# 1 Introduction to Seasonal Pools

## 1.1: Introduction

Seasonal pools are dynamic habitats that have cycles of standing water (Plate 1-1). These unique pools fill with rainwater, surface runoff, snowmelt, or groundwater in the fall, winter, or spring and may completely dry out by the summer. Seasonal pools are referred to by a variety of names, including vernal pools, spring pools, ephemeral wetlands, autumnal pools, woodland ponds, and temporary ponds. Seasonal pools provide important ecological services to the mid-Atlantic region (Box 1-1).

Photo: Tim Maret

**Plate 1-1. Mid-Atlantic seasonal pool.** This seasonal forest pool is located in south-central Pennsylvania.

Seasonal pools' periodic dry-downs exclude permanent populations of predatory fish. This reduced-predator environment provides critical breeding habitat for certain species of amphibians whose eggs and larvae would be at increased risk of predation in more permanent waters. In the mid-Atlantic region, seven species in the mole salamander family (*Ambystoma spp.*), the wood frog (*Rana sylvatica*), and the toad-like eastern spadefoot (*Scaphiopus holbrookii*) depend upon seasonal pools for their successful reproduction (Plate 1-2). The fairy shrimp (*Eubranchipus spp., Streptocephalus sealii*) and other invertebrates use seasonal pools for their complete life cycle (Belk, 1975). Some of the species that rely on seasonal pools for optimal breeding are rare, threatened, or endangered in parts of their mid-Atlantic range, such as the eastern tiger salamander (*Ambystoma tigrinum tigrinum*) that is state-listed as endangered in Delaware, New Jersey, and Virginia. In the mid-Atlantic region, 26% of all state-listed threatened and endangered amphibians are dependent on seasonal pools.

**Box 1-1**
**Ecological services provided by seasonal pools**

☑ **Important Breeding Habitat**
Supply essential breeding grounds for amphibians, including rare, threatened, or endangered species.

☑ **Unique Invertebrate Community**
Support a diverse invertebrate fauna, including rare species.

☑ **Support of Aquatic and Terrestrial Food Webs** Supply food (amphibian and invertebrate biomass) to wildlife including amphibians, turtles, snakes, birds, and mammals. Serve as "stepping-stones" across the landscape for wetland- or aquatic-dependent organisms.

Photo: Steven M. Roble

**Plate 1-2. Spotted salamander (*Ambystoma maculatum*).** Spotted salamanders are characteristic members of seasonal pool biological communities of the mid-Atlantic region.

Seasonal pools are inextricably linked to their surrounding terrestrial landscape and support aquatic and terrestrial food webs. Bordering and in-pool vegetation provide organic material to seasonal pools. Bacteria, algae, and fungi colonize this vegetative matter, supplying food for invertebrates and developing tadpoles. Invertebrates and amphibian larvae are, in turn, prey for predatory invertebrates and larger-sized amphibian larvae. Amphibians and some insect species eventually metamorphose, leaving the pools and providing a major source of biomass (i.e., food for other wildlife) to the surrounding terrestrial habitat.

Seasonal pools also serve as "stepping-stones" through the landscape for animals moving among wetlands. By providing feeding and watering opportunities, they support local and regional biodiversity. Developing amphibian larvae and invertebrates in the pools are important prey for visiting turtles, snakes, birds, and mammals.

## 1.2: Purpose and Scope

Seasonal pools support biological diversity by providing important habitat. However, the same qualities that make seasonal pools uniquely valuable to wildlife render them especially vulnerable to human disturbance. Their small size, surficial hydrologic isolation, lack of fish populations, and impermanent water make them less likely to attract attention for conservation. Also, they generally are not protected by state or federal regulations. Many seasonal pools may not meet the strict hydrologic, soil, and vegetation requirements to be classified as wetlands at the federal or state level (see Cowardin et al., 1979) or may fall beneath the minimum size requirements to be protected under wetlands regulatory programs.

