

VERNAL POOL CONSERVATION AND MANAGEMENT

A landowner's guide to vernal pool stewardship

The Pennsylvania Natural Heritage Program is a partnership of:



Western Pennsylvania Conservancy
Pennsylvania Department of Conservation and Natural Resources
Pennsylvania Fish and Boat Commission
Pennsylvania Game Commission

TABLE OF CONTENTS

BEST MANAGEMENT PRACTICES BY VERNAL POOL ZONES.....	3
Introduction	3
Vernal Pool Depression.....	3
Vernal Pool Core Habitat	4
Vernal Pool Supporting Upland.....	6
SPECIAL CONSIDERATIONS.....	11
Vernal Pool Complexes	11
Species of Conservation Concern.....	11
Species Migration Distances	12
Landscape Corridors	12
Wetland Mitigation	12
Wetland Creation and Restoration.....	13
Vernal Pool Monitoring	14
Getting to Know your Vernal Pool	14
Prevent Spread of Disease	15
Mosquito Control and West Nile Virus.....	17
Herbicides and Amphibians	19
References	20

BEST MANAGEMENT PRACTICES BY VERNAL POOL ZONES

Introduction

Best Management Practices can be adopted by landowners, natural resource agencies, and forestry industries to optimally manage their natural resources. Best management practices for vernal pools address the pool itself and the surrounding habitat.

The first step to managing vernal pools at a site is to develop a management plan. If possible work with a biologist to locate vernal pools and inventory the plants and animals present. This will help determine the measures that will benefit the vernal pool and specific conservation targets such as rare species. Develop a simple monitoring program to evaluate the health of the pool and it's wildlife over time.

Listed below are questions to consider when developing a vernal pool management plan:

- What activities take place currently or potentially in the management plan area?
- Where are vernal pools located in relation to the activities?
- What are the potential impacts on vernal pools?
- What are the physical characteristics of the pools?
- What plant and animal species are present in the pools?

Maintenance of vernal pool communities is largely dependent upon protecting the pools and the surrounding uplands from disturbances that would degrade water quality, change how water flows and gathers on the surface, or physically harm animals as they move between pool and upland habitats. The following recommendations have been designed to protect vernal pool habitats and the plants and animals that use them.

Vernal Pool Depression

The vernal pool depression is a shallow basin that floods in the fall or spring. The vernal pool typically reaches its greatest area and depth in the spring when reptiles, amphibians, invertebrates, and other wildlife arrive to breed and feed. The vernal pool depression is protected by state and federal regulations. This is where vernal pool animals breed and lay their eggs. Their young hatch, feed, and develop within the vernal pool 'nursery'.

Management Considerations – Vernal Pool Depression

The vernal pool basin is very sensitive to any sort of disturbance. Avoid any activities that disturb the pool water, soil, or vegetation. Such activities in the pool basin have the potential to damage adults, eggs, or larvae resting in the leaves on the pool bottom, as well as change and degrade the environment the animals require.

Best Management Practices – Vernal Pool Depression

- 1) **Identify the pool basin and designate it as a no disturbance zone.** Find and document each vernal pool and mark its perimeter. This is best accomplished during high waters in the spring (March-April). Pools can be mapped other times of the year, but this can be challenging even for experienced vernal pool researchers. A vernal pool can be recognized during the dry season by one or more of the following features:
 - dark stained leaves
 - tree trunks that are widened and buttressed at the base or that have high-water stains
 - soils that show evidence of being inundated for part of the year (for example a dark black organic layer laying over soils grey in color, mottled with red patches of iron, etc.)
 - a dry depression with leaves but without any other vegetation that is characteristic of the surrounding upland
 - a dry depression with wetland plants growing in it, often with mosses in the basin and around the perimeter
- 2) **Protect the vernal pool basin floor.** Prevent soil compaction or disturbance in the pool basin. Year round, regardless if the pool is wet or dry, keep out motorized vehicles, heavy equipment (but see #4 below), all-terrain vehicles, dirt bikes, mountain bikes, snowmobiles, and horseback riders.
- 3) **Retain sources of food and shelter.** Leave trees and branches that fall naturally into pools because they provide valuable fodder for the food web and habitat for vernal pool animals. Avoid disturbing naturally fallen logs. Moving them can injure animals resting underneath.
- 4) **Maintain good water quality.** Avoid all use of pesticides, herbicides, or other chemicals such as road salts in or near the pool basin. If invasive species control is needed, hand cutting and mowing (when the pool basin is dry) are the preferred methods. The risk of using mechanical mowers to remove invasive plants should be weighed against the risk of habitat loss/degradation caused by a serious invasion. If herbicides are necessary, the U.S. Environmental Protection agency has approved Glyphosate for use in wetlands. Seek formulations without surfactants, which are highly toxic to pond-breeding amphibians (see the ‘Wetland-approved Herbicides’ section under Special Considerations section for more information). The vernal pool dry phase is the ideal time for herbicide application.
- 5) **Retain native vegetation in the pool basin.** Vernal pools may naturally be vegetated with marshy vegetation, shrubs, and even trees. Other pools may be completely unvegetated (black leaf pools).

Vernal Pool Core Habitat

The vernal pool core habitat, also known as the envelope or protection zone, encompasses the uplands immediately surrounding the pool. This area heavily influences conditions in the pool and regulates water quality. Adult amphibians concentrate in the vernal pool envelope as they move to and from a pool during the breeding season. The core also supports high densities of recently metamorphosed amphibians which leave the pool in the summer and fall. Young adult

frogs and salamanders are especially vulnerable to drying out the first months after metamorphosis. They need close access to shaded, forested conditions as they leave the pool.

The core is a minimum 100 foot zone of upland surrounding a pool, measured from the edge of a pool when it is fully inundated. The core should be increased to a minimum 200 foot zone for good quality pools in natural forested settings, vernal pool complexes, and/or sites with rare species. See Figures 1 and 2 for more information on how to determine the core habitat.

Management Considerations – Vernal Pool Core Habitat

Maintaining or encouraging native trees, shrubs, and ground cover within the vernal pool envelope helps keep a pool healthy by trapping sediments and increasing the ability of the system to purify water. Buffers reduce the inflow of chemicals used for pest and weed control of lawns. Buffers will help maintain good water quality in the pool so that a diverse and balanced animal community of predators and prey are present. Increasing naturally vegetated buffers around pools will also provide more suitable habitat for the adult, terrestrial life stage of predators including salamanders, frogs, and insects. Large pieces of woody debris and standing snags should be retained in this area because they provide food and shelter for amphibians outside of the breeding season and create suitable places where they can overwinter.

