Water and sediment samples collected during the *Pseudacris* larval trials were analyzed for chlorpyrifos by The Institute of Wildlife and Environmental Toxicology. Results indicate that pesticide is rapidly absorbed by the sediment. For example, chlorpyrifos was added to a tank at a concentration of 112 ppb, and 24 hours later the concentration in water was 23 ppb. At termination of the experiment (after 4 repeated applications of pesticide), the concentration of chlorpyrifos in the sediment was 443 ppb. Because many frog tadpoles feed in the substrate and are detritivores, this pathway may be a more important contributor than pesticide residues in the water column.

In summary, Larval trials on *Bufo* were completed and data indicates that pesticide concentrations have effects on survival, growth, and time to metamorphosis of tadpoles which are significant and similar to previous trials on the genus *Pseudacris*. Sediment analysis indicates that pesticide added to the water column becomes concentrated in the sediment. Larval trials using *Rana* are in progress.

Field Studies. In March of 1998, egg masses of *Ambystoma jeffersonianum* (Jefferson salamander) and *Pseudacris triseriata* (chorus frog) were translocated into each of the six experimental ponds. Estimates indicate that 90.7 percent of *A. jeffersonianum* and 64.5 percent of *P. triseriata* larvae had successfully hatched. After larvae metamorphosed, individuals were captured by pitfall traps, funnel traps, or time constrained searches. Captured individuals were marked via toe clipping and/or freeze branding for identification in subsequent seasons. Experimental ponds, as well as ponds located on the Rocky Gap Golf Course, have been monitored for natural colonization by local amphibian species. Egg masses found have been identified to species, total number of eggs was estimated, and location of deposition within experimental ponds has been mapped. Larvae that have been dipnetted have also been identified to species.

In the spring and summer of 1998, the following species (in addition to the introduced species) had colonized experimental ponds: *Rana clamitans* (green frog), *Rana sylvatica* (wood frog), *Bufo americanus* (American toad), *Pseudacris crucifer* (spring peeper), *Hyla veriscolor* (gray treefrog), and *Notophthalmus viridescens* (red-spotted newt). Egg masses and/or larvae of the following species were found on ponds associated with the golf course at Rocky Gap: *Rana catesbeiana* (bullfrog), *R. clamitans*, *B. americanus*, and *P. crucifer*.

Although the species composition of experimental and golf course ponds seem similar, several important distinctions should be clarified. The absence of *R. catesbeiana* colonization in experimental ponds should aid in the colonization of smaller species of frogs because *R. catesbeiana* has been implicated in the local extirpation of smaller species due to predation. In addition, ponds associated with the golf course are not colonized as ubiquitously by smaller frog species as experimental ponds are. For instance, not only have we failed to find evidence of *H. versicolor* breeding in golf course ponds, but larvae of *P. crucifer* only were found in one golf course pond while all experimental ponds have contained them. The design of our experimental ponds may promote colonization success of some species. Nearly 60 percent of egg masses were deposited on narrow pond shelves designed to support vegetation that, in part, provides structure for the oviposition of amphibian egg masses. Similarly, the one golf course pond constructed with a shallow shelf on its perimeter is the only course pond that has shown evidence of *B. americanus* and *P. crucifer* colonization.

In summary, egg masses of two species of amphibians have been translocated into experimental ponds at Rocky Gap State Park. Hatching success has been monitored in the egg masses and metamorphosed individuals of both species have been captured and marked for future identification. Experimental ponds, as well as golf course ponds, have been monitored for natural colonization of amphibian species. We have detected six amphibian species that use experimental ponds for breeding and we have detected four species that use golf course ponds for breeding. More importantly, the species composition of our ponds suggests that golf course ponds lack the colonization of smaller species of frogs. However, they support the colonization of a large species (i.e., *R. catesbeiana*) that prey on (and could extirpate) smaller species.

Avian Community Response to a Golf Course Landscape Unit Gradient

Clemson University

David H. Gordon

Start Date: 1998
Number of Years: 3
Total Funding: $60,188

Objectives:

1. *Determine the composition and species richness of avian communities occupying a gradient of golf course landscape units located along the South Atlantic Coast during the breeding season.*
2. *Determine the composition and species richness of avian communities for habitat types found on golf course landscape units located along the South Atlantic Coast during breeding season.*
3. *Examine the influence of landscape context and characteristics of golf course landscape units on the composition and species richness of avian communities.*
4. *Produce a set of outreach products including a technical publication with management and design recommendations, a brochure, and color poster targeted at golf course stakeholder groups.*

David Gordon is assessing the value of golf course landscapes to avian communities. The results of the assessment will be used to produce a technical manual with management and design recommendations, as well as a brochure and color poster targeted at golf course stakeholder groups. The study will

be conducted on several golf courses along the *Grand Strand* area near Myrtle Beach, South Carolina.

