



FORESTED RIPARIAN BUFFER PLANTING GUIDE FOR LANDOWNERS AND DEVELOPERS



**BRANDYWINE
CONSERVANCY**

*Preserving Our
Land & Water*

www.brandywine.org/conservancy

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FUNDING

Grant funding from organizations like [Treevitalize](#) is sometimes available for the purchase of trees.

Additionally, funding can be available for tree protection and site maintenance. Call or email the **Brandywine Conservancy** contacts at left for information.

ACKNOWLEDGEMENTS

This work follows upon prestigious work focused on the optimal function, form, and composition of riparian buffers completed by Stroud Water Research Center, USDA, PA Conservation Districts, Penn State Extension, and many, many more. Brandywine Conservancy and PALTA are proud to be cooperative partners with so many leaders in the field with a focus on the health of our precious water systems.



The protection of forested riparian buffers often depends on local land use regulations. An increasing number of Pennsylvania townships, boroughs, and cities are enacting regulations to require buffer protection and restoration.

This document is a how-to guide for the planting and maintenance of forested riparian buffers, the most effective and cost-efficient way to protect water quality.

This guide was created to inform each step of the planting project, whether undertaken voluntarily, or in accordance with a municipal riparian buffer ordinance. It can also be used in the creation of a planting and maintenance plan for revegetating an impacted riparian buffer, voluntarily or when required by your municipality.

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RIPARIAN BUFFER PLANTING GUIDE

WHY FORESTED RIPARIAN BUFFERS?

USDA FS <http://nac.unl.edu/documents/workingtrees/brochures/wria.pdf>



**RIPARIAN BUFFERS
ARE IDEALLY FORESTED
LANDS THAT BORDER
STREAMS, RIVERS,
RESERVOIRS,
PONDS, LAKES,
WETLANDS, & OTHER
WATER BODIES.**



<https://allianceforthebay.org/2014/05/chesapeake-riparian-forest-buffer-leadership-summit/>

FORESTED RIPARIAN BUFFERS
are essential for healthy streams
that are sources of drinking water.
They are the most *cost-effective* way
to:

filter excess nutrients, sediment,
and pesticides from runoff,

improve the safety and reliability
of the water supply,

reduce water treatment costs,

stabilize stream banks,

reduce flooding,

maintain ideal water temperature
for aquatic animals,

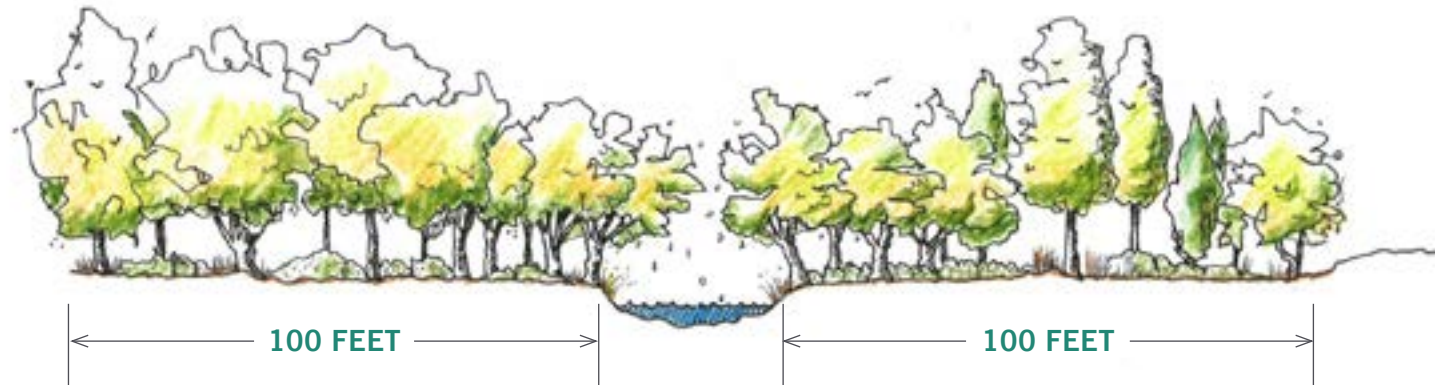
protect native plant species and
provide habitat for wildlife,

absorb and store carbon from the air,

feed streams with organic matter
essential for bottom dwelling organisms,

and help conserve scenic and
recreation areas.

WHAT DOES A FORESTED RIPARIAN BUFFER PROTECTED BY A LOCAL ORDINANCE LOOK LIKE?



A cross-section illustration of a forested riparian buffer from PALTA's model overlay district.

The publication, [Riparian Buffer Protection via Local Government Regulation, A Guide and Model Ordinance for Pennsylvania Municipalities](#), authored by the Brandywine Conservancy on behalf of the Pennsylvania Land Trust Association (PALTA), includes a model riparian buffer protection overlay district suitable for municipal zoning ordinances. A forested riparian buffer that is required by this model overlay district is defined as (see illustration above):

“An area that begins at each edge of a water body and extends landward a minimum width of one hundred (100) feet. This area is to be measured horizontally on a line perpendicular to the nearest edge of the water body. Where a floodplain extends greater than one hundred (100) feet from the water body, the riparian buffer area extends to the outer edge of this defined 100-year floodplain.”

According to the model overlay district, the regulated riparian buffer is to be continually maintained with a diverse mix of locally adapted native species of canopy trees, understory trees, shrubs, and herbaceous plants that provide a minimum of sixty (60) percent uniform canopy coverage. Uses of land within this forested buffer are limited, and include stream restoration projects, stream crossings for farm vehicles, natural trails, and docks, and other “low-impact” uses (see model ordinance for complete listing). Also permitted within the outer fifty (50) feet of the buffer, but subject to special municipal approval, are paved trails, stormwater outfalls and conveyance structures, and up to twenty (20) percent land clearing or disturbance for uses permitted by the zoning.

Where existing buffers do not yield the sixty (60) percent canopy coverage, the model overlay district requires their restoration to be the full one

hundred (100) feet. The model overlay district includes planting standards for restoration purposes. A planting and maintenance plan is a required submittal of applicants seeking municipal approvals (building or zoning permits, conditional use, special exception, variance applications, subdivision or land development approvals).

The actual width of a forested riparian buffer when required by a municipal ordinance may be wider or narrower than that of the PALTA model. Additionally, streams designated by Pennsylvania's Department of Environmental Protection as Special Protection Waters, may require wider buffers. Consult your municipality for any established forested riparian buffer requirements.