Most vernal pools in Pennsylvania occur in a forested setting. Tree harvesting should not take place within the vernal pool envelope because the trees provide essential resources to a vernal pool and its wildlife. Removing trees changes how much light reaches the pool and can change many conditions within the pool that impact vernal pool plants and animals. Use of heavy equipment close to a pool can create ruts in the soil that interfere with the ability of vernal pool amphibians to reach their breeding sites, and can harm amphibians overwintering close to the surface under leaves and fallen wood.

However, limited tree felling by hand within the vernal pool envelope may be beneficial to vernal pool wildlife in certain situations. Some vernal pools occur in places where there are gaps in the tree canopy, such as small forest clearings, shrub lands, old fields, and the like. These pools will favor plants and animals that require more light. Human intervention may be necessary to keep these habitats open. Small openings around or near vernal pools can be maintained by periodically removing a few trees and/or infrequent mowing (e.g., every 2-3 years). Vernal pool complexes may be ideal for managing pools in a variety of settings from partially open to heavily forested to encourage wildlife that have differing habitat requirements.

Best Management Practices – Vernal Pool Core Habitat

- 1) **Establish a minimum ‘no disturbance zone’ area of 100 feet (60 meters) as the core.** Measure the no disturbance zone from the edge of the vernal pool when the water levels are highest in the spring. Increase this distance to a minimum of 200 feet for good quality vernal pools, vernal pool complexes and/or sites with rare species. Allow overlapping core habitats around multiple pools in a complex to blend to create one zone that encompasses all the pools. Create a corridor twice the width of the core distance (e.g., 200 or 400 feet) to capture slightly more distant pools that are greater than the core distance but less than 1000 feet from

another pool. Flag the core protection zone prior to any logging or other management activities.

- 2) **Protect the forest floor in the vernal pool core.** Prevent soil compaction or disturbance in the vernal pool envelope by keeping out motorized vehicles, heavy equipment, all-terrain vehicles, dirt bikes, and snowmobiles. Exceptions may be made for management activities intended to improve the vernal pool habitat such as invasive species control and wetland restoration. In these instances, conduct activities when soils are completely dry or frozen.
- 3) **Retain sources of food and shelter.** Vernal pool animals find food and shelter on the forest floor. Do not cut down dead standing trees in the core, or remove trees and branches that fall naturally onto the forest floor or in the pool basin. These provide valuable fodder for the food web and habitat for vernal pool animals in their terrestrial upland habitat where they spend most of the year. Avoid disturbing naturally fallen logs. Moving them can injure animals resting underneath.
- 4) **Maintain good water quality.** Avoid use of pesticides, herbicides, or other chemicals in the vernal pool core. If vegetation control is necessary, hand cutting and mowing are the preferred methods (when the soils are dry). Herbicides may be necessary in some instances to kill invasive species. The U.S. Environmental Protection Agency has approved Glyphosate for use in wetlands. Seek formulations without surfactants, which are highly toxic to pond-breeding amphibians. See the ‘Wetland-Approved Herbicides’ section under Special Considerations for more information. Late summer and fall is the ideal time for herbicide application when amphibians are less active at the surface.
- 5) **Retain native trees and understory vegetation.** Encourage native trees and understory vegetation in structural layers. Native vegetation in and around the perimeter of vernal pools should not be mowed, cut, or otherwise cleared.
 - Avoid planting or permitting the spread of exotic or invasive plant species in the vernal pool basin or buffer zones. Mechanical treatments should be used to control invasive plant species.
 - Some vernal pools occur in naturally open habitats or, more commonly, at managed sites where trees were harvested or low vegetation is maintained intentionally. Some rare, threatened, or endangered plants (e.g., *Scirpus ancistrochaetus*) and animals (foraging bats) may prefer vernal pools with more open tree canopies. Selective removal of a few trees around the pool perimeter may be specified by a wildlife professional to maintain or increase a local population of a listed species.

Vernal Pool Supporting Upland

Outside of the breeding season, vernal pool animals live in the forests adjacent to vernal pools seeking food, shelter, and overwintering sites. The supporting upland is the area that encompasses over 95% of populations of pool-breeding salamanders (Brown and Jung 2005) in the uplands where they spend most of the year. The terrestrial habitat zone is important as a corridor between pools allowing animals to safely move between pools and their upland habitats. The terrestrial habitat also plays a role in regulating water quality.

The supporting upland habitat, also known as the terrestrial habitat or life zone, is defined as a minimum 300 foot zone of upland surrounding a pool. This distance is measured from the edge of the 100 foot vernal pool envelope, which places the outer edge of this zone a total of 400 feet away from the pool edge. The supporting habitat should be increased to an 800 foot zone for good quality vernal pools in natural forested settings, vernal pool complexes, and/or sites with rare species. This distance is measured from the edge of a 200 foot envelope, which places the outer edge of this zone a total of 1000 feet away from the pool edge. See Figures 1 and 2 for more information on how to determine the supporting upland habitat.

Management Considerations – Supporting Upland

The main goal is to maintain or create a forested environment that can provide shade, deep leaf litter, and abundant downed trees and other woody debris all around the pool. This will provide cover and food for vernal pool amphibians in their upland habitat. It is important to protect the forest floor from damage from motorized vehicles. Deep ruts that fill with water in the spring may intercept amphibians as they are returning to their breeding pools and cause them to lay their eggs in a site where their young won't be able to survive.

Best Management Practices – Supporting Upland

- 1) **Identify the vernal pool supporting terrestrial habitat and designate it as a limited disturbance zone.** Flag this zone prior to any logging or other management activities and limit disturbance to this zone using the recommendations that follow. Moderate protection can be accomplished with a 400 foot terrestrial buffer. Good quality vernal pools, pool complexes, and sites with species of conservation concern should have a larger 1000 foot limited disturbance zone. Measure this distance from the edge of the vernal pool during the highest water levels in spring.
- 2) **Protect the upland forest floor.** Minimize soil compaction or disturbance in the supporting upland. Prevent access by motorized vehicles, heavy equipment, all-terrain vehicles, dirt bikes, and snowmobiles. Exceptions may be made for management activities intended to improve the vernal pool habitat such as invasive species control or wetland restoration. In these instances, conduct activities when soils are completely dry or frozen.
- 3) **Retain sources of food and shelter.** Vernal pool animals need abundant coarse-woody debris on the forest floor. Aim to have 1-2 larger and older trees per acre, as they are best source of big downed limbs and trunks (Calhoun and deMaynadier, 2009).
- 4) **Maintain good water quality.** Avoid use of pesticides, herbicides, or other chemicals in the terrestrial habitat. If chemicals are needed (e.g., to control invasive species), apply them in late summer or fall when amphibians are less active at the surface. Avoid chemical use in the spring. See the 'Wetland-Approved Herbicides' section under Special Considerations for more information.

