Adopt-A-Buffer Toolkit:

Monitoring and Maintaining Restoration Projects

September 2003

DELAWARE RIVERKEEPER NETWORK

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A **pdf** version of this Toolkit is available and can be downloaded free of charge from the Delaware Riverkeeper Network web site at www.delawareriverkeeper.org. For more information, call the Delaware Riverkeeper Network at 215-369-1188.

Please Note: Limited hard copies of this publication are available free to watershed groups actively monitoring restoration projects.

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Foreword

If we are to be successful in defending our River, its tributary streams and watershed, then our work cannot stop simply with "protecting," it has to include effective restoration. Ecologically sensitive stream restoration projects allow us to bring our waterways and their ecosystems back to life, to give them back the health and integrity they once enjoyed. To be truly effective, our riparian restoration efforts cannot end upon the implementation of a project. Long-term monitoring and maintenance are the keys to success.

Monitoring and maintenance enable us to identify and rectify problems before they become catastrophes. Our streams, rivers and wetlands are suffering daily assaults. Legal protections aren't sufficient to protect them. In fact, in many instances, our environmental laws aren't designed to provide true protection, just reduced damage and destruction. That is why community protection and nurturing – which underlie the Delaware Riverkeeper Network approach to restoration, monitoring and project maintenance – are crucial.

Our waterways need our help and loving attention if we are to ensure that a restoration project that helped bring a stream back to life can continue this role. It is through our commitment to this work that our efforts for the River meet with success.

Maya K. van Rossum
Delaware Riverkeeper

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Introduction

Delaware Riverkeeper Network (DRN) has been planting native, trees, shrubs, and wetland plants along streams and tributaries of the Delaware River Watershed since 1992. In that time, we have partnered with private landowners, local and regional watershed groups, and township municipalities to restore over fifteen stream miles. Our projects have included restoration of riparian buffers and wetland habitats, invasive plant species control, dam removal, bioengineering stabilization, biofiltering wetlands, elements of natural channel design, stormwater basin retrofit and naturalization projects.

Though projects are designed to require little maintenance, our experience has shown that most restoration projects do need some oversight and "tender loving care" for long-term success. A number of factors can jeopardize the success of restoration projects. DRN recognized these threats and, in 2001, developed the **Adopt-A-Buffer Initiative** to help monitor and maintain restoration projects using trained Volunteer Project Stewards. **With consistent volunteer monitoring and periodic maintenance, our goal is to keep adopted projects on a trajectory that will ultimately lead to a self-sustaining and functioning natural system that infiltrates runoff, stabilizes stream banks, provides wildlife habitat, and improves the quality of the Delaware River Watershed.** Volunteer Project Stewards also collect data to help us learn from methods and materials used in completed projects in order to improve and expand future restoration work.

This ***Adopt-A-Buffer Toolkit*** has been designed specifically for DRN Volunteer Project Stewards and our project partners who adopt or implement a restoration project in their community. In addition, the Toolkit can assist restoration practitioners and volunteer monitors across Pennsylvania and beyond with a suite of monitoring protocols that can be used to assess a variety of restoration projects. The **Monitoring Techniques** included in this Toolkit are designed so that volunteers, with minimal training and equipment, can collect information that leads to effective management and oversight of a project. Volunteers and managers can choose appropriate techniques from this menu, based on a restoration project's goals and demands, to develop a monitoring study design that generates useable data on a project over time. Monitoring study design, put simply, is determining the "who, what, when, why and where" of your monitoring project in order to gain the most pertinent data to achieve your specific goals.

In addition to the monitoring protocols, this Toolkit includes a section on **Restoration Project Maintenance** with information on common maintenance activities that can be used to help guide follow-up work that may be needed at the project site.

Adopt-A-Buffer Volunteer Initiative

We believe that by providing volunteers with proper training and tools, we can build a strong foundation of sustainable monitoring that will help us better protect and restore our watersheds.
In exchange for training and materials, Adopt-A-Buffer Volunteer Project Stewards agree to:

- ✓ Attend a workshop and/or field training to learn appropriate monitoring techniques
- ✓ Monitor adopted project site at least twice a year (June and August suggested)
- ✓ Copy and provide monitoring results to DRN and other project partners
- ✓ Help organize Maintenance Work Days if necessary
- ✓ Help to recruit and train new volunteers for the Initiative

The Benefits of Streamside Vegetation

1. Woody vegetation and tall grasses along streambanks shade the water, helping to maintain cooler water temperatures many aquatic organisms require to survive.
2. Native plants provide food and cover for wildlife. Nesting, breeding, and roosting sites are common in riparian areas.
3. The roots of trees and shrubs not only stabilize stream banks, thus preventing erosion and stream bank failure; they also take up excess nutrients entering the stream from the surrounding lands. This root material also slows the velocity of a flooding stream thereby decreasing damage and allowing greater groundwater infiltration.
4. Fallen leaves and other plant debris provide food and shelter for many organisms.

Options For Riparian Restoration

Riparian (or streamside) vegetation is an important part of a healthy ecosystem. The presence or absence of riparian buffers directly affects water quality, water quantity, stream channel stability and wildlife habitat. Unfortunately, many streams in the Delaware River Watershed lack these protective buffer zones. As a result, many of our waterways suffer from high levels of nutrients, high temperatures, and excessive sediment pollution. While transporting sediment is what waterways naturally do, excessive sediment and pollutants are carried by rainwater that runs off roads and lawns, playing fields, agricultural lands, and construction sites. A significant part of the sediment in our urban and suburban streams is due to excessive and unnatural stream channel erosion caused by poor stormwater management that sends increased volumes of runoff to our waterways.

The goals of DRN's Restoration Program are to re-establish riparian buffers and restore the functions and benefits that healthy streamside vegetation provides. To do this, we plant native plants and use a variety of ecologically sensitive bioengineering techniques. DRN has implemented a variety of restoration project types. A description and rationale behind each of the project types is presented below.

Riparian Buffer Projects – Buffer projects can be a combination of streambank fencing, establishing no-mow zones, and planting native trees, shrubs, and herbaceous species. As a buffer grows, it holds the streambanks, creates shade for the stream, and provides cover and food for wildlife. Native plants also filter and use excess nutrients, uptaking these nutrients before they reach the stream. The wider the buffer, the greater the positive benefits to the stream.

Dam Removal Projects – Dams fragment habitat, preventing movement of both resident and migratory fish as well as other aquatic life. By their very existence, dams degrade water quality, altering temperatures and oxygen levels. Dams hold back silt, debris, and nutrients, interfering with a river's natural function of moving sediment. A dammed river is sometimes referred to as a "hungry" river as it will often scour its banks and bed downstream from the dam. Dams may actually eliminate flood-storage capacity and can exacerbate upstream flooding by keeping a stream at constant bankfull and even flood stage, with no excess storage capacity. Dam removal projects look to restore a stream to a free-flowing condition.

Stormwater Basin Retrofit Projects – Traditional detention basins are designed to collect and hold stormwater for a period of time and then release it directly into the local stream through a pipe sized to pass flows at what are calculated to be pre-development peak rates. These basins do not allow for groundwater infiltration, do not reduce the increased volume of runoff coming from developed sites, nor do they filter out pollution from stormwater runoff. The result is that a greater volume of polluted water is discharged to the receiving stream over a longer period of time causing erosion, increased flooding, and habitat degradation.

Retrofit projects are designed with infiltration trenches and a variety of other techniques to encourage stormwater to infiltrate through the soil to replenish groundwater. As infiltration occurs, soil microbes help clean the stormwater. Infiltration also reduces the volume of stormwater discharged to the stream, thus decreasing erosion, flooding and habitat degradation. Basin naturalization projects replace the familiar mowed, manicured basin we are accustomed to seeing with native trees, shrubs, and herbaceous species. These native plants provide multiple benefits for wildlife, safeguard water quality, and create a more interesting place for our eye to wander than the barren landscape of a mowed basin.

Bioengineering Projects – In cases where streambanks are suffering from severe erosion, bioengineering techniques using plant material to stabilize streambanks may be implemented. Bioengineering techniques provide multiple benefits such as increasing infiltration, safeguarding water quality, protecting in-stream and floodplain habitats, preventing erosion, slowing floodwater and reducing flood frequency. Traditional engineering techniques that use riprap (rock) to stabilize banks do not afford these benefits to the stream. Coconut matting and coir logs, live wattles, and recycled Christmas trees are some of the materials that are often used to help protect streambanks.

Biofiltering Wetland Projects – Wetlands are natural sponges that help store and cleanse floodwaters, provide a nursery and hiding places for juvenile fish, and provide habitat for many wildlife species. Biofiltering wetlands can be designed to help store and cleanse stormwater before it enters a stream. These wetlands also increase infiltration and alleviate flooding.

We grow up hearing so often that a straight line is the shortest distance between two points that we end up thinking it is also the best way to get there. A river knows better – it has to do with how it dissipates energy of its flow most efficiently; and how, in its bends, the sediment deposited soon turns into marshes and swampy islands, harboring all manner of interesting life, imparting charm and character to the whole waterway. I would defy you to find a river on this planet that prefers to run straight, unless it has been taught so by the U.S. Army Corps of Engineers.

--Tom Horton

Adopt-A-Buffer Protocols

Level 1 Protocols (performed every June and August):

- *Restoration Project Survey (RPS)* – A visual assessment factoring six different indicators to document the progress of a project.
- *Photo Monitoring Survey* – Supplements the RPS with photo documentation that records project status.

Level 2 Protocols (performed as needed depending on the project study design and/or volunteer interest):

- *Photo-Monitoring Survey* – Uses a profile board to estimate percent vegetation coverage using photographs.
- *Cross Section and Bank Pin Monitoring* – Stream cross sections and bank pins are utilized to determine stream profile and bank changes over time.
- *Macroinvertebrate Monitoring* - A survey of the health of the macroinvertebrate community that uses a kick net or D-frame net to collect and identify insects, streamside. Insects are identified to Order level and returned to the stream unharmed.
- *Wildlife Survey* – A visual and auditory survey that summarizes wildlife use of the restoration project and surrounding area.

Monitoring Protocols Overview

A menu of monitoring protocols has been compiled to provide tools that can be used to monitor a variety of restoration projects. A mix of these protocols is used by the Volunteer Project Steward to gather sufficient information to identify problems and track progress about a restoration project site. **Level 1 Protocols**, which concentrate on collecting basic visual information about the overall status of a project, are mandatory and should be used by all stewards for every restoration project. **Level 2 Protocols** can be added to the monitoring study design if more in-depth monitoring data is required to evaluate progress toward restoration goals.

For Volunteer Project Stewards participating in DRN's Adopt-A-Buffer Program, each restoration site has a Project Folder that outlines what protocols would be most suitable for the adopted site. An Initial Level 1 Restoration Project Survey (RPS), completed after the project was implemented to provide a baseline, is included in the Project Folder. Other items in the Project Folder - project designs/drawings, photos, plant nursery lists, directions to the site, and landowner contact information - help stewards familiarize themselves with their projects. For other restoration practitioners using this toolkit, development of a similar Project Folder is recommended to assist volunteers.

Data Utilization

Data collected by Volunteer Project Stewards under our Adopt-A-Buffer Initiative will be used by DRN and our project partners to track the progress of restoration projects and determine maintenance needs. When maintenance work requires added technical or logistical assistance, DRN will allocate resources and staff to lead maintenance efforts on an as-needed basis for a limited number of sites. These sites will be selected based on monitoring data results, the identified needs of the project, and the ability to positively impact the project using maintenance techniques.

DRN strongly encourages project partners and Volunteer Project Stewards to follow through with maintenance efforts, and we will gladly provide recommendations and support to help guide these efforts. A helpful section on Restoration Project Maintenance is included in this Toolkit to assist with some of the most common maintenance concerns that stewards and project partners may encounter at project sites. By working together, we can assess project conditions and also react effectively when a project needs our help to thrive.

Before Your Site Visit

Although you may be eager to get out in the field, you must first do some homework for your project. By acquainting yourself with your adopted site on paper, you will be a better investigator in the field.

1. Familiarize yourself with the Project Folder. Project folders, provided by DRN, will include most of the following components:

a. A brief summary and history of the project;
b. Contact information for project partners and landowners;
c. A map and/or directions to get to the site;
d. Plant lists for species planted at the site and a diagram that shows a general sketch of the project site;
e. A completed Level 1 Restoration Project Survey (RPS) that was completed for the project shortly after implementation; and
f. Photographs and photo points of the project site before and after implementation.

2. Build relationships. Work with DRN to build a partnership. Contact project partners to let them know you have adopted the project and will be sending them copies of your completed datasheets. Contact these partners when maintenance is needed or to alert them to project problems.

3. If the project is located on private land, contact the landowner to let them know you will be performing an assessment on their property. Invite the landowner to join you in the field to enhance their understanding of the project and build a relationship that will be helpful if maintenance is needed. Consider sending a copy of your assessment results to landowners to keep them involved.

4. Get to know common invasive plants. Review *Plant Invaders of Mid-Atlantic Natural Areas*, published by the National Park Service and U.S. Fish and Wildlife Service and supplied with this Toolkit, to familiarize yourself with invasive plants. Better yet, grab *Plant Invaders* and take a hike in a nearby woods or along a roadside (likely habitat for invasive plants) looking for species that appear to be aggressive. These aggressors are frequently the invasive plants that will show up at your project. The more you become familiar with invasive plants, the more effective you will be at detecting them at your site. Remember, maintenance is more feasible and eradication may be possible when the invasive infestation is small.

5. Review the project nursery list located in the Project Folder. Become familiar with the tress and shrubs that were planted. A native plant guide can be helpful to learn characteristics to identify species at the site.

6. Gather the equipment and information you will need to take with you in the field.

Safety Tips

Stream work can be exciting, but you should be aware of potential hazards. Follow these tips to ensure that you stay safe when monitoring restoration sites:

1. **Work with a partner** - NEVER work alone!! A companion provides added security *and* is invaluable should an accident occur. Plus, its more fun working in teams and working through the datasheets together.
2. **Wear protective clothing** - Long sleeves, durable pants, and waterproof boots will help you investigate your project site thoroughly. Restoration projects often have high grasses and thorny plants so you'll be thankful you had protective clothing even if it is a hot day in June or August!
3. **Beware of ticks** - Be sure to check yourself for ticks during and after you get home from your site. Wearing light-colored clothing will help you spot ticks. Deer ticks are the size of a pepper flake so be thorough! Deer tick enthusiasts say that these little blood suckers won't start feasting on you for hours so early detection is critical to protecting yourself from Lyme disease and other tick-borne diseases.
4. **Stay Hydrated** - June and August are hot months, so be sure to bring plenty of drinking water with you to your site. Dehydration is one of the biggest causes of accidents in the field so stay hydrated! If you feel dizzy or weak, find a shade tree, take a break, and drink plenty of water.

Level 1 Monitoring Techniques

Level 1 Monitoring Techniques

The Restoration Project Survey (RPS) is a visual assessment that tracks the progress of a restoration project over time. The information obtained helps to determine what, if any, maintenance action needs to be taken at the site. It also helps determine the overall status of restoration techniques and helps to plot the trajectory of the restoration project over time. Level 1 Techniques are mandatory and should be completed at least twice a year, preferably in June and August.

The Restoration Project Survey

When you arrive at the site, be sure to walk the entire project reach before completing the RPS. For some sites, the project area may not be contiguous or obvious so reference the Project Folder, the initial diagram of the site, and photo points to become familiar with the adopted site. **Be aware that when you are recording information, face downstream to determine the left and right banks of the stream.** Note that some projects may be on only one side of the stream.

Project Code

Each DRN Restoration Project is assigned a unique four-letter project code. This code helps with tracking and data entry of sites and should be recorded on your RPS.

Project Type

The project type is also listed in your project folder. There can be several project types located within one restoration project site. For example, a fencing project may also involve a buffer planting or bioengineering. Check all types that apply to your project.

Project Completion Date

Projects are often completed in phases based on complexity. A fencing project may be started in the fall with the installation of an electric fence. Buffer planting within the fenced area may follow in spring. Information on project phases and dates can be found in your project folder.

Plant Types and Number Installed

This information (see the project plant list in your Project Folder) helps to determine the overall size of the project and the types of vegetation installed. In most cases, a variety of different vegetation types are planted at each project site to increase diversity and structure of the plant community. Your Project Folder has a nursery list indicating the scientific names of vegetation planted at your site. Before visiting the site, review this list using a native plant guide to learn identifying characteristics for each species. To assist in locating plantings, as a general rule, planted trees and shrubs are spaced anywhere from 6 to 20 feet apart, while herbaceous plants are typically from 1 to 3 feet apart.

Equipment Required For Level 1 Protocols

Adopt-A-Buffer Toolkit
Clipboard
Restoration Project Folder
Datasheets
Pencils and Erasers
Camera
Extra Batteries
Film/Memory Sticks
Tape Measure/Meter Stick
Drinking Water
Binoculars (Optional)
Waders or Hip Boots (Optional)
Compass (Optional)
Sunscreen
Bug Spray
Plant Invaders of Mid-Atlantic Natural Areas
Re-sealable Plastic Bags/Plant Containers

Common Plants Used at DRN Restoration Projects

Common Name/*Scientific Name*

Trees
Red maple/*Acer rubrum*
Silver maple/*Acer saccharinum*
River birch/*Betula nigra*
Eastern redbud/*Cercis canadensis*
Green ash/*Fraxinus pennsylvanica*
Witchhazel/*Hamamelis virginiana*
Tulip poplar/*Liriodendron tulipfera*
American sycamore/*Platanus occidentalis*
Pin oak/*Quercus palustris*
Sassafras/*Sassafras albidum*

Shrubs
Black chokeberry/*Aronia melanocarpa*
Sweet pepperbush/*Clethera alnifolia*
Silky dogwood/*Cornus amomum*
Red-osier dogwood/*Cornus sericea*
Winterberry/*Ilex verticillata*
Elderberry/*Sambucus canadensis*
Arrowwood/*Viburnum dentatum*

Scratch test of a live stake: The green color of the exposed cambium indicates that this plant is still alive.

Plant Survey

Percentage of Trees/Shrubs Planted That Are Alive and Healthy - Check all options that apply. Estimate the percentage of trees and shrubs that are alive and healthy. Note areas void of trees or shrubs, which could indicate that plants in this area were mowed, trampled by foot traffic, or browsed.

Status of Live Stakes – Live stakes are dormant branches from trees and shrubs that have the ability to root and grow from cuttings (see *Maintenance Series #5: Pole Plantings And Live Stakes* for more information). If live stakes were planted at your project site, determine if they are alive and growing. Newly installed live stakes may establish roots before they begin sending out green leaves. If no leaves are present, perform a "scratch test" on the bark. Using your fingernail, lightly scratch off a small portion of outer bark. If the exposed material (cambium) is green, the live stake is still alive.

Damage to Plants

Determine the cause of plant mortality and damage, indicate the type of impact and estimate the extent of damage. Take spot photos if the damage is extensive. Brief descriptions of impacts you may encounter in the field follow (for more information about these impacts and to learn how to address them, refer to the Restoration Project Maintenance section of this Toolkit).

Herbivory - Rodents and deer may find species planted at the project site appealing, but early detection can limit damage. Check the base of woody plants for rodent damage. Look for signs of gnawing especially during winter months. Deer browse is recognized by the way the deer snap off smaller, tender branches. A "browse" line - branches above a deer's height left untouched - may also be evident in the vicinity. Most damage from deer occurs in late winter and early spring.

Fungus/leaf dieback.

Girdling of Trunk - In woody plants, nutrients are transported by tissue just under the bark. If this plant tissue around the entire trunk is destroyed, or girdled, the plant will die. Common impacts that result in girding include rubbing by deer, gnawing by rodents and mowing or weed whipping by humans.

Fungus/Disease/Leaf Dieback - A variety of fungi and diseases may affect plants. Powdery mildew and molds can become a problem during wet years or if plants are watered incorrectly. Many tree species are also susceptible to anthracnose, a virus whose early symptoms include spots with tan or maroon borders on leaves. Verticillium wilt, rust, and scale are other elements you may encounter. If you suspect a fungus or disease, take a specimen home with you and log on to http://www.upenn.edu/paflora/plantclinic, the Plant ID Clinic at the Morris Arboretum of the University of Pennsylvania, to diagnose the problem.

Mowing or Other Manmade Impacts - Careless mowing and weed whipping, the most widespread impact we encounter, can devastate a project site. Check the base of woody plants for damage as equipment often nicks trees and damages bark.

Some managers may mow around newly established woody plants to help curb competition from existing grasses for the first two seasons after installation. **DRN generally does not encourage mowing at a project site. For meadow projects, DRN recommends mowing meadow species once a year early in spring. Do not mow to a height of less than 6 inches.** Many tall wildflower species and native grasses may get mowed since landscapers are often programmed to "keep the grass short."

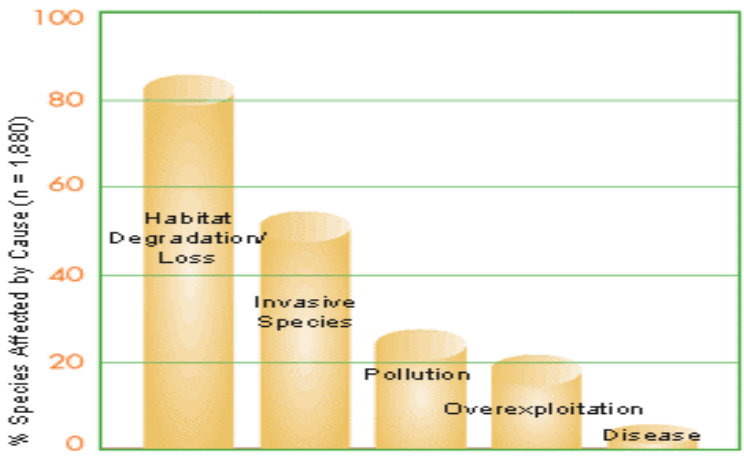
Trampling, or foot traffic, can also impact project sites. Projects usually incorporate natural access points to the stream, but park users may not always confine themselves to these areas. Vandalism may also be a problem in public areas.

Flood/Storm Damage - Natural flooding may uproot plants that have not had time to establish new roots. In some cases, uprooted plants may be re-planted and survive. In other cases, plants may be washed downstream, leaving only empty holes.

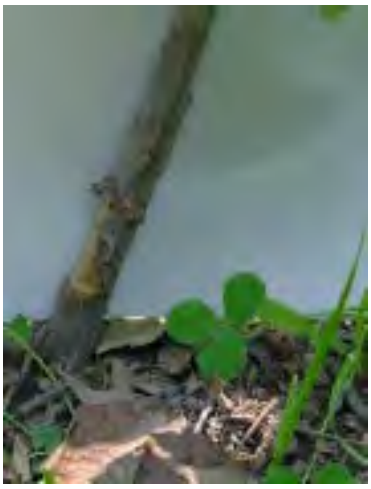
Poor Planting Technique - In most cases, restoration project managers inspect newly installed plants after a volunteer planting effort to ensure that plants are neither too deep nor too shallow. Planting too deeply or too shallowly can result in increased plant mortality (see *Maintenance Series #4: Tree Planting Guidance*). If mulching has been completed, mulch should not touch the base of trees or shrubs.

Invasive Plant Species

An invasive plant is a species, usually from another country or region that grows aggressively, spreads rapidly, and displaces other native plants, resulting in a loss of biodiversity and degradation of habitats. Invasive species are the second largest threat to biodiversity after habitat loss (see table below).



Source: The Nature Conservancy



Mower damage.

Invasive plants are a large threat in disturbed environments.

Recently installed or young restoration projects are ideal locations for these invaders that are often able to:

1) Grow and mature quickly;
2) Exploit and colonize disturbed ground;
3) Produce an abundance of seeds and/or spread by roots or shoots; and
4) Grow in a variety of soil and light conditions.

Monitoring and detecting invasive species EARLY before they are well established at your site is critical and can lead to much more effective maintenance and eradication of the problem plant. To detect these early colonizers, you need to become familiar with these invaders.

The best time to control invasive species is when they initially colonize a site and are present in small pockets or individual plants. This is why monitoring for invasive species is so critical. Early detection can help trigger early removal while the problem is still manageable. To identify invasives at this early colonizing stage, you should review, *Plant Invaders of Mid-Atlantic Natural Areas*. This guide will help you become familiar with the species that may be threatening the success of your project site. You can also refer to the Restoration Project Maintenance section of this Toolkit to learn when these plants emerge and flower, often the best time to identify these invaders (see *Maintenance Series #3: Invasive Plant Timeline*). If you suspect a plant is invasive but are not certain, take a **spot photo** of the suspected plant and send it to DRN for identification. Another good resource is the Plant ID Clinic at the Morris Arboretum of the University of Pennsylvania, in Philadelphia. The Plant ID Clinic supports seasonal interns that are available to identify specimens of unknown plants.

