Bay Watershed Action Grant Final Report

Ecosystem Science in Community Action: A Report on the Integrated Watershed Assessment and Outreach Project in the Branch River Watershed, Rhode Island and Massachusetts

December 2005

By Kristen Puryear, Conservation Biologist
Rhode Island Natural History Survey

RHODE ISLAND
NATURAL HISTORY SURVEY
Providing Ecosystem Science and Information

In partnership with:
Rhode Island Rivers Council
Rhode Island Land Trust Council
Blackstone River Coalition

Table of Contents

List of Figures

List of Appendices

Introduction

The goal of this project was to pilot Ecosystem Science in Community Action, a new working relationship among three of Rhode Island's statewide organizations with missions to promote good land stewardship – The Rhode Island Natural History Survey (RINHS), the RI Rivers Council, and the RI Land Trust Council. The purpose of Ecosystem Science in Community Action was to bring the science capabilities of RINHS to local organizations that need them, using existing networks of contacts available through the Rivers Council and Land Trust Council, with the result that local, grassroots organizations can use science activities to attract public participation and build their own capacity to use and understand ecosystem science. In addition, the scientific questions that we pursued were designed to provide results that could further the local partners' own organizational priorities.

The pilot project for this partnership is an Integrated Watershed Assessment and Outreach, an assessment of the health of the HUC-12 basin of the Branch River, in Burrillville and North Smithfield, RI, and Uxbridge, Mass. (Figure 1), using three assessment criteria – 1) human disturbance measured using satellite imagery to determine impervious surface as a percentage of land area and vegetated riparian buffer as a ratio of vegetated to unvegetated stream bank length, 2) the ratio of potential to observed odonate community diversity, and 3) qualitative assessment of benthic habitat health based on observed aquatic macroinvertebrate and vertebrate community diversity.

The Branch River, a sub-basin of the Blackstone River, was chosen for this project because 1) it met the needs of the Blackstone River Coalition, which is looking for help recruiting volunteers for its watershed monitoring and outreach projects, particularly in the RI portion of the Blackstone watershed, and 2) it would help RINHS refine bioassessment strategies for watershed-scale projects. In addition, RINHS has a large data set available for the Branch from its Odonata Atlas of Rhode Island project.

By working on a watershed-wide scale, and partnering with two organizations that serve as umbrellas for many land trusts and watershed groups, RINHS hoped multiple organizational benefits would be achieved by all three partners. First, RINHS could connect to a wide network of organizations (through the Rivers Council and the Land Trust Council), and find new users of its ecosystem science services. Second, the Rivers Council and Land Trust Council would be able to provide sound scientific data from the watershed to their constituents, to be used to help build their capacity for conservation management, planning, and stewardship. Third, the partners could advance their own outreach and organizing efforts through a series of public events where volunteers could be introduced to the collection of natural history data, and contribute to the data gathering process.

This report summarizes the Integrated Watershed Assessment and Outreach project results in three ways: 1) to present and discuss the scientific data gathered by researchers and volunteers, 2) to evaluate the scientific and organizational values of this process, and 3) to provide project partners with recommendations for future application of the Branch River watershed data, and biological assessment and outreach methodologies.

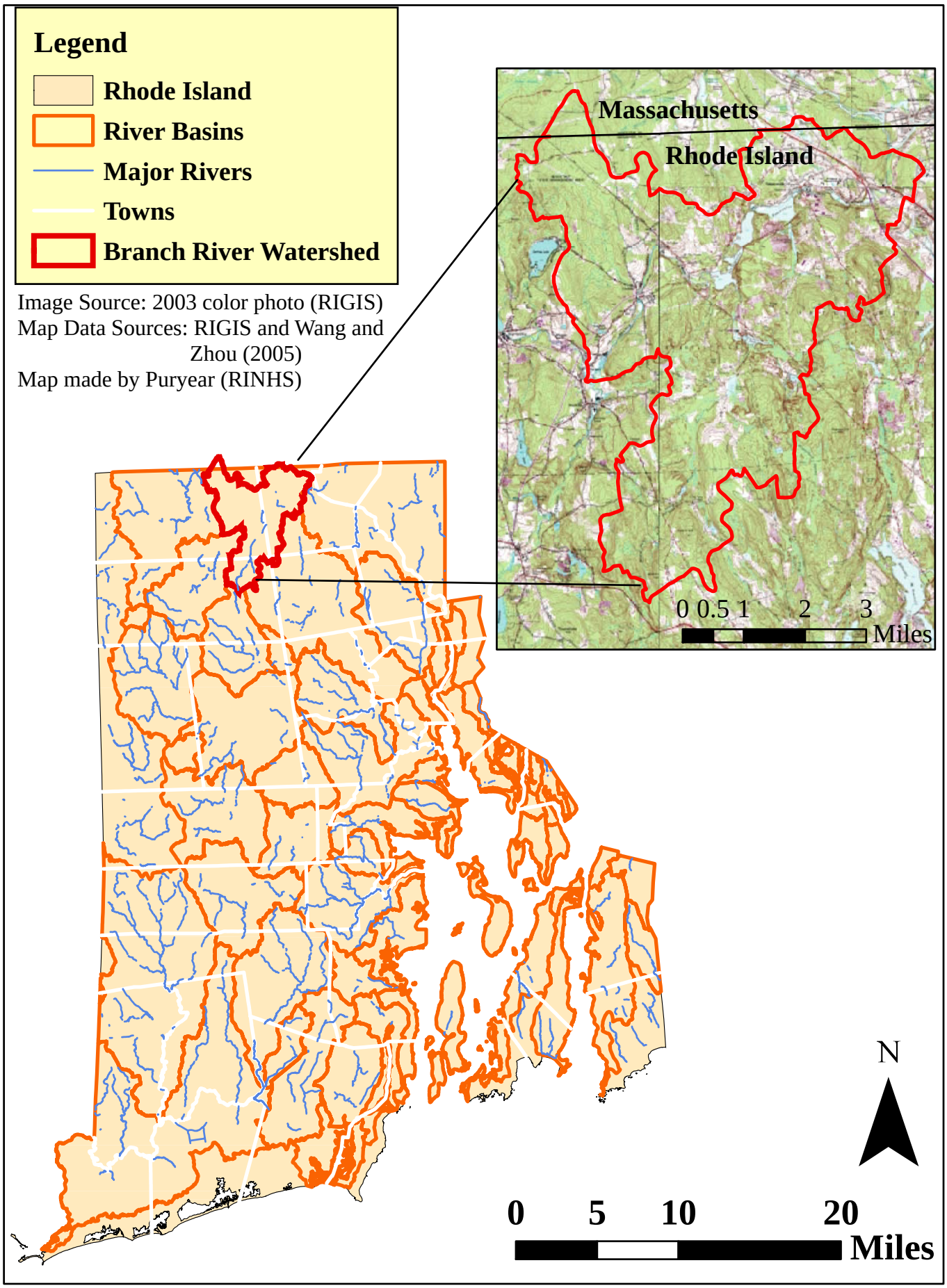


Figure 1. Map of Branch River watershed project area in Rhode Island and Massachusetts. The Branch River watershed was the focus of the Bay Watershed Action Grant project called Ecosystem Science in Community Action.

Methods, Partners, and Events

RINHS connected with potential volunteers and interested community members and organizations through work in the field, in the classroom, and at a series of scheduled public events and meetings.

Public Meetings

On May 25 RINHS and the Blackstone River Coalition (BRC) held an initial public meeting in North Smithfield, RI. The meeting was advertised through local and regional newspapers, email discussion forum lists, and contact with organization members. The purpose of this initial meeting was to allow RINHS and BRC to present the project goals and methods, and then moderate an open discussion with attendees to assess their interest in the project, identify segments of the river that peaked their interest, and recruit volunteers for field surveys.

A second public meeting was held in November to present the results of the outreach efforts and scientific surveys within the Branch watershed. This final meeting was meant to wrap up and summarize the results of the project, foster the transfer of scientific and technical knowledge between groups, and provide an opportunity for community and group members to begin discussions about how to use this new information to further their own watershed, water quality, and/or organizational goals.

Collection and Analysis of Existing Data Sets

Following the first public meeting, we proceeded with collecting environmental health data for the watershed through field surveys and research into existing data sets. Ten years of existing fisheries data from the watershed were contributed by the Department of Environmental Management, and the locations of rare, threatened, and endangered plant and animal species were compiled from the RI Natural Heritage database (maintained by RINHS).

Virginia Brown (RINHS Contractor) compiled seven years of dragonfly and damselfly data collected for the Odonate Atlas of Rhode Island (Brown, in press), analyzed the results within the Branch River watershed, and identified data gaps that needed additional attention. Seven volunteers assisted Brown with Odonate surveys along the Branch River; six during the Odonate Atlas surveys from 1998-2004 and one in 2005 along under-sampled sections of the watershed.

University of Rhode Island researcher Dr. Y.Q. Wang and graduate student Yuyu Zhou conducted a GIS-based remote sensing analysis of the watershed. Using available Landsat TM imagery and RIGIS land use interpretation maps, they calculated the percent and number of acres of land in impervious surface verses land in forest, wetland, water, or agricultural cover (Appendix A, Wang and Zhou 2005). The Branch River watershed was divided into three zones for the purposes of conducting a comparative analysis within the watershed (Figure 2). Land cover types were calculated for two time periods, 1985 and 1999. The analysis and conclusions based on these four data sets are included in this report, in Appendix A, and in Brown (2005).

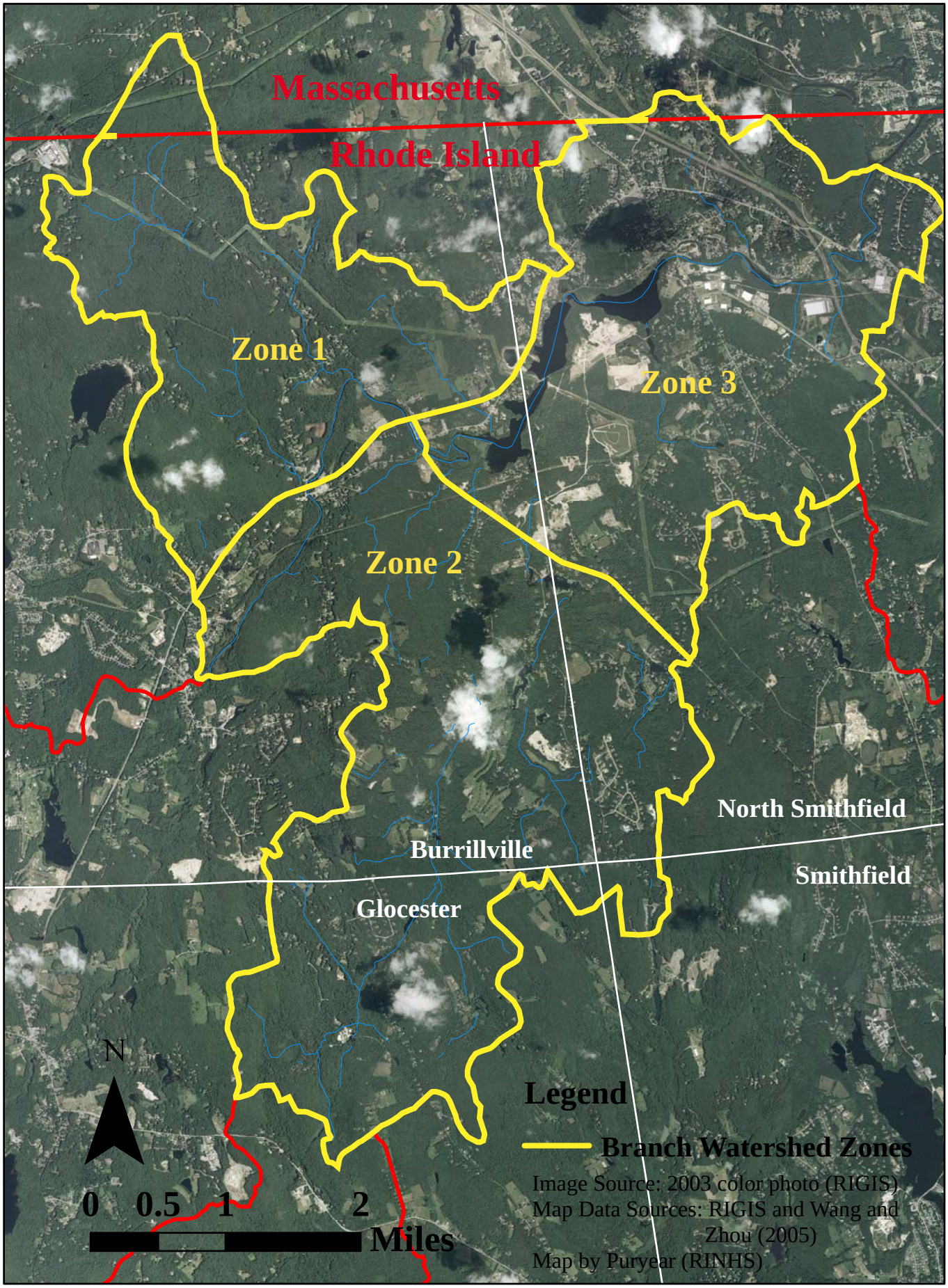


Figure 2. Map of the three Branch River watershed zones that were used for the impervious surface area analysis (Wang and Zhou 2005). Most of the watershed is within Rhode Island, however the northern extent reaches into Uxbridge and Millville Massachusetts. The border between Zones 1 and 2 follows Rt. 102, and the border between Zones 2 and 3 follows Rt. 7.

Volunteer Field Days and Mini-Bioblitz
Volunteers that had been recruited from the initial public meeting and through organizational volunteer pools were contacted for assistance in collecting field data. Volunteers received "on-the-job" training in water quality monitoring techniques, aquatic macroinvertebrate surveys, and plant identification methods. Three volunteers assisted Kristen Puryear (RINHS Conservation Biologist) with biological surveys of the Branch River watershed on three separate dates in July, August, and September. One experienced naturalist also volunteered to help search for rare plant species in an effort to relocate and confirm old records from the RI Natural Heritage Program database.

On July 30th RINHS and the Blackstone River Coalition hosted a mini-Bioblitz at Tarkiln Pond in North Smithfield. RINHS hosts an annual Bioblitz that is designed to get naturalists and taxonomic specialists out into the field to collect as much biological information about a site as possible within a 24-hour period. The idea behind the mini-Bioblitz was to invite the public to spend an afternoon in hands-on exploration of aquatic and riparian area life within one portion of the watershed. Specialists were recruited for the event to help with the biological surveys and to lead educational walks, including:

- Nina Briggs (Volunteer), Odonate survey
- Rick Enser (Zoologist, RI Natural Heritage Program), botanical and bird survey
- David Gregg (Executive Director, RINHS), butterfly survey
- Ray Hartenstine (Volunteer), freshwater mollusc survey
- Sindy Hempstaed (Volunteer), aquatic plant survey
- Alan Libby (Fisheries Biologist, Department of Environmental Management), fish survey
- Kristen Puryear (Conservation Biologist, RINHS), botanical and bird survey

Classroom Outreach
In addition to the field surveys and public events, RINHS also brought concepts of watershed science and watershed stewardship to classrooms in towns surrounding the Branch River. Kristen Puryear (RINHS) collected a sample of aquatic macroinvertebrates from Tarkiln Pond and brought them to two 5th grade classes at Callahan Elementary School. Students were given tools such as hand lenses and easy-to-use insect keys to identify the invertebrates and learn some of the key biological adaptations that allow them to survive. By plugging the students' data into a water quality rating system, their results added to the body of volunteer-collected biological knowledge about the condition of the Branch River. Puryear also brought a lesson on "Water Quality and Watershed Stewardship" to a class of seniors at Burrillville High School. Students learned about how land-use changes can impact water quality and watershed health. They then contributed to the BayWAG project by calculating some of the changes in land-use within the Branch River watershed.

All new data gathered during the project contributed to the watershed assessment reported here and will be added to RINHS databases.

Summary of Methods, Partners, and Events

Methods

Conducted biological surveys using volunteers and specialists
Researched and compiled existing data sets
Presented educational programs (Callahan Middle School, Burrillville High School)
Held public education and outreach events (two public meetings, mini-Bioblitz)
Wrote final reports presenting data and conclusions (Brown 2005, Wang and Zhou 2005, this report)

Organizing and Contributing Project Partners

Rhode Island Natural History Survey
Rhode Island Rivers Council
Rhode Island Land Trust Council
Blackstone River Coalition
Rhode Island Natural Heritage Program
University of Rhode Island Terrestrial Remote Sensing Laboratory
Department of Environmental Management, Division of Fish and Wildlife
Department of Environmental Management, Division of Planning and Development

Organized Events

Public organizational and discussion meetings
Mini-Bioblitz
Educational programs

Members of the public watching a fish shocking demonstration by Alan Libby (Fisheries Biologist, RI Department of Environmental Management) at Tarkiln Pond, Burrillville. This was one of several biological surveys that took place during the mini-Bioblitz on July 30th.

Results of Integrated Watershed Assessment

Public Meetings

On May 25 RINHS and the Blackstone River Coalition held an initial public meeting in North Smithfield, RI. Approximately 25 people attended. In addition to members of the general public, the meeting attracted representatives from the Audubon Society of Rhode Island, Trout Unlimited, the Blackstone River Watershed Coalition, National Park Service (Blackstone Valley Heritage Corridor), Cumberland Conservation Commission, Brown University Center for Environmental Studies, and the local river paddlers club.

The final public meeting and project wrap-up was held on November 9. Attendance was low; however RINHS presented project results, including a summary of the remote sensing analysis, biological surveys, and final recommendations. The Blackstone River Coalition and RINHS began a discussion about strategies for future applications of the project results and ways to disseminate these findings to a larger audience of active watershed and conservation groups.

Mini-Bioblitz at Tarkiln Pond

Eight specialists participated in the mini-Bioblitz, assisting with field surveys and educational demonstrations, and contributing biological data to the project. Approximately 20 people attended the event, including residents from around Tarkiln Pond. As a result of the field surveys, we were able to document 118 species of plants (including one that is listed as a species of concern by the RI Natural Heritage Program [Enser 2002]), 27 species of birds, six species of fish, three mammals, two amphibians, one reptile, and 47 invertebrates, including 19 species of odonata (dragonflies and damselflies), nine species of aquatic invertebrates (including mussels and crayfish), one beetle, and 15 lepidoptera (butterflies and moths) (Appendix B). The total number of species was 204.

Data Collection and Analysis

Data were collected and handled according to RINHS's Environmental Protection Agency (EPA) approved Quality Assurance Project Plan (QAPP) (Appendix C).

Remote Sensing and Impervious Surface Area Analysis

The Branch River watershed was divided into three zones for the purposes of conducting a comparative analysis within the watershed (Figure 2). Land cover types were calculated for two time periods, 1985 and 1999. All procedures for this analysis, as well as results, can be found in Wang and Zhou (2005), which is located in Appendix A. Zone 3 had the most impervious surface area in 1999 (23.80%), followed by Zone 1 (12.04%) and Zone 2 (7.09%). In 1999, the percent of impervious surface in Zone 3 increased with distance from the river, from 20.4% to 23.8%. The results were opposite in Zones 1 and 2: impervious surface area decreased with distance from the river. As impervious surface increased throughout the watershed between 1985 and 1999, results show that deciduous forest cover underwent the largest decrease, suggesting that impervious surfaces were increasing primarily at the expense of forest cover.

Odonata

From 1998 through 2005, 55 volunteers assisted with an Odonate inventory of Rhode Island including the Branch River watershed. This multi-year state-wide inventory project was funded by The Nature Conservancy, along with RINHS and the RI Foundation (Brown, in press). The data were gathered over the seven year period in order to produce

a comprehensive set of data that could be comparable in terms of intensity and effort hours to a single-year survey. This multiple year approach resulted in a cumulative density of data despite any potential constraints in volunteer power, funds, or other resources. First analysis of the Odonate Atlas results revealed some data gaps in the Branch watershed. Nonetheless the Atlas provided extensive information that contributed to this project, and additional sites were visited during this project to fill the gaps. Seven volunteers assisted Virginia Brown (RINHS Contractor) with Odonate surveys along the Branch River; six during the Odonate Atlas surveys from 1998-2004 and one in 2005 along under-sampled sections of the watershed. The results from the Branch River watershed can be found in Brown (2005), which is located in Appendix D. Twenty-eight sites within the watershed were sampled between 1998 and 2005, yielding 97 species of dragonflies and damselflies (Figure 3). This number represents 70.8% of the 137 species known to occur in Rhode Island. A summary of the major results are as follows:

1. Zone 2 had the highest # of Odonate species per site, Zone 3 had the lowest.
2. Zone 2 had the highest # of species per *river* site (sampling sites within the Branch River itself), Zone 3 had the lowest.
3. Three species found on the river are considered sensitive to pollution and degradation; all three were found below the Oakland Dam in Burrillville. Their presence suggests that water quality is very good along this section of river.
4. 71% of Odonate species are located just below the Oakland Dam. This portion of the watershed exhibits high species diversity and has large populations of four rare species.
5. Impervious surface area is lowest in Zone 2 and highest in Zone 3; the number of Odonate species per surveyed site increases as % of impervious area decreases in each Zone.
6. The Branch River watershed contains five species that are considered rare, threatened or endangered by the RI Natural Heritage Program.

<u>Fish</u>

Fisheries Biologist Alan Libby (RI Department of Environmental Management) conducted a broad survey of Rhode Island's streams and ponds between 1993 and 2002 (Figure 3). His survey is the only source of cumulative, wide spread fisheries data for the Branch River. Although the data from each site are not contemporary (each site was only sampled once during the 10-year survey period), his was the most comprehensive data set we could find, and we have therefore made comparisons between the sites. His survey of Rhode Island's portion of the Blackstone River watershed (Libby 2002) found 18 species of fish (12 native and six introduced) across nine sampling stations (Appendix E). Of these species, the three most commonly found fish were all introduced species (largemouth bass, bluegill, and yellow bullhead). Conversely, the three least commonly found fish were also all introduced species (black crappie, rainbow trout, and smallmouth bass). When Libby's (2002) data are broken down by watershed zone, Zone 1 has on average the lowest number of species per site (2.5, as compared to the averages in Zones 2 and 3). Watershed Zone 3 has on average the highest number of species per site (6.75, as compared to the averages in Zones 1 and 2) (Appendix E). It is worth noting that Zone 2 has only a slightly lower average number of fish species than Zone 3 (6.6 species/site, compared to 6.75 species/site).

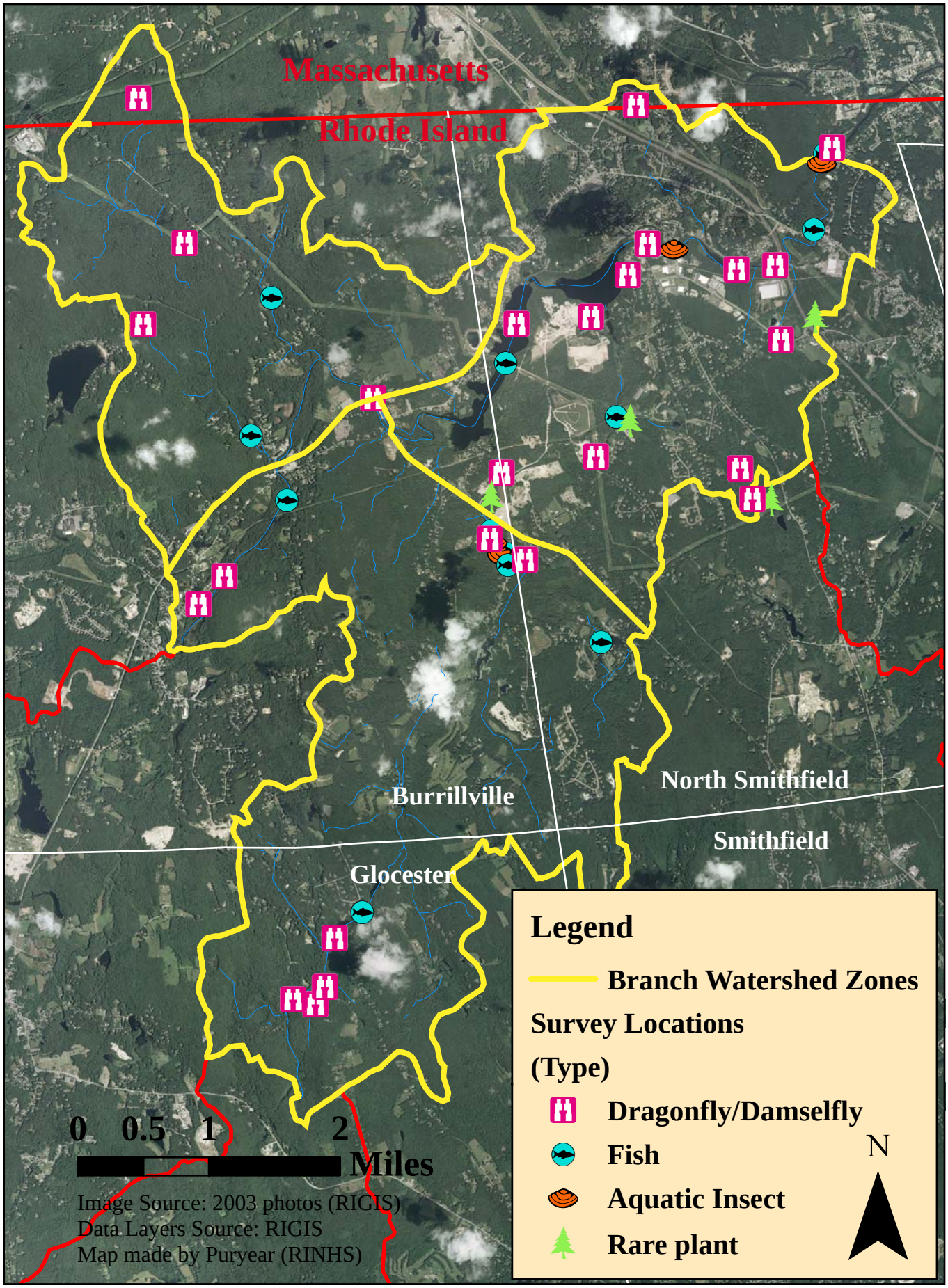


Figure 3. Map of all biological survey locations within the Branch River watershed. Odonate surveys are described in Brown (2005), fish survey data are courtesy of Libby (2004) and Gauvin (pers. com.). Rare plant surveys were coducted by Puryear in 2005 based on data available through the Rhode Island Natural Heritage Program (RINHP Data 2005). Aquatic insect surveys were also conducted by Puryear in 2005.

