Keeping all the Pieces: Restoring Natural Processes for Easier Golf Course Management

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Golf courses can be compatible with wildlife when management practices support natural habitats. For example, several amphibians use ponds for larval development, and many adult species congregate around ponds during the year. Golf courses can benefit local amphibian populations because they frequently have ponds on their property. Managing golf courses in ways that help amphibians can provide benefits such as tadpoles grazing on algae, young salamanders eating mosquito larvae, and adult amphibians feeding voraciously on nuisance insects.

Golf is one way more than 25 million people per year in the US spend time in nature breathing the fresh air of a blue sky that is ready to usher their ball to wherever on the course it will land. Although a golf course will never replace unfettered nature, it is a green space akin to a park that can restore the souls of humans and preserve some of the local biodiversity of an area. One group that golf courses can potentially benefit are amphibians—frogs and salamanders—species that are found on every continent except Antarctica and are experiencing declines around the world due to habitat loss, disease, chemical contaminants, and exotic species (Semlitsch 2003). Golf courses can provide quality recreation while mitigating the loss of natural habitat and preserve some of the diversity present in an area. However, protecting wildlife like amphibians does not have to be completely altruistic, because the presence of these organisms could make managing golf courses easier.

The USGA supported a study in Oxford, Ohio by scientists at Miami University to examine how buffer vegetation around ponds could benefit amphibians. The goal was to reduce nutrient and pesticide runoff into ponds, and provide valuable habitat for adult amphibians to survive during the winter. The scientists found that sensitive species like Blanchard´s cricket frogs (*Acris blanchardi*) benefited from buffer zones and taller grass surrounding ponds.

Pond–breeding amphibians start their lives in water and metamorphose to live on land until they return to ponds to reproduce, making them critical players in both aquatic and terrestrial ecosystems. Because designers frequently plan wetlands on golf courses, these courses have the potential to attract local amphibians. Amphibian communities are most diverse in habitats with temporary ponds, because these habitats are nutrient rich and lack fish, predators that frequently eliminate most species of amphibians. Because frogs and toads feed on algae as tadpoles, they can keep pond water clear and reduce the likelihood of floating algal mats. Salamander larvae feed on small organisms in the water larval mosquitoes, thereby

reducing the number of flying pests. As adults, all amphibians eat insects and are voracious predators, further reducing the number of nuisance species.

While one can use other means, like pesticides, to combat pest species, there are financial and time costs associated with them, not to mention environmental costs, warranting application on an as needed basis. Although pesticides may eliminate algae or mosquito larvae for one season, managers may need to spray yearly or even multiple times per year. Spraying with pesticides can also reduce the abundance of natural invertebrate predators of insect pests, which means managers may reduce the ability of nature to take care of other pests that arrive, thus requiring greater chemical management. Additionally, many courses use herbivorous fish to control algae or mosquitofish (*Gambusia* spp.) to prey upon mosquitoes. While stocking ponds with fish may be a one–time cost investment, it will likely exclude the potential for diverse amphibian communities. For instance, we found cricket frog (*Acris crepitans*) and green frog (*Rana clamitans*) survival was reduced dramatically when reared in experimental ponds with herbivorous triploid grass carp (*Ctenopharyngodon idella*; a species introduced at one of our local courses) or predatory bluegill sunfish (*Lepomis macrochirus*; Ade et al. 2010). This research indicates that presence of fish, regardless of their diet, can negatively influence amphibians. By providing suitable habitat for amphibians, they will often arrive on their own and can provide pest control over time without any major investment from course managers.

If using native amphibians as biocontrol agents sounds great, then what does it take to attract diverse amphibians to your course? When golf courses are relatively close to natural habitats, it can be as simple as "build it and they will come." Most of the courses we have visited appear to have some amphibians using those sites. The amphibian populations on a golf course can be self–sustaining or population sinks—habitats that attract local amphibians from nearby sites that ultimately fail to produce offspring. In the last few years, my lab has investigated if golf courses can provide suitable habitat for self–sustaining amphibian communities. Initially, we conducted studies in Missouri at two golf course and two reference ponds using enclosures containing larvae of three local amphibian species in the presence or absence of overwintered bullfrog (*Rana catesbeiana*) tadpoles (Boone et al. 2008), a common competitor found in golf course ponds (Scott et al. 2008).

We predicted that golf courses would be poor habitat for amphibians because of fertilizer and pesticide use, which could subsequently enter aquatic environments where amphibians develop. However, we were surprised to find that amphibians reared in golf course enclosures without bullfrog tadpoles did as well or better than those at reference sites (Boone et al. 2008). In retrospect, this finding is not unexpected given that amphibians persist in areas like the Midwest despite heavy pesticide use. Presence of bullfrogs, however, reduced survival of all three species of amphibians in golf course ponds dramatically.