The United States has lost more than half of its original acreage of wetlands due to draining, filling, dredging, flooding, and leveling associated with land development and agriculture (Dahl, 1990). Although seasonal pools are not comprehensively included in studies of wetland loss, partly because methods that inform these studies do not work as well for identifying relatively small seasonal pools, it is highly likely that seasonal pools have been lost at a rate equal to or exceeding that of the larger wetlands included in these studies. The smaller the wetland or pool, the less likely it is to fall under the jurisdiction of federal or state wetlands regulations and the easier it can be filled-in or drained. It is likely that pools continue to be lost at a rapid pace in the mid-Atlantic region.

The purpose of this publication is to introduce readers to seasonal pool ecology and conservation in the mid-Atlantic region, which is comprised of Delaware (Del.), Maryland (Md.), New Jersey (N.J.), Pennsylvania (Pa.), Virginia (Va.), West Virginia (W. Va.), and the District of Columbia (D.C.). For many readers, seasonal pools will be a new subject area or serve as a new synthesis of ecological concepts.

This publication presents a working definition for seasonal pools, describes landscape settings and vegetative communities of seasonal pools, and explores the seasonal pool ecosystem. Following an introduction to seasonal pools and their fauna, conservation challenges facing resource managers and land-use planners wanting to conserve seasonal pools are considered. The authors then put forward recommendations for future directions in the management of seasonal pool resources in the mid-Atlantic region.

A pictorial Field Guide to mid-Atlantic seasonal pool amphibians, invertebrates, amphibian larvae, and amphibian egg masses is provided to aid readers in the field. The Appendices present information on techniques and references for surveying seasonal pools.

## 1.3: Definition of "Seasonal Pool"

In the mid-Atlantic region and elsewhere, seasonal pools display tremendous diversity in terms of landscape setting, surrounding vegetative community, hydrological source (groundwater, surface runoff, rainfall, snowmelt), hydroperiod, and faunal communities, among other variables. The definition of a seasonal pool must be broad enough to encompass this variation.

For the purposes of this publication, we define seasonal pools based on four distinguishing features: surficial hydrologic isolation, periodic drying, small size and shallow depth, and distinctive biological community (Box 1-2; *cf.* Wiggins et al., 1980, Calhoun and Klemens, 2002; Zedler, 2003; Calhoun and deMaynadier, 2004; Colburn, 2004).

**Box 1-2**
**Definition of a seasonal pool**

☑ **Surficial Hydrologic Isolation**
No permanent surface water connections to other water bodies.

☑ **Periodic Drying**
Water levels generally fluctuate by season; pools experience drying or lowered water levels on a regular basis (frequency ranges from every year to just drought years).

☑ **Small Size and Shallow Depth**
Small area and shallow depth compared to other productive aquatic habitats (such as lakes and types of wetlands).

☑ **Distinctive Biological Community**
Support animals that are adapted to seasonal pool drying; support the breeding of animals that reproduce optimally without fish populations; do not support permanent populations of predatory fish.

### Surficial Hydrologic Isolation

Isolation from other surface waters is one of the defining characteristics of seasonal pools. The lack of permanent surface water connections protects pools from successful invasion by predatory fish. There is a range in the degree of isolation of pools, however. Some pools are completely surrounded by terrestrial environment with the nearest aquatic habitat a half-mile or farther away, while other pools may occur within a larger wetland complex. Seasonal pools, despite being isolated from permanent surface water connections, are very much connected to the greater hydrology and ecology of the landscape. Isolated pools may receive their water from rainwater, surface water run-off, snowmelt, subsurface flow, groundwater, and possibly intermittent streams (Tiner, 2003b; Whigham and Jordan, 2003; Winter and LaBaugh, 2003). Seasonal pools are connected biologically to both aquatic and terrestrial habitats by the movement of animals (Gibbons, 2003; Leibowitz, 2003).

