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Freshwater Biological Traits Database

National Center for Environmental Assessment
Office of Research and Development

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Global Change Research Program
National Center for Environmental Assessment
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U.S. Environmental Protection Agency
Washington, DC 20460

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ABSTRACT

The Freshwater Biological Traits Database (http://www.epa.gov/ncea/global/traits) currently contains traits data for 3,857 North American macroinvertebrate taxa and includes habitat, life history, mobility, morphology, and ecological trait data. Species traits are the characteristics that explain an organisms' relationship to the surrounding environment, including how it grows, feeds and moves. The traits data were compiled for a project on climate change effects on river and stream ecosystems that was conducted by the Global Change Research Program in the National Center for Environmental Assessment in the U.S. EPA Office of Research and Development. The traits data were gathered from multiple sources. Data gathering efforts focused on data that were published or well-documented, available, appropriate for the regions being studied, in a standardized format that could be analyzed or easily converted to a format that could be analyzed, and ecologically relevant to the gradients being considered. The database has been posted online to facilitate further research. This is intended to be a 'living' database, and researchers are encouraged to contribute data and provide suggestions or feedback on how the database can be expanded and improved upon in the future.

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PREFACE

The report and database were prepared by Tetra Tech, Inc. and the Global Change Research Program (GCRP) in the National Center for Environmental Assessment (NCEA) of the Office of Research and Development at the U.S. Environmental Protection Agency (EPA). They are intended for resource managers and scientists working in freshwater ecosystems who are interested in species traits, biological indicators, bioassessment, biomonitoring, and climate change. The database is intended to be modified and augmented by scientists and resource managers with data and research results.

AUTHORS, CONTRIBUTORS, AND REVIEWERS

The Global Change Research Program, within the National Center for Environmental Assessment (NCEA), Office of Research and Development, is responsible for publishing this report and the database. The report and database were prepared by Tetra Tech, Inc. under Contract No. GS-10F-0268K, U.S. EPA Order No. 1107. Britta Bierwagen, PhD served as the Technical Project Officer, provided overall direction and technical assistance, and contributed as an author.

AUTHORS

Center for Ecological Sciences, Tetra Tech, Inc., Owings Mills, MD
Jen Stamp, MS, Anna Hamilton, MS, Liejun Wu, MS, Jeffrey White, MS

U.S. EPA
Britta G. Bierwagen, PhD

REVIEWERS

U.S. EPA Reviewers
Wayne Davis, MS (OEI), Lilian Herger, MS (R10), Rachael Novak, MS (OW/OST), Lester Yuan, PhD (ORD/NCEA, now OW/OST)

Other Reviewers
Daren Carlisle, PhD (USGS), M. Siobhan Fennessy, PhD (Kenyon College), Eric P. Smith, PhD (Virginia Polytechnic Institute and State University), R. Jan Stevenson, PhD (Michigan State University), N. Scott Urquhart, PhD (Statistical Consultant)

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1. INTRODUCTION

The Freshwater Biological Traits Database (http://www.epa.gov/ncea/global/traits) was compiled as part of a project conducted by the Global Change Research Program (GCRP) in the National Center for Environmental Assessment in the U.S. Environmental Protection Agency (EPA) Office of Research and Development on climate change effects on river and stream ecosystems (U.S. EPA, 2011). For this project, long-term trend analyses were performed on biomonitoring data from Maine, North Carolina, Ohio, and Utah to examine whether biological responses to changes in temperature and hydrology could be detected. One component of these analyses involved compiling and analyzing traits data for North American macroinvertebrate taxa found in lotic systems. Species traits are the characteristics that explain an organisms' relationship to the surrounding environment, including growth, feeding habits and dispersal. Advantages of using traits data for these types of analyses are that they are less susceptible to taxonomic ambiguities or inconsistencies in long-term data sets; they can detect changes in functional community characteristics; and they vary less across geographical areas, which allows for larger-scale trend analyses across regional species pools. Because it took substantial effort to gather the traits data into one place, and because we would like to save other researchers from having to undergo similar efforts, we have integrated the traits data that were gathered for this project into one database and have made it available online.

2. METHODS

Data gathering efforts focused on data that were published or well-documented, available, appropriate for the regions being studied, in a standardized format that could be analyzed or easily converted to a format that could be analyzed, and ecologically relevant to the gradients being considered. The data search revealed that traits data compilations in North America have been at smaller scales and are less comprehensive than the European efforts (i.e., Euro-limpacs Consortium: www.freshwaterecology.info—The Taxa and Autecology Database for Freshwater Organisms), but nevertheless show promise. In 2006, the U.S. Geological Survey (USGS) published a database of lotic invertebrate traits for North America (Vieira et al., 2006). This database represented the first comprehensive summary of traits for North American invertebrate taxa and the first effort to compile this traits information in a Web-based database.

The traits information was gathered from over 3,000 keys, texts, peer-reviewed publications, and reports on North American aquatic invertebrates.

Another important source of traits information for North American lotic insect taxa is the Traits Matrix that was published in Poff et al. (2006). The Traits Matrix provides information on 20 traits (in 59 trait states) that span four broad categories of trait groups (life history, morphological, mobility, and ecological) for 311 taxa from 75 families. The traits information in the Traits Matrix was cross-referenced with the USGS (i.e., Vieira et al., 2006) traits database described above. An older series of publications was also included in the traits database: the EPA series on environmental requirements and pollution tolerance of Ephemeroptera, Plecoptera, Trichoptera, and Common Freshwater Chironomidae (Surdick et al., 1978; Beck et al., 1977; Harris et al., 1978; Hubbard et al., 1978). Traits information in these publications was compiled from general literature searches. The database created for this project contains information on 362 Plecoptera taxa, 240 Trichoptera taxa, 218 Chironomidae taxa, and 396 Ephemeroptera taxa from this older series of EPA publications.

Also included in the database are thermal optima and tolerance data that were generated from weighted average or generalized linear model calculations that were performed on biomonitoring data from Maine, North Carolina, Ohio, and Utah (U.S. EPA, 2011), as well as from Oregon (Yuan, 2006), Idaho (Brandt, 2001), and the Lahontan/Sierra Nevada region of California (Herbst and Silldorff, 2007). Weighted-average inference is a simple, robust approach for estimating the central tendencies of different taxa, for example, optima and tolerance values (i.e., ter Braak and Looman, 1986). For the climate change pilot study analyses in Maine, North Carolina, and Utah, the guidelines of Yuan (2006) were used to calculate optima values based on instantaneous water-temperature measurements and occurrences of organisms. Optima values for Maine and Utah were derived from weighted-average inferences. The lists for Utah were supplemented with weighted-average inferences derived from data sets from Idaho (i.e., Brandt, 2001) and Oregon (i.e., Yuan, 2006). Maximum-likelihood inferences were used in North Carolina because North Carolina Department of Environment and Natural Resources abundance data are categorical (1 = rare: 1–2 species; 3 = common: 3–9 species; 10 = abundant: ≥10 species). To improve model performance, optima values were calculated only for taxa occurring in >9 sites or samples.

These tolerance data were used to derive lists of cold- and warm-water-preference taxa in Maine, North Carolina, and Utah. Because the methods used to derive the thermal optima values and the specific characteristics of the data sets (e.g., range of collection dates, station locations, elevation) varied, an arbitrary ranking scheme was developed to make results more comparable across data sets. Taxa in each state were assigned rankings ranging from 1 to 7 based on percentiles within each data set. Initially, taxa with rankings ≤3 (<40th percentile) were designated as cold-water taxa and taxa with rankings ≥5 (>60th percentile) as warm-water taxa. Thermal optima values were not available for all taxa, so literature—primarily the traits matrix in Poff et al. (2006) and the USGS traits database (Vieira et al., 2006)—were used as a basis for making some additional initial designations.

After making initial cold- and warm-water designations, the lists in each state were refined based on case studies and best professional judgment from regional advisory groups. Thermal tolerance values, which were calculated using the methods described above (i.e., Yuan, 2006), were also taken into consideration. We thought these additional considerations were necessary because some taxa occurred with greater frequency in warm- or cold-water habitats but were not present exclusively in one or the other. For example, some taxa initially designated as cold-water taxa also were present at sites that had the hottest recorded water temperatures. During the refinement process, these taxa were removed from the cold-water list. In some cases, taxa were removed from the lists because regional taxonomists did not think that the literature-based designations were appropriate for their region. The cold-water-preference lists in Maine, North Carolina, and Utah consisted of 39, 32, and 33 taxa, respectively. The warm-water-preference lists in Maine, North Carolina, and Utah consisted of 40, 27, and 16 taxa, respectively. Lists of the cold and warm water taxa can be found in Appendix A. The relatively low number of taxa on the Utah warm-water-preference list was partially a consequence of the need to use a family-level operational taxonomic unit (OTU) for Chironomidae because of inconsistencies in the long-term data set that arose from a change in taxonomic laboratories.

These lists of cold- and warm-water taxa are included in region-specific traits tables that were compiled for the Maine, North Carolina, and Utah climate change pilot study analyses (U.S. EPA, 2011). Also included in these tables are information on traits related to life-cycle features (i.e., life-cycle duration, reproductive cycles per year, aquatic stages), resilience or resistance potentials (i.e., dispersal, locomotion, resistance forms), physiology and morphology (i.e., respiration, maximum size), and reproduction and feeding behavior (i.e., reproduction, food, and feeding habits). Table 1 contains a list of the traits that were included the climate

Table 1. Summary of the traits and trait states in the Maine, North Carolina, and Utah climate change traits tables (modified from Poff et al., 2006)

Trait Category	Trait	Trait States
Life history	Voltinism	Semivoltine (<1 generation/yr), univoltine (1 generation/yr), bi- or multivoltine (>1 generation/yr)
	Development	Fast seasonal, slow seasonal, nonseasonal
	Synchronization of emergence	Poorly synchronized (wk), well synchronized (d)
	Adult life span	Very short (<1 wk), short (<1 mo), long (>1 mo)
	Adult ability to exit	Absent (not including emergence), present
	Ability to survive desiccation	Absent, present
Mobility	Dispersal (adult)	Low (<1 km flight before laying eggs), high (>1 km flight before laying eggs)
	Adult flying strength	Weak (e.g., cannot fly into light breeze), strong
	Occurrence in drift	Rare (catastrophic only), common (typically observed), abundant (dominant in drift samples)
	Maximum crawling rate	Very low (<10 cm/h), low (<100 cm/h), high (>100 cm/h)
	Swimming ability	None, weak, strong
Morphology	Attachment	None (free-ranging), some (sessile, sedentary)
	Armoring	None (soft-bodied forms), poor (heavily or partly sclerotized), good (i.e., some cased caddisflies, hard-shelled organisms)
	Shape	Streamlined (flat, fusiform), not streamlined (cylindrical, round or bluff)
	Respiration	Tegument, gills, plastron or spiracle (aerial)
	Size at maturity	Small (<9 mm), medium (9–16 mm), large (>16 mm)
Resource acquisition/preference	Rheophily	Depositional, depositional and erosional, erosional
	Habit (primary)	Burrower, climber, sprawler, swimmer, clinger, diver, skater
	Functional feeding group (primary)	Collector-filterer, collector-gatherer, predator, shredder, scraper, piercer, herbivore, parasite

Table 1. continued…

Trait Category	Trait	Trait States
Temperature	Temperature optimum	Numeric value derived from weighted average calculation
	Temperature tolerance	Numeric value derived from weighted average calculation
	Rank of temperature optimum	Scores range from 1 (lowest optima values) to 7 (highest optima values), based on percentile of optimum value
	Rank of temperature tolerance	Scores range from 1 (narrowest tolerance ranges) to 7 (widest temperature ranges), based on percentile of tolerance value
	Rank of temperature optimum-tolerance	Combination of the optimum and tolerance ranks. Values range from 1−1 to 7−7
	Temperature indicator	Cold or warm. Designations were made by Jen Stamp of Tetra Tech, Inc., based on weighted average or maximum likelihood calculations, literature, best professional judgment, and case studies
Enrichment tolerance	Tolerance	Values range from 0 (most intolerant) to 10 (most tolerant)

change traits tables, which were modeled after the Poff et al. (2006) Traits Matrix. These traits were selected for their relevance to the climate change pilot studies, which focused on biological responses to changes in temperature and hydrology.

Data from multiple sources were incorporated into the Maine, North Carolina, and Utah climate change traits tables. Main sources were the USGS traits database (Vieira et al., 2006) and the Poff et al. trait matrix (2006), which were available in an electronic format and were imported directly into the database. The EPA's 1970s publications had to be hand-entered. Quality assurance procedures were performed on 10% of these entries, and the data entry error rate was less than 5%. To maintain consistency and standardization across the multiple data sources, data integration rules were developed. These rules are described in detail in the 'Data Integration Rules' documents (see Appendix B). Efforts were also made to identify gaps in each traits data set. Results of these 'traits gap' analyses can be found in the 'Traits Gap Analysis' documents (see Appendix C).

Although species-level data were available in each of the state databases, genus-level or higher OTUs were used in the Maine, North Carolina, and Utah climate change traits tables. This was due to taxonomic ambiguities in the long-term data that had resulted from factors such as changes in taxonomic keys and changes in taxonomic labs. Previous research has shown that traits analyses utilizing genus and family levels have been successful at characterizing aquatic communities for bioassessment purposes (i.e., Vieira et al. [2006] cites Dolédec et al. [1998, 2000] and Gayraud et al. [2003]) and that congeneric species typically have similar functional trait niches (Poff et al., 2006). Species-level identification is typically not necessary for traits-based analytical approaches used in biomonitoring programs, is more costly and error prone, and may result in taxonomic ambiguities because individuals are not identifiable to the same taxonomic level (Vieira et al. [2006] who also cites Moulton et al. [2000]).

3. RESULTS

The Freshwater Biological Traits Database is available online at http://www.epa.gov/ncea/global/traits. The database currently has 11,912 unique records for 3,857 different taxa and includes location, habitat, life history, mobility, morphology, and ecological traits data, along with tolerance calculations for temperature and flow. A list of traits and metadata can be found in Appendix D. Levels of taxonomic resolution vary, as do data types (i.e., binary, categorical, text notes entries). Instructions on how to conduct data searches can be found in Appendix E.

Listed below are brief descriptions of the 14 data sources that have been integrated into the database at this time. These data sources are available for download online on the Data Source page.

- **Vieira et al., 2006**

  Description: In 2006, the U.S. Geological Survey (USGS) published a database of lotic invertebrate traits for North America. This was a collaborative effort between the USGS National Water-Quality Assessment Program and Colorado State University. This database represented the first comprehensive summary of traits for North American invertebrate taxa and the first effort to compile this traits information in a Web-based database. The traits information was gathered from over 3,000 keys, texts, peer-reviewed publications, and reports on North American aquatic invertebrates. Traits were grouped into four general categories: ecology, morphology, behavior, or physiology. Trait states were established based on the types of information available in the literature and were expressed in categorical, binary, and quantitative terms. The traits could be mutually exclusive (only one or the other) or co-occurring (more than one trait state is appropriate and is, therefore, listed). Species-level resolution was used, but the focus and quality assurance efforts were concentrated on genus and family-level trait summaries.

- **Poff et al., 2006**

  Description: The Traits Matrix in the Appendix of this journal article provides information on 2 traits (in 59 trait states) that span four broad categories of trait groups (i.e., life history, morphological, mobility, and ecological) for 311 taxa from 75 families. Each trait has anywhere from 2 to 6 trait states. Each taxonomic unit is assigned to only one trait state (based on literature information and expert opinion). The traits information in the Traits Matrix was cross-referenced with the USGS (i.e., Vieira et al., 2006) traits database. This database is in a format that can be readily analyzed.

- **U.S. EPA, 2011**

  Description: These tables were compiled for the Maine, North Carolina, and Utah climate change pilot study analyses. The focus of these analyses was to look for biological responses to changes in temperature and hydrology. Data from multiple sources are incorporated into these data sets. Main sources include the USGS traits database (2006) and the Poff et al. trait matrix (2006).

- **Rankin and Yoder, 2009**

  Description: This report was prepared by the Midwest Biodiversity Institute for the USEPA GCRP Climate Change Pilot Project (U.S. EPA, 2011). Appendix Table 2 of the report contains thermal optima and current optima data (referred to as Weighted Stressor Values [WSVs] in this document) for macroinvertebrates in headwater and wadeable streams and were calculated using Ohio EPA data. In addition to weighted average values, general tolerance and functional feeding group assignments specific to Ohio were included in the database entries. Fish data are also available in Appendix Table 2 but have not yet been incorporated into the Freshwater Biological Traits Database.

- **Brandt, 2001**

  Description: Thermal optima and tolerance data for were obtained from Idaho Department of Environmental Quality (DEQ). Data were derived from Idaho DEQ bioassessment program samples collected from water bodies throughout Idaho. Included in this report is a list of cold water obligate taxa, which are based on Idaho's water quality criterion for cold water taxa (which is not to exceed a daily average stream temperature of 19ºC).

- **Herbst and Silldorff, 2007**

  Description: Thermal optima data for 99 taxa were provided by David Herbst and Erik Silldorff of the Sierra Nevada Aquatic Research Laboratory—University of California (see pages 9−11 of report). Data were derived from summer sampling events in the eastern Sierra Nevadas. Taxa were designated as 'thermal sensitive' if the optima values were ≤13ºC and 'thermal tolerant' if the optima values were ≥17ºC.

- **Huff et al., 2008**

  Description: Thermal optima and tolerance data for 234 taxa were provided by Shannon Hubler of Oregon DEQ. These data were derived from Oregon DEQ data from a wide range of wadeable stream types and span all of the major ecoregions in Oregon.

- **Yuan, 2006**

  Description: Thermal optima values from Table C-1 in Appendix C of this report were entered into the database. These data were derived from EMAP-West samples that were collected in 2000-2001.

- **EPA 1970s series on environmental requirements and pollution tolerance of aquatic macroinvertebrates**

  Description: Traits information for this series was compiled from general literature searches (it does not include exhaustive surveys of the literature, only major sources). Data are grouped into broad categories such as general habitat, specific habitat, turbidity, current, temperature, pH, dissolved oxygen, seasonal distribution, timing of emergence, and geographical distribution (by EPA region). Each page has a species profile that summarizes the range of environmental conditions under which the species has been found (values and ranges reflect the experimental and observational bias of each study), along with the sources from which the information was gathered. These publications were intended to provide a baseline to which further information could be added as further research was conducted and more information became available. Some might consider the information in these publications to be outdated. However, there have been very few comprehensive efforts to gather this information (especially that compile and publish it in one place and in a consistent format), and the comprehensive bibliographies and documentation are very valuable. Electronic copies of this publication are not available, and hard copies are difficult and expensive to obtain. To obtain lists of citations for the primary literature that was reviewed for these publications, one needs to reference the hard copies. This series is composed of four publications:

- **Beck, 1977**

  Description: Information on 216 Chironomidae taxa was taken from this publication and included in the online database.

- **Harris and Lawrence, 1978**

  Description: Information on 240 Trichoptera taxa was taken from this publication and included in the online database.

- **Hubbard and Peters, 1978**

  Description: Information on 396 Ephemeroptera taxa was taken from this publication and included in the online database.

- **Surdick and Gaufin, 1978**

  Description: Information on 362 Plecoptera taxa was taken from this publication and included in the online database.

4. FUTURE DIRECTIONS

Currently, there are no plans to further develop this database, although there are several possible directions. Next steps could include adding fish and periphyton data, along with more functionality (e.g., new queries, automated import function, interactive map). The automated import function in particular is important because in order for this database to reach its full potential, researchers will need to actively contribute to it. Further development of this database would also benefit from collaborations with other agencies, institutions, and researchers, domestically and internationally, interested in freshwater species traits.

APPENDIX A

List of Cold- and Warm-Water Preference Taxa

This appendix contains the lists of taxa that were included in the cold- and warm-water preference trait groups in Utah, Maine, and North Carolina. Lists have been sorted first by state, then by taxon. These lists were developed using thermal optima and tolerance values specific to each state and/or region, literature, case studies, and best professional judgment (BPJ) from regional advisory groups. These lists are meant as a first step—not a final product. They should be further refined as more data become available. These lists have been developed for particular regions, but there is some overlap (e.g., some taxa occur on the cold-water list in more than one state).

