Presence of Freshwater Mussel Host-Fish Species in the Tallaseehatchee Creek Watershed Following an Extended Drought

United States Department of Agriculture Forest Service
Southern Research Station
Center for Aquatic Technology Transfer
1710 Ramble Rd.
Blacksburg, VA 24060-6349

C. Andrew Dolloff, Team Leader

Report prepared by:
Colin Krause and Craig Roghair
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Introduction

The upper Tallaseehatchee Creek watershed is located on the Talladega National Forest, which is part of the National Forests in Alabama (NFAL). This watershed is home to common (*Villosa vibex*), sensitive (*Villosa nebulosa* and *Villosa umbrans*), and federally threatened (*Hamiota altilis*) freshwater mussel species, as well as a variety of fish species. Multiple dams and associated reservoirs limit overall connectivity within the watershed (Figure 1).

An extended drought influenced the Tallaseehatchee Creek watershed in 2006 and 2007, resulting in dewatered areas for a two week time period in September/October 2007. At this time there was no flowing water in Tallaseehatchee Creek (hereafter referred to as 'stream A', Figure 1) at the inlet of Lake Virginia and at the FS 607 road crossing (some stagnant pools were present; J. Moran, NFAL, personal observation). An unnamed tributary to Tallaseehatchee Creek (Figure 1, stream C), which flows into Lake Howard, was dry at the FS 601 road crossing.

NFAL personnel conducted quick non-intensive mussel surveys in two reaches (1.4 and 1.3 km) on stream C in July 2007 and in a 1.2 km reach on stream B in April 2008 (Figure 1). The 2007 survey was performed shortly before the most severe portion of the drought and at this time stream C was flowing, but water levels were low. The 2008 survey took place post-drought. Live mussels were found during both the 2007 and 2008 surveys, though in stream C live mussels were only found in the reach upstream of reservoir 578.

Specific Centrarchid, as well as Cottid, fish species are necessary for mussel reproduction in Tallaseehatchee Creek because they host the parasitic glochidia stage (Table 1; Williams et al. 2008). NFAL personnel found all primary and secondary mussel host-fish species present in stream A, with the exception of banded sculpin during pre-drought electrofishing inventories (J. Moran, NFAL, personal communication). No pre-drought fish sampling occurred in streams B or C. It is assumed that the species in stream A were also present in stream B because there are no movement barriers between these reaches. The only fish observations in stream C were made during the 2008 post-drought mussel survey, and only *Lepomis spp*., a Centrarchid, were observed.

The NFAL wanted to assess the current distribution of host-fish species within streams A, B, and C in reaches known to contain post-drought mussel populations or quality mussel habitat. A USDA Forest Service, Southern Research Station, Center for Aquatic Technology Transfer (CATT) field crew and National Forests in Alabama (NFAL) personnel performed diving and electrofishing inventories to assess their presence. The CATT deployed 1 biologist and 3 technicians to the Talladega National Forest; June 14 – 15, 2010 to perform host-fish distribution inventories.

Methods

Site Selection

We inventoried Tallaseehatchee Creek and two unnamed tributaries to Tallaseehatchee Creek on the Talladega National Forest for the presence of mussel host-fish using diving and electrofishing (Figure 1). Stream A (Tallaseehatchee Creek) and unnamed stream B flow into Lake Virginia, and unnamed stream C into reservoir 578 and then Lake Howard before entering Tallaseehatchee Creek. Reaches on these streams were selected by NFAL to overlap or be near the locations where mussel surveys were performed in 2007 and 2008. Stream order, watershed area, bankfull width, wetted width, and gradient are shown in Table 2. Observations of stream channel substrate made by J. Moran (NFAL, personal communication) during mussel surveys in stream B included sand in slow-water habitat units and large gravel, small gravel, cobble, sand, and bedrock (in fast-water habitat units; listed in order of abundance); in stream C channel substrate was mostly small gravel, sand, and bedrock.