Rare and Endangered Species

The RI Natural Heritage Program database, which tracks information about rare, threatened, or endangered species for the state, has records of thirteen Heritage species and one rare natural community occurring in the Branch River watershed (RINHP 2005). These include nine plants, three invertebrates, one reptile, and one natural community (Appendix F). In 2005 with the help of four volunteers RINHS looked for and successfully relocated three plant records, confirming their presence in the watershed (Figure 3). One of these species (Early Saxifrage, *Saxifraga virginiensis*) was on conservation land owned by the Audubon Society of Rhode Island. The other two (Climbing Fern, [*Lygodium palmatum*], and Maidenhair Spleenwort [*Asplenium trichomanes*]) were on private land. All three were in good condition.

Maidenhair Spleenwort (*Asplenium trichomenes*), a fern that is listed as a species of concern in Rhode Island. This plant was found in North Smithfield, and is one of nine plants in the Branch River watershed that are listed as rare, threatened or endangered by the RI Natural Heritage Program.

Classroom Outreach

Fifty-fifth graders at Callahan Elementary School learned about the concept of a watershed and how aquatic insects can tell us something about water quality because of their different adaptations for survival. Students were able to identify different sub-Orders or Families of insects found in a sample from Tarkiln Brook (the outlet from Tarkiln Pond) in Burrillville (Figure 3), and together their identifications suggest that the water quality in this stream is Fair (on a scale of Good, Fair, or Poor).

Twenty-two students in a Bio-Tech class at Burrillville High school were given a demonstration of how Geographic Information Systems (GIS) and remote sensing technologies can be used to evaluate land use on a watershed scale. Students calculated how different land use types changed over time and found that as the amount of impervious surface area increased, the amount of runoff into the river increased. They also found that the amount of land in forest increased after the 1930s, initially because abandoned fields were converting to forest, but by 1988 forestland had begun to decrease due to the increase in impervious surface area.

Discussion and Conclusions:
An Integrated Analysis of Organizational, Scientific, and Methodological Results

Organizational Conclusions (Public Outreach and Educational Opportunities)

Public Meetings

The two public meetings provided an important forum for discussion between project partners and community groups that work within the watershed. Information generated from the initial public meeting was very helpful in the recruitment of volunteers for field work and the identification of topics of interest, such as water quality, recreation, and fishing. Unfortunately, attendance at the final public meeting was low, and our findings about the Branch River and its watershed were not shared with the community members and organizations that could use them, as envisioned in the proposal. Nonetheless RINHS has made the presentation prepared for the meeting available on its website and watershed groups are encouraged to refer their constituents to it. Also RINHS has been asked to present the project findings to the Natural Resources Conservation Service (NRCS) in Rhode Island, to help them prioritize their own projects within the watershed. Finally, RINHS discussed the results with The Nature Conservancy biologists and administrators who were interested in how its results may contribute to their strategic planning.

Mini-Bioblitz at Tarkiln Pond

The Tarkiln Pond Bioblitz not only provided an opportunity to assemble large quantities of previously uncollected environmental data about the pond, it provided another opportunity for community members to become a part of the process of inquiry and research about their watershed. By sharing their knowledge of a particular taxa or group of organisms (mussels, dragonflies, etc.) and explaining relationships between the organism and its environment, the specialists who helped collect the data were integral to making this event a success. Our presence around the pond that day also attracted the attention of nearby landowners, who stopped by to ask questions about the pond, gave us permission to walk on their property, and shared their own knowledge of the pond, gained from years of living along its margin. For example, one abutter remarked that weeds and leeches have greatly reduced the swimmability at the pond since her youth. Also she remembered in the past pouring gallons of bleach into the pond before swimming to kill or repel leeches.

Classroom Outreach

RINHS originally proposed a second mini-Bioblitz. It was decided that redirecting that effort into classroom outreach would be another fun and interesting way to bring lessons about watershed health and watershed assessment to a different audience. The aquatic macroinvertebrate lesson went very well with the 5th graders and is a great way of getting kids involved in making their own discoveries about the river in their community. This lesson is also very adaptable and could be done in the field as part of RINHS's annual Bioblitz event. Through the classroom activities, RINHS was able to increase its capacity for teaching environmental lessons to different age groups while introducing its services to a larger audience.

Scientific Conclusions (Biological Surveys and Remote Sensing)

Remote Sensing and Impervious Surface Area Analysis

The remote sensing analysis of the Branch River watershed gave a relative approximation of the differences in land use across the watershed for two different time periods. As might be expected, the percent of impervious surface area increases toward the zone that is closest to the larger population centers of Woonsocket and Providence. A closer look at the undeveloped portions of the watershed reveals some important patterns in the distribution of conservation land. Zone 1 has the most conservation land (1353 acres), most of which is in Black Hut Wildlife Management Area (Department of Environmental Management), and includes portions of the river's headwaters. Zone 2 has the least amount of conservation land (234 acres), most of which is in small parcels that are 500 ft or more from any river or water body. Zone 3 has 487 acres in conservation, but again most of it is in small parcels that are 500 ft or more away from the river. Zone 2, with the least amount of conservation land and the lowest percentage of land in impervious surface area, likely has the largest potential for land use change, either towards conservation of forestland, wetlands, and riparian buffers or towards development.

Limitations in the state's GIS coverages that were used for defining landuse types raised questions as to the relevance of certain analyses, especially of riparian buffers. For example, we had hoped to measure buffer widths from the centerline of streams, as mapped by the GIS rivers coverage. However the coverage did not assign stream segments a hierarchical order number, so the type or size (width) of a stream was not evident. Furthermore, landuse types were identified based on what could be seen on the rivers coverage and Landsat photo; as a result, smaller streams seem to have been missed and some streams were broken up into discontinuous segments simply because the entire length could not be seen.

The size of the watershed and the resolution of the Landsat photo presented another challenge during the analysis process. The configuration of the watershed was such that once a 1500 ft. zone of analysis was placed around all water bodies, the zone covered such a large proportion of that watershed that the difference between water buffer zones and the rest of the watershed was no longer meaningful for our analysis. As a result, it was impossible to apply the same analysis process to all water bodies (small tributaries, vs. large impoundments, etc.) within the watershed, and our analysis was limited to a more coarse-filtered method that only captured larger sized features.

Finally, some calculations of land use change between years showed increases in some cover types at the unlikely expense of others. For example, the percent area in wetlands was found to decrease in Zone 1 between 1985 and 1999, which is unlikely given wetlands development regulations. A similar unlikely change was seen in the increase in percent cover of water in Zone 3. Although Wang and Zhou (2005) state that the level of accuracy for the Landsat images is 91%, our results suggest that this application of remote sensing technology may be inappropriate at certain scales or that some land cover types are mapped with less accuracy than others.

Odonate Survey

Brown (2005) wrote the following summary of recommendations for the Branch River watershed:

- Protect large parcels of land through acquisition
- Focus protection on land adjacent to the Branch River, particularly from Oakland dam downstream to Glendale and from the confluence of the Blackstone upstream to Route 146, as well as at Tarkiln Pond
- Maintain forested buffers of at least 300 meters adjacent to and surrounding water bodies, where feasible, with no less than 30 meters of forested buffer in other areas
- Monitor populations of rare species for both presence and population size and analyze threats

Fish Data

Ten years of accumulated data suggest that fish diversity is lowest in Zone 1, which encompasses the headwaters of the Branch River. This may in part be due to the fact that streams are smaller in Zone 1, and are upstream from impoundments that restrict the extension of large river species. Conversely, the higher level of fish species diversity in Zone 3 may be due to the fact that it includes both small and large water courses, it is below many of the large impoundments, and it has open access to a portion of the Blackstone River. It is, however, noteworthy that Zone 2 had almost as many fish species as Zone 3, despite having much in common with Zone 1 in terms of the structure of fish habitat. Efforts to restore native fish populations to the Branch River could have compounded beneficial results. Such restoration projects often require attention to stream bank restoration and/or buffering, water quality improvements or maintenance, and species management. Improvements along these lines can lead to better overall riparian habitat, improved recreational opportunities, and better water quality; factors that would improve habitat for other animal species as well and should be considered in any restoration project.

RI Natural Heritage Program Database

The Branch River watershed contains 13 records of species that are listed as rare, threatened, or endangered by the RI Natural Heritage Program (RINHP Data 2005). Of these, nine are plants. Plants are the least mobile of the taxa, making them more vulnerable to any loss or conversion in land use, or degradation of land cover. In addition, most of these rare species occurrences are on private land. Zone 3 has the highest number of rare species but 1/3 the number of conservation acres of Zone 1. Zone 2 has the 2nd highest number of rare species but the lowest number of conservation acres. This distribution of rare species and conservation land means that private landowners are the stewards of the majority of the rare species that are found in the watershed, whether they are aware of it or not. In addition, the rare plants found here require undisturbed and/or uncommon habitats that are unique to northern Rhode Island. As a result, outreach and education about watershed health and stewardship, and the involvement of community members in watershed protection, are of particular importance. Although we were able to relocate three (out of three) listed plants, future monitoring of the remaining listed species is recommended to verify their presence and assess threats, especially for those with older (>5 years) records.

Volunteer Field Days

Aquatic macroinvertebrate surveys were a positive way for volunteers to become involved in a biological inventory project that produces informative and useful results. Water quality and macroinvertebrate data collected for this project were primarily for outreach and education purposes, and provided an opportunity for RINHS to expand its technical experience. Even at low intensities, these aquatic surveys also helped us screen for significant water quality problems at three sampling points. Of the three sites surveyed (one in Zone 2, and two in Zone 3), each had water quality ranks of Fair, the middle of a three-point scale. While this is positive news, it may not be good enough to support some habitat, species population, or recreational goals, such as swimming, or habitat restoration for pollution intolerant Odonate species or certain native fish populations. These water quality and macroinvertebrate surveys fulfilled our reconnaissance, organizational, and methodological goals. Nonetheless, future studies may require a different level of intensity or additional metrics, depending upon the research question, watershed goals, and available resources, all of which should be considered in the study design process.

Mini-Bioblitz at Tarkiln Pond

Tarkiln Pond is a man-made water body that supports a diversity of obligate wetland plant and animal species. It also provides important habitat for odonates, including one listed by the Heritage Program as a species of concern (RINHP Data 2005). The discovery of a new population of Climbing Fern (a species of concern in RI) downstream from the pond suggests that some stretches of riparian habitat adjacent to Tarkiln Pond are relatively undisturbed and intact. The abundance and types of aquatic plant species suggest that the pond has high nutrient levels, a factor that has solicited complaints from some of the landowners on the pond that we spoke with. Two non-native invasive aquatic plants, Fanwort (*Cabomba caroliniana*) and Diverse-leaved Milfoil (*Myriophyllum heterophyllum*), are abundant, forming dense mats in some parts of the pond. A description, photos, and control recommendations for fanwort can be found at the following website: http://www.issg.org/database/species/ecology.asp?si=402&fr=1&sts=

It is notable that Purple Loosestrife (*Lythrum salicaria*), a very common and extremely invasive non-native wetland plant, was absent from the pond shores and adjacent marsh. If any individuals are found around the pond, they should be removed and disposed of to prevent spread (Appendix G).

Integration of Results and Take Home Messages

In our analysis of the biological (fish, odonata, aquatic insects), physical (habitat, riparian condition, water quality), and land-use features of the Branch River watershed, we came to the following conclusions:

To protect as many biological and hydrological features as possible, conservation and protection efforts should be focused on large parcels of land close to or on the Branch River and its tributaries, especially in areas that have been found to have high values for biodiversity yet low amounts of protection, such as in Zone 2 and land immediately adjacent to the Branch River in Zone 3.

Zone 2 has high Odonate and fish diversity yet the lowest percent of impervious area within the entire watershed. Therefore it could be argued that Zone 2 has the potential to undergo the most change in the future. Zone 2 is an area where town planners,

conservation groups, and interested members of the public could focus their efforts to make smart-growth and smart-development decisions that take into consideration the future health of the Branch River and its watershed. Areas in that would make good candidates for focused stewardship and advocacy include the stretch below Oakland Dam (Burrillville) and the area around and including Tarkiln Pond (Burrillville/North Smithfield). Properties within these areas could be prioritized for conservation through fee simple purchase or easements. Watershed stewardship activities could include: planting streamside areas with native vegetation, reducing or removing non-point and point sources of pollution, educating landowners about what they can do to protect the river, and helping landowners become educated stewards of their land, in particular where rare, threatened, or endangered species are found.

Zone 3 contains the main stem of the Branch River, which supports higher fish species diversity, as well as good quality Odonate habitat at the confluence with the Blackstone. Furthermore, our land cover analysis shows that the percent impervious area increases with distance from the Branch River. Consequently, the riparian zones adjacent to the river, which serve as the final buffers for water quality, have the potential to undergo significant negative (or positive) land cover and land use changes. The riparian areas in Zone 3 are therefore a second area that could serve as a focal point for future conservation, restoration, planning, and/or educational efforts.

Further conservation land purchase in Zone 1, while potentially valuable for some goals such as protecting wildlife corridors, large forested tracts, or rare habitats, may not be as important for biodiversity protection within the watershed as action in Zones 2 or 3.

Suggestions for Further Work

- Develop a watershed-wide action plan that identifies goals for watershed protection (for example # of species protected, miles of river in conservation, water quality rankings improved, etc.)
- Identify good fish habitat and work to improve/protect high quality fisheries (either through streambank restoration, riparian protection, dam removal, or water quality improvement)
- Monitor populations of rare species, especially at identified hot spots such as the Branch River below Oakland Dam, for both presence and population size and assess threats

Methodological Summary

The purposes of this project were the following: 1) bring the science capabilities of RINHS to local organizations that need them, using existing networks of contacts, 2) enable the Rivers Council and Land Trust Council to provide sound scientific data from the Branch watershed to their constituents, to be used to help build their capacity for conservation management, planning, and stewardship, 3) give partners the opportunity to advance their own outreach and organizing efforts through a series of public events, and 4) help RINHS refine bioassessment strategies for watershed-scale projects.

For the most part, we feel we were able to meet all four of these goals. The Integrated Watershed Assessment project used three different methods to gather real data about the health of the watershed (purposes #2 & #4) while utilizing volunteers from an existing network (#1), and increasing public outreach efforts (#3). The outcomes of each method were variable in terms of the volume of scientific data and volunteer involvement and retention; however each made valuable contributions to the project.

The remote sensing project involved specialized computer skills and technology that produced strongly science-based results and a valuable set of data that can be used for a variety of community and watershed-based projects by town planners, scientists, and concerned citizens alike. However, some caution should be used in interpreting the results, for the reasons discussed on page 15 of this report. In addition the work was conducted by academics and graduate students at the University of Rhode Island and did not involve any public input or volunteer effort. Because the general public was so disconnected from the remote sensing process, the results needed to be interpreted and presented in a way that would interest and inform them to make it a valuable part of the BayWAG project. Graphs, charts, and summary information were created in a final report and are summarized here in order to provide the public with valuable take-home messages and conclusions about the dynamics and processes within their watershed.

The odonate survey involved a small cohort of the general public in surveys, data entry, and specimen preparation. It was a strongly science-based project that involved training volunteers and using quality-assurance quality-control protocols to ensure accurate results. Individuals involved in the Odonate surveys had a strong connection with the locations where they worked and the scientific data they collected. The responsibilities of the project gave them ownership over the results and likely strengthened their connection to the river, the project, and volunteerism in general. This method therefore resulted in producing well-trained volunteers who were able to contribute to scientific knowledge that can be used to answer conservation, environmental health, and planning-related questions within the watershed. Concomitant with its impact on volunteers is the high cost of a survey such as the Odonate Atlas (Brown, in press). The BayWAG project was able to benefit from the fact that the Odonate Atlas project was pre-existing, with volunteers, training, knowledge, and results already in place. A <1year long project such as BayWAG would not have the resources or time needed to train and organize such a large group of volunteers and volume of data and get a similar caliber of results. In addition, while the odonate survey directly involved more of the public in actually collecting scientific information about the watershed than the remote sensing project did, it still only involved a small group of people who likely already had some previous interest in field biology, entomology, or dragonflies and did not reach out to as much of the larger community as other methods might.

Volunteer field days with the RINHS Conservation Biologist engaged volunteers with a broad range of interests. For the most part people got involved because they were looking for a way to learn more about the Branch River, had a skill that they felt they could contribute to the project, or wanted to get outside and learn something more about their environment. Volunteer interests ranged from fishing to water quality to recreation to botanical surveys, and the fieldwork was designed with flexibility to allow people to pursue those interests as they collected data about the river itself. RINHS staff spent a small amount of time organizing field work, but spent relatively little time training or recruiting volunteers. In exchange, volunteers helped gather valuable data about the watershed, connected to the project through direct participation, acquired new skills or experience, and explored sections of the river or watershed that were previously unknown to them, thus fostering additional connections to the watershed. With this method, volunteers were directly involved in gathering new scientific information to be used for this project. While this volunteer effort made positive scientific contributions to the project, and had positive impacts on individual participants, it did not do much to advance the outreach needs of our partnering organizations. Because the volunteers were drawn from an existing pool of people previously organized by the Blackstone River Coalition, our outreach efforts did not attract significant numbers of new members or volunteers. We were "dipping from the same pool" and did not experience the increased public involvement or expansion of the volunteer base that we had initially hoped for.

Public knowledge about the Branch watershed, and the interest of a few people in getting involved in some of the field work, provided RINHS with information and resources that improved our understanding of the watershed as well as our methods for large-scale bioassessment. However, the public and the other project stakeholders were not involved in the final analysis of the results. In addition, the low turnout for the final meeting meant it could not serve as a catalyst or jumping-off point for people and organizations to get their memberships, neighbors or communities involved. It seems that this is a problem of disconnect between Producers (RINHS, Blackstone River Coalition, etc) and Consumers (general public, some of whom are members of the Producer organizations). While we believe the results could ultimately prove valuable for protecting watershed health in a variety of ways, we either did not identify an appropriate pool of Consumers that would be able to use the results to formulate their own action plan, or we did not do enough publicity and outreach to attract their attention to that final meeting.

On the other hand, the project attracted the attention of the USDA Natural Resources Conservation Service, The Nature Conservancy, and other groups and agencies working in the Branch River watershed. Also the project provided numerous and varied organizational and development benefits to RINHS, including 1) insights into outreach methods, 2) improvements to our educational programs, tools, and equipment and 3) additional organizational and public contacts. RINHS also now has a solid, informative product to present to any of the watershed commissions, conservation groups, or towns that have questions about the Branch River and its watershed. The methods we used could provide either scientific knowledge directly to the watershed members, or serve as a template for other projects in other watersheds. In the latter situation, it would be ideal to have the audience and stakeholders – the people who will be carrying out watershed stewardship and science activities – identified in advance so as to get more individuals involved in the process, to include research, analysis, planning, and implementation of advocacy and conservation efforts.

The organizational contacts and public interest resulting from this project could be taken as supportive of the Department of Environmental Management's (DEM) proposed rotating basin approach for a statewide water quality monitoring strategy (DEM 2005). DEM's method would focus scientific monitoring projects on a few basins a year on a 5-year rotation. Our experience with the BayWAG project could provide rationale for this method, provided that it includes a significant public outreach component for each analysis.

In terms of both the scientific and organizational contributions to this project, we feel that our combination of methods produced much greater results than a single method alone. The mini-Bioblitz attracted a greater variety of public interest and produced a large quantity of data. The volunteer field days were critical not only in terms of gathering data but also in involving watershed members in the research process. And finally, the public meetings provided a valuable opportunity to learn from the residents of the watershed. Their involvement helped us locate access points to the river, identify issues of interest, and perhaps most importantly, allowed us to get a glimpse of their dedication to improving the health of the watershed.

Acknowledgements
This project was made possible by a grant from the Narragansett Bay Estuary Project and the Environmental Protection Agency. Volunteers Nina Briggs, Ray Hartenstine, Sindy Hempstaed, Jo-Anne Pacheco, June Egee, Charlie Brown, and Roland Gauvin helped with field surveys. Virginia Brown, Erik Endrulat (RINHS), Rick Enser (RI Natural Heritage Program), David Gregg, Allan Libby, Todd McLeish, Y.Q. Wang, and Yuyu Zhou (University of Rhode Island Terrestrial Remote Sensing Laboratory) and numerous Odonate Atlas volunteers contributed data to this project. Teachers Charles Boucher (Burrillville High School) and Rachel Auclair (Callahan Elementary School) welcomed us into their classrooms. This project was completed with the assistance of the Blackstone River Coalition, Rhode Island Land Trust Council, and Rhode Island Rivers Council.

References Cited

Brown, V.A. In press. Dragonflies and damselflies of Rhode Island. The Nature Conservancy and Rhode Island Natural History Survey.

Brown, V.A. 2005. Odonata (dragonflies and damselflies) of the Branch River watershed. Unpublished report submitted to the Rhode Island Natural History Survey.

Department of Environmental Management (DEM), Office of Water Resources. 2005. State of Rhode Island and Providence Plantations, water monitoring strategy 2005-2010. Providence, Rhode Island. www.ci.uri.edu/Projects/RI-Monitoring/Docs/DEM_WQ_Oct_14_05.pdf

Enser, R. W. 2002. Rare native plants of Rhode Island. Rhode Island Natural Heritage Program, Rhode Island Department of Environmental Management, Providence, RI.

Gauvin, R. 2005. Personal communication. North Smithfield, Rhode Island.

Libby, A.D. 2004. A preliminary summary of fish surveys that were conducted in Rhode Island's streams and ponds between 1993 and 2002. Appendix: Blackstone River watershed. Unpublished report submitted to the Rhode Island Department of Environmental Management.

Rhode Island Natural Heritage Program (RINHP) Data. 2005. Rhode Island Natural History Survey, Kingston, Rhode Island.

Wang, Y.Q., and Y. Zhou. 2005. Land cover remote sensing for impervious surface in the Branch River watershed. Unpublished report submitted to the Rhode Island Natural History Survey.

Appendix A:

Methods and Results from Land Cover Remote Sensing for Impervious Surface in the Branch River Watershed

(Wang and Zhou 2005)

Land Cover Remote Sensing for Impervious Surface in the Branch River Watershed

By Y.Q. Wang and Yuyu Zhou, 2005

Methodology:

Impervious surface area (ISA) is useful for environmental monitoring and management, such as human disturbance. ISA is defined as any impenetrable material that prevents infiltration of water into the soil. Urban pavements, such as rooftops, roads, sidewalks, parking lots, driveways and other manmade concrete surfaces, are among impervious surface types that featured the urban and suburban landscape. Remote sensing is effective in acquiring the landscape characteristics. Multispectral and multitemporal capabilities can provide the landscape characteristics and its temporal change. Spatial distribution of ISA can be obtained from remote sensing data based on classification methods.

According to the purpose of the project and the advantage of remote sensing data, two satellite images were acquired to produce the land cover map and the final ISA data in Blackstone area. They include a Landsat–5 Thematic Mapper (TM) image acquired on October 28, 1985 with 30-meter spatial resolution and six spectral bands ranging from visible to the mid-infrared portions of the spectrum and a Landsat-7 Enhanced Thematic Mapper Plus (ETM+) image acquired on October 27, 1999 with the same spatial and spectral resolution as the TM data.

With these data, unsupervised and supervised classification methods were applied to create the land cover map and ISA distribution. The categories used in the classification included: (1) Urban (impervious surface), (2) Urban grass, (3) Agriculture, (4) Deciduous forest, (5) Coniferous forest, (6) Mixed forest, (7) Brushland, (8) Water, (9) Herbaceous wetland, (10) Deciduous forest, and (11) Coniferous forest. Accuracy assessments for final land cover classification were conducted. The results were compared with the original Landsat images, 1:5000 Digital Orthophotographs, GPS ground reference data, and land use data from RIGIS. The overall classification accuracy for both the 1985 and 1999 land cover product in whole Rhode Island state was 91%. In order to make the comparison Blackstone was divided into three zones, and the land covers were combined into six categories: (1) Urban, (2) Agriculture, (3) Forest, (4) Brushland, (5) Water, and (6) Wetland.