Table A-1. Metadata

State	State that the list was developed for (ME = Maine, NC = North Carolina, UT = Utah)
Order	Taxonomic level
Taxon	Highest level of taxonomic resolution
Percentage Abundance	Percentage of total individuals in the state database composed of that taxon
Percentage Stations	Percentage of stations at which the taxon has been documented to occur
Source	Source of data

Table A-2. Maine—cold-water list

Order	Taxon	% Abundance	% Stations	Source Type	Source Citation
Coleoptera	Oulimnius	0.0	4.4	Literature	Vieira et al., 2006
Diptera	Heterotrissocladius	0.1	8.6	Empirical—Maine	U.S. EPA, 2011
Diptera	Larsia	0.1	6.8	Empirical—Maine	U.S. EPA, 2011
Diptera	Macropelopia	0.1	5.1	Empirical—Maine	U.S. EPA, 2011
Diptera	Natarsia	0.1	7.7	Empirical—Maine	U.S. EPA, 2011
Diptera	Pagastia	0.1	11.3	Empirical—Maine	U.S. EPA, 2011
Diptera	Prodiamesa	0.1	3.3	Empirical—Maine	U.S. EPA, 2011
Diptera	Pseudodiamesa	0.0	1.4	Literature	Beck, 1977
Ephemeroptera	Ameletus	0.0	3.1	Literature	Poff et al., 2006
Ephemeroptera	Epeorus	0.4	20.3	Empirical—Maine	U.S. EPA, 2011
Ephemeroptera	Eurylophella	0.3	20.0	Empirical—Maine	U.S. EPA, 2011
Ephemeroptera	Rhithrogena	0.0	2.7	Literature	Poff et al., 2006
Megaloptera	Nigronia	0.1	20.0	Empirical—Maine	U.S. EPA, 2011
Odonata	Boyeria	0.3	37.8	Empirical—Maine	U.S. EPA, 2011
Odonata	Lanthus	0.0	1.3	Literature	Poff et al., 2006
Plecoptera	Capnia	0.0	0.6	Literature	Poff et al., 2006
Plecoptera	Leuctra	0.4	16.7	Empirical—Maine	U.S. EPA, 2011
Plecoptera	Nemoura	0.0	0.5	Literature	Poff et al., 2006
Plecoptera	Paracapnia	0.0	2.0	Literature	Poff et al., 2006
Plecoptera	Paranemoura	0.0	0.4	Literature	Poff et al., 2006
Plecoptera	Peltoperla	0.0	0.5	Literature	Surdick & Gaufin, 1978
Plecoptera	Perlodidae	0.3	25.0	Empirical—Maine	U.S. EPA, 2011
Plecoptera	Prostoia	0.0	0.1	Literature	Poff et al., 2006
Plecoptera	Pteronarcys	0.0	9.4	Empirical—Maine	U.S. EPA, 2011
Plecoptera	Sweltsa	0.1	7.8	Empirical—Maine	U.S. EPA, 2011
Plecoptera	Tallaperla	0.0	1.4	BPJ Regional Workgroup	2008-2011
Plecoptera	Utacapnia	0.0	0.4	Literature	Poff et al., 2006
Plecoptera	Utaperla	0.0	0.2	Literature	Poff et al., 2006
Plecoptera	Zapada	0.0	0.1	Literature	Poff et al., 2006
Trichoptera	Apatania	0.0	2.7	Literature	Poff et al., 2006
Trichoptera	Diplectrona	0.2	5.5	Empirical—Maine	U.S. EPA, 2011
Trichoptera	Glossosoma	0.2	14.0	Empirical—Maine	U.S. EPA, 2011
Trichoptera	Hydatophylax	0.0	5.8	Empirical—Maine	U.S. EPA, 2011
Trichoptera	Limnephilus	0.2	7.3	Empirical—Maine	U.S. EPA, 2011
Trichoptera	Micrasema	0.1	10.3	Empirical—Maine	U.S. EPA, 2011
Trichoptera	Oligostomis	0.1	10.3	Empirical—Maine	U.S. EPA, 2011
Trichoptera	Palaeagapetus	0.0	0.1	Literature	Harris & Lawrence, 1978
Trichoptera	Parapsyche	0.1	3.2	Empirical—Maine	U.S. EPA, 2011
Trichoptera	Psychoglypha	0.1	4.4	Empirical—Maine	U.S. EPA, 2011

Table A-3. Maine—warm-water list

Order	Taxon	% Abundance	% Stations	Source Type	Source Citation
Arhynchobdellida	Erpobdella	0.0	7.7	Empirical—Maine	U.S. EPA, 2011
Basommatophora	Ferrissia	0.1	12.0	Empirical—Maine	U.S. EPA, 2011
Basommatophora	Helisoma	0.1	7.8	Empirical—Maine	U.S. EPA, 2011
Basommatophora	Physa	0.2	13.6	Empirical—Maine	U.S. EPA, 2011
Basommatophora	Physella	0.3	18.3	Empirical—Maine	U.S. EPA, 2011
Coleoptera	Stenelmis	0.4	33.0	Empirical—Maine	U.S. EPA, 2011
Decapoda	Orconectes	0.1	11.7	Empirical—Maine	U.S. EPA, 2011
Diptera	Cardiocladius	0.0	6.1	Empirical—Maine	U.S. EPA, 2011
Diptera	Dicrotendipes	0.3	19.9	Empirical—Maine	U.S. EPA, 2011
Diptera	Hemerodromia	0.3	30.6	Empirical—Maine	U.S. EPA, 2011
Diptera	Labrundinia	0.1	16.1	Empirical—Maine	U.S. EPA, 2011
Diptera	Nilotanypus	0.1	15.7	Empirical—Maine	U.S. EPA, 2011
Diptera	Parachironomus	0.2	9.8	Empirical—Maine	U.S. EPA, 2011
Diptera	Pentaneura	0.2	16.4	Empirical—Maine	U.S. EPA, 2011
Diptera	Psectrocladius	0.3	19.0	Empirical—Maine	U.S. EPA, 2011
Diptera	Rheopelopia	0.1	17.0	Empirical—Maine	U.S. EPA, 2011
Diptera	Tribelos	0.3	9.2	Empirical—Maine	U.S. EPA, 2011
Ephemeroptera	Caenis	0.3	19.9	Empirical—Maine	U.S. EPA, 2011
Ephemeroptera	Isonychia	0.9	26.5	Empirical—Maine	U.S. EPA, 2011
Ephemeroptera	Leucrocuta	0.6	24.5	Empirical—Maine	U.S. EPA, 2011
Ephemeroptera	Plauditus	0.2	14.7	Empirical—Maine	U.S. EPA, 2011
Ephemeroptera	Pseudocloeon	0.2	13.3	Empirical—Maine	U.S. EPA, 2011
Ephemeroptera	Serratella	0.4	22.5	Empirical—Maine	U.S. EPA, 2011
Ephemeroptera	Stenacron	1.1	23.1	Empirical—Maine	U.S. EPA, 2011
Ephemeroptera	Stenonema	5.2	63.1	Empirical—Maine	U.S. EPA, 2011
Ephemeroptera	Tricorythodes	0.5	24.2	Empirical—Maine	U.S. EPA, 2011
Hoplonemertea	Prostoma	0.0	7.2	Empirical—Maine	U.S. EPA, 2011
Hydroida	Hydra	0.1	13.3	Empirical—Maine	U.S. EPA, 2011
Neotaenioglossa	Amnicola	0.8	18.9	Empirical—Maine	U.S. EPA, 2011
Odonata	Argia	0.2	16.1	Empirical—Maine	U.S. EPA, 2011
Plecoptera	Acroneuria	0.8	39.0	Empirical—Maine	U.S. EPA, 2011
Plecoptera	Attaneuria	0.0	4.2	Literature	Poff et al., 2006
Plecoptera	Paragnetina	0.1	12.1	Empirical—Maine	U.S. EPA, 2011
Trichoptera	Ceraclea	0.2	17.9	Empirical—Maine	U.S. EPA, 2011
Trichoptera	Helicopsyche	0.4	12.3	Empirical—Maine	U.S. EPA, 2011
Trichoptera	Hydroptila	0.3	22.3	Empirical—Maine	U.S. EPA, 2011
Trichoptera	Macrostemum	0.8	19.8	Empirical—Maine	U.S. EPA, 2011
Trichoptera	Neureclipsis	2.6	37.7	Empirical—Maine	U.S. EPA, 2011
Trichoptera	Oecetis	0.6	36.0	Empirical—Maine	U.S. EPA, 2011
Tubificida	Chaetogaster	0.1	8.2	Empirical—Maine	U.S. EPA, 2011

Table A-4. North Carolina—cold-water list

Order	Taxon	% Abundance	% Stations	Source Type	Source Citation
Coleoptera	Promoresia	0.4	11.8	Empirical—North Carolina	U.S. EPA, 2011
Diptera	Antocha	0.6	25.3	Empirical—North Carolina	U.S. EPA, 2011
Diptera	Atherix	0.2	8.5	Empirical—North Carolina	U.S. EPA, 2011
Diptera	Cardiocladius	0.3	13.4	Empirical—North Carolina	U.S. EPA, 2011
Diptera	Diamesa	0.1	6.6	Empirical—North Carolina	U.S. EPA, 2011
Diptera	Dicranota	0.2	10.1	Empirical—North Carolina	U.S. EPA, 2011
Diptera	Eukiefferiella	0.4	19.0	Empirical—North Carolina	U.S. EPA, 2011
Diptera	Heleniella	0.0	1.8	Empirical—North Carolina	U.S. EPA, 2011
Diptera	Pagastia	0.1	5.6	Empirical—North Carolina	U.S. EPA, 2011
Diptera	Potthastia	0.1	10.4	Empirical—North Carolina	U.S. EPA, 2011
Diptera	Rheopelopia	0.0	2.3	Empirical—North Carolina	U.S. EPA, 2011
Ephemeroptera	Acentrella	0.3	15.2	Empirical—North Carolina	U.S. EPA, 2011
Ephemeroptera	Cinygmula	0.0	1.4	Literature	Poff et al., 2006
Ephemeroptera	Drunella	0.3	7.8	Empirical—North Carolina	U.S. EPA, 2011
Ephemeroptera	Epeorus	0.6	14.3	Empirical—North Carolina	U.S. EPA, 2011
Ephemeroptera	Nixe	0.0	0.6	Empirical—North Carolina	U.S. EPA, 2011
Ephemeroptera	Rhithrogena	0.1	5.4	Empirical—North Carolina	U.S. EPA, 2011
Odonata	Lanthus	0.1	10.7	Empirical—North Carolina	U.S. EPA, 2011
Plecoptera	Amphinemura	0.1	10.0	Empirical—North Carolina	U.S. EPA, 2011
Plecoptera	Clioperla	0.1	5.5	Literature	Poff et al., 2006
Plecoptera	Cultus	0.0	2.5	Literature	Poff et al., 2006
Plecoptera	Diploperla	0.1	4.3	Literature	Poff et al., 2006
Plecoptera	Isoperla	0.5	17.7	Empirical—North Carolina	U.S. EPA, 2011
Plecoptera	Malirekus	0.1	4.7	Literature	Poff et al., 2006
Plecoptera	Tallaperla	0.4	13.4	Empirical—North Carolina	U.S. EPA, 2011
Plecoptera	Zapada	0.0	0.1	Literature	Poff et al., 2006
Trichoptera	Agapetus	0.0	1.9	Literature	Poff et al., 2006
Trichoptera	Apatania	0.0	1.7	Literature	Poff et al., 2006
Trichoptera	Arctopsyche	0.0	1.4	Literature	Poff et al., 2006
Trichoptera	Dolophilodes	0.4	11.2	Empirical—North Carolina	U.S. EPA, 2011
Trichoptera	Glossosoma	0.2	11.0	Empirical—North Carolina	U.S. EPA, 2011
Trichoptera	Parapsyche	0.0	1.9	Empirical—North Carolina	U.S. EPA, 2011

Table A-5. North Carolina—warm-water list

Order	Taxon	% Abundance	% Stations	Source Type	Source Citation
	Erpobdella/Mooreobdella	0.1	7.5	Empirical—NC	U.S. EPA, 2011
Basommatophora	Physella	0.8	30.4	Empirical—NC	U.S. EPA, 2011
Coleoptera	Berosus	0.2	9.9	Empirical—NC	U.S. EPA, 2011
Coleoptera	Lioporeus	0.0	3.0	Empirical—NC	U.S. EPA, 2011
Decapoda	Palaemonetes	0.3	9.6	Empirical—NC	U.S. EPA, 2011
Diptera	Nilothauma	0.0	4.4	Empirical—NC	U.S. EPA, 2011
Diptera	Parachironomus	0.1	4.6	Empirical—NC	U.S. EPA, 2011
Diptera	Pentaneura	0.1	5.5	Empirical—NC	U.S. EPA, 2011
Diptera	Procladius	0.4	25.1	Empirical—NC	U.S. EPA, 2011
Diptera	Stenochironomus	0.4	26.7	Empirical—NC	U.S. EPA, 2011
Ephemeroptera	Tricorythodes	0.6	12.9	Empirical—NC	U.S. EPA, 2011
Hemiptera	Belostoma	0.0	3.5	Empirical—NC	U.S. EPA, 2011
Isopoda	Caecidotea	0.4	19.4	Empirical—NC	U.S. EPA, 2011
Odonata	Epicordulia	0.0	2.8	Empirical—NC	U.S. EPA, 2011
Odonata	Helocordulia	0.0	3.4	Empirical—NC	U.S. EPA, 2011
Odonata	Hetaerina	0.1	5.4	Empirical—NC	U.S. EPA, 2011
Odonata	Ischnura	0.0	3.6	Empirical—NC	U.S. EPA, 2011
Odonata	Macromia	0.6	28.9	Empirical—NC	U.S. EPA, 2011
Odonata	Neurocordulia	0.2	9.9	Empirical—NC	U.S. EPA, 2011
Odonata	Tetragoneuria	0.1	7.2	Empirical—NC	U.S. EPA, 2011
Rhynchobdellida	Helobdella	0.1	8.0	Empirical—NC	U.S. EPA, 2011
Rhynchobdellida	Placobdella	0.1	12.1	Empirical—NC	U.S. EPA, 2011
Trichoptera	Chimarra	0.6	19.7	Empirical—NC	U.S. EPA, 2011
Trichoptera	Macrostemum	0.2	4.8	Empirical—NC	U.S. EPA, 2011
Trichoptera	Neureclipsis	0.3	8.6	Empirical—NC	U.S. EPA, 2011
Trichoptera	Phylocentropus	0.1	7.2	Empirical—NC	U.S. EPA, 2011
Unionoida	Elliptio	0.2	6.7	Empirical—NC	U.S. EPA, 2011

Table A-6. Utah—cold-water list

Order	Taxon	% Abundance	% Stations	Source Type	Source Citation
	Nematoda	0.3	39.2	Empirical—Utah	U.S. EPA, 2011
Coleoptera	Heterlimnius	0.0	7.9	Empirical—Utah	U.S. EPA, 2011
Diptera	Bezzia	0.2	36.5	Empirical—Utah	U.S. EPA, 2011
Diptera	Bibiocephala	0.0	2.4	Empirical—Utah	U.S. EPA, 2011
Diptera	Chelifera	0.2	41.1	Empirical—Utah	U.S. EPA, 2011
Diptera	Dicranota	0.1	34.7	Empirical—Utah	U.S. EPA, 2011
Diptera	Oreogeton	0.0	2.1	Empirical—Idaho	Brandt, 2001
Diptera	Pericoma	0.3	33.1	Empirical—Utah	U.S. EPA, 2011
Diptera	Rhabdomastix	0.0	0.2	Empirical—Idaho	Brandt, 2001
Diptera	Wiedemannia	0.0	2.1	Empirical—Idaho	Brandt, 2001
Ephemeroptera	Ameletus	0.0	21.6	Empirical—Utah	U.S. EPA, 2011
Ephemeroptera	Cinygma	0.0	0.9	Empirical—Oregon	Yuan, 2006
Ephemeroptera	Cinygmula	1.0	43.8	Empirical—Utah	U.S. EPA, 2011
Ephemeroptera	Ephemerella	1.9	46.0	Empirical—Utah	U.S. EPA, 2011
Ephemeroptera	Ironodes	0.0	0.9	Empirical—Oregon	Yuan, 2006
Ephemeroptera	Rhithrogena	0.4	38.3	Empirical—Utah	U.S. EPA, 2011
Plecoptera	Capniidae	0.2	35.9	Empirical—Utah	U.S. EPA, 2011
Plecoptera	Chloroperlidae	0.4	48.7	Empirical—Utah	U.S. EPA, 2011
Plecoptera	Cultus	0.0	15.3	Empirical—Utah	U.S. EPA, 2011
Plecoptera	Glutops	0.0	0.6	Empirical—Idaho	Brandt, 2001
Plecoptera	Kogotus	0.0	2.2	Empirical—Idaho	Brandt, 2001
Plecoptera	Leuctridae	0.1	16.7	Empirical—Utah	U.S. EPA, 2011
Plecoptera	Megarcys	0.0	10.2	Empirical—Utah	U.S. EPA, 2011
Plecoptera	Taenionema	0.2	13.7	Empirical—Utah	U.S. EPA, 2011
Plecoptera	Visoka	0.0	0.2	Empirical—Oregon	Yuan, 2006
Plecoptera	Yoraperla	0.0	0.8	Empirical—Idaho	Brandt, 2001
Trichoptera	Anagapetus	0.0	0.3	Empirical—Idaho	Brandt, 2001
Trichoptera	Apatania	0.0	6.1	Empirical—Utah	U.S. EPA, 2011
Trichoptera	Ecclisomyia	0.0	2.2	Empirical—Oregon	Yuan, 2006
Trichoptera	Lepidostoma	0.8	37.8	Empirical—Utah	U.S. EPA, 2011
Trichoptera	Neothremma	0.3	15.8	Empirical—Utah	U.S. EPA, 2011
Trichoptera	Oligophlebodes	0.3	15.9	Empirical—Utah	U.S. EPA, 2011
Trichoptera	Parapsyche	0.0	6.3	Empirical—Utah	U.S. EPA, 2011

Table A-7. Utah—warm-water list

Order	Taxon	% Abundance	% Stations	Source Type	Source Citation
Coleoptera	Microcylloepus	0.2	7.9	Empirical—Utah	U.S. EPA, 2011
Coleoptera	Ordobrevia	0.0	0.8	Empirical—Oregon	Yuan, 2006
Coleoptera	Psephenus	0.0	0.6	Empirical—Idaho	Brandt, 2001
Diptera	Caloparyphus	0.0	4.1	Empirical—Utah	U.S. EPA, 2011
Diptera	Maruina	0.0	2.5	Empirical—Oregon	Yuan, 2006
Ephemeroptera	Caenis	0.0	1.7	Empirical—Oregon	Yuan, 2006
Ephemeroptera	Leptohyphidae	1.4	31.0	Empirical—Utah	U.S. EPA, 2011
Hemiptera	Ambrysus	0.1	6.1	Empirical—Utah	U.S. EPA, 2011
Isopoda	Asellidae	3.1	12.8	Empirical—Utah	U.S. EPA, 2011
Odonata	Coenagrionidae	0.1	18.4	Empirical—Utah	U.S. EPA, 2011
Plecoptera	Calineuria	0.0	1.4	Empirical—Oregon	Yuan, 2006
Trichoptera	Cheumatopsyche	0.4	16.5	Empirical—Utah	U.S. EPA, 2011
Trichoptera	Nectopsyche	0.0	5.5	Empirical—Utah	U.S. EPA, 2011
Trichoptera	Ochrotrichia	0.0	4.6	Empirical—Utah	U.S. EPA, 2011
Trichoptera	Oecetis	0.1	14.2	Empirical—Utah	U.S. EPA, 2011
Trichoptera	Tinodes	0.0	5.4	Empirical—Utah	U.S. EPA, 2011

Note: The warm-water preference list for Utah was limited by the need to retain a family-level operational taxonomic unit for Chironomidae in the long-term data set.

Table A-8. Additional notes—cold-water taxa

The following genera were excluded from the ***cold-water*** lists in the designated states because of variation in thermal preference at the species level:
Brachycentrus (UT)
Drunella (UT)
Epeorus (UT)
Ephemerella (NC)
Eukiefferiella (ME)
Eurylophella (NC)
Goera (NC)
Neophylax (NC)
Paragnetina (NC)
Rhyacophila (UT, ME, NC)
Zapada (UT)

Table A-9. Additional notes—warm-water taxa

The following genera were excluded from the ***warm-water*** lists in the designated states because of variation in thermal preference at the species-level:
Brachycentrus (ME)
Ceratopsyche (ME)
Hydropsyche (ME)
Hydropsyche (NC)
Oecetis (NC)
Polypedilum (NC)

Table A-10. Sources

Study Name	Study Type	Full Citation
Beck, 1977	Literature	Beck, WM Jr. (1977) Environmental requirements and pollution tolerance of common freshwater chironomidae. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, OH; EPA/600/4-77/024
Harris and Lawrence, 1978	Literature	Harris, TL; Lawrence, TM. (1978) Environmental requirements and pollution tolerance of trichoptera. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC; EPA/600/4-78/063.
Poff et al., 2006	Literature	Poff, NL; Olden, JD, Vieira, NKM, et al. (2006) Functional trait niches of North American lotic insects: traits-based ecological applications in light of phylogenetic relationships. N Am Benthol Soc 25(4):730–755.
Surdick and Gaufin, 1978	Literature	Surdick, RF; Gaufin, AR. (1978) Environmental Requirements and Pollution Tolerance of Plecoptera. U.S. Environmental Protection Agency, Washington, DC; EPA-600/4-78/062. 423 p.
Vieira et al., 2006	Literature	Vieira, NKM; Poff, NL; Carlisle, DM; et al. (2006). A database of lotic invertebrate traits for North America. U.S. Geological Survey Data Series 187.
U.S. EPA, 2011	Empirical—North Carolina	U.S. EPA. (2011) Implications of climate change for state bioassessment programs and approaches to account for effects. External Review Draft. Global Change Research Program, National Center for Environmental Assessment, Washington, DC: EPA/600/R-11/036A. Maximum likelihood inferences were based on a subset of the NC biomonitoring database comprised of standard qualitative/full-scale collection method samples only. Maximum likelihood calculations were used instead of weighted-average inference because abundance data in the NC biomonitoring database are categorical (1 = rare (1−2 specimens), 3 = common (3−9 species) and 10 = abundant (10 or more species). Calculations were based on instantaneous water-temperature measurements and occurrences of organisms using the guidelines described by Yuan (2006).

