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...Using Science to Benefit Golf

University of Rhode Island scientists are studying amphibian movements in and around golf courses in the Northeast to gain an understanding of how golf course design of water features can help bolster amphibian populations. Shown above are Wood Frogs that are among the most common pond-breeding amphibians found in the Northeast. Males and females typically arrive at breeding ponds after snow melt in early March.

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PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 215 projects at a cost of $21 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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Strategies to Maintain Pond-Breeding Amphibians on Golf Courses

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SUMMARY

Pond-breeding amphibians have complex life cycles that make them vulnerable to habitat loss and fragmentation. Adults of most species typically spend less than one month annually in breeding ponds. During the remainder of the year, they reside in adjacent forested uplands and wetlands (sometimes over 200 yards away or farther). Juveniles disperse among ponds and are capable of moving great distances (~1.5 miles). Therefore, golf course designers and superintendents interested in maintaining ecosystem integrity need to manage breeding ponds, habitats used during the non-breeding season, and habitats used as movement corridors.

Since 1997, we have been studying the habitat characteristics of breeding ponds and dispersal corridors. Our research has shown that most pond-breeding amphibian species prefer ponds that dry annually, with different species preferring ponds with varying hydroperiods (i.e., days of surface inundation), generally avoid ponds with fish, are more likely to disperse through forested landscapes with a shrub understory, and often avoid moving across broad expanses of turf, such as fairways or greens.

Superintendents that 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.

Biologists are increasingly concerned with amphibian populations because of documented declines at local, regional, and even global scales. A variety of factors have been implicated in these declines (e.g., introduced predators, fertilizers, pollutants, and UV-B radiation in sunlight), and one of the leading factors is the impact of habitat fragmentation on pond-breeding amphibians (4).

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

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 impact amphibian populations. Amphibian 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 (i.e., the transformation into terrestrial organisms). Adults are usually highly site faithful to their breeding pond,

An example of a typical, natural pool used by pond-breeding amphibians in the Northeast. This pond has a relatively closed canopy, with trees surrounding the pond. This pond usually dries every year by September and has five species of frogs and three species of salamanders that use this pond as a breeding site.

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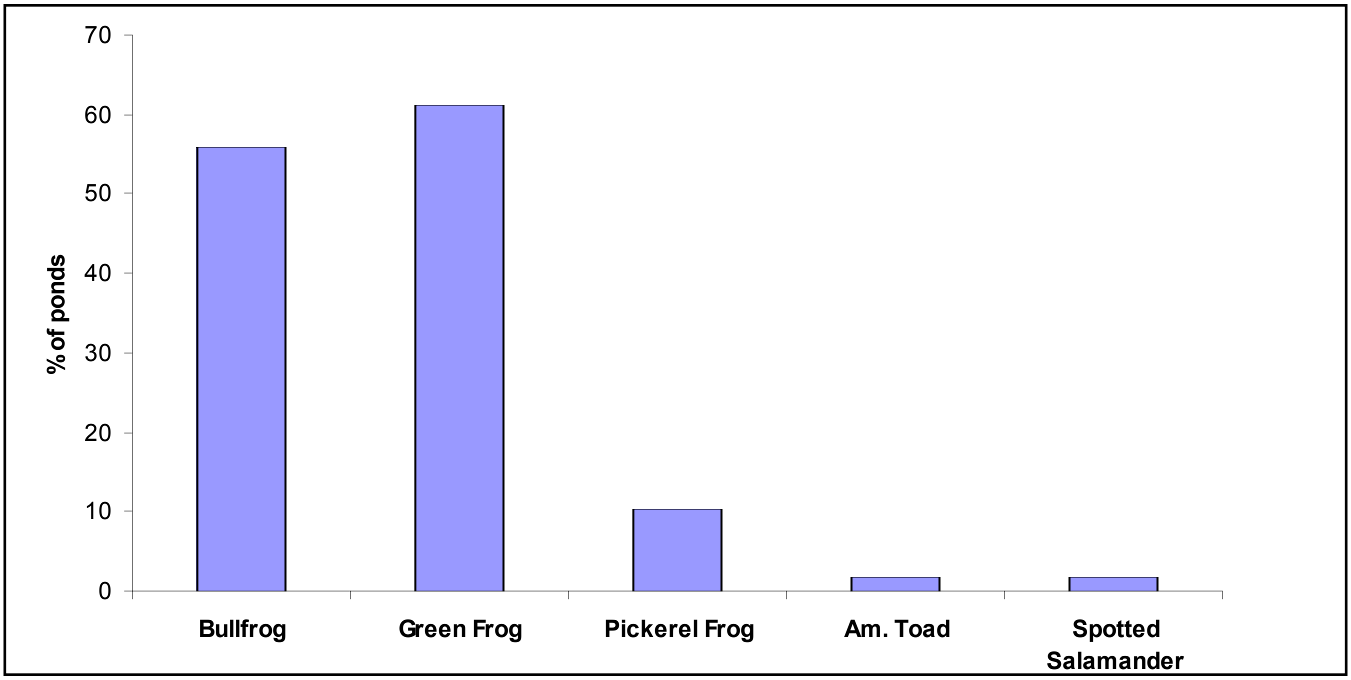