The water area was extracted from the land cover classification maps, and these raster data was transformed to GIS shape file format. With the transformed data, three buffers were built to make the further analysis based on GIS techniques. The buffers were clipped out for three zones. With the assist of remote sensing software, the statistics of the land cover and ISA in these zones were calculated for three buffers. The percents of ISA in each zone and buffer were also obtained. Furthermore, the acquired statistic was compared between 1985 and 1999.

The results of this research have provided valuable insight into the ISA percent and change in different distance buffers in Blackstone area and the human disturbance on three zones. With the development of remote sensing technique, there are higher spatial resolution imageries available. More accurate land cover and ISA information can be obtained with the higher spatial resolution imageries, and it will be helpful for the measurement of human disturbance in small area.

Appendix A. Results of land cover remote sensing for impervious surface in the Branch River Watershed **(Percent area coverage).**

1985
500feet

	Zone 1	Zone 2	Zone 3
Urban	8.81%	9.00%	6.68%
Urban Grass	1.26%	2.37%	2.45%
Agriculture	6.29%	7.81%	7.35%
Deciduous Forest	55.95%	59.79%	63.15%
Coniferous Forest	6.06%	3.26%	2.42%
Mixed Forest	7.09%	7.57%	7.85%
Brush Land	0.57%	1.68%	1.97%
Water	2.17%	0.94%	0.60%
Herbaceous Wetland	7.89%	4.45%	3.37%
Deciduous Wetland	2.86%	2.62%	3.85%
Coniferous Wetland	0.92%	0.45%	0.29%
Coastal Land	0.11%	0.05%	0.03%

1999
500feet

	Zone 1	Zone 2	Zone 3
Urban	13.37%	9.01%	20.40%
Urban Grass	1.66%	3.69%	1.26%
Agriculture	6.06%	2.51%	0.47%
Deciduous Forest	47.67%	29.24%	20.40%
Coniferous Forest	4.57%	9.10%	12.57%
Mixed Forest	13.70%	19.53%	14.63%
Brush Land	0.08%	0.26%	0.51%
Water	2.24%	6.26%	16.90%
Herbaceous Wetland	6.48%	7.35%	8.58%
Deciduous Wetland	3.41%	9.65%	3.28%
Coniferous Wetland	0.75%	3.18%	0.73%
Coastal Land	0.00%	0.24%	0.26%

1985
1000feet

	Zone 1	Zone 2	Zone 3
Urban	5.16%	5.18%	4.26%
Urban Grass	2.67%	2.57%	2.36%
Agriculture	3.19%	3.35%	3.26%
Deciduous Forest	36.38%	42.48%	47.02%
Coniferous Forest	7.10%	7.22%	6.80%
Mixed Forest	19.49%	20.74%	19.53%
Brush Land	0.83%	0.68%	0.57%
Water	6.07%	2.70%	1.80%
Herbaceous Wetland	7.73%	4.46%	3.54%
Deciduous Wetland	7.73%	7.58%	8.15%
Coniferous Wetland	3.50%	2.97%	2.66%
Coastal Land	0.13%	0.07%	0.06%

1999
1000feet

	Zone 1	Zone 2	Zone 3
Urban	13.60%	8.23%	23.33%
Urban Grass	1.50%	2.47%	1.26%
Agriculture	8.25%	2.57%	0.72%
Deciduous Forest	48.57%	33.78%	24.42%
Coniferous Forest	4.70%	9.70%	11.97%
Mixed Forest	15.92%	23.06%	18.16%
Brush Land	0.41%	0.23%	0.39%
Water	0.92%	2.96%	9.41%
Herbaceous Wetland	3.65%	4.45%	5.63%
Deciduous Wetland	2.15%	9.28%	3.63%
Coniferous Wetland	0.34%	3.17%	0.92%
Coastal Land	0.00%	0.12%	0.16%

Appendix A. Results of land cover remote sensing for impervious surface in the Branch River Watershed **(Percent area coverage).**

1985
1500feet

	Zone 1	Zone 2	Zone 3
Urban	14.43%	16.87%	5.18%
Urban Grass	2.76%	3.26%	2.57%
Agriculture	0.56%	1.04%	3.35%
Deciduous Forest	22.58%	28.84%	42.48%
Coniferous Forest	6.61%	6.24%	7.22%
Mixed Forest	19.91%	21.05%	20.74%
Brush Land	0.93%	1.76%	0.68%
Water	18.98%	10.53%	2.70%
Herbaceous Wetland	9.04%	5.90%	4.46%
Deciduous Wetland	3.37%	3.59%	7.58%
Coniferous Wetland	0.58%	0.76%	2.97%
Coastal Land	0.25%	0.17%	0.07%

1999
1500feet

	Zone 1	Zone 2	Zone 3
Urban	12.04%	7.09%	23.80%
Urban Grass	1.46%	1.83%	1.17%
Agriculture	7.10%	2.50%	0.63%
Deciduous Forest	53.47%	37.29%	26.85%
Coniferous Forest	4.26%	9.40%	11.21%
Mixed Forest	14.77%	24.16%	19.75%
Brush Land	0.46%	0.21%	0.36%
Water	0.59%	1.99%	7.02%
Herbaceous Wetland	2.69%	3.51%	4.49%
Deciduous Wetland	2.91%	8.95%	3.66%
Coniferous Wetland	0.26%	2.99%	0.90%
Coastal Land	0.00%	0.08%	0.15%

Appendix B:
Tarkiln Pond Mini-Bioblitz Survey Results, 2005

Appendix B. Vertebrates found in and around Tarkiln Pond and Tarkiln Stream, Burrillville, Rhode Island during the mini-Bioblitz held July 29, 2005.

	Common Name	*Latin Name*
Mammals (3)	Eastern Chipmunk	*Sciurus carolinensis*
	Red Squirrel	*Tamiasciurus hudsonicus*
	White-tailed Deer	*Odocoileus virginianus*
Fish (6)	Bluegill	*Lepomis macrochirus*
	Brown Bullhead	*Ameiurus nebulosus*
	Chain Pickerel	*Esox niger*
	Largemouth Bass	*Micropterus salmoides*
	Pumpkinseed	*Lepomis gibbosus*
	Yellow Bullhead	*Ameiurus natalis*
Reptiles and Amphibians (3)	Bull Frog	*Rana catesbeiana*
	Green Frog	*Rana clamitans melanota*
	Northern Water Snake	*Neroidia s. sipedon*
Birds (27)	American Crow	*Corvus brachyrhynchos*
	American Goldfinch	*Carduelis tristis*
	American Redstart	*Setophaga ruticilla*
	American Robin	*Turdus migratorius*
	Belted Kingfisher	*Ceryle alcyon*
	Black and White Warbler	*Mniotilta varia*
	Black-capped Chickadee	*Poecile atricappilus*
	Blue Jay	*Cyanocitta cristata*
	Broad-winged Hawk	*Buteo platypterus*
	Canada Goose	*Branta canadensis*
	Cedar Waxwing	*Bombycilla cedrorum*
	Chimney Swift	*Chaetura pelagica*
	Chipping Sparrow	*Spizella passerina*
	Common Grackle	*Quiscalus quiscula*
	Downy Woodpecker	*Picoides pubescens*
	Gray Catbird	*Dumetella carolinensis*
	House Wren	*Troglodytes aedon*
	Mourning Dove	*Zenaida macroura*
	Northern Cardinal	*Cardinalis cardinalis*
	Northern Flicker	*Colaptes auratus*
	Northren Rough-winged Swallow	*Stelgidopteryx serripennis*
	Red-eyed Vireo	*Vireo olivaceus*
	Song Sparrow	*Melospiza melodia*
	Spotted Sandpiper	*Actitis macularius*
	Tufted Titmouse	*Baeolophus bicolor*
	Warbling Vireo	*Vireo gilvus*
	Yellow Warbler	*Dendroica petechia*

Total Vertebrates: 39

Appendix B. Invertebrates found in and around Tarkiln Pond and Tarkiln Stream, Burrillville, Rhode Island during the mini-Bioblitz held July 29, 2005.

	Common Name	Latin Name
Lepidptera (Butterflies and Moths) (15)	American Copper	*Lycaena phlaeas*
	Appalachian Brown	*Satyrodes appalachia*
	Cabbage White	*Pieris rapae*
	Common Sootywing	*Pholisora catullus*
	Eyed Brown	*Satyrodes eurydice*
	Great Spangled Fritillary	*Speyeria cybele*
	Gypsy Moth	*Lymantria dispar*
	Mourning Cloak	*Nymphalis antiopa*
	Northern Broken Dash	*Wallengrenia egeremet*
	Pearl Crescent	*Phyciodes tharos*
	Peck's Skipper	*Polites peckius*
	Red Admiral	*Vanessa atalanta*
	Red Spotted Purple	*Limenitis arthemis*
	Wood Nymph	*Cercyonis pegala*
	Wood Satyr	*Megisto cymela*
Odonata (Dragonflies & Damselflies) (19)	Common Green Darner	*Anax junius*
	Variable Darner	*Argia fumipennis*
	Powdered Darner	*Argia moesta*
	River Jewlewing	*Calopteryx aequabilis*
	Halloween Pennant	*Celithemis eponina*
	Eastern Pondhawk	*Erythemis simplicicollis*
	Dragonhunter	*Hagenius brevistylus*
	Fragile Forktail	*Ischnura posita*
	Eastern Forktail	*Ischnura verticalis*
	Lestes sp.	*Lestes sp.*
	Slaty Skimmer	*Libellula incesta*
	Widow Skimmer	*Libellula luctuosa*
	Twelve-spotted Skimmer	*Libellula pulchella*
	Blue Dasher	*Pachydiplax longipennis*
	Eastern Amberwing	*Perithemis tenera*
	Emerald sp.	*Somatochlora sp.*
	Yellow-legged Meadowhaw	*Sympetrum vicinum*
	Carolina Saddlebags	*Tramea carolina*
	Black Saddlebags	*Tramea lacerata*
Coleoptera (Beetles) (1)	Chrysomelid Beetle sp.	Chrysomelidae sp.
Decopoda (Crayfish) (1)	Crayfish	*Procambarus acutus acutus*
Hemiptera (True Bugs) (2)	Whirlygig Beetle	Family Gyrinidae
	Water Strider	*Gerris remigis*
Homoptera (Cicadas, Leaf Hoppers, & Aphids) (1)	Cicada	Family Cicadidae

Appendix B. Invertebrates (continued)

	Common Name	Latin Name
Plecoptera (Stoneflies) (1)	Stoneflies	Family Perlidae
Tricoptera (Caddisflies) (1)	Caddisfly larvae	Family Hydropsychidae
Ephemeroptera (Mayflies) (1)	Mayfly larvae	Family unkown
Unionoida (Freshwater Bivalves) (1)	Easter Elliptio	*Elliptio complanata*
Bassomatophora (Physid Snails) (1)	Snail	*Campaloma decisun*
Diptera (2)	Deerfly	Family Tabanidae
	Mosquitoes	Family Culicidae
Phylum Porifera (Sponges) (1)	Freshwater Sponges	

Total Invertebrates: 47

Appendix B. Plants found in and around Tarkiln Pond and Tarkiln Stream, Burrillville, Rhode Island during the mini-Bioblitz held July 29, 2005.

RHODE ISLAND NATURAL HISTORY SURVEY
Providing Ecosystem Science and Information

Species	Common Name	Habit:[1]	RI Status:	Abundance:
Family: **Sphagnaceae (Sphagnum Moss Family)**				
Sphagnum	Sphagnum Moss			IV
Synonyms:				
Family: **Aceraceae (Maple Family)**				
Acer pseudoplatanus	Sycamore Maple	IT	4*	III
Synonyms: Acer pseudo-platanus L. [F50; S93]				
Acer rubrum	Red, Swamp-, or Soft Maple	NT	1	IV
Synonyms: Acer rubrum L. var. rubrum [K94; S93] & var. trilobum K. Koch [F50; S93]; Acer rubrum L. var. trilobum T. & G. ex K. Koch [K94; USDA82]				
Family: **Alismataceae (Water Plantain Family)**				
Sagittaria latifolia var. latifolia	Broad-leaved or Common Arrowhead, Duck-potato, Wapato	NPEF	1	III
Synonyms: Sagittaria latifolia Willd. [HC81]; S. latifolia Willd. forma hastata (Pursh) Robins. & forma gracilis (Pursh) Robins. [F50]; Sagittaria latifolia Willd. var. obtusa (Muhl.) Wieg. [F50; S93; USDA82]				
Family: **Anacardiaceae (Sumac family)**				
Rhus copallinum	Shining, Winged, or Dwarf Sumac	NST	1	III
Synonyms: Rhus copallina L. var. latifolia Engler [F50; S93]				
Toxicodendron radicans	Poison Ivy		1	IV
Synonyms:				

[1] RI Status and Abundance Data from "Vascular Flora of Rhode Island." Explanation of headings and codes located on last page of Appendix.

Species	Common Name	Habit: [1]	RI Status:	Abundance:
Family: **Apiaceae (Carrot family)**				
Daucus carota	Queen Anne's Lace, Wild Carrot, Devil's-plague, Bird's-nest	IBF	4	IV
Synonyms:				
Family: **Apocynaceae (Periwinkle Family)**				
Apocynum	Dogbane	NPF	1	III
Synonyms:				
Family: **Aquifoliaceae (Holly Family)**				
Ilex verticillata var. verticillata	Winterberry, Black Alder (RI Colloq.)	NEST	1	III
Synonyms: Ilex verticillata (L.) A. Gray [K94; USDA82]; Ilex verticillata (L.) A. Gray var. tenuifolia (Torr.) S. Wats. [F50; S93]				
Family: **Araceae (Arum Family)**				
Peltandra virginica	Arrow-arum, Tuckahoe	NPEF	1	III
Synonyms: Peltandra virginica (L.) Kunth [USDA82]; Peltandra virginica (L.) Schott [K94]				
Symplocarpus foetidus	Skunk-cabbage	NPF	1	IV
Synonyms: Symplocarpus foetidus (L.) Salisb. [USDA82]; Symplocarpus foetidus (L.) Salisb. ex Nutt. [K94]				
Family: **Araliaceae (Ivy and Ginseng Family)**				
Aralia nudicaulis	Wild Sarsaparilla	NPF	1	IV
Synonyms:				
Aralia racemosa	Wild Spikenard, Life-of-man	NPF	1	II
Synonyms:				
Family: **Asclepiadaceae (Milkweed Family)**				
Asclepias incarnata var. pulchra	Swamp-milkweed	NPEF	1	III
Synonyms: Asclepias incarnata L. ssp. pulchra (Ehrh. ex Willd.) Woods. [K94]				

[1] RI Status and Abundance Data from "Vascular Flora of Rhode Island." Explanation of headings and codes located on last page of Appendix.

Species	Common Name	Habit: [1]	RI Status:	Abundance:
Family: **Asclepiadaceae (Milkweed Family)**				
Asclepias syriaca	Common Milkweed, Silkweed	NPF	1	IV
Synonyms:				
Family: **Asteraceae (Sunflowers)**				
Achillea millefolium millefolium	Common Yarrow, Milfoil	NIPF	1 or 4 (origin unclear)	IV
Synonyms: Achillea millefolium L. var. millefolium [K94]				
Ambrosia artemisiifolia	Common Ragweed, Roman Wormwood	NAF	1	IV
Synonyms: Ambrosia artemisiifolia L. var. elatior (L.) Descourtils [F50; K94; S93; USDA82]				
Eupatorium rugosum var. rugosum	White Snakeroot	NPF	1	III
Synonyms: Ageratina altissima (L.) King & H. E. Robins. var. altissima [K94; USDA82]				
Solidago rugosa	(Rough) Rough Goldenrod	NPF	1	III
Synonyms: Solidago aspera Aiton [S93]; Solidago rugosa Ait. var. aspera (Ait.) Fern. [F50]				
Family: **Balsaminaceae (Balsam, Impatiens Family)**				
Impatiens capensis	Spotted or Orange Touch-me-not, Jewelweed, Snapweed	NAF	1	IV
Synonyms: Impatiens biflora Walt.				
Family: **Berberidaceae (Barberry Family)**				
Berberis thunbergii	Japanese Barberry	IS	4*	IV
Synonyms:				
Family: **Betulaceae (Alder, Birch)**				
Alnus serrulata	Common or Smooth Alder	NST	1	III
Synonyms: Alnus serrulata (Aiton) Willd. var. serrulata; Alnus serrulata (Aiton) Willd. var. subelliptica Fern.				

[1] RI Status and Abundance Data from "Vascular Flora of Rhode Island." Explanation of headings and codes located on last page of Appendix.

Species	Common Name	Habit: [1]	RI Status:	Abundance:
Family: **Betulaceae (Alder, Birch)**				
Betula populifolia	Gray, Oldfield Birch, or White Birch	NT	1	IV
Synonyms:				
Family: **Brassicaceae (Mustard family)**				
Raphanus raphanistrum	Wild Radish, Jointed Charlock	IAF	4	IV
Synonyms:				
Family: **Cabombaceae (Water-shield Family)**				
Brasenia schreberi	Water-shield, Purple Wen-dock	NPZ/F	1	III
Synonyms:				
Cabomba caroliniana	Fanwort	NPZ/F	2*	III
Synonyms:				
Family: **Campanulaceae (Bellflower Family)**				
Lobelia cardinalis var. cardinalis	Cardinal-flower	NPF	1	III
Synonyms: Lobelia cardinalis L. ssp. cardinalis [K94; USDA82]				
Family: **Caprifoliaceae (Honeysuckle Family)**				
Lonicera morrowii	Morrow's Fly-honeysuckle	IS	4*	IV
Synonyms: Lonicera morrowi Gray [F50]				
Lonicera sp.	Honeysuckle			III
Synonyms:				
Sambucus canadensis	American Elder		1	III
Synonyms:				

[1] RI Status and Abundance Data from "Vascular Flora of Rhode Island." Explanation of headings and codes located on last page of Appendix.

Species	Common Name	Habit: [1]	RI Status:	Abundance:
Family: **Caprifoliaceae (Honeysuckle Family)**				
Viburnum dentatum var. venosum	Southern Arrowwood	NS	1	III
Synonyms: Viburnum dentatum L. [F50; Viburnum dentatum L. var. dentatum [S93]				
Family: **Ceratophyllaceae (Hornwort Family)**				
Ceratophyllum demersum	(submerged) Hornwort, Coontail	NPZF	1	III
Synonyms:				
Family: **Clethraceae (White-alder Family)**				
Clethra alnifolia	Sweet Pepperbush, Soapbush, Coast White Alder, Summer-sweet	NS	1	IV
Synonyms:				
Family: **Clusiaceae (St John's wort family)**				
Hypericum boreale	Northern St. John's-wort	NPF	1	III
Synonyms:				
Triadenum virginicum	Marsh St. John's-wort	NPEF	1	III
Synonyms: Hypericum virginicum L. [F50; S93]				
Triadenum virginicum	Marsh St. John's-wort	NPEF	1	III
Synonyms: Hypericum virginicum L. [F50; S93]				
Family: **Cornaceae (Dogwood Family)**				
Cornus racemosa	Gray or Red-panicled Dogwood, Northern Swamp-dogwood	NS	1	III
Synonyms: Cornus foemina Miller ssp. racemosa (Lam.) J. S. Wilson [USDA82]				
Family: **Cupressaceae (Cypress Family)**				
Juniperus virginiana	Eastern Red Cedar	NT	1	IV
Synonyms:				

[1] RI Status and Abundance Data from "Vascular Flora of Rhode Island." Explanation of headings and codes located on last page of Appendix.

Species	Common Name	Habit: [1]	RI Status:	Abundance:
Family: **Cyperaceae (Sedge Family)**				
Carex lurida	(reddish-yellow) Sedge	NPEG	1	IV
Synonyms:				
Carex pensylvanica var. pensylvanica	Early Sedge	NPG	1	IV
Synonyms: Carex pensylvanica Lam. [K94; USDA82]				
Carex stricta	Tussock Sedge	NPEG	1	III
Synonyms: Carex stricta Lam. var. stricta [S93]; Carex stricta Lam. var. strictior (Dewey) Carey [F50; S93; USDA82]				
Eleocharis palustris	(marsh) Spike-rush	NPEG	1	III
Synonyms: Eleocharis halophila [F50; K94; S93; USDA82]; E. palustris [F50; K94; USDA82]; E. palustris var. major Sonder. [F50]; E. smallii Britt. [F50; K94; S93; USDA82] + var. major [S93]; E. uniglumis (Link) Schultes [F50;K94; USDA82] [see Flora]				
Scirpus cyperinus var. cyperinus	Wool-grass, Woolly Bulrush	NPEG	1	III
Synonyms: Scirpus cyperinus (L.) Kunth [GC91; K94; USDA82]; S. cyperinus var. pelius Fern. [F50; S93]; S. rubricosus Fern [F50]				
Family: **Dennstaedtiaceae (Fern Family)**				
Dennstaedtia punctilobula	Hay-scented Fern, Boulder-fern	NPF	1	IV
Synonyms:				
Pteridium aquilinum	Bracken Fern, Brakes (RI Colloq.)	NPF	1	IV
Synonyms:				
Family: **Dryopteridaceae (Wood Fern Family)**				
Dryopteris intermedia	Intermediate or Fancy Wood-fern	NPF	1	III
Synonyms: Dryopteris intermedia (Muhl.) A. Gray [GC91; Dryopteris intermedia (Willd.) Gray [USDA82]; Dryopteris spinulosa (O. F. Muell.) Watt. var. intermedia (Muhl.) Underwood [F50; S93]				
Onoclea sensibilis	Sensitive Fern	NPEF	1	IV
Synonyms:				

[1] RI Status and Abundance Data from "Vascular Flora of Rhode Island." Explanation of headings and codes located on last page of Appendix.

Species	Common Name	Habit: [1]	RI Status:	Abundance:
Family: **Dryopteridaceae (Wood Fern Family)**				
Polystichum acrostichoides	Christmas Fern, Dagger-fern, Canker-brake	NPF	1	III
Synonyms:				
Family: **Elaeagnaceae (Oleaster Family)**				
Elaeagnus umbellata	Autumn Olive, "russian Olive" (RI Colloq.)	IST	4*	IV
Synonyms:				
Family: **Ericaceae (Heath Family)**				
Chamaedaphne calyculata	Leatherleaf, Cassandra	NS	1	III
Synonyms: Cassandra calyculata (L.) D. Don. var. angustifolia (Ait.) F.C. Seymour [S93]; Chamaedaphne calyculata (L.) Moench var. angustifolia (Ait.) Rehd. [F50]				
Lyonia ligustrina	Maleberry, He-huckleberry	NS	1	III
Synonyms:				
Rhododendron viscosum	Clammy Azalea, Swamp-azalea, Swamp-honeysuckle	NS	1	IV
Synonyms:				
Vaccinium angustifolium	Common Lowbush-blueberry, Low or Late Sweet Blueberry	NS	1	IV
Synonyms: Vaccinium angustifolium var. laevifolium House [F50; S93] & var. nigrum (Wood) Dole [F50; S93]				
Vaccinium corymbosum	Highbush Blueberry	NS	1	IV
Synonyms: V. atrococcum (A. Gray) Heller [F50 & S93 list as sep. sp.]; V. caesariense MacKenzie [F50; K94, S93 & USDA82 list as sep. sp.]; V. corymbosum var. albiflorum & var. glabrum [F50; S93], var. corymbosum [S93]				
Family: **Fabaceae (Legume family)**				
Trifolium pratense	Red Clover	IPBF	4	IV
Synonyms: Trifolium pratense L. var. pratense [S93]; Trifolium pratense L. var. sativum (Mill) Schreb. [F50]				

[1] RI Status and Abundance Data from "Vascular Flora of Rhode Island." Explanation of headings and codes located on last page of Appendix.

Species	Common Name	Habit: [1]	RI Status:	Abundance:
Family: **Fagaceae (Beech Family)**				
Quercus alba	White Oak	NT	1	IV
Synonyms:				
Quercus bicolor	Swamp White Oak	NT	1	III
Synonyms:				
Quercus velutina	Black Oak	NT	1	IV
Synonyms:				
Family: **Haloragaceae (Water-milfoil Family)**				
Myriophyllum heterophyllum	(Diverse-leaved) Water-milfoil	NPZF	1	III
Synonyms:				
Family: **Iridaceae (Iris Family)**				
Iris	Iris	PF		III
Synonyms:				
Family: **Juncaceae (Rush Family)**				
Juncus greenei	(greene's) Rush	NPG	1	III
Synonyms:				
Family: **Lemnaceae (Duckweed Family)**				
Lemna minor	Lesser Duckweed, Duck's-meat	NP/F	1	III
Synonyms: Lemna turionifera Landolt [K94]				
Family: **Lentibulariaceae (Bladderworts)**				
Utricularia radiata	Inflated or Floating Bladderwort	NAPZ/	1	III
Synonyms: Utricularia inflata Walter var. minor Chapman [F50; S93]				

[1] RI Status and Abundance Data from "Vascular Flora of Rhode Island." Explanation of headings and codes located on last page of Appendix.

