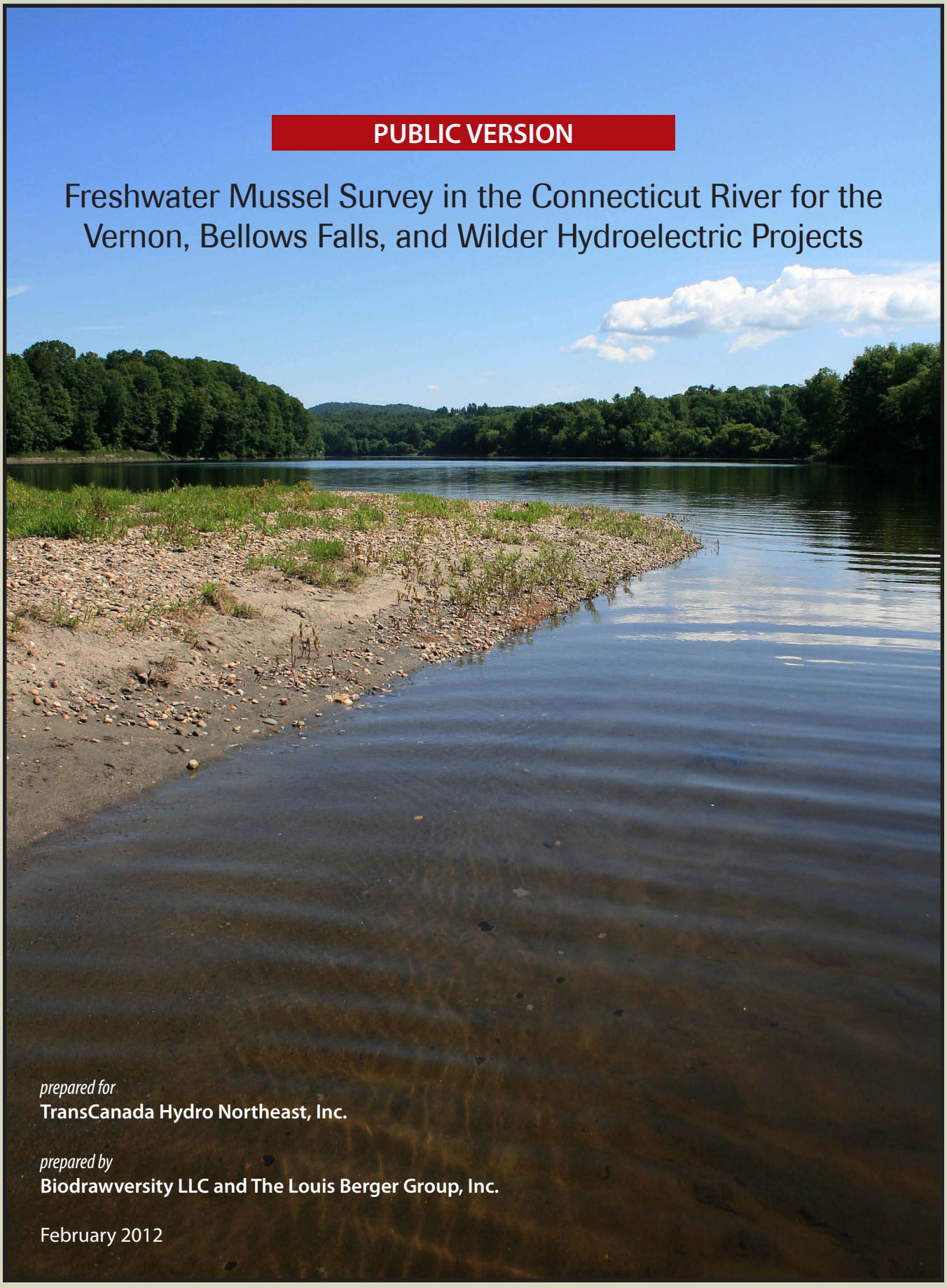
PUBLIC VERSION

Freshwater Mussel Survey in the Connecticut River for the Vernon, Bellows Falls, and Wilder Hydroelectric Projects



prepared for
TransCanada Hydro Northeast, Inc.

prepared by
Biodrawversity LLC and The Louis Berger Group, Inc.

February 2012

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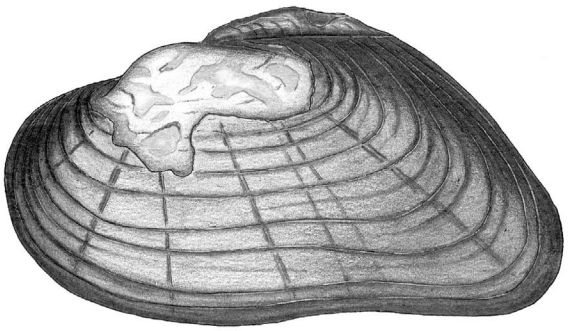

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*Appendix 4 has been removed from the public version of this document since it contains detailed locations of a federally endangered species.

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CPUE: Catch-per-unit-effort
FERC: Federal Energy Regulatory Commission
PAD: Pre-Application Document

Freshwater Mussel Survey in the Connecticut River for the Vernon, Bellows Falls, and Wilder Hydroelectric Facilities

EXECUTIVE SUMMARY

Biodrawversity LLC conducted freshwater mussel surveys in the Connecticut River in the Wilder, Bellows Falls, and Vernon hydroelectric project areas in 2011. Surveys were conducted throughout all three impoundments plus a short distance (<1.0 mile) downstream of each dam. The primary objectives were to assess the distribution, abundance, demographics, and habitat of dwarf wedgemussel (*Alasmidonta heterodon*), a federally endangered species known to occur in the Connecticut River, as well as to gather similar information on co-occurring mussel species. This study was requested during agency consultation meetings in advance of relicensing proceedings associated with the above mentioned projects. It provides updated information for the associated pre-application documents (PADs) for each project.

Field surveys were conducted at 119 sites, including 50 for Wilder, 46 for Bellows Falls, and 23 for Vernon. Of these, 116 were in impoundments and three were downstream of the dams (one site per dam). Surveys were carried out between May and September, and included semi-quantitative mussel sampling (i.e., timed searches) and documentation of habitat conditions.

A total of 50 dwarf wedgemussels were counted in the Bellows Falls and Wilder impoundments; none were found in the Vernon impoundment. In the Wilder impoundment, 39 dwarf wedgemussels were found in 13 survey sites (26.5 percent of the sites), for an average of only 0.8 mussels/site and a maximum catch-per-unit-effort (CPUE) of 8.0 mussels/hour. These 39 mussels were found between Sites 29-47, located between 27-41 miles upstream of the Wilder Dam. In the Bellows Falls impoundment, 11 dwarf wedgemussels were found in nine survey sites (20.0 percent of the sites), for an average of only 0.24 mussels/site and a maximum CPUE of 3.0 mussels/hour. These 11 mussels were found sporadically between Sites 14-46, which were located in the upper 17 miles of the impoundment. Dwarf wedgemussels in the Bellows Falls impoundment were found slightly more frequently in the impounded portion of the Black River, in the Connecticut River near the Black River confluence, and near Wethersfield Bow. Dwarf wedgemussels were not found in the tailwaters of any of the three dams. Shell length data for dwarf wedgemussels indicated evidence of recruitment, small average shell length compared to other known populations in the watershed, and lack of older mature mussels (none were more than 40 mm in length).

Six other species of freshwater mussels were found during the surveys; these were eastern elliptio (*Elliptio complanata*), eastern lampmussel (*Lampsilis radiata*), alewife floater (*Anodonta implicata*), triangle floater (*Alasmidonta undulata*), creeper (*Strophitus undulatus*), and eastern floater (*Pyganodon cataracta*). The mussel communities were dominated by eastern elliptio and eastern lampmussel, which were found at 98.3 and 94.9 percent of survey sites, respectively. Together, these two species comprised more than 99 percent of the mussels observed at most survey sites. Alewife floater, listed as S1 in Vermont, was the third most common species overall, occurring at 15.1 percent of all survey sites, and at 66.7 percent of all survey sites located downstream of the Bellows Falls Dam. A total of 460 alewife floater were counted, including 75 below the Vernon Dam, 166 in the Vernon impoundment, and 217 below the Bellows Falls Dam. Only two alewife floater were found upstream of the Bellows Falls Dam.

The other three species were far less common. Creeper was found at 16 survey sites (13.4 percent) and was usually only present at very low numbers. It was found at four sites (six animals) in the Vernon impoundment, 11 sites (40 animals) in the Bellows Falls impoundment, and one site (one animal) in the Wilder impoundment. None were found downstream of any of the three dams. Triangle floater was found at 20 (16.8 percent) survey sites and usually at very low numbers, including two sites (two animals) in the Vernon impoundment, eight sites (17 animals) in the Bellows Falls impoundment, eight sites (17 animals) in the Wilder impoundment, five animals downstream of the Bellows Falls Dam, and three animals downstream of the Wilder Dam. Eastern floater occurred primarily in two locations: within the downstream half of the Vernon impoundment and the impounded mouth of the Black River in the Bellows Falls impoundment.

The rarity and apparent patchy distribution of the three fluvial mussel species—dwarf wedgemussel, triangle floater, and creeper—should raise the level of concern for the viability of these populations in the Connecticut River. Critical areas for these species in the Bellows Falls impoundment appear to include the lower Black River, the Connecticut River near the Black River confluence, and Wethersfield Bow. Critical areas in the Wilder impoundment are primarily confined to a 14-mile reach in the upper third of the impoundment. Eastern elliptio and eastern lampmussel are the only two species that appear to be thriving under current conditions at all three project areas, although there also appear to be stable alewife floater populations in areas of the Connecticut River downstream of the Bellows Falls Dam.

The Connecticut River in the upper Bellows Falls impoundment (Site 45), looking across to Mt. Ascutney.

1. INTRODUCTION

A nearly 130-mile reach of the Connecticut River from near the Massachusetts border to North Haverhill, New Hampshire, is influenced by the presence and operations of three major hydroelectric facilities: Vernon, Bellows Falls, and Wilder (Figure 1). The impoundments of these three facilities are 26, 26, and 45 miles long, respectively, and they impound the mouths of several rivers such as the Sugar, Ompompanoosuc, Black, Williams, and West. The operations of the hydroelectric facilities, especially when they are in a peaking hydropower schedule, influence both upstream and downstream areas with daily or subdaily flow fluctuations. Thus, the three facilities influence both a very large geographic area and a wide variety of aquatic, wetland, and terrestrial ecosystems.

TransCanada owns and operates the Vernon, Bellows Falls, and Wilder hydroelectric facilities, and the current Federal Energy Regulatory Commission (FERC) license for these will expire in 2018. One of the early steps in the relicensing process is the development of a Pre-Application Document (PAD) that, among other things, is a compilation and synthesis of information on the natural resources that the facilities affect. The PAD also identifies data gaps and sets the stage for stakeholder involvement and review. Although the PAD for the Vernon, Bellows Falls, and Wilder hydroelectric facilities has not been drafted yet, it was clear that one of the important data gaps was an incomplete understanding of the freshwater mussel communities in the areas affected by them. This was a particularly critical gap because some of the affected areas were known to support the dwarf wedgemussel

Dwarf wedgemussels from Site 43 in the Wilder impoundment.

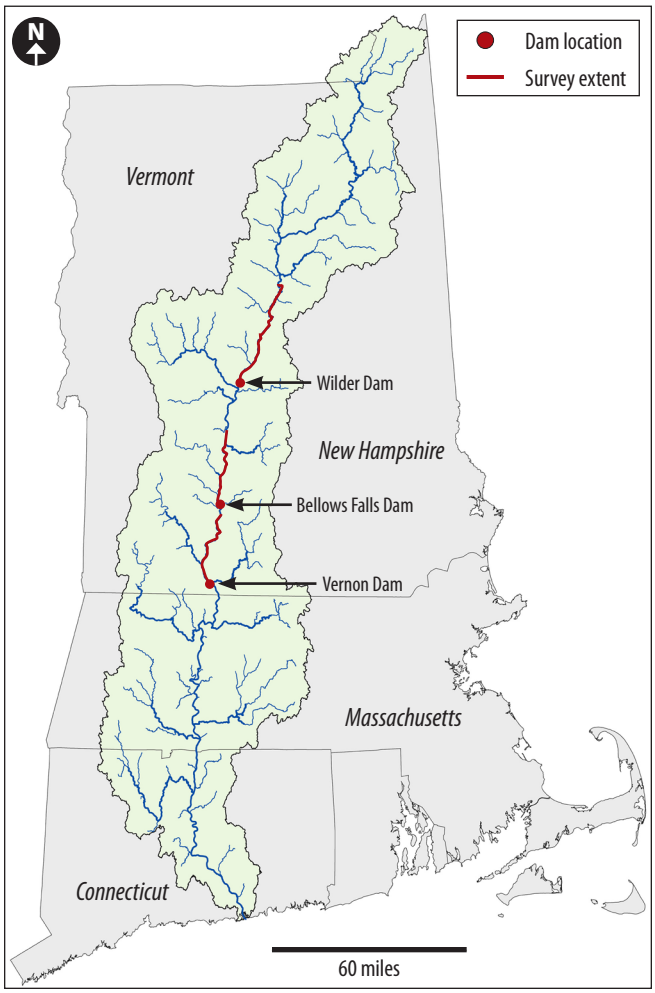


Figure 1. Locations of the Vernon, Bellows Falls, and Wilder hydroelectric projects in the Connecticut River watershed, and the linear extent of the 2011 mussel surveys.