Feeling unsure of your plant ID skills? We don't expect you to have all the answers right away. If you suspect an unknown plant may be invasive, take a spot photo or specimen and have it identified by DRN or the Morris Arboretum Plant ID Clinic (see *Maintenance Series #2: Invasive Plants* for more information)

Invasive Plants In or Near the Project Area

Check the project folder and initial RPS to learn what invasive species were present in the past. Determine if there are invasive plant species established in the project area and competing with the installed plants. In some cases, invasive plants may be surrounding the project area, but not yet present within the project area. These areas can eventually lead to establishment of plants from seed dispersal. Be sure to list the types of invasive species you find and rank the extent of infestation as low, medium, or high. Small infestations are ranked as low and are much easier to control than infestations that have been established for several years and ranked as high.

Low Infestation	Medium Infestation	High Infestation
Low infestations typically are identified as the presence of an individual plant or small, localized population less than 2 meters in diameter. Seed sources are limited at this stage and the infestation is fairly new.	Medium infestations are delineated where invasives have either established themselves scattered sporadically throughout an area, or are found in a large localized population. Seed banks are becoming more established season to season.	High infestations are well-established populations in an area that will require extensive, repeated removal or control. In this case, these plants are impacting the success of the native planted vegetation and are dominating the project area.

Mapping Invasive Plants
Where possible, map the location and extent of the larger or new invasive plant colonies on your project site diagram. Make sure you include easily identified, fixed features to assist in locating the invasive plant colony. This will help in control efforts and will also assist in tracking changes over time. If there are large stands or new colonies of invasive plants, you should also include these areas as **photo points**. Make sure a recognizable feature is included in the photograph and that the photo point is labeled on the diagram.

Bioengineering Physical Survey

Many DRN restoration projects incorporate bioengineering techniques into the project design. Bioengineering generally refers to actions taken to reduce the force or impact of stream energy. As the term implies, it is a blend of engineering and biological techniques. Re-grading and re-vegetating stream banks are common techniques. Re-grading allows the stream's water under high-flow conditions to rise gently on the bank, thus dissipating energy. Re-grading also allows room for streamside plantings that cannot be installed on undercut banks. Incorporating trees, shrubs, and grasses into a stabilization project allows for natural filtration of excess runoff and creates an appealing landscape that provides habitat to aquatic and terrestrial wildlife that use the riparian corridor. In-stream methods are also used to help deflect damaging and unnatural flows. Bioengineering practices include a wide variety of materials, methods and techniques. Wherever alterations to the channel or bank are integrated with the use of plantings, the term bioengineering can be applied.

On your datasheet, record the condition of all bioengineering components present at your site. Check all indicators that apply to the project area. In addition, if erosion is occurring, note the extent of damage in approximate square feet and the location of that damage both vertically and horizontally.

Bioengineering Types You May Encounter

Coir Matting - A woven blanket of coir twine. Coir is traditionally processed from coconut husks cured in freshwater for at least six months. Coir matting is used to cover a graded streambank to help stabilize soil and provide support to plants that are planted within the matting. Wooden stakes driven into the ground hold the matting in place (be careful not to trip over these stakes when you're in the field!). Coir matting has a life of 4 to 6 years and decomposes as plants mature. Establishment of native vegetation, with soil stabilizing root structures, is critical to long-term success.

Coir matting installed over a re-graded streambank (Note: Wooden stakes not yet installed completely).

Close-up of woven coir matting. Source: RoLanka International

Warning: Be careful not to trip over wooden stakes used to secure coir matting. As vegetation grows, these stakes are obscured and can cause quite a trip.

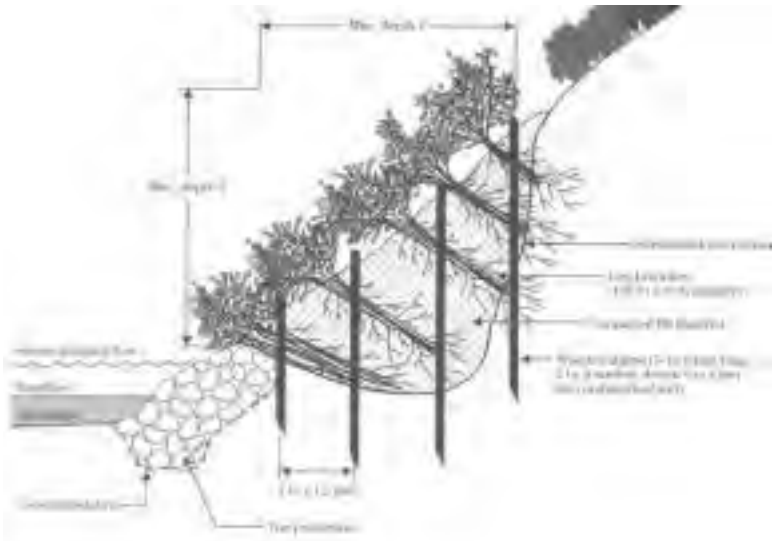
High quality water is more than the dream of the conservationists, more than a political slogan, high quality water, in the right quantity at the right place at the right time, is essential to health, recreation, and economic growth.

--Edmund S. Muskie

Coir Logs – Tightly-packed coconut or other fiber tubes, held together by netting, from 10 to 20 feet long and one foot in diameter, used at the toe of the bank to help with stabilization. Coir logs are designed to fill readily with sediment and decompose naturally over time allowing planted trees and shrubs to secure banks with their roots. Coir logs are often held in place by wooden stakes that crisscross around the log. If coir logs are installed incorrectly, erosion can occur behind the log or the log can become submerged. Plants (usually in the form of plugs or live stakes) are often planted within the log. If plants do not establish in areas where coir logs are installed, then long-term protection of the bank will be compromised.

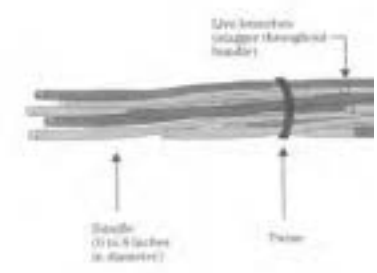
Live Stakes - Unrooted, dormant cuttings from plants such as dogwood and willow. Live stakes are inexpensive but timing of installation in the early spring is essential for success. Dogwoods and willows are often incorporated into restoration projects so that these native plants can provide a source for live stakes for future plantings (see *Maintenance Series #5: Pole Plantings And Live Stakes* for more information).

Branchpacking - Alternating layers of live branches and soil incorporated into a washed out bank. Rope and/or stakes are used to help secure this live material in place. This technique is used to repair a small slump or gully. It is one of the most effective techniques for re-vegetating holes scoured in a bank.



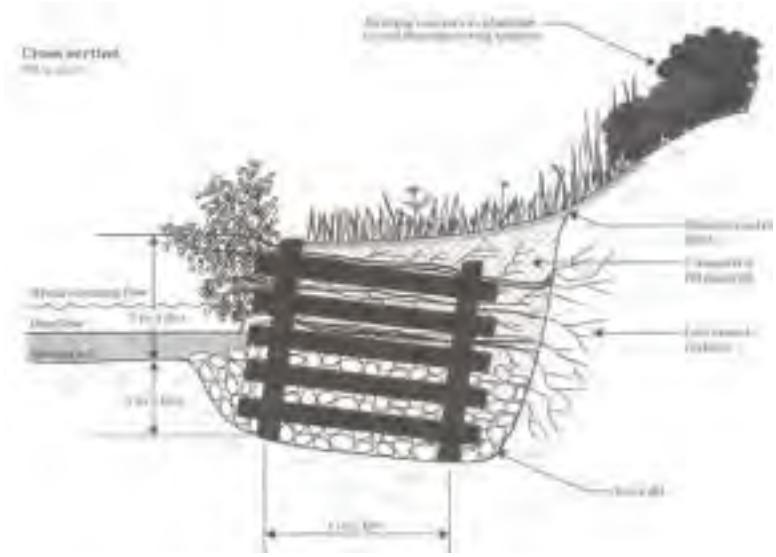
An example of a branch pack design to fill a slumped bank.
Source: Engineering Field Handbook

Wattles or Live Fascines - Bundles of dormant cuttings from shrubs and trees that are bound together in sausage-like structures. Long straight branches are used to form 6 to 8 inch diameter bundles. The wattles are placed in shallow trenches across the slope of the bank and staked into place with live or dead stakes. The wattle provides immediate bank support and within one growing season, roots and shoots grow along the length of the wattle, quickly stabilizing the bank.



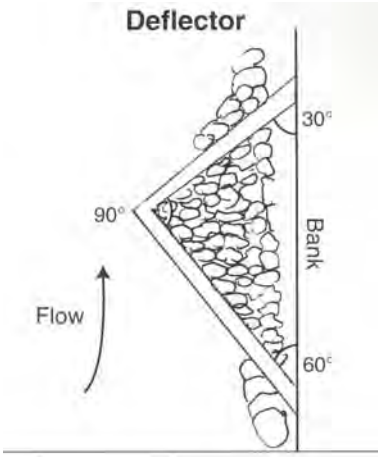
An example of a wattle made of dormant cuttings.
Source: Engineering Field Handbook

Cribwalls - An interlocking arrangement of untreated logs often installed where strong currents are present. The structure is filled with bank material and layers of live branch cuttings. The cuttings take root and gradually hold the bank in place over time.



An example of a cribwall.
Source: Engineering Field Handbook

Deflectors - Triangle structures angled out into a stream from the bank. In most cases, deflectors have an upstream angle of 30 degrees and a downstream angle of 60 degrees. Deflectors are used to turn flow away from the lower portion of the bank where it might cause erosion; to create an alternating flow pattern to simulate stream sinuosity; and for habitat. Opposing deflectors are used to narrow the stream channel. Deflectors are built from brush, logs, stone, or logs and stone. A variety of deflectors are used for different stream conditions.



An example of a log and stone deflector.
Source: Engineering Field Handbook

Rootwads - Used to control erosion on outside bends. In addition to the root mass, rootwads include approximately 20 feet of tree trunk. The trunk is embedded in a trench in the bank and angled upstream with the root mass facing the flow. Rootwads dissipate energy by receiving the brunt of the stream flow. They also protect against large debris and ice that could harm the bank.

Revetments - Structures and/or materials placed against and into a stream bank to protect it. The placement of a rootwad or deflector into a bank is an example.

If your project site includes stormwater retrofit, monitor after a significant rain event to determine how long the basin is holding water. Also, look for signs of sediment settling out into the basin.

Stormwater Retrofit Survey

Development prior to the 1970s had little-to-no stormwater management. Systems were built only to carry and quickly convey stormwater runoff to the stream. In the 1970's, efforts began to address runoff-induced flooding. These systems are generally comprised of stormwater conveyance systems designed to gather rainwater from rooftops, roadways, parking lots, lawnscapes and other impervious surfaces and convey the water, via detention basin, directly to the local stream. This method of stormwater management systems focused on addressing only the peak rate of runoff (holding the runoff for a few hours before it is sent through a deliberately sized pipe directly to the local waterway), but not the **volume** of stormwater runoff to the detriment of our streams.

As a result of the increased volume of stormwater they receive, streams overflow their banks more often, increasing the frequency and severity of existing flooding, while at the same time causing new flooding where once there was none. Moreover, standard peak rate methods for controlling stormwater alter the natural flow regime of streams, impact the established pattern of natural hydrologic variation, change habitat dynamics and disturb species that are adapted to the stream's hydrology.

Stormwater retrofit projects are often implemented in urban watersheds where the use of detention basins has resulted in a greater volume of water being discharged to the stream over a longer period of time. The major goal of these retrofits is to increase stormwater infiltration and decrease the amount of stormwater entering the stream. Retrofits are also designed to provide more time and mechanisms for removing pollutants and sediment from stormwater.

If stormwater retrofit techniques were employed at your project site, they will be listed in your Project Folder. On your datasheet, record the condition of all stormwater retrofit components present. Check all indicators that apply to the project area. In addition, if erosion is occurring, note the extent of damage in approximate square feet and the location of that damage both vertically and horizontally.

Retrofit Types You May Encounter

Determine which type or types of retrofit structures are implemented at your project site. The list of retrofit structures is a long one. We have listed the most likely retrofits that you may encounter at your site and have left room for you to list any others employed at your project site. Your project folder will list the types implemented. In many cases, naturalization (planting of native vegetation) will accompany structural adjustments such as the installation of an infiltration trench or a weir on the ouflow structure.

Plants are superb opportunists, making the most of different combinations of water, air, soil, and climate. Their grip on the planet, their capacities for colonization, and their integration with the environment are due to an astounding diversification and variety.

--Anthony Huxley

Naturalization - The designation of "no-mow" zones within an existing basin or the planting of native trees, shrubs, and grasses in the basin. No structural adjustments have been made to the basin. These projects work to filter out pollutants in stormwater and create wildlife habitat. However, they do not significantly reduce the impacts of stormwater volume.

Naturalization of a detention basin and the installation of an infiltration trench (see area of stone).

Infiltration Trench - A trench constructed within a basin to provide a porous substrate promoting faster infiltration of stormwater. They often consist of large areas of rock, gravel or cobble with an underlying layer of sand.

Outflow Structure/Weir - A simple structure affecting the amount of discharge allowed to flow out of the outfall. This is done with the installation of a weir or similar structure near the culvert or discharge pipe.

Berm - The creation of a series of meanders or "micro-typography," in a basin through which stormwater must flow, thereby promoting infiltration.

Presence of Water in Basin

If possible, determine approximately how long the stormwater basin holds runoff after a substantial rain. The township or design engineer should be able to assist you. Increased holding time allows for pollutants and sediment to settle to the bottom of the basin, while the cleaner water remains on the surface, entering the stream through the outflow structure. If you are not able to monitor the basin during or shortly after a rain event, look for signs that water was present in the basin recently. Accumulated sediment on the basin bottom or sediment adhering to the vegetation is a good indication that water had in fact, entered the basin during a rain event. Water stains on concrete structures may also be visible.

He that plants trees loves others beside himself.

--Thomas Fuller

Substrate Size Categories

- **Silt/Clay/Mud:** *sticky, cohesive feeling, sediments that ooze*
- **Sand:** *tiny gritty particles, smaller than gravel but courser than silt;*
- **Gravel:** *pea- to tennis ball-sized material;*
- **Cobble:** *tennis ball- to basketball-sized material;*
- **Boulder:** *material larger than a basketball but smaller than car;*
- **Bedrock:** *material larger than a car.*

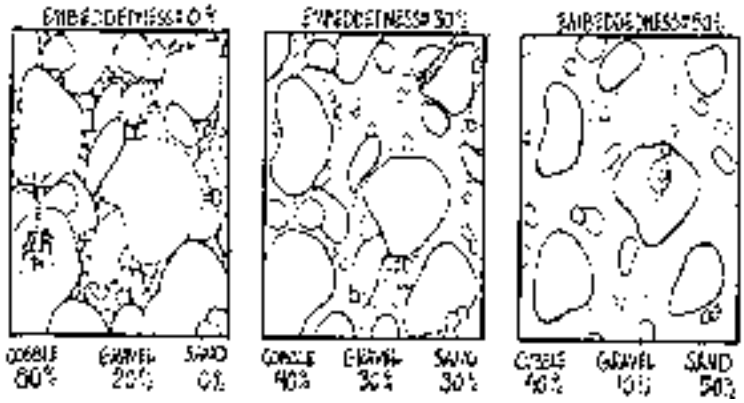
Tip: You may want to photocopy your site diagram and use it as a template from year to year to note changes.

Presence of Sediment in Basin

Monitor the basin floor and outlet structure to see if sediment is accumulating within the basin. If too much sediment has accumulated, it is likely that the basin is no longer functioning as intended and needs to have the excess sediment removed.

Receiving Stream Characteristics

If the receiving stream is near the basin, investigate the stream conditions around the outfall structure. Do high discharge volumes appear to be eroding away the streambank? If riffles are present along the stream, choose an upstream and downstream riffle and compare the dominant and sub-dominant substrate types for each. Fine sediment in stream riffles smothers the macroinvertebrates living there and is an indication that erosion is occurring somewhere upstream. Near a basin, this could indicate that the basin is not adequately filtering out the sediment before it discharges into the stream. Also determine the relative ease of dislodging cobble-sized rocks from each of the riffles. This measurement, ranging from "Loose" to "Difficult To Dislodge" is listed as "riffle consolidation" on the RPS.



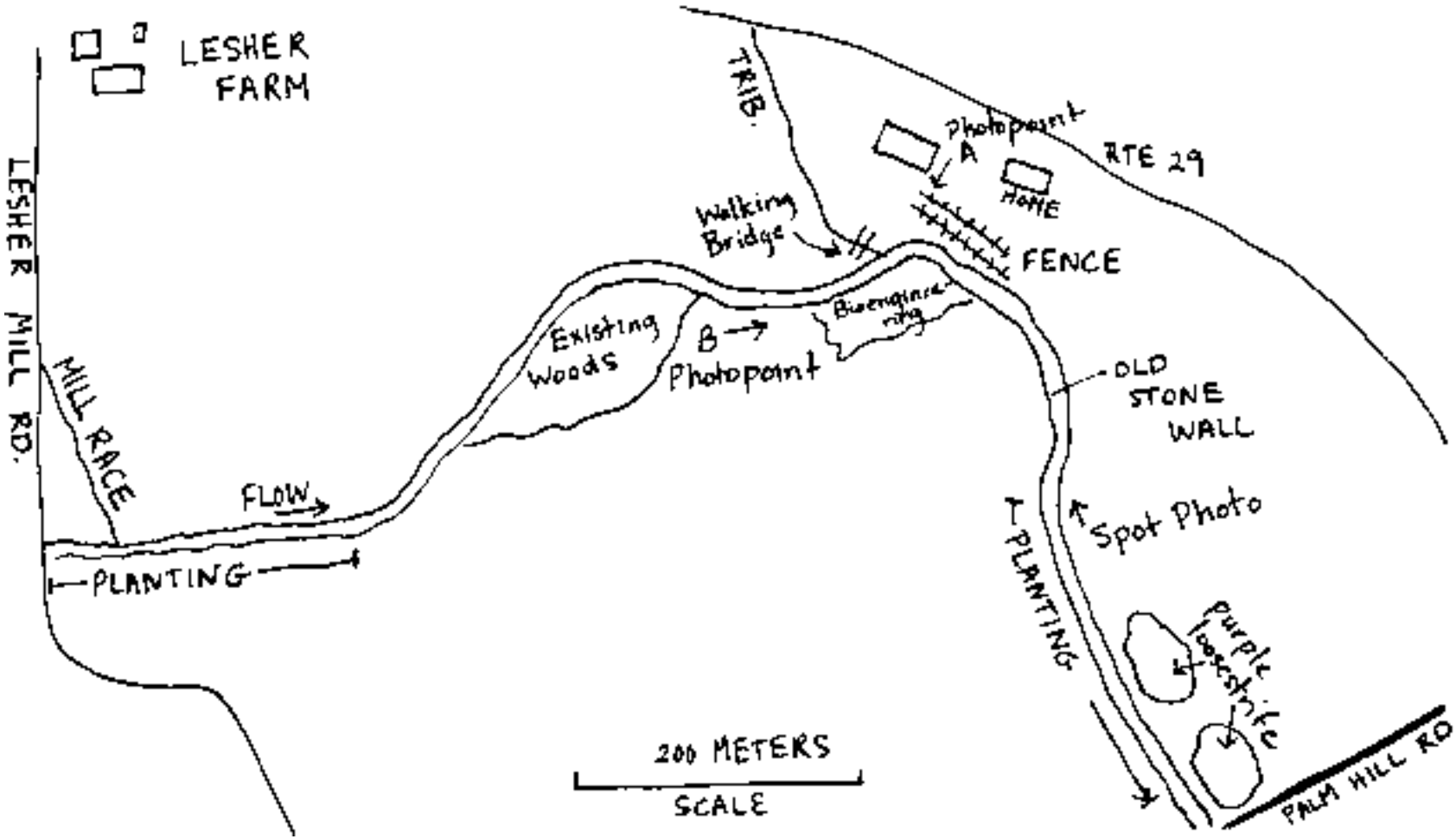
The greater the sand, silt, and mud, the poorer the fish spawning and macroinvertebrate habitat.

Source: The Streamkeeper's Field Guide

Diagram Or Drawing Of Site

A site diagram is helpful for recording and directing follow up work. If a detailed site plan has been completed (lucky you!), use this to record your additional observations and the location of your photo points. Otherwise, draw a sketch of the site. The RPS includes a full page for you to express your artistic abilities, so please use it. Be sure to include important information such as the general contour of the project area, stream location, stream flow direction, photo point locations and their orientation, cross section locations, planting locations, coir log and/or and matting sections, problem areas, major invasive plant infestations, and other landmarks. Be sure to include an approximate scale. An example of a site diagram is shown on the following page.

Example of a site diagram ***(compliments of Eugene Marks, Volunteer Project Steward)***



Photography Tips

✓ *Record your exposure information!* Don't rely on your memory; record photo information on the data sheet after each shot. The RPS has a full page dedicated to recording your photo information so please use it. You may want to **use a photo sign, a picture of a sign marked with the location, subject, date and time that is taken just prior to the intended photo.** With a digital camera, the **photo sign** can be deleted after proper records have been made.

✓ *Maintain a level (horizontal) camera angle,* unless the terrain is sloped.

✓ *Watch the weather.* Especially overcast days are not good for taking pictures. Mornings and late afternoons are best, when sunlight does not drown out the photo subjects and contrast is maximized. Medium and long view photos are best shot with the sun at the photographer's back.

✓ *"Data is in the eye of the beholder."* You may feel as though your photos convey little information. On the contrary, DRN staff are often clued into other aspects of the site that you may not be aware of such as hydrology, the appearance of new invasive species, and other changes to the site. So, click away! We can never have too many photos for your project!

Photo Monitoring Survey

Photo Monitoring provides a visual record of a restoration site from year to year and is a crucial component of the RPS. Photos taken are used as a qualitative record of a site's condition. The two types used in photo monitoring are **photo points** and **spot photos.**

Photo points are photographs taken from a specific location and angle each year. These photos must be taken from the exact same location and angle and under similar conditions from year to year so that any changes in the project are evident. In many cases, some photo points may already have been established for your site and are included in the Project Folder. Continue to document the project using established photo points, but also feel free to establish new photo points where you feel they are needed. **A spot photo documents a particular occurrence in the restoration area**, such as damage to a tree, erosion caused by a storm, the appearance of invasive plants, destruction due to mowing or vandalism, or other occurrences that catch the monitor's eye.

Record photo information in the field. Include photo exposure, zoom extent, picture quality, direction of photograph, shutter speed, etc., on your **Photo Monitoring Datasheet**. Label the back of the photographs with this information as well. Indicate location and orientation of photo points on your site diagram for future reference.

When Establishing A New Photo Point:

✓ **Include landscape features or "focal points"** that are unlikely to change and that can serve as a reference point in future years. These may include buildings, other structures, or natural features such as rock outcrops, large trees or peaks.

✓ **Include the planted/restored area in the frame.**

✓ **Take a picture of the photo point** for further documentation (see picture at right).

✓ **Mark the location and orientation of your photo point on your site diagram.**

When Matching A Previous Year's Photo Point:

✓ **Use the site diagram, which is part of your RPS project folder, as a guide.** The location of the photo point and the orientation of the photo should be indicated on your site diagram.

✓ **Use "focal points" from previous photos.** These are the unchanging features of the landscape that you can use to position yourself correctly. **Follow instructions on existing photos.** If there is a picture of the photo point, this should help.

Photo point depicting site before implementation of the restoration project. Note footbridge and pavilion in background.

Photo point depicting site after implementation of restoration project that included re-grading and the installation of coir matting and rock vanes. Note footbridge and pavilion in background.

Tip: If your restoration project is nearby, drop by frequently to take photos of your established photo points. The more photos we have at different times of the year the better.

A woodland in full color is awesome as a forest fire, in magnitude at least; but a single tree is like a dancing tongue of flame to warm the heart.

--Hal Borland

Spot photo of *Trillium* sp.
Photos can be used to later identify unknown plant species. Remember if you don't know a plant, no worries, take a picture or specimen so you can identify it later at home or ask DRN or the Morris Arboretum to help with identification.

When taking a spot photo:

✓ **Convey the scale of the image** by including a ruler, person, automobile, or other object. Cardboard arrows can be used to highlight specific points in the photo.

✓ **Minimize shadows by taking close view photographs from the north (facing south).**

✓ **Give detailed information about the photo:** record time and date of photo, what the photo is meant to highlight, and where it was taken. Draw a small map on the back of the photo and also mark where the photo was taken on your site diagram.

Unseen buds, infinite, hidden well,
Under the snow and ice, under the darkness, in every square or cubic inch,
Germinal, exquisite, in delicate lace, microscopic, unborn,
Like babes in wombs, latent, folded, compact, sleeping;
Billions of billions, and trillions of trillions of them waiting,
Urging slowly, surely forward, forming endless,
And waiting ever more, forever more behind.