Species	Common Name	Habit: [1]	RI Status:	Abundance:
Family: **Lentibulariaceae (Bladderworts)**				
Utricularia vulgaris	Common or Greater Bladderwort	NP/F	1	III
Synonyms: Utricularia macrorhiza Le Conte [K94; MT97; USDA82]				
Family: **Liliaceae (Lily Family)**				
Maianthemum canadense var. canadense	False or Wild Lily-of-the-valley, Canada Mayflower, Two-leaved Solomon's Seal	NPF	1	IV
Synonyms: Maianthemum canadense Desf. [K94]				
Medeola virginiana	Indian Cucumber-root	NPF	1	III
Synonyms:				
Smilacina racemosa	False Solomon's Seal, False or Wild Spikenard, Solomon's Plume	NPF	1	IV
Synonyms: Maianthemum racemosusm (L.) Link ssp. racemosum [K94]; Smilacina racemosa (L.) Desf. var. cylindrata Fern. [F50; S93; USDA82] & var. racemosa [S93]				
Uvularia sessilifolia	Wild Oats, Sessile Bellwort	NPF	1	III
Synonyms:				
Family: **Lycopodiaceae (Clubmoss Family)**				
Lycopodium obscurum	Prince's- or Princess-pine, Ground-pine, Flat-branched Tree-clubmoss	NPF	1	III
Synonyms: Lycopodium obscurum L. forma obscurum [S93]				
Family: **Lygodiaceae (Climbing Fern Family)**				
Lygodium palmatum	Climbing or Hartford Fern	NPF	1	II
Synonyms:				
Family: **Monotropaceae (Indian Pipe Family)**				
Monotropa uniflora	Indian Pipe, Corpse-plant	NP-$F	1	III
Synonyms:				

[1] RI Status and Abundance Data from "Vascular Flora of Rhode Island." Explanation of headings and codes located on last page of Appendix.

Species	Common Name	Habit: [1]	RI Status:	Abundance:
Family: **Nymphaeaceae (Water-lily Family)**				
Nuphar variegata	Yellow Pond Lily, Spatterdock, Bull-lily, Bullhead-lily	NPE/F	1	III
Synonyms: Nuphar lutea (L.) Sm. ssp. variegata (Dur.) E. O. Beal [K94]; Nuphar luteum (L.) Sibth. & J. E. Smith ssp. variegatum (Engelm. ex G. W. Clinton) E. O. Beal [USDA82]; Nuphar variegatum Engelm. [F50; S93]				
Nymphaea odorata odorata	Fragrant Water-lily, Pond-lily	NPZ/F	1	IV
Synonyms: Nymphaea odorata Aiton [HC84; K94]; Nymphaea odorata Aiton subsp. odorata [FNA97]; Nymphaea odorata Soland. in Aiton [USDA82]				
Family: **Oleaceae (Olives)**				
Fraxinus americana	White Ash	NT	1	IV
Synonyms:				
Family: **Onagraceae (Evening-primrose Family)**				
Ludwigia palustris	Common Water-purslane	NPEF	1	III
Synonyms: Ludwigia palustris (L.) Elliott var. americana (DC.) Fern. & Grisc. [F50; S93]				
Family: **Osmundaceae (Royal Fern Family)**				
Osmunda cinnamomea	Cinnamon Fern	NPEF	1	IV
Synonyms: Osmunda cinnamomea L. var. cinnamomea [GC91; K94; S93]; Osmunda cinnamomea L. var. glandulosa Waters [F50; K94; S93]				
Osmunda regalis	Royal Fern		1	IV
Synonyms:				
Family: **Oxalidaceae (Wood Sorrel Family)**				
Oxalis stricta	Common Yellow Wood-sorrel	NPF	1	IV
Synonyms: Oxalis europaea Jord. [F50 + S93 list as sep. sp.]				

[1] RI Status and Abundance Data from "Vascular Flora of Rhode Island." Explanation of headings and codes located on last page of Appendix.

Species	Common Name	Habit: [1]	RI Status:	Abundance:
Family: **Papaveraceae (Poppy Family)**				
Chelidonium majus	Celandine, Swallowwort	IBF	4	IV
Synonyms:				
Family: **Phytolaccaceae (Pokeweed Family)**				
Phytolacca americana	Pokeweed, Pokeberry, Scoke, Poke, Inkberry, Pigeon-berry	NPF	1	IV
Synonyms:				
Family: **Pinaceae (Pine family)**				
Pinus strobus	Eastern or Northern White Pine	NT	1	IV
Synonyms:				
Family: **Poaceae (Grasses)**				
Panicum clandestinum	Deertongue, (hidden) Panic-grass	NPG	1	IV
Synonyms: Dichanthelium clandestinum (L.) Gould [K94; USDA82]				
Panicum dichotomum	(forking) Panic-grass	NPG	1	III
Synonyms: Dichanthelium dichotomum (L.) Gould var. dichotomum [K94; USDA82]; P. dichotomum var. barbulatum [F50; S93] & var. d. [S93]; P. mattamuskeetense [F50; S93]; P. microcarpon Muhl. [F50; S93] [USDA82 lists under D. sphaerocarpon var. isophyllum]				
Phleum pratense	Meadow- or Common Timothy, Herds' Grass	IPG	4	IV
Synonyms: Phleum pratense L. ssp. nodosum (L.) Arcang. [K94]; Phleum pratense L. ssp. pratense [K94]; Phleum pratense L. var. pratense [S93] & var. nodosum (L.) Hudson [F50; S93; USDA82]				
Family: **Polygonaceae (Buckwheat family)**				
Polygonum cuspidatum	Japanese Knotweed or Knotwood, "Bamboo" [RI Colloq.]	IPF	4*	IV
Synonyms: Fallopia japonica				

[1] RI Status and Abundance Data from "Vascular Flora of Rhode Island." Explanation of headings and codes located on last page of Appendix.

Species	Common Name	Habit: [1]	RI Status:	Abundance:
Family: **Pontederiaceae (Pickerelweed Family)**				
Pontederia cordata	Pickerelweed	NPEF	1	IV
Synonyms:				
Family: **Potamogetonaceae (Pondweed Family)**				
Potamogeton epihydrus	Ribbonleaf-pondweed	NP/F	1	III
Synonyms: Potamogeton epihydrus Raf. var. nuttallii (C. & S.) Fern. [F50]; Potamogeton epihydrus Raf. var. ramosus (Peck) House [HC80; S93]				
Potamogeton natans	Floating Pondweed, Floating Brownleaf	NP/F	1	III
Synonyms:				
Potamogeton pulcher	Spotted Pondweed	NP/F	1	III
Synonyms:				
Family: **Primulaceae (Primrose Family)**				
Lysimachia quadrifolia	Whorled Loosestrife	NPF	1	IV
Synonyms:				
Trientalis borealis	Starflower	NPF	1	III
Synonyms: Trientalis americana Pursh				
Family: **Rhamnaceae (Buckthorn Family)**				
Rhamnus cathartica	Common Buckthorn	IT	4*	III
Synonyms:				
Family: **Rosaceae (Rose Family)**				
Potentilla simplex	Common or Old-field Cinquefoil, Five-fingers	NPF	1	IV
Synonyms: Potentilla simplex Michx. var. calvescens Fern. [F50, S93 & USDA82] & var. simplex [S93]				

[1] RI Status and Abundance Data from "Vascular Flora of Rhode Island." Explanation of headings and codes located on last page of Appendix.

Species	Common Name	Habit: [1]	RI Status:	Abundance:
Family: **Rosaceae (Rose Family)**				
Prunus serotina	Wild Black Cherry, Rum Cherry	NT	1	IV
Synonyms:				
Prunus virginiana var. virginiana	Choke-cherry	NST	1	III
Synonyms: Prunus virginiana L. [S93; USDA82]				
Rosa palustris	Swamp-rose	NS	1	III
Synonyms:				
Rubus	Dewberry, Blackberry			
Synonyms:				
Rubus hispidus	Bristly, Swamp-, or Evergreen Dewberry	NS	1	IV
Synonyms: Rubus hispidus L. var. obovalis (Michx.) Fern. [F50; USDA82]				
Spiraea alba var. latifolia	Meadowsweet	NS	1	IV
Synonyms: Spiraea latifolia (Aiton) Borkh. [F50; USDA82]				
Spiraea tomentosa	Steeple-bush, Hardhack	NS		
Synonyms:				
Family: **Rubiaceae (Madder family)**				
Cephalanthus occidentalis var. occidentalis	Buttonbush	NEST	1	III
Synonyms:				
Galium asprellum	Rough Bedstraw	NPF	1	III
Synonyms:				
Mitchella repens	Partridge-berry, Twinberry, Two-eyed Berry, Running Box	NPF	1	III
Synonyms:				

[1] RI Status and Abundance Data from "Vascular Flora of Rhode Island." Explanation of headings and codes located on last page of Appendix.

Species	Common Name	Habit: [1]	RI Status:	Abundance:
Family: **Salicaceae (Willow Family)**				
Populus grandidentata	Big-toothed Aspen	NT	1	IV
Synonyms:				
Populus tremuloides	Quaking Aspen, Quiver-leaf	NT	1	IV
Synonyms: Populus tremula L. ssp. tremuloides (Michx.) A. & D. Love [USDA82]; Populus tremuloides Michx. var. tremuloides [S93]				
Family: **Scrophulariaceae (Figwort family)**				
Digitalis purpurea	Common Foxglove	IBPF	3c/7	I
Synonyms:				
Family: **Smilacaceae (Catbrier Family)**				
Smilax glauca	Sawbrier, Wild Sarsaparilla	NSWV	1	IV
Synonyms: Smilax glauca Walter var. leurophylla Blake [F50; USDA82]				
Smilax rotundifolia	Bullbrier, Common Greenbrier, Catbrier, Horsebrier	NWV	1	IV
Synonyms:				
Family: **Sparganiaceae (Burr-reed Family)**				
Sparganium americanum	Lesser, American, or Common Bur-reed	NPEF	1	III
Synonyms:				
Sparganium androcladum	Branching or Shining Bur-reed	NPEF	1	III
Synonyms:				
Sparganium sp.	Bur-reed, Burreed			
Synonyms:				
Sparganium sp.	Bur-reed, Burreed			
Synonyms:				

[1] RI Status and Abundance Data from "Vascular Flora of Rhode Island." Explanation of headings and codes located on last page of Appendix.

Species	Common Name	Habit: [1]	RI Status:	Abundance:
Family: **Thelypteridaceae (Thelypteris Family)**				
Thelypteris noveboracensis	New York Fern	NPF	1	IV
Synonyms: Dryopteris noveboracensis (L.) Gray [F50]				
Thelypteris palustris var. pubescens	Marsh- or Meadow-fern	NPEF	1	IV
Synonyms: Dryopteris thelypteris (L.) Gray var. pubescens (Lawson) Nakai [F50]; Thelypteris thelypteroides (Michx.) J. Holub [USDA82]				
Family: **Typhaceae (Cattail family)**				
Typha latifolia	Common Cattail, Cat-o'-nine-tails	NPEF	1	IV
Synonyms:				
Family: **Urticaceae (Nettle Family)**				
Boehmeria cylindrica	Bog-hemp, False Nettle	NPF	1	III
Synonyms: Boehmeria cylindrica (L.) Swartz var. cylindrica [S93]; var. drummondiana Wedd. [F50; S93]; var. drummondiana (Wedd.) Wedd. [USDA82]				
Family: **Verbenaceae (Vervain Family)**				
Verbena hastata	Common or Blue Vervain, Simpler's-joy	NPF	1	III
Synonyms:				
Family: **Violaceae (Violets, Violettes)**				
Viola sororia	Wooly Common or Northern Blue Violet, Dooryard-violet	NPF	1	III
Synonyms: Viola papilionacea Pursh [F50, S93, & USDA82 list as sep. sp.]; Viola septentrionalis Greene [F50, K94, S93, & USDA82 list as sep. sp.]				
Family: **Vitaceae (Grapevine family)**				
Parthenocissus quinquefolia	Virginia Creeper, Woodbine	NWV	1	IV
Synonyms: Parthenocissus quinquefolia (L.) Planchon forma hirsuta (Donn) Fern. [F50]				

[1] RI Status and Abundance Data from "Vascular Flora of Rhode Island." Explanation of headings and codes located on last page of Appendix.

Species	Common Name	Habit: [1]	RI Status:	Abundance:
Family: **Vitaceae (Grapevine family)**				
Parthenocissus quinquefolia	Virginia Creeper, Woodbine	NWV	1	IV
Synonyms: Parthenocissus quinquefolia (L.) Planchon forma hirsuta (Donn) Fern. [F50]				
Vitis labrusca	Fox-grape	NWV	1	IV
Synonyms:				

[1] RI Status and Abundance Data from "Vascular Flora of Rhode Island." Explanation of headings and codes located on last page of Appendix.

Species	Common Name	Habit: [1]	RI Status:	Abundance:

Explanation of Headings

Habit

N = Native	G = Grasslike	$ = Succulent
I = Introduced	S = Shrub	/ = Floating
A = Annual	T = Tree	-- = Saprophytic
B = Biennial	W = Woody	+ = Parasitic
P = Perennial	H = Partly Woody	E = Emergent
F = Herbaceous	V = Vine	Z = Submerged

In many cases codes are combined to indicate a variable growth form

Abundance

I Status undetermined: needs more study.
II Rare: only species listed by the Rhode Island Natural Heritage Program
III Present (from common to fairly common to uncommon).
IV Ubiquitous (widespread and abundant. Considered to be typical representatives of the Rhode Island flora, generally found in all or nearly all municipalities).
H "Historical" (native species known to have been extirpated in Rhode Island).
-- Used only with a "6" Status category; because we do not believe the plant to be in Rhode Island, we do not assign it an Abundance code.

RI Status

1 Native to Rhode Island.
2 Native to North America, naturalized in Rhode Island.
3 Native to North America, with little evidence of full naturalization in Rhode Island.
a) Species which persist at former cultivation sites, but do not reproduce and spread.
b) Species which spread vegetatively, or sprout from seeds at dump sites, but not fully naturalized.
c) Species which may be reproducing and spreading but on a very limited basis at this point in time.
4 Native to other continents, naturalized in Rhode Island.
* = Invasive Exotic
5 Native to other continents, with little evidence of full naturalization in Rhode Island (a, b, c same as listed under 3).
6 Species included in Palmatier's 1952 list of Rhode Island flora, Seymour's 1993 "The Flora of New England," or in the "Flora of North America" 1993 (Volume 2, 2nd printing), but for which we have been unable to locate any other literature references (beyond generalized range descriptions), herbarium specimens, or field evidence that these plants are part of the state's flora.
7 Species which have been reported by field notes but for which there are no herbarium specimens or other formal documentation.

[1] RI Status and Abundance Data from "Vascular Flora of Rhode Island." Explanation of headings and codes located on last page of Appendix.

Appendix C:
Quality Assurance Project Plan (QAPP) for
Ecosystem Science in Community Action:
Integrated Watershed Assessment and Outreach

Quality Assurance Project Plan

for

Ecosystem Science in Community Action: Integrated Watershed Assessment and Outreach

Signature: _____ Date: ____6/22/05__

David W. Gregg, RINHS Executive Director, Project Manager

Signature: _____ Date: ____6/30/05__

Margherita Pryor, US EPA Region 1 Project Officer

Signature: _____ Date: _____7/05/05__

Steve DiMattei, US EPA Region 1 QA Officer

Signature: _____ Date: _____6/27/05__

Rebecca Weidman, NEIWPCC Project Officer

Signature: _____ Date: _____6/27/05__

Michael Jennings, NEIWPCC QA Officer

Participating Organizations and QAPP Distribution List:

Rhode Island Natural History Survey (RINHS):
David Gregg, Executive Director, Project Manager, dgregg@rinhs.org
Kristen Puryear, Conservation Biologist, kpuryear@rinhs.org
P.O. Box 1858
Kingston, RI 02881
401-874-5800

Laboratory for Terrestrial Remote Sensing, URI (LTRS):
Yeqiao Wang, Director, yqwang@uri.edu
Coastal Institute, Kingston
URI
Kingston, RI 02881
401-874-4345

Narragansett Bay Estuary Program:
Richard Ribb, Executive Director, rribb@gso.uri.edu
235 Promenade St.
Providence RI 02908
401-874-6233

US Environmental Protection Agency Region 1:
Margharita Pryor, Project Officer, Pryor.Margherita@epamail.epa.gov
Steve DiMattei, QA Officer, Dimattei.Steve@epamail.epa.gov
1 Congress Street, Suite 1100
Boston MA 02114-2023
888-372-7341

New England Interstate Water Pollution Control Comm. (NEIWPCC):
Rebecca Weidman, Project Officer, RWeidman@neiwpcc.org
Michael Jennings, QA Officer, mjennings@neiwpcc.org
Boott Mills South
116 John Street
Lowell, MA 01852
978-323-7929

RI Rivers Council (RIRC):
Meg Kerr, Executive Director, MegKerr@cox.net
P.O. Box 1565
North Kingstown, RI 02852
401-714-1597

RI Land Trust Council (RILTC):
Rupert Friday, Executive Director, rfriday@tnc.org
159 Waterman Street
Providence, RI 02906
401-331-7110 x39

Blackstone River Coalition (BRC):
Tammy Gilpatrick, Executive Director, brcoalition@yahoo.com
414 Massasoit Road
Worcester, MA 01604
508-949-3936

Table of Contents:

Key Personnel:

RINHS Executive Director, David Gregg

Task: overall coordination of project; supervision of K. Puryear and V. Brown; responsible for QAPP, including ensuring that all project participants receive and are using the most recent version of the QAPP, that fieldwork is being conducted in accordance with the QAPP, and that--should the situation warrant it--the QAPP is revised to address unforeseen circumstances; write final report assessing outreach and science results; help disseminate results; write NBJ article

RINHS Conservation Biologist, Kristen Puryear

Task: overall coordination of science component; undertake investigations of study area; immediate supervision of volunteers; report QAPP compliance and science results to D. Gregg.

RINHS Contract Odonata Specialist, Virginia Brown

Task: undertake investigations of aquatic invertebrates in study area; analyze historical data for study area; work with volunteers; present at public meetings; report science results to D. Gregg.

LTRS Director, Y.Q. Wang

Task: supervise Yuyu Zhou

Technician (URI graduate student), Yuyu Zhou

Task: deliver impervious surface and riparian buffer analysis of study area using remote sensing; provide accuracy and error report for results

BRC Executive Director, Tammy Gilpatrick

Task: provide community and organizational contacts and logistical coordination within the study area; evaluate outreach results of project; help disseminate scientific results

RIRC Director, Meg Kerr

Task: review outreach results of project

RILTC Director, Rupert Friday

Task: review outreach results of project

Project Description:
The purpose of this project is to pilot **Ecosystem Science in Community Action** (ESCA).

The goal of ESCA is to excite public interest in watershed and land conservation, and thereby strengthen local conservation organizations, by having field scientists and interested members of the public work together to conduct simple scientific projects of limited scope. The result of this interaction should be the demystification of natural science and the empowerment of individuals and local organizations to engage further in discourse that involves scientific activities. In addition, each ESCA project provides a simple, limited, science product to further the participants' own priorities and perhaps to help prioritize further, in-depth research.

The local partner in this first ESCA project will be the Blackstone River Coalition (BRC) and its collaborating organizations, including the Blackstone River Watershed Council. This partner was selected in consultation with the RIRC and RILTC because it was seeking to increase public participation in northern Rhode Island in its programs.

The particular science project to be undertaken to achieve the ESCA goal is **Integrated Watershed Assessment and Outreach** (IWAO). IWAO was selected for the ESCA science project through consultation between RINHS and BRC because it fits the skills of the RINHS and meets the needs of the BRC and because it includes scientific methodologies RINHS wishes to refine for use elsewhere.

The Branch River, a HUC-12 sub-basin of the Blackstone River that straddles the RI/Mass. border (see map, Appendix 2, or http://www.edc.uri.edu/spfdata/rigisup2003/Hydrography/senehuc_shp.zip), was chosen because: a) it was within the Blackstone River watershed; b) was in an area where the BRC wanted to recruit new public support; c) on initial review it had a gradient of development within it; d) it was spread across the Mass./RI border and so would attract public interest in both states.

A public meeting prior to the field work will be used to recruit volunteers, evaluate community priorities, and gather practical information on habitat health and threats, target species, and possible study sites and access. Since it is a goal of this project to involve the public in the selection of specific study sites, it is impossible to include details about specific study sites in the QAPP. Five to ten study sites within the project area will be selected based on input from the public during the course of the project. Selection criteria will include access, public interest, representitiveness of typical habitats within the project area, uniqueness within the project area, and distribution across a range of development impacts.

For certain segments of the Branch River system, selected in consultation with the public, RINHS scientists, working with volunteers and observers, will generate simple IBI habitat health assessments using a variety of indicators. In addition, LTRS will assess the percent impervious surface and percent vegetated riparian buffer in the entire project area. A public meeting following the field work will present results and elicit feedback. For the final report, BRC will report on the organization-building results of the project and the other participating organizations (RINHS, RILTC, and RIRC) will discuss the observed value of this way of creating partnerships and make recommendations for future ESCA-type projects.

As described in the project work plan, deliverables are:

1) two public meetings
2) seven field days with scientists and small groups of volunteers
3) two large, public field days, or one such day and a school program
4) an organizational debriefing
5) two interim reports
6) a final report that includes the following:
    a) an assessment of impervious surface percentage and vegetated riparian buffer percentage in the project area
    b) an assessment of biological integrity at selected sites in the project area
    c) a simple, qualitative methodological evaluation
    d) an evaluation of organizational development over the course of the project
7) an article for publication in the Narragansett Bay Journal

Project Tasks and Timetable:
(for complete details see BayWAG proposal work plan attached as Appendix 1)
RINHS
Coordinate work of all participants
Secure approved QAPP
Secure and review historic data for biological integrity of watershed in the project area, especially odonata and aquatic macroinvertebrates
Between June, 2005, and October, 2005, conduct 7 days of fieldwork with select volunteers to gather information on odonata assemblages and other biological indicators of habitat integrity
Participate in a public field day in July, 2005
Participate in a school outreach event in September, 2005
Gather, and report on the scientific results at meetings and to funders
Report on the outreach results at meetings and to funders

RINHS and BRC
Organize two public meetings, one in May, 2005, and one in October, 2005
Recruit and coordinate volunteers
Organize a public field day in July, 2005
Organize outreach event, perhaps with a school, in the study area in September, 2005

LTRS
Before September 1, 2005, gather, pre-process, process, and analyze data; and report on land use in project area and subdivisions of it
Provide error report and assessment

RINHS, BRC, RIRC, and RILTC
Meet in November, 2005, or December, 2005, to evaluate the outreach and organizational development success of the project and make recommendations for future

Data Quality Control:
IWAO uses scientific methodologies, some of which include data collection, to achieve its primarily organizational development and public outreach goals. Because of the small size of the project, the scientific results are expected to be limited, and these limitations will be discussed in the final report.

Data to be collected by this project include: **biological specimens and observations**, associated field data, taxonomic identifications, and metadata; **georeferencing data** associated with field observations and collected specimens, **physical environmental data** such as temperature, RH, pH, etc. In addition, the project will use secondary data, including satellite imagery and odonata assemblage data, derived as described below.

Generally, data collection, processing, handling, and storage follow policies described in the RINHS Quality Control Management Plan (see Appendix 3).

Biological specimens to be collected include fish, amphibians, adult and immature odonata, ephemeroptera, diptera, tricoptera, plecoptera, neuroptera, mollusca, crustacea, anelida, and nematoda. Some specimens will be observed and/or counted and released in the field, some may be retained. Retained specimens will be curated individually or in lots using generally accepted professional practices appropriate for the nature of the specimen(s). Labeling will include at least date, location (site, town, county), habitat description, method of collection, and reference to associated metadata. Biological observations will include odonata species, bird species, and vascular plant species. Identifications, to species where possible, will be made or verified by RINHS taxonomic authorities (see Appendix 3). Each group of observations will have associated metadata recorded by RINHS staff using field note books (field books are retained by RINHS as described in Appendix 3). In certain instances, biological specimens and observations may be recorded in RINHS's Biota and Natural Heritage Databases, using the standardized forms in Appendix 3, which databases have some potential regulatory and compliance uses.

Georeferencing data are important for making sure data are collected within the project area and are attributed to the appropriate subsection thereof. The technical standards of RINHS georeferencing data are discussed below under documentation and instrumentation and in Appendix 3. Georeferencing data associated with biological specimens and observations may have regulatory or compliance uses. A RIGIS boundary file will be used to define the area of interest for all project activities. In RIGIS, hydrologic unit boundaries generally were digitized within 0.01 inches of their locations on the digitizing source (a USGS DRG file). Edge match locations are exact because the data were extracted from a New England-based hydrologic units layer which had been electronically edge-matched. The data quality of this file is discussed in detail at http://www.edc.uri.edu/ spfdata/ rigisup2003/ Hydrography/ dbasin12.htm.

Physical environmental data will be collected as part of the biological specimens' associated metadata, in order to demonstrate basic field techniques to the participating public, and to demonstrate to the public the importance of microclimates within habitat structure. All measurements will be taken in several different locations at each field site to demonstrate microclimates. Data gathered will include air temperature and relative humidity and water temperature, pH, conductivity, and turbidity as measured by

appropriately calibrated hand-held meters. Stream flow will be measured for demonstration purposes using floats, stop watches, and meter tapes.

Secondary data are described below and their limitations will be discussed in depth in the final reports.

Data Uses:
There are no legal or compliance uses anticipated for most IWAO data. It is, however, possible that certain species or community occurrence observations made during IWAO will be incorporated into RINHS Biota and Natural Heritage Databases, which have potential legal or compliance uses. It is also possible that biological assessment methodologies demonstrated in IWAO can be further developed to have legal or compliance uses, especially methodologies based on comparison of odonata atlas data and remote sensing data. Typical anticipated uses of IWAO data, however, include public education and outreach and non-profit organizational development.

