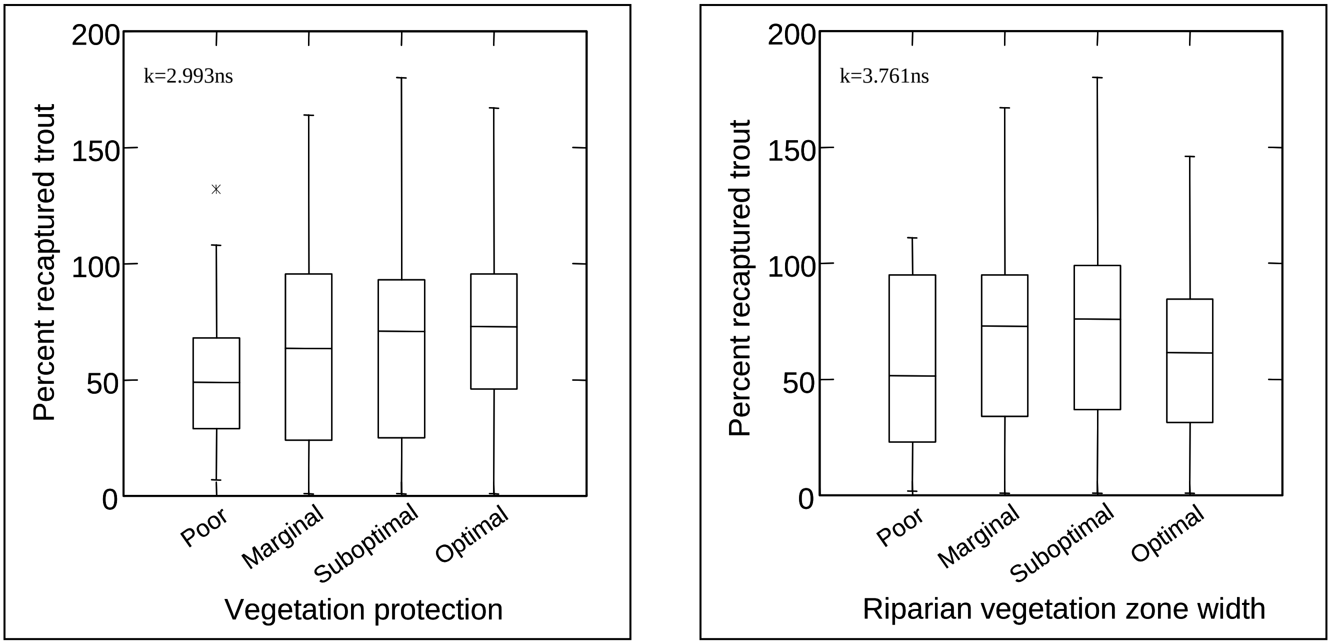

Figure 7. Continued box plots of the percent trout recaptured to habitat characteristics for high gradient streams. Habitat characteristics were classified into one of four categories; poor, marginal, sub optimal, and optimal. Kruskal-Wallis k-sample test values are listed in the upper left corner of each plot. Ns= no significant difference was found; * = $P < 0.05$ (significant); ** = $P < 0.01$ (highly significant); *** = $P < 0.001$ (very high significant).

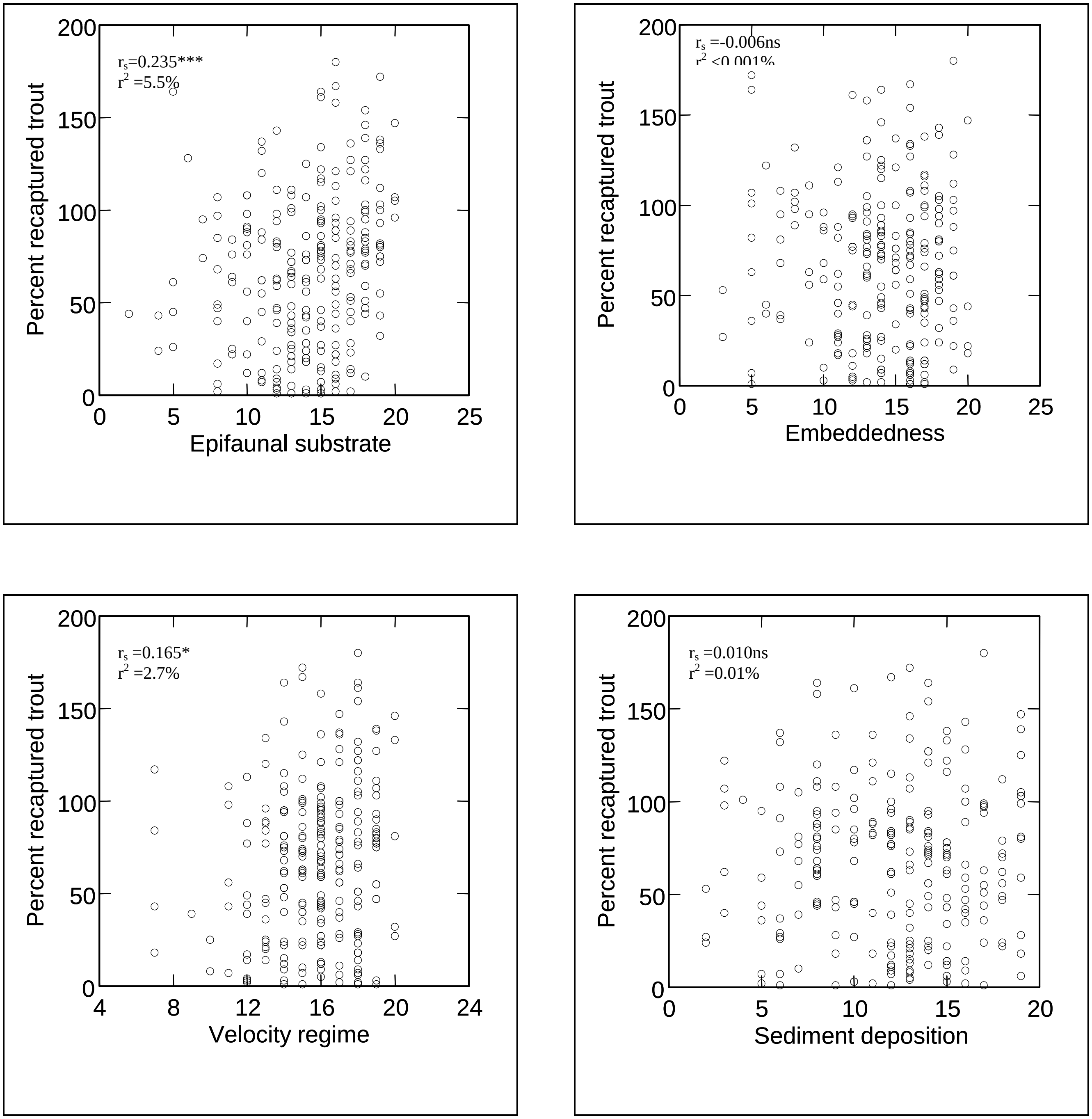

Figure 8. Scatter plots of the percent trout recaptured to habitat characteristics for high gradient streams. Spearman's Rank correlation (r_s) and the coefficient of determination (r^2) values are listed in the upper left corner of each plot. ns= no significant difference was found; * = P < 0.05 (significant); ** = P < 0.01 (highly significant); *** = P < 0.001 (very high significant), continued.