Figure 1. Percent of 59 ponds sampled on golf courses in southern New England (Rhode Island, Connecticut, and Massachusetts) with various species of pond-breeding amphibians.

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. For most of the year, adults and juveniles of most pond-breeding species reside in forested uplands and forested wetlands near breeding ponds, with many individuals traveling considerable distances to reach their non-breeding territories (e.g., salamanders of the genus *Ambystoma* travel 180 yards and farther; 8).

Pond-breeding amphibians migrate twice a year, once from their non-breeding habitat to the breeding pond, and then back to their non-breeding 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 the physical and habitat characteristics of breeding ponds, an understanding of habitat requirements during the non-breeding season, and knowledge of the intervening habitats used during migration to and from ponds and non-breeding habitat. What makes it even more difficult is that biologists are just beginning to untangle the complex habitat requirements of pond-breeding amphibians, particularly during migration and the non-breeding 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 pond-breeding amphibians in southern Rhode Island. Our goal in this paper is to give readers a sense of what we believe are the key management issues that people working in the golfing profession need to understand

Hydroperiod of breeding ponds

To assess pond-breeding amphibian use of ponds on golf courses, we used dip-nets to sample 59 ponds at 32 golf courses in Rhode Island, Connecticut, and Massachusetts during the spring and early summer of 1999. Most ponds on golf courses had either green frogs (*Rana clamitans*) or American bullfrogs (*R. catesbeiana)*, with few other species detected (Fig. 1). This was primarily because most of the ponds we sampled on golf courses were permanent. In addition, many ponds on golf courses we sampled 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 hydrope-