Pool Inventory

A two person crew, comprised of one diver and one data-recorder, observed (using mask and snorkel) and recorded the presence of mussel host-fish in slow-water habitat units (i.e. pools and glides). We dove every 10th slow-water unit in streams A and B and every 5th unit in stream C due to its shorter length (Table 3). Divers entered habitat units at the downstream end and proceeded upstream. In units that were too wide to view from bank to bank, a zigzag dive pattern was used. Occasionally the unit was divided into halves when obstructions (e.g. gravel bars) were present. The diver counted target species (longear sunfish *Lepomis megalotis*, redeye bass *Micropterus coosae*, and banded sculpin *Cottus carolinae*) as well as secondary host species (green sunfish *Lepomis cyanellus*, bluegill *Lepomis macrochirus*, redear sunfish *Lepomis microlophus*, spotted bass *Micropterus punctulatus*, and largemouth bass *Micropterus salmoides*). Other species groups were noted (e.g. shiner, darter, sunfish, etc). The location of all dove habitat units was recorded with a GPS unit (Appendix Table A1).

We recorded the location of every 10th fast-water habitat unit (i.e. riffle or run) encountered during the pool inventory with a GPS unit and marked it with flagging tape. We returned and electrofished the fast-water units for presence/absence of banded sculpin.

Riffle Inventory

A two person crew, comprised of one electrofishing unit operator and one dip-netter, sampled (single-pass, DC current, using an Appalachian Aquatics backpack electrofishing unit) every 10th fast-water habitat unit (i.e. riffle or run; due to stream C's shorter reach some additional riffles were sampled)

to assess the presence or absence of banded sculpin (Appendix Table A1). Banded sculpin are the only host-fish species known to prefer fast-water habitat (Boschung et al. 2004; Mettee et al. 1996). The presence of other fish species was not recorded, and riffles were not sampled by divers because visual observation of the cryptic cottid is ineffective.

Results

The pool inventories completed by the CATT and NFAL personnel found that 2 of the 3 primary host-fish species (longear sunfish and redeye bass, are present in multiple habitat units throughout streams A, B, and C (Tables 4, 5, and 6). Banded sculpin were not observed in either pre or post-drought inventories. Secondary host-fish species (bluegill and largemouth bass) were observed in streams B and C (Tables 5 and 6). The only primary host-fish species not observed by divers or captured with electrofishing was banded sculpin (Tables 4, 5, and 6). In addition to host-fish species, our inventory also found numerous non host-fish species/families present in all three streams (Table 7).

Discussion

Mussel survival during dry stream conditions is difficult and has been shown to result in large population losses (Golladay et al. 2004; Haag and Warren 2008). Haag and Warren (2008) found an 80% reduction in abundance in a small stream in Alabama that had 73% of the examined reach length go completely dry. In their study Haag and Warren observed numerous dead mussels, found neither live mussels, nor any water down to depths of 15 cm in the substrate. Such losses result from mussel's limited ability to migrate forcing them to tolerate drought conditions, which result in reduced depth and flow, in-turn reducing food, dissolved oxygen, and elevating water temperatures (Golladay et al. 2004). These conditions are all the more prevalent in small shallow streams like those in the Tallaseehatchee Creek watershed due to few deepwater refuges and an increased likelihood of low flows. Post drought, the only live mussels Haag and Warren (2008) found were in the few areas of the channel that had retained some water. Other small streams in their study that remained mostly watered also had large (65-83%) losses in abundance due to secondary effects of drought conditions (e.g. reduced dissolved oxygen and increased water temperature). However, Golladay et al. (2004) observed one stream in Georgia where mussel abundance did not decrease as a result of a dry channel; the stream had a considerable quantity of large wood, which may have acted as a refuge. To survive drought conditions mussels can move short distances to avoid receding water, some are able to lower metabolic activity, respire via exposing the mantle to exchange gases during emersion, switch from aerobic to anaerobic respiration, and migrate deep into the sediments (Golladay et al. 2004).

Successful mussel reproduction requires mussel host-fish species to recolonize the stream post-drought. During drought conditions fish are forced either downstream or into isolated refuge pools as water recedes. When flow returns, the source of immigrants is typically from downstream, even if refuge pools are present (Adams and Warren 2005). Immigration is also impaired by dams which prevent immigration from downstream and limit mussel assemblages to their existing populations for reproduction (Haag and Warren 2008). The rate at which fish recolonization occurs depends on season and species-specific life histories; recolonization can be slow during winter and rapid in spring and early summer (Adams and Warren 2005). Recolonization begins with low abundance of primarily adult (at least age-1) fishes of many species (i.e. high richness) and is followed by reproduction and continued immigration which increases abundance (Adams and Warren 2005). A year or more may be required for the pre-drought fish assemblage to return.