(*Alasmidonta heterodon*), one of only two federally endangered aquatic species known to occur in the Connecticut River. The other is the shortnose sturgeon (*Acipenser brevirostrum*). The primary objectives of this project were to assess the distribution, abundance, demographics, and habitat of dwarf wedgemussel in the impoundments and areas a short distance downstream of each facility. The surveys were designed to also provide information on the diversity, abundance, and habitat of the entire freshwater mussel community in these locations.

2. PROJECT AREA DESCRIPTIONS

2.1 Vernon Hydroelectric Project (Appendix 1)

The Vernon impoundment is 26 miles long. The upper reaches of this impoundment extend to less than four miles below the dam at the Bellows Falls facility. Its upper reaches are located in a relatively wide and open section of the Connecticut River valley, with agricultural and residential land uses prevalent along the river corridor. Further downstream, the valley narrows and landscape becomes more mountainous and heavily forested. Vermont's West River is the most significant tributary in this reach, although many small streams enter from both the east and west. There are historical records of dwarf wedgemussels in the Connecticut River in the lower Vernon impoundment, near Brattleboro. However, dwarf wedgemussels have not been found within this impoundment or its tributaries in at least 30 years (Nedeau 2005).

2.2 Bellows Falls Hydroelectric Project (Appendix 2)

The Bellows Falls impoundment is 26 miles long and its upper reaches end 17 miles downstream from the Wilder Dam. Land use along the river corridor is primarily mixed agriculture, forests, and residential. Several mid-sized tributaries flow into the impoundment, including Mill Brook, Sugar River, Little Sugar River, Williams River, and Black River. Dwarf wedgemussels were already known to occur in the impoundment of the Bellows Falls Dam and in the impounded section of the lower Black River (Ferguson 1999, Nedeau 2008a-b).

2.3 Wilder Hydroelectric Project (Appendix 3)

The Wilder impoundment is 45 miles long and includes 105 total miles of shoreline. Several tributaries are influenced by the impoundment, including the Ompompanoosuc and Waits Rivers from the west, as well as smaller and higher-gradient tributaries from the east, such as Oliverian Brook, Jacobs Brook, and Grant Brook. The land along the river corridor is mostly comprised of mixed farmland, residential areas, and forests, although substantially more developed areas occur near Hanover, Fairlee, and Bradford. In 2006, dwarf wedgemussels were documented along a 16-mile reach of the impoundment between Orford and Haverhill, New Hampshire (Nedeau 2006, 2008b).

3. METHODS

3.1 Site Selection

Sampling sites were selected to provide adequate spatial coverage of each impoundment and to target habitats suitable for dwarf wedgemussels. In the planning phase of this project, the impoundments were divided into sections based on reach-scale habitat (e.g., hydrology, geomorphology, and valley form/floodplains), tributary locations, prior mussel survey data, and personal experience of the principal investigator (Ethan Nedeau) who had already conducted surveys throughout many of these areas. Survey sites were selected within each of these impoundment sections. In the field, actual survey locations often deviated from those originally proposed because surveyors

Table 1. Level of survey effort allocated to the Vernon, Bellows Falls, and Wilder project areas.

Statistic	Project Area Vernon	Bellows Falls	Wilder
Number of survey sites below dam	1(8)*	1(8)*	1(8)*
Number of survey sites in impoundment	22	45	49
Total number of survey sites	23	46	50
Average distance between sites (impoundment)	1.2	0.6	0.9
Maximum distance between survey sites	1.8	1.3	1.8
Total search-hours	23.5	51.8	52.3
Average search-hours per survey site	0.78	0.98	0.92

*8 sites were surveyed downstream of each dam, and these were combined into a single composite site

selected the most suitable habitats within a general area (rather than simply arriving at a pre-determined point). In addition to the impoundment surveys, eight locations were surveyed downstream of each dam. These locations were generally less than 200-300 meters apart and they were combined into a single composite site. Table 1 provides statistics for the number and frequency of survey sites in each project area. Survey site locations for each impoundment are shown in Appendices 1-3.

In addition to the systematic surveys in each impoundment, time was also reserved to return to specific areas where dwarf wedgemussels were *not* found, especially where suitable habitat existed and where dwarf wedgemussels were found nearby. This extra time consisted of one day for Bellow Falls and one day for Wilder. In the Bellows Falls impoundment, the additional sites were located in the Wethersfield Bow reach of the river. In the Wilder impoundment, the additional sites were located in the Piermont (New Hampshire) section of the river, toward the lower end of the reach where dwarf wedgemussels are known to occur.

In general, more fieldwork was allocated to the Bellows Falls and Wilder impoundments because dwarf wedgemussels were known to occur in these impoundments; the Vernon impoundment was surveyed less intensively because the likelihood of finding dwarf wedgemussels was deemed to be low based on prior experiences. In the Vernon and Wilder impoundments, all sampling sites were confined to the Connecticut River. In the Bellows Falls impoundment, the lower reaches of the Black River, Sugar River, and Williams River were surveyed.

SCUBA diver downstream of the Bellows Falls Dam.

3.2 Field Surveys

Field surveys were conducted during May-September, 2011. Survey methods varied according to specific habitat conditions at each site, but surveys were generally conducted by SCUBA diving in any water deeper than five feet, and snorkeling in shallower areas. Nearly all survey sites were accessed by a motorboat, while a select few were accessed from convenient entry points on land (e.g., bridges, boat launches, and fishing areas). Surveyors spent approximately one person-hour at each site searching for mussels. This typically involved two biologists each conducting a 30-minute timed search. During these searches, one biologist surveyed a deep area (5-20 ft) while the second biologist remained in shallower areas (2-7 ft). In areas downstream of the dams, shorter-duration surveys (0.5 person-hours/site) were conducted since biologists had to complete their work before late morning or early afternoon, prior to water being released from the dams.

The following information was recorded:

- Precise counts of uncommon species (dwarf wedgemussel, triangle floater, creeper, alewife floater, and eastern floater)
- Qualitative abundance category (Table 2) for eastern elliptio and eastern lampmussel
- Shell length and shell condition for every dwarf

Table 2. Abundance categories for eastern lampmussel and eastern elliptio.

Score	Descriptor	General Range*
0	None	0
1	Very Low	1-20
2	Low	21-50
3	Medium	51-100
4	Medium-High	101-200
5	High	201-400
6	Very High	401-800
7	Extreme	>800

*Range for numbers of mussels counted or estimated in a 1-hr search

wedgemussel, triangle floater, and creeper, and more cursory observations of the length range and shell conditions for other species. Shell condition refers to the degree of shell erosion (i.e., loss of periostracum and other damage). For each mussel, this was recorded as one of five numeric scores: 0 (light), 0.25 (light-medium), 0.5 (medium), 0.75 (medium-heavy), and 1 (heavy). These scores were averaged for all mussels in a sample to produce an overall shell condition index that ranged from 0-1.

- General descriptions of bank condition, surrounding land use, other noteworthy observations
- Representative photographs of habitats and species
- Notes on instream habitat such as water depth, substrate, flow conditions, submerged aquatic vegetation, and woody debris at each survey site
- GPS coordinates

3.3 Data Analysis

Data collected during field surveys were entered into a Microsoft Excel spreadsheet and GPS coordinates were imported into ArcGIS to generate maps. Catch-per-unit-effort (CPUE, expressed as mussels/hour) statistics were computed for the five species that were precisely counted. Shell length data collected for rare species (dwarf wedgemussels, triangle floaters, and creepers) were used to develop length-frequency histograms (a surrogate for age-frequency; reviewed in Nedeau 2008a). Counts and descriptive statistics were tabulated, graphed, and mapped.

4. RESULTS

4.1 Species Richness by Project Area

Vernon Project Area: Mussels were encountered at every survey site in the Vernon project area (Table 3, Figure 2). Four species were found downstream of the Vernon Dam; these were eastern elliptio, eastern lampmussel, alewife floater, and eastern floater. Six species were found in the Vernon impoundment; these were the same species from below the dam plus triangle floater and creeper. Downstream of the dam, average species richness (i.e., number of species) was 2.88 (range = 1-4) among the eight survey locations that comprised the single composite site. In the impoundment, average species richness was 3.05 (range = 2-5) among the 22 sites, and there was no apparent pattern to the species richness (Figure 3). Dwarf wedgemussels were not found in the project area.

Bellows Falls Project Area: Mussels were encountered at all but two survey sites in the Bellows Falls project area (Table 3, Figure 4). Five species were found downstream of the Bellows Falls Dam; these were eastern elliptio, eastern lampmussel, alewife floater, eastern floater, and triangle floater. Seven species were found in the Bellows Falls impoundment; these were the same species from below the dam plus dwarf wedgemussel and creeper. Downstream of the dam, average species richness was 3.50 (range = 2-4) among the eight survey locations that comprised the single composite site. In the impoundment, average species richness was 2.62 (range = 0-6) among the 45 sites, and species richness was generally highest in areas between Sites 14-23 and Sites 30-46 (Figure 6). Three of the four highest species richness values were from survey sites in the Black River (Sites 18-20). The only two locations where mussels were not found were in the impounded mouth of the Williams River and in the Sugar River.

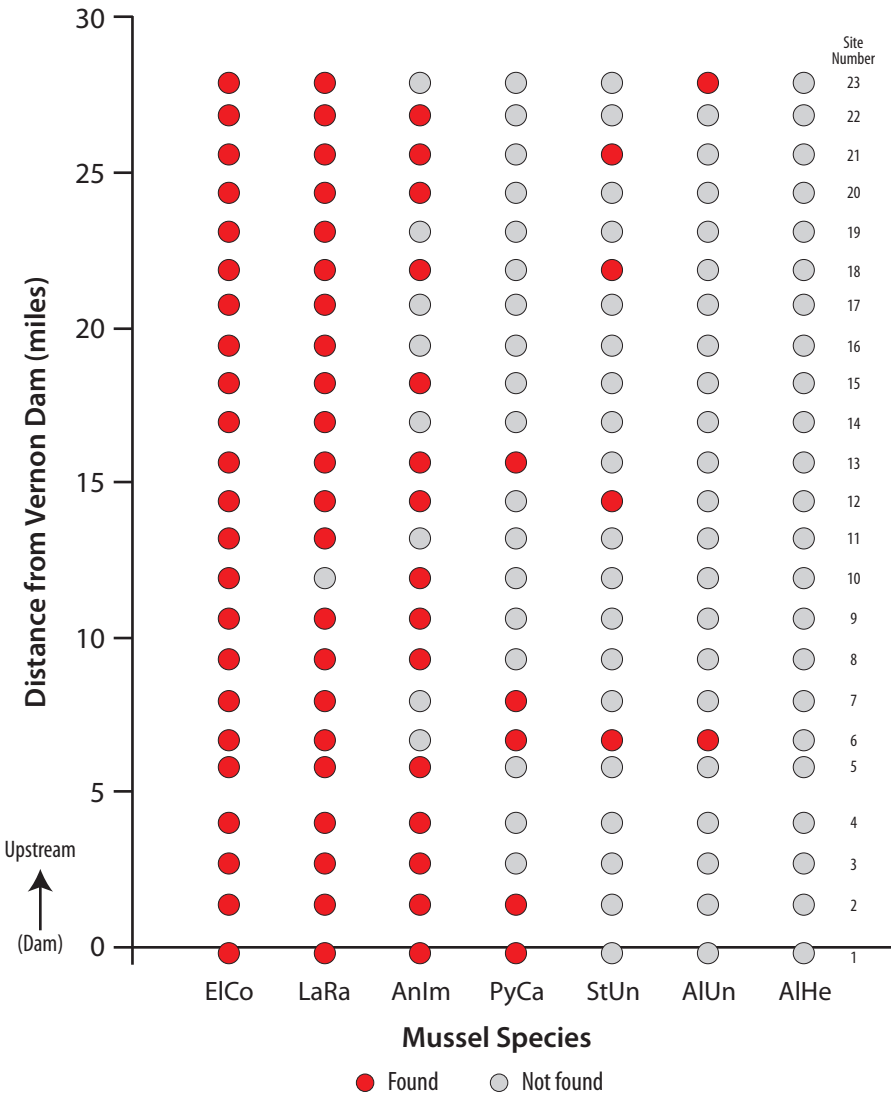
Wilder Project Area: Mussels were encountered at every survey site in the Wilder project area (Table 3, Figure 5). Three species were found downstream of the Wilder Dam; these were eastern elliptio, eastern lampmussel, and triangle floater. Five species were found in the Wilder impoundment; these were the same species from below

Table 3. Species richness statistics and species found in the Vernon, Bellows Falls, and Wilder project areas.

