

PRELIMINARY RESULTS OF ENDANGERED

MUSSEL DISTRIBUTION SURVEYS

INTERIM REPORT

*Draft*

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Prepared for:

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**yma**

*young—morgan & associates, inc.*

## INTRODUCTION

Young-Morgan & Associates (YMA) has been retained by the Upper Duck River Development Agency to reevaluate the endangered mussel population data collected during TVA's CMCP. Review of TVA endangered mussel population data for the Duck, Clinch, and Powell rivers shows that these surveys did not provide data to accurately estimate the population of endangered mussels for these systems. Accurate population estimates are essential to the U.S. Fish and Wildlife Services issuance of a technically sound "jeopardy" or "no jeopardy" opinion pursuant to Endangered Species Act consultation with TVA related to the Columbia Dam portion of the Duck River Project.

Specifically, YMA proposed the development and execution of the following tasks:

- TASK 1: Development of a technically sound sampling plan which will provide statistically valid endangered mussel population data.
- TASK 2: Annual survey of the four TVA Mussel Transplant Sites. Site maintenance plans call for annual surveys of transplant sites to determine survival and reproduction success.

TASKS 3, 4 & 5:

*no way* Repeat survey of streams known to support the endangered mussels. The Clinch, Powell and Elk rivers will be resurveyed to determine the number of endangered mussels currently existing in these rivers. Biological assessments of population "viability" and proportionate distribution of the known population will be made.

TASK 6: Repeat survey of the endangered mussel populations from Lillard's Mill to the Columbia Dam site. This intensive survey would provide detailed maps of mussels in the study area, as well as the data necessary to assess the true numbers of endangered mussels impacted by the dam (i.e. 600 ft. and 630 ft. elevation). This task would provide the basis for understanding the population ecology of endangered mussels (i.e. age class distributions, natural mortality and recruitment) and other life history studies called for in TVA's mussel conservation plan but never completed. These data are needed before we can make informed estimates of how many mussels constitute a "viable population".

TASK 7: Establish an endangered mussel propagation facility at the old Columbia Dam to evaluate existing techniques to propagate endangered mussels in large numbers. Once these procedures are established, these "laboratory" animals can be returned to protected sites in the Duck, Clinch, Powell, Elk and other rivers to insure survival of the species. This technique has and is currently being used to survive other endangered species.

The following summarizes work efforts completed toward each task (excluding Task 7) as of November 30, 1989.

#### TASK RESULTS

##### Task 1 - Study Design

Historical TVA data from the Clinch, Duck and Powell rivers were entered into the computer and transmitted to Roger Green of the University of Western Ontario. Data were analyzed to determine the most technically sound sampling design applicable to endangered mussels. Statistical interpretations of the data are summarized in "Sampling for Rare Freshwater Mussels: A Statistical Basis and

Recommended Protocol" (YMA 1990). Statistical analysis of the current TVA dataset indicated the probability of finding a rare species, at a given density, increases with the number of quadrats sampled (Figure 1). For example, in 1988, TVA sampled from 12 to 41 0.25 m<sup>2</sup> quadrats at each collection site on the Duck River. The maximum probability of finding an individual of a rare species with a given density of 0.02/m<sup>2</sup> was approximately 53% with TVA's sampling design (Table 1). Increasing minimal sampling effort to a standard 40 0.5 m<sup>2</sup> quadrats (equal to 80 0.25 m<sup>2</sup> quadrats), would increase the minimum probability of collecting an individual (at densities of 0.02/m<sup>2</sup>) to 80%. At densities greater than 0.08 individuals per square meter, the probability of finding rare species with the study design proposed by YMA would be greater than 95 %. Therefore, confidence of collecting a rare species is increased with this sampling design. The specified sampling protocol required identification of a 10 meter X 20 meter area. Each area was traversed by 4 line transects. Each line transect (I, II, III, IV) consisted of 40 sampling locations resulting in 160 sequential 0.5 m<sup>2</sup> sample points within the grid (Figure 2). A table of random numbers was utilized to randomly select 40 numbers between 1 and 160 which correspond to sampling points on the line transects. Forty 0.5 m<sup>2</sup> samples represented 10 percent of the area within the grid. This procedure resulted in less than 5 percent of the total habitat of any selected site (shoal) being disturbed.

