IDENTIFICATION AND CONSERVATION OF VERNAL POOLS IN PENNSYLVANIA

Notes to accompany the PowerPoint presentation of the same name developed October 2015 by the Pennsylvania Natural Heritage Program. Numbers in parentheses correspond with the slide numbers.
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(1) Hello everyone, thank you for joining us today, we really appreciate your interest in vernal pools!

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(2) We'll start by defining vernal pools, how to recognize them, and what kinds of animals use them. Then we'll look at:

1. Wetland regulations
2. Threats and amphibian diseases
3. Conservation and Best Management Practices
4. Vernal pool resources for landowners

Note that this presentation and associated notes are available as downloadable PDFs on the "**Vernal Pools of Pennsylvania**" website at the address listed below. You can click on the hyperlinks to open the various websites mentioned throughout the presentation.

Weblink: *http://www.naturalheritage.state.pa.us/VernalPools.aspx*

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(3) Let's start with a **definition and examples** of vernal pools.

- First and foremost vernal pools are true wetlands, as defined by soils, hydrology, and (usually) vegetation. They typically have fluctuating water levels with a period of dryness in late summer. There is no permanent inlet or outlet, though they often seasonally overflow. While they are typically small and shallow, they can come in a great variety of shapes and sizes. They support a distinctive community of plants and animals.
- An important quality of vernal pools is that they do not support populations of fish. The dry phase of a vernal pool prevents fish from becoming permanent fixtures. Fish are top predators in ponds and lakes, so when they are missing from the food chain there is less predation and competition pressure. Vernal pool amphibians therefore have greater reproductive success when fish are absent.

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(4) *Vernal pools in Pennsylvania range from little leafy puddles you can jump across…*
to large wetland thickets where your can easily fill your hip waders.
Here are some general types of vernal pools commonly encountered in PA.

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(5) Unvegetated (black leaf) pool
(6) Swamp forest pool
(7) Marsh dominated pool
(8) Blend of shrub and marsh vegetation
(9) Shrub dominated pool

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(10) *Recognizing a vernal pool in the **dry phase** is an important skill because they are easily overlooked when there is no standing water.*

Unvegetated or black leaf pools are especially unremarkable in the dry phase. They are just shallow depressions in the forest. The basin will lack any trees or other vegetation. Leaves in the basin will appear compacted and gray, and there may be a ring of mosses marking the basin edge.

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(11) Starting with the **photo at left**, some black leaf vernal pools will develop a low herbaceous plant layer after they dry down. This type of pool has a relatively short period of inundation, with enough of a canopy opening that non-wetland plants can become established after the pool dries.

The photo **in the center** shows a forested swamp pool that formed in a shallow depression. These are often part of a larger swamp forest matrix. You often see trees with buttressed bases growing in the pool basin. Look for staining on the tree trunks indicating a high water mark.

The **photo at right** shows a vegetated pool, which will tend to have moist or mucky soils even in the dry phase. They support lush wetland vegetation such as sedges, woolgrasses, mannagrasses, and ferns. Wetland shrubs such as highbush blueberry, alder, and buttonbush can grow in pool basins, around the perimeter, or on hummocks.

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(12) Here is an example of trees at a vernal pool with buttressed bases and a high water mark line

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(13) Top Right: Vernal pools that can support breeding amphibians will hold water long enough to develop **wetland (hyric) soils.**

At bottom left: Another clue to look for is evidence of **recent aquatic life** in the dry pool basin. You may find empty ampibian egg masses, old caddisfly cases, or shells of snails or fingernail clams.

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(14) Now let's look at some vernal pools in the dry phase.
First is an unvegetated (black leaf) pool
(15) Swamp forest pool
(16) Marsh pool
(17) Shrub pool

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(18) Identifying a vernal pool during its wet phase can be accomplished by looking for the **Distinctive Biological Community**. There are several animals called '**vernal pool indicators**' whose presence in a wetland indicates that it likely has a seasonal hydrology and no fish. Vernal pool indicator species have special adaptations to utilize vernal pools in spite of the dry phase.

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(19) **VERNAL POOL INDICATOR (or obligate) SPECIES** are specialists that reproduce most successfully in fishless waters. In Pennsylvania, there are **six amphibians* and two types of crustaceans**** that use vernal pools almost exclusively for breeding and larval development.
*wood frog, spotted salamander, Jefferson salamander, marbled salamander, eastern spadefoot, blue-spotted salamander
**fairy shrimp and clam shrimp

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(20) ***Four of our vernal pool indicators are mole salamanders***. These surprisingly large salamanders spend most of the year underground in the forest surrounding a vernal pool. Each spring the adults leave their safe burrows and migrate to the vernal pool ***where they were born*** to find a mate and lay eggs.

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(21) The **Marbled Salamander** is a chunky black & white mole salamander. Males and females rendezvous in dry pool basins in early autumn. The female lays her eggs and often guards them until the pool floods. Her eggs hatch before the other mole salamanders which arrive in spring, so her larvae have a size advantage and are first to leave the pool the following summer.

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(22) The **Jefferson Salamander** is the first salamander to arrive at a vernal pool in the spring, often crossing snow & ice.

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(23) The **Blue-spotted Salamander** was first confirmed present in Pennsylvania in 2000. It is known from only a few counties in the state. It looks similar to the Jefferson salamander and can hybridize with them*.

*Learn more in the May/June 2012 issue of PA Angler & Boater at *http://fishandboat.com/angon2.htm*

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(24) The **Spotted Salamander** is a large salamander (up to 10 inches long!). It is instantly recognizable by it's bright yellow spots. It is the most commonly encountered mole salamander in Pennsylvania vernal pools.