- 5) **Retain native trees and understory vegetation.** Natural vegetation in forests should form structural layers. The highest levels are the tree canopy and subcanopy, the middle layers are composed of tall and short shrubs, and the lowest layer is ground cover of herbaceous vegetation. The understory vegetation should not be cleared by mowing or other measures.
- 6) **Practice forestry best management practices** (adapted from Calhoun and deMaynadier (eds.) 2008).
- Maintain or create a partially closed forest canopy with 50-75% tree canopy cover throughout the zone. In understocked stands, wait to harvest trees until the overstory canopy cover has exceeded 50%. Avoid creating any canopy openings that are greater than $\frac{3}{4}$ of an acre in size.
 - For even-aged stand management, employ a shelterwood system which removes the overstory through two or three harvests. This method retains a partial but continuous overstory for a period of time while regeneration in the understory begins under partial shade. Forest floor conditions are therefore not altered as dramatically as in a single clear cut.
 - Naturally occurring forest types for the site should be maintained. The composition and nutritional content of leaf litter is different in hardwood versus softwood forests. Diverse stands of native trees create better habitat for most wildlife than plantations of a single species.
 - Minimize compaction and damage to the soil by heavy machinery. Harvest trees when soils are completely frozen or completely dry to avoid creating ruts (the months of November through January are best because amphibians are not active at the surface). Use a variety of best management practices such as controlled yarding that uses preplanned routes and limited passes, minimize sharp turns, and place slash in high impact areas to help protect the soil.
 - If ruts are formed by skidding or haul road maintenance and repair, those greater than 6 inches in depth should be repaired to original contour.
 - Use existing logging infrastructure where possible. Placement of new roads and log landings can be designed in advance to create the smallest footprint, and to stay outside of the terrestrial habitat zone or towards the outer edge whenever possible.
 - Implement erosion and siltation best management practices on skid or haul roads or landings (see DEP 2007 and Chunko 2001). Silt fences act as a barrier to salamander migration, so avoid using them in this area and remove them as soon as possible.
 - During timber operations do not disturb logs that fell naturally prior to the harvest. Tree limbs and tops can be left where they are felled. In whole tree removal, the slash should be returned to the terrestrial habitat zone. However avoid very large or continuous slash piles that could potentially block migration of pond-breeding amphibians and limit access to the vernal pond by other wildlife.
 - Retire the road network properly at the completion of operations. Close roads to prevent access by off road vehicles to the pool basins or their terrestrial buffer zones.
- 7) **Protect migrating amphibians.** The rains of early spring prompt vernal pools amphibians to leave their overwintering habitats and move to breeding pools. Amphibian movement typically begins during spring rains when overnight temperatures stay above 42 F. Early species like the Jefferson salamander (*Ambystoma jeffersonianum*) and the wood frog (*Lithobates sylvaticus*) can start moving as early as February. Close traffic on roads that pass near vernal pools during the peak migration months of February and March if possible, or enlist volunteers to help move animals across the road on rainy nights.

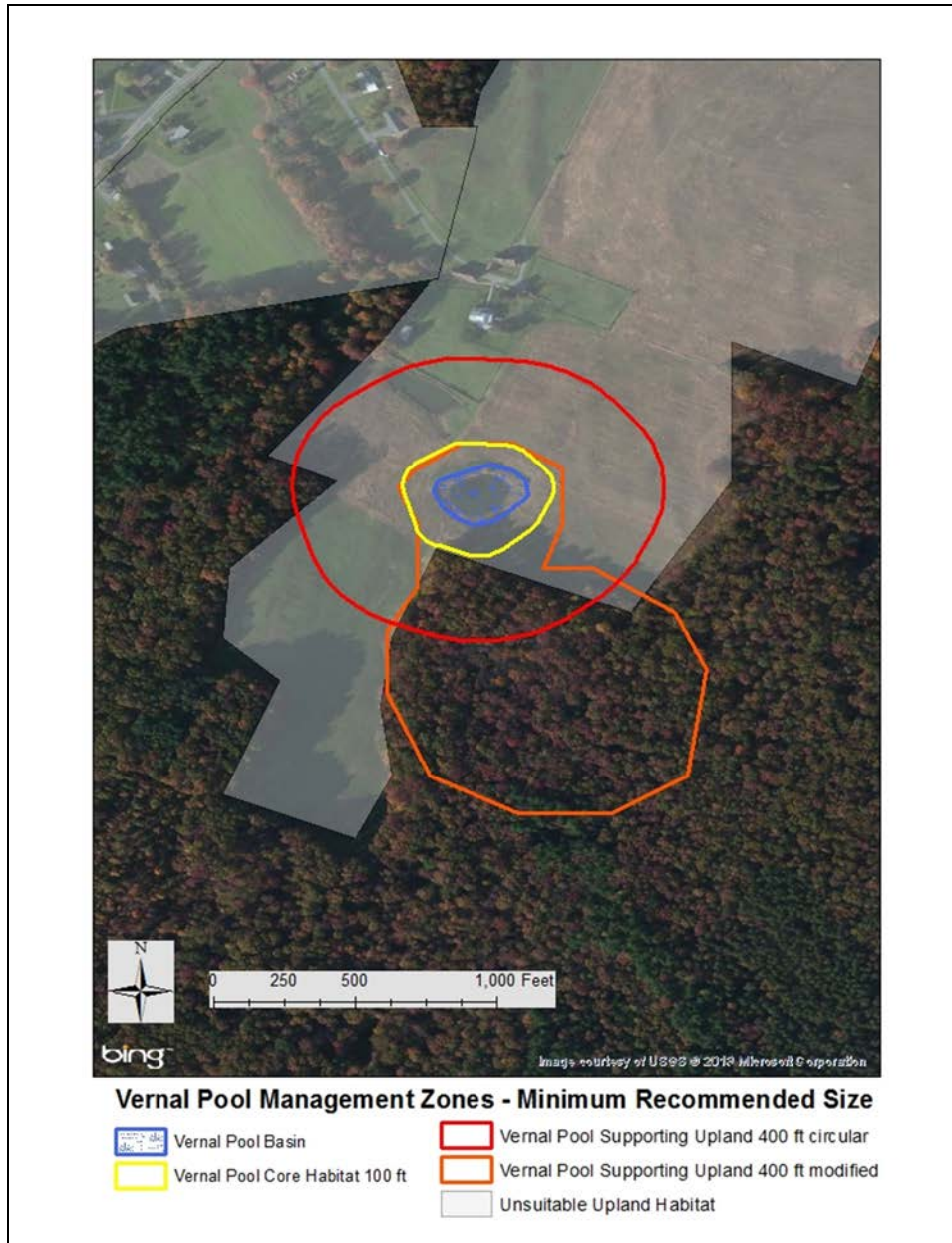


Figure 1. The core habitat for a single pool of average or lower quality is a minimum 100 foot zone of upland around the pool, drawn from the edge of the pool when it is fully inundated. The supporting upland habitat is defined as a minimum 300 foot zone of upland surrounding the core. Measured from the edge of the 100 foot vernal pool core, the outer edge of this zone is a total of 400 feet away from the pool edge. The supporting upland should initially be drawn as a circular feature around the vernal pool(s) as shown in red above. If unsuitable habitat such as agriculture or development falls within the supporting upland, the zone should be adjusted to capture more suitable habitat if possible. The modified supporting upland is shown in orange. When adjusting the shape of the zone, try to maintain the same total area of upland as was captured in the original circular feature.