$$.08/m^2 = 1/12.5m^2$$

$$.02/m^2 = 1/50m^2$$

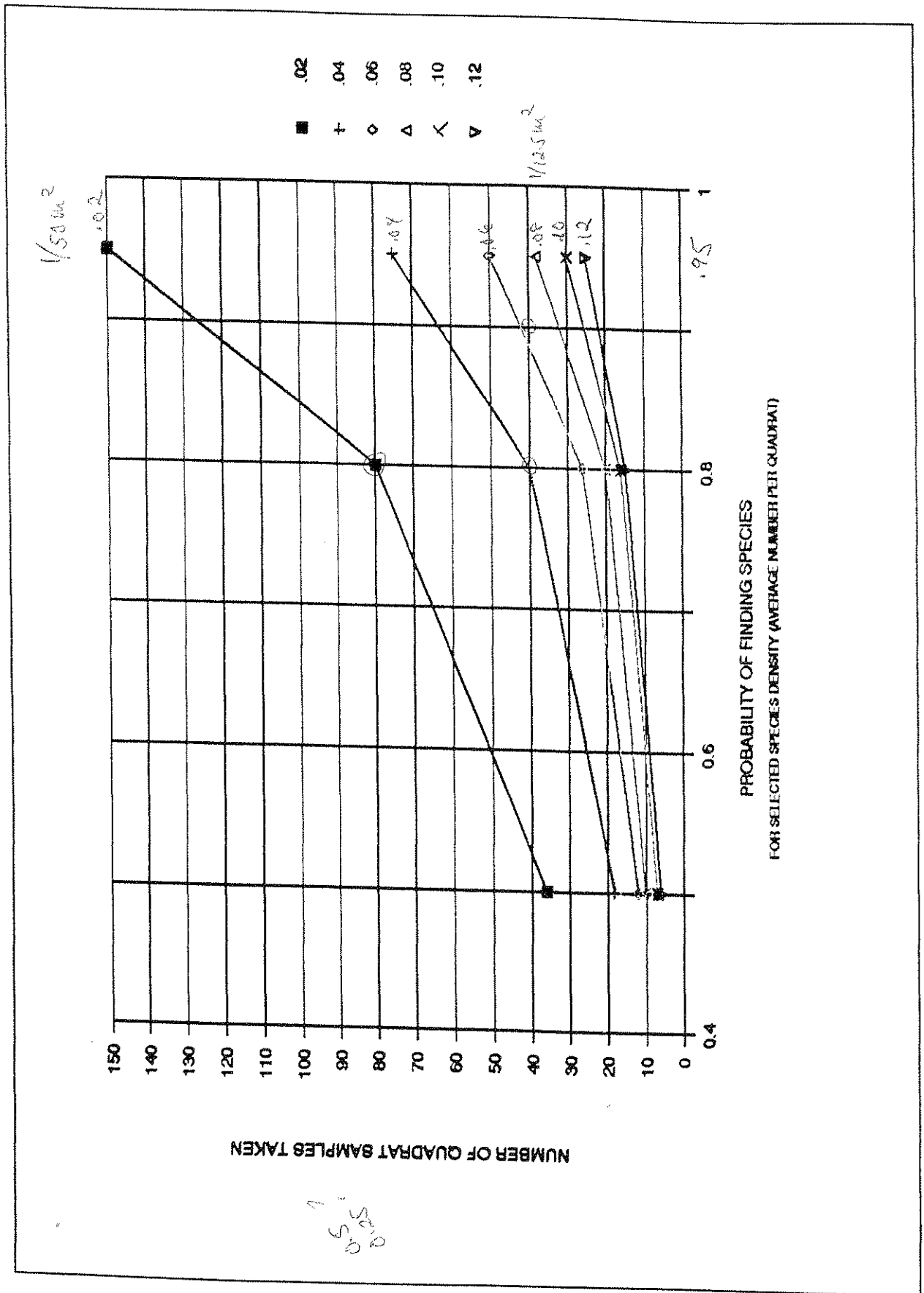


Figure 1. Probability of Finding a Species at Given Densities and Sampling Effort.

Table 1. Probability (%) of Finding a Species at Given Densities and Sampling Effort.

Quadrats Taken (#) YMA (TVA)	Density (#/square meter)								Mean
	0.02	0.04	0.06	0.08	0.1	0.12	0.12	0.12	
6 (12)	< 50	< 50	~ 50	~ 57	~ 67	~ 69	~ 69	~ 69	< 57
8 (16)	< 50	< 50	~ 58	~ 67	~ 75	~ 77	~ 77	~ 77	< 63
10 (20)	< 50	~ 53	~ 67	~ 80	~ 84	~ 86	~ 86	~ 86	< 70
12 (24)	< 50	~ 60	~ 80	~ 85	~ 90	~ 95	~ 95	~ 95	< 77
16 (32)	< 50	~ 70	~ 85	~ 90	> 95	> 95	> 95	> 95	< 81
20 (40)	~ 53	~ 80	~ 88	> 95	> 95	> 95	> 95	> 95	> 84
24 (48)	~ 58	~ 83	~ 94	> 95	> 95	> 95	> 95	> 95	> 87
40 (80)	~ 80	> 95	> 95	> 95	> 95	> 95	> 95	> 95	> 93

Designates TVA's Maximum Sampling Effort.