--Walt Whitman

RPS Scoring

This section is designed to develop an overall score for your project site. There are six elements you will assess and each element will be ranked with a score from 1 to 10. Low scores indicate poor conditions while higher scores indicate ideal conditions. Record the score that best fits the observations you make based on the narrative descriptions that are provided on your datasheet. Do not score elements that are not applicable to your site. Be sure to refer to the baseline RPS that was done for your site shortly after the project was completed. Use the **Comments** section to provide additional information about each indicator to help us better understand the conditions you scored.

Restoration Buffer Width - Larger buffers produce greater benefits for both wildlife and water quality. Estimate the width of the planted buffer project in feet. The RPS allows you to assess each bank separately if plantings are present on both sides of the stream. **Note only the area of the buffer planted as part of your project. If additional buffer already exists beyond the planted area, note this in the Comments section but do not consider when scoring your site.**

Planted vegetation extends >75 feet from the active channel	Planted vegetation extends 50 feet from the active channel	Planted vegetation extends 35 feet from the active channel	Planted vegetation extends 15 feet from the active channel	Planted vegetation extends less than 1 foot from the active channel
10	7	5	3	1

As trees mature and canopies widen, the buffer will ultimately broaden as well. Even if there are no trees planted at the site, remember that tall meadow grasses and wildflowers also function as healthy buffers. You may notice that mowing has decreased buffer width or quality. Grasses and wildflowers should not be mowed, particularly after trees and shrubs have become established (normally within 2 to 3 years). A plant community, consisting of trees surrounded by tall native herbaceous grasses and wildflowers, generally supports good buffer function.

Note your observations on buffer width in the Comments section. Note in your Maintenance Recommendations the possibility of expanding the buffer by expanding the "no-mow" zone. Few projects will have a pre-existing buffer of native trees, shrubs, or meadow grasses, which is why a buffer was established in the first place.

Trees and Shrubs - This element focuses on the status of planted trees and shrubs in the project area and the distribution of these trees and shrubs throughout the project area. **If the project was designed to be a meadow and not a forested buffer, do not rate this indicator.**

These six categories are for evaluation of the restoration project area only. That is, areas where plantings and any bioengineering activities have been carried out. Do not include surrounding land use and conditions.

RPS Scoring Tips

- ✓ **Two educated opinions are better than one. We encourage you to pair up with another trained steward to perform the assessment.**
- ✓ **You can assign scores between categories. For example, if a buffer is 60 feet wide, you can give the buffer a score of 8.**
- ✓ **This scoring system is semi-quantitative in nature. It requires that you distinguish significant differences. For example, do not sweat over assigning a score of 8 or 9.**

Careless mowing will kill trees and shrubs. If mowing is evident check the base of trees and shrubs for damage. In most cases, buffers should not be mowed.

>90% of the project area has trees and shrubs that are healthy and growing	~70% of the project area has trees and shrubs that are healthy and growing	~50% of the project area has trees and shrubs that are healthy and growing	~30% of the project area has trees and shrubs that are healthy and growing	<10% of the project area has trees and shrubs that are healthy and growing
10	7	5	3	1

Healthy trees and shrubs should have signs of growth, including green leaves, buds, flowers or fruits, depending on the time of year. Be sure to note any impacts that may be affecting plant survival such as mowing, herbivory and disease. If your project site has a site map, refer to it to note where trees and shrubs were planted originally. If you notice gaps where trees and shrubs are absent, this could indicate damage by mowing, trampling, or mortality. In most cases, if a buffer project was planted, the plantings will be somewhat contiguous. As a rule of thumb, trees and shrubs are usually spaced anywhere from 6 to 20 feet apart while herbaceous plants are typically spaced from 1 to 3 feet apart. In some cases, an access area may have been left unplanted in order to decrease trampling, but these access points should be marked on your project's site map.

When you notice specific mortality and other impacts, take spot photos to document the damage. Also, if mowing is performed at the site, be sure to take a look at the base of the trees and shrubs to see if they have suffered mower or weed whip damage. Trees can recover from this damage if girdling did not occur, but careless mowing practices will kill trees. Note impacts to trees and shrubs in the Comments section and contact the project partner or maintenance crew immediately if mower damage is evident to encourage the installation of "no mow" signs. Herbivory, trampling, flood and ice damage, disease, and dieback are all other impacts that you should consider for this category and note in the Comments section. **You may notice that volunteer native trees and shrubs have colonized the project area on their own. Count these native volunteers in your score as they help create a natural buffer for the stream.** Note volunteer species in the Comments section if known.

Herbaceous Vegetation - This element scores the status of grasses, herbs, wildflowers, and wetland plants planted at the project site. Ideally, herbaceous vegetation will be greater than six inches in height and not impacted by mowing.

>90% of herbaceous vegetation is green and healthy with a height of at least six inches	~70% of herbaceous vegetation is green and healthy with a height of at least six inches	~50% of herbaceous vegetation is green and healthy with a height of at least six inches	~30% of herbaceous vegetation is green and healthy with a height of at least six inches	<10% of herbaceous vegetation is green and healthy with a height of at least six inches
10	7	5	3	1

If there are areas of bare soil, note this in the Comments section and list re-seeding as a possible maintenance option. **You may notice that volunteer native grasses, herbs, wild-flowers, and wetland plants have colonized the project area on their own. Count these native volunteers in your score as they help create a natural buffer for the stream.** Note volunteer species, if known, in the Comments section. If mowing is impacting vegetation, contact the project partners immediately and encourage the installation of "no-mow" signs.

Biodiversity - This element looks at the number of different species present at the project site. Count the number of different native plant species found in the project area. **Be sure to include only native trees, shrubs and herbaceous plants. Do <u>not</u> include invasive species in this count**.

Improved biodiversity means a healthier buffer with higher wildlife values.

There are at least 16 different native plant species growing in the project area	There are at least 12 different native plant species growing in the project area	There are at least 8 different native plant species growing in the project area	There are at least 4 different native plant species growing in the project area	There is only one native plant species growing in the project area
10	7	5	3	1

You will likely notice that volunteer plants have established themselves in the project area. This is ideal as long as they are not invasive species. Include native volunteers in your count. If you can identify the different species, list them in the Comments section. Otherwise, simply count the different types of species you see at the project site.

Exotic Invasive Vegetation - Determine the extent of exotic invasive species present in the project area. First, look in your Project Folder to determine if any invasive plants were noted in the area in the past. If they were present in the past, they are likely still present to some extent.

No invasives present in the project area or general vicinity around project area	~25% of project area has invasive species present and competing with planted vegetation	~50% of project area has invasive species present and competing with planted vegetation	~75% of project area has invasive species present and competing with planted vegetation	Invasive species dominate the project area – few natives unaffected by invasives
10	7	5	3	1

In the Comments section, note the degree of infestation and plant distribution. Draw invasive plant locations on your diagram to help with future maintenance efforts. If you are unfamiliar with invasive plants, be sure to take *Plant Invaders of Mid-Atlantic Natural Areas* with you as well as re-sealable plastic bags to preserve a suspected invasive plant for later identification. Take pictures of the plant (preferably against a white background) to help with identification. Early detection is the key to controlling invasive plants so becoming familiar with common invasive species is a big help.

Bioengineering Techniques - This element is applicable only to projects that involved re-grading and re-vegetating of stream banks. If bioengineering techniques were employed at your project site, they will be listed in your Project Folder.

This element focuses on how well bioengineering techniques are holding up over time and how plant establishment is progressing. Bioengineering techniques are designed to degrade over time as the planted native vegetation takes root and grows to hold the banks in place.

>90% of all bioengineering materials intact and functioning; plants well-established	~70% of bioengineering materials intact; minor patches of erosion; majority of plants established	~50% of bioengineering materials intact; erosion common and compromising planted vegetation	~30% of bioengineering materials intact; high erosion areas with few surviving plants	<10% of bioengineering materials intact; bare soil, gullies and erosion dominate area
10	7	5	3	1

Look at your site to determine if bare soil and erosion are dominating the project area and causing sediment pollution during times of rain. If no vegetation is present within the bioengineering structures, it is likely that erosion will worsen as the materials degrade. Check to make sure that materials are pinned down securely. Note if coir logs are missing from the toe of the bank, leaving only the crisscrossed stakes that once pinned these structures into the toe of the bank. Record any other observations in the Comments section.

Overall Score Calculation

Total the scores for each applicable element then divide that number by the total number of categories scored. This is your Overall Score for the site. Circle the Poor, Fair, Good, or Excellent rating calculated for your project site.

Total Points		**< 4.0 = Poor**
Number of Categories Scored		**4.1 - 6.0 = Fair**
OVERALL SCORE (Divide Total Points by Number of Categories Scored)		**6.1 - 8.9 = Good** **> 9.0 = Excellent**

Congratulations! You did it.

Double check that your RPS is complete. Attach labeled photos. Keep your original completed RPS for future reference, but do **send a copy of your datasheet and photos to DRN.**

IF YOU OBSERVE ANY URGENT PROBLEMS AT YOUR SITE THAT NEED IMMEDIATE ATTENTION, CALL DRN AND/OR OTHER PROJECT PARTNERS IMMEDIATELY.

Maintenance Recommendations

As you are completing the RPS, note any maintenance recommendations that would benefit the site. If you are willing to lead maintenance efforts at your site, let DRN know and we will provide you with support and advice. You may also refer to the Restoration Project Maintenance section of this Toolkit for help with maintenance concerns. If you perform maintenance, be sure to document what you have done on the Maintenance Log (see page 110) and send a copy to DRN for our records.

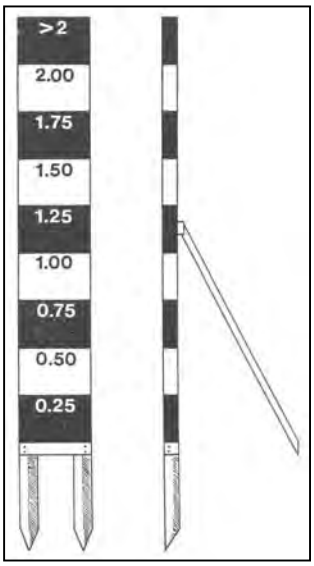
Level 2 Monitoring Techniques

Level 2 Monitoring Techniques

When is it appropriate to include Level 2 Protocols? When more information is needed to determine how well a project is achieving its goals, consider adding Level 2 monitoring techniques. There are four Level 2 monitoring techniques. You may choose to add one, two or all four to your monitoring program. **Remember, all Level 1 Protocols are required.** Level 2 Protocols are optional additions that build on the information you gather through Level 1 monitoring.

Photo Monitoring Survey Using A Profile Board

Level 2 Photo Monitoring utilizes a mix of both a quantitative and a qualitative approach to visual monitoring, using a **vegetation profile board** (see diagram at right). The vegetation profile board is a narrow board erected within the site. Two people, an observer and a person to hold the board, are required to perform this survey. The observer stands away from the board and estimates how much of the board is obscured by vegetation.



Source: Estimating Wildlife Habitat Variables.

The vegetation profile board can be used in a variety of ways. How you set up your profile board plots should be site-specific and depend on what you want to illustrate and how much detail you require. Suggestions for using the profile board follow:

- ✓ You may choose a location based on a specific portion of vegetation to illustrate a specific issue or area. For example, a large invasive shrub may have been removed and you wish to determine how well the area is recovering over time.
- ✓ You may want to illustrate the overall growth of the project area and show progression of different planted layers over time by setting up a photo point using the profile board.
- ✓ You may want to illustrate and compare the coverage of different plant types based on their structure. For example, herbaceous areas will only cover lower sections of the profile board while shrubs will likely have a greater coverage throughout the board due to their structure.

There are two possible approaches for viewing a profile board: fixed distance plots and variable distance plots. With the **fixed distance plot**, the observer steps back from the profile board a prescribed distance and views the board at different highlighted heights, usually every 0.25 meters. We recommend a distance of about 15 meters, or 50 feet. At this distance, the observer

Constructing a Vegetation Profile Board:
Make your own profile board using plywood, three wooden stakes, nails, and black and white paint. We recommend making a board 2 meters high and 0.3 meters wide. Paint black and white bands at 0.25-meter intervals. If you have someone to help you with monitoring, you will not need to attach a support stake.

When I discovered a new plant, I sat down beside it for a minute or a day, to make its acquaintance and hear what it had to tell . . . I asked the boulders I met, whence they came and whither they were going.

--John Muir

estimates and records the amount of the targeted height that is obscured by vegetation in their site line for each height marked on the profile board. DRN recommends this approach and **the Level 2 Photo Monitoring Datasheet allows you to establish up to two locations where this fixed distance approach is used.**

The second approach is the **variable distance plot.** For this method, the observer stands at a fixed point while another crewmember moves the profile board away from the observer. As the observer focuses on a single sample height, the profile board is moved farther away until 50% of the target height is obscured. The distance at this point is measured and recorded. This method may be more difficult at a restoration project due to tall grasses and plants that may make moving the board cumbersome.

Using the Profile Board to Enhance Photo Points

DRN also recommends using the profile board to enhance photo points. First, set the board up at a fixed location. The observer stands at a fixed location and takes a picture of the overall project with the board in place. Be sure to record information for each photo point so you can return to the same positions in the future. There are no calculations for this method but rather a visual documentation of changes of the project over time. Be sure that you choose at least one photo point that illustrates the average of the site. Avoid heavy clumps of shrubs if the rest of the site is sparsely vegetated. As the plants continue to grow and fill out over time, you should see less of the board in your photo points, as long as different layers of the project are developing. **The Level 2 Photo Monitoring Datasheet allows room for you to establish three different photo points.**

Again, your choices for using the profile board will be dependent on your site so feel free to use it other ways not mentioned above. Be sure to document the placement of the board and observer on the datasheet in order to replicate the plots from year to year. Photographs of the fixed distance plots will provide future reference.

Cross Section And Bank Pin Monitoring

Natural streams are rarely unchanging. Unless geologically constrained by bedrock and other hard material, most streams move in response to upstream land use changes. A watershed that is originally forested, then logged, then farmed, and finally urbanized will respond accordingly. Local, regional or global climate changes also leave their mark on our waterways.

Lateral, or side-to-side, meandering is the most noticeable change. This occurs as streams erode the outside bend of curves and deposit material on the inside bend, opposite the erosion. Over long periods of time, a stream moves back and forth "snakelike" across its floodplain and valley and meanders move downstream as if the stream was a giant whip being cracked. Cross section changes are caused by changes in the amount of water and sediment a stream carries. An increase in the volume of water carried results in erosion of a stream's bed and banks, thereby increasing the size of the stream channel. An increase in the volume of sediment carried results in deposition along the stream's bed and banks and the formation of sand bars, decreasing the size of the stream channel.

Streams are complex and change is to be expected. Determining the changes that shouldn't be happening is key. Monitoring the fluctuations in a channel cross section over time is one way of doing this. Surveys of stream cross-sections answer three fundamental questions:

- Is the cross sectional area increasing or decreasing?
- Is the streambed's elevation increasing or decreasing?
- Is the width to depth ratio increasing or decreasing?

An increase in cross sectional area might reflect an increase in the volume of stormwater runoff a stream is receiving. A decrease might reflect re-forestation as agricultural land leaves production. An increase in a stream's bed elevation is likely due to the stream being filled with sediment transported from eroded areas upstream. If the elevation is decreasing, an increased flow of water is eroding the stream's bed. An increase in the width to depth ratio suggests either increased sedimentation of the streambed or increased erosion of streambanks. A decrease in the width to depth ratio suggests either that the streambed is incising (i.e., cutting downward) or that material is being deposited along streambanks.

You should monitor cross section if your restoration project was designed to change the profile of the stream or if erosion was a concern before project implementation. For example, if a log deflector was implemented at your project to help change the stream course, you may want to monitor a cross section to document any changes made by that deflector. Cross sections are most valuable when done before and after a streambank re-grading project to document changes that occur after restoration implementation.

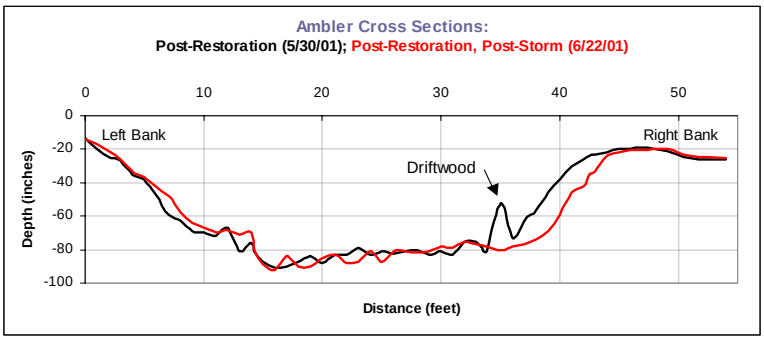
Monitor cross sections if your restoration project was designed to change the profile of the stream or if erosion was a concern before project implementation.

A river is more than an amenity…it is a treasure. It offers a necessity of life that must be rationed among those who have power over it.

--Oliver Wendell Holmes, Jr.

Monitoring a cross section involves setting up a level line or measuring tape across the stream and taking depth measurements from this level tape to the ground surface and stream bottom as well as a measurement from the level tape to the surface of the water. The result, when graphed, is a visual diagram of the profile of banks and the stream channel.

From June 16th to June 17th, 2001, less than one month after the completion of a restoration project in Ambler, Pennsylvania, over 5 inches of rain fell on the region. This graph below and pictures that follow illustrate fluctuations in a stream cross section that resulted from storm flows during this rain event.



Cross section at a project site illustrating bank erosion after a storm event.

DRN restoration project in Ambler, PA

When to Measure Cross-Sections

Plot a cross section profile at least once a year. It can coincide with other monitoring, but will generally be easier in the spring before leaf-out and in the fall after the first frost. Although it is also important to measure cross sections after major floods, **never measure a section alone and never when the stream is at bankfull or when currents pose a hazard to personnel.**

Field Crew

Measuring a cross section works best with two or three people. A minimum of two people is required for safety reasons. **Watch your footing and use caution around undercut banks, deep pools, and submerged logs.**

Cross Section Location

Cross sections are, by definition, perpendicular to stream flow. Where you set up cross sections depends on what you are trying to measure. To monitor a bank stabilization structure or its effects on the stream channel, set up cross sections immediately above the structure, at the structure itself, and below the structure where there are likely to be failures and changes. Monitor trouble spots: locations along the stream with active erosion, unstable banks, gullying along slopes, and impacts caused by compaction. Or monitor for impacts downstream from new stormwater discharges or recent development. Contact DRN for help establishing locations for cross sections. In many cases, if needed, cross section points will already be established for your site. Refer to your Project Folder for information.

Cross Section Start and End Points

Establishing permanent cross section end points, such as trees or stakes, saves time in the long run, but requires advance planning. These points must be far enough from streambanks (10 or 20 yards) so that they will not be damaged by floods.

A simple, low-cost method uses cup hooks screwed into trees or on the side of a wooden stake. This method makes it easier to establish a level line for future monitoring. First, select a tree or place a stake in the floodplain. Start at a height that will be convenient for measurement in the stream and screw in the cup hook. Balance a carpenter's level on top of the cup hook and sight across the stream, perpendicular to its flow, to get an approximate idea of a convenient and level end point on the other side of the stream. Have a helper mark the end point while you mark the starting point. Use a line level and string to make final adjustments as necessary. Stretch a string between the cup hooks, place one or two line levels on the string in the center of the section, and adjust the end cup hook until the string is level. Record the distance to the ground surface at the starting and end points so that the line can be re-leveled more easily for future monitoring. Also take photos of the start and end points. Record descriptive information about these locations on your datasheet.

Equipment Required For Level 2 Cross Section Survey

Clipboard with Rain Cover
Cross Section & Bank Pin Monitoring Datasheet
Restoration Project Folder
Pencils and Eraser
Stakes, Cup Hooks, Flagging
Surveying Rod or Tape Measure (Marked in Tenths of Feet)
Hand Level,
2 or 3 Line Levels
String, Mason's Twine
Reel Tape Measure
Waders or Hip Boots
Camera
Extra Batteries
Film/Memory Sticks

Tips for Locating Start and End Points

- Set up a permanent "monument". Stakes can also be used, but could be subject to vandalism in public areas. A painted iron pin flush with the ground surface may be the best method to mark cross section end points. Be sure to map the location of the pin with respect to fixed points. When you go out to collect measurements, simply place a temporary stake next to the iron pin.
- Find two permanent landmarks in the distance (a water tower and a tall building, for example). Take a compass bearing on both. The starting spot will always be found where these bearings intersect. This is good information to have, just as a backup, even if another method is chosen.
- Use a GPS unit, if one is available and reasonably accurate, to determine coordinates.

Avoid climbing up and down streambanks in the vicinity of the cross section except when actually surveying to prevent changes caused by the surveyor.

Measuring the Cross-Section

Once permanent end points have been established and are approximately level, measure the horizontal distance. DRN recommends using string marked in tenths of feet or a metric tape. **The string or tape should be as level as possible.** You can use a string level (available at your local hardware store for under $2.00). Attach the 0-point of the string to the start point of the cross section. Extend the string across the stream, stretch it taut, check to make sure the string is level, and attach it to the end point. Complete the diagram on your datasheet drawing the end points, stream banks, and channel. The section should be oriented so that it is approximately perpen-dicular to the stream flow, but note that flow direction may change at different flow rates or over time due to obstructions or other changes in stream channel. If it is not perpendicular at the time of survey, make a note of it on the diagram.

Measure the Vertical Distance

Surveying equipment ranges from cheap tools available at a hardware store to high tech laser surveying equipment that costs thousands of dollars. This survey method requires two pieces of equipment: a **surveying rod** and a **hand level.** A **surveying rod** is a 6-foot stick, marked in tenths of feet. If you purchase a surveying rod that has more tick marks than needed, match the background color and point out the lines that won't be used. This makes reading the surveying rod with a hand level much easier. You can purchase an inexpensive surveying rod or choose to make your own surveying rod instead. A **hand level** is a tube or small telescope that you look through. The hand level contains an internal bubble. When the bubble is centered on the line in the center of the tube, the tube is level and a reading can be taken. The hand level can be attached to the surveying rod (easily done with tape or screws), but make sure it is level. Hand levels costing approximately $15.00 can be purchased at a hardware store.

Be sure to record the direction of the survey, i.e., the bank where the survey begins: left bank or right bank looking downstream.

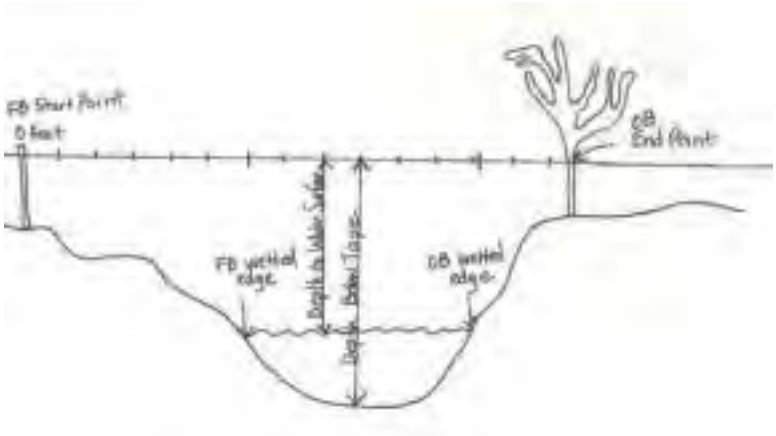
Taking Measurements

One person holds the surveying rod while another checks the hand-level and references the string levels to make sure that the rod is vertical and that the tape remains level. The rod person is responsible for reading the horizontal distance from the tape. The hand level operator reads the measurements from the rod and usually is responsible for data-recording and directing rod placement. When a third person is present, he or she can ensure that the tape remains level and help with data recording.

Beginning at 0 feet, your start point, and using the surveying rod, the rod person reads the horizontal distance and the hand-level person reads the vertical distance from the top of the tape to the ground. Your first few readings will only include two measurements (horizontal distance from the 0 point) and vertical distance (the distance from the tape to the ground).

When the team reaches the wetted edge, be sure to record the exact horizontal distance along the section. While in the stream, you will take three measurements at every location: 1) the horizontal distance from the start point, or 0 measurement; 2) the distance from the tape to the stream bottom; and 3) the distance from the tape to the water surface. When in the water, make sure to stand downstream of the surveying rod so you don't influence the top of water surface measurement. Continue recording these three measurements until after you reach the opposite bank's wetted edge. After recording the horizontal and vertical distances for the wetted edge, continue measuring the horizontal distance from the 0 point and the distance from the tape to the ground until you reach the end point. The data recorder should check for data completeness and make sure all numbers are legible.

Be sure to catch all the changes in slope. These changes yield valuable clues as to the bankfull flow and other stream characteristics. Generally, measurements should be taken at one-foot intervals, although measurements should also be taken to portray abrupt changes in slope, bioengineering structures, boulders, logs, and the location of the wetted edges of the stream. Make note of these structures and changes on your datasheet. The data recorder should complete comments and sketch any logs, gravel bars, and other materials that are encountered along the section. Notes are very important for graphing and interpreting data so use the Comments section of the datasheet when needed.



