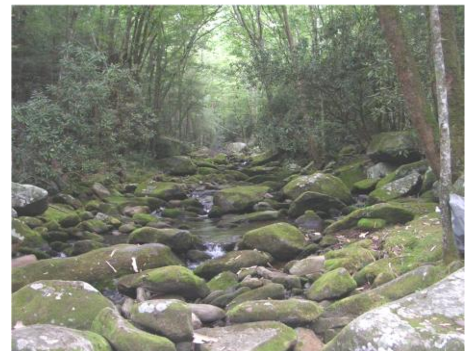
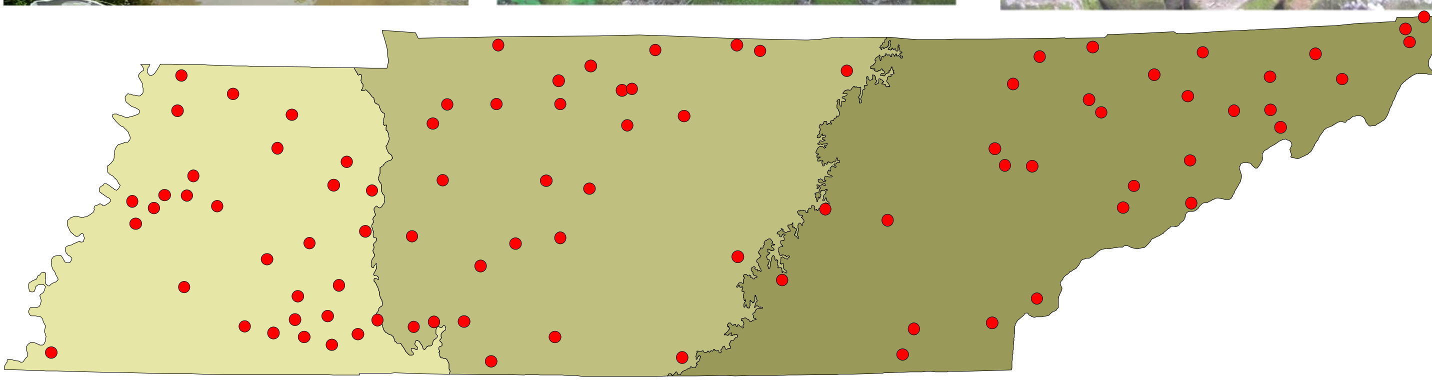
2007-8 PROBABILISTIC MONITORING OF WADEABLE STREAMS IN TENNESSEE

Volume 3: Macroinvertebrates and Habitat

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Volume 3

Macroinvertebrates
and
Habitat

By

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DEPARTMENT OF ENVIRONMENT & CONSERVATION

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Tony Olsen with the USEPA Western Ecology Division in Corvallis, Oregon assisted with the statistical survey design and provided a subsample of randomly selected wadeable streams for each of the three regions. Barbara Rosenbaum, INDUS Corporation, contractor for EPA, assisted with the random selection process.

Water Pollution Control staff from the eight Environmental Field Offices conducted the field surveys which included reconnaissance, sample collection, field measurements and habitat assessments. The managers of these staff during the study period were:

Chattanooga EFO	Dick Urban	Johnson City EFO	Jeff Horton
Columbia EFO	Tim Wilder	Knoxville EFO	Paul Schmierbach
Cookeville EFO	Rob Howard	Memphis EFO	Terry Templeton
Jackson EFO	Pat Patrick	Nashville EFO	Joe Holland

Taxonomists with the Aquatic Biology Section, Tennessee Department of Health (TDH) and the Aquatic Resources Center (contractor for TDH) processed the macroinvertebrate samples. The manager of the Aquatic Biology Section is Pat Alicea. The director of the Aquatic Resources Center is Todd Askegaard.

Cover photos provided by Water Pollution Control staff biologists.

1. INTRODUCTION

In 2000, the Division of Water Pollution Control (WPC) began to incorporate probabilistic monitoring into its stream assessment program. The 2007 Wadeable Streams Assessment (WSA) study is a probabilistically-based survey of wadeable streams in Tennessee that will build upon EPA's 2004 Wadeable Streams Assessment survey of the nation's streams (USEPA, 2006). Biological, bacteriological, physical, and chemical data from a random sub-sampling of Tennessee streams will be extrapolated to all wadeable streams in Tennessee. These data will provide a baseline to which future efforts can be compared, thus providing an opportunity for scientifically valid trend analysis.

For the purpose of this study, Tennessee was divided into three divisions based on level III ecoregions. A random sample of 30 wadeable streams was selected in each third of the state for a total of 90 sites. Results of the study will be reported in 6 volumes. Details of the site selection process and sampling protocols can be found in Volume 2 of this report series. Later volumes will address chemical, bacteriological and pathogen results.

This volume provides detail on the condition of macroinvertebrate populations and habitat quality. Biometric and habitat assessment results are presented and compared for each of the three divisions. A Tennessee Macroinvertebrate Index score was calculated for the biological data at each site and compared to regional biocriteria goals. Habitat scores were compared to regional guidelines. Statewide results were compared to the 2004 National Wadeable Stream study as well as the state's targeted monitoring program for one watershed cycle (2002-2006) and in 2007. The purpose of this volume is only to present statistical comparisons of data and not assessments of use support which is presented in Volume 1. Macroinvertebrate biometrics and habitat parameter scores for each site are provided in the appendices.

2. MACROINVERTEBRATE MONITORING

The macroinvertebrate community was sampled once at each site between July and October. Eighteen sites were sampled in 2004 as part of the national probabilistic survey. The rest were sampled in 2007 unless the biologist determined that stream conditions had changed since 2004 in which case a 2007 sample was collected. A single habitat semi-quantitative approach was used to determine the health of the aquatic community (TDEC, 2006). Riffles were sampled in middle and east Tennessee. Undercut rooted banks were sampled in low gradient west Tennessee streams.

Samples were collected by experienced stream biologists and delivered to the Aquatic Biology Lab, Tennessee Department of Health who oversaw quality assurance and calculated metrics. The majority of the samples were sub-contracted to the Aquatic Resources Center for sorting and identification. Taxa were identified to genus level within a 200 organism subsample.

The advantages of using macroinvertebrates as indicator organisms include:

- Sensitivity to nutrients and metals.
- Sensitivity to physical changes such as dissolved oxygen or temperature.
- Dependency on stable habitat.
- Limited mobility to avoid sources of pollution.
- Abundance and diversity.
- Vital position in the food chain.
- Short life cycle.

Macroinvertebrate samples were compared to the Tennessee Macroinvertebrate Index (TMI) developed for interpretation of narrative biological criteria (Arnwine and Denton, 2001). This is a multi-metric index composed of seven biometrics. The individual biometrics measure different aspects of the macroinvertebrate population from four categories that are commonly used to evaluate biological conditions (Table 1). The index ranges from 0 to 42 with a score of 32 meeting expectations. Each study site was compared to scoring criteria calibrated to the bioregion it was in (Figure 1). Biocriteria tables from Appendix A of the 2006 QSSOP for Macroinvertebrate Stream Surveys were used for scoring (TDEC, 2006).

Mayflies are important indicators of stream health. *Photo obtained from the North American Benthological Society Image Library.* ***Rich Merritt photographer.***

Table 1: Biometrics used for determination of the Tennessee Macroinvertebrate Index. Adapted from Barbour et al, 1999.

Category	Metric	Definition	Predicted response to increase in disturbance
Richness Metrics	Total Number of Taxa	Measures the overall variety of the macroinvertebrate assemblage.	Decrease
	Number of EPT taxa	Number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies).	Decrease
Composition Metrics	% EPT	Percent of the composite of mayfly, stonefly and caddisfly larvae.	Decrease
	%OC	Percent of the composite of oligochaetes (worms) and chironomids (midges).	Increase
Pollution Tolerance Metrics	NCBI	North Carolina Biotic Index uses tolerance values to weight abundance in an estimate of overall pollution (Lenat, 1993).	Increase
	% NuTol	Percent of the composite of 14 nutrient tolerant taxa (Brumley et al, 2003).	Increase
Habit Metrics	% Clingers	Percent of the macrobenthos having fixed retreats or adaptations for attachment to surfaces in flowing water.	Decrease

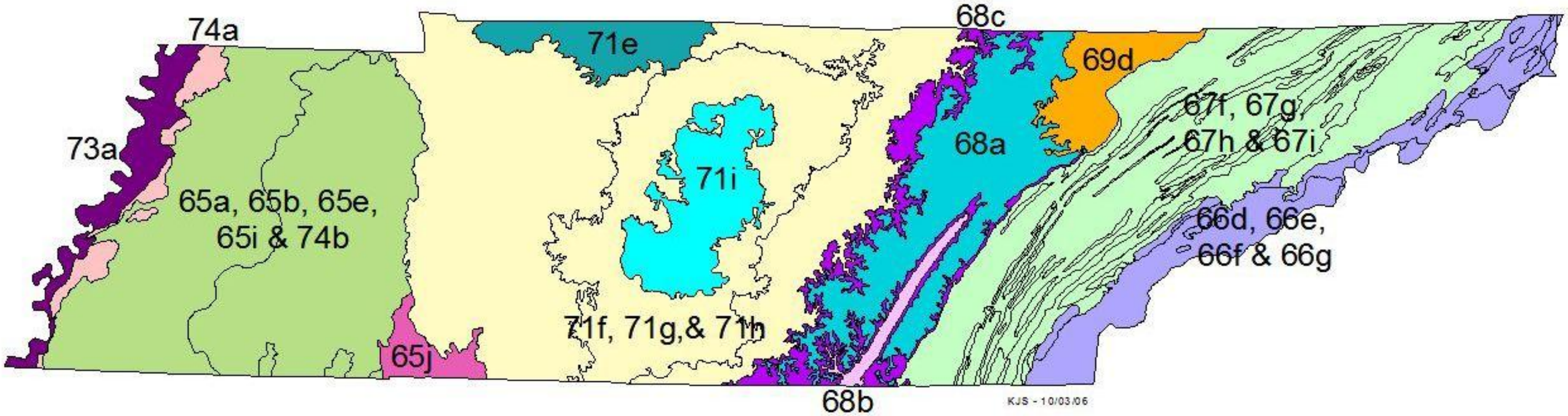


Figure 1: The thirteen bioregions of Tennessee.

a. Macroinvertebrate Results

Individual biometric and index scores for each site are presented in Appendix A. Statewide, less than half of the sites met regional biocriteria guidelines (Figure 2). The condition of the macroinvertebrate populations in east and middle Tennessee was better and relatively comparable with 57-60% of the sites meeting regional guidelines. The greatest number of streams failing to meet biological criteria was in the western portion of the state (Figure 3). Only two of the sites met regional guidelines. Although the extreme drought conditions in 2007 probably had some effect (Volume 2), riparian disturbance was also highest in this part of the state when compared to ecoregional guidelines. Only two sites (one in west Tennessee) were assessed as not meeting the target TMI score due to natural low water conditions (Volume 1). However, it is possible that drought conditions made macroinvertebrate populations more vulnerable to pollution and habitat alteration at other sites.

Loss of richness and abundance of Ephemeroptera, Plecoptera and Trichoptera (EPT), were the most common changes in macroinvertebrate populations across the state (Figure 4). An increase in the abundance of oligochaetes and chironomids was least likely to occur although it was slightly more common in west Tennessee. The abundance of nutrient tolerant organisms was generally within acceptable levels in west Tennessee streams although this division generally has more agriculture and higher nutrient levels. This metric was developed in Kentucky primarily for moderate to high gradient streams and is thought to be less sensitive in low gradient areas (Brumley et al, 2003).

