

Text of the Final Guidelines

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[New sections added to [Appendix C to Part 1191 – Architectural Barriers Act: Scoping](#)]

ABA CHAPTER 1: APPLICATION AND ADMINISTRATION

F106.5 Defined Terms

Boards. Boards include, but are not limited to, wood, plastic, metal, and composite products.

Camp Shelter. A partially enclosed structure that provides campers and hikers cover from weather and that does not contain plumbing fixtures or kitchen appliances. Camp shelters are not transient lodging facilities or residential dwelling units.

Camping Facility. A site, or portion of a site, developed for outdoor recreational purposes that contains camping units.

Camping Unit. An outdoor space in a camping facility used for camping that contains outdoor constructed features, parking spaces for recreational vehicles or other vehicles, tent pads or tent platforms, or camp shelters.

Outdoor Constructed Features. Picnic tables, fire rings, grills, fireplaces, wood stoves, trash and recycling receptacles, water hydrants, utility and sewage hookups, outdoor rinsing showers, benches, and viewing scopes provided at outdoor recreation facilities.

Picnic Facility. A site, or portion of a site, developed for outdoor recreational purposes that contains picnic units.

Picnic Unit. An outdoor space in a picnic facility used for picnicking that contains outdoor constructed features.

Trail. A pedestrian route developed primarily for outdoor recreational purposes. A pedestrian route developed primarily to connect elements, spaces, or facilities within a site is not a trail.

Trailhead. An outdoor space that is designated by an entity responsible for administering or maintaining a trail to serve as an access point to the trail. The junction of two or more trails or the undeveloped junction of a trail and a road is not a trailhead.

Viewing Area. An outdoor space developed for viewing landscapes, wildlife, or other points of interest.

ABA CHAPTER 2: SCOPING REQUIREMENTS

F201.4 Requirements Apply to Facilities Constructed or Altered by or on Behalf of Federal Agencies. The requirements in F216.13, F244 through F248, and 1011 through 1019 shall apply only to facilities constructed or altered by federal agencies or by non-federal entities on federal land on behalf of federal agencies pursuant to a concession contract, partnership agreement, or similar arrangement.

F201.4.1 Documentation and Notification When Exceptions Used for Trails and Beach Access Routes.

Federal agencies shall document the basis for not fully complying with a specific provision in 1017 or 1018 on a portion of a trail or beach access route based on Exception 1 in 1017 or Exception 1 in 1018, and shall maintain the documentation with the records for the trail or beach project. Federal agencies shall notify the Access Board if an entire trail is exempted from complying with 1017 based on Exception 2 in 1017.1, and if a beach access route is not provided based on Exception 2 in 1018.1.

Advisory F201.4.1 Documentation and Notification When Exceptions Used for Trails and Beach Access Routes. Forms for notifying the Access Board if an entire trail is exempted from complying with 1017 based on Exception 2 in 1017.1, and if a beach access route is not provided based on Exception 2 in 1018.1 are available at: www.access-board.gov.

F202.3 Alterations. * * * * *

EXCEPTIONS: * * * * *

4. Where elements or spaces are altered in camping facilities, picnic facilities, viewing areas, or trailheads and the circulation path to the altered element or space is not altered, the circulation path shall not be required to comply with 1016.

F202.4 Alterations Affecting Primary Function Areas. * * * * *

EXCEPTIONS: * * * * *

2. Camping facilities, picnic facilities, viewing areas, trailheads, trails, and beach access routes shall not be required to comply with F202.4.

F206.1 General. * * * * *

EXCEPTIONS: 1. Accessible routes shall not be required where outdoor recreation access routes are provided at camping facilities in accordance with F244.5, picnic facilities in accordance with F245.4, viewing areas in accordance with F246.3, or trailheads in accordance with F247.3.2.

2. Accessible routes shall not be required where camping facilities, picnic facilities, viewing areas, or outdoor constructed features are provided on trails.

3. Accessible routes shall not be required where beach access routes are provided in accordance with F248.

F212.3 Sinks. * * * * *

EXCEPTIONS: * * * * *

2. In camping facilities and picnic facilities, sinks shall not be required to comply with F212.3 where a cooktop or conventional range is not provided.

F213.1 General. * * * * *

EXCEPTION: Pit toilets provided on trails and in camping facilities shall not be required to comply with F213.

Advisory F213.1 General. A pit toilet is a primitive outhouse consisting of a toilet riser over a hole dug into the ground or receptacle to receive and naturally decompose human waste.

F216.13 Trailhead Signs. Where new trail information signs are provided at trailheads on newly constructed or altered trails designed for use by hikers or pedestrians, the signs shall comply with 1017.10.

Advisory F216.13 Trailhead Signs. New trail information signs are required to comply with 1017.10 regardless of whether the newly constructed or altered trails comply with 1017. If trail information signs designate the name of the trail, only the name of the trail is required to comply with 703.5. See F216.2. Tactile characters are not required on exterior signs. Trail information signs are not required to display the International Symbol of Accessibility.

F244 Camping Facilities

F244.1 General. Camping facilities, other than camping facilities on trails, shall comply with F244.

Advisory F244.1 General. Camping facilities on trails are addressed in F247.4.1.

F244.2 Camping Units with Mobility Features. Camping facilities shall provide camping units with mobility features complying with F244.2 in accordance with Table F244.2. Where a camping facility provides different types of camping units, Table F244.2 shall apply to each type of camping unit provided.

Table F244.2 Camping Units with Mobility Features

Total Number of Camping Units Provided in Camping Facility	Minimum Number of Camping Units with Mobility Features Required
1	1
2 to 25	2
26 to 50	3
51 to 75	4
76 to 100	5
101 to 150	7
151 to 200	8
201 and over	8, plus 2 percent of the number over 200

Advisory F244.2 Camping Units with Mobility Features. Camping units for recreational vehicles only, camping units for tent camping only, and camping units with camp shelters are different types of camping units.

Camping units with mobility features are not required to be identified by signs. Entities should provide information on the location of camping units with mobility features on websites, in brochures, and at bulletin boards or information kiosks at the camping facility. Where entities operate reservation systems for camping units or assign camping units upon arrival, entities should establish policies to ensure that camping units with mobility features are available for individuals with disabilities until all the camping units are occupied.

F244.2.1 Alterations and Additions. Where camping units are altered or added, the requirements of F244.2 shall apply only to the camping units that are altered or added until the number of camping units with mobility features complies with the minimum number required in Table 244.2.

EXCEPTION: Where an entity is implementing a transition plan for program accessibility developed pursuant to regulations issued under section 504 of the Rehabilitation Act that designates specific camping units to provide mobility features complying with F244.2, the entity shall not be required to comply with F244.2 when altering individual elements within camping units that are not designated to provide mobility features complying with F244.2.

Advisory F244.2.1 Alterations and Additions Exception. When all the elements within a camping unit are altered, the altered camping unit is required to comply with F244.2 unless the minimum number of camping units with mobility features required in Table 244.2 is provided.

F244.2.2 Dispersion. Camping units required to provide mobility features complying with F244.2 shall provide choices of camping units comparable to, and integrated with, those available to others.

F244.2.3 Elements Within Camping Units with Mobility Features. Elements within camping units required to provide mobility features shall comply with F244.2.3.

F244.2.3.1 Outdoor Constructed Features. Where provided, at least one of each type of outdoor constructed features shall comply with 1011. Where more than one of the same type of outdoor constructed features is provided, at least two of the same type of outdoor constructed features shall comply with 1011.

F244.2.3.2 Parking Spaces. Where provided, parking spaces shall comply with F244.2.3.2.

F244.2.3.2.1 Recreational Vehicles. Where parking spaces are provided for recreational vehicles, at least one parking space shall comply with 1012.2, 1012.4, and 1012.5. Where more than one parking space is provided for recreational vehicles, at least two parking spaces shall comply with 1012.2, 1012.4, and 1012.5.

F244.2.3.2.2 Vehicles Other Than Recreational Vehicles. Where parking spaces are provided for vehicles other than recreational vehicles, at least one parking space shall comply with 1012.3, 1012.4, and 1012.5. Where more than one parking space is provided for a vehicle other than a recreational vehicle, at least two parking spaces shall comply with 1012.3, 1012.4, and 1012.5.

F244.2.3.3 Tent Pads and Tent Platforms. Where provided, at least one tent pad and tent platform shall comply with 1013. Where more than one tent pad and tent platform is provided, at least two tent pads and tent platforms shall comply with 1013.

F244.2.3.4 Camp Shelters. Where provided, at least one camp shelter shall comply with 1014. Where more than one camp shelter is provided, at least two camp shelters shall comply with 1014.

F244.3 Outdoor Constructed Features in Common Use and Public Use Areas. Where provided in common use and public use areas that serve camping units with mobility features, at least 20 percent, but not less than one, of each type of outdoor constructed feature provided at each location shall comply with 1011.

F244.4 Pull-up Spaces for Recreational Vehicles at Dump Stations. Where provided, pull-up spaces for recreational vehicles at dump stations shall comply with 1012.2, 1012.4, and 1012.5.

F244.5 Outdoor Recreation Access Routes. Camping facilities shall provide outdoor recreation access routes complying with 1016 in accordance with F244.5.

Advisory F244.5 Outdoor Recreation Access Routes. In alterations to existing camping facilities, there are exceptions in 1016.1 that can be used where conditions specified in 1019 apply.

F244.5.1 Routes Within Camping Units with Mobility Features. At least one outdoor recreation access route shall connect accessible elements, spaces, and facilities provided within camping units with mobility features.

F244.5.2 Routes to and Within Common Use and Public Use Areas. Common use and public use areas serving camping units with mobility features shall provide outdoor recreation access routes in accordance with F244.5.2.

EXCEPTION: Outdoor recreation access routes shall not be required to connect camping units with mobility features and recreational vehicle dump stations where a pull-up space complying with 1012.2, 1012.4, and 1012.5 is provided at the dump station for recreational vehicles.

F244.5.2.1 Routes to Common Use and Public Use Areas. At least one outdoor recreation access route shall connect each camping unit with mobility features with common use and public use areas serving the unit.

F244.5.2.2 Routes Within Common Use and Public Use Areas. At least one outdoor recreation access route shall connect accessible elements, spaces, and facilities provided within common use and public use areas serving camping units with mobility features.

F244.5.3 Routes to Adjacent Recreation Facilities. Where a circulation path connects camping facilities and adjacent recreation facilities, at least one outdoor recreation access route shall connect camping units with mobility features to an accessible route serving the adjacent recreation facilities.

Advisory F244.5.3 Routes to Adjacent Recreation Facilities. F244.5.3 does not modify the accessible route requirements in F206 that apply to recreation facilities.

F244.5.4 Location. Outdoor recreation access routes required by F244.5.2 and F244.5.3 shall coincide with or be located in the same area as general circulation paths.

Advisory F244.5.4 Location. Where a vehicular way serves as the general circulation path for pedestrians at a camping facility, the outdoor recreation access route can be provided within the vehicular way.

F245 Picnic Facilities

F245.1 General. Picnic facilities, other than picnic facilities on trails, shall comply with F245.

Advisory F245.1 General. Picnic facilities on trails are addressed in F247.4.2.

F245.2 Picnic Units with Mobility Features. Picnic facilities shall provide picnic units with mobility features in accordance with F245.2.

Advisory F245.2 Picnic Units with Mobility Features. Picnic units with mobility features are not required to be identified by signs. Entities should provide information on the location of picnic units with mobility features on websites, in brochures, and at bulletin boards or information kiosks at the picnic facility.

F245.2.1 Picnic Facilities with Two or Fewer Picnic Units. Where picnic facilities contain two or fewer picnic units, each picnic unit shall provide mobility features complying with F245.2.

F245.2.2 Picnic Facilities with More Than Two Picnic Units. Where picnic facilities contain more than two picnic units, at least 20 percent, but not less than two, of the picnic units shall provide mobility features complying with F245.2.

F245.2.3 Alterations and Additions. Where picnic units are altered or added, the requirements of F245.2 shall apply only to the picnic units that are altered or added until the number of picnic units with mobility features complies with the minimum number required in F245.2.1 or F245.2.2.

EXCEPTION: Where an entity is implementing a transition plan for program accessibility developed pursuant to regulations issued under section 504 of the Rehabilitation Act that designates specific picnic units to provide mobility features complying with F245.2, the entity shall not be required to comply with F245.2 when altering individual elements within picnic units that are not designated to provide mobility features complying with F245.2.

Advisory F245.2.3 Alterations and Additions Exception. When all the elements within a picnic unit are altered, the altered picnic unit is required to comply with F245.2 unless the minimum number of picnic units with mobility features required in F245.2.1 or F245.2.2 is provided.

F245.2.4 Dispersion. Picnic units required to provide mobility features complying with F245.2 shall provide choices of picnic units comparable to, and integrated with, those available to others.

F245.2.5 Elements Within Picnic Units with Mobility Features. Elements within picnic units required to provide mobility features shall comply with F245.2.5.

F245.2.5.1 Outdoor Constructed Features. Where provided, at least one of each type of outdoor constructed feature shall comply with 1011. Where more than one of the same type of outdoor constructed feature is provided, at least two of the same type of outdoor constructed features shall comply with 1011.

F245.2.5.2 Parking Spaces. Where provided, at least one parking space shall comply with 1012.3, 1012.4, and 1012.5. Where more than one parking space is provided, at least two parking spaces shall comply with 1012.3, 1012.4, and 1012.5.

F245.3 Outdoor Constructed Features in Common Use and Public Use Areas. Where provided in common use and public use areas that serve picnic units with mobility features, at least 20 percent, but not less than one, of each type of outdoor constructed feature provided at each location shall comply with 1011.

F245.4 Outdoor Recreation Access Routes. Picnic facilities shall provide outdoor recreation access routes complying with 1016 in accordance with F245.4.

Advisory F245.4. Outdoor Recreation Access Routes. In alterations to existing picnic facilities, there are exceptions in 1016.1 that can be used where conditions specified in 1019 apply.

F245.4.1 Routes Within Picnic Units with Mobility Features. At least one outdoor recreation access route shall connect accessible elements, spaces, and facilities provided within picnic units with mobility features.

F245.4.2 Routes to and Within Common Use and Public Use Areas. Common use and public use areas serving picnic units with mobility features shall provide outdoor recreation access routes in accordance with F245.4.2.

F245.4.2.1 Routes to Common Use and Public Use Areas. At least one outdoor recreation access route shall connect each picnic unit with mobility features with common use and public use areas serving that unit.

F245.4.2.2 Routes Within Common Use and Public Use Areas. At least one outdoor recreation access route shall connect accessible elements, spaces, and facilities provided within common use and public use areas serving picnic units with mobility features.

F245.4.3 Routes to Adjacent Recreation Facilities. Where a circulation path connects picnic facilities and adjacent recreation facilities, at least one outdoor recreation access route shall connect picnic units with mobility features to an accessible route serving the adjacent recreation facilities.

Advisory F245.4.3 Adjacent Recreation Facilities. F245.4.3 does not modify the accessible route requirements in F206 that apply to adjacent recreation facilities.

F245.4.4 Location. Outdoor recreation access routes required by F245.4.2 and F245.4.3 shall coincide with or be located in the same area as general circulation paths.

Advisory F245.4.4 Location. Where a vehicular way serves as the general circulation path for pedestrians at a picnic facility, the outdoor recreation access route can be provided within the vehicular way.

F246 Viewing Areas

F246.1 General. Viewing areas, other than viewing areas on trails, shall comply with F246.1.

Advisory F246.1 General. Viewing areas on trails are addressed in F247.4.3.

F246.2 Distinct Viewing Locations. Each distinct viewing location within a viewing area shall comply with 1015.

Advisory F246.2 Distinct Viewing Locations. Viewing areas can provide more than one distinct viewing location. For example, a viewing area can provide a distinct viewing location for observing a mountain range, and another distinct viewing location for observing a river. Distinct viewing locations within a viewing area can be designated by signs or other markers.

F246.3 Outdoor Constructed Features. Where provided within viewing areas, at least 20 percent, but not less than one, of each type of outdoor constructed feature shall comply with 1011.

F246.4 Outdoor Recreation Access Routes. At least one outdoor recreation access route complying with 1016 shall connect accessible parking spaces or other arrival points serving the viewing area with accessible elements, spaces, and facilities provided within the viewing area.

Advisory F246.4. Outdoor Recreation Access Routes. There are exceptions in 1016.1 that can be used where conditions specified in 1019 apply.

F247 Trails

F247.1 General. Where a trail is designed for use by hikers or pedestrians and directly connects to a trailhead or another trail that substantially meets the requirements in 1017, the trail shall comply with 1017.

Advisory F247.1 General. The Federal Trail Data Standards classify trails by their designed use and managed use. A trail has only one designed use that determines the design, construction, and maintenance parameters for the trail. A trail can have more than one managed use based on a management decision to allow other uses on the trail. Trails that have a designed use for hikers or pedestrians are required to comply with 1017. Trails that have a designed use for other than hikers or pedestrians are not required to comply with 1017.

A trail system may include a series of connecting trails. Only trails that directly connect to a trailhead or another trail that substantially meets the requirements in 1017 are required to comply with 1017.

F247.2 Existing Trails. Where the original design, function, or purpose of an existing trail is changed and the altered portion of the trail directly connects to a trailhead or another trail that substantially meets the requirements in 1017, the altered portion of the trail shall comply with 1017.

Advisory F247.2 Existing Trails. Routine or periodic maintenance activities that are performed to return an existing trail to the condition to which the trail was originally designed are not required to comply with 1017.

F247.3 Trailheads. Trailheads shall comply with F247.3.

Advisory F247.3 Trailheads. Trailhead information signs are addressed in F216.13.

F247.3.1 Outdoor Constructed Features. Where provided within trailheads, at least 20 percent, but not less than one, of each type of outdoor constructed feature shall comply with 1011.

F247.3.2 Outdoor Recreation Access Routes. At least one outdoor recreation access route complying with 1016 shall connect the following:

1. Accessible parking spaces or other arrival points serving the trailhead;
2. Starting point of the trail; and
3. Accessible elements, spaces, and facilities provided within the trailhead.

Advisory F247.3.2 Outdoor Recreation Access Routes. In alterations to existing trailheads, there are exceptions in 1016.1 that can be used where conditions specified in 1019 apply.

F247.4 Trail Facilities. Where provided on trails, facilities shall comply with F247.4.

Advisory F247.4 Trail Facilities. Facilities are required to comply with F247.4 regardless of whether the trail complies with 1017. Outdoor recreation access routes are not required at camping facilities, picnic facilities, or viewing areas provided on trails.

F247.4.1 Camping Facilities. Camping facilities provided on trails shall comply with F244.2 and F244.3.

F247.4.2 Picnic Facilities. Picnic facilities provided on trails shall comply with F245.2 and F245.3.

F247.4.3 Viewing Areas. Viewing areas provided on trails shall comply with F246.2 and F246.3.

F247.4.4 Routes. Routes that connect trails complying with 1017 to camping facilities, picnic facilities, viewing areas, pit toilets, and accessible elements provided within the facilities shall comply with 1017.

Advisory F247.4.4. Routes. Routes that connect trails that do not comply with 1017 to camping facilities, picnic facilities, viewing areas, pit toilets, and accessible elements provided within the facilities are not required to comply with 1017. An exception to F213.1 exempts pit toilets from the requirements for accessible toilet facilities.

F247.5 Outdoor Constructed Features. Where outdoor constructed features are provided on trails, other than within facilities specified in F247.4, at least 20 percent, but not less than one, of each type of outdoor constructed feature at each location shall comply with 1011.

F248 Beach Access Routes

F248.1 General. Beach access routes complying with 1018 shall be provided in accordance with F248.1. Beach access routes shall be permanent or removable.

EXCEPTION: Beach access routes shall not be required where pedestrian access to the beach is not permitted.

Advisory F248.1 General. There are exceptions in 1018.1 that can be used where conditions specified in 1019 apply. Removable beach access routes can be moved to a protected storage area during storms and other periods when the routes are subject to damage or loss.

F248.1.1 Facilities Serving Beaches. Beach access routes shall be provided in a number complying with F248.2 where the entity that administers or manages a beach constructs or alters any of the following facilities to serve the beach:

1. Circulation paths;
2. Parking facilities;
3. Toilet facilities; or
4. Bathing facilities.

EXCEPTION: The entity shall not be required to expend more than 20 percent of the costs of constructing or altering the facilities to provide beach access routes.

F248.1.2 Beach Nourishment. Beach access routes shall be provided in a number complying with F248.2 where the entity that administers or manages a beach undertakes a beach nourishment project.

EXCEPTION: The entity shall not be required to expend more than 20 percent of the costs of a beach nourishment project to provide beach access routes.

F248.2 Minimum Number. Where beach access routes are required by F248.1, at least one beach access route shall be provided for each 1/2 mile (0.8 km) of beach shoreline administered or managed by the entity.

EXCEPTION: The number of beach access routes shall not be required to exceed the number of pedestrian access points provided by the entity to a beach.

Advisory F248.2 Minimum Number Exception. Pedestrian access points to a beach include parking facilities that serve beaches, dune crossings, and stairways or ramps leading from boardwalks to the beach.

F248.3 Location. Beach access routes shall coincide with or be located in the same area as pedestrian access points to the beach.

CHAPTER 10: RECREATION FACILITIES

1001.1 Scope. The provisions of Chapter 10 shall apply where required by Chapter 2 or where referenced by a requirement in this document.

Advisory 1001.1 Scope. Unless otherwise modified or specifically addressed in Chapter 10, all other requirements in this document apply to the design and construction of recreation facilities. The requirements in 1011 through 1019 apply only to facilities constructed or altered by federal agencies or by non-federal entities on federal land on behalf of federal agencies pursuant to a concession contract, partnership agreement, or similar arrangement. See F201.4. The requirements in 1011 and 1019 allow for limitations and other constraints posed by the existing outdoor environment.

1011 Outdoor Constructed Features

1011.1 General. All outdoor constructed features shall comply with 1011.2 and 1011.3. Outdoor constructed features specified in 1011.4 through 1011.8 shall comply with those provisions, as applicable.

Advisory 1011.1 General. The requirements in 1011 apply to outdoor constructed features provided within camping facilities, picnic facilities, viewing areas, and trailheads or on trails.

1011.2 Clear Ground Space. A clear ground space complying with 1011.2 shall be provided at outdoor constructed features.

EXCEPTIONS: 1. Where individual outdoor constructed features are altered and the ground surface is not altered, the clear ground space shall not be required to comply with 1011.2.2 and 1011.2.3.

2. In alterations, when an entity determines that a condition in 1019 does not permit full compliance with a specific provision in 1011.2, the clear ground space shall comply with the provision to the extent practicable.

1011.2.1 Size and Location. The size and location of the clear ground space shall be in accordance with Table 1011.2.1. Unless otherwise specified in Table 1011.2.1, one full unobstructed side of the clear ground space shall adjoin or overlap an outdoor recreation access route or a trail, as applicable, or another clear ground space.

Table 1011.2.1 Clear Ground Space

Outdoor Constructed Feature	Minimum Size and Location
Picnic tables	36 inches (915 mm) on all usable sides of the table measured from the back edge of the benches
Fire rings, grills, fireplaces, and woodstoves	48 inches (1220 mm) by 48 inches (1220 mm) on all usable sides of the fire ring, grill, fireplace, and woodstove Center the space on each usable side of the grill, fireplace, and woodstove
Trash and recycling receptacles	36 inches (915 mm) by 48 inches (1220 mm) positioned for forward approach to the receptacle opening; or 30 inches (760 mm) by 60 inches (1525 mm) positioned for a parallel approach to the receptacle opening
Water hydrants	72 inches (1830 mm) by 48 inches (1220 mm) with the long side of the space adjoining or overlapping an outdoor recreation access route or trail, as applicable, or another clear ground space Locate the space so that the water spout is 11 inches (280 mm) minimum and 12 inches (305 mm) maximum from the rear center of the long side of the space

Utility and sewage hookups	<p>30 inches (760 mm) by 60 inches (1525 mm) with the long side of the space adjoining or overlapping an accessible parking space or pull-up space for recreational vehicles</p> <p>Locate the space so that the hook-ups are at the rear center of the space</p> <p>Bollards or other barriers shall not obstruct the clear ground space in front of the hook-ups</p>
Outdoor rinsing showers	<p>60 inches (1525 mm) by 60 inches (1525 mm) centered on the shower heads</p> <p>Locate the space so that the shower pedestal or wall with the shower head are at the rear end of the space</p>
Benches	<p>36 inches (915 mm) by 48 inches (1220 mm) positioned near the bench with one side of the space adjoining an outdoor recreation access route or trail, as applicable</p> <p>The clear ground space shall not overlap the outdoor recreation access route or trail, or another clear ground space</p>
Viewing Scopes	<p>36 inches (915 mm) by 48 inches (1220 mm) positioned for forward approach to the viewing scope</p> <p>Provide knee and toe clearance complying with 306 under the viewing scope</p> <p>Locate the space so that the eyepiece is centered on the space</p>

Advisory 1011.2.1 Size and Location. The usable sides of picnic tables, fire rings, grills, fireplaces, and woodstoves are the sides of the outdoor constructed feature that can be used for eating or serving food, building a fire, or cooking. All sides of picnic tables are generally usable, unless the picnic table is placed against a rock or tree that renders the side against the rock or tree not usable. All sides of fire rings and grills are generally usable, unless there is a wall or other structure on a side that renders the side not usable. The front sides of fireplaces and woodstoves are generally the usable side.

1011.2.2 Surface. The surface of the clear ground space shall be firm and stable.

1011.2.3 Slope. The slope of the clear ground space surface shall not be steeper than 1:48 in any direction.

EXCEPTION: Where the surface is other than asphalt, concrete, or boards, slopes not steeper than 1:20 shall be permitted when necessary for drainage.

1011.2.4 Openings. Openings in the clear ground space surface shall not allow the passage of a sphere more than 1/2 inch (13 mm) in diameter.

Advisory 1011.2.4 Openings. Where possible, drainage grates should be located outside of the clear ground space surface. Elongated openings should be placed so that the long dimension is perpendicular, or as close to perpendicular as possible, to the dominant direction of travel.

1011.3 Operable Parts. Operable parts shall comply with 309.3 and 309.4.

EXCEPTIONS: 1. Fire rings, grills, fireplaces, wood stoves, water hydrants, and water utility hookups shall

comply with 309.4 to the extent practicable.

2. Trash and recycling receptacles with hinged lids and controls to keep out large animals shall comply with 309.4 to the extent practicable.

3. Dumpster type trash and recycling receptacles shall not be required to comply with 309.3 and 309.4.

4. Sewage hatches shall not be required to comply with 309.3 and 309.4.

Advisory 1011.3 Operable Parts. New products may be developed with operable parts that comply with 309.4. As products with operable parts that comply with 309.4 become available, entities should provide these products to enable individuals with disabilities to operate them.

1011.4 Picnic Tables. Picnic tables shall comply with 1011.4.

1011.4.1 Height. The tops of picnic tables shall comply with 902.3.

1011.4.2 Wheelchair Space. Picnic tables shall provide at least one wheelchair space for each 24 linear feet (7320 mm) of usable table surface perimeter. Wheelchair spaces shall be 30 inches (760 mm) minimum by 48 inches (1220 mm) minimum. Wheelchair spaces shall be positioned for a forward approach to the table and provide knee and toe clearance complying with 306 under the table.

1011.5 Fire Rings, Grills, Fireplaces, and Wood Stoves. Fire rings, grills, fireplaces, and wood stoves shall comply with 1011.5.

Advisory 1011.5 Fire Rings, Grills, Fireplaces, and Wood Stoves. Fire rings with double walls or insulation on the sides are recommended to prevent burns.

1011.5.1 Fire Building Surfaces. Fire building surfaces shall be 9 inches (230 mm) minimum above the ground.

1011.5.2 Cooking Surfaces. Where provided, cooking surfaces shall be 15 inches (380 mm) minimum and 34 inches (865 mm) maximum above the ground.

1011.5.3 Raised Edges or Walls. Where fire rings, grills, or fireplaces are constructed with raised edges or walls, the depth of the raised edge or wall shall be 10 inches (255 mm) maximum.

1011.6 Water Spouts. Water spouts at water hydrants and water utility hook-ups shall be 28 inches (710 mm) minimum and 36 inches (915 mm) maximum above the ground.

1011.7 Outdoor Rinsing Showers. Outdoor rinsing showers shall provide at least one hand-held shower spray unit with a hose 59 inches (1500 mm) long minimum. The hand-held shower spray unit shall have at least one fixed position located 15 inches (380 mm) minimum and 48 inches (1220 mm) maximum above the ground.

EXCEPTION: Where vandalism is a consideration, a fixed shower head located at 48 in (1220 mm) above the ground shall be permitted in place of a hand-held shower spray unit.

1011.8 Viewing Scopes. Eyepieces on viewing scopes shall be 43 inches (1090 mm) minimum and 51 inches (1295 mm) maximum above the ground.

1012 Parking Spaces Within Camping Units and Picnic Units and Pull-Up Spaces at Dump Stations

1012.1 General. Parking spaces within camping units and picnic units with mobility features and pull-up spaces for recreational vehicles at dump stations shall comply with 1012.

1012.2 Recreational Vehicles. Parking spaces and pull-up spaces for recreational vehicles shall be 20 feet (6100 mm) wide minimum.

EXCEPTION: Where two adjacent parking spaces are provided for recreational vehicles, one parking space shall be permitted to be 16 feet (4880 mm) wide minimum.

1012.3 Other Vehicles. Parking spaces for vehicles, other than recreational vehicles, shall be 16 feet (4880 mm) wide minimum.

EXCEPTION: Where two adjacent parking spaces are provided for vehicles, other than recreational vehicles, one parking space shall be permitted to be 8 feet (2440 mm) wide minimum.

1012.4 Surface. The surface of parking spaces and pull-up spaces shall be firm and stable.

1012.5 Slope. The slope of the surface of parking spaces and pull-up spaces shall not be steeper than 1:48 in any direction.

EXCEPTION: Where the surface is other than asphalt, concrete, or boards, slopes not steeper than 1:20 shall be permitted when necessary for drainage.

1013 Tent Pads and Tent Platforms

1013.1 General. Tent pads and tent platforms shall comply with 1013.

EXCEPTION: When an entity determines that a condition in 1019 does not permit full compliance with a specific provision in 1013, the tent pad and tent platform shall comply with the provision to the extent practicable.

Advisory 1013.1 General. Tent pads and tent platforms are defined spaces with prepared surfaces for setting up and securing tents.

1013.2 Clear Ground Space. Clear ground space complying with 1013.2 shall be provided on all usable sides of tent pads and tent platforms.

1013.2.1 Size. The clear ground space shall be 48 inches (1220 mm) wide minimum.

1013.2.2 Surface. The surface of the clear ground space shall be firm and stable. The surface shall allow use of tent stakes and other tent securement devices.

1013.3 Slope. The slope of the surface of tent pads, tent platforms, and clear ground spaces shall not be steeper than 1:48 in any direction.

EXCEPTION: Where the surface is other than asphalt, concrete, or boards, slopes not steeper than 1:20 shall be permitted where necessary for drainage.

1013.4 Height. Tent platforms shall be 19 inches (485 mm) high maximum measured from the clear ground space to the tent platform surface.

1014 Camp Shelters

1014.1 General. Camp shelters shall comply with 1014.

EXCEPTIONS: 1. When an entity determines that a condition in 1019 does not permit full compliance with a specific provision in 1014, the camp shelter shall comply with the provision to the extent practicable.

2. Camp shelters shall not be required to comply with 307.

1014.2 Entrance. Camp shelters shall provide an entrance complying with 1014.2.1 or 1014.2.2.

1014.2.1 Transfer Access. Where transfer access is provided at the entrance to a camp shelter, the entrance shall comply with 1014.2.1.

1014.2.1.1 Clear Ground Space. A clear ground space shall be provided at the entrance to the camp shelter. The clear ground space shall be 36 inches (915 mm) minimum by 48 inches (1220 mm) minimum and shall be positioned for a parallel approach to the camp shelter. One full unobstructed side of the clear

ground space shall adjoin or overlap an outdoor recreation access route or trail, as applicable, or another clear ground space.

1014.2.1.1.1 Surface. The surface of the clear ground space shall be firm and stable.

1014.2.1.1.2 Slope. The slope of the surface of the clear ground space shall not be steeper than 1:48 in any direction.

EXCEPTION: Where the surface is other than asphalt, concrete, or boards, slopes not steeper than 1:20 shall be permitted where necessary for drainage.

1014.2.1.2 Floor Height. The camp shelter floor at the entrance shall be 19 inches (485 mm) high maximum measured from the clear ground space.

1014.2.2 Roll-in Access. Where roll-in access is provided at the entrance to a camp shelter, the entrance shall comply with 1014.2.2.

1014.2.2.1 Level or Sloped Entry Route. Camp shelters providing roll-in access shall have a level or sloped entry route complying with 1016 or 1017, as applicable.

1014.2.2.2 Turning Space. A turning space complying with 304.3 shall be provided within the camp shelter.

1014.3 Floor. The floor within camp shelters shall comply with 1014.3.

1014.3.1 Surface. The floor surface shall be firm and stable.

1014.3.2 Slope. The slope of the floor surface shall not be steeper than 1:48 in any direction.

EXCEPTION: Where the floor surface is other than asphalt, concrete, or boards, slopes not steeper than 1:20 shall be permitted when necessary for drainage.

1015 Viewing Areas

1015.1 General. Viewing areas shall comply with 1015.

EXCEPTION: In alterations, when an entity determines that a condition in 1019 does not permit full compliance with a specific provision in 1015, the viewing area shall comply with the provision to the extent practicable.

1015.2 Clear Ground Space. A clear ground space shall be provided at each distinct viewing location. The clear ground space shall be 36 inches (915 mm) minimum by 48 inches (1220 mm) minimum and shall be positioned for either a forward or parallel approach to the viewing location. One full unobstructed side of the clear ground space shall adjoin or overlap an outdoor recreation access route or trail, as applicable, or another clear ground space.

1015.3 Viewing Space. Each distinct viewing location shall provide a viewing space adjacent to the clear ground space required by 1015.2 through which the point of interest is viewable. The viewing space shall be 32 inches (815 mm) maximum and 51 inches (1295 mm) minimum high above the ground and shall extend the full width of the clear ground space.

EXCEPTION: Guards or similar safety barriers shall be permitted to obstruct the viewing space to the extent the obstruction is necessary for the guard or safety barrier to serve its intended purpose.

1015.4 Turning Space. A turning space complying with 304.3 shall be provided within viewing areas.

1015.5 Surface. The surface of clear ground spaces and turning spaces shall be firm and stable.

1015.6 Slope. The slope of the surface of clear ground spaces and turning spaces shall not be steeper than 1:48 in any direction.

EXCEPTION: Where the surface is other than asphalt, concrete, or boards, slopes not steeper than 1:20 shall be permitted when necessary for drainage.

1016 Outdoor Recreation Access Routes

1016.1 General. Outdoor recreation access routes shall comply with 1016.

EXCEPTIONS: **1.** In alterations to existing camping facilities, picnic facilities, and trailheads, when an entity determines that a condition in 1019 does not permit full compliance with a specific provision in 1016 on a portion of an outdoor recreation access route, the portion of the outdoor recreation access route shall comply with the provision to the extent practicable.

2. At viewing areas, when an entity determines that a condition in 1019 does not permit full compliance on a portion of an outdoor recreation access route with a specific provision in 1016, the portion of the outdoor recreation access route shall comply with the provision to the extent practicable.

3. Where outdoor recreation access routes are provided within vehicular ways, outdoor recreation access routes shall not be required to comply with 1016.4, 1016.7, and 1016.8.

1016.2 Surface. The surface of outdoor recreation access routes, passing spaces, and resting intervals shall be firm and stable.

1016.3 Clear Width. The clear width of outdoor recreation access routes shall be 36 inches (915 mm) minimum.

1016.4 Passing Spaces. Outdoor recreation access routes with a clear width less than 60 inches (1525 mm) shall provide passing spaces complying with 1016.4 at intervals of 200 feet (61 m) maximum. Passing spaces and resting intervals shall be permitted to overlap.

Advisory 1016.4 Passing Spaces. Entities should consider providing either a 60 inches (1525 mm) minimum clear width on outdoor recreation access routes or passing spaces at shorter intervals if the clear width is less than 60 inches (1525 mm), where the route is:

- Heavily used or adjoins elements, space, or facilities that are heavily used; or
- A boardwalk or otherwise not at the same level as the ground surface adjoining the route.

1016.4.1 Size. The passing space shall be either:

- a. A space 60 inches (1525 mm) minimum by 60 inches (1525 mm) minimum; or
- b. The intersection of two outdoor recreation access routes providing a T-shaped space complying with 304.3.2 where the base and the arms of the T-shaped space extend 48 inches (1220 mm) minimum beyond the intersection. Vertical alignment at the intersection of the outdoor recreation access routes that form the T-shaped space shall be nominally planar.

Advisory 1016.4.1 Size. Where the passing space is the intersection of two outdoor recreation access routes, the intersection must be as flat as possible so that all of the wheels of a mobility device touch the ground when turning into and out of the passing space.

1016.5 Obstacles. Obstacles on outdoor recreation access routes, passing spaces, and resting intervals shall not exceed 1/2 inch (13 mm) in height measured vertically to the highest point.

EXCEPTION: Where the surface is other than asphalt, concrete, or boards, obstacles shall be permitted to not exceed 1 inch (25 mm) in height measured vertically to the highest point.

Advisory 1016.5 Obstacles. The vertical alignment of joints in concrete, asphalt, or board surfaces can be obstacles. Natural features such as tree roots and rocks on outdoor recreation access routes can also be obstacles. Where an outdoor recreation access route is provided within a vehicular way, traffic calming devices can be obstacles. Where possible, obstacles that cross the full width of outdoor recreation access routes should be separated by a distance of 48 inches (1220 mm) minimum.

1016.6 Openings. Openings in the surface of outdoor recreation access routes shall not allow the passage of a

sphere more than 1/2 inch (13 mm) in diameter.

Advisory 1016.6 Openings. Spaces between the boards in a boardwalk and drainage grates are examples of openings. Where possible, drainage grates should be located outside the minimum clear width of the outdoor recreation access route. Elongated openings should be placed so that the long dimension is perpendicular, or as close to perpendicular as possible, to the dominant direction of travel.

1016.7 Slopes. The slopes of outdoor recreation access routes shall comply with 1016.7.

1016.7.1 Maximum Running Slope and Segment Length. The running slope of any segment of an outdoor recreation access route shall not be steeper than 1:10 (10%).

Where the running slope of a segment of an outdoor recreation access route is steeper than 1:20 (5%), the maximum length of the segment shall be in accordance with Table 1016.7.1, and a resting interval complying with 1016.8 shall be provided at the top and bottom of each segment.

Table 1016.7.1 Maximum Running Slope and Segment Length

Running Slope of Outdoor Recreation Access Route Segment		Maximum Length of Segment
Steeper than	But not Steeper than	
1:20 (5%)	1:12 (8.33%)	50 feet (15 m)
1:12 (8.33%)	1:10 (10%)	30 feet (9 m)

Advisory 1016.7.1 Maximum Running Slope and Segment Length. Gradual running slopes are more useable by individuals with disabilities. Where the terrain results in steeper running slopes, resting intervals are required more frequently. Where running slopes are less severe, resting intervals are permitted to be further apart.

1016.7.2 Cross Slope. The cross slope shall not be steeper than 1:48.

EXCEPTION: Where the surface is other than concrete, asphalt, or boards, cross slopes not steeper than 1:20 shall be permitted when necessary for drainage.

1016.8 Resting Intervals. Resting intervals shall comply with 1016.8.

1016.8.1 Length. The resting interval length shall be 60 inches (1525 mm) long minimum.

1016.8.2 Width. Where resting intervals are provided within an outdoor recreation access route, resting intervals shall be at least as wide as the widest segment of the outdoor recreation access route leading to the resting interval. Where resting intervals are provided adjacent to an outdoor recreation access route, the resting interval shall be 36 inches (915 mm) wide minimum.

1016.8.3 Slope. Resting intervals shall have slopes not steeper than 1:48 in any direction.

EXCEPTION: Where the surface is other than concrete, asphalt, or boards, slopes not steeper than 1:20 shall be permitted when necessary for drainage.

1016.8.4 Turning Space. Where resting intervals are provided adjacent to an outdoor recreation access route, a turning space complying with 304.3.2 shall be provided.

Vertical alignment between the outdoor recreation access route, turning space, and resting interval shall be nominally planar.

1016.9 Protruding Objects. Constructed elements on outdoor recreation access routes, passing spaces, and resting intervals shall comply with 307.

Advisory 1016.9 Protruding Objects. Protruding objects on outdoor recreation access routes, passing spaces, and resting intervals can be hazardous for individuals who are blind or have low vision. Signs and other post mounted objects are examples of constructed elements that can be protruding

objects.

1017 Trails

1017.1 General. Trails shall comply with 1017.

EXCEPTIONS: **1.** When an entity determines that a condition in 1019 does not permit full compliance with a specific provision in 1017 on a portion of a trail, the portion of the trail shall comply with the provision to the extent practicable.

2. After applying Exception 1, when an entity determines that it is impracticable for the entire trail to comply with 1017, the trail shall not be required to comply with 1017.

Advisory 1017.1 General Exception 2. An entity must apply Exception 1 before using Exception 2. The entity should consider the portions of the trail that can and cannot fully comply with the specific provisions in 1017 and the extent of compliance where full compliance cannot be achieved when determining whether it would be impracticable for the entire trail to comply with 1017. The determination is made on a case-by-case basis. Federal agencies must document the basis for their determination when using Exceptions 1 or 2, and must notify the Access Board when using Exception 2. See F201.4.1.

1017.2 Surface. The surface of trails, passing spaces, and resting intervals shall be firm and stable.

Advisory 1017.2 Surface. A firm trail surface resists deformation by indentations. A stable trail surface is not permanently affected by expected weather conditions and can sustain normal wear and tear from the expected uses between planned maintenance.

1017.3 Clear Tread Width. The clear tread width of trails shall be 36 inches (915 mm) minimum.

1017.4 Passing Spaces. Trails with a clear tread width less than 60 inches (1525 mm) shall provide passing spaces complying with 1017.4 at intervals of 1000 feet (300 m) maximum. Where the full length of a trail does not fully comply with 1017, a passing space shall be located at the end of the trail segment that fully complies with 1017. Passing spaces and resting intervals shall be permitted to overlap.

Advisory 1017.4 Passing Spaces. Entities should consider providing either a 60 inches (1525 mm) minimum clear tread width or passing spaces at shorter intervals if the clear tread width is less than 60 inches (1525 mm), where a trail is:

- Heavily used; or
- A boardwalk or otherwise not at the same level as the ground surface adjoining the trail.

Where the full length of the trail does not fully comply with 1017, locating a passing space at the end of the trail segment that fully complies with 1017 enables a person who uses a mobility device to turn and exit the trail.

1017.4.1 Size. The passing space shall be either:

- a. A space 60 inches (1525 mm) minimum by 60 inches (1525 mm) minimum; or
- b. The intersection of two trails providing a T-shaped space complying with 304.3.2 where the base and the arms of the T-shaped space extend 48 inches (1220 mm) minimum beyond the intersection. Vertical alignment at the intersection of the trails that form the T-shaped space shall be nominally planar.

Advisory 1017.4.1 Size. Where the passing space is the intersection of two trails, the intersection must be as flat as possible so that all of the wheels of a mobility device touch the ground when turning into and out of the passing space.

1017.5 Tread Obstacles. Tread obstacles on trails, passing spaces, and resting intervals shall not exceed 1/2 inch (13 mm) in height measured vertically to the highest point.

EXCEPTION: Where the surface is other than asphalt, concrete, or boards, tread obstacles shall be permitted to not exceed 2 inches (50 mm) in height measured vertically to the highest point.

Advisory 1017.5 Tread Obstacles. The vertical alignment of joints in concrete, asphalt, or board surfaces can be tread obstacles. Natural features such as tree roots and rocks within the trail tread can also be tread obstacles. Where possible, tread obstacles that cross the full width of the trail tread should be separated by a distance of 48 inches (1220 mm) minimum.

1017.6 Openings. Openings in the surface of trails, passing spaces, and resting intervals shall not allow the passage of a sphere more than 1/2 inch (13 mm) in diameter.

Advisory 1017.6 Openings. Elongated openings should be placed so that the long dimension is perpendicular, or as close to perpendicular as possible, to the dominant direction of travel.

1017.7 Slopes. The slopes of trails shall comply with 1017.7.

1017.7.1 Maximum Running Slope and Segment Length. Not more than 30 percent of the total length of a trail shall have a running slope steeper than 1:12 (8.33%). The running slope of any segment of a trail shall not be steeper than 1:8 (12%). Where the running slope of a segment of a trail is steeper than 1:20 (5%), the maximum length of the segment shall be in accordance with Table 1017.7.1, and a resting interval complying with 1017.8 shall be provided at the top and bottom of each segment.

Table 1017.7.1 Maximum Running Slope and Segment Length

Running Slope of Trail Segment		Maximum Length of Segment
Steeper than	But not Steeper than	
1:20 (5%)	1:12 (8.33%)	200 feet (61 m)
1:12 (8.33%)	1:10 (10%)	30 feet (9 m)
1:10 (10%)	1:8 (12%)	10 feet (3050 mm)

Advisory 1017.7.1 Maximum Running Slope and Segment Length. Gradual running slopes on trails are more useable by individuals with disabilities. Where the terrain results in steeper running slopes, resting intervals are required more frequently. Where running slopes are less severe, resting intervals are permitted to be further apart.

1017.7.2 Cross Slope. The cross slope shall be not be steeper than 1:48.

EXCEPTION: Where the surface is other than concrete, asphalt, or boards, cross slopes not steeper than 1:20 shall be permitted when necessary for drainage.

1017.8 Resting Intervals. Resting intervals shall comply with 1017.8.

1017.8.1 Length. The resting interval length shall be 60 inches (1525 mm) long minimum.

1017.8.2 Width. Where resting intervals are provided within the trail tread, resting intervals shall be at least as wide as the widest segment of the trail tread leading to the resting interval. Where resting intervals are provided adjacent to the trail tread, the resting interval clear width shall be 36 inches (915 mm) minimum.

1017.8.3 Slope. Resting intervals shall have slopes not steeper than 1:48 in any direction.

EXCEPTION: Where the surface is other than concrete, asphalt, or boards, cross slopes not steeper than 1:20 shall be permitted when necessary for drainage.

1017.8.4 Turning Space. Where resting intervals are provided adjacent to the trail tread, a turning space complying with 304.3.2 shall be provided. Vertical alignment between the trail tread, turning space, and resting interval shall be nominally planar.

1017.9 Protruding Objects. Constructed elements on trails, passing spaces, and resting intervals shall comply

with 307.

Advisory 1017.9 Protruding Objects. Protruding objects on trails, passing spaces, and resting intervals can be hazardous for individuals who are blind or have low vision. Signs and other post mounted objects are examples of constructed elements that can be protruding objects.

1017.10 Trailhead Signs. Trail information signs at trailheads shall include the following:

1. Length of the trail or trail segment;
2. Surface type;
3. Typical and minimum tread width;
4. Typical and maximum running slope; and
5. Typical and maximum cross slope.

1018 Beach Access Routes

1018.1 General. Beach access routes shall comply with 1018.

EXCEPTIONS: 1. When an entity determines that a condition in 1019 does not permit full compliance with a specific provision in 1018 on a portion of a beach access route, the portion of the beach access route shall comply with the provision to the extent practicable.

2. After applying Exception 1, when an entity determines that it is impracticable to provide a beach access route complying with 1018, a beach access route shall not be required.

3. Removable beach access routes shall not be required to comply with 1018.7, 1018.8, and 1018.10.

Advisory 1018.1 General Exception 2. An entity must apply Exception 1 before using Exception 2. The entity should consider the portions of the beach access route that can and cannot fully comply with the specific provisions in 1018 and the extent of compliance where full compliance cannot be achieved to determine whether it would be impracticable to provide a beach access route complying with 1018. The determination is made on a case-by-case basis. Federal agencies must document the basis for their determination when using Exceptions 1 or 2, and must notify the Access Board when using Exception 2. See F201.4.1.

1018.2 Connections. Beach access routes shall connect an entry point to the beach to the:

1. High tide level at tidal beaches;
2. Mean high water level at river beaches; or
3. Normal recreation water level at lake, pond, and reservoir beaches.

1018.3 Surface. The surface of beach access routes and resting intervals shall be firm and stable.

1018.4 Clear Width. The clear width of beach access routes shall be 60 inches (1525 mm) minimum.

EXCEPTION: At dune crossings, the clear width of beach access routes that are not removable shall be permitted to be reduced to 48 inches (1220 mm) minimum.

1018.5 Obstacles. Obstacles on beach access routes and resting intervals shall not exceed 1/2 inch (13 mm) in height measured vertically to the highest point.

EXCEPTION: Where the surface is other than asphalt, concrete, or boards, obstacles shall be permitted to not exceed 1 inch (25 mm) in height measured vertically to the highest point.

Advisory 1018.5 Obstacles. The vertical alignment of boards on a beach access route or removable sections of a beach access route can be obstacles.

1018.6 Openings. Openings in the surface of beach access routes and resting intervals shall not allow the passage of a sphere more than 1/2 inch (13 mm) in diameter.

Advisory 1018.6 Openings. Elongated openings should be placed so that the long dimension is perpendicular, or as close to perpendicular as possible, to the dominant direction of travel.

