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Forestry Habitat Management Guidelines for Vernal Pool Wildlife

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While every attempt has been made to solicit input from the individuals and organizations listed above, their acknowledgment does not imply consent or endorsement with every component of Forestry Habitat Management Guidelines for Vernal Pool Wildlife. Their acknowledgment does imply that significant contributions were forthcoming from a diversity of forest natural resource interests, helping to ensure the production of a science-based product accessible to a wide range of user groups.

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FOREWORD

HABITAT MANAGEMENT GUIDELINES (HMGs) are recommended techniques for conserving wildlife habitat values. The recommendations in this document will aid in protecting wildlife associated with vernal pools in a managed or "working" forest landscape. In such landscapes forest canopy disturbance is followed by renewed forest growth with subsequent recovery and improvement of habitat for vernal pool amphibians. This is in contrast to areas where habitat is being permanently converted by development, roads and associated impervious surfaces. A companion document, *Best Development Practices: Conserving pool-breeding amphibians in residential and commercial developments in the northeastern U.S.* (Calhoun and Klemens 2002), should be consulted by land owners and developers working in these developing landscapes. Both the vernal pool HMGs and Best Development Practices were fashioned with the participation of state and federal agencies, scientists, resource managers, and members of the forest management and development communities.

PREFACE

THESE HABITAT MANAGEMENT GUIDELINES (HMGs) are the product of extensive collaboration among a variety of stakeholders, including state and federal agencies, members of the forest management community, conservation organizations, university ecologists, and others. It is only through multi-stakeholder initiatives such as this that conservation science can effectively be integrated into land management practices. The Wildlife Conservation Society is pleased to have the opportunity to publish the results of this collaborative effort. Although the HMGs were originally prepared for use in Maine, the principles and techniques within this document are applicable throughout the northeastern United States and beyond.

The HMGs provide mechanisms for maintaining vernal pool biodiversity in forested landscapes, especially in the commercially harvested forests of northern New York and New England. Therefore, this document is an excellent companion to the Wildlife Conservation Society's MCA Technical Paper 5, which addresses vernal pool conservation in suburban and exurban settings. Together, these publications provide techniques and recommendations that can help to maintain functioning vernal pool landscapes throughout the Northeast—from metropolitan regions to the wilds of northern New England.

PART I

Vernal Pool Ecology and Conservation

WHAT IS A VERNAL POOL?

VERNAL POOLS ARE WETLANDS of great interest to ecologists because, despite their small size and simple structure, they are often characterized by high productivity and specialized animal communities (Skelly et al. 1999, Semlitsch 2000). Within the last decade, interest in vernal pools increased dramatically because of well-publicized, world-wide declines of amphibians, many of which breed in vernal pools or other small wetlands (Pechmann et al. 1991, Lannoo 1998).

Photo: MDIFW

Woodland Pool

Vernal pools are small (usually less than an acre), seasonal wetlands that lack perennial inlet or outlet streams and have no permanent fish populations. During the wettest seasons of the year – spring and often fall – vernal pools are small vegetated or unvegetated bodies of water, while in dry seasons they may only be recognizable as an isolated depression in the forest floor. The duration of surface flooding, known as hydroperiod, varies depending upon the pool and the year, with hydroperiods ranging along a continuum from less than 30 days to more than a year (Semlitsch 2000). Some frogs and salamanders, along with certain invertebrate species (insects and shrimp), have adapted to breed in shorter hydroperiod wetlands to avoid competing with fish. A wide variety of other wildlife species also use vernal pool habitats, including several endangered and threatened species.

RECOGNIZING CANDIDATE VERNAL POOLS FOR THE HABITAT MANAGEMENT GUIDELINES

Indicator Species Approach

The Habitat Management Guidelines (HMGs) in this document are intended for application only to those naturally occurring vernal pools that show evidence of *significant* breeding activity by Maine's vernal pool amphibian indicator species: wood frogs (*Rana sylvatica*), spotted salamanders (*Ambystoma maculatum*), blue-spotted salamanders (*A. laterale*) and four-toed salamanders (*Hemidactylium scutatum*; see Figure 1). Documenting "significant" breeding activity is a relative determination, ultimately made by individual landowners and managers. For purposes of guidance, we recommend the HMGs be implemented, minimally, at those pools hosting breeding evidence by:


Photo: Malcolm Hunter, Jr.
Wood Frog

a) two or more indicator species (evidence may include: mating adults, spermatophores [salamander sperm packets], egg masses, or larvae) or

b) an abundance (> 20 egg masses) of one of the indicator species.

Landowners and managers using the indicator species approach are encouraged to obtain a copy of the "Maine Citizen's Guide to Locating and Documenting Vernal Pools" (Calhoun 2003) or "A Field Guide to the Animals of Vernal Pools" (Kenney and Burne 2000).

Habitat Recognition Approach

In many instances landowners, resource managers, and loggers may be unable to document vernal pools using an indicator species-based definition if they are not working in the field at the time indicator species are breeding, or if they are not familiar with field identification of the indicator species. For this reason, it is important to recognize potential vernal pools for protection using habitat-based attributes. In particular, look for:

Size and Isolation: Small wetlands (typically less than 2 acres; often as small as 0.1 acres or less), isolated from streams. If consulting National Wetland Inventory (NWI) maps, look for small isolated wetlands (those not permanently hydrologically connected to streams or lakes), often designated as PUB/POW (open water), PSS (shrub swamp), PFO (forested wetland), or more rarely, PEM (marsh).

Water Depth and Hydroperiod: Small wetlands that hold at least 12 inches of water at spring maximum and contain standing water for two and one-half months or more during the spring.

Dry Season Evidence of Temporary Flooding: Topographic depressions in the forest floor with compacted leaves, darkened by waterstains or a film of sediment. Water stains or siltation marks can also occur on trees, woody debris, rocks, or other plants in the depression or along its perimeter. Also look for wetland plants (e.g., sphagnum moss, certain ferns or dense grass or sedge species, and wetland shrubs) growing in a forest floor depression. A search of the leaf litter of an active vernal pool depression may yield fingernail clams and the shells or casts of other aquatic insects – further evidence of sufficient seasonal flooding.

If you choose to make determinations based on presence of the indicator species, pools must be inventoried in the spring (mid March to late April in southern Maine; mid April to late May in central and northern Maine). Be aware, however, that vernal pool indicator species may not breed every year. Therefore, pools that do not support indicators one year may support them the following year. Land managers may elect to implement the vernal pool HMGs around pools without current evidence of indicator species with the expectation that, in the future, the pool may function as an active breeding site.