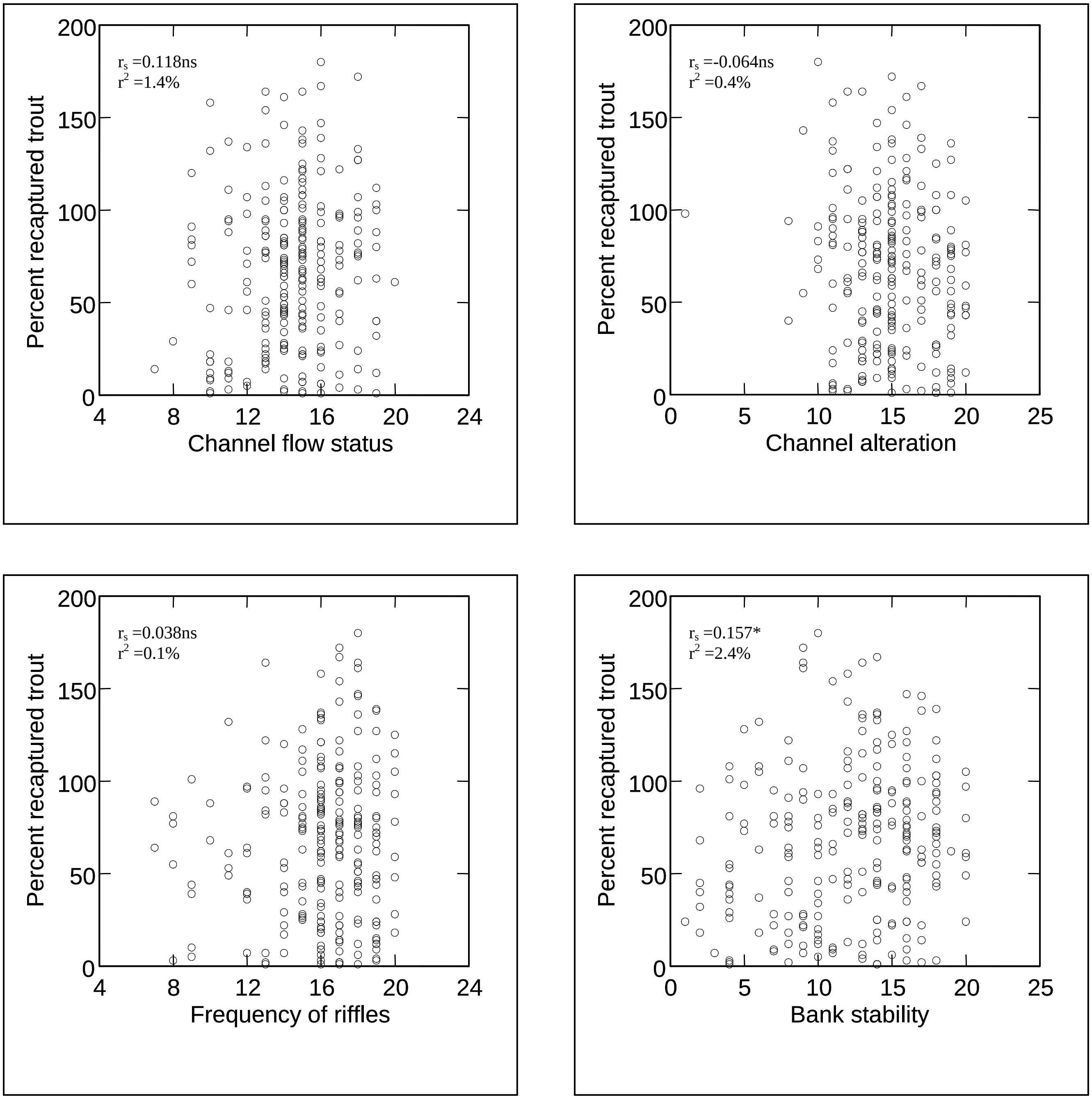

Figure 8. Continued scatter plots of the percent trout recaptured to habitat characteristics for high gradient streams. Spearman's Rank correlation (r_s) and the coefficient of determination (r^2) values are listed in the upper left corner of each plot. ns= no significant difference was found; * = $P < 0.05$ (significant); ** = $P < 0.01$ (highly significant); *** = $P < 0.001$ (very high significant), continued.