1018.7 Slopes. The slopes of beach access routes shall comply with 1018.7.

1018.7.1 Maximum Running Slope and Segment Length. The running slope of any segment of a beach access route shall not be steeper than 1:10 (10%). Where the running slope of a segment of a beach access route is steeper than 1:20 (5%), the maximum length of the segment shall be in accordance with Table 1018.7.1, and a resting interval complying with 1018.8 shall be provided at the top and bottom of each segment.

Table 1018.7.1 Maximum Running Slope and Segment Length

Running Slope of Beach Access Route Segment		Maximum Length of Segment
Steeper than	But not Steeper than	
1:20 (5%)	1:12 (8.33%)	50 feet (15 m)
1:12 (8.33%)	1:10 (10%)	30 feet (9 m)

Advisory 1018.7.1 Maximum Running Slope and Segment Length. Gradual running slopes on beach access routes are more useable by individuals with disabilities. Where the terrain results in steeper running slopes, resting intervals are required more frequently. When running slopes are less severe, resting intervals are permitted to be further apart.

1018.7.2 Cross Slope. The cross slope shall not be steeper than 1:48.

EXCEPTION: Where the surface is other than concrete, asphalt, or boards, cross slopes not steeper than 1:20 shall be permitted when necessary for drainage.

1018.8 Resting Intervals. Resting intervals shall comply with 1018.8.

1018.8.1 Size. Resting intervals shall be 60 inches minimum (1525 mm) by 60 inches (1525 mm) minimum.

1018.8.2 Slope. Resting intervals shall have a slope not steeper than 1:48 in any direction.

EXCEPTION: Where the surface is other than concrete, asphalt, or boards, cross slopes not steeper than 1:20 shall be permitted when necessary for drainage.

1018.9 Protruding Objects. Constructed elements on beach access routes and resting intervals shall comply with 307.

Advisory 1018.9 Protruding Objects. Protruding objects on beach access routes and resting intervals can be hazardous for individuals who are blind or have low vision. Signs and other post mounted objects are examples of constructed elements that can be protruding objects.

1018.10 Dune Crossings. Where the slope of a beach access route at a dune crossing is steeper than 1:20 (5%), handrails complying with 505 and curbs or barriers shall be provided. The curbs or barriers shall prevent the passage of a 2 inch (50 mm) diameter sphere, where any portion of the sphere is within 2 inches (50 mm) of the crossing surface.

1019 Conditions for Exceptions

1019.1 General. Exceptions to specific provisions in 1011, 1013, 1014, 1015, 1016, 1017, and 1018 shall be permitted when an entity determines that any of the following conditions does not permit full compliance with the provision:

1. Compliance is not practicable due to terrain.
2. Compliance cannot be accomplished with the prevailing construction practices.
3. Compliance would fundamentally alter the function or purpose of the facility or the setting.

4. Compliance is limited or precluded by any of the following laws, or by decisions or opinions issued or agreements executed pursuant to any of the following laws:

- Endangered Species Act (16 U.S.C. §§ 1531 et seq.);
- National Environmental Policy Act (42 U.S.C. §§ 4321 et seq.);
- National Historic Preservation Act (16 U.S.C. §§ 470 et seq.);
- Wilderness Act (16 U.S.C. §§ 1131 et seq.); or
- Other federal, state, or local law the purpose of which is to preserve threatened or endangered species; the environment; or archaeological, cultural, historical, or other significant natural features.

Advisory 1019.1 General. Exceptions in the following sections require compliance to the extent practicable when an entity determines that a condition in 1019 does not permit full compliance with a specific provision:

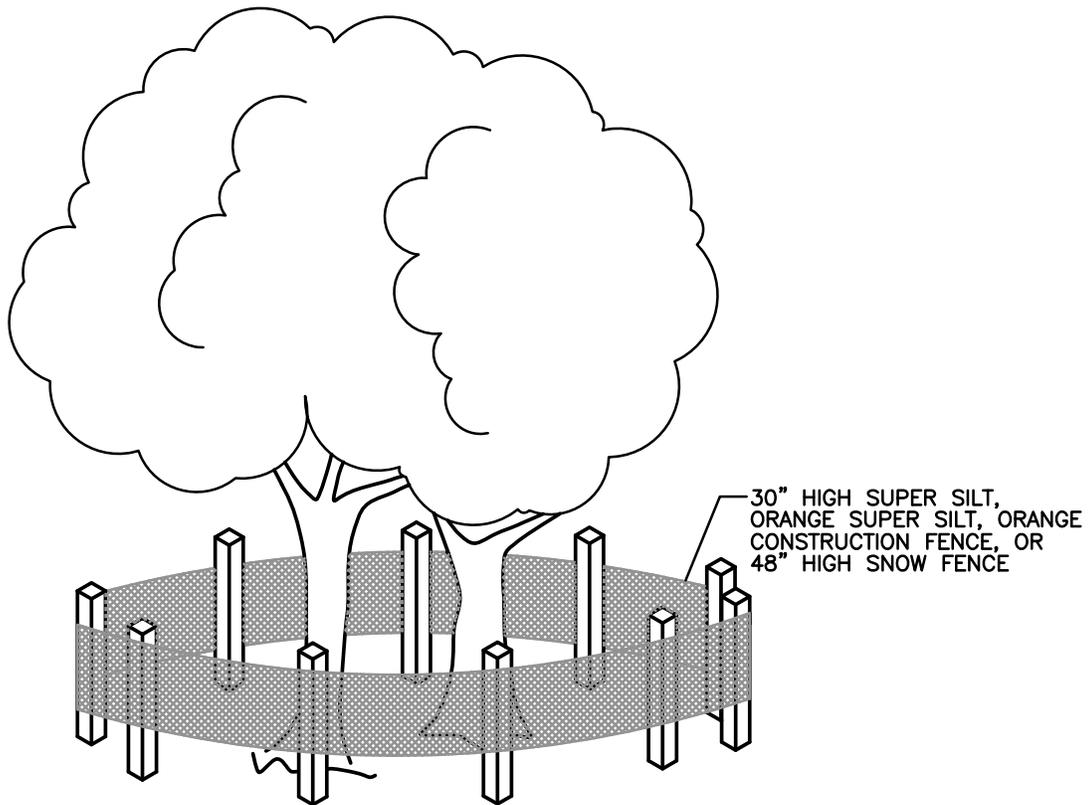
- 1011.2 Exception (clear ground space in alterations to outdoor constructed features);
- 1013.2 Exception (any provision for tent pads and tent platforms);
- 1014.1 Exception 1 (any provision for camp shelters);
- 1015.1 Exception (any provision in alterations to viewing areas);
- 1016.1 Exception 1 (any provision for outdoor recreation access routes in alterations to existing camping facilities, picnic facilities, and trailheads);
- 1016.1 Exception 2 (any provision for outdoor recreation access routes at viewing areas);
- 1017.1 Exception 1 (any provision for trails); and
- 1018.1 Exception 1 (any provision for beach access routes).

Entities should consider all design options before using the exceptions. On outdoor recreation access routes, trails, and beach access routes, the exceptions apply only on the portion of the route where the condition applies. The outdoor recreation access route, trail, or beach access route is required to fully comply with the provisions in 1016, 1017, and 1018, as applicable, at all other portions of the route where the conditions do not apply. There are additional exceptions that apply to an entire trail or beach access route in 1017.1 and 1018.1.

Condition 4 allows the following to be a basis for using the exceptions:

- Opinions issued by the Secretary of the Interior pursuant to the Endangered Species Act stating how a federal agency can implement an action without jeopardizing the continued existence of any endangered species or threatened species, or destroying or adversely modifying the habitat of such species (16 U.S.C. 1536 (b) (3) (A));
- Decisions issued by a federal agency pursuant to the National Environmental Policy Act in actions requiring environmental impact statements stating how it will avoid or minimize environmental harm (42 U.S.C. 4332; 40 CFR 1505.2);
- Agreements executed or decisions issued by a federal agency pursuant to National Historic Preservation Act stating how it will avoid, minimize, or mitigate adverse effects on historical properties (16 U.S.C. 470f and 470h-2; 36 CFR 800.6 (b) (iv) and 800.7 (c) (4)); and
- Provisions in the Wilderness Act that require federal agencies to preserve the wilderness character of designated wilderness areas and prohibit any structure or installation within such areas (16 U.S.C. 1131 (b) and (c)).

Condition 4 also applies where archaeological, cultural, historical, or other significant natural features are eligible for protection under federal, state, or local law.

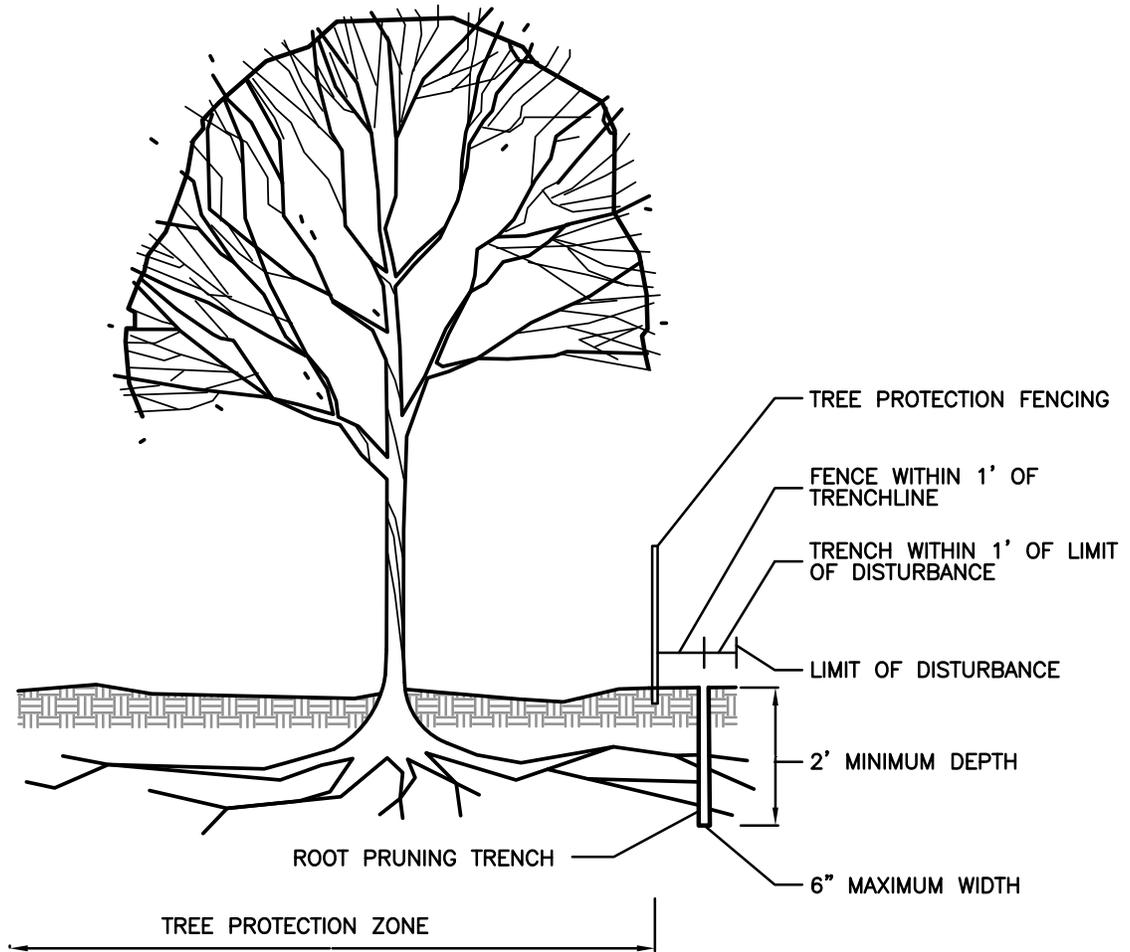


NOTES :

1. TREE PROTECTION FENCE TO BE LOCATED AT ALONG THE BOUNDARY OF THE TREE PROTECTION ZONE (TPZ) AS DEMARCATED IN THE PLAN SET. THE TPZ SHALL BE LOCATED A MINIMUM OF 15' FROM TRUNK, AT THE EDGE OF THE DRIPLINE, OR AT THE EDGE OF THE CRITICAL ROOT ZONE (CRZ) WHICHEVER IS GREATER TO PREVENT INJURY TO EXISTING TREES.
2. FENCE TO BE MOUNTED ON STEEL POSTS LOCATED EIGHT (8) FEET ON CENTER.
3. FENCE TO BE INSTALLED IN ACCORDANCE WITH THE PLAN SET AND INSPECTED PRIOR TO COMMENCING CLEARING AND FURTHER CONSTRUCTION.
4. TREE PROTECTION FENCING SHALL BE MAINTAINED UNTIL ALL WORK AND CONSTRUCTION HAVE BEEN COMPLETED. ANY DAMAGES TO TREE PROTECTION FENCING SHALL BE REPAIRED BEFORE CONSTRUCTION MAY CONTINUE.
5. TPZ TO BE PROTECTED IN ACCORDANCE WITH THE "PROTECTION OF EXISTING TREES" SPECIFICATIONS AS DETAILED IN THIS PLAN SET.

TREE PROTECTION FENCING

NOT TO SCALE



NOTES:

1. TREE PROTECTION ZONES TO BE ESTABLISHED PRIOR TO CONSTRUCTION.
2. BOUNDARIES OF TREE PROTECTION AREAS TO BE STAKED, FLAGGED AND FENCED PRIOR TO TRENCHING.
3. EXACT LOCATION OF TRENCH SHALL BE IDENTIFIED.
4. TRENCH SHALL BE IMMEDIATELY BACKFILLED WITH NATIVE OR OTHER APPROVED ORGANIC SOIL.
5. ROOTS SHALL BE CLEANLY CUT USING VIBRATORY KNIFE OR OTHER APPROVED EQUIPMENT.

ROOT PRUNING DETAIL

NOT TO SCALE

PROTECTION OF EXISTING TREES

1. INSTALLATION OF TREE PROTECTION FENCING

- 1.1. TREE PROTECTION FENCING SHALL BE INSTALLED ON THE SITE IN ACCORDANCE WITH THE TREE PROTECTION ZONE AND TREE PROTECTION FENCING SHOWN IN THE LANDSCAPE PLAN.
- 1.2. FORTY-EIGHT (48) INCH HIGH SNOW FENCE OR OTHER SUITABLE FENCE, SUCH AS SUPER SILT FENCE, MOUNTED ON STEEL POSTS LOCATED EIGHT FEET ON CENTER, SHALL BE PLACED ALONG THE BOUNDARY OF THE TREE PROTECTION ZONE. STANDARD 18" SILT FENCE SHALL NOT BE ACCEPTABLE TO BE USED AS TREE PROTECTION FENCING.
- 1.3. WHEN TREE PROTECTION FENCING HAS BEEN INSTALLED, IT SHALL BE INSPECTED AND APPROVED BY THE OWNER OR THEIR REPRESENTATIVE PRIOR TO COMMENCING CLEARING AND FURTHER CONSTRUCTION.
- 1.4. TREE PROTECTION FENCING DEMARCATING THE TREE PROTECTION ZONE SHALL BE MAINTAINED UNTIL ALL WORK AND CONSTRUCTION HAS BEEN COMPLETED. ANY DAMAGES TO THE PROTECTIVE FENCING SHALL BE REPLACED AND REPAIRED BEFORE CONSTRUCTION SHALL CONTINUE.

2. PROTECTION OF TREES DURING CONSTRUCTION

- 2.1. TREES BEING REMOVED SHALL NOT BE FELLED, PUSHED, OR PULLED INTO THE TREE PROTECTION ZONE OR INTO TREES OR OTHER VEGETATION THAT IS TO BE PRESERVED.
- 2.2. GRADE CHANGES AND EXCAVATIONS SHALL NOT ENCROACH UPON THE TREE PROTECTION ZONE.
- 2.3. NO TOXIC MATERIALS, INCLUDING PETROLEUM PRODUCTS, SHALL BE STORED LESS THAN ONE HUNDRED (100) FEET FROM A TREE PROTECTION ZONE OR A WATERCOURSE. IF FIELD CONDITIONS WARRANT, A GREATER DISTANCE MAY BE REQUIRED.
- 2.4. THE AREA WITHIN THE TREE PROTECTION ZONE SHALL NOT BE BUILT UPON NOR SHALL ANY MATERIALS BE STORED THERE EITHER TEMPORARILY OR PERMANENTLY. VEHICLES AND EQUIPMENT SHALL NOT BE PARKED IN THE TREE PROTECTION ZONE.
- 2.5. SEDIMENT, RETENTION, AND DETENTION BASINS SHALL NOT DISCHARGE INTO THE TREE PROTECTION ZONE.
- 2.6. TREES SHALL NOT BE USED FOR ROPING, CABLES, SIGNS, OR FENCING, AND NAILS AND SPIKES SHALL NOT BE DRIVEN INTO TREES, WITH THE EXCEPTION OF BRACING OR OTHER SUPPORT STRUCTURES SPECIFICALLY INSTALLED BY AN ISA CERTIFIED ARBORIST FOR THE SUPPORT OF THE TREE.
- 2.7. WHEN TREE STUMPS ARE LOCATED WITHIN TEN (10) FEET OF THE TREE PROTECTION ZONE, THE STUMPS SHALL BE REMOVED BY MEANS OF A STUMP GRINDER TO MINIMIZE THE EFFECT ON SURROUNDING ROOT SYSTEMS.
- 2.8. TREE ROOTS SHALL BE PRUNED BY USE OF A TRENCH ONE (1) FOOT FROM THE LIMIT OF DISTURBANCE. TREE ROOTS WHICH MUST BE SEVERED SHALL BE CUT CLEANLY USING A VIBRATORY KNIFE OR OTHER ACCEPTABLE EQUIPMENT. ALL CUTS SHALL BE MADE RADIALLY TO THE TREE(S).

3. TREES DAMAGED DURING CONSTRUCTION

- 3.1. ANY ROOTS SEVERED INADVERTENTLY AS A RESULT OF EXCAVATION SHALL BE TRIMMED SO THAT THE EDGES ARE SMOOTH AND CUT BACK TO A LATERAL ROOT IF EXPOSED.
- 3.2. WITHIN FOUR HOURS OF ANY SEVERANCE OF ROOTS, ALL TREE ROOTS THAT HAVE BEEN EXPOSED AND/OR DAMAGED SHALL BE TRIMMED CLEANLY AND COVERED TEMPORARILY WITH MOIST PEAT MOSS, NATURAL BURLAP OR OTHER BIODEGRADABLE MATERIAL TO KEEP THEM FROM DRYING OUT UNTIL PERMANENT COVER CAN BE INSTALLED.
- 3.3. DAMAGED BRANCHES SHALL BE PRUNED IN ACCORDANCE WITH THE STANDARDS SPECIFIED BY THE TREE CARE INDUSTRY ASSOCIATION IN THE LATEST EDITION OF "AMERICAN NATIONAL STANDARD FOR TREE CARE OPERATIONS" ANSI A300 (PART 1) - 2008 PRUNING OR LATEST EDITION. ALL CUTS SHALL BE MADE SUFFICIENTLY CLOSE TO THE TRUNK OR PARENT LIMB WITHOUT CUTTING INTO THE BRANCH COLLAR OR LEAVING A PROTRUDING STUB. ALL NECESSARY PRUNING CUTS SHALL BE MADE TO PREVENT BARK FROM BEING TORN FROM THE TREE AND TO FACILITATE RAPID HEALING.
- 3.4. ANY OTHER WOUNDS OR DAMAGE THAT OCCURS TO TREES TO BE PRESERVED SHALL BE ADDRESSED BY AN ISA CERTIFIED ARBORIST.



Pennsylvania Woodlands

Number 7

Dead Wood for Wildlife

Most of us would have little difficulty responding if asked what value trees have for people. Living trees provide shade. Trees filter air and produce oxygen with their leaves. Trees can soften the impact of rain, prevent soil erosion, produce food, and are pleasing to the eye. Harvested trees provide many valuable products for people. When a tree is cut, it can be used to frame, insulate, or heat a house. This publication was written and reproduced on paper made from trees.

But most of us would have much difficulty relating the value that trees have for wildlife, especially dead trees. Trees do have special value for wildlife. Dead parts of live trees and dead trees, whether standing (snags) or fallen (logs), are particularly important resources.

Felling a tree for whatever reason alters wildlife habitat. The effects can be beneficial or detrimental, planned or haphazard. Some people believe leaving dead trees in the forest to rot is a waste of resources. However, dead trees offer both shelter and food to many wildlife species. Dead limbs and trees are a natural and desirable part of wildlife habitat. The existence of numerous species depends on the presence of dead trees. A fallen tree becomes infested with fungi and insects. As the tree decomposes, nutrients

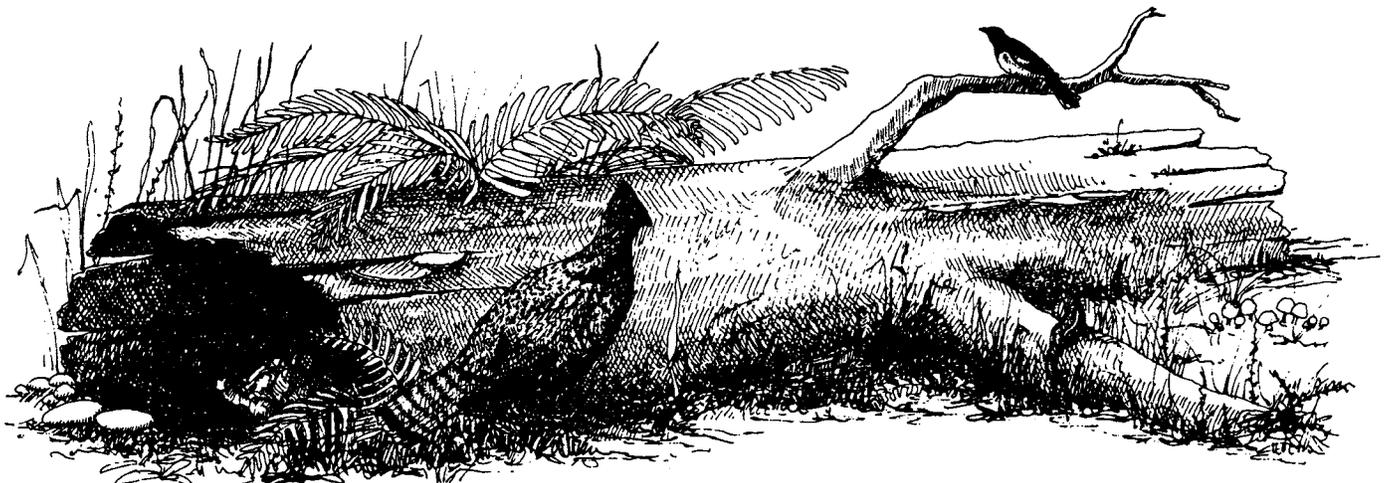
are recycled into the soil and a microhabitat favorable for the growth of new tree seedlings is often created.

Insects, salamanders, snakes, mice, and shrews seek refuge in rotting logs. Skunks, bears, and woodpeckers repeatedly return to these cafeterias for easy pickings. Depending on a log's location relative to good cover, a grouse may use it as a drumming site. Some rot-resistant logs have been used by generations of ruffed grouse.

The accumulation of organic material, including damp, rotting wood and leaves, favorably affects mushroom populations. Mushrooms are food for insects, turtles, birds, mice, squirrels, and deer. During critical winter periods, highly nutritious mushrooms can compensate for nutrient deficiencies in deer's native forage.

Ruffed grouse and eastern towhees, among other species, nest under partially elevated logs. Depending on their size, hollow logs can shelter a variety of forest mammals such as shrews, chipmunks, and bears. Foxes and coyotes also may use logs for dens. For some mammals, including deer mice, chipmunks, and squirrels, log tops are highways over the forest floor. Rattlesnakes often coil next to a log and wait for food to arrive.

Logs and stumps meet the special habitat requirements



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of the redback and slimy salamanders. The four-toed and longtailed salamanders hide in moist, decaying wood. The eggs of the northern spring salamander are laid in running water under logs. Greater and lesser gray tree frogs may be found in hollow trees, under loose bark, or in rotted logs during the summer. Seven species of turtles bask on logs that are in or near water. The eastern box turtle may burrow under a log during hot weather. The northern fence lizard is found in log piles and around stumps and hibernates in the rotting wood. Special habitat requirements of the five-lined skink include open woods with logs and slash piles.

Snakes use logs for shelter and food-seeking activity. Some species, such as the eastern garter snake and the eastern worm snake, hibernate in rotting wood. At least 19 kinds of salamanders and 26 species of reptiles make some use of logs, stumps, bark, and slash piles in Pennsylvania's forests. Ecologists believe dead wood is one of the greatest resources for animals species in the forest.

Wildlife use of dead snags and cavity trees

Standing dead trees (snags) and dead parts of live trees offer both room and board for many kinds of wildlife. Tree cavities in live or dead trees are used by 35 species of birds and 20 species of mammals in Pennsylvania (Tables 1 and 2).

Wood ducks look for tree cavities near water. Barn owls look for nest sites that are near large fields. Bluebirds can nest in wooden fence posts bordering farm fields, or they can occupy holes in snags that are left in recently clearcut areas. Unlike the barn owl and bluebird, pileated woodpeckers are birds of the big woods and next in tree holes far from fields. Table 1 lists the habitat of 35 bird species that nest in free cavities.

In addition to location, the nature of the cavity tree is important to wildlife. Some species choose a cavity in either a live or a dead tree; this is not true of all species. The yellow-bellied sapsucker, for example, constructs a new cavity each year in a live tree. The northern flicker, on the other hand, uses or excavates cavities in dead trees. Whether a snag is hard (sound) or soft (plunky) also determines which birds use it. The pileated and hairy woodpeckers choose to nest in hard snags. The brown creeper nests under exfoliating bark of hard snags. The black-capped and Carolina chickadees prefer to excavate nesting cavities in soft snags.

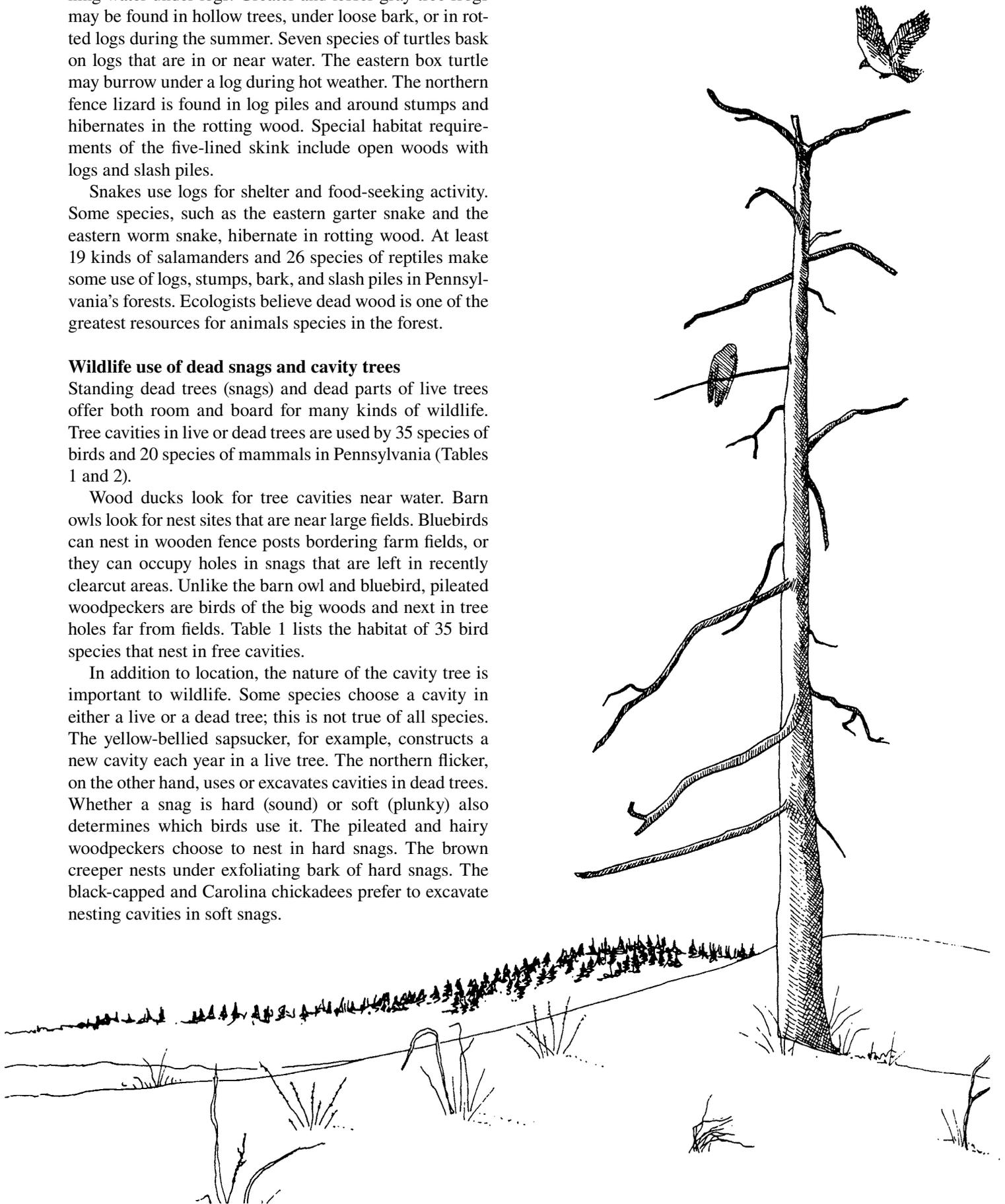


TABLE 1. Birds that use tree cavities in Pennsylvania.

CAVITY-USING BIRDS	CUTTING SITE AND TYPE OF CUTTING ACTIVITY*					FREQUENTLY CHOSEN CAVITY TREE TYPE**		
	FOREST INTERIOR		FOREST-FIELD EDGE	NEAR WATER, WETLAND	SCATTERED TREES, LARGE FIELDS	LT	DEAD	
	A	B	C	D	E		HS	SS
Wood duck				x		x	x	x
Hooded merganser				x		x	x	x
American kestrel			x		x	x	x	x
Barn owl			x		x	x	x	?
Screech owl		x	x		x	x	x	x
Barred owl	x			x		x	x	x
Sawwhet owl	x			x			x	x
Great horned owl	x	x	x	x	x	x	x	x
Chimney swift			x	x	x	x	x	x
Northern flicker		x	x	x	x		x	x
Pileated woodpecker	x			x		x	x	
Yellow-bellied sapsucker	x	x	x	x		x		
Hairy woodpecker	x			x		x		
Downy woodpecker	x	x	x	x			x	x
Red-headed woodpecker		x	x	x	x	x	x	x
Red-bellied woodpecker	x	x		x		x	x	?
Great crested flycatcher	x	x	x	x		x	x	x
Tree swallow			x	x		x	x	x
Black-capped chickadee	x	x	x	x				x
Carolina chickadee	x	x	x	x				x
Tufted titmouse		x	x	x		x	x	x
White-breasted nuthatch	x	x	x	x		x		
Red-breasted nuthatch	x			?		x	x	x
Brown creeper	x			x			x	
Winter wren	x	?		x		x	x	x
Carolina wren	x	x	x	x		x	x	x
House wren		x	x	x	x	x	x	x
Bewick's wren		x	x	x	x	x	x	x
Prothonotary warbler	x			x		x	x	x
Eastern bluebird		x	x		x	x	x	x
Purple martin		x	x		x		x	?
European starling			x		x	x	x	x
House sparrow			x		x	x	x	x
Turkey vulture	x	x	x	x				x
Black vulture	x	x	x	x				x
TOTAL:	19	19	24	27	14	26	29	27
PERCENT:	54	54	69	77	40	74	83	77

* **Type of tree cutting activity.** **A:** partial cutting within a woodlot, often a diameter limit cut or thinning; **B:** cutting heavy enough to create clearings within a woodlot, often a clearcut; **C:** cutting within 100 feet of a field, often fuelwood removal; **D:** any cutting near a stream, pond, or within other wetland sites; **E:** removal of trees competing with crops or for purposes of site development, often the elimination of a fencerow.

** **Cavity tree type.** **LT:** a live tree with a cavity large enough to shelter the indicated species; **HS:** a hard or firm, dead snag with or without bark and with a cavity large enough to shelter the indicated species; **SS:** a soft, punky, dead snag with a suitable cavity.

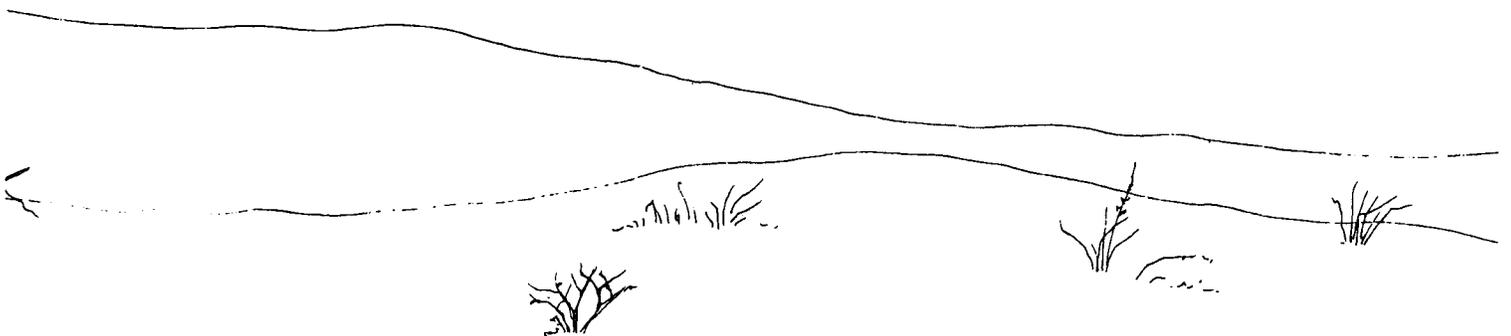


TABLE 2. Mammals that use tree cavities in Pennsylvania.

Opossum	Red squirrel
Pipistrel bat	Eastern flying squirrel
Little brown bat	Northern flying squirrel
Keen bat	Chipmunk
Indiana bat	Deer mouse
Silver-haired bat	White-footed mouse
Big brown bat	Porcupine
Evening bat	Raccoon
Gray squirrel	Black bear
Fox squirrel	Long-tailed weasel

Only the squirrels and perhaps one or two kinds of bats are obligate cavity nesters. Other species may use cavities if they are available.

In addition to the soundness and location of a cavity tree, the following other factors may affect its use by wildlife:

- The size of the cavity. Will the entrance accommodate a bluebird, a barn owl, a squirrel, a raccoon, or a bear?
- The diameter and height of the cavity tree. The house wren and bluebird rarely nest in holes more than 12 feet above the ground, while pileated woodpecker cavities are found higher than 15 feet. Generally speaking, the larger the cavity nester, the larger diameter of the tree selected for nesting.
- The direction faced by the cavity entrance. Screech owls, for example, often choose cavities with north-facing entrances and, consequently, low internal light levels.
- The relationship to other cavity trees. Cavity trees chosen by gray and fox squirrels are often located near other cavity trees.
- The nature of the woodlot. Although most species choose stands of deciduous trees or mixed stands including some evergreens, the sawwhet owl prefers stands of evergreens. Whether a cavity tree is located in a woodlot with a dense or open understory also affects its use by some species. Hairy and downy woodpeckers prefer open and dense understories, respectively. Similarly, dense understories favor gray squirrels, whereas more open understories attract fox squirrels.
- The time of the year. Cavity trees are used for nesting, roosting, winter shelter, escape, food storage, and foraging. One researcher found that amphibian and reptilian use was highest in the summer and early fall, followed by high mammalian use in late fall and winter. Bird use is greatest in spring and early summer. People cleaning bird boxes in early March frequently evict deer mice from the winter apartment.

The presence of cavities or the possibility of excavating cavities in wood with heart rot or other decay is not the only attraction of a dying or dead tree for wildlife. Snags are a common source of insects and other invertebrates. This food source may be exceptionally important for overwintering birds.

If snags are houses and cafeterias, they are also airports. Flycatchers use snags for launch sites as they sally forth time and again after flying insects. A snag that borders a field or orchard may be used constantly by hawks and owls while they wait for an errant field mouse. Similarly, kingfishers, ospreys, and bald eagles perch on or fish from dead trees standing in or near water. At least 30 kinds of birds commonly use snags for foraging perches. In addition, the indigo bunting, northern mockingbird, and crow are among species that regularly use snags for singing perches.

Using dead wood for wildlife rather than fuelwood requires some choices. The fuelwood value of a hollow tree must be weighed against the possible value of the wildlife it attracts.

Aside from food or dollar values, the recreational value of such species are, for many of us, worth leaving a few hollow trees and logs on every acre. You may be hunting squirrels, wood ducks, or grouse, or trying to take that special photograph of a bluebird. The entertaining chickadee on your bird feeder may have been born in the hollow aspen tree behind your house. These values are not measured by dollars but by feeling.

The poet Robert Frost put one such intangible value in perspective:



*The way a crow
Shook down on me
The dust of snow
From a hemlock tree*

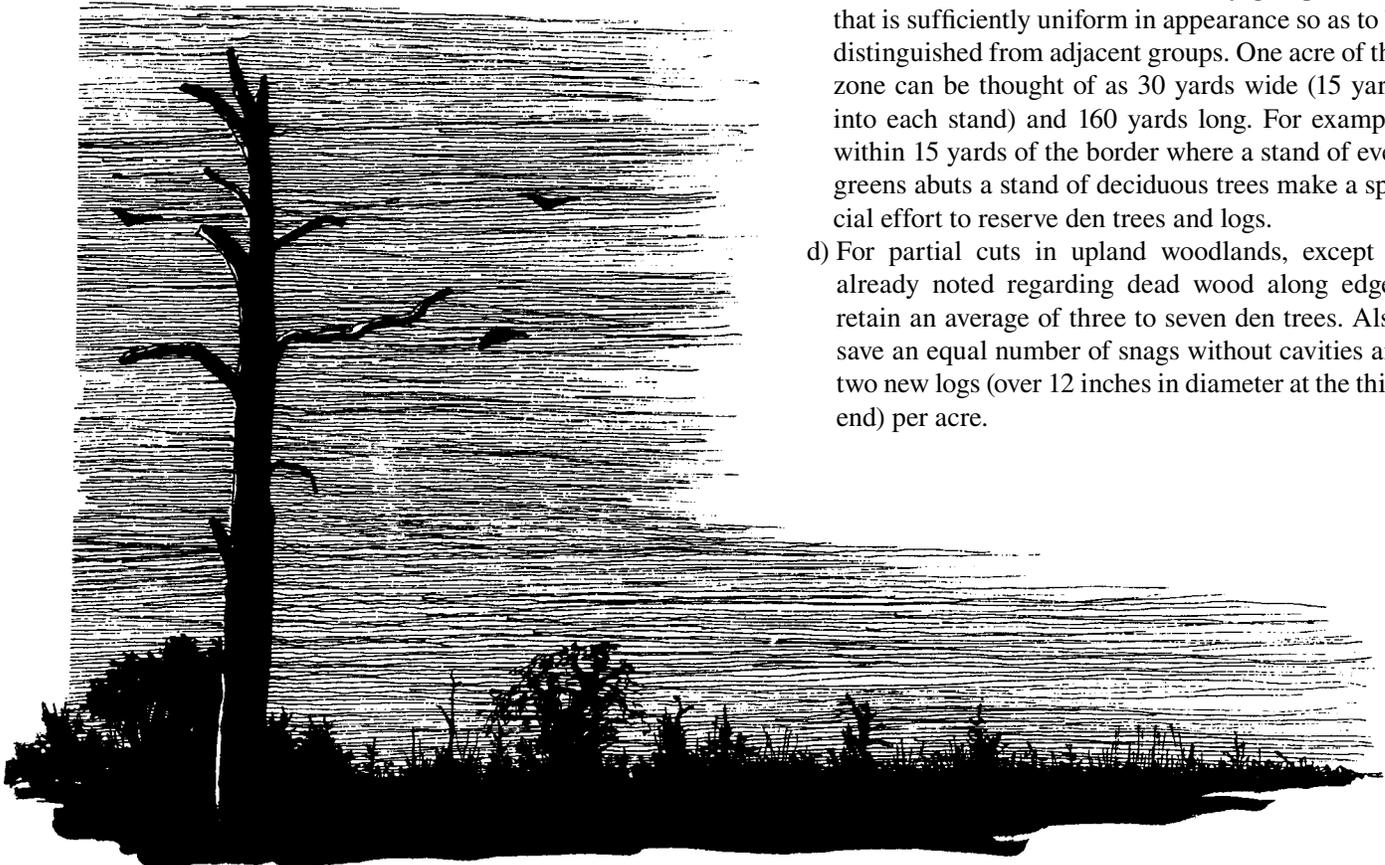
*Has given my heart
A change of mood
And saved some part
Of a day I had rued.*

Insect populations

The regulation of insect populations is a complex issue. Insects form a major part of the diet of 80 percent of the cavity-using birds in Table 1. Nine of 20 mammals using tree cavities depend on insects for food. Shrews, salamanders, and reptiles that make use of logs, stumps, bark, and slash piles constitute an additional 50 species that forage for insects.

Insect damage to trees is a significant cause of loss. Insectivorous cavity-nesting birds, in many cases, play an important role in the regulation of forest insect populations. Scientists believe that the most important role of birds is the prevention, rather than the suppression, of insect infestations. The protection of cavity-nesting bird populations by promoting forest diversity and leaving snags and den trees is advocated as an economical means to help prevent insect outbreaks in the managed forest.

Many people are familiar with the purple martin's ability to consume large quantities of flying insects. A single purple martin may consume hundreds of mosquitoes in one evening, but bats are the champion. They are the only major predator of night-flying insects. A single big brown bat can consume thousands of mosquitoes before dawn. It is evident that woodlots are best protected from insects by a full complement of species including birds, mammals, reptiles, and amphibians. The alternative could be loss of annual tree growth or expensive spraying of insecticides.



MANAGEMENT CONSIDERATIONS

1. Selective cutting, when only a portion of the trees in a stand is removed in activities such as fuelwood cutting or timber stand improvement, is most likely to be concentrated in areas of vehicle accessibility. This procedure results in removal of snags and logs from *woodland border zones* and fencerows and from *wooded bottoms* traversed by both stream and road. These are precisely the sites where use by wildlife and competition for available nesting and cover sites are greatest (Table 1). Observing the following guidelines can lessen the detrimental aspects of tree harvests in these "edge zones."
 - a) Avoid cutting or removing hollow trees and limbs on the ground or standing trees (live or dead) within 15 yards of a field. In woodland areas that are immediately adjacent to this zone, reserve an average of five to ten den trees per acre. Retain all existing logs with varying degrees of composition and at least four new logs (e.g., hollow butt sections of felled trees) per acre.
 - b) Avoid cutting or removing hollow trees and limbs within 30 yards of water zones (e.g., streamside riparian zones). In woodland acres that are immediately adjacent to this waterside zone, reserve up to 25 den trees (average 15) per acre. Again, retain logs as described in "a" above.
 - c) Retain an average of five to ten cavity trees and two new logs per acre in boundary zones of adjacent stands. As used here, a *stand* is any group of trees that is sufficiently uniform in appearance so as to be distinguished from adjacent groups. One acre of this zone can be thought of as 30 yards wide (15 yards into each stand) and 160 yards long. For example, within 15 yards of the border where a stand of evergreens abuts a stand of deciduous trees make a special effort to reserve den trees and logs.
 - d) For partial cuts in upland woodlands, except as already noted regarding dead wood along edges, retain an average of three to seven den trees. Also, save an equal number of snags without cavities and two new logs (over 12 inches in diameter at the thick end) per acre.

2. Clearcutting, when most of the trees in an area are removed, creates a temporary opening and edge in a woodland, and extra bird species are attracted to the forest (Table 1). Under these circumstances, larger woodlands can be attractive to 27 cavity-nesting birds, and most cavity-using mammals and other species *if* the following guidelines are applied.

Clearcuts, in which all trees, dead or alive, are removed, have a long-term detrimental impact on wildlife dependent on dead wood. The young trees that spring up following clearcutting are not large enough to provide the configuration of dead wood accumulated in the mature stands before clearcutting, and dead-wood deficit develops about 15 years after cutting. This deficit occurs earlier if slash is removed by fuelwood cutters. This deficit may span 40 or more years. For example, depending on its location in Pennsylvania, a clean 20-acre clearcut site is relatively unattractive to 100 or more wildlife vertebrates (birds, mammals, amphibians, and reptiles) for 40 or more years. Conversely, observing the following guidelines can help provide long-term benefits for these same species.

- a) Do not clearcut within 30 yards of water. Partial cutting in this waterside buffer strip should be confined to the solid, live hardwood trees. Note: Slopes next to streams should have wider buffer strips; the steeper the slope, the wider the buffer.
- b) Within clearcuts, reserve at least a 1/5- to 1/3-acre clump of trees for every 5 acres clearcut. Each clump should contain one or more live trees with a squirrel-sized (2 1/2 inches) or larger den entrance. Partial cutting within these tree clusters should be avoided.
- c) Beyond clumps, an average of six to thirteen individual den trees and other snags can be reserved per acre. Den trees should be maintained along clearcut borders, in finger draws, and at the low end of slopes that will help minimize blowdowns. Blowdowns are not, however, wholly objectionable because they contribute logs to the forest floor over time. This process benefits a different set of wildlife species.
- d) Logs are important as wildlife habitat because they last longer than slash. For best distribution of logs on clearcut sites, noncommercial sections of butt logs should not be piled at the log-loading site. Rather, they

should be severed from the saleable portion of the log and left at the felling site. Logs oriented along the contour will slow erosion and trap debris. In addition to all older logs with varying degrees of decomposition, at least two new logs (over 12 inches in diameter at the large end) should be retained for every acre cut.

e) Woody debris (slash) should be reserved on at least 10 percent of the area being clearcut.

3. Additional management tips:

- a) No one can have everything on an acre. In effect, all of the above guidelines should be prefixed with: "If the choice exists...?"
- b) A uniform distribution of cavity trees may be both impractical and, from the standpoint of wildlife, undesirable. The figures used in #1 and #2 above are averages that should be used as guidelines. A few acres may have an excess of cavity trees. This excess can compensate for the many acres that have few or no cavity trees.
- c) If the choice exists, large (over 19 inches dbh), medium (10 to 19 inches dbh), and smaller (less than 10 inches dbh) den trees should be reserved on the same acre, especially in edge zones. A mixture of both live and dead cavity trees is also desirable.
- d) If cavity trees do not exist where you want them, reserve trees with potential for developing a cavity. Candidates include dead or partially dead trees, e.g., a live tree with a broken top.

SUMMARY

Dead wood, both standing and down, serves as important wildlife habitat. Wildlife evolved in forests where dead wood was never removed in the name of woodland management. The increasing demand for forest products has, in many instances, resulted in a lack of dead-wood habitat for wildlife. Application of the management guidelines listed in this publication can help provide some of this important habitat in your woodland.

Can you afford to provide some wood for wildlife habitat, to leave some dead and dying trees, as well as a few hollow logs, on every area? Considering the many rewarding values of wildlife that depend on this resource, the question might better be phrased "Can you afford not to do this?"

Prepared by Jerry Hassinger, wildlife biologist, the Pennsylvania Game Commission; and Jack Payne, extension wildlife specialist, The Pennsylvania State University.

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Mulch Application Guidelines

E. Thomas Smiley, Ph. D., Plant Pathologist

Mulches provide many benefits for trees and shrubs. They moderate soil temperatures, reduce soil moisture loss, reduce soil compaction, provide nutrients, improve soil structure, keep mowers and string trimmers away from the trunk. These benefits result in more root growth and healthier plants. When applying mulch the following guidelines should be observed:

1. The best mulch materials are wood chips, bark nuggets, composted leaves or pine needles. Plastic, stone, sawdust, finely shredded bark, and grass clippings should be avoided. Do not use redwood or walnut mulch due to allelopathic effects.

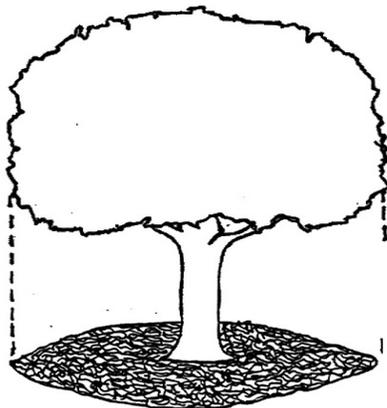


Figure 1. Mulch should be applied from the trunk to the dripline.

2. Mulch should be applied from the dripline to the trunk (Figure 1). If this

is not practical, minimum mulch circle radii should be 3 feet for small trees, 8 feet for medium trees and 12 feet for large trees.

3. When applying mulch it is not necessary to kill or remove existing ground cover. However, turf should be mowed very short and clippings removed prior to application. Mulch should be applied directly to the soil surface, do not use landscape fabric to separate the mulch from the soil.



Figure 2. Mulch layer should be 2-4 inches thick and not be against the trunk.

4. Mulch layer should be 2-4 inches thick depending on tree species and mulch (Figure 2).
5. Additional mulch should be added to maintain a 2-4 inch depth.
6. Mulch should not be placed against the trunk (Figure 2). Mulch will retain too much moisture against the trunk, potentially resulting in disease problems.