	Below Vernon Dam	Vernon Impoundment	Below Bellows Falls Dam	Bellows Falls Impoundment	Below Wilder Dam	Wilder Impoundment
Richness Statistic						
Species Richness	4	6	5	7	3	5
Average Richness/Site	2.88	3.05	3.50	2.62	1.75	2.39
Min Richness	1	2	2	0	0	1
Max Richness	4	5	4	6	3	4
Species						
Eastern Elliptio	x	x	x	x	x	x
Eastern Lampmussel	x	x	x	x	x	x
Alewife Floater	x	x	x	x		
Eastern Floater	x	x	x	x		
Creeper		x		x		x
Triangle Floater		x	x	x	x	x
Dwarf Wedgemussel				x		x

Figure 2. Survey sites where each mussel species were encountered in the Vernon project area. Sites are ordered by distance from the Vernon Dam; Site 1 is downstream of the dam.

Species Abbreviations
ElCo = *Elliptio complanata* (eastern elliptio)
LaRa = *Lampsilis radiata* (eastern lampmussel)
AnIm = *Anodonta implicata* (alewife floater)
PyCa = *Pyganodon cataracta* (eastern floater)
StUn = *Strophitus undulatus* (creeper)
AlUn = *Alasmidonta undulata* (triangle floater)
AlHe = *Alasmidonta heterodon* (dwarf wedgemussel)



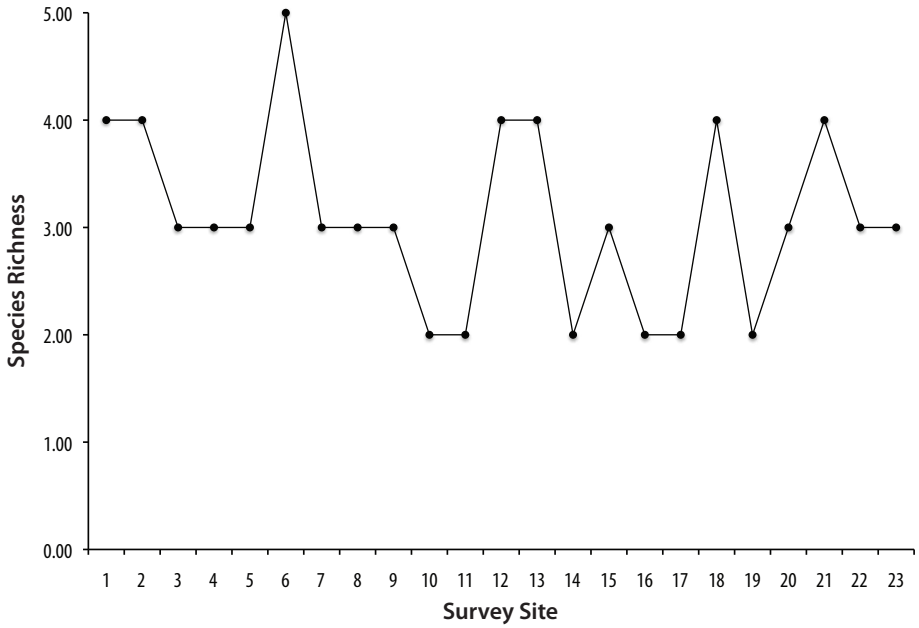


Figure 3. Species richness at survey sites in the Vernon project area.

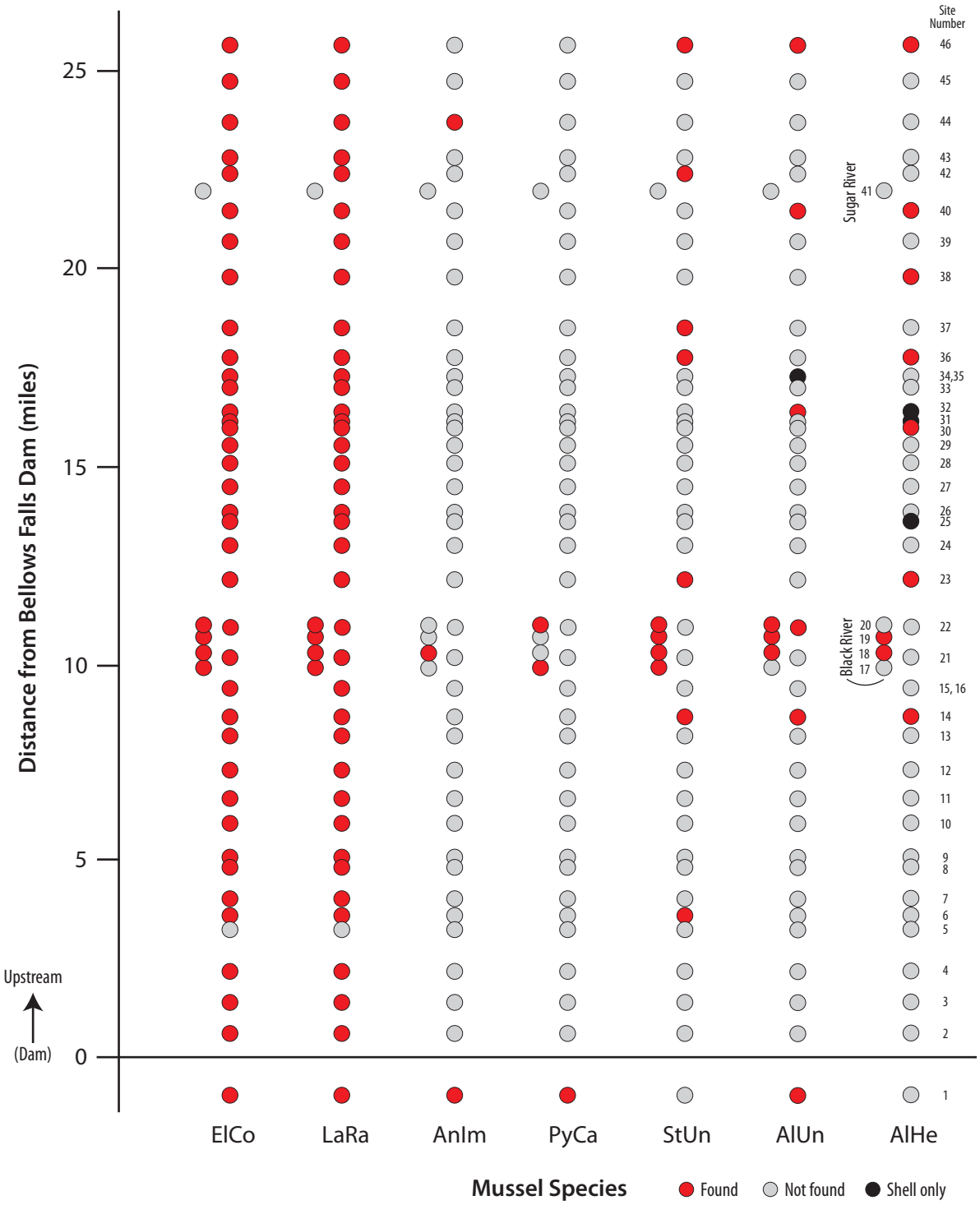


Figure 4. Survey sites where each mussel species were encountered in the Bellows Falls project area. Sites are ordered by distance from the Bellows Falls Dam; Site 1 is downstream of the dam.

Species Abbreviations
ElCo = *Elliptio complanata* (eastern elliptio)
LaRa = *Lampsilis radiata* (eastern lampmussel)
AnIm = *Anodonta implicata* (alewife floater)
PyCa = *Pyganodon cataracta* (eastern floater)
StUn = *Strophitus undulatus* (creeper)
AlUn = *Alasmidonta undulata* (triangle floater)
AlHe = *Alasmidonta heterodon* (dwarf wedgemussel)

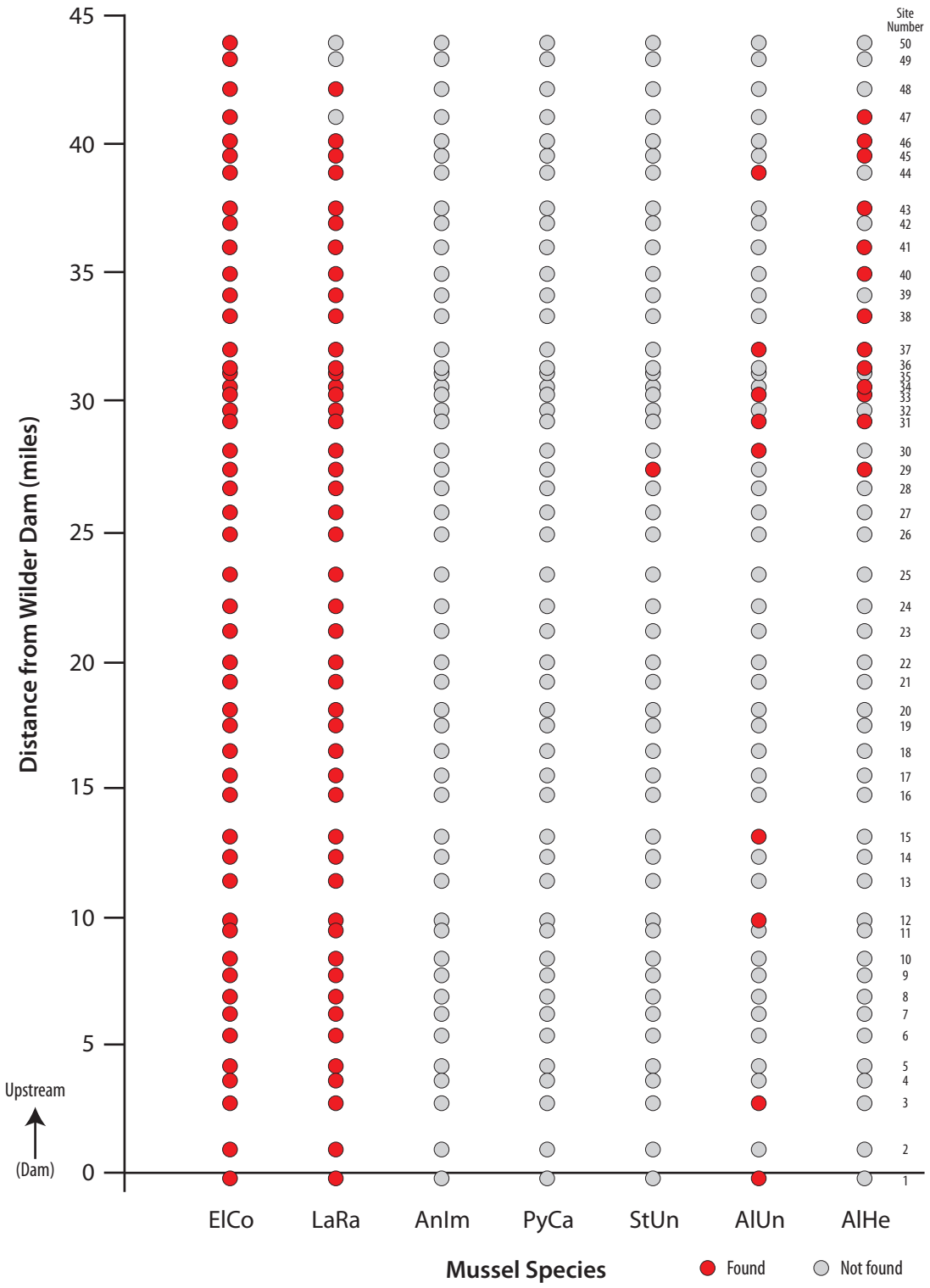


Figure 5. Survey sites where each mussel species were encountered in the Wilder project area. Sites are ordered by distance from the Wilder Dam; Site 1 is downstream of the dam.

