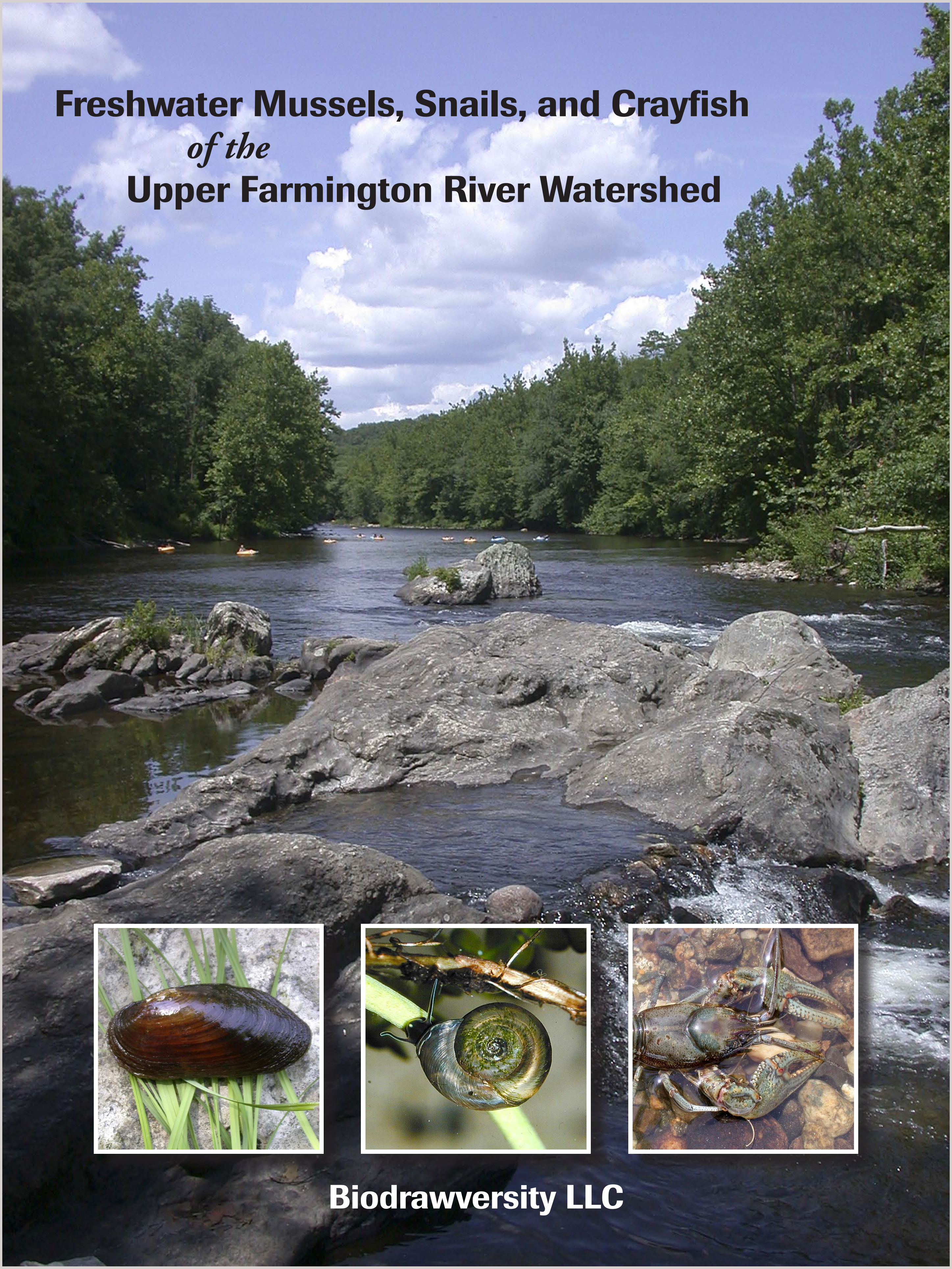
Freshwater Mussels, Snails, and Crayfish *of the* Upper Farmington River Watershed



Biodrawversity LLC

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ABSTRACT

Biodrawversity LLC surveyed freshwater mussels, snails, and crayfish in the West Branch Farmington River, Still River, Sandy Brook, and Clam River in Connecticut and Massachusetts. Fifty-six sites were surveyed on 12 days between May 30 and September 6, 2007. Surveyors recorded information on the distribution, abundance, demographics, shell condition, and habitat of freshwater mussels, as well as the distribution and habitat of snails and crayfish. Seventeen species were found, including six freshwater mussels, eight snails, and three crayfish. Habitat was generally not ideal for snails and only two species—*Amnicola limosa* and *Ferrissia rivularis*—were widespread. Crayfish were present in many locations; *Cambarus robustus* was the most common species. The West Branch and its coldwater tributaries support several of the finest eastern pearlshell populations in southern New England, a species of special concern in Connecticut whose populations rely on trout and salmon populations and excellent water quality. The West Branch also supports a regionally important population of the brook floater, a species that is endangered in Massachusetts and Connecticut. Three mussel species—brook floater, triangle floater, and creeper—appear to be imperiled or highly imperiled in the West Branch and Still River based on low numbers of animals, lack of reproduction, poor condition of animals, or limited habitat. Relevant threats to these species or their habitat are identified in this report. The report recommends long-term monitoring to (1) periodically assess the abundance, demographics, and condition of animals at reference sites, and (2) to identify and address threats as they emerge. The report recommends other actions that will help protect and restore aquatic biodiversity in the upper Farmington River.

Sandy Brook at survey site SB-8 along Sandy Brook Road in Colebrook, CT. (September 2007)

INTRODUCTION

The West Branch Farmington River (hereafter called the West Branch) is perhaps the most valuable recreational river and coldwater fishery in southern New England. Fourteen miles of the West Branch in Connecticut, downstream of the Goodwin Dam, is part of the National Wild and Scenic River System. Each year, tens of thousands of kayakers, tubers, canoeists, anglers, and wildlife watchers enjoy its clean cold water and well-protected upland landscape. The Massachusetts portion of the West Branch is eligible for, but not included in, the National Wild and Scenic River System. It is, however, vital to the health of the lower river. Major tributaries that affect the health of these waters include the Still River, Sandy Brook, Mad River, and Clam River.

As part of the implementation of the Upper Farmington River Management Plan, which is coordinated by the Farmington River Coordinating Committee (FRCC), various studies have been conducted on instream flows, bank and channel condition, invasive plants, water quality, fisheries, and biodiversity. These studies help to define conservation targets and guide protection and management. In 2007, the FRCC engaged Biodrawversity LLC to conduct freshwater mussel, snail, and crayfish surveys in the Wild and Scenic portion of the West Branch, lower Still River, and Sandy Brook.

In 2005 and 2006, freshwater mussel surveys were conducted in the lower Farmington River with funding from the U.S. Fish and Wildlife Service, The Nature Conservancy, and the Connecticut Department of Environmental Protection (CT-DEP) (Nedeau 2005, Nedeau 2006a, Nedeau 2006b). These studies determined that the Farmington River supports the highest diversity of mussels in southern New England and a globally significant population of the federally endangered dwarf wedgemussel (*Alasmidonta heterodon*). Eleven of 12 mussel species native to southern New England occur in the Farmington River—diversity matched in New England only by the 410-mile Connecticut River itself. This intact mussel assemblage is an urgent conservation priority and provided critical justification for the inclusion of the lower Farmington River in the National Wild and Scenic River System.

Mussel studies in the lower Farmington River left questions about how far upstream these populations occur in the Farmington River and whether important mussel assemblages occur in principal tributaries. The brook floater, which is listed as Endangered in Massachusetts and Connecticut, was known to occur in the Massachusetts portion of the West Branch. The Massachusetts Natural Heritage and Endangered Species Program (MNHESP) contributed funds to the FRCC project so that more intensive studies of the brook floater in Massachusetts could be conducted and to provide watershed-wide context for these species (crossing political boundaries). This report combines data from the FRCC and MNHESP studies.

Freshwater mussels are ecologically important animals that are sensitive to habitat alteration and water quality, and are used to assess the health of waterbodies (Nedeau *et al*. 2000, Nedeau 2008). They are one the most imperiled groups of animals in New England. Six of the 12 species native to Connecticut, and seven of 12 native to Massachusetts, are listed as endangered, threatened, or special concern and therefore receive state or federal protection (Nedeau *et al*. 2000, Nedeau and Victoria 2003). There is a critical need to discover populations of endangered mussels in order to protect them. Endangered species can provide justification for protecting riparian corridors and instream habitat, assessing and removing stream barriers, restoring fisheries, and implementing the most protective Best Management Practices (BMPs) for projects that may degrade river conditions (Nedeau 2008).

An interesting aspect of the life history of freshwater mussels is that larvae are obligate external parasites of

Table 1. Nomenclature, habitat, range, and fish hosts of freshwater mussels known to occur in the Farmington River watershed. Distribution based on this survey and Nedeau (2005, 2006a, and 2006b). See Nedeau 2008 for additional information.