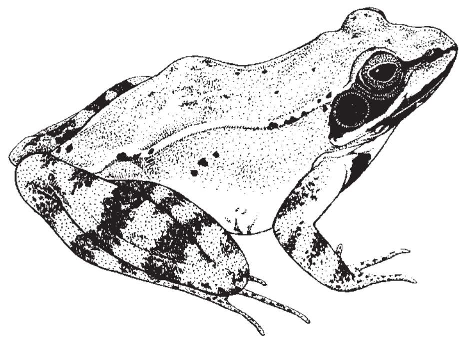
Photo: Phillip deMaynadier

Documenting a Significant Vernal Pool

FIGURE 1

Amphibians and Reptiles of Maine's Vernal Pools

INDICATOR SPECIES

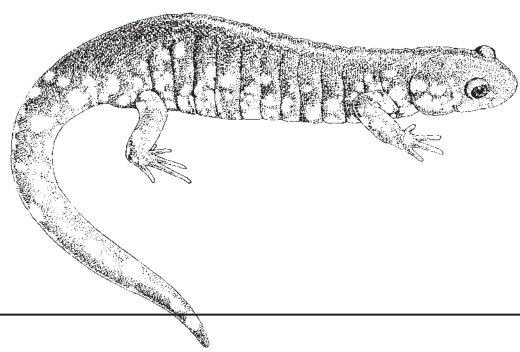


Wood Frog

(Rana sylvatica)

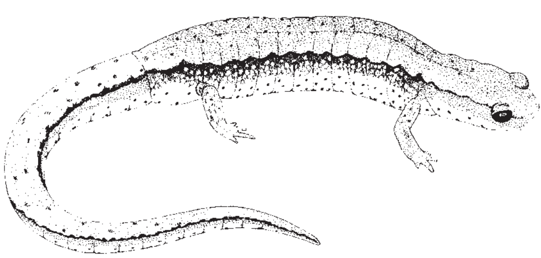
Spotted Salamander

(Ambystoma maculatum)



Blue-spotted Salamander

(Ambystoma laterale)



Four-toed Salamander

(Hemidactylium scutatum)

Status: State Special Concern

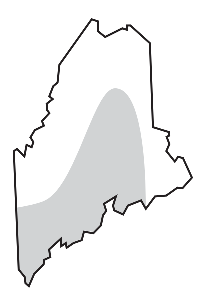
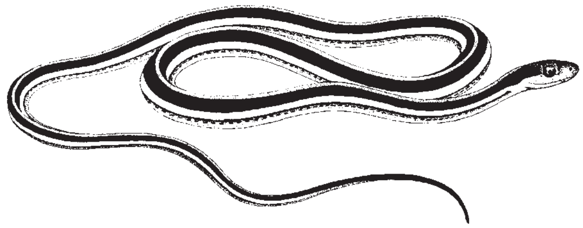


FIGURE 1

Amphibians and Reptiles of Maine's Vernal Pools

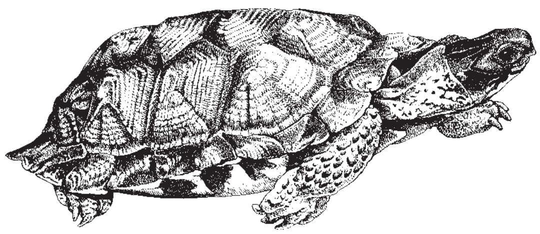
RARE SPECIES



Ribbon Snake

(Thamnophis sauritus)

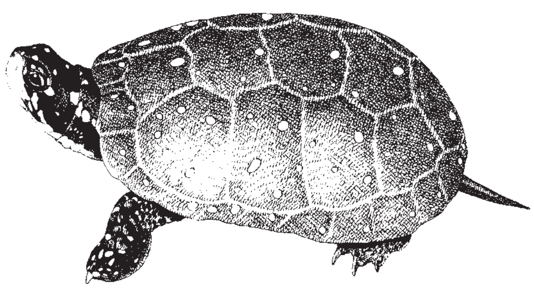
Status: State Special Concern



Wood Turtle

(Clemmys insculpta)

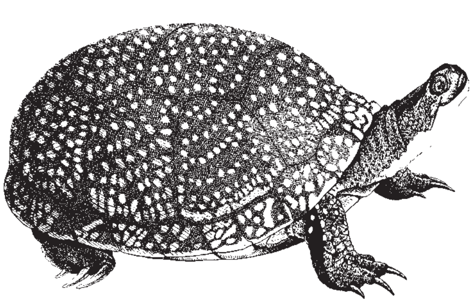
Status: State Special Concern



Spotted Turtle

(Clemmys guttata)

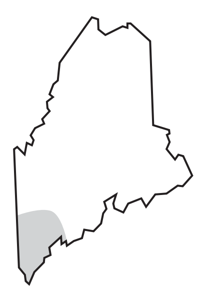
Status: State Threatened



Blanding's Turtle

(Emydoidea blandingii)

Status: State Endangered



WHY DO VERNAL POOLS NEED SPECIAL ATTENTION?

Current federal and state wetland regulations do not adequately protect small wetlands, including vernal pools, or isolated (non-riparian) forested wetlands where vernal pools often occur. Despite their small size, these pools provide critical habitat for a diversity of wildlife species. Four key reasons for conserving vernal pools include the fact that they provide:

1. Special breeding habitat

Vernal pools lack predatory fish populations thus providing optimal breeding habitat for Maine's five vernal pool indicator species: spotted, blue-spotted, and four-toed salamanders, wood frogs, and fairy shrimp (a small crustacean). Wood frog egg masses are vulnerable to fish predation because they lack the toxic compounds and mechanical deterrents that characterize the egg masses of many aquatic amphibians that regularly breed in permanent pools with fish (Henrikson 1990, Crossland 1998). The firm outer jelly coat present in blue-spotted and spotted salamander egg masses is an effective barrier to predation by most fish species. However, the larvae of wood frogs and salamanders are both vulnerable to fish predation because of a lack of defensive adaptations (Kats et al. 1988). While the indicator amphibians occasionally breed in other wetland types, survival and recruitment of juveniles is often limited or absent in wetlands with fish (Petranka 1998). Fairy shrimp are thought to breed exclusively in vernal pools (Kenney and Burne 2000).


