

even insects. It contained a breakdown of all habitat types such as desert, prairie, or woodland, and if the woodland was deciduous or coniferous. It also broke down the water features of the site, by number of ponds and pond acreage, number of lakes and lake acreage, and the amount of wetland area. The model also incorporated the address, state, and zip code and contact name for each site.

A series of reports can now be generated based on the *Resource Inventory Information* logged into the *Managed Land Database Information*. For example reports dealing with geographic regions, address information, land and water acreage, and habitats were developed. This kind of information is very useful and beneficial to the Audubon Cooperative Sanctuary Program and its members. [

## **Developing Methods to Enhance Amphibian Diversity on Golf Courses: Effects of Golf Course Construction on Amphibian Movements and Population Size**

**University of Rhode Island**

*Peter Paton*

Start Date: 1998

Number of Years: 3

Total Funding: \$72,000

Objectives:

1. *Determine the pre-construction population size for amphibians breeding at ponds within the boundaries of a proposed golf course.*
2. *Determine pre-construction travel corridors and movement patterns for amphibians at this same site.*
3. *Quantify population size and movement patterns following construction on the golf course.*

Amphibian movement chronology and community structure was monitored in three ponds in the middle of the proposed golf course construction site starting mid-February 1998. A total of 7,911 amphibian captures representing 11 species were recorded since project initiation. In addition, two species of snakes and seven species of mammals were detected.

Experimental evidence showed that frogs prefer to move through wooded habitats rather than turf areas ( $G = 3.6$ ,  $P = 0.058$ ) or barren areas ( $G = 9.2$ ,  $P = 0.002$ ). This preliminary finding suggests that dispersal corridors from ponds to upland wintering areas will be more effective if designed to include woodlands. However, other research showed that amphibians would readily cross turf.

Experiments with various grass heights (0.25, 0.5, 1.0, and 2.5 inches) found no evidence that grass height affected frog movement patterns ( $G=3.7$ ,  $P = 0.29$ ). This suggests that

varying grass height is not a management option to increase frog use of a potential movement corridor.

Frogs readily crossed a 68 m (225 ft.) wide, mowed grass field, but there was little evidence of amphibian movement across a 175 m (575 ft.) wide grass field. This preliminary evidence suggests that the vast majority of fairways do not represent a dispersal barrier for most species of frogs in New England.

One of the most important scientific findings of this summer's research was that we documented non-random migration of metamorph frogs (e.g., newly transformed young) away from our monitored ponds. We established two 200-m long drift-fence arrays, 100 m to the east (habitat = woodlands) and to the west (habitat = woods and turf fields) of monitored ponds. Several species (Green Frog, Pickerel Frog, and Spotted Salamander) radiate out at random directions from breeding ponds. On the other hand, American Toads, Gray Tree Frogs, Spring Peeper, Wood Frogs, and Red-spotted Newts exhibited habitat preferences, most species were more likely to move through wooded habitats. This suggests that among some species of frogs, metamorphs have an innate genetic predisposition to migrate in specific directions. This has very important implications for management strategies.

**Proposed research for 1999.** Future funding for this research project during the 1999 field season will be used support three types of investigations: 1) we will continue monitoring natural movement patterns amphibians in the North Woods study site (this research will focus on adult movements to/from breeding sites, which was missed during the 1998 field season); 2) a series of experiments will be conducted in the North Woods area to further refine our knowledge of habitat characteristics of amphibian movement corridors, and 3) we propose to initiate a large-scale quantitative survey of the habitat characteristics of breeding sites used by amphibians on golf courses on southern New England, including habitat characteristics of potential movement corridors. [

## **Pesticides and Nutrients in Surface Waters Associated with Golf Courses and Their Effects on Benthic Macroinvertebrates**

**University of Maryland**

*William Lamp*

Start Date: 1998

Number of Years: 2

Total Funding: \$54,896

Objectives:

1. *Measure the concentration of pesticides and nutrients residing in the water column of streams associated with golf courses.*