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Strategies for maintaining pond-breeding amphibians on golf courses

PLANNING COMMISSION EXHIBIT #89

Given the proper habitat and unfragmented access to breeding areas, amphibian species will increase in population and species diversity.

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Biologists are increasingly concerned about documented declines of amphibian populations on local, regional and even global scales. A variety of factors have been implicated in these declines (for example, introduced predators, fertilizers, pollutants and UV-B radiation in sunlight), although the leading cause of declines is the impact of habitat fragmentation and habitat loss on pond-breeding amphibians (4,8).

We are focusing this paper on pond-breeding amphibians because the majority of amphibian species in the northeastern United States breed in ponds (six species of salamanders and 10 species of frogs), whereas fewer species breed in streams or uplands (5). In this paper, we discuss strategies for maintaining populations of pond-breeding amphibians on golf courses in New England based on a variety of studies conducted since 1997 by researchers at the University of Rhode Island.

Photo by Robert S. Egan

Figure 1. This vernal pond in Rhode Island is typical of natural pools used by pond-breeding amphibians in the northeastern United States. Trees enclose the site and create a relatively closed canopy. Five species of frogs and three species of salamanders breed in the pool, which has usually dried by September.

KEY | points

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- **Pond-breeding amphibians** are vulnerable to habitat loss and fragmentation.
- **To maintain ecosystem integrity,** superintendents need to manage breeding ponds, habitats used during the nonbreeding season and habitats used as movement corridors.
- **Superintendents who maintain ponds** that dry annually, do not introduce fish into ponds and maximize the amount of unfragmented forested habitat around seasonally flooded ponds will increase survival probabilities of pond-breeding amphibians on their courses.

Amphibians and habitat fragmentation

Amphibians can be exceptionally sensitive to changes in microclimate and microhabitat because they have permeable skin that makes them susceptible to desiccation. Thus, habitat ecotones, such as the transition between forests and turf fairways, may represent potential dispersal barriers to amphibians moving across the landscape.

Fragmented landscapes, such as golf courses, can have a negative impact on amphibian populations. Amphibians that breed in ponds have complex life cycles that make them particularly vulnerable to fragmentation and loss of habitat. Ponds are often used by adults only for mating and depositing eggs and by larvae during development until metamorphosis (that is, the transformation into terrestrial organisms) (6).

Adults are usually very faithful to their breeding pond, returning to the same pond year after year, whereas metamorphs (young-of-the-year) tend to disperse across the landscape and often breed in new ponds (8). For most of the year, adults and juveniles of most pond-breeding species reside in forested uplands and forested wetlands near breeding ponds (Figure 1), with many individuals traveling considerable distances to reach their nonbreeding territories (for example, salamanders of the genus *Ambystoma* travel 180 yards (164.6 meters) and farther [7]).

What do superintendents need to know?