Designates YMA's Minimum Sampling Effort.

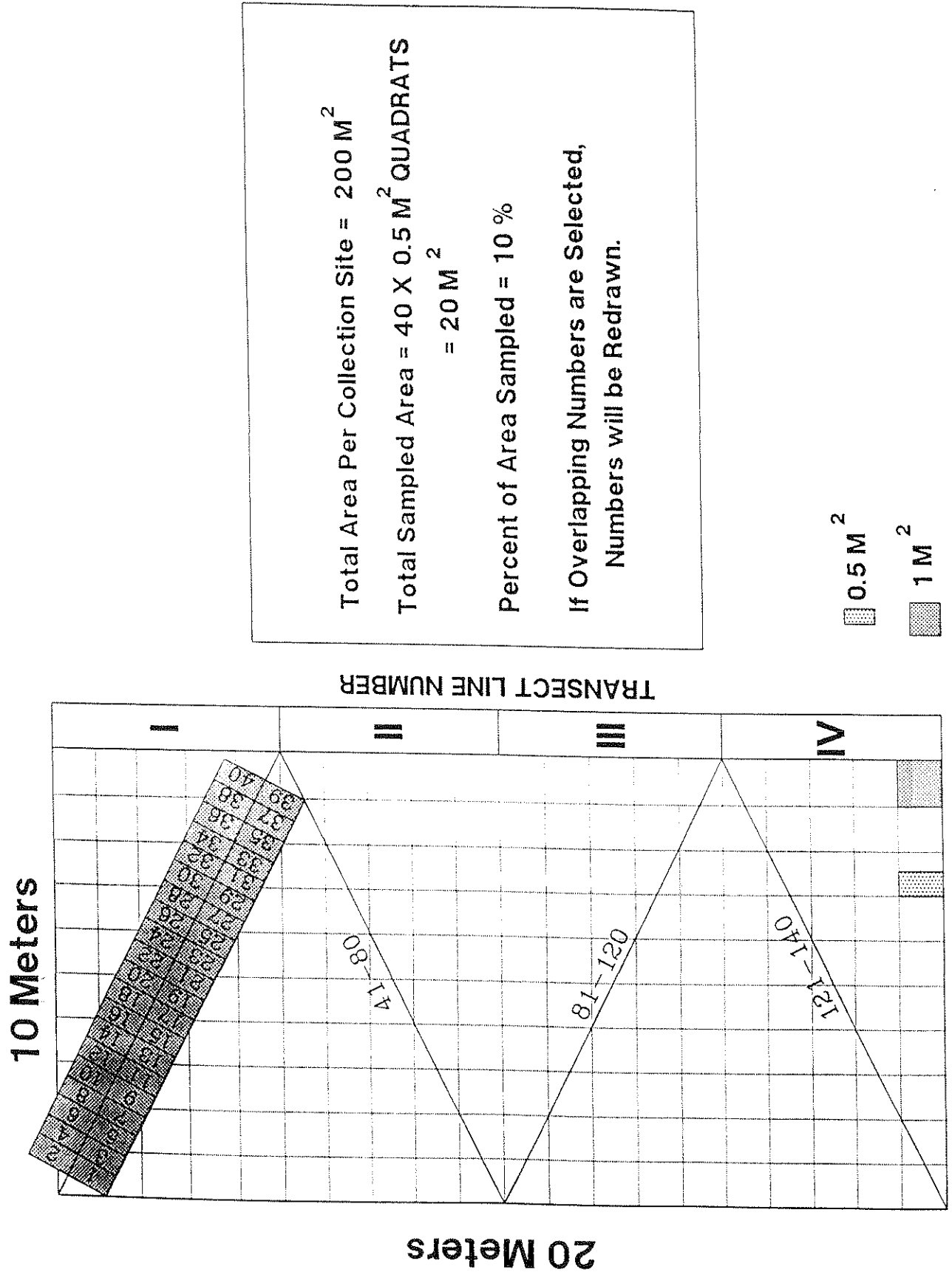


Figure 2. Schematic Design of Quantitative Mussel Sampling Plan.

## Task 2 - Survey of TVA Transplant Sites

In 1982, TVA initiated transplantation of Conradilla caelata to four river systems: the Duck, Buffalo, Nolichucky and North Fork Holston River. After transplanting, TVA returned semiannually (from 1982-1987) and quantitatively sampled (10 quadrats) each transplant site. In 1988, sites were sampled only during the fall season.