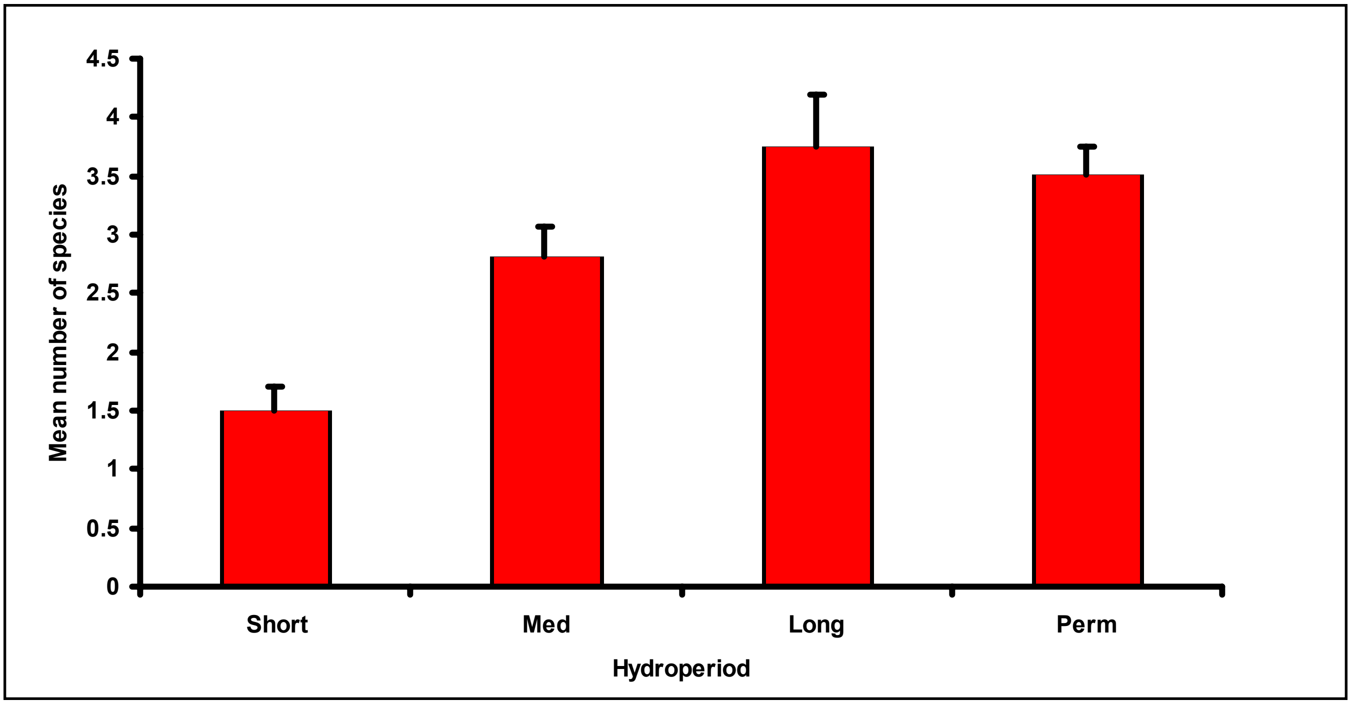

Figure 2. Relationship between pond-breeding amphibian species richness (mean number of species per pond (+ standard error) and hydroperiod in 137 ponds in Rhode Island. Ponds with a short hydroperiod are defined as those drying in June or July, medium-hydroperiod ponds dry in August or September, long-hydroperiod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

riod (i.e., the number of days with standing water in the pond basin) was one of the most important variables determining amphibian community structure. Ponds with a long hydroperiod (drying in October or November) tended to have the most species (Fig. 2), while ponds with a short or medium hydroperiod (drying annually from June through September) tended to have unique species not found in permanent ponds.

Wood frog egg masses attached to buttonbush shrubs in the center of a small pond in western Rhode Island. An estimated 1500 egg masses were in this pond, covering a 5' diameter area. Both wood frogs and spotted salamanders usually attach eggs masses to woody vegetation.

For example, wood frogs (*Rana sylvatica*) and marbled salamanders (*Ambystoma opacum*) were usually detected only in ponds that dried before September. Tadpoles of both species are 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. Both these species have tadpoles that take much longer to complete metamorphosis (two years for bullfrogs and one year for green frogs), thus they require ponds with longer hydroperiods for successful reproduction.

The take home message from this research is that is if you want to maintain the entire amphibian community on your golf course, you have to maintain 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 (10).

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*), where spring peepers tend to thrive in ponds with no canopy closure.

Effect of grass height and habitat on movements

To assess the whether grass height may affect movement behavior of amphibians, during the 1998 field season, we constructed two square pens (50' on each side) on a four-hectare section of 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 0.5-m tall silt fence. The pens were subdivided into 4 quarters (25' per side). Each quarter (randomly selected) was mowed to a grass height that mirrored height typically found on golf greens, fairways, and roughs (0.25", 0.5", 1", and >1.0"-2-5").