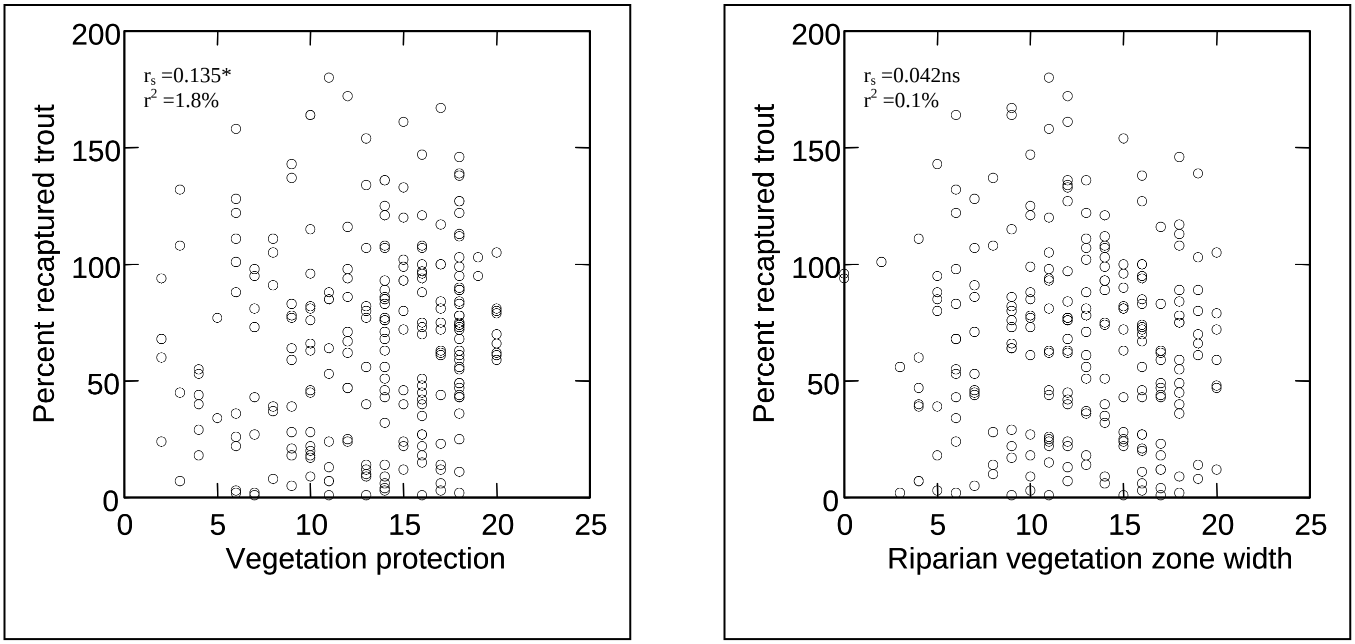

Figure 8. Continued scatter plots of the percent trout recaptured to habitat characteristics for high gradient streams. Spearman's Rank correlation (r_s) and the coefficient of determination (r^2) values are listed in the upper left corner of each plot. ns= no significant difference was found; * = $P < 0.05$ (significant); ** = $P < 0.01$ (highly significant); *** = $P < 0.001$ (very high significant).

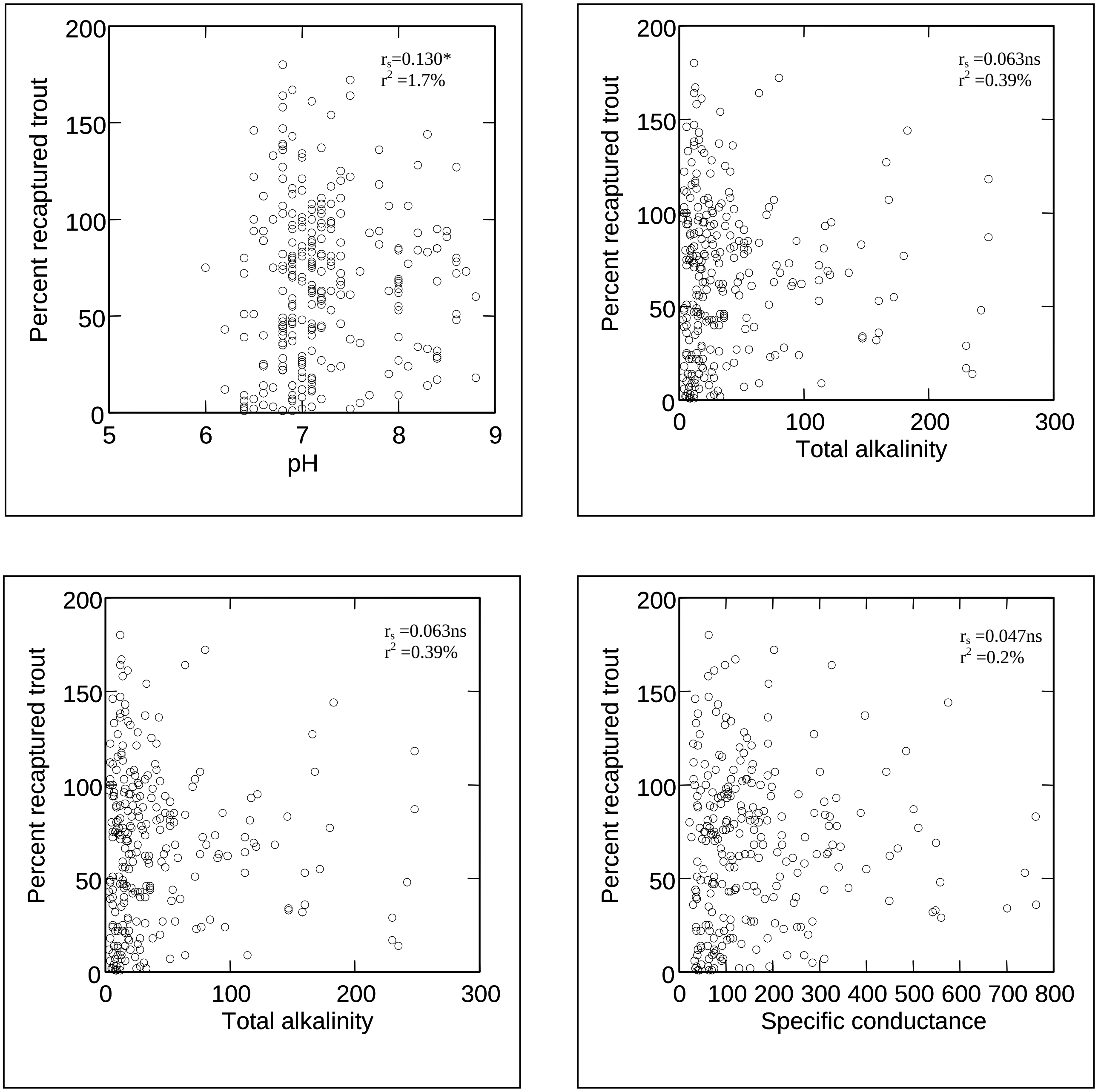

Figure 9. Scatter plots of the percent trout recaptured to water chemistry parameters measured at each site. Spearman's Rank correlation (r_s) and the coefficient of determination (r^2) values are listed in the upper right corner of each plot. ns= no significant difference was found; * = $P < 0.05$ (significant); ** = $P < 0.01$ (highly significant); *** = $P < 0.001$ (very high significant).

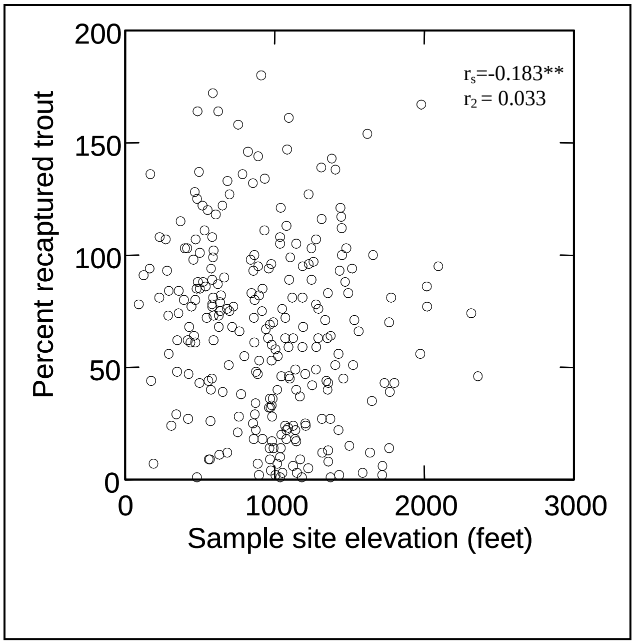

Figure 10. Scatter plots of the percent trout recaptured to sample site elevation as measured at each site. Spearman's Rank correlation (r_s) and the coefficient of determination (r^2) values are listed in the upper right of the plot. ns= no significant difference was found; * = $P < 0.05$ (significant); ** = $P < 0.01$ (highly significant); *** = $P < 0.001$ (very high significant).