For landowners voluntarily reforesting buffers, a forested buffer of at least 100 feet in width is the best practice determined by research¹ to maintain or improve water quality.

¹ http://www.stroudcenter.org/about/pdfs/Sweeney2014-JAWRA-StreamsideBufferWidth_LiteratureReview.pdf

HOW TO PREPARE THE SITE

SITE PREPARATION

The first step in riparian buffer establishment is site preparation. Preparation of a site requires removal of all invasive vegetation (list on [page 7](#)) to reduce competition for new native trees and shrubs. Site preparation includes mowing, cutting, and herbicide application. Always use aquatic-safe herbicides and heed instructions and warnings on herbicide labels. For large projects, hire a licensed professional to apply herbicide (see [Appendix 2](#) contractor list and [Appendix 3](#) herbicide resource list). As bare ground and soil disturbance² lead to erosion and invasive seed germination, mow invasive ground cover down to a low or lawn height, but *do not remove it entirely* from the site. For sites with large invasive populations, allow sufficient time for site preparation (i.e., a growing season). Site preparation techniques vary, as follows, depending on prior land use and current site conditions.

Grassy fields with few woody plants:

Mow site. Cut and remove any large woody invasives ([page 7](#)) and apply concentrated glyphosate herbicide to the cut stems.

Sites with many invasive shrubs & vines but only a few seedlings/saplings:

Eradicate invasive shrubs and vines ([page 7](#)) which will compete with the future sapling plantings. First, use a brush hog to cut out as much invasive vegetation as possible. Then apply glyphosate herbicide with either a backpack sprayer or a boom sprayer. Cut and remove any large woody invasives and apply concentrated glyphosate to the cut stems. Retain any native species ([Appendix 1](#)).



Brush hogs quickly and effectively mow invasive grasses, small shrubs, and small vines.

<http://i.ytimg.com/vi/QHnzBHFh-So/maxresdefault.jpg>



Cut stem method of herbicide application.

<https://greenshootsnews.files.wordpress.com/2012/09/cut-stumpapplication.jpg>

Sites with very young saplings and fewer invasive shrubs & vines:

You may find a few pioneer species (*see box at right for definition*) at your site prior to buffer establishment. Native pioneer species (*list at right*) should be retained during reforestation. Here, the goal is to preserve pioneer species and fill in around them with new plantings. Retain saplings of any species listed in [Appendix 1](#) (Species to Plant) or the list at right. Retained saplings begin desired canopy closure at crown heights of 12-20ft. Remove invasive and noxious saplings ([page 7](#)) by cutting trunks with a chainsaw, then coating the cut stumps with concentrated glyphosate. Remove all invasive shrubs and vines from your site in the manner previously described.

² Earth disturbance of an area greater than one acre requires an National Pollutant Discharge Elimination System (NPDES) Permit. Contact your local Conservation District with questions.

WHAT ARE PIONEER SPECIES:

Pioneer species are the plants which take hold first in a riparian area. They are generally sun-loving and short-lived, so pioneer species will not generally persist as dominant riparian buffer species. However, many should be retained because they do act as a “quick fix” in a riparian area—providing shade, bank stability, filtration, habitat, and food while slower-growing climax vegetation (the species which will ultimately compose your riparian buffer) have a chance to take hold.

NATIVE PIONEER SPECIES THAT SHOULD BE RETAINED

- Smooth/Hazel Alder (*Alnus serrulata*)
- Fringetree (*Chionanthus virginicus*)
- Fothergilla (*Fothergilla major*)
- Black Ash (*Fraxinus nigra*)
- Carolina Silverbell (*Halesia carolinia*)
- Snowbell (*Styrax americanus*)
- American Elm (*Ulmus Americana*)
- Slippery Elm (*Ulmus rubra*)

REMOVE INVASIVE PLANTS AND STATE LISTED NOXIOUS WEEDS IN PENNSYLVANIA

INVASIVE PLANT ERADICATION

When preparing and maintaining your forested riparian buffer site, eradicate the species listed below and never introduce them while planting. For additional photos to help identify these noxious and invasive plants, see the [Pennsylvania Field Guide Common Invasive Plants in Riparian Areas](#).

TREES

Norway Maple (*Acer platanoides*)
 Tree of Heaven (*Ailanthus altissima*)
 Sawtooth Oak (*Quercus acutissima*)
 Princess Tree (*Paulownia tomentosa*)
 Mimosa (*Albizia julibrissin*)
 Siberian Elm (*Ulmus pumila*)
 Ornamental Flowering Pear (*Pyrus calleryana*)
 White Mulberry (*Morus alba*)

SHRUBS

Goatsrue (*Galega officinalis*)
 Bush Honeysuckles (*genus Diervilla*)
 Japanese Spirea (*Spiraea japonica*)
 Privet (*genus Ligustrum*)
 Giant Hogweed (*Heracleum mantegazzianum*)
 Burning Bush (*Euonymus alatus*)
 Barberry (*Berberis vulgaris*)
 Autumn Olive (*Elaeagnus umbellata*)
 Russian Olive (*Elaeagnus angustifolia*)
 Multiflora Rose (*Rosa multiflora*)

GROUND COVERS

Crown Vetch (*Securigera varia*)
 Ajuga (*genus Ajuga*)
 Bamboo (*tribe Bambusoideae*)



Ornamental Flowering Pear
https://en.wikipedia.org/wiki/Pyrus_calleryana



Tree-of-Heaven (*Ailanthus*)
 Bargeron, University of Georgia, Bugwood.org



Mile-a-Minute
 Mehrhoff, University of Connecticut, Bugwood.org



Winged Euonymus (Burning Bush)
 Miller, USDA Forest Service, Bugwood.org



Japanese Hop
<https://gobotany.newenglandwild.org/species/humulus/japonicus/>



Common Reed (*Phragmites*)



Multiflora Rose
 Miller, USDA Forest Service, Bugwood.org



Oriental Bittersweet
 Evans, Illinois Wildlife Action Plan, Bugwood.org

FLOWERS

Purple Loosestrife (*Lythrum salicaria*)
 Japanese Knotweed (*Fallopia japonica*)
 Lesser Celandine (*Ranunculus ficaria*)
 Canada Thistle (*Cirsium arvense*)
 Bull or Spear Thistle (*Cirsium vulgare*)
 Musk or Nodding Thistle (*Carduus nutans*)
 Jimsonweed (*Datura stramonium*)

VINES

Japanese/Chinese Wisteria (*genus Wisteria*)
 Oriental Bittersweet (*Celastrus orbiculatus*)
 Porcelain Berry (*Ampelopsis brevipedunculata*)
 English Ivy (*Hedera helix*)
 Wintercreeper (*Euonymus fortunei*)

