Using Golf Courses to Bolster Amphibian Communities

University of Missouri scientists provide amphibian management guidelines for ecologically minded superintendents.

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Many wildlife species are declining and we face a general biodiversity crisis worldwide. One of the primary reasons for this crisis is the loss and alteration of natural habitat for species.[16] As human populations expand, wildlife is displaced and needed resources are eliminated.

Along with development of living space for humans, we crave green recreational areas to pursue leisure pastimes such as golf and enjoying the outdoors. In fact, in the United States, more than 24.5 million men, women, and youth spend 2.4 billion hours playing on 16,000-plus golf courses.[14] Managing landscapes with an eye for both human use and preservation of natural resources can create a win-win situation for humans and wildlife.[9] Our goal is to provide managers with biologically determined criteria and techniques for bolstering the diversity of amphibians on golf courses.

Restricted practices should include "no mow, no spray" 25-feet-wide buffers adjacent to all core habitats including uplands, followed by another 25-feet-wide buffer where organic fertilizers only are allowed.

AQUATIC HABITAT NEEDS

Amphibians are known to use man-made ponds, like water hazards, sediment retention basins, or farm ponds, so golf course ponds can be managed in such a way to promote amphibian abundance and diversity. Three key factors should be considered when establishing amphibian communities. First, eliminating fish from ponds is a critical step, because ponds without fish allow for greater amphibian abundance and more diverse communities. The presence of fish eliminates most amphibian species through predation on eggs, larvae, and juveniles, and through competition for food resources.[3,6,7,12] Additionally, fish also can carry diseases that are associated with amphibian mortality,[17] especially stock fish obtained from hatcheries.

Man-made ponds are frequently stocked with fish to control mosquitoes or algae; however, amphibians can serve the same role in the aquatic environment,[1,8] as well as insect control in the terrestrial environment. This can be achieved without stocking costs and effort, and without negatively affecting native populations. Researchers have found that removing fish by either draining ponds or repetitive netting can allow amphibian communities to recover.[15]

While common sense might suggest that permanent ponds would be better for amphibians, the greatest amphibian diversity is actually associated with ponds that dry for a short part of the year. Pond drying increases amphibian diversity because it eliminates fish and reduces insect predators as well as large competitors. Many insects live part or all of their life cycle in ponds, and many of these are voracious predators that can eat amphibians 10 to 20 times their own size.

Permanent ponds favor amphibian species with long larval periods that typically exceed one year, like bullfrogs and green frogs. The larger tadpoles of bullfrogs and green frogs have

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a greater ability to secure resources and can negatively affect smaller tadpoles of native species that have to reach metamorphosis in a shorter amount of time.[2] The negative effect of bullfrogs has been associated with amphibian declines, especially in areas where they have been introduced.[4,5]

Although characteristics associated with pond hydroperiod and the predators or competitors that inhabit the pond are important, chemical contamination is another factor that can influence aquatic communities. Because golf courses are routinely treated with chemicals and fertilizers, golf course wetlands are potentially exposed to contaminants.

Indirect effects are those that do not affect individual physiology or behavior, but instead affect the species of interest through changes in the food web, such as decreases in food resources or decreases in the number of predators. Tiny zooplankton and algae are generally more sensitive to insecticides and herbicides, respectively, than are amphibians. Because zooplankton are the food resources for larval salamanders, reduction in zooplankton can result in larval death by starvation, even though environmental concentrations may not be directly lethal to the larvae.

Many contaminants appear to have endocrine-disrupting properties, and such effects also may compromise the sustainability of populations if a significant portion of the population is sterile or all one sex. For these reasons, it would be ideal to minimize the potential for ponds to be exposed to contaminants by increasing no-spray zones or vegetative buffers, which will help filter contaminants so that increased concentrations of contaminants will not reach the aquatic environment. Also, using chemicals only when necessary rather than preventatively should improve water quality for pond-breeding amphibians and other species that live in golf course aquatic habitats.