Table A-10. continued…

Study Name	Study Type	Full Citation
U.S. EPA, 2011	Empirical—Maine	U.S. EPA. (2011) Implications of climate change for bioassessment programs and approaches to account for effects. Global Change Research Program, National Center for Environmental Assessment, Washington, DC: EPA/600/R-11/036F. Weighted average inferences are based on a subset of the Maine biomonitoring data. Average July, August, and September temperature values from 616 sites were used in this analysis. Calculations were based on instantaneous-water temperature measurements and occurrences of organisms using the guidelines described by Yuan (2006). For more information, contact Lei Zheng (Lei.Zheng@tetratech.com).
Yuan, 2006	Empirical—Oregon	Yuan, LL. (2006). Estimation and application of macroinvertebrate tolerance values. National Center for Environmental Assessment, Office of Research and Development, U.S. Environmental Protection Agency, Washington, DC.
U.S. EPA, 2011	Empirical—Utah	U.S. EPA. (2011) Implications of climate change for bioassessment programs and approaches to account for effects. Global Change Research Program, National Center for Environmental Assessment, Washington, DC: EPA/600/R-11/036F. Weighted average inferences are based on a subset of the UT biomonitoring data comprised of 572 fall samples. Calculations were based on instantaneous-water temperature measurements and occurrences of organisms using the guidelines described by Yuan (2006). For more information. contact Lei Zheng (Lei.Zheng@tetratech.com).
Brandt, 2001	Empirical—Idaho	Brandt, D. (2001) Temperature preferences and tolerances for 137 common ID macroinvertebrate taxa. Idaho Department of Environmental Quality. Coeur d'Alene, ID.
2008–2011	BPJ Regional Workgroup	Best professional judgment of regional workgroup.

APPENDIX B

Data Integration Rules

Maine—Data Integration Rules

Three key questions arose during the data compilation process:

1. If traits data for taxa are available from multiple sources, which source should we use? What if they differ?
2. How do we assign genus-level traits information if only species-level information is available? What if trait states vary among species within the genera?
3. What if traits are co-occurring (more than one trait state is appropriate and is, therefore, listed)? This was particularly relevant for functional feeding group (FFG) and habit traits.

Integration rules were developed to maintain consistency when addressing these issues. For most of the traits, the Poff et al. (2006) Traits Matrix was given top priority. If the Traits Matrix lacked information for certain taxa, the U.S. Geological Survey (USGS) traits database (i.e., Vieira et al., 2006) received next highest priority, followed by the U.S. Environmental Protection Agency’s (EPAs) 1970s publications. Weighted-average- and maximum-likelihood calculations received top priority for the temperature preference and tolerance trait assignments. All operational taxonomic units (OTUs) in the state biomonitoring databases, including rare taxa, were included in the Maine traits table. This is because the database is meant to be a living document reflecting user-generated content: individuals using the database can fill in or update information as it becomes available. People using the database are encouraged to check the traits information and customize it as necessary so that the information is more accurate for taxa occurring in their region (in FFG and habit, for which only primary trait state assignments were made).

The traits information that was entered into the Maine traits table came from a number of different sources. Sometimes the sources had slight differences in how traits were categorized and in some of the thresholds that were used when assigning trait states. Another issue was that traits information for certain taxa was available from several different sources, so a decision had to be made about which source to use (sources were generally in agreement, but sometimes slight differences existed). Because of these issues, decisions had to be made during the entry process. One involved interpreting literature in order to get the trait state information into a standardized and usable format for analyses. The other involved deciding which source to use. Rules were developed for the following trait state entries: voltinism, development, life span, dispersal, armoring, size, rheophily, functional feeding group, habit, tolerance values and thermal preference, and tolerance. They are summarized in Tables B-1 through B-11.

Table B-1. Maine—integration rules that were used when assigning voltinism trait states to taxa

Trait	Source	Original Trait States	Assigned Trait States
Voltinism	Poff et al. (2006)	Semivoltine	Semivoltine
		Univoltine	Univoltine
		Bi- or multivoltine	Bi- or multivoltine
Voltinism	Vieira et al. (2006)	<1 Generation per year	Semivoltine
		1 Generation per year	Univoltine
		>1 Generation per year	Bi- or multivoltine
Rules	1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entries. Many of the Vieira et al., 2006 entries went to species-level. If trait states varied among species within a genus, a. The trait state that was most frequently recorded was used (= majority rules). b. If different trait states occurred with the same frequency, the Volt_Comments field was referenced. If it mentioned that one state was more typical than another, the more typical state was used. c. If Volt_ Comments was not helpful, the trait state with the higher number of generations was chosen. For example, if there was one 'univoltine' entry and one 'semivoltine' entry, the 'univoltine' entry was chosen.		

Table B-2. Maine—integration rules that were used when assigning development trait states to taxa

Trait	Source	Original Trait States	Assigned Trait States
Development	Poff et al. (2006)	Fast seasonal	Fast
		Slow seasonal	Slow
		Nonseasonal	Non
Dev_Speed	Vieira et al. (2006)	Fast seasonal	Fast
		Slow seasonal	Slow
		Nonseasonal	Non
Rules	1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entries.		

Table B-3. Maine—integration rules that were used when assigning life span trait states to taxa

Trait	Source	Original Trait States	Assigned Trait States
Adult Life Span	Poff et al. (2006)	Very short	Very short
		Short	Short
		Long	Long
Adult_lifespan	Vieira et al. (2006)	Hours	Very short
		Days	Very short
		Weeks	Short
		Months	Long
Rules	1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entries (reference Adult_lifespan_comments if necessary).		

Table B-4. Maine—integration rules that were used when assigning dispersal trait states to taxa

Trait	Source	Original Trait States	Assigned Trait States
Female Dispersal	Poff et al. (2006)	Low (<1 km flight before laying eggs)	Low
		High (>1 km flight before laying eggs)	High
Adult Dispersal	Vieira et al. (2006)	1 km or less	Low
		10 km or less	High
		10 m or less	NA
		100 km or less	High
Rules	1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entries.		
Notes	In the Poff et al. (2006) table, it specifies 'female dispersal.' In the Vieira et al. (2006) traits database, it specifies 'Adult dispersal.' It was assumed that the information was compatible between sources. In Vieira et al. (2006), there is an entry '10 m or less.' It appears that this was a typo (it likely should have been '10 km or less'). Therefore, this category was excluded.		

Table B-5. Maine—integration rules that were used when assigning armoring trait states to taxa

Trait	**Source**	**Original Trait States**	**Assigned Trait States**
Armoring	Poff et al. (2006)	None (soft-bodied forms)	None
		Poor (heavily sclerotized)	Poor
		Good (e.g., some cased caddisflies)	Good
Armor	Vieira et al. (2006)	Soft	None
		All sclerotized	Poor
		Partly sclerotized	Poor
		Hard shelled	Good
Rules	1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entries.		
Notes	In the Poff et al. (2006) table, it does not mention 'partly sclerotized.' In the Vieira et al. (2006) table, 'partly sclerotized' and 'all sclerotized' were assigned to the 'poor' category.		

Table B-6. Maine—integration rules that were used when assigning size (at maturity) trait states to taxa

Trait	**Source**	**Original Trait States**	**Assigned Trait States**
Size at maturity	Poff et al. (2006)	Large (length >16 mm)	Large
		Medium (length 9−16 mm)	Medium
		Small (length <9 mm)	Small
Max_Body_Size	Vieira et al. (2006)	Large (length >16 mm)	Large
		Medium (length 9−16 mm)	Medium
		Small (length <9 mm)	Small
Rules	1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entries. If more than one trait state was assigned (i.e., there was variation among species within a genus): a. The category that was most frequently recorded was used (majority rules). b. If different categories were recorded the same number of times, the 'medium' entry was used (i.e., if there was one 'small' entry and one 'medium' entry, the medium entry was used).		

Table B-7. Maine—integration rules that were used when assigning rheophily trait states to taxa

Trait	Source	Original Trait States	Assigned Trait States
Rheophily	Poff et al. (2006)	Depositional only	Depo
		Depositional and erosional	Depo_eros
		Erosional	Eros
Rheophily	Vieira et al. (2006)	Current_quiet	Depo
		Current_slow	Depo
		Current_fast_lam	Eros
		Current_fast_turb	Eros
		More than one	If both quiet and slow, depo
		Quiet and slow	Depo
		Quiet and/or slow and fast (either laminar or turbid)	Depo_eros
Flow_pref	EPA 1970s	Standing	Depo
		Slight	Depo
		Standing-slight	Depo
		Standing and flowing	Depo_eros
		Moderate	Eros
		Moderate-fast	Eros
		Fast	Eros
		More than one:	
		Some combination of standing and/or slight and moderate and/or fast	Depo_eros
Rules:	1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entries. 3. Use the EPA 1970s entries. 4. If more than one trait state was assigned (i.e., there was variation among species within a genus), the category that was most frequently recorded was used (majority rules).		

Table B-8. Maine—integration rules that were used when assigning (primary) functional feeding group trait states to taxa

Integration Rules for FFG:
Only one FFG category was assigned to each taxa. The following rules were used: 1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entry (Feed_mode_prim). 3. Use the WSA entry from the Benthics_Master_Taxa table. 4. Use the RBP2 1999 entry from the Benthics_Master_Taxa table. 5. Use the U.S. EPA (1990) Draft entry from the Benthics_Master_Taxa table. If more than one category was assigned within a genus, the one that occurred most frequently was entered (= majority rules). If different states were recorded the same number of times, the next source was used as a 'tie-breaker' (i.e., if Vieira et al. [2006] had two species listed as clinger [CN] and two as sprawler [SP], and the WSA entry was SP, SP was used). If unable to resolve based on these sources, one was randomly selected.

WSA = wadeable Streams Assessment.

Table B-9. Maine—integration rules that were used when assigning (primary) habit trait states to taxa

Integration Rules for Habit:
Only one habit category was assigned to each taxa. The following rules were used: 1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entry (Habit_prim). 3. Use the WSA entry from the Benthics_Master_Taxa table. 4. Use the RBP2 1999 entry from the Benthics_Master_Taxa table. 5. Use the U.S. EPA (1990) Draft entry from the Benthics_Master_Taxa table. If more than one category was assigned within a genus, the one that occurred most frequently was entered (= majority rules). If different states were recorded the same number of times, the next source was used as a 'tie-breaker' (i.e., if Vieira et al. [2006] had two species listed as CN and two as SP, and the WSA entry was SP, SP was used). If unable to resolve based on these sources, one was randomly selected.

Table B-10. Maine—integration rules that were used when assigning tolerance values to taxa

Integration Rules for Tolerance:
Only one tolerance value was assigned to each taxa. The following rules were used: 1. Use the WSA entry. 2. Use the RBP2 1999 entry. 3. Use the U.S. EPA (1990) Draft entry. If there were more than two values from a source, the median value was used. If there were two entries, the higher value was used (i.e., if assigned values were 2 and 3, the 3 was used). NOTE: If state-specific tolerance values were provided, those were also incorporated into the traits table.

Table B-11. Maine—integration rules that were used when assigning thermal preference and tolerance values to taxa

Traits	Source	Original Trait States	Assigned Trait States
Thermal preference	Poff et al. (2006)	Cold_cool	Rank_opt = 3, Rank_tol = 3
		Cool_warm	Rank_opt = 4, Rank_tol = 5
		Warm	Rank_opt = 5, Rank_tol = 3
Thermal_pref	Vieira et al. (2006)	Cold stenothermal (<5°C)	Rank_opt = 3, Rank_tol = 3
		Cold-cool eurythermal (0−15°C)	Rank_opt = 3, Rank_tol = 4
		Hot euthermal (>30°C)	Rank_opt = 5, Rank_tol = 3
		No strong preference	Rank_opt = 4, Rank_tol = 5
		Warm eurythermal (15−30°C)	Rank_opt = 5, Rank_tol = 4
		More than one:	
		Combination of colder and warmer categories	Rank_opt = 4, Rank_tol = 5
Thermal preference	EPA 1970s	Eurythermal (≥15°C)	Rank_opt = 5, Rank_tol = 4
		Euthermal (>30°C)	Rank_opt = 5, Rank_tol = 3
		Mesothermal (15−30°C)	Rank_opt = 5, Rank_tol = 4
		Metathermal (5−15°C)	Rank_opt = 3, Rank_tol = 3
		Oligothermal (<15°C)	Rank_opt = 3, Rank_tol = 4
		Stenothermal (≤5°C)	Rank_opt = 3, Rank_tol = 3
Temp_Opt_Rank	EPA 1970s	Wide range—no apparent preference	Rank_opt = 4, Rank_tol = 5
Temp_Tol_Rank	EPA 1970s	More than one:	
		Combination of colder and warmer categories	Rank_opt = 4, Rank_tol = 5
Rules	1. Use the values generated by U.S. EPA (2011) (or from other databases, like Brandt, 2001 and Yuan, 2006). 2. Use the Poff et al. (2006) entries (for genus-level matches). 3. Use the Vieira et al. (2006) entries. 4. Use the EPA 1970s entries. If more than one trait state was assigned (i.e., there was variation among species within a genus), the category that was most frequently recorded was used (majority rules).		

North Carolina—Data Integration Rules

Three key questions arose during the data compilation process:

1. If traits data for taxa are available from multiple sources, which source should we use? What if they differ?
2. How do we assign genus-level traits information if only species-level information is available? What if trait states vary among species within the genera?
3. What if traits are co-occurring (more than one trait state is appropriate and is, therefore, listed)? This was particularly relevant for functional feeding group and habit traits.

Integration rules were developed to maintain consistency when addressing these issues. For most of the traits, the Poff et al. (2006) Traits Matrix was given top priority. If the Traits Matrix lacked information for certain taxa, the USGS traits database (i.e., Vieira et al., 2006) received next highest priority, followed by the EPA's 1970s publications. Weighted–average- and maximum-likelihood calculations received top priority for the temperature preference and tolerance trait assignments. All OTUs in the state biomonitoring databases, including rare taxa, were included in the North Carolina traits table. This is because the database is meant to be a living document; the intent is that people using the database can fill in or update information as it becomes available. People using the database are encouraged to check the traits information and customize it as necessary so that the information is more accurate for taxa occurring in their region (in particular FFG and habit, for which only primary trait state assignments were made).

The traits information that was entered into the North Carolina traits table came from a number of different sources. Sometimes the sources had slight differences in how traits were categorized and in some of the thresholds that were used when assigning trait states. Another issue was that traits information for certain taxa was available from several different sources, so a decision had to be made about which source to use (sources were generally in agreement, but sometimes slight differences existed). Because of these issues, decisions had to be made during the entry process. One involved interpreting literature in order to get the trait state information into a standardized and usable format for analyses. The other involved deciding which source to use. Rules were developed for the following trait state entries: voltinism, development, life span, dispersal, armoring, size, rheophily, functional feeding group, habit, tolerance values and thermal preference, and tolerance. They are summarized in Tables B-12 through B-22.

Table B-12. North Carolina—integration rules that were used when assigning voltinism trait states to taxa

Trait	Source	Original Trait States	Assigned Trait States
Voltinism	Poff et al. (2006)	Semivoltine	Semivoltine
		Univoltine	Univoltine
		Bi- or multivoltine	Bi- or multivoltine
Voltinism	Vieira et al. (2006)	<1 Generation per year	Semivoltine
		1 Generation per year	Univoltine
		>1 Generation per year	Bi- or multivoltine
Rules	1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entries. Many of the Vieira entries went to species-level. If trait states varied among species within a genus: a. The trait state that was most frequently recorded was used (= majority rules). b. If different trait states occurred with the same frequency, the Volt_Comments field was referenced. If it mentioned that one state was more typical than another, the more typical state was used. c. If Volt_ comments was not helpful, the trait state with the higher number of generations was chosen. For example, if there was one 'univoltine' entry and one 'semivoltine' entry, the 'univoltine' entry was chosen.		

Table B-13. North Carolina—integration rules that were used when assigning development trait states to taxa

Trait	Source	Original Trait States	Assigned Trait States
Development	Poff et al. (2006)	Fast seasonal	Fast
		Slow seasonal	Slow
		Nonseasonal	Non
Dev_Speed	Vieira et al. (2006)	Fast seasonal	Fast
		Slow seasonal	Slow
		Nonseasonal	Non
Rules	1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entries.		

Table B-14. North Carolina—integration rules that were used when assigning life span trait states to taxa

Trait	Source	Original Trait States	Assigned Trait States
Adult Life Span	Poff et al. (2006)	Very short	Very short
		Short	Short
		Long	Long
Adult_lifespan	Vieira et al. (2006)	Hours	Very short
		Days	Very short
		Weeks	Short
		Months	Long
Rules	1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entries (reference Adult_lifespan_comments if necessary).		

Table B-15. North Carolina—integration rules that were used when assigning dispersal trait states to taxa

Trait	Source	Original Trait States	Assigned Trait States
Female dispersal	Poff et al. (2006)	Low (<1 km flight before laying eggs)	Low
		High (>1 km flight before laying eggs)	High
Adult dispersal	Vieira et al. (2006)	1 km or less	Low
		10 km or less	High
		10 m or less	NA
		100 km or less	High
Rules	1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entries.		
Notes	In the Poff et al. (2006) table, it specifies 'female dispersal.' In the Vieira et al. (2006) traits database, it specifies 'Adult dispersal.' It was assumed that the information was compatible between sources. In Vieira et al. (2006), there is an entry '10 m or less.' It appears that this was a typo (it likely should have been '10 km or less'). Therefore, this category was excluded.		

Table B-16. North Carolina—integration rules that were used when assigning armoring trait states to taxa

Trait	Source	Original Trait States	Assigned Trait States
Armoring	Poff et al. (2006)	None (soft-bodied forms)	None
		Poor (heavily sclerotized)	Poor
		Good (e.g., some cased caddisflies)	Good
Armor	Vieira et al. (2006)	Soft	None
		All sclerotized	Poor
		Partly sclerotized	Poor
		Hard shelled	Good
Rules	1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entries.		
Notes	In the Poff et al. (2006) table, it does not mention 'partly sclerotized.' In the Vieira et al. (2006) table, 'partly sclerotized' and 'all sclerotized' were assigned to the 'poor' category.		

Table B-17. North Carolina—integration rules that were used when assigning size (at maturity) trait states to taxa

Trait	Source	Original Trait States	Assigned Trait States
Size at maturity	Poff et al. (2006)	Large (length >16 mm)	Large
		Medium (length 9−16 mm)	Medium
		Small (length <9 mm)	Small
Max_Body_Size	Vieira et al. (2006)	Large (length >16 mm)	Large
		Medium (length 9−16 mm)	Medium
		Small (length <9 mm)	Small
Rules	1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entries. If more than one trait state was assigned (i.e., there was variation among species within a genus): a. The category that was most frequently recorded was used (majority rules). b. If different categories were recorded the same number of times, the 'medium' entry was used (i.e., if there was one 'small' entry and one 'medium' entry, the medium entry was used).		

Table B-18. North Carolina—integration rules that were used when assigning rheophily trait states to taxa

Trait	Source	Original Trait States	Assigned Trait States
Rheophily	Poff et al. (2006)	Depositional only	Depo
		Depositional and erosional	Depo_eros
		Erosional	Eros
Rheophily	Vieira et al. (2006)	Current_quiet	Depo
		Current_slow	Depo
		Current_fast_lam	Eros
		Current_fast_turb	Eros
		More than one:	If both quiet and slow, depo
		Quiet and slow	Depo
		Quiet and/or slow and fast (either lam or turb)	Depo_eros
Flow_pref	EPA 1970s	Standing	Depo
		Slight	Depo
		Standing-slight	Depo
		Standing and flowing	Depo_eros
		Moderate	Eros
		Moderate-fast	Eros
		Fast	Eros
		More than one:	
		Some combination of standing and/or slight and moderate and/or fast	Depo_eros
Rules	1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entries. 3. Use the EPA 1970s entries. If more than one trait state was assigned (i.e., there was variation among species within a genus), the category that was most frequently recorded was used (majority rules).		

Table B-19. North Carolina—integration rules that were used when assigning (primary) functional feeding group trait states to taxa

Integration Rules for FFG:
Only one FFG category was assigned to each taxa. The following rules were used: 1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entry (Feed_mode_prim). 3. Use the WSA entry from the Benthics_Master_Taxa table. 4. Use the RBP2 1999 entry from the Benthics_Master_Taxa table. 5. Use the U.S. EPA (1990) Draft entry from the Benthics_Master_Taxa table. If more than one category was assigned within a genus, the one that occurred most frequently was entered (= majority rules). If different states were recorded the same number of times, the next source was used as a 'tie-breaker' (i.e., if Vieira et al. (2006) had two species listed as CN and two as SP, and the WSA entry was SP, SP was used). If unable to resolve based on these sources, one was randomly selected.

Table B-20. North Carolina—integration rules that were used when assigning (primary) habit trait states to taxa

Integration Rules for Habit:
Only one habit category was assigned to each taxa. The following rules were used: 1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entry (Habit_prim). 3. Use the WSA entry from the Benthics_Master_Taxa table. 4. Use the RBP2 1999 entry from the Benthics_Master_Taxa table. 5. Use the U.S. EPA (1990) Draft entry from the Benthics_Master_Taxa table. If more than one category was assigned within a genus, the one that occurred most frequently was entered (= majority rules). If different states were recorded the same number of times, the next source was used as a 'tie-breaker' (i.e., if Vieira et al. (2006) had two species listed as CN and two as SP, and the WSA entry was SP, SP was used). If unable to resolve based on these sources, one was randomly selected.

Table B-21. North Carolina—integration rules that were used when assigning tolerance values to taxa

Integration Rules for Tolerance:
Only one tolerance value was assigned to each taxa. The following rules were used: 1. Use the WSA entry. 1. Use the RBP2 1999 entry. 2. Use the U.S. EPA (1990) Draft entry. If there were more than two values from a source, the median value was used. If there were two entries, the higher value was used (i.e., if assigned values were 2 and 3, the 3 was used). NOTE: if state-specific tolerance values were provided, those were also incorporated into the traits table.