In our inventories, almost three years after the drought, we found secondary-host and non-host fish species-richness lower than pre-drought richness. However, the two primary host-fish species known to occur pre-drought have returned, and Centrarchid young-of-year were observed. In addition, the reservoirs downstream of each reach may serve as sources of additional Centrarchid species over time.

It is clear that drought conditions, especially in small streams, are a challenge for mussel survival and that the local conditions in a stream (e.g. deepwater refuge areas) have much to do with the ability to survive those conditions. Low reproductive rates coupled with reduced population size and stream fragmentation has the potential to reduce population sizes to the point where they are not able to sustain themselves (Haag and Warren 2008). The post-drought presence of mussel assemblages in the three inventoried Tallaseehatchee Creek watershed streams and the observed recolonization of mussel host-fish species provides hope that these mussel populations will successfully reproduce and sustain themselves.

Given the unknown size and distribution of the mussel populations in the Tallaseehatchee Creek watershed, we recommend additional mussel surveys. An estimate of the mussel population size is needed to assess the risk of falling below minimum sizes necessary for successful reproduction. Knowledge of the mussel population distributions will help locate the refuge areas that allowed the mussels to survive the drought period. Additional fish inventories would clarify whether host-fish species richness has reached a plateau or will eventually return to pre-drought levels.

Data Availability

The 2010 dive and electrofishing data are in a MS Access database, which is stored at the CATT and a copy has been provided to John Moran, NFAL Fish Biologist. We will support the migration of this data into the USFS database tool, Natural Resource Information System Aquatic Surveys (NRIS AqS) as needed. In the interim, we are working with the NFAL to develop custom queries and reports for the MS Access database.