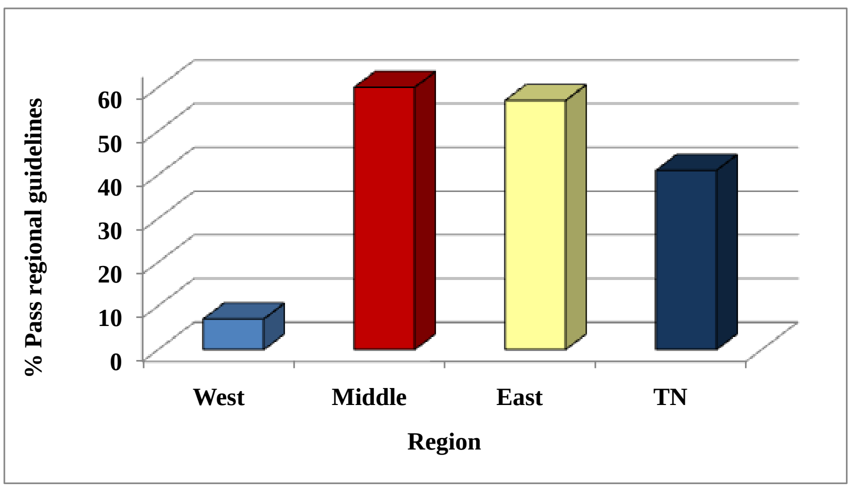
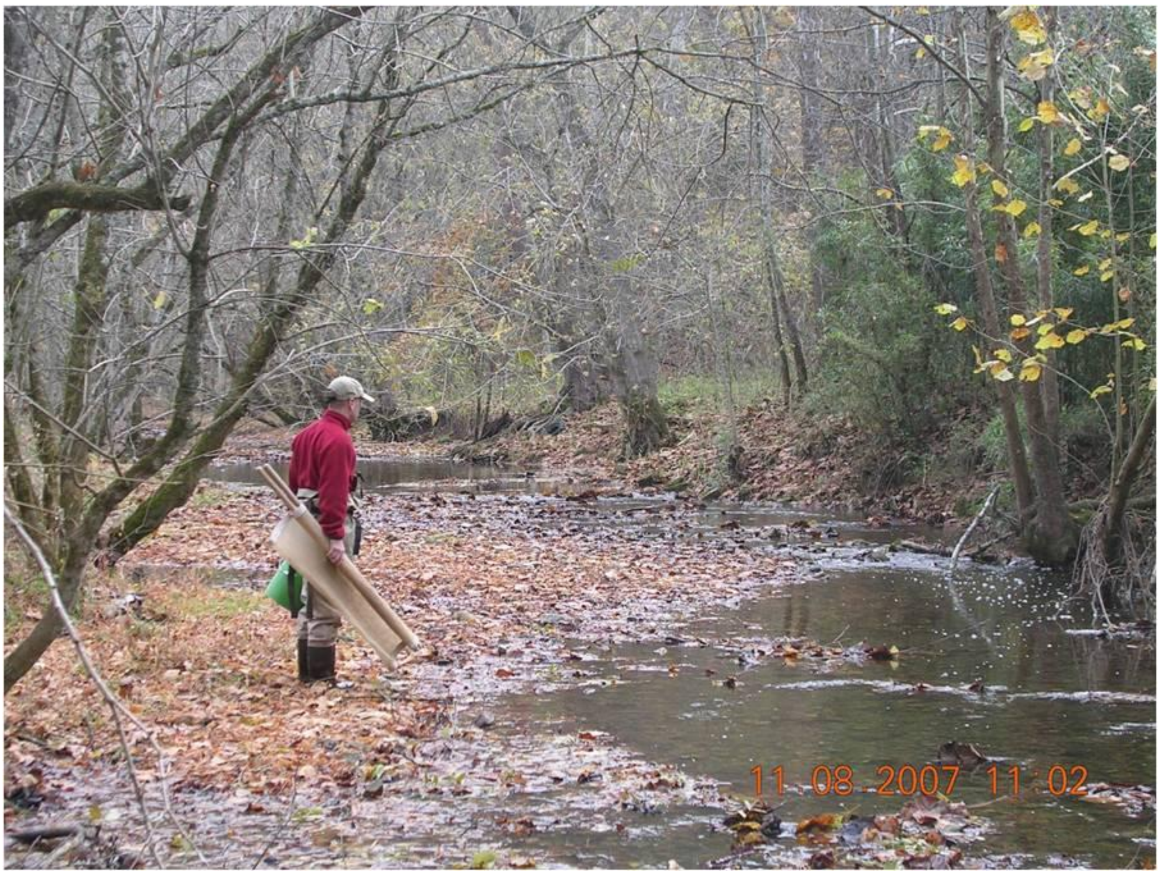


Figure 2: Percent of probabilistic sites with Tennessee Macroinvertebrate Index (TMI) scores passing regional guidelines.

One of the objectives of the study was to identify any potential reference streams from the randomly-selected stations. Macroinvertebrate samples at six sites, two in east, three in middle and one in west Tennessee scored 40 or 42 which is considered an indication of exceptional biology. Additionally, the Antidegradation Policy in Tennessee's general water quality criteria (Chapter 1200.4-3-.06) establishes a TMI score of 40 or 42 as one of the characteristics of an Exceptional Tennessee Water (ETW). These six streams have been added to the ETW list.

High scoring sites will be further studied to see if they are suitable as ecoregion reference streams. Two sites had drainage areas less than two square miles and may qualify as potential headwater reference streams.



KEFO biologist Jonathon Burr surveys Indian Creek in the Southern Limestone/Dolomite Valleys and Low Rolling Hills Ecoregion in east Tennessee. Indian Creek had macroinvertebrate scores indicative of exceptional biological diversity. Water quality and bacteriological data met criteria. Habitat scores were acceptable for the ecoregion although some riparian disturbance was observed. *Photo provided by Knoxville Environmental Field Office.*

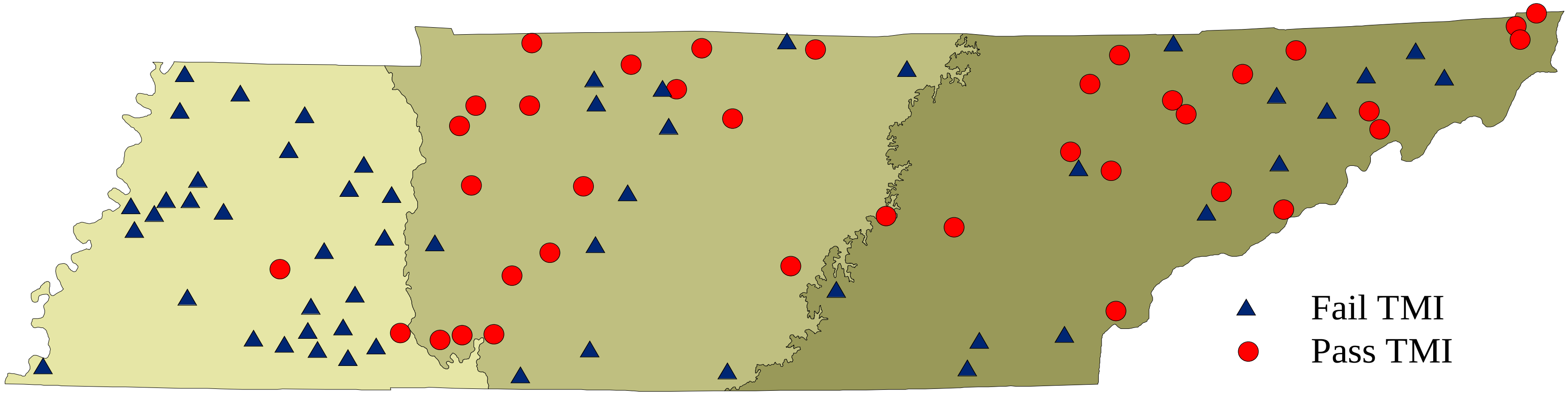


Figure 3: Location of probabilistic monitoring sites showing results of comparison to Tennessee Macroinvertebrate Index (TMI).

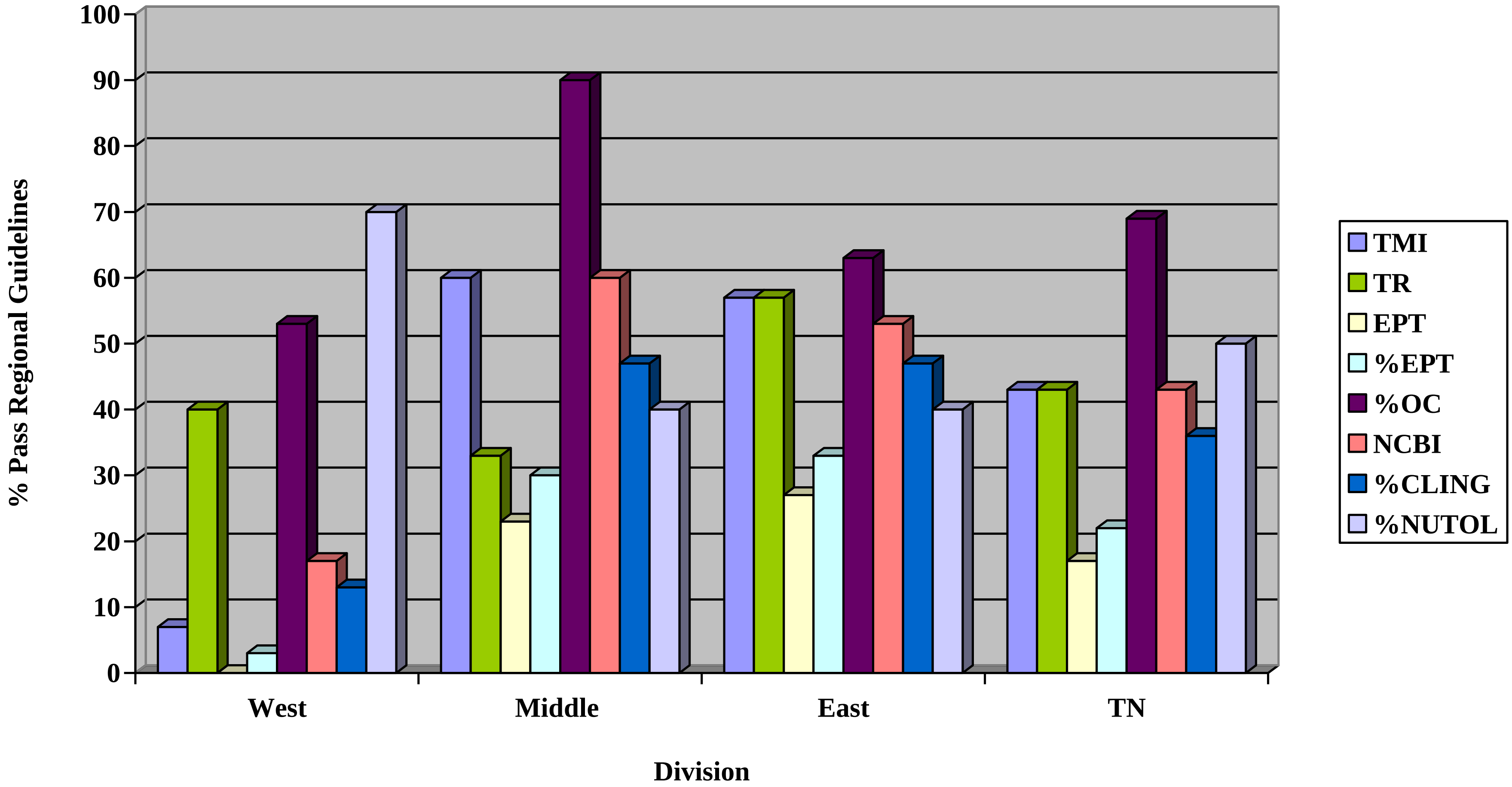


Figure 4: Percent of probabilistic sites passing regional guidelines for individual biological metrics.

b. Comparison of Macroinvertebrate Results to National Probabilistic Study

Tennessee fell into two assessment regions in the National Wadeable Streams Assessment conducted in 2004 (USEPA, 2006). Middle and east Tennessee were included in the Southern Appalachians. This region extended from Pennsylvania into Alabama, through the eastern portion of the Ohio Valley, and included the Ozark Mountains of Missouri, Arkansas and Oklahoma. West Tennessee was included in the Coastal Plains. This region covered the low-elevation areas of the east and southeastern United States, including the Atlantic and Gulf of Mexico coastal plains and the lowlands of the Mississippi Delta.

Macroinvertebrate condition assessments from the EPA report were very different from what was found during the statewide probabilistic study (Figure 5). The National Study found only 28% of the macroinvertebrate populations to be in good condition as compared to 41% in the Tennessee study. In the Southern Appalachians, only 21% of the national study sites were found to be in good biological condition whereas 57 – 60% of the sites in middle and east Tennessee passed biocriteria.

Conversely, biological communities in west Tennessee appeared to be in worse condition than those in the national Coastal Plains region. In the national study, the Coastal Plains fared better than the Southern Appalachians with 36% of the macroinvertebrate populations in the good condition category. Only seven percent of the sites in west Tennessee passed biocriteria in the statewide study.