Pruning Landscape Trees

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Why Should Trees Be Pruned?

Proper pruning of landscape trees improves their structural strength, maintains their health, enhances their beauty, and increases their value. Pruning is advisable if:

- ◆ trees have crossing branches, weak branch unions, or other defects
- ◆ branches are dead, dying, decayed, or hazardous
- ◆ lower branches interfere with people or vehicles, or block visibility of signs
- ◆ branches are growing into buildings or utility wires
- ◆ limbs have been broken by storms
- ◆ trees have grown too large and might injure people or damage property

Landscape trees not only make homes and communities more beautiful, but they also improve our environment and can increase the value of a property up to 20 percent. Trees are truly assets that need to be enhanced and protected. Proper pruning is definitely a worthwhile investment!

Who Is Qualified to Prune Trees?

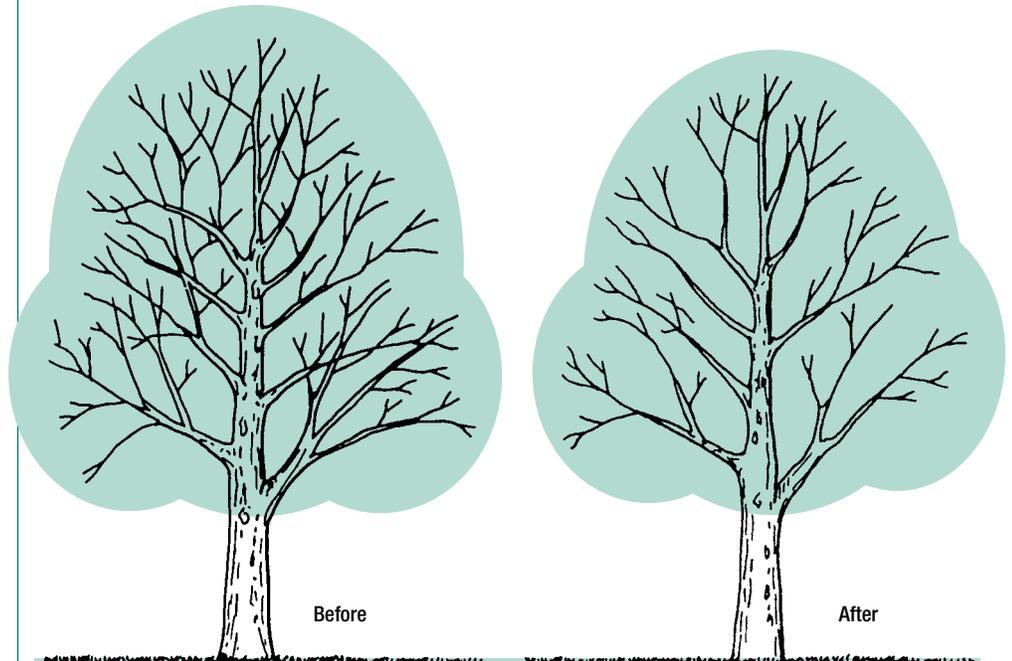
Simple types of pruning, such as cutting lower branches from small trees, can be done by anyone who understands plants and has the proper tools. But only qualified arborists should train young trees or climb into trees to prune them. That type of tree work requires knowledge of scientifically based pruning techniques, tree physiology, and safety practices, as well as working experience with various tools and tree species. Because proper pruning is complicated and examples of shoddy and unsafe work abound, national standards have been developed for the best methods and safety. Any potentially hazardous activity associated with climbing trees, using power tools, and especially working near electric lines should be left to qualified professionals who follow the national tree safety standards.

This circular offers guidance for those who want to prune young trees. It also can help you find a qualified tree professional, understand proper pruning practices, and recognize work that is damaging to trees.

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Crown thinning a tree removes unwanted branches, reduces weight, and allows light and air penetration. If properly done, thinning increases a canopy's photosynthetic area.

Types of Pruning Cuts

—A *thinning cut* removes a branch at its point of origin on the trunk. A reduction cut shortens a limb to a lateral branch large enough to resume the growth of the pruned limb (Fig. 1). Thinning and reduction cuts leave no stubs. They are used to remove damaged, dead, or weak branches, reduce the length and weight of heavy limbs, or reduce the height of a tree. Reduction cuts are placed so as to distribute ensuing growth throughout a tree and retain or enhance a tree's natural shape. Reduction and thinning cuts are the proper type of cut to use in pruning a live tree. Reduction cuts on larger branches can be referred to as drop crotch pruning.

—A *heading cut* trims a branch back to a bud, or trims a branch or leader back to a small branch not large enough to assume the growth of the pruned branch. Heading cuts should only be used when pollarding trees or shaping terminal flowering plants such as roses; they should not be used for topping trees. Topping has been described as the “ultimate in destructive practices,” and in almost all cases it permanently damages a tree's health, structure, and appearance.

—A *stub cut* is like a heading cut but is made indiscriminately to a point on a branch or leader where no bud or branch exists. A stub cut, like a heading cut, is used when a tree is topped. Topping is only appropriate when sections of limbs are cut off during the removal of a tree.

Tree Topping

Topping of trees using stub cuts and heading cuts should not be done for several reasons. Topping reduces the ability of a tree to produce food. Shock and long-term declining health resulting from topping can make a tree more susceptible to insect and disease problems and can lead to its death. By removing the branches that protect a tree's crown, topping can lead to sun scalding of remaining branches. The stubs and sun scalds resulting from topping cuts are highly vulnerable to insect invasion and the spores and actions of decay fungi. Numerous water sprouts resulting from topping are weakly attached and grow so rapidly that a tree can regain its original height in a short time with a more dense and unwieldy crown. With their natural form and beauty disfigured, topped trees are ugly to most people. Topping can reduce the value of a large ornamental tree by thousands of dollars. Although tree topping may cost less and take less time and knowledge than using reduction cuts (the proper pruning technique), you would be paying for an inferior service.

Training Young Trees

Before pruning a young tree, it is important to consider the natural form and desired future growth of the tree. Some trees like pines and sycamores have strong central trunks and require little pruning. Others, such as oaks and maples, branch out more. Pruning should accentuate the natural branching habit of a tree and should also correct structural problems. By correcting any defect in the structure of a young tree, pruning helps develop a mechanically stronger and healthier tree.

A few minutes of thoughtful pruning spent on a young tree can eliminate hours of costly future pruning on mature trees. Ideally, pruning should be done over several years, whether it is to provide clearance or to train a young tree. Prune as little as possible in the first two years after a tree has been planted, so there will be enough temporary branches and leaves to produce food for the growth of roots, trunk, and branches. Newly planted trees will gradually restore the balance between roots and branches; excessive pruning can be detrimental and delay normal growth. When a tree is planted, prune only broken, malformed, or diseased branches. Remove any double leader so that one dominant trunk is maintained. Removing branches

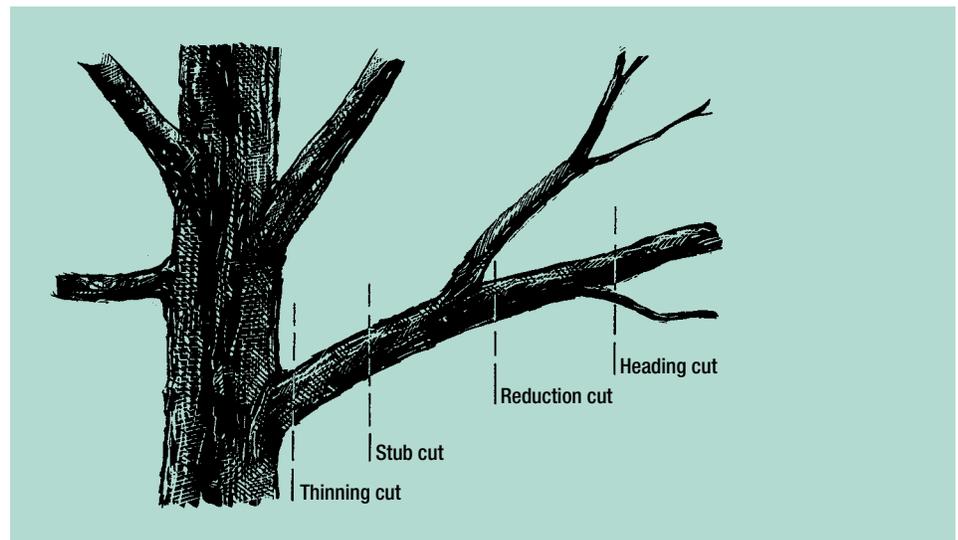


Fig. 1. When using reduction cuts, always remove or shorten a branch to a side branch that is at least one-third the size of the one being cut. A branch that is 3 inches in diameter would be pruned back to a side branch that is at least 1 inch in diameter. Do not remove more than 25 percent of a mature tree's foliage in any year.

before they exceed 1 inch in diameter will keep pruning wounds small.

Clearance requirements are an important consideration. Street trees or trees along walkways and driveways must have limbs high enough to safely accommodate pedestrians and vehicular traffic, signs, and lights. Trees grow from the tips and the tops, not from the bottom. Branches that grow 6 feet off the ground will always remain at that height and may droop as they grow longer. If clearance is not a problem, keep branches on the tree to help the tree grow. The need to prune for clearance can be minimized by purchasing trees that have been nursery grown to street tree specifications.

About two or three years after planting a tree, examine it closely again and prune any broken, malformed, or diseased branches. Also, remove any suckers from the base of the tree. Step back and look at the tree from all sides to select the permanent branches and branch structure that the tree will have for its lifetime. When deciding which branches to remove, consider the following (see Fig. 2):

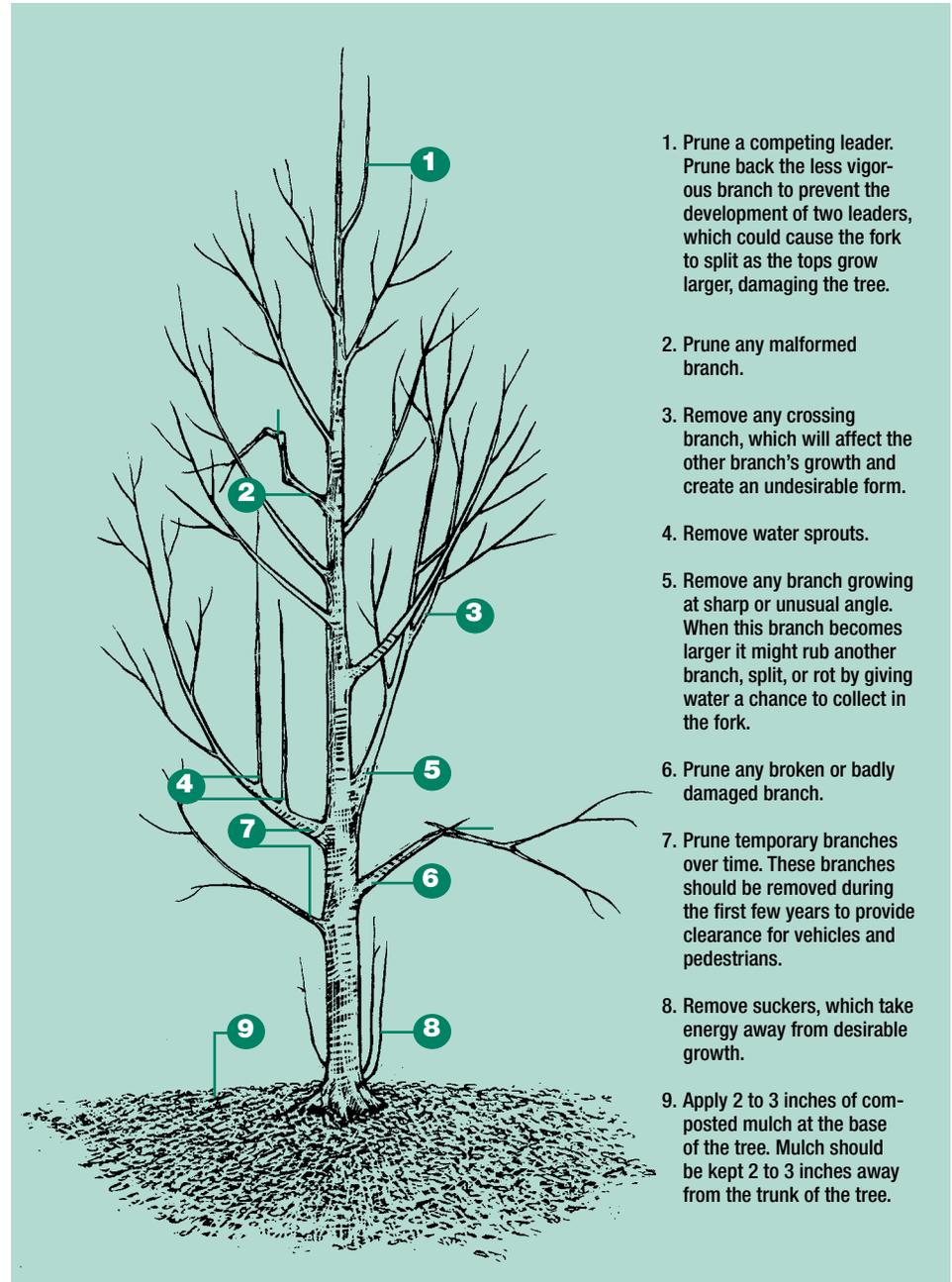
- ◆ Thin or prune back any unusually long branch that competes with the leader for dominance.
- ◆ Remove any branch that crosses or rubs another, keeping the branch that conforms to the natural form of the tree. Thin out excessively crowded branches.
- ◆ Wide angles between the limb and trunk are stronger than narrower ones. Remove branches that have much narrower angles between branch and trunk than are typical for the species.
- ◆ Remove the lower branches to provide safe clearance and visibility, gradually over several years.
- ◆ Branches should be well spaced along and around the trunk of a tree.
- ◆ To correct defects or to thin out an overly dense crown, a young, vigorous tree can have as much as 35 percent of its foliage removed while the tree's structure is being established.
- ◆ Avoid pruning trees from the time of bud break until leaves have grown to full size.
- ◆ Prune hawthorns, crabapples, pears, and other flowering trees immediately

after flowering, thus allowing a tree to develop flower buds for next spring.

The ideal mature tree will have lateral branches that are 18 to 24 inches apart on the trunk and one strong leader. However, some trees differ, such as Japanese maple and other ornamentals, which are meant to have a more bushy appearance. It may take

repeated pruning efforts over a number of years to attain an ideal structure. Remember to retain enough branches on the tree to keep it healthy and vigorous.

Some types of trees have better branching habits than others. Branching also can be affected by nursery pruning practices. Many problems can be avoided by



1. Prune a competing leader. Prune back the less vigorous branch to prevent the development of two leaders, which could cause the fork to split as the tops grow larger, damaging the tree.
2. Prune any malformed branch.
3. Remove any crossing branch, which will affect the other branch's growth and create an undesirable form.
4. Remove water sprouts.
5. Remove any branch growing at sharp or unusual angle. When this branch becomes larger it might rub another branch, split, or rot by giving water a chance to collect in the fork.
6. Prune any broken or badly damaged branch.
7. Prune temporary branches over time. These branches should be removed during the first few years to provide clearance for vehicles and pedestrians.
8. Remove suckers, which take energy away from desirable growth.
9. Apply 2 to 3 inches of composted mulch at the base of the tree. Mulch should be kept 2 to 3 inches away from the trunk of the tree.

Fig. 2. This figure shows examples of branches that should be pruned from newly planted trees. To promote good structure and lessen the need for future pruning, trees should be properly pruned during the first one to five years. Balance between roots and branching will be restored naturally, which is preferable to compensatory pruning. To promote root establishment and growth, as many branches as possible should remain.

purchasing a high-quality tree of the right species that is suited to its purpose and to the site where it is to be planted. Properly prune your young tree to lower future maintenance costs and to create a beautiful and safe mature tree.

Pruning Mature Trees

Not all mature trees need to be pruned. Some only require pruning every 5 to 10 years. The need for pruning can be reduced by planting the right type of tree in the proper place and by properly pruning a tree when it is young. Pruning a mature tree excessively or incorrectly causes more damage than good. When a vigorous branch is cut from a tree, part of the tree's ability to produce food is removed and a wound is created where decay organisms may enter.

When you prune a branch, do not leave a stub or cut flush against the trunk. To remove a branch, make a slanting cut just outside the branch collar (the swollen area at the base of the branch next to the trunk depicted in Fig. 3).

Mature trees should only be pruned for specific purposes and in a manner that protects and preserves the tree's natural form.

Pruning should focus on maintaining tree structure, shape, health, and safety. Types of pruning recommended by the American National Standards Institute and the International Society of Arboriculture are described below:

Crown cleaning—removes dead, dying, diseased, crowded, weakly attached, or low-vigor branches and water sprouts.

Crown thinning—selectively removes branches to increase light penetration and air movement and reduce the weight of heavy limbs.

Crown raising—removes lower branches to provide clearance for buildings, vehicles, pedestrians, and signs.

Crown reduction—reduces the size and spread of crowns using reduction and thinning cuts, resulting in fewer sprouts than heading or stub cuts, and maintaining the structural integrity and natural form of the tree (Fig. 4).

Crown restoration—improves the structure and appearance of trees that have been storm-damaged or deformed by heading or stub cuts.

Selecting a Tree Care Professional

A qualified and reputable person or company should be hired to perform tree work, not an individual with a chain saw trying to make a fast buck. It is very difficult, if not impossible, to repair damage that has been done by poor pruning. In tree work, the old adage "you get what you pay for" is usually true. Tree care practices change based on the latest research, and will continue to change. It is important to hire a qualified arborist, preferably a Certified Arborist, who keeps up with proper, safe tree care techniques and will provide high-quality work at a fair price. The following guidelines can help you to select a qualified arborist and ensure proper tree care.

Always have at least two or three tree care firms examine and bid on your tree work. Usually, these firms will do so at no cost. For referrals, contact a local municipal arborist, the cooperative extension office in your county, or the International Society of Arboriculture (ISA). Tree care professionals are members of professional organizations such as the ISA. Reputable tree service companies generally do not solicit door to door, as they rely mainly on repeat customers. If possible, include a certified arborist among those whom you contact to examine your trees. Arborists certified by the ISA have passed a test of their knowledge and must continue their education to maintain competency.

Ask for a written estimate detailing the work to be done from everyone who examines your trees. Terminology used on bids should match the tree pruning guidelines and standards explained in this publication. If terms like topping or rounding-over are used, consider another firm. Do not blindly accept the lowest bid. Remember, in tree work a good job can be slightly more expensive. Try to schedule work in fall or winter, when rates may be lower. Ask to be shown proof of liability insurance and worker's compensation insurance.

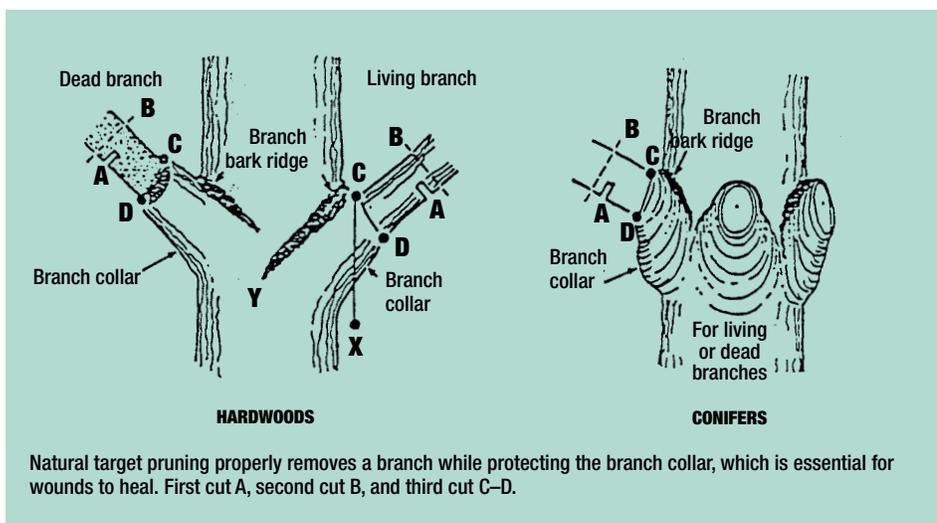


Fig. 3. To promote closing of a pruning wound by wound wood, always use the three-step or natural target pruning method when removing a branch. This pruning method protects the branch collar (the shoulder rings and swollen base of a branch) and prevents the tearing of bark. Do not leave a stub when you prune a branch, and do not cut flush against a trunk. Thinning cuts should be made with sharp tools and should be kept as small as possible, clean and smooth.

Ask the bidders where you can see trees they have pruned and examine their work firsthand. The following are indicators that proper pruning has been done:

- ◆ use of reduction and thinning cuts, rather than topping, heading, or stub cuts, so that the natural form and branching habit of the species is preserved
- ◆ cuts placed just outside the branch collar, not flush cuts
- ◆ absence of torn bark where branches have been cut, and no sign of bark punctured by climbing spurs
- ◆ no “lion-tailing,” or clumps of foliage at the ends of branches caused by removing all or most of the inner foliage
- ◆ cut surfaces untreated with wound dressing or tree paint, which can injure trees

Once you have decided on an arborist, demand a written contract that briefly but clearly states all of the following:

- ◆ type and amount of work to be completed and the techniques to be used, with reference to the *ANSI A 300 Tree Pruning Standards* or *International Society of Arboriculture Tree Pruning Guidelines*
- ◆ total cost of work to be done, not just total cost per tree
- ◆ who will be responsible for clean-up work and to what extent
- ◆ who will receive any firewood or other products
- ◆ starting and completion dates

Do not pay in advance, but wait until all terms of your contract have been fulfilled.

Use the following information to ensure that your trees will be pruned in the proper manner and for the right reasons. Familiarity with pruning methods will help you hire a qualified arborist who will do the job right.

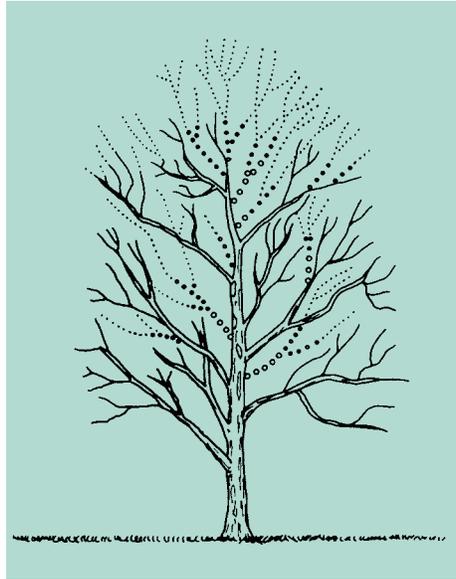


Fig. 4. The method for reducing the size of a crown is the use of small reduction cuts. Using larger reduction cuts that remove a large branch or leader to a large branch is commonly called crotching or drop-crotching. Even though large wounds may result from drop-crotching, this method of pruning is preferable to heading or stub cuts.

Utility Pruning

Trees that can grow or fall into utility wires require special pruning practices. Utility pruning is designed to prevent interruption of electric service, improve public safety, and protect utility workers. Only specially trained line clearance tree trimmers are permitted to prune trees close to electrified lines that carry more than 750 volts, according to regulations of the U.S. Department of Labor Occupational Safety and Health Administration and the American National Standards Institute. If you plan to prune or remove a tree requiring a person, tool, equipment, or any part of the tree to reach within 10 feet of an electrified line exceeding 750 watts, the

work must be performed by a qualified line clearance tree trimmer, or the utility company must be notified several days in advance so that proper safety precautions can be arranged.

Wires leading from a pole-mounted transformer to a residential electrical meter generally carry less than 750 volts, but to be safe, check with your local utility company.

Utility companies determine the amount of clearance that is needed between trees and electric lines to maintain reliable and safe service. Clearances between trees and wires depend on voltages that vary among primary and secondary conductors, and growth rates that differ among tree species. Professional tree service contractors are employed by utilities to prune periodically to specific clearances.

Utility pruning practices changed greatly during the 1990s. Research has shown that tree wounds do not heal, but are compartmentalized both physically and chemically to prevent the spread of decay and closed by wound wood. Accordingly, utilities specify the placement of pruning cuts to utilize natural defense mechanisms of trees and promote faster closure of pruning wounds. Directional pruning, using thinning and reduction cuts, is used because it is better for tree health and structure than topping trees or leaving branch stubs (Fig. 4). In directional pruning, growth of branches is directed away from wires by pruning those that can grow too close, while allowing extension of branches that will not interfere with electric lines. Topping of trees with heading cuts is avoided, as it damages tree health and encourages vigorous sprouting that increases the frequency of pruning cycles. Also, the tunnel or side-wall effect of clearing a row of trees to a uniform distance sometimes can be softened by pruning some branches back various distances, even to the trunk.

Some trees will appear to be disfigured by the pruning practices of utility companies (Fig. 5 and Fig. 6). In particular, trees that previously were topped or rounded-over will be difficult to reshape with directional pruning. Any tall-growing tree that is under or close to electric wires cannot retain a completely natural shape and should be considered for removal if severe pruning is required or has been done in the past.

Two alternatives can be used to reduce unattractive aspects of utility pruning and to lower line clearance costs. Both involve the replacement of large trees, either gradually or in groups, depending on the circumstances and preferences of people in the neighborhood. A formal street tree design with uniformly spaced trees of the same kind and size requires removal and planting all at the same time. An informal planting design can be implemented over several years, with less disruption in the appearance of the neighborhood.

Trees that are replanted should be smaller species that will not grow into wires at maturity. The right tree for planting under utility wires should be no taller than 20 to 30 feet at maturity. Adequate space for root growth also is an important consideration in relation to tree size and

placement. Low-growing trees are most appropriate if the space for roots between a sidewalk and the street is less than 4 feet wide. Medium-size trees, up to 45 feet at maturity, can be planted near utility lines (such as the other side of a street) if they are offset at least 15 feet from the nearest wire. Consider other open spaces away from utility lines for the placement of larger trees, being careful to plant them far enough away from buildings. *Street Tree Factsheets*, a publication available from Penn State, can help you choose the right tree to plant near or beneath utility lines.

Many communities have developed constructive relationships with their utility company to optimize pruning practices and tree removals. Good communication between communities and utility companies will help reduce any problems, and a notification requirement in a municipal street tree ordinance can alert an official, tree commissioner, or municipal arborist of impending tree pruning or removal. A municipal representative then can talk with the utility forester to address any concerns, and thus improve pruning quality that meets community standards.



Fig. 5. Trees under these wires were topped improperly several years ago. Vigorous regrowth of slender branches from the stubs of thicker branches grew into the wires, requiring pruning for clearance.



Fig. 6. After directional pruning of the same trees, branches directed away from the wires were retained, instead of removing all of these branches according to previous practices. Much of the regrowth will now occur on those retained branches, without interfering with the wires. Although the shape of the trees appears unnatural in the winter, they will be more normal in appearance when covered with foliage and will be healthier throughout the year.

For More Information

Arboriculture: Care of Trees Shrubs, and Vines. Hall, Inc., Englewood Cliffs, NJ 07632.

Modern Arboriculture. Shigo and Trees, Associates, 4 Denbow Road, Durham, NH 03824-3105.

How to Prune Young Shade Trees. (Other publications on tree care and maintenance are also available.) The National Arbor Day Foundation, 100 Arbor Avenue, Nebraska City, NE 68410. Phone: 402-474-5655.

Standard Practices for Trees, Shrubs, and Other Woody Plant Maintenance. (ANSI A300) International Society of Arboriculture, PO Box GG, Savoy, IL 61874. Phone: 217-355-9411.

Standard Practices for Tree Care Operations—Pruning, Trimming, Repairing, Maintaining, Removing Trees, and Cutting Brush—Safety Requirements. (ANSI Z133.1-1994) International Society of Arboriculture, PO Box GG, Savoy, IL 61874. Phone: 217-355-9411.

Street Tree Fact Sheets. Publications Distribution Center, 112 Agricultural Administration Building, The Pennsylvania State University, University Park, PA 16802-2602.

Tree-Pruning Guidelines. (Other publications on tree care and maintenance are also available.) International Society of Arboriculture, PO Box GG, Savoy, IL 61874. Phone: 217-355-9411.

Trees Are Good. Created by the International Society of Agriculture to provide the general public with quality tree care information. www.treesaregood.com

International Society of Agriculture. A worldwide organization dedicated to fostering a greater appreciation of trees and their care. www.isa-arbor.com

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RAIN GARDEN MAINTENANCE SPECIFICATIONS

1. MAINTENANCE FIRST GROWING SEASON

- 1.1. MARK YOUNG SHRUBS WITH BRIGHT BIODEGRADABLE FLAGGING MATERIAL TO PREVENT MOWING DURING MEADOW MAINTENANCE.
- 1.2. MARK PLUG PLANT AREAS TO PREVENT MOWING DURING THE FIRST FULL GROWING SEASON.
- 1.3. ALLOW VEGETATION TO STAND UNTIL EARLY SPRING AFTER THE FIRST GROWING SEASON AND THEN MOW TO A HEIGHT OF FOUR (4) TO SIX (6) INCHES WITH A MOWER OR WEED EATER. DO NOT MOW WITH A LAWN MOWER. MOWING TOO CLOSE WILL ENCOURAGE WEEDY SPECIES.
- 1.4. DO NOT MOW BETWEEN APRIL 1 AND JUNE 20 EACH YEAR TO PROTECT GROUND NESTING SITES AND PROVIDE COVER AND FOOD FOR YOUNG ANIMALS.
- 1.5. IF WEED CONTROL BECOMES NECESSARY, MOW VEGETATION IN LATE AUGUST OR SEPTEMBER AFTER THE FIRST GROWING SEASON AND THEN MOW TO A HEIGHT OF FOUR (4) TO SIX (6) INCHES.
- 1.6. MONITOR FOR WEEDY/INVASIVE SPECIES AND REMOVE MECHANICALLY, IF POSSIBLE, OR WITH CAREFUL SPOT TREATMENTS OF HERBICIDE. PROTECT ADJACENT DESIRABLE PLANT MATERIAL FROM HERBICIDE SPRAY.
- 1.7. MONITOR FOR MOWING, ANIMAL OR INSECT DAMAGE.
- 1.8. LEAVE AN UNMOWN BUFFER AROUND SHRUBS TO PROTECT THESE SPECIES. REMOVE INVASIVE SPECIES BY HAND IN THESE AREAS AS NECESSARY.
- 1.9. CONDUCT NORMAL BASIN MAINTENANCE FOR SEDIMENT BUILDUP.

2. MAINTENANCE SECOND YEAR

- 2.1. FOLLOW SAME MAINTENANCE SCHEDULE FOR THE FIRST YEAR, BUT INCLUDE THE PLUG PLANT AREAS IN THE AREA THAT IS MOWN IN EARLY SPRING.

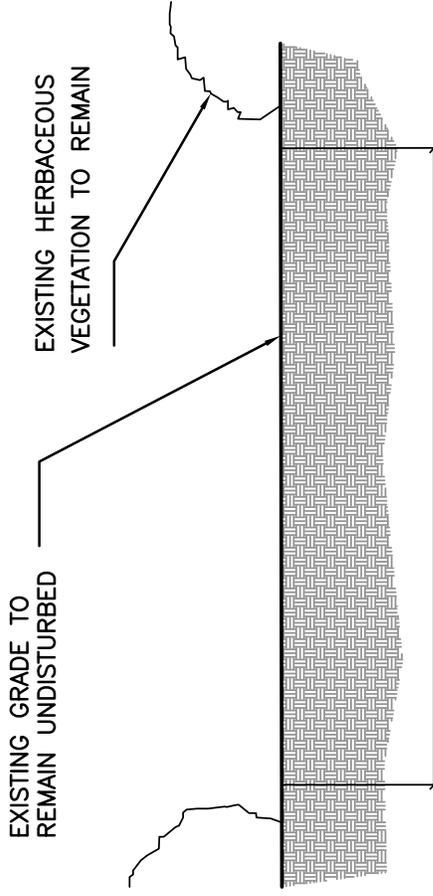
3. MAINTENANCE THIRD YEAR AND ONGOING

- 3.1. MOW ONCE IN SPRING OF EACH YEAR TO FOUR (4) TO SIX (6) INCHES PRIOR TO APRIL 1ST. DO NOT MOW BETWEEN APRIL 1 AND JUNE 20 EACH YEAR TO PROTECT GROUND NESTING SITES AND PROVIDE COVER AND FOOD FOR YOUNG ANIMALS.
- 3.2. MOW IN AUGUST OR SEPTEMBER OF EACH YEAR ONLY IF NECESSARY TO CONTROL WEEDY SPECIES. IF CONTROL OF WEEDY SPECIES IS NOT NECESSARY, ALLOW VEGETATION TO STAND UNTIL SPRING.
- 3.3. MONITOR FOR WEEDY/INVASIVE SPECIES AND REMOVE MECHANICALLY, IF POSSIBLE, OR WITH CAREFUL SPOT TREATMENTS OF HERBICIDE. PROTECT ADJACENT PLANT MATERIAL FROM HERBICIDE SPRAY.
- 3.4. MONITOR FOR MOWING, ANIMAL, OR INSECT DAMAGE.
- 3.5. LEAVE AN UNMOWN BUFFER AROUND SHRUBS TO PROTECT THESE SPECIES. REMOVE UNDESIRABLES BY HAND IN THESE AREAS AS NECESSARY.
- 3.6. CONDUCT NORMAL BASIN MAINTENANCE FOR SEDIMENT BUILDUP.
- 3.7. THE BASINS SHOULD BE MONITORED FOR STRESS FROM POLLUTANTS IN RUNOFF.
- 3.8. CONDUCT SOIL TESTS IF FERTILITY IS A CONCERN.
- 3.9. REMOVE WOODY SPECIES THAT WERE NOT PURPOSEFULLY PLANTED TO PREVENT SUCCESSION.
- 3.10. IF REPLACEMENT PLANTS ARE NECESSARY OR CONTINUING ENHANCEMENT IS DESIRED, CHOOSE GRASS, PERENNIAL AND FERN PLUGS BASED ON IMMEDIATE SITE CONDITIONS AND ANTICIPATED HYDROLOGIC ZONE LOCATIONS PER THE PA BMP NATIVE PLANT LIST.

4. INVASIVE PLANT CONTROL

- 4.1. SURVEY AREAS SURROUNDING THE BASIN TO REMOVE NONNATIVE SPECIES THAT MAY THREATEN THE ESTABLISHMENT OF SEED MIXES AND PLUGS. ERADICATION PROGRAMS FOR SPECIFIC NONNATIVE SPECIES CAN BE FOUND ON THE DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES WEBSITE AT WWW.DCNR.STATE.PA.US/FORESTRY/INVASIVETUTORIAL/LIST.HTM
- 4.2. ESTABLISH A MANAGEMENT PLAN TO MONITOR AND REMOVE NONNATIVE SPECIES FROM THE BASIN AND THE IMMEDIATE SURROUNDING AREA.
- 4.3. IDENTIFY AND MONITOR INVASIVE AND NON-NATIVE SPECIES ON AN ANNUAL BASIS.
- 4.4. CONTINUE MONITORING AREAS WHERE SPECIES HAVE BEEN REMOVED TO DETER NEW GROWTH.
- 4.5. DETERMINE THE MOST EFFECTIVE REMOVAL METHOD BASED ON THE SPECIES AND EXTENT OF GROWTH.
 - 4.5.1. HAND PULLING.
 - 4.5.2. STEM CUTTING AT GROUND LEVEL AND CONTINUED CUTTING UNTIL PLANTS WEAKEN AND DIE
 - 4.5.3. GIRDLING – CUTTING INTO THE INNER BARK CIRCLING THE PLANT
 - 4.5.4. HIGHLY SELECTIVE APPLICATION OF HERBICIDES ONLY IN THE CASE OF EXTENSIVE INVASION OR WHERE OTHER METHODS HAVE FAILED. THIS SHOULD ONLY BE CONDUCTED BY A LICENSED SPRAYER.
 - 4.5.5. BLACK PLASTIC.

NOTES:
 TRAILS SHALL BE FIELD LOCATED TO AVOID REMOVAL OF TREES AND OTHER LARGE VEGETATION.
 IN MEADOW AREAS, TRAILS TO BE MOWN TO A HEIGHT OF 4-6.
 BRUSH AND BRANCHES SHALL BE PRUNED TO A HEIGHT OF 8' WITHIN 3' OF THE TRAIL.



8' +/- MOWN/EARTHEN TRAIL

MOWN/EARTHEN TRAILS - TYP.

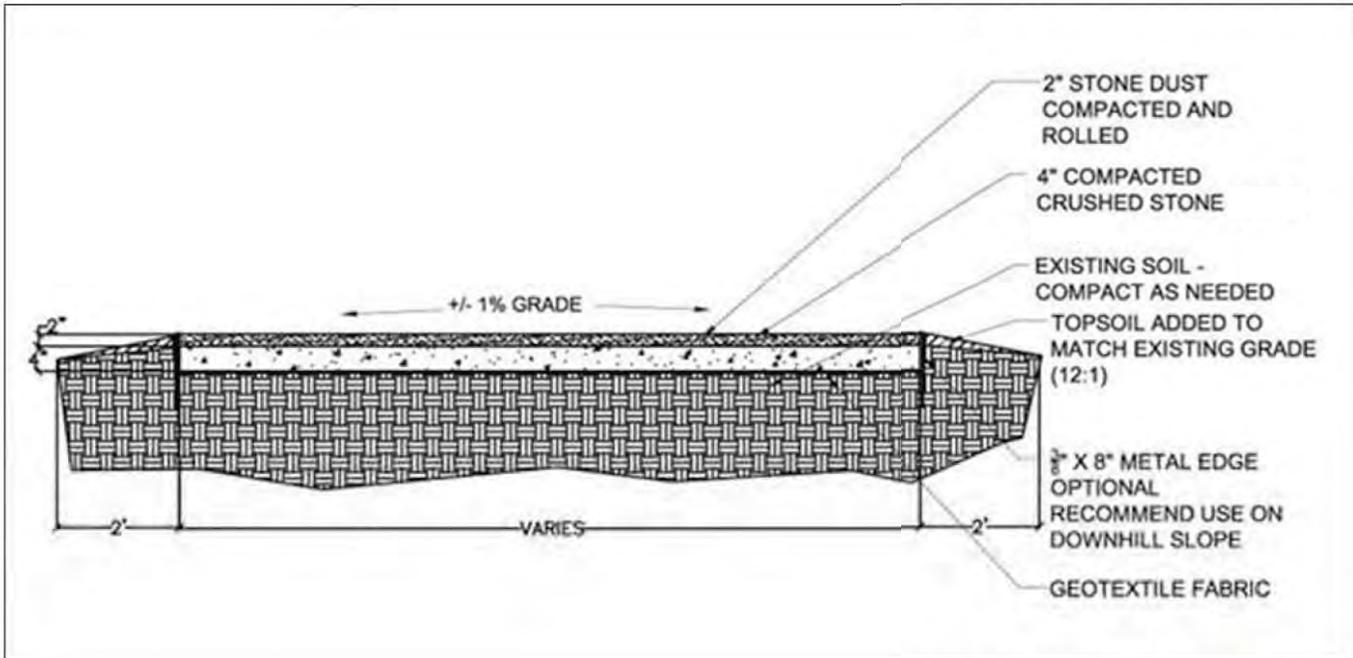
NOT TO SCALE

Use:
 For use in environmentally sensitive areas in the vicinity of wetlands and in other areas where pedestrian access is desired.

Width:
 Proposed Width - 8'. Trails are to be field located in order to avoid sensitive natural features.

Construction:
 All trail construction shall include standard clearing limits as follows: Grub and branches shall be removed to a height of 8' within 3' of the trail except where vegetation is located within delineated wetland areas.

Crushed Stone Trail



Crushed Stone Trail (Not to Scale)

Use:

For use in environmentally sensitive areas in the vicinity of wetlands and other areas where pedestrian access is desired.

Width:

Proposed Width - 8' in order to provide ADA accessibility. Trails are to be field located based on surveyed wetland points in order to avoid as much of the delineated wetland areas as possible.

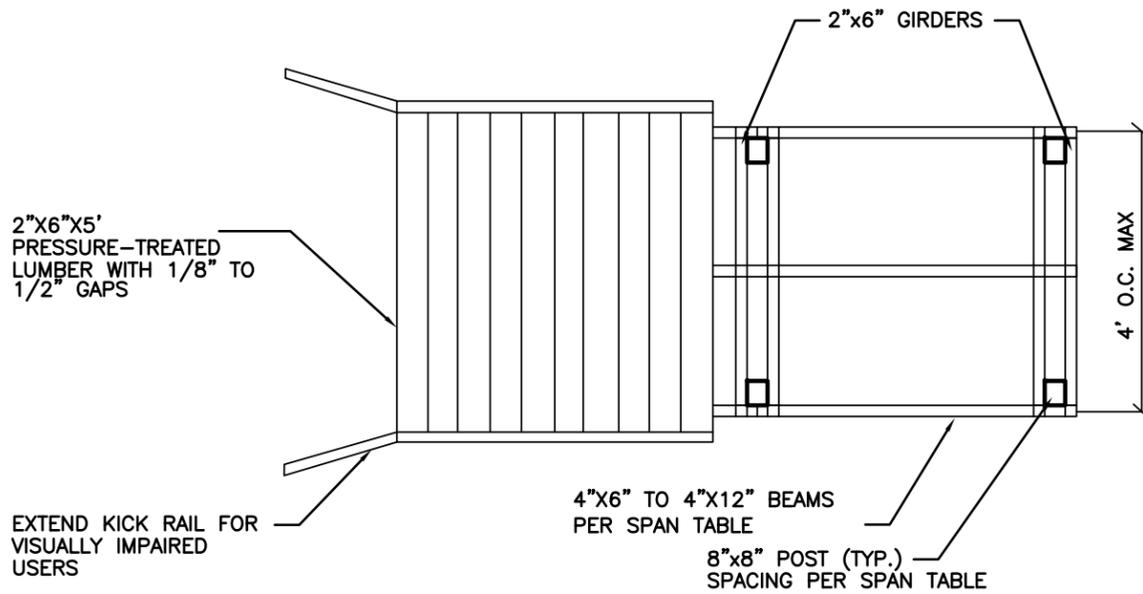
Construction:

All trail construction shall include standard clearing limits as follows: brush and branches shall be removed to a height of 8 feet within 3 feet of the trail except where vegetation is located within delineated wetland areas. Remove all roots and organic debris to a depth of 6 inches, where appropriate. Roots greater than 1" shall be trimmed so that the edges are smooth and cut back to a lateral edge if exposed.

Establish a design cross-slope in sub-grade materials. Provide complete mechanical compaction. Where this is impractical or impossible, compact by hand with an appropriately weighted implement. Overlap all fabric joints by at least 12".

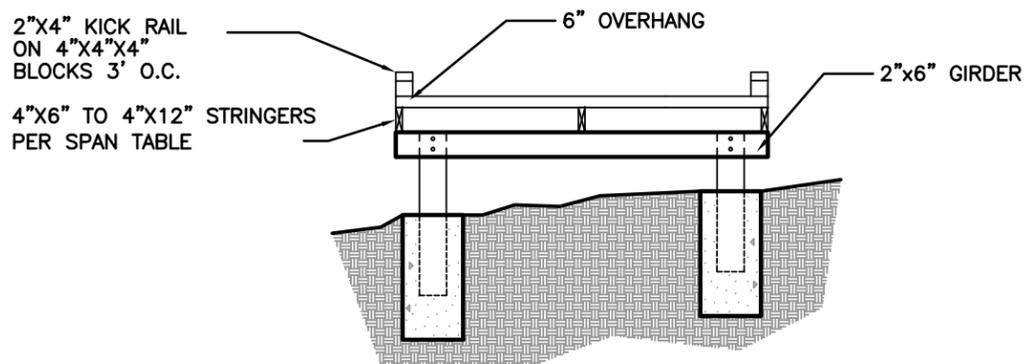


Typical Crushed Stone Trail



ACCESSIBLE BOARDWALK PLAN - 4' WIDTH TRAILS

NOT TO SCALE



ACCESSIBLE BOARDWALK CROSS SECTION - TYP.

NOT TO SCALE

MAXIMUM ALLOWABLE BEAM SPANS

(SEE PLAN FOR BOARDWALK CROSSING LOCATIONS AND APPROXIMATE PIER LOCATIONS)

BOARDWALK CROSSING	CROSSING LENGTH	BEAM SIZE	MAXIMUM ALLOWABLE SPANS
E	10' CROSSING	4"x12" BEAM	UP TO 12' SPANS (BEAMS 4' APART)
F	18' CROSSING	4"x12" BEAM	UP TO 12' SPANS (BEAMS 4' APART)
G	8' CROSSING	4"x8" BEAM	UP TO 8' SPANS (BEAMS 4' APART)
H	18' CROSSING	4"x12" BEAM	UP TO 12' SPANS (BEAMS 4' APART)
I	30' CROSSING	4"x12" BEAM	UP TO 12' SPANS (BEAMS 4' APART)

ACCESSIBLE BOARDWALK NOTES

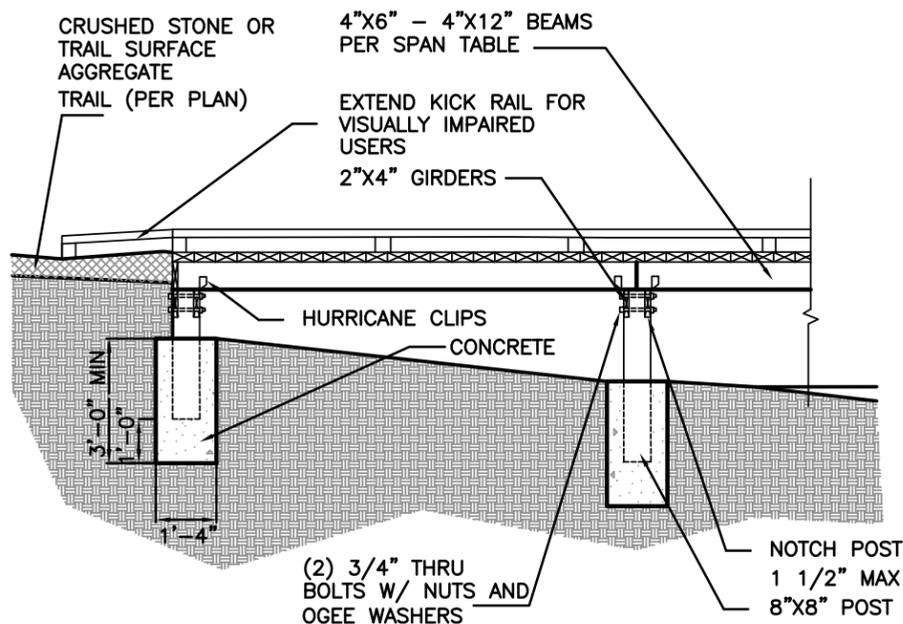
ALL LUMBER SHALL BE PRESSURE TREATED DOUGLAS FIR OR SOUTHERN PINE #2 OR BETTER.

LUMBER SHALL PRESSURE-TREATED WITH COPPER NAPHTHENATE OR ACQ (ALKALINE COPPER QUATERNARY).

CONSULT MAXIMUM ALLOWABLE BEAM SPANS TABLE FOR REQUIRED COMBINATIONS OF STRUCTURAL MATERIALS. ADJUST DIMENSIONS AND FASTENERS AS NEEDED.

ALL FASTENERS AND CONNECTORS IN CONTACT WITH PRESSURE TREATED LUMBER SHALL BE G185 HOT-DIP GALVANIZED FASTENERS. ALL CARRIAGE BOLTS TO BE ASTM A301 OR BETTER.

PAN-HEADED SCREWS SHALL BE USED ON TOP BOARDS. LAG SCREWS AND CARRIAGE BOLTS SHALL BE USED ON STRUCTURAL MEMBERS.



ACCESSIBLE BOARDWALK SECTION - TYP.

NOT TO SCALE

Zenecar, LLC



10224 Durant Rd. Suite 201 Raleigh, NC 27614 919.518.0464 phone 919.518.0866 fax

Standard Specifications

Pedestrian & Light Vehicular Bridges

THE WOODLAND

Manufacturer: Bridge shall be designed and furnished by Enwood Structures, Raleigh, NC.

Bridge Design: Bridge design system shall be THE WOODLAND.

Manufacture: Manufacture of the structural glued laminated wood components shall conform to the manufacturing requirements of the American Institute of Timber Construction Standards and Standard Specifications for Glued Laminated Timber, AITC 117. Quality control shall be provided in accordance with ANSI/AITC A190.1- latest edition and AITC inspection manual, AITC 200. AITC quality marks shall be used for identification. An AITC certificate of conformance shall be furnished upon request.

Manufacturer's and Fabricator's Certification: Bridge's manufacturer, and fabricator, shall be a member of, and hold full certification from, The American Institute of Timber Construction (AITC).

Manufacturer and Fabricator: The manufacturer and fabricator of the shelter's laminated wood components and the shelter's steel connectors shall be one in the same, to assure quality fit of all connections.

Quality Control: Quality Control shall be provided in accordance with ANSI/AITC A190.1-latest edition, American National Standard for Wood Products- Structural Glued Laminated Timber, and the American Institute of Timber Construction Inspection Manual AITC-200.