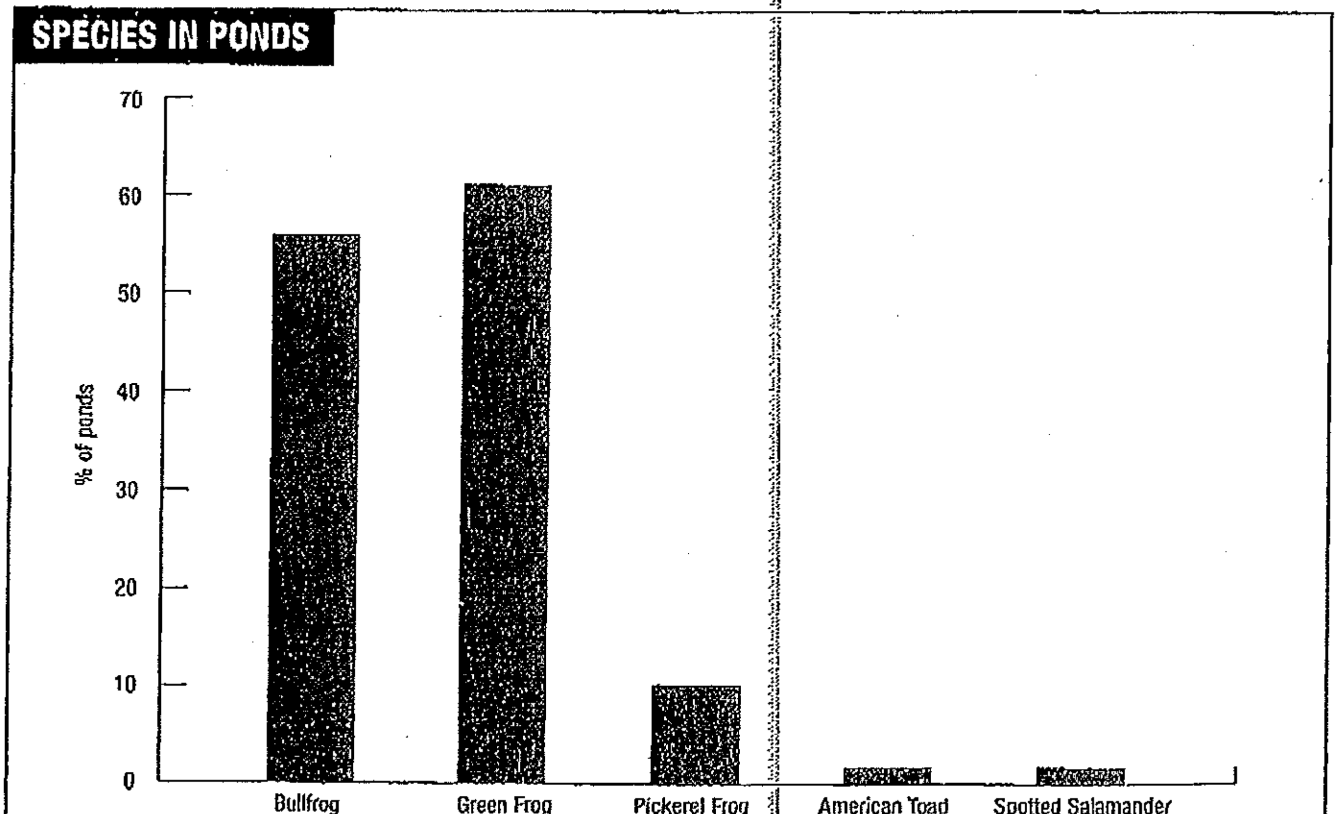
Pond-breeding amphibians migrate twice a year, once from their nonbreeding habitat to the breeding pond, and then back to their nonbreeding territory at the completion of the breeding season. Therefore, managing the landscape to maintain populations of pond-breeding amphibians is a challenge for golf course designers and superintendents because it requires a detailed understanding of the physical and biological habitat characteristics of breeding ponds, an understanding of habitat requirements during the nonbreeding season, and knowledge of the intervening habitats used during migration to and from ponds and nonbreeding habitat. Adding to the difficulty is that biologists are just beginning to untangle the complex habitat requirements of pond-breeding amphibians, particularly during migration and the nonbreeding season.

As part of a Wildlife Links project funded by the USGA, we conducted a number of short- and long-term experiments and observational studies to assess the impact of turf and golf courses on pond-breeding amphibians in southern Rhode Island. Here we present what we believe are the key issues for people working in golf course management.

Figure 2. Bullfrogs such as the American bullfrog thrive in permanent ponds despite the presence of fish.

Hydroperiod of breeding ponds

To assess pond-breeding amphibian use of ponds on golf courses, we used dip-nets to



Graph 1. The percentage of 59 ponds sampled on golf courses in southern New England (Rhode Island, Connecticut and Massachusetts) in which particular species of pond-breeding amphibians were present.