During a field reconnaissance with TVA personnel (Steve Ahlstedt), specific transplant site locations were identified. Young-Morgan & Associates returned to each river and quantitatively sampled the four transplant sites. The following summarizes the results of these surveys (Table 2).

### Duck River

During the site visit, Steve Ahlstedt commented on the dramatic physical change of the transplant site. Areas of which were originally shoals (0 - 2') in 1982, were now greater than three feet deep, and the reverse for deep areas of the stream. Therefore, transplanted Conradilla caelata in shallow areas were probably scoured away and relocated along with the substrate.

Forty 0.5 m<sup>2</sup> quadrats were sampled within the transplant site boundary on November 29, 1989. Three specimens were found within the transplant site resulting in an overall density of 0.15 individuals per square meter within the transplant site. An additional 40 quadrats were sampled immediately downstream of the original transplant site on November 30, 1989. Four specimens of



Table 2. Results of the YMA Survey of TVA *Conradilla caelata* Transplant Sites.

Transplant Site	Number Collected		Sample Area (square meter)	Density (#/square meter)	Transplant Area (square meter)	Residing Population
	within Site	Number Collected outside Site				
Duck	3	4	40	0.175	400	70
Buffalo	1	0	40	0.025	500	13
Nolichucky	2	*	28	0.07	125	9 <sup>plc 8/01</sup>
North Fork Holston	16	*	40	0.4	380	152

*Conradilla*

\* No sampling was completed outside transplant site.

Conradilla caelata were collected in the downstream quadrats for an estimated density of  $0.2/m^2$ . The overall site density was  $0.175$  individuals/ $m^2$ . Based upon the area sampled ( $\sim 400 m^2$ ) and the overall density ( $0.175/m^2$ ), approximately 70 Conradilla caelata still exist within the sampled area.

#### Buffalo River

During the visit to the Buffalo River transplant site, an apparent alteration of substrate was observed. Erosion of the streambanks had caused a tree to fall along the transplant site which created a depositional zone of fine sediments. The fallen tree also restricted the channel resulting in higher velocities through the transplant site.

Quantitative sampling of the transplant site was completed on November 20-21, 1989. Forty  $0.5 m^2$  quadrats were sampled within the transplant site and forty additional quadrats were collected downstream of the site. Substrate downstream of the transplant site was dominated by limestone bedrock. Only one specimen of Conradilla caelata was collected within the transplant site and no individuals were found downstream. The calculated density within the transplant site was  $0.05/m^2$ . The density of the area sampled was  $\sim 0.025$  individuals per square meter. The riffle area sampled was approximately  $500 m^2$  resulting in a population estimate of 13 Conradilla.

### Nolichucky River

According to TVA personnel (Steve Ahlstedt), heavy predation by muskrats, extensive siltation and substrate shifts have occurred at this site since 1982. In addition, during periods of drought (1985-1988), approximately one-third of the transplant site was exposed. He believed due to these situations, success of establishing new populations at this site would be limited.

The transplant site is basically a run-type habitat with gravel and cobble substrate.

On November 14, 1989, fifty-six 0.5 m<sup>2</sup> quadrats were sampled within the transplant site boundary. Two specimens were found within the transplant site resulting in an overall density of 0.07 individuals per square meter within the transplant site. It was noted that both specimens were collected in the deepest area of the transplant site, areas which were not exposed during drought conditions. No additional quadrats were sampled downstream of the original transplant site. Based upon the area of the transplant site (~125 m<sup>2</sup>) and the overall density (0.07/m<sup>2</sup>), approximately 8 Conradilla still exist within the sampled area.

### North Fork Holston

Of all transplant sites, the North Fork Holston River (NFHR) was believed to be the most likely site for a successful transplant (Steve Ahlstedt, personal communication). The basis for this opinion was due to the overall features of the site including excellent water quality, relative lack of anthropogenic

perturbations, and substrate stability and composition.

Quantitative sampling of the transplant site was completed on October 28-29, 1989. Eighty 0.5 m<sup>2</sup> quadrats were sampled within the transplant site for a total of 40 m<sup>2</sup>. Sixteen Conradilla were found resulting in an overall site density of 0.4 per m<sup>2</sup>. During qualitative sampling (~0.5 man hours) downstream of the site, six additional Conradilla were collected. Given the area of the transplant site (~380 m<sup>2</sup>) and density estimate (0.4/m<sup>2</sup>), approximately 152 Conradilla still remain in the transplant site.