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(25) ***Two of our vernal pool indicators are frogs…***

The **Wood Frog** has a distinctive dark mask through its eye and white 'upper lip'. It makes a distinctive quacking call from the vernal pool in early spring. The wood frog is our most commonly encountered vernal pool indicator.

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(26) Like the mole salamanders, wood frogs adults spend most of the year on the forest floor in the uplands surrounding a vernal pool. Wood frogs overwinter in leaves on the ground. They become completely frozen and enter an essentially lifeless state. As temperatures start to go down in the fall, they begin creating an internal 'antifreeze' that prevents their cells from bursting when their bodies freeze. In the spring they thaw out, wake up, and return to their natal vernal pool to breed.

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(27) While the **Eastern Spadefoot** is often called the Spadefoot Toad, it is actually a primitive species of frog. A hard projection on its webbed hind feet works like a digging spade. The Spadefoot is a fossorial species, spending most of its life underground. It has unpredictable breeding events that take place after heavy rainstorms, and tends to use quick-drying vernal pools in sandy woodlands and even agricultural areas.

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(28) One of the easiest ways to identify a vernal pool is to look for the **egg masses of indicator amphibians** in March and April. The egg masses of the Spotted and Jefferson Salamanders and the Wood Frog are easy to see from the pool edge and persist for several weeks in March and April.

The **spotted salamander** is the only amphibian that lays large, cloudy, white egg masses in vernal pools (as shown at bottom right), BUT, they will also lay clear egg masses (as shown at upper left)! The eggs are protected within a firm, fist-sized gelatinous mass.

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(29) **Jefferson salamander egg masses** (shown at top left) are always clear, but distinguishing them from **Spotted salamander egg masses** can be difficult.

In the bottom right photo, a **spotted salamander egg mass** is on the left side of the stick, and a **Jefferson salamander egg mass** is to the right. Spotted egg masses can be cloudy white, or clear as shown here. They have a very firm outer jelly matrix that is 'blob-shaped'. In the clear egg masses, you can see that a thick milky white ring encircles the individual embryos.

For comparison, you can **see a Jefferson egg mass** on the right side of the stick in the bottom right photo. They are smaller & more linear in shape than Spotted egg masses. Individual Jefferson embryos are encircled with a very thin milky white ring making the egg mass harder to see.

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(30) **Wood Frog Egg Masses** are made of a much softer and looser jelly than the Spotted Salamander egg masses. They lack a firm outer matrix. Communal masses like the one shown help the eggs retain heat and allow the embryos to develop faster.

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(31) You may have noticed that all these vernal pool indicator amphibians take advantage of vernal pools in a similar way. Terrestrial adults migrate to the pool to lay eggs. Aquatic young develop in the pool and metamorphose into a terrestrial-living juvenile that must leave the pool before it dries. The juveniles and adults spend the rest of the year feeding and overwintering in the upland forest.

This brings us to a key aspect of vernal pool amphibian conservation –
the 'home range' of these species is more than the vernal pool.

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(32) Take this wood frog for example, who had the misfortune of being captured by a research team and saddled with a radio transmitter. He traveled between a vernal pool, a forested woodland, and an upland forest in order to find a mate, make his contribution to the next generation, find food and shelter, and select a suitable overwintering site. He only spent a portion of the year in the vernal pool. The breeding pool is critical because without it there would be no 'Next Generation', but the adults can't survive without the surrounding forest.

Weblink: *http://nhanrs.org/Buffer/VPGuide.pdf*

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(33) *How far away from the breeding pool do vernal pool amphibians move?*

To put it into perspective, we'll look at a standard American football field which is 300 feet long.

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(34) Now let's look at the distances travelled by our two most common vernal pool amphibians:

- Wood frogs move a distance of 4-5 football fields. For a 2.5 inch frog, that's about 7,680 body lengths. For a 5 ft 8" human, the equivalent would be about 8 1/4 miles.
- Spotted salamanders move an average of 1 ½ football fields, but up to 9 football fields away from the pool!

We'll explore the importance of the uplands later. The point to remember is that the uplands are a necessary resource in the life of a vernal pool amphibian.

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(35) ***Our final two vernal pool indicators are crustaceans!***

Fairy Shrimp are small crustaceans only found in seasonal pools. The Springtime Fairy Shrimp is the most common species encountered in Pennsylvania pools, but several other species have been documented in the state.

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(36) Male fairy shrimp (at top right) have long 'trunks' or claspers on their head which they use to grab hold of a female. Females (at bottom left) have eggs protected within a small pouch at the base of their swimmerettes.

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(37) **Clam Shrimp (in the order Spinicaudata)** are less commonly encountered than fairy shrimp. They look like a fingernail clam from the outside, but on the inside is the body of a little shrimp-like creature. Several species have been documented in PA*.

*The Euroamerican clam shrimp (*Limnadia lenticularis*) and the diversity clam shrimp (*Eulimnadia diversa*)

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(38) *Vernal pool crustaceans take a different approach to using a temporary body of water.*

This is a generalized depiction of how vernal pool crustaceans and some insects have adapted to vernal pools. The egg stage overwinters (diapauses) in the dry pool bed. The eggs hatch when the pool refloods, and environmental conditions are right (such as photoperiod and water temperature). The juveniles mature, reproduce, and lay eggs. They may go through several egg to adult cycles before the pool begins to dry up. As the water levels drop, conditions in the pool change as well, triggering the last generation of adults to lay hardier eggs that have a tough outer coating which allows them to withstand drought and freezing temperatures.