Species	General Habitat	Farmington River Watershed	Host Species
Eastern Pearlshell *Margaritifera margaritifera*	Small streams and small rivers; mainly coldwater habitats; inhabits a variety of substrates in riffles, runs, and pools	Sparse or absent in lower Farmington River (Farmington to Windsor); present in West Branch and in several coldwater tributaries	Atlantic salmon, brook trout, brown trout, rainbow trout
Triangle Floater *Alasmidonta undulata*	Small streams to large rivers; rarely in lakes; inhabits a variety of substrates and flow conditions	Present throughout the Farmington River watershed and several tributaries	Common shiner, blacknose dace, longnose dace, pumpkinseed sunfish, fallfish, slimy sculpin, white sucker, largemouth bass
Brook Floater *Alasmidonta varicosa*	Small streams and small rivers; mainly cold or coolwater habitats; inhabits sand, gravel, and cobble in riffles and runs	Confined to Massachusetts portion of the West Branch in Otis and Sandisfield; not known from any tributaries	Longnose dace, blacknose dace, slimy sculpin, golden shiner, pumpkinseed sunfish, yellow perch, margined madtom
Dwarf Wedgemussel *Alasmidonta heterodon*	Small streams to large rivers; inhabits a variety of substrates and flow conditions	Present in lower Farmington River from Avon to upper end of Rainbow Dam impoundment	Tesselated darter, slimy sculpin, possibly juvenile Atlantic salmon
Creeper *Strophitus undulatus*	Small streams to large rivers; inhabits a variety of substrates and flow conditions	Found sporadically in lower river from Rainbow Dam impoundment to Farmington; rare in upper watershed	Creek chub, longnose dace, blacknose dace, white sucker, pumpkinseed sunfish, largemouth bass, fallfish, golden shiner, common shiner, yellow perch, slimy sculpin
Eastern Floater *Pyganodon cataracta*	Small to large rivers and lakes; mainly cool or warmwater habitats; prefers lentic or depositional habitats	Rare in Farmington River and West Branch, except for Massachusetts portion of West Branch; probably common in lakes and ponds	Generalist: Warmwater species (probably sunfish, bass, and perch)
Alewife Floater *Anodonta implicata*	Small to large rivers and coastal lakes with anadromous (clupeid) fisheries; inhabits a variety of substrates and flow conditions	Found sporadically between Avon and the Rainbow Dam impoundment; more common near mouth of Connecticut River	American shad, alewife, blueback herring
Eastern Elliptio *Elliptio complanata*	Habitat generalist; abundant in most permanent aquatic habitats	Present throughout the Farmington River watershed and several tributaries; rare in high-gradient coldwater streams	Generalist
Eastern Pondmussel *Ligumia nasuta*	Small to large rivers and lakes; primarily coastal or within reach of anadromous fish; inhabits a variety of substrates and flow conditions	Present in lower Farmington River from Farmington to the Connecticut River	Unknown: anadromous or with a coastal affinity; possibly banded killifish
Tidewater Mucket *Leptodea ochracea*	Small to large rivers and lakes; primarily coastal or within reach of anadromous fish; inhabits a variety of substrates and flow conditions	Found only in low-gradient waters near the mouth of the river	Anadromous or with a coastal affinity; possibly white perch, striped bass, alewife, yellow perch
Eastern Lampmussel *Lampsilis radiata*	Small to large rivers and lakes; mainly cool or warmwater habitats; inhabits a variety of substrates and flow conditions	Present in lower Farmington River from Farmington to the Connecticut River	Generalist: Warmwater species (probably sunfish, bass, and perch)

Table 2. Nomenclature and habitat of snails and crayfish collected during this survey.

Species	General Habitat
SNAILS	
Family Hydrobiidae: *Amnicola limosa*	Found on rocks and other submerged objects in lakes, ponds, streams, and rivers
Family Viviparidae: *Campeloma decisum*	A burrowing species that inhabits lakes and ponds but may be found in slow rivers, usually in sand or silt near banks and submerged logs
Family Ancylidae: *Ferrissia rivularis*	Restricted to streams and rivers where it grazes algae on the surfaces of rocks and other submerged objects
Family Planorbidae: *Helisoma anceps* *Planorbella trivolvis* *Micromenetus dilatatus*	Each of these three species are fairly common and widely distributed in rivers and lakes in Connecticut, usually less common in small coldwater rivers
Family Lymnaeidae: *Pseudosuccinia columella*	Mainly found in lakes and ponds in Connecticut but does occur in slow streams
Family Physidae: *Physa heterostropha* *Physa sp.* (juvenile)	Common in permanent aquatic habitats, usually on rocks and organic debris
CRAYFISH	
Family Cambaridae: *Cambarus robustus* *Orconectes limosus* *Orconectes virilis*	*C. robustus* is not native; it is prevalent in large rocky streams with moderate current. *O. limosus* is native and occurs in rivers and lakes of varying sizes. *O. virilis* is not native and occurs in a variety of permanent aquatic habitats throughout southern New England.

freshwater fish—larvae attach to the fins or gills of fish until they metamorphose into free-living juveniles. Mussels can be specific about which species of fish they will parasitize. For example, the eastern pearlshell will only use salmonids (brook trout, Atlantic salmon, brown trout, and rainbow trout). Thus, the distribution, abundance, and dynamics of freshwater mussel populations are closely tied to that of their host fish (Nedeau 2008). Table 1 summarizes habitat, distribution, and host fish of freshwater mussels in the Farmington River watershed.

Snails and crayfish were also inventoried for this project to better characterize the stream fauna. Agencies and other groups that monitor stream health, such as the Department of Environmental Protection in Connecticut and Massachusetts, generally do not sample these and other non-insect taxa as rigorously as aquatic insects. Table 2 profiles the snails and crayfish encountered during this survey.

Based on results of the survey and a summary of population status, habitat, and threats, this report discusses opportunities for research and monitoring, conservation, and management.

STUDY AREA

The study area included the Wild & Scenic portion of the West Branch in Connecticut (Canton to Hartland), the West Branch and Clam River in Massachusetts (Otis and Sandisfield), the lower Still River (Winchester, Colebrook, and Barkhamsted), and Sandy Brook (Colebrook, CT and Sandisfield, MA) (Figure 1). Representative reaches, and areas most likely to support high species richness and rare species, were chosen based on topographic maps, aerial photographs, field reconnaissance, and best professional judgment. Fifty-six sites were surveyed in Sandy Brook (ten sites plus York Lake), Still River (five sites), West Branch in Massachusetts (19 sites), Clam River in Massachusetts (one site), and West Branch in Connecticut (20 sites) (Table 3).

METHODS

Two surveyors spent 12 days (from late May to early September, 2007) surveying the Still River (1.5 days), Sandy Brook (2.5 days), and West Branch (four days in Connecticut and four days in Massachusetts). Surveyors spent an average of 1.8 person-hours per site (range: 0.5 to four hours). All sites were surveyed using masks and snorkels, and in addition, many sites were surveyed using clear-bottom buckets and aquatic D-nets. Mussels were identified, counted, and measured in the field and all were released unharmed. At 19 sites (but not within the Massachusetts portion of the West Branch), snails and crayfish were collected using an aquatic D-net and hand-picked while snorkeling; representative specimens were preserved in alcohol and identified under a dissecting microscope. Snails and crayfish were identified using keys of Jokinen (1983, 1992), Burch and Yung (1992), Peckarsky *et al.* (1995), and Smith (1995). Snails and crayfish were surveyed qualitatively and this report provides presence-absence data only. These taxa were not surveyed at every site because it was time consuming to collect them and to process and identify samples. The crayfish *Cambarus robustus* was noted where it occurred but was not always collected because killing that many specimens seemed needless.

Mussel surveys were, with a few exceptions, comprised of one to four 30-minute timed searches at each site. Timed searches provide an index of relative abundance that can help identify source populations, habitat preference, and distribution patterns. In this report, timed search data are pooled for each survey site. The following data were recorded separately for each 30-minute search:

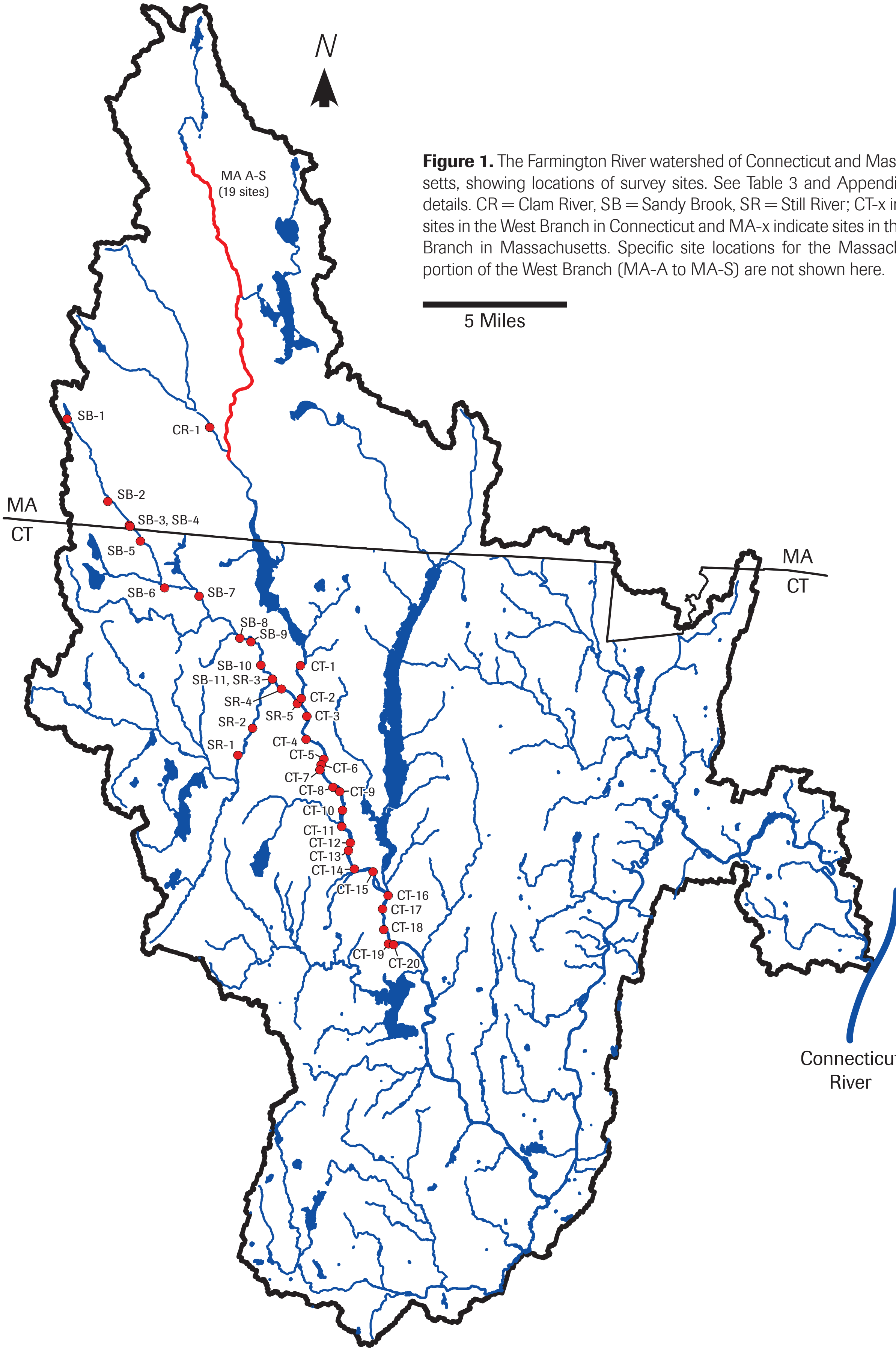

Figure 1. The Farmington River watershed of Connecticut and Massachusetts, showing locations of survey sites. See Table 3 and Appendix 1 for details. CR = Clam River, SB = Sandy Brook, SR = Still River; CT-x indicate sites in the West Branch in Connecticut and MA-x indicate sites in the West Branch in Massachusetts. Specific site locations for the Massachusetts portion of the West Branch (MA-A to MA-S) are not shown here.

Table 3. Locations of survey sites in Sandy Brook, Still River, Clam River, and West Branch. Location information for the survey sites in the Massachusetts portion of the West Branch are removed and their order has been randomized; people interested in this information should contact the Massachusetts Natural Heritage and Endangered Species Program. See Appendix 1 for site descriptions.

CODE	WATERBODY	LONGITUDE	LATITUDE	TOWN	COUNTY	STATE	DATE
SB-1	York Lake	-73.1822	42.0953	New Marlborough	Berkshire	MA	5/31/2007
SB-2	Sandy Brook	-73.1525	42.0554	Sandisfield	Berkshire	MA	6/8/2007
SB-3	Sandy Brook	-73.1374	42.0441	Sandisfield	Berkshire	MA	5/31/2007
SB-4	Sandy Brook	-73.1369	42.0436	Sandisfield	Berkshire	MA	5/30/2007
SB-5	Sandy Brook	-73.1295	42.0365	Norfolk	Litchfield	CT	6/7/2007
SB-6	Sandy Brook	-73.1119	42.0140	Colebrook	Litchfield	CT	5/30/2007
SB-7	Sandy Brook	-73.0888	42.0107	Colebrook	Litchfield	CT	6/7/2007
SB-8	Sandy Brook	-73.0602	41.9909	Colebrook	Litchfield	CT	5/30/2007
SB-9	Sandy Brook	-73.0529	41.9894	Colebrook	Litchfield	CT	6/7/2007
SB-10	Sandy Brook	-73.0455	41.9780	Colebrook	Litchfield	CT	5/31/2007
SB-11	Sandy Brook	-73.0375	41.9714	Colebrook	Litchfield	CT	9/6/2007
SR-1	Still River	-73.0580	41.9328	Winchester	Litchfield	CT	6/7/2007
SR-2	Still River	-73.0490	41.9466	Winchester	Litchfield	CT	6/7/2007
SR-3	Still River	-73.0375	41.9714	Colebrook	Litchfield	CT	9/6/2007
SR-4	Still River	-73.0311	41.9666	Colebrook	Litchfield	CT	5/31/2007
SR-5	Still River	-73.0201	41.9597	Barkhamsted	Litchfield	CT	6/7/2007
MA-A	WB Farmington River			Otis	Berkshire	MA	6/14/2007
MA-B	WB Farmington River			Otis	Berkshire	MA	6/15/2007
MA-C	WB Farmington River			Otis	Berkshire	MA	6/8/2007
MA-D	WB Farmington River			Otis	Berkshire	MA	6/14/2007
MA-E	WB Farmington River			Otis	Berkshire	MA	6/15/2007
MA-F	WB Farmington River			Sandisfield	Berkshire	MA	7/10/2007
MA-G	WB Farmington River			Otis	Berkshire	MA	6/15/2007
MA-H	WB Farmington River			Otis	Berkshire	MA	7/10/2007
MA-I	WB Farmington River			Otis	Berkshire	MA	6/14/2007
MA-J	WB Farmington River			Otis	Berkshire	MA	6/14/2007
MA-K	WB Farmington River			Otis	Berkshire	MA	6/14/2007
MA-L	WB Farmington River			Otis	Berkshire	MA	6/14-15/2007
MA-M	WB Farmington River			Otis	Berkshire	MA	7/10/2007
MA-N	WB Farmington River			Otis	Berkshire	MA	6/8/2007
MA-O	WB Farmington River			Otis	Berkshire	MA	7/10/2007
MA-P	WB Farmington River			Sandisfield	Berkshire	MA	7/10/2007
MA-Q	WB Farmington River			Otis	Berkshire	MA	6/15/2007
MA-R	WB Farmington River			Otis	Berkshire	MA	7/10/2007
MA-S	WB Farmington River			Otis	Berkshire	MA	6/15/2007
CR-1	Clam River	-73.08694	42.09461	Sandisfield	Berkshire	MA	9/6/2007
CT-1	WB Farmington River	-73.01915	41.97868	Hartland	Hartford	CT	7/5/2007
CT-2	WB Farmington River	-73.01756	41.96247	Barkhamsted	Litchfield	CT	7/5/2007
CT-3	WB Farmington River	-73.01339	41.95374	Barkhamsted	Litchfield	CT	7/5/2007
CT-4	WB Farmington River	-73.01318	41.94220	Barkhamsted	Litchfield	CT	7/5/2007
CT-5	WB Farmington River	-73.00072	41.93293	Barkhamsted	Litchfield	CT	7/5/2007
CT-6	WB Farmington River	-73.00245	41.92999	Barkhamsted	Litchfield	CT	7/2/2007
CT-7	WB Farmington River	-73.00312	41.92755	Barkhamsted	Litchfield	CT	7/2/2007
CT-8	WB Farmington River	-72.99381	41.91919	Barkhamsted	Litchfield	CT	7/2/2007
CT-9	WB Farmington River	-72.98908	41.91719	Barkhamsted	Litchfield	CT	9/6/2007
CT-10	WB Farmington River	-72.98675	41.90804	Barkhamsted	Litchfield	CT	7/2/7007
CT-11	WB Farmington River	-72.98688	41.89992	Barkhamsted	Litchfield	CT	7/26/2007
CT-12	WB Farmington River	-72.98039	41.89192	New Hartford	Litchfield	CT	7/26/2007
CT-13	WB Farmington River	-72.98162	41.88802	New Hartford	Litchfield	CT	7/26/2007
CT-14	WB Farmington River	-72.97696	41.87909	New Hartford	Litchfield	CT	7/2/2007
CT-15	WB Farmington River	-72.96469	41.87819	New Hartford	Litchfield	CT	7/26/2007
CT-16	WB Farmington River	-72.95394	41.86676	New Hartford	Litchfield	CT	7/3/2007
CT-17	WB Farmington River	-72.95721	41.86000	New Hartford	Litchfield	CT	7/3/2007
CT-18	WB Farmington River	-72.95571	41.84973	New Hartford	Litchfield	CT	7/26/2007
CT-19	WB Farmington River	-72.95227	41.84284	New Hartford	Litchfield	CT	7/3/2007
CT-20	WB Farmington River	-72.94877	41.84259	New Hartford	Litchfield	CT	7/3/2007

- Tallies for each species. At some sites, we estimated numbers of eastern elliptio and eastern pearlshell if they were very abundant and distracted us from finding rarer species.
- Shell lengths for all, or a representative subset of, eastern pearlshells, triangle floaters, brook floaters, and creepers. Length data were used to create length histograms that were used to assess recruitment, survivorship, and possible population trends.
- Shell condition (degree of shell erosion) for each eastern pearlshell, triangle floater, brook floater, and creeper. Shell erosion was subjectively ranked as low (0), medium (0.5) or high (1.0) for each animal and then averaged for all individuals at a site or within a river. The degree of shell erosion provided insight into the integrity of shells and the expected longevity of an animal.
- Depth and substrate for each triangle floater, brook floater, and creeper.

Notes on habitat and water quality conditions, presence of fish, water temperature, and other relevant observations were recorded for each survey site (Appendix 1). Location was recorded using a handheld GPS, and several digital photographs of habitat and biota were taken. Most of the information is contained within this report or in Appendix 1; additional photographs and raw data can be requested from the primary author. Location information for survey sites in the Massachusetts portion of the West Branch, where the state-endangered brook floater was found, are not included in this report. People interested in location information for the brook floater should contact the MNHESP.