During the project, RINHS staff will demonstrate techniques for georeferencing and collecting basic environmental physical parameters, such as water and air temp, relative humidity, pH, etc. RINHS staff or qualified volunteers will also demonstrate principles of taxonomy and biological diversity using field collected biological specimens. In these cases, the data collected should be understood as being for demonstration purposes and will either be discarded or identified as limited. If unexpected conditions or species are encountered during demonstrations, they will be verified by additional authorities before being reported in end products other than public education and outreach (see below regarding biological data).

To demonstrate biological assessment methodology, RINHS will also conduct qualitative evaluations of environmental health at study sites in the project area based on biological data. These assessments will be achieved in two ways:

a) by analysis of existing data from the Rhode Island Odonata Atlas, in particular odonata assemblages in the project area. The Odonata Atlas includes over 14,000 specimens from over 1,000 habitats in Rhode Island. Coverage within the study area is excellent, including thousands of specimens and dozens of sites. The nature of the Odonata Atlas project and its quality control measures are discussed in Appendix 5. Biological assessments are generally multiyear projects and the Odonata Atlas data, gathered between 1997 and 2004, will be taken to be contemporary to the 1999 remote sensing data for the purposes of this project.

b) by conducting field work to gather additional data on odonata assemblages and habitat conditions and to conduct limited surveys for and assessments of biological integrity at study sites within the project area. Field work will follow protocols developed by Wisconsin Department of Natural Resources (see http://clean-water.uwex.edu/ wav/otherwav/ riverkey.pdf) and Fleming and Henkel (2001) and assess assemblages of aquatic and riparian macroinvertebrates, fish, and riparian birds, as well as the ratio of invasive to native plants in the riparian zone. This assessment will be carried out by RINHS staff in cooperation with local volunteers and observers.

As described in the project work plan, these biological assessments will result in a general, qualitative statement about habitat health at the selected study sites on a point scale (e.g. 1=not impacted by human activity, 2=minor impact, 3=substantial impact, 4=very highly

impacted). Because of the limited scope of this project, extrapolation to the Branch River watershed as a whole from the biological integrity assessments made at a limited number of study sites for demonstration purposes will not be attempted. Nonetheless, it is hoped these assessments will produce results of public interest, of general use to local constituent organizations, or suggestive of fruitful avenues for future research.

As described in the project work plan, the IWAO project will attempt an assessment of overall watershed health within the study area, but not by extrapolation from habitat integrity assessments made for demonstration purposes. Watershed-wide assessments will use Odonata species assemblage diversity and composition (number of species and percentage of disturbance and pollution sensitive species) taken from data in the RI Odonata Atlas (see above and Appendix 5). IWAO will also conduct an analysis of impervious surface and riparian buffer percentages derived using remote sensing.

Odonata species assemblage diversity and composition (number of species and percentage of disturbance and pollution sensitive species) have been shown to correlate grossly to habitat plot size, and inversely to habitat fragmentation, itself a well established indicator of environmental impairment (Brown, in prep), although thresholds in odonata diversity for different levels of impairment are not yet thoroughly understood. The experimental nature of the use of odonata assemblage data for watershed health assessment, and its limitations and uncertainties, will be discussed in the final report.

IWAO also includes quantification of percent impervious surface and percent vegetated riparian buffer in the entire project area using remote sensing in order to test cooperation between field biology teams and remote sensing technicians and to provide a quantitative evaluation of overall watershed health, for which impervious surface and riparian buffers are taken to be surrogates, as described below and by Civco, et al (1997, 2002).

The data for the remote sensing analysis were collected in 1999 using the Thematic Mapper instrument on Landsat 7. All the remote sensing data will be processed using ERDAS Imagine software system that is available at URI's Laboratory for Terrestrial Remote Sensing. In preprocessing, a spatial resolution merger of panchromatic and multispectral data will provide a maximum analytical resolution of 15m. Supervised land cover classification using a modified USGS classification will take place. Impervious surface and riparian buffer areas will be identified, characterized, and quantified using generally accepted techniques described by Anderson et al. (1976) and Civco, et al (1997, 2002), Novak and Wang (2004), and Wang and Zhang (2004). After initial classification, we will conduct post-classification modeling to improve the classification accuracy. Existing land use and land cover maps, GPS field reference data, and other ground truthing data will be referenced in the model.

Four field days for ground truthing are included in the project plan. A randomly selected set of ground verification points will be used for accuracy assessment. These points will be subset from the data and not used for the supervised classification of remote sensing data. We will produce an error matrix that will describe the producer and user accuracy for all classes, as well as the overall accuracy. With its final analysis, LTRS will provide to RINHS a detailed accuracy assessment and error report for incorporation into final products. LTRS is a recognized world leader in this type of analysis and have provided

Error Tables for similar Rhode Island data summarizing the expected accuracy for this project (see Appendix 4).

With regard to watershed-wide environmental health assessments, the final report will emphasize the limitations inherent in a project like IWAO, which is limited in size, time, and scope and whose primary goals are organizational. The final report will acknowledge the experimental nature of watershed health assessments using odonata data and will discuss the methodological and other limitations of watershed health assessments derived by analysis of impervious surface and riparian buffers. Methodological conclusions from comparison of remote sensing and odonata derived analyses are also necessarily limited by the small scale of this project, but it is hoped they may provide insight into avenues for further, more detailed, research in the future.

Training and Volunteers:
RINHS personnel assigned to this project are nationally recognized for their expertise on odonata ecology, have extensive experience with a range of conservation science techniques, and have many years' experience in public interpretation and outreach. LTRS is nationally recognized as one of the foremost facilities for deriving terrestrial ecological information using remote sensing.

Generally, RINHS has three types of volunteers: 1) ecological/biological professionals volunteering time in their field of expertise, 2) avocational naturalists volunteering time in a field in which they have developed substantial knowledge and experience, and 3) volunteers generally untrained and inexperienced in the work that will be taking place. Once volunteers of the first two types are vetted by Project Managers, their contributions are accepted with little or no additional review except for checks of clerical accuracy, although training in Standard Operating Procedures may be necessary. Volunteers of the third type are trained as necessary and assigned suitable tasks. They work under the guidance of authoritative participants and have their work systematically double checked.

Documentation and Instrumentation:
Field notes and specimen records will be made using note books and existing field forms developed for and tested by the RI Odonata Atlas project. RINHS project notes are maintained in office conditions indefinitely. Most instruments for this project, such as thermometers and other handheld instruments, will be used for demonstration purposes or for determining habitat suitability within a relatively broad range of values and consumer-type equipment and procedures will be sufficient. GPS receivers are the only critical instrument to project science goals, for ensuring field data are attributed to the correct watershed or sub-area. RINHS uses Trimble GeoXT and Garmin GPSMAP receivers. Even without dGPS and other post-processing, the precision and accuracy of these instruments (no greater than 15m radius at 2 s.d. in the project area) is more than sufficient for project requirements. GPS data will be downloaded and checked by the RINHS Data Manager using GIS software and RIGIS base data.

Secondary Data:
(See Appendices 4 and 5 regarding Landsat data and Odonata Atlas data and http://www.edc.uri.edu/spfdata/rigisup2003/Hydrography/dbasin12.htm *regarding RIGIS-based georeferencing.)*

Data Handling:
Field data submitted by anyone other than qualified staff or an approved volunteer are inspected by the Project Manager and are then returned to the RINHS office. In the office, appropriately qualified staff or volunteers enter data from field data sheets into one of several interlinked Access databases. The RINHS Data Manager recovers georeferencing data from instruments. He and the Project Manager do a QC check on a draft map. The georeferencing data and other data are used in parallel during analysis and report writing. Ultimately, the Data Manager transfers all data into an appropriate database, transfers or writes metadata, does a field-by-field QC check on all tabulated data, and creates suitable links between locational and other data. Field sheets are maintained indefinitely in office conditions. See Appendix 3 regarding RINHS electronic data security and archiving.

Data Quality Review and Adaptive Project Management:
Public outreach and the development of organizational capacity are the main goals of this project. In order to maximize organizational development, regular feedback regarding the organizational goals is of utmost importance. As put forth in the project description, this feedback will take place at public meetings, when the results to date are presented by each participant. There is sufficient flexibility in the planned field days to accommodate adjustments that become necessary. In addition, there is an existing working relationship between the leaders of the participating organizations.

Feedback from field staff to project management in important if the project is to adapt to unforeseen circumstances. At RINHS there are only four people with substantial involvement, including the Project Manager, David Gregg. Informal feedback takes place constantly. Formal feedback takes place at monthly staff meetings and ad hoc project meetings. See Appendix 6 for a project personnel chart.

As part of the final project, the Project Manager will write an appropriate accuracy assessment and error report summarizing theoretical and measured accuracy for project data collection, processing, and interpretation, and incorporate the results of the accuracy assessment and error report into the project metadata. The final report will include a statement about how data usability may effect the conclusions.

References:

Anderson, J.R., E.E. Hardy, J.T. Roach, and R.E. Witmer, 1976. A Land Use and Land Cover Classification System for Use with Remote Sensor Data, U.S. Geological Survey Professional Paper 964. (Reston, VA: U.S. Geological Survey).

Brown, Virginia. in prep. *Dragonflies and Damselflies of Rhode Island*. Kingston, RI: Rhode Island Natural History Survey.

Civco, D.L., J.D. Hurd. 1997. Impervious surface mapping for the state of Connecticut, Proceedings of ASPRS/ACSM 1997 Annual Convention, 07-10 April, Seattle, Washington, 3:124-35.

Civco, D.L., J.D. Hurd, E.H. Wilson, C.L. Arnold, and S. Prisloe. 2002. Quantifying and Describing Urbanizing Landscapes in the Northeast United States. Photogramm. Eng. Remote Sens., 68(10): 1083-90.

Fleming, B. and D. Henkel. 2001. Community-Based Ecological Monitoring: A Rapid Appraisal Approach. Journal of the American Planning Association, 67(4): 456-65.

Novak, A. and Y. Wang. 2004. Effects of suburban sprawl on Rhode Island's forest: A Landsat view from 1972 to 1999, Northeast Naturalist, 11(1) 67-74.

Wang, Y. and K. Zhang, 2004. A SPLIT Model for Extraction of Subpixel Impervious Surface Information, Photogrammetric Engineering & Remote Sensing, 70(7): 821-28.

Appendix 1:

BayWAG Project Workplan: The work plan has the following components: **1**) Approval of QAPP is necessary and an approved plan will be sought. Data acquisition will follow appropriate protocols and be conducted to the relevant professional standards, such as IBI. All new biological data gathered (species records, communities identified, etc.) will be entered into the Survey's existing databases. These databases are managed to national standards promulgated by NatureServe. QAPP of the remote sensing interpretation will be done to nominal standards by the Terrestrial Remote Sensing Lab as negotiated with EPA.
2) Two public meetings are integral to the project's scientific and capacity building-objectives. For each meeting, the Blackstone River Coalition will provide a venue, refreshments, publicity, etc., and RINHS will prepare and conduct the agenda. The goal is to get at least 20 members of the public interested in the health of the target watershed and representing various stakeholders, to come and participate in a discussion with Survey scientists. **The first meeting** will take place in early spring. The Survey will present and describe in lay person's terms the scientific basis, methodology, and possible outcomes of the watershed assessments it plans on conducting. The public attendees will communicate local community priorities for the watershed, including perceived threats, ideal uses, and criteria, and practical information on target species, possible study sites and site access, and fieldwork schedule to the Survey. The project will use the meeting to recruit volunteers. **The second meeting** will take place in early fall. The Survey will present the scientific results of the project. Volunteers who participated in data gathering or other aspects of the project will be invited to present their observations about the study sites. The Blackstone River Coalition will present the case for continued participation by volunteers in Coalition projects.
3) Following critical public input, the Survey and the Blackstone River Coalition will select three segments of the Branch River watershed to be the focus of fieldwork. Public input is important for making this choice. The RIDEM Office of Sustainable Watersheds began an assessment of riparian buffers in the Blackstone valley using aerial photography in 2004, but this work did not cover the Branch River. Scott Millar asked to participate in site selection because he felt this work would compliment his.
4) RINHS will seek and review available historical data on aquatic life in the selected river segments. This is important because this data will supplement the new but limited field data gathered. Existing data sources that may be used include the Survey's Odonata Database, Biota of RI Database, and Natural Heritage Database, benthic macroinvertebrate monitoring data gathered by DEM, and fish data.
5) Key to the project is use of satellite imagery for assessment of land use relevant to watershed health. This will be done by providing a summer stipend to a URI graduate student studying remote sensing and ecosystem science, to be selected and supervised by Y.Q. Wang in consultation with RINHS. 1999 Landsat TM data and existing statewide land cover interpretations, all at 30 m. resolution. Ground verification will be done to ensure accuracy of land cover interpretation for the target basin. RIGIS overlays will be used to identify stream centerlines. Assessments will be verified by field trips including volunteers. The results will be presented at the second public meeting and in subsequent reports.
6) Critical to the capacity building objectives are two public field days and seven small field team days. These will be organized by the Blackstone River Coalition. RINHS will organize and conduct the agendas for each. Through out the field season small teams of selected volunteers will travel to study areas with Survey scientists to gather new data and to verify historical data and remote sensing interpretations.
7) For the final report, the participating organizations will discuss the observed value of this partnership and make recommendations for the future. In addition to the foregoing seven

components, deliverables for this project are: a) progress reports submitted to NEIWPCC in June and September 2005, b) a final report summarizing project results submitted to NEIWPCC and NBEP in December 2005, and c) an article summarizing the project results submitted to NBEP for publication in the Narragansett Bay Journal.

Appendix 2:

Map of Project Area: Branch River HUC-12
based on maps from RIGIS (Rhode Island Geographic Information System--
http://www.edc.uri.edu/spfdata/rigisup2003/Hydrography/senehuc_shp.zip)

Appendix 3:

Quality Control Management Plan

Approved by the Board of Trustees: PENDING

1. Purpose and Scope

An essential element of the mission of the Rhode Island Natural History Survey (RINHS) is to gather, analyze, report, and store high quality environmental data. The organization's ability to meet its mission thus depends upon its data quality control and assurance (QA/QC) policies and practices and its ability to maintain rigorous standards throughout its operations. Data quality control and assessment are integral to all RINHS projects. They will be planned for from inception to completion following this Quality Control Management Plan (QCMP). The QCMP is approved by the Information Dissemination and Database Standards Committee of the Board of Directors and its implementation is the responsibility of the Executive Director.

a. RINHS Data Quality Philosophy-

The Rhode Island Natural History Survey recognizes its responsibility for three distinct types of data:

i. proprietary scientific data where RINHS has the sole ownership interest
ii. proprietary scientific data where an RINHS customer or organizational partner has an ownership interest
iii. administrative data including financial and membership records

RINHS makes every reasonable effort to ensure the accuracy, integrity, and security of all three types of data; the QCMP applies only to science data of types i) and ii)

b. Objectives for RINHS Quality Control Management Plan-

- Outline overall RINHS policy and expectations with regard to instrument selection, use, and maintenance, personnel qualifications, sample collection, data recording, analysis, management, and storage;
- Provide guidelines for the preparation and review of RINHS project Quality Assurance Project Plans (QAPP);
- Provide a means by which the quality of information produced by RINHS activity can be judged;
- Ensure appropriate data standards for particular projects;

2. Project Planning

Adequate project planning is essential to gathering high-quality and meaningful data. Before data gathering commences, every RINHS project will have an appropriate Quality Assurance Project Plan (QAPP) that incorporates the relevant data gathering and handling considerations. RINHS programs frequently conducting similar projects will operate under a single QAPP.

The QAPP, is a written document that outlines the procedures a project will use to ensure that the samples participants collect and analyze, the data they store and manage, and the reports they write are of high enough quality to meet project needs.

QAPP planning includes:
Designate responsible Project Manager
Identify project goals and objectives
Specify sampling, analytical, and data requirements
Evaluate and select techniques and instruments to be used
Plan for data collection given limitations and requirements of selected instruments
Specify project output (e.g., web database, publication, etc.)
Describe appropriate QA/QC measures
Prototype data forms and project output and test data acquisition and entry
Review of process and results by appropriate parties
Incorporate feedback

Twenty four distinct elements can be included in a QAPP, although not all elements may be necessary for all projects, depending on the project's goals, objectives, scope, data uses, and on guidance received from state or EPA regional quality assurance contacts. The 24 elements are grouped into four overall categories and are:

Project Management

1. Title and Approval Page
2. Table of Contents
3. Distribution List
4. Project/Task Organization
5. Problem Identification/ Background
6. Project/Task Description
7. Data Quality Objectives for Measurement Data
8. Training Requirements/Certification
9. Documentation and Records

Measurement/Data Acquisition

10. Sampling Process Design
11. Sampling Methods Requirements
12. Sample Handling and Custody Requirements
13. Analytical Methods Requirements
14. Quality Control Requirements
15. Instrument/Equipment Testing, Inspection, and Maintenance Requirements
16. Instrument Calibration and Frequency
17. Inspection/Acceptance Requirements for Supplies
18. Data Acquisition Requirements

19. Data Management

Assessment and Oversight

20. Assessment and Response Actions
21. Reports

Data Validation and Usability

22. Data Review, Validation, and Verification Requirements
23. Validation and Verification Methods
24. Reconciliation with Data Quality Objectives

In preparing the QAPP, a Project Manager makes an explicit statement about the data quality requirements for the overall goals and objectives of that particular project. This statement should be made in consultation with project personnel and data end-users. QA/QC measures are selected to achieve and document the minimal data quality required for usability.

3. Measurement and Data Acquisition

a) Field data:

Data collected may include taxonomic, geospatial, physical, and community data, and also collection metadata. Project Managers are responsible for employing equipment and expert knowledge appropriate to the data requirements of particular projects. To the extent practical, all data of any particular type are collected and handled in the same way. Where appropriate, projects will have written Standard Operating Procedures for certain types of data collection and handling. Generally, field data are written in field notebooks and entered into either Microsoft Excel or Access in the RINHS office and stored in Microsoft Access in an RINHS-designed spreadsheet. Additional databases may result from projects and these may be in Access, Excel, or GIS, and may include an effort database, habitat types, site codes, and maps for all point locations. Field books made by RINHS staff or subcontractors in the course of their work are the property of RINHS and are curated as part of the Survey's permanent records.

b) Spatial data:

Depending on the needs of a particular project, spatial data may be recorded on paper USGS topographic maps or aerial or satellite photographs and manually digitized, or it may be recorded in the field using GPS and transferred to georeferencing software. Spatial data are collected and stored at a precision appropriate to the project. RINHS has the instrumentation and post processing capability to achieve sub-meter accuracy where necessary. Once downloaded from field equipment, spatial data are plotted onto appropriate maps and reviewed for errors by the Data Manager and by project personnel before being used for analysis or archived.

c) Specimen data:
Specimen information will be recorded at the time of collection or as soon after as practical, on or in the specimen container, or if containers are numbered, in a field book. Appropriate specimen information includes place and time of collection, behavior, size of population, habitat description, associated species, collection and preservation technique, method of identification, etc.

RINHS has significant expertise and resources for conducting ecological inventory studies. RINHS relies on experts, either on staff, contracted, or volunteer, to develop appropriate collection techniques and make taxonomic and community type identifications. RINHS maintains a substantial natural history reference library.

In RINHS projects, species identifications are generally accepted from individuals whose qualifications on the subject have been reviewed and accepted by the Project Manager. Any identification of cryptic, listed, or exotic or unexpected species should be reviewed by the Project Manager or an appropriate taxonomic authority and be accompanied by literature citations and photographic or specimen vouchers where possible. A Project Manager is responsible citing in the project metadata the taxonomic authorities or literature used. Project Managers or other designated taxonomic authorities will verify all identifications made by individuals whose knowledge is not up to the Project Manager's standard. Specimen identifications are matched with Taxonomic Serial Numbers (TSNs) from the Interagency Taxonomic Information System (ITIS; www.itis.usda.gov)

All specimen data are checked by project managers for unexpected results; i.e., species outside of their normal range.

RINHS collects biological specimens only when necessary to voucher presence or identification or when survey techniques otherwise appropriate to a project's overall goals result in the death of specimens. Survey techniques are chosen to minimize death of unnecessary or non-target specimens to minimize unnecessary suffering to organisms. RINHS follows all applicable state and federal laws regarding the collection of biological specimens, including but not limited to the Convention on the International Trade in Endangered Species (CITES), the Endangered Species Act, and Migratory Bird Act, and follows all applicable land owner stipulated regulations and rules regarding collecting.

Specimens owned by or housed at RINHS are managed according to a Collections Policy approved by the Board of Directors. Unless otherwise specified in writing, specimens collected by RINHS belong to the owner of the land where they were collected and are treated as loans as described in the Collections Policy. To the extent possible, RINHS will stipulate in contracts and agreements that the ownership of specimens taken be transferred to RINHS upon completion of a project. RINHS curates all specimens in its possession to appropriate museological

standards unless the owner requests other arrangements. RINHS may seek appropriately qualified partners to house, either as loans or gifts, collections it owns or is borrowing.

d) Metadata:
Appropriate, associated metadata will also be recorded as soon as practical, including for instance the name of the collector, weather, time on site, other parties present, instrument specifications and calibration information, DGPS data, taxonomic and other authorities used, etc. The frequency with which metadata are recorded may vary as appropriate for the project.

e) Instruments:
Project Managers design projects using instruments and data collection techniques with adequate design precision and ensure that data collection equipment is operating within limits of error expected for its design. Instruments are maintained and calibrated according to manufacturer's instructions. Managers should perform tests to determine and document the standard deviation of data collected using field instruments.

RINHS endeavors to maintain and provide to Project Managers state-of-the-art equipment appropriate to each project task. Before acquisition of equipment, specifications are reviewed by the EIMS Coordinator and Data Manager for suitability and interoperability/compatibility with existing equipment and data handling routines. Technical specifications of all equipment are maintained by the EIMS Coordinator. Project Managers are responsible for calibration and verification of equipment they use.

f) Volunteers:
For some inventory-based projects, RINHS also draws on volunteer help for data collection and processing. Volunteers may be individuals with basic field skills, skills with equipment being used, or with knowledge of specific organisms or taxonomic groups. They are instructed on the methods and procedures for each project that they work on. Project Managers take appropriate measures to ensure that volunteers collect and process data appropriately to the project. Appropriate measures include a skills assessment upon intake, training as necessary, and reviews or retraining, as well as periodic reviews of all or a subset of data handled by the volunteer. In some cases, RINHS relies on an outside agency to train volunteers. For example, volunteers trained by the New England Plant Conservation Program (NEPCoP) collect rare species data for the Rhode Island Natural Heritage Database. RINHS retains contact information for its staff and volunteers so that they may be contacted regarding specific projects as needed.

g) Assessment:
At appropriate points during data acquisition, Project Managers should review field data and the various elements of the acquisition process--instruments, tools

and supplies, personnel including volunteers, etc.--and plan steps to address conditions that could jeopardize the minimal data quality.

4. Data Management

a) Forms:

Data forms are designed prior to data collection and are approved by the Project Manager. These forms are designed to capture necessary data and reduce the amount of inaccurate or extraneous data collected.

Data forms for the RI Natural Heritage Program (RINHP) are available online. These forms may be printed out and filled in by observers, and digital forms are available so that volunteers can directly enter data and email them to the data manager. See appendix for examples of RINHP data forms.

QA/QC measures to ensure data quality:

- Attribute names are consistent and meet project standards
- Data forms are designed so that they match, as best as possible, the digital structure of the data entry form
- Measurement units are always specified on the data forms (when applicable)
- Data completeness is reviewed by the data manager using automatic processes
- Check that crucial information, such as date, time, location, and collector(s) are given
- Data is checked so that values and codes are correct for the given attributes
- Data is checked to assure that measurements fall within appropriate range
- Random record checks for quality assurance
- Metadata is collected to increase data quality and longevity

b) Storage:

At RINHS, data in all stages of collection, processing, use, and storage are secured in such a way as to provide reasonable protection against intentional or unintentional loss or alteration while facilitating appropriate use by diverse parties.

Most data are stored on a secure, password-protected server. Passwords are rotated on a monthly schedule. The server is equipped with level 5-RAID hard drives, preventing loss of information due to hardware failure. A back up power supply is used. The server is protected from attacks outside of the internal network by a firewall maintained by the URI's Environmental Data Center. All data on the server are backed up weekly by an automated tape backup system. Backup data is securely stored in two separate facilities, one located in the Coastal Institute at Kingston, the other at a private archival facility in East Greenwich, Rhode Island. To prevent data from being used outside of their intended purpose, data are retrieved from all staff upon leaving their job and are cleaned off all media upon

their disposal. Data are provided to users on a need-to-know basis, with access requests filled following the procedures specified in this document. Only persons pre-screened by the Data Manager and by the appropriate scientific or administrative staff are given authority to work with the database directly--to add to, or to alter entries.

Data being processed, developed, and used may be on staff members' computers. Computer hardware is updated regularly, computer software is updated automatically. Computers operate on URI's institutional network, which is protected from infiltration by various central and local software installations. RINHS computers are password protected, in locked offices, backed up on zip disks, CDs, removable hard drives, or flash drives at least weekly, with back up copies stored both on and off site, and are turned off overnight.