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(39) There are many reptiles, amphibians, insects, and other invertebrates that are found around vernal pools that are not considered indicator species. We call these animals **ASSOCIATED (or facultative) SPECIES**. They commonly breed in vernal pools but they can also reproduce successfully in permanent waters.

These animals opportunistically utilize vernal pool habitats
but don't depend on them as heavily as the indicators do.

Many vernal pool amphibians like this spring peeper utilize the same Life History Strategy as the mole salamanders and wood frogs, breeding in the pool but spending most of the year in the surrounding forest. Many vernal pool invertebrates like this seed shrimp utilize the second strategy we discussed, with a diapausing egg in the dry pool basin.

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(40) Others associated species like this **Red-spotted Newt**, employ a third strategy, where the adults move between permanent wetlands and streams where they overwinter to vernal pools in the spring. They feed and breed in the pools, taking advantage of the rich resources. Their aquatic offspring must leave the pool before it dries. Interestingly enough the juvenile stage of the red-spotted newt is the red eft, which becomes terrestrial for several years before it returns to water as an aquatic adult.

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(41) A seldom seen but often heard vernal pool associate is the **Spring Peeper**. Full grown spring peepers are about 1.5" long and have an **X** on the back.

The recent metamorph on the right fits on the tip of a pencil!

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(42) Male spring peepers must attract a female with his song. With potentially thousands of peepers gathering at a single pool, he must sing loudly to be heard over the competition! A single male can peep louder than a vacuum cleaner. A pond full of peepers can produce a wall of sound around 120 decibles, which is as loud as the engine of a jet plane at take off. This is louder than a snow mobile or a chain saw and is literally on par with what your ears experience at a rock concert! (source: Nationalaquarium.com).

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(43) A few additional commonly encountered <u>vernal pool associates</u> include the **American Toad.** This is the common hop-toad you find in your yard. The males have a steady, high, trilling call.

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(44) **Toad eggs** are laid in long ropy strands

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(45) **Gray Tree Frogs** are perfectly patterned to blend in on a tree trunk. As their name suggests, they live in forest trees, using those handy toe-pads like suction cups to cling to their perch. Their call sounds kind of like the trilling ring of an old-fashion telephone.

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(46) **Gray tree frogs** are well camoflaged on the back, but have dandilion yellow on the inside of their legs and belly.

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(47) The **Spotted Turtle** is a species of concern in PA that is closely associated with vernal pools.

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(48) The **Wood Turtle**, and the

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(49) **Eastern Box Turtle** are two other turtles of species of concern in PA that may be encountered around vernal pools.

*With all these cool big-bodied reptiles and amphibians breeding and feeding at vernal pools, there must be a strong **FOOD WEB** that supports them.*

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(50) There is an amazing assemblage of small insects and crustaceans that make up the bulk of the biodiversity and biomass in a vernal pool. With the exception of the fairy and clam shrimp, these critters are found in other wetland types. However, many vernal pool invertebrates have strong affinities to ephemeral wetlands and reach exceptionally high densities in vernal pools in the spring.

Let's explore the vernal pool food web by starting with the 'spiders in the web' so to speak. The larvae of mole salamanders are top predators in the vernal pool environment. But there are also many **INSECT PREDATORS** who help control the abundance of prey items such as mosquitos and midges. Immature dragonflies and damselflies nymphs are aquatic at this stage, and are big hunters in vernal pools.

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(51) Adult **dragonflies and damselflies** hunt for food in the air space over vernal pools, seek mates, and lay eggs in wet or dry pool basins.

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(52) **Predaceous Diving Beetles**, and

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(53) **Backswimmers** are other top insect predators in vernal pools

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(54) The **SHREDDERS** are insects that begin the process of releasing the energy locked up in the leaf and woody debris that accumulates in a vernal pool. Two common shredders in vernal pools are the larvae of the Log Cabin Caddisfly (Family Limnephilidae) and the Cigar tube Caddisfly (Family Phryganeidae).

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(55) Very small insects and crustaceans flourish in vernal pools in the spring and create a nutritious '**Vernal Pool Soup**'. These creatures provide a smorgasborg of protein and fat rich meals that are consumed by growing salamander larvae and insect predators.

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(56) **Characteristic insects** include Phantom Midges (top 2), Mosquitos (a pupa is shown at bottom left); and Midges or blood worms (the reddish larva at bottom right)

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(57) **Characteristic crustaceans** include Water Fleas (top 2), Copepods (bottom left and center), and Seed Shrimp (bottom right)

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(58) ***Vernal pools are important*** *because they are often the only wetland in an otherwise dry forest setting. They provide much needed food, water, and shelter to wildlife in the upland forest.*

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(59) *Vernal pools provide food, water and shelter for many kinds of **game and non-game species.***

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[60] **Vernal pools provide valuable Ecological Services like all wetlands do… FREE of CHARGE**

- They slow Flooding & Erosion by trapping RUNOFF
- They remove Pollutants & Sediments by slowly FILTERING water through plants and soils
- They improve the Quality & Quantity of our DRINKING WATER
- And they improve the Health of our STREAMS

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[61] *Since vernal pools can be so small and ephemeral, some people wonder if they are **PROTECTED BY LAW**. Vernal pool habitats and vernal pool plants and animals are in fact protected under a number of state and federal laws.*

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[62] Vernal pools can receive protection the Federal Clean Water Act, administered by the **U.S. Army Corps of Engineers (USACE).** The USACE cannot regulate "isolated wetlands" that lack a connection to a stream or waterway. However, indirect wetland connections may count (e.g., the vernal pool is connected to another wetland which drains into a stream or located in the floodplain of a stream).