Conservation of Native Pollinators on Golf Courses

Xerces Society

Melody Allen

Start Date: 1997
Number of Years: 3
Total Funding: $136,500

Objectives:

The aim of the project is to foster and increase insect pollinator populations including native bees, wasps, moths, flies, and butterflies to offset the effects of habitat fragmentation, and to augment the species composition of native plants in the out-of-play areas to produce continuous flowering throughout the growing season.

In the late summer of 1997, consulting scientists and Xerces Society staff visited several golf courses in eastern Washington and Oregon to rate their appropriateness for study. The interest of the golf course superintendent in participating in the plant and pollinator enrichment program also was determined. Soon after conducting the site visits and interviews, the project team selected four golf courses for inclusion: Wildhorse Resort in Mission, OR; Veterans Memorial Golf Course in Walla Walla, WA; Horn Rapids Golf Course in Richland, WA; and Coeur d'Alene Resort in Coeur d'Alene, ID.

Insect Surveys. The research scientists then initiated surveys on Wildhorse, Veterans Memorial, and Horn Rapids to obtain a background estimate of the number of individuals and species of flower-visiting *Hymenoptera* (bees and wasps) present in late summer and fall. The survey was implemented by a Master of Science student at Washington State University. Coeur d'Alene Resort was declared a reference site because of its abundance of insects and native plant communities.

In late spring of 1998 through fall of 1998, the same estimation process was implemented under Dr. Heidi Dobson at Whitman College in Walla Walla, Washington. In addition to collecting specimens, nesting block stations using blocks of wood drilled with varying sized holes to attract a diversity of hole nesting bee and wasp species were set up. The blocks were attached to 3-foot posts and placed in the ground at each golf course and in a reference site approximately one mile away. The reference sites were chosen for quality of native vegetation.

Preliminary analysis of these nesting blocks is in Table 12. Entomologists at the USDA Bee Biology and Systematics Laboratory in Logan UT have opened the blocks, extracted, and dissected each nest into its component cells. After recording this data, the cells were placed in gel capsules and stored at 3 to 5 °C for the winter. Next spring they will be returned to the golf course where the bees and wasps will be allowed to emerge normally.

Collection Technique. The baseline data at Wild Horse Horn Rapids and Veterans Memorial has been obtained using a passive trapping technique with colored plastic cereal bowls. The bowls were filled with a dilute solution of detergent and water that attracts bees, wasps and flies. The insects land on the surface of the solution and drown. The trap bowls were laid out once per week in transects in the out-of-play areas of the three courses. The survey design called for alternation of the 45 three colored bowls (15 each, white, yellow, and blue), at 10 to 15 feet apart.

The surveying activities are ongoing; however, the project scientists have identified the specimens from 1997. Thus far, 79 species of bees (all native except for the introduced honeybee) and 51 species of wasps from weekly collections in August, September, and October 1997 were trapped at the three golf courses. Specimens from the 1998 season are being prepared for identification at the USDA laboratory. Data will be available next year. The bees include a wide range of species from genera whose members tend to be somewhat specialized in their flower-foraging habits (*Anthidium, Dianthidium, Megachile, Andrena, Nomadopsis*), to those that are quite generalized (all genera in the bee family *Halictidae*).

The wasps also represent a surprising diversity for such a brief sampling period. All are predaceous on arthropods, many of which are considered pests. For example, all *Eumenidae* capture caterpillars, many *Larridae* (*Liris, Larropsis, Tachytes,* and *Tachysphex*) prey on *Orthoperans* (grasshoppers and crickets). *Oxybelus* and *Bembix* are valuable because they hunt and kill flies, and *Podalonia* is a cutworm predator. Although it is early in the analysis, a pattern of abundance seems to be present among the three courses. For a number of *Hymenoptera* individuals captured per bowl trap, Wildhorse had significantly more than the other two golf courses. Walla Walla had significantly more than Horn Rapids (Wildhorse averaged from 8.9 to 19.1 insects per bowl; Walla Walla averaged from 1.4 to 6.8 insects per bowl; and Horn Rapids averaged only 1.0 to 3.7 insects per bowl). This result was somewhat surprising in that Horn Rapids, on cursory inspection, appeared to have the highest representation of native plant species. At the same time, the total vegetation cover at Horn Rapids appeared rather low.

Project scientists have also analyzed the 1997 data for the influence of bowl color but have found no consistent differences among colors.

Native Plant Surveys. During the 1997 field season, the project team contracted with a local botanist and soil scientist to conduct plant and soil analyses of Wildhorse and Veterans Memorial Golf Courses. The goal was to develop a list of native plants occurring historically in the two geographic areas. From these lists, the researchers created a list of target plants for augmenting the existing plantings in the out-of-play areas of the two golf courses. The plant lists were annotated to provide fuller information on each plant species to make it easier for course superintendents to choose and purchase plants. A botanist employed by the Horn Rapids Golf Course produced a plant list