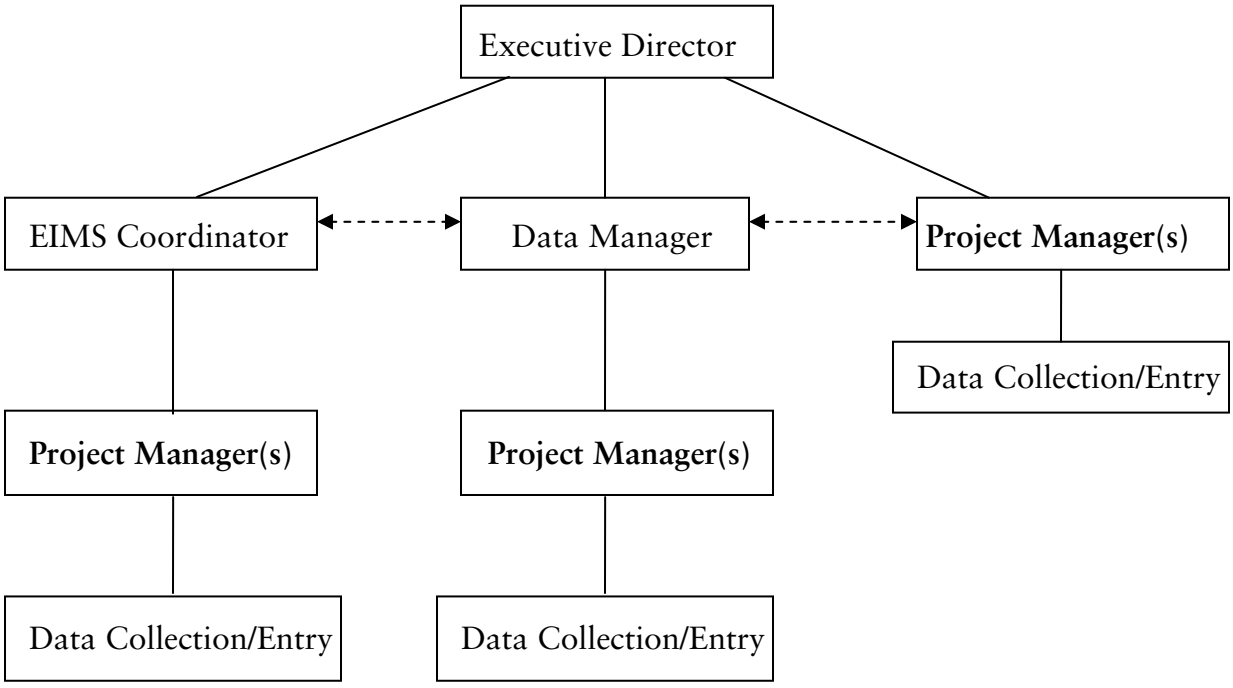
Paper field records, including field books, field forms, and other notes are catalogued and then maintained in office conditions. It is the responsibility of the EIMS Coordinator to collect, organize, and retain all paper records relating to RINHS fieldwork.

c) Review:
Project Managers should review data and assess procedures periodically during projects and make adjustments where necessary. As part of any final project, a Project Manager will write an appropriate accuracy assessment and error report summarizing theoretical and measured accuracy for project data collection, processing, and interpretation and incorporate results of accuracy assessment and error report into project metadata.

Project reviews should summarize data validation and verification procedures and a statement about how the conclusions affect data usability in light of project data quality objectives.

Table 1. Chart of QA/QC Responsibility at RINHS

This chart illustrates the location of immediate QA/QC responsibility with designated Project Managers. Every RINHS project has a designated Project Manager, who may be an RINHS staff, a contractor, or volunteer, depending on the nature of the project.



RHODE ISLAND NATURAL HISTORY SURVEY
Providing Ecosystem Science and Information

Rhode Island Natural History Survey
Species Information Request Form

Rm. 101, Coastal Institute In Kingston
1 Greenhouse Road, URI
Kingston, RI 02881-0804

Note: This data form should be filled out as completely as possible. Call if you have questions.

Requestor Information

Name: _____ **Today's Date:** _____

Address: _____

City: _____ **State:** _____ **Zip:** _____

Email Address: _____ **Telephone:** _____

Affiliation: _____ **Type:** ☐ Non-Profit ☐ Private ☐ Government ☐ Other: _____

Request Description

Information Needed: ☐ Federal and/or state listed species ☐ Invasive species ☐ Other: _____

Species: ☐ all plants ☐ all animals ☐ all vertebrates ☐ all invertebrates ☐ other (specify groups/taxa): _____

Area of Interest: ☐ Statewide ☐ County ☐ Town ☐ Quad ☐ Specific Local: _____

Details of Information Required (if applicable): _____

How will the information be used?: _____

Date Information is Needed?: _____

Digital Data Delivery Options:

Digital Format:

Tabular- ☐ Access table(s) ☐ Excel Document ☐ ASCII file ☐ Other: _____

GIS- ☐ ESRI Shapefile ☐ ArcInfo Coverage ☐ Other: _____

Hardcopy Format:

☐ Standard Report ☐ Map ☐ Other

Details: _____

Please enter information into form and email to: datarequest@rinhs.org Form may also be printed, filled-in and mailed to address above or faxed to: (401)874-4561. Please call (401)871-5822 with any data request questions.

Rhode Island Natural History Survey Instructions for Information Request Form

Rm. 101, Coastal Institute In Kingston
1 Greenhouse Road, URI
Kingston, RI 02881-0804

Please read the following before making any information requests:

- The Requestor will be contacted within one-week of submitting the request form with a price estimate for work.
- Turn-around time for information request varies, but is often 2-weeks
- For requests on areas not at the town, county, USGS topo quad, or state level, please provide map of area of interest, or GIS shapefile if available.

Data License Fees

The Rhode Island Natural History Survey operates the largest general database of Rhode Island biota available. It also operates the Rhode Island Natural Heritage Database under an agreement with the Rhode Island Department of Environmental Management. In order to help support this resource, RINHS charges fees to parties wishing to use the databases.

The fees are:

Initial research and cost estimate with text summary -- $75.
Data report with one year data license -- $225.00 plus $0.50 per element occurrence if requesting EO data.

Data are delivered electronically as a table or GIS overlay. Other report formats may include media and postage charges. Complicated requests requiring substantial programming or custom report formats or products are available for the basic fee plus $75/hour.

Data updates and license renewals after one year are considered on a case by case basis. Additional fees will apply.

Fees may be negotiated for non-profit organizations, organizational members of the Rhode Island Natural History Survey, and personal, non-professional use by individuals. Typically, fees cannot be discounted below $75/hour for whatever labor is involved in making the requested report.

RINHS holds the copyright to its databases. The RINHS data license fee does not include the right to publish data or descriptions from RINHS databases. These rights must be purchased on a different basis depending on the rights requested. Contact RINHS for further information.

Data Management Office
Rhode Island Natural History Survey
Rm. 101, Coastal Institute, Kingston
1 Greenhouse Road
Kingston, RI 02881-0804

RI Natural Heritage Program –
Rhode Island Department of Environmental Management
Rare Plant Element Occurrence Record

OFFICE USE ONLY: Date Received: __/___/____
New: ___ Update: ___ Transcriber: _____
Entered into DB: ___ Mapped: ___ QC: ___

Please submit field forms, a copy of a USGS map, and supporting documentation to Rhode Island Natural Heritage Program, 235 Promenade St., Providence, RI 02908.
Email: rinhp@rinhs.org

General Element Data:

Element Scientific Name: _____ **Element Occurrence #** *(if known):* _____
Element Found: Yes ☐ No ☐ **Element Code** *(if known):* _____

Observed By: _____ **Observation Date:** _____ **Today's Date:** _____
Observer's Address: _____
Observer's Email Address: _____ **Telephone:** _____
Approximate Time Spent at Site: _____
Site Name: _____ **USGS Quad Name:** _____
Town: _____ **County:** _____
GPS Coordinates: *(at, or near center of population):* _____ _____

system (circle one): UTM LAT/LONG RI State Plane **Datum:**
Directions to element site (if found) or search area (if not found):

Photos taken: Yes ☐ No ☐ *(Please attach photo to form or email (rinhp_photos@rinhs.org) digital photos, indicating your name, species name, locality, and date collected)*
Specimen taken: Yes ☐ No ☐ *If yes*: Collection #: Repository:

Population Data:

Approximate Area: occupied by population: _____ (circle appropriate unit): meters^2 / hectares / feet^2 / yards^2 / acres
of potential habitat: _____
Population Size:
Total number of *genets* (genetically distinct, clearly separate individuals):_____(precise count/estimate)
Total number of *ramets* (e.g., clonal stems or shoots off of single organism): _____(precise count/estimate)

Population Structure (check all that apply)**:**

Age Classes Present:

- ☐ Seedlings
- ☐ Immature plants
- ☐ Mature plants
- ☐ Plants of unknown age

Reproductive Condition of the Population on this Date:

- ☐ Vegetative (in leaf)
- ☐ In bud
- ☐ In flower
- ☐ Immature fruit
- ☐ Mature fruit
- ☐ Seed dispersing
- ☐ Senescent
- ☐ Dormant

Evidence of Disease, Predation, or Injury? Yes ☐ No ☐ **Pollinators:** ____

Comments on Disease, Predation, or Injury...____

How would you characterize the vigor of this population? ☐ Excellent ☐ Good ☐ Poor

Environmental Setting:

Describe the plant community and list the associated species:

List any exotic plant species present and discuss their possible impacts:

Describe evidence of natural or human-caused disturbance (including changes in ecological processes) **and effects on population:**

Surrounding Land Use:

Elevation: ☐ft. or ☐m? **Soil Type(s):**

c. Surficial Geology:

d. Bedrock Geology:

Landform/Topography	Aspect °	Slope %	Light	Soil Moisture Regime	Important Ecological Processes
☐summit/crest	☐N ☐NE	☐flat	☐open	☐xeric	☐seasonal or regular flooding
☐upper slope	☐E ☐SE	☐gentle	☐filtered	☐dry	☐groundwater seepage
☐mid slope	☐S ☐SW	☐average	☐shade	☐mesic	☐colluvial processes
☐lower slope	☐W ☐NW	☐rather steep		☐wet	☐alluvial processes
☐rolling terrain/plain	☐ flat/variable	☐steep		☐inundated	☐wind/salt spray
☐flood plain/terrace		☐very steep			☐erosion
☐wetland		☐abrupt			☐fire
☐shore/pond/lake/stream					☐none apparent

Describe Microhabitat Conditions:

e. Check Appropriate Habitat Descriptors:

Conservation:

Land Owned/Managed by:

Name(s) Address Telephone

Managed Area Name: *Contact Person:*

Owner Comments:

Are any *past* or *existing* negative impacts on the Element Occurrence evident? What additional factors might *potentially* threaten the population?

What are your recommendations for future inventory, monitoring, research, and/or management?

What are your protection recommendations?

Additional Comments:

Appendix 4:

LTRS classification accuracy assessment report for 1999 land-cover product.

REFERENCE DATA

CLASSIFIED DATA	U	UG	A	DF	CF	MF	B	W	HW	DW	CW	CA	Totals
U	**173**	5	1	16	1	9	0	0	0	0	0	0	205
UG	2	**52**	0	0	0	5	0	0	0	0	0	0	59
A	0	0	**71**	0	0	0	0	0	0	0	0	0	71
DF	5	3	1	**398**	0	18	2	0	0	0	0	0	427
CF	0	1	1	2	**95**	13	0	0	0	0	0	0	112
MF	3	3	0	14	0	**159**	2	1	0	0	0	0	182
B	0	0	0	1	0	0	**36**	0	0	0	0	0	37
W	0	1	0	1	0	0	0	**52**	1	0	0	0	55
HW	1	0	0	0	0	0	0	7	**74**	4	1	1	88
DW	0	0	0	0	0	0	0	1	2	**119**	4	0	126
CW	0	0	0	0	0	0	0	0	0	2	**49**	0	51
CA	0	0	0	0	0	0	0	1	0	0	0	**36**	37
Totals	184	65	74	432	96	204	40	62	77	125	54	37	**1450**

Land-Cover Categories		Producer's Accuracy	User's Accuracy
U	Urban	94%	84%
UG	Urban Grass	80%	88%
A	Agriculture	96%	100%
DF	Deciduous Forest	92%	93%
CF	Coniferous Forest	99%	85%
MF	Mixed Forest	78%	87%
B	Brushland	90%	97%
W	Water	84%	95%
HW	Nonforested: Herbaceous Wetland	96%	84%
DW	Forested Wetland: Deciduous	95%	94%
CW	Forested Wetland: Coniferous	91%	96%
CA	Coastal and Sandy Areas	97%	97%

Overall Accuracy: 91%

Overall KAPPA: .89

Appendix 5:

Rhode Island Odonata Atlas

Executive Summary:
The Rhode Island Odonata Atlas is a multi-year state-wide inventory of dragonflies and damselflies. General information and accomplishments include:

- Discovery of 22 species previously unreported in the state
- Discovery of two damselfly species previously unrecorded in New England
- Distribution and abundance information have been gathered for 136 species in 39 townships
- 14 species were recommended for listing by the Rhode Island Natural Heritage Program as State Threatened or State Concern
- Discovery of areas of extraordinary species diversity and abundance in previously understudied regions of the state.
- Conservation organizations utilized Atlas data in conservation planning, purchasing land for open space in the Queen's River and Ponaganset River as a result of data from the Odonata Atlas
- A collection of over 14,000 Rhode Island voucher specimens and the associated computer database are managed by Atlas personnel
- A volunteer army of 55 individuals produced approximately 65% of the specimen records and 61% of the new records for species listed by the Rhode Island Natural Heritage Program
- Volunteers were responsible for 90% of the data entry, most of the collections management, and 90% of the public relations

Methodology:
1. References for specimen identification:
    - Dragonflies: Needham, J.G., M.J. Westfall, Jr. , and M.L. May. 2000. Dragonflies of North America. Scientific Publishers, Gainesville, FL.
    - Damselflies: Westfall, M.J., Jr. and M.L. May. 1996. Damselflies of North America. Scientific Publishers, Gainesville, FL.

2. Personnel for specimen identification: Virginia Brown and Nina Briggs, occasionally an experienced volunteer would attempt identification at the time of collection, but these would always be verified by V. Brown or N. Briggs.

3. Quality Control of identification: V. Brown was lead on this, as principal investigator for the project.

4. Software Format: collection data is stored in Microsoft Access in a self-designed spreadsheet that contains the following fields: specimen number, TSN, genus, species, author, sex, country, state, county, township, location, date collected, collector, and determiner (i.e. who identified the specimen). Additional databases evolved from the project and these are in Access, Excel, and GIS, and include but are not limited to the effort database, habitat types, site codes, and maps for all point locations. Spatial data was first recorded on paper USGS topographic maps (by site code) by V. Brown and subsequently mapped electronically by RINHS Coastal Fellow Emily Troiano.

5. Quality control of database: this was accomplished by both V. Brown and N. Briggs, with V. Brown taking the lead. The most significant quality control problem related to site names. In order to simplify quality control of site names, V. Brown assigned individual 9 character site codes to each of the1100 individual collecting locations.

6. Storage: the voucher specimen collection is stored at the University of Connecticut in Storrs, CT. The data is stored at the University of Rhode Island in the database of the Rhode Island Natural History Survey.

7. Vouchers: The Rhode Island Odonata Atlas was a collection based state-wide inventory project. Volunteers and personnel collected 1-4 adult voucher specimens for each species observed at each location. If possible, pairs in copula were collected to verify reproductive activity. In some cases, exuviae (larval shells) were collected as vouchers for some species that are difficult to capture as adults. Sight records (i.e. observations) were accepted only from experienced individuals (in this case V.Brown, C. Brown, and N. Briggs) and only for species identifiable “on the wing”.

8. Record keeping: Odonata Atlas data sheets were completed for each visit to each location. Information recorded included: collectors name(s), township, date, location detail, habitat description, weather, start time, and stop time, notes on observation of reproductive activity, numbers of individuals, etc. In addition, information was recorded with each specimen (on a card or on the glassine envelope): date, location detail, state, township, time (optional), collector’s name, species name (optional).

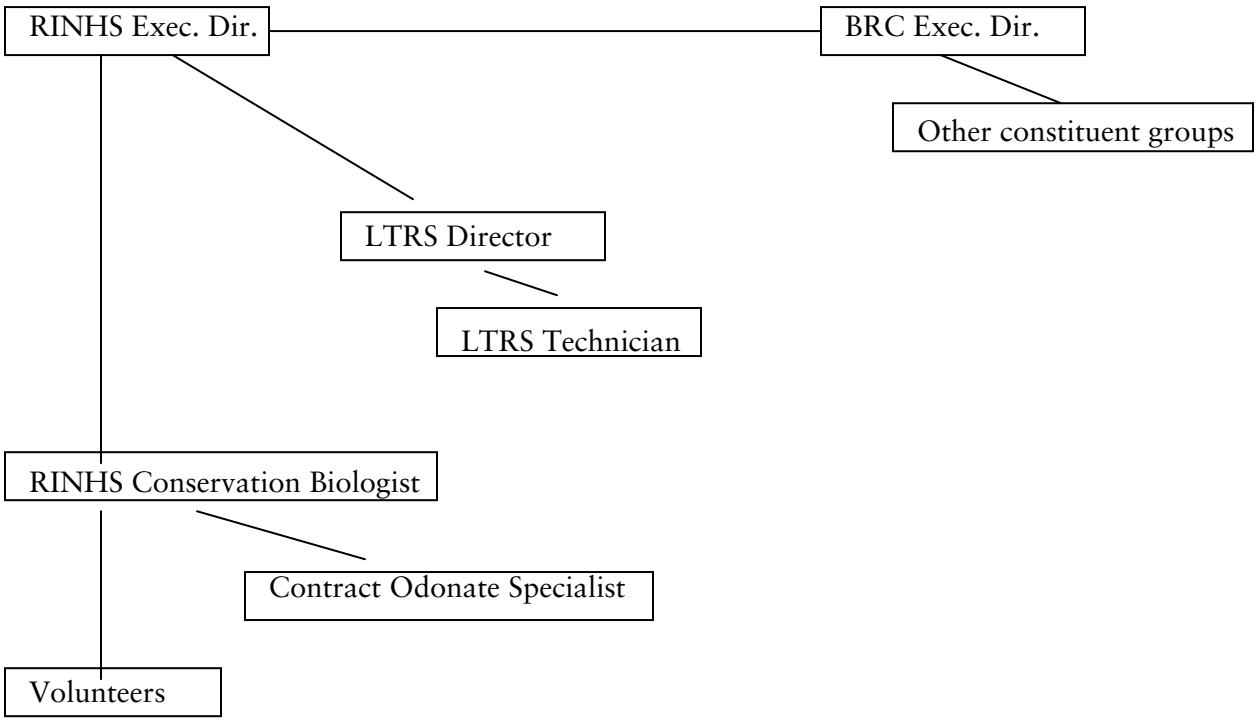
9. Time of recording: workers were instructed to record specimen information at the time of collection (on envelope or card in envelope as described above) or when preparing the specimen. Data sheets were completed either in the field at the location or immediately after the visit.

10. Collection and handling of data: All data was collected and handled the same way. Reports from the database vary in content and appearance based on the purpose and disposition of each report.

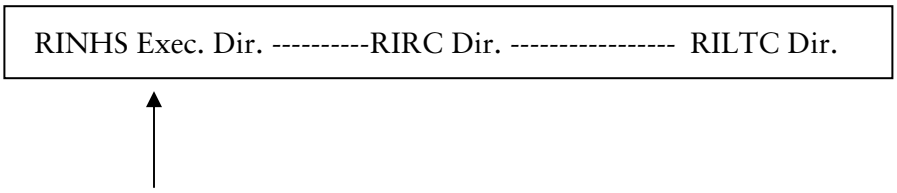
Appendix 6:

Project Personnel Chart

IWAO team:



ESCA team:



BRC Exec. Dir. reports on the organizational development results of the IWAO to the ESCA team, who decide, based on the results, whether to recommend future ESCA projects with other organizations in the future.

Appendix D:
Odonata (Dragonflies and Damselflies) of the Branch River Watershed

By Virginia Brown (2005)

Odonata (Dragonflies and Damselflies) of the Branch River Watershed

Virginia Brown
14 November 2005

Introduction:
From 1998 through 2005, inventory of the insect order Odonata (dragonflies and damselflies) was conducted in the Branch River watershed in northern Rhode Island. Data collected from 1998 through 2004 was associated with the Rhode Island Odonata Atlas, a multi-year state-wide inventory project that utilized the energy of 55 volunteers in all facets of the project. This project was funded by The Nature Conservancy, with additional support from the Rhode Island Natural History Survey (RINHS) and the Rhode Island Foundation. Data collected from the Branch River watershed in 2005 was associated with the Rhode Island Natural History Survey's Bay Watershed Action Grant (BayWAG) through the Narragansett Bay Estuary Program.

Dragonflies and damselflies are large, colorful predatory insects that inhabit aquatic habitats as eggs and larvae and emerge to fly about terrestrial habitats for a brief period as adults, returning to water to reproduce. A wide variety of aquatic sites provide habitat for Odonata. These include rivers, streams, lakes, ponds, vernal pools, marshes, bogs, fens, swamps, brackish marshes, and coastal ponds. Because of their dependence upon both aquatic and terrestrial habitats, dragonflies and damselflies may be considered important species for conservation planning. Furthermore, some species are particularly sensitive to degradation of aquatic and terrestrial habitats in the form of pollution, impoundment of rivers and streams, removal of forest cover, and development. Therefore, the Odonata are also potential indicators of wetland or watershed health.

During the BayWAG project period, the data gathered in the Branch River watershed during Odonata Atlas years (1998-2004) was enhanced by additional 2005 inventory in under-sampled areas of the watershed, with a focus on the Branch River itself. In this report, results of 2005 Odonata inventory are presented in combination with earlier data from the Atlas project. Additionally, comments on the condition of the river habitat are made (based on its odonate fauna), and comparisons of species diversity with landscape context in three BayWAG project zones are presented.

Methods:
Dragonfly and damselfly surveys were focused on adults, but some data were gathered from larval and exuvial (cast larval skins) collections. Volunteers and project workers were required to collect voucher specimens for each species encountered at each surveyed site. These specimens were prepared according to accepted standards and are curated at the University of Connecticut and the University of Rhode Island. Nomenclature and English names for dragonflies and

damselflies follow Needham et al (2000), Paulson (2004), Paulson and Dunkle (1999), and Westfall and May (1996).

Surveys were conducted either on foot or by boat or as a combination of the two. The most complete coverage of large aquatic systems such as rivers can be accomplished most efficiently from kayaks or canoes, particularly at high water when rivers may not be wadable. Insect nets are used to capture flying adults which are then prepared as museum quality specimens using Acetone.

During Odonata Atlas years, six volunteers contributed to dragonfly and damselfly surveys in the Branch River watershed BayWAG project area. In 2005, one experienced volunteer assisted the author of this report with BayWAG field inventory and specimen preparation.

BayWAG Project Area and Sites Surveyed:
The Branch River watershed is part of the larger Blackstone River drainage, a system that encompasses portions of Massachusetts and Rhode Island. Within the BayWAG portion of the watershed, the following aquatic habitats are utilized by Odonata: rivers and streams, reservoirs and impoundments, ponds, bogs, fens, Atlantic white cedar swamps, and red maple swamps. Terrestrial habitats which may attract groups of foraging or dispersing odonates in the project area include cemeteries, power lines rights-of-way, fields, dirt roads in forested areas, and gravel pits.

Because rivers and streams support a relatively large odonate species group (including 39 species which prefer or are found exclusively in rivers) with several pollution sensitive species, complete coverage of the Branch River itself was a goal of both Odonata Atlas work and 2005 BayWAG surveys. The Branch River is impounded at six dams between its headwaters at the confluence of the Chepachet River and the Branch River in Burrillville and the end of its run at the Blackstone River in North Smithfield. A large three-pond reservoir (Slatersville Reservoir) and several smaller impoundments are also part of the main stem of the Branch River in North Smithfield. Between dams and impoundments, some relatively high quality riverine habitat can be found. In particular, the run below the dam at Oakland (Burrillville), the run between Route 5 and Route 146 (North Smithfield), and the run above the confluence of the Branch and the Blackstone (North Smithfield) provide moderate to good quality riverine habitat for Odonata. In these areas, flow, riffle length and quality, sediment, and oxygen content are suitable for river dragonflies and damselflies. The condition of the riparian areas adjacent to these portions of the river varies, but in general the riparian areas appear to be in better condition in the upper areas of the watershed.

The Branch River was and to some extent still is a working river, so even at its upper reaches in Burrillville, the remnants of historic mills and manufacturing operations can still be seen. Historically, riverside industry impacted the condition

of the river as a result of chemical and other toxic spills, even as far upstream as Oakland (Burrillville). The impacts of current and historic industry on rivers can have a profound influence on the odonate species that inhabit these rivers today.

Results:
Between 1998 and 2005, dragonfly and damselfly inventories were conducted at 28 sites in the BayWAG project area. Table 1 (at the end of this document) provides a list of these sites with reference to watershed zone as assigned during the 2005 BayWAG project. Sites designated as *incidental* in Table 1 include terrestrial sites which did not receive comprehensive seasonal inventory but may have been surveyed for one or two species as appropriate.