Weblink: *http://www.usace.army.mil/Portals/2/docs/civilworks/regulatory/materials/cwa_sec404doc.pdf*

With the recent EPA Clean Water Rule, the USACE recovered some jurisdictional authority that was lost with the SWANCC decision of 2001.

Weblink: *http://www2.epa.gov/cleanwaterrule/final-clean-water-rule*

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[63] You need a permit from the **PA Department of Environmental Protection** to directly impact a body of water. A permit is necessary to directly impact ANY vernal pool or other wetland by fill or excavation, regardless of the size.

Weblink: *http://www.pacode.com/secure/data/025/chapter105/chap105toc.html*

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[64] According to the Chapter 105 Water Obstructions and Encroachment General Permit, **wetland mitigation (=wetland replacement) is required for alteration of wetlands *over 0.05 acres* in size**.

For scale, a 46 ft x 46 ft square is approximately 0.05 acres in size

REPLACEMENT VALUES (105.20a)

- Minimum 1 to 1 acreage replacement with a wetland of equal function & value
- Minimum 2 to 1 acreage replacement with a wetland of different function & value

Weblink: *http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-99378/3150-PM-BWEW0500_CopiesRev_Feb2014.pdf*

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[65] Many vernal pools in PA are **smaller than 0.05 acres** and therefore are not directly mitigated when they are destroyed. But their acreage is added to the total acreage of wetlands lost, and Pennsylvania has a 'no-net wetland loss' policy and programs to create wetlands to offset all lost acreage.

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[66] In spring of 2014, a proposed In-Lieu Fee (ILF) compensatory mitigation program, to be run by the **PA Department of Environmental Protection,** was posted for public review. If approved, the **Pennsylvania Integrated Ecological Services Enhancement and Support (PIESCES) In-lieu fee (ILF)** program would replace the PA Wetland Replacement Project.

- DEP will continue to ensure "no net loss" of acerage and/or functions of wetlands, but the system would be more adaptable, transparent, scientific, and effective.

- We expect improved ecological results because DEP would assume legal responsibility for satisfying the compensatory mitigation requirements (versus leaving it in the hands of the permittee).
- Stay tuned for potential partnerships for wetland restoration.

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(67) The **Pennsylvania Fish and Boat Commission** is responsible for regulations concerning game and non-game fish, reptiles, amphibians, and aquatic invertebrates. Current regulations prohibit the collection or possession of many reptiles and amphibians that may be found around seasonal pools:

- Eastern Spadefoot and Blue-spotted Salamander (Threatened or Endangered)
- Four-toed, Jefferson, and Marbled salamanders
- Mountain, Upland, and Western Chorus Frogs
- Box, Spotted, and Wood Turtles
- Hognose, ribbon, mountain earth, shorthead garter, and ribbon snakes

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(68) **WETLAND DELINEATION**

Wetland delineation is the process of identifying the boundaries of a wetland by looking for certain criteria in the soils, vegetation, and hydrology. Vernal pools can be challenging to define according to these standardized criteria because of their ephemeral nature.

Resources for wetland delineation:

- Corps of Engineers Wetlands Delineation Manual
  http://www.bwsr.state.mn.us/wetlands/publications/corpsmanual.pdf
- Clarification and Interpretation of the 1987 Manual
  http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_025086.pdf
- USACE Regional Supplements – two apply in Pennsylvania:
  - Eastern Mountains and Piedmont, and
  - Northcentral and Northeast

  http://www.usace.army.mil/Missions/CivilWorks/RegulatoryProgramandPermits/reg_supp.aspx

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(69) **National Wetland Plant List**

This website allows you to download a list of wetland plants for Pennsylvania. On the left hand side of the home window, look under 'Download Plant Lists'. Click on US State/Territory Lists and select '2014 Lists by State'. A window will pop up where you can download an Excel file or a PDF of the wetland plants of Pennsylvania.

You can also search for information on individual plant species under the 'NWPL Viewer Tool'. On the left hand side of the home window, click on "Plant Searches, Species Detail & Custom Plant Lists with Reports'.

A new window will open. In the very top right corner of the window a 'species search' box will open where you can type in a plant name. You must click on the blue button with the magnifying glass to activate a search. Below that box are two search criteria. The first criteria is set by default to 'Scientific Name', but you can change that to 'Common Name'. The second criteria is set by default to find names 'Starting with' whatever common name you type in. If you type in 'Oak' you will only get four plants whose Common Name starts with the word Oak. If you change the second criteria to 'that Contains', your search will be more comprehensive and you will get 39 species in the results window. Note that if you search on Common Name, the search is case sensitive. For example, if you want to find information on maples, you must select 'Common Name' and 'that Contains', then enter the term 'Maple'.

If you click on a species name, a window with more information on that species. You will be able to see that plants wetland indicator status in different regions of the US. Pennsylvania is mostly contained within the Eastern Mountains and Piedmont region (EMP), except for the glaciated northeast and northwest corners of the state which are in the Northcentral and Northeast region (NCNE). There is a tiny sliver of Atlantic and Gulf Coastal Plain (AGCP) on the south-east edge of the state. Plants with a wetland status are those with a designation of OBL, FACW, or FAC are considered to be typically adapted for life in anaerobic wetland soil conditions. Under the 'Species Detail' tab, you can display different information in the left and center screens of this window.