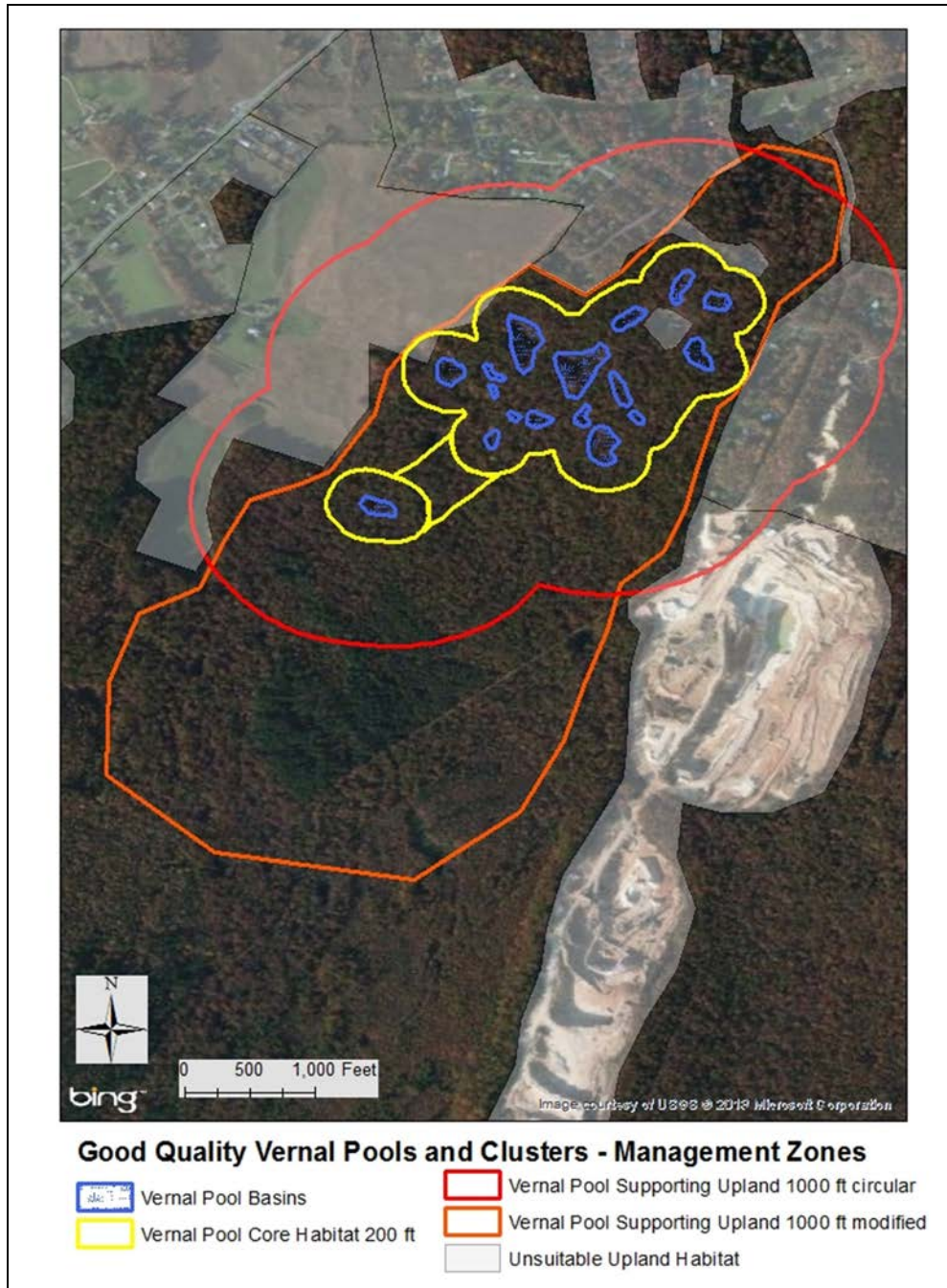


Figure 2. The **core habitat** for good to high quality vernal pools and complexes is a minimum 200 foot zone, drawn from the edge of the pool when it is fully inundated. Allow overlapping core habitats to blend to create one zone that encompasses all the pools. Create a corridor twice the width of the core distance (e.g., 400 ft in this example) to incorporate slightly more distant pools that are greater than 200 feet but than 1000 feet from another pool. The **supporting upland** is an 800 foot zone measured from the edge of the 200 foot core. The outer edge of this zone is a total of 1000 feet away from the pool edge. Initially draw the supporting upland as a roughly circular feature around the vernal pool(s) as shown in red. If unsuitable habitat such as agriculture or development falls within the supporting upland, modify the zone to capture more suitable habitat if possible (as shown in orange). When adjusting the shape of the zone, maintain the same approximate area of upland as was captured in the original circular feature.

SPECIAL CONSIDERATIONS

Vernal Pool Complexes

Vernal pool complexes deserve special consideration when applying buffers. Pool complexes support large populations of pond-breeding amphibians. They have greater overall stability and serve as source populations for satellite vernal pool wetlands. These areas can serve as critical foraging sites for game such as deer and turkey and feed local bat populations in the summer.

If one or more pools within a complex are known to support vernal pool obligate species, then all the pools in the vicinity (within 500 feet) should be assumed to support them as well unless surveys determine otherwise. Most vernal pools that seasonally flood for several months or more will be able to support one or more vernal pool obligates, though the use of some pools may vary by species and seasonal rainfall. Even very ephemeral pools can function as 'stepping stones' between more stable vernal pool breeding habitats and upland habitats.