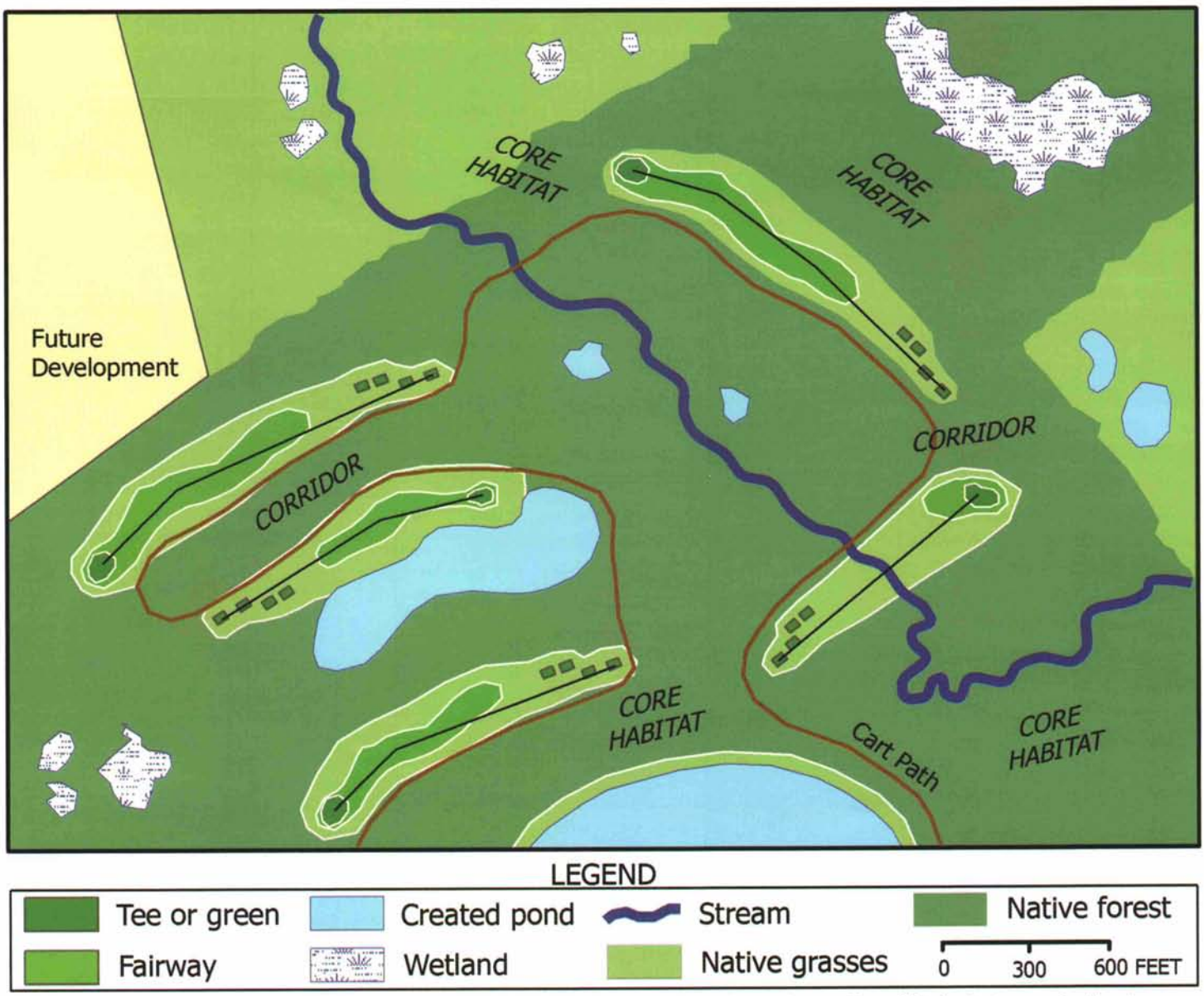
TADPOLE SURVIVAL IN GOLF COURSE PONDS

We recently conducted a study on several golf courses where we placed a total of 40 enclosures in two golf ponds and two reference ponds. Into each enclosure, tadpoles of American toads and southern leopard frogs, and larvae of spotted salamanders were placed; half of the enclosures also included five over-wintered bullfrog tadpoles. We found greater tadpole survival in golf course ponds compared to reference sites.