Weblink: *http://rsgisias.crrel.usace.army.mil/NWPL/*

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(70) **Soil Resources**

- Soil Survey Manual (3rd Edition, 1993) http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_054262
- Field Indicators of Hydric Soils in the US: A guide for Identifying and Delineating Hydric Soils (Version 7.0, 2010) http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_050723.pdf
- A Guide to the Hydric Soils in the Mid-Atlantic Region (Ver. 2.0, 2011) http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052291.pdf
- Printed soil surveys by county were the standard in the past and can be downloaded as pdfs online http://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=PA
- Now soil data is maintained and updated online (next 2 slides).

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(71) **Web Soil Survey:** The Natural Resources Conservation Service (NRCS) has this really nice soil website, where you can look up the soil type for an area. You can get lots of information about the soil properties, its hydric soil rating, and its rating for different activities. You won't find out whether or not your specific spot is a vernal pool or not, but you can learn a lot about what sort of wetland you are likely to encounter in those soils. Note that these maps are not intended to give soil data at a fine scale for a specific property. Variations exist and soils should always be examined on site.

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(72) **Official Soil Series Descriptions** - Descriptions and maps of soil types.

Website: *https://soilseries.sc.egov.usda.gov/osdname.asp*

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(73) **Common Wetland Soil Types in PA***

A11 Indicator - This type can be found in any soil texture. A11 applies to any depleted soil found below dark surface indicators.

(74) A11 Indicator: Significant organic accumulations.

(75) A11 Indicator: Generally, the darker and thicker the surface horizon, the wetter the site.

**Thanks to Frank Plewa of the USACE for the photos and descriptions of these soil types*

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(76) **F3 Depleted Matrix**

- Our most common wetland indicator soil
- F series are loamy and clayey soils
- Many also have an A11 indicator
- Often found along the boundaries of wetlands

(77) F3 Depleted Matrix soil profile

(78) F3 Indicator: the frequency and size of the iron concentrations (mottles) indicates the soil frequently wets and dries.

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(79) F6 Redox Dark Surface – A soil indicator commonly found in very wet hillside seeps.

(80) Iron (Fe) concentrations in the dark surface is a key element

(81) …along with organic accumulations

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(82) **F19 Piedmont Floodplain Soil Indicator**

Common in south central areas where legacy sediments have built up. Allows for brighter colors as the soils are young and developing, but usually have obvious wetland hydrology.

(83) F21 Red Parent Material Soils - Common in south central Pennsylvania in red bed areas where the parent materials or alluvium is from red shales.

(84) F21 Red Parent Material Soils: Note the iron (Fe) concentrations.

(85) F21 Red Parent Material Soils
Compare the soil profiles (left is wet F21, right is dry F21). The wet soil has a bright color an overall red cast which is allowed because the iron in the parent material is very resistant to reduction.

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(86) **F2 Loamy Gleyed Matrix**

(87) F2 soils are found in obvious wetlands near the interiors. These develop grayish blue to green colors because they are so wet.

(88) They often change color immediately upon exposure to the air. Iron (Fe) oxidizes immediately when they are wet.

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(89) **ARE THE EXITING LAWS ENOUGH?**

- Federal and state laws only go so far. They regulate impacts to the pool basin as defined by soils, hydrology, and vegetation, but neglect the **critical upland habitat**.
- There is definitely room to grow with better state laws and local ordinances to protect the upland habitat.
- We also need greater outreach by the scientific and conservation community, and more interest and engagement with landowners and the general public.

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(90) **THREATS**

Vernal pools face a laundry list of threats. Habitat loss and fragmentation are big, along with degraded upland habitat and pool water quality.

- Habitat Loss (fill and conversion)
- Fragmentation (roads, home and energy development)
- Disturbances to the Vernal Pool and it's Uplands (development, motorized vehicles, logging)
- Changes in Hydrology (ground water, flooding, drought, extreme weather events)

- Changes in Vegetation (mowing, spraying, invasive species, succession)
- Water Quality (lawn and agricultural run-off, fertilizers, herbicides, insecticides, acid rain)
- Diseases (Ranavirus and Chytrid fungus)

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(91) Another threat we are more aware of now is **climate change**. Other threats are being exacerbated by climate change. There is a growing body of scientific study showing that the life cycles and geographic ranges of plants and animals are shifting in response to changes in climate. All aspects of life in a seasonal pool depend on environmental cues and conditions related to temperature and rainfall patterns.

- amphibian migration
- egg and larval development
- adult feeding and thermoregulation
- reproductive success

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(92) To illustrate the legacy of wetland loss and degradation we have in Pennsylvania, here's a little historical fable of how **land uses change over time** impacted vernal pool habitats.

Once upon a time, there was a little cluster of four vernal pools in the forest.

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(93) Along comes a European settler who discovers this woodland that is full of wildlife. He builds his cabin here to take advantage of the good hunting.

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(94) *Fast forward 200 years...*

- The settler's cabin turned into a compound, then a small hamlet, then a town.
- One useless wet area in the woods was drained to allow for crops to grow.
- A second vernal pool was drained to make way for houses and lawns.
- The third vernal pool was excavated into a watering hole for livestock and was later stocked with fish.
- The last vernal pool remaining lost its three neighbors. It is now much more at risk to 'health' problems from poor water quality from runoff from the road, lawns, and agricultural fields.
- In this scenario at this site, the amount of breeding habitat for vernal pool animals at this site was reduced 75%. Equally important, the amount of upland habitat for the adults was also reduced 75%.
- In Pennsylvania, we have lost over half of our wetlands, and we can assume that small ephemeral wetlands were lost at an even higher rate because they weren't as well recognized or documented.