Within a vernal pool complex, individual pools should not be treated as isolated 'islands' but rather as an integral part of the entire complex. Pools less than 500 feet apart are well within the migration distance of most vernal pool reptiles and amphibians (Table 1), and genetic exchange is expected to occur. Management zones that overlap around multiple pools should be merged to create a single zone that contains all the individual pools (see Figure 2). Corridors and management zones will help protect the integrity of vernal pool complexes during logging or other management activities

Species of Conservation Concern

One method of prioritizing seasonal pools for conservation is based on presence of species of conservation concern based on rarity or evidence of decline. Priority species in Pennsylvania's Wildlife Action Plan (PCWCS 2005) are placed in one of five levels or tiers. Vernal pool indicator or facultative species under each category are listed. Reserve boundaries should be set to encompass the maximum migratory distances of target species.

Conservation Tier 1: Immediate Concern – those species most at risk across their range. Species: wood turtle (*Glyptemys insculpta*), spotted turtle (*Clemmys guttata*), mountain chorus frog (*Pseudacris brachyphona*)

Conservation Tier 2: High-level Concern – nationally or regionally significant species that are vulnerable in Pennsylvania. Species: eastern spadefoot (*Scaphiopus holbrookii*), New Jersey chorus frog (*Pseudacris triseriata kalmi*), northern cricket frog (*Acris crepitans*)

Conservation Tier 3: Responsibility Species – core populations or a significant proportion of the regional population occurs in Pennsylvania. Species: Jefferson salamander (*Ambystoma jeffersonianum*), mountain chorus frog (*Pseudacris brachyphona*), spotted turtle (*Clemmys guttata*), wood turtle (*Glyptemys insculpta*)

Conservation Tier 4: Pennsylvania Vulnerable – species most at risk or experiencing dramatic declines in Pennsylvania but not at risk elsewhere. Species: southern leopard frog (*Lithobates sphenoccephalus utricularius*), western chorus frog (*Pseudacris triseriata triseriata*), upland chorus frog (*Pseudacris triseriata feriarum*)

Conservation Tier 5: Maintenance Concern – species that are fairly secure in Pennsylvania but warrant some level of management attention. Species: eastern box turtle (*Terrapene carolina*), northern leopard frog (*Lithobates pipiens*), four-toed salamander (*Hemidactylium scutatum*), marbled salamander (*Ambystoma opacum*), Fowler’s toad (*Anaxyrus fowleri*)

The federally listed northeastern bulrush (*Scirpus ancistrochaetus*) is also closely associated with vernal pools in Pennsylvania.

Species Migration Distances

The Environmental Protection Agency recommends managing a 1000 ft radius area beyond the edge of a vernal pool basin as forested upland habitat. This distance will protect 95% of a vernal pool’s amphibians in the uplands where they spend most of the year (Brown & Jung 2005). The 1000 ft distance is based on scientific studies of animal movement. See Table 1 for information on amphibian movement between upland and breeding pool habitats.

Table 1.

Common Name	Scientific Name	Average Movement	Maximum Movement
Wood frog	<i>Lithobates sylvaticus</i>	1,200-1,600 ft (366-488 m)	
Spotted salamander	<i>Ambystoma maculatum</i>	500 ft (153 m)	2700 ft (824 m)
Jefferson salamander	<i>Ambystoma jeffersonianum</i>	820 ft (250 m)	2050 feet (625 m)
Marbled salamander	<i>Ambystoma opacum</i>	635 ft (194 m)	1475 ft (450 m)
Spotted turtle	<i>Clemmys guttata</i>	870 ft (265 m)	

Table 1 sources: Brown and Jung 2005, Calhoun and deMaynadier (eds.) 2008, Colburn 2004, Milam and Melvin 2001, Semlitsch and Bodie 2003

Landscape Corridors

Corridors are important for long term conservation of seasonal pool species. Corridors were discussed previously on a local scale to ensure vernal pools in complexes were protected together as a unit. Corridors can also be drawn on a broader scale, where swaths of forest, wetlands, or streamside riparian habitat connect multiple vernal pool sites over a larger area. Forested corridors protect and sustain animals as they travel and enable them to find and colonize new habitats over time.

Wetland Mitigation

The primary strategy for vernal pool conservation should be to direct development away from vernal pools and the adjacent supporting uplands. In Pennsylvania where healthy, natural vernal

pools are still abundant in forested and undeveloped landscapes, protection and preservation should be a top priority. The National Research Council (2001) identified vernal pools as the most difficult wetland to create. Poorly constructed vernal pools can function as biological sinks that attract breeding amphibians but do not support successful recruitment of their young.

However, when wetlands are lost to filling or other alterations in Pennsylvania, state law requires that they are mitigated to ensure “no-net-loss” of wetland resources (see the Federal and State Regulations section for details). Wetland mitigation is a regulatory requirement to replace or enhance wetland areas destroyed or damaged during development activities.

When considering vernal pool creation as part of a wetland mitigation project, consider the following (adapted from Calhoun and deMaynadier (eds., 2008)):

- If wetland loss mitigated by wetland creation is the only option for a site, consider adding a preservation or restoration component of existing vernal pools at another site for a stronger overall mitigation outcome.
- Gather baseline data on pools before they are destroyed in order to know what has been lost and should be replaced.
- Develop a list of desired plant and animal species for the created pool. Use baseline data from the pools that were lost, or, if mitigation is taking place off site, inventory natural pools nearest where the pools will be created. These can be used as paired controls to evaluate the quality of constructed wetlands.
- Extend the monitoring of created pools beyond the 3-5 year period typically required by regulatory agencies. Develop measures of success by which to evaluate the created wetland over a period of years. Identify what steps should be taken if the created pool does not meet the project goals and how any additional work will be funded.
- Vernal pools created for mitigation should be managed as natural vernal pools with Best Management Practices.

Wetland Creation and Restoration

Voluntary restoration of damaged or destroyed vernal pools or creation of new ones can yield benefits to the landowner and the surrounding community. In the right situations, restoring and creating new vernal pools can help turn the tide against the overwhelming loss of wetlands that has occurred over the past decades.

The decision to build or restore a wetland should only be made after consulting with someone who can provide an expert review of the property. Alteration of any existing wetland requires a permit from the Department of Environmental Protection. Great care must be taken not to alter natural healthy wetland habitats. Small quick-drying vernal pools and natural spring/seepage wetlands are unique habitats that are not necessarily in need of enlargement or deepening, even if they can't support certain vernal pool species. Deepening a wetland may increase its water holding capacity to a point where species common in permanent ponds will be favored and vernal pool species will be discouraged.

Techniques for restoring healthy vernal pools exist. Two excellent publications have been written by Thomas Biebighauser, including a small booklet on how to create vernal pools

(Biebighauser 2003), and a book that delves into the history of wetland drainage and techniques for restoration and repair (Biebighauser 2007).

There are several federal and state agencies with staff expertise in wetland creation and restoration projects. They can provide technical assistance and information on funding sources.