Photo: Phillip deMaynadier

Spotted Salamander

2. Rare species habitat

Worldwide declines in amphibian and reptile populations have attracted increasing attention to herptile conservation (Alford and Richards 1999, Gibbons et al. 2000). Many vernal pool species in the northeastern United States are state-listed. For example, the blue-spotted salamander is a Species of Special Concern in Vermont, Massachusetts and New York, and the pure diploid population is listed as Threatened in Connecticut. Conserving vernal pools will help to keep blue-spotted salamanders common in Maine. Blanding's turtles (*Emydoidea blandingii*, Maine Endangered) and spotted turtles (*Clemmys guttata*; Maine Threatened) use vernal


Photo: MDIFW

Spotted Turtle

pools extensively in southern Maine. The ringed boghaunter dragonfly (*Williamsonia lintneri*; Maine Endangered) and four-toed salamander (*Hemidactylium scutatum;* Maine Special Concern) can both be found breeding in acidic, sphagnum-filled vernal pools. Wood turtles (*Clemmys insculpta*; Maine Special Concern) use vernal pools near streams and rivers extensively while foraging in the spring. Among Maine's plants, featherfoil (*Hottonia inflata*; Maine Threatened) and Tuckerman's sedge (*Carex tuckermanii*) are two rare wetland plants found exclusively, to date, in vernal pools.

3. Wetland stepping-stones in an upland landscape

Vernal pools, and other small wetlands (< 10 acres), play an important landscape role for Maine's wildlife. Gibbs (1993) simulated the loss of small wetlands in a 230 mi^2 (600 km^2) area of Maine to evaluate how their loss might affect populations of wetland-associated animals. His model revealed that local populations of wetland-dependent turtles, small birds, and small mammals faced a significant risk of extinction if small wetlands were lost. Semlitsch and Bodie (1998) further suggested that the incremental loss of vernal pools and other small wetlands erodes the effective dispersal ability of amphibians as distances among remaining suitable breeding pools increase.

4. Biological linkages to surrounding uplands

Vernal pools contribute a significant amount of amphibian and invertebrate biomass (and hence food for other wildlife) to surrounding forest ecosystems. After leaving the vernal pool, young and mature wood frogs and salamanders provide easy prey to a wide variety of forest animals including predatory insects, snakes, turtles, birds, and small mammals (Wilbur 1980, Pough 1983, Ernst and Barbour 1989). Windmiller (1990) found the collective weight (or biomass) of vernal pool-breeding amphibians to be greater than the biomass of all breeding birds and small mammals combined in the 50-acre upland forest surrounding his study pool in Massachusetts. He concluded that vernal pool amphibians exert a powerful influence on the ecology of the surrounding forests, up to 1/4 mile from the pool edge. Other researchers have speculated that amphibians may play a critical role in forest nutrient cycling by regulating populations of soil invertebrates responsible for the breakdown of organic material (Burton and Likens 1975, Wyman 1998).

Photo: Phillip deMaynadier

Upland Forest Habitat

WHY IS IT IMPORTANT TO CONSERVE UPLAND FOREST AROUND VERNAL POOLS?

The surrounding upland forest supports vernal pool amphibians during the 11.5 months in which they are not using breeding pools. Indeed, the close dependence on the surrounding upland landscape for survival of vernal pool amphibians has prompted one researcher (Semlitsch 1998) to refer to this critical terrestrial habitat around pools as a "life zone," not a "buffer zone." Pool-breeding salamanders, and to a lesser degree wood frogs, are especially sensitive to desiccation and temperature extremes (Shoop 1974, Stebbins and Cohen 1995). Therefore, areas of uncompacted, deep litter, coarse woody debris, and patches of canopy shade are important for maintaining a suitable forest floor environment (deMaynadier and Hunter 1995, DiMauro and Hunter 2002).

The sensitivity of wood frogs, blue-spotted salamanders, and spotted salamanders to these habitat elements (particularly canopy shade) was highlighted in two studies in Maine (deMaynadier and Hunter 1998, 1999). Similarly, four-toed salamanders belong to a family of lungless salamanders (Plethodontidae) shown to be especially sensitive to forest canopy loss because of their need to maintain a cool, moist, skin layer for respiration (Feder 1983). Indeed, a review of 15 studies identified lungless salamanders as the most sensitive group of amphibians in North America to intensive forest management practices (deMaynadier and Hunter 1995). Recent research in Minnesota suggests that wood frogs may be less sensitive to overstory removal around breeding pools than pool-breeding salamanders, with habitat recovery following clear-cutting occurring within 10-30 years (Hanson and Ossman 2000, Palik et al. 2001). However, Skelly et al. (2002) reported that the distribution of amphibian larvae is affected by pool canopy cover: wood frog larvae are better adapted to closed canopy pools than are larvae of other frog species and hence they may experience less competition in closed canopy pools.

Although much of amphibian terrestrial life history is still unknown, researchers have documented travel distances from breeding pools of juvenile wood frogs and adult mole salamanders (Berven and Grudzien 1990, Windmiller 1996, Semlitsch 1998) and, to a lesser extent, four-toed salamanders (Windmiller, unpub. data and A. Richmond, pers. comm.). Pool-breeding salamanders readily travel 400 feet or more from breeding pools, while juvenile wood frogs may disperse 3/4 mile from natal pools (Figure 2).

Recent investigations of vernal pool invertebrates in forested landscapes have found significant differences in the composition of aquatic macroinvertebrate communities (especially amphipods, isopods, and chironomid midges) among pools surrounded by different forest age-classes (Batzer and Sion 1999, Hanson and Ossman 2000). Although preliminary, these studies suggest that landscape history—as well as pool-specific factors—may play an important role in structuring the species composition of seasonal pool fauna.