Table B-22. North Carolina—integration rules that were used when assigning thermal preference and tolerance values to taxa

Traits	Source	Original Trait States	Assigned Trait States
Thermal preference	Poff et al. (2006)	Cold_cool	Rank_opt = 3, Rank_tol = 3
		Cool_warm	Rank_opt = 4, Rank_tol = 5
		Warm	Rank_opt = 5, Rank_tol = 3
Thermal_pref	Vieira et al. (2006)	Cold stenothermal (<5°C)	Rank_opt = 3, Rank_tol = 3
		Cold-cool eurythermal (0−15°C)	Rank_opt = 3, Rank_tol = 4
		Hot euthermal (>30°C)	Rank_opt = 5, Rank_tol = 3
		No strong preference	Rank_opt = 4, Rank_tol = 5
		Warm eurythermal (15−30°C)	Rank_opt = 5, Rank_tol = 4
		More than one:	
		Combination of colder and warmer categories	Rank_opt = 4, Rank_tol = 5
Thermal preference	EPA 1970s	Eurythermal (≥15°C)	Rank_opt = 5, Rank_tol = 4
		Euthermal (>30°C)	Rank_opt = 5, Rank_tol = 3
		Mesothermal (15−30°C)	Rank_opt = 5, Rank_tol = 4
		Metathermal (5−15°C)	Rank_opt = 3, Rank_tol = 3
		Oligothermal (<15°C)	Rank_opt = 3, Rank_tol = 4
		Stenothermal (≤5°C)	Rank_opt = 3, Rank_tol = 3
Temp_Opt_Rank	EPA 1970s	Wide range—no apparent preference	Rank_opt = 4, Rank_tol = 5
Temp_Tol_Rank	EPA 1970s	More than one:	
		Combination of colder and warmer categories	Rank_opt = 4, Rank_tol = 5
Rules	1. Use the values generated by U.S. EPA (2011) (or from other databases, like Brandt, 2001 and Yuan, 2006). 2. Use the Poff et al. (2006) entries (for genus-level matches). 3. Use the Vieira et al. (2006) entries. 4. Use the EPA 1970s entries. If more than one trait state was assigned (i.e., there was variation among species within a genus), the category that was most frequently recorded was used (majority rules).		

Utah—Data Integration Rules

Three key questions arose during the data compilation process:

1. If traits data for taxa are available from multiple sources, which source should we use? What if they differ?
2. How do we assign genus-level traits information if only species-level information is available? What if trait states vary among species within the genera?
3. What if traits are co-occurring (more than one trait state is appropriate and is, therefore, listed)? This was particularly relevant for functional feeding group and habit traits.

Integration rules were developed to maintain consistency when addressing these issues. For most of the traits, the Poff et al. (2006) Traits Matrix was given top priority. If the Traits Matrix lacked information for certain taxa, the USGS traits database (i.e., Vieira et al., 2006) received next highest priority, followed by the EPA's 1970s publications. Weighted-average- and maximum-likelihood calculations received top priority for the temperature preference and tolerance trait assignments. All OTUs in the state biomonitoring databases, including rare taxa, were included in the Utah traits table. This is because the database is meant to be a living document; the intent is that people using the database can fill in or update information as it becomes available. People using the database are encouraged to check the traits information and customize it as necessary so that the information is more accurate for taxa occurring in their region (in particular FFG and habit, for which only primary trait state assignments were made).

The traits information that was entered into the Utah traits table came from a number of different sources. Sometimes the sources had slight differences in how traits were categorized and in some of the thresholds that were used when assigning trait states. Another issue was that traits information for certain taxa was available from several different sources, so a decision had to be made about which source to use (sources were generally in agreement, but sometimes slight differences existed). Because of these issues, decisions had to be made during the entry process. One involved interpreting literature in order to get the trait state information into a standardized and usable format for analyses. The other involved deciding which source to use. Rules were developed for the following trait state entries: voltinism, development, life span, dispersal, armoring, size, rheophily, functional feeding group, habit, tolerance values and thermal preference, and tolerance. They are summarized in Tables B-23 through B-33.

Table B-23. Utah—integration rules that were used when assigning voltinism trait states to taxa

<table>
<tr><th>Trait</th><th>Source</th><th>Original Trait States</th><th>Assigned Trait States</th></tr>
<tr><td rowspan="3">Voltinism</td><td rowspan="3">Poff et al. (2006)</td><td>Semivoltine</td><td>Semivoltine</td></tr>
<tr><td>Univoltine</td><td>Univoltine</td></tr>
<tr><td>Bi- or multivoltine</td><td>Bi- or multivoltine</td></tr>
<tr><td rowspan="3">Voltinism</td><td rowspan="3">Vieira et al. (2006)</td><td><1 Generation per year</td><td>Semivoltine</td></tr>
<tr><td>1 Generation per year</td><td>Univoltine</td></tr>
<tr><td>>1 Generation per year</td><td>Bi- or multivoltine</td></tr>
<tr><td>Rules:</td><td colspan="3">1. Use the Poff et al. (2006) entries (for genus-level matches).
2. Use the Vieira et al. (2006) entries.
Many of the Vieira entries went to species-level. If trait states varied among species within a genus,
a. The trait state that was most frequently recorded was used (= majority rules).
b. If different trait states occurred with the same frequency, the Volt_Comments field was referenced.
If it mentioned that one state was more typical than another, the more typical state was used.
c. If Volt_ comments was not helpful, the trait state with the higher number of generations was chosen
For example, if there was one 'univoltine' entry and one 'semivoltine' entry, the 'univoltine' entry was chosen.</td></tr>
</table>

Table B-24. Utah—integration rules that were used when assigning development trait states to taxa

<table>
<tr><th>Trait</th><th>Source</th><th>Original Trait States</th><th>Assigned Trait States</th></tr>
<tr><td rowspan="3">Development</td><td rowspan="3">Poff et al. (2006)</td><td>Fast seasonal</td><td>Fast</td></tr>
<tr><td>Slow seasonal</td><td>Slow</td></tr>
<tr><td>Nonseasonal</td><td>Non</td></tr>
<tr><td rowspan="3">Dev_Speed</td><td rowspan="3">Vieira et al. (2006)</td><td>Fast seasonal</td><td>Fast</td></tr>
<tr><td>Slow seasonal</td><td>Slow</td></tr>
<tr><td>Nonseasonal</td><td>Non</td></tr>
<tr><td>Rules</td><td colspan="3">1. Use the Poff et al. (2006) entries (for genus-level matches).
2. Use the Vieira et al. (2006) entries.</td></tr>
</table>

Table B-25. Utah—integration rules that were used when assigning life span trait states to taxa

Trait	Source	Original Trait States	Assigned Trait States
Adult Life Span	Poff et al. (2006)	Very short	Very short
		Short	Short
		Long	Long
Adult_lifespan	Vieira et al. (2006)	Hours	Very short
		Days	Very short
		Weeks	Short
		Months	Long
Rules	1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entries (reference Adult_lifespan_comments if necessary).		

Table B-26. Utah—integration rules that were used when assigning dispersal trait states to taxa

Trait	Source	Original Trait States	Assigned Trait States
Female dispersal	Poff et al. (2006)	Low (<1 km flight before laying eggs)	Low
		High (>1 km flight before laying eggs)	High
Adult dispersal	Vieira et al. (2006)	1 km or less	Low
		10 km or less	High
		10 m or less	NA
		100 km or less	High
Rules	1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entries.		
Notes	In the Poff et al. (2006) table, it specifies 'female dispersal.' In the Vieira et al. (2006) traits database, it specifies 'Adult dispersal.' It was assumed that the information was compatible between sources. In Vieira et al. (2006) there is an entry '10 m or less.' It appears that this was a typo (it likely should have been '10 km or less'). Therefore, this category was excluded.		

Table B-27. Utah—integration rules that were used when assigning armoring trait states to taxa

Trait	Source	Original Trait States	Assigned Trait States
Armoring	Poff et al. (2006)	None (soft-bodied forms)	None
		Poor (heavily sclerotized)	Poor
		Good (e.g., some cased caddisflies)	Good
Armor	Vieira et al. (2006)	Soft	None
		All sclerotized	Poor
		Partly sclerotized	Poor
		Hard shelled	Good
Rules	1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entries.		
Notes	In the Poff et al. (2006) table, it does not mention 'partly sclerotized.' In the Vieira et al. (2006) table, 'partly sclerotized' and 'all sclerotized' were assigned to the 'poor' category.		

Table B-28. Utah—integration rules that were used when assigning size (at maturity) trait states to taxa

Trait	Source	Original Trait States	Assigned Trait States
Size at maturity	Poff et al. (2006)	Large (length >16 mm)	Large
		Medium (length 9−16 mm)	Medium
		Small (length <9 mm)	Small
Max_Body_Size	Vieira et al. (2006)	Large (length >16 mm)	Large
		Medium (length 9−16 mm)	Medium
		Small (length <9 mm)	Small
Rules	1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entries. If more than one trait state was assigned (i.e., there was variation among species within a genus): a. The category that was most frequently recorded was used (majority rules). b. If different categories were recorded the same number of times, the 'medium' entry was used (i.e., if there was one 'small' entry and one 'medium' entry, the medium entry was used).		

Table B-29. Utah—integration rules that were used when assigning rheophily trait states to taxa

Trait	Source	Original Trait States	Assigned Trait States
Rheophily	Poff et al. (2006)	Depositional only	Depo
		Depositional and erosional	Depo_eros
		Erosional	Eros
Rheophily	Vieira et al. (2006)	Current_quiet	Depo
		Current_slow	Depo
		Current_fast_lam	Eros
		Current_fast_turb	Eros
		More than one:	If both quiet and slow, depo
		Quiet and slow	Depo
		Quiet and/or slow and fast (either lam or turb)	Depo_eros
Flow_pref	EPA 1970s	Standing	Depo
		Slight	Depo
		Standing-slight	Depo
		Standing and flowing	Depo_eros
		Moderate	Eros
		Moderate-fast	Eros
		Fast	Eros
		More than one:	
		Some combination of standing and/or slight and moderate and/or fast	Depo_eros
Rules	1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entries. 3. Use the EPA 1970s entries. If more than one trait state was assigned (i.e., there was variation among species within a genus), the category that was most frequently recorded was used (majority rules).		

Table B-30. Utah—integration rules that were used when assigning (primary) functional feeding group trait states to taxa.

Integration Rules for FFG:
Only one FFG category was assigned to each taxa. The following rules were used: 1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entry (Feed_mode_prim). 3. Use the WSA entry from the Benthics_Master_Taxa table. 4. Use the RBP2 1999 entry from the Benthics_Master_Taxa table. 5. Use the U.S. EPA (1990) Draft entry from the Benthics_Master_Taxa table. If more than one category was assigned within a genus, the one that occurred most frequently was entered (= majority rules). If different states were recorded the same number of times, the next source was used as a 'tie-breaker' (i.e., if Vieira et al. [2006] had two species listed as CN and two as SP, and the WSA entry was SP, SP was used) If unable to resolve based on these sources, one was randomly selected.

Table B-31. Utah—integration rules that were used when assigning (primary) habit trait states to taxa.

Integration Rules for Habit:
Only one habit category was assigned to each taxa. The following rules were used: 1. Use the Poff et al. (2006) entries (for genus-level matches). 2. Use the Vieira et al. (2006) entry (Habit_prim). 3. Use the WSA entry from the Benthics_Master_Taxa table. 4. Use the RBP2 1999 entry from the Benthics_Master_Taxa table. 5. Use the U.S. EPA (1990) Draft entry from the Benthics_Master_Taxa table. If more than one category was assigned within a genus, the one that occurred most frequently was entered (= majority rules). If different states were recorded the same number of times, the next source was used as a 'tie-breaker' (i.e., if Vieira et al. (2006) had two species listed as CN and two as SP, and the WSA entry was SP, SP was used). If unable to resolve based on these sources, one was randomly selected.

Table B-32. Utah—integration rules that were used when assigning tolerance values to taxa.

Integration Rules for Tolerance:
Only one tolerance value was assigned to each taxa. The following rules were used: 1. Use the WSA entry. 2. Use the RBP2 1999 entry. 3. Use the U.S. EPA (1990) Draft entry. If there were more than two values from a source, the median value was used. If there were two entries, the higher value was used (i.e., if assigned values were 2 and 3, the 3 was used). NOTE: If state-specific tolerance values were provided, those were also incorporated into the traits table.

Table B-33. Utah—integration rules that were used when assigning thermal preference and tolerance values to taxa.

Traits	Source	Original Trait States	Assigned Trait States
Thermal preference	Poff et al. (2006)	Cold_cool	Rank_opt = 3, Rank_tol = 3
		Cool_warm	Rank_opt = 4, Rank_tol = 5
		Warm	Rank_opt = 5, Rank_tol = 3
Thermal_pref	Vieira et al. (2006)	Cold stenothermal (<5°C)	Rank_opt = 3, Rank_tol = 3
		Cold-cool eurythermal (0−15°C)	Rank_opt = 3, Rank_tol = 4
		Hot euthermal (>30°C)	Rank_opt = 5, Rank_tol = 3
		No strong preference	Rank_opt = 4, Rank_tol = 5
		Warm eurythermal (15−30°C)	Rank_opt = 5, Rank_tol = 4
		More than one:	
		Combination of colder and warmer categories	Rank_opt = 4, Rank_tol = 5
Thermal preference	EPA 1970s	Eurythermal (≥15°C)	Rank_opt = 5, Rank_tol = 4
		Euthermal (>30°C)	Rank_opt = 5, Rank_tol = 3
		Mesothermal (15−30°C)	Rank_opt = 5, Rank_tol = 4
		Metathermal (5−15°C)	Rank_opt = 3, Rank_tol = 3
		Oligothermal (<15°C)	Rank_opt = 3, Rank_tol = 4
		Stenothermal (≤5°C)	Rank_opt = 3, Rank_tol = 3
Temp_Opt_Rank	EPA 1970s	Wide range—no apparent preference	Rank_opt = 4, Rank_tol = 5
Temp_Tol_Rank	EPA 1970s	More than one:	
		Combination of colder and warmer categories	Rank_opt = 4, Rank_tol = 5
Rules	1. Use the values generated by U.S. EPA (2011) (or from other databases, like Brandt,2001 and Yuan, 2006). 2. Use the Poff et al. (2006) entries (for genus-level matches). 3. Use the Vieira et al. (2006) entries. 4. Use the EPA 1970s entries. If more than one trait state was assigned (i.e., there was variation among species within a genus), the category that was most frequently recorded was used (majority rules).		

APPENDIX C

Traits Gap Analysis

Maine—Traits Gap Analysis

The Maine traits table contains information for 548 operational taxonomic units (OTUs). The majority of the OTUs were at the genera-, genera-group level (94%), or 4% family-level, and the remaining were order-level or higher. One hundred thirty-nine families and 39 higher taxonomic groups (generally order-level) are represented in the Maine data set. The source of most of the nontemperature traits information was the Traits Matrix (Poff et al., 2006) (see Table C-1). This was mainly supplemented by the U.S. Geological Survey (USGS) traits database (Vieira et al., 2006). Most of the temperature traits information was derived from weighted-average calculations that were performed on a subset of the Maine data. Gaps in temperature traits information were mainly filled using the Poff et al. (2006) Traits Matrix, the USGS traits database (Vieira et al., 2006), and the U.S. Environmental Protection Agency's (EPAs) 1970s publications. EPA's 1970s publications were also an important supplemental source of information for rheophily. Most of the habit and functional feeding group (FFG) information was taken from the Traits Matrix (Poff et al., 2006) and was supplemented mostly by data from the Wadeable Streams Assessment (WSA; U.S. EPA, 2006), Rapid Bioassessment Protocol (RBP2; Barbour et al., 1999), and the USGS traits database (Vieira et al., 2006).

Traits information was available for approximately 35−50% of the OTUs (see Table C-2). Exceptions were the habit and functional feeding group traits, for which 83 and 92% of the OTUs had information, respectively. Numerical temperature traits information was available for about 30% of the taxa, and categorical temperature traits information (based on rankings and literature) was available for 58% of the taxa.

Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa generally had more traits information than other taxa (see Table C-3). Habit and FFG is available for over 90% of the EPT taxa, categorical temperature traits information is available for 89−94% of the EPT taxa, and other traits information is available for about 70−80% of the EPT taxa. A large number of taxa in the Maine data set are EPT taxa: 72 are Trichopterans, 45 are Ephemeropterans, and 34 are Plecopterans. Dipterans (193 taxa), Odonates (35 taxa), and Coleopterans (53 taxa) are also well-represented in the data set. For the Dipterans and Coleopterans, habit and FFG information is available for 87−96% of the taxa and temperature traits information for 40−45%. Other traits information is available for 23% of the Dipterans and 38% of the Coleopterans. Habit and FFG information is available for 89−97% of the Odonates, while other traits information is available for 71−74% of the taxa. There are a number of orders (or higher level OTUs) that only have FFG information (i.e., Pharyngobdellida, Tubificida, Acariformes, Collembola, Copepoda); most of these OTUs occur in low abundances and are represented by few taxa. In terms of overall abundance in the Maine database, the largest number of individuals in the Maine database are Trichopterans (overall abundance equals 42%), Dipterans (34%), and then Ephemeropterans (12%). Amphipods, Plecopterans, Isopods, Coleopterans, and Haplotaxida have overall abundances of 1−2%. The remaining 540 OTUs have overall abundances of less than 1%.

Table C-1. Summary of the sources that were used to derive traits information for the Maine traits table. The values equal the number of taxa that the source provided information on. NA equals the number of taxa for which no traits information was available

Traits	**Sources**								
Life History	**Poff et al., 2006**	**Vieira et al., 2006**	**U.S. EPA (ME), 2011**	**EPA 1970s[a]**	**VT DEC, 2008**	**U.S. EPA, 2006**	**Barbour et al., 1999**	**U.S. EPA, 1990**	**NA**
Voltinism	190	80							278
Development	200	9							339
Synchronization of emergence	200								348
Adult life span	198	27							323
Adult ability to exit	200								348
Ability to survive desiccation	200								348
Mobility									
Dispersal (adult)	194	27							327
Adult flying strength	200								348
Occurrence in drift	200								348
Maximum crawling rate	200								348
Swimming ability	200								348
Morphology									
Attachment	200								348
Armoring	192	80							276
Shape	200								348
Respiration	200								348
Size at maturity	192	92							264
Resource acquisition/preference									
Rheophily	194	54		67	4				229
Habit	154	166				127	5		96
Functional feeding group	161	145				159	24	13	46
Temperature									
Temperature optimum			161						387
Temperature tolerance			161						387
Rank of temperature optimum	95	17	161	45					230
Rank of temperature tolerance	95	17	161	45					230
Rank of temperature optimum-tolerance	95	17	161	45					230
Tolerance						390	8	27	123

[a]Beck ,1977; Harris and Lawrence, 1978; Hubbard and Peters, 1978; Surdick and Gaufin, 1978.