- Pennsylvania County Conservation Districts
- Pennsylvania Department of Environmental Protection (DEP) Watershed Management
- USDA Natural Resource Conservation Service (NRCS)
- US Army Corps of Engineers

Vernal Pool Monitoring

Adopting a vernal pool monitoring program will provide feedback on the status of the wetlands and their species. Continued use of the vernal pool habitats by vernal pool obligates and species of conservation concern will provide a means of assessing management success.

A basic monitoring program for vernal pools begins with an initial set of measures of vernal pool indicator species and environmental conditions in the pool. Repeat the baseline survey every 1, 3, or 5 years as resources permit.

Baseline data during one spring visit can include the following:

- A map of the vernal pool(s) using a GPS unit or topographic map.
- Photographs of each pool at the study site. Try to take at least one set of the photos around the same time each year and from the same direction so photos are comparable across years.
- Measure the pool depth when it reaches its maximum size in the spring. A PVC pipe with depth markers can be driven into the deepest part of each pool basin during the dry phase to assist with water depth measurements in the spring.
- Count the egg masses present in the pool. Distinguish between wood frog and mole salamander egg masses if you are able (see the Pennsylvania Vernal Pool website for tips).

If time and resources allow additional visits, the following information can be added:

- Record the approximate date the pool first floods in the fall or spring, and when it first dries (or comes closest to drying) in the fall. Record the water depth every two weeks during the inundated season.
- Keep a log of the dates of the first rainy nights in spring when nighttime temperatures stay above 42°F. Record the start dates of amphibian calling. Note which species are calling if known. Visit the North American Amphibian Monitoring Program for information on frog call count protocols and to learn the frog calls you might hear in your area (<http://www.pwrc.usgs.gov/naamp/>)
- Photograph the pool during each season (spring, summer, fall, and winter). This can provide a lot of information on the qualities of a vernal pool.

Getting to Know your Vernal Pool

While visiting your vernal pool and learning about the amazing creatures that live there, there are some basic practices to remember to promote safe wading and handling of vernal pool critters.

- Wear rubber knee-high boots or hip waders with solid (versus felt) soles because they are easy to clean. Make sure they are scrubbed clean and totally dry prior to visiting the site.
- All equipment including fish and dip nets should be scrubbed clean and totally dry prior to visiting the site.
- Hands should be washed to remove residual suntan lotion, insect repellent, etc.
- Stay out of the pool as much as possible, a lot of can be seen from the edge. When moving from place to place, get completely on dry land. The very shallow waters at the edge of a pool are favored places for larval amphibians.
- If entering a pool is necessary, limit the number of people to one or two. Move slowly and carefully to avoid stepping on egg masses resting on the bottom and to minimize kicking up sediments
- Wet hands with pool water before handling animals and return them promptly to the water.
- Don't take animals or egg masses home or move them between pools.
- Egg masses can be lifted gently to the surface to inspect, photograph, etc., but it's best not to lift them out of the water. They might break apart, or if they are attached to a stick they might fall off.

We recommend use of the following guides to help you identify the reptiles, amphibians, and invertebrates that you may encounter in or near vernal pools. Note that these guides contain some species that may be uncommon, rare, or not found in Pennsylvania. Consider photographing species you encounter and include them with your site documentation. Please take extra care not to disturb or harm vernal pool animals. It is especially important that you not take any vernal pool animals into captivity.

Brown, L. J. and R. E. Jung. 2005. An Introduction to Mid-Atlantic Seasonal Pools, EPA/903/B-05/001. U.S. Environmental Protection Agency, Mid-Atlantic Integrated Assessment, Ft. Meade, Maryland. The 'EPA 2005' publication can be downloaded from this website last accessed October 1, 2012: <http://www.epa.gov/bioiweb1/pdf/EPA-903-B-05-001AnIntroductiontoMid-AtlanticSeasonalPools.pdf>.

Hulse, A. C., C. J. McCoy, and E. J. Censky. 2001. Amphibians and Reptiles of Pennsylvania and the Northeast. Cornell University Press, Ithaca, New York.

Kenney, L. P., and M. R. Burne. 2000. A Field Guide to the Animals of Vernal Pools. Massachusetts Division of Fisheries & Wildlife Natural Heritage & Endangered Species Program. Westborough, MA.

Prevent Spread of Disease

There is an ever growing number of invasive species and diseases in Pennsylvania that can have devastating effects on native amphibian populations. Two particularly troublesome amphibian diseases are ranavirus and chytrid. Ranavirus has been linked to massive die-offs in reptiles and amphibians, including at sites in Pennsylvania. Chytrid is a category of fungus that contains many harmless species, but one species in particular (*Batrachochytrium dendrobatidis*, or 'Bd')

for short) infects the skin of amphibians and can lead to high mortality in some species. The Global Bd Mapping Project (<http://www.bd-maps.net/maps/>) has a map showing where *Bd* has been confirmed (zoom in on the map to see the sample points). In Pennsylvania, *Bd* has been confirmed at a few sites in the north-west and north-east, but an organized effort is needed to sample at many additional sites throughout the state.

It is not that difficult to make sure you are not inadvertently moving diseases around. First and foremost, don't move animals from one location to another, or release pet reptiles and amphibians into the wild. When working in wetlands, it is important to clean and disinfect gear between sites to prevent spread of diseases and invasive species. Wear rubber-soled footwear for field work since it is difficult to properly disinfect felt-soled boots. If you have several days between site visits and have plenty of time for gear to fully dry (48+ hours), you can use the Dry Gear Technique. If surveying multiple sites in a day or over several days in a row without time for gear to fully dry, follow the Dilute Bleach or Nolvasan Technique.

Dry Gear Technique

If you visit a stream or wetland and won't visit another site for a number of days, an easy way to clean your gear (anything that touched the water) is to take it home and scrub away loose dirt, vegetation, algae, etc. with soapy water, then let it dry completely at less than 70% relative humidity for a minimum of 48 hours.

Disinfectant Techniques

If you plan on visiting multiple wetlands or streams in a day, then you will need to disinfect your gear between sites. Take your equipment (nets, boots, etc.) away from the wetland or stream. Rinse the equipment with water and scrub away loose dirt, vegetation, algae, etc. Spray all equipment that contacted the wetland with a disinfectant (see two options below). Rinse with plain water and let dry (in the sun if possible) for 5 minutes.

Household Bleach - Add 1/2 cup bleach to 1 gallon water*

- Cheap and convenient
- Solution lasts 1 month if kept in an opaque container
- Solution only lasts 5 days if exposed to sunlight/air
- Bleach is more damaging to clothing and equipment**

*1:32 dilution of bleach:water for a 3% solution using 6% concentration household bleach

**To neutralize the corrosive action of bleach, you can apply a solution of sodium thiosulfate at 800 ppm solution (3 grams per gallon of water). Sodium thiosulfate is available online or from pool supply stores. After rinsing out the bleach, spray on the sodium thiosulfate solution. Let it stand for a couple minutes, then rinse well with water.