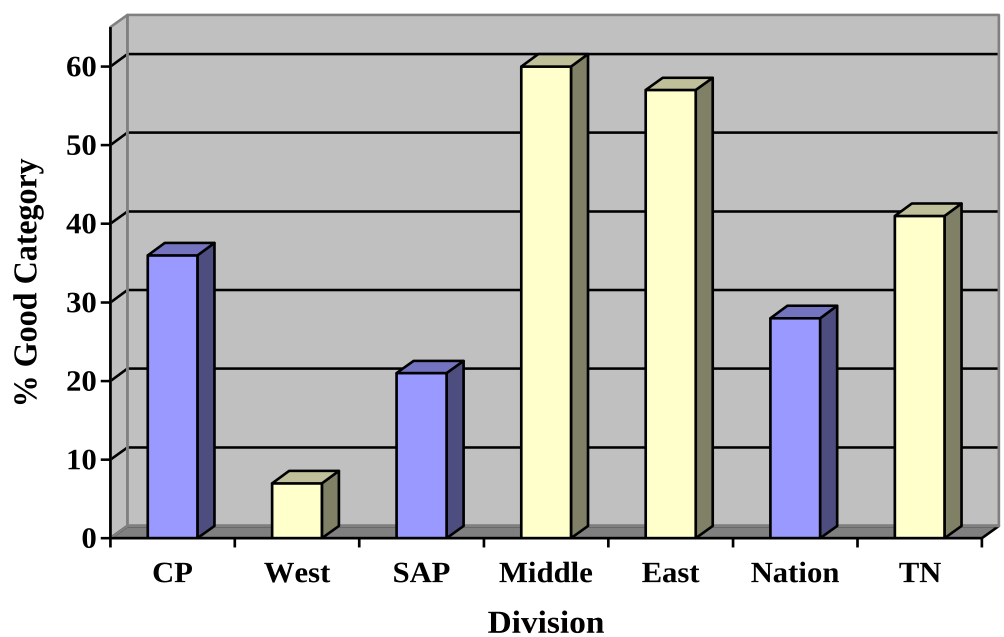
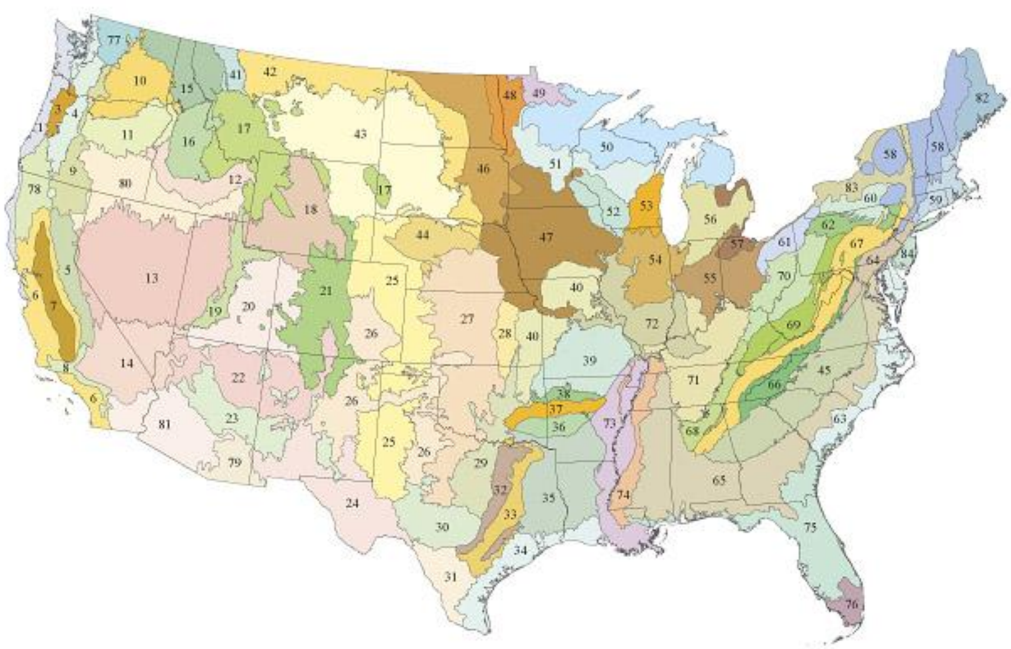


Figure 5: Comparison of 2004 national and 2007 state probabilistic study macroinvertebrate results. SAP is Southern Appalachians and CP is Coastal Plains assessment regions in the national study. Good category for state results (TN, east, middle, west) is defined as passing biocriteria guidelines.

There are several possibilities for the discrepancy in results from the national and state probabilistic studies. The most likely reason is the definition of reference condition. The national study combined multiple Level III ecoregions in order to obtain a statistically valid number of data points on a national level. There are 84 Level III Ecoregions in the continental United States (Figure 6). Each ecoregion is defined as having similarity in key ecological factors such as soils, vegetation, climate, geology and physiography (Omernik, 1995). These ecoregions are at a relatively coarse scale and have been further refined in most states to Level IV. The 84 ecoregions were combined into nine assessment units for the national study (Figure 7). This resulted in a broadening of the definition of reference condition as increasingly variable ecological systems were aggregated. For example the Southern Appalachian combined 14 relatively dissimilar Level III ecoregions such as the Blue Ridge Mountains and the Interior Plateau. Nine of these ecoregions are not found in Tennessee. Likewise, the Coastal Plains combined ten Level III ecoregions, only three of which occur in Tennessee.

To increase applicability of comparing biological indices to reference condition, the Division of Water Pollution Control uses Level IV ecoregions which are a further refinement of the relatively coarse Level III regions (Griffith et al, 1997). Ecoregions are only combined for bioassessment purposes after multiple reference streams demonstrate statistically similar macroinvertebrate populations (Arnwine et al, 2001). Whereas all streams in the national study were compared to reference condition based on nine large regions, Tennessee uses 13 bioregions for assessment purposes within the state as was previously shown in figure 1.



Map Source: USEPA, 2007

Figure 6: Level III Ecoregions in the Contiguous United States.

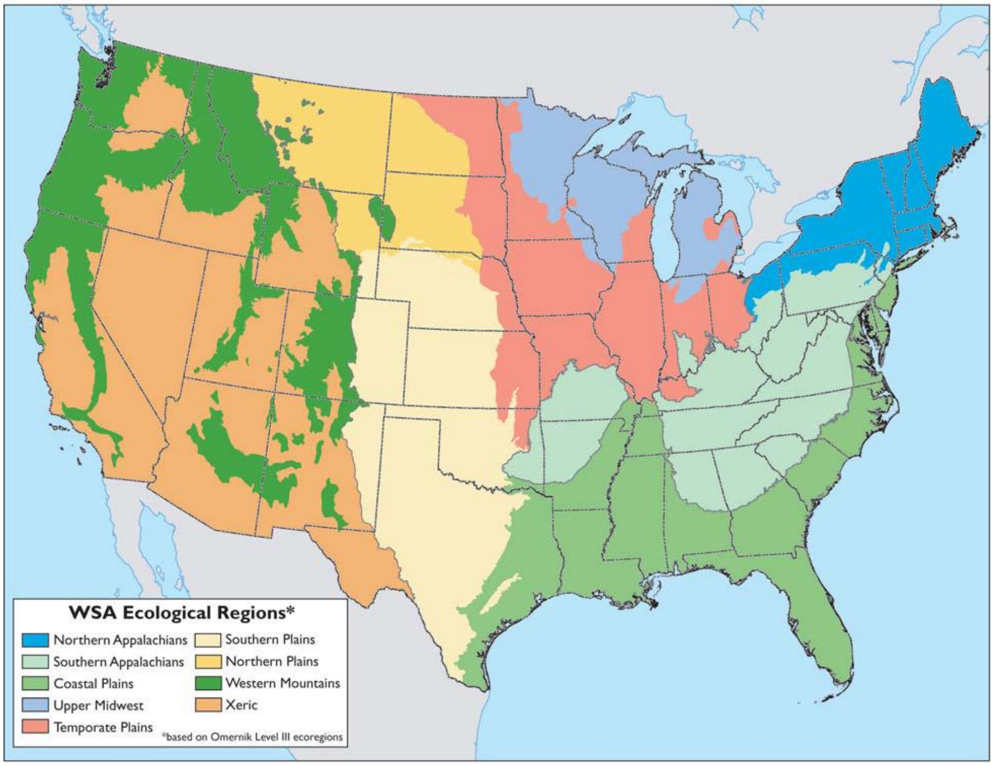


Figure 7: Aggregated ecoregions used in the 2004 national probabilistic study of wadeable streams. ***Map copied from EPA Wadeable Stream Assessment website.***

Another possible reason for the differences in biological condition is that streams in middle and east Tennessee are in better shape than those in other parts of the country included in the Southern Appalachian assessment region. West Tennessee streams may be in worse condition than other areas included in the Coastal Plains. This is impossible to determine without comprehensive probabilistic data compared to local reference streams in the other states.

Differences in sampling methodology were reviewed as another potential factor. The national study collected macroinvertebrates on eleven transects. Bottom substrate was sampled at a randomly selected point on each transect regardless of habitat type. As described earlier, the Tennessee method targets the single most productive habitat. Also the national method used a 500 organism subsample versus Tennessee's 200 organism subsample.

A side-by-side comparison of both methods used at the 24 sites collected in Tennessee during the 2004 national study was done to further explore this possibility. When compared to Tennessee bioregion criteria, there were no differences in the assessments using either method (Figure 8). The same 14 sites passed biocriteria guidelines regardless of sampling method.

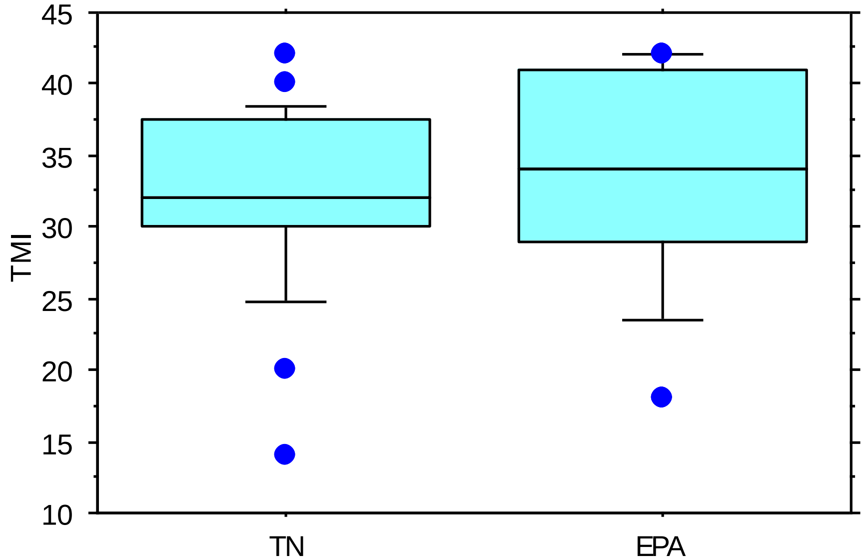


Figure 8: Comparison of TMI scores between Tennessee targeted habitat and EPA reachwide sampling methods. N = 24

c. Comparison of Probabilistic Macroinvertebrate Results to Targeted Monitoring Program.

Tennessee has a comprehensive targeted biological monitoring program. Each year, staff biologists conduct biological surveys at 400 to 500 sampling stations across the state. The sites are primarily concentrated in 20% of the watersheds on a five year rotating basis. Sampling includes a combination of semi-quantitative and qualitative sampling depending on the purpose of the survey. Semi-quantitative samples are more definitive while qualitative samples are primarily for screening purposes. The level of identification also varies depending on the focus of the survey. Probabilistic monitoring tends to be used for special studies.

Biological results from the probabilistic wadeable streams project were compared to targeted monitoring for both the 2007 drought year and one full watershed cycle (2002 – 2006) where flow and temperature conditions were more typical. After correction for ambiguous biorecons (Table 2), probabilistic data in the eastern division had comparable scores to targeted monitoring results (Figure 9). The number of sites that passed biological guidelines was within four percent between the drought and non-drought years and between probabilistic and targeted monitoring.

Division staff in east Tennessee conducted the most targeted biological surveys during each monitoring cycle (Figure 10). The majority of the samples were semi-quantitative allowing for a wider range of variables in the biological community to be statistically evaluated. When qualitative biorecons were collected, they were identified to the more sensitive genus level. These factors may help account for the greater similarity of results between targeted and probabilistic sites in this division.

Targeted monitoring between drought and non-drought years was also comparable in the middle division of the state. There was a 13 to 16% discrepancy between targeted and probabilistic results. Although slightly fewer samples are collected in this division, there is comprehensive coverage of watersheds. The discrepancy may be a reflection of sample type. The majority of targeted samples were qualitative biorecons identified to the family level. This limits the number of metrics that can be used and is generally less sensitive than either semi-quantitative samples or biorecons identified to genus. However, it does allow for screening of a large number of sites with fewer staff.

The biggest discrepancy occurred in west Tennessee. There was a 12% difference between targeted monitoring in 2002-06 and 2007. This could be a result of drought, a reflection of which watersheds were sampled or a result of reduced targeted monitoring in 2007 because of the probabilistic study. There was an even bigger difference between probabilistic and targeted monitoring. Only seven percent of the probabilistic sites passed regional guidelines while 41-53% of the targeted sites passed. The majority of west Tennessee is covered by a single field office. Due to staff covering a larger geographical area, far fewer targeted sites are sampled in the western division watersheds. This may help account for the discrepancy.

Table 2: Results of targeted biological monitoring from 2002 – 2007.