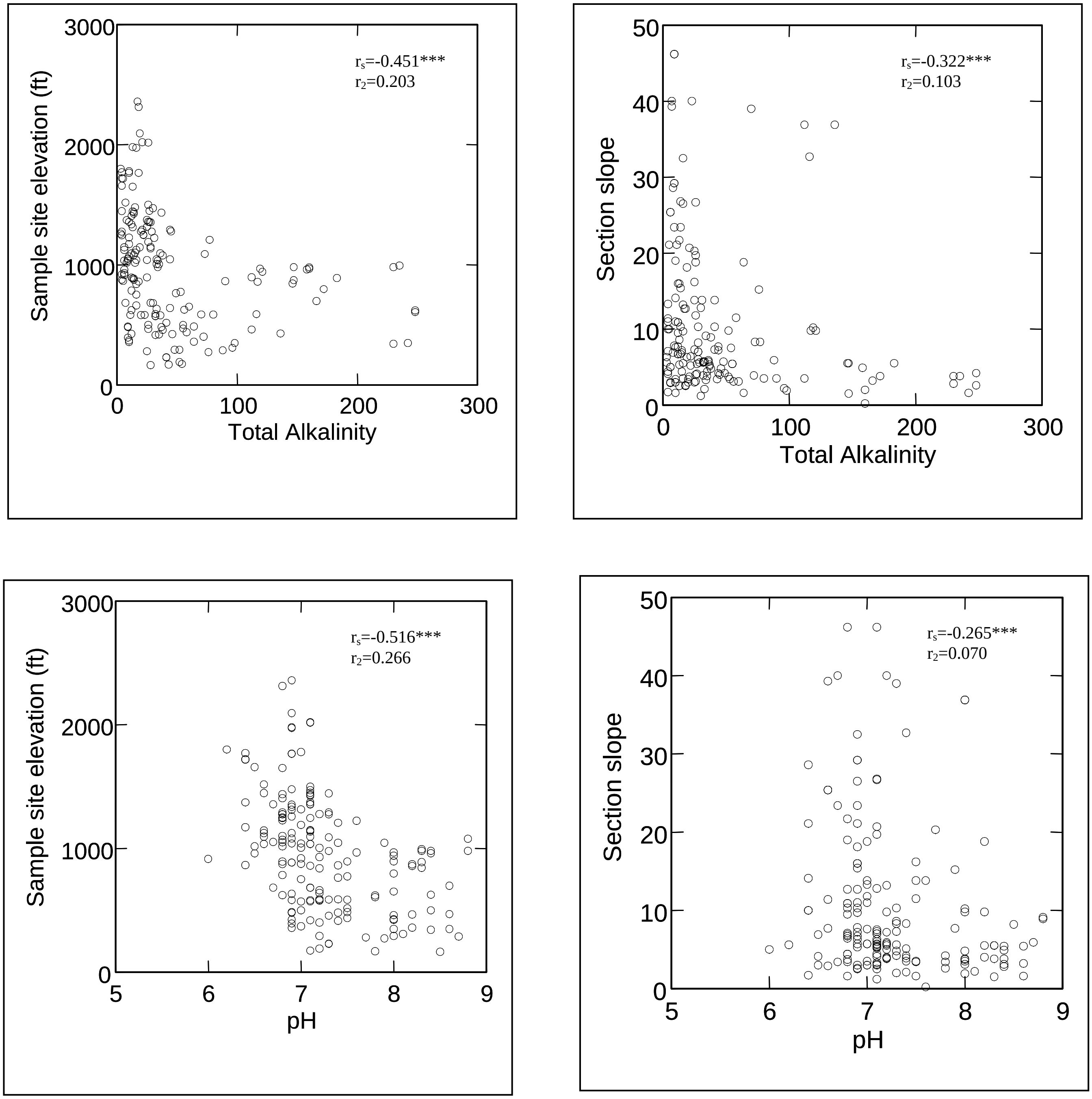

Figure 11. Scatter plots of the sample site elevation and section slope to total alkalinity and pH at each site. Spearman's Rank correlation (r_s) and the coefficient of determination (r^2) values are listed in the upper right corner of each plot. ns= no significant difference was found; * = $P < 0.05$ (significant); ** = $P < 0.01$ (highly significant); *** = $P < 0.001$ (very high significant).