Vinca Periwinkle (*Vinca major & minor*)
 Mile-a-Minute (*genus Polygonum*)
 Trumpet Creeper (*Campsis radicans*)
 Kudzu (*Pueraria lobata*)
 Japanese Hops (*Humulus japonicas*)
 Japanese Honeysuckle (*Lonicera japonica*)

GRASSES

Japanese Silver Grass (*Miscanthus sinensis*)
 Pampas Grass (*Saccharum ravennae*)
 Reed Canary Grass (*Phalaris australis*)
 Common Reed (*Phragmites*)
 Shattercane (*Sorghum bicolor*)

HOW TO SELECT AND SOURCE MATERIALS

River Birch is suitable for wet soil conditions, located within the inner 50 feet of a 100-foot riparian buffer—nearest the water body.



www.eyota.govoffice.com

White Pine is suitable for dryer soil conditions, located within the outer 50 feet of a 100-foot riparian buffer.



Dr. Green Thumb Identification (<http://www.treeplantflowerid.com/Pinus-parviflora.php>)

LOCATION	TREE CHARACTERISTICS	EXAMPLES
Inner 50 Feet of Buffer Nearest Water Body:	Must provide shade and organic matter to stream Must be flood tolerant Should be deciduous	Red maple
		River birch
		Sycamore
Outer 50 Feet of Buffer:	Must be moderately flood tolerant Can be deciduous or coniferous	White oak
		White pine
		Black cherry
		Sugar maple

The next step in riparian buffer establishment is the selection of plants—appropriate to your objectives and site conditions—and plant protection to ensure high survival rates.

PLANT SELECTION

Plant selection relies on a combination of many factors and objectives. The main objective of your planting is water quality improvement. Secondary objectives may include improved wildlife habitat, privacy screening, fall color diversity, or special features such as nut or fruit production. Consider these additional objectives when selecting plants.

The vegetation in the outer 50 feet should slow and disperse any concentrated flow as it approaches the inner 50 feet of the buffer and ultimately the body of water. The 100-foot model riparian buffer may consist of different tree and shrub species. The plants closest to the water body must be flood tolerant and ideally, deciduous. See the chart at left for a small selection of suggested species per location.

Evaluate site conditions, as these will dictate which plants are most appropriate. An initial way to identify species that will flourish on your property is to observe the native species that already grow there and on similar sites nearby. Then get to know your soil, as soil drainage is an important factor in plant selection. Consult an online soil survey, such as the [Web Soil Survey](#) for a basic understanding of your area’s soil type (contact the [PA Natural Resources Conservation Service](#) for interpretation help).

Developers and those establishing very large forested riparian buffers should hire a soil consultant and conduct a [soil test](#) to better understand pH and fertility (available at [county offices of Penn State Extension](#) and online). Project managers and landowners can conduct simple tests to evaluate soil.

Determine your soil texture by squeezing a damp handful of soil into a ball. Balls of sandy soil break when even slight pressure is applied. Balls of loam change shape easily and may crumble a bit under



<http://gastromomica.net/2012/05/12/seed-balls/>

pressure. Clayey soils feel sticky, resist breaking, and can be molded easily. Learn an advanced version of this test at [soil-quality.org](#).

Test your soil’s drainage by digging a hole with a volume of one cubic foot. Fill it with water, then refill it once it drains. If the water takes more than



<http://www.walterreeves.com/landscaping/soil-percolation-rate/>

24 hours to drain from the hole the second time, your soil likely has poor drainage. If this is the case, select flood tolerant or very flood tolerant species.

HOW TO SELECT AND SOURCE MATERIALS




SELECTING NATIVE PLANTS

Why plant native species? Native tree species support natural ecosystems by providing habitat and food for birds, mammals, and insects. Dr. Douglas Tallamy, wildlife ecologist and researcher on the impact of alien plants on native ecosystems, found that Pennsylvania native plant species support over four times the insect biomass commonly found on non-native species. This is because both terrestrial and aquatic insects coevolved with native plants, developing mouthparts that are only able to feed on specific native leaves and flowers. For more information about native plantings, see *Landscaping with Native Plants in the Middle Atlantic Region* by Elizabeth N. du Pont in collaboration with the Brandywine Conservancy, [Native Plants for Wildlife Habitat and Conservation Landscaping: Chesapeake Bay Watershed](#) by the U.S. Fish & Wildlife Service, and [Bringing Nature Home](#) by Dr. Douglas Tallamy.

For a list of native tree species to plant, including preferred site conditions, see [Appendix 1](#), page 15. For a list of shrubs, forbs, ferns, grasses, groundcovers, and additional trees to plant in your riparian buffer, see Table 7-1 of the [Chesapeake Bay Riparian Handbook](#).

CHOOSING STOCK TYPE

Stock refers to the specific age and packaging of young trees for purchase. For riparian reforestation projects, year-old seedlings are generally the best choice, followed by 2- or 3-year-old seedlings for smaller-scale projects. There are pros and cons associated with each stock choice.

STOCK TYPE	PROS	CONS
 <p>Bare Root</p>	<p>Cheapest option</p> <p>Easy to transport to stream</p>	<p>Often needs staking</p> <p>Roots can dry out</p>
 <p>Container</p>	<p>Comes in a range of sizes</p> <p>Leaves root system in tact</p>	<p>Roots hard to inspect</p> <p>Can be expensive</p> <p>Discontinuity between potting mix and site soil</p>
 <p>Balled & Burlapped</p>	<p>Can be large and generate instant impact</p> <p>Roots have best chance of survival</p>	<p>Heavy</p> <p>Expensive</p> <p>Requires lots of moisture maintenance</p>

TREE PROTECTION OPTIONS

Some form of tree protection is essential to sapling survival, as unprotected plantings in Pennsylvania succumb to the intense deer browse and buck rub. According to [Sweeney and Czapka](#) (2004), on average, tree shelters increase tree survival by 39% and increase growth by 300%. Alternatives to the plastic tube-style shelters pictured throughout this guide include 5-foot-high mesh tubes, most often selected in areas prone to flooding, and 8-foot-high perimeter [fencing](#), which can be a cost-effective option for large reforestation projects. Visit this [Penn State Extension webpage](#) for more about tree protection.