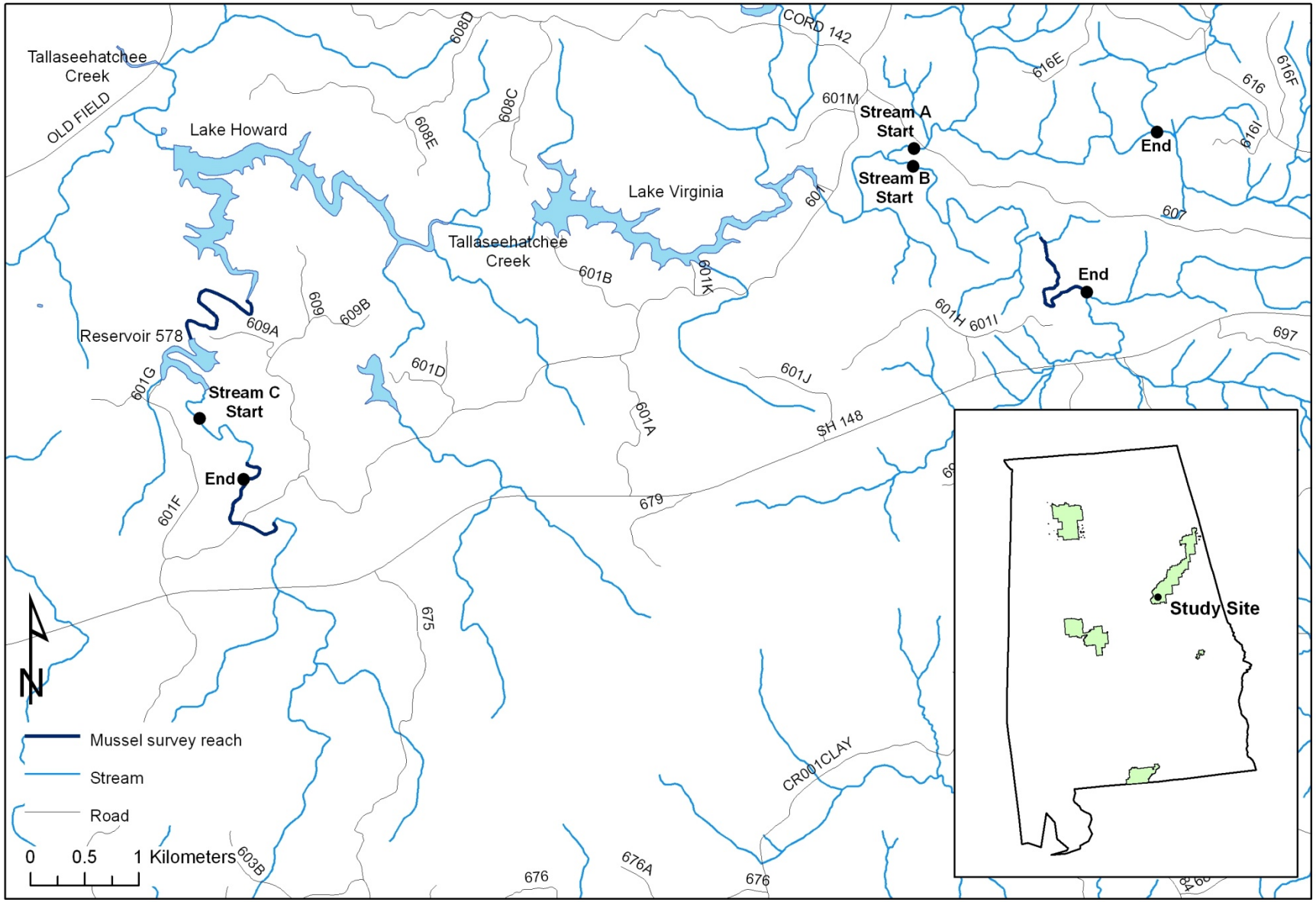

Figure 1. Tallaseehatchee Creek (stream A) and unnamed streams (B and C) inventoried for the presence of mussel host-fish; Tallaseehatchee Creek watershed, Talladega National Forest, AL.

Table 1. Mussel species and their host-fish species in the Tallaseehatchee Creek watershed (Williams et al. 2008).

Host-Fish Species		Mussel Species			
		Villosa vibex	*Villosa nebulosa*	*Villosa umbrans*	*Hamiota altilis*
Centrarchidae					
Lepomis cyanellus	Green sunfish	secondary		*	secondary
Lepomis macrochirus	Bluegill			*	
Lepomis megalotis	Longear sunfish		primary	*	
Lepomis microlophus	Redear sunfish			*	
Micropterus coosae	Redeye bass	primary	primary		primary
Micropterus punctulatus	Spotted bass	primary	primary		primary
Micropterus salmoides	Largemouth bass	secondary	primary		primary
Cottidae					
Cottus carolinae	Banded sculpin			*	

* According to Williams et al (2008) host use varies among individuals and populations, with some using either Lepomis or Cottus (species not identified in book).

Table 2. Summary of inventoried stream characteristics.

Stream	Stream Order	Watershed Area (sq. km) at Inventory Start	Avg. Bankfull Width (m)[1]	Avg. Wetted Width (m)[1]	Gradient[2]
A	4th	16.8	NA	NA	1%
B	4th	17.9	7.5-9.5	9	1%
C	2nd	11.9	6-8	NA	1%

[1] J. Moran, NFAL, personal communication
[2] Based on GPS recorded elevations and GIS calculated distances.

Table 3. Summary of pool and riffle inventory parameters.

Stream	Reach Length (km)	# of Pools within Inventory Reach	# Pools Dived	# of Riffles within Inventory Reach	# of Riffles Electrofished	Total Seconds Electrofished
A	2.9	82	8	75	7	1,130
B	3.8	86	8	86	8	1,326
C	1.3	38	4	36	5	1,624

Table 4. Count of primary and secondary mussel host-fish species observed via diving in slow-water habitat units (pools) and count of banded sculpin captured via electrofishing in fast-water habitat units (riffles) in Tallaseehatchee Creek, **stream A**.

	Primary Host Species			Secondary Host Species				
	Longear sunfish *Lepomis megalotis*	Redeye bass *Micropterus coosae*	Banded sculpin *Cottus carolinae*	Green sunfish *Lepomis cyanellus*	Bluegill *Lepomis macrochirus*	Redear sunfish *Lepomis microlophus*	Spotted bass *Micropterus punctulatus*	Largemouth bass *Micropterus salmoides*
pool 10	0	1	0	0	0	0	0	0
riffle 10			0					
pool 20	0	0	0	0	0	0	0	0
riffle 20			0					
pool 30	1	1	0	0	0	0	0	0
riffle 30			0					
pool 40	1	1	0	0	0	0	0	0
riffle 40			0					
pool 50	0	0	0	0	0	0	0	0
riffle 50			0					
pool 60	2	4	0	0	0	0	0	0
riffle 60			0					
pool 70	1	3	0	0	0	0	0	0
riffle 70			0					
pool 80*	0*	0	0	0*	0*	0*	0	0
Total	**5**	**10**	0	0	0	0	0	0

* Unidentifiable young-of-the-year sunfish (*Lepomis spp*.) were observed.