Cross Section Illustration.

Graphing the Data

After all measurements have been taken, it is time to plot the data. You can choose to plot your data by hand with graph paper or let a computer do it. In addition to spreadsheet software, programs are available for plotting and computing cross sectional information with a computer. The Ohio Department of Natural Resources' website offers one: http://www.ohiodnr.com/soilandwater/streammorphology.htm.

A river seems a magic thing. A magic, moving, living part of the very earth itself—for it is from the soil, both from its depth and from its surface, that a river has its beginning.

--Laura Gilpin

For real company and friendship, there is nothing outside of the animal kingdom that is comparable to a river.

--Henry Van Dyke

Determine a scale that makes sense for your measurements. Plot the horizontal distance from the start (0 measurement) to the end point across the *X*-axis and the distance from the tape to the stream bottom and distance from the tape to the water surface on the *Y*-axis (see plot on page 32 for example). Use two different colors to plot the points on the *Y*-axis to prevent confusion. Then connect the points.

Augmenting Survey Data With Bank Pins

In addition to stream cross sections, you may also want to incorporate bank pin monitoring into your site assessment. When cross section surveys suggest that a stream channel is rapidly eroding or enlarging, bank pins can be employed to answer the question, "How fast?" By placing marked rebar into the side of the bank, you can document erosion that may occur over time as the rebar becomes exposed.

We recommend using 3-foot rebar. Spray paint increments in alternating colors in tenths of feet along the length of the rebar. Drive the rebar into the stream bank with a sledgehammer where you want to document erosion levels. Multiple pins can be placed into the bank to assess several locations.

Bank Pin Placement.

Drive the rebar into the bank until only an inch or two remains visible. Flag bank pins with survey tape and record information about their placement on the **Cross Section & Bank Pin Monitoring Datasheet.** Pictures will also be helpful to locate the pin in the future.

Since the goal is to determine an erosion rate, it is better if bank pins are checked more frequently than the cross section surveys, especially after high flow events. The changing amount of exposed pin is a measure of bank erosion. Monitors should also verify visually that the bank pin exposure represents natural erosion and is not causing erosion.

Bank pins present some hazard to people climbing a stream bank and can be prone to vandalism. They should not be used where the general public is likely to come into contact with them. Reset the pins if too much of the pin becomes exposed.

Macroinvertebrate Survey

Aquatic insects, or macroinvertebrates, many with life spans of a year or longer, can be found in streams year round. Many aquatic insects spend much of their lives, their entire immature development, in water. Only a small fraction of their lives is spent as terrestrial adults.

These insects, which form the base of the aquatic food chain, are heavily dependent on vegetation within and surrounding the stream area. Macroinvertebrates living in streams that are substantially buffered by native vegetation benefit from abundant organic matter as well as improved water quality. Macroinvertebrates serve as excellent indicators of stream health because their populations are directly impacted by our management of streamside lands.

Aquatic insects can be divided into three groups based on their pollution tolerance:

- Group I organisms are sensitive to pollution and will quickly disappear if water quality is degraded. This group includes mayflies, stoneflies, both case-making and free-living caddisflies, Dobson flies (hellgrammites), and gilled snails.
- Group II organisms are able to tolerate moderate amounts of pollution. This group generally includes aquatic sowbugs, scuds, dragonflies, craneflies, and freshwater clams.
- Group III organisms are the most pollution tolerant and include aquatic earthworms, the true flies (e.g., midgeflies and blackflies), leaches, and lunged snails.

Because of their varied tolerances, aquatic insects are often used as indicators of stream health. For example, a continuous discharge of untreated sewage will initiate a change in the macroinvertebrate population downstream from the discharge. The most sensitive invertebrates will be eliminated. As these macroinvertebrates are eliminated and greater amounts of nutrients are introduced into the stream, the pollution-tolerant macroinvertebrates thrive and achieve greater population numbers. Their dominance, along with low numbers of different species present and high numbers of individuals, is an indicator of high nutrient content (organic pollution). However, continued untreated discharges will eventually eliminate virtually all of the macroinvertebrates. In cases of toxic pollution, there will be very few species of macroinvertebrates present and the number of individuals will be low. Heavy amounts of sediment eroded from upstream farmland and construction sites will also eliminate most macroinvertebrates by smothering the insects as well as their habitat.

Equipment Required For Level 2 Macro-invertebrate Survey

Fishing License and Sampling Permit
Toolkit
Restoration Project Folder
Clipboard
Macroinvertebrate Datasheet
Macroinvertebrate Identification Key
Pencils and Eraser
Waders or Boots
Kick Net and D-Frame Net (500 µM Mesh)
PVC Grid
White Plastic Basin
Paint Brushes
Plastic Petri Dishes or Ice Cube Trays
Magnifying Lens
Specimen Bottle with Alcohol
Extra Water Bottles
Thermometer

Caddisflies in "houses" made of leaf material.
Source: Stroud Water Research Center

You must have a sampling permit and a fishing license to survey macroinvertebrates.

Annual sampling permits are available from the Pennsylvania Fish and Boat Commission for $10. Fishing licenses are available on-line at: http://www.fish.state.pa.us.

Surber nets (~$240), kick nets (~$157), and D-Frame nets (~$63) are available from Ben Meadows Company. Order by phone at 800-241-6401 or on-line at benmeadows.com

Kick nets can also be purchased from Earthforce for approximately $47 but you will have to supply your own poles. Order by phone at 703-519-6877 or on-line at earthforce.org

A square-foot grid can be made with four PVC pipe lengths and four 90° PVC elbows. Be sure that when assembled, the sample area inside the grid is one square foot.

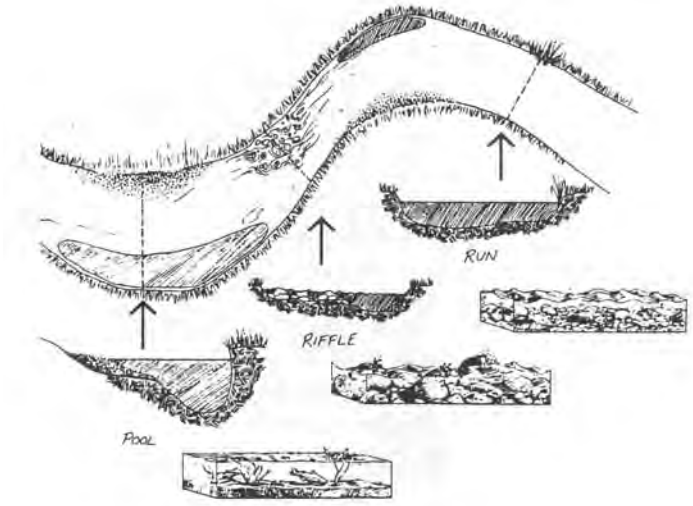
Completing the Macroinvertebrate Survey

Sampling Equipment

Sampling equipment used should have microfilament mesh openings of 500 microns. A Surber net is recommended for riffle sampling, but if one is not available, use a standard kick net with a homemade 1-foot square grid made out of PVC pipe. The grid mimics the sample size of the Surber net. A 1-foot diameter dip net or D-Frame net should be used to collect the course particulate organic matter (CPOM) sample. The mesh openings of the D-Frame net should be 500 microns.

Habitat Types Sampled

Indicate all habitats types sampled at each monitoring station.



Habitats of a Stream.
Source: Volunteer Stream Monitoring: A Methods Manual

Predominant Surrounding Land Use

Adjacent land use can have a great impact on the quality and state of the stream and riparian zone. **Surrounding land use is defined as that area one-quarter mile upstream and adjacent to the sampling area.** Rank as 1 the dominant land use. Rank as 2 the subdominant land use. Note also minor land uses in the area that may impact water quality. Pay attention to land use when traveling to and from the site or refer to a land use map.

Stream Shading

Estimate the extent to which the stream is overhung and shaded by trees, shrubs, and tall grasses adjacent to your sampling area.

Approximate Riparian Width

Choose the width that best describes the size of the natural riparian buffer for both sides of the stream surrounding your sampling area. Natural buffers include trees, shrubs, and un-mowed herbaceous plants. **Face downstream to determine left and right side of banks.**

Aquatic Vegetation

Note any aquatic vegetation or algae that is visible on rocks or in the water. Aquatic plants provide food and cover for organisms and can also indicate stream quality. Aquatic plants can be either rooted to the stream bottom or free-floating. Duckweeds are an example of free-floating aquatic plants while Coontail is rooted to the stream bottom. Abundant plants could indicate over-enrichment by nutrients. Aquatic plants can also indicate stream velocity conditions as plants cannot take root in fast-flowing streams.

Algae are simple plants that do not grow true roots, stems, or leaves. Algae (usually green or brown in color) are usually found growing on rocks, sticks, or other submerged materials, or floating on the surface of the water. There are two forms of freshwater algae: the branched form (green to grayish-green and course feeling like wet cotton), and the single filamentous form (slimy to the touch and green to brown in color). Large amounts of algae can indicate excessive nutrients in the water.

Stream Bottom Survey of Riffle Habitat

Please note: Substrate sampling must be performed AFTER you have finished macroinvertebrate sampling in order to prevent disturbance of the sample area.

The material on the bottom of a stream, or substrate, has a great deal of influence on the types of organisms present and is an important stream quality indicator. It can also be an indicator of human impacts. For example, in areas with a high housing density streams may be carrying a great deal of fine sediment that, as it settles out, smothers eggs and macroinvertebrates, damages fish gills, and buries habitat. The stream bottom survey has three steps:

- ✓ First, estimate the dominant and subdominant substrate in the riffle habitat that you sampled. Put a check in the appropriate boxes.
- ✓ Then, determine **Consolidation**, the degree of difficulty with which rocks in the riffle habitat you sampled can be dislodged. Do this by kicking some cobble-sized rocks. The greater the degree of difficulty, or consolidation, the poorer the macroinvertebrate habitat.
- ✓ Finally, check the types of habitats that are present within the sampling reach and restoration project area.

A root, a stem, a leaf, some means of capturing sunlight and air and making food—in sum, a plant. The green substance of this earth, the chlorophyll, is all summed up in the plants. Without them we perish, all of us who are flesh and blood.

--Hal Borland

Substrate Size Categories

- **Silt/Clay/Mud:** *sticky, cohesive feeling, sediments that ooze;*
- **Sand:** *tiny gritty particles, smaller than gravel but courser than silt;*
- **Gravel:** *pea- to tennis ball-sized material;*
- **Cobble:** *tennis ball- to basketball-sized material;*
- **Boulder:** *material larger than a basketball but smaller than car;*
- **Bedrock:** *material larger than a car.*

Sampling Procedures For Rocky Bottom Streams

Use consistent sampling techniques and keep accurate records when conducting macroinvertebrate surveys. DRN or project partners will help you determine the location and number of sites to be surveyed for your project. Each site should be surveyed at least once a year at the same time. **Excessive surveying can harm benthic, or bottom, environments so do not disturb your site more frequently than this.** Early spring is a good time to monitor macroinvertebrates as well as late fall and early winter when leaves are becoming food for macro-invertebrates.

When surveying more than one station in a stream, always start with the furthest downstream station and work upstream to avoid sample contamination caused by material you have dislodged. Two people are needed to conduct the survey, one person to hold the net and the other to work the streambed. **Go slowly and be careful - streambeds are slippery places!**

Identifying Habitat for Macroinvertebrate Sampling

Sampling areas should be within the area of the restoration project. For restoration project monitoring, you will be collecting macroinvertebrates from two riffles as well as CPOM within the area of the restoration project. Riffle areas are shallow areas of the stream where turbulent water flows over cobble-sized stones. CPOM habitat consists of submerged organic matter including: decaying leaf packs, submerged aquatic vegetation, log jams, or other vegetation present in and along the stream.

Some types of macroinvertebrates prefer living on stones in a riffle, while others are found primarily within CPOM. The majority of species can be found in both types of habitat. As plants at restoration projects grow and mature and as their leaf litter enters the stream, macroinvertebrates who feed on this leaf litter may become more abundant.

If CPOM areas are not present within the restoration project area, collect a third kick net sample in a run habitat. A run is an area of deep, fast water with little turbulence. Be sure to note the habitats sampled on the datasheet. Samples from the three areas will be combined in the field to yield a single composite sample that can be identified streamside. After identification, the macroinvertebrates should be returned to the stream unharmed.

Collecting Macroinvertebrates

Riffle Sampling - Benthic macroinvertebrates should be collected from two riffle areas within each study segment. **Be sure to sample the riffle most downstream first to avoid biasing your second riffle with dislodged sediment and organisms.**

The method described here uses a standard kick net in conjunction with a 1-foot square grid. Two team members, one kicker and one net holder, are needed to collect the riffle samples. Determine the riffle area to be sampled and approach the sampling area from downstream. The net holder should place the net just downstream of the sampling area at a 45º angle. This placement will allow the organisms that are disturbed to wash downstream and collect in the net. The bottom edge of the kick net should be weighted down with rocks to ensure close contact with the streambed. Be sure to clean rocks of macroinvertebrates prior to placing them along the bottom of the net. For each riffle sample, organisms should be collected only from within the 1-foot square grid. The area within this square-foot grid should be disturbed thoroughly by the kicker. The kicker can hold the grid in place with a foot or a third person can anchor the grid. Clean larger cobbles by hand using vigorous rubbing, followed by removal of the rock from the grid. After cleaning larger rocks, the sampling area should be disturbed to an approximate depth of 10 centimeters (cm), or four inches, using a side-to-side kicking motion to dislodge organisms from the substrate. You may also use your hands to stir up the bottom as long as protective heavy-duty gloves are worn.

When kicking is complete, remove the larger rocks anchoring the net. While the net holder holds the top of the net poles, the kicker grabs the bottom of the poles anchored in the substrate and carefully scoops up the bottom of the net. Transfer the contents on the net to a sample container using stream water to rinse the net. Inspect the net to make sure no organisms remain. Use tweezers or paintbrushes to brush any organisms clinging to the net into the sample container.

Kick Net Sampling.
Source: Volunteer Stream Monitoring: A Methods Manual

Rocks used to weigh down the kick net shall be taken from outside the square foot grid and should be cleaned of macroinvertebrates before being placed on the net.

Keep your sample container out of direct sunlight to minimize stress to macroinvertebrates due to heat.

CPOM Sampling - Macroinvertebrates should also be collected from appropriate CPOM areas within each stream segment using a D-Frame net. CPOM areas should be sampled by scraping and/or jabbing CPOM areas and collecting the dislodged material in the net. You can sample several CPOM areas along the project reach, but you must be consistent with the level of effort (e.g., area sampled, # of jabs, etc). **DRN's CPOM sampling requires the collector to perform 20 total jabs of CPOM.** A jab is defined as one sweeping or jabbing motion under or along CPOM. After jabs have been completed, the contents on the D- Frame net can be combined with the macroinvertebrates collected from the two riffles areas. This is called a composite sample.

CPOM Sampling with a D-Frame net.
Source: Volunteer Stream Monitoring: A Methods Manual

Laminated macro-invertebrates field key are available from The Isaak Walton League of America for $4.00. Call toll-free 1-800-BUG-IWLA or visit http://www.iwla.org.

Identifying Macroinvertebrates

Before you begin sorting macroinvertebrates by type, fill several small containers, such as ice cube trays or Petri dishes, with cold stream water. When you begin your sorting, you will be identifying macroinvertebrates primarily to Order level. However, in some cases such as with the caddisflies and true flies, you can identify organisms to Family level quite easily. The DRN datasheet breaks out organisms to Family level for these insects. Depending on the metrics you use, you can later lump families together if necessary.

Place like organisms in the same container for counting. Use the *Key to Macroinvertebrate Life in the River* (see Appendix B), developed by the University of Wisconsin-Extension Environmental Resources Center, or any keys you may find useful to identify the macroinvertebrates you collected. With a little practice, generalized identification of these indicator organisms can be made quickly and easily.

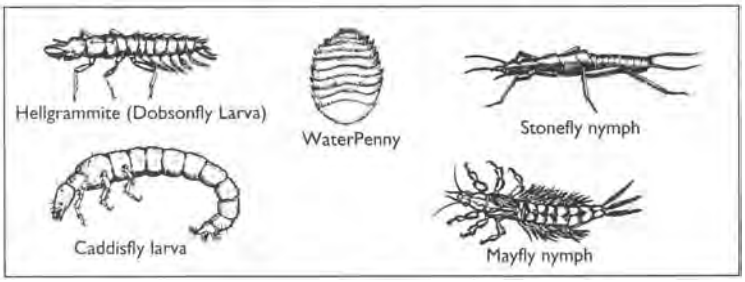
Count individuals periodically, recording the numbers of each type on the datasheet, and return them to a larger bucket with cold stream water or to the stream. Continue counting all the macroinvertebrates in the sample. If you reach 100 individuals of one type, you do not need to count the remaining individuals in that group. Record the number as 100^{+} on your datasheet. All macroinvertebrates should be counted streamside and returned unharmed back to the stream. Be sure to look closely and use a hand lens -- many small macroinvertebrates could easily go unnoticed.

Interpreting What You Find

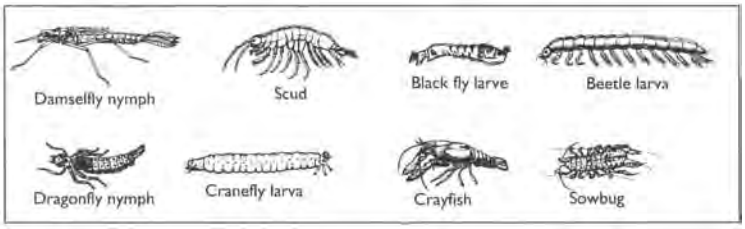
In healthy streams, representatives from Groups I, II and III are present. The occurrence of moderately tolerant or tolerant organisms does not necessarily mean that the stream is being degraded by pollution. It is only when one or both of these groups become dominant, and few or no pollution-sensitive macroinvertebrates are found, that stream pollution is indicated. As a rule, the greater the diversity, the better the water quality.

There are many metrics that can be used to interpret your results. DRN uses metrics developed by the Environmental Protection Agency and available in *Volunteer Stream Monitoring: A Methods Manual* (EPA 841-B-97-003). Another useful metric developed by the Virginia Save Our Streams Program is available on line at http://www.vasos.org.

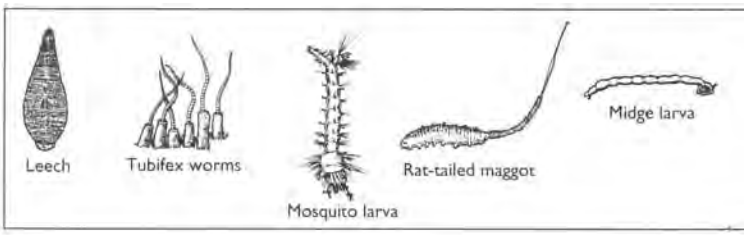
Group I organisms



Group II organisms



Group III organisms



And the world cannot be discovered by a journey of miles, no matter how long, but only by a spiritual journey, a journey of one inch, very arduous and humbling and joyful, by which we arrive at the ground at our feet, and learn to be at home.

--Wendell Berry

Equipment Required For Level 2 Wildlife Survey

Clipboard with rain cover
Binoculars
Level 2. Wildlife Datasheet
Pencils
Headlamp (for night surveys)
Various wildlife field guides

Wildlife Survey

Restoration projects are often designed to incorporate plant species that have a high wildlife value and riparian areas are by far, among the most important corridors for our wildlife friends. A survey of the wildlife that use and visit your project site can provide insight into the effectiveness and health of your restoration. The types of wildlife present at the project site provide an indication into the structure and use of the ecosystem.

You do not have to be an experienced naturalist to identify wildlife species or to distinguish signs that wildlife has left behind. A wildlife survey includes looking for amphibians, birds, mammals, aquatic life, and more. Don't be intimidated if you are unable to identify individual species; simply taking note of what *types* of animals are present will be beneficial in characterizing the site.

Common Plants With High Wildlife Values

Common Name/*Scientific Name*
Dogwoods/*Cornus sp*.
Serviceberries/*Amelanchier* sp.
Oaks/*Quercus* sp.
Alders/*Alnus* sp.
Sumacs/*Rhus* sp.
Birches/*Betula* sp.
Viburnums/*Viburnum* sp.
Winterberries/*Ilex* sp.

Incorporating a wildlife survey into other regularly scheduled monitoring at your project site may seem convenient, but it is best to schedule a trip specifically for this survey. In addition, different animals are active at different times. Dawn and dusk are active periods for many animals and are generally the best times of day to spot wildlife, especially birds. Most animals are inactive during the middle of the day. At night and during their breeding season, you are more likely to encounter salamanders and frogs. You can find wildlife during every season, but some types of animals, such as reptiles, amphibians, and some bird species, will only be found part of the year.

The key to surveying wildlife is **patience and using good observation skills**. There are two major components to your wildlife survey. The first is an observation period. Arrive early and find a good location where you can blend in and observe wildlife. Sit quietly at a location where you can view the majority of the project area. We recommend quiet observation for at least one hour. In addition, to using your eyes for observation, also listen for different vocalizations. After you've observed the site's use, you can begin the second component of the survey by actively searching out signs of wildlife. This will include identifying scat, tracks, nests, and other signs left behind by animals. Be patient and quiet as you search out the inhabitants of the restored site. Some tips for finding and identifying wildlife at your site can be found on the following pages.

Amphibians

All amphibians have thin, smooth skin and are cold-blooded. They typically start life in fresh water and later become at least partly terrestrial. From early spring into the fall months, amphibians can often be found in shaded, moist areas along water edges. During winter they burrow deep into leaf litter, soft soils, and the mud of ponds or streams where they maintain an inactive state.

Pickerel frog.

Frogs/Toads must stay near water to keep their skin moist. Male vocalization can be heard in the early spring, when they are attempting to find a mate. Fertilized eggs are laid in the water, and will hatch into tadpoles. The tadpoles will transform into tail-less air-breathing adults. True frogs are large, with slim waists, long legs, pointed toes, and webs on their hind feet. *Toads* are a family of frogs, recognizable with their shorter legs (used for hopping on land rather than swimming) and dry, "warty" skin.

Pickerel frogs and toads can be easily identified by their calls. Wood frogs and Spring peepers gather in noisy groups at dusk near water in early spring. Bullfrogs, green frogs, and American toads can be heard in the daytime. A cassette tape, *Voices of the Night*, is available from the Cornell Laboratory of Ornithology, and can help you learn frog calls.

Salamanders have blunt rounded heads, long slender bodies, short legs, and long tails. They are a challenge to identify since many have different variations and stages of development. Most lay eggs in fresh water. The hatched larvae lose theirs gills and come ashore after several months or years. However, some salamanders remain aquatic their entire lives and some lay eggs on land and skip the gilled larvae state. Common salamanders you may encounter include the red-backed salamander, spotted salamander, and the dusky salamander. You may also encounter the red-spotted newt, which in the eft stage, is a brilliant salmon red.

Look for salamanders among heavy leaf litter, under logs and rocks during the day. You can also check for salamanders when they are active at night, using a headlamp. Fallen logs are a great home for salamanders. Lifting up logs during the fall months may reveal clusters of salamander eggs, resembling fish eggs, except on land. Be sure to put logs back the way you found them so as to limit disturbance.

Source: U.S. Environmental Protection Agency

Reptiles

Turtles are probably the most visible family of the reptiles as well as being slow and easy to identify. They can be seen in the late spring and summer months basking in the sun. There are both terrestrial and pond turtles. Turtles you might see include mud turtle, snapping turtle, painted turtle, spotted turtle, wood turtle, Eastern red-bellied turtle, or the Eastern box turtle. The non-native red-eared slider is also becoming a common resident of creeks and ponds.

Snakes are the other family of scaled reptiles. Although most snakes are active both day and night, their shy behavior is difficult to detect. Snakes, like other reptiles, will bask in the sun on top of logs, rocks, and shrubby vegetation. In warmer temperatures, snakes can be found near the water's edge and under thick brush or grasses.

Common snakes you may encounter include common garter snake, eastern ribbon snake, northern water snake, eastern hognose snake, rat snake, ringneck snake, and eastern black racer. There are only two poisonous snakes that inhabit the area, the Copperhead and Timber Rattlesnake. Although well camouflaged on a shady forest floor, these pit vipers often warn intruders by rapid tail vibrations (in rattlesnakes, the vibrations are greatly enhanced by the rattle).

Source: U.S. Environmental Protection Agency

Birds

Birds can be an intimidating subject to survey because of the difficulty in identifying individual species. Even the most experienced birders sometimes have difficulty distinguishing among species. However, because of their diversity in our region, they are a fun and interesting animal to learn about and identify. When completing a wildlife survey it is not necessarily most important to identify species, but to recognize, when possible, the type of bird. Listing the species that you can identify is encouraged if known. A birder's field guide and binoculars will be especially helpful.