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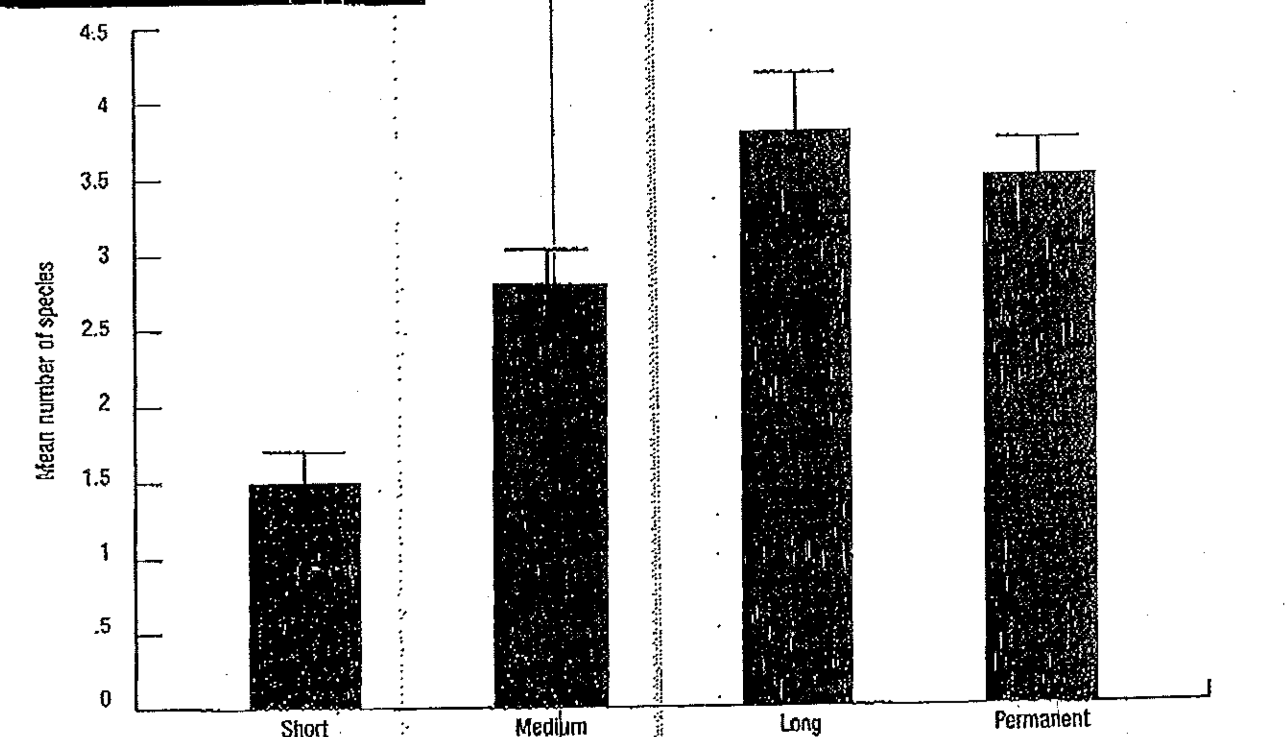
sample 59 ponds at 32 golf courses in Rhode Island, Connecticut and Massachusetts during spring and early summer 1999. Most ponds on golf courses had either green frogs (*Rana clamitans*) or American bullfrogs (*R. catesbeiana*), with few other species detected (Graph 1). The ponds lacked species diversity because most of the ones we sampled on golf courses were permanently flooded. In addition, many ponds we sampled on golf courses had fish.

During 2000 and 2001, we used dip-nets to sample amphibian community structure at 137 randomly selected ponds across the urbanization gradient in Rhode Island. We found that hydroperiod (that is, the number of days with standing water in the pond basin) was one of the most important variables determining amphibian community structure and breeding densities (3). Ponds with a long hydroperiod (drying in October or November) tended to have the most species (Graph 2), whereas ponds with a short or medium hydroperiod (drying annually from June through September) tended to have unique species not found in permanent ponds.

Figure 3. Wood frog egg masses are attached to buttonbush shrubs in the center of a small pond in western Rhode Island. An estimated 1,500 egg masses were in this pond, covering an area 5 feet (1.5 meters) in diameter. Spotted salamanders also attach egg masses to woody vegetation.

For example, wood frogs (*R. sylvatica*) and marbled salamanders (*Ambystoma opacum*) were usually detected only in ponds that dried before September. Tadpoles of both species are

SPECIES VS. HYDROPERIOD



Graph 2. Relationship between pond-breeding amphibian species richness (mean number of species per pond [+ standard error]) and hydroperiod in 137 ponds in Rhode Island. Ponds with a short hydroperiod dry in June or July; medium-hydroperiod ponds dry in August or September; long-hydroperiod ponds dry in October or November; permanent ponds never dry during the year.

among the first to complete metamorphosis, typically emigrating from ponds by early July (5). In contrast, tadpoles of American bullfrogs were found only in permanent ponds, and green frogs were more likely to be found in long- or permanent-hydroperiod ponds (Figure 2). Both of these species have tadpoles that take much longer to complete metamorphosis (two years for bullfrogs and one year for green frogs) and therefore require ponds with longer hydroperiods for successful reproduction.