In terms of overall odonate species diversity, the Branch River watershed supports 97 species of dragonflies and damselflies. This represents 70.8% of the 137 species known to occur in Rhode Island. For the purposes of the BayWAG project, the Branch River watershed was divided into three zones: Zone 1, Zone 2, and Zone 3. Tables 2-4 list dragonfly and damselfly species found in each of the three zones with their associated Rhode Island status.

Prior to 2005 surveys, inventory effort in Zone 1 was lower than that in Zones 2 and 3. Therefore, in 2005, additional effort was spent in Zone 1 to close this gap. As a result, 16 species were added to the pre-2005 list for Zone 1 of the Branch River watershed, and all of these were recorded from a single site. Similarly, six (6) species were added to Zone 3 in 2005, again from a single site. No new species were added to Zone 2, where survey effort had been extensive prior to 2005.

Table 5 summarizes the species diversity in each zone, the number of sites surveyed, and the species diversity corrected for the number of sites surveyed. Correcting species diversity for the number of sites surveyed is necessary because a different number of habitats were surveyed in each zone and this will influence the total number of odonate species found.

Table 5: Odonate species found in the Branch River watershed by BayWAG zone.

Zone	# Species	# Sites Surveyed	# Species/site
1	47	6	7.83
2	71	9	7.88
3	80	13	6.15

The results of the Branch River watershed odonate inventory suggest that overall species diversity is highest in Zone 3 (lower reaches of the watershed, 80 species), followed by Zone 2 (71 species) and Zone 1 (47 species). However, the number of sites surveyed was not uniform across the three zones, and this may skew total species diversity figures. For example, a substantial portion of the high total

species diversity in Zone 3 can be accounted for by a single boggy pond habitat in North Smithfield. Zone 1 does not contain a site with similarly high odonate species diversity. Zone 2 contains a river site of extraordinary odonate diversity, and thus has a high total species diversity figure. Additionally, the number of sites surveyed was greatest in Zone 3, followed by Zone 2, and Zone 1. Species diversity would be expected to increase with increasing number of survey sites. Therefore, overall species diversity in each zone was corrected for variability in the number of sites surveyed. Species diversity figures then shift somewhat among the zones, with Zone 2 exhibiting the highest species diversity per site (7.88), followed closely by Zone 1 (7.83/site). Species diversity of the lower portion of the watershed is markedly lower than the two upper zones, with just 6.15 species per site in Zone 3.

Of 28 surveyed sites, a few stand out in terms of species diversity. These include two pond sites in North Smithfield (29 and 33 species) and one Branch River site below the dam at Oakland in Burrillville (35 species). Ponds that supported particularly high numbers of odonate species include Tarkiln Pond in North Smithfield (33 species), and a pond on Audubon Society of Rhode Island property, also in North Smithfield (29 species). These ponds, in addition to exhibiting high odonate species diversity, also support populations of rare species, one in each pond.

Of the 97 species found in the watershed, five are listed by the Rhode Island Natural Heritage Program as State Concern or State Threatened. These are *Enallagma pictum* (Scarlet Bluet; **State Concern**), *Leucorrhinia glacialis* (Crimson-ringed Whiteface; **State Threatened**), *Somatochlora georgiana* (Coppery Emerald; **State Threatened**), *Stylurus scudderi* (Zebra Clubtail; **State Threatened**), and *Stylurus spiniceps* (Arrow Clubtail; **State Concern**). The Arrow Clubtail is found only in the Blackstone River system (including the Branch River watershed), and the Zebra Clubtail in the Pawcatuck and Blackstone systems. The Crimson-ringed Whiteface, a species of northern distribution, is known from just one site in Rhode Island. The Coppery Emerald is a southern species of small streams which appears to be expanding its range northward.

Ponds which have very high odonate diversity tend to be those with high micro-habitat diversity: with areas of dense emergent vegetation over muck, with areas of open water and floating vegetation, with boggy shorelines, or shorelines with shrub swamp. Many, but not all of these ponds are semi-permanent, with a cycle of inundation and drying that precludes the existence of fish. Fish are voracious predators of odonate larvae. Some odonate species are unable to survive with fish because they do not possess behaviors that allow them to escape from fish. Rivers with high odonate diversity often have well-developed riffles in open sun (although banks may be shaded), pools of still water, a mix of sediments including rock, cobble, gravel, sand, and mud, areas of well-developed aquatic vegetation, stable banks, and intact bank vegetation. Most high quality riverine odonate habitat in

Rhode Island is also undeveloped, with intact riparian forest and generally good water quality. Variables of water quality that may influence dragonflies and damselflies include dissolved oxygen, siltation, and water temperature.

Because variability in the types and number of habitats surveyed across the three watershed zones influence odonate species diversity figures, examining species diversity of the Branch River alone may produce a more focused analysis of the three zones. Additionally, survey effort on the river has been thorough and consistent across the three zones. River habitats support a relatively large group of species, many of which do not occur in other habitat types. A portion of this species group is sensitive to degradation in rivers.

Inventory of Odonata at six stations along the Branch River from 1998 through 2005 has yielded a species list of 49 dragonflies and damselflies. Of these, 26 species prefer or are found exclusively in lotic habitats, representing 66.6% of the states river fauna. Three species are considered sensitive to pollution and other forms of degradation. Two species are listed by the Rhode Island Natural Heritage Program: *Stylurus scudderi* (Zebra Clubtail) and *Stylurus spiniceps* (Arrow Clubtail). Table 6 summarizes the species and state status for Branch River Odonata.

Table 7 shows the total number of species found in the Branch River in each zone, the number of sites surveyed, and the species diversity figure corrected for number of sites surveyed. The differences in odonate species diversity on the Branch River among the three zones are striking when viewed in this way. Zone 2, with just one river site, shows extraordinary odonate diversity at 35 species. Zone 1, also with a single river site, supports 17 species, followed by Zone 3 at just 9.75 species/site.

Table 7: Odonate species found in the Branch River by BayWAG zone.

Zone	# Species	# Sites Surveyed	# Species/site
1	17	1	17
2	35	1	35
3	39	4	9.75

Discussion:

With 97 odonate species recorded, the Branch River watershed is one of the most diverse watersheds in Rhode Island. Furthermore, the river itself, supporting 49 dragonfly and damselfly species, is one of the most diverse rivers in the state. It ranks among the top five rivers, fourth overall for odonate diversity behind the Wood, Queen's, and Pawcatuck Rivers. Much of the diversity in the Branch River is found below the Oakland dam, where 35 of 49 species were found.

Odonate species diversity in any given area is influenced by a number of factors. Results of the Rhode Island Odonata Atlas indicate that species diversity at both the township and watershed level are correlated with amount of developed land and roads as well as the amount of forested land in these areas (Brown, in press). Townships and watersheds with high percentages of developed land and roads and low percentages of forest have fewer odonate species. Conversely, townships and watersheds with low percentages of developed land and roads and high percentages of forest have more odonate species. Dragonflies and damselflies depend upon both good quality wetland habitat and good quality upland habitat. Some dragonflies, a number of which inhabit rivers such as the Branch, are forest species as adults and are thought to be canopy species which rarely leave the upper levels of the forest. Conversion of forest to development therefore causes direct destruction of adult dragonfly habitat. Additionally, forests buffer odonate egg and larval habitat (aquatic sites) from the impacts of development. Conversion of forest to development negatively impacts aquatic sites by lowering water quality, altering water temperature, increasing bank de-stabilization, changing aquatic plant species composition, and in some cases allowing the introduction of invasive species.

In the Branch River watershed, the amount of impervious surface (1999) is lowest in Zone 2, followed by Zone 1 and Zone 3, the latter zone having the highest percentage of impervious surface (Wang and Zhou 2005). Impervious surface is impenetrable material that prevents water from soaking into the soil. Impervious surfaces are found in developed areas, and include concrete surfaces and pavements on roads, sidewalks, parking lots, roofs of buildings, etc. The amount of impervious surface in a particular area is therefore a measure of the amount of development. An initial comparison of odonate species diversity in the three BayWAG zones of the Branch River watershed shows that the number of species per surveyed site increases as the percent impervious surface in each of the three watershed zones decreases, with a very small increase in species diversity from Zone 1 to Zone 2. A similar, but much stronger relationship exists when river diversity alone (number of species per surveyed site) is compared to impervious surface. Tables 8 and 9 summarize species diversity and impervious surface data from both the Branch River watershed and the Branch River, respectively. These results are similar to the results of the Odonate Atlas project, which examined the relationship of odonate species diversity to the percentage of development and roads at a larger scale (watershed and township).

The Branch River, despite historic and current industrial use and other forms of development, contains a diversity of high quality odonate habitat, most notably in its upper reaches below the dam at Oakland (Burrillville). The quality of this stretch of river manifests itself in both high odonate species diversity and the presence of large populations of four rare dragonfly species. Good quality riffles and a forested riparian zone make this particular run of river extraordinarily important as odonate habitat in northern Rhode Island, possibly the most critical

river habitat in this part of the state. Any undeveloped land in this part of the watershed, particularly forested land adjacent to the river itself, should be considered a high priority for conservation. Forested buffers retain water temperature, water quality, and bank condition better than other fields or other types of vegetative cover. Undeveloped land in other parts of the Branch River watershed, from its headwaters at the confluence of the Chepachet River all the way to the confluence of the Blackstone River, is also important to protect. Even undeveloped land upstream from the Branch River should be considered a priority for conservation, since good landscape quality in and around headwater streams is critical to the quality of the river downstream. In particular, conservation organizations should focus their efforts on protecting remaining forest and undeveloped land on both sides of the Branch River at and below Oakland dam and above the confluence of the Blackstone. The Rhode Island Department of Environmental Management owns and manages land at the confluence of the Branch and the Blackstone Rivers. Adding to this protected land would help maintain the health of the river.

Other aquatic habitats in the watershed that support high odonate species diversity and/or rare species should also be the focus of conservation groups. This includes in particular Tarkiln Pond in North Smithfield which contains a diverse odonate fauna as well as a population of a regionally rare damselfly.

Conservation groups are often faced with the difficult question of how much land to protect to ensure that aquatic habitats remain in good condition and that the diversity of life they support is sustained. Results of the Rhode Island Odonata Atlas showed a positive correlation between the size of conservation areas and the number of species (of dragonflies and damselflies) present (Brown, in press). Therefore, conservation groups should strive to protect the largest parcels possible, given the constraints of availability and budget. For dragonflies, of course, the focus is on aquatic habitats and the conservation question becomes more specifically oriented towards the width of protected buffers around odonate breeding sites. As studies have shown, not only is the width of this buffer important, but the vegetative condition is important as well. Suggested buffer width in order to maintain odonate diversity ranges from 30 meters to a few hundred meters (Samways and Steytler 1996; Rith-Najarian 1988). Furthermore, these studies recommend that such buffers be managed as undisturbed forest. It should be noted that the research cited here focused on the impacts of forest management (such as logging, thinning, and planting) on odonate species diversity. In Rhode Island, the greatest threat to populations of dragonflies and damselflies is not forestry but development. The impacts of development on aquatic systems are far more severe than those of forestry. Therefore, managers of both private and public land and conservation agencies in Rhode Island should seek to maintain at least 300 meters of forest around aquatic habitats.

In addition to high odonate species diversity, the Branch River watershed supports large populations of several rare species, two of which are considered to be of regional conservation interest and another whose only Rhode Island population occurs in this watershed. Aquatic habitats that support populations of rare odonates should be protected to the highest degree possible and managed to maintain water quality, hydrologic regime, and aquatic plant communities. Terrestrial habitats surrounding water bodies serve as adult habitat for rare dragonflies, and must be included in conservation planning. While it is difficult to pinpoint how much land (in acres) is required to protect a population of a rare dragonfly and its breeding habitat, conservation groups should aim to protect the largest areas possible. Of the five state-listed odonates in the Branch River watershed, two (*Leucorrhinia glacialis*, *Somatochlora georgiana*) occur on protected land. Populations of three others (*Enallagma pictum*, *Stylurus scudderi*, and *Stylurus spiniceps*) occur in unprotected areas. The most critical portions of the Branch River for conservation of two of these species are the section below Oakland dam and the section at and above the confluence of the Blackstone River. Populations of these species should be monitored regularly and it is recommended that data be gathered on population size and threats. The presence of species of conservation interest further elevates the significance of the watershed and increases the urgency of both land conservation and appropriate land management in this part of the state.

Summary of Odonate Conservation Recommendations in the Branch River Watershed:

- Protect large parcels of land through acquisition
- Focus protection on land adjacent to the Branch River, particularly from Oakland dam downstream to Glendale and from the confluence of the Blackstone upstream to Route 146, as well as at Tarkiln Pond
- Maintain forested buffers of at least 300 meters adjacent to and surrounding water bodies, where feasible, with no less than 30 meters of forested buffer in other areas
- Monitor populations of rare species for both presence and population size and analyze threats

Acknowledgments

Inventory of Odonata in the Branch River watershed was funded by the following organizations and agencies: The Nature Conservancy, Rhode Island Natural History Survey, Narragansett Bay Estuary Program through its BayWAG program, and the Rhode Island Foundation. The author would like to thank the volunteers of the Rhode Island Odonata Atlas, Erik Endrulat, and Charles Brown, for assistance with this project.

Literature Cited

Brown, V.A. In press. Dragonflies and damselflies of Rhode Island. The Nature Conservancy and Rhode Island Natural History Survey.

Needham, J.G., M.J. Westfall Jr., and M.L. May. 2000. Dragonflies of North America. Scientific Publishers, Gainesville, FL. 939pp.

Paulson, D.R. 2004. New common names for some North American Odonata. Argia 16(3): 29-30.

Paulson, D.R. and S.W. Dunkle. 1999. A checklist of North American Odonata, including
English name, etymology, type locality, and distribution. Slater Mus. Nat. Hist. Occ. Pap.56.

Rith-Najarian, J.C. 1998. The influence of forest vegetation variables on the distribution and diversity of dragonflies in a northern Minnesota forest landscape: a preliminary study (Anisoptera). Odonatologica 27 (3): 335-351.

Samways, M.J. and N.S. Steytler. 1996. Dragonfly (Odonata) distribution in urban and forest landscapes and recommendations for riparian management. Biological Conservation 78: 279-288.

Wang, Y.Q. and Yuyu Zhou. 2005. Land cover remote sensing for impervious surface in the Branch River watershed. Unpublished report submitted to Rhode Island Natural History Survey.

Westfall, M.J. Jr. and M.L. May. 1996. Damselflies of North America. Scientific Publishers, Gainesville, FL. 649pp.

Table 1: list of Odonata survey sites for Branch River watershed BayWAG zones 1-3. *Incidental* refers to single species survey or incidental catch without full survey.

Zone 1:

Branch River at Route 102 in Glendale, Burrillville
Black Hut Management Area Bog, Burrillville
Black Hut Management Area Impoundment, Burrillville
Black Hut Management Area Powerline ROW, Burrillville
Black Hut Management Area Parking Lot, Burrillville
Black Hut Management Area roads, Burrillville

Total sites: 6

Zone 2:

Branch River below Oakland Dam, Burrillville
Harmony Hill School Fen, Glocester
Harmony Hill School Pond, Glocester
Lapham Pond, Burrillville
Mowry Paine Brook, two stations, Glocester
Tarkiln Brook, two stations, Burrillville and North Smithfield
Tarkiln Pond, North Smithfield

Total sites: 9

Zone 3:

Branch River at Route 146 Pump Station, North Smithfield
Branch River east of Route 5, North Smithfield
Branch River above Forestdale Dam, North Smithfield
Branch River at confluence of Blackstone River, North Smithfield
Fort Refuge (Audubon Society of Rhode Island) Middle Pond, North Smithfield
Fort Refuge (Audubon Society of Rhode Island) Upper Pond, North Smithfield
Pound Hill Road Powerline ROW, North Smithfield (*incidental*)
Pratt Pond, North Smithfield
Route 146 Powerline, North Smithfield (*incidental*)
St. John the Evangelist Cemetery, North Smithfield (*incidental*)
Slatersville Reservoir, North Smithfield
Tefft Road at Pound Hill Road, North Smithfield (*incidental*)
Tifft Road gravel pit, North Smithfield (*incidental*)

Total sites: 13 (5 *incidental*)

Table 2: Odonata collected in Branch River watershed Zone 1.

SPECIES NAME	COMMON NAME	RHODE ISLAND STATUS
Aeshna clepsydra	Mottled Darner	Widespread/Common
Aeshna constricta	Lance-tipped Darner	Widespread/Common
Aeshna tuberculifera	Black-tipped Darner	Widespread/Common
Anax junius	Common Green Darner	Ubiquitous/Abundant
Argia fumipennis	Variable Dancer	Ubiquitous/Abundant
Argia moesta	Powdered Dancer	Widespread/Common
Boyeria vinosa	Fawn Darner	Widespread/Common
Calopteryx aequabilis	River Jewelwing	Limited/Uncommon
Calopteryx dimidiata	Sparkling Jewelwing	Limited/Uncommon
Calopteryx maculata	Ebony Jewelwing	Ubiquitous/Abundant
Celithemis elisa	Calico Pennant	Ubiquitous/Abundant
Celithemis martha	Martha's Pennant	Limited/Uncommon
Chromagrion conditum	Aurora Damsel	Widespread/Common
Didymops transversa	Stream Cruiser	Widespread/Common
Dorocordulia lepida	Petite Emerald	Widespread/Common
Enallagma aspersum	Azure Bluet	Widespread/Common
Enallagma divagans	Turquoise Bluet	Widespread/Abundant
Enallagma exsulans	Stream Bluet	Widespread/Common
Epitheca cynosura	Common Baskettail	Ubiquitous/Abundant
Gomphus exilis	Lancet Clubtail	Widespread/Abundant
Hagenius brevistylus	Dragonhunter	Widespread/Common
Ischnura posita	Fragile Forktail	Ubiquitous/Abundant
Ischnura verticalis	Eastern Forktail	Ubiquitous/Abundant
Lestes congener	Spotted Spreadwing	Widespread/Common
Lestes disjunctus	Common Spreadwing	Ubiquitous/Abundant
Leucorrhinia frigida	Frosted Whiteface	Limited/Common
Leucorrhinia intacta	Dot-tailed Whiteface	Ubiquitous/Abundant
Libellula cyanea	Spangled Skimmer	Ubiquitous/Abundant
Libellula exusta	White Corporal	Widespread/Common
Libellula incesta	Slaty Skimmer	Ubiquitous/Abundant
Libellula julia	Chalk-fronted Corporal	Limited/Uncommon
Libellula pulchella	Twelve-spotted Skimmer	Ubiquitous/Abundant
Libellula quadrimaculata	Four-spotted Skimmer	Widespread/Uncommon
Macromia illinoiensis	Illinois River Cruiser	Limited/Common
Nehalennia gracilis	Sphagnum Sprite	Widespread/Abundant
Nehalennia irene	Sedge Sprite	Widespread/Common
Pachydiplax longipennis	Blue Dasher	Ubiquitous/Abundant
Perithemis tenera	Eastern Amberwing	Ubiquitous/Abundant
Somatochlora georgiana	Coppery Emerald	Limited/Uncommon:STATE CONCERN
Somatochlora linearis	Mocha Emerald	Limited/Common
Somatochlora tenebrosa	Clamp-tipped Emerald	Widespread/Common
Somatochlora walshii	Brush-tipped Emerald	Limited/Uncommon
Stylogomphus albistylus	Eastern Least Clubtail	Limited/Common
Sympetrum internum	Cherry-faced Meadowhawk	Ubiquitous/Abundant

Table 3: Odonata recorded in Branch River watershed Zone 2.

SPECIES NAME	COMMON NAME	RHODE ISLAND STATUS
Aeshna constricta	Lance-tipped Darner	Widespread/Common
Aeshna tuberculifera	Black-tipped Darner	Widespread/Common
Aeshna umbrosa	Shadow Darner	Ubiquitous/Abundant
Aeshna verticalis	Green-striped Darner	Widespread/Abundant
Anax junius	Common Green Darner	Ubiquitous/Abundant
Argia fumipennis	Variable Dancer	Ubiquitous/Abundant
Argia moesta	Powdered Dancer	Widespread/Common
Arigomphus furcifer	Lily-pad Clubtail	Limited/Uncommon
Arigomphus villosipes	Unicorn Clubtail	Widespread/Common
Basiaeschna janata	Springtime Darner	Widespread/Common
Boyeria vinosa	Fawn Darner	Widespread/Common
Calopteryx aequabilis	River Jewelwing	Limited/Uncommon
Calopteryx dimidiata	Sparkling Jewelwing	Limited/Uncommon
Calopteryx maculata	Ebony Jewelwing	Ubiquitous/Abundant
Celithemis elisa	Calico Pennant	Ubiquitous/Abundant
Celithemis eponina	Halloween Pennant	Ubiquitous/Common
Chromagrion conditum	Aurora Damsel	Widespread/Abundant
Cordulegaster maculata	Twin-spotted Spiketail	Limited/Uncommon
Didymops transversa	Stream Cruiser	Widespread/Uncommon
Dorocordulia lepida	Petite Emerald	Widespread/Common
Dorocordulia libera	Racket-tailed Emerald	Limited/Uncommon
Dromogomphus spinosus	Black-shouldered Spinyleg	Widespread/Common
Enallagma daeckii	Attenuated Bluet	Limited/Uncommon
Enallagma divagans	Turquoise Bluet	Widespread/Abundant
Enallagma exsulans	Stream Bluet	Widespread/Common
Enallagma geminatum	Skimming Bluet	Ubiquitous/Abundant
Enallagma laterale	New England Bluet	Widespread/Abundant
Enallagma pictum	Scarlet Bluet	Limited/Uncommon:STATE CONCERN
Enallagma signatum	Orange Bluet	Ubiquitous/Abundant
Enallagma traviatum	Slender Bluet	Widespread/Common
Enallagma vesperum	Vesper Bluet	Limited/Uncommon
Epiaeschna heros	Swamp Darner	Widespread/Common
Epitheca cynosura	Common Baskettail	Ubiquitous/Abundant
Epitheca princeps	Prince Baskettail	Ubiquitous/Common
Erythemis simplicicollis	Eastern Pondhawk	Ubiquitous/Abundant
Gomhaeschna furcillata	Harlequin Darner	Widespread/Common
Gomphus abbreviatus	Spine-crowned Clubtail	Restricted/Rare
Gomphus adelphus	Mustached Clubtail	Restricted/Rare
Gomphus exilis	Lancet Clubtail	Widespread/Abundant
Gomphus lividus	Ashy Clubtail	Limited/Uncommon
Hagenius brevistylus	Dragonhunter	Widespread/Common
Helocordulia uhleri	Uhler's Sundragon	Limited/Uncommon
Hetaerina americana	American Rubyspot	Limited/Uncommon
Ischnura hastata	Citrine Forktail	Widespread/Common
Ischnura kellicotti	Lilypad Forktail	Widespread/Common
Ischnura posita	Fragile Forktail	Ubiquitous/Abundant
Ischnura verticalis	Eastern Forktail	Ubiquitous/Abundant

Table 3 (continued):

SPECIES NAME	COMMON NAME	RHODE ISLAND STATUS
Lanthus vernalis	Southern Pygmy Clubtail	Restricted/Rare
Lestes disjunctus	Common Spreadwing	Ubiquitous/Abundant
Lestes forcipatus	Sweetflag Spreadwing	Widespread/Abundant
Lestes inaequalis	Elegant Spreadwing	Widespread/Common
Lestes rectangularis	Slender Spreadwing	Ubiquitous/Abundant
Leucorrhinia frigida	Frosted Whiteface	Limited/Common
Leucorrhinia intacta	Dot-tailed Whiteface	Ubiquitous/Abundant
Libellula cyanea	Spangled Skimmer	Ubiquitous/Abundant
Libellula exusta	White Corporal	Widespread/Common
Libellula incesta	Slaty Skimmer	Ubiquitous/Abundant
Libellula luctuosa	Widow Skimmer	Ubiquitous/Abundant
Libellula lydia	Common Whitetail	Ubiquitous/Abundant
Libellula pulchella	Twelve-spotted Skimmer	Ubiquitous/Abundant
Macromia illinoiensis	Illinois River Cruiser	Limited/Common
Nasiaeschna pentacantha	Cyrano Darner	Widespread/Uncommon
Nehalennia irene	Sedge Sprite	Widespread/Common
Ophiogomphus mainensis	Maine Snaketail	Restricted/Uncommon
Pachydiplax longipennis	Blue Dasher	Ubiquitous/Abundant
Perithemis tenera	Eastern Amberwing	Ubiquitous/Abundant
Stylogomphus albistylus	Eastern Least Clubtail	Limited/Common
Stylurus scudderi	Zebra Clubtail	Restricted/Rare: STATE THREATENED
Sympetrum internum	Cherry-faced Meadowhawk	Ubiquitous/Abundant
Sympetrum semicinctum	Band-winged Meadowhawk	Widespread/Common
Sympetrum vicinum	Autumn Meadowhawk	Ubiquitous/Abundant

Table 4: Odonata recorded in Branch River watershed Zone 3.