Birds can be roughly divided into the following groups:

- *Passerines/Songbirds* comprise more than half of the world's birds. Their sizes range from 3 ½" kinglets to 24" ravens, but they are generally small land birds with pleasing songs. Many of these birds are frequent visitors to neighborhood bird feeders and include black-capped chickadees, downy and hairy woodpeckers, flickers, catbirds, cardinals, mocking birds, gold finches, nuthatches, sparrows, eastern bluebirds, and towhees.

The birds I heard today, which, fortunately did not come within the scope of my science, sang as freshly as if it had been the first morning of creation.

--Henry David Thoreau

- *Neotropicals* breed and nest in North America, but migrate to warmer, tropical climates in the winter. Neotropicals are a subcategory of songbirds and many are in great decline. This subgroup includes the warblers, flycatchers and many others. Species you may encounter include yellow-rumped warblers, eastern kingbirds, yellow-throat warblers, barn swallows, ruby-throated hummingbirds, wood thrushes, Baltimore orioles, and the great-crested flycatcher.
- *Wading Birds* include herons, egrets, cranes, snipes and other birds that can be spotted standing in shallow water fishing. The great blue heron, snowy egrets, and green heron are some of the birds you may encounter along riparian areas.
- *Shorebirds* is a subcategory of wading birds that generally refers to sandpipers and plovers as well as killdeer. These birds have long, slender bills. Oystercatchers, willets, sanderlings, and ruddy turnstones are some species you may find.
- *Waterfowl* are those birds that swim and dive. Ducks and geese are the most common examples. Some include Canada geese, mallards, wood ducks, green-winged teals, American black ducks, and common golden eyes.
- *Raptors/Birds of Prey* are often seen soaring overhead. Hawks, falcons, owls and vultures all fall under this category. You may find Red-tailed hawks, osprey, turkey vultures, northern harriers, Cooper's hawk, bald eagles, and the American kestrel.
- *Upland Game Birds* are those that have historically been hunted. Relatively scarce in the wild, this group includes pheasants, turkeys, quail, doves and grouse.

Mammals

There are a variety of mammals that may visit or use the project area. Most mammals are generally nocturnal and not nearly as easy to observe as birds. The most common mammals are the nut-eaters, squirrels and chipmunks. The most abundant mammals, though rarely seen, are the various rodents like the white-footed mouse and deer mouse, which are an important source of food for predators. White-tailed deer can be very abundant and are often feeding at dawn and dusk. Meadow voles, cottontail rabbits, and groundhogs are also common. Mammals including raccoons, skunks, foxes, opossums, and coyotes are present in low numbers and are usually nocturnal.

Evidence of mammal activity includes tracks, scat (fecal matter), burrow openings, nutshells, or scent. Here are some signs to look for at your project site:

- *Moles:* Piles of dirt outside burrow openings or low raised ridges on soil surfaces.
- *Mice and Voles:* Runways and burrows on forest floor, small dark droppings.

Local Audubon Society Chapters throughout the region often offer free bird walks – newcomers are welcome.

Source: U.S. Environmental Protection Agency

I must leave it as beautiful as I found it. I would enjoy it and discover all that was to be found and learn as time went on that here perhaps was all I might ever hope to know. I named this place Listening Point because only when one comes to listen, only when one is aware and still, can things be seen and heard. Everyone has a listening point somewhere. Some place of quiet where the universe can be contemplated with awe.

--Sigurd Olson

***Track Finder* by Dorcas Miller is a great pocket guide to help identify animal tracks. For a catalog, write Nature Study Guild, Box 10489, Rochester, NY 14610**

Gray Squirrel.

Source: U.S. Environmental Protection Agency

- *Chipmunks:* Burrow entrances 2 inches wide, without dirt piles, on a wooded slope.
- *Squirrels:* Mounds of nutshells under feeding branches, large leaf nests high in trees.
- *Woodchucks:* Burrow entrances 8 inches to 12 inches, with dirt piles on the side.
- *Rabbits:* Scat is piles of dark brown, pea-size pellets.
- *Muskrats:* Conspicuous lodge of cattails, roots and mud floats that rise up to 3 feet above surface of water. Burrows in stream banks.
- *Beavers:* Dams, lodges, cone-shaped tree stumps.
- *Porcupines:* Tooth marks on bark; irregular patches of bark stripped from tree trunks and limbs. Scat is piles of variable-shaped pellets near crevice or base of a feeding tree.
- *Raccoons:* Den is in hollow tree or crevice.
- *Coyotes:* Scat is dog-like, usually full of hair. Den is built on slopes, with a two-foot opening.
- *Foxes:* Den is hidden in natural crevice in the woods, and often has snagged hair and bone scraps near entrance. They often leave their scat in prominent places, such as on top of a large rock or log.
- *Deer:* Browsed vegetation along well-worn trails or "buck rubs" where males rub the bark off of the trees with their antlers. Flattened beds in the grass or snow are left behind after they nest there for a few hours.

Fish

Most fish congregate in shaded pools and overhanging banks of the stream. However, some types, such as darters and sculpins, are adapted to life in stream riffles and use their pectoral fins to grasp to the stream bottom. Wearing polarized sun glasses can help see fish in these areas. You may also be able to notice fish spawning nests (redds) in gravel areas of the stream. Different fish spawn at different times. Many fish species spawn in spring but there are exceptions to this rule as some, like the native brook trout, are known to spawn in late fall. These nests, usually cleared by female fish, appear as sandy areas and are often guarded. Minnows, trout, sunfish, catfish, suckers, sculpins, and darters are some of the fish you may see in your stream.

Level 1 And Level 2 Monitoring Techniques Datasheets

Date (mm/dd/yy): _____ **Project Code:** _____

Monitor: _____

Phone: _____ **E-mail:** _____

Stream/Watershed/Sub-Watershed: _____

Project Name: _____

Project Type(s): ❒ Buffer; ❒ Fencing; ❒ Bioengineering; ❒ Basin Retrofit;
❒ Other _____

Project Completion Date: Phase 1 _____ Phase 2 _____

Approximate number of plants installed (from nursery lists): _____

Plant types installed: ❒ Trees; ❒ Shrubs; ❒ Grasses/Wildflowers; ❒ Emergent/Wetland Vegetation

Plant Survey:

Percentage of trees/shrubs planted that are alive and healthy (check all that apply):

❒ Less than 25% alive/healthy
❒ 26-50% alive/healthy
❒ 51-75% alive/healthy
❒ Greater than 75% alive/healthy

❒ Green leaves present
❒ Budding present
❒ Flowering/Fruiting present
❒ Trees/Shrubs increasing in size

Status of Live Stakes (if planted): _____

Comments: _____

Damage to Plants:

Type of Impact	Extent of Impact (none-low-med-high)	Comments/Description
Herbivory (indicate deer or rodent damage)		
Girdling of trunk		
Fungus/Disease/Leaf Die Back		
Mowing or other man-made impacts (trampling)		
Flood/storm damage (uprooted plants)		
Invasive plant competition		
Poor planting technique		
Unknown/Other:		

Additional Comments: _____

_____

_____

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Invasive Plant Species:

Are there invasive plant species present in the project area?

❒ Yes; ❒ No Comments**:** _____

Are there invasive plant species near but not yet established in the project area?

❒ Yes; ❒No Comments**:** _____

If invasive plant species are present, specify type and extent of colonization below:

Invasive Plant	**Extent Of Damage** *none-low-medium-high*
Multiflora rose (S) (*Rosa multiflora*)	
Japanese honeysuckle (*Lonicera japonica*) (V)	
Oriental bittersweet (V) (*Celastrus orbiculatus*)	
Purple loosestrife (H) (*Lythrum salicaria*)	
Lesser celandine (H) (*Ranunculus ficaria*)	
Norway maple (T) (*Acer platanoides)*	
This is not a comprehensive list of invasive plants. Refer to the NPS Handbook for other invaders. S= shrub; V= vine; H= herbaceous; T= tree	

Invasive Plant	**Extent Of Damage** *none-low-medium-high*
English Ivy (V) *(Hedera helix)*	
Common reed (H) (*Phragmites australis*)	
Japanese knotweed (H) (*Polygonum cuspidatum*)	
Mile-a-minute (V) (*Polygonum perfoliatum*)	
Garlic mustard (H) *(Alliaria petiolata)*	
Others:	

Bioengineering Physical Survey:

Erosion Control Matting (check all that apply):

❒ Intact/pinned down
❒ Seed mix/grasses growing in matting
❒ Torn up/removed
❒ Bare earth under matting
❒ Erosion under matting
❒ Live stakes/plants growing in matting

Erosion is Occurring:
Vertically
❒ Toe of slope
❒ Middle of slope
❒ Top of slope
Horizontally
❒ Upstream end of project reach
❒ Middle of project reach
❒ Downstream end of project reach

Status Of Stabilization Materials/ Structures - *branch packs, fascines, coir logs, rock* - (check all that apply):
❒ Intact/staked down
❒ Torn up/removed
❒ No vegetation growing in materials
❒ Erosion behind log
❒ Live stakes/plants growing in materials
❒ Herbaceous vegetation growing in materials

Approximate extent of area damaged:
_____ (square feet)
_____ (square feet)
_____ (square feet)
Approximate extent of area damaged:
_____ (linear feet)
_____ (linear feet)
_____ (linear feet)

Comments on Bioengineering: _____

_____

_____

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Stormwater Retrofit Survey (if applicable):

Retrofit Type: ❒ Naturalization; ❒ Infiltration trench; ❒ Outflow structure; ❒ Berm;
❒ Other _____

Is water present in basin: ❒ 3 hrs after rain; ❒ 6 hours after rain; ❒ 12 hours after rain;
❒ 24 hours after rain; ❒ Other_____

Are installed retrofit structures intact and functioning?

❒ Yes; ❒ No; Comments: _____

Do intake and outfall structures appear to be working?

❒ Yes; ❒ No; Comments: _____

Is there accumulated sediment present in the basin/adhering to vegetation?

❒ Yes; ❒ No; Comments: _____

Is maintenance needed for proper functioning of retrofit structures (i.e., sediment removal)? ❒ Yes; ❒ No; **Needed Maintenance**: _____

_____

_____

Receiving Stream Characteristics

Is stormwater discharge eroding the banks of the receiving stream?
❒ Yes; ❒ No; Comments: _____

Substrate Composition of Upstream Riffle
Dominant Substrate: ❒ Bedrock; ❒ Boulder; ❒ Cobble; ❒ Gravel; ❒ Sand; ❒ Silt/Clay/Mud
Sub-Dominant Substrate: ❒ Bedrock; ❒ Boulder; ❒ Cobble; ❒ Gravel; ❒ Sand; ❒ Silt/Clay/Mud
Riffle Consolidation: ❒ Loose; ❒ Moderate; ❒ Difficult To Dislodge

Substrate Composition of Downstream Riffle
Dominant Substrate: ❒ Bedrock; ❒ Boulder; ❒ Cobble; ❒ Gravel; ❒ Sand; ❒ Silt/Clay/Mud
Sub-Dominant Substrate: ❒ Bedrock; ❒ Boulder; ❒ Cobble; ❒ Gravel; ❒ Sand; ❒ Silt/Clay/Mud
Riffle Consolidation: ❒ Loose; ❒ Moderate; ❒ Difficult To Dislodge

Additional Comments: _____

_____

_____

Project Maintenance Recommendations

List Recommended Maintenance Activities: _____

_____

_____

_____

_____

_____

Send a copy of datasheets and photos to:
Delaware Riverkeeper Network (DRN), P.O. Box 459 St. Peters, PA 19470.

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Restoration Project Survey Scores (1-10):
See scoring descriptions on back to rate each of the six components.
Consider only the restoration project area in this assessment.
Rate only those elements appropriate to the restoration project.

	Score	Comments
Restoration Buffer Width (Left bank facing downstream)		
Restoration Buffer Width (Right bank facing downstream)		
Trees and Shrubs		
Herbaceous Vegetation		
Biodiversity (List native species present if known):		
Exotic Invasive Vegetation (List species present if known):		
Bioengineering Techniques		

Total Points		**< 4.0 = Poor**
Number of Categories Scored		**4.1 - 6.0 = Fair**
OVERALL SCORE (Divide Total Points by Number of Categories Scored)		**6.1 - 8.9 = Good** **> 9.0 = Excellent**

Comments & Observations: (Describe any notable conditions about the restoration project not covered above) _____

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Scoring Descriptions for Restoration Project Survey

Each assessment element is rated with a value of 1 to 10. Record the score that best fits the observations you make based on the narrative descriptions provided.

Restoration Buffer Width

Planted vegetation extends >75 feet from the active channel	Planted vegetation extends 50 feet from the active channel	Planted vegetation extends 35 feet from the active channel	Planted vegetation extends 15 feet from the active channel	Planted vegetation extends less than 1 foot from the active channel
10	7	5	3	1

Trees and Shrubs - note gaps with no trees in project area (could indicate mortality)

>90% of the project area has trees and shrubs that are healthy and growing	~70% of the project area has trees and shrubs that are healthy and growing	~50% of the project area has trees and shrubs that are healthy and growing	~30% of the project area has trees and shrubs that are healthy and growing	<10% of the project area has trees and shrubs that are healthy and growing
10	7	5	3	1

Herbaceous Vegetation

>90% of herbaceous vegetation is green and healthy with a height of at least six inches	~70% of herbaceous vegetation is green and healthy with a height of at least six inches	~50% of herbaceous vegetation is green and healthy with a height of at least six inches	~30% of herbaceous vegetation is green and healthy with a height of at least six inches	<10% of herbaceous vegetation is green and healthy with a height of at least six inches
10	7	5	3	1

Biodiversity - list species you can identify (do not include invasive species in count)

There are at least 16 different native plant species growing in the project area	There are at least 12 different native plant species growing in the project area	There are at least 8 different native plant species growing in the project area	There are at least 4 different native plant species growing in the project area	There is only one native plant species growing in the project area
10	7	5	3	1

Exotic Invasive Vegetation

No invasives present in the project area or general vicinity around project area	~25% of project area has invasive species present and competing with planted vegetation	~50% of project area has invasive species present and competing with planted vegetation	~75% of project area has invasive species present and competing with planted vegetation	Invasive species dominate the project area – few natives unaffected by invasives
10	7	5	3	1

Bioengineering techniques – only applicable to projects with bank regrading

>90% of all bioengineering materials intact and functioning; plants well-established	~70% of bioengineering materials intact; minor patches of erosion; majority of plants established	~50% of bioengineering materials intact; erosion common and compromising planted vegetation	~30% of bioengineering materials intact; high erosion areas with few surviving plants	<10% of bioengineering materials intact; bare soil, gullies and erosion dominate area
10	7	5	3	1

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Project Site Diagram

Use this sheet or project plan maps to record information. Include things like: general contour of project area and stream, stream flow direction, photo point locations and orientation of photo, cross section locations, planting locations, coir log and matting locations, problem areas, major invasive plant infestations, and other land marks. Include an approximate scale.

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Photo Documentation Sheet

Label photos with exposure #, date, location, description, and, photographer. Be sure to mark photo-point locations and orientation on diagram or project plan.

Photo Points

Exposure Number/Label	Marked on Diagram?	Direction of Photograph/ Focal or Reference Point	Description

Spot Photos

Exposure Number/Label	Photo Description

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Date (mm/dd/yy): _____ **Project Code:** _____

Monitors: _____

Phone: _____ **E-mail:** _____

Project Name: _____

Photo Points Using Profile Board

Photo Point A: Exposure Number _____ Location of Profile Board _____

Description of Photo: _____

Comments: _____

_____

Photo Point B: Exposure Number _____ Location of Profile Board _____

Description of Photo: _____

Comments: _____

_____

Photo Point C: Exposure Number _____ Location of Profile Board _____

Description of Photo: _____

Comments: _____

_____

Fixed Distance Plots

Plot 1		**Plot 2**	
Distance from Observer to Board		**Distance from Observer to Board**	
Height on Board	**% Coverage**	**Height on Board**	**% Coverage**
0.25		0.25	
0.50		0.50	
0.75		0.75	
1.00		1.00	
1.25		1.25	
1.50		1.50	
1.75		1.75	
2.00		2.00	

Photographs of Profile Board in Fixed Distance Plots: ❒ Yes; ❒ No; Description: _____

_____

_____

Additional Comments: _____

_____

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Date (mm/dd/yy): _____ **Project Code:** _____

Monitor: _____

Phone: _____ **E-mail:** _____

Stream/Watershed/Sub-Watershed: _____

Project Name: _____

Project Type(s): ❒ Buffer; ❒ Fencing; ❒ Bioengineering; ❒ Basin Retrofit;
❒ Other _____

Description of Cross Section Location: _____

_____

Photographs of Cross Section Location: ❒ Yes; ❒ No; Description: _____

_____

Start Point (SP) and End Point (EP) distance from Ground: SP _____ EP _____

Diagrams Of Cross-Section And Bank Pin Locations

Show Cross-section End Points (△▽), Bank Pins (⊙), flow direction, scale, and any photo points. Bank Pin Installation. Record the direction of the survey (i.e., left or right bank as start point).

Bank Pin Location Description/Photos: _____

Installation Data				**Monitoring Data**			
Pin ID & Install Date	***Description of Installation Point & Photo ID Number***	***Length* of Pin Exposed***	***Total Pin Length****	***Reading Date***	***Length* of Pin Exposed***	***Reading Date***	***Length* of Pin Exposed***

* Length in feet and tenths of a foot.

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Date (mm/dd/yy): _____ **Project Code:** _____

Horizontal Distance: (Distance along line of cross-section, from start point)

Point	First Bank Start Point	First Bank Wetted Edge	Opposite Bank Wetted Edge	Opposite Bank End Point
Distance (m)	0 feet			

Stream Depth At One-Foot Intervals:

Horizontal Distance (Feet) #	Depth From Tape to Ground/ Streambottom (Feet-Tenths)	Depth To Water Surface (Feet-Tenths)	Comments
0			

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Date (mm/dd/yy): _____ **Time (e.g. 1420):** _____

Monitor: _____

Phone: _____ **E-mail:** _____

Project Name/Watershed: _____

Project Code: _____

U.S.G.S 7.5 Minute Quad Map: _____

Distance in inches from southeast corner of quad: North: _____ **West:** _____

Latitude: _____ **Longitude:** _____

Sampling Equipment: ❒ Kick Net only; ❒ Kick Net w/1-ft sq. grid; ❒ Dip Net; ❒ Surber Net

Habitat Type(s) Sampled: ❒ Riffle; ❒ Run; ❒ Pool; ❒ Woody Vegetation (CPOM)

Predominant Surrounding Land Use Type (1 = dominant; 2 = subdominant):

Row Crops_____; Meadow/Hayfield_____; Grazing/Pasture_____; Forest_____

Residential_____; Commercial_____; Industrial_____; Other_____

Extent to Which Vegetation Shades Stream: ❒ 0%; ❒ 25%; ❒ 50%; ❒ 75%; ❒ 100%

Approximate Riparian Buffer Width:
Left Bank: ❒ >70'; ❒ 50'; ❒ 35'; ❒ 15'; ❒ 1'
Right Bank: ❒ >70'; ❒ 50'; ❒ 35'; ❒ 15'; ❒ 1'

Present Weather Conditions: _____

Weather Conditions Past 2-5 Days: _____

Air Temperature: _____ ^{o} C; **Water Temperature:** _____ ^{o} C

General Water Conditions (color, odor, etc.): _____

_____

Aquatic Vegetation (algal growth and in-stream vegetation): _____

_____

Stream Bottom Survey of Riffle Habitat:

Identify and monitor riffle habitat for the stream bottom survey to help track changes in macro-invertebrate habitat due to sediment. Check the dominant substrate and subdominant substrate.

	Silt/Clay/Mud: *Sticky/cohesive feeling, sediments behave like ooze*	**Sand:** *tiny gritty particles, smaller than gravel but courser than silt*	**Gravel:** *pea to tennis ball size*	**Cobble:** *Tennis ball to basketball size*	**Bedrock:** *Greater than basketball & smaller than car*	**Boulder:** *Larger than a car*
Dominant Substrate						
Subdominant Substrate						

Consolidation of Riffle: ❒ Loose; ❒ Moderate; ❒ Difficult to dislodge

Habitat Types Present: ❒ Fine Woody Debris; ❒ Submerged Logs; ❒ Leaf Packs;
❒ Cobble; ❒ Boulders; ❒ Course Gravel; ❒ Vegetated Bank Margins;
❒ Other_____

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Macroinvertebrate Count

Group I:	Count	Group II:	Count	Group III:	Count
Water penny larvae		Other beetle larvae		Aquatic worms	
Mayfly nymphs		Riffle beetle adults		Blackfly larvae	
Stonefly nymphs		Crane fly larvae		Leeches	
Non-net spinning caddisfly larvae		Damselfly nymphs		Midge larvae	
Fingernet Caddisfly larvae*		Dragonfly larvae		Pouched/Lunged snails	
Free-living caddisfly larvae*		Scuds		Rat-tailed maggots	
Water snipe fly larvae		Aquatic sowbugs		Horsefly larvae	
Dobsonfly larvae (hellgrammites)		Alderfly larvae		Flatworms	
Fishfly larvae		Net-spinning caddisfly larvae**		Water striders	
Fishing spiders		Crayfish		Giant water bugs	
Gilled snails		Water mites		Water boatmen	
		Clams			

* The Philopotamidae family of caddisflies, known as the fingernet caddisfly make a fragile net-like retreat like the other netspinners. However, they are sensitive to pollution. Fingernet caddisflies are usually yellow-orange in color and are almost always collected free from their dwelling. Free living caddisfly (Rhyacophilidae) is also a sensitive caddisfly that is found free from its dwelling. This family is green in color but in general, larger than the Hyropsychidae family and a brighter green.

** Net spinning caddisflies make net-like retreats that are often destroyed during collection. Two families of netspinners that are considered tolerant to pollution include the Hyropsychidae family and the Polycentropodidae family. The Hydropsychidae family, known as the common netspinners, have brushes or gills on their abdomens and are often green in color. The Polycentropodidae family of caddisflies, known as the trumpet net or tubemaker caddisflies, appear yellow in color. Both are collected free from their dwelling.

Notes/Comments: _____

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Date (mm/dd/yy): _____ **Time (e.g. 1420):** _____

Monitor: _____

Phone: _____ **E-mail:** _____

Project Name/Watershed: _____

Project Code: _____

Observation Time Period: _____

Active Search Time Period: _____

Amphibians *Time of survey (e.g. 1420):* _____

Type	#	**Comments (Species, Tracks, Vocalization)**
Frogs/Toads		
Salamanders		

Reptiles *Time of survey (e.g. 1420):* _____

Type	#	**Comments (Species, Tracks)**
Turtles		
Snakes		

Birds *Time of survey (e.g. 1420):* _____

Type	#	**Comments (Species, Tracks, Nesting, In-Flight, Vocalization)**
Passerine/Songbirds		
Neotropical Birds		
Wading Birds		

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Birds (cont.) *Time of survey (e.g. 1420): _____*

Type	#	**Comments (Species, Tracks, Nesting, In-Flight, Vocalization)**
Shore Birds		
Waterfowl		
Raptors		
Upland Game Birds		

Mammals *Time of survey (e.g. 1420): _____*

Type	#	**Comments (Species, Tracks, Scat, Vocalization)**
Small Mammals		
Medium Mammals		
Large Mammals		

Fish *Time of survey (e.g. 1420): _____*

Type	#	**Comments (Species, Redds/Nests)**

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Restoration Project Maintenance

Project Maintenance Overview

Project Maintenance Goals and Objectives

Restoration projects will not succeed without people dedicated to maintenance. Project maintenance is more than just clipping vines, it's a process of assessing conditions, determining priorities, tracking changes, and adjusting methods. The first step in the process of defining your maintenance objectives is to review the restoration goals for your project site. The overall goals of most restoration projects are to return function to riparian corridors, to enhance habitat, and to preserve native plant communities. The specific goals at your site depend on the scope of the project and the conditions at the site. If a bioengineering structure was installed to stabilize a streambank, your maintenance objectives may be to repair the structure and encourage plantings until they are capable of protecting the bank. If the restoration goal is to improve stream shading and the plantings are threatened by trampling, your objective may be to install and maintain fencing. So, step back, review the Restoration Project folder for your site, take a hard look at the site conditions, and develop some short-term and long-term objectives.

A typical restoration project objective is to eradicate or control invasive plants at the project site and encourage a native plant community (see *Maintenance Series #2: Invasive Plants*). Invasive plants grow very quickly and can overtake a project in a few seasons. This overview does provide some guidance on the control of invasive plants, but it looks at a number of other factors that can also affect the success of a project, such as mowing by uninformed maintenance crews and herbivory. Remember, successful project maintenance must include tasks such as communicating with project partners, identifying problems, researching solutions, recruiting volunteers, and documenting maintenance activities.