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(95) *If we don't protect vernal pools and their upland habitats, the **unique vernal pool community** is at stake. Vernal pool indicator species depend on vernal pools for successful development and survival of their young. In the mid-Atlantic region, 26% of all threatened & endangered amphibians depend upon vernal pools (Colburn, 2004).*

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(96) **Vernal Pool Conservation**

Given our historic loss of wetlands and insufficient legal protection, what else should be done? There are many way that landowners and concerned citizens can act to protect their vernal pool resources. Please note that more detailed information is available in the Vernal Pool Conservation and Management Guide. You can download this as a pdf from the Vernal Pools of Pennsylvania website.

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(97) We've established that vernal pool animals need the breeding wetland and also the surrounding upland forest. In vernal pool conservation, there are three management zones to consider

1. Vernal pool basin (or depression)
2. Vernal pool core habitat (or envelope)

3. Vernal pool upland habitat

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(98) Here is an illustration of the **Habitat Management Zones**

1. Vernal pool basin: perimeter of the pool when it is fully flooded in the spring
2. Core habitat: minimum zone from the pool edge out to 100 ft (but up to 200 ft for higher quality sites)
3. Upland habitat: minimum zone from the pool edge out to 400 ft (but up to 1000 ft for higher quality sites)

We'll discuss the recommended distances more a little later. First we'll go over definitions and recommendations for each zone.

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(99) The **vernal pool basin** is the depression on the forest floor that floods each year.

- This is where vernal pool indicator and facultative animals breed and lay their eggs. Their young hatch, feed, and develop within the vernal pool 'nursery'.
- The vernal pool basin is very sensitive to any sort of disturbance. Disturbances in the pool basin and can damage adults, juveniles, eggs, or larvae resting in the leaves and degrade the environment the animals require.
- The vernal pool depression is protected by state and federal regulations.

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(100) The **vernal pool core habitat** is the uplands immediately surrounding the pool. The condition of this zone strongly influences the condition of the pool and is important for water quality.

- Adult amphibians concentrate around a vernal pool 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.

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(101) The following **five basic management recommendations** apply to both the vernal pool basin and the core.

Number 1: Identify the pool basin and core habitat. Map the pool basin and core habitat on property maps. Flag these areas if logging activities are planned in the vicinity.

Number 2: Protect the native trees, vegetation and soils of the pool basin and core in both the wet and dry phases. Prevent soil compaction or disturbances from motorized vehicles, mountain backs, horseback riders, etc. 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.

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(102) **Number 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. Do not conduct salvage cutting or firewood collection from the basin or core.

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(103) *Downed trees provide basking sites for turtles, and smaller sticks and twigs are used as attachment sites for egg masses.*

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(104) **Number 4: Maintain good water quality.** Avoid use of pesticides, herbicides, or other chemicals. If invasive species control is needed, hand cutting and mowing (when the pool basin is dry) are the preferred methods. In the case of extensive invasive species problems, wetland approved herbicides can be used, ideally in the vernal pool dry phase.

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(105) *The vernal pool core is critical to protecting **vernal pool water quality**. This pool is degraded by the run-off it receives from a nearby road. Avoid applying salts to roads and drives in the core habitat.*

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(106) **Number 5: Retain native vegetation in the pool basin.** Vernal pools may be naturally vegetated with marshy vegetation, shrubs, and even trees. Other pools are naturally unvegetated (black leaf pools). Native vegetation in the basin and core provides the best food and shelter for wildlife. Healthy vernal pools in PA typically have trees around the pool perimeter and 100% canopy cover in the core upland habitat zone (but there are exceptions).

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(107) There are few management recommendations that apply to all species, in all situations. There are always **exceptions** so it's a good idea to seek several informed opinions.

- It is a great idea to consult with as many different experts as possible (Game Commission Private Landowner Assistance Program, Service Foresters, DCNR or Conservancy Biologists, etc.).
- Each expert will bring a different perspective based on their agency and areas of interest. Ultimately the land manager has to decide what their priorities are for the property…what species, habitats and other resources they want to promote.
- A good question might be whether to promote forest or meadow around a vernal pool.

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(108) **Openings around Vernal Pools**

- Open canopy pools happen naturally when trees die in storms, due to insect outbreaks, or fires. These pools support more wetland vegetation.
- Open canopy pools are preferred by some species (e.g. American toads, spring peepers, red-spotted newts, spring peepers, turtles)
- Clearings near vernal pools provide sunny spots where turtles can nest and lay their eggs.
- Drawbacks – open pools dry out more quickly, may experience algal blooms, and have bigger invasive species problems
- When maintaining an herbacous or low shrub vegetation in the core, don't over-do it. Mowing every few years will suffice.

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(109) Finally we have the **UPLAND HABITAT ZONE**. Outside of the breeding season, vernal pool animals live in the forests adjacent to vernal pools seeking food, shelter, and overwintering sites. They live under rocks, rotting logs, and the moist layer of leaves on the forest floor. Mole salamanders and spadefoots move into underground burrows. The terrestrial habitat also plays a role in regulating water quality.

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(110) *To recap the distances these animals are moving to their upland habitats, here is an illustration of the average distance four species of vernal pool amphibians move to and from pools. Marbleds, spotteds, jeffersons, and wood frogs move between 368 to 633 feet, **on average**, meaning some individuals move less, and others move more to find their home turf. Both adults and recently transformed juveniles must make the trek.*

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(111) Now let's discuss the nitty gritty of **UPLAND HABITAT – How Much is Enough?**

- The EPA recommends managing a 1000 foot 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 foot distance is based on scientific studies of animal movement.
- As you can see from this example, the three vernal pools in blue have lost almost all of their natural core and upland habitat to agriculture and development.