### Task 3, 4 & 5 - Survey of the Clinch, Elk and Powell Rivers

#### Clinch River

The survey was conducted on August 11-14, 1989 and included 5 sites between river miles 183.5 and 194.2. Site selection was based on historical surveys (TVA and Bates and Dennis) and presence of suitable habitat for Conradilla caelata as determined by Dr. Yokely. All sampled sites consisted of riffles ranging from 0.25 to 1.00 meter deep. Both qualitative and quantitative surveys were performed at CRM 183.5, 189.3, 189.6 and 192.4. Only a qualitative survey was taken at CRM 194.2.

As described in the project proposal, a representative area of each site was traversed by 4 line transects. Each transect consisted of 40 possible sampling locations resulting in 160 sequential 0.5 m<sup>2</sup> quadrats within the grid. Forty quadrats were selected from a table of random numbers and intensively examined for mussels with the use of SCUBA or mask and snorkel. Where

possible the substrate was excavated to a depth of 15 cm and all live mussels were carefully lifted and placed in a mesh diving bag. All specimens were counted and identified to species by Dr. Yokely and returned to the river.

Qualitative collections were made by randomly hand picking specimens from selected areas or habitats not falling within the sampling grid. The presence and relative abundance of each species was noted and the mussels returned to the river (Table 3). A representative collection of relic shells was retained by Dr. Yokely.

The birdwing pearly mussel, Conradilla caelata, was collected from three locations. One live specimen was found at CRM 183.5 (Brooks Island), two live specimens were found at 192.4 and one relic shell was found at CRM 189.6. In 1979 and again in 1988, TVA collected one live C. caelata from CRM 189.6. A complete listing of all mussels found during the quantitative surveys are provided in Table 4.

In 1979 and 1988, TVA quantitatively sampled ten sites on the Clinch River (CRM 159.2, 172.2, 184.5, 189.6, 206.9, 211.1, 219.1, 219.2, 226.3, 235.1, 270.9 and 321.7). Conradilla caelata were collected from only one site in 1979 and two sites in 1988. YMA has presently completed four quantitative sites and C. caelata has been collected from 50 % of the sampling locations. Mean densities (#/m<sup>2</sup>) of Conradilla collected by TVA from the ten sites were 0.01 and 0.02 for 1979 and 1988, respectively. YMA quantitative sampling has yielded three specimens of Conradilla

Table 3. Results of YMA Qualitative Sampling of the Clinch River System.

SPECIES	RIVER MILE				
	183.5	189.3	189.6	192.4	194.2
<i>Actionaias carinata</i>	*	*	+	*	
<i>Actinonaias pectorosa</i>	*	*	**	*	
<i>Alasmidonta marginata</i>	*	*	+		*
<i>Amblyema plicata</i>	*		**	*	
<i>Conradilla caelata</i>	*		**		*
<i>Cumberlandia monodonta</i>	*	*	+		*
<i>Cyclonaias tuberculata</i>	*	*			
<i>Cyprogenia irrorata</i>	*	*			
<i>Dromus dromas</i>	*	*			
<i>Elliptio crassidens</i>	*	*	**	*	*
<i>Elliptio dilatatus</i>	*	**		*	
<i>Epioblasma brevidens</i>	*	**	*	*	
<i>Epioblasma capsaeformis</i>	**	**	**	*	
<i>Epioblasma triquetra</i>	*	*	**	*	*
<i>Fusconaia barnesiana</i>	*	*	*	*	*
<i>Fusconaia cuneolus</i>	*	*	*	*	*
<i>Lampsilis fasciola</i>	*	*	**	*	
<i>Lampsilis ovata</i>	*	*	**	*	*
<i>Lasimigona costata</i>	*	*	**	*	*
<i>Lastena lata</i>	*	*			
<i>Ligumia recta</i>	*	*	*	*	
<i>Medionidus conradicus</i>	*	*	*	*	
<i>Pleurobema oviforme</i>	*	*	*	*	*
<i>Potamilus alata</i>	*	*	**	*	*
<i>Ptychobranchius fasciolaris</i>	*	*	*	*	*
<i>Ptychobranchius subtentum</i>	*	*	*	*	*
<i>Quadrula cylindrica</i>	*	*	*	*	*
<i>Quadrula pustulosa</i>	*	*	**	*	
<i>Strophitus undulatus</i>	*	*	**	*	
<i>Truncilla truncata</i>	*	*	+	*	
<i>Villosa iris</i>	*	*	*	*	
Total Number of Live(Dead) Species	28(1)	17(2)	11(12)	16(0)	11(0)

Table 4. Number of Mussels per Square Meter in YMA Clinch River Quantitative Sampling.

