

CONSERVATION OF RED-HEADED WOODPECKERS (*Melanerpes  
erythrocephalus*) ON MIDWESTERN GOLF COURSES: A CASE STUDY IN OHIO

A Thesis

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By

Melissa Jo Santiago, B.S.

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The Ohio State University

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Master's Examination Committee:

Dr. Amanda D. Rodewald, Advisor

Dr. Robert J. Gates

Dr. Thomas C. Grubb, Jr.

Dr. Paul G. Rodewald

Approved by

---

Advisor

The School of Natural Resources

## ABSTRACT

The red-headed woodpecker (*Melanerpes erythrocephalus*) has declined dramatically since the early 1900's throughout its range (Peterson 1980, Robbins et al. 1987, Sauer et al. 2003), and both the National Audubon Society and Partners in Flight have listed the species as one of high conservation priority (Muehter 1998, Smith et al. 2000). These birds are strongly associated with oak-savanna ecosystems (Smith et al. 2000, Brawn 2001, Hunter et al. 2001), which are now largely absent in midwestern states. However, because golf courses possess some features characteristic of oak-savannas (e.g., widely spaced trees and open understory), they may provide habitat for red-headed woodpeckers. The primary goal of this project was to assess the suitability of midwestern golf courses in Ohio as breeding habitat for red-headed woodpeckers. Specific objectives were to: 1) identify habitat and landscape characteristics associated with the occurrence of red-headed woodpeckers on golf courses, 2) compare habitat structure of golf courses to oak-savannas and other open spaces used by red-headed woodpeckers, 3) assess nesting success of breeding woodpeckers both on and off golf courses, 4) survey for potential nest competitors and predators of red-headed woodpeckers, 5) characterize the foraging behavior of red-headed woodpeckers on golf courses and non-courses, 6) determine if behavior of breeding pairs differed between golf

courses and non-courses, and 7) provide golf course managers with recommendations to maintain or create habitats for red-headed woodpeckers.

I censused for red-headed woodpeckers and measured habitat characteristics on 100 golf courses in central and northern Ohio from May-August 2002 and 2003. I also located 49 nests and measured surrounding habitat characteristics (i.e., nest patch) and monitored 16 of these nests to determine nesting success on golf courses. Red-headed woodpeckers were detected on 26% of golf courses and were positively associated with large (49 cm diameter at breast height) mast trees (e.g., *Quercus* spp.), snags ( $\geq 16$  cm dbh and  $\geq 2$  m tall), and dead limbs ( $\geq 30$  cm dbh) at both the golf course and nest patch scale. Sixty-seven percent of nests were located in dead limbs of living trees, suggesting that snags are not the only nesting substrates used by red-headed woodpeckers.

Landscape context was important, with 33% of golf courses in rural areas having red-headed woodpeckers, versus only 16% of courses located in urban areas (i.e., within town or city limits). No significant associations were identified between the number of red-headed woodpeckers and European starlings (*Sturnus vulgaris*) or house sparrows (*Passer domesticus*) from the surveys. Twelve of 16 golf course nests (75%) monitored over two years successfully fledged young, and this success rate was comparable to birds nesting off courses ( $n=11$ , 73% success).

For comparisons of red-headed woodpecker nesting success, habitat, and behavior on golf courses versus non-courses, I compared 10 pairs on courses to 10 pairs on non-

courses (i.e., remnant oak-savannas and open spaces). Pairs experienced similar rates of nesting success. Seventy percent of nests were successful (i.e., fledged one or more young) on golf courses and 80% of nests were successful on non-courses. Higher numbers of snags and dead limbs were available at non-course sites, but average dbh of trees on golf courses and non-courses was similar (ca. 45 cm). Oaks were the most common tree species found in the nest patch, both for golf courses (39%) and non-courses (44%). Foraging observations of adult individuals ( $n = 95$ ) showed that red-headed woodpeckers frequently gleaned insects from the ground and especially on golf course turf (38%), which may make them vulnerable to pesticides used on golf courses. Otherwise, behavior and time budgets of red-headed woodpeckers on and off courses were comparable, with birds devoting most of their time to resting (ca. 40%). Active foraging accounted for approximately 15% of the observations. Results suggest that golf courses offer valuable habitat for breeding red-headed woodpeckers and have the potential to contribute to the conservation of this declining species. However, future research is needed to assess the potential for pesticide exposure, differences in productivity between red-headed woodpeckers breeding on golf courses and more natural habitats, and other possible fitness consequences of golf course management practices.