This outcome may be surprising, but it can be easily explained by a reduction of insect predators found in golf course ponds, as well as greater food resources — both of which could be attributed to chemical contamination. This suggests that amphibians could survive in golf course ponds or other habitats that receive some chemical contamination. Yet, interestingly, over-wintered bullfrog tadpoles negatively affected survival to metamorphosis of amphibians whether on golf course or reference ponds. This result highlights the importance of creating environments that are less favorable to competitors and predators of amphibians in order to support diverse amphibian communities.

While amphibians frequently appear at newly created wetlands, there are conditions that will favor more or less diverse communities. The least diverse communities are very likely ones that contain bullfrogs only, which often results with the presence of fish in permanent ponds. Having bullfrogs in ponds is not a sign of successfully managing a site for amphibian population diversity; in fact, it indicates just the opposite. This species has been widely introduced around the world where it has become a pest species, causing amphibian extinctions and reducing abundance of native amphibian populations.

Designing and constructing aquatic environments that support diverse amphibian communities can be accomplished through periodic drying of wetlands in the late summer to eliminate or reduce fish and bullfrog populations, and through reduced chemical contamination. These straightforward techniques can increase the likelihood



Good amphibian habitat requires complementation between aquatic and terrestrial habitats so that each is readily available for their respective function. Separating aquatic and terrestrial habitats by fairways, roads, or buildings disrupts or potentially stops natural migrations for many species and leads to population declines.

of supporting amphibians in a critical portion of their life cycle, and they could help buffer amphibian populations from declines in regions experiencing rapid habitat loss and alteration.

TERRESTRIAL HABITAT NEEDS

Although many amphibians can be seen in ponds around golf courses, for most species, the majority of their time is actually spent on land. We have only recently begun to discover where and how far amphibians go after breeding and what habitats are important for their survival and for persistence of the population. Ponds are often used for breeding by a single population. They are faithful to that pond and migrate to and from the pond each breeding season. They also appear to be faithful to the terrestrial habitat surrounding ponds. We know that individuals migrate in and out of the pond in the same place each year and that they travel several hundred yards away from ponds into the forest or fields, depending on species' preference.[13]

It is not just distance from the pond that is critical for protection of terrestrial amphibian populations; attention must be focused on protection of specific features necessary for life functions. It becomes imperative that we protect areas that include specific critical habitats as determined for the particular set of species in a region.

We need to maintain the complementation between aquatic and terrestrial habitats (e.g., foraging and overwintering habitats) so that each is readily available for its respective life history function. This means that aquatic habitats are readily available to adults for breeding and for growth and development of larvae. Further, the

Spadefoot toads are often associated with temporary wetlands located in grasslands.

terrestrial core habitat needed by metamorphosing juveniles and adults after breeding should be directly adjacent to the pond. Natural and created water bodies, including seasonal shallow wet areas, are the best starting points as these are sites of amphibian breeding. For long-term persistence of amphibians on the golf course, it is important to connect core habitats (where amphibians spend most of their time) not only within your property but also to potential core habitats adjacent to your property.

We believe that amphibians can provide a number of hidden benefits to golf courses and the golfing community. First, because pond-breeding amphibians occupy both aquatic and terrestrial environments, amphibians play an integral role in most wetland, stream, and adjacent forest ecosystems.[10,11] As such, they provide a number of functions and services that can be beneficial to all members, including humans. As herbivores (plant eaters), frog and toad tadpoles consume vast amounts of algae, periphyton, and plant material in the aquatic environment that would otherwise clog waterways and create unsightly algal mats caused by fertilizer runoff. As carnivores (meat eaters), salamander larvae consume zooplankton and aquatic insects like mosquito larvae that infest ponds and, in some regions, carry diseases like West Nile virus.

There is no doubt that many conservation biologists perceive golf and golf courses as contributing to the growing problem of habitat loss and alteration. However, the recreational needs of the human population are a legitimate and an important use of resources. Balancing the use of these natural resources with the conservation of biodiversity is also important and, as biologists, we consider it our ultimate objective.

Table 1

Summary of major recommendations for bolstering amphibians on golf courses.