Species Abbreviations
ElCo = *Elliptio complanata* (eastern elliptio)
LaRa = *Lampsilis radiata* (eastern lampmussel)
AnIm = *Anodonta implicata* (alewife floater)
PyCa = *Pyganodon cataracta* (eastern floater)
StUn = *Strophitus undulatus* (creeper)
AlUn = *Alasmidonta undulata* (triangle floater)
AlHe = *Alasmidonta heterodon* (dwarf wedgemussel)

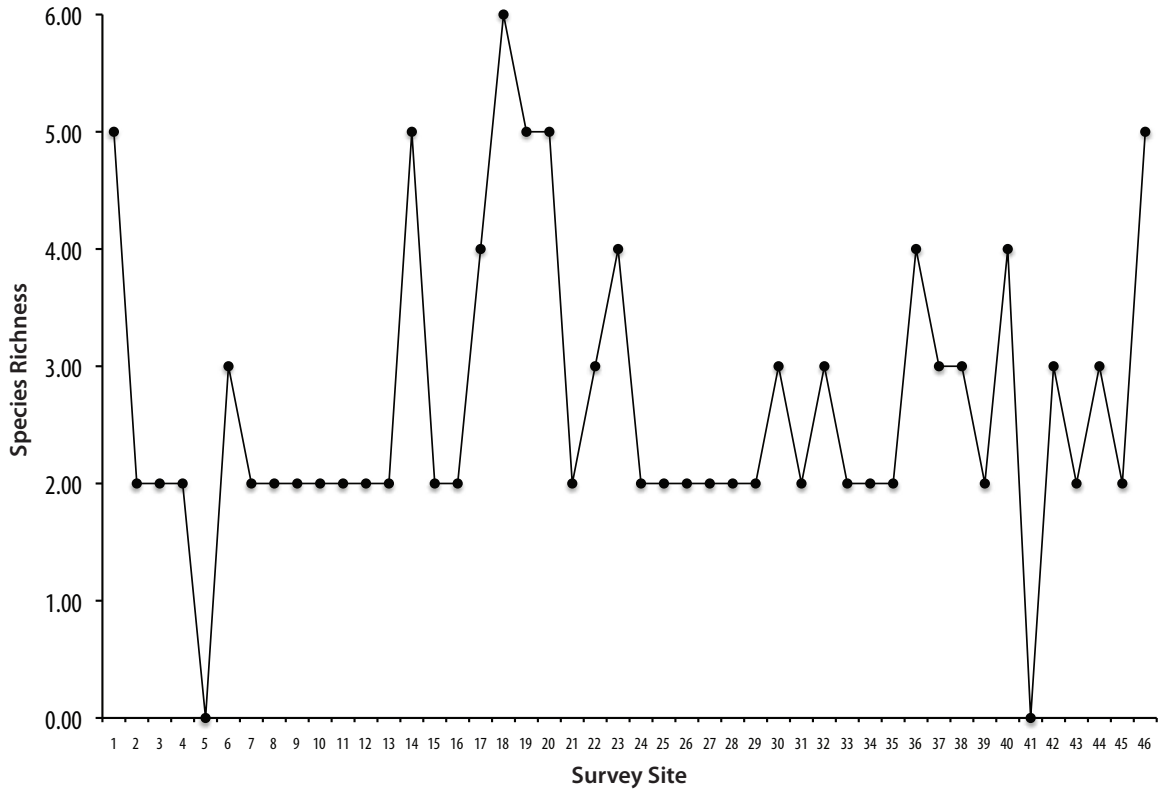


Figure 6. Species richness at survey sites in the Bellows Falls project area.

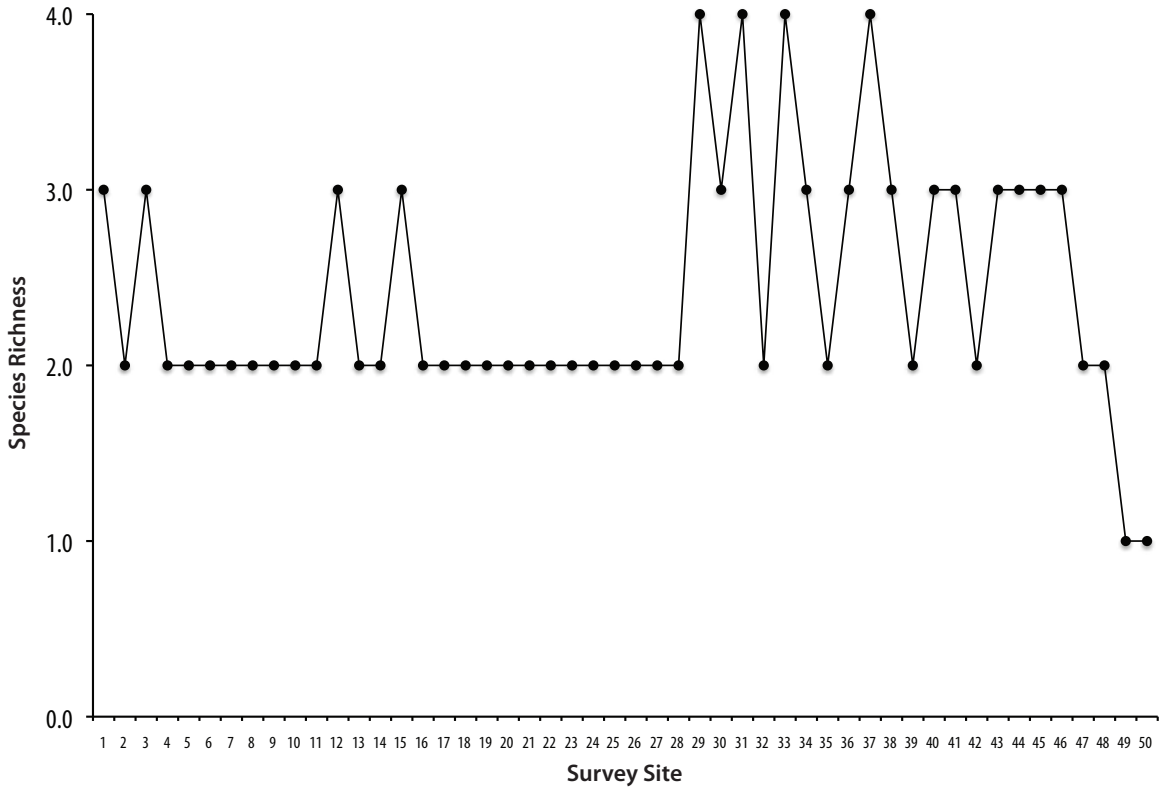


Figure 7. Species richness at survey sites in the Wilder project area.

the dam plus dwarf wedgemussel and creeper. Downstream of the dam, average species richness was 1.75 (range = 0-3) among the eight survey locations that comprised the single composite site. In the impoundment, average species richness was 2.39 (range = 1-4) among the 49 sites, and species richness was generally highest in areas between Sites 29-46 where dwarf wedgemussels were found (Figure 7).

4.2 Species Summaries

4.2.1 Dwarf Wedgemussel

Distribution: Dwarf wedgemussels were only found in the Bellows Falls and Wilder impoundments (Table 4). In the Bellows Falls impoundment, they were found at nine survey sites (20.0 percent), including two sites in the lower Black River and seven sites in the Connecticut River between Sites 14-46, located in the upper 17 miles of the impoundment (Figures 4, 8). In addition, shells were found at three sites (25, 31, and 32) within this same reach. Dwarf wedgemussels in the Bellows Falls impoundment were found slightly more frequently near the Black River confluence, near Wethersfield Bow, and in the Black River. In the Wilder impoundment, they were found at 13 survey sites (26.5 percent) between Sites 29-47, located 27-41 miles upstream of the Wilder Dam (Figures 5, 9).

Table 4. Summary statistics for dwarf wedgemussels in areas where they were found.

Statistic	Bellows Falls Impoundment	Wilder Impoundment
Catch Statistics		
Number of sites where found	9	13
Percent of sites where found	20.0	26.5
Total number of animals	11	39
Average count per site	0.24	0.80
Max count per site	3	8
Average CPUE (mussels/hr)	0.24	0.77
Max CPUE (mussels/hr)	3.00	8.00
Demographics and Condition Statistics		
Shell Condition Index	0.41	0.46
Average shell length (mm)	29.8	26.9
Standard deviation	7.81	4.50
Min shell length (mm)	10	18
Max shell length (mm)	40	37
Length Class Frequency		
<20 mm	1	2
20 - 24.9 mm	0	11
25 - 29.9 mm	5	12
30 - 34.9 mm	4	13
35 - 39.9 mm	0	1
40 - 44.9 mm	1	0
45 - 49.9 mm	0	0
50 - 54.9 mm	0	0

Abundance: A total of 50 dwarf wedgemussels were found (Table 4). Eleven dwarf wedgemussels were found in the Bellows Falls impoundment, for an average of only 0.24 mussels/site and an average CPUE of 0.24 mussels/hour. The highest CPUE recorded in the Bellows Falls impoundment was 3.0 mussels/hour at Site 18 in the Black River (three animals). Usually only one dwarf wedgemussel was found per site in the Bellows Falls impoundment. A total of 39 dwarf wedgemussels were found in the Wilder impoundment, for an average of 0.80 mussels/site and an average CPUE of 0.77 mussels/hour. The highest CPUE recorded in the Wilder impoundment was 8.0 mussels/hour at Site 43 (eight animals). Figure 10 shows dwarf wedgemussel CPUE by site for both the Bellows Falls and Wilder project areas.

Demographics and Shell Condition: Average shell length for all dwarf wedgemussels encountered was 27.5 mm, and individuals ranged from 10.0-40.0 mm (Table 4). Dwarf wedgemussels were slightly smaller in the Wilder impoundment (average = 26.9 mm, range = 18-37 mm) than in the Bellows Falls impoundment (average = 29.8 mm, range = 10-40 mm), but there was evidence of recruitment in both areas and the differences in shell length were statistically insignificant. The shell condition index indicated moderate levels of shell erosion in both project areas (0.41 and 0.46). Low sample sizes precluded more robust demographic and shell condition analyses.

Habitat: Nearly all dwarf wedgemussels were found by SCUBA diving in water depths of 5-20 feet. They were found in a variety of substrate types, often with some combination of clay, silt, sand, and gravel. Some were found in pockets of these fine substrates in areas dominated by cobble, boulder, or bedrock. Most dwarf wedgemussels were found in areas with light to moderate flow velocities. They tended to be associated with two other uncommon mussel species—creeper and triangle floater.

Representative dwarf wedgemussels.

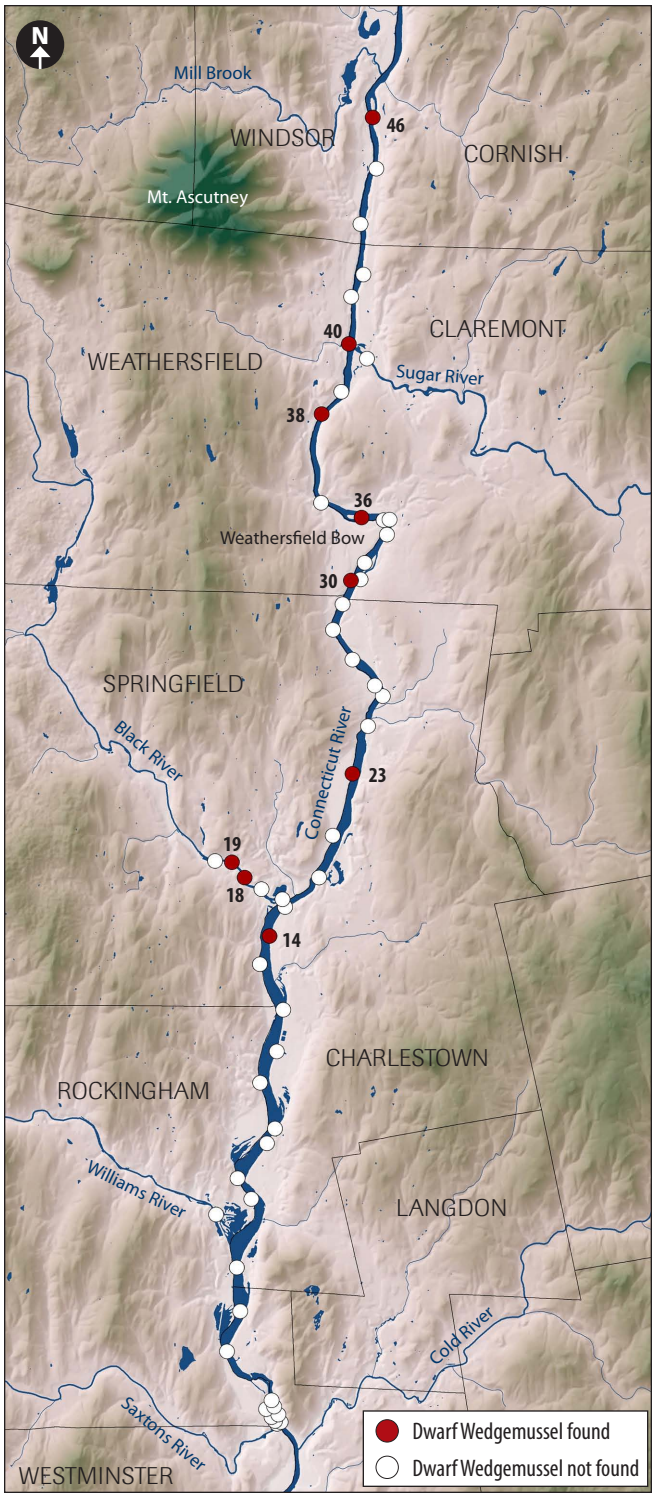


Figure 8. Survey sites where dwarf wedgemussels were found in the Bellows Falls impoundment. See Appendix 2 for a fully labeled map.