SPECIES NAME	COMMON NAME	RHODE ISLAND STATUS
Aeshna canadensis	Canada Darner	Limited/Uncommon
Aeshna clepsydra	Mottled Darner	Widespread/Common
Aeshna tuberculifera	Black-tipped Darner	Widespread/Common
Aeshna umbrosa	Shadow Darner	Ubiquitous/Abundant
Aeshna verticalis	Green-striped Darner	Widespread/Abundant
Amphiagrion saucium	Eastern Red Damsel	Limited/Uncommon
Anax junius	Common Green Darner	Ubiquitous/Abundant
Argia apicalis	Blue-fronted Dancer	Limited/Uncommon
Argia fumipennis	Variable Dancer	Ubiquitous/Abundant
Argia moesta	Powdered Dancer	Widespread/Common
Argia translata	Dusky Dancer	Limited/Uncommon
Arigomphus furcifer	Lilypad Clubtail	Limited/Uncommon
Arigomphus villosipes	Unicorn Clubtail	Widespread/Common
Basiaeschna janata	Springtime Darner	Widespread/Common
Boyeria vinosa	Fawn Darner	Widespread/Common
Calopteryx aequabilis	River Jewelwing	Limited/Uncommon
Calopteryx dimidiata	Sparkling Jewelwing	Limited/Uncommon
Calopteryx maculata	Ebony Jewelwing	Ubiquitous/Abundant
Celithemis eponina	Halloween Pennant	Ubiquitous/Common
Chromagrion conditum	Aurora Damsel	Widespread/Abundant
Cordulegaster maculata	Twin-spotted Spiketail	Limited/Uncommon
Cordulia shurtleffi	American Emerald	Limited/Uncommon
Didymops transversa	Stream Cruiser	Widespread/Uncommon
Dorocordulia lepida	Petite Emerald	Widespread/Common
Dorocordulia libera	Racket-tailed Emerald	Limited/Uncommon
Dromogomphus spinosus	Black-shouldered Spinyleg	Widespread/Common
Enallagma aspersum	Azure Bluet	Widespread/Common
Enallagma boreale	Boreal Bluet	Limited/Uncommon
Enallagma divagans	Turquoise Bluet	Widespread/Abundant
Enallagma exsulans	Stream Bluet	Widespread/Common
Enallagma geminatum	Skimming Bluet	Ubiquitous/Abundant
Enallagma laterale	New England Bluet	Widespread/Abundant
Enallagma traviatum	Slender Bluet	Widespread/Common
Epiaeschna heros	Swamp Darner	Widespread/Common
Epitheca cynosura	Common Baskettail	Ubiquitous/Abundant
Epitheca princeps	Prince Baskettail	Ubiquitous/Common
Erythemis simplicicollis	Eastern Pondhawk	Ubiquitous/Abundant
Gomphaeschna furcillata	Harlequin Darner	Widespread/Common
Gomphus abbreviatus	Spine-crowned Clubtail	Restricted/Rare
Gomphus exilis	Lancet Clubtail	Widespread/Abundant
Gomphus lividus	Ashy Clubtail	Limited/Uncommon
Hagenius brevistylus	Dragonhunter	Widespread/Common
Hetaerina americana	American Rubyspot	Limited/Uncommon
Ischnura hastata	Citrine Forktail	Widespread/Common
Ischnura kellicotti	Lilypad Forktail	Widespread/Common
Ischnura posita	Fragile Forktail	Ubiquitous/Abundant
Ischnura verticalis	Eastern Forktail	Ubiquitous/Abundant

Table 4 (continued):

SPECIES NAME	COMMON NAME	RHODE ISLAND STATUS
Lestes congener	Spotted Spreadwing	Widespread/Common
Lestes disjunctus	Common Spreadwing	Ubiquitous/Abundant
Lestes dryas	Emerald Spreadwing	Restricted/Uncommon
Lestes forcipatus	Sweetflag Spreadwing	Widespread/Abundant
Lestes inaequalis	Elegant Spreadwing	Widespread/Common
Lestes rectangularis	Slender Spreadwing	Ubiquitous/Abundant
Lestes vigilax	Swamp Spreadwing	Widespread/Abundant
Leucorrhinia frigida	Frosted Whiteface	Limited/Common
Leucorrhinia glacialis	Crimson-ringed Whiteface	Restricted/Rare:STATE THREATENED
Leucorrhinia hudsonica	Hudsonian Whiteface	Limited/Uncommon
Leucorrhinia intacta	Dot-tailed Whiteface	Ubiquitous/Abundant
Leucorrhinia proxima	Red-waisted Whiteface	Limited/Uncommon
Libellula cyanea	Spangled Skimmer	Ubiquitous/Abundant
Libellula exusta	White Corporal	Widespread/Common
Libellula incesta	Slaty Skimmer	Ubiquitous/Abundant
Libellula julia	Chalk-fronted Corporal	Limited/Uncommon
Libellula luctuosa	Widow Skimmer	Ubiquitous/Abundant
Libellula lydia	Common Whitetail	Ubiquitous/Abundant
Libellula quadrimaculata	Four-spotted Skimmer	Widespread/Uncommon
Libellula semifasciata	Painted Skimmer	Widespread/Common
Macromia illinoiensis	Illinois River Cruiser	Limited/Common
Nannothemis bella	Elfin Skimmer	Limited/Uncommon
Nasiaeschna pentacantha	Cyrano Darner	Widespread/Uncommon
Nehalennia gracilis	Sphagnum Sprite	Widespread/Abundant
Nehalennia irene	Sedge Sprite	Widespread/Common
Pachydiplax longipennis	Blue Dasher	Ubiquitous/Abundant
Pantala flavescens	Wandering Glider	Ubiquitous/Common
Perithemis tenera	Eastern Amberwing	Ubiquitous/Abundant
Stylogomphus albistylus	Eastern Least Clubtail	Limited/Common
Stylurus spiniceps	Arrow Clubtail	Restricted/Rare:STATE CONCERN
Sympetrum internum	Cherry-faced Meadowhawk	Ubiquitous/Abundant
Sympetrum semicinctum	Band-winged Meadownhawk	Widespread/Common
Sympetrum vicinum	Autumn Meadownhawk	Ubiquitous/Abundant

Table 6: Odonata of the Branch River, including Rhode Island status rank

SPECIES NAME	COMMON NAME	RHODE ISLAND STATUS
Aeshna constricta	Lance-tipped Darner	Widespread/Common
Aeshna tuberculifera	Black-tipped Darner	Widespread/Common
Aeshna umbrosa	Shadow Darner	Ubiquitous/Abundant
Anax junius	Common Green Darner	Ubiquitous/Abundant
Argia apicalis	Blue-fronted Dancer	Limited/Uncommon
Argia fumipennis	Variable Dancer	Ubiquitous/Abundant
Argia moesta	Powdered Dancer	Widespread/Common
Argia translata	Dusky Dancer	Limited/Uncommon
Basiaeschna janata	Springtime Darner	Widespread/Common
Boyeria vinosa	Fawn Darner	Widespread/Common
Calopteryx aequabilis	River Jewelwing	Limited/Uncommon
Calopteryx dimidiata	Sparkling Jewelwin	Limited/Uncommon
Calopteryx maculata	Ebony Jewelwing	Ubiquitous/Abundant
Didymops transversa	Stream Cruiser	Widespread/Uncommon
Dromogomphus spinosus	Black-shouldered Spinyleg	Widespread/Common
Enallagma aspersum	Azure Bluet	Widespread/Common
Enallagma divagans	Turquoise Bluet	Widespread/Abundant
Enallagma exsulans	Stream Bluet	Widespread/Common
Enallagma geminatum	Skimming Bluet	Ubiquitous/Abundant
Enallagma traviatum	Slender Bluet	Widespread/Common
Epiaeschna heros	Swamp Darner	Widespread/Common
Epitheca cynosura	Common Baskettail	Ubiquitous/Abundant
Epitheca princeps	Prince Baskettail	Ubiquitous/Common
Gomphus abbreviatus	Spine-crowned Clubtail	Restricted/Rare
Gomphus adelphus	Mustached Clubtail	Restricted/Rare
Gomphus exilis	Lancet Clubtail	Widespread/Abundant
Gomphus lividus	Ashy Clubtail	Limited/Uncommon
Hagenius brevistylus	Dragonhunter	Widespread/Common
Helocordulia uhleri	Uhler's Sundragon	Limited/Uncommon
Hetaerina americana	American Rubyspot	Limited/Uncommon
Ischnura posita	Fragile Forktail	Ubiquitous/Abundant
Ischnura verticalis	Eastern Forktail	Ubiquitous/Abundant
Lestes disjunctus	Common Spreadwing	Ubiquitous/Abundant
Lestes inaequalis	Elegant Spreadwing	Widespread/Common
Lestes rectangularis	Slender Spreadwing	Ubiquitous/Abundant
Libellula incesta	Slaty Skimmer	Ubiquitous/Abundant
Libellula luctuosa	Widow Skimmer	Ubiquitous/Abundant
Libellula lydia	Common Whitetail	Ubiquitous/Abundant
Libellula pulchella	Twelve-spotted Skimmer	Ubiquitous/Abundant
Macromia illinoiensis	Illinois River Cruiser	Limited/Common
Nasiaeschna pentacantha	Cyrano Darner	Widespread/Uncommon
Ophiogomphus mainensis	Maine Snaketail	Restricted/Uncommon
Pachydiplax longipennis	Blue Dasher	Ubiquitous/Abundant
Stylogomphus albistylus	Eastern Least Clubtail	Limited/Common
Stylurus scudderi	Zebra Clubtail	Restricted/Rare: STATE THREATENED
Stylurus spiniceps	Arrow Clubtail	Restricted/Rare: STATE CONCERN
Sympetrum internum	Cherry-faced Meadowhawk	Ubiquitous/Abundant
Sympetrum semicinctum	Band-winged Meadowhawk	Widespread/Common
Sympetrum vicinum	Autumn Meadowhawk	Ubiquitous/Abundant

Table 8: Odonate species diversity and impervious surface data (1999) for the Branch River watershed, by zone.

Zone	No. of species	No. of sites	Corrected No. Species	% Impervious (500'buffer)	% Impervious (1000'buffer)	% Impervious (1500')
1	47	6	7.83	13.37	13.6	12.04
2	71	9	7.88	9.01	8.23	7.09
3	80	13	6.15	20.04	23.33	23.8

Table 9: Odonate species diversity and impervious surface data (1999) for the Branch River, by zone.

Zone	No. of species	No. of sites	Corrected No. Species	% Impervious (500')	% Impervious (1000')	% Impervious (1500')
1	17	1	17	13.37	13.6	12.04
2	35	1	35	9.01	8.23	7.09
3	39	4	9.75	20.04	23.33	23.8

Appendix I: Definition of Rhode Island Odonata status categories**.**

Distribution rank:

1. **Ubiquitous**: a species found in 30 or more townships
2. **Widespread**: a species found in 18-29 townships
3. **Limited:** a species found in 7-17 townships
4. **Restricted**: a species found in 6 or fewer townships

Abundance rank:

1. **Abundant**: 200 or more specimens (damselflies), 150 or more specimens (dragonflies) and/or more than 2 sites per township
2. **Common:** 71-199 specimens (damselflies), 75-149 specimens (dragonflies) and/or 2 sites per township
3. **Uncommon:** 10-70 specimens (damselflies), 10-74 specimens (dragonflies) and/or fewer than 2 sites per township
4. **Rare**: fewer than 10 specimens (dragonflies and damselflies)

Appendix E:
Results of analysis of existing and newly collected (2005) data on fish populations in the Branch River watershed

Appendix E. Results of analysis of existing and newly collected (2005) data on fish populations in the Branch River watershed. Selected data from 1994 through 2005 (Libby 2005 and Gauvin personal communication).

Common Name	Latin Name	Status*	Location**		
			Upper Slatersville Reservoir (1995)	Branch River at Great Rd., N. Smithfield (2002)	Tarkiln Brook, Burrillville (1994)
Largemouth Bass	*Micropterus salmoides*	Common in RI; Introduced in 1897	X	X	
Bluegill	*Lepomis macrochirus*	Common in RI; Introduced in 1914	X	X	X
Yellow Bullhead	*Ameiurus natalis*	Present in RI; Introduced	X	X	X
Pumpkinseed	*Lepomis gibbosus*	Common in RI; Native	X		X
Chain Pickerel	*Esox niger*	Common in RI; Native	X	X	X
Brown Bullhead	*Ameiurus nebulosus*	Common in RI; Native			X
Yellow Perch	*Perca flavescens*	Common in RI; Native	X		X
White Sucker	*Catostomus commersoni*	Present in RI; Native	X	X	X
Fallfish	*Semotilus corporalis*	Present in RI; Native		X	X
Redfin Pickerel	*Esox americanus*	Common in RI; Native			
Brook Trout	*Salvelinus fontinalis*	Common in RI; Resident and anadromous; Native			
Common Shiner	*Luxilus cornutus*	Common in RI; Native		X	X
Golden Shiner	*Notemigonus crysoleucas*	Common in RI; Native	X		
Tessellated Darter	*Etheostoma olmstedi*	Common in RI; Native		X	
Longnose Dace	*Rhinichthys atratulus*	Common in RI; Native		X	
Black Crappie	*Pomoxis nigromaculatus*	Present in RI; Introduced	X		
Rainbow Trout	*Oncorhynchus mykiss*	Present in RI; Anadromous; Introduced	X		
Smallmouth Bass	*Micropterus dolomieu*	Present in RI; Introduced in 1870		X	
		TOTAL # species at Location:	**10**	**10**	**9**

	Watershed Zone 1
	Watershed Zone 2
	Watershed Zone 3

* Rhode Island population status and distribution information from August et al. (2001)

** Fish data for all years prior to 2005 are from Libby 2004; 2005 data are courtesy of Alan Libby (RI Department of Environmental Management) and Roland Gauvin (Trout Unlimited member, Volunteer)

Common Name	Latin Name	Location					
		Branch R. at Snake Hill Rd., Burrillville (1995)	Rankin Brook at Mattity Rd., N. Smithfield (1994)	Tarkiln Brook, Burrillville (2005)	Tarkiln Pond, Burrillville (2005)	Trout Brook at Pound Hill Rd., N. Smithfield (1994)	Branch River at confluence with Blackstone, N. Smithfield (2005)
Largemouth Bass	*Micropterus salmoides*	X	X	X	X	X	X
Bluegill	*Lepomis macrochirus*			X	X	X	X
Yellow Bullhead	*Ameiurus natalis*	X		X	X	X	
Pumpkinseed	*Lepomis gibbosus*		X	X	X		X
Chain Pickerel	*Esox niger*	X			X		
Brown Bullhead	*Ameiurus nebulosus*		X	X			
Yellow Perch	*Perca flavescens*						
White Sucker	*Catostomus commersoni*		X				
Fallfish	*Semotilus corporalis*	X				X	
Redfin Pickerel	*Esox americanus*	X	X				
Brook Trout	*Salvelinus fontinalis*		X				
Common Shiner	*Luxilus cornutus*	X					
Golden Shiner	*Notemigonus crysoleucas*						
Tessellated Darter	*Etheostoma olmstedi*	X					
Longnose Dace	*Rhinichthys atratulus*	X					
Black Crappie	*Pomoxis nigromaculatus*						
Rainbow Trout	*Oncorhynchus mykiss*						
Smallmouth Bass	*Micropterus dolomieu*						
	TOTAL # species at Location:	**8**	**6**	**5**	**5**	**4**	**3**

	Watershed Zone 1
	Watershed Zone 2
	Watershed Zone 3

** Fish data for all years prior to 2005 are from Libby 2004; 2005 data are courtesy of Alan Libby (RI Department of Environmental Management) and Roland Gauvin (Trout Unlimited member, Volunteer)

Common Name	Latin Name	Location			
		Mowry Paine Brook at Long Entry Rd., Glocester (1994)	Rocky Brook at Spring Lake Rd., Burrillville (1994)	Tucker Brook at Joslin Rd., Burrillville (1994)	**Total # sites (out of 11)**
Largemouth Bass	*Micropterus salmoides*			X	**9**
Bluegill	*Lepomis macrochirus*				**7**
Yellow Bullhead	*Ameiurus natalis*				**7**
Pumpkinseed	*Lepomis gibbosus*				**6**
Chain Pickerel	*Esox niger*				**5**
Brown Bullhead	*Ameiurus nebulosus*	X			**4**
Yellow Perch	*Perca flavescens*				**4**
White Sucker	*Catostomus commersoni*				**4**
Fallfish	*Semotilus corporalis*				**4**
Redfin Pickerel	*Esox americanus*	X	X		**4**
Brook Trout	*Salvelinus fontinalis*	X	X	X	**4**
Common Shiner	*Luxilus cornutus*				**3**
Golden Shiner	*Notemigonus crysoleucas*		X		**2**
Tessellated Darter	*Etheostoma olmstedi*				**2**
Longnose Dace	*Rhinichthys atratulus*				**2**
Black Crappie	*Pomoxis nigromaculatus*				**1**
Rainbow Trout	*Oncorhynchus mykiss*				**1**
Smallmouth Bass	*Micropterus dolomieu*				**1**
	TOTAL # species at Location:	**3**	**3**	**2**	

	Watershed Zone 1
	Watershed Zone 2
	Watershed Zone 3

** Fish data for all years prior to 2005 are from Libby 2004; 2005 data are courtesy of Alan Libby (RI Department of Environmental Management) and Roland Gauvin (Trout Unlimited member, Volunteer)

Appendix F:
Rhode Island Natural Heritage Program's list of rare, threatened, and endangered species in the Branch River Watershed

Appendix F. Rare, threatened, and endangered species in the Branch River watershed, as recorded in the Rhode Island Natural Heritage Program database*, December 2005.

Common Name	Latin Name	Taxon Group	Ranking
Coppery emerald	*Somatochlora georgiana*	Invertebrate	State Threatened
Crimson-ringed whiteface	*Leucorrhinia glacialis*	Invertebrate	State Threatened
Scarlet bluet	*Enallagma pictum*	Invertebrate	Species of Concern
Southern New England acidic level fen	*N/A*	Natural Community	Not Listed
Climbing fern	*Lygodium palmatum*	Plant	Species of Concern
Early coral-root	*Corallorhiza trifida*	Plant	Species of Concern
Early saxifrage	*Saxifraga virginiensis*	Plant	Species of Concern
Golden heather	*Hudsonia ericoides*	Plant	Species of Concern
Lily-leaved twayblade	*Liparis liliifolia*	Plant	State Endangered
Maidenhair spleenwort	*Asplenium trichomanes*	Plant	Species of Concern
Variable sedge	*Carex polymorpha*	Plant	State Endangered
Wood lily	*Lilium philadelphicum*	Plant	Species of Concern
Woodland horsetail	*Equisetum sylvaticum*	Plant	Species of Concern
Eastern hognose snake	*Heterodon platirhinos*	Reptile	Species of Concern

*The data provided by the Rhode Island Natural History Survey are based solely on existing information in our databases. In the absence of field surveys, we cannot tell you whether a given site includes rare species or significant natural communities. The Natural Heritage Database is the most current and comprehensive information source about the rare biota of Rhode Island. However, such databases are only as complete as the information that has been collected. The RI Natural Heritage Database is funded by a grant from the Rhode Island Foundation and by the RI Agricultural Experiment Station and URI College of Environmental and Life Sciences. Data provided here are intended to provide a baseline dataset for element occurrence locations for the specific site of interest. Uses of the data can include: natural resource management, conservation planning, environmental review, biological and ecological research, land acquisition, and economic development. RINHS holds copyright to its databases. The RINHS data license fee does not include the right to publish data or descriptions from RINHS databases. These rights must be purchased on a different basis depending on the rights requested. Contact RINHS for further information.

Appendix G:
Fact Sheet for Purple Loosestrife (*Lythrum salicaria*)

(Maine Natural Areas Program 2001)

Bulletin #2508

MAINE INVASIVE PLANTS

Purple Loosestrife

Lythrum salicaria
(Loosestrife Family)

Threats to Native Habitats

An invasion of purple loosestrife leads to a loss of plant and wildlife diversity. Infestations of purple loosestrife appear to follow a pattern of establishment, maintenance at low numbers, and then dramatic population increases when conditions are optimal. This plant flourishes in wetland habitats that have been disturbed or degraded by draining, natural water drawdown in dry years, bulldozing, siltation, shore manipulation, cattle trampling, or dredging. Mudflats exposed following drawdowns will quickly be colonized if a loosestrife seed source is present. Seeds are usually present in such large numbers and germinate in such high densities that growth of native seedlings is prevented. High seed viability and prolific seed production can build up a seedbank of massive proportions. The buildup of debris around the roots enables loosestrife to invade deeper water and to form dense stands that shade out other emergent plants and push out floating vegetation by closing open water spaces.

Description

Purple loosestrife is a stout, erect, perennial herb with a strongly developed taproot. The plant's flower clusters are spike-like and range from four to 20 inches tall, topping a plant that ranges in height from two to six feet. The four-angled stem can be smooth to somewhat fuzzy. The leaves attach directly to stems at their bases, and they are opposite or in whorls, narrow to narrowly oblong, with heart-shaped bases. The flowers are magenta, or occasionally white or light pink, with five to seven petals. The flowers open in July and continue to bloom through September or October. The fruit is a dry capsule generally containing 100 or more tiny, dark-colored seeds. From a distance, purple loosestrife may be confused with several other tall native herbs with long red or purple spike-like flower clusters. Up close, however, it is easily distinguished from native plants. Consult a natural resource professional to confirm identification.

Purple Loosestrife (photo by Frank Bramley, courtesy of the New England Wild Flower Society)

Habitat

Purple loosestrife is found in wetlands such as cattail marshes, sedge meadows and open bogs. It also occurs along streams, riverbanks, and lakeshores. It is opportunistic in areas that have experienced recent soil disturbance. It is not uncommon to find it growing in man-made storm-water retention ponds and in ditches next to parking lots and roads. Purple loosestrife grows best in highly organic soils, but tolerates a wide range of soils including clay, sand, muck and silt. Generally, the plant is found in full sun, but it can survive in partial shade.

Distribution

Purple loosestrife is native to Eurasia and was first reported on the coast of northeastern North America in 1814. Although purple loosestrife occurs in nearly

all sections of the United States, the heaviest concentrations are in the glaciated wetlands of the Northeast. In Maine, purple loosestrife has been documented in all but three counties.

Control

Current methods for getting rid of large, dense populations of loosestrife are not totally effective. Several control methods have been attempted with varying degrees of success. Natural area managers must determine their objectives first, and determine if it is more feasible to contain or to destroy populations of purple loosestrife. Large populations extending over three acres or more are difficult, if not impossible, to completely destroy using presently known methods. These large populations should be contained at their present position. Preventing the expansion can be accomplished through hand-pulling new plants along the edges or spraying herbicide on plants extending beyond the main body of the population. Smaller populations can be eradicated: populations up to three acres can be cleared with herbicides or hand-pulled, depending upon the size of the work crew and time available.

Biological: On-going experiments have successfully demonstrated that certain loosestrife-eating insects can cause its populations to decrease in size. Although these creatures do not completely eliminate purple loosestrife from a site, they can reduce populations to more manageable and less harmful densities.

Chemical: The herbicide glyphosate is most commonly used for purple loosestrife control. However, over-spray can cause native vegetation to die back, and ultimately lead to even greater explosions of loosestrife invading from the seedbank. Spot application directly onto plants can ensure that no large holes appear in adjacent vegetation and that competition is relatively unaffected. The safest method of applying glyphosate herbicide is to cut off all stems at about 6 inches and then paint or drip onto the cut surface a 20 to 30 percent solution. Spraying should be done after the period of peak bloom, usually late August. It is critical that any control effort be followed up the same growing season and for several years afterwards since some plants will be missed, new seedlings may sprout from the extensive seedbank, and some plants might survive the treatment. For larger infestations where spot application of glyphosate is not practical, broadleaf herbicides can be used. They have the advantage of not harming grasses and other grass-like species, which are the dominants in most wetlands. This fact sheet does not contain all the available information on methods of herbicide treatments for purple loosestrife. Consult a licensed herbicide applicator for more information.

Pulling: Hand-removal is recommended for small populations and isolated stems. Ideally, the plants should be pulled out before they have set seed. The entire rootstock must be pulled out since regeneration from root fragments is possible. Be sure to minimize disturbances to the soil and native vegetative cover. Remove uprooted plants and broken stems from the area since the broken stems can resprout.

References:

Josselyn Botanical Society of Maine. 1995. *Checklist of the Vascular Plants of Maine, Third Revision.* Orono, ME: Maine Agricultural and Forest Experiment Station.

Bender, J. & J. Rendall. 1987. *Element Stewardship Abstract for Lythrum salicaria.* Arlington,VA: The Nature Conservancy in collaboration with the International Network of Natural Heritage Programs and Conservation Data Centers. Natural Heritage Databases.

For more information or for a more extensive list of references on invasive species contact:
Don Cameron
Maine Natural Areas Program
Department of Conservation, #93 State House Station
Augusta, ME 04333-0093
(207-287-8044)
or
Lois Berg Stack
University of Maine Cooperative Extension
495 College Avenue, Orono, ME 04469
(800-870-7270)

Materials developed by the Maine Natural Areas Program for use by University of Maine Cooperative Extension. This fact sheet was made possible by a gift from New England Grows.

1865 THE UNIVERSITY OF MAINE Cooperative Extension

DEPARTMENT OF CONSERVATION MAINE

A Member of the University of Maine System

Published and distributed in furtherance of Acts of Congress of May 8 and June 30, 1914, by the University of Maine Cooperative Extension, the Land Grant University of the state of Maine and the U.S. Department of Agriculture cooperating. Cooperative Extension and other agencies of the U.S.D.A. provide equal opportunities in programs and employment. 7/01