2002- 2006 Targeted Monitoring									
	Semi-Quantitative			**Biorecon**			**Total**		
	West	Middle	East	West	Middle	East	West	Middle	East
Ambiguous	NA	NA	NA	66	128	78	66	128	78
Fail	80	46	330	76	64	70	156	110	400
Pass	16	88	312	207	468	126	223	556	438
Total	96	134	642	349	660	274	445	794	916
No. pass after ambiguous sample assessment	NA	NA	NA	NA	NA	NA	235	601	483
2007 Targeted Monitoring									
	Semi-Quantitative			**Biorecon**			**Total**		
	West	Middle	East	West	Middle	East	West	Middle	East
Ambiguous	NA	NA	NA	12	30	34	12	30	34
Fail	18	9	82	11	17	17	29	26	99
Pass	5	19	82	18	94	34	23	113	116
Total	23	28	164	41	141	81	64	169	249
No. pass after ambiguous sample assessment	NA	NA	NA	NA	NA	NA	26	124	136

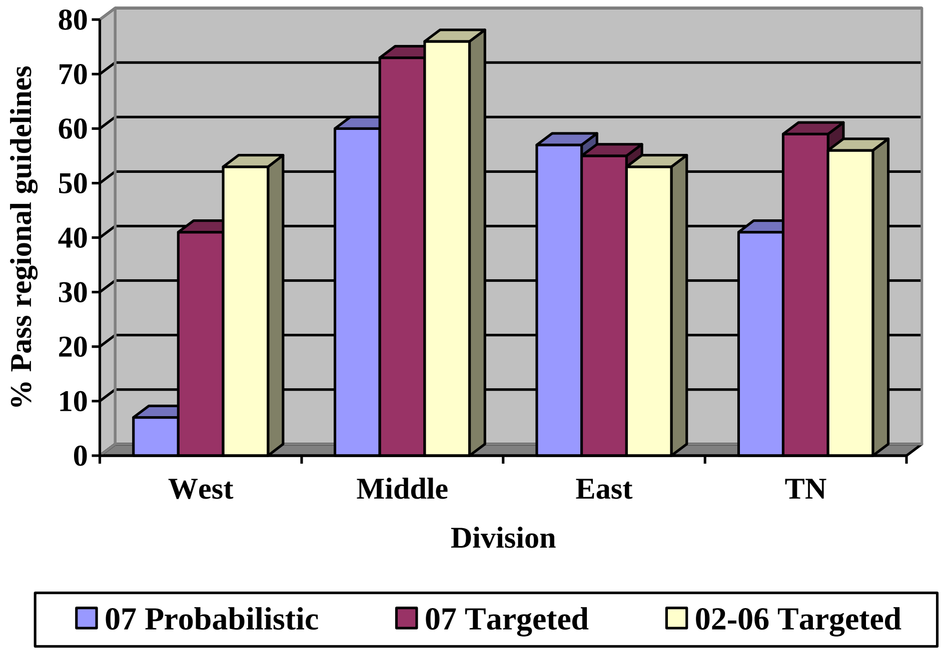


Figure 9: Comparison of targeted and probabilistic samples passing regional biological guidelines after correction for ambiguous biorecon results. Data include both semi-quantitative and qualitative biorecon samples. Correction of ambiguous biorecons from 2002–2006 is based on assessments. Corrections for targeted 2007 are based on extrapolations of the percentage of ambiguous results passing guidelines from 2002-2006.

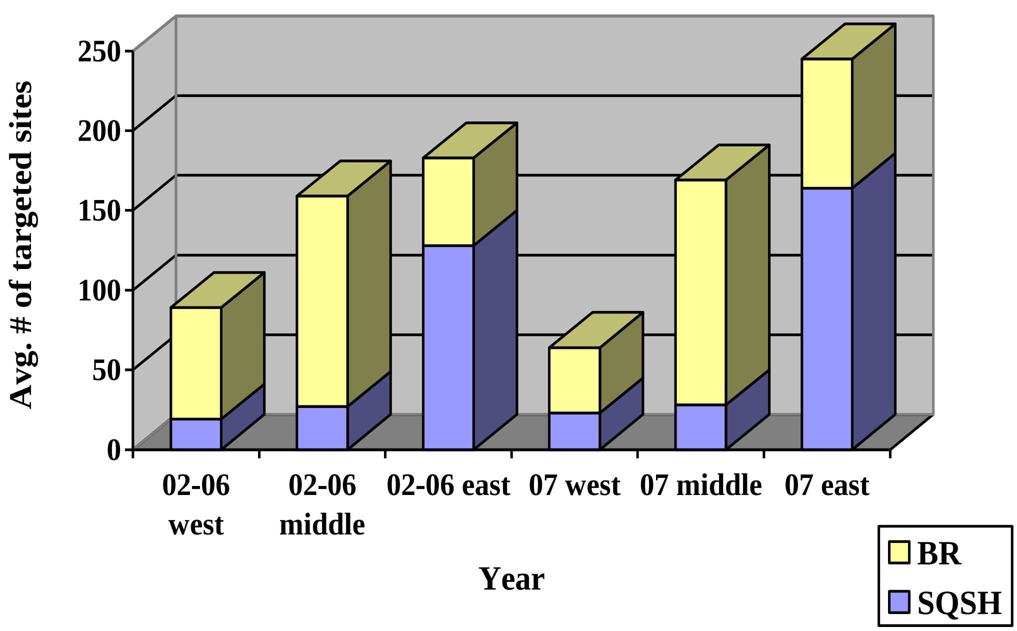


Figure 10: Average number of biological samples collected at targeted monitoring sites 2002 – 2007. SQSH is semi-quantitative single habitat, BR is qualitative biorecon.

3. HABITAT

Clean, diverse and stable habitat is a necessity to maintain a healthy stream community. Habitat assessments were conducted concurrently with the macroinvertebrate samples using EPA's Rapid Bioassessment technique (Barbour et al, 1999). This method uses qualitative assessments of ten parameters that varied depending on stream gradient (Table 3). High gradient protocols were used in east and middle Tennessee. Low gradient protocols were used in west Tennessee except for three sites in the Transition Hills (ecoregion 65j). Assessments were conducted by two experienced stream biologists with scores arbitrated in the field. The entire sample reach was evaluated for each parameter.

Table 3: Habitat assessment parameters.

High Gradient Streams	**Low Gradient Streams**
Epifaunal Substrate/Available Cover	Epifaunal Substrate/Available Cover
Embeddedness	Pool Substrate Characterization
Velocity/Depth Regime	Pool Variability
Sediment Deposition	Sediment Deposition
Channel Flow Status	Channel Flow Status
Channel Alteration	Channel Alteration
Frequency of Riffles or Bends	Channel Sinuosity
Bank Stability	Bank Stability
Vegetative Protective Score	Vegetative Protective Score
Riparian Vegetative Zone Width	Riparian Vegetative Zone Width

Total habitat scores range from 0 to 200. Regional expectations for each parameter as well as the total habitat score have been calibrated for each Level IV ecoregion in Tennessee (TDEC, 2006). These guidelines were used to determine if the seven components of the habitat assessment that were common to all three divisions as well as if the total habitat scores were sufficient to support stream biota at each site (Table 4). Habitat scores for all parameters are provided in Appendix B.

Approximately half of the sites met regional expectations for total habitat (Figure 11). The majority of sites in middle Tennessee were at or above habitat guidelines for ecoregions in that division. A little less than half of the sites in east Tennessee met guidelines while a third met them in west Tennessee. Loss of riparian habitat was a common factor in all three divisions and was the most frequent parameter to fall below guidelines in east and west Tennessee. Only ten percent of the probabilistic sites in the western division had adequate riparian width. Lack of flow due to drought was the parameter most often below guidelines in middle Tennessee.

Table 4: Number of probabilistic monitoring sites that met regional expectations for select habitat parameters. N = 30 for each division.

	West	Middle	East	Tennessee
Epifaunal Substrate/ Available Cover	11	26	19	56
Sediment Deposition	19	21	18	58
Channel Flow Status	9	17	19	45
Channel Alteration	17	25	26	68
Bank Stability	25	19	16	60
Vegetative Protective Score	16	25	16	57
Riparian Vegetative Zone Width	3	20	13	36
Total Habitat Score (10 parameters)	10	26	13	49

Four of the habitat parameters used by TDEC (sediment deposition, epifaunal substrate, riparian vegetation width and vegetative protection) were similar to components of the habitat assessed in the 2004 national study. However, it should be noted that the national study used a more comprehensive and somewhat more quantitative approach. Maps showing the distribution of Tennessee sites that met or failed regional guidelines for these parameters are provided in Appendix B.

NEFO biologist Kim Sparks assesses habitat at Drakes Creek in Sumner County.

Photo provided by PAS.

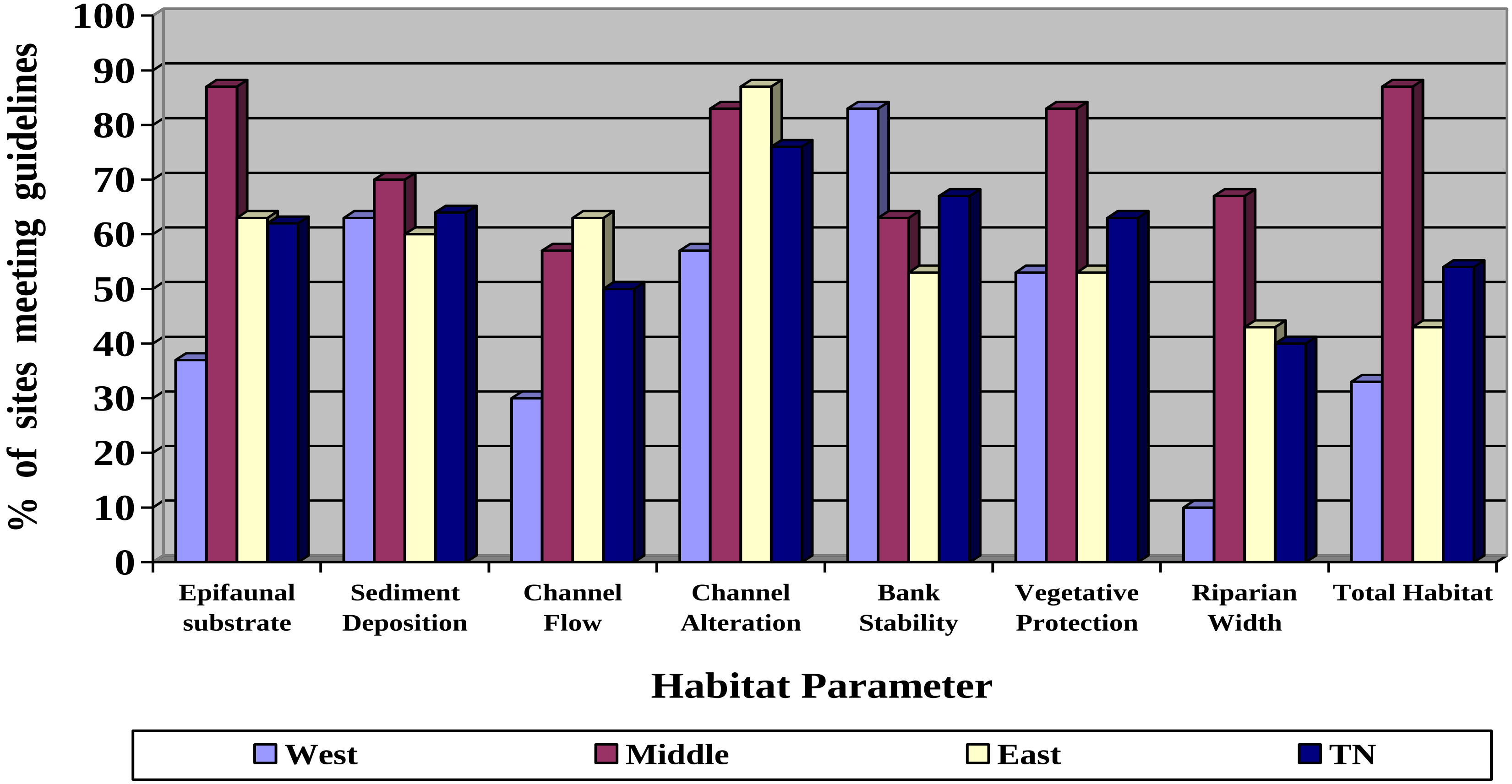


Figure 11: Percent of probabilistic sites meeting regional guidelines for habitat.

a. Epifaunal Substrate and Available Cover

In the national study this component of the habitat was called in-stream fish habitat. The purpose of both studies was to evaluate the quantity and variety of natural structures in the stream such as cobble riffles, boulders, rock crevices, fallen trees, macrophyte beds and undercut, rooted banks. A wide variety of submerged structures provide the stream biota with numerous places to hide, feed and reproduce. As the variety of cover is reduced, biotic diversity is compromised and there is less potential for recovery following disturbances.

Tennessee streams were slightly more likely to be in the good category than the nation as a whole (Figure 12). East Tennessee was comparable to other streams in the Southern Appalachian region while middle Tennessee had a higher percentage of sites where the complexity of substrate had not been compromised. It should be noted that this does not mean middle Tennessee streams have more variety of cover than those in east Tennessee as the scoring for each parameter is calibrated for typical streams in each region. For example, mountain streams are expected to have a higher degree of substrate complexity than those in the Interior Plateau. Streams in west Tennessee were slightly more likely to have disturbed cover compared to streams in the national Coastal Plains assessment region.