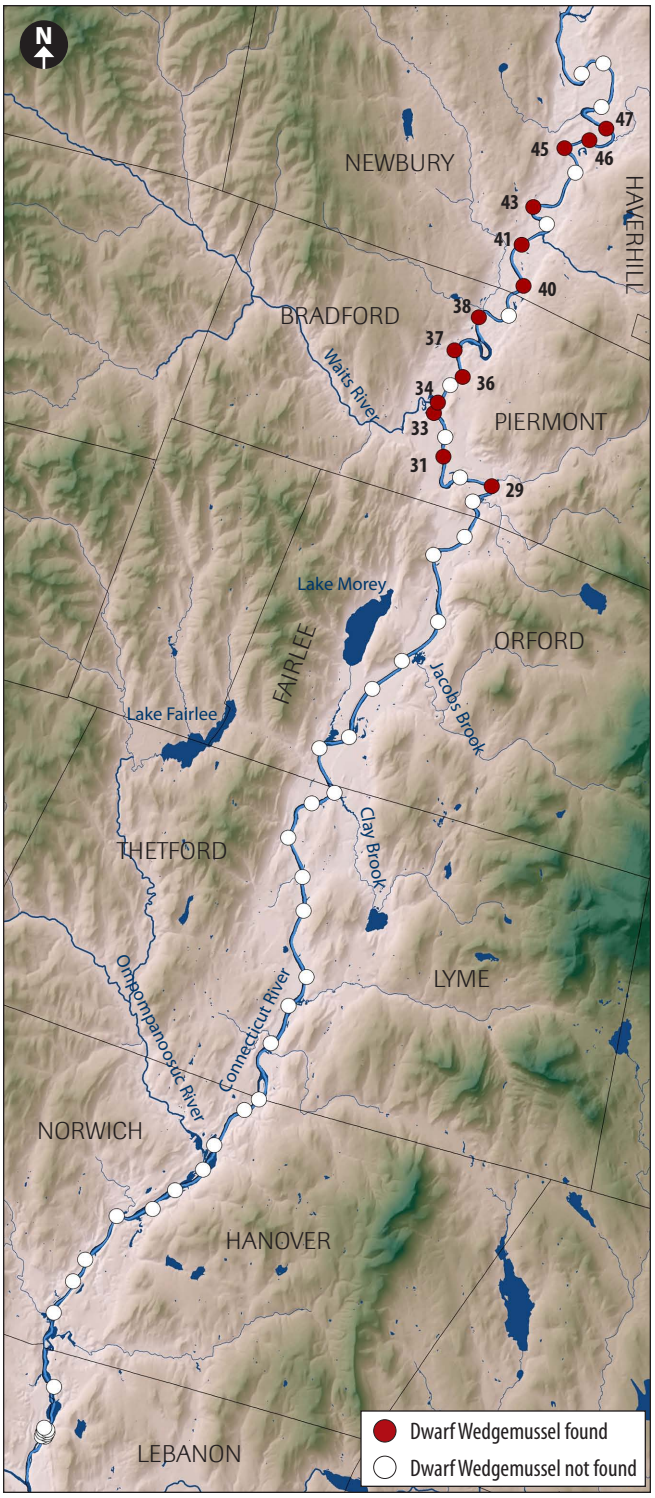


Figure 9. Survey sites where dwarf wedgemussels were found in the Wilder impoundment. See Appendix 3 for a fully labeled map.

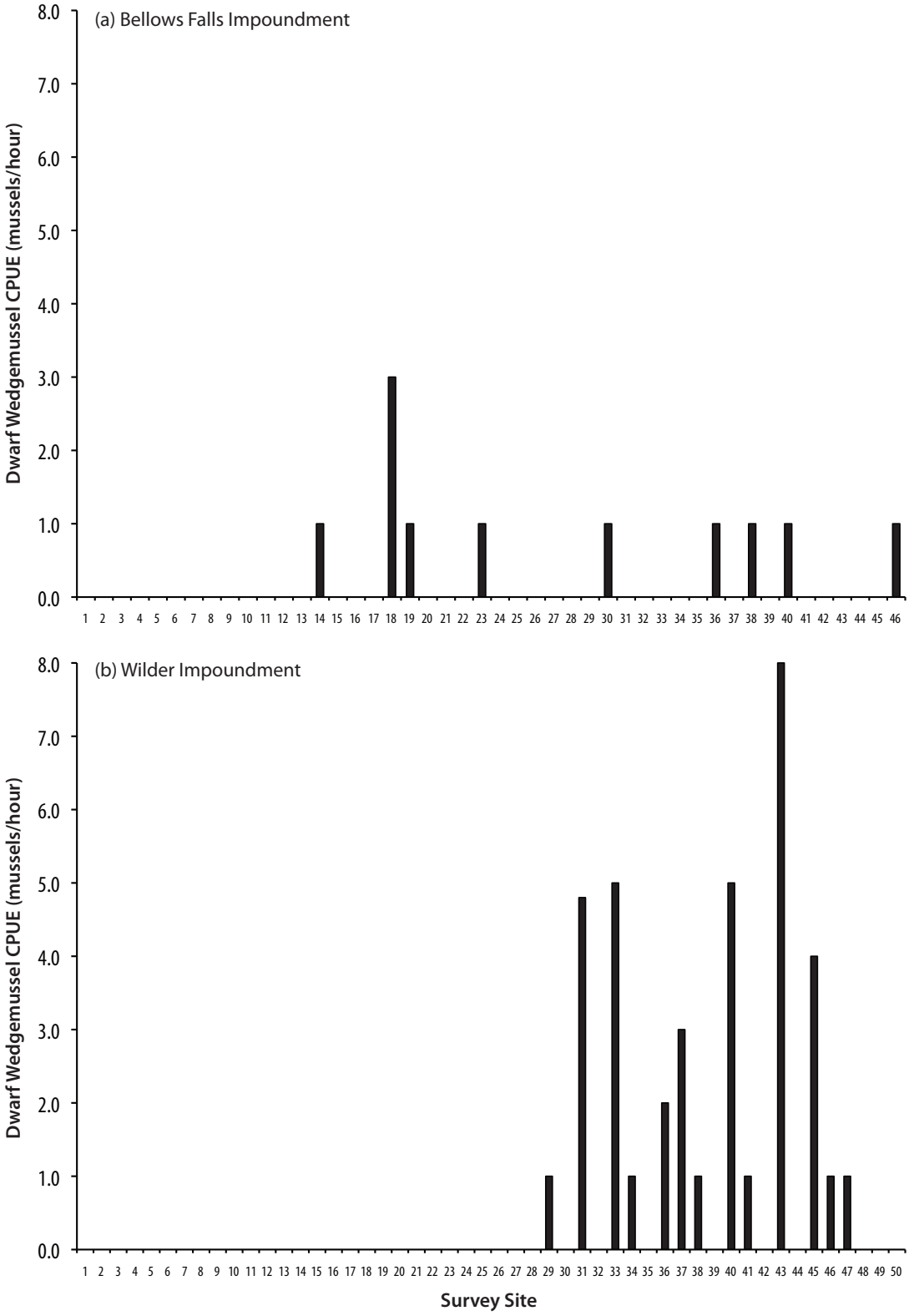


Figure 10. Dwarf wedgemussel CPUE for each survey site in the (a) Bellows Falls impoundment, and (b) Wilder impoundment.

4.2.2 Creeper

Distribution: Creepers were found in the Vernon, Bellows Falls, and Wilder impoundments (Table 5); none were found downstream of the three dams. In the Vernon impoundment, they were found at four survey sites (18.2 percent) at least four miles apart (Figure 2). In the Bellows Falls impoundment, they were found at 11 survey sites (24.4 percent), including at all four sites in the lower Black River and seven sites in the Connecticut River widely spaced throughout much of the impoundment (Figure 4). In the Wilder impoundment, they were found at just one survey site (Site 29) located 27.3 miles upstream of the dam (Figure 5).

Table 5. Summary statistics for creepers in areas where they were found.

Statistic	Vernon Impoundment	Bellows Falls Impoundment	Wilder Impoundment
Catch Statistics			
Number of sites where found	4	11	1
Percent of sites where found	18.2	24.4	2.0
Total number of animals	6	40	1
Average count per site	0.27	0.89	0.02
Max count per site	3	18	1
Average CPUE (mussels/hr)	0.27	0.90	0.02
Max CPUE (mussels/hr)	3.00	18.00	1.00
Demographics and Condition Statistics			
Shell Condition Index	0.29	0.29	0.00
Average shell length (mm)	54.7	55.1	31.0
Standard deviation	4.97	11.31	-
Min shell length (mm)	47	31	31
Max shell length (mm)	62	78	31
Length Class Frequency			
<20 mm	0	0	0
20 - 24.9 mm	0	0	0
25 - 29.9 mm	0	0	0
30 - 34.9 mm	0	2	1
35 - 39.9 mm	0	0	0
40 - 44.9 mm	0	4	0
45 - 49.9 mm	1	7	0
50 - 54.9 mm	1	9	0
55 - 59.9 mm	3	4	0
60 - 64.9 mm	1	5	0
65 - 69.9 mm	0	3	0
70 - 74.9 mm	0	4	0
75 - 79.9 mm	0	2	0

Abundance: A total of 47 creepers were found (Table 5). Four creepers were found in the Vernon impoundment, for an average of only 0.27 mussels/site and an average CPUE of 0.27 mussels/hour. The highest CPUE recorded in the Vernon impoundment was 3.0 mussels/hour at Site 21 (three animals). Forty creepers were found in the Bellows Falls impoundment, for an average of 0.89 mussels/site and an average CPUE of 0.90 mussels/hour. The highest CPUE recorded in the Bellows Falls impoundment was 18.0 mussels/hour at Site 18 in the Black River (18 animals). In fact, 82.5 percent (33 of 40) of the creepers found in the Bellows Falls impoundment were found in the Black River. Only one creeper was found in the Wilder impoundment, for an average CPUE of 0.02 mussels/hour. Figure 11 shows creeper CPUE by site for all three project areas.

Demographics and Shell Condition: Average shell length for all creepers encountered was 54.5 mm, and individuals ranged from 31.0-78.0 mm (Table 5). Average shell length was nearly identical in the Vernon and Bellows Falls impoundments, although there was a greater size range in the Bellows Falls impoundment (31.0-78.0 mm vs. 47.0-62.0 mm). The single creeper found in the Wilder impoundment was 31.0 mm in length. The shell condition index was identical in both project areas (0.29); this value suggests light-moderate levels of shell erosion. Low sample sizes precluded more robust demographic and shell condition analyses.

Habitat: Nearly all creepers were found in water depths between 3-15 feet. They were found in a variety of substrate types, often with some combination of clay, silt, sand, and gravel. Some were found in pockets of these fine substrates in areas dominated by cobble, boulder, or bedrock. All were found in areas with light to moderate flow velocities. They tended to co-occur with dwarf wedgemussel and triangle floater.

Creeper from Site 23 in the Bellows Falls impoundment.

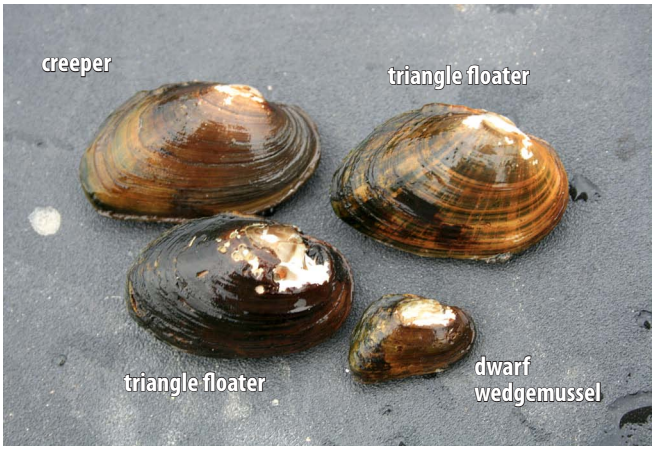
Table 6. Summary statistics for triangle floaters in areas where they were found.