### Periodic Drying

Seasonal pools are water bodies that experience alternating periods of filling and drying. Pools in the Northeast, including the mid-Atlantic region, typically begin to fill with water in mid-autumn to early winter due to the onset of fall rains and decreased water uptake by plants (i.e., the rate of evapotranspiration by trees lessens due to leaf senescence) (Phillips and Shedlock, 1993; Brooks, 2004). However, some seasonal pools may not begin filling until late winter or early spring. Most seasonal pools reach their maximum depth and size in the spring due to snowmelt and spring rains. As spring and summer progress with increasing temperatures and rates of evapotranspiration by trees and other vegetation, water levels decrease and pools may dry completely (Plate 1-3; Fig. 1-1; Brooks, 2004).


Photos: USGS PWRC

**Plate 1-3. A seasonal pool's wet stage and dry stage.** A seasonal pool in Rock Creek Park, D.C., is shown (A) in spring when the pool is full of water and (B) in fall when the pool has dried.

Seasonal pools display considerable variation in hydroperiods (length of time that a pool is filled with water) and water levels (depth at which the pool is filled) across the landscape (Williams, 1987; Semlitsch, 2000). The hydroperiod is the most powerful abiotic factor determining the composition of a seasonal pool community (Wiggins et al., 1980; Skelly, 1997; Morey, 1998). The differences between pools are due to regional climatic patterns and characteristics of each pool's depression and watershed (Brooks and Hayashi, 2002; Winter and LaBaugh, 2003). In addition to these inter-pool differences, a seasonal pool has intra-pool hydrologic variability, with varying hydroperiods and water levels over time, depending upon the season and the weather conditions (Plate 1-3; Fig. 1-1; e.g., Rowe and Dunson, 1993; Semlitsch et al., 1996; DiMauro and Hunter, 2002).

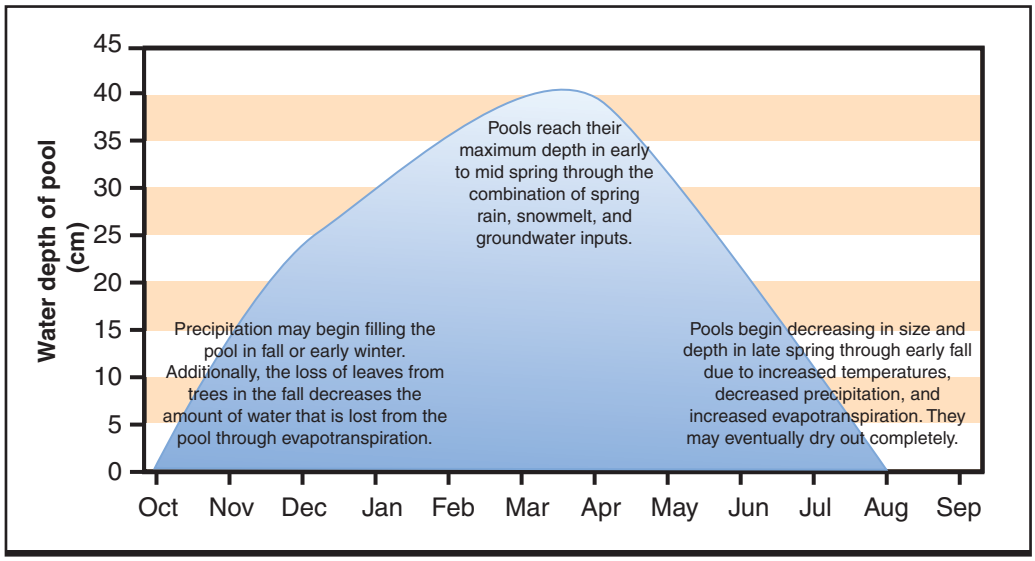



**Figure 1-1. Hydrograph of a seasonal pool.*** The water depth of a seasonal pool is shown according to month of year. This hydrograph is meant to reflect a typical seasonal pool; individual pools will have different depths and dates of filling and drying due to the characteristics of pool depressions and precipitation and temperature patterns.