Lumber: Laminating lumber shall be kiln-dried, with 15% moisture content, Southern Yellow Pine graded to meet the requirements of Standard Specifications for Structural Glued Laminated Timber, AITC 117. Lumber combination shall be determined by the design requirements for each component and designated on the fabricator's shop drawings.

Appearance Grade: Laminated components shall be per AITC architectural appearance grade. Solid sawn lumber for decking shall be Southern Yellow Pine graded in accordance with SPIB.

Preservative treatment: The preservative treatment for glulam components shall consist of pressure treated laminated lumber (treated prior to gluing) with CCA (chromated copper arsenate) in accordance with AITC 109 Standard. Exterior stringers shall be .6 pcf or .3 pcf retention and all other glulam components shall be .3 pcf retention. Solid sawn decking shall be pressure treated in accordance with AITC 109 Standard.

Adhesives: Adhesives shall be wet-use (waterproof) complying with ANSI/AITC A190.1- latest edition.

Hardware: All connecting steel and hardware shall be furnished by the manufacturer. Material shall be hot dipped galvanized.

Note: Anchor bolts/leveling plates are supplied by others.

Penetrating Sealer: All glulam materials to receive one factory applied coat of clear penetrating sealer. Optional factory staining is available.

Foundations: The purchaser shall secure all necessary information about the site and soil conditions. Information as to the bridge support reactions, anchor bolt location and placement, will be supplied by the fabricator. Actual design and construction of the bridge supporting foundation (abutments, pier or footings) shall be the responsibility of the purchaser.

Enwood Structures can provide foundation designs as an option if all pertinent soil data is supplied.

Storage and Erection: The client or installer is responsible for protection of materials after arrival at destination. If materials are stored temporarily, they should be placed on blocks well off the ground and separated with wood strips so air can circulate between members. Cover top and bottom with moisture resistant paper. Use non-marring slings when handling the materials.

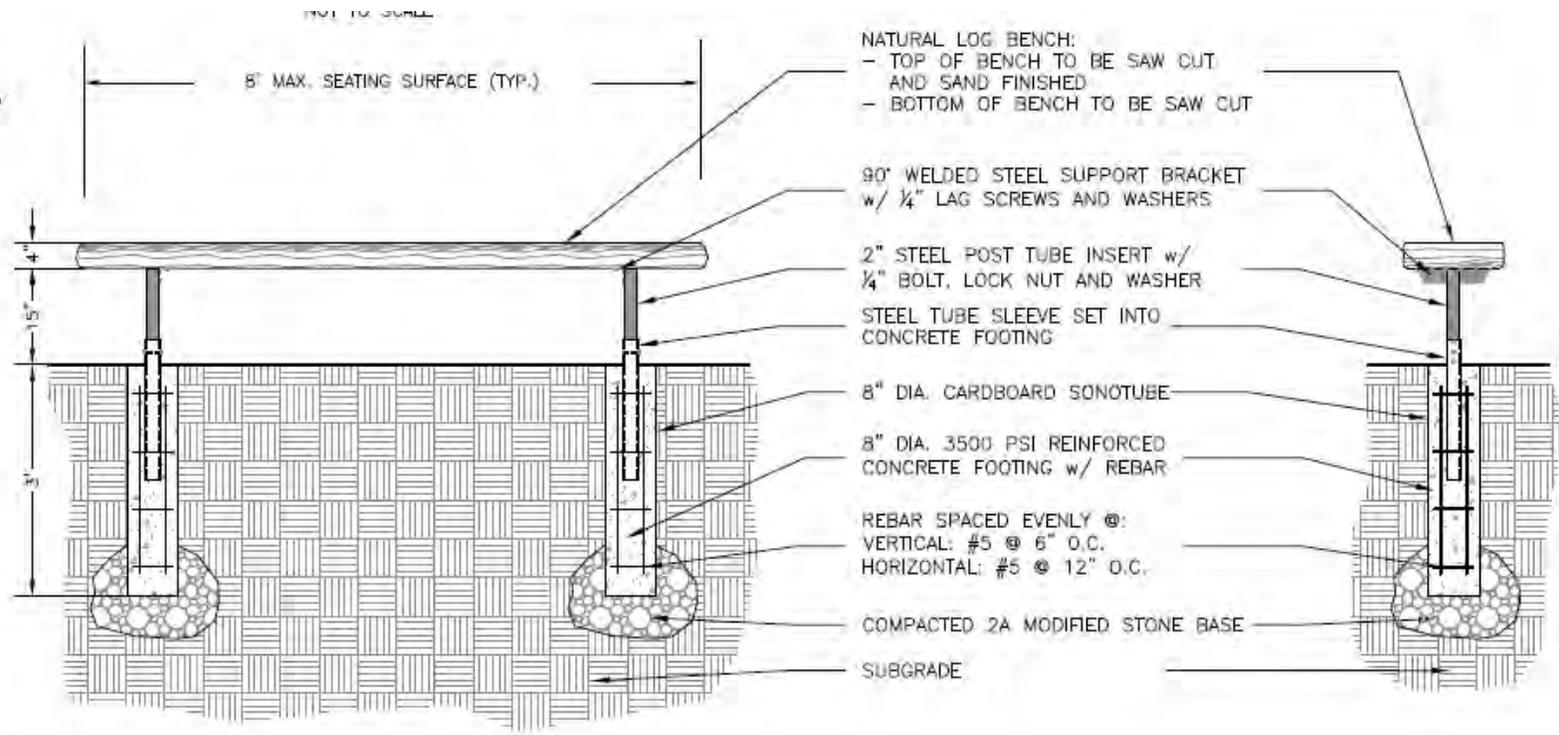
Shop Drawings: A complete set of shop drawings shall be furnished by the fabricator detailing all member sizes and connections.

For additional information, assistance with pricing, or technical inquiries
please contact:

Enwood Structures, LLC 919.518.0464

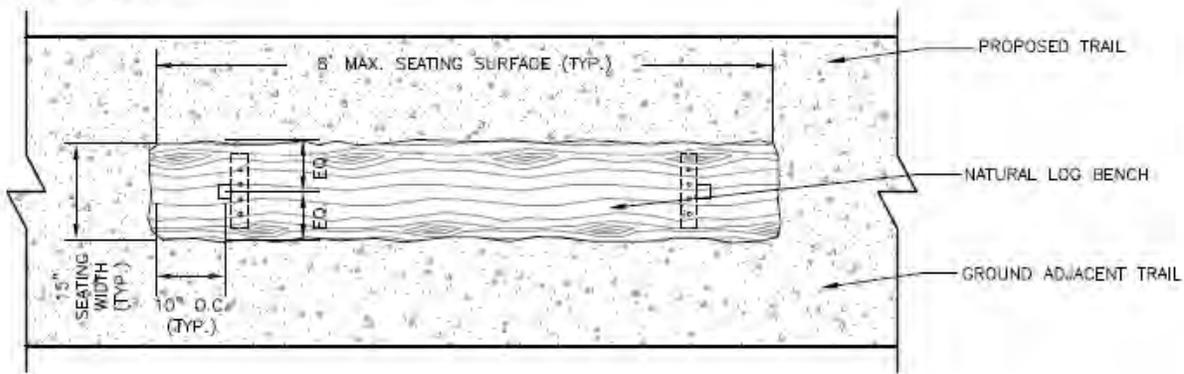
or

www.enwood.com



NATURAL LOG BENCH – SECTION/ELEVATION DETAIL

NOT TO SCALE



BENCH GENERAL NOTES:

1. ALL FASTENERS & HARDWARE TO BE G185 HOT-DIP GALVANIZED.
2. LUMBER SHALL BE UNTREATED CEDAR OR APPROVED EQUAL
3. LUMBER SHALL BE COATED WITH CLEAR WATERPROOFING SEALANT GUARANTEED FOR A MINIMUM OF 2 YEARS

NATURAL LOG BENCH – PLAN VIEW DETAIL

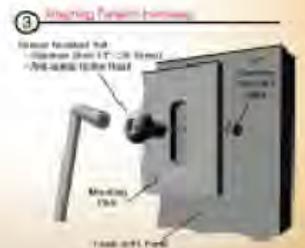
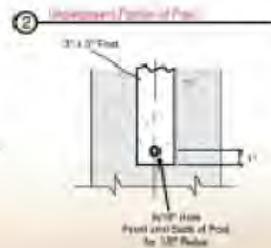
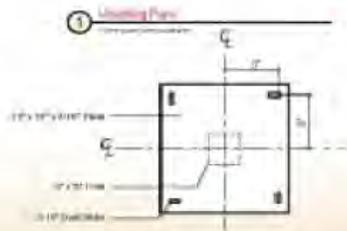
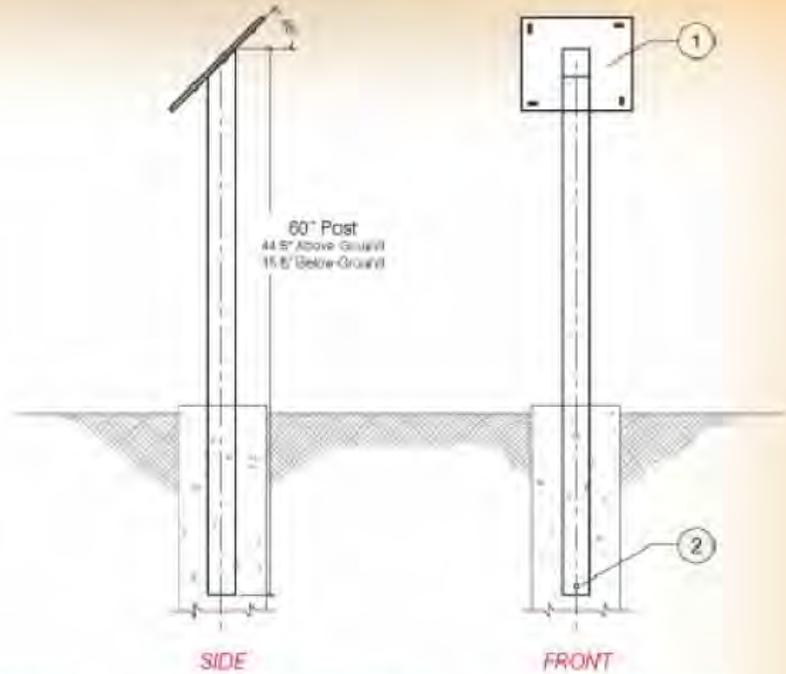
NOT TO SCALE

FOSSIL
INDUSTRIES

SINGLE POST PEDESTAL: In Ground

- Black Powder Coated Aluminum
- Custom Sizes and Colors Available

Part #: SPG1212



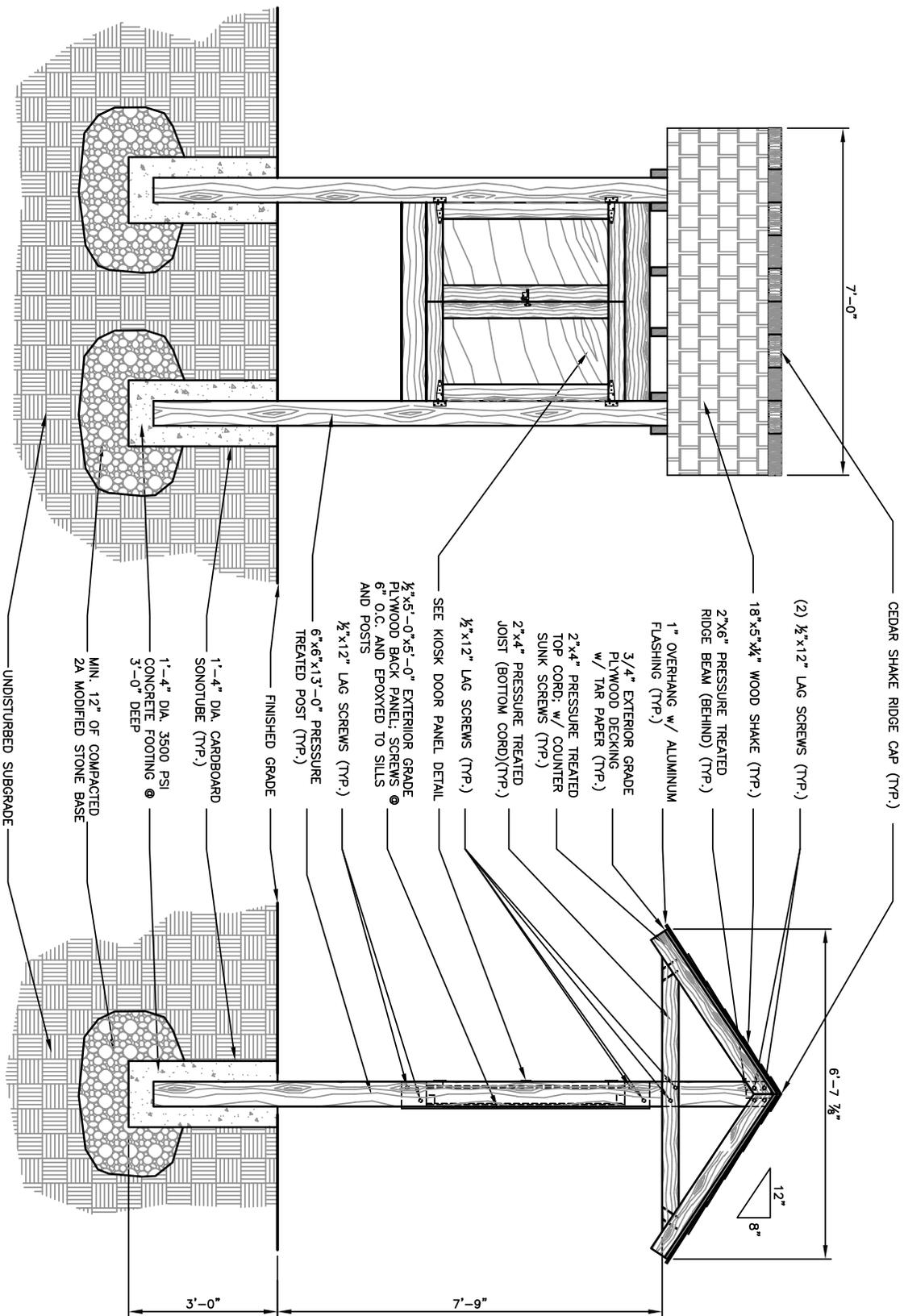
WWW.FOSSILGRAPHICS.COM

EDUCATIONAL SIGNAGE

NOT TO SCALE

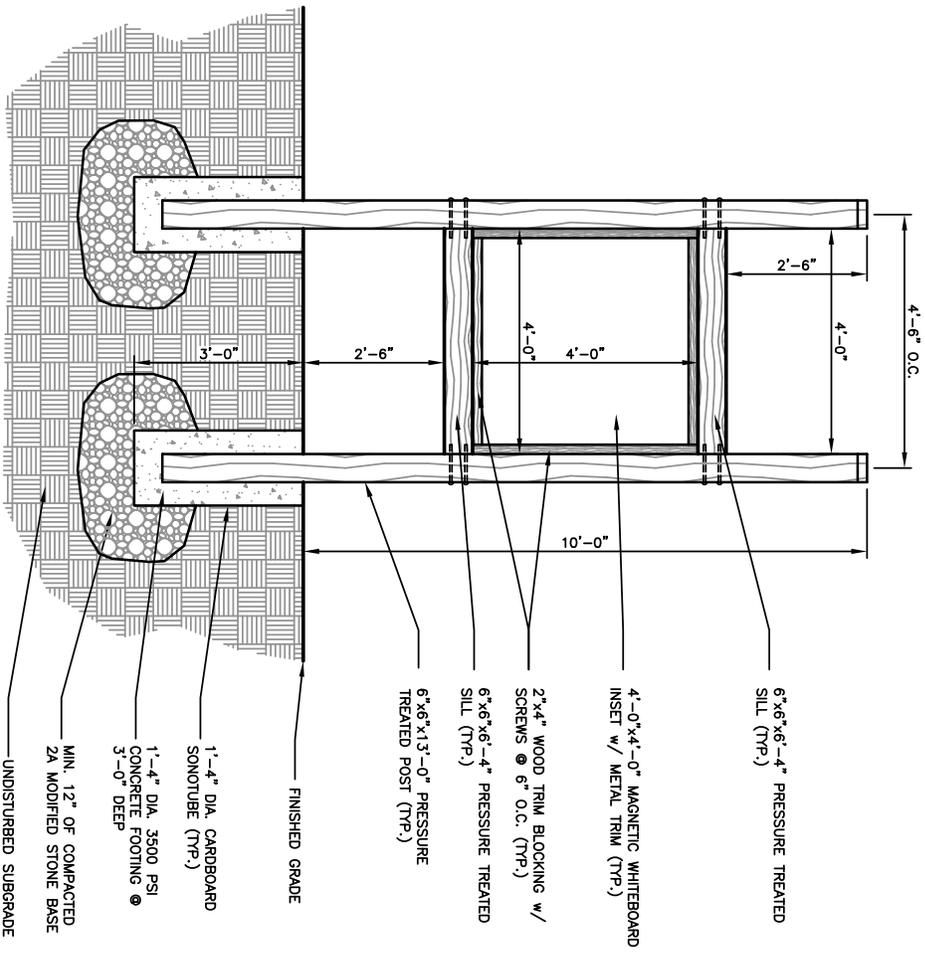
NOTES:

1. FOSSIL SINGLE POST PEDESTAL AND EXTERIOR CHPL GRAPHIC OR APPROVED EQUAL
2. E12-06-T4 1/2" EXTERIOR CHPL GRAPHIC, PANEL SIZE 24"X36", THREADED INSERTS WITH TAMPER RESISTANT BOLTS
3. SPG1212 SINGLE POST PEDESTAL (45 DEGREE), BLACK POWDER COATED ALUMINUM, IN-GROUND MOUNT
4. GRAPHICS MUST BE MANUFACTURED AS CUSTOM HIGH PRESSURE LAMINATE (CHPL).
5. CHPL GRAPHIC SIGN MATERIAL TO BE COMPOSED OF SEVERAL LAYERS OF PHENOLIC RESIN IMPREGNATED KRAFT FILLER PAPER, A DIGITALLY IMAGED GRAPHIC, A LAYER OF MELAMINE RESIN, SURFACED BY A LAYER OF TRANSLUCENT EXTERIOR UV/GRAFFITI OVERLAY PROTECTION.
6. THE ENTIRE PANEL, INCLUDING EXTERIOR OVERLAY, MUST BE BONDED UNDER HEAT AND EXTREME PRESSURE TO FORM A COMPOSITE PANEL.
7. FINISH MUST BE SMOOTHLY TEXTURED WITH REFLECTIVITY OF 30 + OR -5 GLOSS UNITS.
8. CHPL GRAPHICS MUST BE WARRANTED FOR A MINIMUM OF 10 YEARS AGAINST FADING, DE-LAMINATION AND WEATHER DETERIORATION.
9. THERE SHALL BE NO WARRANTY REQUIREMENTS FOR ANNUAL APPLICATION OF WATER SEALANT, NO EXCLUSIONS FOR PANELS USED IN "EXTREME TEMPERATURES," AND NO CLAUSE THAT WARRANTIES CAN BE DENIED DUE TO "IMPROPER MAINTENANCE."
10. PANELS MUST BE ABLE TO BE CLEANED WITH ANY SOLVENT AND NOT RESTRICT USE OF PRODUCTS CONTAINING LACQUER THINNER OR ACETONE.
11. ALL CUTTING AND FINISHING TO BE DONE USING A CNC ROUTER.
12. GRAPHICS MUST BE MADE USING 12-COLOR HIGH DEFINITION PRINTING TECHNOLOGY.
13. VENDOR SHALL PROVIDE A SAMPLE FROM A SUPPLIED FILE TO CONFIRM QUALITY.
14. PANELS MUST BE MADE ENTIRELY IN THE U.S.A.
15. LOCATIONS SHOWN IN PLAN ARE APPROXIMATE. TO BE FIELD LOCATED BY ENGINEER BASED ON SITE CONDITIONS.
16. GRAPHICS IN THE REQUIRED FORMAT TO BE PROVIDED TO MANUFACTURER BY THE OWNER OR OWNER'S REPRESENTATIVE.



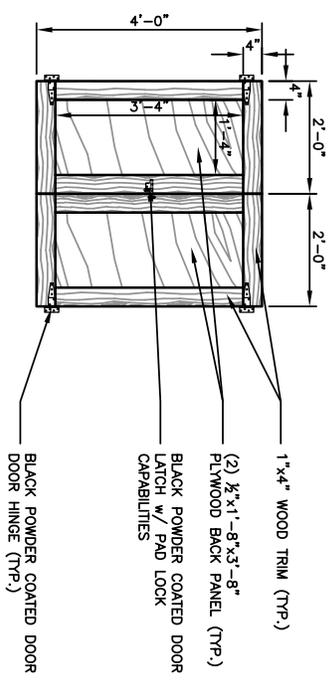
KIOSK – FRONT & SIDE ELEVATION DETAIL

NOT TO SCALE



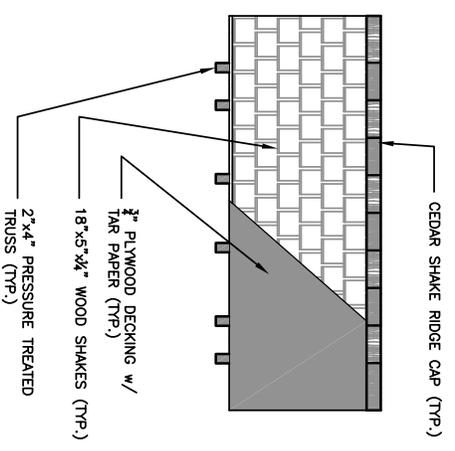
KIOSK FRAMING ELEVATION DETAIL

NOT TO SCALE



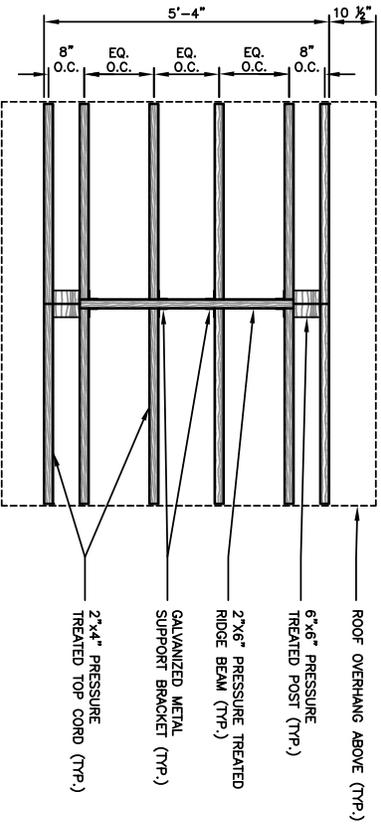
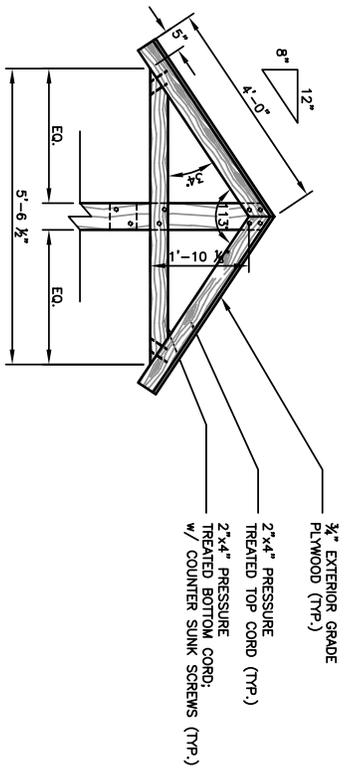
KIOSK DOOR PANEL - ELEVATION (FRONT)

NOT TO SCALE



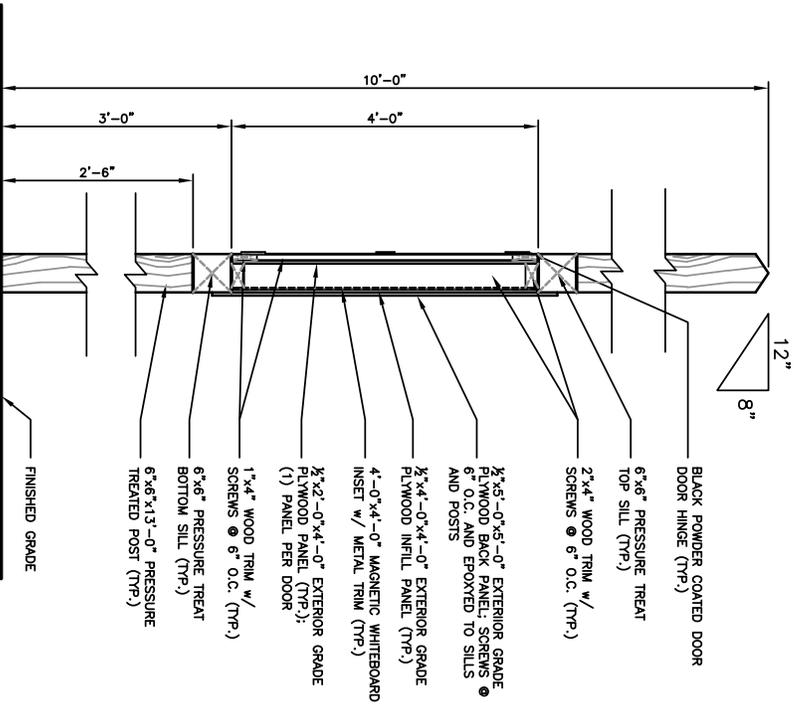
KIOSK ROOF ASSEMBLY DETAIL

NOT TO SCALE



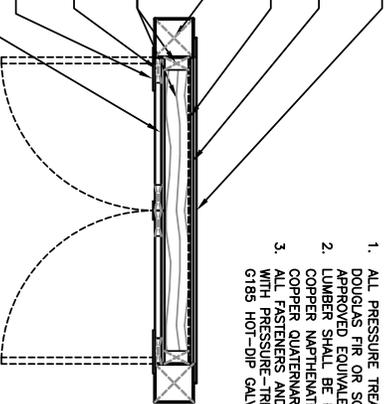
KIOSK TRUSS FRAMING AND SIDE ELEVATION DETAIL

NOT TO SCALE



- BLACK POWDER COATED DOOR DOOR HINGE (TYP.)
- 6"x6" PRESSURE TREAT TOP SILL (TYP.)
- 2"x4" WOOD TRIM w/ SCREWS @ 6" O.C. (TYP.)
- ½"x5'-0"x5'-0" EXTERIOR GRADE PLYWOOD BACK PANEL; SCREWS @ 6" O.C. AND EPOXYED TO SILLS AND POSTS
- ½"x4'-0"x4'-0" EXTERIOR GRADE PLYWOOD INFILL PANEL (TYP.)
- 4'-0"x4'-0" MAGNETIC WHITEBOARD INSERT w/ METAL TRIM (TYP.)
- ½"x2'-0"x4'-0" EXTERIOR GRADE PLYWOOD PANEL (TYP.); (1) PANEL PER DOOR
- 1"x4" WOOD TRIM w/ SCREWS @ 6" O.C. (TYP.)
- 6"x6" PRESSURE TREAT BOTTOM SILL (TYP.)
- 6"x6"x13'-0" PRESSURE TREATED POST (TYP.)

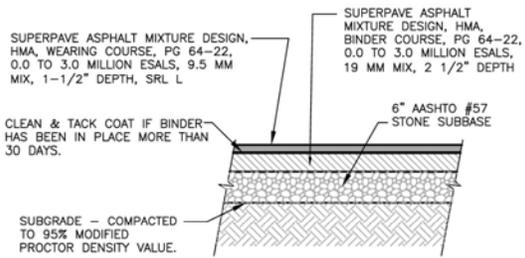
- ½"x5'-0"x5'-0" EXTERIOR GRADE PLYWOOD BACK PANEL; SCREWS @ 6" O.C. AND EPOXYED TO SILLS AND POSTS
- ½"x4'-0"x4'-0" EXTERIOR GRADE PLYWOOD INFILL PANEL (TYP.)
- 4'-0"x4'-0" MAGNETIC WHITEBOARD INSERT w/ METAL TRIM (TYP.)
- 6"x6"x13'-0" PRESSURE TREATED POST (TYP.)
- 2"x4" WOOD TRIM w/ SCREWS @ 6" O.C. (TYP.)
- 1"x4" WOOD TRIM w/ SCREWS @ 6" O.C. (TYP.)
- BLACK POWDER COATED DOOR DOOR HINGE (TYP.)
- ½"x2'-0"x4'-0" EXTERIOR GRADE PLYWOOD PANEL (TYP.); (1) PANEL PER DOOR



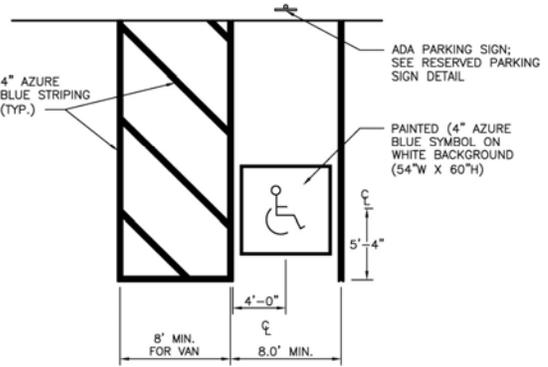
- KIOSK GENERAL NOTES:**
1. ALL PRESSURE TREATED LUMBER SHALL BE DOUGLAS FIR OR SOUTHERN PINE #2 OR APPROVED EQUIVALENT.
 2. LUMBER SHALL BE PRESSURE-TREATED WITH COPPER NAPHTHENATE OR ACO (ALKALINE COPPER QUATERNARY).
 3. ALL FASTENERS AND CONNECTORS IN CONTACT WITH PRESSURE-TREATED LUMBER SHALL BE G185 HOT-DIP GALVANIZED.

KIOSK SECTION/ELEVATION DETAIL

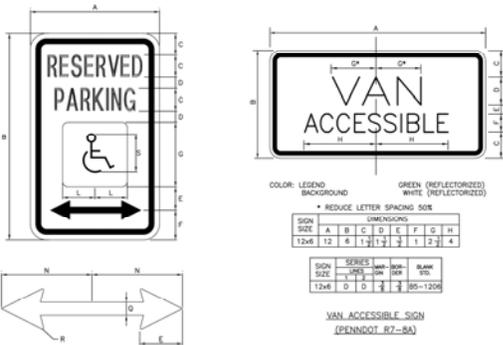
NOT TO SCALE



BITUMINOUS PAVEMENT ADA PARKING PAD – SECTION
NOT TO SCALE



A.D.A ACCESSIBLE PARKING STRIPING
NOT TO SCALE

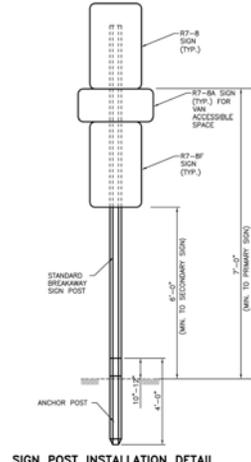
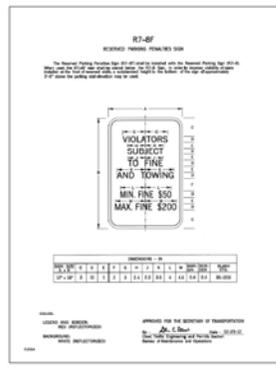


SIGN SIZE	DIMENSIONS																				
	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	MARGIN	BORDER		
12x18	12	18	2	1	1 1/2	2 1/2	6	4	1/8	5	4	1/4	3	1/2	3 7/8	7/8	3/4	1/8	4	3/8	3/8

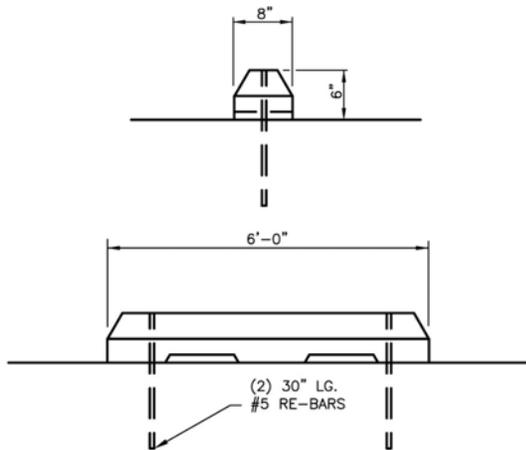
RESERVED PARKING SIGN (R7-B)
NOT TO SCALE

SIGNAGE AND STRIPING NOTES

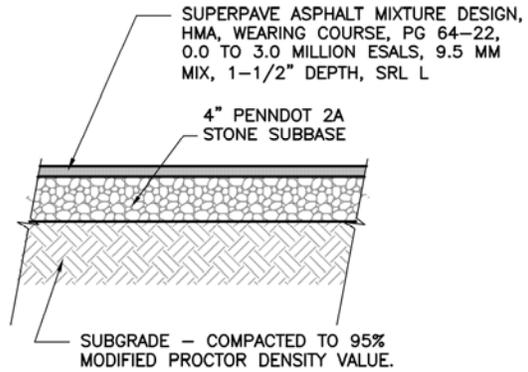
1. ALL PROPOSED SIGNS SHALL BE IN ACCORDANCE WITH PENNDOT PUBLICATION 2386, "HANDBOOK OF APPROVED SIGNS", LATEST VERSION.
2. ALL PROPOSED PAVEMENT MARKINGS SHALL BE IN ACCORDANCE WITH PENNDOT PUBLICATION 111W (TR8600), LATEST VERSION.



SIGN POST INSTALLATION DETAIL
NOT TO SCALE



PRECAST CONCRETE WHEEL STOP DETAIL
NOT TO SCALE



WALKING PATH
NOT TO SCALE

BMP 6.4.5: Rain Garden/Bioretention

RECHARGE GARDEN / BIORETENTION BED



A Rain Garden (also called Bioretention) is an excavated shallow surface depression planted with specially selected native vegetation to treat and capture runoff.

<p style="text-align: center;"><u>Key Design Elements</u></p> <ul style="list-style-type: none"> ▪ Flexible in terms of size and infiltration ▪ Ponding depths generally limited to 12 inches or less for aesthetics, safety, and rapid draw down. Certain situations may allow deeper ponding depths. ▪ Deep rooted perennials and trees encouraged ▪ Native vegetation that is tolerant of hydrologic variability, salts and environmental stress ▪ Modify soil with compost. ▪ Stable inflow/outflow conditions ▪ Provide positive overflow ▪ Maintenance to ensure long-term functionality 	<p style="text-align: center;"><u>Potential Applications</u></p> <p>Residential: Yes Yes Commercial: Ultra Yes Urban: Industrial: Yes Yes Retrofit: Yes Yes Highway/Road: Yes</p>
	<p style="text-align: center;"><u>Stormwater Functions</u></p> <p>Volume Reduction: Medium Recharge: Med./High Peak Rate Control: Low/Med. Water Quality: Med./High</p>
	<p style="text-align: center;"><u>Water Quality Functions</u></p> <p>TSS: TP: 85% 85% NO3: 30%</p>

Other Considerations

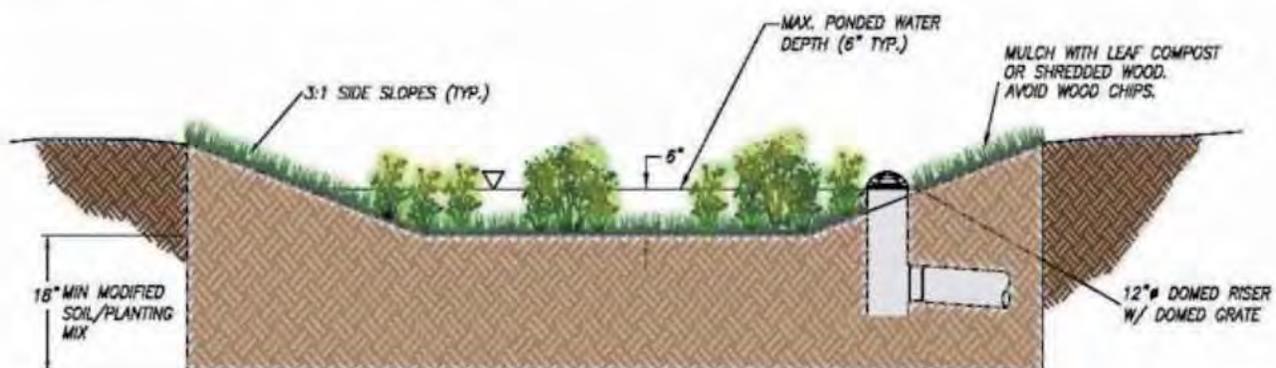
- **Protocol 1. Site Evaluation and Soil Infiltration Testing and Protocol 2. Infiltration Systems Guidelines** should be followed, see Appendix C

Description

Bioretention is a method of treating stormwater by pooling water on the surface and allowing filtering and settling of suspended solids and sediment at the mulch layer, prior to entering the plant/soil/microbe complex media for infiltration and pollutant removal. Bioretention techniques are used to accomplish water quality improvement and water quantity reduction. Prince George's County, Maryland, and Alexandria, Virginia have used this BMP since 1992 with success in many urban and suburban settings.

Bioretention can be integrated into a site with a high degree of flexibility and can balance nicely with other structural management systems, including porous asphalt parking lots, infiltration trenches, as well as non-structural stormwater BMPs described in Chapter 5.

The vegetation serves to filter (water quality) and transpire (water quantity) runoff, and the root systems can enhance infiltration. The plants take up pollutants; the soil medium filters out pollutants and allows storage and infiltration of stormwater runoff, and the bed provides additional volume control. Properly designed bioretention techniques mimic natural ecosystems through species diversity, density and distribution of vegetation, and the use of native species, resulting in a system that is resistant to insects, disease, pollution, and climatic stresses.



Rain Gardens / Bioretention function to:

- Reduce runoff volume
- Filter pollutants, through both soil particles (which trap pollutants) and plant material (which take up pollutants)
- Recharge groundwater by infiltration
- Reduce stormwater temperature impacts
- Enhance evapotranspiration
- Enhance aesthetics
- Provide habitat

Primary Components of a Rain Garden/Bioretention System

The primary components (and subcomponents) of a rain garden/bioretention system are:

Pretreatment (optional)

- Sheet flow through a vegetated buffer strip, cleanout, water quality inlet, etc. prior to entry into the Rain Garden

Flow entrance

- Varies with site use (e.g., parking island versus residential lot applications)
- Water may enter via an inlet (e.g., flared end section)
- Sheet flow into the facility over grassed areas
- Curb cuts with grading for sheet flow entrance
- Roof leaders with direct surface connection
- Trench drain
- Entering velocities should be non-erosive.

Ponding area

- Provides temporary surface storage of runoff
- Provides evaporation for a portion of runoff
- Design depths allow sediment to settle
- Limited in depth for aesthetics and safety

Plant material

- Evapotranspiration of stormwater
- Root development and rhizome community create pathways for infiltration
- Bacteria community resides within the root system creating healthy soil structure with water quality benefits
- Improves aesthetics for site
- Provides habitat for animals and insects
- Reinforces long-term performance of subsurface infiltration
- Should be tolerant of salts if in a location that would receive snow melt chemicals

Organic layer or mulch

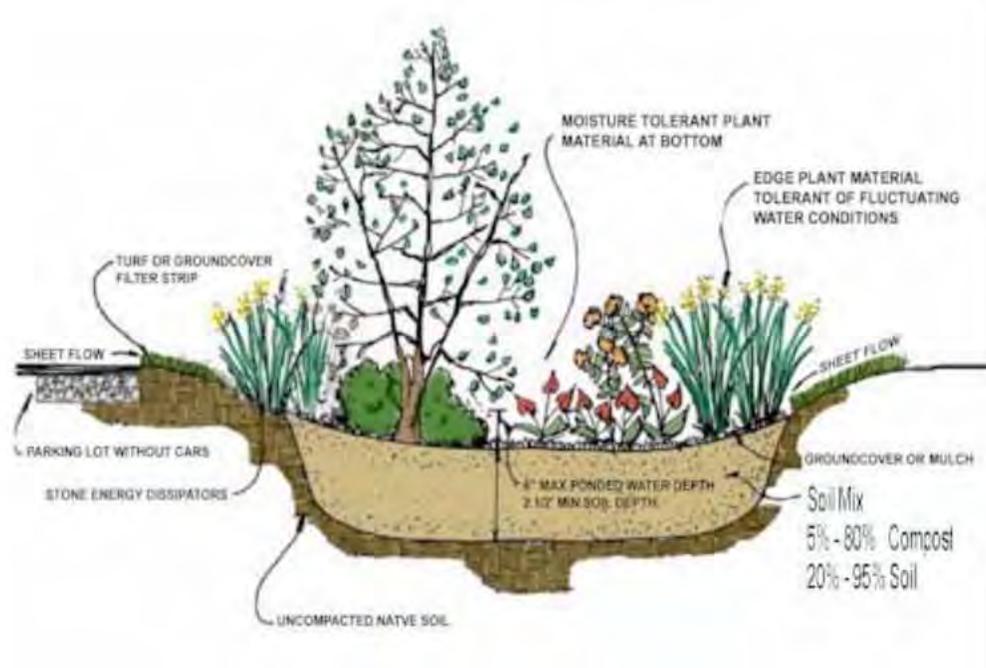
- Acts as a filter for pollutants in runoff
- Protects underlying soil from drying and eroding
- Simulates leaf litter by providing environment for microorganisms to degrade organic material
- Provides a medium for biological growth, decomposition of organic material, adsorption and bonding of heavy metals
- Wood mulch should be shredded - compost or leaf mulch is preferred.

Planting soil/volume storage bed

- Provides water/nutrients to plants
- Enhances biological activity and encourages root growth
- Provides storage of stormwater by the voids within the soil particles

Positive overflow

- Will discharge runoff during large storm events when the storage capacity is exceeded. Examples include domed riser, inlet, weir structure, etc.
- An underdrain can be included in areas where infiltration is not possible or appropriate.



Variations

Generally, a Rain Garden/Bioretention system is a vegetated surface depression that provides for the infiltration of relatively small volumes of stormwater runoff, often managing stormwater on a lot-by-lot basis (versus the total development site). If greater volumes of runoff need to be managed or stored, the system can be designed with an expanded subsurface infiltration bed or the Bioretention area can be increased in size.

The design of a Rain Garden can vary in complexity depending on the quantity of runoff volume to be managed, as well as the pollutant reduction objectives for the entire site. Variations exist both in the components of the systems, which are a function of the land use surrounding the Bioretention system.

The most common variation includes a gravel or sand bed underneath the planting bed. The original intent of this design, however, was to perform as a filter BMP utilizing an under drain and subsequent discharge. When a designer decides to use a gravel or sand bed for volume storage under the planting bed, then additional design elements and changes in the vegetation plantings should be provided.

Flow Entrance: Curbs and Curb Cuts



Flow Entrance: Trench Drain



Positive Overflow: Domed Riser



Positive Overflow: Inlet



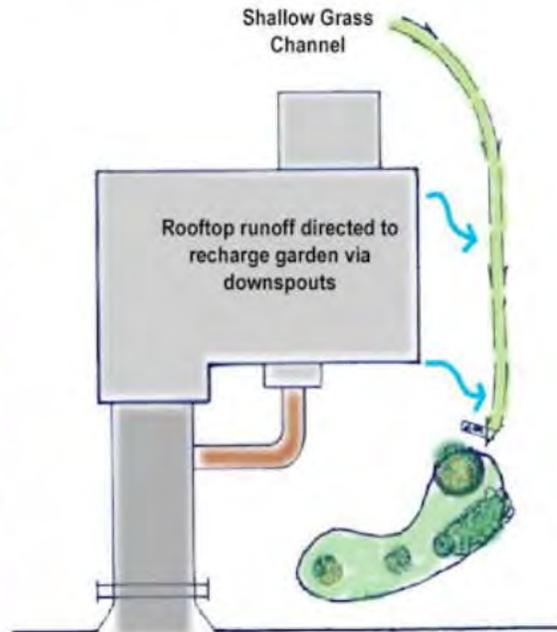
Applications

Bioretention areas can be used in a variety of applications: from small areas in residential lawns to extensive systems in large parking lots (incorporated into parking islands and/or perimeter areas).

- Residential On-lot**

Rain Garden (Prince George's County)

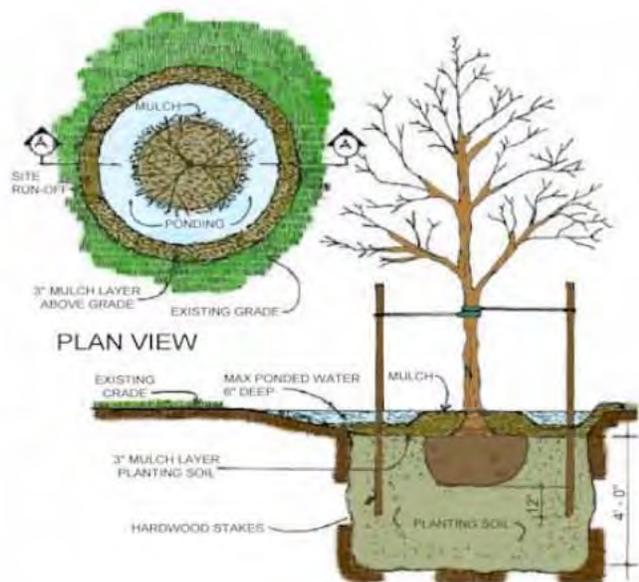
Simple design that incorporates a planting bed in the low portion of the site



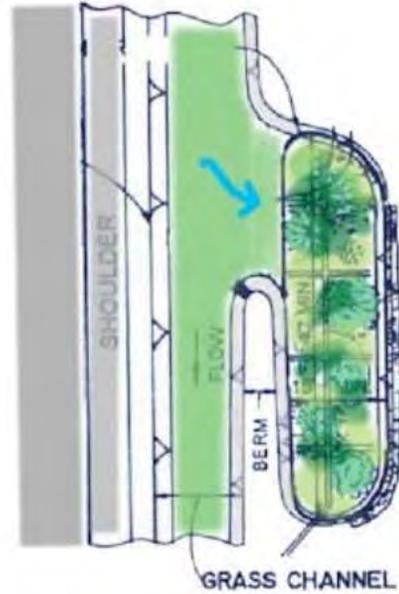
- Tree and Shrub Pits**

Stormwater management technique that intercepts runoff and provides shallow ponding in a dished mulched area around the tree or shrub.

Extend the mulched area to the tree dripline



- **Roads and highways**



- **Parking Lots**
- **Parking Lot Island Bioretention**



- **Commercial/Industrial/Institutional**

In commercial, industrial, and institutional situations, stormwater management and greenspace areas are limited, and in these situations, Rain Gardens for stormwater management and landscaping provide multifunctional options.

- **Curbless (Curb cuts) Parking Lot Perimeter Bioretention**

The Rain Garden is located adjacent to a parking area with no curb or curb cuts , allowing stormwater to sheet flow over the parking lot directly into the Rain Garden. Shallow grades should direct runoff at reasonable velocities; this design can be used in conjunction with depression storage for stormwater quantity control.



- **Curbed Parking Lot Perimeter Bioretention**



- **Roof leader connection from adjacent building**



Design Considerations

Rain Gardens are flexible in design and can vary in complexity according to water quality objectives and runoff volume requirements. Though Rain Gardens are a structural BMP, the initial siting of bioretention areas should respect the Integrating Site Design Procedures described in Chapter 4 and integrated with the preventive non-structural BMPs.

It is important to note that bioretention areas are not to be confused with constructed wetlands or wet ponds which permanently pond water. Bioretention is best suited for areas with at least moderate infiltration rates (more than 0.1 inches per hour). In extreme situations where permeability is less than 0.1 inches per hour, special variants may apply, including under drains, or even constructed wetlands.

Rain Gardens are often very useful in retrofit projects and can be integrated into already developed lots and sites. An important concern for all Rain Garden applications is their long-term protection and maintenance, especially if undertaken in multiple residential lots where individual homeowners provide maintenance. In such situations, it is important to provide some sort of management that insures their long-term functioning (deed restrictions, covenants, and so forth).

1. Sizing criteria

- a. **Surface area** is dependent upon storage volume requirements but should generally not exceed a maximum loading ratio of 5:1 (impervious drainage area to infiltration area; see Protocol 2. Infiltration Systems Guidelines (Appendix C) for additional guidance on loading rates.)
- b. **Surface Side slopes** should be gradual. For most areas, maximum 3:1 side slopes are recommended, however where space is limited, 2:1 side slopes may be acceptable.
- c. **Surface Ponding depth** should not exceed 6 inches in most cases and should empty within 72 hours.
- d. **Ponding area** should provide sufficient surface area to meet required storage volume without exceeding the design ponding depth. The subsurface storage/infiltration bed is used to supplement surface storage where feasible.
- e. **Planting soil depth** should generally be at least 18" where only herbaceous plant species will be utilized. If trees and woody shrubs will be used, soil media depth may be increased, depending on plant species.

2. **Planting Soil** should be a loam soil capable of supporting a healthy vegetative cover. Soils should be amended with a composted organic material. A typical organic amended soil is combined with 20-30% organic material (compost), and 70-80% soil base (preferably topsoil). Planting soil should be approximately 4 inches deeper than the bottom of the largest root ball.
3. **Volume Storage Soils** should also have a pH of between 5.5 and 6.5 (better pollutant adsorption and microbial activity), a clay content less than 10% (a small amount of clay is beneficial to adsorb pollutants and retain water), be free of toxic substances and unwanted plant material and have a 5 –10% organic matter content. Additional organic matter can be added to the soil to increase water holding capacity (tests should be conducted to determine volume storage capacity of amended soils).