Statistic	Vernon Impoundment	Below Bellows Falls Dam	Bellows Falls Impoundment	Below Wilder Dam	Wilder Impoundment
Catch Statistics					
Number of sites where found	2	4	8	2	8
Percent of sites where found	9.1	50.0	17.8	25.0	16.3
Total number of animals	2	5	17	3	17
Average count per site	0.09	0.63	0.38	0.38	0.35
Max count per site	1	2	5	2	5
Average CPUE (mussels/hr)	0.09	0.63	0.38	0.75	0.37
Max CPUE (mussels/hr)	1.00	2.00	5.00	4.00	5.33
Demographics and Condition Statistics					
Shell Condition Index	0.38	0.39		0.24	
Average shell length (mm)	32.0	42.8		39.7	
Standard deviation	5.66	10.70		8.32	
Min shell length (mm)	28	25		27	
Max shell length (mm)	36	65		58	
Length Class Frequency					
<20 mm	0	0		0	
20 - 24.9 mm	0	0		0	
25 - 29.9 mm	1	3		2	
30 - 34.9 mm	0	3		4	
35 - 39.9 mm	1	2		5	
40 - 44.9 mm	0	5		2	
45 - 49.9 mm	0	4		5	
50 - 54.9 mm	0	2		1	
55 - 59.9 mm	0	1		1	
60 - 64.9 mm	0	1		0	
65 - 69.9 mm	0	1		0	
70 - 74.9 mm	0	0		0	
75 - 79.9 mm	0	0		0	

4.2.3 Triangle Floater

Distribution: Triangle floaters were found in all three impoundments and below both the Bellows Falls and Wilder Dams (Table 6). In the Vernon impoundment, they were found at two survey sites (9.1 percent) nearly 20 miles apart (Figure 2). In the Bellows Falls impoundment, they were found at eight survey sites (17.8 percent), including at all three sites in the lower Black River and six sites in the Connecticut River between Site 14 and the upper end of the impoundment (Figure 4). They were found at eight survey sites (16.3 percent) widely spaced throughout the Wilder impoundment (Figure 5).

Abundance: A total of 44 triangle floaters were found (Table 6). Two triangle floaters were found in the Vernon impoundment, for an average of only 0.09 mussels/site and an average CPUE of 0.09 mussels/hour. Seventeen triangle floaters were found in the Bellows Falls impoundment, for an average of 0.38 mussels/site and an average CPUE of 0.38 mussels/hour. The highest CPUE recorded in the Bellows Falls impoundment was 5.0 mussels/hour at Sites 18 and 19, both of which were in the Black River. In fact, 64.7 percent (11 of 17) of the triangle floaters found in the Bellows Falls impoundment were found in the Black River. Seventeen triangle floaters were found in the Wilder impoundment, for an average of 0.35 mussels/site and an average CPUE of 0.37 mussels/hour. The highest CPUE recorded in the Wilder impoundment was 5.3 mussels/hour (4 mussels) at Site 12 in the lower impoundment. Triangle floater were also found downstream of the Bellows Falls Dam (5 mussels, average CPUE =



Three uncommon species from Site 46 in the upper Bellows Falls impoundment.

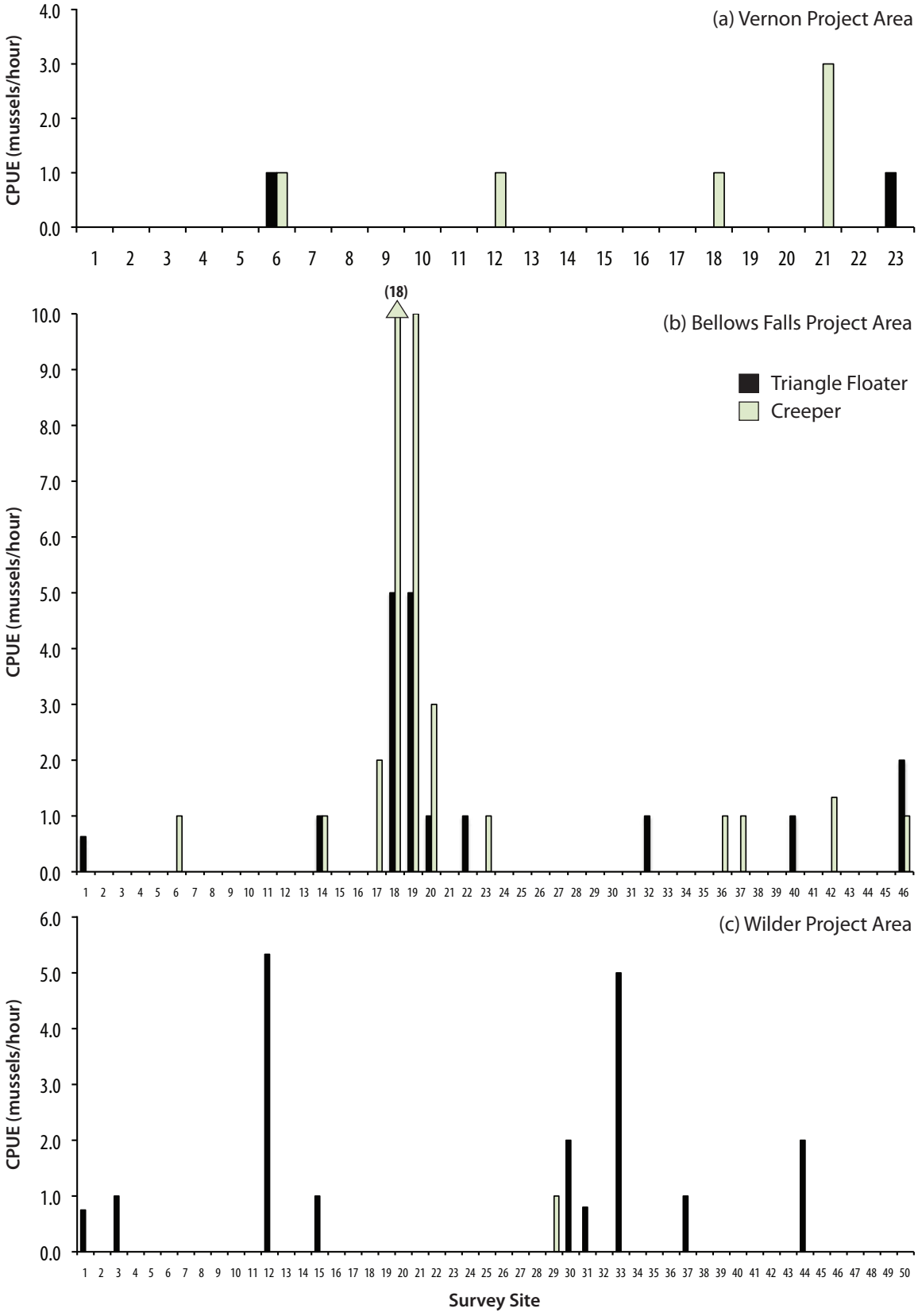


Figure 11. Triangle floater and creeper CPUE for each survey site in the (a) Vernon, (b) Bellows Falls, and (c) Wilder project areas.

0.63 mussels/hour) and Wilder Dam (3 mussels, average CPUE = 0.75 mussels/hour). Figure 11 shows triangle floater CPUE by site for all three project areas.

Demographics and Shell Condition: Average shell length for all triangle floaters encountered was 40.9 mm, and individuals ranged from 25.0-65.0 mm (Table 6). Triangle floaters were slightly smaller in the Wilder project area (average = 39.7 mm, range = 22.0-58.0 mm) than in the Bellows Falls project area (average = 42.8 mm, range = 25.0-65.0 mm), but there was evidence of recruitment in both areas and the differences in shell length were small and statistically insignificant. Only two triangle floaters were found in the Vernon project area and both were relatively small (28.0 and 36.0 mm). The shell condition indices were similar in all project areas, and was 0.30 overall, indicating light-moderate levels of shell erosion. Low sample sizes precluded more robust demographic and shell condition analyses.

Habitat: Nearly all triangle floaters were found in water depths between 3-15 feet. They were found in a variety of substrate types, often with some combination of clay, silt, sand, gravel, and small cobble. Most were found in areas with light to moderate flow velocities, but the triangle floaters found at the upstream end of the Vernon and Wilder impoundments, and below the Bellows Falls and Wilder Dams, were in areas with stronger flows. They tended to co-occur with dwarf wedgemussel and creeper.

4.2.4 Alewife Floater

Distribution: Alewife floater was the third most common species overall. Alewife floaters were found in the Vernon and Bellows Falls project areas, both upstream and downstream of the dams (Table 7). In the Vernon impoundment, they were found at 14 survey sites (63.6 percent) (Figure 2). In the Bellows Falls impoundment, they were found at only two survey sites (4.4 percent), including at one site in the lower Black River (Site 21) and one site in the upper end of the impoundment (Site 44) (Figure 4). None were found in the Wilder project area.

Abundance: A total of 460 alewife floater were found (Table 7); 166 were found in the Vernon impoundment, for an average of 7.55 mussels/site and an average CPUE of 8.44 mussels/hour. Only two alewife floater were found in the Bellows Falls impoundment, for an average of 0.04 mussels/site and an average CPUE of 0.05 mussels/hour. Alewife floater were numerous downstream of the Vernon

Table 7. Summary statistics for eastern elliptio, eastern lampmussel, eastern floater, and alewife floater in areas where they were found.

Catch Statistic	Below Vernon Dam	Vernon Impoundment	Below Bellows Falls Dam	Bellows Falls Impoundment	Below Wilder Dam	Wilder Impoundment
Eastern Elliptio						
Number of sites where found	8	22	8	43	7	49
Percent of sites where found	100.0	100.0	100.0	95.6	87.5	100.0
Average abundance estimate*	4.50	4.27	5.38	4.78	2.38	4.88
Maximum abundance estimate*	7.0	6.0	7.0	7.0	4.0	7.0
Eastern Lampmussel						
Number of sites where found	7	21	8	43	5	46
Percent of sites where found	87.5	95.5	100.0	95.6	62.5	93.9
Average abundance estimate*	1.75	2.18	2.63	3.27	1.50	2.73
Maximum abundance estimate*	4.0	4.0	4.0	6.0	4.0	7.0
Eastern Floater						
Number of sites where found	5	4	1	2	0	0
Percent of sites where found	62.5	18.2	12.5	4.4	0.0	0.0
Total number of animals	20	6	1	8	0	0
Average count per site	2.50	0.27	0.13	0.18	0.00	0.00
Max count per site	8	3	1	7	0	0
Average CPUE (mussels/hr)	5.00	0.32	0.13	0.18	0.00	0.00
Max CPUE (mussels/hr)	16.00	3.00	1.00	7.00	0.00	0.00
Alewife Floater						
Number of sites where found	3	14	7	2	0	0
Percent of sites where found	37.5	63.6	87.5	4.4	0.0	0.0
Total number of animals	75	166	217	2	0	0
Average count per site	9.38	7.55	27.13	0.04	0.00	0.00
Max count per site	41	37	50	1	0	0
Average CPUE (mussels/hr)	18.75	8.44	29.75	0.05	0.00	0.00
Max CPUE (mussels/hr)	82.00	37.00	50.00	1.33	0.00	0.00

*See Table 2 for abundance categories for eastern elliptio and eastern lampmussel.