RESULTS AND DISCUSSION

I. Mussels: Distribution

Six mussel species were found during this survey (Table 4). The highest number of species (five) was found in the Massachusetts portion of the West Branch; four species were found in the Connecticut portion of the West Branch and Still River, and two species were found in Sandy Brook. Together, the eastern pearlshell and eastern elliptio comprised 96.9 percent of all mussels encountered during this survey, which may be a slight underestimate because accurate counts were not feasible in areas where these species were abundant. Although both species were locally abundant and far outnumbered other species, their dominance was inversely related to each other. Sites gen-

Table 4. Counts or estimates of each mussel species found at each site (see Table 3). Cells shaded green are those where abundance was estimated to nearest 100 for survey duration. P = present and not counted or estimated. Species abbreviations use the first two letters of the genus and species name (see Table 1); MaMa = eastern pearlshell, ElCo = eastern elliptio, AlUn = triangle floater, AlVa = brook floater, StUn = creeper, PyCa = eastern floater.

	Freshwater Mussels					
CODE	MaMa	ElCo	AlUn	AlVa	StUn	PyCa
SB-1	0	0	0	0	0	0
SB-2	3	200	0	0	0	0
SB-3	15	200	0	0	0	0
SB-4	500	10	0	0	0	0
SB-5	0	0	0	0	0	0
SB-6	200	0	0	0	0	0
SB-7	29	0	0	0	0	0
SB-8	13	0	0	0	0	0
SB-9	1	0	0	0	0	0
SB-10	1	1	0	0	0	0
SB-11	7	1	0	0	0	0
SR-1	0	2	0	0	0	0
SR-2	0	3	0	0	0	0
SR-3	7	1	0	0	0	1
SR-4	15	5	0	0	0	0
SR-5	4	0	1	0	0	0
MA-A	0	300	0	0	0	P
MA-B	0	200	0	5	0	0
MA-C	2	100	0	9	0	0
MA-D	0	300	3	1	0	P
MA-E	0	3	0	0	0	0
MA-F	75	3	0	2	0	0
MA-G	-	-	-	-	-	-
MA-H	13	0	0	0	0	0
MA-I	0	300	4	0	0	P
MA-J	0	300	1	0	0	P
MA-K	0	300	0	0	0	0
MA-L	0	300	34	24	0	P
MA-M	20	25	0	0	0	0
MA-N	0	500	2	23	0	P
MA-O	8	18	0	10	0	0
MA-P	91	0	0	0	0	0
MA-Q	0	300	0	1	0	0
MA-R	3	2	0	0	0	0
MA-S	0	300	1	5	3	0
CR-1	50	0	0	0	0	0
CT-1	0	0	0	0	0	0
CT-2	1	0	0	0	0	0
CT-3	30	1	1	0	0	0
CT-4	18	1	4	0	1	3
CT-5	61	0	9	0	0	0
CT-6	7	0	0	0	0	0
CT-7	6	0	0	0	0	0
CT-8	39	0	14	0	0	0
CT-9	200	0	8	0	0	0
CT-10	38	1	1	0	0	0
CT-11	31	0	3	0	0	0
CT-12	1	0	0	0	0	0
CT-13	100	0	0	0	0	0
CT-14	54	0	0	0	0	0
CT-15	103	0	0	0	0	0
CT-16	5	0	0	0	0	0
CT-17	19	0	0	0	0	1
CT-18	40	1	4	0	0	0
CT-19	10	0	0	0	0	0
CT-20	105	0	2	0	0	0
Sandy Brook	769	412	0	0	0	0
Still River	26	11	1	0	0	1
MA West Branch	212	3251	45	80	3	P
CT West Branch	868	4	46	0	1	4
Clam River	50	0	0	0	0	0

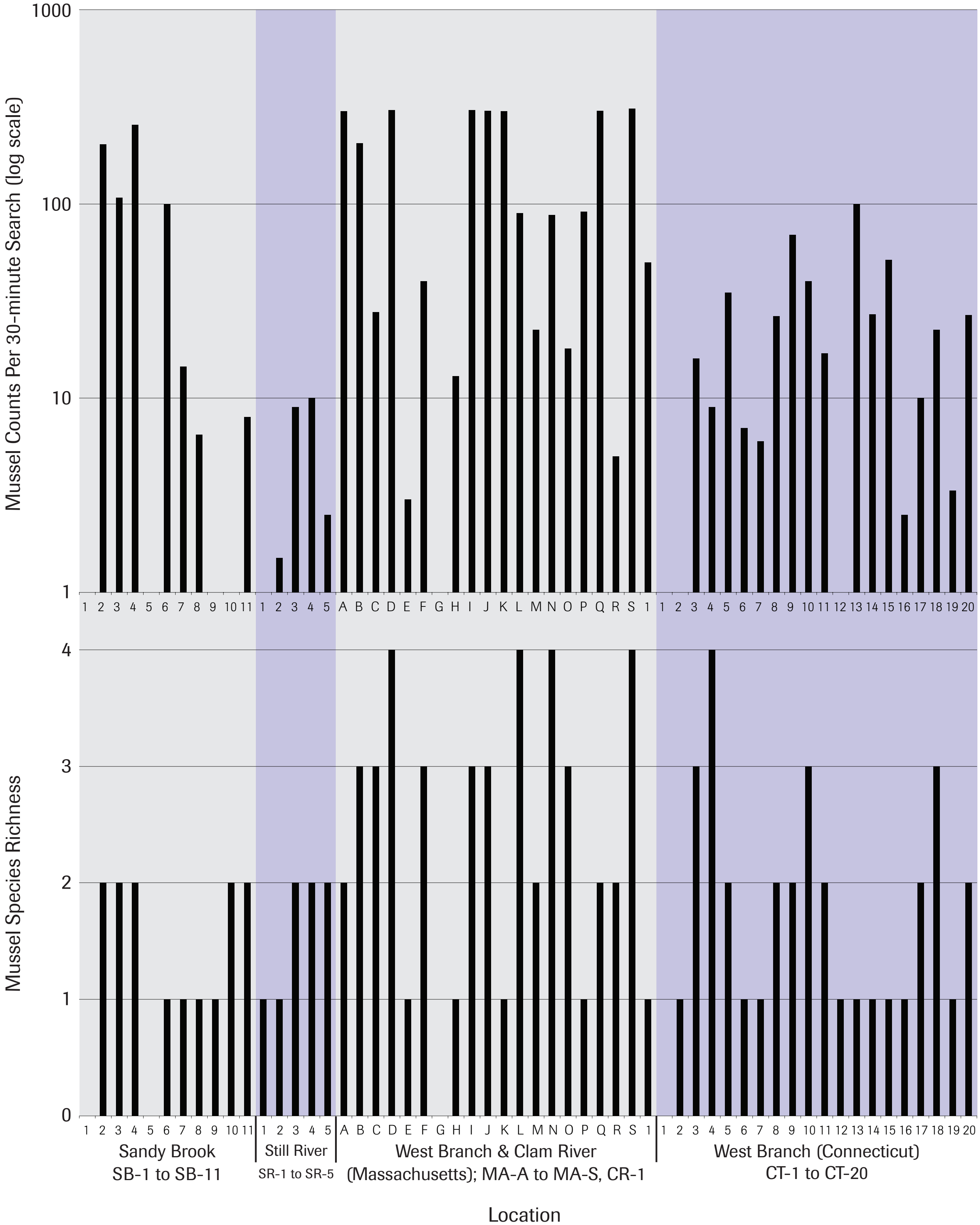

Figure 2. (a) Number of mussels (all species) counted or estimated per 30-minute interval at survey sites; actual counts or estimates are provided in Table 4. (b) Number of mussel species observed at each survey site; species are listed in Table 4. Data for Sandy Brook, Still River, and West Branch in Connecticut are arranged in order from upstream to downstream, whereas data for the West Branch in Massachusetts is arranged randomly.

One of the brook floater sites in the West Branch in Massachusetts. (June 2007)

erally fell into three categories based on the mussel community: (1) sites with very low overall mussel abundance, (2) sites with high mussel abundance, dominated by eastern pearlshell, and with low numbers of any other species, or (3) sites with high mussel abundance, dominated by eastern elliptio, and with low to moderate numbers of other species. Figures 2 and 3 illustrate mussel diversity and abundance patterns for the entire study area.

Sites with highest mussel diversity (four species) were in the Massachusetts portion of the West Branch, except for one location in the Connecticut portion (CT-4) where four species were found. Except for CT-4, these sites occurred in stream reaches classified as "warmwater" and where the eastern elliptio was the dominant species. From Hayden Pond to Tolland State Forest (Otis), the mussel community was comprised of eastern elliptio, brook floater, triangle floater, creeper, and eastern floater. Of the more than 3000 eastern elliptio counted or estimated in the entire West Branch, all but four were found in a ten-mile reach in Otis, Massachusetts. All brook floaters, all but four eastern floaters, and three of four creepers were also found in this same reach. The eastern pearlshell was absent throughout that same reach; it first appeared near Tolland State Forest and it became the dominant species as the river flowed into a high-gradient segment near Cold Spring Campground. Other species disappeared during the transition to a pearlshell-dominated community.