1. Preserve and restore existing seasonal or temporary wetlands and streams, including their natural ability to fill and dry, typically in late summer/autumn.
2. Provide created ponds without fish by regularly netting or by draining during late summer/autumn.
3. Preserve, restore, and create many sizes and types of ponds, wetlands, and streams with and without forest canopy and no more than 200-500 yards apart.
4. Include forested and grassed uplands around aquatic sites that extend 150-300 yards from the water with management for native habitat at least in the 100 yards closest to the water. Manage aquatic and surrounding terrestrial areas as amphibian core habitat.
5. Augment core habitats with minimum 50-yard-wide corridors of managed native forest and grasses.
6. Use Best Management Practices (BMPs), Integrated Pest Management (IPM), and a management plan during construction and maintenance of the golf course, especially to reduce or eliminate pollutants.
7. Monitor surface and ground water quality to assess the effectiveness of the management plan.
8. Monitor amphibian populations for successful reproduction, juvenile recruitment, and a diverse group of species.
9. Adapt management as needed based on monitoring and current research.
10. Reach out to local, regional, and national groups to educate and be educated on amphibians and golf.

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Some amphibian species such as the spotted salamander are associated with forests.

LITERATURE CITED

1. Beard, K. H., K. A. Vogt, and A. Kulmatiski. 2002. Top-down effects of a terrestrial frog on forest nutrient dynamics. *Oecologia* 133:583-593.

2. Boone, M. D., E. E. Little, and R. D. Semlitsch. 2004. Overwintered bullfrog tadpoles negatively affect salamanders and anurans in native amphibian communities. *Copeia* 2004:683-690.

3. Boone, M. D., R. D. Semlitsch, E. E. Little, and M. C. Doyle. 2007. Multiple stressors in amphibian communities: Interactive effects of chemical contamination, bullfrog tadpoles, and bluegill sunfish. *Ecological Applications* (in press).

4. Hayes, M. P., and M. R. Jennings. 1986. Decline of ranid frog species in western North America: Are bullfrogs (*Rana catesbeiana*) responsible? *J. Herpetol.* 20:490-509.

5. Hecnar, S. J., and R. T. McCloskey. 1997. Changes in the composition of a ranid frog community following bullfrog extinction. *American Midland Naturalist* 137:145-150.

6. Heyer, W. R., R. W. McDiarmid, and D. L. Weigmann. 1975. Tadpoles, predation, and pond habitats in the tropics. *Biotropica* 7:100-111.

7. Knapp, R. A. 2005. Effects of non-native fish and habitat characteristics on lentic herpetofauna in Yosemite National Park, USA. *Biological Conservation* 121:265-279.

8. Kupferberg, S. J. 1997. The role of larval diet in anuran metamorphosis. *American Zoologist* 37:146-159.

9. Rosenzweig, M. L. 2003. Win-win ecology: How Earth's species can survive in the midst of human enterprise. Oxford University Press, New York.

10. Semlitsch, R. D. 2006. A paradigm shift in wetland boundaries. *National Wetlands Newsletter* 28:6-8.

CONNECTING THE DOTS

A Q&A with Dr. Raymond Semlitsch, *University of Missouri, regarding the use of golf courses to bolster populations of amphibians.*

Q: *How serious is the decline of amphibian populations throughout the U.S.? Are there wildlife census data that depict just how serious this is?*

A: There are a number of reliable published accounts of species declines in the U.S. and globally. The most recent study estimates one-third or 1,896 species of amphibians are threatened with extinction worldwide. Amphibians are now considered more threatened than birds or mammals.

Q: *It seems to me that one of the first things that a typical landowner may want to do with a newly constructed pond is to stock it with fish. For that reason, do you think that golf course water features could be more successful than homeowner ponds in bolstering amphibian populations?*

A: Building a pond in your backyard for fishing is great, especially if you have children who can learn about wildlife through fishing. But not every pond needs to have fish, especially on golf courses where fishing is not the primary activity. For that reason, golf course ponds can be maintained fish-free more easily and may supplant natural wetlands to promote amphibian diversity. I see golf courses as potential nature sanctuaries.