Developing a Strategy

Every site is different, so a strategy must be developed that matches the goals and conditions at each site. The process of determining maintenance priorities and identifying which factors, such as invasive plant species, are blocking the attainment of restoration goals takes place over several seasons. As a project monitor or maintenance crewmember you will observe and get to know the site through changing conditions - summer, winter, drought and flood. Management objectives and maintenance methods must be flexible in order to adapt to changing conditions at the project site.

Adaptative Management Approach

One method to consider in developing your maintenance strategy is the "Adaptative Management Approach" developed by The Nature Conservancy (TNC) for managing invasive plants and modified by DRN to meet maintenance challenges at restoration project sites:

1. Establish management objectives for the site with the project partners;
2. Determine which factors, such as mowing conflicts or invasive plant species, block or have potential to block attainment of the restoration goals;
3. Determine which approaches or methods are available to address these factors;
4. Develop and implement a management plan that is designed to move conditions toward restoration goals;
5. Use the Level 1 Restoration Project Survey and other Level 2 protocols to monitor and assess the impacts of management actions in terms of their effectiveness and determine maintenance needs; and
6. Re-evaluate goals and objectives, modify as needed, and start the cycle again.

To select successful approaches for invasive plant controls, compare control techniques for each target species.
The Morris Arboretum of the University of Pennsylvania, the Virginia Native Plant Society (VNPS) and the Plant Conservation Alliance (PCA) all have informative factsheets to reference. You can download factsheets free from the VNPS and PCA websites.

Setting Project Priorities

Ideally, you should conduct your first maintenance session immediately after the project has been planted. This session should include checking for proper planting techniques. You would be surprised how often you find an unplanted container plant, a bundle of bare root seedlings, or a few plugs scattered around. Finish the job by adding deer protection; deer form feeding habitats very quickly and just-planted shrubs and trees are easy targets. After this first visit, management objectives will be established by the results of the Level 1 Restoration Project Survey (RPS), input from project partners, and/or a site-specific management plan. For example, observation of damaged deer exclosures should trigger a rapid maintenance response and possibly experimentation with another technique. In the first few seasons after project installation, priorities are likely to focus on maintenance and encouragement of plantings, and repair of bioengineering structures after spring floods.

As you become more familiar with the site, you will identify and research obstacles to project success, determine approaches to address these obstacles, and develop a management plan with short-term objectives (STO). For invasive plants, this means assessing control methods and scheduling maintenance during times that will be most effective for controlling the target species and most protective of both site conditions and people. TNC provides one of the more comprehensive on-line resources for identifying invasive plants, researching control methods, setting priorities, and creating management plans. There are also informative invasive plant factsheets available from the Morris Arboretum of the University of Pennsylvania, the Virginia Native Plant Society and the Plant Conservation Alliance.

Other short-term maintenance needs might include the selection and installation of fencing, posting of “no mow” boundaries, installing educational signs, or barriers to discourage trampling of plantings by resource users. In some cases maintenance resources may be focused on preparing the project site for another phase of planting or bioengineering. Maintenance priorities must consider the amount of resources that can be committed to maintenance, the condition of the site prior to the project, current land uses, and outside forces such as weather.

Developing a Maintenance Schedule

A maintenance plan should state the restoration project goals and identify both STO and long-term objectives (LTO). Maintenance plans should include a clearly identified maintenance schedule, based on the findings of your RPS, your labor availability, and control methods selected. When developing a maintenance schedule, consider pre-existing site conditions, the maintenance commitment of project partners, deer and rodent pressure, outside sources of invasive plant seed and re-invasion, and seasonal conditions.

As you move forward with implementation of your maintenance plan, don't be afraid to adjust the timetable, shift priorities, or invest time in experimenting with alternative control methods. The most effective maintenance plans include continued monitoring of the effectiveness of maintenance efforts and making adjustments as necessary.

The following table is a sample inspection and maintenance schedule for a hypothetical riparian buffer project adjacent to a public park. The project included grading back and stabilizing 100 feet of stream bank, a 40-foot buffer planting of trees and shrubs, and two deflectors for fish habitat. Note that many tasks are suitable for volunteer groups (schools, scouts, etc.).

Season	Inspection/Survey	Maintenance
Late Winter	Wetland & Terrestrial Habitat	Repair Deer Protect, Maint. In Wet Areas (Frozen)
Early Spring	RPS, Develop STO, Macroinvertebrate Survey	Repair Structures & Signs, Mow Field, Live Stake
Spring	Spring Ephemerals, Wildlife Survey	Pull Garlic Mustard, Re-Seed Bare Soil, Trash Pick-up (P/U)
Summer	Check for Flood Damage	Ailanthus Drill/Treat, Cut Bittersweet & Stilt Grass
Late Summer	Map Herbaceous Plants	Repair Struct., Overseed, Maintain Deer Protect.
Fall	RPS, Develop LTO, Cross-Section Survey	Vine Cutting & Treating, Fencing, Trash P/U
Winter	Check For Deer, Rodent Damage	Remove Multi Flora & Ailanthus, Mulching

Communicating With Partners

Regular coordination and communication on maintenance issues between the volunteer stewards, maintenance crew, property owner, and other local stakeholders will make the job a lot easier. By keeping everyone in the loop, you may avoid having new plantings mowed down for lack of one phone call.

Selecting Control Methods

You may establish a number of maintenance objectives for your project site but, to the extent that invasive plants have entered a site, early maintenance efforts must focus on invasive control. Invasive plant species tend to be very vigorous in their growth and survival. As a result, the eradication of invasive plants and return to a healthy native plant community happens in stages. Early stages rely heavily on your maintenance activities.

Vinca/periwinkle, invasive ground-cover still sold commercially.
Source: Barry A. Rice/ The Nature Conservancy

Understanding the ways that invasive plants reproduce, spread, or colonize areas can help focus your research and efforts on the more successful control methods. The following table, adapted from a presentation by Art Gover of the Department of Horticulture at Pennsylvania State University, is a general order of increasing invasiveness according to reproduction traits. However, there are many exceptions; e.g., garlic mustard not only reproduces by seed, but also is aggressive because it produces chemicals that inhibit germination and growth of other plants.

Increasing Invasiveness According to Reproduction

Plant Type - Examples	Description	Primary Control Method/ Objectives	Maintenance Cautions
Annuals*/ Biennials** - Garlic mustard - Japanese stiltgrass	Reproduction only by seed.	Prevent seed set. Long-term reduction of seed bank.	Disturbing soil can encourage seed germination. Seed can be spread by boots & tools.
Aboveground Perennials*** - Norway maple - Amur honeysuckle	Non-suckering trees and shrubs.	Killing all stem tissue - kills the plant.	Elimination of shade can cause colonization by other invasive plants.
Belowground Perennials - English ivy - Canada thistle	Mainly reproduces vegetatively from roots or stems.	Weaken overtime by repeated cutting. Remove or kill roots.	Plant fragments can grow. Dry or properly dispose of plant material off-site.
Belowground Perennials and Prolific Seeders - Oriental bittersweet - Japanese knotweed	Reproduces from both seed and root.	Kill entire root system. Long-term reduction of seed bank.	Root fragments can grow. Disturbed soil can encourage seed germination. Seed can be spread by boots, tools.

Adapted from A. Glover, Dept. of Horticulture, Pennsylvania State University

* *Annuals* - a plant that completes its life cycle in 1 year.

** *Biennial* - a plant that completes its life cycle over a 2-year period.

*** *Perennial* - a plant that completes its life cycle over more than 2 years.

Considering Your Options

Although the following quote from TNC's *Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas* focuses on invasives, it can be applied to most project challenges:

> "Successful weed control requires the combination or sequential use of several methods. For example, cutting followed by herbicide applications has been used successfully in many programs, and prescribed fires followed by spot-applications of herbicides have been used well in others. Consider all available control options: manual, mechanical, promoting competition from native plants, grazing, biocontrol, herbicides, prescribed fire, solarization, flooding, and other, more novel, techniques. Each has advantages and disadvantages in terms of its effects against the target weed(s), impacts to untargeted plants and animals, risks to human health and safety, and costs."

The most effective method of controlling invasive plants over the long-term is prevention, so educate yourself and neighboring property owners about these plants and the harm they can cause. You can find a great deal of information on invasive plants, control methods that have been tried, and practical advice available on the Internet.

Invasive plant control methods to consider include: Plantings and other Cultural Controls; Manual and Mechanical Control Methods; Heat and Prescribed Burns; Biological Controls; and Chemical Controls.*

Invasive mile-a-minute vine. Source: John M. Randall/ The Nature Conservancy

* **Please Note: DRN does not promote the use of herbicides when other methods can be effective, particularly when applying near aquatic habitats such as wetlands.** The surfactant used in many common formulations of glyphosate is toxic to aquatic organisms and new evidence indicates that the functioning of animals (including humans) endocrine systems can be severely altered by low-level cumulative exposure to some synthetic chemicals such as herbicides. The use of chemical controls is a serious decision and should be based on a careful evaluation of site conditions and research on the available control methods. However, DRN recognizes that site conditions may make use of herbicides the only viable means to control populations of well-established invasives and may be needed to "make room" for a native plant community in the short term. In all cases the good must outweigh the potential harm. DRN believes that the long-term success of individual projects lies more in public education, fostering stewardship, and local actions and support to improve the function and enhance the habitat of our waterways. Projects should attempt to move forward on both fronts and not become reliant on herbicide use for long-term land management.

Plants should be regarded as jewels in the devalued currency of our world environment.

--Uberto Tosco

Plantings and Other Cultural Controls

Cultural controls implemented on a watershed basis can often prove to be the most effective long-term strategy for restoration of stream function and riparian habitat. They take the longest to implement and show results, but they generally have the greatest benefit and least negative impact to ecological systems. Cultural controls create conditions that are inhospitable to invasive plants. For example, shading-out some invasive plants with installed plantings can be an effective form of cultural control. Likewise, encouraging desired plant species with a little mulching or over-seeding disturbed areas can be used to minimize new infestations.

Other cultural controls include fencing (for humans or livestock), installing interpretative signage, and establishing access points. Cultural controls can also extend beyond the project site by encouraging conservation planting, use of rain barrels, and removal of exotic invasive species from neighboring landscaped spaces. The following is a brief list of cultural approaches to improve the effectiveness of restoration projects:

Urge your neighborhood nursery to carry more native plants. Inform them about the harmful impacts of the exotic species they sell.

Educating the Community involves raising awareness of the project through press releases and working with existing educators, local schools, watershed groups, or environmental centers to increase involvement in site maintenance. Mailings to neighbors about the project's progress and press releases about volunteer opportunities can help build support. DRN and many other organizations can provide a speaker to address a wide variety of issues.

The Delaware Riverkeeper Network's brochure, *25 Ways To Protect Your Streamside Property*, is available to help partners and volunteer stewards educate neighbors along riparian corridors about stream-friendly practices.

Educating Adjacent Land Owners involves teaching those whose properties abut the project site about land management practices that will affect the functions and quality of the riparian system. This includes education on harmful practices, such as burying native ground vegetation under leaf piles and disposal of viable exotic plant clippings and seed, as well as beneficial practices, such as landscaping with native plants and establishing "no-mow" buffer areas. In addition to DRN's publication, *25 Ways To Protect Your Streamside Property*, DRN can provide you with assistance in organizing watershed group meetings.

Preventing Mower Damage requires educating the property owner, volunteers, and maintenance personnel about potential damage caused by mowing, weed whipping and trampling. Spring site visits with maintenance partners can be used to review the location of plantings, desired native species, and target areas on the seasonal maintenance schedule. DRN can provide additional copies of *Maintenance Series #8: Meadows And "No Mow" Areas* upon request.

Planting trees, shrubs, and forbs or encouraging existing native plants can be used to increase the density of canopy cover and effectively shade out some species of invasives. Likewise, over-seeding of meadows with grasses and wildflowers can also provide invasive plants with increased competition for light, water, and nutrients. These plantings also help to fill in canopy gaps in woodlands, shade-out forest edges, and fill in areas where invasives have been removed or where soils have been disturbed. Plants selected should be well suited to site conditions (light, moisture, soils) and should be installed in the early spring or fall to ensure the best success possible.

Implementing Stormwater Best Management Practices (BMPs) can provide an opportunity to reduce overland flow across the project site and prevent the discharge of nutrient laden waters to receiving streams and rivers. Stormwater BMPs focus on restoring and mimicking natural systems and include minimizing impervious cover and capturing and infiltrating water on-site. If the project site is at a park, a rain barrel at a pavilion could be a means of demonstrating simple water conservation practices while providing a source of water for plantings. Run-off, localized flooding, and drainage problems can be a unifying issue for many communities near project sites.

Erecting Stream Fencing and Temporary Barriers are effective means of keeping plants from being trampled and encouraging establishment of native ground cover. Stream fencing for livestock and the creation of crossings have an almost immediate benefit to diversity and stability of the stream system. In public areas, temporary barriers should have a sign with project partner contact information, the reason for the fencing, and how long it will be up.

Fencing Buffers can be accomplished through the use of brush piles designed to limit stream access, "no mow" signs, or attractive split rail fence along trail corridors. Design details and maintenance responsibility for more permanent fencing or other structures are best worked out in advance with the site owner, project partners, neighbors, and other stakeholders.

Installing Deer and Rodent Protection is often necessary at project sites with signs of existing browse or buck rubs. Deer will quickly learn where your plantings are, so it is best to install deer protection immediately after plant installation. There are various options for deer control including exclosures, tree guards, and sacrifice planting. The important point is to install a system BEFORE animals develop a feeding habit *(see Maintenance Series #6: Herbivory And Mowing)*.

The Delaware Riverkeeper Network has "no mow" signs available to post at project sites if destructive mowing is a concern.

"No mow" signage used to protect a Delaware Riverkeeper Network project.

Manual and Mechanical Control Methods

Manual and mechanical control methods are generally more effective with relatively small populations of plants. The methods can also be used selectively in areas with desirable plants or sensitive site conditions. As with all control methods, **timing is everything** and the schedule is dictated by the life cycle of target weeds, timing of seasonal activities at the project site, and conditions comfortable for physical labor. These methods are generally **more time and labor intensive**, and must often be repeated several times per season over a period of three to five years to see significant results. Handling, disposal, composting, or burning of large quantities of plant material generated is a consideration.

Many of these methods are well suited to large groups of regular volunteers who have adopted the project site for recreation, study, and other reasons. Target LOCALS - a nearby school, neighborhood groups, scouts, clubs, and other potential resources (*see Maintenance Series #7: Volunteer Recruitment And Retention*). Many of these methods are more effective when used in conjunction with cultural, biological and chemical control methods.

Hand-pulling of wisteria roots.

Hand-pulling allows for selective removal of invasive plants without disturbing desirable adjacent plants. It works best in moist soil conditions with smaller annual and biennial plants before they have had a chance to produce seed. Specialized tools such as a "weedwrench" are available to assist in pulling out small shrubs and trees. Try to remove as much of the root system with a minimum of soil disturbance. When you create disturbance you increase the potential for re-invasion. Replant native species when possible or mulch until re-planting is possible. Many invasive plants will come back with a vengeance, but they are exhausting resources every time they do. This technique is best applied to small populations of plants or in sensitive areas where harsher methods would impact native species and are not necessary to achieve management goals.

Manual Cutting involves repeated cutting of the above ground portions of a plant. The main objectives of these methods are to prevent seed set and to exhaust the root system of non-suckering species. Timing is critical when the objective is to prevent seed set or kill roots. Cutting is more appropriate in wooded areas where trees shade the cleared area and the plants must rely on food reserves to re-foliate. Cutting is less effective in open areas or edge areas where quick-growing invasives can out-compete native plants. In some cases, this method may be accompanied by herbicide application to cut stems and stumps or could be used as a way to reduce vegetative mass for subsequent foliar herbicide application on new growth.

Mechanical Cutting or Mowing works best in meadows or grasslands (*see Maintenance Series #8: Meadows And "No Mow" Areas*) and *Weed Whipping* works best in woodlands or on uneven terrain. While the objectives are the same as manual cutting (to prevent seed set or exhaust roots), mechanical methods are generally less selective than manual cutting. In general, repeated mowing will favor species that can re-foliate faster such as grasses and other species that grow close to the ground and are less effected by mowing. Mowing is best accomplished in open areas where obstacles, such as rocks and logs, and sources of invasive seed, such as multiflora rose, have been removed. Trunks of desired plants should be protected in BOTH mowing and weed whipping areas.

Girdling is effective on non-suckering, single trunk trees such as Norway Maple. It entails cutting through the bark and growing layer (cambium) about six inches above the ground. TNC suggests making two parallel cuts, creating a three-inch strip, all the way around the trunk. Girdling is reported to be most effective in spring and middle to late summer. Follow-up inspection is needed to trim back or treat new sprouts.

Solarization employs a cover over the soil surface to trap solar radiation and increase soil temperatures to kill plants, seeds, plant pathogens, and insects. When black plastic or other opaque materials are used, sunlight is blocked which can also kill existing plants. Others have reported that clear plastic generates higher soil temperatures that can be effective at killing shallow perennial root systems. Solarization can cause significant biological, physical, and chemical changes in the soil lasting up to two years, and deterring the growth of desirable native species.

Mulching with wood chips or weed block can be effective in relatively small areas such as around installed plantings, but it also interferes with the growth of desirable native species. Mulching should mainly be used to buy time and weaken perennial weeds until herbicide or other management techniques can be applied. Many tree-removal companies will provide wood chips as a mulch free of charge. Wood chips should be composted for a month or two before being placed around desired plantings. Be sure that the stockpiling location is acceptable to the property owner and not in an area that receives invasive seed. If possible, use mulch that has been sterilized through heat or solarization to prevent the unintended introduction of invasive species seeds that can be found in "dirty" mulch. Make sure that your mulch source knows that you want chips upon request only, or you may end up with a pile to get rid of every time they are in the neighborhood.

Norway maple leaf, invasive plant still sold in nurseries.
Source: John M. Randall/ The Nature Conservancy

Tilling, or turning over the soil, is mainly limited to large areas infested with invasive plants and restoration sites where soils are badly disturbed. Although tilling may be effective against annuals and shallow-rooted perennials, small fragments of perennials with rhizomes can re-sprout following tillage if soils are moist. The best control results during dry conditions. Complete tilling before seeds develop.

Heat and Prescribed Burn controls are for PROFESSIONALS ONLY and are best used in combination with other management tools. Spot burns, field and woodlot burns, and even burning plant cuttings can be dangerous to life and property. Most property owners and municipalities are not receptive to these methods. The local fire department may be receptive to a training exercise, but the burn should be planned and controlled by experienced individuals.

Heat and Prescribed Burns

Fire represents one of the oldest weed management tools employed by mankind. Deliberate and accidental fires have given rise to fire-adapted native species that respond well to intermittent, moderate-temperature fires. Prescribed burns can be useful at regular intervals to give these fire-adapted natives a competitive advantage over exotic invaders. New methods using super-heated foam designed to duplicate the effects of fire are being studied and may have potential application to project sites in the future.

Biological Controls

An increasing number of biological controls are being used or researched to reduce and control severe invasive plant infestations. Traditional methods include grazing goats to eliminate vines. Recently, the U.S. Department of Agriculture (USDA) approved importing beetle species to control purple loosestrife.

Grazing uses livestock to perform the task of repeated, non-selective cutting. Grazing is best used in combination with other methods, and can actually increase invasives, if used improperly. Grazing can be a viable choice where large invasive infestations have eliminated native plant communities. The need for electric fencing and potential for human contact often precludes the use of grazing in public areas. Where grazing is appropriate, an experienced professional can help assess the site and develop a site-specific grazing and manure management plan.

Other Biological Controls include importing insects, fungi, and even fish that selectively kill or eat a target plant. History has shown that it is best to be very cautious about using one exotic invader to control another, therefore the use of biological controls not the option supported by DRN and, if employed, it is best left to experienced professionals. At the same time it is important to be aware of biological control options, and be on the lookout for things eating or killing invasive plants at your site. You may just find the cure for Japanese knotweed or some other pernicious invasive.

Chemical Controls

Please Note: DRN does not promote the use of herbicides when other methods can be effective, particularly when applying near aquatic habitats such as wetlands, and never on a long-term basis. The decision to use chemical control methods must consider the health and safety of the applicators and others nearby, the effectiveness of the treatment and other non-chemical methods on the target weed, the presence of desired native species, and the effect on adjacent waterways and the entire ecological system. Most herbicides work by altering or blocking the biochemical processes found exclusively in plants and, consequently, are thought by some to pose relatively low risk to human beings and other animals. DRN does not subscribe to this belief.

The surfactant used in many common formulations of glyphosate is toxic to aquatic organisms. In addition, new evidence indicates that the functioning of animal, including human, endocrine systems can be severely altered by low-level cumulative exposure to some synthetic chemicals such as herbicides. Disrupting the endocrine system can include altered growth, development, and reproduction rates in various wildlife species and humans. Remember, you are not the only person that is likely to be using herbicides within the watershed. Herbicides should be a last resort or used only when research and experience show that other methods will not achieve management goals and that there will be greater harm to the ecosystem if the invasive plants are not controlled.

After all other alternatives have been exhausted, when considering chemical controls, you should carefully consider the harm versus good. In some cases, a more complete treatment may do less ecological harm and provide less exposure to personnel and other people than a series of ineffective treatments at inappropriate times. **Chemical methods should only be used by trained adults following protocols in a site-specific Conservation Plan.** The adults should be trained in both the safe use of herbicides and the identification of desirable native species at the site. Developing a concise invasives management plan can be fairly straightforward using TNC's Site Conservation Program on-line, http://www.consci.org/scp. This web site can help you identify targets and threats and help prepare a Site Conservation Plan. The Nature Conservancy's Weed Management Plan Template, http://tncweeds.ucdavis.edu, can help you set control priorities, estimate costs, develop a schedule, and implement selected methods.

The frog does not drink up the pond in which he lives.
--Native American Proverb

Japanese hops, invasive vine.
Source: John M. Randall/
The Nature Conservancy

All over-the-counter chemical methods such as spot application of Roundup® are limited to certified applicators and agents or employees who have permission of the property owner. All controlled herbicides and over-the-counter products are to be applied by a trained or certified applicator following all local, state, and federal regulations. Controlled herbicides, such as Rodeo® can only be applied by a certified applicator. Both over-the counter and controlled herbicides must be applied following product labels and all local, state, and federal regulations. Using an herbicide in a manner inconsistent with its label is a violation of federal law. Contact your state's department of agriculture or your county agricultural extension office for information about state and local regulations regarding applicator training, certification, permits, posting, record keeping, and notification requirements.

The Site Conservation Plan should spell out the reasons for the selection of chemical method, the application timing and rates, safe handling and mixing procedures, procedures for storing and transporting chemicals, protective gear, emergency precautions and equipment, posting of treated areas, application methods, record-keeping requirements, and proper disposal of unused chemicals and containers. The plan should also spell out the risks of using an herbicide as a control so all who review and follow the plan are fully informed and can make a knowledgeable decision about their participation in the implementation of the control.

There are three general ways in which herbicides are applied: to leaves, to stems and stumps, and to the soil to control weeds coming from seed. In all cases a dye should be used to show covered areas to prevent over-application and minimize personnel exposure. **PLEASE NOTE: This summary of the more common chemical control methods is provided solely as an overview of these methods and is neither intended nor adequate to provide instruction in their use.**

Foliar Methods apply herbicide to the leaves of a plant by wiping or spraying. Spot applications can be made with a wicking device, a spray bottle, backpack applicator, or by using an outer cotton glove sprayed with herbicide. These methods are very selective and useful in areas with invasives scattered among desirable plants. Spraying methods for larger infestations in vehicle-accessible areas may utilize trailer or truck-mounted tanks with a boom applicator or an operator-directed sprayer. Over spray, harming desired plants and impacting non-target areas are concerns with any scale of spraying and should be avoided.

Stem and Stump Treatments have the benefit of being more selective than foliar methods and require a smaller quantity of herbicides. These methods are often used on woody species such as ailanthus and multiflora rose that can re-sprout vigorously after being cut. Basal bark application involves using a wick applicator or backpack sprayer to apply a band of herbicide around the base of the trunk. Cut-stem or stump treatments can be applied to cambium with a squirt bottle, sponge paintbrush, or wick within minutes of cutting. Frilling or hack and squirt methods are preferred for woody species with thick trunks; a knife or hatchet is used to make a downward cut and herbicide is squirted inside. Drilling holes at a downward angle in the trunk is an alternative method that prevents the herbicide from running out. TNC recommends drilling one hole for every inch of diameter at breast height.

Pre-Emergence Herbicides are typically used to control the continued emergence of invasives from seed in areas where desired vegetation is well established and will not be effected by herbicide application. These herbicides are applied to the soil making potential dispersion and impact to non-target organisms important considerations. This method has been successful at controlling persistent weeds like mile-a-minute and Japanese stiltgrass.

Vinegar as an Herbicide - Vinegar (acetic acid) has been gaining popularity as a method of killing invasive plants. Researchers at the USDA's Agricultural Research Service have found that spraying household-strength vinegar (about a 5% concentration) is effective at killing many annual weed species and that higher-strength vinegar (10% to 20% concentrations), available from chemical supply companies, proved effective on older plants.