ESTIMATING COSTS

The following figures may be helpful when estimating the cost of your project. For budgeting purposes, a 100-foot buffer on a 100-foot linear stream length would require approximately 121 trees (calculated using 10-foot center spacing of trees within the 10,000-square-foot area). A probable cost for 121 plants, stakes, and tree tubes—using 2015 pricing—would be approximately \$1,200. For labor estimates, a healthy person can plant 8 to 10 trees per hour by themselves (not including the time to lay out the site in a 10-foot grid). The aforementioned 10,000-square-foot buffer would take a single person 12 hours to plant—not including project layout (for more on laying out the site see [page 10](#)).

See [page 2](#) for information about funding resources for reforestation projects.

PLANNING THE PLANTING

There are many contractors that can help with your reforestation project; see [Appendix 2](#) for a list of local planting contractors. Whether you will be planting the riparian buffer yourself or using a contractor, the steps are the same.

WHEN TO PLANT

Determine the best time to plant based on your goals, site conditions, and plant selection.

	SPRING	FALL
PROS:	long growing season and usually plenty of precipitation	moderate to cool temperatures are gentle on plantings and encourage root growth
CONS:	excessive rain fall or a shortened season can damage plantings	shorter growing season
	SPRING	FALL
EVERGREEN TIMING SUGGESTION:	plant later (before full extension of new growth)	plant earlier (after summer heat has fallen)
DECIDUOUS TIMING SUGGESTION:	plant earlier (before bud break)	plant later (after leaf drop)



Trees planted in rows for accessibility by mower.

BEGIN BY LAYING OUT THE SITE

Determine the plant spacing and density goals for your reforestation project. Recommended planting density is more than 350 trees per acre. Your municipality's riparian buffer ordinance may require a

different minimum planting density. Mowing is recommended to minimize competition for water and light, control invasives, and prevent rodent damage. If you plan to mow your site ([page 13](#)), plant trees in rows far enough apart for the mower to fit between. Use the chart below to find your maximum planting density based on the width of your mower. Otherwise, random spacing of trees and shrubs can create a natural forest effect but will require hand work to maintain.

SPACING (FEET)	TREES PER ACRE
9 x 9:	538
10 x 10:	435
11 x 11:	360
12 x 12:	302
13 x 13:	258

HOW TO PLANT (USING 1-YEAR OLD TREE SEEDLINGS)



1 Using a sharp shovel, dig a hole about 8-10 inches wide and as deep as the tree's root mass.



2 Save the soil (and sod) that you remove from the hole. This will be used to backfill around the tree. Use shovel to cut and loosen the soil from the sod.



3 Gently free the tree from its pot. Squeezing the pot helps to separate the root mass from the pot.



4 Place the tree in the hole, making sure it is planted at the correct depth (the soil from the pot should be level with or slightly above the ground

level). A tree planted too low will die, and a tree planted too high will dry out.

5 Now backfill around the tree while holding it upright. You can include some grass placed upside down at the bottom of your hole— it will provide the tree with extra nutrients.

6 Gently firm the soil around the tree with your foot, being careful not to damage the tree.



7 When using tree shelters, as is highly recommended, place a 5-foot-tall shelter over the tree, making sure to try

to preserve the natural shape of the branches (best done with a partner). Be sure to place the shelter flare-side-up, as shown in photo.

Steps 8 and 9 are specific to the plastic tube shelters pictured. Installation techniques vary for mesh shelters; check manufacturers' instructions.



8 Sink the tree shelter about an inch into the soil (this will help prevent damage to the tree from rodents).

Twisting the shelter in a cutting motion can help achieve this.



9 Slip the stake through both zip ties (already attached to plastic tubes) and pound, using a mallet or hammer, until only 1 - 2 inches of the stake are above the top zip tie (soil conditions permitting).

Tighten the zip ties. The stake should prohibit any major shelter movement.

10 Consider tying colored ribbons or flags to the tree shelter for visibility during maintenance.

11 If desired, slide a bird net onto the shelter so that half of the net's length is on the shelter and the other half extends above. Bird nets should be removed just prior to the tree exiting the tube.

HOW TO MAINTAIN YOUR BUFFER PLANTING

Continued maintenance of your riparian planting will greatly increase the survival rate of your trees. The most common causes of tree failure include rodent damage, invasive species competition, and flooding. Preventing these hazards and correcting any recent damage can save your riparian planting investment. See [Appendix 2](#) for a list of local maintenance contractors.

THE FIRST FIVE YEARS

ALL SEASONS

Shelter and Stakes Maintenance: Proper maintenance of shelters and stakes can help prevent damage to trees by rodents, deer, herbicides, and mowers or weed-whackers. Ensure tree shelters are upright, straight, and that the bottom edge is pressed one inch into the ground to prevent rodent entry. Check stakes for cracks, curves, and rot.



For other types of tree protection, maintain according to manufacturer's instructions. Be sure to remove any bird nets from protective tubes where trees will exit the tube that season. Cautiously remove any insect nests from trees or shelters.

A method of protecting trees from deer rub once trees have outgrown plastic tube shelters.

Tree shelters are made of #5 plastic (polypropylene). Check with your local refuse/recycling provider for recycling options.

LATE WINTER

Shelter Removal (Years 3, 4, 5): Shelter removal¹ can prevent rot, disease, and trunk girdling. Remove shelters when trees measure 1.5 to 2.5 inches in diameter at top of shelter. Avoid removing shelters too early, as deer rub their antlers on 1- or 2-inch-diameter trees and cause girdling (see photo left). Take steps to minimize damage to trees by herbivores, herbicides, and string trimmers before removing tree shelters from young trees.



<http://www.serratedtussock.com/?q=content/spot-spraying>

SPRING

Broad-Spectrum

Herbicide Application

(Years 1-4): Application of herbicide, a vital step in riparian reforestation success, keeps plant competition at bay, reduces the risk of rodent damage, and greatly increases tree survival and growth rates (Sweeney, Czapka, and Petrow 2007). However,

herbicide application near waterways is controversial, as aquatic organisms are very sensitive to herbicides and pesticides. We recommend herbicide use in forested riparian buffer establishment because the long-term ecological benefits of a healthy, functioning buffer outweigh the potential short-term harm herbicides may cause to aquatic organisms. After leaves have emerged in the spring, small landowners can apply glyphosate in a 3-foot radius around the base of sheltered trees

(alternatively, if trees are planted in a row, apply a 6-foot-wide strip of glyphosate centered on the line of seedlings). Landowners or developers with large areas to plant should hire a licensed professional to apply herbicide in the same fashion (a pre-emergent may also be included in the mix). Because riparian areas are sensitive ecosystems, always use aquatic-safe glyphosate and heed all instructions and warnings on labels. See [Appendix 3](#) for herbicide application resources.