4. Proper **plant selection** is essential for bioretention areas to be effective. Typically, native floodplain plant species are best suited to the variable environmental conditions encountered. If shrubs and trees are included in a bioretention area (which is recommended), at least three species of shrub and tree should be planted at a rate of approximately 700 shrubs and 300 trees per acre (shrub to tree ratio should be 2:1 to 3:1). An experienced landscape architect is recommended to design native planting layout.
5. **Planting periods** will vary, but in general trees and shrubs should be planted from mid-March through the end of June, or mid-September through mid-November
6. A maximum of 2 to 3 inches of shredded **mulch** or leaf compost (or other comparable product) should be uniformly applied immediately after shrubs and trees are planted to prevent erosion, enhance metal removals, and simulate leaf litter in a natural forest system. Wood chips should be avoided as they tend to float during inundation periods. Mulch / compost layer should not exceed 3" in depth so as not to restrict oxygen flow to roots.
7. Must be designed carefully in areas with **steeper slopes** and should be aligned parallel to contours to minimize earthwork.
8. Under drains should not be used except where in-situ soils fail to drain surface water to meet the criteria in Chapter 3.

Detailed Stormwater Functions

Infiltration Area

Volume Reduction Calculations

The storage volume of a Bioretention area is defined as the sum total of 1. and the smaller of 2a or 2b below. The surface storage volume should account for at least 50% of the total storage. Inter-media void volumes may vary considerably based on design variations.

1. Surface Storage Volume (CF) = Bed Area (ft²) x Average Design Water Depth
- 2a. Infiltration Volume = Bed Bottom area (sq ft) x infiltration design rate (in/hr) x infiltration period (hr) x 1/12.
- 2b. Volume = Bed Bottom area (sq ft) x soil mix bed depth x void space.

Peak Rate Mitigation

See Chapter 8 for Peak Rate Mitigation methodology, which addresses link between volume reduction and peak rate control.

Water Quality Improvement

See Chapter 8 for Water Quality Improvement methodology, which addresses pollutant removal effectiveness of this BMP.

Construction Sequence

The following is a typical construction sequence; however, alterations might be necessary depending on design variations.

1. Install temporary sediment control BMPs as shown on the plans.
2. Complete site grading. If applicable, construct curb cuts or other inflow entrance but provide protection so that drainage is prohibited from entering construction area.
3. Stabilize grading within the limit of disturbance except within the Rain Garden area. Rain garden bed areas may be used as temporary sediment traps provided that the proposed finish elevation of the bed is 12 inches lower than the bottom elevation of the sediment trap.
4. Excavate Rain Garden to proposed invert depth and scarify the existing soil surfaces. Do not compact in-situ soils.
5. Backfill Rain Garden with amended soil as shown on plans and specifications. Overfilling is recommended to account for settlement. Light hand tamping is acceptable if necessary.
6. Presoak the planting soil prior to planting vegetation to aid in settlement.
7. Complete final grading to achieve proposed design elevations, leaving space for upper layer of compost, mulch or topsoil as specified on plans.
8. Plant vegetation according to planting plan.
9. Mulch and install erosion protection at surface flow entrances where necessary.



Maintenance Issues

Properly designed and installed Bioretention areas require some regular maintenance.

- While vegetation is being established, pruning and weeding may be required.
- Detritus may also need to be removed every year. Perennial plantings may be cut down at the end of the growing season.
- Mulch should be re-spread when erosion is evident and be replenished as needed. Once every 2 to 3 years the entire area may require mulch replacement.
- Bioretention areas should be inspected at least two times per year for sediment buildup, erosion, vegetative conditions, etc.
- During periods of extended drought, Bioretention areas may require watering.
-
- Trees and shrubs should be inspected twice per year to evaluate health.

Cost Issues

Rain Gardens often replace areas that would have been landscaped and are maintenance-intensive so that the net cost can be considerably less than the actual construction cost. In addition, the use of Rain Gardens can decrease the cost for stormwater conveyance systems at a site. Rain Gardens cost approximately \$5 to \$7 (2005) per cubic foot of storage to construct.

Specifications

The following specifications are provided for informational purposes only. These specifications include information on acceptable materials for typical applications, but are by no means exclusive or limiting. The designer is responsible for developing detailed specifications for individual design projects in accordance with the project conditions.

1 Vegetation - See Appendix B

2 Execution

a. Subgrade preparation

1. Existing sub-grade in Bioretention areas shall NOT be compacted or subject to excessive construction equipment traffic.
2. Initial excavation can be performed during rough site grading but shall not be carried to within one foot of the final bottom elevation. Final excavation should not take place until all disturbed areas in the drainage area have been stabilized.
3. Where erosion of sub-grade has caused accumulation of fine materials and/or surface ponding in the graded bottom, this material shall be removed with light

equipment and the underlying soils scarified to a minimum depth of 6 inches with a York rake or equivalent by light tractor.

4. Bring sub-grade of bioretention area to line, grade, and elevations indicated. Fill and lightly regrade any areas damaged by erosion, ponding, or traffic compaction. All bioretention areas shall be level grade on the bottom.
 5. Halt excavation and notify engineer immediately if evidence of sinkhole activity or pinnacles of carbonate bedrock are encountered in the bioretention area.
- b. Rain Garden Installation

1. Upon completion of sub-grade work, the Engineer shall be notified and shall inspect at his/her discretion before proceeding with bioretention installation.
2. For the subsurface storage/infiltration bed installation, amended soils should be placed on the bottom to the specified depth.
3. Planting soil shall be placed immediately after approval of sub-grade preparation/bed installation. Any accumulation of debris or sediment that takes place after approval of sub-grade shall be removed prior to installation of planting soil at no extra cost to the Owner.
4. Install planting soil (exceeding all criteria) in 18-inch maximum lifts and lightly compact (tamp with backhoe bucket or by hand). Keep equipment movement over planting soil to a minimum – **do not over compact**. Install planting soil to grades indicated on the drawings.
5. Plant trees and shrubs according to supplier's recommendations and only from mid-March through the end of June or from mid-September through mid-November.
6. Install 2-3" shredded hardwood mulch (minimum age 6 months) or compost mulch evenly as shown on plans. Do not apply mulch in areas where ground cover is to be grass or where cover will be established by seeding.
7. Protect Rain Gardens from sediment at all times during construction. Hay bales, diversion berms and/or other appropriate measures shall be used at the toe of slopes that are adjacent to Rain Gardens to prevent sediment from washing into these areas during site development.
8. When the site is fully vegetated and the soil mantle stabilized the plan designer shall be notified and shall inspect the Rain Garden drainage area at his/her discretion before the area is brought online and sediment control devices removed.
9. Water vegetation at the end of each day for two weeks after planting is completed.

Contractor should provide a one-year 80% care and replacement warranty for all planting beginning after installation and inspection of all plants.

BMP 6.4.8: Vegetated Swale



A Vegetated Swale is a broad, shallow, trapezoidal or parabolic channel, densely planted with a variety of trees, shrubs, and/or grasses. It is designed to attenuate and in some cases infiltrate runoff volume from adjacent impervious surfaces, allowing some pollutants to settle out in the process. In steeper slope situations, check dams may be used to further enhance attenuation and infiltration opportunities.

<ul style="list-style-type: none"> ▪ Plant dense, low-growing native vegetation that is water-resistant, drought and salt tolerant, providing substantial pollutant removal capabilities ▪ Longitudinal slopes range from 1 to 6% ▪ Side slopes range from 3:1 to 5:1 ▪ Bottom width of 2 to 8 feet ▪ Check-dams can provide limited detention storage, as well as enhanced volume control through infiltration. Care must be taken to prevent erosion around the dam ▪ Convey the 10-year storm event with a minimum of 6 inches of freeboard ▪ Designed for non-erosive velocities up to the 10-year storm event ▪ Design to aesthetically fit into the landscape, where possible ▪ Significantly slow the rate of runoff conveyance compared to pipes 	<p style="text-align: center;"><u>Potential Applications</u></p> <p style="text-align: center;">Residential: Commercial: Yes Yes Ultra Urban: Limited Industrial: Yes Yes Retrofit: Yes Highway/Road:</p> <hr/> <p style="text-align: center;"><u>Stormwater Functions</u></p> <p style="text-align: center;">Volume Reduction: Low/Med. Recharge: Low/Med. Peak Rate Control: Med./High Water Quality: Med./High</p> <hr/> <p style="text-align: center;"><u>Water Quality Functions</u></p> <p style="text-align: center;">TSS: 50% TP: 50% NO3: 20%</p>
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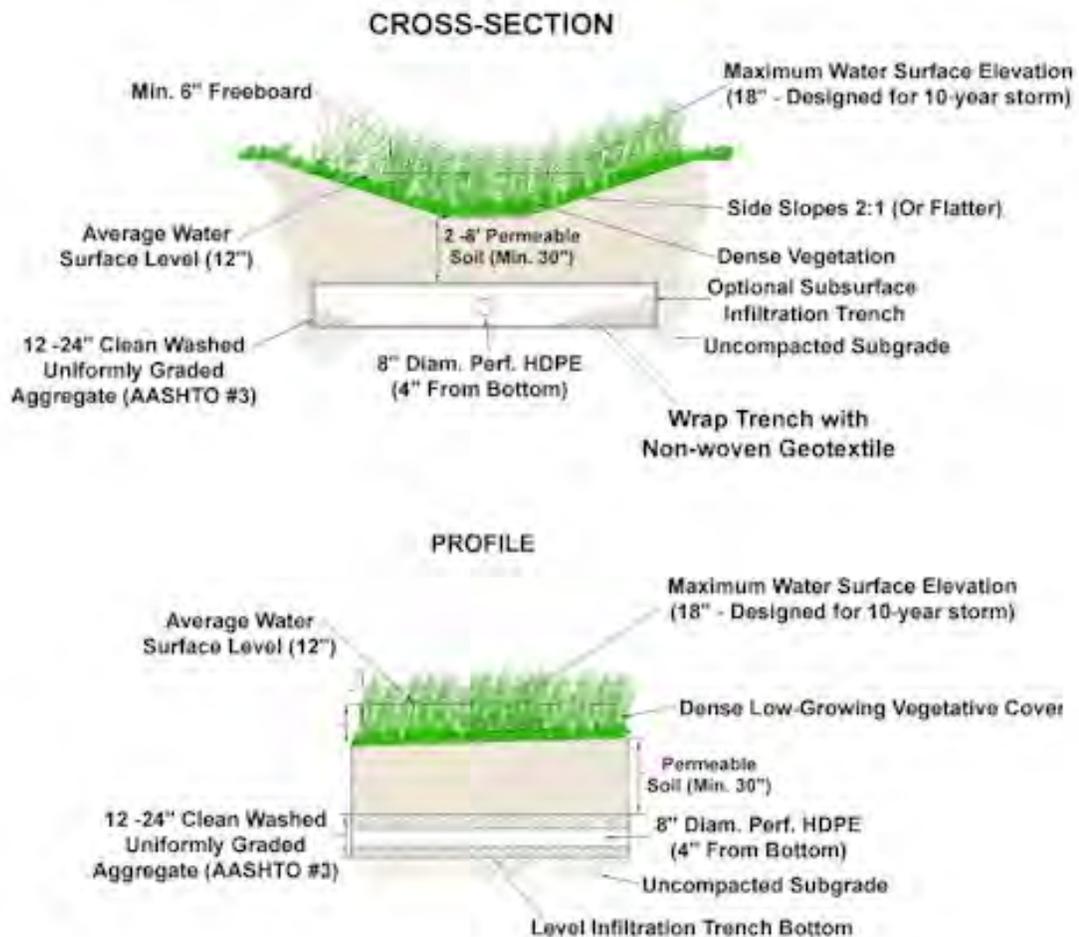
Other Considerations

- **Protocol 1. Site Evaluation and Soil Infiltration Testing** and **Protocol 2. Infiltration Systems Guidelines** should be followed whenever infiltration of runoff is desired, see Appendix C

Description

Vegetated swales are broad, shallow channels designed to slow runoff, promote infiltration, and filter pollutants and sediments in the process of conveying runoff. Vegetated Swales provide an environmentally superior alternative to conventional curb and gutter conveyance systems, while providing partially treated (pretreatment) and partially distributed stormwater flows to subsequent BMPs. Swales are often heavily vegetated with a dense and diverse selection of native, close-growing, water-resistant plants with high pollutant removal potential. The various pollutant removal mechanisms of a swale include: sedimentary filtering by the swale vegetation (both on side slopes and on bottom), filtering through a subsoil matrix, and/or infiltration into the underlying soils with the full array of infiltration-oriented pollutant removal mechanisms.

A Vegetated Swale typically consists of a band of dense vegetation, underlain by at least 24 inches of permeable soil. Swales constructed with an underlying 12 to 24 inch aggregate layer provide significant volume reduction and reduce the stormwater conveyance rate. The permeable soil media should have a minimum infiltration rate of 0.5 inches per hour and contain a high level of organic material to enhance pollutant removal. A nonwoven geotextile should completely wrap the aggregate trench (See BMP 6.4.4 Infiltration Trench for further design guidelines).



A major concern when designing Vegetated Swales is to make certain that excessive stormwater flows, slope, and other factors do not combine to produce erosive flows, which exceed the Vegetated Swale capabilities. Use of check dams or turf reinforcement matting (TRM) can enhance swale performance in some situations.

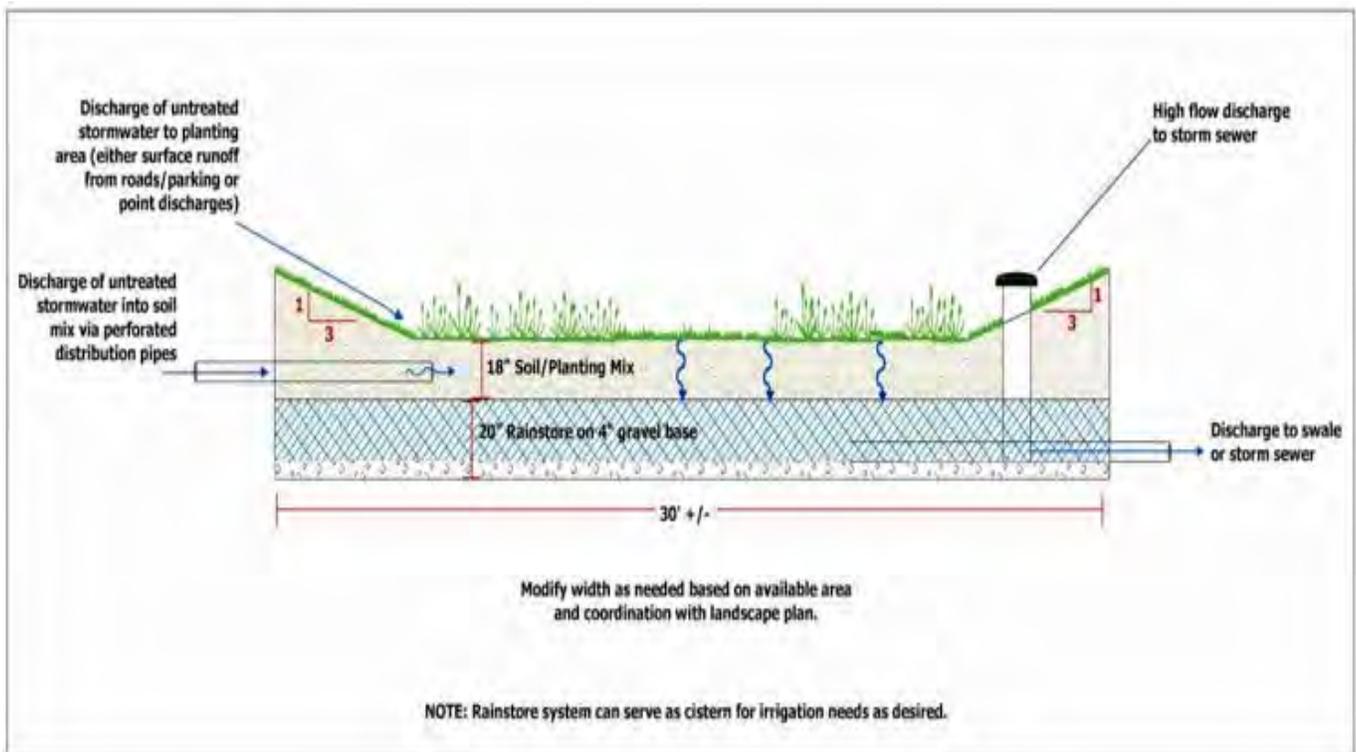
A key feature of vegetated swale design is that swales can be well integrated into the landscape character of the surrounding area. A vegetated swale can often enhance the aesthetic value of a site through the selection of appropriate native vegetation. Swales may also discreetly blend in with landscaping features, especially when adjacent to roads.



Variations

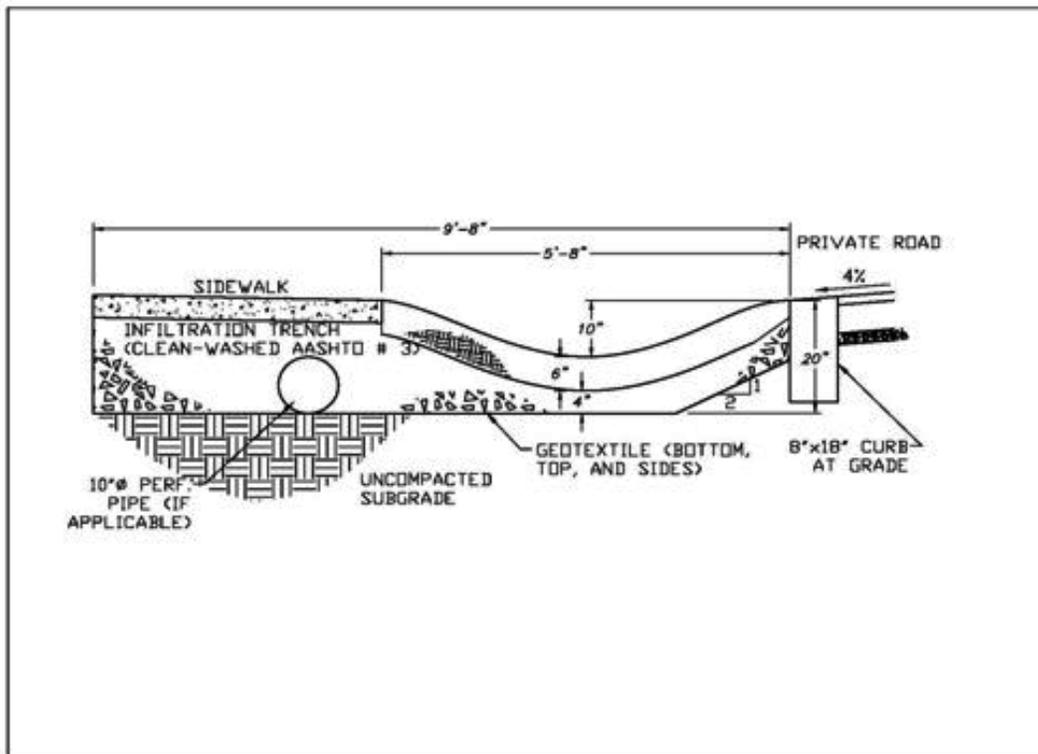
Vegetated Swale with Infiltration Trench

This option includes a 12 to 24 inch aggregate bed or trench, wrapped in a nonwoven geotextile (See BMP 6.4.4 Infiltration Trench for further design guidelines). This addition of an aggregate bed or trench substantially increases volume control and water quality performance although costs also are increased. Soil Testing and Infiltration Protocols in Appendix C should be followed.



Vegetated Swales with Infiltration Trenches are best fitted for milder sloped swales where the addition of the aggregate bed system is recommended to make sure that the maximum allowable ponding time of 72 hours is not exceeded. This aggregate bed system should consist of at least 12 inches of

uniformly graded aggregate. Ideally, the underdrain system shall be designed like an infiltration trench. The subsurface trench should be comprised of terraced levels, though sloping trench bottoms may also be acceptable. The storage capacity of the infiltration trench may be added to the surface storage volume to achieve the required storage of the 1-inch storm event.



Grass Swale

Grass swales are essentially conventional drainage ditches. They typically have milder side and longitudinal slopes than their vegetated counterparts. Grass swales are usually less expensive than swales with longer and denser vegetation. However, they provide far less infiltration and pollutant removal opportunities. Grass swales are to be used only as pretreatment for other structural BMPs. Design of grass swales is often rate-based. Grassed swales, where appropriate, are preferred over catch basins and pipes because of their ability to reduce the rate of flow across a site.



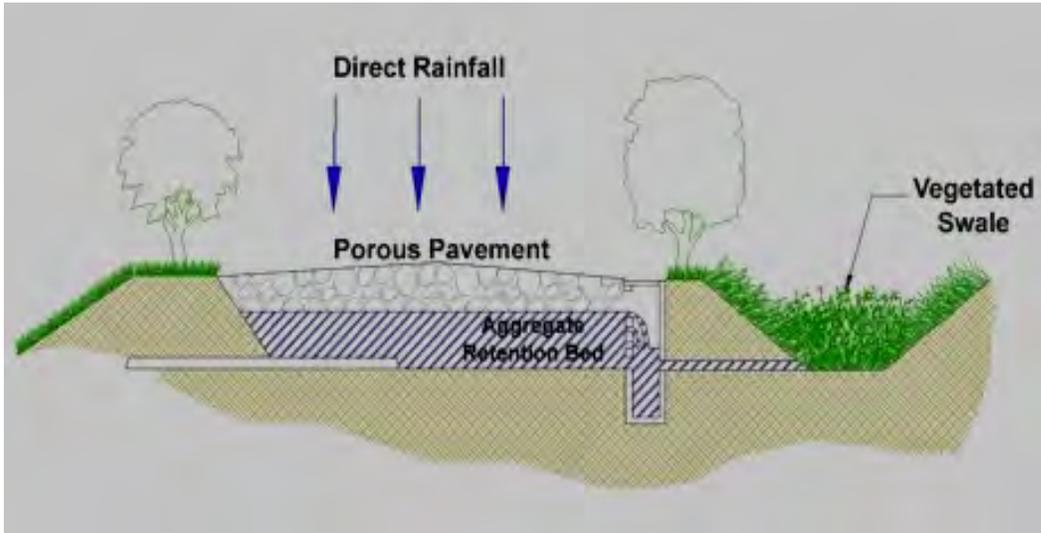
Wet Swales

Wet swales are essentially linear wetland cells. Their design often incorporates shallow, permanent pools or marshy conditions that can sustain wetland vegetation, which in turn provides potentially high pollutant removal. A high water table or poorly drained soils are a prerequisite for wet swales. The drawback with wet swales, at least in



residential or commercial settings, is that they may promote mosquito breeding in the shallow standing water (follow additional guidance under Constructed Wetland for reducing mosquito population). Infiltration is minimal if water remains for extended periods.

Applications



- **Parking**
- **Commercial and light industrial facilities**
- **Roads and highways**
- **Residential developments**
- **Pretreatment for volume-based BMPs**
- **Alternative to curb/gutter and storm sewer**

Design Considerations

1. Vegetated Swales are sized to temporarily store and infiltrate the 1-inch storm event, while providing conveyance for up to the 10-year storm with freeboard; flows for up to the 10-year storm are to be accommodated without causing erosion. Swales should maintain a maximum ponding depth of 18 inches at the end point of the channel, with a 12-inch average maintained throughout. Six inches of freeboard is recommended for the 10-year storm. Residence times between 5 and 9 minutes are acceptable for swales without check-dams. The maximum ponding time is 48 hours, though 24 hours is more desirable (minimum of 30 minutes). Studies have shown that the maximum amount of swale filtering occurs for water depths below 6 inches. It is critical that swale vegetation not be submerged, as it could cause the vegetation to bend over with the flow. This would naturally lead to reduced roughness of the swale, higher flow velocities, and reduced contact filtering opportunities.

2. Longitudinal slopes between 1% and 3% are generally recommended for swales. If the topography necessitates steeper slopes, check dams or TRM's are options to reduce the energy gradient and erosion potential.
3. Check dams are recommended for vegetated swales with longitudinal slopes greater than 3%. They are often employed to enhance infiltration capacity, decrease runoff volume, rate, and velocity, and promote additional filtering and settling of nutrients and other pollutants. In effect, check-dams create a series of small, temporary pools along the length of the swale, which shall drain down within a maximum of 72 hours. Swales with check-dams are much more effective at mitigating runoff quantity and quality than those without. The frequency and design of check-dams in a swale will depend on the swale length and slope, as well as the desired amount of storage/treatment volume. Care must be taken to avoid erosion around the ends of the check dams.



Check-dams shall be constructed to a height of 6 to 12 in and be regularly spaced. The following materials have been employed for check-dams: natural wood, concrete, stone, and earth. Earthen check-dams however, are typically not recommended due to their potential to erode. A weep hole(s) may be added to a check-dam to allow the retained volume to slowly drain out. Care should be taken to ensure that the weep hole(s) is not subject to clogging. In the case of a stone check-dam, a better approach might be to allow low flows (2-year storm) to drain through the stone, while allowing higher flows (10-year storm) drain through a weir in the center of the dam. Flows through a stone check-dam are a function of stone size, flow depth, flow width, and flow path length through the dam. The following equation can be used to estimate the flow through a stone check dam up to 6 feet long:

$$q = h^{1.5} / (L/D + 2.5 + L^2)^{0.5}$$

where:

- q = flow rate exiting check dam (cfs/ft)
- h = flow depth (ft)
- L = length of flow (ft)
- D = average stone diameter (ft) (more uniform gradations are preferred)

For low flows, check-dam geometry and swale width are actually more influential on flow than stone size. The average flow length through a check-dam as a function of flow depth can be determined by the following equation:

$$L = (ss) \times (2d - h)$$

where:

ss = check dam side slope (maximum 2:1)

d = height of dam (ft)

h = flow depth (ft)

When swale flows overwhelm the flow-through capacity of a stone check-dam, the top of the dam shall act as a standard weir (use standard weir equation). (Though a principal spillway, 6 inches below the height of the dam, may also be required depending on flow conditions.) If the check-dam is designed to be overtopped, appropriate selection of aggregate will ensure stability during flooding events. In general, one stone size for a dam is recommended for ease of construction. However, two or more stone sizes may be used, provided a larger stone (e.g. R-4) is placed on the downstream side, since flows are concentrated at the exit channel of the weir. Several feet of smaller stone (e.g. AASHTO #57) can then be placed on the upstream side. Smaller stone may also be more appropriate at the base of the dam for constructability purposes.

4. The effectiveness of a vegetated swale is directly related to the contributing land use, the size of the drainage area, the soil type, slope, drainage area imperviousness, proposed vegetation, and the swale dimensions. Use of natural low points in the topography may be suited for swale location, as are natural drainage courses although infiltration capability may also be reduced in these situations. The topography of a site should allow for the design of a swale with sufficiently mild slope and flow capacity. Swales are impractical in areas of extreme (very flat or steep) slopes. Of course, adequate space is needed for vegetated swales. Swales are ideal as an alternative to curbs and gutters along parking lots and along small roads in gently sloping terrain.

Siting of vegetated swales should take into account the location and function of other site features (buffers, undisturbed natural areas, etc.). Siting should also attempt to aesthetically fit the swale into the landscape as much as possible. Sharp bends in swales should be avoided.

Implementing vegetated swales is challenging when development density exceeds four dwelling units per acre, in which case the number of driveway culverts often increases to the point where swales essentially become broken-pipe systems.

Where possible, construct swales in areas of uncompacted cut. Avoid constructing side slopes in fill material. Fill slopes can be prone to erosion and/or structural damage by burrowing animals.

5. Soil Testing is required when infiltration is planned (see Appendix C).
6. Guidelines for Infiltration Systems should be met as necessary (see Appendix C).
7. Swales are typically most effective, when treating an area of 1 to 2 acres although vegetated swales can be used to treat and convey runoff from an area of 5 to 10 acres in size. Swales serving greater than 10-acre drainage areas will provide a lesser degree water quality treatment, unless special provisions are made to manage the increased flows.
8. Runoff can be directed into Vegetated Swales either as concentrated flows or as lateral sheet flow drainage. Both are acceptable provided sufficient stabilization or energy dissipation is

included (see #6). If flow is to be directed into a swale via curb cuts, provide a 2 to 3 inch drop at the interface of pavement and swale. Curb cuts should be at least 12 inches wide to prevent clogging and should be spaced appropriately.

9. Vegetated swales are sometimes used as pretreatment devices for other structural BMPs, especially roadway runoff. However, when swales themselves are intended to effectively treat runoff from highly impervious surfaces, pretreatment measures are recommended to enhance swale performance. Pretreatment can dramatically extend the functional life of any BMP, as well as increase its pollutant removal efficiency by settling out some of the heavier sediments. This treatment volume is typically obtained by installing check dams at pipe inlets and/or driveway crossings. Pretreatment options include a vegetated filter strip, a sediment forebay (or plunge pool) for concentrated flows, or a pea gravel diaphragm (or alternative) with a 6-inch drop where parking lot sheet flow is directed into a swale.
10. The soil base for a vegetated swale must provide stability and adequate support for proposed vegetation. When the existing site soil is deemed unsuitable (clayey, rocky, coarse sands, etc.) to support dense vegetation, replacing with approximately 12 inches of loamy or sandy soils is recommended. In general, alkaline soils should be used to further reduce and retain metals. Swale soils should also be well-drained. If the infiltration capacity is compromised during construction, the first several feet should be removed and replaced with a blend of topsoil and sand to promote infiltration and biological growth.
11. Swales are most efficient when their cross-sections are parabolic or trapezoidal in nature. Swale side slopes are best within a range of 3:1 to 5:1 and should not be greater than 2:1 for ease of maintenance and side inflow from sheet flow.
12. To ensure the filtration capacity and proper performance of swales, the bottom widths typically range from 2 to 8 feet. Wider channels are feasible only when obstructions such as berms or walls are employed to prohibit braiding or uncontrolled sub-channel formation. The maximum bottom width to depth ratio for a trapezoidal swale should be 12:1.
13. Ideal swale vegetation should consist of a dense and diverse selection of close-growing, water-resistant plants whose growing season preferably corresponds to the wet season. For swales that are not part of a regularly irrigated landscaped area, drought tolerant vegetation should be considered as well. Vegetation should be selected at an early stage in the design process, with well-defined pollution control goals in mind. Selected vegetation must be able to thrive at the specific site and therefore should be chosen carefully (See Appendix B). Use of native plant species is strongly advised, as is avoidance of invasive plant species. Swale vegetation must also be salt tolerant, if winter road maintenance activities are expected to contribute salt/chlorides.

Table 6.8.1

Commonly used vegetation in swale (New Jersey BMP Manual, 2004)		
Common Name	Scientific Name	Notes
Alkali Saltgrass	<i>Puccinellia distans</i>	Cool, good for wet, saline swales
Fowl Bluegrass	<i>Poa palustris</i>	Cool, good for wet swales
Canada Bluejoint	<i>Calamagrostis canadensis</i>	Cool, good for wet swales
Creeping Bentgrass	<i>Agrostis palustris</i>	Cool, good for wet swales, salt tolerant
Red Fescue	<i>Festuca rubra</i>	Cool, not for wet swales
Redtop	<i>Agrostis gigantea</i>	Cool, good for wet swales
Rough Bluegrass	<i>Poa trivialis</i>	Cool, good for wet, shady swales
Switchgrass	<i>Panicum virgatum</i>	Warm, good for wet swales, some salt tolerance
Wildrye	<i>Elymus virginicus/rigarius</i>	Cool, good for wet, shady swales

Notes: These grasses are sod forming and can withstand frequent inundation, and are ideal for the swale or grass channel environment. A few are also salt tolerant. Cool refers to cool season grasses that grow during the colder temperatures of spring and fall. Warm refers to warm season grasses that grow most vigorously during the hot, mid summer months.

By landscaping with trees along side slopes, swales can be easily and aesthetically integrated into the overall site design without unnecessary loss of usable space. An important consideration however, is that tree plantings allow enough light to pass and sustain a dense ground cover. When the trees have reached maturity, they should provide enough shade to markedly reduce high temperatures in swale runoff.

14. Check the temporary and permanent stability of the swale using the standards outlined in the Pennsylvania Erosion and Sediment Pollution Control Program Manual. Swales should convey either 2.75 cfs/acre or the calculated peak discharge from a 10-year storm event. The permissible velocity design method may be used for design of channel linings for bed slopes <0.10 ft/ft; use of the maximum permissible shear stress is acceptable for all bed slopes. Flow capacity, velocity, and design depth in swales are generally calculated by Manning’s equation.

Prior to establishment of vegetation, a swale is particularly vulnerable to scour and erosion and therefore its seed bed must be protected with temporary erosion control, such as straw matting, compost blankets, or curled wood blankets. Most vendors will provide information about the Manning’s ‘n’ value and will specify the maximum permissible velocity or allowable shear stress for the lining material.

The post-vegetation establishment capacity of the swale should also be confirmed. Permanent turf reinforcement may supersede temporary reinforcement on sites where not exceeding the maximum permissible velocity is problematic. If driveways or roads cross a swale, culvert capacity may supersede Manning’s equation for determination of design flow depth. In these cases, the culvert should be checked to establish that the backwater elevation would not exceed the banks of the swale. If the culverts are to discharge to a minimum tailwater condition, the exit velocity for the culvert should be evaluated for design conditions. If the maximum permissible velocity is exceeded at the culvert outlet, energy dissipation measures should be implemented. The following tables list the maximum permissible shear stresses (for various channel liners) and velocities (for channels lined with vegetation) from the Pennsylvania Erosion and Sediment Pollution Control Program Manual.

Maximum Permissible Shear Stresses for Various Channel Liners

Lining Category	Lining Type	lb/ft ²
Unlined - Erodible Soils*	Silts, Fine - Medium Sands	0.03
	Coarse Sands	0.04
	Very Coarse Sands	0.05
	Fine Gravel	0.10
Erosion Resistant Soils**	Clay loam	0.25
	Silty Clay loam	0.18
	Sandy Clay Loam	0.10
	Loam	0.07
	Silt Loam	0.12
	Sandy Loam	0.02
	Gravelly, Stony, Channery Loam	0.05
	Stony or Channery Silt Loam	0.07
Temporary Liners	Jute	0.45
	Straw with Net	1.45
	Coir - Double Net	2.25
	Coconut Fiber - Double Net	2.25
	Curled Wood Mat	1.55
	Curled Wood - Double Net	1.75
	Curled Wood - Hi Velocity	2.00
	Synthetic Mat	2.00
Vegetative Liners	Class B	2.10
	Class C	1.00
	Class D	0.60
Riprap***	R-1	0.25
	R-2	0.50
	R-3	1.00
	R-4	2.00
	R-5	3.00
	R-6	4.00
	R-7	5.00
	R-8	8.00

- * Soils having an erodibility "K" factor greater than 0.37
- ** Soils having an erodibility "K" factor less than or equal to 0.37
- *** Permissible shear stresses based on rock at 165 lb/cuft. Adjust velocities for other rock weights used. See Table 12.

Manufacturer's shear stress values based on independent tests may be used.

xture	<5	5	4
Reed Canarygrass	5-10	4	3
Serecea Lespedeza	<5	3.5	2.5
Weeping Lovegrass			
Redtop			
Red Fescue			
Annuals	<5	3.5	2.5
Temporary cover only			
Sudangrass			

¹ Cohesive (clayey) fine grain soils and coarse grain soils with a plasticity index OF 10 TO 40 (CL, CH, SC and GC). Soils with K values less than 0.37.

² Soils with K values greater than 0.37.

³ Use velocities exceeding 5 ft/sec only where good cover and proper maintenance can be obtained.

15. Manning’s roughness coefficient, or ‘n’ value, varies with type of vegetative cover and design flow depth. Two common methods are based on design depth (see adjacent graph) and based on vegetative cover (as defined in the Pennsylvania Erosion and Sediment Pollution Control Program Manual). Either of these can be used in design.

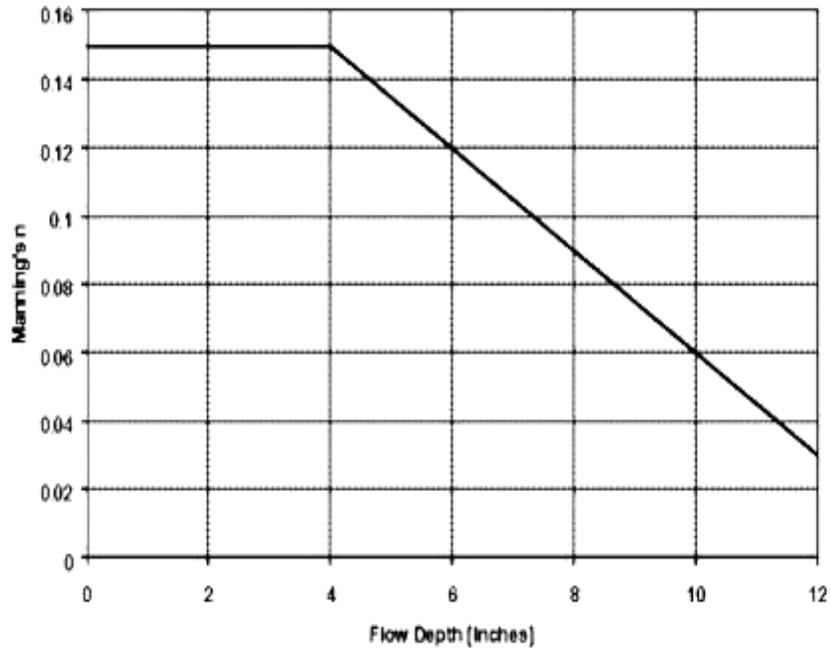


Figure D9.1 Manning’s n Value with Varying Flow Depth (Source: Claytor and Schueler, 1986)

- 16. If swales are designed according to the guidelines discussed in this section, significant levels of pollutant reduction can be expected through filtration and infiltration. In a particular swale reach, runoff should be well filtered by the time it flows over a check-dam. Thus, the stabilizing stone apron on the downhill side of the check-dam may be designed as an extension of an infiltration trench. In this way, only filtered runoff will enter a subsurface infiltration trench, thereby reducing the threat of groundwater contamination by metals.
- 17. Culverts are typically used in a vegetated swale at driveway or road crossings. By oversizing culverts and their flow capacity, cold weather concerns (e.g. clogging with snow) are lessened.
- 18. Where grades limit swale slope and culvert size, trench drains may be used to cross driveways.
- 19. Swales should discharge to another structural BMP (bioretention, infiltration basin, constructed wetlands, etc.), existing stormwater infrastructure, or a stable outfall.

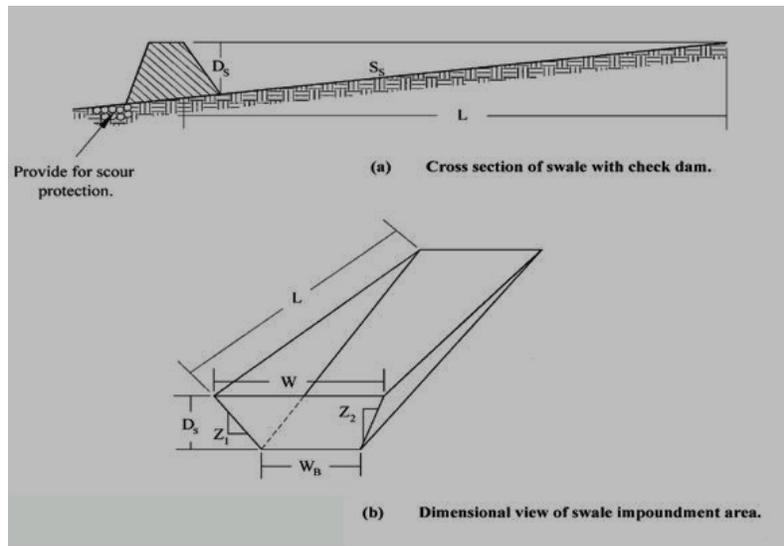
Detailed Stormwater Functions

Infiltration Area (if needed)

Volume Reduction Calculations

The volume retained behind each check-dam can be approximated from the following equation:

$$\text{Storage Volume} = 0.5 \times \text{Length of Swale Impoundment Area Per Check Dam} \times \text{Depth of Check Dam} \times (\text{Top Width of Check Dam} + \text{Bottom Width of Check Dam}) / 2$$



Peak Rate Mitigation

See Chapter 8 for Peak Rate Mitigation methodology, which addresses link between volume reduction and peak rate control.

Water Quality Improvement

See Chapter 8 for Water Quality Improvement methodology, which addresses pollutant removal effectiveness of this BMP.

Construction Sequence

1. Begin vegetated swale construction only when the upgradient temporary erosion and sediment control measures are in place. Vegetated swales should be constructed and stabilized early in the construction schedule, preferably before mass earthwork and paving increase the rate and volume of runoff. (Erosion and sediment control methods shall adhere to the Pennsylvania Department of Environmental Protection’s *Erosion and Sediment Pollution Control Program Manual*, March 2000 or latest edition.)
2. Rough grade the vegetated swale. Equipment shall avoid excessive compaction and/or land disturbance. Excavating equipment should operate from the side of the swale and never on the bottom. If excavation leads to substantial compaction of the subgrade (where an infiltration trench is not proposed), 18 inches shall be removed and replaced with a blend of topsoil and sand to promote infiltration and biological growth. At the very least, topsoil shall be thoroughly deep plowed into the subgrade in order to penetrate the compacted zone and promote aeration and the formation of macropores. Following this, the area should be disked prior to final grading of topsoil.
3. Construct check dams, if required.
4. Fine grade the vegetated swale. Accurate grading is crucial for swales. Even the smallest non-conformities may compromise flow conditions.

5. Seed, vegetate and install protective lining as per approved plans and according to final planting list. Plant the swale at a time of the year when successful establishment without irrigation is most likely. However, temporary irrigation may be needed in periods of little rain or drought. Vegetation should be established as soon as possible to prevent erosion and scour.
6. Once all tributary areas are sufficiently stabilized, remove temporary erosion and sediment controls. It is very important that the swale be stabilized before receiving upland stormwater flow.
7. Follow maintenance guidelines, as discussed below.

Note: If a vegetated swale is used for runoff conveyance during construction, it should be regraded and reseeded immediately after construction and stabilization has occurred. Any damaged areas should be fully restored to ensure future functionality of the swale.

Maintenance Issues

Compared to other stormwater management measures, the required upkeep of vegetated swales is relatively low. In general, maintenance strategies for swales focus on sustaining the hydraulic and pollutant removal efficiency of the channel, as well as maintaining a dense vegetative cover. Experience has proven that proper maintenance activities ensure the functionality of vegetated swales for many years. The following schedule of inspection and maintenance activities is recommended:

Maintenance activities to be done annually and within 48 hours after every major storm event (> 1 inch rainfall depth):

- Inspect and correct erosion problems, damage to vegetation, and sediment and debris accumulation (address when > 3 inches at any spot or covering vegetation)
- Inspect vegetation on side slopes for erosion and formation of rills or gullies, correct as needed
- Inspect for pools of standing water; dewater and discharge to an approved location and restore to design grade
- Mow and trim vegetation to ensure safety, aesthetics, proper swale operation, or to suppress weeds and invasive vegetation; dispose of cuttings in a local composting facility; mow only when swale is dry to avoid rutting
- Inspect for litter; remove prior to mowing
- Inspect for uniformity in cross-section and longitudinal slope, correct as needed
- Inspect swale inlet (curb cuts, pipes, etc.) and outlet for signs of erosion or blockage, correct as needed

Maintenance activities to be done as needed:

- Plant alternative grass species in the event of unsuccessful establishment

- Reseed bare areas; install appropriate erosion control measures when native soil is exposed or erosion channels are forming
- Rototill and replant swale if draw down time is more than 48 hours
- Inspect and correct check dams when signs of altered water flow (channelization, obstructions, erosion, etc.) are identified
- Water during dry periods, fertilize, and apply pesticide **only when absolutely necessary**

Most of the above maintenance activities are reasonably within the ability of individual homeowners. More intensive swales (i.e. more substantial vegetation, check dams, etc.) may warrant more intensive maintenance duties and should be vested with a responsible agency. A legally binding and enforceable maintenance agreement between the facility owner and the local review authority might be warranted to ensure sustained maintenance execution. Winter conditions also necessitate additional maintenance concerns, which include the following:

- Inspect swale immediately after the spring melt, remove residuals (e.g. sand) and replace damaged vegetation without disturbing remaining vegetation.
- If roadside or parking lot runoff is directed to the swale, mulching and/or soil aeration/manipulation may be required in the spring to restore soil structure and moisture capacity and to reduce the impacts of deicing agents.
- Use nontoxic, organic deicing agents, applied either as blended, magnesium chloride-based liquid products or as pretreated salt.
- Use salt-tolerant vegetation in swales.

Cost Issues

As with all other BMPs, the cost of installing and maintaining Vegetated Swales varies widely with design variability, local labor/material rates, real estate value, and contingencies. In general, Vegetated Swales are considered relatively low cost control measures. Moreover, experience has shown that Vegetated Swales provide a cost-effective alternative to traditional curbs and gutters, including associated underground storm sewers. The following table compares the cost of a typical vegetated swale (15 ft top width) with the cost of traditional conveyance elements.

ot)			
Total Annual Cost (per linear foot)	\$1 (from seed) (from sod)	\$2	No data
Lifetime (years)	50		20

It is important to note that the costs listed above are strictly estimates and shall be used for design purposes only. Also, these costs do not include the cost of activities such as clearing, grubbing, leveling, filling, and sodding (if required). The Southeastern Wisconsin Regional Planning Commission (SEWRPC, 1991) reported that actual costs, which do include these activities, may range from \$8.50 to \$50.00 per linear foot depending on swale depth and bottom width. When all pertinent construction activities are considered, it is still likely that the cost of vegetated swale installation is less than that of traditional conveyance elements. When annual operation and maintenance costs are considered however, swales may prove the more expensive option, though they typically have a much longer lifespan.

Specifications

The following specifications are provided for information purposes only. These specifications include information on acceptable materials for typical applications, but are by no means exclusive or limiting. The designer is responsible for developing detailed specifications for individual design projects in accordance with the project conditions.

1. **Swale Soil** shall be USCS class ML (Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity), SM (Silty sands, poorly graded sand-silt mixtures), SW (Well-graded sands, gravelly sands, little or no fines) or SC (Clayey sands, poorly graded sand-clay mixtures). The first three of these designations are preferred for swales in cold climates. In general, soil with a higher percent organic content is preferred.
2. **Swale Sand** shall be ASTM C-33 fine aggregate concrete sand (0.02 in to 0.04 in).
3. **Check dams** constructed of natural wood shall be 6 in to 12 in diameter and notched as necessary. The following species are acceptable: Black Locust, Red Mulberry, Cedars, Catalpa, White Oak, Chestnut Oak, Black Walnut. The following species are not acceptable, as they can rot over time: Ash, Beech, Birch, Elm, Hackberry, hemlock, Hickories, Maples, Red and Black Oak, Pines, Poplar, Spruce, Sweetgum, and Willow. An earthen **check dam** shall be constructed of sand, gravel, and sandy loam to encourage grass cover (Sand: ASTM C-33 fine aggregate concrete sand 0.02 in to 0.04 in, Gravel: AASHTO M-43 0.5 in to 1.0 in). A stone **check dam** shall be constructed of R-4 rip rap, or equivalent.
4. Develop a native **planting mix**. (see Appendix B)
5. If infiltration trench is proposed, see BMP 6.4.4 Infiltration Trench for specifications.

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Appendix 1 - Native Riparian Tree/Shrub Plant Selection

Common/ Scientific Name	Region	Hardi ness Zone	Soil pH	Flood Tolerance	Height(ft)	Shade Tolerance	Wildlife Value	Economic Value
Red maple <i>Acer rubrum</i>	P, R, A	3a	4.5-6.5	tolerant	75-100	tolerant	food source-fruits and young shoots	used in furniture, flooring and grown as an ornamental
+Silver maple <i>A. saccharinum</i>	P, R, A	3b	5.5-6.5	tolerant	75-100	intermediate	food source - seeds and young twigs	
Sugar maple <i>A. saccharum</i>	R, A	3a	6.0-7.5	intolerant	75-100	very tolerant	food source-seeds and twigs	important lumber source and maple sugar source
Shadbush <i>Amelanchier arborea (laevis)</i>	P, R, A	4,5,6		tolerant	15-20	very tolerant	food source-fruit	
*Pawpaw <i>Asimina triloba</i>	P, R, A	5b	6.0-8.0	intolerant	20-35	tolerant	food source-fruit	
*Yellow birch <i>Betula alleghaniensis</i>	P, R, A			tolerant	60-70	tolerant	moderate value to wildlife - seeds	important source of hardwood lumber
Black (Sweet) birch <i>B. lenta</i>	R, A	3b	4.5-5.0	intolerant	50-75	intermediate	food source - catkins, buds, seeds, and twigs	lumber and fuel source
+Hornbeam <i>Carpinus caroliniana</i>	P, R, A	2	6.0-7.5	intolerant	35-50	very tolerant	minimal value, food source seeds, buds, catkins and twigs	
*Bitternut hickory <i>Carya cordiformis</i>	P, R, A	4a	5.6-8.0	intermediate	75-100	intermediate	bitter nuts not favored as much as other hickories	high value for fuel
Shagbark hickory <i>C. ovata</i>	P, R, A	4a	6.0-6.5	intolerant	75-100	intermediate	food source-twigs and nuts	one of the best commercial hickories-lumber source
Redbud <i>Cercis canadensis</i>	P, R	5a	6.0-8.0	intolerant	20-35	tolerant	minimal food source-seeds	grown as an ornamental
Hackberry <i>Celtis occidentalis</i>	P, R	3a	6.5-8.0	intermediate	75-100	intermediate	food source-fruits and twigs	little importance as timber producer
Flowering dogwood <i>Cornus florida</i>	R, A	5b	5.5-6.5	very intolerant	35-50		food source-fruit	Only dogwood important for its wood
Persimmon <i>Diospyros virginiana</i>	P	5a	6.0-6.5	intermediate	50-75	intolerant	food source-fruit	yields an inferior grade of lumber

+ Short Lived
Trees < 100 years Shrubs < 20 years

* May be hard to find in a nursery.