Table C-2. Numbers and percentages of the 548 total taxa (at the established OTU level) in the Maine database that have traits information

Traits	Number of Taxa With Traits information	Percentage of Taxa With Traits information
Life history		
Voltinism	270	49.3
Development	209	38.1
Synchronization of emergence	200	36.5
Adult life span	225	41.1
Adult ability to exit	200	36.5
Ability to survive desiccation	200	36.5
Mobility		
Dispersal (adult)	221	40.3
Adult flying strength	200	36.5
Occurrence in drift	200	36.5
Maximum crawling rate	200	36.5
Swimming ability	200	36.5
Morphology		
Attachment	200	36.5
Armoring	272	49.6
Shape	200	36.5
Respiration	200	36.5
Size at maturity	284	51.8
Resource acquisition/preference		
Rheophily	319	58.2
Habit	452	82.5
Functional feeding group	502	91.6
Temperature		
Temperature optimum	161	29.4
Temperature tolerance	161	29.4
Rank of temperature optimum	318	58
Rank of temperature tolerance	318	58
Rank of temperature optimum-tolerance	318	58
Tolerance	425	77.6

Table C-3. Percentage of taxa within each order (or, in some cases, higher taxonomic level) that have life history traits information in the Maine traits table contained within the Freshwater Species Traits Database

Order	Number of Taxa Within Each Order	Abundance (Percentage of Total)	Other Traits (Average)	Temperature	Habit	FFG	Tolerance
Trichoptera	72	42.3	71.8	90.3	93.1	97.2	83.3
Diptera	193	34.2	23.4	45.1	87	91.7	82.9
Ephemeroptera	45	12.4	80.1	88.9	93.3	95.6	84.4
Amphipoda	4	1.9	26.5	100	100	100	100
Plecoptera	34	1.7	80.1	94.1	91.2	91.2	70.6
Isopoda	1	1.6	29.4	100	100	100	100
Coleoptera	53	1.4	37.5	39.6	96.2	90.6	73.6
Haplotaxida	20	1.1	0	30	40	90	80
Basommatophora	15	0.8	2.7	33.3	73.3	86.7	86.7
Odonata	35	0.5	74.3	71.4	88.6	97.1	82.9
Mesogastropoda	7	0.5	1.7	14.3	42.9	57.1	57.1
Rhynchobdellida	7	0.3	14.3	57.1	28.6	85.7	28.6
Veneroida	4	0.3	10.3	75	75	100	100
Tricladida	4	0.3	0	75	50	50	50
Megaloptera	5	0.2	82.4	80	100	100	80
Trombidiformes	1	0.1	0	100	0	0	0
Lumbriculida	3	0.1	0	66.7	0	33.3	66.7
Hydroida	1	0.1	17.6	100	0	100	100
Arhynchobdellida	3	0	15.7	66.7	66.7	100	33.3
Heterostropha	1	0	0	100	0	100	0
Decapoda	3	0	29.4	33.3	100	100	100
Pharyngobdellida	1	0	0	0	0	100	0
Hoplonemertea	1	0	0	100	0	100	100
Cladocera	1	0	0	0	0	100	100
Tubificida	3	0	0	0	0	66.7	0
Nemata (phylum)	1	0	0	0	0	100	100
Hemiptera	14	0	52.5	42.9	100	100	64.3

Table C-3. continued…

Order	Number of Taxa Within Each Order	Abundance (Percentage of Total)	Other Traits (Avg)	Temp Rank	Habit	FFG	Tolerance
Lepidoptera	1	0	0	0	100	100	100
Veneroidea	1	0	0	0	0	100	100
Acariformes	1	0	0	0	0	100	0
Collembola	4	0	0	0	0	100	0
Aeolosomatida	1	0	23.5	100	0	0	0
Branchiobdellida	2	0	0	0	50	50	50
Neuroptera	1	0	100	100	100	100	100
Copepoda	1	0	0	0	0	100	0
Nematomorpha (phylum)	1	0	0	0	100	100	100
Neotaenioglossa	1	0	0	0	0	100	100
Unionoida	1	0	0	0	100	100	100
Ectoprocta (phylum)	1	0	0	0	0	0	0

North Carolina—Traits Gap Analysis

The North Carolina traits table contains information for 797 OTUs. The majority of the OTUs were at the genera-, genera-group level (97%), or 2% family-level, and the remaining were order-level or higher. Two hundred sixty-three families and 72 higher taxonomic groups (generally order-level) are represented in the North Carolina data set. The source of the majority of nontemperature traits information was the Poff et al. (2006) Traits Matrix (see Table C-4). This was mainly supplemented by the USGS traits database (Vieira et al., 2006). Most of the temperature traits information was derived from the maximum likelihood calculations on a subset of North Carolina data. Gaps in temperature traits information were mainly filled using the Traits Matrix (Poff et al., 2006), the USGS traits database (Vieira et al., 2006), and the EPA's 1970s publications. EPA's 1970s publications were also an important supplemental source of information for rheophily. Most of the habit and functional feeding group information was taken from the Poff et al. (2006) Traits Matrix and was supplemented mostly by WSA (U.S. EPA, 2006), RBP2 (Barbour et al., 1999), and the USGS traits database (Vieira et al., 2006).

Traits information was available for approximately 25−40% of the OTUs (see Table C-5). Exceptions were the habit and functional feeding group traits, for which 61 and 68% of the OTUs had information, respectively. Numerical temperature optima information was available for about 30% of the taxa, and categorical temperature optima information (based on rankings and literature) was available for 44% of the taxa. Because of the type of data that was available for the maximum likelihood analysis (categorical abundance data), less temperature tolerance information could be generated. Accordingly, there were fewer numerical temperature tolerance values, and 36% of the taxa had categorical temperature tolerance (ranking) information.

EPT taxa generally had more traits information than other taxa (see Table C-6). Habit and FFG is available for over 90% of the EPT taxa, categorical temperature traits information is available for about 93% of the EPT taxa, and other traits information is available for 79−88% of the EPT taxa. A large number of taxa in the North Carolina data set are EPT taxa: 62 are Trichopterans, 57 are Ephemeropterans, and 41 are Plecopterans. Dipterans (197 taxa), Odonates (46 taxa), and Coleopterans (67 taxa) are also well represented in the data set. For the Dipterans, habit and FFG information is available for 80−85% of the taxa, temperature traits information, 43%, and other traits information, 20%. For the Coleopterans, habit and FFG information is available for 91−94% of the taxa, temperature traits information, 49%, and other traits information, 29%. Habit and FFG information is available for 89−96% of the Odonates, while other traits information is available for 65−72% of the taxa. No traits information is available for 37 taxa; most of these OTUs occur in low abundances and are represented by few taxa. In terms of overall abundance in the North Carolina database, the largest number of individuals are Dipterans (overall abundance equals 29%), followed by Ephemeropterans (20%), then Trichopterans (16%), then Coleopterans (8%), then Odonates, (7%) and then Plecopterans (6%). Bassomatophora, Megaloptera, Haplotaxida, Veneroida, Lumbriculida, Amphipoda, and Decapoda have overall abundances of 1−2%. The remaining 784 OTUs have overall abundances of less than 1%.

Table C-4. Summary of the sources that were used to derive traits information for the North Carolina traits table. The values equal the number of taxa that the source provided information on. NA equals the number of taxa for which no traits information was available

Traits	**Sources**								
Life History	**Poff et al., 2006**	**Vieira et al., 2006**	**U.S. EPA (NC), 2011**	**EPA 1970s[a]**	**VT DEC, 2008**	**U.S. EPA, 2006**	**Barbour et al., 1999**	**U.S. EPA, 1990**	**NA**
Voltinism	205	85							507
Development	214	11							572
Synchronization of emergence	214								583
Adult life span	212	36							549
Adult ability to exit	214								583
Ability to survive desiccation	214								583
Mobility									
Dispersal (adult)	208	28							561
Adult flying strength	214								583
Occurrence in drift	214								583
Maximum crawling rate	214								583
Swimming ability	214								583
Morphology									
Attachment	214								583
Armoring	203	104							490
Shape	214								583
Respiration	214								583
Size at maturity	203	114							480
Resource acquisition/preference									
Rheophily	208	63		65	4				457
Habit	179	173				127	4		314
Functional feeding group	184	169				151	23	15	255
Temperature									
Temperature optimum			233						564
Temperature tolerance			0						797
Rank of temperature optimum	93	20	233	8					443
Rank of temperature tolerance	93	20	166	8					510
Rank of temp optimum-tolerance	93	20	166	8					510
Tolerance						410	9	18	360

[a]Beck ,1977; Harris and Lawrence, 1978; Hubbard and Peters, 1978; Surdick and Gaufin, 1978.

Table C-5. Numbers and percentages of the 797 total taxa (at the established OTU level) in the North Carolina database that have traits information

Traits	Number of Taxa With Traits information	Percentage of Taxa With Traits information
Life history		
Voltinism	290	36.4
Development	225	28.2
Synchronization of emergence	214	26.9
Adult life span	248	31.1
Adult ability to exit	214	26.9
Ability to survive desiccation	214	26.9
Mobility		
Dispersal (adult)	236	29.6
Adult flying strength	214	26.9
Occurrence in drift	214	26.9
Maximum crawling rate	214	26.9
Swimming ability	214	26.9
Morphology		
Attachment	214	26.9
Armoring	307	38.5
Shape	214	26.9
Respiration	214	26.9
Size at maturity	317	39.8
Resource acquisition/preference		
Rheophily	340	42.7
Habit	483	60.6
Functional feeding group	542	68
Temperature		
Temperature optimum	233	29.2
Temperature tolerance	0	0
Rank of temperature optimum	354	44.4
Rank of temperature tolerance	287	36
Rank of temperature optimum-tolerance	287	36
Tolerance	437	54.8

Table C-6. Percentage of taxa within each order (or, in some cases, higher taxonomic level) that have life history traits information in the North Carolina traits table

Order	Number of Taxa Within Each Order	Abundance (Percentage of Total)	Other Traits (Average)	Temp Optima Rank	Habit	FFG	Tolerance
Diptera	197	28.68	20.08	43.1	79.7	85.3	76.1
Ephemeroptera	57	19.75	79.17	93	91.2	93	78.9
Trichoptera	62	15.46	78.53	93.5	96.8	96.8	88.7
Plecoptera	41	5.67	87.96	92.7	90.2	92.7	70.7
Coleoptera	67	7.71	29.1	49.3	91	94	68.7
Odonata	46	7.09	64.81	71.7	89.1	95.7	69.6
Basommatophora	13	2.31	2.4	23.1	84.6	92.3	84.6
Megaloptera	5	2.11	81.25	100	100	100	80
Haplotaxida	34	1.73	0.37	20.6	29.4	70.6	58.8
Veneroida	20	1.75	2.5	10	25	35	25
Lumbriculida	1	1.32	0	100	100	100	100
Amphipoda	25	1.01	3.5	16	16	24	20
Decapoda	24	1.04	3.13	16.7	20.8	16.7	16.7
Neotaenioglossa	11	0.97	0	18.2	9.1	27.3	27.3
Isopoda	13	0.51	5.77	15.4	15.4	46.2	23.1
Mesogastropoda	7	0.5	6.25	14.3	57.1	71.4	42.9
Trombidiformes	1	0.58	0	100	100	100	100
Tricladida	4	0.49	0	0	50	50	25
Rhynchobdellida	7	0.25	8.93	42.9	42.9	100	28.6
Hemiptera	11	0.22	44.89	54.5	100	100	63.6
Unionoida	11	0.2	0	9.1	0	36.4	18.2
Branchiobdellida	2	0.14	3.13	50	0	0	0
Arhynchobdellida	6	0.13	19.79	100	83.3	83.3	16.7
Opisthopora	1	0.11	0	100	0	0	0
Hoplonemertea	2	0.07	0	0	0	50	50
Lepidoptera	2	0.06	50	50	100	100	100

Table C-6. continued…

Order	Number of Taxa Within Each Order	Abundance (Percentage of Total)	Other Traits (Average)	Temp Optima Rank	Habit	FFG	Tolerance
Polychaeta (class)	17	0.01	0	0	0	0	0
Neuroptera	1	0.03	100	100	100	100	100
Aciculata	21	0.02	0	0	0	0	0
Sessilia	2	0.02	0	0	0	50	0
Mytiloida	4	0.01	0	0	0	0	0
Mysida	2	0.01	0	0	0	0	0
Canalipalpata	11	0	0	0	0	0	0
Neogastropoda	8	0	0	0	0	0	0
Proseriata	1	0	0	0	0	0	0
Tanaidacea	2	0	0	0	0	50	0
Nematoda (phylum)	1	0	0	0	0	100	100
Porifera (phylum)	1	0	0	0	0	100	100
Ostreoida	3	0	0	0	0	0	0
Cheilostomata	3	0	0	0	0	0	0
Hydrobiidae	2	0	0	0	0	0	0
Heteronemertea	1	0	0	0	0	0	0
Heterostropha	5	0	0	0	0	20	0
Myoida	3	0	0	0	0	**0**	0
Ophiurida	2	0	0	0	0	0	0
Polycladida	2	0	0	0	0	0	0
Hydroida	2	0	9.38	0	0	50	50
Leptothecatae	3	0	0	0	0	0	0
Pleurogona	2	0	0	0	0	0	0
Cumacea	1	0	0	0	0	0	0
Gordiida	1	0	0	0	0	0	0
Heteroptera	3	0	35.42	66.7	66.7	100	0
Nudibranchia	2	0	0	0	0	0	0
Ctenostomata	2	0	0	0	0	0	0

Table C6. continued…

Order	Number of Taxa Within Each Order	Abundance (Percentage of Total)	Other Traits (Average)	Temp Optima Rank	Habit	FFG	Tolerance
Pantopoda	1	0	0	0	0	0	0
Paleonemertea	2	0	0	0	0	0	0
Arcoida	2	0	0	0	0	0	0
Hymenoptera	1	0	0	0	0	0	0
Anthoathecatae	1	0	0	0	0	0	0
Cephalaspidea	1	0	0	0	0	0	0
Actiniaria	1	0	0	0	0	0	0
Apodida	1	0	0	0	0	0	0
Arbacioida	1	0	0	0	0	0	0
Cidaroida	1	0	0	0	0	0	0
Dendrochirotida	1	0	0	0	0	0	0
Echiurida (phylum)	1	0	0	0	0	0	0
Enteropneusta (class)	1	0	0	0	0	0	0
Neoloricata	1	0	0	0	0	0	0
Pholadomyoida	1	0	0	0	0	0	0
Pterioida	1	0	0	0	0	0	0
Temnopleuroida	1	0	0	0	0	0	0

Utah—Traits Gap Analysis

The Utah traits table contains information for 272 OTUs. The majority of the OTUs were at the genera-, genera-group level (85%), or 12% family-level, and the remaining were order-level or higher. One hundred seventeen families and 32 higher taxonomic groups (generally order-level) are represented in the Utah data set. The source of the majority of nontemperature traits information was the Poff et al. (2006) Traits Matrix (see Table C-7). This was mainly supplemented by the USGS traits database (Vieira et al., 2006). Most of the temperature traits information was derived from the weighted-average calculations that were performed on a subset of the Utah data. Gaps in temperature traits information were mainly filled using the Traits Matrix (i.e., Poff et al., 2006), the USGS traits database (Vieira et al., 2006), and data from Brandt's (2001) and Yuan's (2006) weighted-average calculations. Most of the habit and functional feeding group information was taken from the Poff et al. (2006) Traits Matrix and was supplemented mainly by WSA (U.S. EPA, 2006), RBP2 (Barbour et al., 1999), and the USGS traits database (Vieira et al., 2006).

Traits information was available for approximately 50−65% of the OTUs (see Table C-8). Exceptions were the habit and functional feeding group traits, for which 85 and 92% of the OTUs had information, respectively. Numerical temperature traits information was available for about 50% of the taxa, and categorical temperature traits information (based on rankings and literature) was available for 68% of the taxa.

EPT taxa generally had more traits information than other taxa (see Table C-9). When tolerance values are excluded, about 80−100% of the EPT taxa have traits information. A large number of taxa in the Utah data set are EPT taxa: 60 are Trichopterans, 26 are Ephemeropterans, and 31 are Plecopterans. Dipterans (58 taxa), Odonates (17 taxa), and Coleopterans (30 taxa) are also well represented in the data set. For the Dipterans and Coleopterans, habit and FFG information is available for approximately 90% of the taxa, temperature traits information, 50%, and other traits information is available for about 35−45% of the taxa. Habit and FFG information is available for about 80−90% of the Odonates, while other traits information is available for about 65% of the taxa. Some of the remaining orders (or higher levels) have traits information for all taxa (i.e., Megaloptera, Isopoda, Amphipoda, Hirudinea), but these generally have only one or two taxa in the data set. On the opposite end of the spectrum, no traits information is available for some OTUs (i.e., Archaeogastropoda, Amphineura, Sepiolida, Unionoida), but these taxa are rare (they comprise less than 0.1% of the total number of individuals in the data set), and each are only represented by one taxa in the data set. In terms of overall abundance in the Utah database, the largest number of individuals are Dipterans (overall abundance equals 36%), followed by Ephemeropterans (24%), then Trichopterans (12%), and then Coleopterans (8%). Only 11 of the OTUs have overall abundances greater than 1%.

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Table C-7. Summary of the sources that were used to derive traits information for the Utah traits table. The values equal the number of taxa that the source provided information on. NA equals the number of taxa for which no traits information was available

Traits	**Sources**										
Life History	**Poff et al., 2006**	**Vieira et al., 2006**	**U.S. EPA (UT), 2011**	**Brandt (ID), 2001**	**Yuan, 2006**	**EPA 1970s[a]**	**VT DEC, 2008**	**U.S. EPA, 2006**	**Barbour et al., 1999**	**U.S. EPA, 1990**	**NA**
Voltinism	141	21									110
Development	146	3									123
Synchronization of emergence	146										126
Adult life span	144	11									117
Adult ability to exit	146										126
Ability to survive desiccation	146										126
Mobility											272
Dispersal (adult)	142	9									121
Adult flying strength	146										126
Occurrence in drift	146										126
Maximum crawling rate	146										126
Swimming ability	146										126
Morphology											272
Attachment	146										126
Armoring	142	32									98
Shape	146										126
Respiration	146										126
Size at maturity	142	28									102
Resource acquisition/preference											272
Rheophily	144	14				1	4				109
Habit	125	38						64	4		41
Functional feeding group	128	26						70	20	6	22

Table C-7. continued…

Temperature											272
Temperature optimum			104	19	10						139
Temperature tolerance			104	19							139
Rank of temperature optimum	48	2	104	19	10	3					86
Rank of temperature tolerance	48	2	104	19	10	3					86
Rank of temperature optimum-tolerance	48	2	104	19	10	3					86
Tolerance								173	2	5	92

[a]Beck ,1977; Harris and Lawrence, 1978; Hubbard and Peters, 1978; Surdick and Gaufin, 1978.

Table C-8. Numbers and percentages of the 272 taxa (at the established OTU level) in the Utah database that have traits information

Traits	Number of Taxa With Traits information	Percentage of Taxa With Traits information
Life history		
Voltinism	162	59.6
Development	149	54.8
Synchronization of emergence	146	53.7
Adult life span	155	57
Adult ability to exit	146	53.7
Ability to survive desiccation	146	53.7
Mobility		
Dispersal (adult)	151	55.5
Adult flying strength	146	53.7
Occurrence in drift	146	53.7
Maximum crawling rate	146	53.7
Swimming ability	146	53.7
Morphology		
Attachment	146	53.7
Armoring	174	64
Shape	146	53.7
Respiration	146	53.7
Size at maturity	170	62.5
Resource acquisition/preference		
Rheophily	163	59.9
Habit	231	84.6
Functional feeding group	250	91.9
Temperature		
Temperature optimum	133	48.9
Temperature tolerance	133	48.9
Rank of temperature optimum	186	68.4
Rank of temperature tolerance	186	68.4
Rank of temperature optimum-tolerance	186	68.4
Tolerance	180	66.2

Table C-9. Percentage of taxa within each order (or, in some cases, higher taxonomic level) that have life history traits information in the Utah traits table

Order	Number of Taxa Within Each Order	Abundance (Percentage of Total)	Other Traits (Average)	Temp Rank	Habit	FFG	Tolerance
Diptera	58	35.7	45.6	50	87.9	91.4	69
Ephemeroptera	26	24.2	88.5	88.5	92.3	96.2	69.2
Trichoptera	60	12.4	78.7	91.7	88.3	90	56.7
Coleoptera	30	7.7	34.5	50	93.3	90	73.3
Isopoda	1	3.1	0	100	100	100	100
Trombidiformes	1	3	0	100	0	100	100
Haplotaxida	3	3	0	33.3	66.7	100	100
Plecoptera	31	2.5	87.3	100	96.8	100	54.8
Neotaenioglossa	5	2.2	16.5	0	60	100	20
Podocopida	1	1.8	0	100	0	100	0
Amphipoda	2	1.4	29.4	100	100	100	100
Tricladida	2	0.7	0	50	50	50	50
Basommatophora	9	0.6	4.6	44.4	77.8	100	100
Diplostraca	1	0.5	0	0	0	100	0
Copepoda (subclass)	1	0.3	0	100	0	100	0
Dorylaimida	1	0.3	0	100	0	100	100
Hirudinea (subclass)	1	0.2	0	100	100	100	100
Pelecypoda (class)	1	0.2	0	100	0	100	0
Odonata	17	0.1	67.5	64.7	82.4	88.2	76.5
Hemiptera	5	0.1	20	40	100	100	100
Lepidoptera	2	0	50	50	100	100	100
Veneroida	3	0	13.7	33.3	66.7	100	100
Megaloptera	2	0	100	100	100	100	100
Archaeogastropoda	1	0	0	0	0	0	0
Hydroida	1	0	17.6	0	0	100	100
Amphineura (class)	1	0	0	0	0	0	0

Table C-9. continued…

Order	Number of Taxa Within Each Order	Abundance (Percentage of Total)	Other Traits (Average)	Temp Rank	Habit	FFG	Tolerance
Heterostropha	1	0	0	0	0	100	0
Decapoda	1	0	0	100	0	100	100
Sepiolida	1	0	0	0	0	0	0
Nematomorpha (phylum)	1	0	0	0	100	100	100
Lumbriculida	1	0	0	0	100	100	100
Unionoida	1	0	0	0	0	0	0

APPENDIX D

List of Traits and Associated Metadata

Table D-1. List of traits in alphabetical order included in the Freshwater Biological Traits Database.