SUMMER

Selective Herbicide Spot-Application (Years 1-5):

To control persistent woody invasive and noxious weeds (list on [page 7](#)), landowners with smaller-scale projects should cut undesirable stems near the ground and paint the surface of the stump with concentrated glyphosate (this technique is known as the cut stem treatment). For larger projects or more serious cases of woody invasives, landowners or developers should hire a licensed professional ([Appendix 2](#)) to perform spot application of a selective herbicide (for example, in the basal bark technique). Always use aquatic-safe herbicides and heed all instructions and warnings on labels. See [Appendix 3](#) for herbicide application resources.



Cut Stem Treatment
Natural Areas Notebook (<https://oaklandnaturalareas.files.wordpress.com/2014/11/imgp4285.jpg>)



Basal Bark Treatment
<http://www.thesanguineroor.com/?p=170>

HOW TO MAINTAIN YOUR BUFFER PLANTING

Mowing (Years 2-3): Combine herbicide use with mowing during the first 2-3 years. Be sure to mow before undesirable plants set seed. Mowing suppresses the growth of vegetation around the saplings, freeing up sunlight, water, and nutrients for the saplings to use. To allow for spontaneous growth of native trees from seeds stored in the seedbank and dropped by birds, reduce mowing frequency once planted saplings reach a height of 15 feet and begin canopy closure. Continue woody invasive removal once mowing is reduced.

LATE SUMMER/EARLY FALL

Broad-spectrum Herbicide Application and Vole Suppression (Years 1-4): During the winter, voles nest in tree tubes and gnaw trees. Reducing groundcover deprives voles of hiding places, making them vulnerable to predation. To suppress vole populations in this way, apply another round of glyphosate around tree shelters in early fall ([Appendix 3](#)). Always use aquatic-safe herbicides and heed all instructions and warnings on herbicide labels. Large site landowners and developers should hire a licensed professional to apply herbicide. If vole damage is persistent and severe, a small amount of rodenticide may be applied by a professional.



Damage from voles can be fatal to young trees
Next-Door Nature (<http://nextdoornature.org/tag/vole/>)

BRANDYWINE CONSERVANCY



A mowed tree planting.

ALL SEASONS RESPONDING TO CHALLENGES

Replanting Due To Seedling Failure (Years 2-3 Likely): Replant if tree survival rate falls below 70% or density falls below 250 trees/acre. Replanting can occur in either fall (using containerized seedlings) or spring (using containerized seedlings or bare root stock). Before replanting, address the initial cause of seedling failure. Common causes include vole damage (visible as girdling at the base of seedlings), excessive vegetative competition (usually vines that crowd seedlings within shelters), and improper shelter maintenance (fallen shelters or shelters not sunk into soil).

Floods (Years 1-4): After a flood, check for and correct damage to tree structures and stakes.

HERBICIDE-FREE PLANTING MAINTENANCE

While the use of herbicides is generally accepted as the most effective way to maintain a newly planted buffer, those wishing to limit the use of herbicides can mulch and mow to control and remove competitive vegetation instead.

Mulching: Site preparation is critically important, as mulching is most effective when the ground is nearly free of actively growing vegetation. Mulch can be either organic (wood chips, hardwood mulch, coconut fiber mats, or grass clippings) or inorganic (landscape/weed fabric squares). Apply mulch in a circular fashion at the base of the tree to a diameter of 18-36". Mulch must be kept away from tree trunks; mulch touching the trunk promotes decay. Organic mulches will need to be reapplied every couple years and after any flood event. Inorganic mulches should be secured to the ground with fabric staples and be removed once the tree planting is established.

Mowing: Another method of herbicide free maintenance, used in conjunction with mulch or as a stand-alone technique, is mowing. If mowing will be the primary maintenance method, be sure to design the planting to allow passage of the mower deck between all individual trees. Since the goal is to remove all competitive vegetation, mowing in both directions is recommended. Mowing can damage young trees and/or their protective tubes, so extra care is needed. When mowing a mulched planting, be sure to set the mower deck height to not interfere with the mulch. A recently planted site may need mowing several times over the course of the growing season. It is important to mow before undesirable plants set seed and also in late summer/fall to remove cover for voles. The use of weed whackers is not recommended, as they can quickly cut through the protective tubes causing considerable damage to the young trees.

MAINTENANCE

ONGOING MAINTENANCE & MONITORING

MAINTENANCE AFTER FIVE YEARS

By the time a planting is five years old, the trees should stand roughly 10-15 feet tall (size will vary based on species); the canopy will likely not yet be fully closed. Any mortality should be evenly distributed and not exceed 20-25%. It is important to backfill any patches of significant mortality with new plantings, as consistent shade discourages invasive growth. After the first five years of maintenance, supplement your canopy tree planting with understory plantings such as native small trees, shrubs (see table below), grasses, and forbs. Also, watch for and address any invasive resurgence.

APPROPRIATE SHRUBS TO SUPPLEMENT YOUR ESTABLISHED CANOPY TREE PLANTING

- Serviceberry (*Amelanchier Canadensis*)
- Alleghany serviceberry (*Amelanchier laevis*)
- Sweet pepperbush (*Clethra alnifolia*)
- Silky dogwood (*Cornus amomum*)
- Red osier dogwood (*Cornus sericea*)
- Winterberry (*Ilex verticillata*)
- Spicebush (*Lindera benzoin*)
- Red chokeberry (*Photinia pyrifolia*)
- Arrowwood (*Viburnum dentatum*)

Just as with young trees, shrubs should be protected from excessive deer browse. In many cases, 4-5' high mesh cages measuring 18-24" in diameter and held with 1" oak stakes will provide both protection and room for the shrub to grow.

Monitoring the Success of Your Project

After planting and maintaining your forested riparian buffer for the first five years, you may enjoy gathering feedback on the success of your project through a monitoring program.