All experiments were conducted on rainy nights, when amphibians were likely to move. During the experiment, an individual amphibian (wood frog, American toad, green frog, bullfrog, or pickerel frog) was placed in the center of the

A young Pickerel Frog, one of the more common species in large, permanent ponds in New England.

An adult male Green Frog, one of two species of frogs usually seen in ponds on golf courses in New England. Tadpoles of this species take one year to complete metamorphosis, thus they usually only breed in permanent ponds. This species overwinters in ponds and streams.

array and it's movements monitored for a 3-minute period. We also constructed another set of experimental pens at ecotones between a forest and mowed lawn <0.5", and a forest and lawn.

During grass height experiments, we found no evidence that frogs preferred any grass height during the 3-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, that is typical of current golf courses in North America, does not hinder or enhance amphibian movements. This is true for the species we sampled, but we did not have the opportunity to investigate any salamanders or some frogs (Spring Peepers, Gray Tree Frogs, and Wood 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 to either turf or barren areas. In both cases, the evidence shows that wooded habitats were preferred over barren ground or turf. This suggests that amphibians preferred forested habitat as movement corridors over open habitats such as fairways.

Effect of turf on dispersal of amphibians from a series of ponds

We also conducted an observational study to assess the influence of habitat on movement behavior of amphibians. From 1998-2000, we monitored the immigration and emigration of adults and emigration of metamorphs 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 occurred less often at an ecotone between a turf field and a woodland (e.g., wood frog, spotted salamander, spring peeper, gray treefrog, and red-spotted newt). In contrast, species that winter in aquatic habitats readily crossed the turf-woodland edge (e.g., green frog, American bullfrog, pickerel frog). Metamorphs of most species tended to be habitat generalists during migration, whereas adults tended to exhibit more habitat selection.

To further test the influence of habitat on migration, we removed the overstory and understory in five small patches (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 movement patterns of at least four species were affected by small scale vegetation removal.

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 non-breeding season and winter in forest habitats (e.g., 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 that avoid open habitats more than young-of-the-year.

An adult Gray Treefrog, a species common in ponds in New England. This species breeds during May. They are an arboreal species that overwinters in trees. Because they prefer trees, fairways can be a dispersal barrier to this species.

A adult male Wood Frog near the water's surface. Males arrive at breeding ponds in early March and actively call to attract females to breeding ponds. This species spends most of the year in forested habitats within 200 meters of breeding ponds. In experiments in Rhode Island, this species was reluctant to cross open expanses of turf such as fairways.

In contrast, species that winter in aquatic habitats such as streams or ponds (e.g. American bullfrog, green frog, and pickerel frog) are less likely to be impacted by forest fragmentation because they are willing to cross open habitats.

This explains why ponds on golf courses tended to be dominated by this latter group of species. 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/wintering sites.

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

So what does this mean for golf course designers and superintendents of existing courses? Available evidence suggests the habitat characteristics of a golf course can impact 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 should maximize the amount of forest cover on a course, while simultaneously creating forested travel corridors between breeding ponds and non-breeding habitat.

A young Red-spotted Newt, often referred to as an eft, that has recently emerged from a breeding pond. Efts remain on land for three to seven years, often wandering great distances before returning to ponds to breed.

A juvenile Gray Treefrog that recently emerged from a breeding pond. Note the cryptic green coloration, which acts as camouflage when hiding in shrubs and trees.

The species most sensitive to habitat fragmentation all primarily breed 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, however Semlitsch (8) estimated that approximately 95% of the population of mole salamanders usually occurs within 180 meters of the pond.

Maintaining such a wide forest buffer around all seasonally-flooded ponds on a course may be impractical. Yet, alternative management steps could include maximizing the forest/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 non-breeding habitat.

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