Variable	**Data Type**	**Description**
AbilityToSurviveDesiccation_abbrev	Text (categorical)	Abbreviated ability to survive desiccation entries: present, absent
AbilityToSurviveDesiccation_comments	Text	Description of abbreviated adult ability to survive desiccation entries: present = able to survive desiccation; absent = not able to survive desiccation
Adult	Text (ADULT) or blank	Identifies if traits were compiled for aquatic adults, otherwise entries pertain to immature life stage
Adult_disp	Text (categorical)	Adult dispersal distance. Entries = 1 km or less, 10 km or less, 10 m or less, 100 km or less
Adult_lifespan	Text (categorical)	Adult lifespan. Entries: days, hours, weeks, months
Adult_lifespan_abbrev	Text (categorical)	Abbreviated adult life span: very_short, short, long
Adult_lifespan_comments	Text	Description of abbreviated adult life span entries: very short = less than 1 week; short = less than 1 month; long = greater than 1 month
AdultFlyingStrength_abbrev	Text (categorical)	Abbreviated flying strength entries: weak, strong
AdultFlyingStrength_comments	Text	Description of abbreviated flying strength entries: weak = e.g., cannot fly into light breeze
Armor	Text	Degree of body armoring. Entries = all sclerotized, hard shelled, partly sclerotized, soft
Armor_abbrev	Text (categorical)	Abbreviated armoring entries = none, poor, good
Armor_comments	Text	Description of abbreviated armoring entries: none = soft-bodied forms; poor = heavily sclerotized; good = e.g., some cased caddisflies
Attach_abbrev	Text (categorical)	Abbreviated attachment entries = none, some, both
Attach_comments	Text	Description of abbreviated attachment entries: none = free-ranging; some = sessile, sedentary; both = free-ranging and sessile, sedentary. Other (nonabbreviated) entries include: normally free living and capable of locomotion; both sessile and free living and capable of locomotion; normally sessile
Body_shape	Text	Body shape. Entries = bluff (blocky), dorsoventrally flattened, round (humped), streamlined/fusiform, tubular

Variable	Data Type	Description
Body_shape_abbrev	Text (categorical)	Abbreviated body shape entries = streamlined, not_streamlined
Body_shape_case	Text	Body shape with case/retreat. Entries = bluff (blocky), dorsoventrally flattened, round (humped), streamlined/fusiform, tubular
Body_shape_comments	Text	Description of abbreviated body shape entries: streamlined = flat, fusiform; not streamlined = cylindrical, round, or bluff
Current_Comments	Text	Brief description of how CurrentOptima and CurrentOptima_Rank values were derived.
Current_fast_lam	Number (binary)—1 or blank	1 = current preference—fast laminar currents
Current_fast_turb	Number (binary)—1 or blank	1 = current preference—fast turbulent currents
Current_moderate	Number (binary)—1 or blank	1 = current preference—moderate
Current_quiet	Number (binary)—1 or blank	1 = current preference—quiet
Current_slow	Number (binary)—1 or blank	1 = current preference—slow
CurrentOptima	Number (decimals)	Numerical optima values for current data that were derived from weighted average or maximum likelihood calculations
CurrentOptima_Rank	Number (integers)	Rank values were derived using a 1−7 scoring scheme based on the following percentiles: 0, 0.1, 0.25, 0.4, 0.6, 0.75, 0.9, 1, such that low CurrentOptima_Rank scores = preference for slower water and high CurrentOptima_Rank scores = preference for faster water. Rankings allow for comparisons across data sets, because optima and tolerance values will vary depending on the data set they were derived from.
Data_entry	Text	Person who entered data
Data_entry_date	Date	Date person entered data
Dev_pattern	Text	Development pattern text notes
Dev_speed	Text	Development speed. Entries: fast seasonal, slow seasonal, nonseasonal
Dev_speed_abbrev	Text (categorical)	Abbreviated development entries: fast, slow, non
Diapause	Text (categorical)	Indicates whether diapause occurs. Entries: no, yes, unknown, blank

Variable	Data Type	Description
Drift_abbrev	Text (categorical)	Abbreviated occurrence in drift entries: rare, common, abundant
Drift_comments	Text	Description of abbreviated occurrence in drift entries: rare = catastrophic only; common = typically observed; abundant = dominant in drift samples
Drift_early	Text (categorical)	Drift propensity of early instars. Entries = strong (active/often), medium (mostly passive/occasional), weak (catastrophic only)
Drift_late	Text (categorical)	Drift propensity of late instars. Entries = strong (active/often), medium (mostly passive/occasional), weak (catastrophic only)
Eggs_1mass	Number (binary)—1 or blank	1 = Egg type—one mass
Eggs_cement	Text	Indicates whether eggs are cemented. Entries = no, yes, unknown, blank
Eggs_multiple_batch	Number (binary)—1 or blank	1 = Egg type—multiple batches
Eggs_single	Number (binary)—1 or blank	1 = Egg type—single
Emerge_behav_climb	Number (binary)—1 or blank	1 = emergence behavior—climbing
Emerge_behav_comment	Text	Emergence behavior text notes
Emerge_behav_crawl	Number (binary)—1 or blank	1 = emergence behavior—crawling
Emerge_behav_drift	Number (binary)—1 or blank	1 = emergence behavior—drifting
Emerge_season_1	Text (categorical)	Season that emergence begins. Entries = winter, spring, summer, fall
Emerge_season_2	Text (categorical)	Season that emergence ends. Entries = winter, spring, summer, fall
Emerge_season_all_year	Text	Indicates whether emergence can occur all year. Entries = no, yes, unknown, blank
Emerge_season_comments	Text	Seasons during which sexually mature forms have been reported. Entries = winter, spring, summer, fall
Emerge_synch	Text	Indicates whether emergence is synchronous
Emerge_synch_abbrev	Text (categorical)	Abbreviated synchronization of emergence entries = poorly, well
Emerge_synch_comments	Text	Description of abbreviated synchronization of emergence entries: poorly = week; well = days

Variable	Data Type	Description
EnrichTolScore	Number (integer)	Numerical tolerance score ranging from 0 (most intolerant) to 10 (most tolerant). Typically based on tolerances to organic enrichment.
EnrichTolScore_comments	Text	Description of enrichment tolerance scores and sources
Exit_temporarily	Text	Indicates ability to temporarily exit water. Entries = no, yes, unknown, blank
Exit_temporarily_abbrev	Text (categorical)	Abbreviated adult ability to exit entries: present, absent
Exit_temporarily_comments	Text	Description of abbreviated adult ability to exit entries: present = has ability to exit; absent = does NOT have ability to exit. This does NOT include emergence.
Family	Text	Taxonomic level
Fecundity	Text (categorical)	Fecundity. Entries: <100 eggs, >10,000 eggs, 100 to 1,000 eggs, 1,000 to 10,000 eggs
Feed_mode_comments	Text	Description of abbreviated primary functional feeding group entries: CF, CG, HB, PA, PR, SH
Feed_mode_prim	Text	Primary feeding mode based on mouthpart morphology
Feed_mode_sec	Text	Secondary feeding mode based on mouthpart morphology
Feed_prim_abbrev	Text (categorical)	Abbreviated primary functional feeding group entries: CF = collector-filterer; CG = collector-gatherer; HB = herbivore (scraper); SH = shredder; PR = predator (piercer, engulfer); PA = parasite. Other (nonabbreviated) entries include text notes on food material consumed
Female_disp_abbrev	Text (categorical)	Abbreviated female dispersal entries: low, high
Female_disp_comments	Text	Description of abbreviated female dispersal entries: low = less than 1-km flight before laying eggs; high = greater than 1-km flight before laying eggs
Genus	Text	Taxonomic level
Habit_comments	Text	Description of abbreviated primary habit entries: BU, CB, CN, SK, SP, SW
Habit_prim	Text	Primary habit
Habit_prim_abbrev	Text (categorical)	Abbreviated habit entries: BU = burrower; CB = climber; CN = clinger; SK = skater; SP = sprawler; SW = swimmer. Other (nonabbreviated) entries include text notes on habit

Variable	Data Type	Description
Habit_sec	Text	Secondary habit
Hatch_time	Text (categorical)	Time required for eggs to hatch. Entries: hours, minutes, days, months, weeks
Hatch_time_comments	Text	Time required for eggs to hatch text notes
Larval_disp	Text (categorical)	Larvel dispersal distance. Entries = <1 m, 1−10 m, 11−100 m
Lat_comments	Text	Lateral habitat position in water column text notes
Lat_hyporheic	Number (binary)—1 or blank	1 = Lateral habitat position in water column—hyporheic
Lat_lentic_shore	Number (binary)—1 or blank	1 = Lateral habitat position in water column—shoreline
Lat_lotic_margin	Number (binary)—1 or blank	1 = Lateral habitat position in water column—margin
Lat_pool	Number (binary)—1 or blank	1 = Lateral habitat position in water column—pool
Lat_riffle	Number (binary)—1 or blank	1 = Lateral habitat position in water column—riffle
Low_lethal_DO	Number (integer)	Observed lethal DO levels
Max_body_size	Text	Maximal body size of immatures. Entries = Large (length >16 mm), Medium (length 9−16 mm), Small (length <9 mm)
Max_body_size_abbrev	Text (categorical)	Abbreviated maximal body size entries = small, medium, large
Max_lethal_temp	Number (decimals)	Observed maximum lethal temperature
Max_temp_reported	Number (decimals)	Maximum temperature reported
MaxCrawlRate_abbrev	Text (categorical)	Abbreviated maximum crawling rate entries: very_low, low, high
MaxCrawlRate_comments	Text	Description of abbreviated maximum crawling rate entries: very low = less than 10 cm per hour; low = less than 100 cm per hour; high = greater than 100 cm per hour
Measured_height	Number (decimals)	Measured body height of immatures (mm)
Measured_length	Number (decimals)	Measured body length of immatures (mm)
Measured_width	Number (decimals)	Measured body width of immatures (mm)
Mediate_drag	Text	Indication of whether shape mediates drag. Entries = no, yes, unknown, blank
Microhab_algae	Number (binary)—1 or blank	1 = Microhabitat substrate preference—algae
Microhab_boulder	Number (binary)—1 or blank	1 = Microhabitat substrate preference—boulder

Variable	Data Type	Description
Microhab_comments	Text	Microhabitat substrate preference text notes
Microhab_detritus	Number (binary)—1 or blank	1 = Microhabitat substrate preference—detritus
Microhab_gravel	Number (binary)—1 or blank	1 = Microhabitat substrate preference—gravel
Microhab_LWD	Number (binary)—1 or blank	1 = Microhabitat substrate preference—large woody debris (LWD)
Microhab_pelagic	Number (binary)—1 or blank	1 = Microhabitat substrate preference—pelagic
Microhab_phyto	Number (binary)—1 or blank	1 = Microhabitat substrate preference—macrophytes
Microhab_plants	Number (binary)—1 or blank	1 = Microhabitat substrate preference—plants
Microhab_rocks	Number (binary)—1 or blank	1 = Microhabitat substrate preference—rocks
Microhab_sand	Number (binary)—1 or blank	1 = Microhabitat substrate preference—sand
Microhab_silt	Number (binary)—1 or blank	1 = Microhabitat substrate preference—silt
Min_temp_reported	Number (decimals)	Minimum temperature reported
Morph_adapt_ballast	Number (binary)—1 or blank	1 = taxon has ballast
Morph_adapt_friction	Number (binary)—1 or blank	1 = taxon has friction pads or other structures to reduce friction coefficient with surface
Morph_adapt_hairy	Number (binary)—1 or blank	1 = taxon has hair
Morph_adapt_hooks	Number (binary)—1 or blank	1 = taxon has hooks
Morph_adapt_other	Text	Text to further describe morphological adaptations
Morph_adapt_silk	Number (binary)—1 or blank	1 = taxon has silk
Morph_adapt_suckers	Number (binary)—1 or blank	1 = taxon has suckers
NoAquatic_stages	Text (categorical)	Number of aquatic life stages
O2_comments	Text (categorical)	General oxygen tolerance categories: high, moderate, moderate-high, low, low-moderate, anaerobic, low-anaerobic, no strong preference
O2_high	Number (binary)—1 or blank	1 = Oxygen tolerance—high dissolved oxygen (DO) levels
O2_low	Number (binary)—1 or blank	1 = Oxygen tolerance—low DO levels
O2_normal	Number (binary)—1 or blank	1 = Oxygen tolerance—normal (intermediate) DO levels
Order	Text	Taxonomic level
Ovipos_behav_comments	Text	Oviposition behavior text notes
Ovipos_behav_prim	Text	Primary oviposition behavior

Variable	Data Type	Description
Ovipos_behav_sec	Text	Secondary oviposition behavior
Ovipos_duration	Text	Duration of oviposition period. Entries = days, months, weeks
pH_acidic	Number (binary)—1 or blank	1 = pH tolerance—acidic
pH_alkaline	Number (binary)—1 or blank	1 = pH tolerance—alkaline
pH_comments	Text (categorical)	General pH tolerance categories: acidic, acid-neutral, alkaline, alkaline-neutral, neutral, no strong preference
pH_normal	Number (binary)—1 or blank	1 = pH tolerance—intermediate
Primary_WB_type	Text	Primary waterbody type where organism is found
Published	Yes/no	Yes/no
Resp_abbrev	Text (categorical)	Abbreviated respiration entries = tegument, gills, plastron_spiracle
Resp_adult	Text	Respiration mode of aquatic adults
Resp_comments	Text	Respiration text notes
Resp_early	Text	Respiration mode of early instars
Resp_late	Text	Respiration mode of late instars
Rheophily_abbrev	Text (categorical)	Abbreviated rheophily entries: depo, depo_eros, eros
Rheophily_comments	Text	Description of abbreviated rheophily entries: depo = depositional only, depo_eros = depositional and erosional; eros: erosional only. Other (categorical) entries include: fast, moderate, moderate-fast, standing and flowing, standing-slight, slight
Salin_brackish	Number (binary)—1 or blank	1 = salinity tolerance—brakish
Salin_fresh	Number (binary)—1 or blank	1 = salinity tolerance—fresh
Salin_salt	Number (binary)—1 or blank	1 = salinity tolerance—saline
Study_Citation	Text	Citation
Study_Citation_abbrev	Text	Abbreviated citation
Study_dates	Format varies: e.g., Summer 1997, May-87, 1981−1982	Date of study
Study_elevation_max	Number (integer)	Upper elevation where taxon reported (in meters above sea level)

Variable	Data Type	Description
Study_elevation_min	Number (integer)	Lower elevation where taxon reported (in meters above sea level)
Study_latitude	Format varies: e.g., 34° 54 3.4" or 28º 48' 32" N	Latitude, when reported in study
Study_location_county	Text	U.S. county in which study occurred
Study_location_region	Text	Region in which study occurred
Study_location_state	Text	U.S. state or Canadian province in which study occurred
Study_longitude	Format varies: 79° 20' 56.3" or 97º 01' 45: W	Longitude, when reported in study
SwimmingAbility_abbrev	Text (categorical)	Abbreviated swimming ability entries: none, weak strong
Taxon	Text	Highest level of taxonomic resolution
Thermal_comments	Text	Text notes pertaining to thermal entries. Where applicable, includes brief descriptions of how the lists of cold and warm preference taxa were derived.
Thermal_eurythermal	Number (binary)—1 or blank	1 = taxon documented in eurythermal (≥15°C) temperature range
Thermal_euthermal	Number (binary)—1 or blank	1 = taxon documented in euthermal (≥30°C) temperature range
Thermal_Indicator	Text (categorical)	Cold and warm water preference taxa for particular states or regions. NOTE: these lists are preliminary.
Thermal_mesothermal	Number (binary)—1 or blank	1 = taxon documented in mesothermal (15−30°C) temperature range
Thermal_metathermal	Number (binary)—1 or blank	1 = taxon documented in metathermal (5−15°C) temperature range
Thermal_oligothermal	Number (binary)—1 or blank	1 = taxon documented in oligothermal (<15°C) temperature range
Thermal_pref	Text (categorical)	General thermal preference categories: cold stenothermal (<5°C), cold-cool eurythermal (0−15°C), warm eurythermal (15−30°C), hot euthermal (>30°C), no strong preference
Thermal_Source	Text	Brief description of how the ThermalOptima and ThermalTolerance values were derived, and of the data sets that were used in these calculations

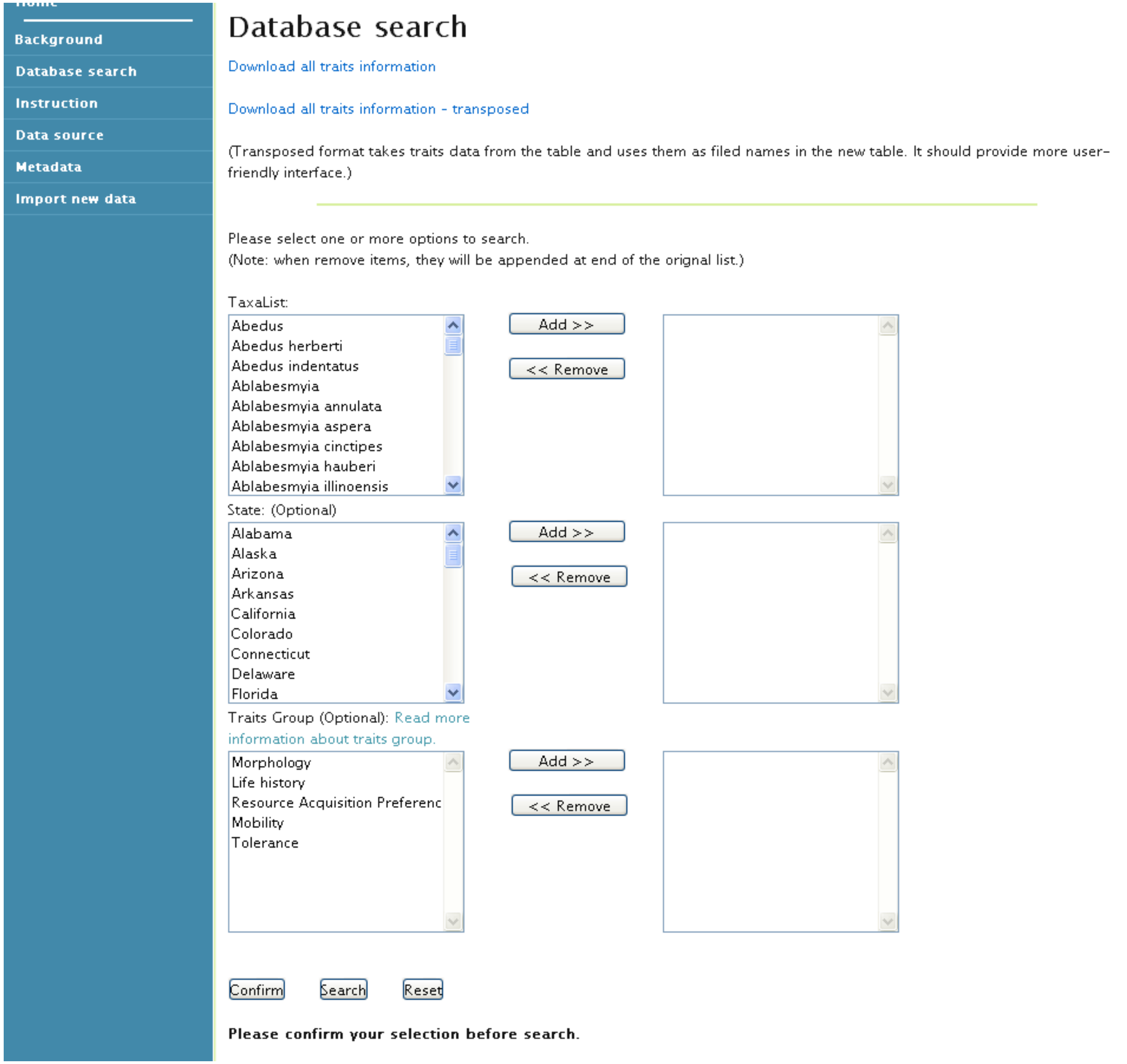
Variable	Data Type	Description
Thermal_stenothermal	Number (binary)—1 or blank	1 = taxon documented in stenothermal (≤5°C) temperature range
ThermalOptima	Number (decimals)	Numerical optima values for temperature data that were derived from weighted average or maximum likelihood calculations
ThermalOptima_Rank	Number (integers)	Rank optima value for temperature data (based on a scoring scale of 1−7)
ThermalRank_comments	Text	Description of how thermal rankings were derived. The 1−7 scoring scheme is based on the following percentiles: 0, 0.1, 0.25, 0.4, 0.6, 0.75, 0.9, 1, such that low ThermalOptima_Rank scores = preference for colder water and high ThermalOptima_Rank scores = preference for warmer water, and low ThermalTolerance_Rank scores = narrow temperature range and high ThermalTolerance_Rank scores = wide temperature range. Rankings allow for comparisons across data sets, because optima and tolerance values will vary depending on the data set they were derived from.
ThermalTolerance	Number (decimals)	Numerical tolerance values for temperature data that were derived from weighted average or maximum likelihood calculations
ThermalTolerance_Rank	Number (integers)	Rank tolerance value for temperature data (based on a scoring scale of 1−7)
TraitRecord_ID	Number (integer)	This is a unique ID that came from the source documents. It is being retained in case there is a need to link back to the original source.
TSN	Number (integer)	Taxonomic serial number (from itis.gov Web site)
Turbidity	Text (categorical)	General turbidity tolerance categories: clear water, silted/murky water, no preference
Vert_bed	Number (binary)—1 or blank	1 = Vertical habitat position in water column—benthic
Vert_comments	Text	Vertical habitat position in water column text notes
Vert_hyporheic	Number (binary)—1 or blank	1 = Vertical habitat position in water column—hyporheic
Vert_pelagic	Number (binary)—1 or blank	1 = Vertical habitat position in water column—pelagic

Variable	Data Type	Description
Vert_phytes	Number (binary)—1 or blank	1 = Vertical habitat position in water column—macrophytes
Vert_surface	Number (binary)—1 or blank	1 = Vertical habitat position in water column—surface
Volt_Comments	Text	Voltinism text comments (i.e., overwintering of eggs or immatures)
Voltinism	Text	Voltinism. Entries: >1 generation per year, 1 generation per year, <1 generation per year
Voltinism_abbrev	Text (categorical)	Abbreviated voltinism entries: semivoltine, univoltine, bi_multivoltine
WB_type_2-4_order	Number (binary)—1 or blank	1 = taxon is found in second-through-fourth- order streams
WB_type_brackish	Number (binary)—1 or blank	1 = taxon is found in brackish waters
WB_type_cold_sp	Number (binary)—1 or blank	1 = taxon is found in cold springs
WB_type_eph_lotic	Number (binary)—1 or blank	1 = taxon is found in ephemeral lotic waters
WB_type_headwater	Number (binary)—1 or blank	1 = taxon is found in headwater streams
WB_type_lake	Number (binary)—1 or blank	1 = taxon is found in lakes
WB_type_other	Number (binary)—1 or blank	1 = taxon is found in an unlisted waterbody type
WB_type_other_specify	Text	Describes WB_type_other entry
WB_type_pond	Number (binary)—1 or blank	1 = taxon is found in ponds
WB_type_river	Number (binary)—1 or blank	1 = taxon is found in rivers
WB_type_temp_lentic	Number (binary)—1 or blank	1 = taxon is found in temporary lentic waters
WB_type_warm_sp	Number (binary)—1 or blank	1 = taxon is found in warm springs
WB_type_wetland	Number (binary)—1 or blank	1 = taxon is found in wetlands