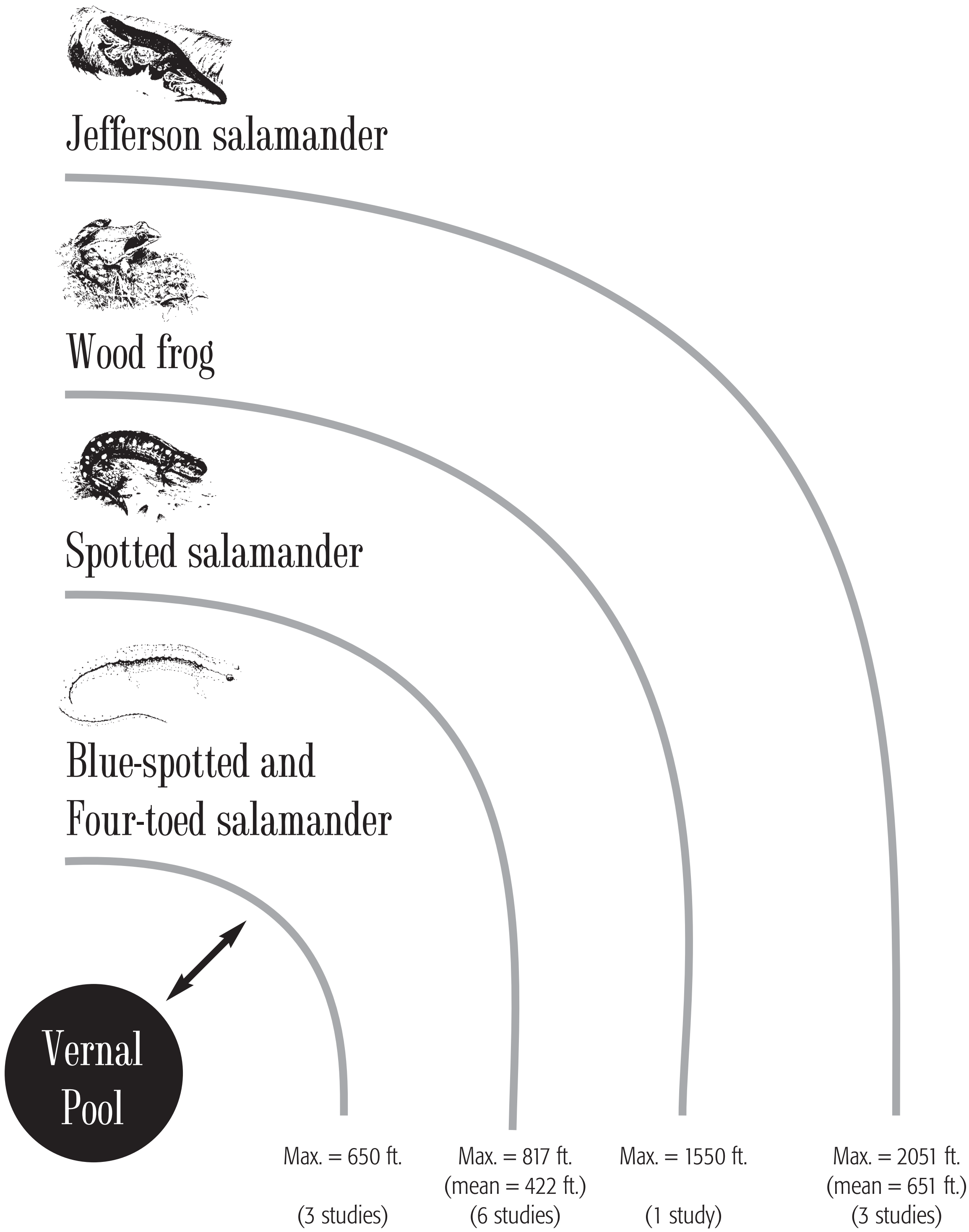


FIGURE 2: Maximum and mean (where available) adult migration distances for Maine's vernal pool amphibian indicator species. Hybridization between blue-spotted salamanders *(Ambystoma laterale)* and Jefferson salamanders *(A. jeffersonianum)* is common in Maine. The number of studies contributing data is listed parenthetically for each species or group. Sources for migration data included: Windmiller 1996; Semlitsch 1998 (review of several studies); Faccio 2003; and A. Richmond, unpublished data.

CAN ARTIFICIAL POOLS CREATED BY FORESTRY OPERATIONS SUBSTITUTE FOR NATURAL POOLS?

Depressions that can serve as artificial breeding pools may be created during normal harvesting activities and include skidder ruts, borrow pits, blocked road drainages, and road ditches. These pools may contribute significantly to the total number of seasonal pools available to breeding wood frogs and spotted salamanders, and may in fact outnumber natural pools in areas with management activity (Waldick 1997, DiMauro and Hunter 2002). However, artificial pools often dry significantly faster than natural pools. Therefore, artificial pools may not replace natural pools as successful breeding habitat for wood frogs and spotted salamanders because the period of time the pool holds water is too short to permit successful juvenile recruitment (especially in drier years). Furthermore, harvesting may have changed the upland habitat conditions (such as canopy shade or soil conditions), potentially reducing pool suitability as breeding habitat in the near term.

HOW CAN SMALL WOODLOT OWNERS HELP CONSERVE VERNAL POOLS?

Identifying the vernal pools on your property

The first and most critical step is to be aware of where the vernal pools on your land are located. The easiest way to locate pools is to be in the woods in early spring when vernal pool amphibians are breeding. Often calling wood frogs (a raucous chorus often likened to a group of quacking ducks), and sometimes spring peepers (a high-pitched, sleigh-bell sounding chorus), alert you to where the best breeding sites are that would otherwise go unnoticed. We encourage you to obtain a copy of the *"Maine citizen's guide to locating and documenting vernal pools"* (Calhoun 2003). Also keep in mind that there are a growing number of resource professionals statewide that can offer guidance and support for locating vernal pools on your property (see **Appendix A** for vernal pool resource and contact information).

Implementing the vernal pool Habitat Management Guidelines (HMGs)

Following their identification, adopting the HMGs described below for timber harvesting around vernal pools will help conserve their value for wildlife. Keep in mind that the pre-harvest Forest Management Planning HMGs and the Harvest Operations HMGs are the best recommended guidelines based on current knowledge. In some cases, small woodlot owners may own or be managing less land than the recommended management zones include. If that is the case, applying the **principles or spirit** of the recommendations (e.g., limiting disturbance around the pool, leaving enough canopy cover in the upland to maintain suitable habitat on the forest floor) will greatly aid in conservation of these breeding pools. By simply adhering to the basic principles of the HMGs to the greatest extent possible, the cumulative effects of hundreds of small woodlot owners can contribute significantly to the conservation of vernal pools and their surrounding upland habitats.

HOW CAN LARGE FOREST LANDOWNERS HELP CONSERVE VERNAL POOLS?

Large landowners, particularly industrial ownerships, have tremendous potential to contribute to the conservation of vernal pools and their wildlife in Maine, both because of the scale of their holdings and the staff and technical resources available to them. Whenever possible, companies and large landowners should implement both the pre-harvest Forest Management Planning and Harvest Operation HMGs to the full extent described below.

On the ground

When possible, incorporate pool identification into forest management planning activities or timber cruising operations. Landowners may incorporate pool searches into their ground surveys or simply be sure to map, or locate with GPS, pools that are encountered during timber inventories or other field surveys. Spring is the best time to search for pools, but landowners can learn to identify the characteristics of potential pools in late summer and fall as well using some of the attributes described in the Habitat Recognition Approach described on page 2. Remember that an unoccupied pool may serve as habitat in future years since the indicator species do not necessarily use every pool during every breeding season.

From the air

Forest managers and landowners often make use of remote sensing technology to identify forest cover types and to plan operations. In many cases, it is possible to identify potential pools using aerial photography. Tips for doing so are provided in **Appendix B**. Be aware that remote mapping of pools may result in the inclusion of pools that do not currently support breeding indicator species.