Table 5. Count of primary and secondary mussel host-fish species observed via diving in slow-water habitat units (pools) and count of banded sculpin captured via electrofishing in fast-water habitat units (riffles) in **stream B**.

	Primary Host Species			Secondary Host Species				
	Longear sunfish *Lepomis megalotis*	Redeye bass *Micropterus coosae*	Banded sculpin *Cottus carolinae*	Green sunfish *Lepomis cyanellus*	Bluegill *Lepomis macrochirus*	Redear sunfish *Lepomis microlophus*	Spotted bass *Micropterus punctulatus*	Largemouth bass *Micropterus salmoides*
pool 10	5	3	0	0	8	0	0	0
riffle 10			0					
pool 20	10	2	0	0	15	0	0	0
riffle 20			0					
pool 30	2	3	0	0	4	0	0	0
riffle 30			0					
pool 40	0	0	0	0	0	0	0	0
riffle 40			0					
pool 50	7	4	0	0	0	0	0	0
riffle 50			0					
pool 60	6	0	0	0	0	0	0	0
riffle 60			0					
pool 70	0	0	0	0	1	0	0	0
riffle 70			0					
pool 80	0	0	0	0	0	0	0	0
riffle 80			0					
Total	**30**	**12**	0	0	**28**	0	0	0

Table 6. Count of primary and secondary mussel host-fish species observed via diving in slow-water habitat units (pools) and count of banded sculpin captured via electrofishing in fast-water habitat units (riffles) in **stream C**.

	Primary Host Species			Secondary Host Species				
	Longear sunfish *Lepomis megalotis*	Redeye bass *Micropterus coosae*	Banded sculpin *Cottus carolinae*	Green sunfish *Lepomis cyanellus*	Bluegill *Lepomis macrochirus*	Redear sunfish *Lepomis microlophus*	Spotted bass *Micropterus punctulatus*	Largemouth bass *Micropterus salmoides*
riffle 5			0					
pool 5	11	0	0	0	2	0	0	1
pool 10	9	1	0	0	6	0	0	0
riffle 10			0					
pool 15	6	2	0	0	2	0	0	0
riffle 15			0					
pool 20	1	1	0	0	6	0	0	0
riffle 24			0					
riffle 36			0					
Total	**27**	**4**	0	0	**16**	0	0	**1**

Table 7. Host and non host-fish species presence pre-drought and post-drought in streams A, B, and C.

Family	Scientific Name	Common Name	Stream A		Stream B			Stream C		
			Pre[1] (2006)	Post (2010)	Pre[2]	Post[3] (2008)	Post (2010)	Pre[4]	During[5] (2007)	Post (2010)
Host-Fish Species										
Centrarchidae	*Lepomis cyanellus*	Green sunfish	✓		✓[2]					
	Lepomis macrochirus	Bluegill	✓		✓[2]		✓			✓
	Lepomis megalotis	Longear sunfish[6]	✓	✓	✓[2]		✓			✓
	Lepomis microlophus	Redear sunfish	✓		✓[2]					
	Lepomis spp.	"Sunfish"							✓	
	Micropterus coosae	Redeye bass[6]	✓	✓	✓[2]	✓	✓			✓
	Micropterus punctulatus	Spotted bass	✓		✓[2]					
	Micropterus salmoides	Largemouth bass	✓		✓[2]					✓
Cottidae	*Cottus carolinae*	Banded sculpin[6]								

[1] Pre-drought stream A species presence based on NFAL electrofishing inventories conducted in summer 2006.
[2] Fish species present in stream A are assumed to also reside in stream B because there are no fish barriers, thus allowing unrestricted access of all fish in the mainstem into stream B. However, no electrofishing sampling occurred to verify species presence.
[3] Post-drought in 2008, species presence in stream B is based on one-time visual observations made by NFAL personnel during a mussel survey.
[4] Stream C is disconnected from the mainstem by a reservoir and no records of pre-drought fish sampling are known.
[5] During the drought in 2007, species presence in stream C is based on one-time visual observations made by NFAL personnel during a mussel survey.
[6] Primary host-fish species; other species are secondary hosts.