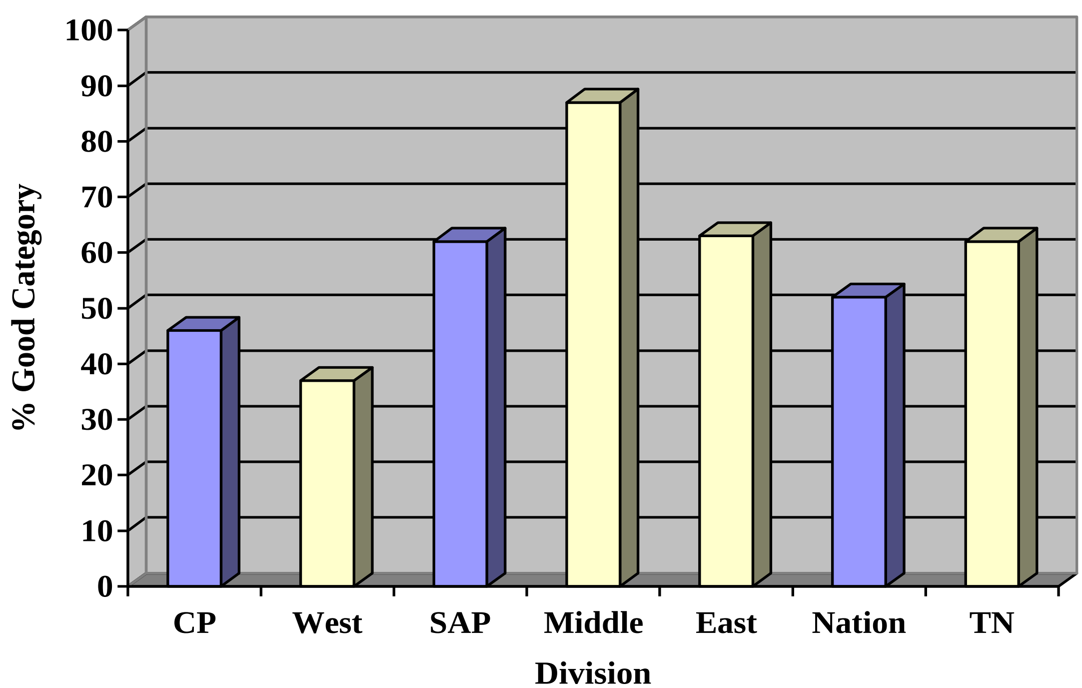


Figure 12: Comparison of epifaunal substrate and available cover between the national and state wadeable stream probabilistic surveys.

b. Sediment Deposition

Sediment deposition was compared to streambed sediments in the national study. Although the national study used a much more comprehensive method, both surveys attempted to determine whether there was an increase in the amount of fine sediments over reference condition that resulted in changes to the natural stream substrate and flow patterns. High levels of sediment deposition are characteristic of an unstable stream that becomes unsuitable habitat for many organisms. Based on these methods, 20-30% more streams in east and middle Tennessee would fall in the good category than those in the EPA Southern Appalachians assessment region (Figure 13). The condition of west Tennessee streams was comparable to those in the Coastal Plains.

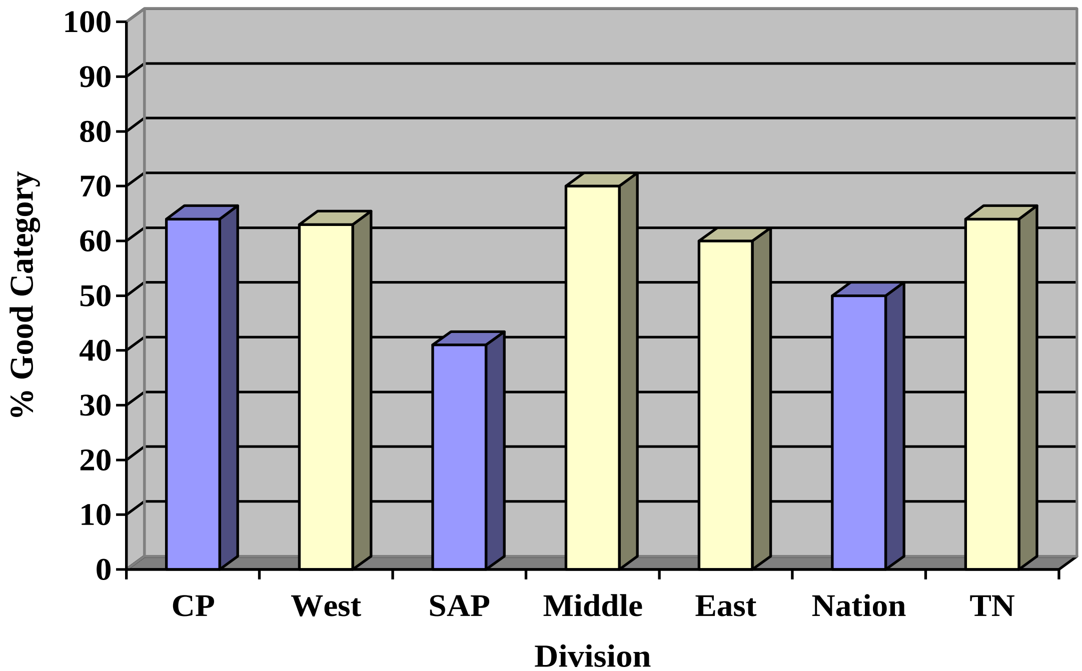


Figure 13: Comparison of assessments of fine sediments between the national and state wadeable stream probabilistic surveys.

c. Riparian Vegetation Width

This parameter was compared to riparian disturbance in the national study. The metric determines the proportion of riparian zone vegetation that has been disturbed by human activities. This vegetative zone serves to buffer pollutants entering a stream from runoff and controls erosion. The riparian zone also provides habitat and food to stream organisms.

Although riparian disturbance was one of the most frequent habitat problems documented at east and middle Tennessee sites, streams were generally in better condition than those in EPA's Southern Appalachian assessment region (Figure 14). However, west Tennessee streams were more likely to have riparian disturbance than those in the Coastal Plains region.

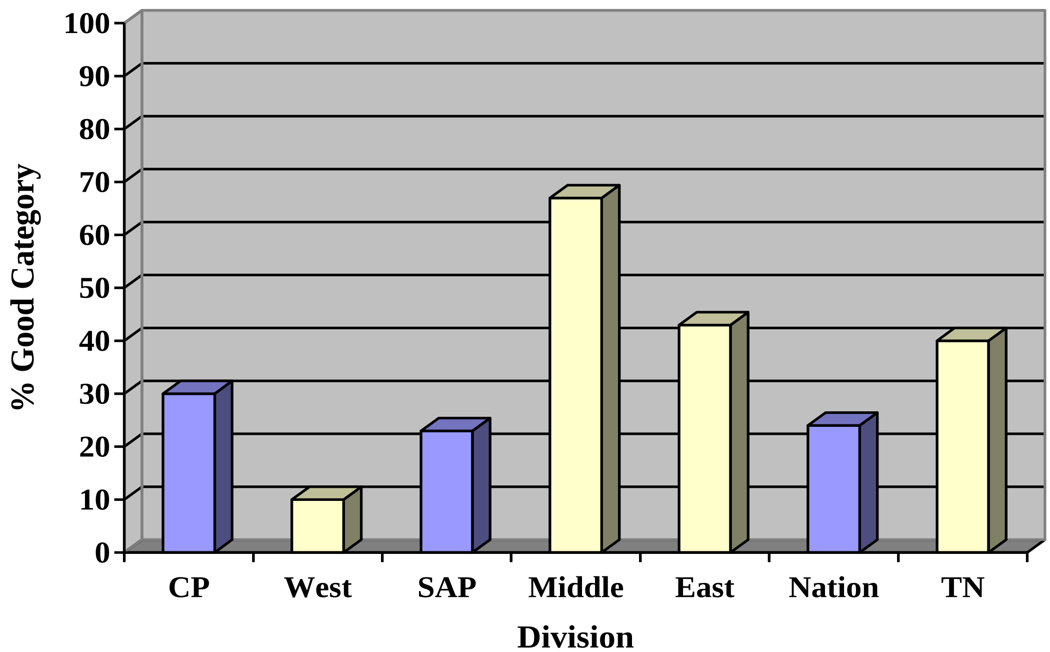


Figure 14: Comparison of assessments of riparian zone disturbance between the national and state wadeable stream probabilistic surveys.

d. Vegetative Protection

This category corresponds to the riparian vegetative cover in the national study. The parameter determines whether the streambank is covered by multiple layers of native vegetation. Undisturbed streambank riparian helps reduce pollutant runoff, stabilizes banks and reduces water temperatures through shading. Streambank vegetation also provides food and habitat for a variety of aquatic organisms. Ideally, the streambank should be covered by native vegetation including a mixture of large trees, understory and groundcover.

The condition of bank vegetation in east and west Tennessee was comparable to streams in the national study for their respective assessment regions (Figure 15). Middle Tennessee streams were more likely to have bank vegetation in the good category.

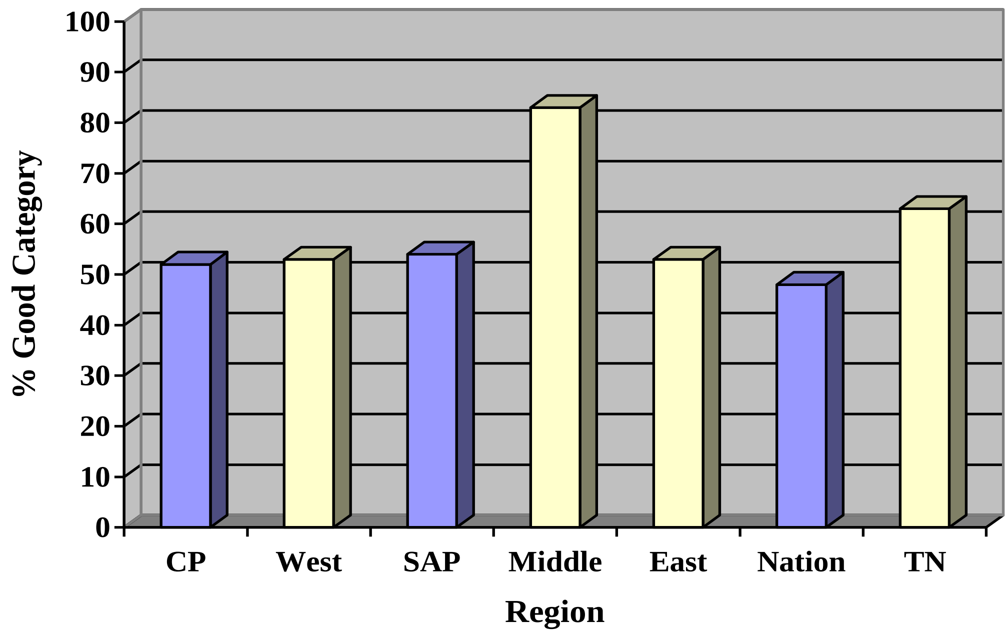


Figure 15: Comparison of assessments of native vegetative cover between the national and state wadeable stream probabilistic surveys.

Streambanks covered by native vegetation including trees, understory and ground cover is important for aquatic life. *Photo provided by Nashville Environmental Field office.*

4. SUMMARY

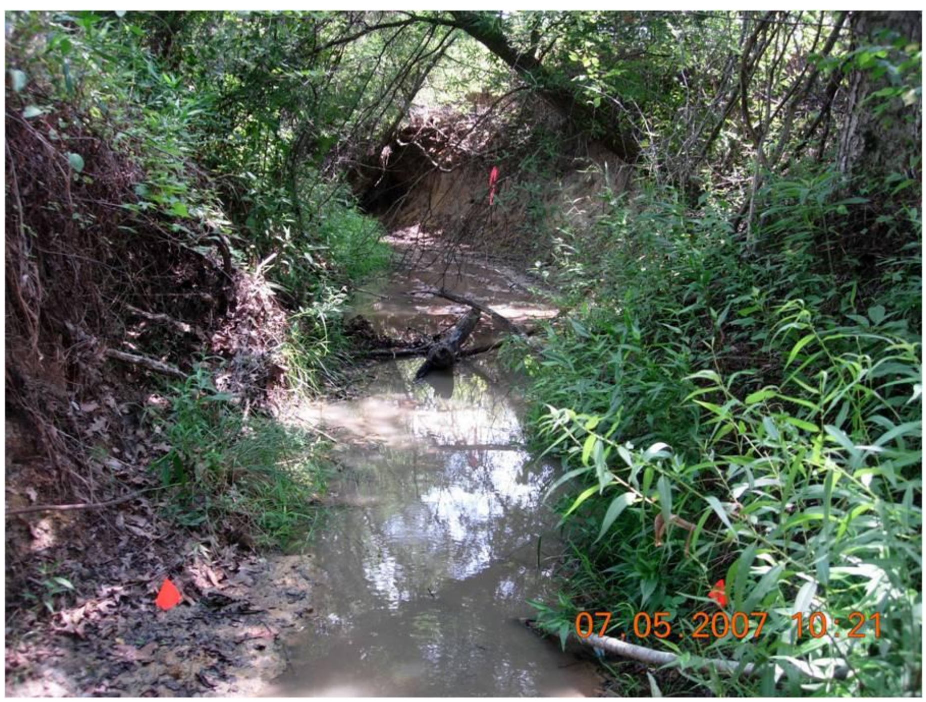
Probabilistic monitoring results indicate approximately 60% of the wadeable streams in middle and east Tennessee have macroinvertebrate populations meeting regional guidelines. Less than ten percent of streams in west Tennessee met regional guidelines. Loss of richness and abundance of generally intolerant EPT taxa were the most common indicators of stress across the state. Six sites, including two headwater streams, scored high enough to be considered for inclusion in the reference stream program.