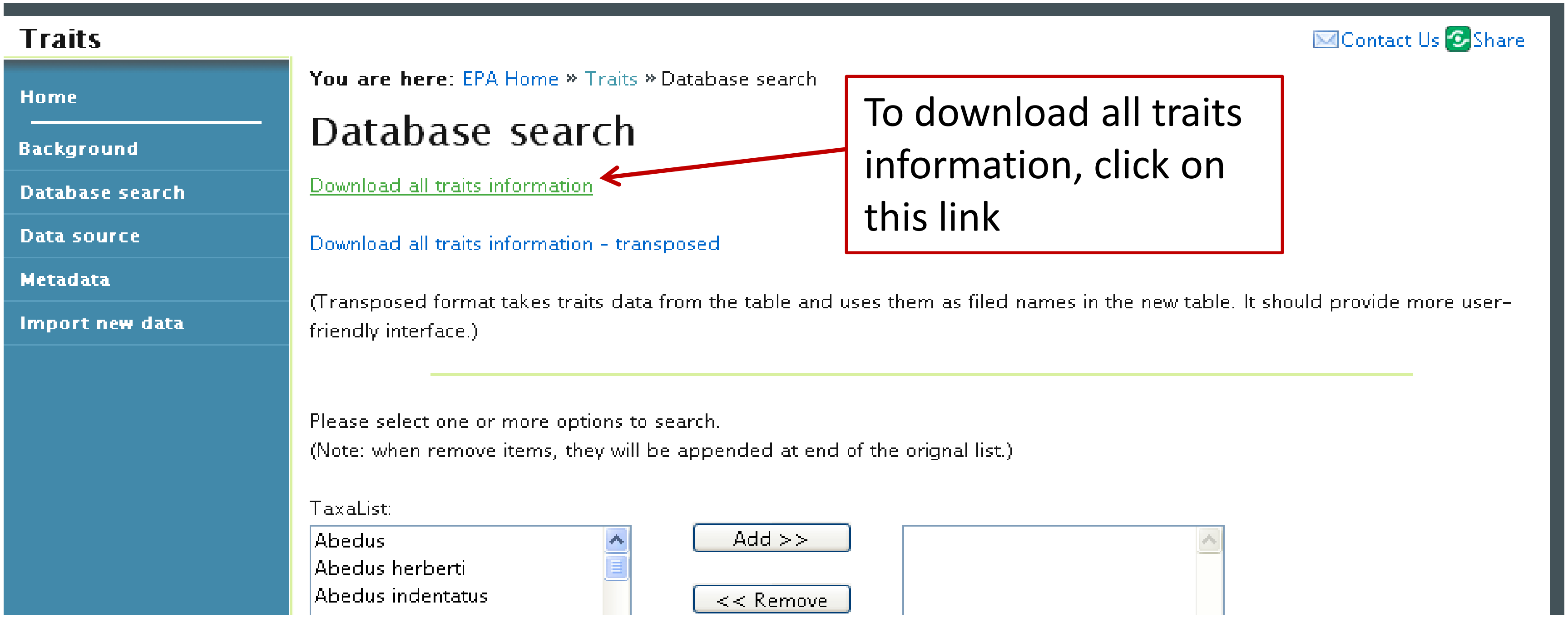
APPENDIX E

Instructions for Using the Freshwater Biological Traits Database

Access the Traits Database at http://www.epa.gov/ncea/global/traits. There are several different options for downloading data.



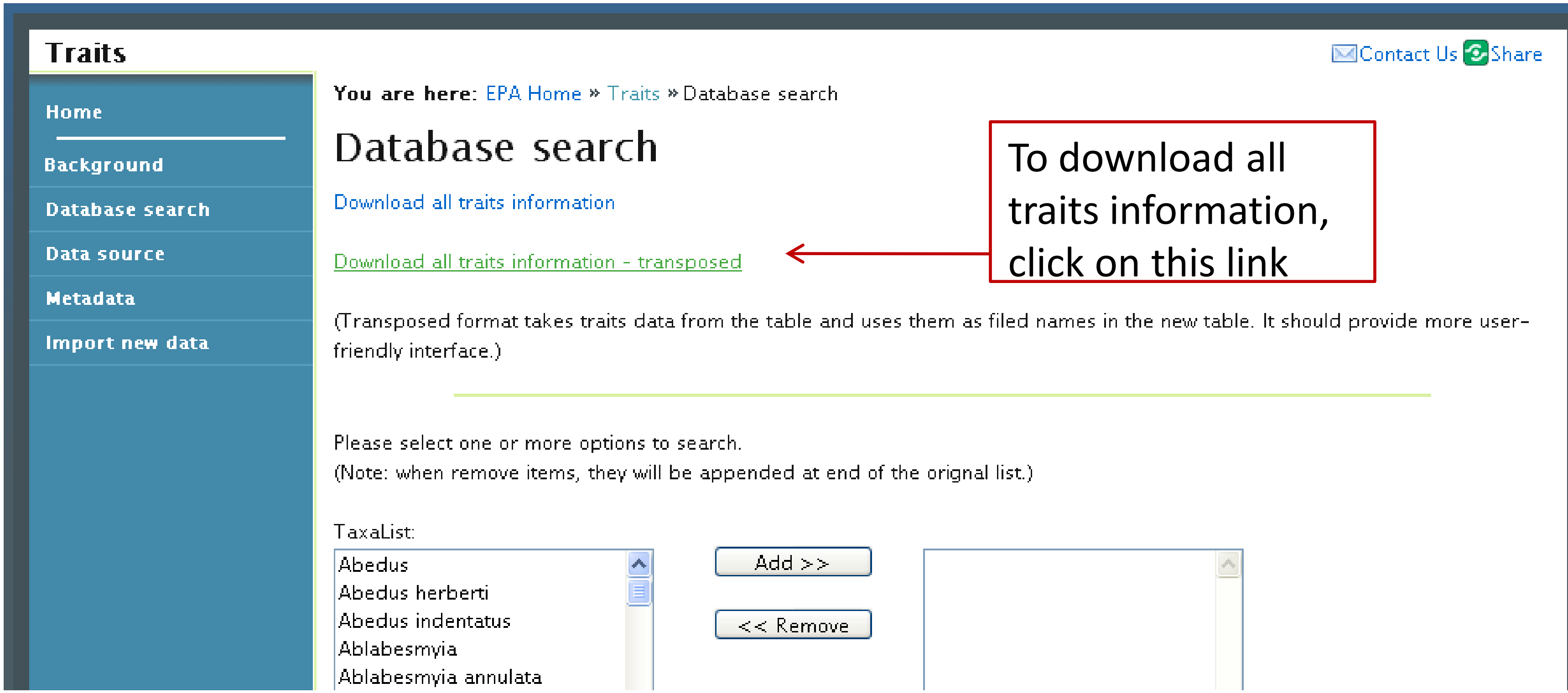
OPTION 1: DOWNLOAD ALL DATA



To download all the data (i.e. you do not want to select for taxa, state or trait group), click on the 'Download all traits information' link.

A zipped Excel file titled 'FreshwaterBioTraits_20100927.zip' will automatically download onto your computer.

OPTION 2: DOWNLOAD ALL DATA – TRANSPOSED FORMAT



To download all the data in a transposed format, click on the 'Download all traits information - transposed' link.

A zipped Excel file titled 'FreshwaterBioTraits_Transposed_20100927.zip' will automatically download onto your computer.

Why the two formats?

Data is stored in the database in the format shown below because it is more efficient than the transposed format (it eliminates all the blanks, of which there are many in this database).

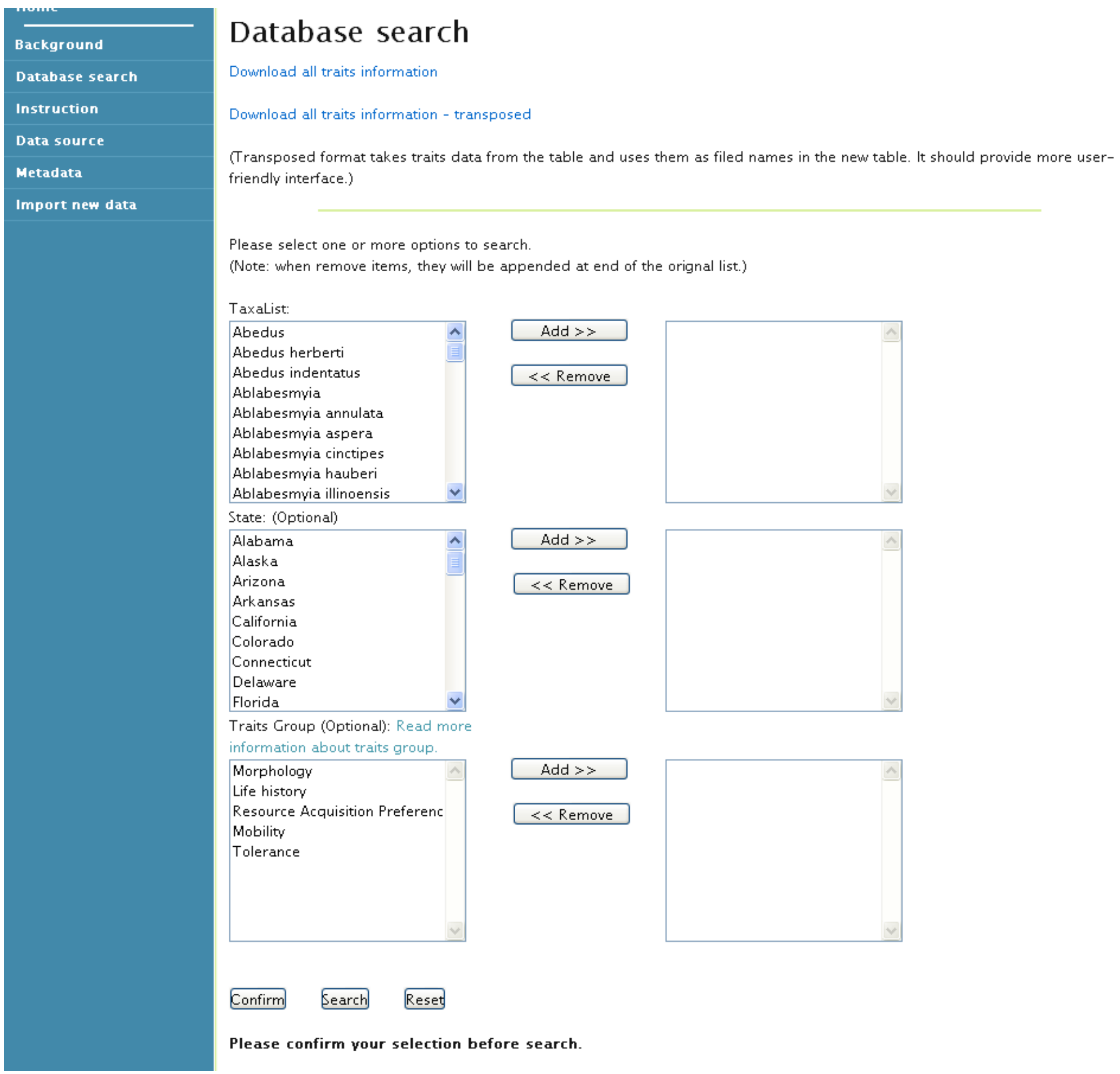
A	B	C	D	E	F
TAXON	CATEGORY_NAME	TRAITS_NAME	VALUE_YN	VALUE_NUMBER	VALUE_TEXT
Acentrella	Waterbody Type	Second-fourth order streams	Y		
Acentrella	Morphology - Adaptation	Suckers	Y		
Acentrella	Mobility	Swimming ability			strong
Acentrella	Tolerance	Thermal Indicator			cold
Acentrella	Tolerance	Thermal optima rank		3	
Acentrella	Tolerance	Thermal optima value		16.92	
Acentrella	Tolerance	Thermal tolerance rank		4	
Acentrella	Resource Acquisition Preference	Vertical habitat position benthic	Y		
Acentrella	Resource Acquisition Preference	Vertical habitat position	Y		
Acentrella	Life history - emergence	Voltinism			> 1 Generation per year

Although it may be more efficient at storing data, it is likely to be less user-friendly for many of you, so we wanted to provide you with the option of downloading the data in a transposed format, as shown below (trait names are column headings, etc.).

TSN	Taxon	Study_Citation_abbrev	WB_type_headwater	WB_type_2-4_order	Max_body_size	Body_shape_abbrev	ThermalOptima
100801	Acentrella	EPA GCRP North Carolina (2010)		1		streamlined	16.93
100801	Acentrella	EPA GCRP Maine (2010)		1		streamlined	20.61
100801	Acentrella	Rankin and Yoder (2009)		1			23.90
100801	Acentrella	Yuan (2006)		1			17.00
100801	Acentrella	USGS (2006)		1			
100801	Acentrella	Poff et al. (2006)		1	Small (length < 9 mm)	streamlined	
609528	Acentrella alachua	USGS (2006)		1	Small (length < 9 mm)		
568571	Acentrella ampla	USGS (2006)		1			
568571	Acentrella ampla	USGS (2006)		1			
568571	Acentrella ampla	USGS (2006)		1	Small (length < 9 mm)		
609529	Acentrella feropagus	USGS (2006)			Small (length < 9 mm)	streamlined	
568572	Acentrella	Oregon DEQ (2008)		1			22.20

OPTION 3: DOWNLOAD SELECTED DATA

You can select for taxa, state (optional) and/or trait group (optional)



SELECTING FOR A TAXON OR MULTIPLE TAXA – Step 1: Highlight the taxa of interest

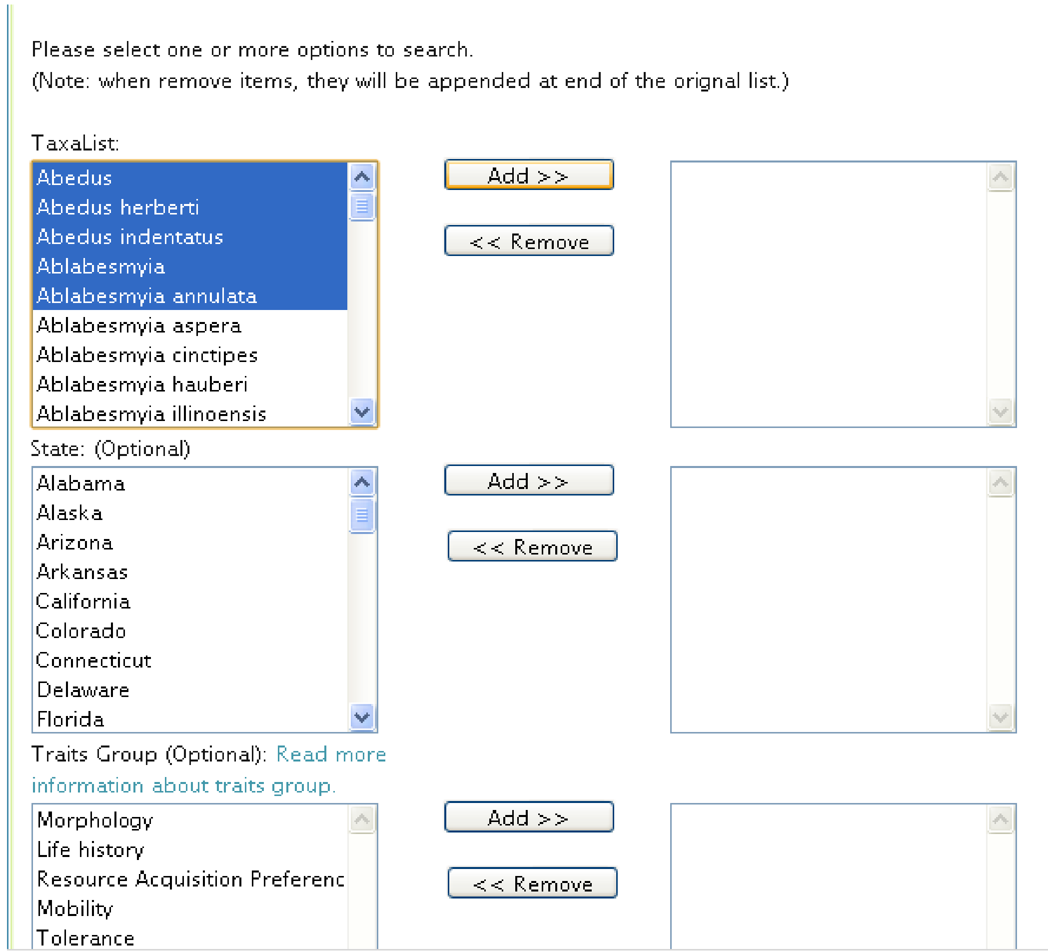
The taxa list is sorted alphabetically.

You can select a single taxon or multiple taxa.

To select a single taxon, click on the name of the taxon. The name will then be highlighted.

To select multiple taxa, if sequential, you can hold the shift key down while left clicking on the taxa of interest. If not sequential, use Ctl+Shift to make your selections, or select each taxa and click on 'Add' individually.

You will see the selected taxa highlighted in blue.

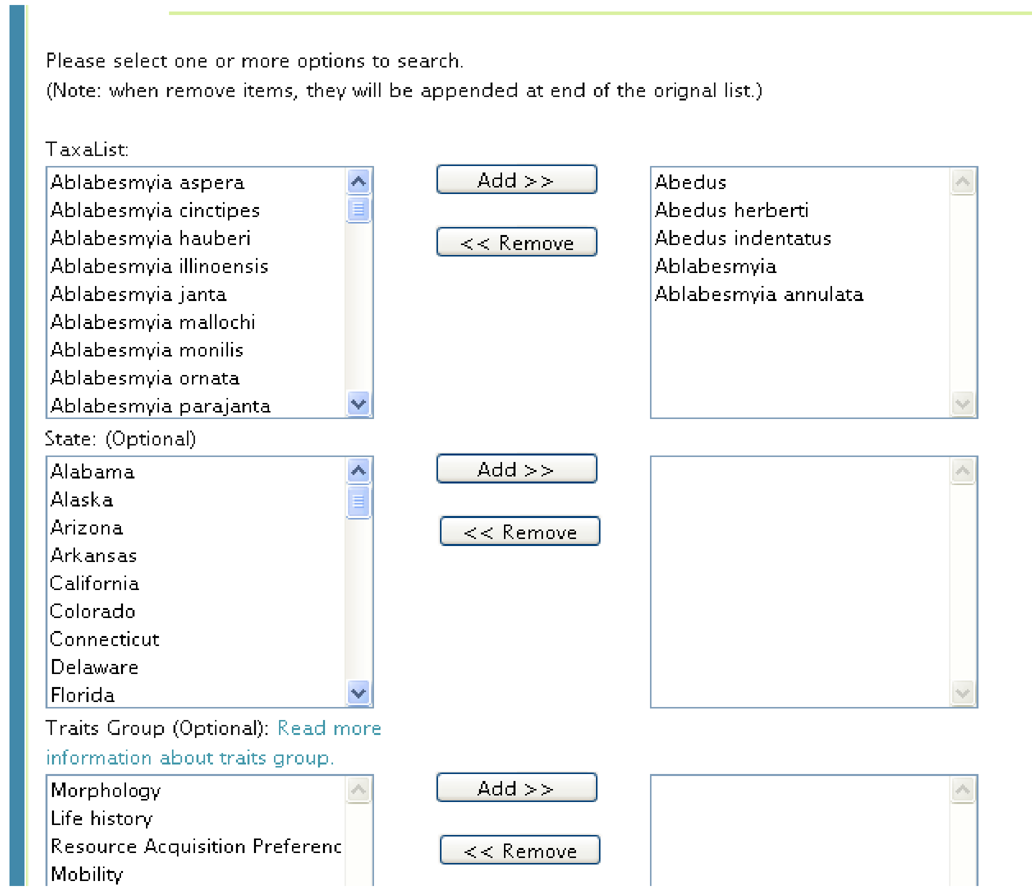


SELECTING FOR A TAXON OR MULTIPLE TAXA – Step 2: Click ‘Add’

After you click ‘Add,’ the names of the highlighted taxa will appear in the box to the right, as shown.

If you would like to remove any of these taxa from this list, click ‘Remove.’

The names of the removed taxa will be appended to the bottom of the taxa list. If you want to resort the taxa list, click the ‘Reset’ button at the bottom of the page.