A total of 923 mussels were counted (or estimated) in the Connecticut portion of the West Branch. The eastern pearlshell comprised 94 percent (868 animals) of the total, followed by the triangle floater (five percent; 46 animals), eastern elliptio and eastern floater (0.43 percent; four animals each), and creeper (0.1 percent; one dead animal). Mussels were sparse or absent in the reach between Goodwin Dam and Route 20, and their abundance further downstream was highly variable and patchy. These patches were often located along stable protected banks, at downstream ends of islands, and at downstream ends of long pools just prior to the start of another riffle. Riffles, deeper portions of pools (toward the middle and upstream ends), and areas with strong current and rocky substrates supported the fewest number of mussels. Because mussel distribution and abundance was very patchy, 30-minute timed searches may not have effectively characterized their abundance and distribution because 30 minutes was sometimes too little time to find a patch of mussels.

Only 39 mussels were found at five sites in the Still River. Five eastern elliptio were found at sites SR-1 and SR-2 during surveys of 1.5 hours and 2.5 hours, respectively. This represents extremely low densities; to put this into context, approximately 300 eastern pearlshell were tallied during a 30-minute timed search in Sandy Brook.

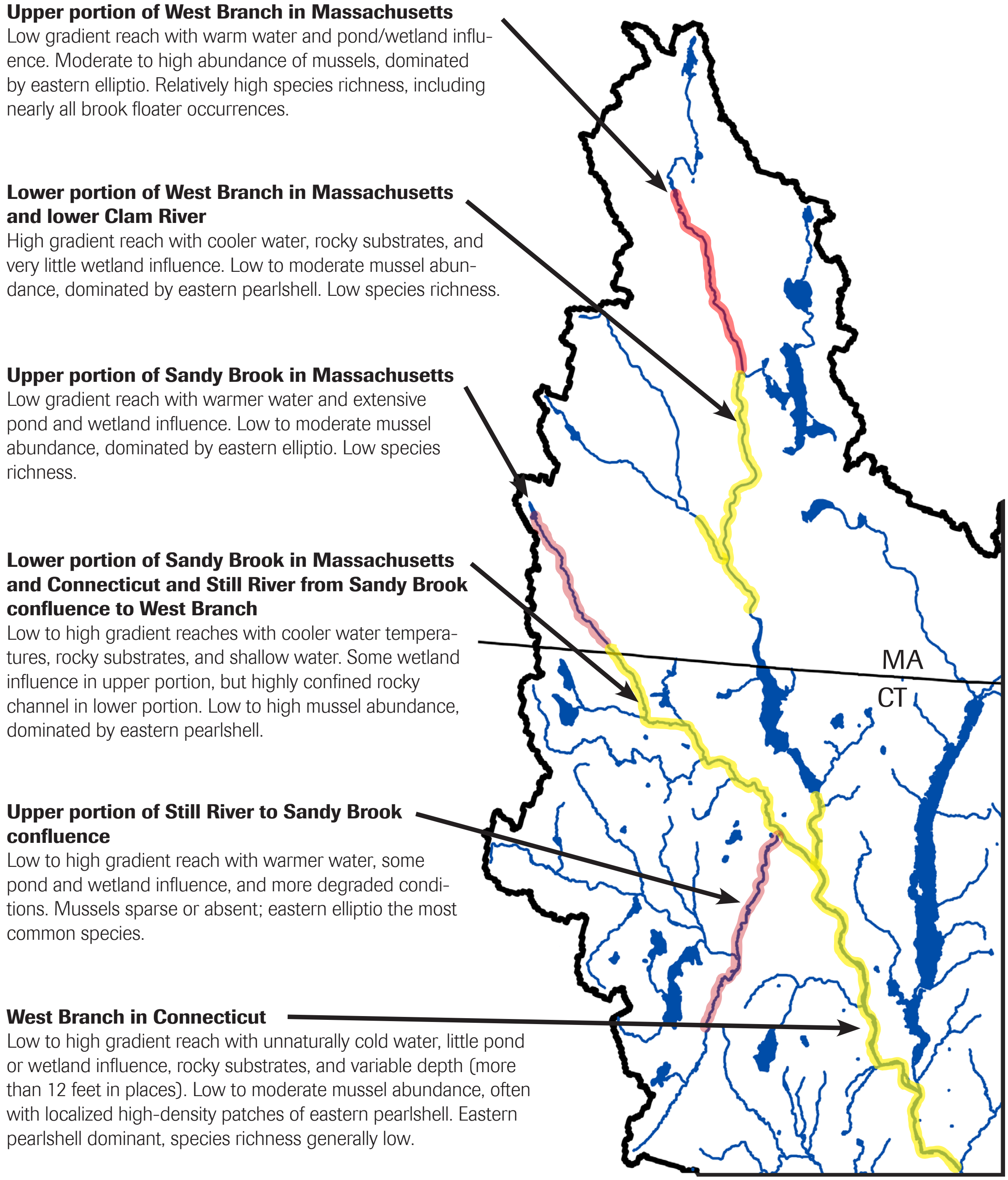

Figure 3. General patterns freshwater mussel diversity, abundance, and habitat in the study reaches.

Though habitat seemed appropriate for mussels at SR-1 and SR-2 (especially the latter), the scarcity of mussels suggests historic habitat degradation or water quality problems that the mussels have not yet recovered from. The mussels found at SR-3, which included seven eastern pearlshell, were precisely at the confluence of Sandy Brook and were probably more within Sandy Brook water than within Still River water. Mussels were sparse at SR-4 and SR-5, including one old triangle floater at SR-5. We looked for a survey site in and upstream of Winsted but the river was small, difficult to access, and it seemed highly altered/impaired by land use in the area between Torrington Road and Route 8. Broken glass, old scrap metal, bricks, and other types of trash and debris at SR-1 and SR-2, together with the appearance of the river at sites further upriver and the smell of the river downstream

The transition from a elliptio-dominated community to a pearlshell-dominated community in Sandy Brook occurred approximately here (SB-3), where the stream exited a low-gradient reach with extensive wetlands and entered a high-gradient forested reach.

High-density patch of eastern pearlshell from Sandy Brook.

of the wastewater treatment plant, suggest a long history of habitat degradation and poor water quality.

Sandy Brook supported very high densities of the eastern pearlshell, far exceeding abundances that were observed anywhere in the West Branch. Like the upstream parts of the study area in the West Branch, the upper reaches of Sandy Brook were fairly low-gradient, warmwater environments that flowed through a series of wetlands and small ponds. Eastern elliptio were abundant in upper portions of this watershed; of the 412 elliptio counted or estimated in Sandy Brook, 400 (97 percent) were found at Sites SB-2 and SB-3 (SB-1 was York Lake in Sandisfield State Forest where no mussels were found). The transition from a mussel community dominated by eastern elliptio to one dominated by eastern pearlshell occurred abruptly less than one mile downstream of Rood Hill Road (about one mile upstream of the border between Connecticut and Massachusetts), where the stream exited a low-gradient reach that was strongly influenced by wetlands and entered a confined, high-gradient, and heavily forested reach. At SB-4, several hundred yards downstream, more than 300 eastern pearlshell were found in a 30-minute search, at least 200 more were found in the next 30-minute search, and densities exceeded 100 per square meter in some spots. Of the 769 eastern pearlshell counted or estimated in Sandy Brook, nearly 96.5 percent were found at four sites (SB-4, SB-6, SB-7, and SB-8). Further downstream, Sandy Brook was a high gradient and rocky stream, particularly along Sandy Brook Road, and provided very little mussel habitat even though water quality seemed very good.

II. Mussels: Demographics and Condition

Data on demographics and shell condition were collected for the eastern pearlshell, triangle floater, brook floater, and creeper. The creeper was too rare to characterize demographics or condition. Eastern elliptio and eastern floater, the two most common species in the Connecticut River watershed, are discussed later.

Eastern Pearlshell: A total of 677 eastern pearlshells were measured. Shell condition was recorded during the first part of the survey, but it was evident that nearly all of the eastern pearlshell exhibited very little shell erosion and we stopped recording that data. Length data were assessed on a site-by-site basis and then pooled for the four major river segments (Still River, Sandy Brook, West Branch in Massachusetts, West Branch in Connecticut). Table 5 provides length statistics for eastern pearlshell. Length-frequency histograms for the major river segments are shown in Figure 4. Although Table 5 shows data for the Still River, too few eastern pearlshell were found in the Still River for a rigorous analysis. Since juvenile eastern pearlshells generally bury themselves in the sediment, and our survey methods would have only detected animals visible at the surface, lack of small eastern pearlshells (>30 millimeters) in our dataset is not evidence of poor recruitment. Two points are important:

1. In Sandy Brook and the Connecticut portion of the West Branch, the eastern pearlshell was locally abun-

Table 5. Length data and size class distribution of eastern pearlshell at sites throughout the study area. Discrepancies between actual counts (Table 4) and data provided here are because only a portion of eastern pearlshell were measured.