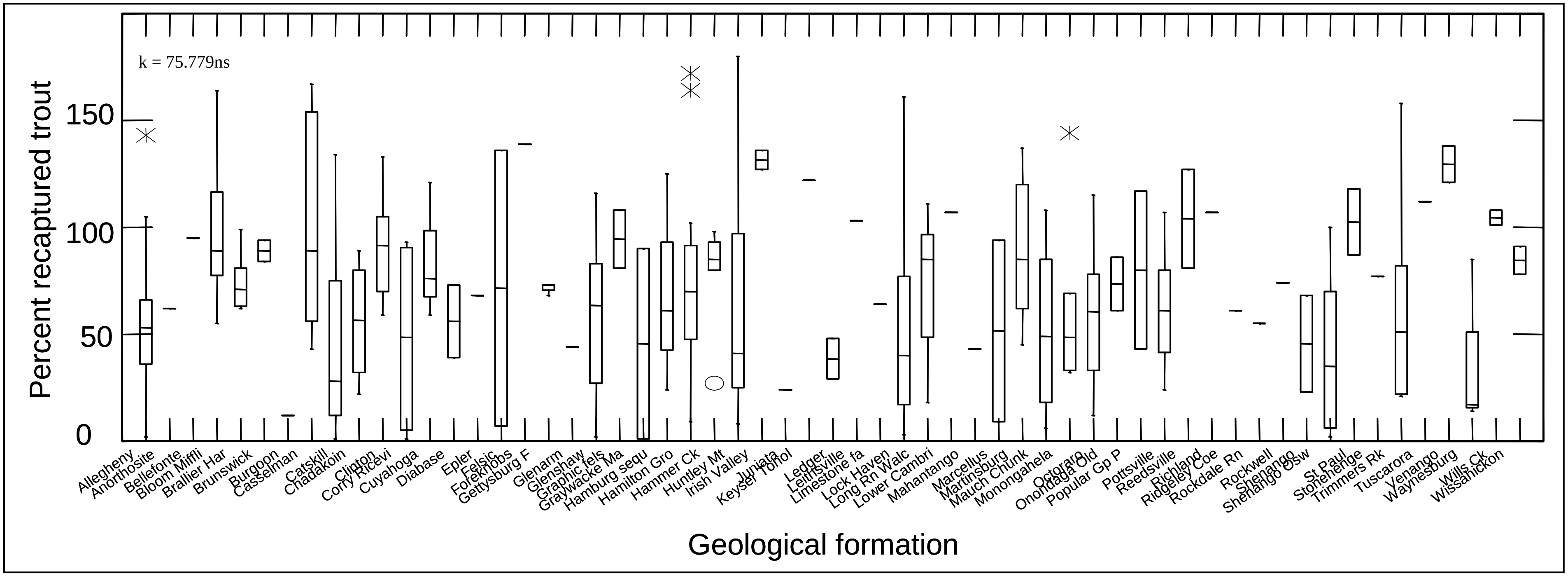

Figure 12. Comparison of the percent recaptured trout for geological formations within Pennsylvania. All geological formations were included in the analysis regardless of sample size (refer to table at end of summary). A total of 17 geological formations (Anorthosite, Bellefonte Formation, Burgoon Sandstone, Epler Formation, Foreknobs Formation, Juniata Formation, Keyser and Tonoloway Formations, undivided, Limestone fanglomerate, Lower (Middle?) Cambrian rocks, undivided, Mahantango Formation, Richland Formation, Ridgeley Formation through Coeymans Formation, undivided, Rockdale Run Formation, Stonehenge Formation, and Tuscarora Formation) had only one occurrence of a sample site with an additional 17 geological formations that had only two occurrences of sample sites with in each formation No significant difference (Kruskal-Wallis k = 75.779, P = 0.058) of percent recaptured trout was found between the 59 different geological formations.

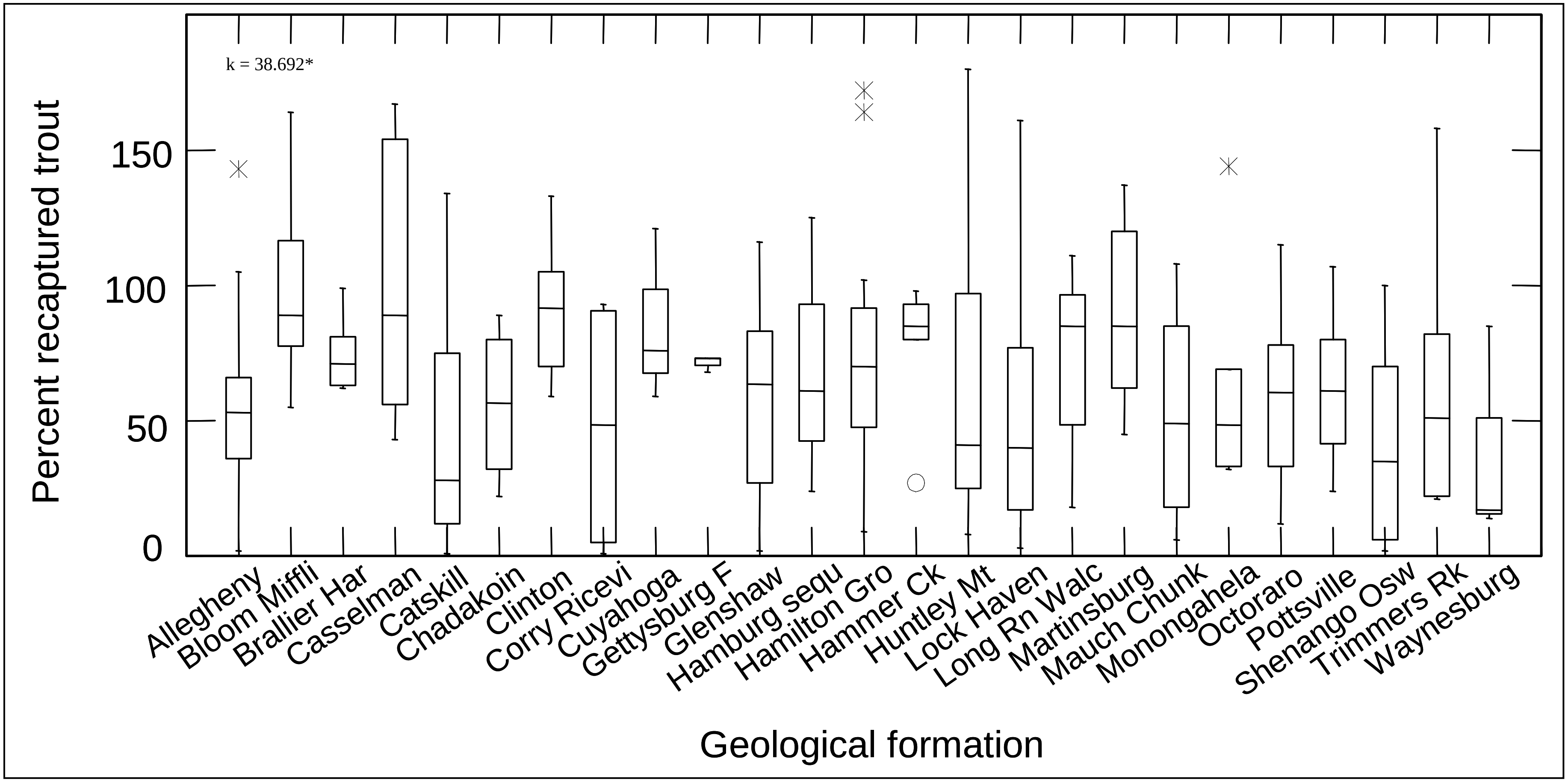

Figure13. Comparison of the percent recaptured trout between the different geological formations within Pennsylvania. Only those geological formations that had three or more occurrences of sample sites were included in the analysis. A significant difference (Kruskal-Wallis k = 38.692, *P* = 0.029) of recaptured trout was found between the remaining 25 different geological formations.