Nolvasan S - Add 2 Tbsp Nolvasan to 1 gallon water*

- More expensive
- Solution made with tap water lasts 1 week (up to 6 weeks with deionized water)
- Doesn't damage gear like bleach can

*1:127 (Nolvasan:water) for a 0.75% solution using 2% concentration Chlorhexidine diacetate.

For more information on amphibian diseases

Amphibian Ark for information on Chytrid Fungus and Chytridiomycosis: <http://www.amphibianark.org/the-crisis/chytrid-fungus/>

Northeast Partners in Amphibian and Reptile Conservation fact sheet on Ranavirus http://www.northeastparc.org/products/pdfs/NEPARC_Ranavirus_FAQ.pdf

Amphibia Web for information on Bsal (*Batrachochytrium salamandrivorans*): <http://amphibiaweb.org/chytrid/Bsal.html>

Northeast Partners in Amphibian and Reptile Conservation fact sheet on disinfection protocols: http://www.northeastparc.org/products/pdfs/NEPARC_Pub_2014-02_Disinfection_Protocol.pdf
a 5% bleach solution and let it dry in the sun for a minimum of 5 minutes.

Mosquito Control and West Nile Virus

When development takes place near wetland habitats, municipalities and homeowners may take measures to control mosquitoes and other nuisance insects. This is necessary in some cases to protect human health. Mosquitoes are a concern because their bites are unpleasant and they can potentially spread diseases such as West Nile Virus (WNV), eastern equine encephalomyelitis, and St. Louis encephalitis. However vernal pools may get unfairly targeted for pest control when in fact the problem lies close by in the yards of homes rather than in nearby wetlands. This is a concern for vernal pool conservation because small insect larvae like mosquitoes are an important part of the food web. Mosquito larvae consume fine bits of algae and other fine suspended materials and turn it into fats and proteins in their bodies. In turn they become food for other aquatic animals like frogs and salamanders. Adult mosquitoes also are a source of food for winged predators such as swallows, blue birds, and bats.

The Department of Environmental Protection's West Nile Virus Surveillance and Control Program takes samples of mosquitoes from many sites each year. Between 2001 and 2007 over 50,000 larval mosquito collections were taken. WNV biologists identify the collected mosquitoes and test them for WNV. A subset is also tested for the other mosquito-borne diseases. There are sixty-two species of mosquitoes currently known from Pennsylvania, but only a few of these species are the leading carriers of the disease that affect humans. Research into the life history of the species that are most responsible for infecting humans with WNV indicates that vernal pools are not the typical habitat for the leading offenders.

According to the West Nile Virus program, over 95% of the mosquitoes that have tested positive for WNV come from species in the genus *Culex*, particularly *Culex pipiens* and *Culex restuans* (Hutchinson 2010, personal correspondence). *Culex pipiens* is the primary vector of WNV to people. It prefers artificial habitats to natural ones and for this reason is closely tied to human habitation. They reproduce in artificial containers that collect water such as tires, buckets, flower pots, and bird baths that are not refreshed regularly. *Culex pipiens* is tolerant of pollution and likes highly organic water, such as occurs in wastewater treatment plants (Darsie and

Hutchinson 2009). *Culex restuans* is very common in the spring and is a habitat generalist. *Culex restuans* rarely bites humans, with a strong preference for birds. But they are probably responsible for much of the amplification of WNV in the early part of the season by increasing the virus in bird populations. *Culex restuans* is one of the least discriminating of mosquitoes. They will lay their eggs in a wide variety of habitats. They are extremely easy to find in artificial containers such as tires, bird baths, etc. They are also very common in tire ruts. They are one of the few species that can be found in tree holes, too. As for other natural habitats, they can be very common in large shallow wetlands with lots of emergent vegetation for cover. *Culex restuans* will exploit vernal pools, but to a lesser degree than the other habitats previously mentioned (Hutchinson 2010, personal correspondence).

Vernal pools do support populations of mosquitoes which will bite people who come near the wetland, but they are not major vectors of WNV because virus levels are fairly low in the spring when their populations are highest (Hutchinson, personal communication, 2010).

The pesticides people use to control pest insects can have many negative effects on non-target wildlife. Broad-based killing agents that kill all types of insects can collapse the food chain of a vernal pool. More specific killing agents are available that only harm black flies or mosquitoes, but they still affect other wildlife by decreasing the availability of their food. Removal of all the vegetation around vernal pools followed by frequent mowing is sometimes done to control mosquitoes, in a similar manner to how some storm water basins are maintained. This practice is also very detrimental to the health of a vernal pool. Pest insects in vernal pools are consumed and controlled by natural predators such as salamanders, dragonflies and damselflies, predaceous diving beetles, water boatmen, and backswimmers. These animals need trees, shrubs, and ground cover around a pool. The key to limiting mosquitoes in vernal pools is to maintain and enhance the ecosystem that is naturally there.

The best preventative measures against West Nile Virus and other mosquito borne diseases focus on personal protection. The following recommendations are taken from the website West Nile Virus.com at <http://www.west-nile-virus-prevention.com/preventative-measures.html> and The Center for Disease Control at http://www.cdc.gov/ncidod/dvbid/westnile/wnv_factsheet.htm.

- Get rid of mosquito breeding sites by emptying standing water from flower pots, buckets and barrels, watering cans, tarps, and other artificial containers to eliminate breeding habitat for mosquitoes around your home. Change the water in pet dishes and replace the water in bird baths weekly. Drill holes in tire swings so water drains out. Keep children's wading pools empty and on their sides when they are not being used.
- Avoid getting bitten. Peak times for mosquitoes are at dawn, dusk, and early evening. Stay indoors during these times if the mosquitos are actively biting. If you need or want to be outdoors at these times, wear long sleeved shirts and long pants.
- When mosquitoes are biting, use an inset repellent containing and EPA-registered active ingredient such as DEET, Picaridin, Oil of Lemon Eucalyptus (or PMD), or IR3535. See <http://wwwnc.cdc.gov/travel/yellowbook/2016/the-pre-travel-consultation/protection-against-mosquitoes-ticks-other-arthropods> for more information on repellents. Mosquito netting can be worn over hats and placed over child strollers and back packs to protect against bites.
- Keep screen doors and windows in good repair to keep mosquitoes out.