		Length Data (mm)				Length Classes (%)						
Site	Count	Average	StDev	Min	Max	<20	21-40	41-60	61-80	81-100	101-120	121-140
SB-2	3	113.0	5.6	108	119	0.0	0.0	0.0	0.0	0.0	100.0	0.0
SB-4	37	93.1	19.1	37	122	0.0	2.7	2.7	10.8	43.2	35.1	5.4
SB-6	37	93.9	22.9	47	131	0.0	0.0	16.2	10.8	21.6	45.9	5.4
SB-7	29	74.8	32.4	30	126	0.0	17.2	31.0	3.4	17.2	17.2	13.8
SB-8	13	74.8	32.2	27	114	0.0	23.1	15.4	7.7	30.8	23.1	0.0
SB-9	1	57.0	-	57	57	0.0	0.0	100.0	0.0	0.0	0.0	0.0
SR-3	7	99.6	19.4	76	121	0.0	0.0	0.0	14.3	42.9	28.6	14.3
SR-5	3	83.7	14.0	70	98	0.0	0.0	0.0	33.3	66.7	0.0	0.0
MA-C	2	83.5	10.6	76	91	0.0	0.0	0.0	50.0	50.0	0.0	0.0
MA-F	18	113.1	27.6	37	138	0.0	5.6	0.0	11.1	11.1	11.1	61.1
MA-H	13	118.2	17.4	69	131	0.0	0.0	0.0	7.7	7.7	23.1	61.5
MA-O	8	124.4	6.0	116	131	0.0	0.0	0.0	0.0	0.0	25.0	75.0
MA-P	37	75.7	16.8	46	100	0.0	0.0	24.3	32.4	43.2	0.0	0.0
MA-R	3	116.7	16.6	99	132	0.0	0.0	0.0	0.0	33.3	33.3	33.3
CT-2	1	103.0	-	103	103	0.0	0.0	0.0	0.0	0.0	100.0	0.0
CT-3	22	105.5	16.7	62	125	0.0	0.0	0.0	13.6	18.2	45.5	22.7
CT-4	18	110.3	20.0	56	128	0.0	0.0	5.6	11.1	0.0	50.0	33.3
CT-5	20	101.5	19.6	62	130	0.0	0.0	0.0	10.0	40.0	25.0	25.0
CT-6	7	76.1	34.6	42	133	0.0	0.0	42.9	28.6	0.0	14.3	14.3
CT-7	6	99.7	24.6	60	128	0.0	0.0	16.7	0.0	33.3	33.3	16.7
CT-8	39	65.7	16.4	51	128	0.0	0.0	48.7	38.5	7.7	0.0	5.1
CT-10	38	77.4	23.7	31	126	0.0	10.5	18.4	26.3	26.3	13.2	5.3
CT-11	31	87.0	27.4	29	137	0.0	12.9	3.2	16.1	35.5	25.8	6.5
CT-12	1	91.0	-	91	91	0.0	0.0	0.0	0.0	100.0	0.0	0.0
CT-13	22	90.5	25.9	32	136	0.0	4.5	13.6	9.1	36.4	27.3	9.1
CT-14	54	84.4	26.4	31	134	0.0	9.3	11.1	24.1	18.5	31.5	5.6
CT-15	65	87.4	21.2	36	133	0.0	1.5	6.2	29.2	36.9	20.0	6.2
CT-16	5	82.0	31.8	52	117	0.0	0.0	40.0	20.0	0.0	40.0	0.0
CT-17	19	88.5	21.3	56	137	0.0	0.0	5.3	36.8	26.3	26.3	5.3
CT-18	40	87.6	17.0	48	120	0.0	0.0	2.5	40.0	37.5	20.0	0.0
CT-19	10	97.6	25.6	67	139	0.0	0.0	0.0	30.0	30.0	20.0	10.0
CT-20	68	82.9	25.0	36	136	0.0	5.9	11.8	30.9	27.9	13.2	10.3
River Summary												
Sandy Brook	120	87.1	26.9	27	131	0	7.5	15.8	8.3	27.5	34.2	6.7
Still River	10	94.8	18.8	70	121	0	0.0	0.0	20.0	50.0	20.0	10.0
West Branch (MA)	81	97.4	28.0	37	138	0	1.2	11.1	19.8	25.9	9.9	32.1
West Branch (MA, minus MA-P)	44	115.6	21.8	37	138	0	2.3	0.0	9.1	11.4	18.2	59.1
West Branch (CT)	466	86.5	24.6	29	139	0	4.1	12.2	26.0	26.4	22.1	9.0

dant, it exhibited strong recruitment (though areas with juveniles were highly patchy), and adult survivorship was high. Even the largest animals had very little shell erosion.

2. In the Massachusetts portion of the West Branch, the eastern pearlshell exhibited symptoms of a population with poor recruitment. MA-P was somewhat anomalous and Table 5 separates this from the other sites. Eastern pearlshells from survey sites other than MA-P were, on average, significantly larger than mussels from other portions of the watershed. The length-frequency histogram was strongly skewed toward larger animals (Figure 4). We found only one animal that was less than 68 millimeters long.

Eastern pearlshell from Sandy Brook.

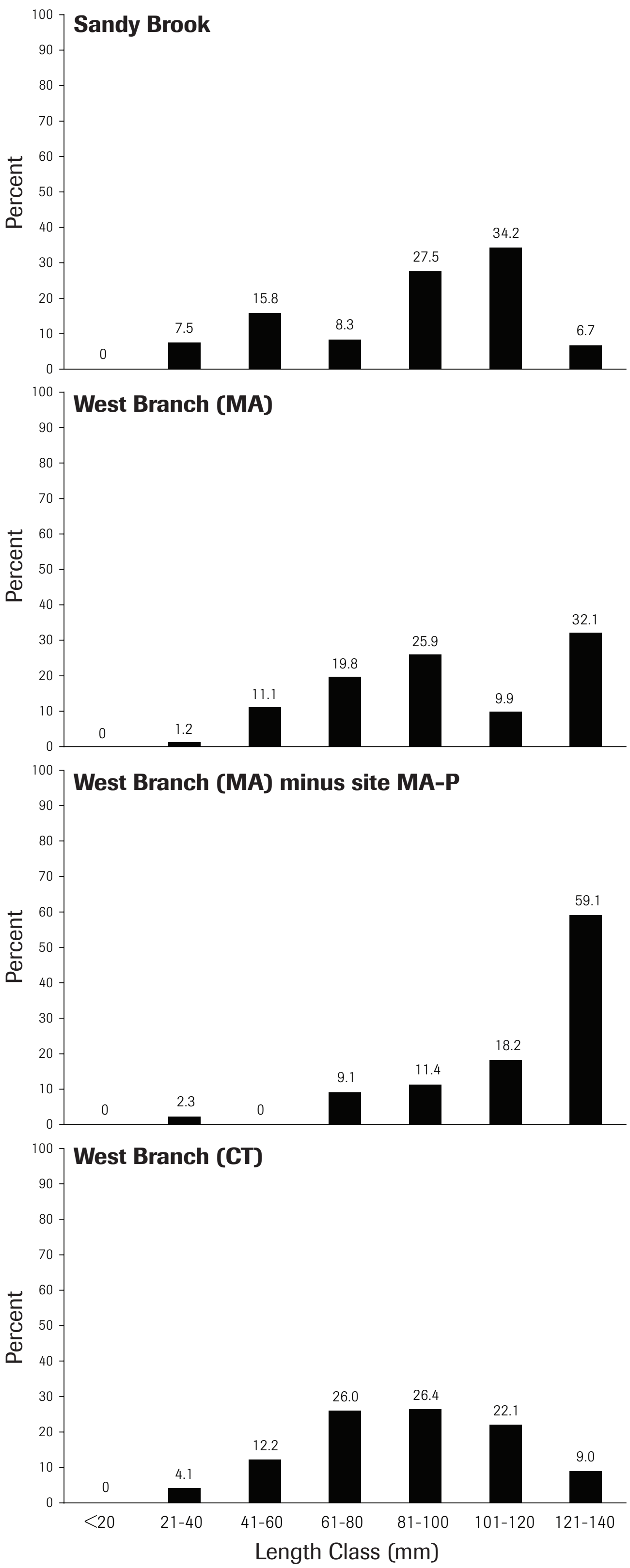

Figure 4. Length class data for eastern pearlshell pooled by major rivers or river segments. The same data are shown in Table 5.

Triangle Floater: A total of 80 triangle floaters were measured (of the 92 found during this survey). Forty-five of these were from the Massachusetts portion of the West Branch, 34 were from the Connecticut portion of the West Branch, and one was from the Still River. Except for one site in Massachusetts, numbers were too low at any site to analyze length data on a site-by-site basis, thus data were pooled. Table 6 provides length and shell condition statistics for the triangle floater. The following points are important:

1. The triangle floater population at the Massachusetts site with the highest number of animals (MA-L) exhibited symptoms of poor recruitment. These 34 animals were, on average, more than 15 millimeters larger than the 34 triangle floaters collected in the Connecticut portion of the West Branch (53.4 vs. 38.2) and more than 9 millimeters larger than triangle floaters found at other sites in Massachusetts (53.4 vs. 44.1). The smallest triangle floater collected at MA-L was 43 millimeters, and only three triangle floaters from the entire West Branch in Connecticut were larger. The length-frequency histogram was strongly skewed toward larger animals.
2. Triangle floaters exhibited a high degree of shell erosion, especially at MA-L (0.88) and the entire West Branch in Connecticut (0.83). Each can be explained differently. High shell erosion at MA-L was probably due to natural shell erosion that comes with old age, since these animals were all very old. High shell erosion in the Connecticut portion of the West Branch was probably due to water chemistry (low pH and limited calcium availability) and heavy scour that can afflict even young animals that should otherwise be in better condition.

A fairly young but heavily eroded triangle floater typical of animals observed in the West Branch in Connecticut.

Table 6. Length data and shell condition of the triangle floater in the West Branch in Massachusetts and Connecticut. Discrepancies between actual counts (Table 4) and data provided here are because not all triangle floaters were measured.