MEASURES OF SUCCESS TO MONITOR INCLUDE:

degree of establishment of planted vegetation— *the goal is to have established diverse non-invasive vegetation*

amount of tree or shrub cover— *the goal is at least 60%*

changes in water quality— *the goal is to have cooler water temperatures with more oxygen present and to observe less algae and aquatic plants, while seeing an increase in woody debris and/or leaf packs*

changes in bank stability— *the goal is to observe less visible erosion*

changes in stream channel morphology— *the goal is to observe a widening and shallowing of the stream channel and a greater amount of coarser rocks in the stream bed*

wildlife population estimates and habitat use measurements— *the goal is to observe more diversity and abundance of both visiting and resident wildlife*



APPENDIX 1: SUGGESTED SPECIES TO PLANT

Tree	pH	Flood Tolerance	Shade Tolerance	Short-Lived (may need replacement)	Height	Pioneer Species
Boxelder (<i>Acer negundo</i>)	4.0-7.0	very tolerant	tolerant		understory	yes
Red Maple (<i>Acer rubrum</i>)	5.5-7.0	tolerant	tolerant		canopy	
Silver Maple (<i>Acer saccharinum</i>)	4.0-6.5	tolerant	intermediate	yes	canopy	
Sugar Maple (<i>Acer saccharum</i>)	4.0-7.0	intolerant	very tolerant		canopy	
Pawpaw (<i>Asimina triloba</i>)	5.0-7.0	intolerant	tolerant	yes	understory	
Sweet Birch (<i>Betula lenta</i>)	5.0-7.0	intolerant	intermediate		canopy	
River Birch (<i>Betula nigra</i>)	4.5-7.5	tolerant	intolerant		canopy	
Gray Birch (<i>Betula populifolia</i>)	5.0-6.5	intolerant	intolerant	yes	understory	
American Hornbeam (<i>Carpinus caroliniana</i>)	4.0-7.5	tolerant	very tolerant	yes	understory	
Hackberry (<i>Celtis occidentalis</i>)	6.0-8.0	intermediate	intermediate		canopy	
Eastern Redbud (<i>Cercis Canadensis</i>)	4.5-7.0	intolerant	tolerant	yes	understory	
Alternate Leaf Dogwood (<i>Cornus alternifolia</i>)	5.0-7.0	very tolerant	intermediate		understory	
American Holly (<i>Ilex opaca</i>)	<6.8	intolerant	tolerant		understory	
Eastern Red Cedar (<i>Juniperus virginiana</i>)	6.8-7.2	intolerant	intermediate		understory	yes
Sweetgum (<i>Liquidambar styraciflua</i>)	4.0-7.0	very tolerant	very intolerant		canopy	
Tulip Poplar (<i>Liriodendron tulipifera</i>)	4.5-6.5	intermediate	intermediate		canopy	
Black Gum (<i>Nyssa sylvatica</i>)	4.5-6.0	intermediate	intolerant		canopy	
White Pine (<i>Pinus strobus</i>)	<6.8	intolerant	intermediate		canopy	
American Sycamore (<i>Platanus occidentalis</i>)	5.0-6.5	intermediate	intermediate		canopy	
American Plum (<i>Prunus americana</i>)	5.5-7.5	intolerant	intolerant	yes	understory	
Black Cherry (<i>Prunus serotina</i>)	5.0-7.5	very intolerant	intolerant		canopy	yes
White Oak (<i>Quercus alba</i>)	4.5-7.0	intolerant	intermediate		canopy	
Swamp White Oak (<i>Quercus bicolor</i>)	4.5-6.5	tolerant	intermediate		canopy	
Chestnut Oak (<i>Quercus montana</i>)	4.5-7.0	intolerant	intermediate		canopy	
Pin Oak (<i>Quercus palustris</i>)	4.5-6.5	tolerant	intolerant		canopy	
Willow Oak (<i>Quercus phellos</i>)	4.5-5.5	tolerant	intolerant		canopy	
Black Locust (<i>Robinia pseudoacacia</i>)	4.5-8.0	tolerant	intolerant		canopy	yes
Black Willow (<i>Salix nigra</i>)	5.0-8.0	very tolerant	very intolerant	yes	canopy	
Sassafras (<i>Sassafras albidum</i>)	6.0-7.0	intolerant	intolerant		understory	yes
Basswood (<i>Tilia Americana</i>)	4.5-7.5	intolerant	tolerant		canopy	

APPENDIX 2: SOURCING AND CONTRACTORS



Basswood
<http://thewalpolean.org/2014/07/27/distant-hill-gardens-8214/comment-page-1/>



American Sycamore
<http://davesgarden.com/guides/pf/showimage/185754/>



Red Maple
<http://www.florafinder.com/Species/Acer.php>



Alternate Leaved Dogwood
 Bargeron, University of Georgia, Bugwood.org



Black Locust, a pioneer species
<http://greenskydesigns.com/weed-of-the-week-9-black-locust-robinia-pseudo-acacia-fabaceae>



Mockingbird eating hackberries
<http://www.birderslounge.com/2008/06/northern-mocking-bird-a-beautiful-singer/mocking-bird-hackberry-1a-we/>

Inclusion on this list does not imply a recommendation. Consider choosing a nursery that supplies phenotypes local to your property.

PLANT SOURCING IN PA

Berks County

Sugarbush Nursery
 4272 Morgantown Rd., Mohnton, PA 19540
 Phone: (610) 856-0998
www.sugarbushnursery.com

Bucks County

American Native Nursery (Archewild)
 2191 Hillcrest Rd, Quakertown, PA 18951
 Phone: (855) 752-6862
 Email: contact@archewild.com
<http://archewild.com/>

Gino's Nursery and Landscaping
 2237 Second Street Pike
 Newtown, PA 18940
 Phone: (315) 598-3992
<http://www.ginosnursery.com/contact.html>

Northeast Natives & Perennials
 1716 E Sawmill Rd., Quakertown, PA 18951
 Phone: (215) 901-5552
www.nenativesandperennials.com

Chester County

Arbor Glen Nurseries
 500 Gum Tree Road, Cochranville, PA 1933
 Phone: (610) 857-9810
<http://www.arborglennnurseries.com/>

Natural Landscapes Nursery (Wholesale only)
 354 North Jennersville Road, West Grove, PA 19390
 Phone: (610) 869-3788
<http://www.naturallandscapesnursery.com>

Chester County (continued)

North Creek Nurseries
(Specializes in native perennials, grasses, ferns and shrubs in plug form. Available wholesale only, so work with your landscaper. An especially good source for meadow restoration and/or rain garden installation.)
 124 Wedgewood Road, Oxford, PA 19363
 388 North Creek Road, Landenberg, PA 19350
 Phone: (610) 255-0100
<http://www.northcreeknurseries.com/>

R-P Nurseries
 649 Unionville Road, Kennett Square, PA 19348
 Phone: (610) 444-1116
 Fax: (610) 444-6476
<http://www.rpnurseries.com/>

Ticklewood Nursery
 270 Baker Road, Cochranville, PA 19330
 Phone: (610) 869-8086
 Fax: (610) 869-8654
<http://www.ticklewoodnursery.com/>