Table 7 Continued. Host and non host-fish species presence pre-drought and post-drought in streams A, B, and C.

Family	Scientific Name	Common Name	Stream A		Stream B			Stream C		
			Pre[1] (2006)	Post (2010)	Pre[2]	Post[3] (2008)	Post (2010)	Pre[4]	During[5] (2007)	Post (2010)
Non Host-Fish Species										
Catostomidae	*Hypentelium etowanum*	Alabama hog sucker	✓	✓	✓[2]	✓	✓		✓	✓
	Moxostoma duquesnei	Black redhorse	✓		✓[2]					
Cyprinidae	*Campostoma oligolepis*	Largescale stoneroller	✓	✓	✓[2]					
	Cyprinella callistia	Alabama shiner	✓		✓[2]					
	Cyprinella & Notropis spp.	"Shiner"		✓		✓	✓		✓	✓
	Cyprinella venusta	Blacktail shiner	✓		✓[2]					
	Notropis stilbius	Silverstripe shiner	✓		✓[2]					
Ictaluridae	*Ameiurus natalis*	Yellow bullhead	✓		✓[2]					
	Noturus spp.	"Madtom"								✓
Percidae	*Percina & Etheostoma spp.*	"Darter"		✓		✓			✓	✓
	Etheostoma coosae	Coosa darter	✓		✓[2]					
	Percina kathae	Mobile logperch	✓	✓	✓[2]	✓	✓		✓	✓
	Percina nigrofasciata	Blackbanded darter	✓		✓[2]					

[1] Pre-drought stream A species presence based on NFAL electrofishing inventories conducted in summer 2006.
[2] Fish species present in stream A are assumed to also reside in stream B because there are no fish barriers, thus allowing unrestricted access of all fish in the mainstem into stream B. However, no electrofishing sampling occurred to verify species presence.
[3] Post-drought in 2008, species presence in stream B is based on one-time visual observations made by NFAL personnel during a mussel survey.
[4] Stream C is disconnected from the mainstem by a reservoir and no records of pre-drought fish sampling are known.
[5] During the drought in 2007, species presence in stream C is based on one-time visual observations made by NFAL personnel during a mussel survey.