Parameter	West Branch (MA) All Sites	West Branch (MA) Site MA-L	West Branch (MA) Except MA-L	West Branch (CT) All Sites	All Sites
Length Statistics					
Count	45	34	11	34	80
Average	51.1	53.4	44.1	38.2	45.7
Standard Deviation	6.9	5.2	6.9	4.7	8.8
Min	33	43	33	22	22
Max	63	63	53	49	63
Length Classes (percent)					
<20	0.0	0.0	0.0	0.0	0.0
21-30	0.0	0.0	0.0	2.9	1.3
31-40	8.9	0.0	36.4	61.8	31.3
41-50	31.1	26.5	45.5	32.4	31.3
51-60	55.6	67.6	18.2	0.0	32.5
61-70	4.4	5.9	0.0	0.0	2.5
Shell Condition	0.81	0.88	0.59	0.83	0.82

Brook Floater: A total of 80 brook floaters were measured at nine different locations in the Massachusetts portion of the West Branch. Table 7 provides length and shell condition statistics for the brook floater. The following points are important:

1. The brook floater population at the site with the highest number of animals (MA-L) exhibited symptoms of poor recruitment. These 24 animals were, on average, 19.3 millimeters larger than the 56 brook floaters collected elsewhere in the West Branch (67.3 vs. 48.0). The length-frequency histogram was strongly skewed toward larger animals and all but two animals were larger than 63 millimeters, which is near the maximum published size for the species.
2. The brook floater population at MA-L exhibited extremely poor shell condition (0.81), especially compared to brook floaters from other locations in the West Branch (0.33). High shell erosion is probably due to natural shell erosion that comes with old age, since these animals are all very old.
3. It is interesting to note that MA-L supported both the highest number of brook floaters and the highest number of triangle floaters, but both species at this site exhibited symptoms of a geriatric population that had been unable to recruit new individuals and whose surviving animals were very old and heavily eroded. Determining the causes for this should be a conservation priority.

Creeper: Only three live creepers were encountered during this survey and all were in the West Branch in Massachusetts (Site MA-S). The length of these animals was 65 mm, 55 mm, and 51 mm. All had a light degree of shell erosion and were found in less than two feet of water in a sandy and gravelly substrate. One dead animal was found in the West Branch in Connecticut.

A large and heavily eroded brook floater from the West Branch in Massachusetts.

A small creeper that exhibits light shell erosion.

Table 7. Length data and shell condition of the brook floater in the West Branch in Massachusetts.

Parameter	West Branch (MA) All Sites	West Branch (MA) Site MA-L Only	West Branch (MA) Except MA-L
Length Statistics			
Count	80	24	56
Average	53.8	67.3	48.0
Standard Deviation	12.1	7.9	8.5
Min	32	41	32
Max	79	79	72
Length Classes (percent)			
<20	0.0	0.0	0.0
21-30	0.0	0.0	0.0
31-40	15.0	0.0	21.4
41-50	31.3	8.3	41.1
51-60	21.3	0.0	30.4
61-70	22.5	62.5	5.4
71-80	10.0	29.2	1.8
Shell Condition	0.48	0.81	0.33

III. Mussels: Species Status

This section recommends the status of each species in the study area based on distribution, abundance, demographics, shell condition, and habitat. Recommendations apply only to this watershed and can be considered in watershed-level conservation and management. These recommendations should not be confused with statewide status in Massachusetts and Connecticut—the CT-DEP and MNHESP list species as Special Concern, Threatened, or Endangered based on statewide data. To avoid confusion, this report uses the terms stable, imperiled, or highly imperiled to describe each species.

Eastern Pearlshell: Stable

Legal Status: Special Concern in CT, not listed in MA

The upper West Branch and its tributaries support several of the healthiest eastern pearlshell populations in southern New England. The species relies on salmonid hosts (brook trout, brown trout, rainbow trout, and Atlantic salmon) and is therefore confined to high-quality coldwater rivers. Its abundance and distribution in the West Branch is anomalous in southern New England because the West Branch is such a large river, but the release of cold water from Goodwin Dam created a thermal environment that favored trout and the eastern pearlshell. Special management of trout waters and efforts to restore Atlantic salmon will likely contribute to the long-term viability of the eastern pearlshell in the upper West Branch and elsewhere in Connecticut.

Triangle Floater: Imperiled

Legal Status: not listed in CT, Special Concern in MA

Based on low overall abundance, a highly patchy distribution, a high degree of shell erosion that presumably limits longevity, and possible reproductive failure at the best site in the West Branch in Massachusetts (MA-L), the triangle floater population is at risk in the study area. Better populations exist in the lower Farmington River between Rainbow Reservoir and Farmington (Nedeau 2005, 2006a), and elsewhere in Connecticut. Its rarity in the West Branch in Connecticut may be related to the unnaturally cold thermal regime that limits the distribution of warmwater fish hosts and that is physiologically challenging for the species.

Brook Floater: Highly Imperiled

Legal Status: Endangered in CT and MA

Though the brook floater in the West Branch seems to be faring better than other known populations in Massachusetts and Connecticut, its abundance is very low, its distribution is highly patchy, reproductive failure seems to be an issue, and shell erosion is high. This population is a high conservation priority in Massachusetts.

Creeper: Highly Imperiled

Legal Status: not listed in CT, Special Concern in MA

The West Branch and portions of the Still River provide suitable habitat for this species. Its rarity should be cause for concern, especially since the Farmington River is such a large and relatively intact watershed that supports healthy populations of so many other species. The creeper

Deep-release water from the West Branch Reservoir through Goodwin Dam creates a unnaturally cold thermal environment that persists for 12-15 miles downstream, creating an excellent coldwater fishery but fragmenting habitat for non-adapted species.

was also rarely encountered in the lower Farmington River between Windsor and Canton. It occurs infrequently in many rivers in Connecticut and usually at low population densities. If the Farmington River population is indicative of its distribution and status elsewhere in Connecticut, then it should be evaluated for possible listing under Connecticut's Endangered Species Act.

Eastern Elliptio: Stable

Legal Status: not listed in CT or MA

Very few animals were found in lower Sandy Brook, Still River, or the Connecticut portion of the West Branch. Based on small population sizes in these waters, population viability of the eastern elliptio is considered very low. However, it is very abundant in the upper portions of Sandy Brook and the West Branch, as well as the lower Farmington River near Farmington and Avon. This observation follows a pattern observed elsewhere in the Connecticut River watershed that the species tends to be more abundant in low gradient warmwater rivers than in high-gradient coldwater rivers (Nedeau 2008). The release of cold water from Goodwin Dam, which keeps the West Branch cold throughout the summer, may have eradicated this species from the West Branch and prevents it from recolonizing this portion of the river.

Eastern Floater: Stable

Legal Status: not listed in CT or MA

None were found in Sandy Brook and very few were found in the Still River or the West Branch in Connecticut. Though not counted or measured, many were found in the low-gradient portion of the West Branch between Route 8 and Hayden Pond in Massachusetts, which is more typical habitat for this species. Its rarity elsewhere in the study area is not cause for concern because this species generally prefers large warmwater rivers and lakes—habitats that were poorly represented during this survey.

IV. Snails

Eight species of snails were collected during this survey (Table 8). *Amnicola limosa* was the numerically dominant snail and was found at ten of 19 survey sites (six of seven sites in the West Branch, one of five sites in the Still River, and three of seven sites in Sandy Brook). This tiny snail (less than five millimeters) was frequently abundant on rocks and submerged logs, especially in calmer waters near streambanks and in pools. They were particularly abundant in the upper portion of Sandy Brook (SB-1 to SB-3). It is likely that this species existed virtually everywhere in the study area but concerted effort would be needed to

Table 8. Snails and crayfish collected during this survey.

	Sandy Brook (SB-)									Still River (SB-)					West Branch in Connecticut (CT-)											
Taxa	1	2	3	4	5*	6	7*	8	10	1	2	3	4	5	1*	2*	4*	6	7*	8	9*	10	14	16	19	20
Snails																										
Amnicola limosa	x	x	x										x					x		x		x	x		x	x
Campeloma decisum										x	x															
Ferrissia rivularis				x		x		x			x			x				x		x		x			x	x
Helisoma anceps	x																									
Micromenetus dilatatus																		x								
Planorbella trivolvis											x	x	x													
Physa heterostropha												x	x									x	x	x		
Physa sp. (young)																										x
Pseudosuccinnia columella																		x								
Crayfish																										
Cambarus robustus			x	x	x	x	x	x	x				x	x	x	x	x	x	x		x					
Orconectes limosus						x						x	x	x								x				
Orconectes virilis	x										x	x														

*Snails and crayfish not collected but *Cambarus robustus* noted if seen.

find it in marginal habitats (e.g., rocky erosional environments). Since the species is very common and widespread in Connecticut (Jokinen 1983), and therefore not a species of concern, we did not attempt to find it everywhere.

The other common snail species was the limpet *Ferrissia rivularis*, which was also found at ten of 19 survey sites. This species was found on rocks and submerged logs, in both erosional and depositional environments. It is generally confined to streams and rivers throughout its North American range (Jokinen 1983). It was rarely abundant, and it likely occurred throughout the entire study area. Like *Amnicola limosa*, this species is very common and widespread, and therefore we did not attempt to find it everywhere.

The other six species of snails were rarely encountered. Generally, rocky coldwater rivers support a lower diversity and abundance of snails than most other permanent aquatic habitats, so the lack of snails in our study area was not a surprise. Snails were much more common and diverse in the upper West Branch in Massachusetts, especially downstream of Hayden Pond, but snails were not collected in Massachusetts waters. Lakes, wetlands, vernal pools, swamps, marshes, and low-gradient streams (especially with a warmer thermal regime) in the upper Farmington River watershed likely support more species than the waterbodies that were surveyed in this study.