While vinegar is reported to be biodegradable and only have a short-term effect on soil pH, it is important to remember that it is non-selective and is considered hazardous to your health (can cause burns) at concentrations greater than 5% concentration. In addition, the use of acetic acid to kill invasive plants is illegal and a violation of Federal Insecticide, Fungicide, and Rodenticide Act unless the material is specifically labeled as an herbicide.

Let man heal the hurt places and revere whatever is still miraculously pristine.

--David Brower

Maintenance Series #1
Restoration Project Maintenance Tips

1. You Are Not Alone. You may feel like it when only a few volunteers show up on a workday, but DRN is here to help you or at least to direct you to the many other resources in the region. Volunteer recruitment and retention strategies are key factors for long-term success (*see Maintenance Series #7: Volunteer Recruitment And Retention*). Not to mention that it's a lot more fun to dig holes, pound stakes, cut vines and get muddy with others.

2. Maintenance Is More Than Invasive Plant Control. Keep focused on the goals of the restoration project - **to stabilize and return ecological function to stream and riparian communities.** Don't focus only on eliminating invasives. Remember to encourage the native plant community. Maintenance also includes watering plants while they're getting established, installing and repairing deer protection, laying brush lines to reduce trampling, identifying and acting on mowing or other maintenance conflicts, checking the site after a flood, and dealing with unforeseen challenges that could affect project success.

3. The Long Haul. Don't get discouraged by the continued growth of invasives or by new colonies. The project site was degraded over a long period of time and it will take years to move the process in the direction of the project goals. Revel in your accomplishments, "That pin oak really filled out this year," or "Those wildflowers look great!" Visit your project site for enjoyment and show it off to family and friends. You might just find some new folks interested in helping out.

4. Pick Your Battles. Develop a strategy and an adaptive management approach. Prioritize maintenance needs. Develop a realistic timeline. Your efforts may start out small, but over time and as volunteer help builds, you will achieve more goals. Be flexible and modify techniques as needed.

5. Document Maintenance Activities. Documenting your maintenance activities may seem tedious, but this information is essential for evaluating success, identifying mistakes, and modifying management techniques. The Nature Conservancy recommends that documentation (notes or pictures) also include the abundance and condition of targeted weeds and nearby desirable plants. And, when using herbicide, keep records of plants/areas treated, amounts and types of herbicide used, and application date.

6. Timing Is Everything. The best time to pull, cut, or treat a plant with herbicide is determined by the plant's life cycle. For example, herbicide application is often more effective when plants are in bloom and transferring food to their roots. In other cases, you should remove the plant or at least the flowering portions before they go to seed. A little research can save you both time and effort.

7. Less Can Be Better. For herbicide use, follow the concentration and application instructions on the label to the letter. Improper technique, inappropriate (high) concentrations, or over-application can make herbicide treatment ineffective or harmful to desired plants. Always use a dye mixed with the herbicide to assist you in getting correct coverage and help minimize personnel contact in treated areas. The "less is better" philosophy can also apply to management strategies where it's sometimes better to leave an area alone until you are prepared to deal with it effectively.

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Maintenance Series #2
Invasive Plants

What is an Invasive Plant?

An invasive plant is a species, often from another country or region, that grows aggressively, spreads rapidly, and displaces other plants. The most aggressive of these plants can change the character and function of entire ecosystems if left uncontrolled. Invasive plants are not often eaten by resident insects and animals or affected by local diseases, so they are able to put all their energy into growth and reproduction. This makes them difficult to control, and once established, can require a great deal of effort and expense to restore the diversity and function to the habitat affected. Invasive plants grow very quickly and can overtake native plants in a few seasons.

Characteristics and Identification of Invasive Plants

Even a casual observer will quickly learn to spot a plant that may be invasive, particularly when they begin to dominate the landscape. Look for invasive plants in edge habitats like tree lines, gaps in the canopy, and places where the soil has been disturbed from restoration projects, construction, fire, or flooding. Invasive plants can be trees, shrubs, vines, grasses, or wildflowers. Look for plants that occur in dense patches, or colonies, that appear to be spreading to or from other areas. At some restoration sites there are both a wide variety and a great population of invasive plants. Your chief focus is to identify plants that are within or near the restoration project that may threaten its success, if not controlled. The Pennsylvania Department of Conservation and Natural Resources lists the following general characteristics of invasive plants:

- ✓ They are not native to North America;
- ✓ They spread rapidly, reproducing by roots or shoots;
- ✓ They grow and mature quickly;
- ✓ If spread by seed, they produce numerous seeds that disperse and sprout easily;
- ✓ They can grow in a variety of soil and light conditions; and
- ✓ They are exploiters and colonizers of disturbed ground.

Once you know or suspect you have an invasive plant, you can refer to the *Plant Invaders of Mid-Atlantic Natural Area,* produced by the National Park Service and the US Fish and Wildlife Service (enclosed in your workshop packet), to identify and learn more about the plant. This booklet has pictures and identification tips as well as management methods for most of the invasive plants you are likely to encounter at your site. **Refer to *Maintenance Series #3: Invasive Plant Timeline* included in the Restoration Project Maintenance section of this toolkit for a quick guide to when different invasive plants emerge or flower, often the best time to identify them.**

There are many native look-a-likes out there, so be sure of your identification. It's always easier to spot and identify invasive plants when they are in flower. Take reference pictures of invasives and natives during plant emergence, flower, with leaves, etc. so you can have a library of photos for training your own volunteers. Many other invasive plants (as well as other plant pests) can be identified using the Internet. You may also call The Morris Arboretum of the University of Pennsylvania's free plant identification service, 215-247-5777 ext. 141, which is available 1:00 PM to 3:00 PM, Monday through Friday or drop off a sample at the Arboretum's Widener Visitor Center from 10:00 AM to 4:00 PM, Monday through Friday. Leave a sample of your plant and provide a description of where it was found, your concern, and how they can reach you with an answer.

What Do I Do About Invasive Plants?

The first step when you know or suspect you have an invasive plant is to remember your main objective: to monitor the project over time, not to solve all the problems. Don't panic. We frequently observe invasive plants competing with natives species at restoration projects. The trick is to be watchful, visit your project site regularly, spot them early, and get rid of them before they get entrenched. Complete the appropriate sections of the **Restoration Project Survey** (RPS) on invasive plants. Make sure you complete the **Comments** sections with enough detail so that someone unfamiliar with the project can understand the nature and extent of the invasive plant problem.

Where possible, map the **location** and **extent** of the larger or new invasive plant colonies on your **Project Site Diagram**. Make sure you include easily identified, fixed features (big willow tree, sewer manhole, large rock in stream) to assist in locating the invasive plant colony. This will help your project partners and DRN in control efforts and will also assist in tracking changes over time. If there are large stands or new colonies of invasive plants, you should also document these areas with **photo points**. Make sure a recognizable feature is included in the photograph and that the photo point is labeled on the diagram (see tips for photo points in the **Level 1 Restoration Project Survey** section).

Separate Monitoring from Maintenance Activities

Take time to learn what's happening at and around your project site. Before going out, look over the RPS and make a list of things you want to check. The list might include checking an invasive tree stump to see if it is re-sprouting or a patch of volunteer native flowers to see how it's doing. Make detailed notes about maintenance needs, locations, and potential constraints. For example, the wildflowers next to the bull thistle may not be visible when the maintenance crew sprays herbicide. If you see a vine twining around some of the plantings during a monitoring visit, you can perform some quick maintenance, but be sure to keep good notes on what you did and where you did it.

Which Invasive Plants Are the Biggest Concern?

The answer depends on site conditions, the plant species, extent of plant(s) in question, and the resources available for maintenance. DRN has included some of the "worst" plants to look out for in the RPS, but others, specific to your site, may be of equal or greater threat than those listed. Refer to the Project Maintenance Overview and Internet resources for more information, but in general use the following list to guide your eye during project surveys. Look for:

- ✓ Invasive plants crowding-out or crawling on the installed plants. Native plants need time to get established in order to compete with the invasives.
- ✓ New colonies of invasive plants inside the project site. Removing a few scattered plants is easier than eradicating a well-established colony that has created a seed bank or that has a well-developed and deep root system.
- ✓ Areas where maintenance activities (i.e., disturbance) have been conducted inside the project site and recently disturbed areas adjacent to the project site. Disturbed areas increase the risk for re-invasion by invasive plants that are good colonizers.
- ✓ An invasive plant colony outside of the project site that may spread into the project area by seed (upstream, uphill, upwind) or shoots. **Please respect the rights of adjacent property owners and do not enter or cross private property without permission.**

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Maintenance Series #3
Invasive Plant Timeline

	WINTER		SPRING			SUMMER			FALL			WINTER
	January	February	March	April	May	June	July	August	September	October	November	December
Trees												
Norway Maple			Emergence	Flowering	Fruiting							
Acer platanoides					CHEMICAL: (1, 2)							
			MANUAL: (A, D, E)									
Tree of Heaven				Emergence		Flowering		Fruiting				
Ailanthus altissima							CHEMICAL: (1, 2, 3)					
			MANUAL: (A, D, E)									
Princess Tree					Flowering		Emergence		Fruiting			
Paulownia tomentosa						CHEMICAL: (1, 2)						
			MANUAL: (A, D, E)									
Shrubs												
Japanese Barberry			Emergence	Flowering	Fruiting							
Berberis thunbergii					CHEMICAL: (1, 3, 4)							
			MANUAL: (A) & (D)									
Autumn Olive				Emergence		Flowering		Fruiting				
Elaeagnus umbellata							CHEMICAL: (1, 3)					
	MANUAL: (A, D)											
Winged Euonymus				Emergence	Flowering			Fruiting				
Euonymus alatus						CHEMICAL: (1, 3, 4)						
	MANUAL: (A, D)											
Common Privet				Emergence		Flowering				Fruiting		
Ligustrum vulgare							CHEMICAL: (1, 3, 4)					
	MANUAL: (A, D)											
Bush Honeysuckle			Emergence	Flowering						Fruiting		
Lonicera sp.						CHEMICAL: (1, 3, 4)						
	MANUAL: (A, D)											
Jetbead			Emergence	Flowering					Fruiting			
Rhodotypos scandens						CHEMICAL: (1, 3)						
			MANUAL: (A, D)									
Multiflora Rose				Emergence		Flowering				Fruiting		
Rosa multiflora					CHEMICAL: (1, 3)				CHEMICAL: (1, 3, 4)			
	MANUAL: (A, D)											

	WINTER		SPRING			SUMMER			FALL			WINTER
	January	February	March	April	May	June	July	August	September	October	November	December
Vines												
Fiveleaf Akebia	Evergreen				Flowering				Fruiting			
Akebia Quinata	CHEMICAL: (1, 3, 4)								CHEMICAL: (1, 3, 4)			
	MANUAL: (A, D)				MANUAL: (B, C, F)				MANUAL: (A, B)			
Porcelain Berry			Emergence		Flowering					Fruiting		
Ampelopsis brevipedunculata							CHEMICAL: (1, 3, 4)					
			MANUAL: (A, B, D, F)			MANUAL: (B, C, F)			MANUAL: (A, B, C, F)			
Asiatic Bittersweet			Emergence		Flowering					Fruiting		
Celastrus orbiculatus			CHEMICAL: (1, 3)			CHEMICAL: (1, 3, 4)						
			MANUAL: (A, B, D, F)			MANUAL: (A, B, C)			MANUAL: (A, B, C, F)			
Creeping Euonymus	Evergreen				Flowering						Fruiting	
Euonymus fortunei	CHEMICAL: (1)		CHEMICAL: (1, 3, 4)									
	MANUAL: (A, C, D)											
English Ivy	Evergreen								Flowering		Fruiting	
Hedera helix			CHEMICAL: (1, 3, 4)						CHEMICAL: (1, 3, 4)			
	MANUAL: (A)		MANUAL: (A, B, F)			MANUAL: (B, D, F)			MANUAL: (A, B)		MANUAL: (A)	
Japanese Honeysuckle			Emergence			Flowering				Fruiting		
Lonicera japonica			CHEMICAL: (1, 3, 4)									
			MANUAL: (A, B, D, F)			MANUAL: (A, B, C, F)			MANUAL: (A)			
Mile-a-Minute		Emergence				Flowering			Fruiting			
Polygonum perfoliatum				CHEMICAL: (1, 3, 4)								
		MANUAL: (A, D)										
Periwinkle	Evergreen		Flowering						Fruiting			
Vinca minor		CHEMICAL: (1, 3, 4)										
	MANUAL: (A)		MANUAL: (A, B, F)			MANUAL: (B, C, F)			MANUAL: (A, B)		MANUAL (A)	
Wisteria			Emergence		Flowering				Fruiting			
Wisteria sp.			CHEMICAL: (1, 2, 3)						CHEMICAL: (1, 3, 4)			
			MANUAL: (A, B, D)									

	WINTER		SPRING			SUMMER			FALL			WINTER
	January	February	March	April	May	June	July	August	September	October	November	December
Herbaceous												
Garlic Mustard	Evergreen			Flowering				Fruiting				
Alaria petiolata		CHEMICAL: (3, 4, 5)		CHEMICAL: (3,4)								
	MANUAL: (A)			MANUAL: (A, B, C, F)								
Spotted Knapweed						Emergence		Flowering				Fruiting
Centaurea maculosa								CHEMICAL: (3,4)				
						MANUAL: (F, G)		MANUAL: (A, B, C, D)				
Canada Thistle				Emergence			Flowering					Fruiting
Cirsium arvense				CHEMICAL: (3, 4)								
					MANUAL: (A)		MANUAL: (C, D, F)					
Crown Vetch					Emergence			Flowering				Fruiting
Coronilla varia					CHEM: (3, 4)							
				MANUAL:(F) & (G)			MANUAL: (A)		MANUAL: (B), (C) & (D) (G)			
Common Daylily					Emergence	Flowering	Fruiting					
Hemerocallis fulva						CHEMICAL: (3)& (4)						
					MANUAL: (A)			MANUAL: (B, C, D)				
Purple Loosestrife					Emergence			Flowering				Fruiting
Lythrum salicara							CHEMICAL: (3, 4)					
	MANUAL: (A)						MANUAL: (A, C, D)			MANUAL (A)		
Japanese Stilt Grass					Emergence				Flowering			Fruiting
Microstegium vimineum					CHEMICAL: (3, 4, 5)							
				MANUAL: (G)		MANUAL: (A, B, F)			MANUAL: (B, C, F)		MANUAL: (C)	
Common Reed						Emergence		Flowering		Fruiting		
Phragmites australis								CHEMICAL: (1, 3, 4)				
						MANUAL: (A, B)			MANUAL: (B, C)			
Exotic Bamboos						Emergence			Flowering		Fruiting	
Phyllostachys sp.								CHEMICAL: (1, 3, 4)				
					MANUAL: (B, D)							
Japanese Knotweed			Emergence					Flowering		Fruiting		
Polygonum cuspidatum									CHEMICAL: (1, 3, 4)			
			MANUAL: (A)			MANUAL: (C, D)						
Lesser Celandine			Emergence		Flowering		Fruiting					
Ranunculus ficaria			CHEMICAL: (1, 3, 4)									
			MANUAL: (C)									

Before using the information included in this management timeline

1. Double check control guidelines and time of application as listed in appropriate fact sheets for each plant, management guides, or other scientifically based literature (see websites of the Virginia Native Plant Society, Plant Conservation Alliance, and the Morris Arboretum of the University of Pennsylvania for free invasive plant factsheets).
2. Make sure that the specifics of each control application are understood (e.g., cutting heights, chemical concentrations, timing, etc.)

Emergence	Perennials first emerge through soil, seedlings sprout, and woody plants leaf out. Evergreen plants indicated by shading in late winter.
Flowering	When the plant typically flowers, many invasive species have early and/or extended blooming times. Most Invasives are easier to identify when in flower.
Fruiting	When the plant typically produces fruit or seed. Plants with extended fruiting times indicate prolific seed producers or fruit persistent through winter.
MANUAL	**Manual & Mechanical Methods** *(Methods including cultural controls like planting and prescribed burns are covered elsewhere in guidance)* (A) PULL seedlings, small shrubs, and vines with shallow roots when the soil is moist. Dig out larger root systems. Use a spading fork or weed wrench for small trees and shrubs. Minimize or heal soil disturbance and replant native cover when possible. *(B)* MOW OR CUT BACK at least 3 times per growing season to deplete the underground stores of food. Time cutting to reduce seed formation and remove cuttings flower heads when necessary. Repeat yearly, if necessary, for control or use in combination with chemical methods for eradication. *Note: Mowing can assist in spreading seed of some invasive species if conducted at the wrong time of year. See individual fact sheets for species-specific information.* (C) DEADHEAD flowers by carefully cutting and removing flowers or cut off seed heads before they ripen. For small populations or sensitive areas. Bag cutting and dispose of properly. (D) CUT ABOVEGROUND PORTION of all stems or trunks. The stems should be cut slightly below the ground surface. This includes repeated cutting of sprouts and using techniques like stabbing to sever the root. (E) GIRDLE TREE by cutting through the bark and the cambium all the way around the trunk, about 6 inches from the ground. Girdling is most effective in the spring when the sap is rising or in the fall when the tree begins to send food down to the roots. Repeated cutting of sprouts may be needed. (F) MULCHING/SOLARIZATION are most often considered temporary control methods until a more rigorous form of control can be applied. (G) TILLING is fairly drastic method of control that is appropriate for large infestations where mechanized equipment can be used.
CHEMICAL	**Chemical Control Methods *(These methods should ONLY be used by trained and authorized individuals)*** (1) CUT AND PAINT stem or stump with glyphosate. Use caution in cutting down large trees. Cut and paint re-sprouts. Use caution in applying this method to vines with rootlets, which can transport herbicide to a non-target tree or other plant. (2) GIRDLING or DRILL and SQUIRT. This method is for 3-inch or larger trunks, penetrate into growing layer and squirt only enough glyphosate to fill the hole. (3) PAINT FOLIAGE with glyphosate using an envelope dauber or “bloody” glove method, taking care not to drip on desired plants. (4) FOLIAR SPRAY of glyphosate is appropriate for limited situations such as monoculture infestations that are not near sensitive habitats. (5) PRE-EMERGENT herbicides are appropriate for limited situations such as controlling large seed banks that are not near sensitive habitats.

Maintenance Series #4
Tree Planting Guidance

Modifed from *The International Society of Arboriculture*
http://www.isa-arbor.com/consumer/planting.html

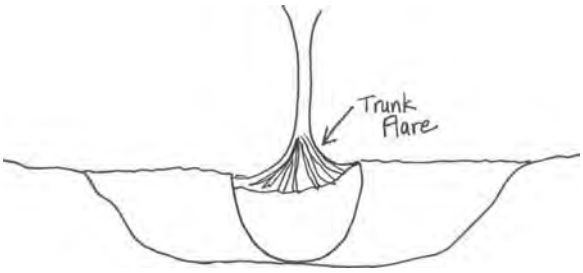
The Best Time To Plant

The ideal time to plant trees and shrubs is during the dormant season -- in the fall after leafdrop or early spring before bud-break. Weather conditions are cool and allow plants to establish roots in the new location before spring rains and summer heat stimulate new top growth. However, trees properly cared for in the nursery or garden center, and given the appropriate care during transport to prevent damage, can be planted throughout the growing season. In either situation, proper handling during planting is essential to ensure a healthy future for new trees and shrubs. **Be sure you have located all underground utilities before you dig.**

If the tree you are planting is balled and burlapped, or bare rooted, it is important to understand that the tree's root system has been reduced by 90% to 95% of its original size during transplanting. As a result of the trauma caused by the digging process, trees will commonly exhibit what is known as **transplant shock** (or TS). Transplant shock is indicated by slow growth and reduced vigor following transplanting. Proper site preparation, coupled with good follow-up care will reduce the amount of time the plant experiences TS and will allow the tree to quickly establish in its new location. **Follow these eight simple steps to significantly reduce the stress placed on plants at the time of planting.**

1. **Dig a shallow, broad planting hole -** Make the hole wide, as much as three times the diameter of the root ball, but only as deep as the root ball. It is important to make the hole wide because the tree roots on the newly establishing tree must push through surrounding soil to establish. On most planting sites in new developments, the existing soils have been compacted and are unsuitable for healthy root growth. Breaking up the soil in a large area around the tree provides the newly emerging roots room to expand into loose soil to hasten establishment.

2. **Identify the trunk flare -** The trunk flare is where the roots spread at the base of the tree. This point should be partially visible after the tree has been planted (see diagram). If the trunk flare is not partially visible, you may have to remove some soil from the top of the root ball. Find it so you can determine how deep the hole needs to be for proper planting.



3. **Place the tree at the proper height -** Before placing the tree in the hole, check to see that the hole has been dug to the proper depth, and no more. The majority of the roots on the newly planted tree will develop in the top 12 inches of soil. If the tree is planted too deep, new roots will have difficulty developing due to a lack of oxygen. **It is better to plant the tree a little high, 1 to 2 inches above the base of the trunk flare, than to plant it at or below the original growing level.** This will allow for some settling. To avoid damage when setting the tree in the hole, always lift the tree by the root ball, and never by the trunk.

4. **Straighten the tree in the hole -** Before you begin backfilling, have someone view the tree from several directions to confirm the tree is straight. Once you begin backfilling, it is difficult to reposition.

5. **Fill the hole, gently but firmly -** Fill the hole about 1/3 full and gently but firmly pack the soil around the base of the root ball. Then, if the tree is balled and burlapped, cut and remove the string and wire from around the trunk and the root ball. Be careful not to damage the trunk or roots in the process. Fill the remainder of the hole, taking care to firmly pack soil to eliminate air pockets that may cause roots to dry out. To avoid this problem, add the soil a few inches at a time and settle with water. Continue this process until the hole is filled and the tree is firmly planted. It is not recommended to apply fertilizer at the time of planting.

6. **Protect the tree, if necessary -** If the tree is grown and dug properly at the nursery, staking for support is not necessary. Studies have shown that trees will establish more quickly and develop stronger trunk and root systems if they are not staked at the time of planting. For restoration projects, protective staking may be required on sites where lawnmower damage, trampling, or deer browse are concerns. If mowing and trampling are concerns, we recommend posting "no mow" signs (see *Maintenance Series #6: Herbivory And Mowing*). If deer herbivory and buck rubs are concerns, we recommend using 4 wooden stakes and fishing line (see also *Maintenance Series #6*).

7. **Mulch the base of the tree -** Mulch is simply organic matter applied to the area at the base of the tree. It acts as a blanket to hold moisture, protect against harsh soil temperatures, both hot and cold, and reduces competition from grass and weeds. Some good choices are leaf litter, pine straw, shredded bark, peat moss, or wood chips. A two to four inch layer is ideal. More than four inches may cause a problem with gas exchange. **When placing mulch, care should be taken so that the actual trunk of the tree is not covered.** This may cause decay of the living bark at the base of the tree. A mulch-free area, one to two inches wide at the base of the tree, is sufficient to avoid moist bark conditions and prevent decay.

8. **Follow-up care -** Keep the soil moist but not soaked; over watering will cause leaves to turn yellow or fall off. Water trees at least once a week, barring rain, and more frequently during hot weather. When the soil is dry below the surface of the mulch, it is time to water. Water at the base of the tree and limit the amount of water that contacts the leaves. Continue until mid-fall, tapering off for lower temperatures that require less frequent watering.

Modified from a fact sheet developed by the International Society of Arboriculture (ISA), a non-profit organization supporting tree care research around the world and dedicated to the care and preservation of shade and ornamental trees.

For further information, contact: ISA, P.O. Box 3129, Champaign, IL 61826-3129, USA.

Tips for Different Planting Materials

Modified from *Treehelp.com*
http://www.treehelp.com/howto/howto-plant-a-tree.asp

Balled and Burlapped Trees

Balled and burlapped trees, although best planted as soon as possible, can be stored for some time as long as the ball is kept moist and the tree is stored in a shady area. The trees should always be lifted by the ball, never by the trunk. The burlap surrounding the ball of earth and roots should either be cut away completely (mandatory, in the case of synthetic or plastic burlap) or at least pulled back from the top third of the ball (in the case of natural burlap). Any string or twine should also be removed.

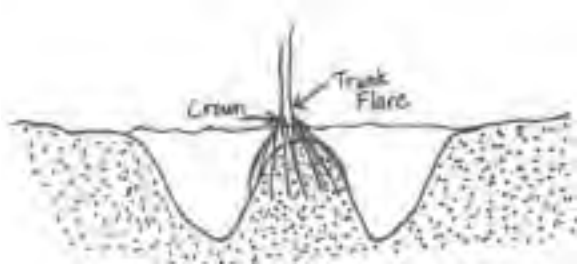
Container Trees

The procedure for planting container trees is similar to that for balled and burlapped trees. In the case of metal or plastic containers, remove the container completely. In the case of fiber containers, tear the sides away. Once the tree is carefully removed from the container, check the roots. If they are tightly compressed, use your finger or a blunt instrument to carefully tease the fine roots away from the tight mass. Loosening the root structure in this way is extremely important in the case of container plants. Failure to do so may result in the roots "girdling" and killing the tree. At the very least, the roots will have difficulty expanding beyond the dimensions of the original container. To further assist this, lightly break up the soil outside the planting zone. This allows roots that quickly move out of the planting zone to be more resilient as they anchor into existing surrounding soils.