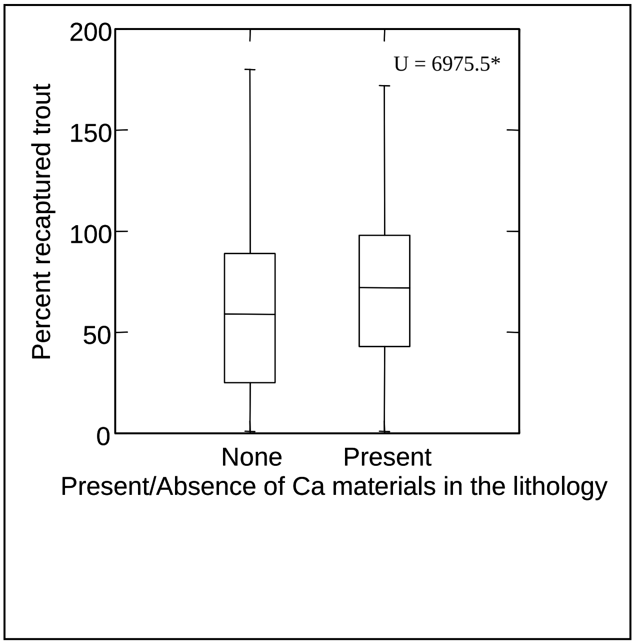

Figure 14. Box plots of the percent trout recaptured based on the presence or absence of calcium in the underlying geology. A significant difference (Mann-Whitney U=2606.0, P=0.010) of recaptured trout was found between classifications of calcareous materials with higher trout recaptured at sample sites classified as having calcareous materials present. A sample site was assigned to the presence of calcium only if the primary and/or secondary lithology description included limestone, calcareous shale, argillaceous limestone, fossiliferous limestone, and dolomite.

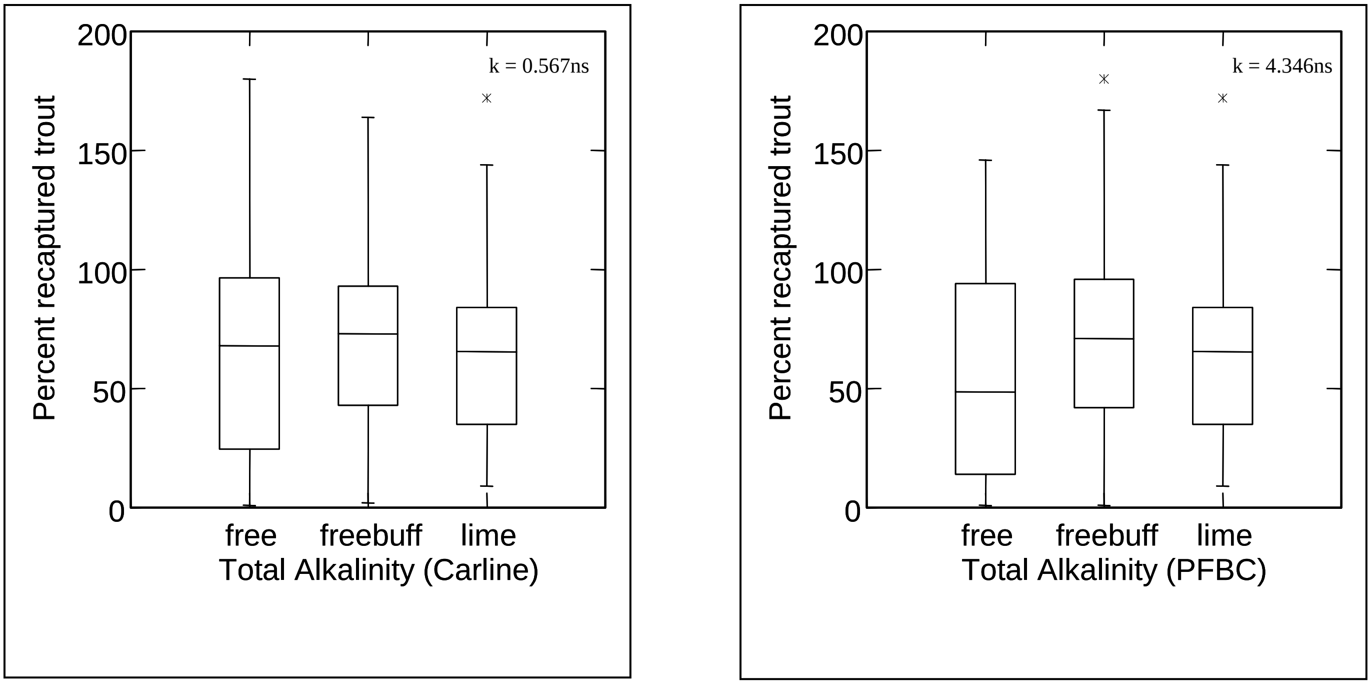

Figure 15. Comparisons of total alkalinity to the percent recaptured trout were re-examined to help clarify the influence of stream chemistries on trout residencies. No significant difference (Kruskal-Wallis, $P > 0.05$) of recaptured trout was found between either comparisons of total alkalinity. Total alkalinity was classified into three categories based on traditional PFBC values (0-10 free stone stream; 10-75 some buffer capacity; 75 and up limestone stream) and on Kocovsky and Carline (Trans Am Fish. Soc 135: 76-8; 0-24 free stone stream, 25-75 some buffer capacity; 75 and up limestone).