Water Cress Farms Nursery
 190 Woodcrest Road, West Grove, PA 19390
 Phone: (610) 869-3883
 Email: info@wdwells.com
<http://www.watercrestfarmsnursery.com/>

Yellow Springs Farm Native Plants Nursery
 1165 Yellow Springs Rd., Chester Springs, PA 19425
 Phone: (610) 827-2014
<http://www.yellowspringsfarm.com/>
 (Hours by appointment only; orders can be made online)

Delaware County

Redbud Native Plant Nursery
 643 West Baltimore Ave, Media, PA 19063
 Phone: (610) 892-2833
<http://www.redbudnativeplantnursery.com/>

APPENDIX 2: SOURCING AND CONTRACTORS

Lancaster County

Go Native Tree Farm
Nursery: 678 S Chiques Rd
Office: 2310 Chestnut View Dr
Manheim, PA 17545
Lancaster, PA 17603
Phone: (717) 399-0195
Email: gonative@voicenet.com
<http://www.gonativetrees.com/>

Groff's Plant Farm
6128 Street Road, Kirkwood, PA 17536
Phone: (717) 529-3001
[groffsplantfarm.com](http://www.groffsplantfarm.com)

Octoraro Native Plant Nursery
(Wholesale only)
6126 Street Road, Kirkwood, PA 17536
Phone: (717) 529-3160
<https://www.octoraro.com/>

Lehigh County

Edge of the Woods Native Plant Nursery
2415 Route 100, Orefield, PA 18069
Phone: (610) 395-2570
<http://www.edgeofthewoodsnursery.com/>

York County

Mid Atlantic Native Plants
(Wholesale only)
12506 Susquehanna Trail South
New Freedom, PA 17349
Phone: (717) 227-0924
https://midatlanticnatives.com/Native_Plants_.html

Sylva Native Nursery & Seed Company
3815 Roser Road, Glen Rock, PA 17327
Phone: (717) 227-0484
Email: sylvanat@aol.com
<http://www.sylvanative.com/index.htm>

OUT OF STATE PLANT SOURCING

Gateway Garden Center
7277 Lancaster Pike, Hockessin, DE 19707
Phone: (302) 239-2727
gatewaygardens.com

Pinelands Nursery & Supply
(Wholesale only)
323 Island Rd, Columbus, NJ 08022
Phone: (609) 291-9486
Email: sales@pinelandsnursery.com
<http://www.pinelandsnursery.com/p/home-page.html>

CONTRACTORS FOR TREE INSTALLATION

Applied Ecological Services
Ben Wollman
Phone: (607) 592-1684
<http://www.appliedeco.com/>

LandStudies, Inc
315 North Street, Lititz, PA 17543
Jimmy Kreider or Mark Gutshall
Phone: (717) 627-4440
www.landstudies.com

Red Tail Restoration & Land Management
Greg Gagliano: redtailrestoration@yahoo.com
Phone: (203) 556-7385
<http://www.redtailrestore.com/>

Teti Farms / Bill Teti
486 Chesterville Road, Landenberg, PA 19350
Phone: (610)-888-8848
Email: tetifarm@verizon.net

MAINTENANCE CONTRACTORS

All Seasons Landscaping
3915 Market St, Upper Chichester, PA 19014
Steve Gansz
Phone: 610-494-8050

Applied Ecological Services
Ben Wollman
Phone: (607) 592-1684
<http://www.appliedeco.com/>

Cotswold Gardens, Inc
176 Woodview Road, West Grove, PA 19390
Lori Hollis: cotswoldgardensinc@verizon.net
Phone: (610) 345-1076
<http://www.cotswoldgardensinc.com/>

GreenWeaver Landscapes, LLC
Gregory Nichols: greg@green-weaver.com
Phone: (610) 772-1837; (610)-358-8900
www.green-weaver.com

LandStudies, Inc
315 North Street, Lititz, PA 17543
Jimmy Kreider or Mark Gutshall
Phone: (717) 627-4440
www.landstudies.com

Red Tail Restoration
Greg Gagliano: redtailrestoration@yahoo.com
Phone: (203)-556-7385
<http://www.redtailrestore.com/>

Teti Farms / Bill Teti
486 Chesterville Road, Landenberg, PA 19350
Phone: (610)-888-8848
Email: tetifarm@verizon.net

Weeds, Inc.
250 Bodley Road, Aston, PA 19014
Phone: (610) 358-9430
<http://www.weedsinc.com/>

APPENDIX 3: HERBICIDE APPLICATION RESOURCES

Ferrell, Jason, Ken Langeland, and Brent Sellers. "Herbicide Application Techniques for Woody Plant Control." University of Florida IFAS Extension. 2012. <http://edis.ifas.ufl.edu/ag245>

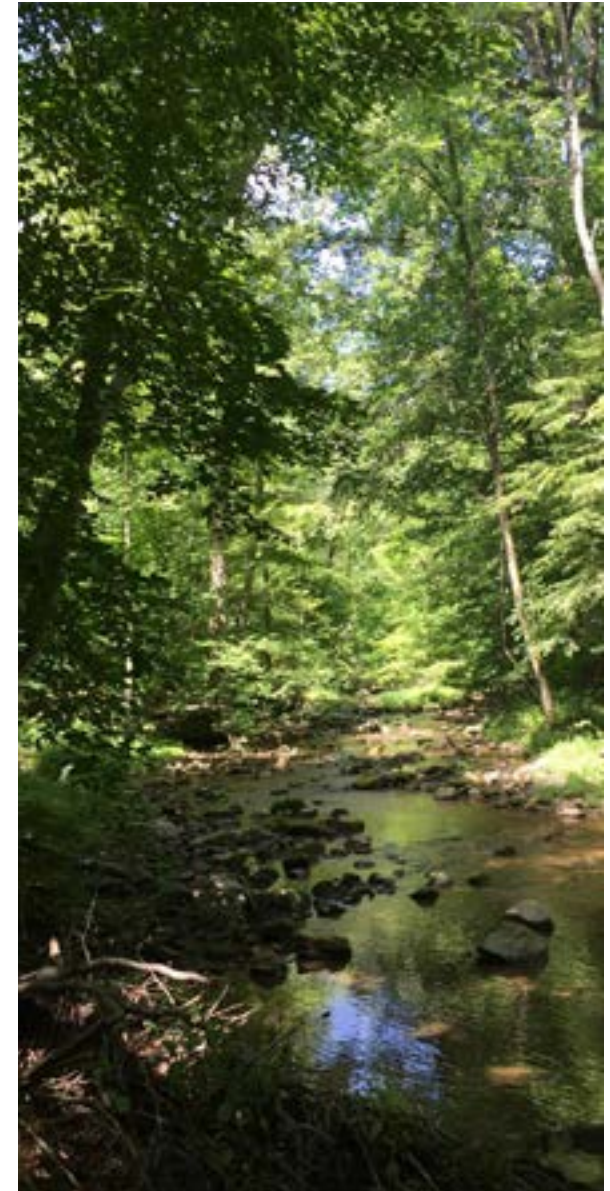
Glyphosate Facts. Industry Task Force on Glyphosate. 2013. <http://www.glyphosate.eu/>