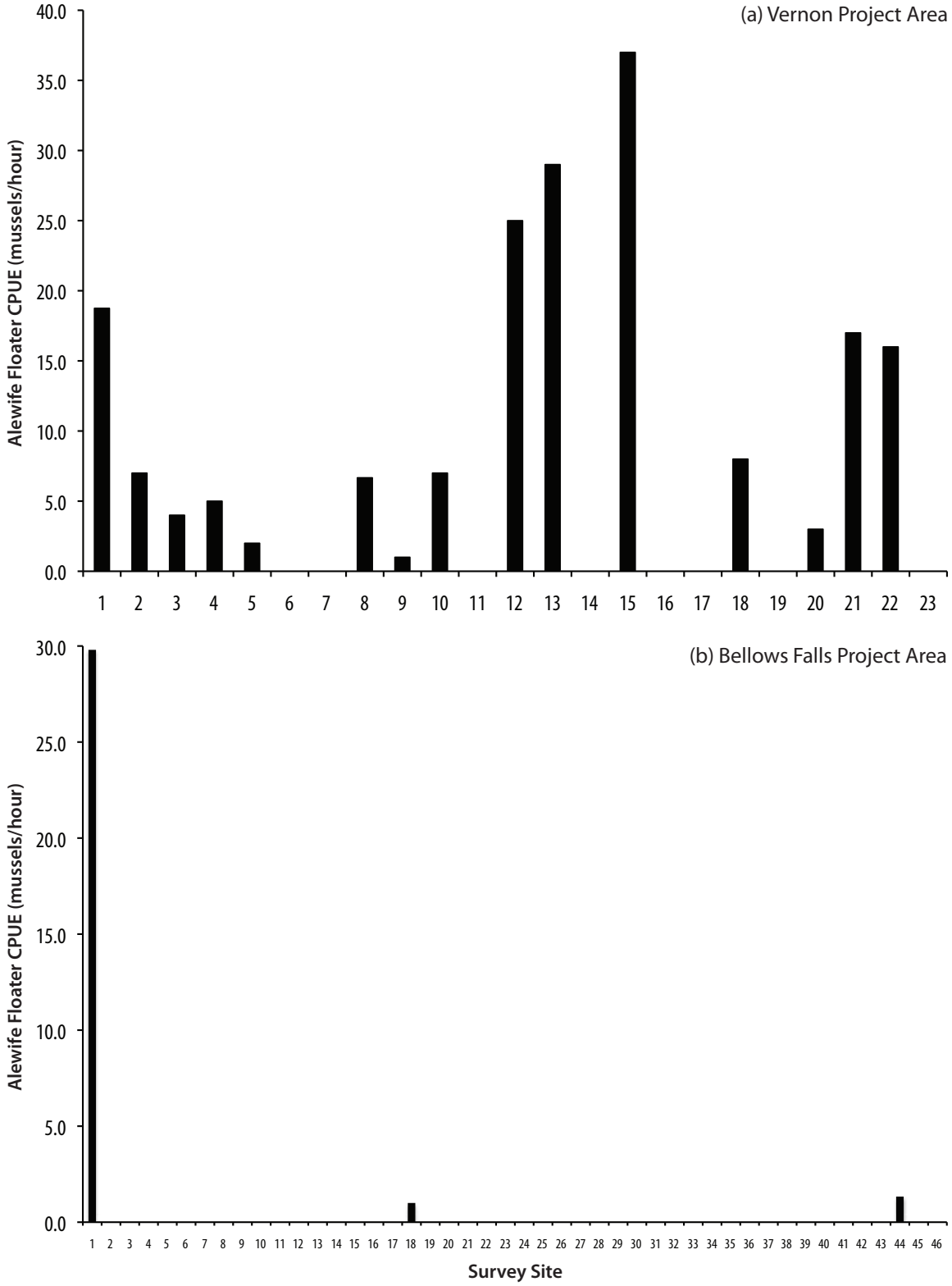
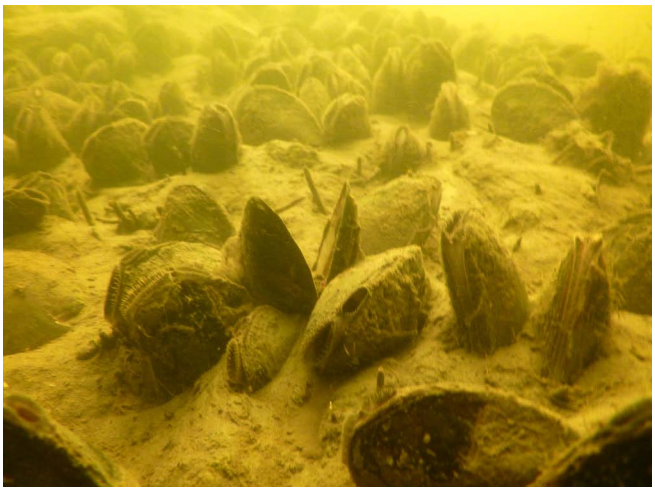


Figure 12. Alewife floater CPUE for each survey site in the (a) Vernon, and (b) Bellows Falls project areas.

Live alewife floater in its natural position, observed downstream of the Bellows Falls Dam.

Eastern elliptio in its natural position, observed downstream of the Bellows Falls Dam.

Alewife floater.



Bed of eastern elliptio in the Wilder impoundment.

Dam (75 mussels, average CPUE = 18.7 mussels/hour) and Bellows Falls Dam (217 mussels, average CPUE = 29.7 mussels/hour). Figure 12 shows alewife floater CPUE by site in the project areas where they were found.

Demographics and Shell Condition: Neither shell length nor shell condition were recorded for alewife floater. Generally, both young animals (30-50 mm) and older animals (>120 mm) were observed downstream of both the Vernon Dam and the Bellows Falls Dam, and in the Vernon impoundment. The live alewife floater found toward the upstream end of the Bellows Falls impoundment was 71.0 mm in length; based on annular rings it was probably 7-10 years old. Alewife floater inhabiting silt and sand substrates toward the downstream end of the Vernon impoundment exhibited light shell erosion, whereas those animals living in gravel and cobble substrates and areas with higher flow velocities tended to exhibit moderate to heavy shell erosion.

Habitat: Alewife floaters were found in water depths between 3-20 feet. They were found in a variety of substrate types, often with some combination of clay, silt, sand, gravel, and small cobble. Most were found in a broad range of flow velocities, including in strong flows downstream of the Vernon and Bellows Falls dams.

4.2.5 Eastern Elliptio

Eastern elliptio was the most widespread and abundant mussel species (Table 7, Figures 2, 4, and 5). It was found at 98.3 percent of all survey sites and comprised 65-95 percent of the mussels observed. Eastern elliptio were not found at only two sites—the impounded mouths of the Sugar River and Williams River.

Abundance was considered High to Extremely High (abundance indices of 5-7) at eight sites (36.3 percent) in the Vernon impoundment, 30 sites (66.7 percent) in the Bellows Falls impoundment, and 34 sites (61.2 percent)

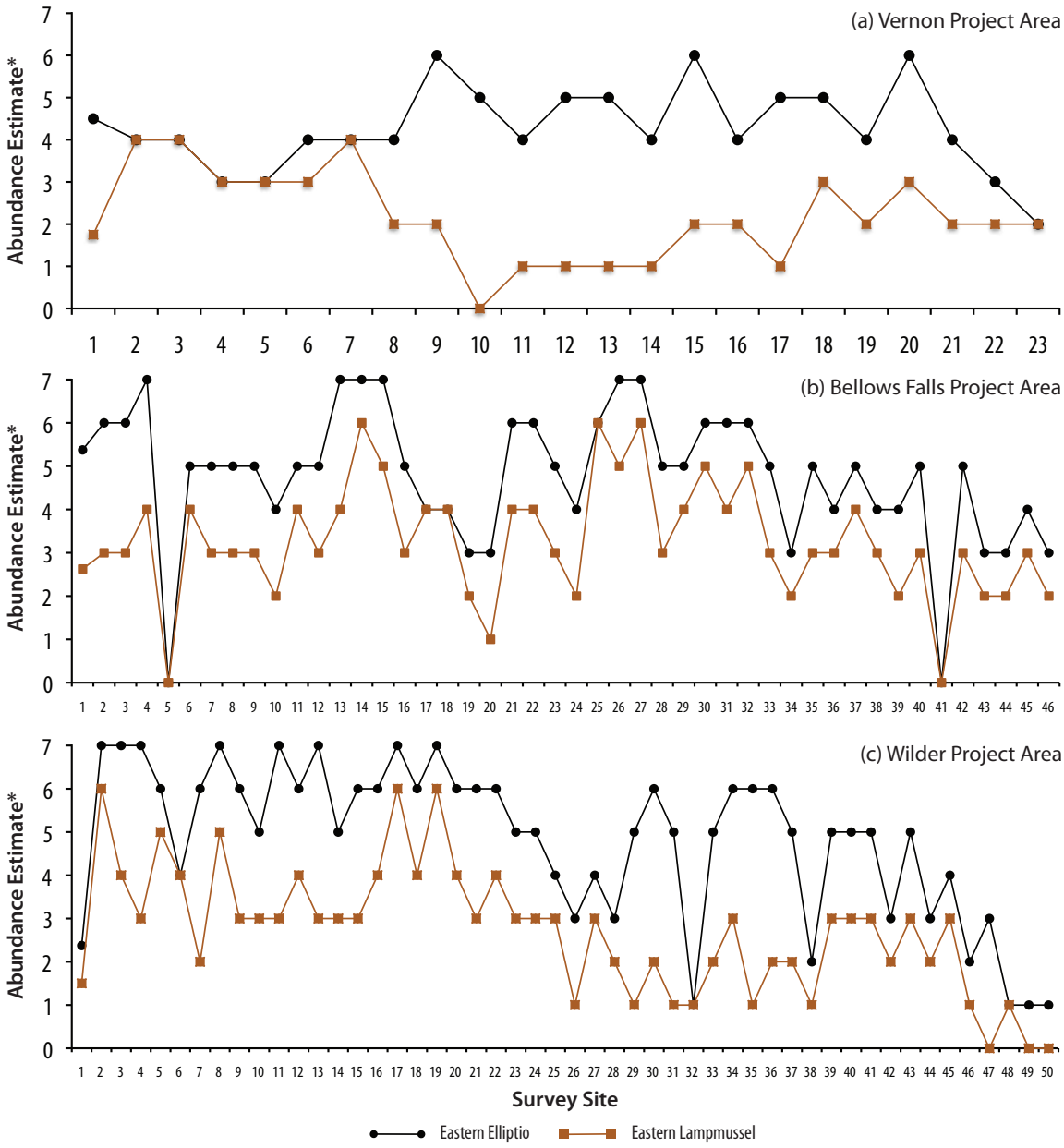


Figure 13. Abundance estimates for eastern elliptio and eastern lampmussels in the (a) Vernon, (b) Bellows Falls, and (c) Wilder project areas. See Table 2 for definition of the abundance categories 0-7.

in the Vernon impoundment (Figure 13). Elliptio were also very common downstream of the Vernon Dam and Bellows Falls Dam, but far less common downstream of the Wilder Dam. Though highly variable, elliptio abundance was generally lowest toward the upper end of each impoundment. There was strong evidence of recruitment (small animals less than 30 mm in length) throughout all three project areas. Elliptio occupied a broad range of habitats, from the nearshore submerged streambanks in only 3-4 feet of water, out to the middle of the channel in water depths greater than 25 feet.

4.2.6 Eastern Lampmussel

Eastern lampmussel was the second-most widespread and abundant mussel species (Table 7, Figures 2, 4, and 5). They were found at 94.9 percent of the survey sites, including all but one, two, and three survey sites in the Vernon, Bellows Falls, and Wilder project areas, respectively. They were found downstream of each of the dams, but usually at lower abundances than in impoundments.

Abundance was considered High to Very High (abundance indices of 5-6) at only seven sites (15.6 percent) in

Eastern lampmussel.

the Bellows Falls impoundment and five sites (10.2 percent) in the Wilder impoundment (Figure 13). In contrast, abundance was considered Very Low to Low, or Absent (abundance indices of 0-2) at 15 sites (65.2 percent) in the Vernon project area, 11 sites (23.9 percent) in the Bellows Falls project area, and 20 sites (40 percent) in the Wilder project area.

Though highly variable, eastern lampmussels were most abundant in the downstream third of the Vernon and Wilder impoundments, and also in the middle third of the Bellows Falls impoundment. Abundance generally diminished toward the upper end of all three impoundments. There was evidence of recruitment (small animals less than 50 mm in length) throughout all project areas, and large numbers of gravid females were observed luring fish and discharging glochidia. Although eastern lampmussels occupied a broad range of habitats, they seemed to be more prevalent in nearshore areas at depths of 3-10 feet, in clay, silt, sand, and gravel substrates.

4.2.7 Eastern Floater

Eastern floaters were found downstream of the Vernon and Bellows Falls Dams, at four locations in the Vernon impoundment, and at two locations in the Bellows Falls impoundment (Table 7, Figures 2, 4, and 5). A total of 35 animals were found, including 20 downstream of the Vernon Dam, six in the lower half of the Vernon impoundment, one downstream of the Bellows Falls Dam, and eight in the lower Black River in the Bellows Falls impoundment. It is possible that some of the animals identified above or below the Vernon Dam were alewife floater, as younger animals of these two species are very difficult to distinguish without sacrificing (i.e., killing) animals.

5. DISCUSSION

5.1 Vernon Hydroelectric Project

The mussel community at the Vernon project area, both downstream of the dam and in the impoundment, was dominated by eastern elliptio. This species was found at every survey location and outnumbered other species by at least 10:1, except in the lowermost part of the impoundment (Sites 2-7), near the dam, where eastern lampmussel were nearly as abundant. The four species found at the sites downstream of the Vernon Dam are the same four species found consistently in the reach of the Connecticut River between the Vernon Dam and the Turners Falls Dam about 19 miles downstream (Biodrawversity 2012).

Of the three impoundments surveyed, Vernon was the only one with a significant population of the alewife floater, a species that relies on American shad and alewife as hosts and whose presence in the Vernon impoundment can be attributed to anadromous fish passage at three facilities downstream: the Holyoke Dam, Turners Falls Dam, and Vernon Dam (Smith 1985, Nedeau 2008a). Alewife floater is listed S1 in Vermont but not officially listed as Threatened or Endangered; this survey provides critical information for the state of Vermont's status assessment for alewife floater.