Q: *If bullfrogs or green frogs have taken over water features, can they be selectively removed to allow greater species diversity of the amphibians using that water feature? How?*

A: The adult bullfrogs and green frogs are recruited from metamorphosing tadpoles within that pond. The only effective method to remove them is by stopping the recruitment through drying the pond once a year, at the end of the summer or in early fall, after all other species have metamorphosed.

Q: *How important are amphibians as a food source to other wildlife predators? Is it likely if golf course water features are managed to bolster amphibian populations that additional predator wildlife species will be attracted to the area? If so, what predators would that include?*

A: A primary role of amphibians in any ecosystem is that of providing food for predators. Their presence will increase the diversity of predator species and create a more natural complex and balanced community. I would predict that more birds, especially wading or shore birds, would be seen in or around golf course water features during the day. Other predators, like small mammals and snakes would also increase, but most of these are noctural and less easily encountered.

Q: *You mentioned that many potential contaminants to wetlands have endocrine-disrupting properties. What are some of these? Is there evidence that golf courses are a source of these contaminants?*

A: The primary source of endocrine-disrupting chemicals is from herbicides; both atrazine and glyphosate are typically the active chemical ingredients. It is less likely that golf courses are a major source of endocrine disruptors or even use much herbicide compared to agricultural landscapes in the Midwestern U.S.

Q: *What are some instances where endocrine-disrupting contaminants have been detected in water features, and what has been the effect on wetland species?*

A: Endocrine-disrupting chemicals in herbicides are very commonly found in agricultural fields, ditches, and streams flowing through farming regions of the U.S. Effects that have been reported include feminizing of male frogs, skewed sex ratios toward female frogs, an increase in the number of inter-sex (half male/half female) frogs, and abnormal sexual development.

Q: *Did it surprise you that your study showed greater tadpole survival in the golf course ponds compared to the reference ponds? Do you think that would hold true for most golf courses?*

A: It was very surprising. We really thought most golf course ponds were full of chemicals from years and years of runoff and that our tadpoles would die overnight. When we thought about it, however, we understood that managers are more careful using chemicals, probably using fewer and safer chemicals now than 10 or 20 years ago. Of course, our study clearly showed that chemicals were still present in levels great enough to eliminate insects, the main reason tadpoles did poorly in our permanent reference ponds. I really think our results are applicable to other golf courses; how broadly, we don't know. That would be interesting to pursue, especially across regions that may have different management guidelines for chemical use.

Q: *What's the best reason that golf course superintendents should consider managing wetlands and water features to support amphibian populations?*

A: I think the bigger reason is that it would be a chance for superintendents to contribute to a "greater good" of their town and its citizens, to our society, and to our planet by helping to conserve our natural wildlife. At the same time, it would create a different environment than people would envision on most golf courses; it would help create a more balanced, complex, and natural ecosystem. The golf course would become a showcase for nature and attract more people to enjoy a stroll, birdwatch, or just listen to frogs peeping as the moon rises. I think it would generate great pride in any superintendents to know that they played an active role in helping to educate the public about the natural world and that they may have helped save a species or two.

Jeff Nus, Ph.D., *manager, Green Section research.*

11. Semlitsch, R. D. (ed.). 2003. Amphibian conservation. Smithsonian Institution, Washington, D.C.

12. Semlitsch, R. D. 1988. Allotopic distribution of two salamanders: Effects of fish predation and competitive interactions. *Copeia* 1988:290-298.

13. Semlitsch, R. D., and J. R. Bodie. 1998. Are small, isolated wetlands expendable? *Conservation Biology* 12:1129-1133.

14. U.S. Golf Association. 2006. General articles: Golf courses benefit people and wildlife. USGA Website.

15. Vrendenburg, V. T. 2004. Reversing introduced species effects: Experimental removal of introduced fish leads to rapid recovery of a declining frog. *Proceedings of the National Academy of Sciences USA* 101:7646-7650.

16. Wilcove, D. S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. *BioScience* 48(8):607-615.

17. Willoughby, L. G. 1985. Rapid preliminary screening of *Saprolegnia* on fish. *Journal of Fish Diseases* 8:473-476.

Editor's Note: *A more complete report of this work can be found at USGA Turfgrass and Environmental Research Online at http://usgatero.msu.edu/v06/n01.pdf.*

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