V. Crayfish

Three species of crayfish were collected during this survey (Table 8). *Cambarus robustus* was the most common species; it was collected at seven of 19 survey sites but it was noted at 15 sites and probably occurred at many more sites. These large robust animals were often bluish in color, and since adults lack many natural predators, large adults were often seen sitting on the bottom of the river not trying to hide. Juveniles and small adults were often under rocks, logs, and other hiding places. We began to feel guilty about killing these large animals, and since they were quite conspicuous, we stopped collecting them and tried to note where we saw them. The species was observed at every location in Sandy Brook except SB-1 (York Lake) and SB-2 (a low-gradient warmwater site). The species was observed at every location in the Still River downstream of the Sandy Brook confluence, and at several sites in the West Branch including the site closest to Goodwin Dam (CT-1).

Cambarus robustus is not native to New England; it was introduced sometime in the early twentieth century (Smith 1995). It prefers large rocky streams with moderate current, thus its presence in the West Branch, Still River, and Sandy Brook was expected. The ecological effects of this large non-native predator are unknown, but in gen-

Cambarus robustus from Sandy Brook.

eral, crayfish are predators of snails and juvenile mussels and may regulate mollusk populations in areas where they are abundant.

Orconectes limosus is native to the Connecticut River watershed. It was found in the Still River (three sites), Sandy Brook (one site), and West Branch (one site). Smith (1995) notes that the species is most frequently found in large rivers and streams with weak to moderate current. *Orconectes virilis* is not native and was found in York Lake (SB-1) and two sites in the Still River. Smith (1995) considers it the most common species in Massachusetts; it occurs in nearly every type of permanent aquatic habitat.

Crayfish are tolerant of moderate water quality impairment and are adaptable to a variety of habitat conditions (Thorp and Covich 1991). They have good ability to disperse within watersheds and quickly establish populations in suitable areas. Adults are often immune to most aquatic predators, especially in smaller waterbodies where most fish are small-bodied omnivores. Muskrat, otter, and some wading birds might eat them but this predation usually has insignificant effects on crayfish populations. For these reasons, this report does not make any conservation or management recommendations for crayfish.

SUMMARY OF THREATS

The following is a summary of threats that may be relevant for mussels, snails, and crayfish in the study area. The term "threat" is used to describe something that may have significantly affected, or has the potential to affect, the distribution, abundance, and viability of species via the quantity and quality of water and habitat, the ability of a species to reproduce and disperse, and the health and survival of individuals. In general, the study area provides exemplary habitat and water quality, and biological diversity is less "threatened" here than in many other rivers in southern New England.

Flow Regime: Periods of low flow may be a significant problem for aquatic fauna in some portions of the West Branch, Still River, and Sandy Brook. This was particularly evident in 2007 when drought conditions persisted throughout the summer and rivers were near or below historic low levels. Problems seemed to be mainly confined to the Still River, Sandy Brook, Massachusetts portion of the West Branch, and other small tributaries. Many of the sites surveyed during normal flows in May and June were significantly dewatered by September. Associated problems observed in 2007 include:

Survey site SR-5 in the Still River during normal spring flows (June) and baseflow conditions (early September). Extensive dewatering helps to explain scarcity of mussels encountered during the June survey.

- High predation of mussels by scavengers
- Large dewatered areas where mussels either perished or were forced into small refugia (if they could move)
- Accumulation of silt due to a lack of flushing flows
- Excessive algal growth due to warm water temperatures and concentrated nutrients
- Warm water temperatures that approached or exceeded the thermal tolerance of some species (primarily in the Massachusetts portion of the West Branch)

Persistent droughts might cause water resource managers to seek a balance between human demands for water (recreation and consumption) and the ecological flows needed to maintain fisheries and aquatic biodiversity in these rivers (Trout Unlimited 2006). This might lead to difficult compromises; in that case, a study of the instream flow needs of fish and aquatic invertebrates would be needed.



More than 90 percent of the eastern pearlshell observed in this small pool in Sandy Brook (SB-4) in early June, which was one of the highest concentrations of the species encountered anywhere in the upper Farmington River watershed, were eaten by a predator by early September. Piles of animals were left behind, each with the posterior end of its shell broken so the predator could pry open the shells.

Dams: The Colebrook Lake Project likely had a significant effect on the freshwater mussel fauna of the West Branch by permanently fragmenting the river and creating a thermal regime that only favored coldwater species. The extraordinary freshwater mussel diversity in the lower Farmington River declined precipitously in the reach between Farmington and Canton, as the eastern pearlshell, which comprised a tiny fraction of the mussel community in downstream areas, became the dominant species in the colder waters of the West Branch. The presence of the eastern pondmussel in Highland Lake in Winchester, and the absence of this species in the Farmington River between Hartland and Farmington, provides some evidence that species typically found in warmwater environments and that occur in the lower Farmington River—such as the eastern lampmussel, eastern floater, eastern elliptio, dwarf wedgemussel, and eastern pondmussel—may have been eradicated (or nearly so) when the West Branch was converted to a coldwater river. Nevertheless, the West Branch is a regionally important coldwater fishery and provides an important source of drinking water to many of Connecticut's citizens. This perspective on mussels is only offered to help people understand why the diversity of mussels in the West Branch in Connecticut is low compared to diversity in the lower Farmington River.

The possible failure of Hayden Pond Dam in Otis could have catastrophic consequences for the brook floater population in the West Branch. The stone dam is located just upstream of Ed Jones Road whose crossing is comprised of three large culverts. If the dam were breached, it would likely destroy that stream crossing and send a pulse of sediment and debris downstream into brook floater habitat. The Massachusetts Office of Dam Safety has posted signs to keep people away from the dam.

Nonpoint source pollution (NPS): Although much of the land area within the study area is protected, and the river itself is fiercely protected as southern New England's finest coldwater fishery, NPS can stem from myriad locations in the watershed and have locally important effects on the rivers. Primary problems may include sediment from roadways and construction sites, stormwater runoff from urban areas, road salt and snow dumping practices, inadequate or failed septic systems, leachate from landfills and disposal sites, and nutrients (primarily nitrogen and phosphorus) from a variety of nonpoint sources and point sources (such as wastewater treatment plants). Rapid ur-

The old stone dam at the outlet of Hayden Pond in Otis, Massachusetts, is a decrepit structure that may fail. The Massachusetts Department of Dam Safety prohibits trespassers because of safety concerns. Its failure would likely have short-term yet catastrophic effects on downstream areas, and possibly threaten populations of the endangered brook floater.

banization in nearby Granby, Simsbury, Avon, and Canton is likely to spread into this area and put additional pressure on its natural resources.

Non-native species: Notable non-native species in the study area include common reed (*Phragmites australis*) in wetlands along much of the upper Sandy Brook, two crayfish, smallmouth bass in the upper West Branch, and brown trout and rainbow trout throughout most of the study area. The common reed likely has locally important effects on the ecology of Sandy Brook and its adjacent wetlands. The effects of the non-native crayfishes are unknown, but they are large benthic predators that consume snails and juvenile mussels. Smallmouth bass, brown trout, and rainbow trout may eat or compete with native fish. However, trout are a conservation target and also serve as hosts for the eastern pearlshell, so they are not considered a threat.

Beavers: Beavers are a natural and integral part of the ecosystem and should not necessarily be viewed as a threat. Nevertheless, they are particularly active in the upper West Branch in Massachusetts and the large dams that are being built tend to fragment flows, create dispersal barriers, reroute and divide the stream channel, create depositional environments upstream, and increase water temperatures. Mussels are susceptible to some of these effects, and since mussels are already faring poorly in this area (especially the brook floater and triangle floater), the effects of beavers may be significant. Beavers may also help to stabilize streamflows in these areas, which might be beneficial for mussels.

The West Branch at site CT-13. A sizeable population of eastern pearlshell existed at the downstream end of this large pool and near the tip of an island.

CONCLUSIONS AND RECOMMENDATIONS

The West Branch and its coldwater tributaries support several of the finest eastern pearlshell populations in southern New England, a species of special concern in Connecticut whose populations rely on trout and salmon populations and excellent water quality. The West Branch also supports an important population of the brook floater, an endangered species in Massachusetts and Connecticut. Three species—brook floater, triangle floater, and creeper—appear to be imperiled or highly imperiled in the West Branch and Still River. Although species diversity is low in the West Branch compared to the lower Farmington River, four of six species that occur in the West Branch, Still River, and Sandy Brook are sensitive to environmental stressors and are therefore good candidates for long-term monitoring. Since the West Branch contributes significantly to the quantity and quality of water in the lower Farmington River, it plays a pivotal role in the vitality of the globally important freshwater mussel assemblage in the lower river. With regard to the conservation and management of freshwater mussels in the West Branch and its tributaries, this report recommends the following:

1. Develop a long-term monitoring program for the triangle floater, brook floater, and eastern pearlshell in the West Branch and for the eastern pearlshell in the Still River and Sandy Brook. The goals should be to (1) periodically assess the abundance, demographics, and condition of animals at reference sites, and (2) to identify and address new threats as they emerge.
2. Delineate important and sensitive areas based on presence of rare species or their host fish, connectivity between populations, and their contribution to critical ecosystem processes. Work with landowners, towns, and others to identify threats and protect these areas.

It goes without saying that the health of the West Branch and its tributaries are already a high priority for many natural resource agencies, non-government environmental organizations, citizen groups, and particularly the people who live along it or enjoy what it offers. With all of these people already vested in the Farmington River watershed, protection of its aquatic biodiversity should be successful.

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