Herbicides and Amphibians

Invasive exotic plants can wreak havoc on natural ecosystems, replacing diverse communities of native plants with dense stands of aggressive weedy species. Invasive species can dramatically alter a habitat and render it unsuitable for many kinds of native plants and animals. Large, dense stands of a native species may be undesirable in certain situations as well. Herbicides are a tool that can be employed to meet management objectives, but herbicides bring their own set of risks.

Controlling invasive species with manual methods such as hand-pulling and cutting works well in situations where there is enough people-power to eradicate the invasives or to prevent them from spreading. The benefit to manual methods is that no chemicals are introduced to the environment that can cause unintended harm to non-target plants in animals. In other situations, the area that needs treated may be too large to manage in this manner. Pulling up large numbers of shrubs or running mechanized equipment like a brush hog may be damaging to soils as well. When an herbicide is selected as the control method, the goal is to find the least toxic chemical that will meet management goals while protecting sensitive species.

Glyphosate is a broad-spectrum, non-selective systemic herbicide used to kill undesired vegetation, especially annual broadleaf weeds and grasses. It is considered relatively safe to use around humans and most terrestrial wildlife because the herbicide acts on certain enzymes that are only found in plants. Glyphosate used alone does not appear to be especially toxic to adult amphibians, though more research is needed. However glyphosate is often combined with surfactants into a formulation that helps the herbicide adhere to leaf surfaces. Many of these surfactants are toxic to aquatic organisms and adult amphibians. Glyphosate can be used effectively without surfactants for controlling woody vegetation using 'cut stem', 'hack and squirt', or 'stem injection' methods where the herbicide is applied by hand in a very direct and controlled fashion to cut surfaces. These methods are more time consuming than a broadcast spray and work best in small or sensitive habitats where minimizing the risk to native plants and animals is a priority. The North Carolina Partners in Amphibian and Reptile Conservation (Hughes 2009) website has a good article that summarizes herbicide issues as they relate to amphibians. They list the following products as surfactant-free 53.8% glyphosate: Accord Concentrate (Dow Agrosiences), Foresters Non Selective (Nufarm), Aquamaster (Monsanto), AquaNeat (Nufarm), and Rodeo (Dow Agrosiences). The label should either say 'aquatic herbicide' or be listed as appropriate for forestry, right-of-way, habitat restoration, etc. applications where wetlands are included.

In some situations a surfactant is needed in order for the herbicide application to be effective. For example, broadcast foliar treatments for woody species (e.g., laurel, witch hazel) probably require a surfactant to be added to the 53.8% glyphosate. Even surfactants marketed as aquatic-safe may be problematic for certain aquatic organisms. Hughes (2009) rates Agri-Dex (Helena) as the safest product currently available. Agri-Dex is probably the least likely to cause harm to fish and aquatic organisms (including frogs).

Hughes (2009) found that mixing 53.8% glyphosate with the Agri-Dex surfactant is very effective on all types of invasives. It is appropriate for use in upland, wetland, and transitional

sites because amphibians can be found in all of these settings. Another promising product is Roundup Biactive (Monsanto). This is a less toxic formulation of glyphosate plus surfactant. This product is not currently available in the United States, but it is worth watching for this or other improved lower toxicity products in the future.

It's important to remember that vernal pool amphibians are present in the supporting uplands, up to 1000 feet or more from the edge of a vernal pool, during most of the year. Therefore the safest herbicide formulations for wetlands should be used in all of the vernal pool management zones – the basin, core, or supporting uplands.

References

Biebighauser, Thomas. 2003. A Guide to Creating Vernal Ponds: all the information you need to build and maintain an ephemeral wetland. USDA Forest Service, Morehead, KY. 33 pp. Available online at << <http://herpcenter.ipfw.edu/outreach/vernalponds/vernalpondguide.pdf>>>.

Biebighauser, Thomas. 2007. Wetland drainage, restoration, and repair. The University Press of Kentucky. Ix + 241 pp.

Brown, L.J. and R.E. Jung. 2005. An introduction to Mid-Atlantic seasonal pools. EPA/903/B-05/001. US Environmental Protection Agency, Mid-Atlantic Integrated Assessment, Ft. Meade, MD. Online: <http://www.dnrec.delaware.gov/fw/dplap/information/Documents/Mid-Atlantic%20Seasonal%20Ponds%20-%20EPA.pdf>.

Calhoun, A. J. K. and P. G. deMaynadier (eds). 2008. Science and conservation of vernal pools in Northeastern North America. CRC Press, Boca Raton, FL. xxvii+363 pp.

Chunko, S. E. (ed.). 2001. Best management practices for Pennsylvania forests: promoting forest stewardship through education, cooperation, and voluntary action. Code #UH090. Best Management Practices Task Force, College of Agricultural Sciences, Penn State University. 48 pp. Online: <http://pubs.cas.psu.edu/FreePubs/pdfs/uh090.pdf>.

Colburn, E. A. 2004. Vernal Pools: Natural History and Conservation. The McDonald and Woodward Publishing Company, Blacksburg VA. xiii + 426 pp.

Darsie, R. F. and M. L. Hutchinson. 2009. The Mosquitoes of Pennsylvania. Technical Bulletin #2009-01 of the Pennsylvania Vector Control Association. 191 pp.

Hughes, K. 2009. "Observations on Herbicide Choices and Amphibian Conservation." North Carolina Partners in Amphibian and Reptile Conservation. Online at <http://www.ncparc.org/pubs/Herbicide%20Choices%20&%20Amphibian%20Conservation.pdf>

Milam, J. C. and S. M. Melvin. 2001. Density, habitat use, movements, and conservation of spotted turtles (*Clemmys guttata*) in Massachusetts. Journal of Herpetology 35:418-427.

National Research Council (NRC). 2001. Compensating for wetland losses under the Clean Water Act. National Academy Press, Washington, D.C.

Pennsylvania Department of Environmental Protection (DEP). 2007. The Timber Harvest Operations Field Guide for Waterways, Wetlands and Erosion Control. Rev. 6/2007. The Commonwealth of Pennsylvania Department of Environmental Protection, Bureau of Watershed Management, Harrisburg, PA. ii+43 pp.

Online: <http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-109376/3150-BK-DEP4016.pdf>

Semlitsch, R. D. and J. R. Bodie. 2003. Biological criteria for buffer zones around wetlands and riparian habitats for amphibians and reptiles. *Conservation Biology* 17(5):1219-1228.

The Pennsylvania Game Commission and Pennsylvania Fish and Boat Commission. 2005. Pennsylvania Comprehensive Wildlife Conservation Strategy (PCWCS). Version 1.0.

Questions or comments? Please contact:

*Document revised,
November 5, 2015*

*Vernal Pool Coordinator
Western Pennsylvania Conservancy
PA Natural Heritage Program
PO Box 8552
Harrisburg, PA 17105-8552
spcoordinator@paconserve.org*