Common/ Scientific Name	Region	Hardi ness Zone	Soil pH	Flood Tolerance	Height(ft)	Shade Tolerance	Wildlife Value	Economic Value
American beech <i>Fagus grandifolia</i>	P, R, A	3b	5.5-6.5	very intolerant	75-100	very tolerant	food source-fruit	wood not durable, but used in some furniture
White ash <i>Fraxinus americana</i>	P, R, A	3b	6.0-7.5	intermediate	75-100	tolerant	food source-fruit	wood used for many purposes
*Black ash <i>F. nigra</i>	R, A	2	4.5-6.5	very tolerant	50-75	intolerant	food source-fruit	wood used for baskets, furniture
Red ash <i>F. pennsylvanica</i>	P, R	2	6.0-7.5	tolerant	50-75	intolerant	minimal food source-twigs and fruits	important lumber tree
Honey-locust <i>Gleditsia triacanthos</i>	R, A	4b	6.0-7.5	intermediate	50-75	intolerant	food source - seeds and pods	not widely used as lumber source a thornless variety used for street and shade tree
*Kentucky coffee-tree <i>Gymnocladus dioica</i>	A	5a	6.5-7.5	intermediate	75-100	intolerant	low appeal to wildlife	wood used for various purposes, though not abundant
Black walnut <i>Juglans nigra</i>	P, R	4b	6.5-8.0	intermediate	75-100	intolerant	food source-twigs and nuts	very important lumber tree
Sweet-gum <i>Liquidambar styraciflua</i>	P	6	6.0-6.5	tolerant	75-100	intolerant	low value to wildlife	wood used as veneer in furniture
Tuliptree <i>Liriodendron tulipifera</i>	P, R, A	5a	6.0-6.5	intermediate	75-100	intermediate	food source-fruits	very valuable hardwood species
Sweet-bay magnolia <i>Magnolia virginiana</i>	P	6a	5.0-6.5	very tolerant	12-20	tolerant	food source-seeds	grown as an ornamental
Black-gum <i>Nyssa sylvatica</i>	P, R, A	5a	6.0-6.5	intermediate	50-75	intolerant	food source-fruits and twigs	lumber source
*+Hop-hornbeam <i>Ostrya virginiana</i>	P, R	5a	6.0-8.0	very intolerant	35-50	very tolerant	food source-seeds	
Eastern white pine <i>Pinus strobus</i>	P, R, A	3b	4.5-6.5	intolerant	75-100	intermediate	high value food source - needles and seeds	formerly a very valuable timber species - grown as an ornamental
Sycamore <i>Platanus occidentalis</i>	P, R, A	4a	6.5-8.0	intermediate	75-100	intermediate	moderate value for cover and food source - fruits	very limited commercial value

+ Short Lived

Trees < 100 years Shrubs < 20 years

* May be hard to find in a nursery.

Common/ Scientific Name	Region	Hardi ness Zone	Soil pH	Flood Tolerance	Height(ft)	Shade Tolerance	Wildlife Value	Economic Value
*Eastern cottonwood <i>Populus deltoides</i>	P, A	3b	6.5-7.5	tolerant	75-100	intolerant	food source-seeds, twigs, buds	softwood used mostly for paper pulp
*Large-toothed aspen <i>P. grandidentata</i>	P, R, A	3a	5.0-6.5	intolerant	50-75	very intolerant	food source-seeds	wood is very valuable
Wild black cherry <i>Prunus serotina</i>	P, R, A	3b	6.0-7.5	very intolerant	50-75	intolerant	food source-fruits and twigs	excellent lumber tree
White oak <i>Quercus alba</i>	P, R, A	4a	6.0-7.5	intolerant	75-100	intermediate	food source-acorns and twigs	important lumber tree
Swamp white oak <i>Q. bicolor</i>	P, R	4a	6.0-6.5	tolerant	75-100	intermediate	food source-acorns and twigs	lumber occasionally used in general construction
*Chestnut oak <i>Q. montana</i>	P, R	5a	6.0-6.5	intolerant	50-75	intermediate	food source-acorns and twigs	lumber used for various uses
Pin oak <i>Q. palustris</i>	P, R, A	5a	5.5-6.5	tolerant	50-75	intolerant	food source-acorns and twigs	lumber often sold as white oak
*Willow oak <i>Q. phellos</i>	P	5,6	<6.0	tolerant	75-100	intermediate	food source-acorns and twigs	important lumber source
Northern red oak <i>Q. rubra</i>	P, R, A	5,6		intermediate	75-100	intermediate	medium value for nesting, food source	only willow of any commercial value
*Sandbar willow <i>Salix exigua</i>	P, R, A			very tolerant	15-20	very intolerant	food source-fruits and twigs	
+Black willow <i>S. nigra</i>	P, R, A	3a	7.5-8.0	very tolerant	35-50	very intolerant	food source-buds, fruit, and twigs	excellent for wicker baskets and furniture
Sassafras <i>Sassafras albidum</i>	P, R, A	5b	6.0-6.5	very intolerant	35-50	intolerant	food source-twigs and fruits	poor quality wood used occasionally
*American basswood <i>Tilia americana</i>	P, R, A	3a	6.5-7.5	intolerant	75-100	tolerant	food source-twigs and seeds	important timber tree and for paper pulp
Canada hemlock <i>Tsuga canadensis</i>	P, R, A	3b	4.5-6.5	intolerant	75-100	very tolerant	food source - seeds, twigs, needles and bark	poor quality wood used occasionally for pulp
*Red (Slippery) elm <i>Ulmus rubra</i>	P, R, A			tolerant	50-80	intermediate	food source - seeds and twigs	wood inferior to American Elm but used for furniture and paneling

+ Short Lived

Trees < 100 years Shrubs < 20 years

* May be hard to find in a nursery.

SMALL TREES/ SHRUBS	Region	Hardi ness Zone	Soil pH	Flood Tolerance	Height(ft)	Shade Tolerance	Wildlife Value	Economic Value
*Smooth alder <i>Alnus serrulata</i>	P, R, A	5a	5.5-7.5	very tolerant	12-20	very intolerant	food source-fruit	
Serviceberry <i>Amelanchier canadensis</i>	P, R, A	3a	6.0-6.5	intolerant	5-25	very tolerant	food source-fruit, twigs, and leaves	grown as an ornamental
Red chokeberry <i>Aronia arbutifolia</i>	P, R, A	4b	5.0-6.5	very tolerant	6-12	intermediate	very low wildlife value	
Black chokeberry <i>A. melanocarpa</i>	P, R, A	3a	5.0-6.5	very tolerant	3-6	intermediate	food source-seeds and twigs	
*Groundsel-bush <i>Baccharis halimifolia</i>	P	4a	7.0-8.5	very tolerant	6-12	very intolerant	little value to wildlife	
Buttonbush <i>Cephalanthus occidentalis</i>	P, R, A	4a	6.0-8.5	very tolerant	6-12	very intolerant	food source-fruit	
Fringe tree <i>Chionanthus virginicus</i>	P	5b	4.5-6.5	intolerant	20-35	very tolerant	food source-fruit	grown as an ornamental
Summersweet <i>Clethra alnifolia</i>	P	4a	4.5-6.5	very tolerant	6-12	tolerant	food source-fruits and twigs	grown as an ornamental
Silky dogwood <i>Cornus amomum</i>	P, R, A	4a	6.0-7.5	very tolerant	6-12	intolerant	food source-fruits	
Grey dogwood <i>C. racemosa</i>	P, R, A	3a	6.0-8.5	intermediate	6-12	tolerant		
Red-osier dogwood <i>C. sericea</i>	P, R, A	2	6.0-8.5	very tolerant	6-12	very intolerant	food source-fruits, buds, and twigs	
*Amer. hazelnut <i>Corylus americana</i>	P, R, A	3a	6.0-7.5	intolerant	6-12	tolerant	food source-nuts	
*Black huckleberry <i>Gaylussacia baccata</i>	P, R, A		< 6.0	intolerant	1-3		food source - fruits	
Witchhazel <i>Hamamelis virginiana</i>	P, R, A	5a	6.0-6.5	intolerant	20-35	very tolerant	low value to wildlife; leaves toxic to some animals	

+ Short Lived

Trees < 100 years Shrubs < 20 years

* May be hard to find in a nursery.

SMALL TREES/ SHRUBS	Region	Hardi ness Zone	Soil pH	Flood Tolerance	Height(ft)	Shade Tolerance	Wildlife Value	Economic Value
Inkberry <i>Ilex glabra</i>	P	4a	4.5-6.0	very tolerant	6-12	tolerant	high value for food source - fruits	
Winterberry <i>I. verticillata</i>	P, R, A	3b	4.5-6.0	very tolerant	6-12	intermediate	intermediate wildlife value	
Mountain laurel <i>Kalmia latifolia</i>	P, R, A	5a	4.5-6.0	intolerant	12-20	very tolerant	high value as food esp. for winter browse for deer	
Common spicebush <i>Lindera benzoin</i>	P, R, A	5a	4.5-6.5	intermediate	6-12	very tolerant	low value as food source - fruits	
Bayberry <i>Myrica pennsylvanica</i>	P, R	4b	5.0-6.5	very tolerant	6-12	intolerant	food source - fruits	
*Ninebark <i>Physocarpus opulifolius</i>	P, R, A	2	6.0-8.5	very tolerant	6-12	intolerant	food source-fruit	
Rosebay rhododendron <i>Rhododendron maximum</i>	P, R, A	3b	4.5-6.0	tolerant	20-35	intolerant	food source-buds and twigs (winter browse)	
*Swamp azalea <i>R. viscosum</i>	P	4a	4.0-6.0	very tolerant	6-12	intermediate		
Staghorn sumac <i>Rhus typhina</i>	P, R, A	3a	6.0-7.0	intolerant	35-50	very tolerant	food source-fruit	
*Swamp rose <i>Rosa palustris</i>	P, R, A		5.5 - 8.0	very tolerant	4-10		food source-fruit	
American elder <i>Sambucus canadensis</i>	P, R, A	3a	6.1-7.5	very tolerant	6-12	very tolerant	food source-fruit	
Meadowsweet <i>Spiraea latifolia</i>	P, A	3a	6.5-7.5	very tolerant	3-6	intermediate	food source-fruit and twigs	
Highbush blueberry <i>Vaccinium corymbosum</i>	P	4b	3.5-6.0	very tolerant	6-12	tolerant	food source-fruit	commercial food crop

+ Short Lived

Trees < 100 years Shrubs < 20 years

* May be hard to find in a nursery.

SMALL TREES/ SHRUBS	Region	Hardi ness Zone	Soil pH	Flood Tolerance	Height(ft)	Shade Tolerance	Wildlife Value	Economic Value
*Wither-rod <i>Viburnum cassinoides</i>	P, R, A	2	5.0-6.5	very tolerant	6-12	tolerant	food source - fruit	
Southern arrowwood <i>V. dentatum</i>	P	3a	5.0-6.5	tolerant	6-12	tolerant	food source-fruit	
Nannyberry <i>V. lentago</i>	P, A	2	6.0-7.5	intolerant	20-35	intermediate	food source - fruit & twigs	
Blackhaw <i>V. prunifolium</i>	P, R, A	3b	6.5-8.0	very intolerant	20-35	intolerant	food source - fruit	
*Northern arrowwood <i>V. regonitum</i>	P, R, A			tolerant	6-12	tolerant	food source - fruit	
Highbush cranberry <i>V. trilobum</i>	R	2	6.5-7.5	tolerant	6-12	very tolerant	food source - fruit	

+ Short Lived

Trees < 100 years Shrubs < 20 years

* May be hard to find in a nursery.



Forest Landowners Guide to Tree Planting Success



PennState Extension

In many ways, planting trees is visionary.

Imagine a forest where there was once pasture, or woodland where there were once crops. Imagine a healthy, diverse forest, resistant to insects, fire, and disease, that will contribute to the property for generations. Planting trees has many benefits: improved wildlife habitat, high-quality trees for timber or specialty wood products, revegetated buffers along streams to protect water quality, increased species diversity and resiliency, enhanced attractiveness, and a more valuable estate for your family or heirs. Many view tree planting as an opportunity to leave behind a legacy—one that may benefit future generations, wildlife, and the environment. Whatever your purpose for planting trees, following the guidelines outlined in this publication can help you transform your land.

Most often, forests regenerate and old fields grow up in trees without our intervention. Sometimes the best plan is simply to monitor and support the natural growth of new trees. Some information in this publication can help you protect emerging and desired seedlings that have naturally occurred. However, planting trees can accelerate the natural progression or succession from field to forest or enrich a newly regenerating forest with an uncommon species.

Desired results are often evident in as little as 5 years following planting; the planted area will begin to transform into a forest. The most immediate benefits are food and cover for wildlife, soil erosion control, and improved water quality. Harvesting trees in a first thinning could begin as early as

15 to 20 years. It takes a dedicated landowner to plan decades ahead. Thankfully, many of us are, and our grandchildren and great grandchildren will benefit.

This publication focuses on the values and methods of establishing wooded areas on rural property. We'll begin with suggestions to help analyze the planting site and select appropriate tree species, then provide guidelines for preparing the site and the planting process, and finally, offer advice on maintaining and supporting the seedlings as they mature. Appendix A provides a calendar outlining steps for tree planting reforestation projects. Use this helpful calendar as a guide to the tasks you should consider before you start your project and how to follow up for success.

FIGURE 1

This old pasture was planted with a mixture of hardwood seedlings 4 years ago.

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Determining Planting Objective(s)

Determining objectives for planting is important because it will often dictate the species and number of seedlings needed. Objectives for planting are numerous and varied and include:

- Improving wildlife habitat—food and/or cover
- Producing future timber/investment
- Providing a privacy screen or windbreak
- Restoring a woodland
- Reintroducing a tree species
- Controlling erosion/improving water quality
- Reforesting an old field
- Special uses such as Christmas trees, sugarbush, nuts, or energy crops

Try answering the following questions to help you determine your objectives: What purpose(s) do you want the planting to serve? Why do you want to plant trees? With some thoughtful planning and decision making, the trees you plant will meet your objectives and provide numerous environmental benefits as well.

Assessing the Planting Site

Not all tree species are suited to all sites. Observing and learning about the planting site a year or more before planting will provide useful insights. Consider the following:

- Soil type (drainage, fertility, and texture)
- Periodic flooding
- Amount of available sunlight
- Existing plant competition
- Exposure/aspect/orientation of the terrain (north and east slopes generally have better



FIGURE 2 TOP LEFT
These Norway spruce were planted in a dense clump to provide wildlife cover.
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FIGURE 3 TOP RIGHT
These conifers were planted on an abandoned strip mine site. To alleviate compaction, the soil was ripped prior to planting. The site was also treated with a herbicide prior to planting to control competing vegetation.
S. SMITH
PENN STATE EXTENSION



FIGURE 4 BOTTOM
Sycamores, with their distinctive bark pattern, can be seen growing along streams and in bottom lands.
D. JACKSON
PENN STATE EXTENSION

growing conditions, while south and west slopes are generally hotter and drier)

These site factors influence species selection. Some site conditions such as soil moisture, soil texture, and exposure are inherent to the site and not easily changed. It is important to select tree species that can thrive under given conditions. For example, aspen, black cherry, larch, red pine, and black walnut are shade-intolerant species.

These trees will not tolerate even moderate levels of shade. If the site already has tree cover, shade-tolerant trees such as eastern hemlock, blackgum, red spruce, or sugar maple would be better choices.

Soil acidity or alkalinity (pH) is another key factor in determining which trees will grow best on a given site. Most tree species prefer neutral or slightly acidic soils. Also important is soil structure. Soils that are too tightly compacted will resist root

penetration, slow the passage of water and nutrients, and inhibit the free movement of oxygen and carbon dioxide. Hardwood (broadleaf deciduous) trees tend to grow best in loamy soils, a mixture of sand, silt, and clay. Many conifers do just fine in heavy clay or well-drained sandy soils and can tolerate dry southern exposures better than most hardwoods. As a rule, conifers can withstand adverse conditions better than hardwoods.

If a nearby but similar site already has trees, those trees may be a good indicator of existing site and soil conditions and what species may do well on your site. For example, speckled alder does well on moist, heavy clay; sugar maple prefers fertile, moderately well-drained soils; and American sycamore prospers in periodically flooded soils along stream banks and in bottom lands.

Another way to determine the soil type on your site is to consult the U.S. Department of Agriculture's Soil Survey Maps, which are available at your local conservation district office or online at websoilsurvey.nrcs.usda.gov. Soil samples can also be brought to your local Penn State Extension office where, for a nominal fee, they are sent out to assess

soil fertility and pH. Contact your county extension office for details.

Primary factors that limit tree planting success

- Soil drainage: excessively drained or poorly drained
- Existing competing vegetation: grasses, weeds, and invasive plants
- Exposure/aspect: wind, sun, and shade
- Wildlife: deer, bear, voles, and other small mammals

Selecting Tree Species

The likelihood of project success greatly improves with clearly identified planting objectives and a selection of tree species that meet objectives and are compatible with site conditions. The goal is to plant the right trees in the right location. In other words, plant tree species that will meet objectives and grow well under the given site conditions.

The choice of tree species for planting in the northeastern hardwood region is extensive. There are dozens of species to choose from. Since tree planting is somewhat permanent, carefully consider your choices. Selecting a diversity of native species that have no major pest problems and

are adapted to the site is important. The use of exotic species is discouraged today because many have become invasive and now cause damage to native plant and animal communities. Because choosing the best tree species for a particular site is so important, consider seeking advice from a knowledgeable natural resource professional or forester before ordering.

Planting Density and Arrangement

Determining an appropriate spacing between trees is necessary when developing a planting design. In general, plant trees at a closer spacing for quality hardwood production. This encourages straight boles and small lower branches that self-prune at an earlier age. Plantings for wildlife use wider spacings, up to 20 feet, to encourage crown development and earlier seed production. When determining spacing, consider the tree's crown width when it reaches a useful size. For example, when growing trees for timber, allocate space so individual trees are just beginning to crowd one another when they are large enough to support a commercial firewood or pulpwood thinning, generally an 8- to 10-foot spacing. Higher densities will require thinning at an earlier age to remove excess trees and reduce competition.

Planting arrangement refers to the pattern or distribution of tree and shrub species across a planting site. For example, a mixed hardwood plantation may concentrate black walnut seedlings on the deeper soils of the lower slope and plant red and white oak seedlings on hill tops and convex-shaped slopes.

FIGURE 5

For a planting project to be successful, find the overlap among site conditions, ownership objectives, and characteristics of desired species. Some projects have more overlap and thus more choices for species selection.

P. SMALLIDGE
CORNELL COOPERATIVE EXTENSION

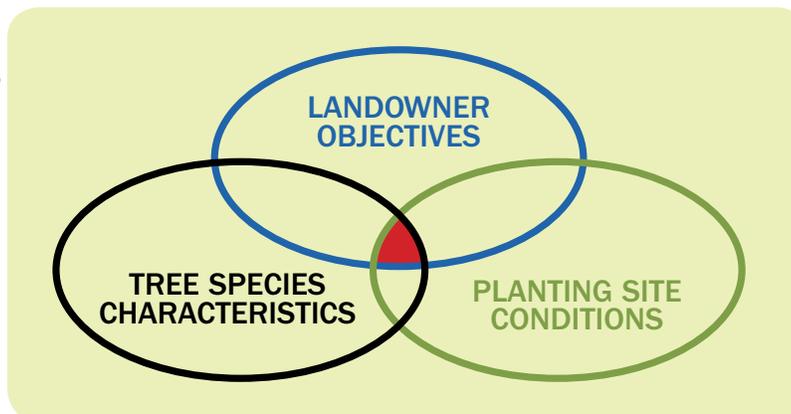


TABLE 1 | Tree selection table.

Tree selection tables cross-reference the primary reason for planting with soil and site conditions to compile a list of possible tree species.

Tree species	Site			Use				Deer browse tolerant	Insect/disease tolerant	Shade tolerant
	Wet (hydric)	Moist (mesic)	Dry (xeric)	Windbreak/screen	Timber/lumber	Wildlife	Stream bank/riparian buffer			
Conifers										
Eastern red cedar (<i>Juniperus virginiana</i>)	P	G	G	G	P	G	P	F	G	P
American larch (<i>Larix laricina</i>)	G	G	G	F	P	F	F	G	G	P
Norway spruce (<i>Picea abies</i>)*	G	G	F	G	P	G	F	G	G	F
White spruce (<i>Picea glauca</i>)	G	G	F	G	P	G	P	G	G	F
Red spruce (<i>Picea rubens</i>)	G	G	G	G	P	G	G	G	G	G
Red pine (<i>Pinus resinosa</i>)	P	G	G	P	P	F	P	G	F	P
Pitch pine (<i>Pinus rigida</i>)	F	F	G	P	F	F	P	G	F	P
White pine (<i>Pinus strobus</i>)	F	G	G	G	F	G	F	F	F	F
Scotch pine (<i>Pinus sylvestris</i>)*	P	G	G	P	P	F	P	G	P	P
Virginia pine (<i>Pinus virginiana</i>)	P	G	F	P	P	F	F	F	F	P
Northern white-cedar (<i>Thuja occidentalis</i>)	G	G	F	G	P	G	G	P	G	G
Eastern hemlock (<i>Tsuga canadensis</i>)	G	G	P	G	F	G	G	P	P	G
Hardwoods										
Box elder (<i>Acer negundo</i>)	G	G	F	F	P	F	G	F	G	G
Red maple (<i>Acer rubrum</i>)	G	G	F	P	F	P	G	F	G	G
Silver maple (<i>Acer saccharinum</i>)	G	G	P	F	F	F	G	P	G	G
Sugar maple (<i>Acer saccharum</i>)	P	G	F	P	G	G	F	P	G	G
Buckeyes (<i>Aesculus</i> spp.)	F	G	P	P	P	P	G	G	G	G
Serviceberries (<i>Amelanchier</i> spp.)	P	G	F	P	P	G	G	F	G	G
Yellow birch (<i>Betula alleghaniensis</i>)	F	G	P	P	G	F	P	F	G	F
Black birch (<i>Betula lenta</i>)	P	G	F	P	F	P	F	G	G	P
River birch (<i>Betula nigra</i>)	G	F	P	P	P	F	G	G	G	P
Paper birch (<i>Betula papyrifera</i>)	F	G	G	F	P	F	F	G	P	F
Hickory (<i>Carya</i> spp.)	P	G	F	P	F	G	F	F	G	F
American chestnut (<i>Castanea dentata</i>)	P	G	G	P	G	G	F	P	P	F
Hackberry (<i>Celtis occidentalis</i>)	P	G	G	F	P	G	G	F	G	F
Eastern redbud (<i>Cercis canadensis</i>)	P	G	F	P	P	F	G	F	G	G
Flowering dogwood (<i>Cornus florida</i>)	P	G	F	P	P	G	F	P	P	G
Hawthorn (<i>Crataegus</i> spp.)	F	G	G	F	P	G	F	P	G	P
American beech (<i>Fagus grandifolia</i>)	F	G	P	P	F	G	F	G	P	G
White ash (<i>Fraxinus americana</i>)	P	G	P	P	G	P	G	P	P	F
Green ash (<i>Fraxinus pennsylvanica</i>)	G	G	F	P	F	P	G	F	P	F
Butternut (<i>Juglans cinerea</i>)	P	G	G	P	F	F	G	F	P	P
Black walnut (<i>Juglans nigra</i>)	P	G	P	P	G	G	G	G	F	P
Yellow poplar (<i>Liriodendron tulipifera</i>)	P	G	F	P	G	P	F	P	G	P
Cucumber tree (<i>Magnolia acuminata</i>)	P	G	P	P	F	F	G	P	G	P
Blackgum (<i>Nyssa sylvatica</i>)	G	G	F	P	P	F	G	P	G	G
Sycamore (<i>Platanus occidentalis</i>)	G	G	F	P	P	F	G	F	G	F
Eastern cottonwood (<i>Populus deltoides</i>)	G	G	F	G	P	F	G	F	G	P
Bigtooth aspen (<i>Populus grandidentata</i>)	F	G	G	P	P	G	G	G	F	P
Quaking aspen (<i>Populus tremuloides</i>)	F	G	G	P	P	G	G	G	F	P
Black cherry (<i>Prunus serotina</i>)	P	G	G	P	G	G	F	G	G	P
White oak (<i>Quercus alba</i>)	P	G	G	P	G	G	F	P	F	F
Swamp white oak (<i>Quercus bicolor</i>)	G	G	P	P	F	G	G	P	F	F
Chestnut oak (<i>Quercus montana</i>)	P	G	G	P	G	G	P	F	F	F
Pin oak (<i>Quercus palustris</i>)	G	G	F	P	P	G	G	P	F	P
Northern red oak (<i>Quercus rubra</i>)	P	G	G	P	G	G	F	P	F	F
Black locust (<i>Robinia pseudoacacia</i>)	F	G	G	G	F	F	G	F	P	P
Black willow (<i>Salix nigra</i>)	G	F	P	F	P	F	G	P	G	P
Sassafras (<i>Sassafras albidum</i>)	P	G	F	P	P	G	F	F	G	P
Basswood (<i>Tilia americana</i>)	P	G	F	P	G	F	F	P	G	G
American elm (<i>Ulmus americana</i>)	G	G	F	P	P	P	G	F	P	F
Slippery elm (<i>Ulmus rubra</i>)	F	G	P	P	P	P	G	F	P	G

*Nonnative species.

G = good; F = fair; P = poor.

Source: Revised from "Northeastern Tree Planting and Reforestation" (Cornell University Cooperative Extension).

Sycamore and red maple will do better on the wetter sites. Planting a diversity of species will ensure the site is less prone to attack by insects and diseases. The planting will also provide a diverse habitat for wildlife. Mixing conifers (e.g., white pine) and hardwoods on a site is recommended. The benefits of these mixtures include earlier crown closure, reduced cost over pure hardwood plantings, wind protection, and improved hard-

wood quality as conifers force hardwoods to grow straight and self-prune lower branches earlier.

Ordering Seedlings

After gathering information about the site, the best tree species, the number of seedlings needed, and the planned layout, it is time to order seedlings. Plan to order trees in the fall or winter so they can be shipped or picked up in the spring. Ordering trees grown from seeds collected from the region where you will be planting is preferred. These trees are better adapted to local soil and weather conditions and will likely have a higher survival rate. State forestry and wildlife agency nurseries, county conservation districts, and private nurseries are possible sources of tree seedlings. A rule of thumb is to avoid ordering from nurseries more than 100 miles south and west of the state line.

Essentially, two types of seedlings are used in large planting projects, bare-root and contain-

erized. Bare-root seedlings are the most common since they are economical and easy to handle. Nurseries grow bare-root seedlings in nursery beds, lift them during the dormant season, and bundle them without soil. They are stored in refrigeration units so they remain dormant until shipped. They are described using two numbers, such as 1-0, 2-0, or 2-1 stock. The first number refers to how many years the seedlings grew in the original nursery seedbed, and the second refers to how many years they grew in a transplant bed. Transplants generally cost more, but they may be more resilient to transplanting stress. Seedlings should have a balanced 1:1 shoot-to-root ratio. Those with large shoots in comparison to roots may be prone to dieback.

Containerized seedlings, or tublings, are usually grown in a greenhouse in containers between 1 and 2 inches in diameter. These containers are either plastic or biodegradable; with plastic containers, it is necessary to remove the container prior to planting. Containerized seedlings offer the advantage of less transplant shock and are useful for planting on dry sites or for planting later into the growing season. A third alternative is to purchase potted or balled and burlapped trees. These are quite expensive, difficult to handle, and not recommended for large-scale plantings.

TABLE 2 | *Spacing by trees per acre.*

Spacing (feet)	Trees per acre
4 by 4	2,723
5 by 5	1,742
6 by 6	1,210
7 by 7	889
8 by 8	681
9 by 9	538
10 by 10	436
11 by 11	360
12 by 12	303

To calculate numbers of trees per acre, multiply the planned spacing (in feet) within rows by the spacing (in feet) between rows and divide that number into 43,560, the number of square feet in an acre.

TABLE 3 | *Wildlife benefits of common trees and shrubs.*

Plant type	Species	Wildlife benefits
Evergreens/ conifers	White pine	Winter cover for songbirds, deer, and other wildlife
	Eastern hemlock	Nest sites for mourning doves and many songbirds
	Spruce	Food for red squirrels and many other songbirds
	Red cedar	
	White cedar	
Nut trees	Oak	Food for songbirds, chipmunks, squirrels, deer,
	Hickory	wild turkey, bears, and many other species
	Beech	
	Walnut	
Fruiting trees	Black cherry	Food for songbirds, fox, deer, wild turkey, and bear
	Serviceberry	Nesting sites for cardinals and many other songbirds
	Flowering dogwood	
	Hawthorn	
	Blackgum	
	Hackberry	

Source: Revised from 4-H project book *The Wildlife Manager* (Penn State Extension).

Preparing the Site

Proper site preparation is essential for planting success. It is especially critical when planting hardwoods. Lack of site preparation is a leading cause of seedling mortality. Controlling weeds, grasses, undesirable brush, and invasive plants prior to planting is necessary. Soil conditions will make little difference if the young tree receives little water or sunlight and has no room to grow. Ideal conditions for seedlings are often ideal for weeds and other plants that compete for sunlight and water. Site preparation often involves mechanical or chemical treatments or a combination of the two. Most site preparation is done the season prior to planting. Therefore, planning ahead is essential.

Preparing Old Field Sites

For old field sites, a combination of mowing and herbicide or herbicide and disking treatments are most effective. Herbicide treatments can include broadcast, spot, or row applications in the late summer or fall prior to planting. Sites are most commonly mowed in mid-August and then treated with a broad-spectrum herbicide such as glyphosate (e.g., Rodeo and Roundup) and/or a preemergent herbicide such as sulfometuron-methyl (e.g., Oust XP and Spyder) a few weeks later. Mowing encourages a flush of new growth, thus increasing herbicide effectiveness. If making spot herbicide applications, it is a good idea to mark your planting spots with flags or stakes as they may not be obvious in the early spring, when most grasses and weeds are brown.



FIGURE 6 TOP
This photo depicts potted, containerized seedlings, or tublings, and “bare-root” seedlings. Because bare-root seedlings are economical and easy to handle, they are most commonly used for large planting projects. However, they are the least flexible of all planting stock and must be planted when seedlings are dormant.

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FIGURE 7 MIDDLE
Stem cuttings, such as this shrub willow, are used to establish willow and poplar plantings. They are inexpensive and often used to establish stream protection plantings and short-rotation woody crop plantations.

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FIGURE 8 BOTTOM LEFT
Sod-forming grasses, like tall fescue, can rob trees of moisture and nutrients. In this photo, the row of trees on the far right received no site preparation treatment. To the left, the sod was sprayed with a glyphosate herbicide prior to planting.

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FIGURE 9 BOTTOM RIGHT
Using a backpack sprayer to spot-treat competing weeds and grasses in the fall prior to planting is an effective way to prepare planting sites. Marking spots with flags or stakes will ensure seedlings are planted in treated locations come spring.

P. PANNILL
U.S. FISH AND WILDLIFE SERVICE

In most cases, mowing or disking alone is insufficient for controlling severe weed competition, except in recently row-cropped sites. These sites generally need little or no site preparation, especially if the crop was har-

vested the fall prior to planting. If soil is compacted, light disking prior to planting may be necessary and can increase seedling survival. Allow time for soil to settle before planting.

Preparing Existing Timber Stands

Generally, carefully designed and implemented silvicultural prescriptions will lead to naturally regenerated hardwood stands in Pennsylvania and across the Northeast. However, there are instances when enrichment plantings are necessary and desirable. Enrichment plantings may be used to introduce genetically improved varieties, such as American chestnut, or species that are difficult to regenerate, such as oak. Landowners may

also wish to introduce native tree species that provide food and cover for wildlife.

Tree planting in existing timber stands is generally more successful when it occurs in openings created by timber harvests or natural tree mortality rather than under an existing canopy. Planting success in these “regeneration openings” can be improved by cutting and using an herbicide to control any undesirable herbaceous vegetation, trees, and shrubs prior to planting. Herbicide applications are

effective at controlling competing grasses and ferns as well as sprouting from freshly cut stumps of undesirable trees and brush.

Herbicides

Properly applied, herbicides provide a safe and effective way to eliminate weeds, grasses, and brush that compete with seedlings for sunlight and water. Fall herbicide applications are a common site preparation treatment prior to planting. Summer herbicide applications are recommended annually following planting until trees are well established, possibly for up to 5 years (see Postplanting Maintenance section).

When choosing an herbicide, consider the targeted weed(s) and application method that best protects desirable plants, the user, and the environment. Apply preemergent herbicides before weeds appear. Use post-emergent herbicides to control already established weeds and other vegetation.

When mixing and applying herbicides, wear appropriate protective clothing (see product label) such as rubber gloves, rubber boots, long-sleeved shirt, and eye protection. Apply herbicides to dry foliage so spray will adhere well. Wind speeds of less than 10 mph reduce chemical drift onto desirable seedlings or nearby plants. See the Penn State Extension Forest Vegetation Management website at extension.psu.edu/fvm for herbicide application methods and products.

FIGURE 10 TOP LEFT
A skid steer with tracks and brush hog deck mounted on the front is used to mow overgrown old field sites prior to planting. Follow-up herbicide treatments will still be necessary to control competing and invasive plants that resprout.

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PENN STATE EXTENSION



FIGURE 11 TOP RIGHT
This striped maple was cut and stump treated with a herbicide containing triclopyr to prevent it from resprouting and competing with planted seedlings.

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FIGURE 12 MIDDLE
This site was prepared by first applying a glyphosate herbicide and then lightly disking a few weeks later.

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FIGURE 13 BOTTOM
This regeneration opening was prepared for planting by felling residual “cull” trees. The seedlings were placed in tree shelters to protect seedlings from deer browse and allow for spot herbicide applications to control competing vegetation.

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Seedling Care and Handling

Plant seedlings soon after they arrive, preferably within 24 hours and no more than one week. Store them in a cool, damp environment in the original packaging, protected from freezing. Stack bundles loosely to provide ventilation. Keep roots moist by adding a small amount of water to the open end of the bundles, and do not handle seedlings until you are ready to plant.

When transporting, take care to protect seedlings from exposure to wind and direct sunlight. Do not transport seedlings in the bed of a truck unless it is a cool, cloudy day or they are covered with a tarp. Be careful not to damage stems and buds. Buds are the source of new growth, which the tree will need to get established. At the planting site, keep extra seedlings wrapped tightly in their original packaging, covered with a reflective tarp, and stored in the shade. Only remove from storage what can be planted that day.

When to Plant

In Pennsylvania, the best time to plant is between early March and early May. Plant once frost leaves the ground and prior to bud break, when seedlings are dormant. It is essential to plant bare-root seedlings before buds begin to swell and new growth starts to emerge. Plant as early in the spring as possible, when there is high soil moisture and cool temperatures. This will help ensure root establishment before the hotter, drier summer months. Trees planted after mid-May might not survive summer's

intense heat and water stress. Planting in the fall may expose trees to severe winds and cold temperatures, which can desiccate seedlings, as well as frost heaving when the ground freezes and thaws. Calm, cool, and overcast days are best for tree planting. Under these conditions, roots are less likely to dry out before getting them in the ground.

Planting Seedlings

1. Seedling roots should be kept moist and cool at all times by carrying them in a bucket of muddy water or planting bag with wet towels, peat moss, or burlap. Roots may also be covered with one of the hydrophilic gels or moisture enhancers. Never carry bundles of seedlings in your hand exposed to the air or completely immersed in a bucket of water for extended periods of time.
2. Dig a hole with a planting shovel, mattock, or auger. If using a planting bar (see Fig. 15), work the blade vertically into soil, first pushing the handle away and then pulling it toward you to open a planting hole. It needs to be deep enough to accommodate roots vertically.
3. Set the seedling at the same depth it grew in nursery, only as deep as the root collar. Roots should be straight, not balled or twisted. Long lateral roots can be pruned to aid in planting.
4. Hold the tree straight while the planting hole is backfilled. If using a planting bar, push the blade into the soil just behind the planting hole; pull the handle toward you to close the bottom of the hole,



FIGURE 14A TOP
Plant seedlings to the same depth they grew in the nursery. Look for the root collar as pointed out in this image and plant to that depth.

G. GILMORE
PENN STATE EXTENSION



FIGURE 14B BOTTOM
While planting, keep seedling roots moist by carrying them in a bucket of muddy water.

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5. Gently pack soil around roots using your hands or the heel of your boot. This will eliminate air pockets, which can desiccate roots. To test whether a seedling is planted properly, give it a firm but gentle tug. It should remain firmly planted.

FIGURE 15

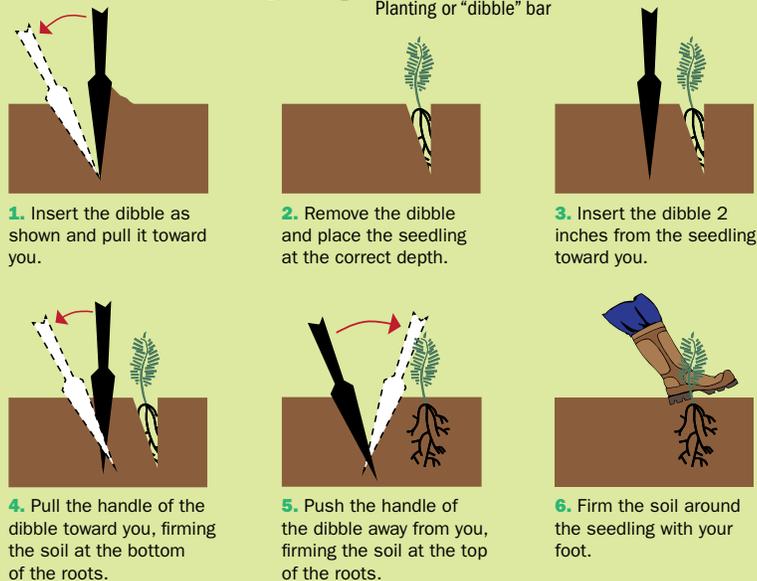
These three diagrams illustrate correct and incorrect planting depths, how to use a planting bar or dibble to plant seedlings, and how to use a mattock to plant seedlings.

SOURCE: REVISED FROM "HOW TO PLANT A TREE" (THE GREEN WORLD PROJECT)

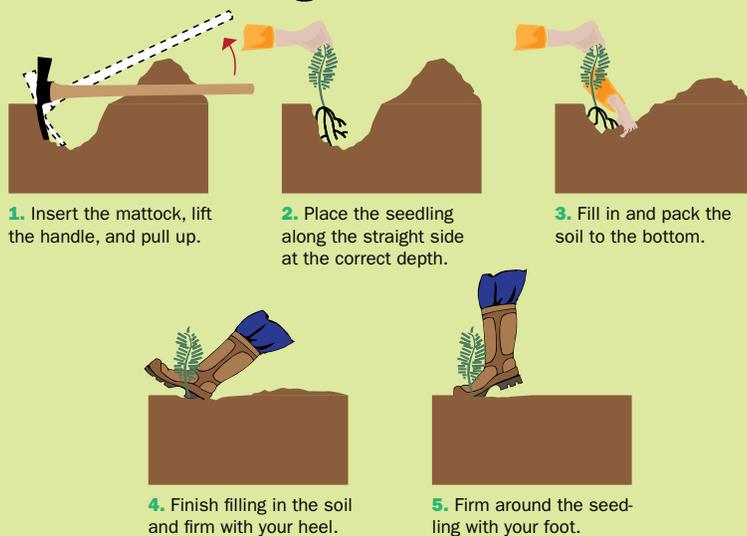
Correct and Incorrect Planting Depths



Dibble Planting



Mattock Planting



Augers

Augers are another useful tool for planting trees. They can be mounted on a tractor or skid steer or handheld and powered by two-cycle engines and are used on steep, rocky soil and where logging debris may be present. There are a couple of pitfalls when using this type of equipment. In clay soils, the sides of the hole can become "glazed," preventing tree roots from growing beyond the loose soil in the backfill. Another common problem is losing backfill material in debris that surrounds the planting hole. Prevent this by first scalping grass, leaves, and other debris away from the hole before augering. Be sure to properly pack soil back into the planting hole to prevent later settling. Settling can also be minimized by augering the hole only as deep as necessary to accommodate the tree roots.

Machine Planting

Machine planting expedites large-scale operations, such as establishing a plantation in a large, open field. Machine planting is not suited for planting in woods or on rocky or steep terrain. Two people are necessary for this job: one to drive the tractor and one to ride on the planter. The planting machine creates an opening or slit in the soil, and the person riding in the tree planter places a seedling in the soil at regular intervals. The angled rear wheels of the planting machine finish the job by closing the hole and packing soil. When conditions are right, planting thousands of seedlings in a single day is possible.

Protection

Protecting seedlings once they're in the ground is one of the most important aspects of any successful planting project. A common recommendation to protect your investment is to use tree shelters, also called tree protectors or tree tubes. Shelters shield seedlings from harsh weather, animal predation, mowers, and herbicide spray. They provide increased protection from deer and rodents, provide a better growing site by reducing wind and increasing humidity, and make follow-up herbicide applications faster and easier by shielding seedlings from spray.

Tree shelters are designed for hardwood seedlings. Most conifer species do not thrive in tree shelters. Tree shelters are expensive and may not be economical for large projects. If deer browsing is a problem, an 8-foot woven-wire fence erected around the entire project area may be more cost effective. The cost of tree shelters should include a support stake and bird netting to cover the top of shelters. Without netting, birds may enter the tubes in search of nesting sites and become trapped. Most tree shelter manufacturers provide instructions for assembly and installation. Stakes are generally purchased separately. Use something durable, such as oak, locust, or treated pine, that will last for a number of years.

Deer

In areas with high deer impact, browsing on newly planted tree seedlings is a real concern. Deer can devastate a planting project, causing tree mortality and deformed seedlings. As seedlings grow into sapling size



FIGURE 16 TOP
Some common tree planting tools include a tree planting bag, KBC bar, dibble bar, mattock, and auger. An auger works well for planting hardwood seedlings with relatively large root systems. A hoedad (inset), similar to a mattock, is another tree planting tool commonly used when planting large quantities of conifers.
D. JACKSON
PENN STATE EXTENSION



FIGURE 17 MIDDLE
Tractor-pulled tree planting machines work well when planting conifers in large, open fields and allow thousands of trees to be planted in a single day with little effort.
H. WEBSTER
PENN STATE DUBOIS, RETIRED



FIGURE 18 BOTTOM
Tree shelters provide a "greenhouse effect" by reducing wind and increasing humidity. They also protect seedlings from deer and rodents and make herbicide applications faster and easier by shielding seedlings from spray.
D. JACKSON
PENN STATE EXTENSION

(1–5 inches in diameter at breast height), bucks rubbing their antlers can also be an issue. Tree shelters at least 4.5 feet tall will minimize deer browsing impact. To deter buck rubbing, keep shelters in place as long as possible, until tree is nearly the diameter of the tube. Another alternative is to cage trees with woven-wire or plastic mesh fencing.

Voles

Voles are small mouselike rodents, and they can be quite numerous in old fields and pas-

tures. Voles can damage and kill trees as large as 3–4 inches in diameter by gnawing on roots and girdling stems. They are a leading cause of failures in tree planting projects. To protect seedlings from voles, use a shelter at least 12–18 inches in height secured tightly to the ground with a stake. Periodically inspect shelters, tapping them tight to ground. This is particularly important in spring, following winter frost heaving soil that lifts shelters and stakes. Weed control around seedlings using

herbicides is another key to avoiding vole damage. Controlling weeds and grasses around seedlings discourages voles by removing their protective cover. Mowing the entire planting area in old fields with severe vole problems is also an option.

Bears

Sometimes bears will destroy your planting investment. Bears are curious animals. Some people speculate that bears view tree shelters as toys. Others have suggested that bears destroy tree shelters in search of wasp larvae, as wasps often build nests inside the tube. Short shelters, 18–24 inches in height, may attract fewer wasps than traditional 4-foot shelters and therefore may help avoid bear damage. However, these short tubes do not protect seedling from deer browsing. In areas where seedlings require protection from deer, consider using woven-wire fence or plastic mesh. Cut fencing or mesh to length and form it into 1- to 2-foot-diameter circles to place around seedlings.

Postplanting Maintenance

Do not expect to walk away from seedlings once they are in the ground. Periodic inspections are necessary several times each year for the first 4–5 years to discover and address problems and ensure seedlings are holding their own against the environment. Maintenance includes controlling weed competition using either mulch or herbicides, repairing or replacing damaged tree shelters and broken stakes, and pruning trees to maintain proper tree form. During inspection, be sure to bring extra shel-

FIGURE 19 TOP LEFT

In areas with high deer impact, a 4-foot-tall tree shelter is inadequate at protecting tree seedlings from browsing. This red oak seedling was browsed heavily as soon as it emerged from the top of the shelter.

D. JACKSON
PENN STATE EXTENSION



FIGURE 20 TOP MIDDLE

Voles will tunnel beneath tree shelters to nest and gnaw on tree roots and stems. Control weeds and grasses around seedlings and push or tap shelters back down in early spring following winter frost heaving.

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FIGURE 21 TOP RIGHT

Rodent gnawing damage.

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PENN STATE EXTENSION

FIGURE 21 BOTTOM

Bears can damage planting projects. Some speculate that they view shelters as toys or that they are possibly looking for a meal of wasp larvae.

D. JACKSON
PENN STATE EXTENSION



ters, ties, stakes, a hammer, and pruning shears.

Checking and maintaining tree shelters is essential; you may find shelters damaged or destroyed by curious bears, wind, snow, or ice, or leaning as a result of broken ties or rotted stakes. Broken stakes can topple trees, pinning and killing them. This also allows rodents easy access to the seedling. As trees approach the top of the tube, remove bird netting. If not removed, growing shoots can become intertwined in netting, causing new growth to curl or “pigtail.” As the tree diameter reaches that of the shelter, remove the shelter to protect the young trunk from possible girdling. Many shelters claim to “break down” or biodegrade from sun exposure over a period of years. However, it is always important to check and make sure the shelter is not restricting tree diameter growth.

Weed Control

Controlling weed competition around individual seedlings is one of the most important maintenance practices performed during the first 3–5 years. Controlling weed competition will reduce vole damage, provide greater air circulation, and increase the amount of sunlight, nutrients, and water available for newly planted trees. Many old field plantings require the application of a broad-spectrum herbicide such as glyphosate (e.g., Rodeo and Roundup) at least twice annually to control competing vegetation around shelters. When using an herbicide, apply it to a 3- to 4-foot-diameter spot around each tree, being careful not to get spray onto seedling foliage. Tree shelters work well at protecting seedlings from her-



FIGURE 22 TOP
Correct for tree form by pruning out double leaders when trees are young. Also, removing lower branches as the tree grows in height will improve tree quality and encourage height growth.
D. JACKSON
PENN STATE EXTENSION



FIGURE 23 BOTTOM LEFT
A better alternative to mowing planted areas to control weeds is to spot-treat around individual trees with a broad-spectrum herbicide.
D. JACKSON
PENN STATE EXTENSION

FIGURE 24 BOTTOM MIDDLE
FIGURE 25 BOTTOM RIGHT
Organic mulches [24] and commercial weed barrier fabric [25] can provide some level of weed control around planted trees.
[24] **H. WEBSTER**
PENN STATE DUBOIS, RETIRED
[25] **D. JACKSON**
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bicide spray. If significant grass and weed growth is trapped inside the shelter, simply slide the shelter up and pull or carefully spray this vegetation.

Mowing

Unless there is a severe small rodent problem, mowing the entire planting area is not recommended and should be avoided

whenever possible. Mowing does not eliminate the roots of vegetation competing for water and nutrients. Mowing may damage seedlings, cause soil compaction, and favor the establishment of grasses that are severe competitors to tree seedlings.

By avoiding such mowing, some natural tree seedling regeneration may occur between planted

trees, giving the site a more natural appearance. Also, mowing destroys beneficial wildlife habitat and prevents natural succession of the site from occurring, thus slowing the reforestation process. However, you may find it necessary to control undesirable and invasive tree and brush species that commonly invade old field sites and disturbed woodlands by mowing, pulling, or spraying.

Conclusion

Even when planned carefully and all necessary precautions are taken, 10–20 percent seedling mortality is not unusual. Replacement planting in successive years can help recoup losses. A successful planting comes from a combination of good timing, good luck, hard work, and knowledge of the planting site and tree spe-

cies. This publication provides an overview of options, but it can't cover detailed advice about specific situations. For that, consult a natural resource professional. With proper planning and implementation, your tree planting project will be successful.