** Approximate water depths and dates were derived from Brooks (2004), Rowe and Dunson (1993), and datasets of the U.S. Geological Survey Amphibian Research and Monitoring Initiative - Northeast (USGS ARMI-NE, unpublished data).*

The umbrella term, "seasonal pool," that will be primarily used in this publication, may be further divided into three general types according to length of hydroperiod, which may provide insight into their respective biological communities: ephemeral pools, annual pools, and semipermanent pools (Box 1-3). Due to differences in precipitation and weather from year to year, pools have different durations and timing of flooding from one year to the next. Thus, the designation of a pool type based on hydroperiod is for provisional descriptive purposes only.
Pools with hydroperiods of less than two months during years of average rainfall are "ephemeral pools." They are formed by intense periods of precipitation. Ephemeral pools may be especially valuable to species of clam shrimp (Class Branchiopoda) and other invertebrates as well as the reproduction of eastern spadefoots (*Scaphiopus holbrookii*).

**Box 1-3**
**Types of seasonal pools based on hydroperiod**

**Ephemeral Pools**
Formed by intense periods of precipitation; hydroperiods less than two months.

**Annual Pools**
Dry annually in typical years; hydroperiods from 2 months to 12 months.

**Semipermanent Pools**
Undergo seasonal fluctuations in water levels; do not dry annually; hydroperiods of greater than 12 months.

Pools that dry annually and have hydroperiods of 2 months to 12 months are "annual pools." The species composition of an annual pool community may be different depending upon the length of the hydroperiod.

At the other end of the spectrum, pools that do not dry on an annual basis and have hydroperiods of greater than 12 months are "semipermanent pools." They still undergo significant seasonal fluctuations in water levels and dry in years of relatively low precipitation. Their surficial hydrologic isolation and periods of very shallow and anoxic waters still preclude permanent populations of predatory fish, thus they may support seasonal pool-dependent organisms. However, they may not support organisms that depend upon complete dry-downs, such as fairy shrimp. In addition, they may harbor higher populations of predators, such as aquatic salamanders and large-sized invertebrates (Semlitsch et al., 1996; Skelly, 1997; Semlitsch, 2003).

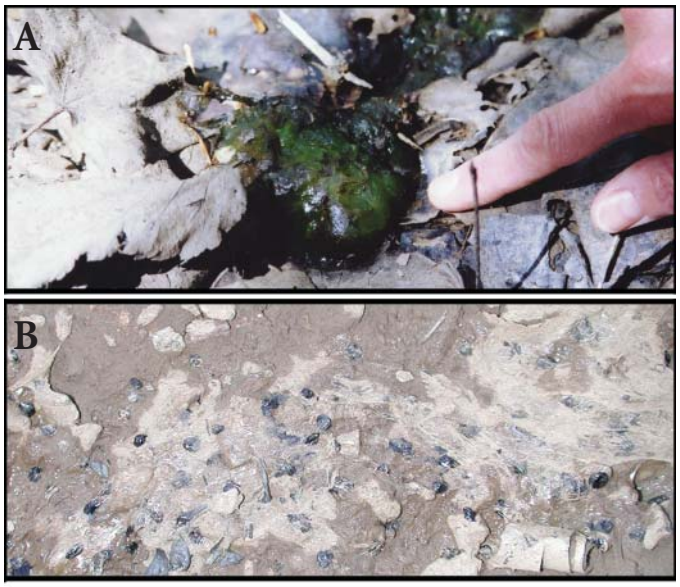
## Small Size and Shallow Depth

Most seasonal pools are very small compared to ponds and lakes, which makes them more vulnerable to pressures from development but does not make them less valuable from a biological standpoint. Their relatively small area and shallow depth are what facilitates their dry periods or drawdowns (Brooks and Hayashi, 2002). Their shallow depth allows pools to warm rapidly, particularly important for amphibians breeding during late winter and early spring (Colburn, 2004).