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Appendix

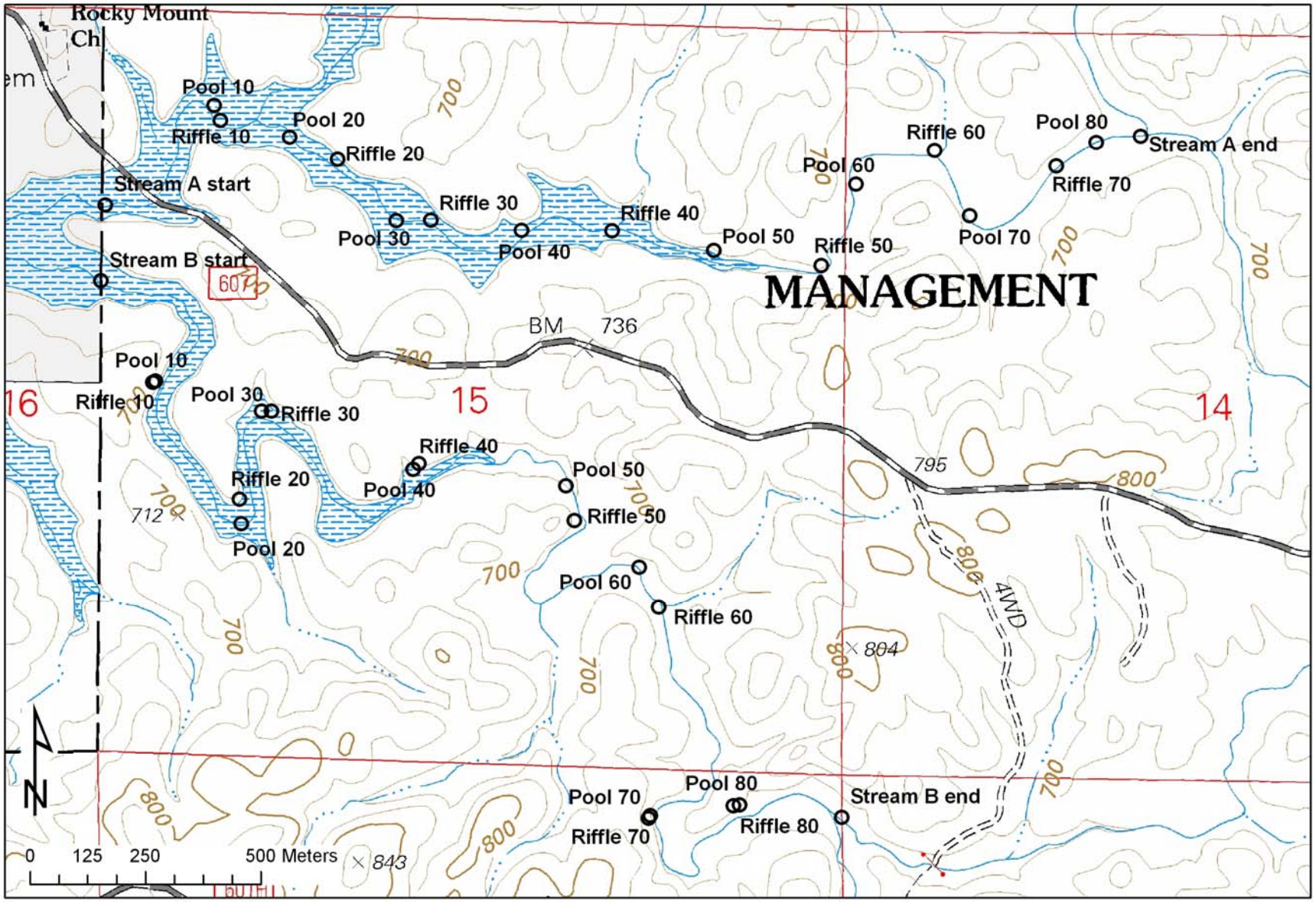

Figure A1. Pools and riffles sampled in stream A and stream B (Tallaseehatchee Creek watershed, Talladega National Forest, AL, 6/14/10).