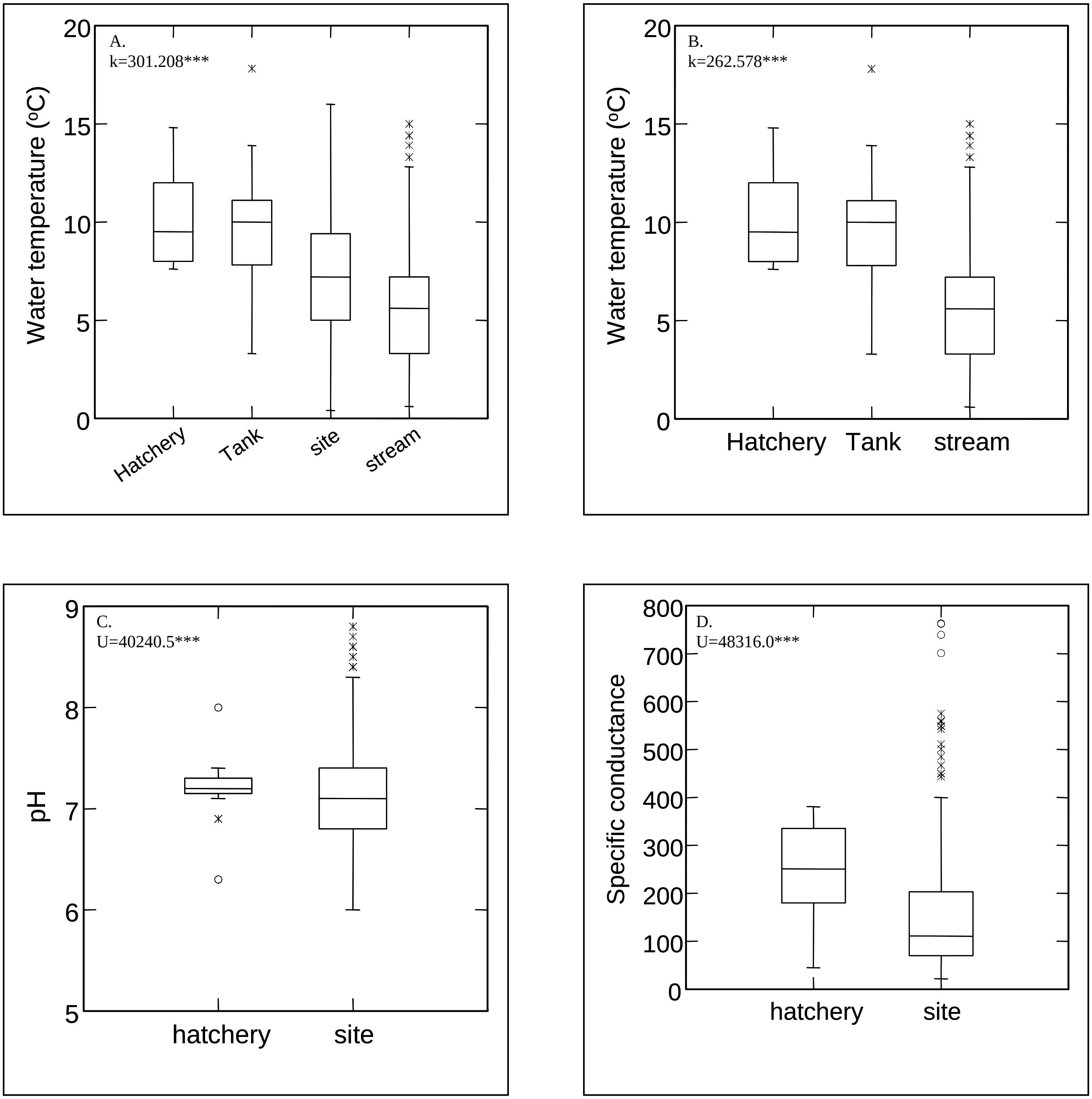

Figure 16. Box plots of the water chemistries compared among hatchery facilities, initial stocking locations (sites), and sample sites (streams). Kruskal-Wallis k-sample test and Mann-Whitney U test values are listed in the upper left corner of plots A-B and C-E, respectively. ns= no significant difference was found; * = P < 0.05 (significant); ** = P < 0.01 (highly significant); *** = P < 0.001 (very high significant), continued.

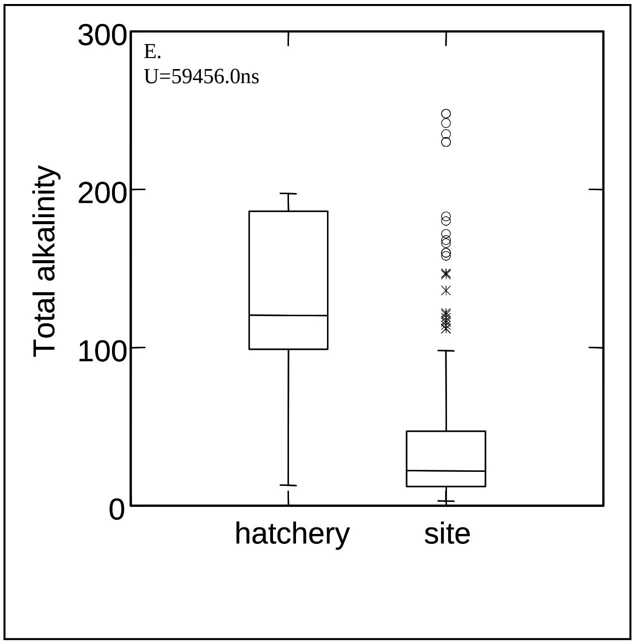

Figure 16. Continued box plots of the water chemistries compared among hatchery facilities, initial stocking locations (sites), and sample sites (streams). Kruskal-Wallis k-sample test and Mann-Whitney U test values are listed in the upper left corner of plots A-B and C-E, respectively. ns= no significant difference was found; * = *P* < 0.05 (significant); ** = *P* < 0.01 (highly significant); *** = *P* < 0.001 (very high significant)

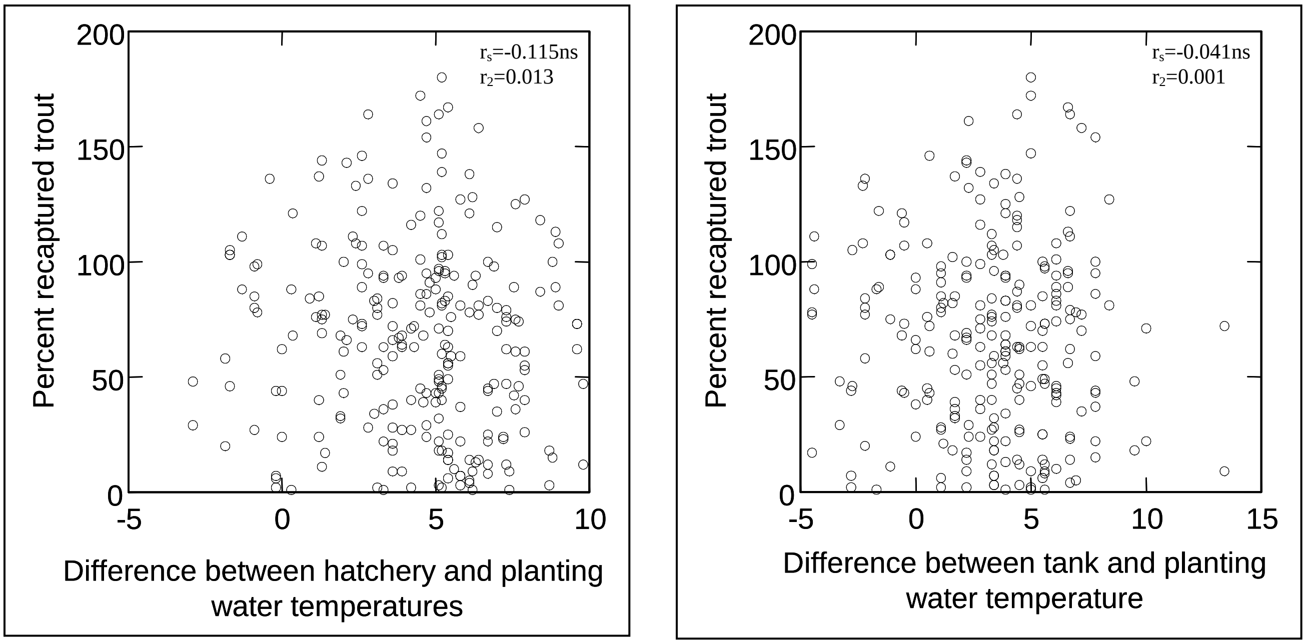

Figure 17. The Spearman's Rank correlation between the difference of hatchery water temperature and the stream water temperatures at the time of planting and the difference between truck tank water temperature and the stream water temperature at the time of planting to the percent recaptured trout. The Spearman's Rank correlation (r_s) and coefficient of determination (r^2) values for each correlation are listed in the upper right corner of each plot. ns= no significant difference was found; * = $P < 0.05$ (significant); ** = $P < 0.01$ (highly significant); *** = $P < 0.001$ (very high significant).