Resources

Publications

Jacobson, M., and D. Jackson, *Forest Finance 7: Tree Shelters—A Multipurpose Forest Management Tool* (University Park: Penn State Extension, 2004), extension.psu.edu/natural-resources/forests/finance/forest-tax-info/publications/tree-shelters.

Ochterski, J., P. Smallidge, and J. Ward, "Northeastern Tree Planting and Reforestation"

(Ithaca: Cornell University Cooperative Extension, 2009), www2.dnr.cornell.edu/ext/info/pubs/management/TreePlantingBulletin12-09.pdf.

Pijut, Paula M., "Planting and Care of Fine Hardwood Seedlings: Planting Hardwood Seedlings in the Central Hardwood Region" (West Lafayette: Purdue University Hardwood Tree Improvement and Regeneration Center, 2008), <https://www.extension.purdue.edu/extmedia/fnr/fnr-210.pdf>.

Wise, D., et al., *Landowner Guide to Buffer Success* (Harrisburg: Chesapeake Bay Foundation, 2007), www.cbf.org/Document.Doc?id=257.

Webinar

Jackson, D., "Landowner Guide to Tree Planting Success," Webinar Recording, Penn State Extension Forest Resources, September 13, 2011, ecosystems.psu.edu/research/centers/private-forests/outreach/pa-forests-web-seminar-center/archive/forestry-series/2011/tree-planting.

Websites

Nursery Industry Business Directory, Find Nurseries.Com: www.findnurseries.com

Penn State Extension Forest Vegetation Management: extension.psu.edu/fvm

Plant Native: www.plantnative.com

FIGURE 26

Natural tree seedling regeneration will be encouraged by not mowing between planted trees. Naturally occurring seedlings, like the walnut shown here, give the site a more natural appearance and speed up reforestation.

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Appendix A: Tree Planting Project Calendar—Steps to Tree Planting Success

Year Prior to Planting

April and May

- Review and identify planting objectives.
- Investigate whether government cost-share programs are available.
- Request tree seedling flyers from nurseries.

May through June

- Walk site with natural resource professional.
- Assess soil moisture and competing vegetation.

August through December

- Prepare site—treat competing vegetation.
- Calculate acres, lay out spacing, determine number of seedlings needed for each species.

Year of Planting

January through March

- Place tree seedling order; note delivery date.
- Schedule time and planting assistance.

March through April

- Receive trees and plant immediately.
- Install tree seedling protection/shelters.

June through October

- Inspect seedlings monthly; maintain protectors.
- Monitor competing vegetation and treat with herbicide as necessary.

Year Following Planting

February through March

- Check tree seedling protectors/shelters.
 - Fix or replace any downed, damaged, or leaning protectors.
 - Replace broken or rotten stakes.
 - Remove any wasp nests.
- Assess survival and mark any missing or dead trees.

April through May

- Replant if necessary.

May through June and August through September

- Herbicide competing vegetation as necessary (two applications may be necessary each year).

Years 2 through 5 Following Planting

February through March

- Maintain tree protectors/shelters and stakes.
- Prune as necessary to promote correct form.
 - Remove any double leaders.
 - Slowly prune lower branches to promote clear stems.

May through June and August through September

- Herbicide competing vegetation as necessary.
- Remove protectors/shelters once tree begins to reach shelter diameter; consider the risks when removing shelters.

Forest Landowners Guide to Tree Planting Success

Prepared by David Jackson, forest resources educator, and Ruth Lunt, Pennsylvania forest steward.

Cover photos by David Jackson (lower left and top right), Katie Mann (lower right), and Brian Salvato (top left).

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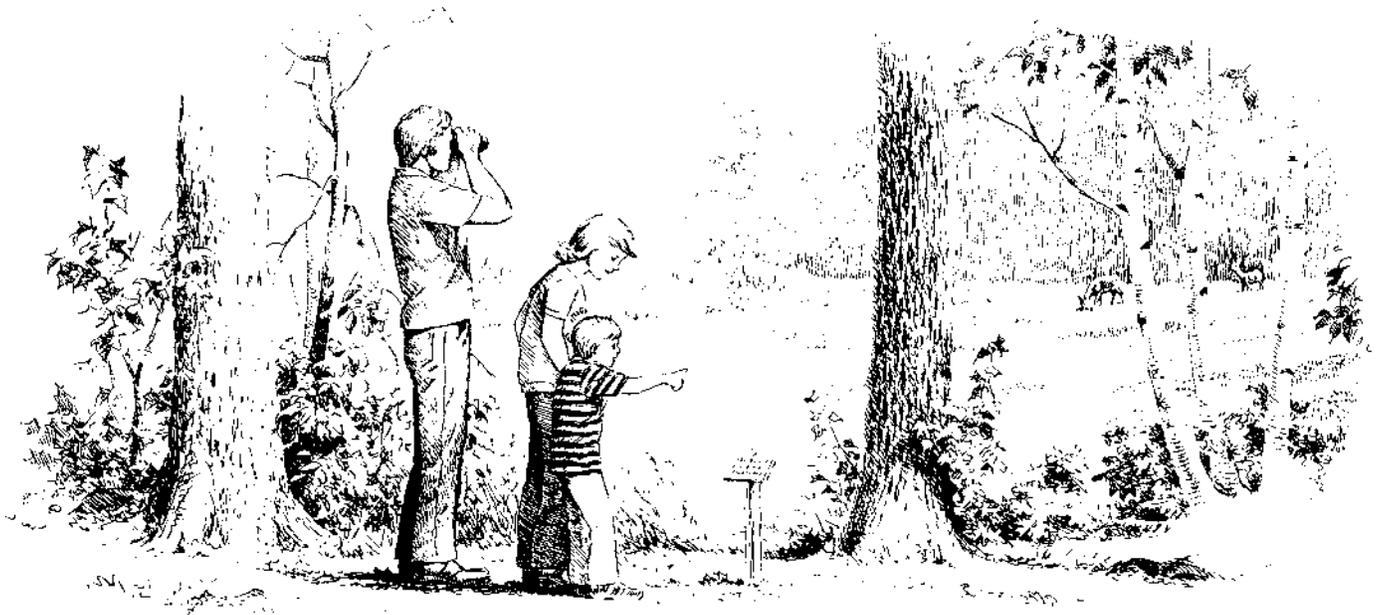
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Management Practices for Enhancing Wildlife Habitat



PennState Extension

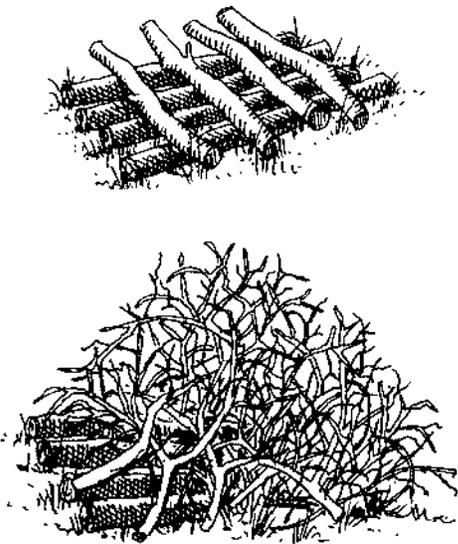
By enhancing wildlife habitat on your property, you can improve the habitat quality for wildlife while increasing wildlife viewing and recreational opportunities. The most common habitat management practices for wildlife are described below. The descriptions are brief and general. For more details about which practices are appropriate for your property, consult a wildlife management specialist.

Brush piles

Brush piles are piles of brush that are assembled to provide resting/escape cover and den sites for wildlife. Brush piles are used for cover by eastern cottontails and other small mammals. Songbirds may use brush piles for perch sites, especially if the piles are located near feeding or nest sites. Also, if brush piles are adjacent to a water source, amphibians and reptiles may use them for breeding, feeding, or resting.

The best brush piles for wildlife start with the largest materials (pole-sized logs) at the bottom and end with the smallest materials (small limbs or shrubs) at the top of the pile. The materials are arranged so that the brush pile is raised slightly above the ground. This makes it easier for animals to get under the brush pile and into cover. Placing the largest materials on the bottom of the pile also slows the brush pile's rate of decay.

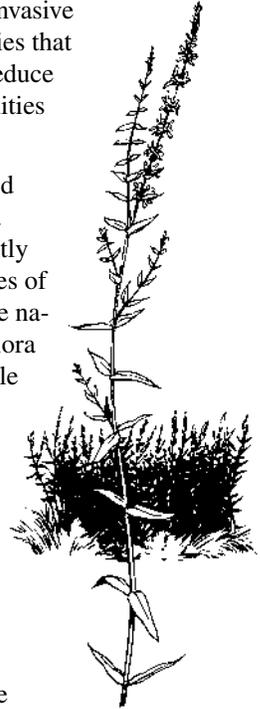
Brush piles are generally placed near food sources and in places where low cover for wildlife may be sparse or absent. Forest openings, forest edges, and timbered areas are good places to build brush piles because many types of wildlife feed in openings and along forest edges, often benefiting from the additional cover provided by the piles.



Controlling noxious weeds and non-native invasive plants

Invasive or aggressive plant species are often easily established, but once established they expand beyond those areas for which they were intended. Invasive species are generally non-native species that can out-compete native species and reduce the diversity of natural plant communities (See Table 1).

Invasive plant species can be dispersed by wildlife, livestock, and/or humans. Many were deliberately or inadvertently introduced by humans. Some examples of invasive species that may out-compete native plants in Pennsylvania are multiflora rose, Japanese honeysuckle, and purple loosestrife. Although some of these species provide benefits for wildlife, they can create problems and, in the long run, have limited value for most wildlife. Consequently, many landowners are experimenting with different techniques to control invasive species and replace them with native plants. Wildlife species in Pennsylvania have evolved with the native plant communities and derive the greatest benefits from the variety of native plants. Controlling the expansion of non-native plant species also contributes to conserving biological diversity.



Purple loosestrife

Some species of invasive plants (e.g., multiflora rose, kudzu vine, and mile-a-minute vine) are classified as noxious weeds in Pennsylvania, and it is illegal to plant them. In areas where you are not sure if a particular species may be invasive, contact local resource professionals to find out as much as possible about which species may be problems in your area. Bureau of Forestry service foresters, Natural Resource Conservation Service personnel, Penn State Cooperative Extension agents, and private natural resource professionals can provide information about the control of non-native species.

TABLE 1 - Non-native species known to have or suspected of having detrimental effects on native plant communities

<i>Acer platanoides</i>	Norway maple
<i>Ailanthus altissima</i>	tree-of-heaven
<i>Berberis thunbergii</i>	Japanese barberry
<i>Elaeagnus angustifolia</i>	Russian olive
<i>Elaeagnus umbellata</i>	autumn olive
<i>Lonicera japonica</i>	Japanese honeysuckle
<i>Lonicera maackii</i>	amur honeysuckle
<i>Lonicera morrowii</i>	Morrow honeysuckle
<i>Lonicera tatarica</i>	Tartarian honeysuckle
<i>Lythrum salicaria</i>	purple loosestrife
<i>Polygonum perfoliatum</i>	mile-a-minute vine
<i>Pueraria lobata</i>	kudzu vine
<i>Rosa multiflora</i>	multiflora rose

Creating snags

Snags are dead or partially dead standing trees that provide a number of important benefits to a variety of wildlife (see Table 2). Snags provide cavities for nesting and resting, perches for hunting and displaying, and an abundant supply of food for insect eaters. In Pennsylvania, there are over 35 species of birds and 20 species of mammals that use snags at some point in their life cycles. In addition, many species of reptiles and amphibians also use the cavities in snags.



Gray squirrel and pileated woodpecker

TABLE 2 - Some of the benefits provided for wildlife by snags

Cavities	Excavated in snags by primary cavity excavators like woodpeckers Used by woodpeckers for shelter and nesting cover Used for nest sites by secondary cavity nesters (i.e., those species unable to excavate their own cavities) like the wood duck, eastern bluebird, and gray squirrel.
Loose bark	Begins to loosen as a tree dies and forms “bark cavities” Bark cavities are used for cover, as roost sites for forest dwelling bats, and as nest sites for brown creepers.
Insects	Become abundant in the decaying wood of snags Provide a valuable food source for insect eaters like woodpeckers and nuthatches
Perch Sites	Perch sites are provided for many birds including songbirds like the indigo bunting (singing perch), raptors like American kestrel (hunting perch), and kingfishers like the belted kingfisher (fishing perch).

Different species of wildlife prefer different types and sizes of snags in a variety of habitats. Some species prefer hard snags (dead or partially dead trees with fairly sound wood and some limbs remaining) while others prefer soft snags (also called “punk,” in advanced stages of decay, and rarely with limbs). Some species, like wood ducks and barred owls, require large snags simply because they need large cavities in which to nest. Other species, such as the tufted titmouse, will forage and nest in cavities inside smaller snags. To accommodate a variety of species, many landowners try to maintain several types and sizes of snags.

The best method to provide snags for wildlife is to retain existing snags in places where they will not create a dangerous situation for people using the nearby area for outdoor activities like hiking or cutting firewood. There are a number of guidelines suggested for the types, sizes, and numbers of snags that are best for wildlife. A reference where details about snags can be found is *Dead Wood for Wildlife* (number 7 in the Pennsylvania Woodlands series), which is available free of charge from your county extension office. When the abundance or distribution of snags is inadequate or if particular types of snags are desired, snags can also be “created.” Creating snags involves deadening trees so that they remain standing. Success depends on the method used,



Gray squirrel

the tree species you are trying to deaden, the current health of the individual tree, and the specific site characteristics such as the presence of forest pests that may accelerate the tree's death.

Retaining or creating snags is often incorporated into other habitat management practices. For instance, if clearing is planned to create an opening, some of the trees that could be removed while clearing could instead be deadened and left standing for use by wildlife. If a forest-edge cutting or a tree and shrub release is planned, some of the trees that would be removed can instead be deadened and left standing.

Establishing permanent vegetation for wildlife

On some properties, trees, shrubs, and herbaceous plants have been planted to provide benefits for wildlife. In most cases, the plants selected provide either food or cover—or both. Examples of the types of vegetation typically established and the benefits they provide to wildlife are listed in Table 3.

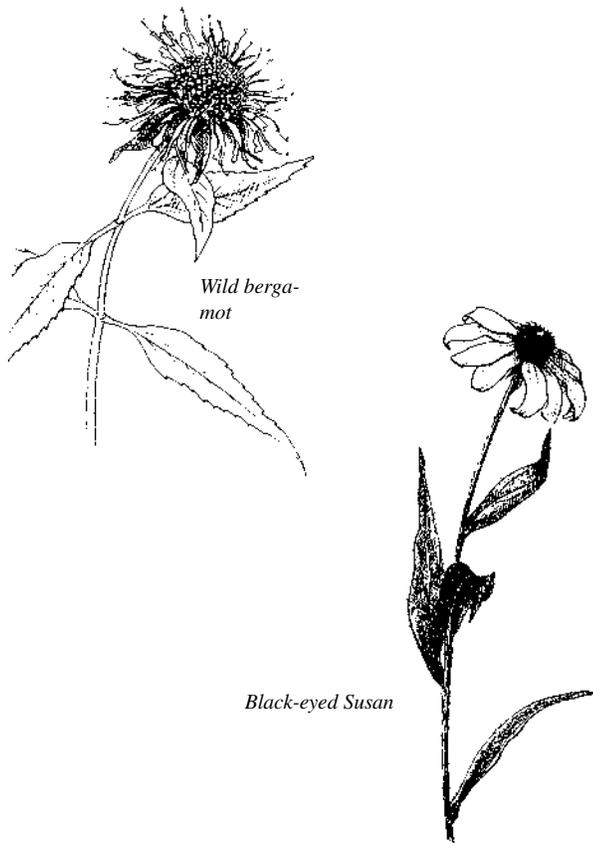


TABLE 3 - Types of plantings for wildlife

Plant Type	Examples	Examples of wildlife benefits
Evergreens, conifers	white pine eastern hemlock rhododendron	<ul style="list-style-type: none"> • thermal cover for ruffed grouse • nest sites for mourning dove • food for red squirrel
Nut trees	oak hickory beech	<ul style="list-style-type: none"> • food for wood duck, ruffed grouse, wild turkey, blue jay, black bear, eastern chipmunk, squirrels, white-tailed deer
Fruiting trees, shrubs, and vines	black cherry elderberry blackberry dogwood grape vine	<ul style="list-style-type: none"> • food for wild turkey, gray catbird, cedar waxwing, many songbirds, black bear, gray fox, white-tailed deer, and small mammals
Cool-season grasses and legumes	Kentucky blue-grass orchard grass red clover white Dutch clover birdsfoot trefoil	<ul style="list-style-type: none"> • insects for poult of ruffed grouse, wild turkey • food for meadow vole, eastern cottontail, white-tailed deer • nest sites for field sparrow, song sparrow, meadow vole • hunting sites for hawks, owls, foxes, snakes
Warm-season grasses	switchgrass big bluestem little bluestem indiangrass side oats grama	<ul style="list-style-type: none"> • nesting cover for upland game birds, waterfowl, and ground nesting songbirds • foraging cover for upland game birds, waterfowl, songbirds, eastern cottontail • food (seeds) for songbirds • winter cover for game birds, waterfowl, cottontail rabbits
Wildflowers, forbs	cardinal flower New England aster beebalm joe-pye weed columbine	<ul style="list-style-type: none"> • nectar for butterflies, moths, bees, hummingbirds • seeds for songbirds • forage for white-tailed deer

Fencing and tree shelters

When trying to establish new plants for wildlife, it is sometimes necessary to protect plants from browsing and other damage until the plants are well established. Wildlife species in Pennsylvania that may damage young plants include meadow voles, cottontail rabbits, and white-tailed deer. Meadow voles and cottontails girdle (chew the bark and cambium layer off the stem near the bottom of the plant) woody-stemmed plants while deer browse seedlings, shrubs, and stump sprouts. In agricultural areas, livestock may browse or trample young plants. Consequently, fencing or seedling protectors may be necessary to protect naturally regenerating or newly planted trees and shrubs. Fencing is also used to exclude livestock from streams and wetlands (see *Stream bank fencing*, p. 8).

There are a variety of fence types, including woven wire, high-tensile strength, and electric fences, used to protect seedlings. There are also a number of commercially available tree shelters. These shelters are tall plastic tubes (usually made of polypropylene) and are used to protect seedlings from animal browsing. They may, in some cases, accelerate seedling growth by creating a “greenhouse effect” around the seedling. The use of tree shelters is a relatively new method of seedling establishment and the long-term benefits of use have yet to be determined. One of the initial problems found with tree shelters was that songbirds like eastern bluebirds and house wrens fly inside of them (probably to feed on insects), but cannot open their wings to fly out and then die within the tubes. Because of this, it is necessary to cover the top of the tubes with bird-excluder nets. Apart from commercially available tree shelters, some landowners create their own seedling protectors from galvanized fencing. These protectors are simply mini-fences and can be custom made for single plants or groups of plants. All of these methods for protecting plants from damage by wildlife or livestock can be used on naturally occurring vegetation as well as newly planted stock.

Forest edge improvement

Many species of wildlife use edge habitat for nesting, feeding, and traveling. The main goal of forest edge improvement is to increase available food and cover along a forest edge by providing a variety of vegetation types and layers, from the shortest herbaceous vegetation to the tallest trees. Multiple layers present in vegetation provide more places where wildlife can feed and find nesting, resting, or escape cover. In addition, current research suggests that the nesting success of birds is greater along “complex” edges with multiple layers of vegetation than along “simple” edges with fewer layers of vegetation.



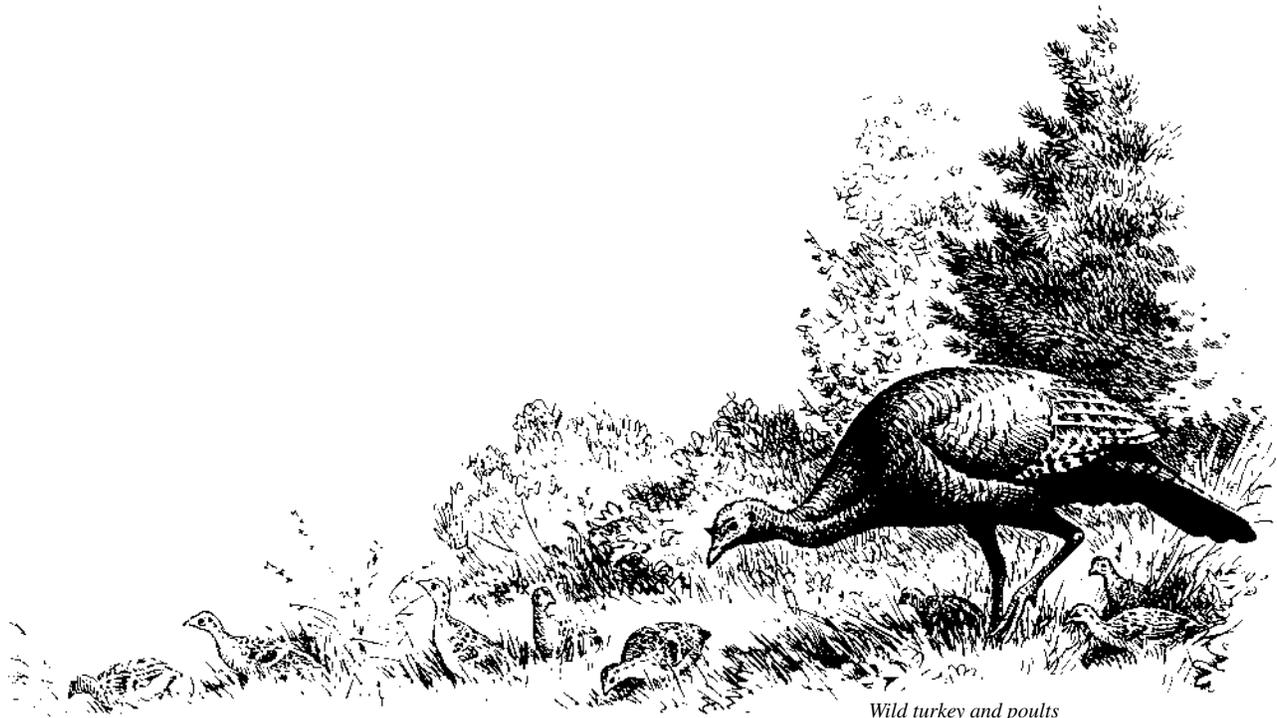
Fox

Edges between forests and fields are used by both species that are typically found within the forest and also by species typically found in fields. For example, the black-capped chickadee, a forest species, may nest along forest edges with the field sparrow, a species typically found in field habitat. In addition, “edge specialists,” such as the indigo bunting, are typically present along forest edges because it is their primary habitat. Other species like the wild turkey, eastern cottontail, or white-tailed deer may feed along a forest edge because they are able to quickly retreat into the forest for safety. Predators like the red fox or long-tailed weasel may be attracted to forest edges because an abundance of prey may be found there.

A number of methods to enhance forest edge habitat are described in this directory, including planting, letting natural succession occur, and cutting. Adding brush piles and nest boxes will also add habitat components along an edge. The result of forest edge improvement work should be a wider edge habitat that provides a gradual transition from the shorter vegetation in the adjacent habitat to the tallest trees in the forest, while providing food and cover for a variety of wildlife species.

Herbaceous forest openings

Herbaceous forest openings are openings in the forest canopy where enough sunlight reaches the forest floor to support herbaceous vegetation. Herbaceous openings can be of varying size and shape. They provide food, nest sites, and cover for selected species of wildlife. Fields, orchards, haul roads, log landings, utility right-of-ways, or openings created within a forested area may all function as herbaceous openings that provide wildlife habitat. Wildlife species that benefit from herbaceous openings are listed in Table 4. Please note that although herbaceous openings in a forest provide many benefits to a number of species, there are times when creating a forest opening can be detrimental to species that require large unbroken expanses of forest (e.g., the pileated woodpecker, northern goshawk, some neotropical migratory songbirds, and amphibians). Trade-offs between benefits and detriments should be carefully considered before creating new openings.



Wild turkey and poults

TABLE 4 - Wildlife species that may benefit from herbaceous forest openings

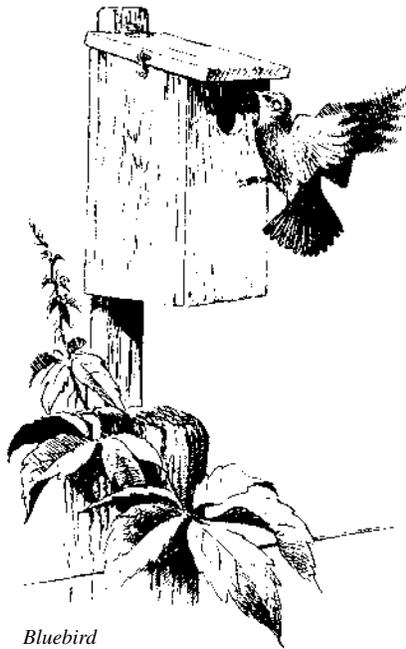
Species	Season*	Use	Species	Season	Use
Reptiles			Songbirds		
Black snake	Sp, S, F	hunting	Eastern bluebird	Sp, S	feeding
Black racer	Sp, S, F	hunting	Indigo bunting	Sp, S	nesting (along edge)
Raptors			Rufous-sided towhee	Sp, S	nesting (along edge)
Great-horned owl	Sp, S, F, W	hunting	Field sparrow	Sp, S	nesting
Cooper's hawk	Sp, S, F, W	hunting	Song sparrow	Sp, S	nesting
Red-shouldered hawk	Sp, S	hunting	Mammals		
Broad-winged hawk	Sp, S	hunting	Eastern cottontail	Sp, S, F, W	feeding, nesting, cover
Barred owl	Sp, S, F, W	hunting	Meadow vole	Sp, S, F, W	feeding, nesting, cover
Game Birds			Woodchuck	Sp, S, F, W	feeding
Wild turkey	Sp, S, F	displaying, feeding, cover	Gray fox	Sp, S, F, W	hunting
Ruffed grouse	Sp, S, F	feeding, cover	Red fox	Sp, S, F, W	hunting
Woodcock	Sp, S	displaying, feeding, nesting	Bobcat	Sp, S, F, W	hunting
Bobwhite quail	Sp, S, F	feeding, cover	White-tailed deer	Sp, S, F, W	feeding, cover

*Sp = Spring F = Fall S = Summer W = Winter

Nest boxes and other nesting structures

One of the most popular ways to improve habitat for wildlife is to provide nest boxes or structures. Nest boxes, platforms, and other types of nesting structures provide nest sites for wildlife in areas where natural nest sites (particularly cavities) are absent or available only in low numbers. They are also used to attract wildlife to specific areas even when nest sites are not limited.

In Pennsylvania, nest boxes are commonly used to provide nest sites for birds such as bluebirds, tree swallows, wrens, and wood ducks. Nest boxes also provide nest sites for mammals like squirrels and bats. Platforms and other structures are used to provide nest sites for species like the eastern phoebe, barn swallow, and some waterfowl.



Bluebird

Releasing trees and shrubs

A tree and shrub release is a technique used to enhance the growth of specific species, individuals, or groups of plants so that they produce more food or cover for wildlife. Releasing a plant involves removing other plants that are shading it and competing for sunlight. Most releases are “crown releases.” However, in some cases, releasing roots from competition may also be used. Crowns of selected species are usually released from overhead shading on at least three sides to help increase growth. When a tree or shrub release is being considered to improve wildlife habitat, the trees and shrubs selected for release should be those that provide quality food or cover for wildlife, such as fruiting shrubs.

The wildlife species that will benefit from a tree or shrub release will depend on the wildlife species present on the property and the types of trees and shrubs selected for release (see Table 5). For example, releases can be planned to improve acorn production that will feed squirrels, deer, and turkey. Releasing can also increase evergreen cover for ruffed grouse and mourning doves, or develop vertical struc-

ture in an understory that will provide nesting and foraging sites for the wood thrush and other songbirds.

Releasing and pruning old fruit trees

Fruit trees provide food for a wide variety of Pennsylvania’s wildlife. For example, white-tailed deer feed heavily on apples in the fall. Other animals that benefit from fruit trees include the black bear, songbirds, and small mammals. Also, as fruit decays on the ground, it creates an environment that is favorable for the presence of earthworms, which is why woodcock can sometimes be seen feeding under fruit trees.

On some properties, old, decadent fruit trees can be found in abandoned fields or young forests. Old fruit trees provide clues to past land use. The property may have been a farm and these fruit trees were part of an orchard or the backyard apple trees. Over time, as other trees grew and shaded these fruit trees, fruit production was greatly reduced. Fruit trees are often still viable, and with a little attention can be returned to fruit-producing condition. “Releasing” these trees may be necessary, especially if a young forest has grown over and around them. Fruit production is very dependent upon light. Removing other trees that are shading the fruit trees will help eliminate competition for sunlight.

TABLE 5 - Benefits provided by a tree or shrub release

If you release	you may benefit	by providing
Fruiting species	songbirds	food, nest sites
	small mammals	food
	black bear	food
	wild turkey	food
Nut-producing species	small mammals	food
	white-tailed deer	food
	ruffed grouse	food
	black bear	food
	blue jay	food
	gray squirrel	food
Understory shrubs	songbirds	nest sites, food, cover
	small mammals	food, cover
Evergreens	ruffed grouse	winter thermal cover
	mourning dove	nest sites
	black-capped chickadee	food, cover
	red squirrel	food, cover, nest sites

Spring seep management

Spring seeps are natural water sources where fresh water from below the ground flows to the surface to form small streams or small bodies of water. Spring seeps can be found in forests or fields, but are often located along hillsides or at the bases of mountains where groundwater flows to the surface. These areas usually have a small, year-round source of fresh water. Spring seeps provide a variety of important benefits for wildlife.

Spring seeps are particularly important during the winter when they may be the only source of fresh water and food. In the winter, groundwater is typically warmer (a constant 50 to 55 degrees Fahrenheit) than air and ground temperatures. Even during the coldest weather, seeps typically remain unfrozen with flowing water and support green vegetation at a time when herbaceous vegetation is scarce. During severe winters, when other sources of water are frozen for extended periods of time, spring seeps are used heavily by wildlife. In early spring, seeps are one of the first areas where vegetation grows. Thus, this food source is available at a critical time of year when most other food sources have been depleted.

During periods of deep snow, spring seeps also provide snow-free travel lanes where wildlife can move and feed. Birds and mammals benefit from the herbaceous vegetation that grows and persists around seeps in the winter when other food is scarce. Insects in and around the seeps provide a year-round source of high-protein food. Deer and small mammals find abundant sources of “browse” and other forage growing around seeps. Bears and other berry eaters benefit from fruit-producing species that grow well in moist conditions. Songbirds benefit from the fruit and insects around seeps, often finding nest sites in the dense vegetation surrounding the seep.

Amphibians and reptiles benefit from seeps that contain slow-moving water. Because most spring seeps do not support fish populations, amphibian eggs can develop without high losses to fish predation. Reptiles such as turtles benefit from the fresh spring water and soft mucky bottom of some seeps where they can bury themselves, seeking relief from very hot weather or hibernating during the winter months. Amphibians and reptiles also benefit from the plant and insect food available around seeps.

The most important management practice for spring seeps is to protect them from any activities that could degrade the seep, such as clear-cutting beside the seep or agricultural pollution. Options for enhancing the habitat associated with a spring seep include releasing or planting beneficial trees and shrubs around the seep and encouraging the growth of herbaceous vegetation around the seep’s perimeter.

Stream bank fencing

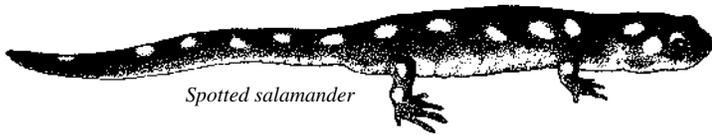
Livestock with free access to streams destroy wildlife and fish habitat, increase erosion and sedimentation, and degrade water quality. Stream bank fencing excludes livestock from sensitive riparian areas. After livestock are excluded, a buffer zone of vegetation grows between the stream and the fence. This new riparian streamside vegetation provides food, cover, and nesting sites for birds and small mammals. Over 80 kinds of birds, including herons, egrets, bluebirds, belted kingfishers, mallards, and pheasants, use streamside vegetation for summer feeding and nesting. Streamside vegetation improves fish habitat by enhancing water quality, providing protective cover, and increasing available food for fish. Stabilized stream crossings provide limited areas where livestock can have access to the stream for drinking and/or crossing the stream.

Temporary pools

Temporary pools are wetland habitats that fill with water during a rainy season and then dry up later in the year. Most people consider temporary pools to be synonymous with vernal pools. “Vernal” means “of, relating to, or occurring in the spring,” and these pools fill with water in the spring and dry up in the late summer or early fall. However, there are also autumnal pools, which fill with water in autumn. Temporary pools are found where small depressions and swales collect runoff or intercept seasonally high water tables.

Although the water supply from these pools is temporary, it is critical because temporary pools are the breeding and hibernating grounds for amphibians like red spotted newts and spring peepers. Temporary pools do not support fish populations so amphibian eggs can develop without high losses to fish predation. These special circumstances make temporary pools essential for the survival of many amphibian populations. Ecologically, amphibians are both predators that prey on small invertebrates and prey contributing to the survival of many other predators. Since the late 1970s, scientists around the world have been reporting disturbing declines in amphibian populations. This decline makes conservation of temporary pool habitats increasingly important. In addition to providing breeding and hibernating habitat for amphibians, temporary pools also support a complex web of interactions between a variety of organisms that include aquatic insects, salamanders, frogs, turtles, snakes, large and small mammals, waterfowl, and songbirds.

The best way for landowners to provide temporary pools for wildlife is to protect any existing pools from destruction. Many temporary pools have been destroyed during development and other land-use changes. (Unfortunately, temporary pools are difficult to identify during the dry season, and many people don’t realize the value of what looks to them



Spotted salamander



Red-spotted newt



Slimy salamander

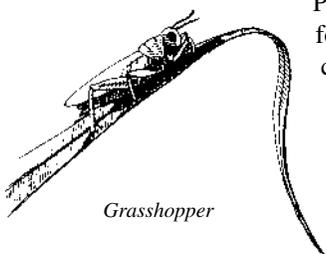
like a mud hole.) Temporary pools should be protected from destruction because of the important function they serve within a larger habitat area. Usually, restricting any potentially degrading activities around a temporary pool is all that is necessary to maintain the pool's healthy environment.

Some successful attempts have been made to create temporary pools for wildlife. These newly created temporary pools may help offset some of the losses of natural temporary pools. However, temporary pool creation requires special circumstances that do not exist on all properties.

Warm-season grasses

Native warm-season grasses are prairie grasses that were present when our ancestors settled what was to become the Commonwealth of Pennsylvania. The four main grasses of tall-grass prairie habitat are switchgrass, big bluestem, little bluestem, and indiangrass. Warm-season grasses, also known as "bunch grasses," grow in thick bunches instead of forming mats like many other grasses. These dense bunches of grass interspersed with open spaces between the bunches provide valuable nesting and foraging cover for upland game birds such as turkeys and pheasants, various waterfowl, and other ground-nesting grassland species like savannah sparrows.

Some warm-season grasses may grow to a height of over 6 feet. Because of their growth form and height, these grasses provide excellent cover for wildlife, especially upland game birds and waterfowl. Cottontail rabbits benefit from both the cover and forage produced by warm-season grasses, and many songbirds feed on the small seeds of the plants. Probably one of the most important benefits of warm-season grasses is that, if left uncut, they remain upright throughout the winter, providing valuable cover for many animals at a time of year when most other plants have died or are dormant.



Grasshopper

Planting warm-season grasses for wildlife has recently become a very popular practice due to the high-quality habitat that is provided by a stand of warm-season grasses. Establishing warm-season grasses requires more

patience than effort. After planting, it may take from one to four years for a full stand of grasses to develop.

Because this is a rather recent habitat management practice in Pennsylvania, new information about establishing these grasses is being learned every day. Consequently, if you are interested in establishing warm-season grasses for wildlife, it is best to talk with someone who has planted some themselves before proceeding. There are some very successful methods being implemented throughout Pennsylvania; learning about them will give you first-hand knowledge of what methods might work best on your land.

Wetland restoration

The wetland restoration program in Pennsylvania was initiated by the U.S. Fish and Wildlife Service's Partners for Wildlife Program. Wetland restorations are done on lands that were previously drained (sometimes to make cropland) and which are then restored to their natural state as a wetland by removing the tiles or plugging the ditches that drain them. The resulting wetlands vary in size and usually have an area of open water with emergent wetland vegetation growing around the perimeter of the water. These wetlands provide breeding, nesting, and feeding habitat for amphibians, waterfowl, shorebirds, and songbirds. They are essential "stop-over," resting, and feeding places for migrating species. The excellent cover offered by the prolific growth of vegetation around wetland habitats also provides food and cover for species like the beaver, muskrat, cottontail rabbit, and white-tailed deer. Animals that rely on wetland habitats, as well as animals that are generally considered upland species, benefit from restored wetland sites. Wetlands help to reduce erosion and flooding, also purifying our water supplies by filtering pollutants and sediments out of the water.

For more information about the wetland restoration program, contact your local NRCS office or call the U.S. Fish and Wildlife Service office in State College, Pennsylvania, at (814) 234-4090.

Wildlife corridors

A wildlife corridor is a habitat “patch” that connects two or more areas of undeveloped habitat that are isolated from one another. There are essentially two major types of wildlife corridors, but other areas can mimic these two types on a very local scale.

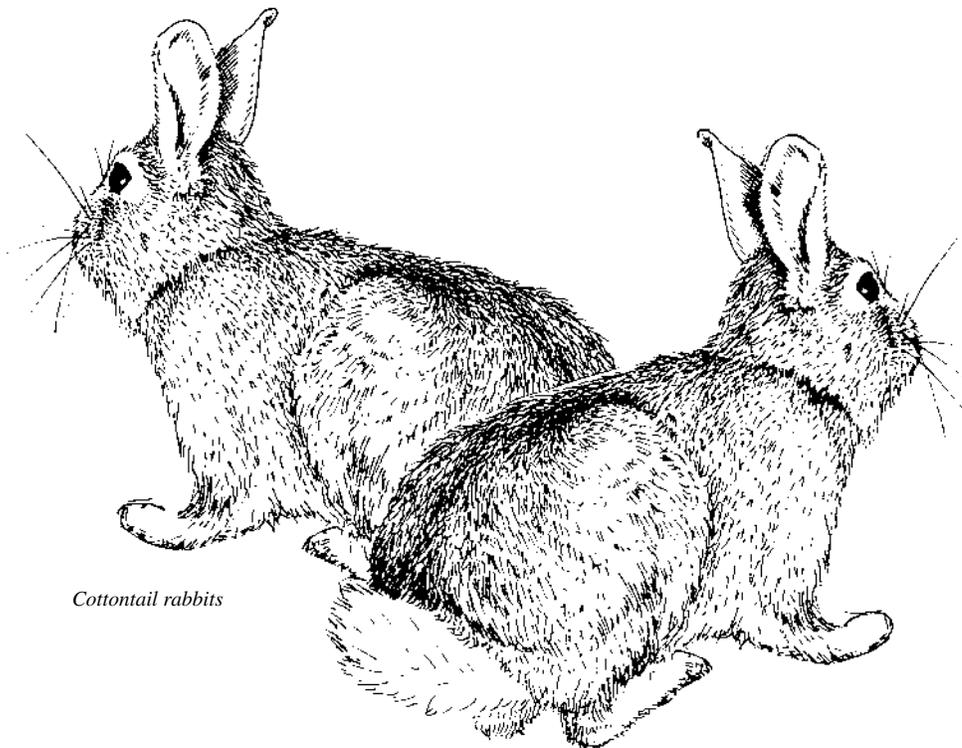
The first type is a corridor that exists on a landscape scale. An example of a landscape-scale corridor is a forested ridge top that connects, like a “bridge” of wilderness, between two or more habitats that are great distances apart. Corridors that are present on the landscape level are generally thought to be serving a connective function, benefiting species that require large expanses of undeveloped habitat because they have large home ranges, disperse over great distances, or need to travel great distances to find mates.

A second type of corridor exists on a smaller scale, usually on a local level, generally connecting two isolated habitats that are not necessarily separated by large distances. In agricultural areas, these types of corridors are often called fencerows or hedgerows. These “strip habitats” provide food and cover for wildlife. If the hedgerow connects two habitats, such as two woodlots on a farm, it may be used as a travel route between the woodlots by some species. This type of corridor can be added to a property, providing additional habitat and potential travel lanes for wildlife. Another type of wildlife corridor that occurs on a local scale is the

buffer strip of vegetation along a stream or river that varies in width. Depending on the length and width of the buffer strip, these areas may function as travel corridors in addition to providing wildlife with valuable food and cover.

Connective corridors established by habitat management practices in Pennsylvania will most likely be wooded patches of habitat that connect two isolated forests or woodlots and will provide additional food and cover for wildlife. Changes in land-use often result in the fragmentation of wildlife habitats, and habitat patches like forests become smaller and more isolated. Perhaps the best reason to plant corridors is that the original landscape was interconnected. New corridors would re-establish some of those past connections. Corridors can also function as a habitat patch, providing wildlife with food and cover whether the animal lives in the corridor or just travels through.

The species of wildlife that will benefit from wildlife corridors in Pennsylvania will depend on what plants and other habitat components exist in the corridor, where it is located, and what species of wildlife are present in the adjacent habitat. Small mammals, such as the gray squirrel and eastern cottontail, and songbirds like song sparrows and gray catbirds are some of the species that may use wildlife corridors for feeding, nesting, or movement.



Cottontail rabbits

ADDITIONAL INFORMATION

The fact sheet series *Pennsylvania Wildlife*, available from all county extension offices, provides additional information on Pennsylvania wildlife and specific habitat management practices. If you are interested in visiting sites where wildlife management practices have been implemented, obtain a copy of *Enhancing Wildlife Habitat: A Directory of Wildlife Habitat Enhancement Demonstration Sites in Pennsylvania* from your local county extension office. The directory includes descriptions of and directions to demonstration sites across Pennsylvania where wildlife habitat enhancement practices have been implemented.

Prepared by

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1998

Illustrators: *Ned Smith*, cover, pages 3, 6, and 7;
Rae Chambers, pages 2 (left column), 4, and 5;
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extension.psu.edu

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Case Study: Black Rock Sanctuary

Establishing a Native Meadow

Background

In 1999 Chester County Parks and Recreation converted 42 acres of the Black Rock Sanctuary into a native warm season grass meadow. The area was formerly a repository for coal silt dredged from the Schuylkill River. Consequently, the soils had very little nutrient value. The existing top growth was a mixture of cool season grasses and seasonal and perennial *forbs* (herbaceous flowering plants other than grass). Warm season grasses thrive in this environment so there was no need for soil amendments prior to establishing the warm season grass meadow.



For More Information Contact

Chester County Parks and Recreation

K. Owen Prusack
382 County Park Road
Pottstown, PA 19465

(610) 469-1916
oprusack@chesco.org

The Process for Replanting

The existing cool season grasses and forbs were suppressed with glyphosate at 1 quart per acre. Warm season grass seed was acquired with funds from the U.S. Fish and Wildlife Service and Pheasants Forever. A Truax Seed Drill (made specifically for warm season grasses), loaned from the Pennsylvania Game Commission Southeast Region, was used to plant the seed mix in July of 1999, which happened to be during one of the worst droughts in recent history. The warm season grass seedlings were not evident until May of 2001; taking two full growing seasons for the seeds to germinate. This is not unusual, but can certainly be a cause for concern.

July is not the optimum time of year to plant. Target planting for mid-May to early June, as ground conditions are typically more conducive to seeding via drill given better moisture content in the soil. However, because of outside grant funding the project had to happen when it did.

Type of Seed Used

A seed mix native to Pennsylvania was chosen. The mix included big bluestem, little bluestem, Indian grass, and switchgrass. The County used 420 pounds of seed (42 acres at 10 pounds of seed per acre). The mix per acre was 3pounds big bluestem, 3pounds little bluestem, 3pounds Indian grass, and 1pound cave-n-rock switchgrass. The approximate cost for the seed was \$5,800.

Maintenance Plan

An established stand of warm season grasses, after about 3 to 5 years of development, is nearly self-sustaining. Annual maintenance is required to mediate competition of cool season grasses, forbs/weeds and woody vegetation. Mowing, using selective herbicides to control herbaceous and woody competitors and prescribed fire are all part of the County's short and long-term management. The County contracts with a local farmer to harvest the warm season grasses annually as a hay crop and staff use prescribed fire on a rotational basis to invigorate the grasses and kill their native and invasive competition. Chemical treatment should be used sparingly because the more effective chemicals can also kill the desired plants.

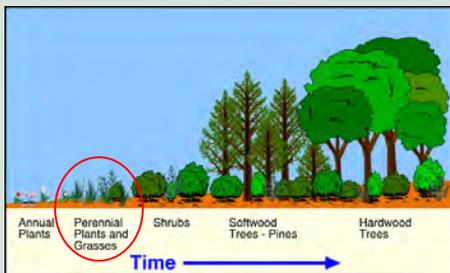
Tips

- Seasonal timing of seed planting is important. It is best to plant warm season grasses from March to May. Mid-May is optimal planting time for southeastern Pennsylvania.
- Be patient! Even with perfect timing germination may take one or more growing seasons.
- Implement a long term meadow management plan.
- Warm season grasses provide valuable nesting habitat and winter cover for wildlife. Plan to mow once a year after the nesting season.
- Consider prescribed fire. It is a huge tool in the long term management and health of a warm season grass meadow. *Note: Prescribed burning should be done only by well-trained personnel and in accordance with federal, state and local laws.*

Step-By-Step Guide

Please keep in mind the following instructions are generalized for the purpose of this guide. Each site will have its own set of conditions that affect the approach taken and the project's ultimate success.

1. Choose a suitable location for the meadow to be established; preferably an open, sunny area that gets at least six hours of sun each day.
2. Seek funding assistance and equipment rental if necessary.
3. Contact a local seed company to help determine the perennial seed mix that will best meet your needs.
4. Treat site in the fall with an herbicide that will kill existing vegetation.
5. Plant seed the following spring (March to May) using a drill seeder or track seeder.
 - a. During the first growing season most growth of warm-season grasses is downward to establish roots.
 - b. Depending on when the seeds are planted some will remain dormant until the second growing season.
6. Manage the area
 - a. A meadow is typically a short-lived successional habitat therefore it must be managed to prevent woody vegetation from becoming established.



- b. Management of weeds during the first three years may be necessary
 - i. Mow at 6-10 inches before the warm-season grasses are very tall.
 - ii. Spot treat with herbicides.
 - iii. Use mechanical or manual means of weed removal until the desired

plants get established.

- c. Once the meadow becomes established, usually from the 3rd year forward, mow the meadow once a year after the nesting season. A general rule is never clip more than the top third of a warm season grass.

Technical Assistance

Partner with regional agencies and organizations for funding, equipment loans and labor, etc. For example:

- Pennsylvania Game Commission
- PennState Cooperative Extension
- USDA Natural Resources Conservation Service
- County Conservation Districts
- Local land conservation organizations
- Local state park maintenance and education staff
- Private organizations (for example, Pheasants Forever)
- Scout groups and other local service groups who might be looking to do a conservation project

For other Technical Guidance please refer to the following documents by the PennState Cooperative Extension:

- PA Wildlife No. 5- Meadows and Prairies: Wildlife-Friendly Alternatives to Lawn
<http://pubs.cas.psu.edu/freepubs/pdfs/uh117.pdf>
- PA Wildlife No. 12- Warm-Season Grasses and Wildlife
<http://pubs.cas.psu.edu/freepubs/pdfs/uh158.pdf>



pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

Invasive Plants in Pennsylvania

Norway Maple

Acer platanoides



Photo: Leslie Mehrhoff, U. of Connecticut,
www.forestryimages.org

Background:

Norway maple was originally introduced into North America by John Bartram of Philadelphia, who received seedlings from London in 1756. Bartram began offering this plant to nurseries and Norway maple subsequently became a popular tree for city plantings. This species is naturalized throughout the state, but is more common in the southern half.

Range:

Norway maple is the most widespread maple in Europe where it occurs from Norway and Sweden to Turkey and northern Iran. Norway maples are widely planted in the U.S., from the Canadian border south to the Carolinas.

Description:

Norway maple is a large, deciduous tree with a broad, rounded crown. It can readily be distinguished from other maples because the leaves and twigs ooze milky sap when cut or torn; however, this may be difficult to detect late in the season. This species grows up to 65 feet in height with up to a seven foot trunk diameter. Norway maple leaves are dark green and are about six inches wide and five inches long, with five to seven lobes. The bark is smooth and gray-brown, twigs are stout, brown with green buds with overlapping bud scales (*see photo on right*).



Photo: Paul Wray, Iowa State U.,
www.forestryimages.org

Habitat:

Norway maple is usually planted in urban and suburban settings but commonly invades deciduous forests adjacent to suburban areas.

Biology and Spread:

Norway maple reproduces by seed, which each tree produces in large amounts. The winged fruits are spread by the wind. The seeds germinate readily, even in dense shade, and grow quickly when young.



Photo: John Randall, The Nature Conservancy,
www.forestryimages.com

Ecological Threat:

This species is a frequent invader of urban and suburban forests. Its extreme shade tolerance allows it to penetrate deep within an intact forest canopy. Recent research has shown that forests invaded by Norway maple have less wildflower diversity compared with forests dominated by native Sugar maple (*Acer saccharum*).