The take-home message from this research is that maintaining the entire amphibian community on your golf course requires ponds with a variety of hydroperiods on or adjacent to the course. It is critical to have ponds that dry annually because some species only use seasonally flooded ponds (9). In addition, ponds should not be stocked with fish. Fish are major predators of amphibian eggs and larvae, which is why many species of amphibians tend to avoid ponds with fish. Finally, we have found that the vegetation in ponds can be important to certain species. For example, wood frogs tend to have larger populations in ponds with extensive coverage of buttonbush (*Cephalanthus occidentalis*) (3), whereas spring peepers (*Pseudacris crucifer*), tend to thrive in ponds with no canopy closure (Figure 3).

Effect of grass height and habitat on movements

To assess whether grass height may affect movement of amphibians, during the 1998 field season we constructed two square pens (50 feet [15.2 meters] on each side) on a 9.8-acre (4-hectare) section of creeping bentgrass, which is used by the turfgrass group at the University of Rhode Island for a variety of experiments. The perimeter of our experimental pens was encircled with 1.6-foot (0.5-meter)-tall silt fence. The pens were subdivided into four quarters (25 feet [7.6 meters] per side). Each quarter (randomly selected) was mowed to a grass height similar to those found on golf courses (0.25 inch [0.635 centimeters], 0.5 inch [1.27 centimeters], 1 inch [2.5 centimeters], and greater than 1 inch.

All experiments were conducted on rainy nights, when amphibians were likely to move. During the experiment, an individual amphibian (wood frog, American toad [*Bufo americanus*], green frog, bullfrog or pickerel frog [*Rana palustris*]) was placed in the center of the array, and its movements were monitored for a three-minute period (Figure 4).

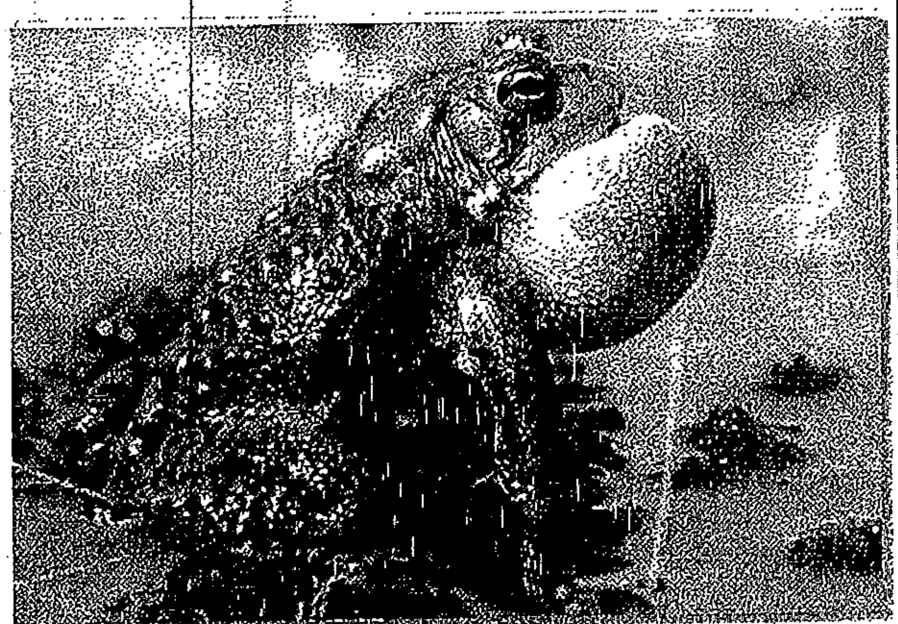


Figure 4. The American toad is widespread throughout North America, with a range that extends from east of the Rocky Mountains to the Atlantic coast and from the middle part of Canada to Mexico.

During grass-height experiments, we found no evidence that frogs preferred any grass height during the three-minute trials; that is, movements were random with respect to grass height. This suggests that grass height, at least in the height range we quantified, which is typical of current golf courses in North America, does not hinder or enhance amphibian movements.

We also constructed another set of experimental pens at ecotones between a forest and turf mowed at 0.5-inch (1.27 centimeters) or less, and a forest and dirt-covered barren areas. During these experiments, all species were more likely to seek cover in the forest and avoided the turf and open habitats.