Because pond drying reduces the presence of aquatic invertebrate predators and strong amphibian competitors like bullfrogs or green frogs, which typically overwinter in ponds and reach large sizes before metamorphosing the following spring, seasonal drying can benefit many species of local amphibians. We also found very few invertebrate predators in golf course ponds (Boone et al. 2008), suggesting that water quality on golf courses was compromised; however, the amphibians may have benefited from reduced predation because predator abundance was very high in reference ponds. Our first golf course study suggested that golf courses that mimic natural hydrology of temporary ponds by drying in late summer to early fall can help support native amphibians communities by excluding some of their competitors and predators.

The aquatic life stage is only one part of the equation for pond–breeding amphibians. Most amphibians spend a few weeks or months in the pond and spend the rest of their life on land, which may last anywhere from one year to a decade or more. If golf courses can serve as suitable habitat for amphibians, as our study in Missouri suggested, then having good terrestrial habitat is also essential. But what makes good terrestrial habitat and how likely is it to coincide with habitats on golf courses? This answer varies with species, but there is a good chance that favorable terrestrial habitat can be

The survival of many smaller amphibians is reduced when herbivorous grass carp or predatory bluegill sunfish are introduced into ponds. Bullfrogs which overwinter in ponds also reduce smaller amphibian populations.

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maintained on golf courses. Many amphibians are forest associated, like spotted salamanders (*Ambystoma maculatum*) and American toads (*Bufo americanus*). For ponds near forested systems that may be nearby, or onsite and undeveloped, many forest–associated species could benefit from golf course ponds. Other amphibians are grassland associated, like cricket frogs (*Acris crepitans*) or northern leopard frogs (*Rana pipiens*); some grassland–associated species will roam terrestrial habitat after laying their eggs in ponds (like northern leopard frogs), while others will stay near ponds during most of the warm months (like cricket frogs). Golf courses seem especially suited to facilitating species that use grassland ponds and that spend much of the year near the pond. But golf course managers should not have to study the natural history of local species to determine which habitat characteristics may be most important, because many amphibian species can benefit from leaving areas that are out–of play more natural by not mowing or directly managing them; this type of management not only saves money, but it can also help amphibians persist at a golf course. One of the sites where we worked placed signs in these unmanaged areas like "Butterfly Wildlife Area" to highlight to golfers the advantages of these spaces. While Studies of amphibians in natural systems suggest that amphibians use approximately 500 to 1000 feet (159 to 290 meters) around a pond (Semlitsch and Bodie 2003); however, they may be able to use less area, particularly if habitats present fulfill the species needs. More research is needed to fully address this issue.

A central management practice that we associate with golf courses is mowing grass, which is essential on the green and areas in play. On some golf courses, however, up to 70% of the golf course may be out of play and is often (or can be) left unmown or less managed, a strategy that could be particularly useful to amphibians when these areas are near ponds. Unmown, grassy areas serve as habitat for many beneficial insects, including butterflies, and also critical habitat for amphibians. For grassland species like cricket frogs, unmown fields provide a refuge from the desiccation of the sun and wind that can be lethal to an amphibian, a place to hide from predators, a pathway to disperse, and a source for insects on which they prolifically feed.

To examine the role of habitat management on golf courses in Ohio, we worked with three courses that each had at least two ponds, one of which the managers left with an unmown grassy area or "buffer zone" of at least three feet (1 meter) and the other that they mowed up to the edge, which was a common practice at these sites (Puglis and Boone 2012). Unmown grass around a pond can serve as an environmental filter for nutrients and chemical contaminants, which reduces their

Cricket frogs were reared in enclosures on golf course ponds which performed as well as natural reference ponds.

movement to other areas or to wetlands; because buffer zones can keep ponds or streams cleaner and diminish the potential for algal blooms, they can be beneficial. We put tadpoles of green frogs and cricket frogs in separate enclosures in these ponds and reared them for a few months until cricket frogs metamorphosed and green frogs grew into larger tadpoles.