PART II

Forestry Habitat Management Guidelines for Vernal Pools

HABITAT MANAGEMENT GUIDELINES (HMGs) for vernal pools are designed to protect the pool's physical basin and water quality, and the integrity of surrounding forest habitat. Applying these HMGs will ensure proper shading, hydrology, and structure of the pool itself, while maintaining a suitable surrounding forest floor environment (shaded, moist, with abundant leaf litter and coarse woody debris cover) for amphibian dispersal, foraging, and hibernation (Figure 2). While harvest strategies outlined in the vernal pool HMGs generally lend themselves to uneven-aged management, it is not the intent of the guidelines to focus on specific silvicultural systems, but rather to suggest desired outcomes and structural thresholds designed to conserve vernal pool wildlife.

Photo: Aram Calhoun

Operation Near a Vernal Pool

The guidelines contained herein are designed for use *only* in working forest landscapes where forest habitat is permitted to regenerate over time. For applications that involve development, impervious surfaces, roads, and other types of permanent habitat fragmentation, please consult the companion guidelines for developed landscapes published by Calhoun and Klemens (2002).

I. VERNAL POOL HMGs FOR FOREST MANAGEMENT PLANNING

Some of the most important steps for conserving wildlife values associated with vernal pools often begin in the office. Ensuring sustainable harvest activities around vernal pools is easier if long-range management planning has pre-identified pools and incorporated their considerations into management strategies. Consideration of the following planning steps **prior** to forest harvest activity will help avoid potential conflicts:

- Pre-identify vernal pools, or likely locations for them, using aerial photography (**Appendix B**), and/or National Wetland Inventory maps.
- Document vernal pools located during forest cruising or other on-the-ground management activities.
- Include vernal pools and surrounding upland habitat zones on all forest management maps.
- Plan forest road construction to avoid vernal pools and their associated upland habitats.
- Plan clearcut harvests and pesticide applications (including roadside maintenance or dust-control chemicals) to avoid vernal pools and their associated upland habitats.
- Wherever possible, maintain a relatively closed canopy forest between pools, or pool clusters that are less than 1/4 mile apart, by limiting road construction, landings, and heavy cutting between them (i.e., applying Amphibian Life Zone HMGs—see below).


Photo: Aram Calhoun

Preharvest Reconnaissance

II. VERNAL POOL HMGs FOR HARVEST OPERATIONS

Recommended HMGs for conserving vernal pools and adjacent forested habitat during harvest operations are described below and apply to three management zones: the **vernal pool depression**, a **vernal pool protection zone** (100 ft), and an **amphibian life zone** (100-400 ft.; Figure 3). The management objectives for each zone are summarized under the heading entitled Desired Management Outcomes. While the Recommended Guidelines are intended to help managers achieve these outcomes, other management strategies may be effective as well and professional judgment is required to accommodate the diversity of field conditions where vernal pools are found. A summary of the Desired Management Outcomes and Habitat Management Guidelines for conserving vernal pool wildlife during forest harvest operations is provided in Table 1.

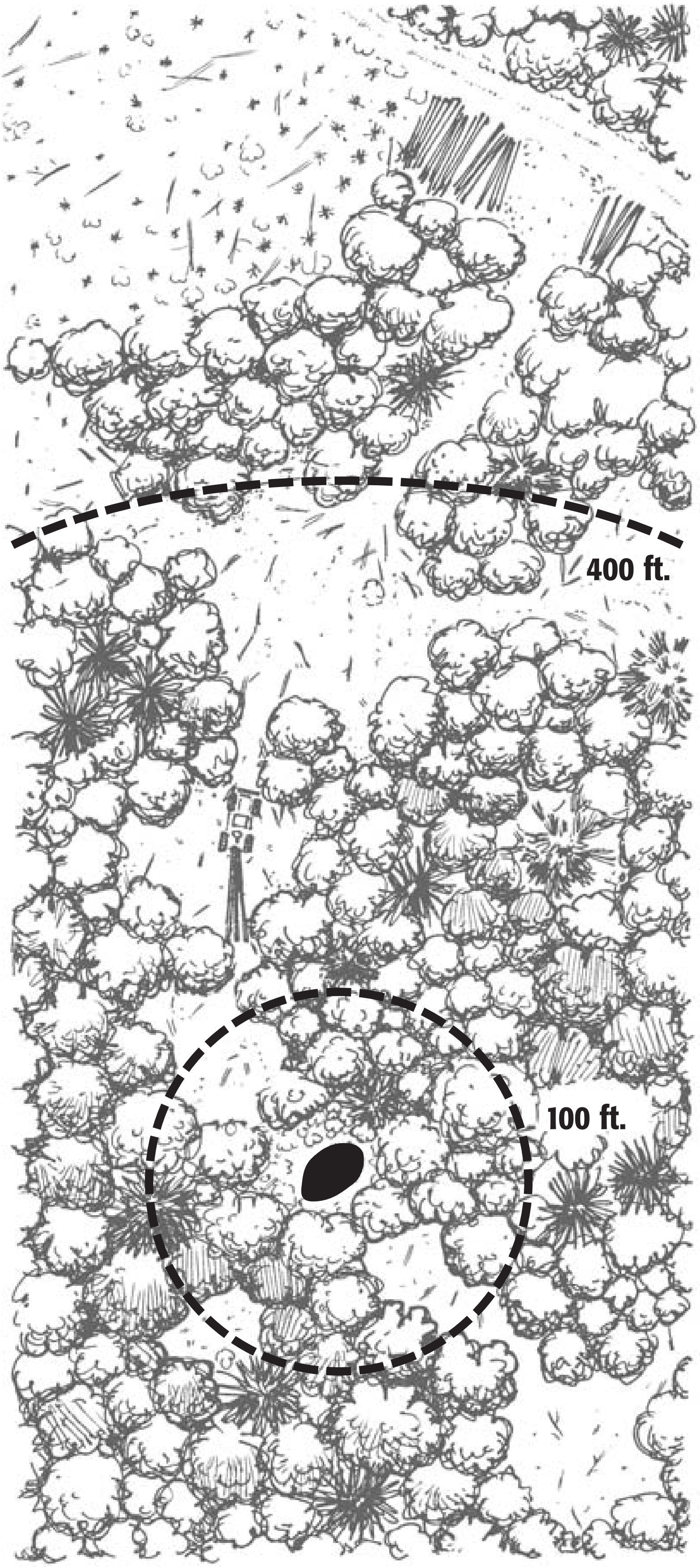


FIGURE 3:
Ecologically sensitive forest management activity around a vernal pool (dark oval at bottom center) located in a mature mixed forest. Note that implementation of the vernal pool Habitat Management Guidelines (HMGs) calls for decreasing timber harvest intensity with increasing proximity to those pools with breeding evidence of amphibian indicator species. HMG zones are drawn to scale. (M. McCollough)

A. Vernal Pool Depression

Description: This zone includes the vernal pool depression at spring high water, which may or may not be wet during the period when timber is being harvested. During the dry season, the high-water mark generally can be determined by the presence of blackened, water-or silt-stained leaves, aquatic debris along the edges, or a clear change in topography from the pool depression to the adjacent upland.