The very low numbers of triangle floater and creeper in the Vernon impoundment were surprising; both of these species are often numerous in the types of habitats present in the Vernon impoundment, especially in the more free-flowing middle and upper reaches. The low numbers, and the low frequency at which they were encountered, suggests either that populations are very small and non-viable, or that they occur in areas of the river that were not surveyed. The survey failed to detect dwarf wedgemussels, which corroborates results of the few recent surveys conducted in the impoundment (Nedeau 2005). Dwarf wedgemussels were found in the impoundment, near Brattleboro, 30 years ago (Vermont Fish and Wildlife, unpublished report).

5.2 Bellows Falls Hydroelectric Project

The mussel community downstream of the Bellows Falls Dam contained five of the same species that occurred throughout the Vernon impoundment, and some of the highest densities of eastern elliptio and alewife floater encountered during the entire survey. This was expected, as the Bellows Falls Dam is only four miles upstream from the upper end of the Vernon impoundment, and because American shad, the primary host fish for alewife floater, shad, reach their upstream limit in the Connecticut River in the tailwaters of the Bellows Falls Dam. However, two alewife floater were also found in the Bellows Falls

impoundment, though these were likely either the result of overland transport of American shad (carrying alewife floater glochidia) above the Bellows Falls Dam by New Hampshire Fish & Game, or the small number of shad that ascended fishways that were designed for only adult Atlantic salmon.

Species richness in the Bellows Falls impoundment (7) was higher than it was in other impoundments or tailwaters, and the impoundment also contained dwarf wedgemussels. However, total counts of the rare species were quite low here. Although dwarf wedgemussels were found over a 17-mile distance, only very small numbers of animals were observed and the distances between them were great. The same was generally true for triangle floaters and creepers, two species that have similar habitat preferences and usually co-occur with dwarf wedgemussels. If these data accurately represent actual population densities, then the viability of these populations in the impoundment may be tenuous. The only two species that appear to be thriving in the Bellows Falls impoundment are eastern elliptio and eastern lampmussel.

The Bellows Falls impoundment also contains the only known tributary population of dwarf wedgemussels among the three project areas. This sub-population is located in the lower reaches of the Black River, where it was first documented in 1999 (Ferguson 1999). In addition, the highest concentration of creepers and triangle floaters in the Bellows Falls impoundment were found in the impounded section of the Black River.

The geography of the impoundment features two physically distinct reaches. Downstream of Wethersfield Bow, the river is wider, flow velocities are slower, the channel is deeper, and the substrate is generally finer (silt, sand, and fine gravel). Upstream of Wethersfield Bow, the dam's influence is less obvious and the river is slightly narrower, flow velocities are stronger, the channel is shallower, and there is a higher proportion of gravel, cobble, and boulder substrates. One habitat characteristic common throughout much of the impoundment was highly unstable and eroding riverbanks. These were prevalent along the edges of agricultural lands that lacked forested buffers (as expected), but also on steep wooded slopes where portions are failing and sliding into the river.

5.3 Wilder Hydroelectric Project

The mussel community downstream of the Wilder Dam exhibited low species richness (3) and low abundance compared to other survey areas. Strong flows, rocky substrates, and high shear stress may limit mussel densities downstream of this dam. The Wilder impoundment had the lowest species richness (5) of the three impoundments, lacking eastern floater and alewife floater, and nearly lacking creeper (just one animal was found). However, mussels were abundant in the impoundment overall—eastern elliptio was abundant throughout much of the impoundment and eastern lampmussel was numerous in the lower half of the impoundment, though the latter species became less abundant toward the impoundment's upper half. Triangle floater were found infrequently and at fairly low abundance throughout the impoundment.

Most importantly, dwarf wedgemussels were found consistently along 14 miles of the river in the Wilder impoundment, from 27-41 miles upstream of the dam. This range generally corresponds to the 16-mile range documented in 2006 (Nedeau 2006), the main difference being that animals were found slightly further downstream in 2006 than in 2011. Most of the 2011 survey sites were in slightly different locations than the 2006 survey sites, confirming an assertion in the 2006 report that dwarf wedgemussels could be found almost anywhere within the core range with careful SCUBA surveys.

The average CPUE for dwarf wedgemussels in the Wilder impoundment was more than three times higher than it was in the Bellows Falls impoundment. Dwarf wedgemussels were usually found at depths of 8-20 feet, often near the toe of the steep-sloped banks or toward the center of the river channel. Areas of the river where dwarf wedgemussels were found typically had light to moderate flow velocities, or at least featured zones of hydraulic refuge near shore, even where the flows in the middle of the channel were quite strong. All dwarf wedgemussels were found by SCUBA diving; snorkeling along the shallow shorelines proved to be ineffective for finding them.

Similar to the Bellows Falls impoundment, a habitat characteristic particularly common throughout the middle and upper Wilder impoundment was unstable and eroding riverbanks. This phenomenon was most acute along the edges of terraced agricultural lands that lacked forested buffers, but significant bank failures and landslides were also occurring even on wooded slopes. These types of active geomorphic processes were observed near almost every location where dwarf wedgemussels were found. These challenges are found throughout each of the impoundments and are common in riverine ecosystems located in geologic conditions similar the Connecticut River valley.

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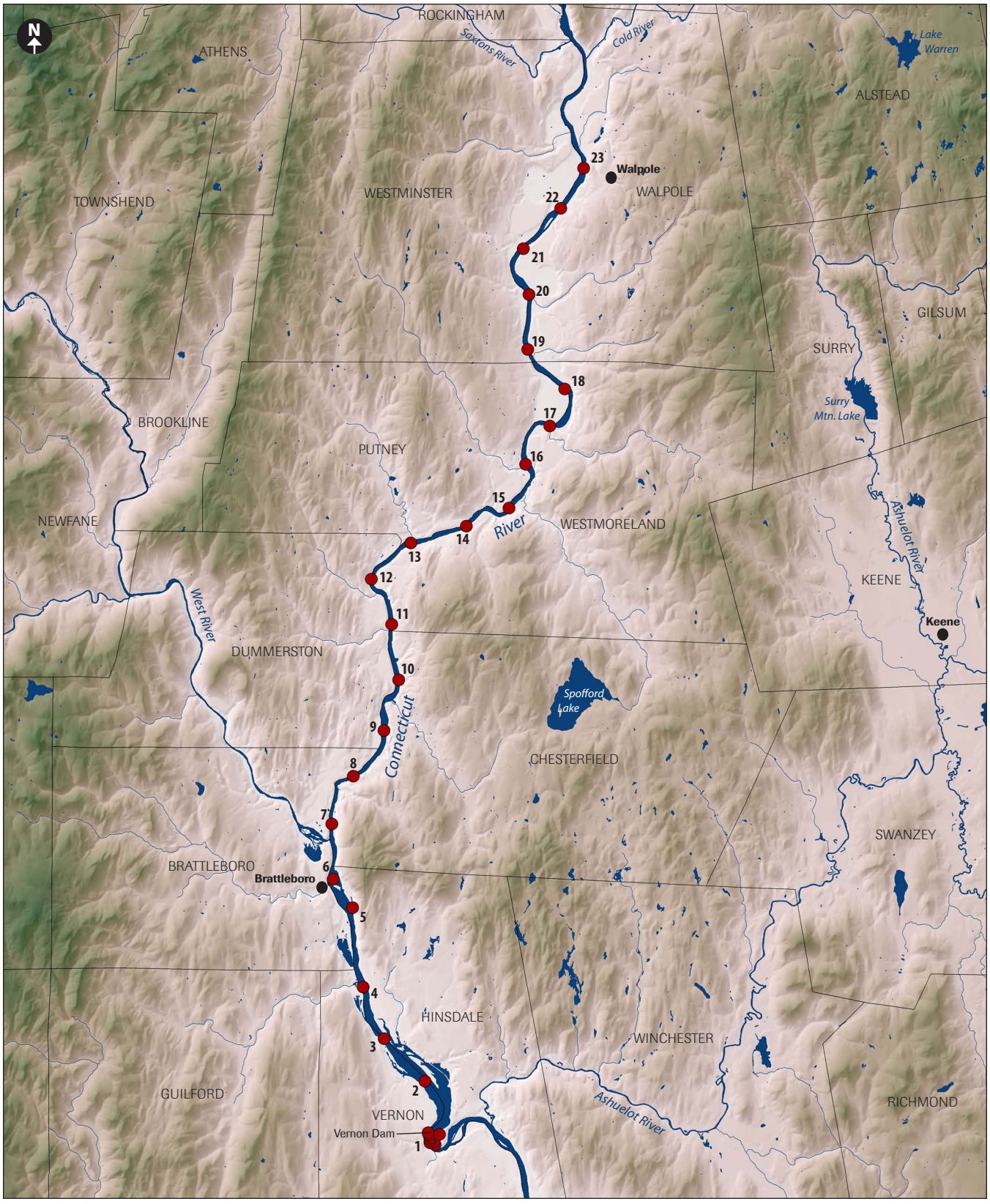
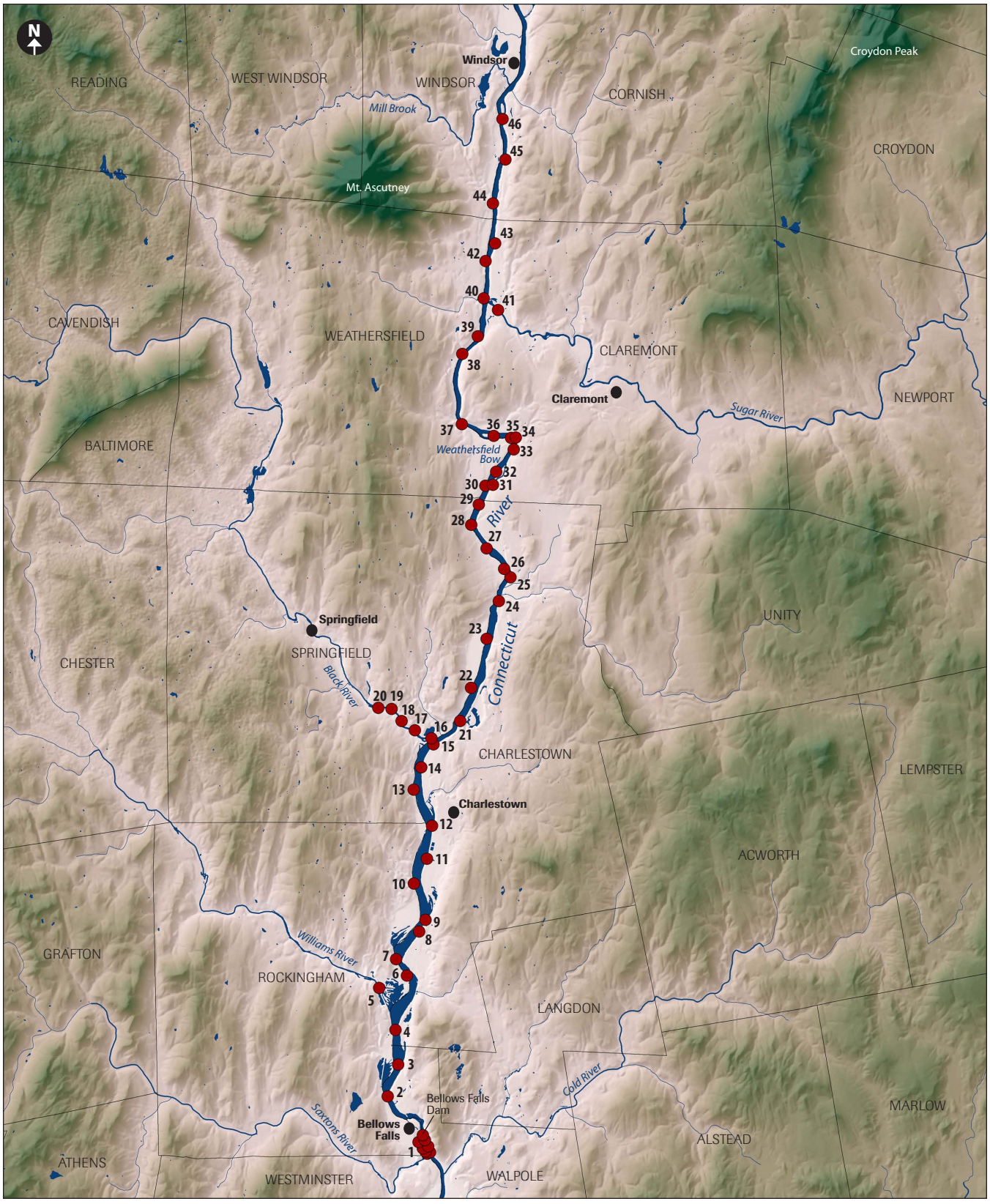
APPENDIX 1

Survey Sites in the Vernon Project Area



APPENDIX 2

Survey Sites in the Bellows Falls Project Area



APPENDIX 3

Survey Sites in the Wilder Project Area