According to this study, middle Tennessee streams are most likely to meet regional habitat guidelines. Loss of riparian was a common factor in all three divisions. Only ten percent of streams in west Tennessee had adequate riparian. East and middle Tennessee were generally in better condition than indicated for the Southern Appalachian assessment region in the national study. West Tennessee was similar to Coastal Plain streams in all categories except riparian disturbance where fewer streams would fall in the good category.

Although drought conditions limited the random selection of streams to those with flow, study results were probably not affected based on a comparison of targeted monitoring in drought and non-drought years. Probabilistic monitoring results appear comparable to targeted monitoring in areas where a large number of sites are surveyed in each watershed. Results were most comparable where the majority of targeted monitoring sites were semi-quantitative and biorecons were identified to a lower taxonomic level. Probabilistic monitoring could be used to supplement monitoring in areas where a comprehensive targeted approach may not be feasible. It also provides a good baseline for future statewide trend analyses by equalizing effort across the state.

An unnamed tributary to South Fork Forked Deer River scored the highest on the macroinvertebrate index in West Tennessee.

Photo provided by Jackson Environmental Field Office.



LITERATURE CITED

Arnwine, D.H., J.I. Broach, L.K. Cartwright and G.M. Denton. 2000. *Tennessee Ecoregion Project.* Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee.

Arnwine, D.H. and G.M. Denton. 2001. *Development of Regionally-based Numeric Interpretations of Tennessee's Narrative Biological Integrity Criteria.* Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee.

Barbour, M.T., Gerritsen, J., Snyder, B.D. and J.B. Stribling. 1999. *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers.* EPA 841-B-99-002. U.S. Environmental Protection Agency, Office of Water, Washington D.C.

Brumley J.F., G.J. Pond and M.C. Compton. 2003. *Determining Nutrient Impairment Using Biological and Other Non-Chemical Indicators in Kentucky Streams.* Kentucky Department for Environmental Protection. Division of Water, Frankfurt, Kentucky.

Griffith, G.E., J.M. Omernik and S. Azevedo. 1997. *Ecoregions of Tennessee.* EPA/600/R-97/022. NHREEL, Western Ecological Division, U.S. Environmental Protection Agency, Corvallis, Oregon.

Lenat, D.R. 1993. *A Biotic Index for the Southeastern United States: Derivation and List of Tolerance Values, With Criteria for Assigning Water Quality Ratings.* Journal of the North American Benthological Society. 12(3):279-290.

Omernik, J.M. 1995. *Ecoregions: A Framework for Environmental Management.* In: Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. W. Davis and T. Simon (eds). Lewis Publishers, Boca Raton, FL. Pp. 49-62.

Tennessee Department of Environment and Conservation. 2006. *Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys.* Division of Water Pollution Control, Nashville, Tennessee.

United States Environmental Protection Agency. 2006. *Wadeable Streams Assessment: A Collaborative Survey of the Nation's Streams.* EPA 841-B-06-002. Office of Research and Development, Office of Water, Washington D.C.

APPENDIX A

MACROINVERTEBRATE RESULTS FROM PROBABILISTIC MONITORING SITES

(Site location provided in Volume 2 of this report series)

STATION ID	REGION	DATE	ECO	TotTaxa	EPTTax	%EPT	%OC	NCBI	%ClingP	%Nut Tol	TMI
BIRCH000.6JO	EAST	9/5/2007	66E	35	16	62.8	13.7	2.86	79.8	4.9	42
LAURE006.3JO	EAST	12/12/2007	66E	39	16	61	25.1	4.2	59	31.8	36
CORN002.5JO	EAST	9/15/2007	66F	36	11	47	16.8	3.44	57.9	15.3	36
COVE003.8SV	EAST	7/25/2007	66F	26	10	32.7	8.9	3.2	38.1	46.5	28
COSBY012.2CO	EAST	10/28/2004	66G	38	18	55.2	36.6	3.74	51.5	21.6	36
TELLI040.5MO	EAST	11/9/2007	66G	42	14	45.9	37.2	3.92	50	32.1	32
TOWEE005.9PO	EAST	6/12/2008	66G	48	8	14.7	64.7	5.74	24	27.5	22
BEAVE008.9KN	EAST	8/24/2007	67F	25	7	70.1	13.8	5.37	87.9	57.6	34
BFLAT018.0UN	EAST	10/26/2004	67F	22	10	82.6	6.6	3.8	67.1	23.4	38
BYRD001.5HS	EAST	8/22/2007	67F	33	16	21.6	4.7	2.98	55.3	68.9	34
CANDI017.1BR	EAST	8/30/2007	67F	37	9	34.5	29.4	5.32	50.3	46.3	30
CLEAR001.3GE	EAST	10/12/2004	67F	29	8	37.4	33.2	5.61	61.3	60.9	30
EFPOP007.3RO	EAST	8/24/2007	67F	23	6	59.2	7.3	5.11	68.7	67	30
FALL001.5UN	EAST	10/27/2004	67F	27	14	33.5	7.7	3.32	51.7	57.9	32
FALL003.2HA	EAST	8/21/2007	67F	28	7	43	24.9	5.61	34.2	42.5	28
GAMMO000.7SU	EAST	10/14/2004	67F	29	5	10.8	78.4	7.17	22.5	64.3	14
GAP000.1CT	EAST	8/29/2007	67F	32	4	4.1	51.6	6.5	11.4	39.7	16
GRASS005.1GE	EAST	8/22/2007	67F	21	7	16.9	21.1	4.53	70.5	63.7	30
HORSE007.0GE	EAST	9/17/2007	67F	31	11	38.7	18	3.74	74.2	50.5	38
INDIA003.7GR	EAST	11/8/2007	67F	37	10	65.9	14.3	4.17	78	26.4	40
RIPLE001.5GE	EAST	10/13/2004	67F	30	10	42.4	4.9	4.31	79	56.6	36
CANDI033.1BR	EAST	9/6/2007	67G	25	4	31.6	36.8	6.29	14.7	31.6	24
MIDDL001.2SV	EAST	10/29/2004	67G	25	7	64.4	14.1	5.65	79.7	78.5	32
SINKI003.0CO	EAST	10/11/2004	67G	19	6	74.3	5.4	5.42	86.2	64.7	28
LAURE002.5GY	EAST	11/3/2004	68A	36	7	9.3	81	5.46	6.3	25.4	18
SEQUA101.2BL	EAST	8/29/2007	68B	22	6	38.5	32.3	4.93	41	44.1	38

Shaded values did not meet guidelines for ecoregion.

STATION ID	REGION	DATE	ECO	TotTaxa	EPTTax	%EPT	%OC	NCBI	%ClingP	%Nut Tol	TMI
HICKO008.4CA	EAST	8/17/2007	69D	27	9	63.9	5.6	3.9	58.9	17.8	38
POPLA000.1MG	EAST	7/28/2004	69D	35	15	56.9	26.5	4.29	50.3	24.9	38
OTOWN008.9CL	EAST	7/29/2004	69E	34	4	17.4	40.8	5.52	51.4	51.7	22
TITUS1T0.1CA	EAST	10/25/2004	69E	39	13	31.3	54.2	3.02	24	4.2	32
MILLE007.3RN	MIDDLE	7/5/2007	71E	15	4	5.1	0.5	5.57	38.5	17.4	24
SULPH036.0RN	MIDDLE	10/26/2007	71E	36	10	47.2	21.1	4.17	32.8	30	36
WFRED010.7MT	MIDDLE	7/18/2007	71E	16	8	69.1	0.6	5.31	57.3	41	34
BRUSH001.1LS	MIDDLE	8/22/2007	71F	36	12	59.4	13.8	3.54	50.4	19.4	42
BSPRI003.9CH	MIDDLE	7/5/2007	71F	27	9	26.2	10.7	3.95	32.7	64.9	26
BUNDR000.6WE	MIDDLE	8/27/2007	71F	24	10	42	9.7	4.77	52.8	35.8	32
CHISH015.4LW	MIDDLE	9/25/2007	71F	35	10	65	9.3	4.41	56.5	25.7	42
DIXON000.4LW	MIDDLE	9/24/2007	71F	26	8	19.7	8.2	3.24	75.4	69.4	30
GREEN016.2WE	MIDDLE	8/27/2007	71F	19	9	38.7	4.8	3.37	69.9	60.2	32
LBART006.5DI	MIDDLE	7/3/2007	71F	27	8	36.2	6.2	6.17	46.9	28.8	32
NFLIC002.0PE	MIDDLE	8/30/2007	71F	23	8	46.8	6.4	4.2	32.2	43.9	30
ROBIN000.6FR	MIDDLE	10/29/2007	71H	26	8	36.2	61.5	5.3	31.6	36.8	24
SHARP014.4WI	MIDDLE	7/9/2007	71F	28	9	57.2	21.1	5.42	29.5	29.5	34
TUMBL003.8HU	MIDDLE	7/23/2007	71F	18	9	75.4	0	4.38	65.3	31.2	36
WELLS007.6HO	MIDDLE	7/1/2004	71F	28	9	56.4	14.2	3.99	63	25.6	40
BEAGL008.3OV	MIDDLE	10/4/2007	71G	24	7	21.6	9.1	3.21	40.9	42	30
CFORK003.4SR	MIDDLE	8/16/2007	71G	28	10	59.1	25.8	4.68	56.2	34.4	38
LONG004.9MA	MIDDLE	9/19/2007	71G	22	8	28.6	3.7	4.03	68.8	60.8	30
TRACE003.5CY	MIDDLE	9/19/2007	71G	23	8	47.6	17.1	4.68	55.9	41.2	34
WFHIC007.0CE	MIDDLE	10/25/2007	71G	32	6	28.5	16.3	4.28	71.9	34.4	34
CANE004.5VA	MIDDLE	9/26/2007	71H	30	8	41.4	11.4	4.18	71.7	26.8	38
CATHE001.5MY	MIDDLE	8/30/2007	71H	27	9	36	15.3	4.62	61.9	52.9	34

Shaded values did not meet guidelines for ecoregion.

STATION ID	REGION	DATE	ECO	TotTaxa	EPTTax	%EPT	%OC	NCBI	%ClingP	%Nut Tol	TMI
DRAKE011.8SR	MIDDLE	7/16/2007	71H	22	7	50.5	5.1	4.72	54.6	39.8	30
PRUN000.1GS	MIDDLE	10/5/2007	71H	21	3	12.4	23.6	5.65	46.1	60.1	20
RUTHE007.4MY	MIDDLE	10/5/2007	71H	26	7	23.2	29.3	4.8	37.4	66.7	24
SCAMP008.3SR	MIDDLE	7/16/2007	71H	26	10	58.8	5.1	5.11	61	42.9	36
SCOTT000.9DA	MIDDLE	7/18/2007	71H	32	3	11.7	44.7	5.75	51.6	63.8	20
WATSO002.3WI	MIDDLE	7/9/2007	71H	22	3	31.6	22.5	5.27	74.9	68.4	24
WHITE013.5HU	MIDDLE	7/2/2007	71H	19	9	33.5	1.1	3.41	57.8	41.6	32
SPRIN009.0WS	MIDDLE	7/17/2007	71I	27	11	48.2	6.2	4.4	39.9	47.7	38
BIRDS012.3BN	WEST	7/12/2007	65E	38	4	3.7	15.5	6.02	15.5	9.1	28
CROOK005.0MC	WEST	7/11/2007	65E	40	4	8	20.8	6.88	19.5	9.7	28
CYPRE023.8MC	WEST	7/6/2007	65E	34	3	3	59	7.72	16.5	7.5	20
HAWKI002.1CR	WEST	7/15/2007	65E	43	3	15.5	28.7	6.53	14.9	6.3	28
HAYES003.3HR	WEST	7/2/2007	65E	42	3	5.4	22.8	6.68	29.3	8.7	30
HROCK002.4CR	WEST	7/23/2007	65E	41	4	5	23.9	6.94	10	5.5	26
HURRI007.4HE	WEST	9/28/2004	65E	38	4	4.6	45	7.4	22.1	42.9	24
MFORK1T1.5HE	WEST	7/3/2007	65E	34	1	0.5	19.5	7.37	7.5	5	20
OWL003.7HD	WEST	7/18/2007	65E	28	3	1.9	12.9	6.56	8.1	4.8	22
ROSE001.3MC	WEST	7/2/2007	65E	36	7	15.7	59.7	5.73	27.2	15.2	30
SFCUB009.5DE	WEST	7/5/2007	65E	36	5	7.9	72.6	6.08	55.8	46.8	24
SFFDE1T0.7MN	WEST	7/5/2007	65E	39	5	33.2	35.8	5.52	38.8	34.8	40
SFMUD003.8MC	WEST	7/17/2007	65E	38	3	6	34.8	7.75	7.6	14.1	22
TAR003.0CS	WEST	8/21/2007	65E	39	4	9.2	34.5	6.65	6.3	14.4	24
BEAR002.1WY	WEST	7/3/2007	74B	44	3	2.7	55.7	6.76	1.1	17.5	22
CANE001.4SH	WEST	8/9/2007	74B	22	1	0.5	89.9	8.16	0	61.4	6
CLOVE1T0.5OB	WEST	7/3/2007	74B	26	1	5.7	41.1	7.64	2.9	51.4	16
CYPRE002.1CK	WEST	7/16/2007	74B	34	2	2.4	52.5	7.72	2.6	15.6	18

Shaded values did not meet guidelines for ecoregion.