SPECIES	RIVER MILE			
	183.5	189.3	189.6	192.4
<i>Actinonaias carinata</i>	13.5	4	1.65	2.9
<i>Actinonaias pectorosa</i>	3.3	2.05	0.45	0.9
<i>Alasmidonta marginata</i>			0.1	
<i>Amblyma plicata</i>		0.1	0.15	0.1
<i>Conradilla caelata</i>	0.05			
<i>Cyclonaias tuberculata</i>		0.25	0.3	
<i>Dromus dromas</i>	0.15	0.05	0.1	
<i>Elliptio crassidens</i>			0.05	
<i>Elliptio dilatatus</i>	0.05	0.15	0.3	0.55
<i>Epioblasma brevidens</i>	0.1		0.05	0.1
<i>Epioblasma capsaeformis</i>	0.05			0.45
<i>Fusconaia barnesiana</i>	0.55	0.2	0.7	0.1
<i>Fusconaia cuneolus</i>	0.1	0.05		0.15
<i>Fusconaia flava</i>			0.1	
<i>Lampsilis fasciola</i>	0.05	0.15	0.2	0.35
<i>Lampsilis ovata</i>	0.15			0.1
<i>Lasmigona costata</i>	0.5	0.05	0.2	0.25
<i>Lastena lata</i>	0.05	0.05		
<i>Lexingtonia dolabelloides</i>			0.05	
<i>Medionidus conradicus</i>	1.3	1.6	2.35	4.15
<i>Pleurobema oviforme</i>			0.15	
<i>Pychobranchus fasciolaris</i>	0.1	0.2	0.25	0.2
<i>Pychobranchus subtentum</i>	1.5	0.8	1.15	1.3
<i>Quadrula pustulosa</i>		0.05	0.05	0.05
<i>Strophitus undulatus</i>				
<i>Truncilla truncata</i>	0.05			
<i>Villosa iris</i>		0.05	0.3	0.35
TOTAL SPECIES	17	16	20	16
TOTAL MUSSELS	431	196	272	240
TOTAL PER SQUARE METER	21.55	9.8	13.6	12

with a mean density of 0.04 organisms per square meter.

Other endangered mussels collected during YMA stream surveys included Dromus dromas and Fusconaia cuneolus. In 1988, TVA estimated mean densities of these two species as 0.01 and 0.09 individuals/m<sup>2</sup>. Density estimates from YMA stream survey data indicates much higher densities for Dromus dromas (0.08 individuals/m<sup>2</sup> as compared to 0.01/m<sup>2</sup>). However, densities for Fusconaia cuneolus (0.08 individuals/m<sup>2</sup>) were similar to 1988 TVA estimates. The relative abundance of the Io fluvialis (spiny river snail ), a current status review species, ranged from common to very abundant at sites surveyed by YMA.

#### Powell River

Qualitative sampling was completed at five sites (PRM 110.2, 106.9, 106.7, 103.2 and 94.8) (Table 5). In addition, two of the five qualitative sites (PRM 110.2 and 94.8) were quantitatively sampled. Quantitative sampling consisted of forty 0.5 m<sup>2</sup> quadrats taken at each of the sites surveyed.

Sixteen species of mussels were collected during quantitative sampling (Table 6). The mussel density at PRM 94.8 during YMA surveys were greater than TVA estimates from the previous year. TVA found 10 species at this site with a density of approximately 2.3 individuals per square meter. Density estimates from data collected by YMA indicates a density of ~7 mussels/m<sup>2</sup> at PRM 94.8. Diversity and density at PRM 110.2 were less than observed at PRM 94.8. Only 9 species of mussels were collected at this site,



Table 5. Results of YMA Qualitative Sampling of the Powell River System.

SPECIES	RIVER MILE				
	94.8	103.2	106.7	106.9	110.2
<i>Actinonaias carinata</i>	*	**	*		*
<i>Actinonaias pectorosa</i>	*				*
<i>Amblyema plicata</i>	*	*	*	**	*
<i>Cyclonaias tuberculata</i>	*		**		*
<i>Dromus dromas</i>	*	**	**		**
<i>Elleptio crassidens</i>	*	**	**		*
<i>Elleptio dilatatus</i>	*		**		
<i>Epioblasma brevidens</i>	*		**		**
<i>Epioblasma capsaeformis</i>	*	**	**		*
<i>Epioblasma triquetra</i>	*		**		*
<i>Fusconaia barnesiana</i>	*				**
<i>Lampsilis fasciola</i>	*	**			**
<i>Lampsilis ovata</i>	*				**
<i>Lasmigona costata</i>	*		**		**
<i>Lexingtonia dolabelloides</i>	*		**		*
<i>Ligumia recta</i>	*		**		**
<i>Medionidus conradicus</i>	*				*
<i>Plethobasus cyphus</i>	*		**		*
<i>Pleurobema oviforme</i>	*		**	**	*
<i>Potamilus alata</i>	*	**	**	**	**
<i>Ptychobranchius fasciolaris</i>	*		**		**
<i>Ptychobranchius subtentum</i>	**		**		**
<i>Quadrula cylindrica</i>		**	**		**
<i>Quadrula intermedia</i>					*
<i>Villosa iris</i>	**				**
Total Number of Live (Dead) Species	19(2)	1(6)	2(12)	(2)	12(9)

\* = Live      \*\* = Dead

Table 6. Number of Mussels per Square Meter in YMA Powell River Quantitative Sampling.