Photo: Jaime Haskins

Vernal Pool Depression

Desired Management Outcome: Maintain the pool's basin, associated vegetation and the water quality, in an undisturbed state.

Rationale: The pool basin is the breeding habitat and nursery for pool-dependent amphibians and invertebrates. Rutting or compaction in the pool can alter the pool's water-holding capacity, disturb eggs or larvae buried in the organic layer, and alter the amphibian's aquatic environment. Harvesting operations in the pool, even during the winter, can disturb vegetation that may serve as egg attachment sites or provide shading. Excess slash and tree-tops in the pool basin can hinder amphibian movement and alter water chemistry.

Recommended Guidelines:

1. **Mark the pool's location**
   a. *Identify the spring high water mark (during the wet season or using dry season indicators) and flag the pool's perimeter during harvest layout and prior to cutting.*
2. **Protect the pool basin and its natural vegetation**
   a. *Leave the depression undisturbed. Avoid harvesting, heavy equipment operation, skidding activity, or landing construction in the vernal pool depression.*
   b. *Keep the pool free of sediment, slash, and tree-tops from forestry operations, including harvesting and road building.*
   c. *Leave slash or other woody debris that accidentally falls into the pool during the breeding season (March to June). Trees and branches that fall naturally into pools can serve as egg attachment sites.*

Vernal Pool Protection Zone

B. Vernal Pool Protection Zone

(100 feet around the pool)

Description: A 100-foot zone around the pool measured from the spring high-water mark. Calhoun and Klemens (2002) refer to this as the Vernal Pool Envelope.

Desired Management Outcome: Protect vernal pool and surrounding habitat by maintaining or encouraging a mostly closed canopy stand in a pole — or greater size class that will provide shade, deep litter, and woody debris around the pool. Maintain a shaded forest floor without ruts, exposed mineral soil, or sources of sedimentation/erosion.

Rationale: The integrity of the forest immediately surrounding the pool depression is critical for maintaining water quality, providing shade and litter for the pool ecosystem, and providing suitable upland habitat for pool-breeding amphibian populations. In the spring, high densities of adult salamanders and frogs occupy the habitat immediately surrounding the pool. Similarly, in late summer and early fall, large numbers of recently metamorphosed salamanders and frogs occupy this same habitat. Juvenile spotted and blue-spotted salamanders are especially vulnerable to desiccation during the first months after metamorphosis (Semlitsch 1981). For these reasons, it is important to maintain a shaded, moist forest floor with ample loose litter material and coarse woody debris.

Recommended Guidelines:

1. **Mark the zone's location**
   a. *Based on the spring high water mark of the pool, flag the perimeter of the protection zone during harvest layout and prior to any cutting.*

M. McCollough

Spring Peeper

2. **Maintain a mostly closed forest canopy**
   a. *Maintain a minimum average of 75% canopy cover of trees a minimum of 20-30 ft. tall, uniformly distributed.*
   b. *In understocked stands, consider delaying harvest activity until canopy cover has increased beyond the recommended minimum.*
3. **Protect the forest floor**
   a. *Harvest only during completely frozen or completely dry soil conditions. Do not create ruts and minimize soil disturbance.*
   b. *Whenever possible, avoid the use of heavy machinery in this zone by employing techniques such as motor-manual crews, directional felling, extended cable winching and/or booms.*
   c. *Avoid road or landing construction. If roads or landings already exist, apply appropriate erosion control BMPs to protect water quality (see Maine Forest Service Forestry BMPs for Water Quality).*
4. **Maintain coarse-woody-debris**
   a. *Leave a supply of older or dying trees to serve as recruitment for coarse woody debris.*
   b. *Avoid disturbing fallen logs.*
   c. *Leave limbs and tops where felled, or return slash to the zone during whole-tree removal.*
5. **Avoid the use of chemicals,** *especially those with surfactants (amphibians are sensitive to toxins that can be absorbed through their skin).*

C. Amphibian Life Zone

(100-400 feet)

Description: A 100-400 foot zone around the pool measured from the spring high-water mark. Calhoun and Klemens (2002) refer to this as the Critical Terrestrial Habitat.

Desired Management Outcome: Provide some suitable upland habitat for pool-breeding amphibian populations by maintaining or encouraging a partially closed-canopy stand that offers shade, deep litter, and woody debris around the pool. Minimize disturbance to the forest floor.

Rationale: This zone is needed to support upland populations of amphibians that breed in vernal pools. The zone's radius is designed to address a portion of the habitat used by Maine's pool-breeding salamanders. The average migration distance of adult spotted salamanders and blue-spotted salamanders is estimated to be 386 and 477 ft, respectively (Figure 2), with as much as half the population, in some instances, dispersing to even greater distances. Four-toed salamanders have been observed migrating similar distances. Concentrations of migrating wood frog juveniles may be high in this zone as well.

Photo: Phillip deMaynadier

Amphibian Life Zone

Forest floor environments suitable for supporting pool-breeding amphibians are most likely to be maintained by light to moderate partial cuts within this management zone. Juvenile and adult wood frogs and spotted salamanders select closed-canopy forests during movements in managed forest landscapes (deMaynadier and Hunter 1998, 1999). Pool-breeding salamanders are often under or closely associated with woody debris on the forest floor (Windmiller 1996). Dramatic shifts in forest cover-type should be avoided, as amphibians are sensitive to the resulting changes in litter composition and chemistry (deMaynadier and Hunter 1995). Rutting and scarification of the forest floor may prevent salamanders from traveling to breeding pools by creating barriers along travel routes (Means et al. 1996). Furthermore, if shallow ruts fill with water, vernal pool amphibians may deposit eggs in these "decoy pools"—habitats that often do not hold water long enough to produce juveniles.