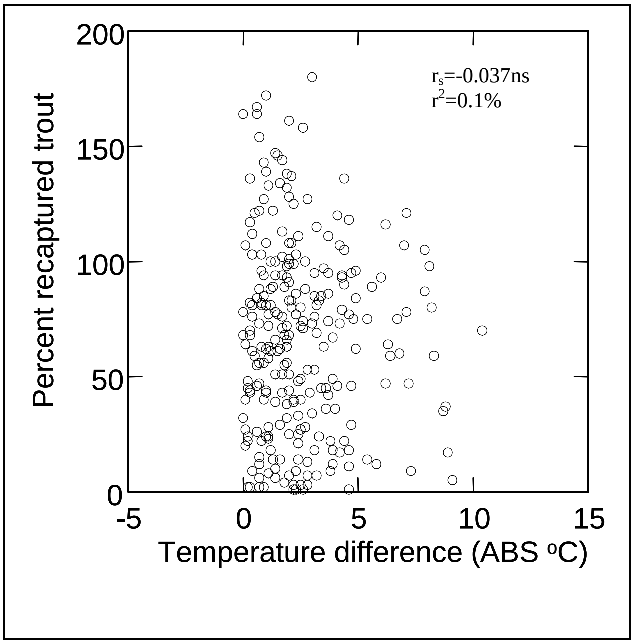

Figure 18. Scatter plot of the percent trout recaptured to the absolute difference between the water temperature at the time of planting and the time of sampling as measured at each sample site. The Spearman's Rank correlation (r_s) and coefficient of determination (r^2) values for each correlation are listed in the upper right corner of each plot. ns= no significant difference was found; * = $P <$ 0.05 (significant); ** = $P < 0.01$ (highly significant); *** = $P < 0.001$ (very high significant).

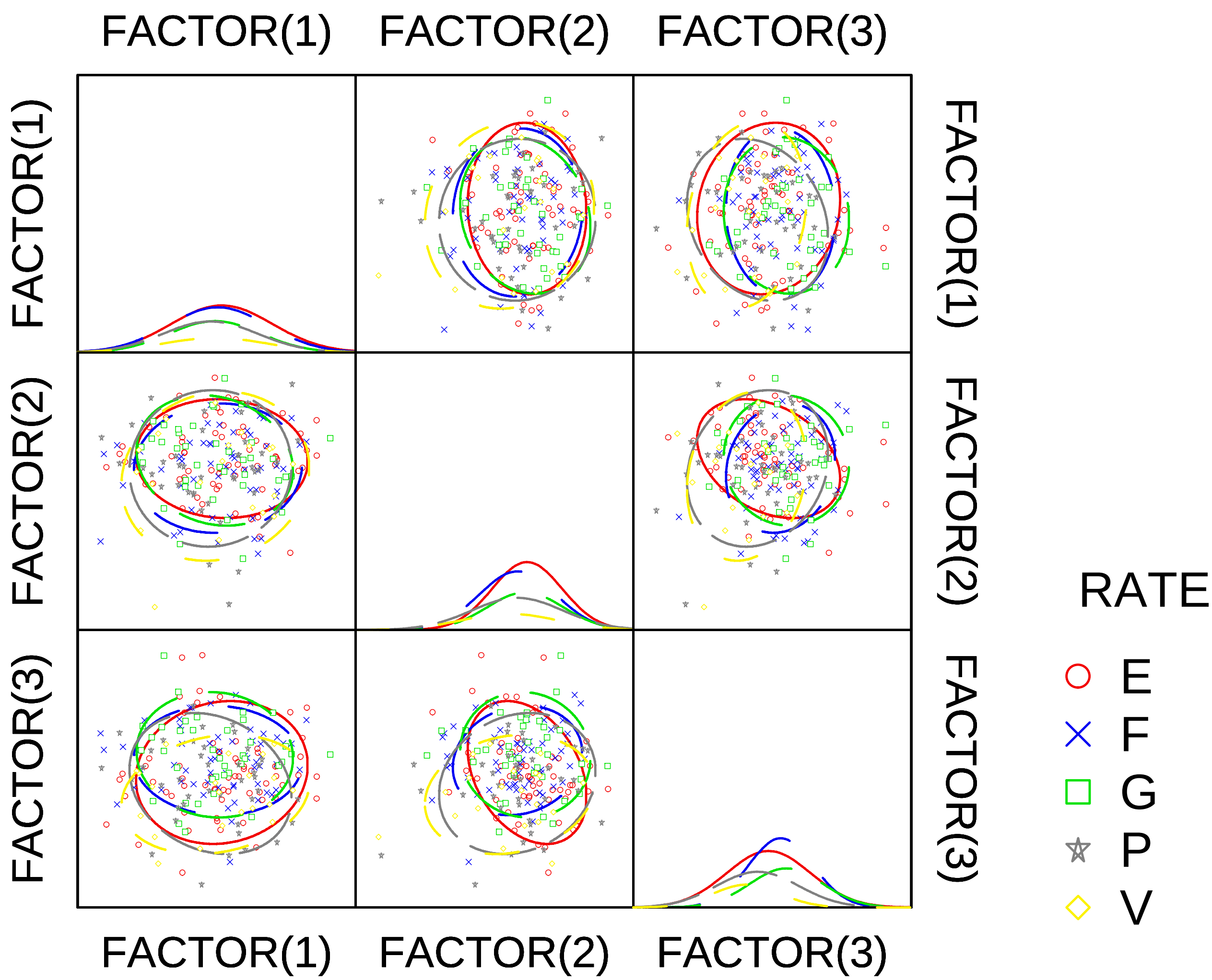

Figure 19. Principal component analysis overlays of trout recaptures as rated based on the percentage of trout recaptured relative to the total number of trout stocked at each sample site for all high gradient sample sites (n=238) plotted on the first three principal components derived from the sample site's physical, chemical, and habitat characteristics. Each rating category is encompassed by 75% confidence ellipses and normal curves illustrate the univariate distribution of the rating scores on the principal component. Letters represent recapture rating based on the scale of: E = excellent (>90%); G = good (75-89.9%); F = fair (40-74.9%); P = poor (10-39.9%); and V = very poor (<9.9%).