How to Control this Species:

Manual and Mechanical

Norway maple seedlings are easy to pull when the soil is moist. For larger plants, dig them out, making sure to get all the roots. Cut down large trees and grind out the stump, or clip off re-growth. Girdle the tree by cutting through the bark and growing layer (cambium) all around the trunk. Girdling is most effective in spring.

Look-A-Likes:

Norway maple is similar to the native sugar maple. However, Norway maple can be readily distinguished from other maples because the leaves and twigs ooze milky sap when cut or torn. It is the only maple in our region with that characteristic.



Photo: Paul Wray, Iowa State U.,
www.forestryimages.org

Chemical

Norway maple can be controlled effectively by using an herbicide such as glyphosate or triclopyr. Trees up to four inches in diameter can be controlled by applying triclopyr mixed with a horticultural oil to the bark, a foot from the base of the trunk. This can be done in early spring or from June 1 to September 30. The cut stump method may also be used – cut the tree and immediately apply the herbicide around the outer ring of the stump.

Native Alternatives:

There are many native trees that make great alternatives. Sugar maple (*Acer saccharum*), red maple (*Acer rubrum*), American basswood (*Tilia americana*), red oak (*Quercus rubra*), white ash (*Fraxinus americana*) and tuliptree (*Liriodendron tulipifera*) are just a few examples.



Photo: Bill Cook, Michigan State U.,
www.forestryimages.org

References:

Center for Invasive Species and Ecosystem Health:

<http://www.invasive.org/browse/subinfo.cfm?sub=3002>

U.S. Forest Service Weed of the Week: http://www.na.fs.fed.us/fhp/invasive_plants/weeds/norway-maple.pdf

Invasive Exotic Plant Tutorial for Natural Lands Managers:

http://www.dcnr.state.pa.us/forestry/invasivetutorial/norway_maple_M_C.htm

For More Information:

Plant Invaders of Mid-Atlantic Natural Areas:

<http://www.invasive.org/eastern/midatlantic/acpl.html>

Invasive Plants Field and Reference Guide, U.S. Forest Service:

http://na.fs.fed.us/pubs/misc/ip/ip_field_guide.pdf

Invasive Plants in Pennsylvania

Callery or Bradford Pear

Pyrus calleryana



Photo: Dan Tenaglia, MissouriPlants.com, www.invasive.org

Background:

Callery pear is native to Asia and was brought to Maryland in 1918 as rootstock for cultivated pears. A non-spiny seedling was selected and named "Bradford." This tree became the second most popular tree in America by the 1980s.

Range:

Reports of this tree as invasive in southeast Pennsylvania are starting to surface, but further south in Maryland, Virginia and beyond they have been dealing with this issue for much longer. These trees can also be found throughout the south and Midwest.

Description:

This ornamental, deciduous tree can grow up to 40 feet in height. The shiny green leaves are alternate, simple and two to three inches long. Their margins are wavy with a slightly-toothed margin.



Photo: Chuck Barger, U. of Georgia, www.invasive.org

The overall shape of the tree is often described as tear-dropped or spade-like. The bark is scaly and gray-brown in color. Abundant small, malodorous, white flowers appear in spring before the leaves emerge. Fruits are under half an inch in diameter and green to brown in color.

Habitat:

Typically found along roads, rights-of-way and old fields where they have escaped from landscape plantings. Callery pears will tolerate a wide range of soil conditions and pollution. It prefers full sun but will tolerate partial shade.

Biology and Spread:

The "Bradford" variety of pear was supposed to produce sterile fruits, but more recent cultivars were created to resist splitting by wind and snow. These trees were able to cross pollinate and produced viable seeds that are spread by wildlife. It also spreads vegetatively.

Ecological Threat:

Naturalized callery pears compete with native early successional trees in old fields and hedgerows.



Photo: Britt Slattery, US Fish and Wildlife Service, www.invasive.org

How to Control this Species:

Manual and Mechanical

Seedlings and shallow-rooted trees can be pulled when soil is moist. Small trees will need to be dug up or pulled out with a Weed Wrench tool to ensure removal of all roots.

If cutting down the tree is not possible, it can be girdled during the spring or summer by cutting through the bark all around the trunk, about six inches above the ground.

Chemical

Cutting the tree, followed by an immediate application of a triclopyr or glyphosate herbicide to the cut stump, is the most practical means of control.

Herbicide can also be applied to a girdled tree if total removal of the tree is not possible.

References:

Center for Invasive Species and Ecosystem Health:

<http://www.invasive.org/browse/subinfo.cfm?sub=10957>

Invasive Exotic Plant Tutorial for Natural Lands Managers:

http://www.dcnr.state.pa.us/forestry/invasivetutorial/gallery_pear.htm

U.S. Forest Service Weed of the Week: http://www.na.fs.fed.us/fhp/invasive_plants/weeds/gallery_pear.pdf

For More Information:

Plant Invaders of Mid-Atlantic Natural Areas, National Park Service:

<http://www.nps.gov/plants/alien/pubs/midatlantic/midatlantic.pdf>

Invasive Plants Field and Reference Guide, U.S. Forest Service:

http://na.fs.fed.us/pubs/misc/ip/ip_field_guide.pdf

USDA PLANTS Database: <http://plants.usda.gov>

Native Alternatives:

There are a variety of native ornamental trees that provide food for wildlife or beauty in landscapes, such as:

Allegheny Serviceberry (*Amelanchier laevis*)



Photo: Dow Gardens, www.forestryimages.org

White Fringetree (*Chionanthus virginicus*)



Photo: Dow Gardens, www.forestryimages.org

Sourwood (*Oxydendrum arboretum*)



Photo: Richard Webb, www.forestryimages.org

Invasive Plants in Pennsylvania

Russian and Autumn Olive

Elaeagnus angustifolia and *E. umbellata*



James H. Miller, USDA Forest Service
www.forestryimages.org

Background:

Both Russian and autumn olive were introduced into the United States in the 1800s. Prized for their silvery foliage, hardiness and plentiful berries, these shrubs were planted as ornamentals, for erosion control and wind-breaks, and in wildlife food plots.

Range:

Russian olive, native to Eurasia, can be found scattered throughout the eastern U.S. and is a problem further west. Native to east Asia, autumn olive has naturalized extensively throughout the eastern half of the United States. Autumn olive is the more common of the two species in Pennsylvania.

Description:

Russian and autumn olive are large, multi-stemmed shrubs that can reach upwards of 20 feet in height. Their most distinctive characteristic is a dusting of silvery scales covering young stems, leaves, flowers and fruit. Small yellow or white flowers become edible fruits in late summer and fall, which are red in autumn olive and orange in Russian olive.



Leslie J. Mehrhoff, U. of Connecticut
www.forestryimages.org

Habitat:

Both species are found along streams, fields, roadsides, sparse woodlands, disturbed sites and open areas. Russian olive does particularly well in sandy floodplains. Neither species does well in densely forested areas.

Biology and Spread:

Both species are spread by birds and other wildlife that feed on the fruit. These shrubs grow rapidly and are able to produce fruit as early as three years of age.

Ecological Threat:

These shrubs are highly competitive against native species, shading out shorter plants. Their nitrogen-fixing capabilities may adversely affect the nitrogen cycle of native communities that depend on infertile soils. Although Russian and autumn olive provide a plentiful source of berries for birds, their fruits are actually quite low in nutrients. Ecologists have found that bird species richness is higher in riparian areas dominated by native vegetation.



Leslie J. Mehrhoff, U. of Connecticut
www.forestryimages.org

How to Control this Species:

Physical

Young seedlings can be pulled by hand when the soil is moist enough to ensure complete removal of the root system.

Small saplings can be pulled sufficiently with a weed wrench. Larger individuals can be cut at ground level or girdled.

Cutting is an initial control measure and should be followed by herbicidal treatment to prevent re-sprouting.

Look-A-Likes:

Russian and autumn olive may be confused with invasive bush-honeysuckles (*Lonicera* spp.) or native deciduous hollies (*Ilex* spp.)



The Dow Gardens Archive
www.forestryimages.org

Chemical

Use a systemic herbicide, such as glyphosate or triclopyr.

Herbicide should be applied immediately to cut stumps to prevent regeneration. It can also be applied to girdle wounds or directly to the lower bark using the basal bark method.

Large thickets, where risk to non-target species is minimal, can be controlled by the foliar spray method.

References:

Global Invasive Species Database: <http://www.issg.org/database/species/ecology.asp?fr=1&si=262>

Plant Conservation Alliance's Alien Plant Working Group:
<http://www.nps.gov/plants/alien/fact/elan1.htm>

For More Information:

DCNR Invasive Species Site: <http://www.dcnr.state.pa.us/conservationscience/invasivespecies/index.htm>

DCNR Invasive Exotic Plant Tutorial for Natural Lands Managers:
http://www.dcnr.state.pa.us/forestry/invasivetutorial/russian_autumn_olive.htm

Native Alternatives:

Many native shrubs are available for re-vegetation projects. Native plants are the best option for wildlife food plots.



Jerry A. Payne, USDA ARS
www.forestryimages.org



The Dow Gardens Archive
www.forestryimages.org

Invasive Plants in Pennsylvania

Privets (Japanese, Border, Chinese and Common)

Ligustrum japonicum, *L. obtusifolium*, *L. sinense* and *L. vulgare*



Photo: Troy Evans, www.bugwood.org

Background:

These four species of privets were originally imported for use in landscaping around 1860. They are still often used in hedges and landscaping.

Range:

The various privets are originally from Japan, China and Europe. They have spread through the eastern United States, from New Hampshire and Michigan in the north to Florida and Texas in the south.

Description:

Privets are deciduous or semi-evergreen shrubs that often form dense thickets. They have opposite or whorled stems that are brown to gray with slightly rough bark. Privets produce white flowers from April to June, which are followed by green drupes from July to March. These fruit gradually ripen to a dark purple or black color in the winter. It is often difficult to differentiate between the four privets to the species level, particularly when they are not flowering.



Photo: Rebekah Wallace, U. of Georgia, www.invasive.org

Habitat:

Privets are often found in bottom-land forests, fence-rows, fields and rights-of-way. They seem to prefer disturbed areas with rich soil.

Biology and Spread:

Privets mainly spread to new areas via their seeds. Often-times, these are distributed by birds, which have eaten the fruit. Once introduced to an area, privet can regenerate from root and stump sprouts, making it difficult to eradicate.

Ecological Threat:

Privets can form dense thickets, which reduce light and moisture availability for native shrubs and wildflowers. This decreases plant diversity and impacts the animals which depend on them for food and shelter.

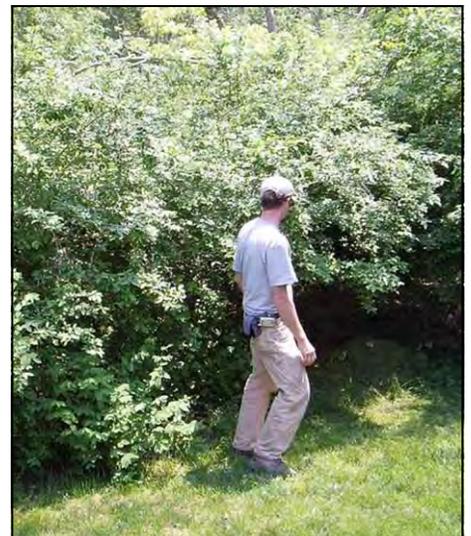


Photo: Leslie Mehrhoff, U. of Connecticut, www.invasive.org

How to Control this Species:

Once established in an area, privet can be difficult to control or remove.

With smaller populations, hand removal can be used. However, fragments of root that are left behind in the ground can re-sprout.

Larger areas can also be treated with herbicides such as glyphosate. Herbicide can be applied to the leaves, or painted on cut stems or stumps. Once the herbicide is applied, disturbances to the privet should be avoided for approximately one year, in order for the herbicide to travel through the privet's root systems.

No biological controls are currently known for privet. Studies show that controlled burning does not appear to have a lasting effect on privet populations, so it is not recommended as a control option.

Look-A-Likes:

There are a large variety of shrub-sized, berry-producing, deciduous alternatives to privets for landscaping purposes. These include species such as spicebush (*Lindera benzoin*), dogwoods (*Cornus* spp.) and chokeberry (*Aronia* spp.). These species will all provide food and cover for wildlife.



Photo: Jessica Sprajcar, DCNR



Photo: Chris Vans, River to River CWMA,
www.forestryimages.org



Photo: Richard Webb, www.forestryimages.org

References:

USDA Plant Guide:

http://plants.usda.gov/plantguide/pdf/pg_lisi.pdf

University of Connecticut Plant Database:

<http://www.hort.uconn.edu/plants/index.htm>

Center for Invasive Species and Ecosystem Health: www.invasive.org

For More Information:

Plant Invaders of Mid-Atlantic Natural Areas, National Park Service:

<http://www.nps.gov/plants/alien/pubs/midatlantic/midatlantic.pdf>

Invasive Plants Field and Reference Guide, U.S. Forest Service:

http://na.fs.fed.us/pubs/misc/ip/ip_field_guide.pdf

Invasive Plants in Pennsylvania

Shrub Honeysuckles

(Amur, Morrow's, Bells, Standish, and Tartarian)

Lonicera maackii, *L. morrowii*, *L. x bella*, *L. standishii*, and *L. tatarica*



Chuck Bargeron, University of Georgia,
www.bugwood.org

Background:

Shrub or bush honeysuckles were introduced to North America for use in landscaping, erosion control and wildlife cover. Unfortunately, these plants then spread throughout much of the country.

Range:

The nonnative bush honeysuckles are native to eastern Asia, Europe and Japan. Currently, they can be found in a variety of habitats from the Great Plains to southern New England, and south to Tennessee.

Description:

Nonnative bush honeysuckles grow to heights of six to 20 feet. Their stems are thornless with a hollow brown pith. Their leaves are opposite and egg-shaped. Their flowers, which bloom from May to June, are fragrant, tubular and less than an inch long. They range in color from white to yellow to pink to red. The berries are small and red or yellow.



Leslie J. Merhoff, University of Connecticut,
www.bugwood.org

Habitat:

Nonnative bush honeysuckles are relatively shade-intolerant, and often occur in disturbed woods or edges, roadsides and abandoned fields where more light is available. Morrow's and Bell's honeysuckles are capable of invading bogs, fens, lakeshores and sandplains.

Biology and Spread:

Nonnative bush honeysuckles produce large numbers of small fruits, particularly when growing in open sunlight. These are eaten by birds, which then spread the seeds in their droppings. Once a population establishes, vegetative sprouting continues the spread of these plants.

Ecological Threat:

These invasive species compete with native plants for sunlight, moisture and pollinators. And while birds eat the fruit, it is poorer in fats and nutrients than fruits from native plants, so the birds do not get enough nutrients to help sustain long flights during migrations.



Leslie J. Merhoff, University of Connecticut,
www.bugwood.org

How to Control this Species:

The two main methods of controlling nonnative bush honeysuckles are mechanical and chemical. Smaller populations can be removed by hand, making sure to include the roots. Larger populations should be cut to ground level at least once per year, in either early spring or late fall.

Glyphosate can be sprayed onto the leaves, or could also be applied to cut stems in order to kill the root system.

No biological controls are known that would target solely nonnative bush honeysuckle species. In open areas, prescribed fire may help to eradicate this species. In order to optimize this approach, however, the burn should be conducted prior to late summer in order to prevent seed dispersal.

Look-A-Likes:

Native bush honeysuckles exist throughout North America. The natives generally have solid stems, as opposed to the hollow pith of the invasive ones. Be very cautious when buying so-called “native” honeysuckles from a nursery or online.

Native Alternatives:

There are a large variety of shrub-sized, berry-producing, deciduous alternatives for landscaping purposes. These include species such as spicebush (*Lindera benzoin*), dogwoods (*Cornus* spp.) and chokeberry (*Aronia* spp.). These species will all provide food and cover for wildlife.



Photo: Jessica Sprajcar, DCNR



Photo: Chris Vans, River to River CWMA, www.forestryimages.org

References:

Invasive Exotic Plant Tutorial for Natural Lands Managers:

http://www.dcnr.state.pa.us/forestry/invasivetutorial/bush_honeysuckles.htm

University of Wisconsin, Invasive Plants of Wisconsin:

http://www.uwgb.edu/biodiversity/herbarium/invasive_species/lonxbe01.htm

Plant Conservation Alliance's Least Wanted List:

<http://www.nps.gov/plants/alien/fact/loni1.htm>

University of Connecticut Plant Database:

<http://www.hort.uconn.edu/plants/index.html>

Robert W. Freckmann Herbarium: <http://wisplants.uwsp.edu/scripts/detail.asp?SpCode=LONTAT>



Photo: Richard Webb, www.forestryimages.org

Invasive Plants in Pennsylvania

Multiflora Rose

Rosa multiflora



Leslie J. Mehrhoff, U. of Connecticut
www.forestryimages.org

Background:

Multiflora rose was introduced into the United States as ornamental rootstock from Japan in 1866. Beginning in the 1930s, the U.S. Soil Conservation Service promoted it for use in erosion control and livestock fencing. It was also encouraged in wildlife plantings and as a crash barrier along highways. Recognition of its tenacious and unstoppable growth habit came too late, and it is now considered a noxious weed in many states.

Range:

Native to Asia, multiflora rose now occurs throughout most of the United States, especially the eastern half.

Description:

Multiflora rose is a dense, thorny shrub, reaching up to 15 feet in height, with arching canes (stems) that are capable of rambling up trees. Its leaves are pinnately compound, divided into seven to nine leaflets, and finely serrate. Clusters of fragrant white to pink flowers appear in May or June. Small bright red hips (fruit) develop during the summer and remain on the plant through winter.



James H. Miller, USDA Forest Service
www.forestryimages.org

Habitat:

This invasive shrub has a wide tolerance for various soil, moisture and light conditions. It can be found in dense woods, along stream banks and roadsides, and in open fields and prairies.

Biology and Spread:

It is estimated that a single plant may produce a million seeds per year, which may remain viable in the soil for up to 20 years. The hips are readily eaten by birds, which are the primary seed dispersers. New plants can also be formed by rooting from the tips of canes touching the ground.

Ecological Threat:

Multiflora rose forms impenetrable thickets that exclude native plant species. This shrub grows very prolifically in riparian areas, where its inedible leaf litter can change the composition of the aquatic macroinvertebrate community. Its occasional habit of climbing can weigh down trees, making them susceptible to breakage.



James H. Miller, USDA Forest Service
www.forestryimages.org

How to Control this Species:

Physical

Frequent cutting or mowing, three to six times per growing season, for two to four years, is effective in achieving high mortality. Be careful – the strong thorns have been known to puncture rubber tires.

Scattered populations may be eliminated by complete removal of the plants. Be sure to remove all root material because this shrub readily re-sprouts.

In areas where multiflora rose is detected early, prescribed fire may limit its establishment.

Chemical

Application of herbicides, such as glyphosate or triclopyr, on freshly cut stems is an effective control method since it destroys the root system and prevents re-sprouting. This may be done during the dormant period, which reduces the likelihood of damaging desirable species.

A foliar spray of fosamine can be used from July through September, but die-back will not be apparent until the following summer. Fosamine will only affect woody species.

Biological

Biological control is currently under investigation. Rose-rosette disease, a native viral pathogen, is spread by a mite, and is slowly spreading eastward from the west. The European rose chalcid, a seed-infesting wasp, promises to reduce seed viability. Unfortunately, both of these measures have the potential to impact native rose species.



Leslie J. Mehrhoff, U. of Connecticut
www.forestryimages.org

Look-A-Likes:

Multiflora rose could easily be confused with other rose species (both native and non-native), especially when not in bloom. This is a concern, since some native species are of conservation interest.



Catherine Herms, Ohio State University
www.forestryimages.org

References:

Plant Conservation Alliance's Alien Plant Working Group:
<http://www.nps.gov/plants/alien/fact/romu1.htm>

Wisconsin Department of Natural Resources:
<http://dnr.wi.gov/invasives/fact/rose.htm>

For More Information:

DCNR Invasive Species Site: <http://www.dcnr.state.pa.us/conservationscience/invasivespecies/index.htm>

DCNR Invasive Exotic Plant Tutorial for Natural Lands Managers:
http://www.dcnr.state.pa.us/forestry/invasivetutorial/Multiflora_rose.htm



Invasive Plants in Pennsylvania

Wineberry

Rubus phoenicolasius Maxim.



Photo: John Randall, The Nature Conservancy,
www.invasive.org

Background:

Also known as wine raspberry, this shrub from eastern Asia was introduced into the U.S. in 1890 as breeding stock for new raspberry cultivars. It is still used today by berry breeders.

Range:

This shrub is found mostly along the Appalachian ridge from Massachusetts to Tennessee, with scattered patches in New York, the Carolinas and parts of the Midwest.



Description:

This is a multi-stemmed shrub that can grow up to nine feet tall under favorable conditions. The entire plant is covered in tiny, reddish hairs and sharp spines. The compound leaves are made up of three heart-shaped, toothed leaflets. The leaves alternate along the stem and are green on top, white on the underside. White, five-petaled flowers appear in the spring and later give way to red, raspberry-like fruits in June and July.



Photo: Tuscarora State Forest

Habitat:

This shrub prefers moist, open areas like fields, roadsides and forest edges.

Biology and Spread:

The berries of this shrub are eaten by a variety of wildlife and humans, thus contributing to its spread. It also reproduces vegetatively through root nodes. New plants can also form as the branches touch the ground and root.

Ecological Threat:

This plant can form extensive, dense thickets that displace native vegetation and restrict light to lower growing vegetation. Wineberry is also host to several viruses that can affect raspberries, like raspberry yellow spot.

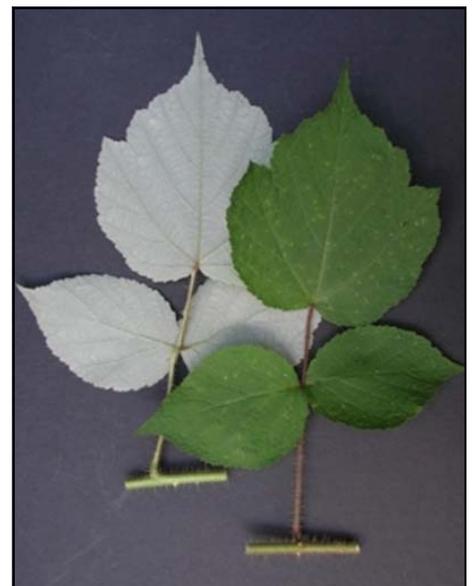


Photo: Leslie Mehrhoff, U. of Connecticut,
www.invasive.org

How to Control this Species:

Manual

Plants can be removed by hand pulling with thick gloves or by using a four-prong spading fork, especially when the soil is moist. All roots and branches must be removed to prevent re-sprouting.

Look-A-Likes:

There are two native *Rubus* shrubs that might be confused with wineberry. Neither has the abundant reddish hairs and thorns (see photo on right) that mark wineberry.

Common blackberry (*Rubus allegheniensis*)



Photo: Britt Slattery, USFWS

Flowering raspberry (*Rubus odoratus*)



Photo: Sten, <http://en.wikipedia.org>

Chemical

Use of a systemic herbicide like glyphosate or triclopyr is also effective at controlling this species. Herbicide can be sprayed on the leaves, or the plant can be cut near the base and the herbicide painted on the exposed stump.



Photo: Leslie Mehrhoff, U. Of Connecticut,
www.invasive.org

Native Alternatives:

In addition to the look-a-alike *Rubus* species shown below, there are other native shrubs that provide good food for wildlife, including red chokeberry (*Aronia arbutifolia*), spicebush (*Lindera benzoin*), American beautyberry (*Callicarpa americana*) and common winterberry (*Ilex verticillata*), shown below).



Photo: Dow Gardens Archive,
www.forestryimages.org

References:

Center for Invasive Species and Ecosystem Health:

<http://www.invasive.org/browse/subinfo.cfm?sub=3072>

Invasive Exotic Plant Pest Tutorial: <http://www.dcnr.state.pa.us/forestry/invasivetutorial/wineberry.htm>

Plant Invaders of Mid-Atlantic Natural Areas: <http://www.nps.gov/plants/alien/pubs/midatlantic/midatlantic.pdf>

For More Information:

To learn more about invasive species in Pennsylvania, visit:

DCNR Invasive Species Site: <http://www.dcnr.state.pa.us/conservation/science/invasivespecies/index.htm>

Invasive Plants in Pennsylvania

Oriental Bittersweet

Celastrus orbiculatus Thunb.



Photo: Jessica Sprajcar, DCNR

Background:

Also known as round-leaved and Asiatic bittersweet, this vine was introduced from China into the U.S. around 1860 as an ornamental.

Range:

Oriental bittersweet can be found throughout New England and the Mid-Atlantic states, down to Louisiana and up through the Midwest as far north as Wisconsin. It is not known to occur further west than that.

Description:

Oriental bittersweet is a deciduous, climbing, woody vine that can grow up to 60 feet in length. Vines can grow up to four inches in diameter. The alternate, elliptical leaves are light green in color, finely toothed and two to five inches in length. Fruits are round and yellow, splitting to reveal bright red berries through the fall and winter months.



Photo: Leslie Mehrhoff, U. of Connecticut,
www.invasive.org

Habitat:

Commonly found on old home sites, in fields and forest edges, and along roadsides and train tracks. While it prefers open, sunny sites it can tolerate shade.

Biology and Spread:

Birds and other wildlife readily consume the large number of berries, spreading seeds far and wide. Humans also spread the seed through the use of bittersweet vines and berries for craft projects. The plant also spreads vegetatively through rhizomes and root suckers.

Ecological Threat:

This vine is able to girdle and kill trees or break their branches off from the weight of the vines. When it grows into the canopy it can shade out natives. Oriental bittersweet has also been shown to hybridize with the American bittersweet, leading to a loss of genetic identity.

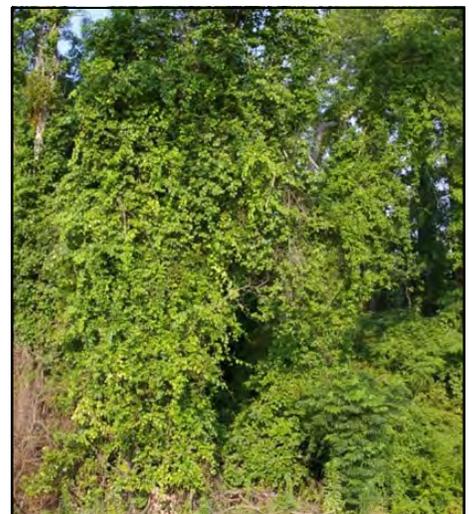


Photo: Nancy Loewenstein, Auburn U.,
www.invasive.org

How to Control this Species:

Manual and Mechanical

Because the seeds of bittersweet are so numerous and can remain viable in the soil for several years, all control efforts will require multiple years to be effective.

Small populations, especially of vines not high up in canopy, can be pulled by hand or dug out prior to fruiting. If fruits are present, all material should be bagged and disposed of.

Vines in trees can be cut close to the ground. The vines will re-sprout, however, unless herbicide is immediately applied to the cut stump.

Weekly mowing will prevent the vines from fruiting, but less frequent mowing will promote root sprouts.

Chemical

Because Oriental bittersweet looks so much like the native American bittersweet, be absolutely sure you have properly identified the species before doing any control work.

Systemic herbicides like glyphosate and triclopyr can successfully manage bittersweet. It is most effective when stems are cut or mowed and the herbicide is applied to the cut area immediately.

For cut stump applications, a 50% solution of glyphosate and water can be applied as long as the air temperature is above 40 degrees F. A 25 percent solution of triclopyr and water can be applied when the air temperature is above 60 degrees F.

For foliar application, a two percent solution of glyphosate or triclopyr and water, plus a 0.5 percent non-ionic surfactant, can be sprayed on the leaves when the air temperature is above 65 degrees F.

Look-A-Likes:

Oriental bittersweet closely resembles the native American bittersweet (*Celastrus scandens*), but American bittersweet has flowers and fruits at the ends of its branches, rather than in the axils of the leaves, like the Oriental variety.

References:

Center for Invasive Species and Ecosystem Health:

<http://www.invasive.org/browse/subinfo.cfm?sub=3012>

Invasive Exotic Plant Tutorial for Natural Lands Managers:

http://www.dcnr.state.pa.us/forestry/invasivetutorial/Oriental_bittersweet.htm

For More Information:

Plant Invaders of Mid-Atlantic Natural Areas, National Park Service:

<http://www.nps.gov/plants/alien/pubs/midatlantic/midatlantic.pdf>

Invasive Plants Field and Reference Guide, U.S. Forest Service:

http://na.fs.fed.us/pubs/misc/ip/ip_field_guide.pdf



Photo: Chris Evans, River to River CWMA,
www.forestryimages.org

Invasive Plants in Pennsylvania

Japanese Stilt Grass

Microstegium vimineum



James H. Miller, USDA Forest Service
www.forestryimages.org

Background:

Japanese stilt grass was first documented in Tennessee in 1919. Its introduction into the United States was accidental, likely a result of its use as a packing material for porcelain.

Range:

Native to Asia, this successful invasive has colonized most of the eastern United States, as far west as Texas.

Description:

Japanese stilt grass is an annual that typically grows one to three feet in height. Despite its branching, sprawling, mat-like manner, it resembles a small, delicate bamboo. Leaves are narrow and lance-shaped with a distinctive, pale, silvery stripe of reflective hairs on the upper surface. Flower spikes appear in September.



James H. Miller & Ted Bodner, SWSS
www.forestryimages.org

Habitat:

Japanese stilt grass occurs in a variety of habitats, including moist ground of open woods, floodplain forests, wetlands, uplands, fields, thickets, roadsides, and ditches. It readily invades areas subject to regular disturbance. Stilt grass appears to prefer moist, acidic to neutral soils that are high in nitrogen.

Biology and Spread:

Stilt grass reproduces exclusively by seed. One plant may produce 100 to 1,000 seeds that typically fall close to the parent plant. Seeds may be carried by water during heavy rains or move about in contaminated hay, soil or mud stuck in footwear. Stilt grass seeds remain viable in the soil for five or more years and germinate readily.

Ecological Threat:

When Japanese stilt grass invades a site, it can quickly crowd out native plant species. Invasions can also change soil nutrient cycling processes, inhibit tree survival and growth, and reduce light availability. After it dies back in late fall, it forms a thick layer of smothering thatch that is slow to decompose. Because stilt grass is relatively unpalatable, it may encourage heavier deer browsing on native plant species.



Chris Evans, River to River CWMA
www.forestryimages.org

How to Control this Species:

Physical

Japanese stilt grass is quite shallow-rooted and can be easily pulled by hand, especially when the soil is moist. Pulling is easiest in late summer when plants are mature. Stilt grass can also be mowed. Follow up monitoring and treatment will be necessary for years.

Hand pulling and mowing should be done in late summer when the plants are just about to flower. Performing these activities earlier in the summer months encourages flowering and early seed dispersal.

Chemical

For extensive infestations, a systemic herbicide can be used quite effectively. Using an herbicide leaves the plants and soil in place, minimizing the likelihood of additional germination of stilt grass seed.

Grass-specific herbicides, such as quizalofop, limit damage to native plants.

Be careful when treating stilt grass in wetland sites. Make sure you use an herbicide suitable for wetlands.



Chris Evans, River to River CWMA
www.forestryimages.org

Look-A-Likes:

The native perennial Virginia cutgrass (*Leersia virginica*) is quite similar. Japanese stilt grass may also be confused with some smartweeds (*Persicaria* sp.).



Leslie Mehrhoff, U. of Connecticut
www.discoverlife.org

References:

Plant Conservation Alliance's Alien Plant Working Group:
<http://www.nps.gov/plants/alien/fact/miv11.htm>

Purdue University Cooperative Extension Service: <http://www.btny.purdue.edu/weedscience/2011/Microstegium-01.pdf>

Wisconsin Department of Natural Resources:
<http://dnr.wi.gov/invasives/fact/japanstgrass.htm>

For More Information:

DCNR Invasive Species Site: <http://www.dcnr.state.pa.us/conservation/science/invasivespecies/index.htm>

DCNR Invasive Exotic Plant Tutorial for Natural Lands Managers:
http://www.dcnr.state.pa.us/forestry/invasivetutorial/Japanese_stiltgrass.htm

Invasive Plants in Pennsylvania

Reed Canary Grass

Phalaris arundinacea



Leslie J. Mehrhoff, U. Connecticut
www.forestryimages.org

Background:

Both Eurasian and native ecotypes of reed canary grass are thought to exist in the United States. Invasive populations may be descendants of non-native cultivars or ecotypes, although this is not clear. Aggressive strains have been planted throughout the United States since the 1800s for forage and erosion control.



John M. Randall, The Nature Conservancy
www.forestryimages.org

Description:

Reed canary grass is large and coarse, reaching up to nine feet in height. Its flat, blue-green leaves are roughly textured. In June and July, large flower plumes are produced, which are green with a purplish tinge, eventually becoming light tan in color. The stems do not remain standing though the winter.



John M. Randall,
The Nature Conservancy
www.forestryimages.org

Habitat:

Reed canary grass can be found growing in most types of wetlands, including marshes, alluvial meadows, stream and river banks, shores and ditches. This plant does best in fertile, moist, organic soils in full sun. It has been known to occasionally grow in dry soils in partial shade in upland habitats.

Range:

This wetland grass is native to temperate regions of Europe, Asia and North America. Non-native strains have become naturalized throughout much of the northern half of the United States, and are still being planted on steep slopes and created wetlands.

Biology and Spread:

Although it produces few viable seeds, which are wind, water, animal and machine-dispersed, reed canary grass manages to colonize new sites quite easily. Once established in a wetland, it spreads aggressively by way of rhizomes.

Ecological Threat:

Reed canary grass forms large, monotypic stands that harbor few other plant species and are little use to most native wildlife. It constricts waterways by promoting silt deposition, yet may also encourage erosion of soil beneath its dense mats in places where water flows rapidly. Overtime, it builds up a tremendous seed bank that will erupt when sites are treated for this invasive.

How to Control this Species:

Physical

Small patches may be effectively dug up or hand pulled. They may also be covered by black plastic for at least one growing season. Be watchful of rhizomes spreading beyond the edge of the plastic.

Mowing twice yearly (early to mid-June and early October) can help control dense stands.

Disrupting the roots every two to three weeks weakens established plants and depletes the seed bank.

Look-A-Likes:

Reed canary grass could be confused with many grasses, including the non-native orchard grass (*Dactylis glomerata*) and native bluejoint grass (*Calamagrostis canadensis*).



Bluejoint Grass

Dave Powell, USDA Forest Service
www.forestryimages.org

Chemical

In small populations, glyphosate can be applied directly to cut stems to avoid collateral damage to native plants nearby.

Herbicide is best applied in early spring when most native species are dormant.

Before applying herbicide, remove dead leaves from the previous year to maximize growing shoot exposure. Use a formulation of glyphosate designed for wetlands.

References:

Center for Invasive Species and Ecosystem Health:

<http://www.invasive.org/browse/subinfo.cfm?sub=6170>

Global Invasive Species Database:

<http://www.issg.org/database/species/ecology.asp?si=394>

Wisconsin Department of Natural Resources:

http://dnr.wi.gov/invasives/fact/reed_canary.htm

For More Information:

DCNR Invasive Species Site: <http://www.dcnr.state.pa.us/conservationscience/invasivespecies/index.htm>

DCNR Invasive Exotic Plant Tutorial for Natural Lands Managers:

http://www.dcnr.state.pa.us/forestry/invasivetutorial/reed_canary_grass.htm

Native Alternatives:

Many native grasses and monocots are available for wetland restoration.



Canada Wildrye

Dave Powell, USDA Forest Service
www.forestryimages.org



Soft Rush

James H. Miller & Ted Bodner, SWSS
www.forestryimages.org

Invasive Plants in Pennsylvania

Canada Thistle

Cirsium arvense



Steve Dewey, Utah State University
www.forestryimages.org

Description:

Canada thistle is an erect herbaceous perennial with an extensive creeping rootstock. Its leaves are irregularly lobed with spiny, toothed margins. Rose-purple or sometimes white flower heads appear in terminal clusters from June through October. The small seeds have feathery plumes.

Biology and Spread:

Canada thistle produces an abundance of feathery seeds, which are quickly dispersed in the wind. The seeds can remain viable in the soil for up to 20 years or more. The fibrous taproot is capable of sending out lateral roots, which sprout shoots at frequent intervals.

Background:

Canada thistle was probably introduced into the United States by accident in the early 1600s. By 1954, it had been declared a noxious weed in 43 states. It is considered one of the most tenacious and economically important agricultural weeds and is becoming increasingly recognized as a problem in natural areas.



Steve Dewey, Utah State University
www.forestryimages.org

Ecological Threat:

Once established in an area, Canada thistle crowds out and replaces native plants, changing the structure and species composition of plant communities and reducing diversity. This thistle outcompetes native plants through shading, competition for soil resources and possibly through the release of toxic allelochemicals.

Range:

Despite its name, Canada thistle is native to temperate regions of Eurasia. In North America, it is distributed throughout Canada and the northern United States, from northern California to Maine and south to Virginia.

Habitat:

This plant does best in open and disturbed upland areas, but also invades wet places with fluctuating water levels, such as stream bank meadows. It is commonly found in barrens, glades, meadows, prairies, fields, pastures and waste places.



Alec McClay, McClay Ecoscience
www.forestryimages.org

How to Control this Species:

Because Canada thistle is a perennial and spreads primarily by its root system, the entire plant must be destroyed for effective control.

Control efforts may be more successful when Canada thistle is under environmental stress, such as during droughts and floods, or after a very severe winter.

Canada thistle is stubborn and difficult to remove. Management practices that limit soil disturbance and encourage diverse native plant communities will help prevent establishment of this species.

Look-A-Likes:

Native species of thistle (*Cirsium* sp.), some of which are rare, could be confused with Canada thistle. Before control is attempted, the thistle species in question should be accurately identified.



Field Thistle

Chris Evans, River to River CWMA
www.forestryimages.org

Physical

For light infestations, black plastic sheeting can be used to smother this thistle. Repeated and frequent pulling or hand-cutting will eventually starve underground stems. This should be performed at least three times each season.

Mowing does not kill Canada thistle unless repeated monthly for up to four years. This method is not recommended for natural areas.

Late spring burns, between May and June, are detrimental to this invasive.

Chemical

In areas interspersed with desirable native plants, targeted application of a systemic herbicide, such as glyphosate, works well. For extensive infestations in disturbed areas, a broad application may be more effective. Repeated applications are usually necessary in order to exhaust the seed bank.

Herbicide treatment is best done in late summer or fall when plants are in the rosette stage.

Varying the type of herbicide used will prevent clone colonies from becoming resistant.

References:

Center for Invasive Species and Ecosystem Health:

<http://www.invasive.org/browse/subinfo.cfm?sub=2792>

Plant Conservation Alliance's Alien Plant Working Group:

<http://www.nps.gov/plants/alien/fact/ciar1.htm>

For More Information:

DCNR Invasive Species Site: <http://www.dcnr.state.pa.us/conservation/science/invasivespecies/index.htm>

DCNR Invasive Exotic Plant Tutorial for Natural Lands Managers:
http://www.dcnr.state.pa.us/forestry/invasivetutorial/canada_thistle.htm

Invasive Plants in Pennsylvania

Crown Vetch

Coronilla varia



Photo: Dan Tenaglia, Missouriplants.com,
www.forestryimages.org

Background:

Crown vetch was introduced throughout North America in the 1950s for erosion control, particularly along roadways. It is still being sold and used in many states that have not officially declared it to be invasive.

Range:

Crown vetch is native to Europe, Asia and Africa. Since its introduction to the U.S., it has spread throughout the country. It is currently reported as invasive in many states, especially through the center of the country and along the eastern seaboard.

Description:

Crown vetch is an herbaceous vine that usually forms sprawling mats or thickets up to three feet tall. The leaves are alternate and pinnately compound, with 15 to 25 pairs of leaflets. The pea-like flowers range in color from white to pink or purple, and bloom during the summer. It has a branched, fibrous root system.



Photo: Dan Tenaglia, Missouriplants.com,
www.forestryimages.org

Habitat:

Crown vetch prefers disturbed, open areas, especially with gravelly or sandy soils. This makes openings and disturbed areas such as fields, waste areas, roadsides and embankments perfect habitats for this species.

Biology and Spread:

Crown vetch spreads through both seeds and rhizomes. The rhizomes can extend up to 10 feet, and an individual plant can cover 70 to 100 square feet within four years.

Ecological Threat:

Crown vetch's main impact is the displacement of native plant species from their habitats. Although it can provide forage for some species, it prevents native flowers and shrubs from establishing in open areas. This, in turn, can be detrimental to native animals and insects which rely upon those native plants or the conditions they provide for food or shelter.



Photo: Chris Evans, River to River CWMA,
www.forestryimages.org

How to Control this Species:

Crown vetch can be controlled with a variety of methods, although some may prove more successful than others.

On younger or smaller populations, manual control can be effective. This can include pulling entire plants (making sure to include as much of the rhizomatous roots as possible). Mowing is another potential method of controlling crown vetch. The mowing should occur in late spring and then multiple times through the growing season, for several consecutive years.

Prescribed burning can also be effective when conducted in late spring and for several consecutive years.

Look-A-Likes:

Many plants in the pea family, like the native American vetch (*Vicia americana*) - shown below - can look similar to crown vetch, so be sure to positively identify this species prior to controlling it.



Photo: Dave Powell, USDA Forest Service, www.forestryimages.org

Few parasites or herbivores prefer crown vetch, although it is used in an agricultural setting for grazing or as a green manure. It is currently unlikely that any form of biocontrol will be introduced to combat this species, as it is used in many states agriculturally and as erosion control.

For areas where crown vetch has established large, dense populations, chemical controls can be used. Glyphosate, triclopyr and metsulfuron were shown in experiments to be effective at treating crown vetch. Herbicides can also be used after removing the aerial portion of the plant by mechanical means, which may improve results.

References:

Invasive Plant Atlas of the U.S.:

<http://www.invasiveplantatlas.org>

USDA Forest Service Northeastern Area: <http://www.na.fs.fed.us>

Invasive Exotic Plant Tutorial for Natural Lands Managers:

<http://www.dcnr.state.pa.us/forestry/invasivetutorial>

Virginia Department of Conservation and Recreation:

http://www.dcr.virginia.gov/natural_heritage

Lady Bird Johnson Wildflower Center:

<http://www.wildflower.org>

Weeds of the Northeast, 1997; R.H. Uva, J.C. Neal, and J.M. DiTomaso

Native Alternatives:

The best way to avoid crown vetch infestations is to avoid planting it in the first place. Native warm season grasses, such as big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*) and Indian grass (*Sorghastrum nutans*) can be used to control erosion. If a legume is desired, use partridge pea (*Cassia fasciculata*) or roundheaded bushclover (*Lespedeza capitata*).



Photo: Karan Rawlins, U. of Georgia, www.forestryimages.org

Invasive Plants in Pennsylvania

Moneywort

Lysimachia nummularia L.



Photo: Richard Old, www.invasive.org

Background:

This plant goes by many common names including creeping Jenny, creeping Charlie, creeping Joan, running Jenny, wandering Jenny and wandering sailor.

It was introduced from Europe and southwest Asia as an ornamental ground cover.

Range:

This plant can now be found through much of the U.S. particularly the east and west coasts and the Midwest (see map on right).

Description:

This herbaceous, low-growing perennial plant is part of the primrose family. It has ever-green to semi-evergreen leaves. The creeping stems can grow up to two feet long and form a mat-like growth. Leaves are opposite and oval in shape, resembling coins, hence its name. Small yellow flowers with small dark red spots bloom from June to August, but may not bloom at all.

Habitat:

This plant can grow in a variety of habitats but it grows best and poses the biggest threat in moist areas like wet meadows, swamps, stream banks and roadside ditches. It prefers rich, shaded soils.

Biology and Spread:

This plant spreads vegetatively by its creeping stems, as well as by small seeds that are located within capsular fruits. These fruits are likely dispersed by flood waters and stormwater runoff. How much this plant's seeds are spread by animals is not fully known, but it is likely.



Photo: Les Mehrhoff, IPANE



Map courtesy of USDA PLANTS Database

Ecological Threat:

Not much is known about its direct impacts to the environment but there is concern that dense mats of this plant may take over habitat for more desirable native plant species.

How to Control this Species:

Prevention

The easiest way to prevent the spread of this species is to stop planting it, manage existing infestations and minimize disturbance to forests, wetlands and other habitats. When prevention fails, there are two control options:

Manual

The plant can be hand pulled, but all stems and stem fragments should be removed to prevent the stems from re-rooting . Planting native grasses can help to shade out this plant. Mowing is not effective since moneywort grows so close to the ground.

Chemical

Several herbicides are effective in controlling moneywort. Because this plant usually grows in or near wetlands, make sure that the herbicide is approved for use in wetlands. Rodeo is one such herbicide that may be effective. Be sure to follow all label directions and state requirements when using any herbicide.

Reference:

USDA Forest Service: Weed of the Week factsheet for Moneywort:

http://www.na.fs.fed.us/fhp/invasive_plants/weeds/monewort.pdf

For More Information:

To learn more about invasive plants in Pennsylvania and the northeast, here are some useful resources:

DCNR Invasive Species Site:

<http://www.dcnr.state.pa.us/conservationscience/invasivespecies/index.htm>

Plant Invaders of Mid-Atlantic Natural Areas, National

Park Service: <http://www.nps.gov/plants/alien/pubs/midatlantic/midatlantic.pdf>

Invasive Plants Field and Reference Guide, U.S. Forest

Service: http://na.fs.fed.us/pubs/misc/ip/ip_field_guide.pdf



Photo: Richard Old, www.invasive.org

Invasive Plants in Pennsylvania

Purple Loosestrife

Lythrum salicaria



Richard Old, XID Services, Inc.
www.forestryimages.org

Background:

Purple loosestrife was intentionally introduced into North America in the early 1800s as an ornamental, as well as accidentally by way of discarded ship ballast. It is now banned as a noxious weed in most states.

Range:

Native to Eurasia, purple loosestrife can now be found throughout much of the United States, especially in the northern and western regions.



Description:

Purple loosestrife is a perennial herb with square, woody stems, which may grow anywhere from four to 10 feet high, depending on conditions. Its lance-shaped leaves occur in opposite or whorled arrangements. Magenta-colored flower spikes are present throughout much of the summer.



Eric Coombs, Oregon Dept. of Ag.
www.forestryimages.org

Habitat:

Purple loosestrife prefers open wetlands, and is capable of invading freshwater wet meadows, tidal and non-tidal marshes, river and stream banks, pond edges, reservoirs and ditches. It is a hardy plant that can tolerate a range of soil pH, as well as drought.

Biology and Spread:

With an extended flowering season, from June to September, and an unusually high number of flowering stems, each purple loosestrife plant is capable of producing two to three million seeds per year. Research has shown that cultivars, advertised as sterile, are capable of producing viable seed. This plant can also reproduce vegetatively by underground stems at a rate of one foot per year.

Ecological Threat:

An enthusiastic invader of wetlands, purple loosestrife outcompetes native plants, including some federally endangered orchids, forming dense homogeneous stands. These monocultures reduce habitat for waterfowl, clog waterways, disrupt nutrient cycling and collect debris, eventually displacing the entire wetland.



Agriculture and Agri-Food Canada
www.forestryimages.org

How to Control this Species:

Prevention

Early detection and prevention are the best approaches to managing purple loosestrife. Monitoring watersheds yearly to identify new infestations is critical, and can be most easily conducted in late July and August when the plant is in full bloom.

Clean seed and plant parts from animals, equipment and clothing before entering wetland areas.

Prevent nearby infestations from going to seed. Use native competitors as barriers.

Physical

Hand-pulling is only effective for seedlings with small roots.

Mowing is not recommended, but may reduce the production of seeds.

Flooding kills seedlings; established plants must be inundated for weeks. Unfortunately, this also kills desirable vegetation.

The site may need to be replanted with native, competitive vegetation.

Chemical

Glyphosate is effective against purple loosestrife. Be sure to use an herbicide permitted for wetland use. Herbicides can be applied directly to cut stems to reduce collateral damage.

Biocontrol

Although they will not eradicate purple loosestrife, biocontrols can reduce the severity of an infestation. Four species of beetles from Europe, which are fairly host-specific on purple loosestrife, are currently available for control efforts.

Look-A-Likes:

From a distance, purple loosestrife may resemble some native flowering plants, such as blazing star (*Liatris* sp.) and obedient plant (*Physostegia virginiana*). These also make great native garden alternatives.



Blazing Star

John D. Byrd, Mississippi State University
www.forestryimages.org

References:

Center for Invasive Species and Ecosystem Health:

<http://www.invasive.org/browse/subinfo.cfm?sub=3047>

Plant Conservation Alliance's Alien Plant Working Group:

<http://www.nps.gov/plants/alien/fact/lysa1.htm>

University of Nevada Cooperative Extension:

<http://www.unce.unr.edu/publications/files/nr/2002/>

For More Information:

DCNR Invasive Species Site: <http://www.dcnr.state.pa.us/conservationscience/invasivespecies/index.htm>

DCNR Invasive Exotic Plant Tutorial for Natural Lands Managers:

http://www.dcnr.state.pa.us/forestry/invasivetutorial/Purple_loosestrife.htm