Bare-Rooted Trees

When planting bare-rooted trees, the time between purchase and planting is a more critical issue. Plant as soon as possible and when the plan is still dormant. When purchasing bare-rooted trees, inspect the roots to ensure that they are moist and have numerous lengths of fine root hairs. Keep the roots moist in the period between purchase and planting. Prune broken or damaged roots, but save as much of the root structure as you can.

To plant, first build a cone of earth in the center of the hole around which to splay the roots. Make sure that when properly seated on the cone the tree is planted so that the trunk flare is clearly visible and the "crown," where the roots and top meet, is just below the soil surface.



Proper bare-root planting

Remember the best time to plant is during the dormant season - in the fall after leaf drop or early spring before bud break.

Maintenance Series #5
Pole Plantings And Live Stakes

Pole Plantings & Live Stakes are used to re-vegetate eroding streambanks (pole plantings are generally larger than live stakes). These cuttings, often from native willow (*Salix* sp.) or dogwood (*Cornus* sp.), sprout and take root, stabilizing the streambank with a dense matrix of roots. Often incorporated into projects where bioenginerring has occurred, they are relatively cheap and easy to install.

Harvest and Preparation

1. Collect cuttings from a local, native stand that is in a healthy, well-established condition. We recommend plantings from an established restoration project be used for harvesting live stakes. You may also harvest live stakes in areas that are slated for development and destruction. Be sure to ask permission before entering private property. Cuttings should be at least 1/2 inch in diameter or larger, depending upon the species. Larger diameter cuttings have a greater supply of stored energy for rooting than smaller diameter cuttings. Bigger diameter and longer lengths are better suited for severely eroded areas and fluctuating water levels.
2. Cuttings should be collected during the dormant season (winter) to ensure the highest success rate. Cuttings can be collected during the growing season if all the leaves are removed from the stem, although establishment success will be lowered. Spring plantings are generally more successful than fall plantings.
3. Prepare cuttings by trimming off the top to remove the terminal bud. This allows the majority of the energy in the stem to be sent to the lateral buds for rooting and sprouting.
4. The cuttings can be tied into bundles for ease of transportation to the site.
5. Soak the bundles in water for 5 to 7 days. Cutting length is determined by site conditions. Cuttings should extend several inches into the permanent water table to ensure adequate moisture for sprouting. At least one-half to two-thirds of the cutting, at least 2 to 3 feet, should be below ground to prevent it from being ripped out during high flows. It should also be long enough to emerge above adjacent vegetation to prevent it from being shaded out.

Planting and Installation

1. Pole plantings are usually planted with a power auger or a punch bar to create a pilot hole. It is critical to ensure the soil is packed around the cutting to prevent air pockets. "Mudding" (filling the hole with water and then adding soil to make a mud slurry) can remove air pockets.
2. It is often advisable to plant at least two rows of cuttings to cover the range in fluctuating water levels. In most cases, one row can be planted at the low-flow line, and the other at the high-flow line. Offset the rows to get better coverage.
3. When planting, angle the cuttings facing downstream to prevent excess debris from catching.

Additional Considerations

1. Shrub willows are used for planting within channel banks, while willow tree species and cottonwoods are normally planted along the upper bank and floodplain areas.
2. Cuttings should be placed in water immediately following harvesting if they are going to be planted during the next week. Cuttings can also be kept in cold storage (32 to 35° F) for up to 6 months. After removal from cold storage, soak cuttings for 5 to 7 days prior to planting.
3. Replanting will probably be necessary to fill in areas where plantings did not grow. It is not uncommon to have some cuttings die due to highly variable water flows from year to year or from wildlife predation.
4. Flood debris lodged around the cuttings should be removed to prevent shading and to allow growth.

Modified from a fact sheet developed by The USDA-NRCS Plant Materials Center

Maintenance Series #6
Herbivory And Mowing

Deer Browsing

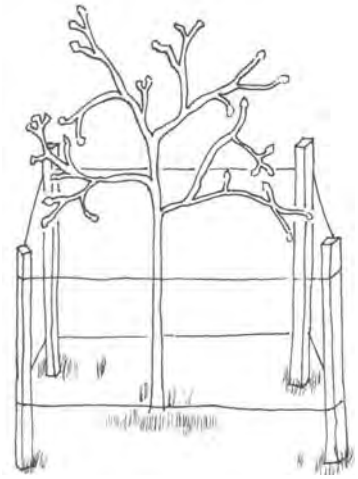
A small group of deer can cause extensive damage to a restored site that offers young, tasty plantings. On average, a healthy adult deer eats from five to ten pounds of vegetation per day. They enjoy the tender branches of young, newly planted trees and shrubs. Most damage is done in late winter and early spring, when other food sources are scarce.

Deer browse is recognizable by the way the deer snap off the smaller, tender branches. A "browse line," branches above a deer's height left untouched, will also be evident. The browse line can reach as high as eight or ten feet.

The plants that deer choose to eat can vary as each plant tastes differently and the availability of other foods is constantly fluctuating. The season, weather, and the deer's nutritional needs also affect their choice of food. The hungrier a deer becomes, the less selective they are. Any plant is at risk to deer browsing.

Breaking deer of established habits can be difficult, therefore preventing damage due to deer requires stopping the behavior before it starts. Once the deer become comfortable with a site, they return and continue their feeding habits. In addition, bucks can girdle larger planted trees by rubbing off the bark with their antlers (buck rub), particularly in the rutting season (fall) when they are in velvet and establishing their territory to advertise their availability to does.

Approaches for preventing or controlling damage due to deer are often limited by budget and means. An effective and economical method for deterring deer is to surround a planting with wooden stakes (we recommend 6-foot stakes) and fishing line. String 10- to 15-pound test fishing line around poles. Pull very taut. The first line should be about waist to chest high off of the ground. A second line should be wrapped around the poles at about knee height (see diagram at right). This type of exclosure will protect larger trees with leaves above the browse line from deer. For smaller trees whose leaves are still within reach, use the same technique, but angle the stakes about 30° and wrap the fishing line around the tree in rows spaced approximately six inches apart. This will protect the leaves and shoots that are still within the browse area of the deer. The deer will stop when they feel the line on their head, chest and legs, but can't see it and don't recognize it as a fence to jump over. This method requires inspection every few months or after a heavy storm. Some project partners have also had success hanging bars of soap as a deer deterrent or using other commercially available deer repellants. Some of these options may need to be re-applied after inclement weather. Structural barriers may need to be added depending on the appetites of the deer.



Deer exclosure to protect trees with leaves and branches above the browse line from buck rub.

Rodent Damage

Rodents, such as mice and rabbits, damage trees and shrubs by chewing the bark off of the trunks or nibbling on the ends of branches. They chew off the bark at ground level or below and can completely girdle a tree, causing it to die. Most of this damage is done during the winter months when a rodent's typical diet of seeds is covered under a blanket of snow. The bark of the young shrubs and trees is a tasty and nutritious alternative for the animals.

Tree guards are effective preventive measures to protect trees and shrubs. **The guards should be installed in the fall and removed in the spring, so as not to hinder the growth of the plant or accumulate organic material that may harm the bark of the tree.** Tree guards can be made of many materials, including aluminum foil, mesh hardware cloth, 1-inch chicken wire or PVC pipe. Chicken wire works well with rabbits, but does not deter mice. The PVC pipe will need to be cut down one side and then wrapped around the base of the tree.

To prevent mice from burrowing beneath the snow line in winter, the tree guard should extend at least 2 1/2 inches below the soil line. The guard also needs to extend 24 to 28 inches above the snow line to prevent damage by rabbits. Keep tree guards free of grass to prevent nesting in the guard.

Natural soaps containing ammonium salts or fatty acids have an unpleasant odor that will discourage munching without harming animals. Commercial repellants that won't harm animals or the tree can be applied to the tree's trunk with a paintbrush. Re-application of repellants after rain may be necessary

Creating a "No Mow" Zone

The lawnmower and weed whip can be deadly foes of newly planted trees and shrubs. Good communication with a restoration site's owner or caretaker is the most effective way to protect plantings. Make an agreement with the site's owner or caretaker to only mow the area once a year (if appropriate for project goals) and to avoid mowing or damaging trees and shrubs. Talking to one or two people isn't always enough because a number of people may share the responsibility of maintaining public places.

DRN has "no-mow" signs available to partners if needed.

Establishing clearly marked "No Mow Zones" will restrict lawn mowers and weed whips, allowing the new plantings as well as the grasses and other plants to grow freely. Posted signs in both English and Spanish should be visible and understandable. The sign could explain the importance of a no mow zone for creating habitat and protecting water sources if space and time allow.

Plantings can also be protected by "flagging" them with brightly colored tape or a stake. Mulching around trees can also help reduce mowing impacts. This eliminates any confusion about whether or not the plant should be there. This may also help to remind the monitor of plantings if the site plan is not available.

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Maintenance Series #7
Volunteer Recruitment And Retention

Volunteer Recruitment

Restoration site maintenance is an activity well suited to volunteers because it provides community members with an opportunity to learn about river systems, experience first-hand river protection efforts, and see improvement overtime. Often volunteer groups are made up of locals, neighbors, or "friends of the park" who are highly trained and effective maintenance partners. If you are interested in organizing such a volunteer group, there are many active volunteer organizations in the region that you can use as a model.

Opportunities to volunteer are numerous, however. How do you find people to work with you? One of the best ways to enlist volunteers to assist you with your project is to advertise. Let people know you are looking for volunteers. Post information around your neighborhood, at your local library, community centers, highs schools, houses of worship and other community gathering places. List your volunteer needs in community calendars in newsletters and on websites. Use local news media to post announcements about volunteer needs or workdays being organized.

Think about others who may share your interest in watershed protection. Consider service organizations, community or youth groups such as scouts, garden clubs, environmental clubs, and even private companies. More and more private and public schools are adding service components to graduation requirements. Some schools have even adopted a restoration project and are helping to plant and maintain the site.

Volunteer Needs

Remember there are many reasons that people want to volunteer at project sites. One of the keys to retaining volunteers is understanding and enhancing the reward each individual gets out of it. Some volunteers are attracted to the educational or recreational aspects of natural areas - they like to know the names of plants, or have the same weed in their yard. Some people volunteer for the opportunity to be outside bird watching, others may be gaining work experience. Teachers may volunteer because they use the site for school field trips. Parents may volunteer simply to have a place where their kids can see a frog or two. Some folks may volunteer to fill service requirements. Tap into the individual motivations for volunteering to understand how you can help to keep the experience rewarding.

Provide clear descriptions of work that needs to be done and give volunteers tasks appropriate to their skills, interests and abilities. Volunteers who aren't into physical labor can contribute by keeping records, making calls, starting a newsletter, and even writing proposals for funding.

Above all, there is an undeniable social aspect of being with like-minded people. Leave time for social interaction at every workday, like a late-lunch. A wise volunteer organizer makes it easy for newcomers to join the group, plans just-for-fun-events, and values every member of the team for their willingness to give their time.

The Keys To Retention

Scheduling workdays each month helps retain volunteers by keeping them involved. Reminder-calls a day or two before the workday are usually appreciated. Make sure there is enough to do, enough tools to go around, and that the activity is appropriate to the size and capabilities of the group. Take before and after pictures and have old ones on hand so that volunteers can see the difference they have made. **Always thank people for their time and effort, send a thank you note if possible.** Some volunteer organizations produce a newsletter to recognize hardworking individuals and keep members up to date on social news.

Volunteer Safety

The safety of volunteers and other site users should always be your primary consideration. Provide potable drinking water, sunscreen and insect repellant. Explain any hazards to volunteers and demonstrate tool safety. Most organizations require that volunteers sign a liability waiver form before allowing them to get their hands dirty. Some maintenance tasks or site improvements are beyond the experience, equipment, and resources of a volunteer organization. This could range from cutting large trees to the application of herbicides. More often than not, these professional services can be provided FREE, if you find the right contractor willing to donate their services.

How To Host A Successful Work Day

Fun is the main ingredient. Be upbeat, and welcome everyone. Here are some tips:

1. Identify target areas, tasks, and equipment needs.
2. Seek out partnerships and volunteers as early as possible.
3. Get permission and notify stakeholders.
4. Be on time, greet everyone, and have a sign-in sheet.
5. Come prepared with tools and refreshments.
6. Provide detailed instruction and demonstration on activity.
7. Develop or provide educational handouts.
8. Allow time for thanking everyone and social interaction.

Free Press And Pictures In The Paper

Most everybody likes to see his or her picture in the paper. Publicity can be a great way to raise awareness and increase support. Peruse print publications for contact information or visit their websites. Call the news desk to find out if they have a reporter who covers the environmental beat.

A press release that announces a volunteer event should answer the "who, what, when, where, and why" questions. Give compelling reasons why this event is important and describe potential photo opportunities. Fax or email the press release at least one week in advance (most newspapers require more time) and call to make sure it was received. If a reporter covers the event as a story, send a thank you note and any information the reporter requested or that you think they may find interesting.

Try, Try Again

Recognize that all volunteer organizations go through cycles of participation levels. Don't get discouraged. Always seek to expand the core group of committed volunteers. Stress your groups' achievements, the importance of each member and don't forget to have fun.

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Maintenance Series #8
Meadows And "No-Mow" Areas

Why Meadow or "No-Mow" Areas (a few good reasons)

- ✓ *Save Money.* It costs an average of $700 per acre per year to maintain a lawn - a wildflower meadow costs $30/acre (*National Wildlife Federation*).
- ✓ *Reduce Air Pollution.* A lawn mower emits 10 to 12 times as much hydrocarbon per hour as a typical car (*National Wildlife Federation*).
- ✓ *Conserve Water.* Thirty percent of water consumed on the East Coast goes to watering lawns. Lawns generate run-off (*Redesigning the American Lawn*).
- ✓ *Improve Water Quality.* More than 70 million pounds of chemical pesticides are applied to lawns in the U.S. each year (*U.S. News and World Report, 10/28/96*).

What are the Site Conditions?

The amount of sunshine, soil moisture, drainage patterns, mowing obstacles and human usage are factors to consider when establishing and maintaining "no-mow" areas, meadows and other buffers. An improperly sited meadow can be very hard to establish. An improperly designed access trail could lead to erosion and bank instability. Meadow and field sites are generally broken down into three types. Pick a native seed mix that is suitable for your site.

1. *Wet Meadows* are usually adjacent to rivers and waterways and are at least seasonally wet or flooded. The soil will contain clay, a high amount of organic matter or saturated sands. Some examples of typical wet meadow & riparian sites are road ditches, retention basins, pond areas, and wetland edges.
2. *Meadow Sites* are characterized by being moderately well drained, silt loam and clay-like fertile soils with moderate organic content. Some examples of meadow sites are floodplain areas, fallow fields, former lawns and park fields.
3. *Upland Sites* are characterized by being dry most of the time, with a thin sandy or shale-like topsoil. They are subject to drought. Some examples of upland sites are naturally rocky soils that have been subject to erosion or steep road cuts and abandoned building/industrial sites.

What are your goals?

Many riparian plantings are designed to stabilize the streambank and provide a natural filter for storm-water runoff and floodwaters. Other functions include enhancing terrestrial and aquatic wildlife habitat by providing food, cover, and nesting sites. Properly designed field plantings can serve multiple purposes and are easier and less costly to maintain than typical lawn. Some municipalities have planted wildflower meadows as "showpieces" adjacent to trail sides or picnic groves.

With your goals in mind, go back to your site, take a hard look at conditions and current usage, and ask yourself where these two are in conflict. For ease of later maintenance, areas should be suitable for mechanized equipment - not too steep or wet, with easy access. Phase in meadow and "no-mow" areas to let people become accustomed to the change and also to learn where access points and activity areas are located. Be flexible, you may want to move a meadow area or provide an area that is managed (cut) for seasonal activities. **Meadows and "no-mow" areas should only be established where invasive plants are under control.** The presence of scattered invasives among desirable native plants requires the use of more labor-intensive management methods.

Siting and Site Preparation

The size and dimensions of the meadow or ”no-mow” area will depend on your goals. A minimum of 70 feet is the target width for most riparian buffers, but you can vary the width to encompass wet areas or provide stream accessibility. Meadows and even “no-mow” areas are occasionally mowed to eliminate woody vegetation or achieve other objectives. Removing obstacles such as stumps, logs, old fencing, and rocks and controlling invasive plants are important first steps for simplifying future maintenance. Consider access points and traffic patterns, and be ready to install temporary or permanent signs and barriers to reduce trampling when the site is getting established.

“No-mow” areas often need the least preparation, perhaps just removal of a few scattered invasives (map them first) and installing durable signs or posts to demark the “no-mow” boundary. Converting fields already covered with cold-season grasses, such as lawn or old pasture, to warm-season grass and wildflower meadows requires removal of sod or control of existing vegetation. Deep-rooted perennials and woody species may require special removal and/or control measures. For larger buffers the primary ways to control existing vegetation is spraying them with glyphosate (Roundup®) or tilling them into the soil.

Tilling is a significant earth disturbance that requires erosion control measures and follow-up inspection and maintenance. When tilling, the soil should be turned to a depth of 2 to 4 inches in lawn areas and 6 inches to 2 feet in old-field or invaded areas dependent on the weed species. Tilling should take place before invasive seeds have set. If deep-rooted invasive plants are present, any exposed roots should be allowed to dry out for at least a week. After tilling, the soil should be cultivated and packed by rolling or tracking to create a firm seedbed as light, fluffy soil will dry out rapidly. Native plants are adapted to poorer soils, so the use of soil amendments such as lime or organic matter are not recommended and may actually encourage weeds or cool-season grasses.

Seeding and Seed Selection

Pick a native seed mix that is suitable for your site conditions and aesthetic goals. For warm-season grasses, ideally plant between March and May, or seed after the first hard frost. Depending on when you plant, you may also add a “nurse” crop of grass seed that will quickly grow and cover the ground, but will not compete later with the your native seed. In some cases, projects include plugs of grasses and wildflowers to quickly establish a more natural appearance. The seeding methods include broadcasting seed by hand or knapsack seeder, hydroseeding, and drill seeding. Hydroseeding and drill seeding require specialized equipment and are not frequently used at project sites.

For broadcast seeding, a rule of thumb is to purchase 10% more seed than you think you need according to the area and seeding rates. Using the suggested seeding amount and rate, proportion your seed to cover parts of the whole planting area. Then divide the seed for each sub-section in half, so you can seed half first in one direction, then the other. Use the extra seed to fill-in any areas that look light. The seed should be raked-in to ensure good seed/soil contact. Just as with the procedure for scattering seed, rake first in one direction, then the other, removing large stones or other debris as you go. Seeding is fairly labor intensive and is a good activity for a volunteer group. On slopes, be sure to cover the area with erosion blankets. On flats, cover the area with a layer of straw mulch or salt hay (caution salt hay can contain seed heads for phragmites, an invasive plant).

No-Mow Maintenance

In the first few months after establishing a no-mow area, it is important to observe how well the desired species are growing as compared to undesirable species. In most cases maintenance of "no-mow" areas entails only maintenance of signs or barriers and an annual mowing or weed whipping to control woody plants. Mowing once per year can keep invasives under control and encourage grass and wildflower species. In some cases, you may need to mow or spot treat more frequently an area where invasives are clustered to prevent them from seeding and to exhaust their root system.

In general, the area should be mowed to a height of no less than 6 inches in early spring, prior to the nesting period at your site. If warm season grasses are desired, never cut more than the top third of a warm season grass. If you desire wildflowers, the cuttings should be removed. Note that most lawn mowers cut too close to the ground, less than 6 inches, and should not be used for meadow management. No matter what the mowing frequency, make sure that all desired trees or shrubs are well marked or protected. A 1-foot length of tree tube or wooden stake is an easy way to visually flag plants and protect their trunks from damage.

Meadow Maintenance

Meadows require a great deal of care and attention during the first three years. After the third year, they more or less take care of themselves. Warm-season or bunch grasses are the dominant plant in most meadows. These grasses have deep roots and are consequently drought resistant and good at holding the soil. Warm-season grasses are so named because they grow from June to August. The following meadow management schedule assumes a spring sowing date, April to May:

- In the **first growing season**, native grasses tend to grow more below the ground to establish their roots. Success in the first season lies in good site preparation, seeding, and a little luck. Not all the seed will germinate in the first growing season. Cut the meadow when it is 12 to 18 inches tall, before weeds go to seed. Removing cut plant material allows the sun to warm the soil, dormant seeds to germinate, and fresh air to circulate around new seedlings. When cutting, you may want to leave an uncut border about 10 feet wide on one side of the meadow to provide habitat for beneficial insects and other wildlife.
- In the **second growing season,** last year's grasses grow very little in height and the dormant seeds germinate and grow. At this point, cool season grasses and other weeds compete vigorously for space. The timing of mowing and spot weed control is critical to the success of the meadow in the second year. Mow one time as close to the ground as possible in early spring and remove the cuttings. This allows the soil to warm more quickly and young native plants to emerge. Do not cut in the summer, unless it's necessary to control weeds, so that wildlife can enjoy your native meadow during the winter.
- In the **third growing season,** if weeds are still abundant, mow the meadow to a height of 6 to 10 inches before the weeds go to seed or when it is 12 to 18 inches tall. You may need to continue to mow more than once a year until cool-season grasses and weeds are under control. After the third year, some land managers recommend burning (by experienced professionals) in the early spring to prevent shrub invasion. Once a meadow of warm-season grasses is well established it does not require frequent mowing, although mowing and raking after the nesting season every 4 to 7 years can remove accumulated growth.

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Restoration Project Maintenance Log

Project Code: _____ **Stewards:** _____

Phone: _____ **E-mail:** _____

Stream/Watershed/Sub-Watershed: _____ **Project Name:** _____

Project Type(s): ❒ Buffer; ❒ Fencing; ❒ Bioengineering; ❒ Basin Retrofit; ❒ Other_____

Invasive Type(s): ❒ Pulling; ❒ Cutting; ❒ Mulching; ❒ Chemical (complete chemical application log); ❒ Other_____

Date	Maintenance Task (size/dimensions)	Equipment/Materials Used	Total Hours	No. of Volun-teers	Observations/Comments

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Chemical Applicator Log

Applicator Name(s)	Applicator Business Address	Phone Number(s)

Describe Prior Site Preparations: _____

Application Methods Used: ❒ Foliar Spray; ❒ Foliar Wipes; ❒ Cut Stem/Stump; ❒ Other _____

Describe Pre-Application Site Conditions: _____

_____

Desired species in the vicinity of the treatment area: _____

_____

Application Location	Application Date/Time	Pesticide(s) Applied	EPA Reg. Numbers	Concentration	Amount Applied	Application Targets/Sites Follow-up Needed

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Diagram of Maintenance Locations

Use this sheet or project plan maps to record information. Show channel, top of bank, wetted edges, flow direction, treated areas, desired species, invasive plants, scale, and photo points.

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Appendix A

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Appendix B

What Is A Riverkeeper?

A Riverkeeper is a full-time, privately funded, non-governmental ombudsperson, whose special responsibility is to be the public advocate for a water body. A Keeper's clients are the river resource and the citizens who fight to protect it.

The Delaware Riverkeeper's job is to advocate for the Delaware River and all of the tributaries and habitats of the watershed. Supported by a committed staff and volunteers, Delaware Riverkeeper Maya K. van Rossum monitors compliance with environmental laws, responds to citizen complaints and need for support, identifies problems that affect the Delaware River Watershed, and responds accordingly. Serving as a living witness to the condition of the ecosystem, the Riverkeeper is an advocate for the people's right to protect and defend the environment.

The Delaware Riverkeeper Network (DRN)

is dedicated to protecting and restoring the Delaware River, its tributaries and habitats. Since 1988, DRN, a nonprofit membership organization and affiliate of the American Littoral Society, has worked throughout the 13,539 square miles of the Delaware River Watershed empowering citizens to take more active roles in protecting the streams and creeks that flow through their neighborhoods. Activities include taking stances on regional and local issues that threaten aquatic ecosystems, organizing and supporting communities working to protect local streams, stream restoration projects, volunteer monitoring, pollution hotlines, an enforcement program, and student intern opportunities.

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On the Web: www.delawareriverkeeper.org

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Interested in Becoming a Member?

❒ Yes, I'd like to become a member of the Delaware Riverkeeper Network.
- ❒ General Membership: $35
- ❒ Family Membership: $50
- ❒ Enclosed is my tax deductible contribution of $_____

With any donation over $100, receive a free Delaware Riverkeeper Network T-shirt

❒ Please charge my **Visa/MasterCard**. Card number_____

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