SPECIES	RIVER MILE	
	94.8	110.2
<i>Actinonaias carinata</i>	3.3	1
<i>Actinonaias pectorosa</i>	0.75	0.25
<i>Ambelma plicata</i>	0.2	0.05
<i>Cyclonaias tuberculata</i>	0.15	0.05
<i>Dromus dromas</i>	0.25	0.1
<i>Elliptio dilatatus</i>	0.1	0.1
<i>Epioblasma brevidens</i>	0.05	
<i>Epioblasma triquetra</i>	0.15	
<i>Fusconaia barnesiana</i>	0.45	0.15
<i>Fusconaia subrotunda</i>		
<i>Lampsilis fasciola</i>	0.05	
<i>Lampsilis ovata</i>	0.05	
<i>Lasmigona costata</i>	0.1	
<i>Ligumia recta</i>	0.05	
<i>Medionidius conradicus</i>	0.8	0.05
<i>Plethobasus cyphus</i>	0.05	
<i>Ptychobranchus fasciolaris</i>	0.1	
<i>Quadrula intermedia</i>		0.05
TOTAL SPECIES	16	9
TOTAL MUSSELS	132	36
TOTAL PER SQUARE METER	6.6	1.8

resulting in a density of 1.8 mussels per square meter.

Two federal endangered species were collected during the Powell River survey. Seven specimens of Dromus dromas and 1 specimen of Quadrula intermedia were collected during quantitative sampling. Overall densities estimates for Dromus dromas were 0.18 individuals/m<sup>2</sup>. TVA estimated the density of Dromus dromas in 1988 to be 0.01 individuals/m<sup>2</sup>. YMA and TVA (1988) surveys resulted in similar density estimates (0.03 mussels/m<sup>2</sup>) for Quadrula intermedia. Occurrence of Io fluvialis (spiny river snail) was common throughout the Powell River system.

#### Elk River

Sampling efforts were postponed due to high water and scheduling conflicts.

#### Task 6 - Survey of the Duck River and Mapping of Lillard's Mill

Mapping of Lillard's Mill was completed and survey data has been entered into the computer. Computerized maps of depths and substrate are currently being generated and revised.

Two sites were quantitatively sampled on the Duck River; DRM 133.4 and 179.2. The number of species collected at each site was 12 and 17, respectively (Table 7). Five specimens of Conradilla caelata were collected from DRM 179.2. One specimen of Arcidens confragosus, which was not previously collected by TVA, was collected at DRM 133.4. TVA collected 16 species at DRM 179.2 and

Table 7. Number of Mussels per Square Meter in YMA Duck River Quantitative Sampling.

SPECIES	RIVER MILE	
	133.4	179.2
<i>Amblyma plicata</i>	1.25	1.9
<i>Arcidens confragosus</i>	0.05	
<i>Carunculina moesta</i>		0.05
<i>Conradilla caelata</i>		0.25
<i>Cyclonaias tuberculata</i>	1.8	5
<i>Elliptio dilatatus</i>		0.65
<i>Lampsilis fasciola</i>	0.1	0.15
<i>Lampsilis ovata</i>	0.1	
<i>Lasmigona complanata</i>	0.05	
<i>Lasmigona costata</i>		0.15
<i>Leptodea fragilaris</i>	0.3	0.05
<i>Lexingtonia dolabelloides</i>		0.25
<i>Meglonaias nervosa</i>	0.15	0.1
<i>Obliquaria reflexa</i>	0.2	0.1
<i>Pleurobema oviforme</i>		0.15
<i>Potamilus alatus</i>		0.05
<i>Quadrula pustulosa</i>	0.75	1.65
<i>Quadrula quadrula</i>	0.45	
<i>Tritogonia verrucosa</i>	0.2	0.35
<i>Truncilla truncata</i>		2.75
<i>Villosa taeniata</i>		0.05
TOTAL SPECIES	12	17
TOTAL MUSSELS	108	273
TOTAL PER SQUARE METER	5.4	13.65

calculated a density of 26.8 mussels/m<sup>2</sup>. YMA calculated density to be approximately 13.7 mussels/m<sup>2</sup>. Mussel density at DRM 133.4 was ~5.4 per square meter.