Cricket frogs are grassland–associated species that are declining in parts of their range, so if green spaces like golf courses could benefit this frog, it may help maintain populations of this species in some areas. Green frogs, in contrast, are doing well throughout their range and are associated with humans; therefore, they may not be as sensitive to habitat manipulation. We found, similar to our Missouri study, that tadpoles survived well in golf course ponds (Puglis and Boone 2012), suggesting that aquatic habitats on golf courses are sufficient for many amphibian species. We also found that the presence of the buffer zone made a difference for both cricket frogs and green frogs. For cricket frogs, the buffer zone increased survival, suggesting that it filtered out contaminants sprayed on a golf course. In contrast, green frogs did better without a buffer zone; because green frogs have been found to be more tolerant to pesticides than cricket frogs (Ade et al. 2010). Our results suggest that even partial buffer zones may be beneficial for many species—management of buffer zones does not have to be an all or none decision. Because cricket frogs are a more sensitive species, our study suggests that buffer zones could benefit these species and could be a useful management tool for maintaining local amphibian diversity at golf course ponds (Puglis and Boone 2012).

We have examinee how the presence of buffer zones influenced cricket frogs overwinter survival in the terrestrial environment. Therefore, we marked and

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Cricket frogs marked with pink powder were released to track their movements in mown and unmown grass buffers around golf course ponds.

released all of the cricket frogs that were reared in our enclosures in golf course ponds and returned to the course in the spring to search for them. However, we found none of the cricket frogs that had been marked (Puglis and Boone 2012). This could result from no individuals surviving at the course, suggesting some aspect of the terrestrial environment was insufficient; however, it could also indicate that individuals moved to other locations away from golf course ponds or that we simply did not release enough cricket frogs to get a good recovery rate. This component of the study did not clarify if golf course ponds could support self–sustaining populations or if golf courses that attracted cricket frogs would serve as population sinks and actually reduce abundance of this species on the landscape.

To understand how characteristics of terrestrial habitats could influence juveniles and adult cricket frogs, we also studied cricket frog preferences for mown versus unmown grass in enclosures where animals had choices in short–term studies (Puglis and Boone 2012); additionally, we also released powdered cricket frogs on golf courses to examine how mown and unmown habitat influenced their movement (Ramirez et al. 2012). First, we found that cricket frogs favored unmown grass over mown grass (Puglis and Boone 2012). Subsequent studies have indicated that cricket frogs prefer habitats with greater moisture, which is afforded by unmown grass (Youngquist unpublished data). Furthermore, we also found that cricket frogs released on golf courses in unmown grass travelled further than those released on mown grass, and that those released in unmown grass were best able to orient toward a pond (Ramirez et al. 2012). These studies suggest that unmown habitat provides a preferred habitat of cricket frogs and could increase their ability to find ponds efficiently. Because unmown grass harbors more food resources, maintains moisture, and provides a place to hide from predators, unmown grass is likely important for amphibians that would use ponds on golf courses.

Our research suggests that many species of amphibians could benefit from the aquatic and terrestrial habitat on golf courses. Ponds on courses result in survival similar to or greater than reference ponds, and unmown buffer zones may benefit terrestrial survival of many species by providing refuge and food. However, our research suggests not all aquatic and terrestrial habitats are created equally. The more closely habitats mimic natural systems, the more likely golf course managers will reap the free rewards of nature. Aquatic habitats that are fishless and dried–down yearly to every other year during the late summer or early fall are most likely to support diverse amphibian communities. Harboring diverse communities means not only protecting more local amphibians, but it also means reaping the ecosystem services of amphibians throughout the year, because different amphibian

The marked cricket frogs were released into mown and unmown buffer zones around golf course ponds. Unmown grass areas around ponds favored cricket frog survival due to greater moisture, greater travel distances, better orientation toward ponds, and by providing food.

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species reproduce and develop from late winter to summer. Water quality of golf course ponds can be increased through the presence of terrestrial buffer zones—grassy edges—around the pond, which can filter out fertilizers and pesticides before reaching the water. Buffer zones around ponds can also provide essential habitat for amphibians during their terrestrial life while they avoid desiccation, hide from predators, and search for food. Looking to nature as a guide for management can serve as a means for keeping all of the pieces (Gibbons 1993), and restoring ecosystem services in managed areas. With over half of the world's wetlands lost (Zedler and Kercher 2005), habitat destruction is a major issue for aquatic–associated species. When green spaces like golf courses can help mitigate the effects of habitat destruction to some extent, everyone wins.

Summary Points

- Amphibian communities are most diverse in habitats with temporary ponds because these habitats are nutrient rich and lack fish, predators that frequently eliminate most species of amphibians.
- Cricket frog (*Acris crepitans*) and green frog (*Rana clamitans*) survival was reduced dramatically when reared in experimental ponds with grass carp (*Ctenopharyngodon idella)* or predatory bluegill sunfish (*Lepomis macrochirus*)
- For grassland species like cricket frogs, unmown fields provide a refuge from the desiccation of the sun and wind, a place to hide from predators, a pathway to disperse, and a source for insects on which they prolifically feed.
- Buffer zones of three feet or more around ponds increased survival of cricket frogs.

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