STATION ID	REGION	DATE	ECO	TotTaxa	EPTTax	%EPT	%OC	NCBI	%ClingP	%Nut Tol	TMI
CYPRE005.9OB	WEST	7/23/2007	74B	32	2	16.3	38.6	6.88	3.3	15.8	22
HALLS001.7LE	WEST	7/18/2007	74B	30	5	30.1	23.3	7.13	8.3	18.1	26
HYDE002.7LE	WEST	7/5/2007	74B	30	1	5.9	37.1	7.16	0	20.4	20
NREEL000.4OB	WEST	7/6/2007	74B	28	3	11.6	54.1	8.22	3.9	32.4	16
POND013.8CK	WEST	7/20/2007	74B	33	2	1	62.7	7.49	1	14.9	14
POPLA014.7HY	WEST	7/5/2007	74B	26	2	2.3	81.9	8.63	0.5	7.4	12
STOKE004.9CK	WEST	7/20/2007	74B	34	2	1.1	26.3	7.38	0.5	12.1	20
THOMP000.2WY	WEST	7/17/2007	74B	52	6	20.5	43.6	6.87	14.4	32.8	26
TISDA1T1.2LE	WEST	7/2/2007	74B	38	2	32.5	44.7	7.51	0.5	9.6	22
KERR000.4HD	WEST	9/29/2004	65J	18	2	45.9	44.3	5.71	56.2	63.9	22
SMITH003.5HD	WEST	7/31/2007	65J	24	10	51.8	2.3	4.57	48.7	48.3	32
COLD006.3LE	WEST	7/18/2007	74A	18	4	57.7	35.6	6.48	13.4	22.7	26

TR = Taxa Richness
EPT = EPT (Ephemeroptera, Plecoptera, Trichoptera) Richness
%EPT = EPT Abundance
%OC = Oligochaeta and Chironomidae abundance
NCBI = North Carolina Biotic Index
%Cling = Clinger abundance
%NutTol = Abundance of nutrient tolerant organisms
TMI = Tennessee Macroinvertebrate Index (Target score = 32)

Shaded values did not meet guidelines for ecoregion.

APPENDIX B

HABITAT ASSESSMENT RESULTS AT PROBABILISTIC MONITORING SITES

HABITAT ASSESSMENT DISTRIBUTION MAPS

Table B-1: Habitat assessment results at probabilistic monitoring sites.

STATION ID	Division	Date	ECO	Epifaunal Substrate	Embeddedness	Velocity Depth Regime	Sediment Deposition	Channel Flow Status	Channel Alteration	Frequency of Riffles	Bank Stability	Vegetative Protection	Riparian Width	Pool Substrate	Pool Variability	Channel Sinuosity	Habitat Score
BEAVE008.9KN	East	8/24/07	67F	17	15	17	13	11	16	18	17	19	13				156
BFLAT018.0UN	East	10/26/04	67F	12	10	15	8	11	20	13	19	13	14				135
BIRCH000.6JO	East	9/5/2007	66E	20	20	19	18	8	20	20	20	20	20				185
BYRD001.5HS	East	8/22/07	67F	16	16	13	16	13	16	16	18	18	16				158
CANDI017.1BR	East	8/30/07	67F	9	6	16	12	13	16	16	4	16	8				116
CANDI033.1BR	East	9/6/07	67G	13	6	15	5	12	16	14	0	0	2				83
CLEAR001.3GE	East	10/12/04	67F	12	12	15	14	19	7	7	15	5	4				110
CORN002.5JO	East	9/5/07	66F	15	16	14	15	17	14	16	12	12	12				143
COSBY012.2CO	East	10/28/04	66G	20	19	16	20	15	20	20	20	17	16				183
COVE003.8SV	East	7/28/07	66G	17	16	19	14	18	16	19	18	17	17				171
EFPOP007.3RO	East	8/24/07	67F	14	13	16	12	17	15	16	15	14	13				145
FALL001.5UN	East	10/27/04	67F	11	9	11	6	17	15	7	17	9	10				112
FALL003.2HA	East	8/21/07	67F	14	11	14	11	16	15	16	10	8	6				121
GAMMO000.7SU	East	10/4/04	67F	3	2	11	6	20	15	11	3	2	0				73
GAP000.1CT	East	8/29/07	67F	10	11	10	6	15	15	16	19	10	10				122
GRASS005.1GE	East	8/22/07	67F	12	8	8	10	9	14	8	13	16	12				110
HICKO008.4CA	East	8/17/07	69D	17	15	15	14	12	17	14	16	19	18				157
HORSE007.0GE	East	9/17/07	67F	16	16	14	16	13	16	17	13	15	16				152
INDIA003.7GR	East	11/8/07	67F	17	16	14	15	12	16	17	13	14	13				147
LAURE002.5GY	East	11/30/04	68A	15	5	7	10	20	20	12	14	20	20				143
LAURE006.3JO	East	12/2/07	66E	18	17	18	16	17	16	19	19	18	16				174
MIDDL001.2SV	East	10/29/04	67G	7	2	14	8	20	13	8	15	12	11				110
OTOWN008.9CL	East	8/13/04	69E	10	8	7	4	20	20	2	7	7	9				94
POPLA000.1MG	East	7/28/04	69D	16	6	18	7	15	15	20	10	13	11				131
RIPLE001.5GE	East	10/13/04	67F	4	5	14	7	20	20	7	4	2	0				83

Shaded values did not meet habitat guidelines for ecoregion.

Table B-1: Habitat assessment results at probabilistic monitoring sites cont.

STATION ID	Division	Date	ECO	Epifaunal Substrate	Embeddedness	Velocity Depth Regime	Sediment Deposition	Channel Flow Status	Channel Alteration	Frequency of Riffles	Bank Stability	Vegetative Protection	Riparian Width	Pool Substrate	Pool Variability	Channel Sinuosity	Habitat Score
SEQUA101.2BL	East	9/12/07	68B	14	13	19	8	17	19	12	8	6	2				118
SINKI003.0CO	East	10/11/04	67G	14	5	18	12	18	14	13	13	14	13				134
TELLI040.5MO	East	11/9/07	66G	17	18	19	18	10	19	19	20	16	15				171
TITUS1T0.1CA	East	10/25/04	69E	17	5	15	8	14	20	12	14	20	20				145
TOWEE005.9PO	East	6/12/08	66G	19	16	13	15	15	19	18	20	16	12				163
BEAGL008.3OV	Middle	10/4/07	71G	17	18	19	15	15	17	18	16	17	20				172
BRUSH001.1LS	Middle	8/22/07	71F	17	19	11	18	13	19	17	18	20	20				172
BSPRI003.9CH	Middle	7/5/07	71F	12	17	10	15	11	14	18	14	10	10				131
BUNDR000.6WE	Middle	8/27/07	71F	18	16	11	16	6	16	15	18	17	16				149
CANE004.5VA	Middle	9/26/07	71H	17	19	17	18	14	18	14	15	18	14				164
CATHE001.5MY	Middle	8/30/07	71H	17	15	14	14	15	18	15	16	14	14				152
CFORK003.4SR	Middle	8/16/07	71G	14	13	15	14	14	15	12	13	14	4				128
CHISH015.4LW	Middle	9/25/07	71F	18	18	15	17	17	18	17	18	18	18				174
DIXON000.4LW	Middle	9/24/07	71F	17	16	12	16	17	13	16	16	12	16				151
DRAKE011.8SR	Middle	7/16/07	71H	10	14	14	11	9	11	12	11	16	13				121
GREEN016.2WE	Middle	8/27/07	71F	14	16	16	15	17	10	13	14	12	12				139
LBART006.5DI	Middle	7/3/07	71F	12	16	14	9	15	19	18	9	16	5				133
LONG004.9MA	Middle	9/19/07	71G	19	17	15	15	17	19	13	19	18	14				166
MILLE007.3RN	Middle	8/8/07	71E	16	9	15	10	8	18	19	17	20	20				152
NFLIC002.0PE	Middle	8/30/07	71F	16	15	14	13	15	15	17	6	6	8				125
PRUN000.1GS	Middle	10/5/07	71H	12	11	10	13	15	11	16	12	8	4				112
ROBIN000.6FR	Middle	10/29/07	71F	11	11	15	12	12	16	7	16	16	12				128
RUTHE007.4MY	Middle	10/5/07	71H	13	10	18	7	12	16	11	6	10	8				111
SCAMP008.3SR	Middle	7/16/07	71H	10	13	10	10	9	15	6	11	18	14				116
SCOTT000.9DA	Middle	7/18/07	71H	13	10	10	8	8	15	16	13	16	13				122
SHARP014.4WI	Middle	7/9/07	71F	17	14	15	9	14	16	8	8	6	3				110

Shaded values did not meet habitat guidelines for ecoregion.

Table B-1: Habitat assessment results at probabilistic monitoring sites cont.

STATION ID	Division	Date	ECO	Epifaunal Substrate	Embeddedness	Velocity Depth Regime	Sediment Deposition	Channel Flow Status	Channel Alteration	Frequency of Riffles	Bank Stability	Vegetative Protection	Riparian Width	Pool Substrate	Pool Variability	Channel Sinuosity	Habitat Score
SPRIN009.0WS	Middle	7/17/07	71I	11	12	14	9	10	13	10	11	15	4				109
SULPH036.0RN	Middle	10/26/07	71E	16	12	18	10	19	19	16	10	18	18				156
TRACE003.5CY	Middle	9/19/07	71G	17	17	10	15	10	18	17	13	14	15				146
TUMBL003.8HU	Middle	7/28/07	71F	18	18	19	14	15	19	11	16	18	20				168
WATSO002.3WI	Middle	7/9/07	71H	7	10	14	8	9	19	12	15	18	8				120
WELLS007.6HO	Middle	7/1/04	71F	17	13	20	6	11	11	15	13	14	12				132
WFHIC007.0CE	Middle	10/25/07	71G	15	12	16	11	14	17	15	18	15	4				137
WFRED010.7MT	Middle	7/18/07	71E	16	14	19	10	13	18	13	13	15	10				141
WHITE013.5HU	Middle	7/2/07	71H	18	16	19	13	16	15	17	11	17	19				161
BEAR002.1WY	West	7/3/07	74B	5			5	6	13		12	14	4	6	7	6	78
BIRDS012.3BN	West	7/12/07	65E	15			15	11	16		16	17	12	15	10	10	137
CANE001.4SH	West	8/9/07	74B	11			15	15	15		9	11	2	15	17	3	113
CLOVE1T0.5OB	West	7/3/07	74A	6	1	6	8	9	11	1	12	14	5				73
COLD006.3LE	West	7/18/07	74A	5	2	8	5	7	13	10	16	16	9				91
CROOK005.0MC	West	7/11/07	65E	6			8	8	13		12	13	2	9	6	3	80
CYPRE002.1CK	West	7/16/07	74B	6			8	10	13		8	10	6	6	6	8	81
CYPRE005.9OB	West	7/23/07	74B	2			12	11	15		12	12	6	5	10	10	95
CYPRE023.8MC	West	7/6/07	65E	17			16	18	14		16	12	2	13	11	4	123
HALLS001.7LE	West	7/18/07	74B	3			6	7	13		4	8	4	6	6	6	63
HAWKI002.1CR	West	7/5/07	65E	16			14	13	15		17	16	13	12	15	7	138
HAYES003.3HR	West	7/2/07	65E	14			14	9	12		16	14	5	11	16	2	113
HROCK002.4CR	West	7/23/07	65E	8			12	14	15		12	16	7	9	7	10	110
HURRI007.4HE	West	7/5/07	65E	6			14	8	6		16	12	2	5	6	2	77
HYDE002.7LE	West	7/2/07	74B	1			8	10	11		10	12	5	6	5	3	71
KERR000.4HD	West	7/11/07	65J	16	18	10	18	18	15	14	18	18	17				162
NFFDE1T1.5HE	West	7/3/07	65E	14			13	8	10		18	16	11	10	13	2	115
NREEL000.4OB	West	7/6/07	74A	3			11	16	11		2	4	6	3	3	2	61

Shaded values did not meet habitat guidelines for ecoregion.

Table B-1: Habitat assessment results at probabilistic monitoring sites cont.

STATION ID	Division	Date	ECO	Epifaunal Substrate	Embeddedness	Velocity Depth Regime	Sediment Deposition	Channel Flow Status	Channel Alteration	Frequency of Riffles	Bank Stability	Vegetative Protection	Riparian Width	Pool Substrate	Pool Variability	Channel Sinuosity	Habitat Score
OWL003.7HD	West	7/18/07	65E	14			11	12	12		16	16	2	13	6	2	104
POND013.8CK	West	7/20/07	74B	1			3	16	11		12	6	0	2	2	3	56
POPLA014.7HY	West	7/5/07	74B	5			6	6	11		10	10	3	6	4	3	64
ROSE001.3MC	West	7/2/07	65E	11			12	14	15		16	16	17	10	10	5	126
SFCUB009.5DE	West	7/5/07	65E	6			6	8	16		8	6	2	7	13	7	79
SFFDE1T0.7MN	West	7/5/07	65E	9			9	8	19		11	16	5	8	7	14	106
SFMUD003.8MC	West	7/17/07	65E	8			13	7	13		8	8	5	10	10	2	84
SMITH003.5HD	West	7/31/07	65J	16	13	15	15	14	15	14	17	17	12				148
STOKE004.9CK	West	7/20/07	74B	5			3	15	11		10	12	5	6	3	5	75
TAR003.0CS	West	8/21/07	65E	18			16	18	15		18	18	20	10	15	3	151
THOMP000.2WY	West	7/17/07	74B	5			14	14	13		16	8	12	1	1	5	89
TISDA1T1.2LE	West	7/2/07	74B	4			6	9	11		12	10	2	6	5	1	66

Shaded values did not meet habitat guidelines for ecoregion.