(112) UPLAND HABITAT – MANAGEING FOR AMPHIBIANS

- So now we have this **optimal upland zone designation** of 1000 feet by the EPA. But you'll notice that in this graphic from a different source, the upland protection zone is only 400 feet. This reduced zone will encompass less than 95% of the vernal pool amphibian population, but it is still much better than no upland habitat zone, and if properly managed will be beneficial to the vernal pool .
- Landowners often don't own or control all the uplands that support their vernal pool. So protection zones are by necessity a balance between our knowledge of vernal pool amphibian movement and habitat needs, and the limitations landowners face with partial ownership or competing management priorities.
- We will illustrate two distances for the vernal pool core and upland habitat zones. The smaller distance is the minimum we recommend for typical vernal pool sites. The larger distance is what we recommend for high quality vernal pools, vernal pool complexes, and sites with rare species.

(113) Here are a couple of examples of how to **apply the vernal pool management zones**.

In **Example 1**, we have an isolated vernal pool at the edge of a farm field. We know from field visits that this isn't a high quality vernal pool, so we are going to apply the minimum habitat zones of 100 feet core habitat (yellow line) and 400 feet supporting upland (red line). Notice how the supporting upland zone encompasses much agricultural land. We know that active agricultural land is not good habitat for vernal pool amphibians, so we adjust the upland habitat zone to encompass more of the nearest block of forest, and we remove the unsuitable agricultural land. The final upland habitat zone is shown in orange.

(114) In **Example 2,** we have a cluster of high quality vernal pools that support a population of spotted turtles. We apply the maximum buffer sizes to the vernal pool complex and merge overlapping polygons. We create corridors in the core zone to make sure outlier pools are connected to the main cluster. We adjust the upland zone to include more forest and less farm and quarry land, keeping the total area the same.

(115) Now let's look at management recommendations for the **upland habitat.** The key recommendations are nearly the same as for the vernal pool basin and core habitat. The main difference is that the upland habitat is open to limited disturbance, such as timber removal. And since limited timber harvest can be sustainable in the vernal pool upland habitat, we add recommendations related to forestry best management practices and the protection of migrating amphibians. You can find forestry BMPs outlined in more detail in the Vernal Pool Conservation and Management Guide.

It is a really great idea for landowners to work with a Service Forester to **develop a timber harvest plan**. The plan should strive to maintain at least 50% tree cover in the upland habitat zone, implement best management practices for erosion and siltation, and identify potentially problematic invasive species that should be monitored and controlled.

(116) It's especially important to **prevent and repair tire ruts**. Amphibians migrating to vernal pools in the spring can get confused when they encounter flooded tire ruts. Instead of continuing to the vernal pool, they may lay their eggs in these dead end ruts that dry too quickly and may get driven over. The best way to avoid soil compaction and rutting is to conduct timber harvests when the soils are frozen or dry.

(117) As in the vernal pool basin and core, it's important to keep **dead & downed woody material** in the upland habitat as well. Limit salvage cutting and the collection of firewood to maintain an ongoing, abundant supply of fallen wood.

(118) We have discussed all of these, but this slide summarizes some of the **key recommendations** for all three management zones.

- Protect the vernal pool basin and core habitat from any disturbances
- Maintain a closed tree canopy in the vernal pool core.
- Maintain at least a 50% canopy cover in the upland habitat
- Maintain natural litter in all habitat zones - avoid significant shifts in forest cover types and control invasives
- Leave dead standing trees and fallen logs and branches in all habitat zones
- Protect the forest floor from soil compaction and tire ruts. Conduct timber harvest (upland habitat only) when soils are frozen or under dry conditions
- Protect water quality: minimize the use of chemicals and prevent run-off

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(119) **Habitat fragmentation** is a problem that greatly impacts vernal pool communities.

- Impacts are direct because smaller forest patches have limited resources for vernal pool amphibians. Roads and other barriers between pools and their uplands increase the odds of amphibian mortality during migration to and from a pool.
- Impacts are also indirect: Some common species such as skunks, raccoons, crows, cow birds, and even feral cats, do very well in fragmented habitats. As their numbers grow they increasingly prey upon and displace vulnerable species.

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(120) **Road mortality** is a big problem for amphibians moving to and from their breeding habitats. The migration of adults to vernal pools in the spring is a very vulnerable time because the movement is so concentrated over a period of a few peak rainy nights.

Posting signs helps increase awareness and encourage drivers to slow down and pay attention. Some communities work with their local government to close traffic on roads that pass near vernal pools during the peak migration months (typically February and March).

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(121) When road closing isn't possible, groups of volunteers can **move animals** across the road on rainy nights.

- The migration of salamanders to seasonal pools is in response to environmental cues. One study showed that salamander migrations started when evening rains occurred with moderate temperatures over 44.6 F during the day and over 40 F at night (Hulse 2001).
- In Pennsylvania, migrations can start as early as the end of February and as late as the beginning of April depending on local temperatures and rainfall.
- This may seem obvious but it bears mentioning. When you encounter frog, salamander, snake or turtle crossing the road and you can safely provide an assist, **Move it across the road in the direction it is already moving!**
- Even if the animal is headed away from the nearest wetland... it is going that way for a reason! Perhaps it's a box turtle looking for a dry sunny nesting site, or an American toad moving to its summer upland home.