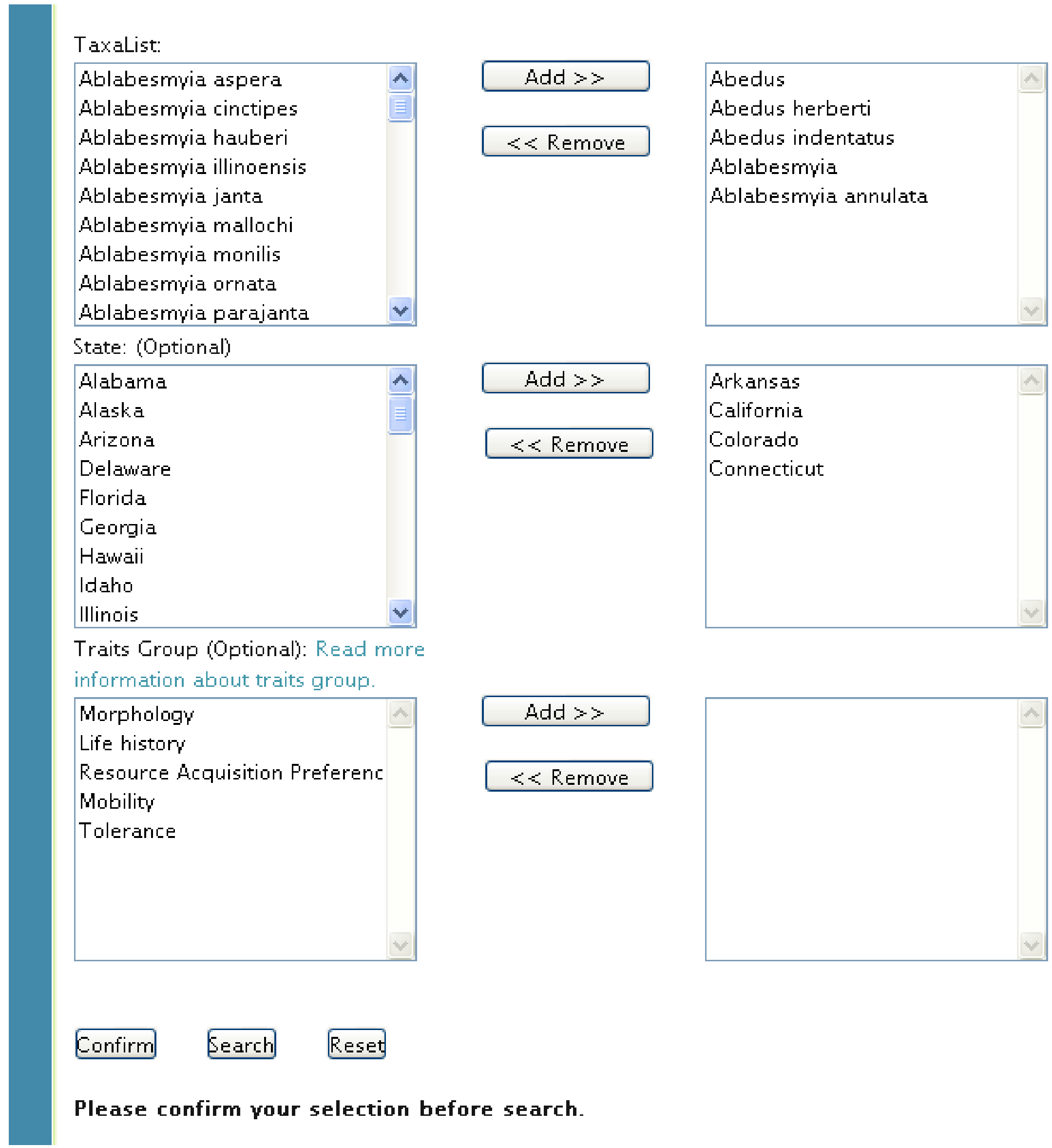
SELECTING FOR A STATE (OPTIONAL) –

You have the option of selecting a state or multiple states.

You can do so by following the same instructions as above.

If you do not select a state, all records will be shown.

IMPORTANT NOTE: search on this field with caution; this type of geographical information has not been entered for all of the records.



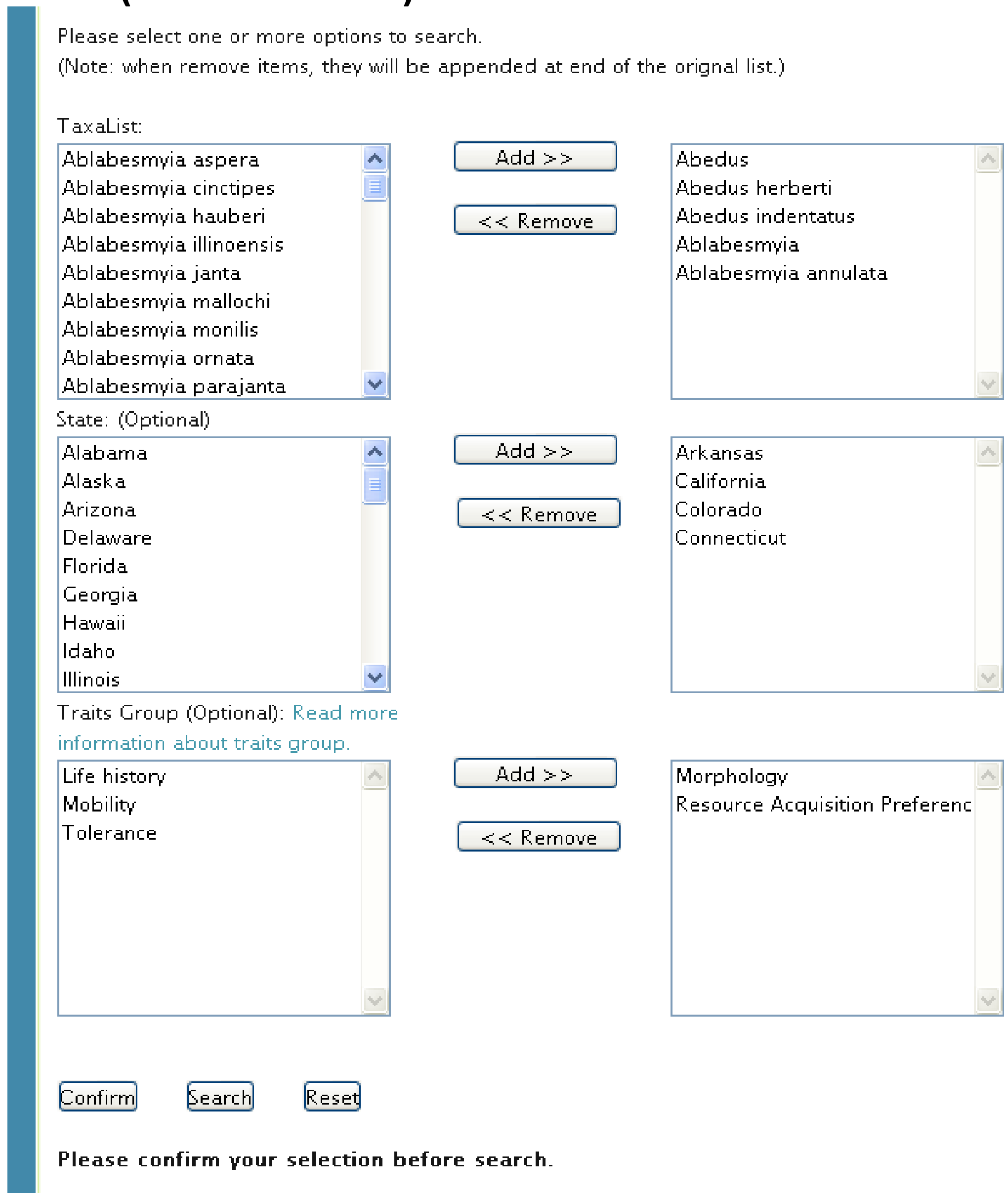
SELECTING FOR A TRAIT GROUP (OPTIONAL) –

You have the option of selecting one or multiple trait groups.

You can do so by following the same instructions as above.

If you do not select a trait group, all records will be shown.

To see which traits are included in each trait group, click on the 'read more information about traits group' link.

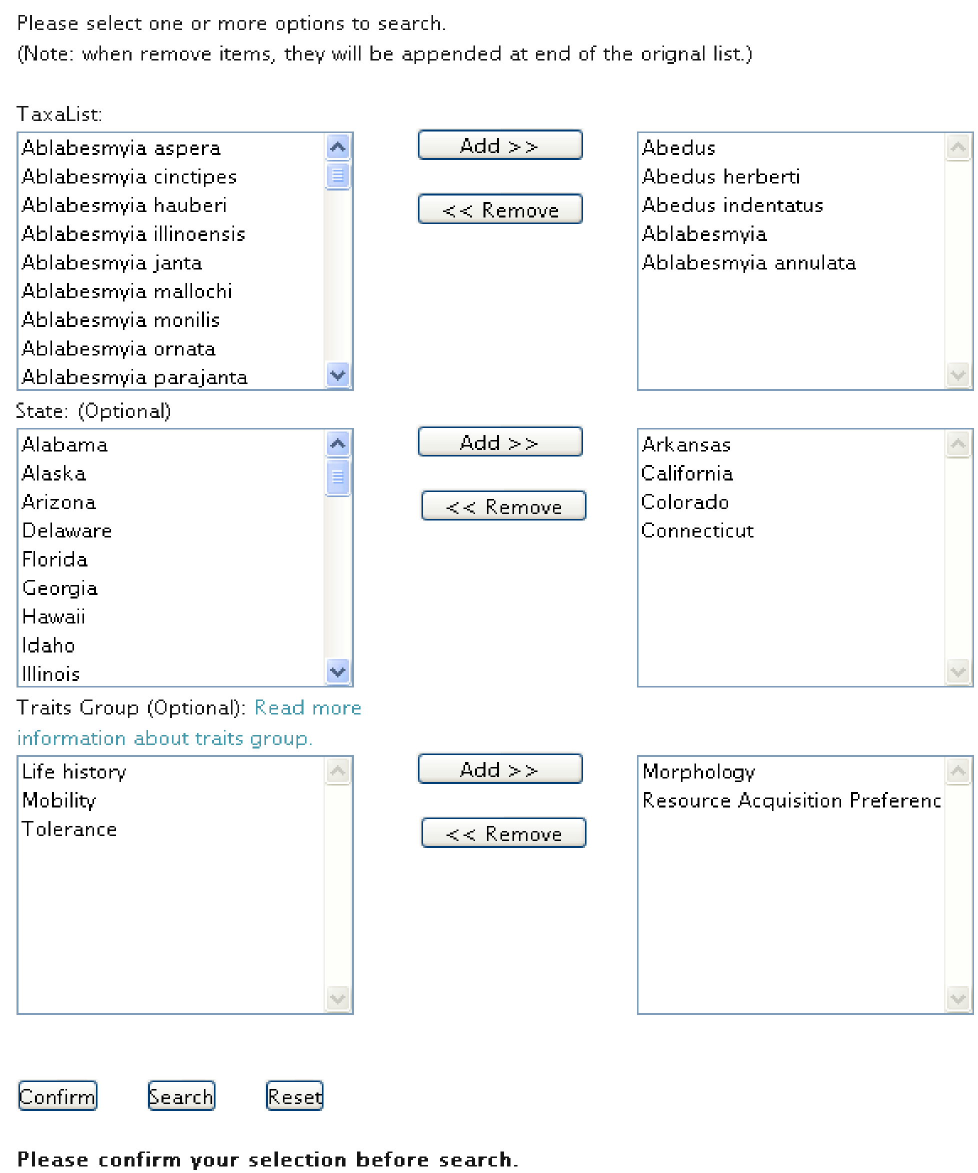


4. CLICK 'CONFIRM'

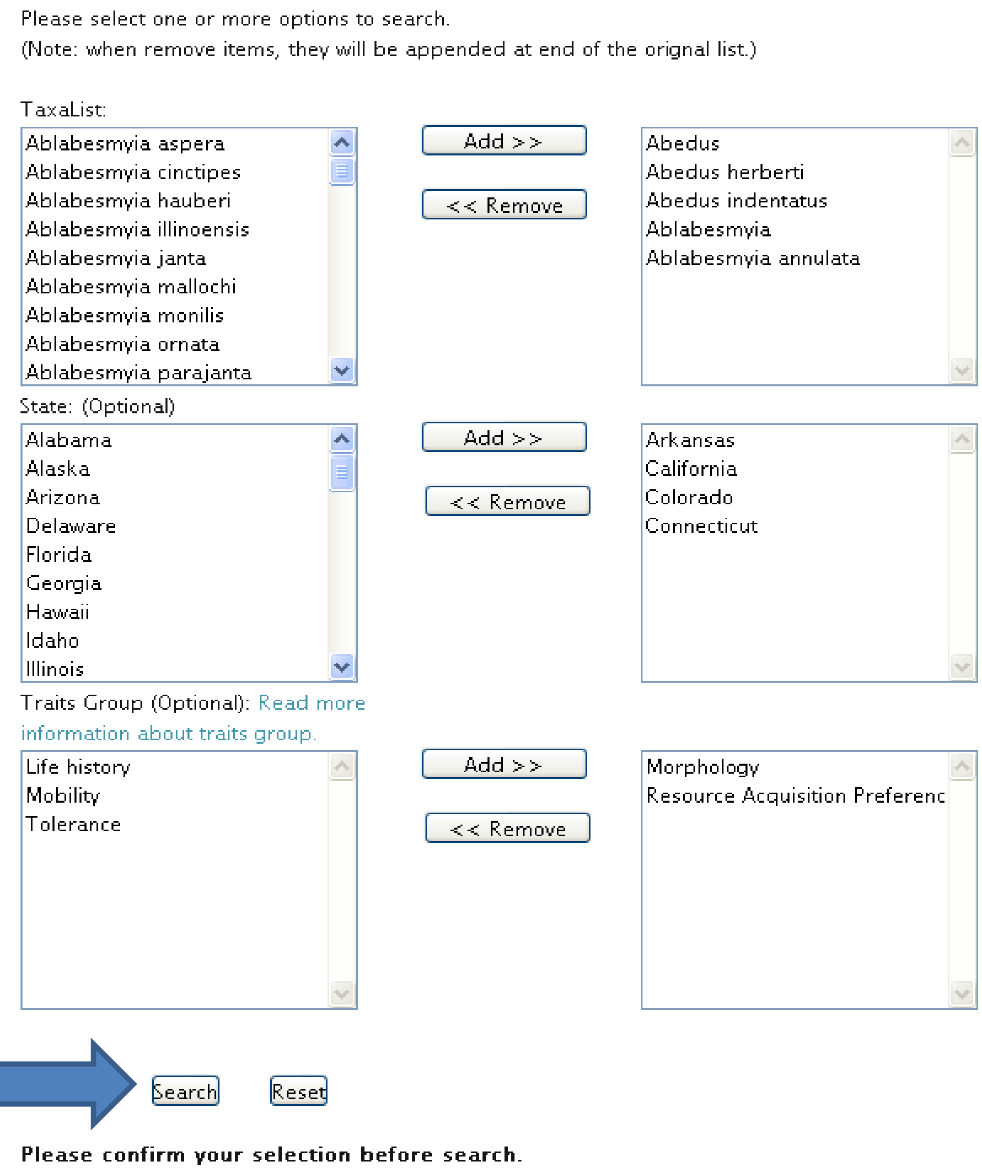
Important!
Do not forget to do this, otherwise you will get an error message when you try to do the data download.

After you click 'confirm,'the selections you have made will be highlighted in gray.

Click on this!



5. CLICK 'SEARCH'



Then click on this!

6. SELECT CITATIONS

You are given a choice of citations.

To find out more about the citations, click on the arrow next to the Data Source column heading, and you will be taken to the Data Source page.

To select individual citations, click on the check boxes.

Or to select all records, click 'select all.'

If, after doing so, you decide you don't want to select them all, click the 'uncheck all' button.

Database search

Here is your search critera:

Taxa List:('Abedus','Abedus herberti','Abedus indentatus','Ablabesmyia','Ablabesmyia annulata','Ablabesmyia aspera','Ablabesmyia cinctipes','Ablabesmyia hauberi')
State List:('Arizona','Arkansas','California','Colorado','Connecticut','Delaware','Florida','Georgia','Hawaii','Idaho','Illinois','Indiana','Iowa
Traits Groups: ('Mobility','Morphology','Resource Acquisition Preference')

Please select the items to download:

Select All | Uncheck All

	Taxon	TSN	Citation	Country	Region	State	Data Source
☐ 3654	Abedus	103721	Aquatic Insects and Oligochaetes of North and South Carolina.	United States	Gulf Coast / Delta Area (TX – FL)	Mississippi	Vieira, N.K.M., N.L. Poff, D.M. Carlisle, S.R. Moulton II, M.K. Koski, and B.C.Kondratieff. 2006. A database of lotic invertebrate traits for North America: U.S. Geological Survey Data Series 187. Available at: http://pubs.water.usgs.gov/ds187
☐ 3663	Ablabesmyia	128079	Secondary production of Chironomidae (Diptera)	United States		Indiana	Vieira, N.K.M., N.L. Poff, D.M. Carlisle, S.R. Moulton II, M.K. Koski, and B.C.Kondratieff. 2006. A database of lotic invertebrate traits for North America: U.S. Geological Survey Data Series 187. Available at: http://pubs.water.usgs.gov/ds187
☐ 3666	Ablabesmyia	128079	Freshwater Biological Traits Table for Maine	United States		Maine	EPA GCRP State Biomonitoring Data Climate Change Pilot Project 2010: Freshwater Biological Traits Table for Maine (traits data came from several different sources (main sources were Vieira et al. 2006 and the Poff et al. 2006 trait matrix).
☐ 3660	Abedus herberti	103731	An Introduction	United States		Arizona	Vieira, N.K.M., N.L. Poff, D.M. Carlisle, S.R. Moulton II, M.K. Koski, and

Whichever citations have checks in the checkboxes will be included in your data output file.

Why are their multiple records for one taxon?

Data has been compiled from numerous different sources. Traits information for a taxon can differ depending on the source. That is why each taxon-citation combination has been entered as a unique record.

7. DOWNLOAD THE DATA

Click on the ‘Download traits information to Excel’ button at the bottom of the page.

Click on this!

Database search

Here is your search critera:

Taxa List: ('Abedus','Abedus herberti','Abedus indentatus','Ablabesmyia','Ablabesmyia annulata','Ablabesmyia aspera','Ablabesmyia cinctipes','Ablabesmyia hauberi')
State
List: ('Arizona','Arkansas','California','Colorado','Connecticut','Delaware','Florida','Georgia','Hawaii','Idaho','Illinois','India
Traits Groups: ('Mobility','Morphology','Resource Acquisition Preference')

Please select the items to download:

Select All | Uncheck All

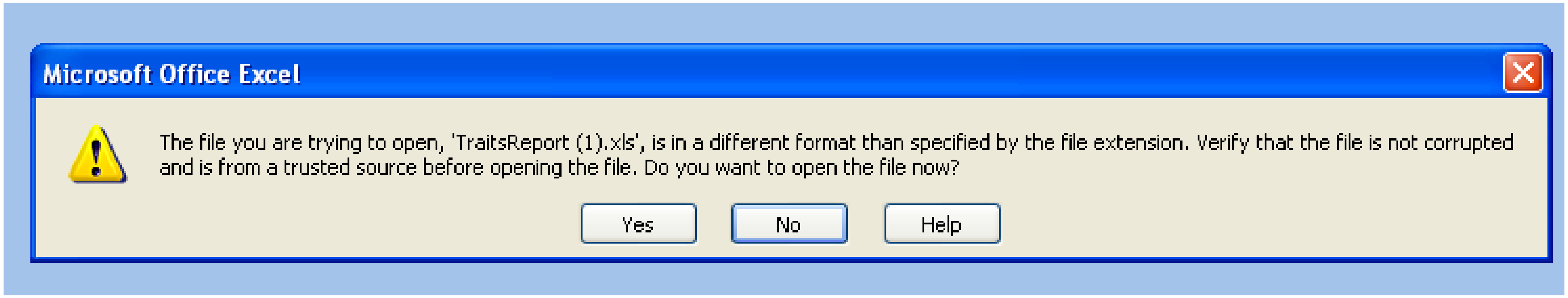
	Taxon	TSN	Citation	Country	Region	State	Data Source
☑ 3654	Abedus	103721	Aquatic Insects and Oligochaetes of North and South Carolina.	United States	Gulf Coast / Delta Area (TX – FL)	Mississippi	Vieira, N.K.M., N.L. Poff, D.M. Carlisle, S.R. Moulton II, M.K. Koski, and B.C.Kondratieff. 2006. A database of lotic invertebrate traits for North America: U.S. Geological Survey Data Series 187. Available at: http://pubs.water.usgs.gov/ds187
☑ 3663	Ablabesmyia	128079	Secondary production of Chironomidae (Diptera)	United States		Indiana	Vieira, N.K.M., N.L. Poff, D.M. Carlisle, S.R. Moulton II, M.K. Koski, and B.C.Kondratieff. 2006. A database of lotic invertebrate traits for North America: U.S. Geological Survey Data Series 187. Available at: http://pubs.water.usgs.gov/ds187
☑ 3666	Ablabesmyia	128079	Freshwater Biological Traits Table for Maine	United States		Maine	EPA GCRP State Biomonitoring Data Climate Change Pilot Project 2010: Freshwater Biological Traits Table for Maine (traits data came from several different sources (main sources were Vieira et al. 2006 and the Poff et al. 2006 trait matrix).
☑ 3660	Abedus herberti	103731	An Introduction to the Aquatic Insects of North America	United States		Arizona	Vieira, N.K.M., N.L. Poff, D.M. Carlisle, S.R. Moulton II, M.K. Koski, and B.C.Kondratieff. 2006. A database of lotic invertebrate traits for North America: U.S. Geological Survey Data Series 187. Available at: http://pubs.water.usgs.gov/ds187

Download Traits Information to Excel

8. RETRIEVE THE EXCEL FILE FROM YOUR DOWNLOAD FOLDER

The Excel file will be named 'TraitsReport.'

When you go to open the file, you will most likely receive an error message like the one shown below. Do not be alarmed. Just click 'Yes' and the file should open without a problem.



Congrats! You have completed your first successful download!

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Environmental Protection
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