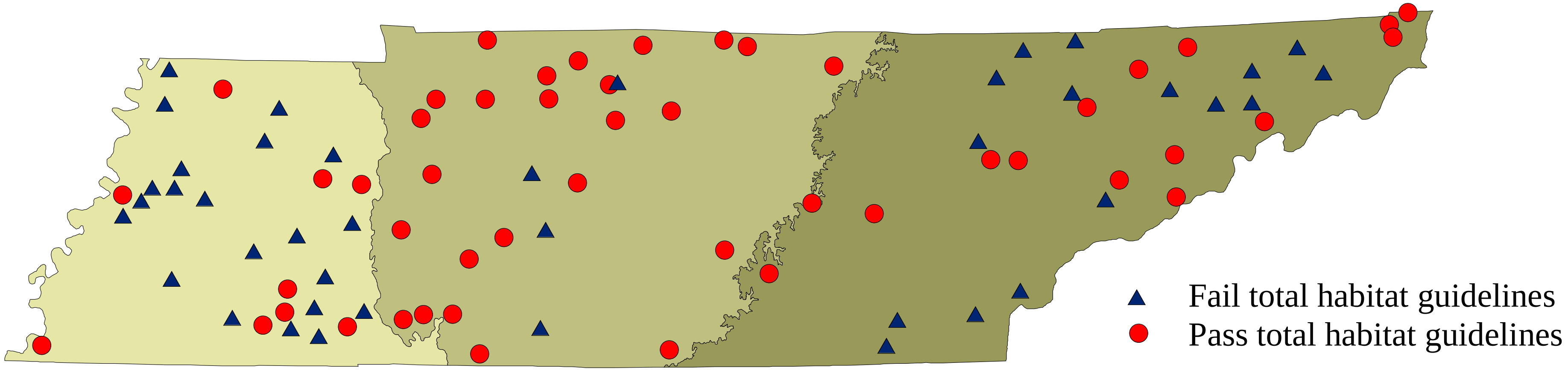


Figure B-1: Distribution of sites that passed total habitat guidelines for ecoregion.

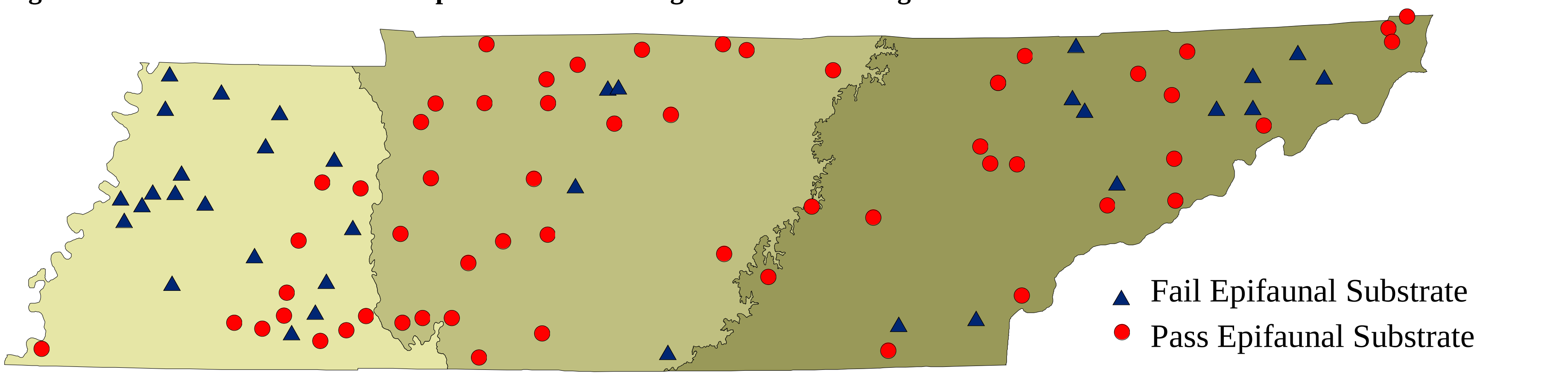


Figure B-2: Distribution of sites that passed epifaunal substrate guidelines for ecoregion.

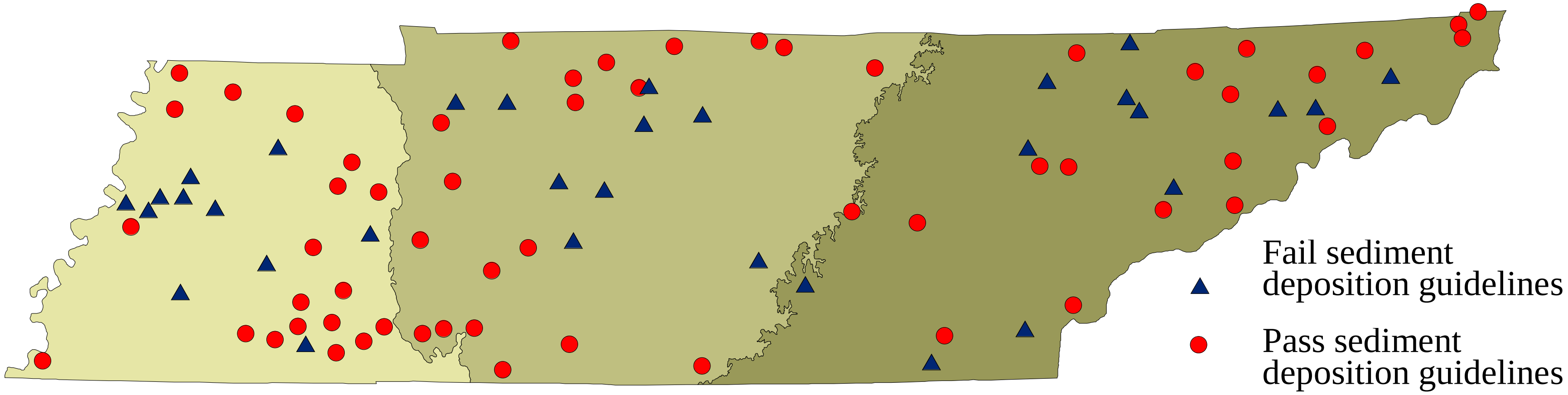


Figure B-3: Distribution of sites that passed sediment deposition guidelines for ecoregion.

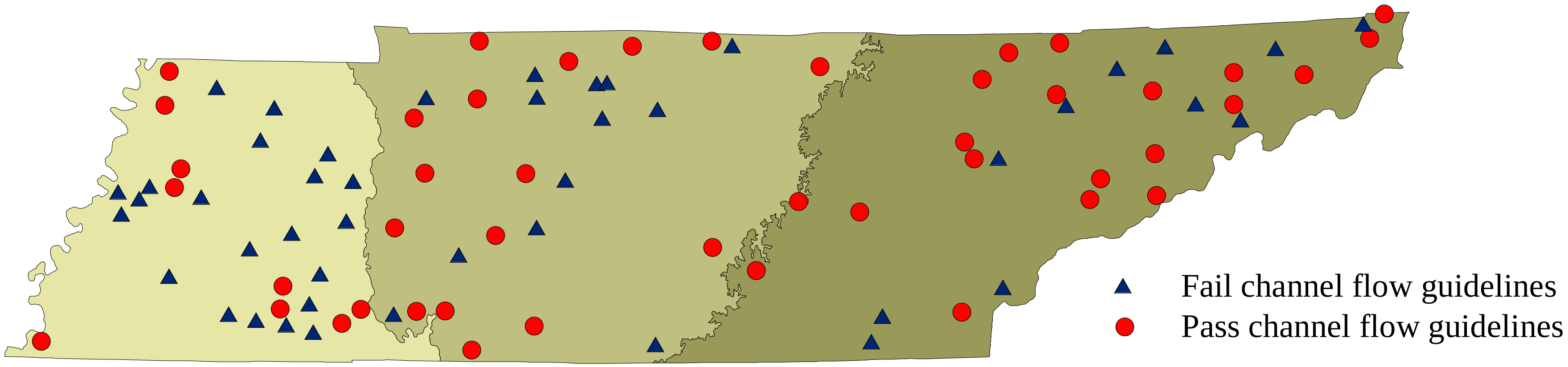


Figure B-4: Distribution of sites that passed channel flow guidelines for ecoregion.

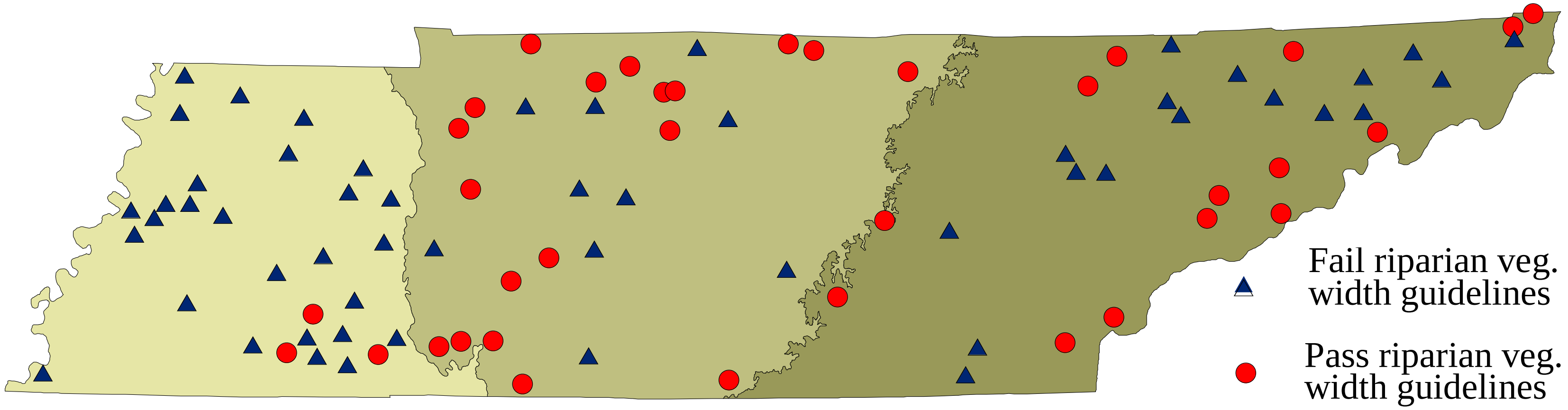


Figure B-5: Distribution of sites that passed riparian vegetation width guidelines for ecoregion.

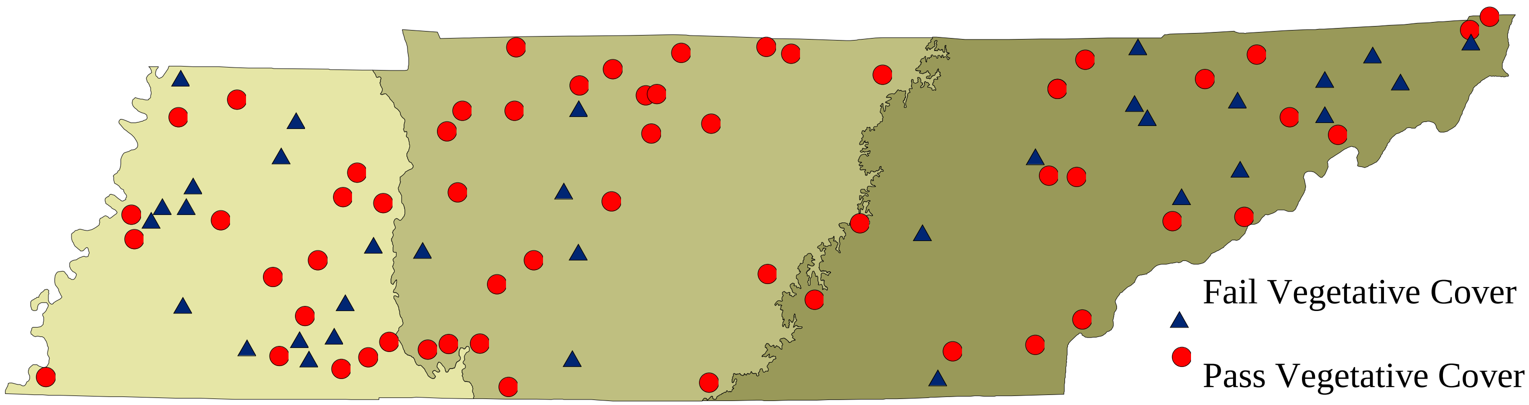


Figure B-6: Distribution of sites that passed vegetative cover guidelines for ecoregion.