According to the New Jersey Division of Fish and Wildlife, most seasonal pools in New Jersey are less than 0.25 acres (1,012 $m^2$) in area (Tesauro, 2004). On the Delmarva Peninsula, seasonal pools are reported to be typically less than 0.4 acres (1,619 $m^2$) in size (Phillips and Shedlock, 1993). Many pools in the mid-Atlantic region are much smaller than these high-range figures suggest. In 2004, 134 seasonal pools of natural origin with standing water and containing wood frog and/or spotted/blue-spotted salamander egg masses were surveyed at National Parks and National Wildlife Refuges in the mid-Atlantic as part of the USGS ARMI-NE program. Pool area (maximum length x maximum width) averaged 0.09 acre (379 $m^2$) and ranged from 54 $ft^2$ to 1.1 acres (5 to 4,350 $m^2$), with 78% of the pools less than 0.1 acre (400 $m^2$). Pool maximum depth averaged 15.4 inches (39 cm) and ranged from 2.8 to 78.7 inches (7 to 200 cm), with 69% of the pools less than or equal to 15.7 inches (40 cm) maximum depth (USGS ARMI-NE, unpublished data).

## Distinctive Biological Community

Seasonal pools of the mid-Atlantic region support characteristic communities of animals due to their unique hydrology and their lack of permanent populations of predatory fish. Many seasonal pool inhabitants lack defenses against predatory fish, and thus are primarily restricted to seasonal pools (Wilbur, 1980; Kats et al., 1988). For example, larvae of species of amphibians that breed in seasonal pools may lack the ability to detect and evade fish by using chemical cues and may be more palatable as prey to fish as compared to species of amphibians that typically breed in permanent waters (Kats et al., 1988). Fish predation may annihilate the entire brood of larvae of these species, resulting in complete reproductive failure (Ireland, 1989). However, not all species of fish pose direct risks to seasonal pool-breeding amphibians; for example, some fish species feed primarily on plankton (Hecnar and M'Closkey, 1997).




Photos: USGS PWRC

**Plate 1-4. Seasonal pools drying before metamorphosis.** Seasonal pools may dry before metamorphoses of amphibians are complete. (A) A spotted salamander (*Ambystoma maculatum*) egg mass remains in a dry seasonal pool in Rock Creek Park, D.C. (B) Wood frog (*Rana sylvatica*) tadpoles are left behind when a pool dries up in Shenandoah National Park, Va.

Seasonal pool species display structural, physiological, or behavioral adaptations to survive and/or reproduce in these temporary waters (Wiggins et al., 1980; Wilbur, 1980; Williams, 1987). Amphibians and some species of invertebrates metamorphose and leave the pool before it dries. Certain species of invertebrates lay eggs that survive the dry period; larvae or adults of some species may burrow into the pool bottom. However, when there is little rain in the spring, a pool can dry out too quickly, causing embryos and amphibian larvae to become desiccated and die (Plate 1-4; Shoop, 1974; Semlitsch et al., 1988; Rowe and Dunson, 1993; Skelly, 1997; Morey, 1998; DiMauro and Hunter, 2002).

Seasonal pools provide optimal breeding habitat for nine species of amphibians across the region, including seven species of mole salamanders in the family Ambystomatidae as well as two anuran species: wood frog and eastern spadefoot (see Section 3 and the Field Guide for descriptions and photographs of these animals).

Certain invertebrate taxa are common among seasonal pool biological communities, including crustaceans, mites, and three insect groups (true bugs, beetles, and midges) (Williams, 1987; Brooks, 2000; Colburn, 2004). The fairy shrimp is a characteristic member of some seasonal pool biotic communities; seasonal pools are the primary habitats in which fairy shrimp species of the mid-Atlantic region occur.

Depending on the weather, there may be years when little or no breeding activity occurs in a pool (Semlitsch et al., 1996). However, seemingly "empty" pools may still support tremendous biodiversity in years with favorable precipitation and temperature patterns.

Seasonal pools may or may not be vegetated. Although in-pool vegetation is not essential for their role as important animal habitat, some seasonal pools may support rare or endemic species of vegetation, such as the Virginia sneezeweed (*Helenium virginicum*), a state-listed threatened plant endemic to sinkhole ponds of Virginia. More research is needed to catalog these pool-dependent species of flora.