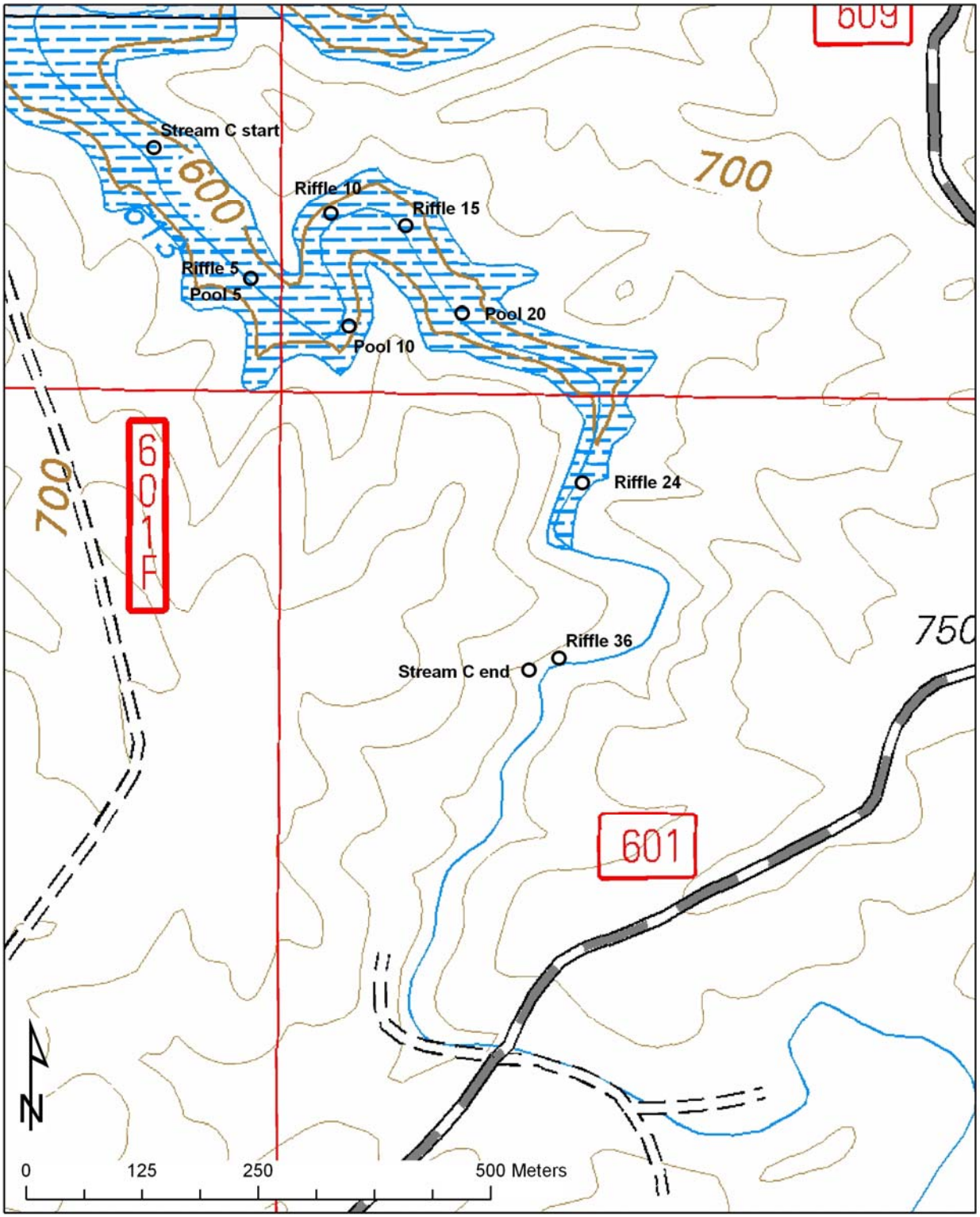

Figure A2. Pools and riffles sampled in stream C (Tallaseehatchee Creek watershed, Talladega National Forest, AL, 6/15/10).

Table A1. Coordinates of sampled pools and riffles, and inventory start & end locations (table continued on next page).

Stream	Location	Coordinates (UTM NAD83)
Stream A	Start	16 S 581959 3674447
	10th pool	16 S 582194 3674664
	10th riffle	16 S 582208 3674631
	20th pool	16 S 582358 3674594
	20th riffle	16 S 582462 3674546
	30th pool	16 S 582589 3674413
	30th riffle	16 S 582664 3674415
	40th pool	16 S 582861 3674392
	40th riffle	16 S 583057 3674391
	50th pool	16 S 583277 3674349
	50th riffle	16 S 583510 3674316
	60th pool	16 S 583585 3674492
	60th riffle	16 S 583755 3674566
	70th pool	16 S 583831 3674424
	70th riffle	16 S 584019 3674532
	80th pool	16 S 584106 3674582
	End	16 S 584202 3674597
Stream B	Start	16 S 581949 3674283
	10th pool	16 S 582067 3674065
	10th riffle	16 S 582062 3674062
	20th pool	16 S 582253 3673755
	20th riffle	16 S 582250 3673808
	30th pool	16 S 582298 3674000
	30th riffle	16 S 582319 3674000
	40th pool	16 S 582625 3673872
	40th riffle	16 S 582638 3673885
	50th pool	16 S 582957 3673837
	50th riffle	16 S 582975 3673762
	60th pool	16 S 583115 3673661
	60th riffle	16 S 583158 3673574
	70th pool	16 S 583139 3673123
	70th riffle	16 S 583135 3673117
	80th pool	16 S 583319 3673144
	80th riffle	16 S 583333 3673146
	End	16 S 583554 3673119

Table A1 Continued. Coordinates of sampled pools and riffles, and inventory start & end locations.

Stream	Location	Coordinates (UTM NAD83)
Stream C	Start	16 S 575359 3671955
	5th riffle	16 S 575463 3671813
	5th pool	16 S 575463 3671813
	10th pool	16 S 575569 3671763
	10th riffle	16 S 575549 3671883
	15th pool	NA
	15th riffle	16 S 575630 3671870
	20th pool	16 S 575691 3671776
	24th riffle	16 S 575820 3671593
	36th riffle	16 S 575795 3671404
	End	16 S 575763 3671392