Herbicide Application Handbook: A guide to proper handling and application of Monsanto herbicides. Monsanto. 2008. [http://www.monsanto.com/site-collectiondocuments/ito/2009%20herbicide%20handbook%20\(2\).pdf](http://www.monsanto.com/site-collectiondocuments/ito/2009%20herbicide%20handbook%20(2).pdf)

Lingenfelter, Dwight D. and Nathan L. Hartwig. "Safe Herbicide Use." Penn State Extension. <http://extension.psu.edu/pests/weeds/control/introduction-to-weeds-and-herbicides/safe-herbicide-use>

Langeland, K.A. "Safe Use of Glyphosate-containing Products in Aquatic and Upland Natural Areas." Agronomy Department, Center for Aquatic and Invasive Plants, Florida Cooperative Extension Service. February 2009. <http://edis.ifas.ufl.edu/ag248>

Pauly, Doon. "Quick Guide to Glyphosate Products—Frequently Asked Questions." Alberta Agriculture and Forestry. 2015. [http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/faq8069](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/faq8069)



APPENDIX 4: REFERENCE DOCUMENTS

The following documents and webpages were referenced in writing this guide, and can be used by landowners and developers to find more information about forested riparian buffer establishment and maintenance.

- “A Guide to Riparian Tree Planting in Southwest Oregon.” M. Bennett and G. Ahrens. September 2007. <http://www.oregon.gov/oweb/docs/pubs/ripariantreereplantingguide.pdf>
- A Homeowner’s Guide to Stormwater Management. Philadelphia Office of Watersheds. January 2006. http://www.phillywatersheds.org/doc/Homeowners_Guide_Stormwater_Management.pdf
- “All about soil.” The Morton Arboretum. 2015. <http://www.mortonarb.org/trees-plants/tree-and-plant-advice/horticulture-care/all-about-soil>
- “Best Management Practices for Control of Non-Native Invasive.” Montgomery County Department of Parks Park Planning and Resource Stewardship Division, Natural Resources Stewardship Section. April 2009. http://www.montgomeryparks.org/PPSD/Natural_Resources_Stewardship/Veg_Management/documents/nni-best_mngmnt_practices-april09.pdf
- “Brush and Tree Removal”. Pleasant Valley Conservancy. <http://pleasantvalleyconservancy.org/brushandtrees.html>
- “Developing a Monitoring Program for Riparian Revegetation Projects.” University of California Division of Agriculture and Natural Resources. May 2009. <http://anrcatalog.ucdavis.edu/pdf/8363.pdf>
- “Guidebook for Riparian Corridor Conservation.” Montgomery County, Pennsylvania. <http://www.montcopa.org/DocumentCenter/View/4122>
- “Fall Planting of Trees and Shrubs.” The Morton Arboretum. <http://www.mortonarb.org/trees-plants/tree-and-plant-advice/horticulture-care/fall-planting-trees-and-shrubs>

- “Forest Finance 2: Fencing for Forest Regeneration: Does It Pay?” Penn State Extension. <http://extension.psu.edu/natural-resources/forests/finance/forest-tax-info/publications/forest-finance-2-fencing-for-forest-regeneration-does-it-pay>
- “Forest Finance 7: Tree Shelters: A Multipurpose Forest Management Tool.” Penn State Extension. <http://extension.psu.edu/natural-resources/forests/finance/forest-tax-info/publications/tree-shelters>
- “Forest Landowners Guide to Tree Planting Success.” Penn State Extension. <http://goo.gl/kAVZC8>
- “Landowner Guide to Buffer Success.” USDA Farm Service Agency et al. <http://www.creppa.org/pdf/landowner%20guide%20revised%2030oct07.pdf>
- Native Plants for Wildlife Habitat and Conservation Landscaping: Chesapeake Bay Watershed. U.S. Fish & Wildlife Service. 2003. <http://www.nps.gov/plants/pubs/chesapeake/pdf/chesapeakenatives.pdf>
- Pennsylvania Field Guide: Common Invasive Plants in Riparian Areas. <http://goo.gl/XDWAFE>
- Pennsylvania Stormwater Best Management Practices Manual. Pennsylvania Department of Environmental Protection. June 18, 2008. <http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-8305>
- “Planning to Purchase a Tree.” Vermont Urban & Community Forestry Program. http://fpr.vermont.gov/sites/fpr/files/Forest_and_Forestry/Community_Forests_and_Trees/Library/Planning%20to%20Purchase%20a%20Tree.pdf
- “Riparian Buffer Brochure.” Stroud Water Research Center. October 2007. http://www.stroudcenter.org/research/projects/StroudPreserve/StroudPreserve-BufferBrochure_Oct2007.pdf

- “Riparian Buffer Protection via Local Regulation: a Guide and Model Ordinance for Pennsylvania Municipalities.” Pennsylvania Land Trust Association & Brandywine Conservancy. June 2014. <http://conservationtools.org/guides/show/119-Riparian-Buffer-Protection-via-Local-Government-Regulation>
- “Riparian Forest Buffer Design and Maintenance.” The Maryland Department of Natural Resources Forest Service. http://www.chesapeakebay.net/publications/title/riparian_forest_buffer_design_and_maintenance
- “Riparian Forest Buffer Guidance.” Pennsylvania Department of Environmental Protection. November 24, 2010. <http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-10767>
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- Sweeney, Bernard W. (Stroud Water Research Center) and Stephen J. Czapka (USDA Forest Service). “Riparian forest restoration: why each site needs an ecological prescription.” February, 2004. Forest Ecology and Management 192: 361-373. http://www.stroudcenter.org/about/pdfs/bs_Sweeney_Czapka2004.pdf
- Sweeney, Bernard W., Stephen J. Czapka, & L. Carol A. Petrow. “How Planting Method, Weed Abatement, and Herbivory Affect Afforestation Success.” 2007. South. J. Appl. For. 31 (2).



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