The results are true for the species we sampled, but we did not have the opportunity to investigate movement patterns of any salamanders or some frogs, spring peepers and gray tree frogs, whose movements could be affected by grass height. However, we did find that amphibians (frogs in this case) preferred to move into forested habitats from either turf or barren areas. In both cases, the evidence shows that wooded habitats were preferred over barren ground or turf. This suggests that, for movement corridors, amphibians preferred forested habitat to open habitats such as fairways.

Turf and amphibian dispersal from a series of ponds

We also conducted an observational study to assess the influence of habitat on movement behavior of amphibians. From 1998 to 2000, we monitored the immigration and emigration of adults and emigration of metamorphs from breeding ponds across a wooded landscape fragmented by turf fields. We documented considerable variation within and among species in their initial departure direction from breeding ponds, which suggests that habitat near breeding ponds has little influence on movement patterns.

Farther from breeding ponds, adults of species that reside in forested habitats during the nonbreeding season (for example, wood frog, spotted salamander [*Ambystoma maculatum*], spring peeper, gray treefrog [*Hyla versicolor*] and red-spotted newt [*Notophthalmus viridescens*]) occurred less often at an ecotone between a turf field and a woodland (Figure 5). In contrast, species that winter in aquatic habitats (for example, green frog, American bullfrog, pickerel frog) readily crossed the turf-woodland edge. Metamorphs of most species tended to be habitat generalists during migration, whereas adults tended to exhibit more habitat selection.

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To test further the influence of habitat on migration, we removed the overstory and understory in five small patches (32.8 feet by 131.2 feet [10 by 40 meters]) in a woodland where we had been monitoring movements for the previous two years. Based on this experiment, we found that small-scale vegetation removal affected the movement patterns of at least four species.

Overall, these results suggest that habitat associations of pond-breeding amphibian species during migration are similar to those during the nonbreeding season. Species that reside during the nonbreeding season and winter in forest habitats (for example, wood frog, marbled and spotted salamander, red-spotted newt, spring peeper, gray treefrog) tend to migrate through forested habitats and avoid open expanses such as fairways. This is particularly true for adult amphibians, which avoid open habitats more than young-of-the-year. In contrast, species that winter in aquatic habitats such as streams or ponds (for example, American bullfrog, green frog and pickerel frog) are less likely to be affected by forest fragmentation because they are willing to cross open habitats.

This explains why ponds on golf courses tended to be dominated by species that are less likely to be affected by habitat fragmentation. As mentioned earlier, both bullfrogs and green frogs prefer permanent ponds for successful reproduction. In addition, both species readily cross open habitats, such as fairways, to reach breeding ponds or wintering sites.

Other researchers have documented patterns similar to those we found in Rhode Island. For example, wood frogs in the forests of Maine were classified as "management sensitive" (1,2) because they avoided traveling across clear-cuts. Adult spotted salamanders also generally avoid openings in woodlands, although other researchers (3) have suggested that migratory movements by spotted salamanders were unaffected by vegetation or topographic structure.

What should superintendents do?

What does this research mean for golf course designers and superintendents of existing courses? Available evidence suggests the habitat characteristics of a golf course can affect movement behavior of some species of pond-breeding amphibians. In New England, species that winter in forested habitats appear to be the most affected by habitat fragmentation. Thus, designers in that area should maximize the amount of forest cover on a course, while simultaneously creating forested travel corridors between breeding ponds and nonbreeding habitat.

Figure 5. The gray treefrog, a species common in ponds in New England, overwinters in trees. Because this species prefers trees, fairways can be a dispersal barrier.

The species most sensitive to habitat fragmentation all breed primarily in ponds that dry annually. These ponds are best identified during surveys conducted in March and April when they are most likely to be flooded. If seasonally flooded ponds are found, steps should be taken to maintain a forested buffer around the pond. No definitive guidelines are available on how wide this forest buffer should be, but it has been estimated that approximately 95% of the population of mole salamanders usually occurs within 591 feet (180 meters) of the pond (7).

Maintaining such a wide forest buffer around all seasonally flooded ponds on a course may be impractical, but alternative management steps could include maximizing the forest and/or shrub buffer around ponds. This includes creating forested travel corridors that allow movement from seasonally flooded ponds and their associated buffer to large patches of potential nonbreeding habitat.

Acknowledgments

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