Twenty-five species were collected at each of the Duck River site (DRM 133.4 and DRM 179.2) during qualitative sampling (Table 8). Two species (Lampsilis terres and Arcidens confragosus) collected during YMA qualitative searches had not previously been collected by TVA. It is unknown if Lampsilis terres and Arcidens confragosus are recent introductions to the river or whether previous sampling efforts did not detect these two species.

Table 8. Results of YMA Qualitative Sampling of the Duck River Sites.

SPECIES	RIVER MILE	
	133.4	179.2
<i>Actinonaias pectorosa</i>		*
<i>Amblema plicata</i>	*	*
<i>Anodonta imbecillis</i>	**	
<i>Arcidens confragosus</i>	*	
<i>Carunculina moesta</i>	**	*
<i>Conradilla caelata</i>	**	*
<i>Cyclonaias tuberculata</i>	*	*
<i>Elliptio dilatatus</i>	*	*
<i>Epioblasma capsaeformis</i>		*
<i>Fusconaia barnesiana</i>		*
<i>Lampsilis fasciola</i>	**	*
<i>Lampsilis ovata</i>	**	*
<i>Lampsilis teres</i>	**	
<i>Lasmigona complanata</i>	**	
<i>Lasmigona costata</i>	*	*
<i>Leptodea fragilaris</i>	*	*
<i>Lexingtonia dolabelloides</i>	*	*
<i>Meglonaias nervosa</i>	*	*
<i>Obliquaria reflexa</i>	*	*
<i>Pleurobema oviforme</i>	*	*
<i>Potamilus alatus</i>	*	*
<i>Ptychobranchnus fasciolaris</i>	**	
<i>Quadrula cylindrica</i>		*
<i>Quadrula pustulosa</i>	*	*
<i>Quadrula quadrula</i>	*	
<i>Tritogonia verrucosa</i>	*	*
<i>Truncilla donaciformis</i>		*
<i>Truncilla truncata</i>	**	*
<i>Villosa iris</i>		*
<i>Villosa taeniata</i>	*	*
<i>Villosa vanuxemi</i>	**	*
Total Number of Live(Dead) Species	15(10)	25(0)
	* = Live	** = Dead

## RECOMMENDATION

Future transplant site surveys should include one of the following methodologies:

**Shallow water/low flow** - set up sampling grid adjacent to downstream end of transplant site, and sample an additional 40 randomly selected 0.5 m<sup>2</sup> quadrats.

**Deep water/high flow** - set up sampling grid in the next section of suitable substrate within the downstream end of the transplant site, and sample an additional 40 0.5 m<sup>2</sup> quadrats.

Addition of these two methodologies would facilitate estimation of the number of Conradilla caelata that are being hydraulically displaced from the transplant sites. Two separate methods are required due to the variation in hydrologic characteristics between the four transplant sites. Transplant sites on the North Fork Holston and Nolichucky rivers consists of mainly riffle habitat, while sites on the Duck and Buffalo rivers are located in run habitat. Therefore, mussels from transplant sites on the Duck and Buffalo rivers are more likely to be displaced a greater distance downstream than those in the North Fork Holston and Nolichucky rivers. However, due to continuously changing hydraulic characteristics of river systems, attempts to locate individuals dispersed further than 200 feet from the original transplant sites would greatly decrease the probability

of finding them. Cost of additional sampling at each site would be minimal in relation to the data that would be collected concerning dispersal of transplanted populations. Subsequent sampling would require approximately one additional day per site.

*compare to other*

Overall recommendations would include float surveying sections of each river. The objective of the mussel surveys is to determine the current status of the mussel fauna throughout the river systems and not to simply resurvey previously sampled areas. Float surveying would allow more complete coverage of the rivers which have only moderate access from roads to locations with favorable mussel habitat.

*check for viability*

To assess the current reproductive status of mussel species, the drift of glochidia could be monitored below known assemblages of mussels. Collection of glochidia and glochidia-infested fish would be indicators that the respective mussel communities are potential viable populations. In order to further <sup>confirm</sup> ~~assess~~ the relative viability of these populations, the collection of juvenile mussels would need to be documented.

To obtain valid population statistics, age determination of a bivalve population is essential. This data <sup>also</sup> describes the age structure of the population providing information on recruitment and reproductive success. Techniques of aging freshwater mussels includes counting external growth bands, shell ashing, thin-sectioning and acetate peels. Recent peer-reviewed literature indicates thin-sectioning of mussel valves is the most accurate and precise method (Neves and Moyer 1988).