Recommended Guidelines:

1. **Maintain a partial forest canopy**
   a. *Maintain a minimum average of >50% canopy cover of trees 20-30 ft. tall, uniformly distributed.*
   b. *Avoid canopy harvest openings greater than 1 acre in size.*
   c. *If even-aged management is necessary, extended shelterwood or similar systems that involve continuous retention of some canopy component will help maintain suitable forest floor habitat.*
2. **Maintain natural litter composition**
   a. *Avoid significant shifts in forest cover type (e.g., hardwood or mixed wood to softwood) to minimize changes in natural litter composition.*
   b. *Avoid plantation silviculture in this zone.*
3. **Maintain coarse-woody-debris**
   a. *Leave two/acre of older or dying trees to serve as recruitment for coarse woody debris.*
   b. *Avoid disturbing fallen logs.*
   c. *Leave limbs and tops where felled, or return slash to the zone during whole-tree removal.*
4. **Protect the forest floor**
   a. *Harvest only during completely frozen or completely dry soil conditions. Do not create ruts.*
   b. *Minimize soil compaction and scarification by using techniques such as: controlled-yarding (including preplanning, adequate trail spacing, and limiting the number of passes), minimizing sharp turns, and using brush to help increase the bearing capacity of soils (American Pulpwood Association 1997).*
   c. *Avoid road or landing construction. If roads or landings already exist, apply appropriate erosion control BMPs to protect water quality (see Maine Forest Service Forestry BMPs for Water Quality).*
5. **Minimize the use of chemicals,** *especially those with surfactants (amphibians are sensitive to toxins that can be absorbed through their moist, permeable skin), particularly in the spring and late summer/fall when amphibian surface movements are greatest.*
6. **Extend the Life Zone and associated HMGs as far as is practical,** *where property boundaries and nonforest land-uses (e.g., residential areas, agricultural land, or pavement) limit the extent of accessible forest in this zone to less than 400 ft.*

PART III

Additional Recommendations

HABITAT MANAGEMENT GUIDELINES for vernal pools are based on current understanding of the biology of amphibians, their upland habitat requirements, and how to maintain these habitats in the working forests of Maine. Current knowledge suggests that wildlife values associated with vernal pools can be maintained if forest practices adhere to the principles outlined in these HMGs.

The following recommendations will further increase the probability of maintaining wildlife values and successfully protecting vernal pool habitats:

1. **Bigger is better.** Whenever possible, expand the protection zones. The 400 ft. lifezone only ensures habitat for a portion of blue-spotted and spotted salamander and wood frog populations. If we assume amphibians are distributed randomly around a pool, the current HMGs will protect less than 50% of the local populations. Extending the suggested forest management practices to a larger area will further help protect vernal pool wildlife values.
2. **Develop a strategy for mapping and tracking potential vernal pools either from aerial photography (see Appendix B) or as discovered in the field.** Use this database to help design ground surveys for documenting the presence of indicator species and for developing future harvest plans. Track losses of vernal pools or impacts to existing pools to refine management strategies and/or identify high risk areas. Archiving existing pools on Geographic Information Systems (GIS) will aid in planning future operations.
3. **Identify highly productive pools suitable for more rigorous protection strategies.**
   a. If you have identified a pool that is particularly productive (large number of egg masses or diverse indicator fauna), or if it is located in a landscape with few if any other pools, consider creating an undisturbed zone 100 feet around the pool and applying HMGs beyond the 400 ft. recommendation.
   b. If you have identified a cluster of pools within 1/4 mile of each other, consider protecting the area as a unit, with contiguous forest between the pools. Extend the recommended buffers around the cluster, rather than around each individual pool. Identify vernal pool clusters as areas to manage for longer rotations.

TABLE 1

Summary of the Recommended Guidelines for conserving vernal pool wildlife during forest harvest operations.

Management Zone (Radial Distance)	Managed Zone[1]	Primary Wildlife Habitat Values	Desired Management Outcomes	Recommended Guidelines
Vernal Pool Depression (0 ft)	0.2 acres	Breeding pool; egg attachment sites.	Good water quality and water-holding capacity; undisturbed basin and marginal vegetation.	No Disturbance
Vernal Pool Protection Zone (100 ft)	1.4 acres	Shade and organic inputs to pool; upland staging habitat for juvenile amphibians.	Heavily shaded forest floor with deep, moist, uncompacted litter and abundant coarse woody debris.	Limited Harvest • >75% canopy cover • Frozen or dry soil conditions • Minimize heavy machinery use • Abundant coarse woody debris
Amphibian Life Zone (400 ft)	13.0 acres	Upland habitat for pool-breeding amphibians.	Partially shaded forest floor with deep, moist uncompacted litter and abundant coarse woody debris.	Partial Harvest • >50% canopy cover • Openings <1 acre • Frozen or dry soil conditions • Abundant coarse woody debris

[1] Acreage estimates based on a pool with a 100 ft. diameter, or approximately 0.2 acres

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APPENDIX A

Vernal Pool Resources and Contact Information

VERNAL POOL MANUALS:

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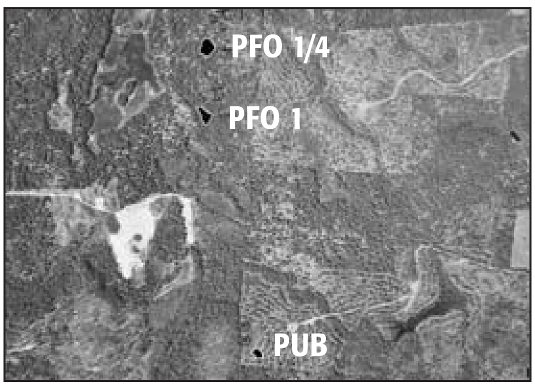
A P P E N D I X B

Using Aerial Photography to Locate Vernal Pools



THREE VERNAL POOLS EMBEDDED IN A MANAGED FOREST LANDSCAPE. *PFO1 (Palustrine Forested Hardwood), PFO2 (Palustrine Forested Softwood), and PUB (Palustrine Unconsolidated Bottom) all refer to National Wetland Inventory wetland classifications commonly used to identify the potential presence of a vernal pool. These pools were delineated on a color infra-red (CIR) aerial photograph taken during early spring at a 1:12,000 scale. Note that the forest surrounding the upper two vernal pools appears to be well-managed whereas the harvest intensity around the lower pool may have exceeded levels recommended in the HMGs.*

THE PRACTICALITY OF USING AERIAL PHOTOGRAPHY TO identify vernal pools varies with predominant forest cover-type, scale, timing, and type of photography. A primer on identifying vernal pools through aerial photography and using Geographic Information Systems to create a database is available in *Massachusetts aerial photo survey of potential vernal pools* (Burne 2001). Aerial photo coverage can provide a landscape overview to aid during reconnaissance-level surveys. From aerial photographs one can identify areas most likely to have pools. For example, topography and breaks in the forest canopy give clues to vernal pool location.

Use of aerial photography must be followed with ground-truthing. In fact, finding existing vernal pools in the field and then characterizing the way they appear on aerial photography in your region (i.e., defining the signature of vernal pools) may help in picking out other potential pools on photography. **NOTE:** Even with good aerial photography and experienced photo-interpreters, many vernal pools are easily missed (either because of their small size, dense conifer cover, tree shadows, or because they are embedded in other wetlands). It is critical to ground-truth!

Below are some common challenges and solutions for using photography for pre-identification of pools based on work completed in Maine, Massachusetts, and Rhode Island.

AERIAL PHOTOGRAPHS: WHAT DO I USE?