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(122) **HEAD CUTS**

Vernal pools are typically isolated basins with no permanent inlet or outlet. But sometimes wetlands that meet most but not all of the typical vernal pool criteria will still support vernal pool indicator species. For example, ephemeral pools that form on floodplains may occasionally get flooded by a nearby stream. But with episodic drying, any fish that are introduced to the pool are eventually eliminated. Some vernal pools may have a have significant groundwater seepage influence, causing water to in and out on a seasonal or semipermanent basin. Head cuts are a potential threat that can occur in vernal pools with inlets or outlets. A headcut is a nick point in the stream as the elevation of the bottom of the stream adjusts to a disturbance that may be natural or manmade in origin. Creating or removing a stream dam or changing the course of a stream

channel (e.g. straighting) are several ways in which a head cut can be initiated. Headcuts can be recognized as an overly steep riffle zone or a small waterfall in the stream. Headcuts can move up a stream or gully overtime, deepening the channel and sending extra sediments downstream. A headcut above a vernal pool will send excess sediments into the pool, causing the bottom of the pool to fill with fine particles over time. A headcut below a vernal pool can advance into the wetland and drain it.

This photo shows a very nice floodplain vernal pool that supports abundant wood frogs and fairy shrimp. This pool has a small outlet that flows into a nearby stream. There is a headcut located downstream on the outlet that is poised to impact this vernal pool.

(123) The photo on the upper left shows the outlet end of the vernal pool. The bottom right photos shows the headcut that is located a short distance downstream along the vernal pool outflow channel.

(124) A short distance downstream on this same stream floodplain we found another headcut below the confluence of the outflow of a constructed pond and a small floodplain wetland (top left photo).

The bottom right photo shows where that the headcut will soon advance up both branches. It will stop at the culvert for the constructed pond, but will progress unhindered into the floodplain wetland, eventually draining it.

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(125) **DISEASES** are increasingly recognized as serious threats to wildlife populations. The two main players in vernal pool ecosystems are the Ranavirus and the Chytrid Fungus (*Batrachochytrium dendrobatidis*).

Both of these diseases have been documented in Pennsylvania. They can cause large die-offs among both reptiles and amphibians. Outbreaks may be induced by an accumulation of environmental stresses including habitat degradation or use of pesticides. Spores and contaminated soils can be spread by wildlife, but also by scientisits, outdoor recreationists, and landowners who carry spores and contaminated soils on their boots, in the tread of tires, or on equipment.

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(126) Ranavirus has been implicated in severe die-offs among vernal pool species. Wood frog larvae have the highest mortality (≥ 95% following exposure) and infection rates of northeast amphibians. Vernal pools may be the main source of the disease for other affected species such as box turtles.

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(127) 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.

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.

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(128) **Dilute Bleach or Nolvasan Technique**

- 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 equipment with water and scrub away loose dirt, vegetation, algae, etc.
- Spray all equipment that has contacted water with a disinfectant (see next slide for options).
- Rinse with plain water and let dry (in the sun if possible) for 5 minutes

Learn more at: http://www.northeastparc.org/products/pdfs/NEPARC_Pub_2014-02_Disinfection_Protocol.pdf

(129) **Disinfectant Solutions**

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 (bleach:water) for a 3% solution using 6% concentration household bleach*

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.*

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(130) **Applying the Disinfectant**

- Easy Application: Mix disinfectant solution in a 1 gallon pump spray bottle. Fill a second pump sprayer (2 gallons works well) with water.
- Stand in a shallow, sturdy tub and spray disinfectant onto boots. Use a long handled brush to scrub the bottom and sides of boots. Excess spray creates a layer of solution in the tub to help soak the bottom of boots.
- Place other gear into the disinfectant tub. Add more solution as needed to effectively clean remaining gear.
- After 5 min, step into an empty tub. Rinse boots with water. Move other gear from the disinfectant tub to the rinse tub and flush with water.

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(131) **Applying the Disinfectant** – Photo of a portable clean-up station

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(132) In addition to these recommendations, there are many other things land owners and land managers can do to benefit wildlife. The **Woodcrafting for Wildlife** website is a great resource you can utilize to get plans on how to build nest boxes and other structures.

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(133) **Professional and Citizen Scientists** can really make a difference by gathering and sharing data on vernal pool habitats and species. There are several different programs out there.

You can **register a pool** with the PA Natural Heritage Program**.** Registry forms and instructions can be downloaded from the Vernal Pools of PA website. You can submit the forms via snail mail or email.

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(134) **RESULTS OF THE REGISTRY**

- Increases understanding of seasonal pools
- Identifies high quality vernal pool sites
- Documents the variety of types of seasonal pool communities
- Helps landowners manage their vernal pool resources
- Builds a database of seasonal pool locations and associated wildlife throughout Pennsylvania
- *Reduces accidental destruction of vernal pools which might be overlooked during permit reviews.*

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[135] You can **REPORT RARE SPECIES** to the PA Natural Heritage Program. The rare species listed below may be found around vernal pools:

Jefferson Salamanders
Blue-spotted Salamanders
Marbeled Salamanders
Eastern Spadefoots
Spotted Turtles
Wood Turtles
Box Turtles

- *Minimum information required*: Date of observation, location (GPS point preferred), observer name, photos of the animal and habitat
- *Bonus*: Related observations and field notes.
- *Must have*: landowner permission to collect data on private property.

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[136] You can also report your findings of any ***common or rare*** reptile and amphibian to **The Pennsylvania Amphibian and Reptile Survey (PARS)**. This is a Partnership between Mid-Atlantic Center for Herpetology (MACHAC) and the PA Fish and Boat Commission.

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[137] Contacts for more information
[138] State Resources
[139] Local Resources
[140] Federal Resources – Many Programs!!
[141] NRCS Programs
[142] Great Websites
[143] References
[144] Photo acknowledgements
[145] Workshop & grant acknowledgements
[146] Links to a downloadable PDF of the presentation and a webinar recording
[147] The End