- **Stereo coverage:** Try to obtain aerial photographs in stereo pairs and view them with a stereoscope. Subtle changes in relief can provide clues to potential vernal pool sites.

- **Season and ground conditions:** Photos taken when the leaves are off the trees, the ground is free of snow, and water levels are high provide the best opportunity for identifying vernal pools. Early spring (March-May) is generally the best period for capturing these conditions, but late fall (November-December) may also provide valuable coverage. Identification of vernal pools is least reliable on photos taken during very dry years or in the middle of summer when tree canopies obscure ground conditions.

- **Scale and film type:**

  Scale: The larger the scale (e.g., 1:4,800 is a larger scale than 1:12,000), the easier it will be to identify small ground features. Generally, scales at least 1:4,800 to 1:12,000 should be obtained to identify small pools. Ultimately, the scale of photography needed to successfully pre-identify vernal pools will depend on the type of film, time of year photos were flown, forest cover type, and size of the pool.

  Color Infrared (CIR): CIR is the most reliable photography for locating vernal pools because water absorbs color infrared light and appears black in contrast to the lighter colored (pink, magenta, orange, yellow) vegetation. A study conducted at the University of Massachusetts, Amherst (MacConnell et al. 1992), found that large scale CIR (1:4,800 or 1:12,000) was the best tool for delineating wetlands, particularly forested wetlands. Specifically, they found that CIR is very sensitive to water and chlorophyll — key features for wetland identification. Photo interpretation was faster, more consistent, more accurate and required less corollary information and field work to maintain a high level of accuracy. CIR had much finer resolution than black and white film at the same scale permitting the use of smaller scale photography. Tiner (1990) and Stone (1992) discuss the advantages of CIR film in photo-interpreting wetlands. The disadvantage of using CIR photography is that it is considerably more expensive than black and white photography.

  Black and White: A pilot project in York and Penobscot Counties evaluating the use of black and white aerial photography at 1:4,800 or 1:12,000 scale found it to be an effective pre-identification tool in deciduous forests in southern Maine. Pre-identification using 1:4,800 scale photography resulted in both a higher percentage of correct predictions and less omissions than did 1:12,000 scale photography. However, in lower Penobscot Valley, pre-identification of vernal pools less than 0.5 acres was not effective in mixed and evergreen forests (both wetland and upland). In some cases, known pools could not be identified on the photography (K. Huggins, Champion International, pers. comm.).

  True Color: An evaluation of true color photography and vernal pool pre-identification has not been conducted. Fall true color photography is effective in picking out red maple swamps in softwood mosaics. These forested wetlands potentially harbor vernal pools. True color photography taken under leaf-off conditions, especially in early spring, may reveal considerable detail of the forest floor. Small water bodies such as vernal pools may appear as dark spots, or occasionally as white patches, if light is reflected off the water surface.

- **What do vernal pools look like on aerial photos?**

1. Vernal pools may appear as small openings in the forest canopy on winter/spring photos; in deciduous forests they can be detected through the canopy.
2. In forests that have not been harvested for 15-20 years, look for a hole or gap in the canopy that seems larger than the typical shadows caused by individual trees. If the gap is black with no visible vegetation, it may be a vernal pool.
3. Use signature color and relief when attempting to distinguish vegetated vernal pools dominated by ferns, sedges, or grasses. Vegetation growing in water or in very wet soils imparts gray shades to black and photos, grayish green tones in color photographs, and grayish pink colors in color infrared photos (CIR).
4. Identifying subtle pockets of variation in relief can be especially helpful when distinguishing vegetated vernal pools in larger wetland complexes. Uneven ground and shallow depressions that may be vernal pools can be seen through a stereoscope on aerial photographs.
5. Vernal pools may occur in clusters due to uneven topography and the composition of the bedrock or soil type (particularly soils with shallow confining layers or shallow to bedrock). You may be able to pick out clusters on topographic maps or aerial photography.
6. In some parts of New England, vernal pools are commonly associated with red maple swamps or mixed evergreen-deciduous swamps. Because the pool may be a small part of a larger wetland, identification can be difficult. If the wetland is in the southern portion of the photo, there might be enough reflection of light off the water surface to highlight the vernal pool. When viewing stands dominated by softwood, a cluster of red maple is sometimes an indicator of a potential vernal pool (particularly when working with fall true color photography). Conversely, patches of softwoods in hardwood uplands may indicate small areas of wet soils that could include vernal pools.

- **What are the most common problems with photo-interpreting vernal pools?**

  Many features can mimic vernal pools including:

  - Overstory or superstory trees with large crowns that cast shadows over the top of the surrounding canopy and appear as black spots. (This is particularly true of photos flown in spring or fall when solar angles are low. Looking at photos in stereo may eliminate some of these tree shadows);
  - Shadows created by narrow pockets in bedrock or streams with deep narrow gorges;
  - Gaps and openings in the canopy from recent forest harvesting operations;
  - Tree shadows along skid trails and near large openings.

  Additionally, vernal pools may be hard to see because:

  - They are small (often less than 0.1 acres);
  - Tree species typically associated with depressional pools in upland settings (particularly red maple and hemlock) often extend their branches into the pool opening, or the pool itself may be forested by flood-tolerant species;
  - Pools associated with forested wetland complexes, particularly in mixed and softwood stands, may be obscured by canopy cover or hard to distinguish from the overall wetland complex.

- **Are National Wetlands Inventory (NWI) maps useful for finding potential pools?**

  Vernal pools range widely in the types and amount of vegetation they contain and the duration of inundation or flooding; for that reason, individual pools might be classified as ponds (POW or PUB)*, marshes (PEM, PAB)*, wet meadows (PEM)*, shrub swamps (PSS)*, or forested wetlands (PFO)*. *National Wetland Inventory classification codes (Cowardin et al. 1979).

  - A 1997 pilot study in southern and central Maine was conducted to test the effectiveness of NWI maps in identifying potential vernal pools. Results from this study suggest:
  - NWI maps can be used to locate many of the larger natural pools (isolated wetlands with PUB, PSS and PFO status are often good candidates), but keep in mind that the resolution of NWI maps is often limited to wetlands $\geq$ 15,000 ft 2 (~0.3 acres). Many of the PUB or POW classifications are likely to be permanent ponds (average mapping unit for NWI is 1-3 acres).
  - Effectiveness of NWI maps for locating potential vernal pools depends on local knowledge of types of wetlands in which pools occur. For example, in this pilot study, vernal pool species occurred in some wetlands with temporary inlets and outlets and in forested wetland complexes associated with other wetland types. Therefore, NWI categories of PFO, even with outlets, were considered potential sites.

  Ideally, NWI maps are used as one of a number of interpretive tools, including aerial photography.