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## VITA

June 26, 1976..... Born – Dayton, Ohio

1998..... B.S. Biological Sciences, The Ohio State University

2002 – 2003..... Graduate Teaching Associate,  
The Ohio State University School of Natural Resources

2001 – 2003..... Research Aide,  
The Ohio State University School of Natural Resources

2001 – 2002..... Student Research Assistant,  
The Ohio State University School of Natural Resources

1998..... Student Research Assistant,  
The Ohio State University Woodlot Project

1997 – 1999..... Student Research Assistant,  
The Ohio State University Museum of Biological Diversity

## FIELDS OF STUDY

Major Field: Natural Resources

## TABLE OF CONTENTS

	Page
Abstract.....	ii
Acknowledgments.....	v
Vita.....	vi
List of Tables.....	ix
List of Figures.....	xi
Chapters:	
1. Overview.....	1
1.1 Introduction.....	1
1.2 Research goals and objectives.....	3
1.3 Thesis format.....	4
1.4 Background.....	5
1.5 Rationale and significance.....	10
1.6 Literature cited.....	13
2. Golf courses: an oak-savanna surrogate for breeding red-headed woodpeckers?.....	18
2.1 Abstract.....	18
2.2 Introduction.....	20
2.3 Methods.....	24
2.3.1 Bird censuses.....	24
2.3.2 Habitat measurements.....	26
2.3.3 Data analysis.....	28
2.4 Results.....	29
2.4.1 Landscape and habitat characteristics.....	29
2.4.2 Breeding pairs: golf course and non-course.....	31
2.4.3 Potential nest competitors and predators.....	31
2.5 Discussion.....	32

2.6	Conservation implications.....	35
2.7	Literature cited.....	37
3.	Nesting and foraging behavior of red-headed woodpeckers ( <i>Melanerpes erythrocephalus</i> ) on Ohio golf courses.....	51
3.1	Abstract.....	51
3.2	Introduction.....	52
3.3	Methods.....	54
3.3.1	Nest monitoring.....	55
3.3.2	Behavioral observations.....	56
3.3.3	Data analysis.....	57
3.4	Results.....	58
3.5	Discussion and conservation implications.....	60
3.6	Literature cited.....	64
	Literature cited.....	73

## APPENDICES

APPENDIX A.	STUDY SITE COORDINATES.....	84
APPENDIX B.	STUDY AREA MAPS.....	89
APPENDIX C.	GOLF COURSE SURVEYS.....	92
APPENDIX D.	RATIO OF JUVENILES TO ADULTS ON GOLF COURSES.....	96
APPENDIX E.	RED-HEADED WOODPECKER TIME BUDGETS ON GOLF COURSES.....	98



## LIST OF TABLES

Table	Page
Table 2.1	Habitat characteristics of 100 golf courses with ( $n = 26$ ) and without ( $n = 74$ ) red-headed woodpeckers in Ohio, May – August 2002-2003.....44
Table 2.2	Habitat characteristics surrounding nests ( $n = 49$ ) of red-headed woodpeckers or averaged over course plots ( $n = 26$ ) in Ohio, May – August 2002-2003.....45
Table 2.3	Percentage and mean ( $\pm$ SE) diameter-breast-height (dbh) of 17 tree species nearest (mean distance = $7.2 \text{ m} \pm 0.41\text{SE}$ ) red-headed woodpecker nests ( $n = 49$ ) on golf courses in Ohio, May – August 2002-2003.....46
Table 2.4	Habitat characteristics of red-headed woodpecker nesting sites ( $n = 10$ ) on golf courses and nesting sites ( $n = 10$ ) on non-courses in Ohio, May – August 2003.....47
Table 2.5	Mean number ( $\pm$ SE) of European starlings, house sparrows, and squirrels on 100 golf courses with ( $n = 26$ ) and without ( $n = 74$ ) red-headed woodpeckers in Ohio, May – August 2002-2003.....48
Table 3.1	Number of red-headed woodpecker nests in 13 tree types for breeding pairs ( $n = 10$ ) on golf courses and pairs ( $n = 10$ ) on non-courses for comparison in Ohio, May – August 2003.....68
Table 3.2	Mean foraging height (m) and mean foraging distance (m) traveled from nest for red-headed woodpecker pairs ( $n = 10$ ) on golf courses and pairs ( $n = 10$ ) on non-courses in Ohio, May – August 2003.....69

Table 3.3	Time budgets, in average number of minutes spent per activity, of 20 red-headed woodpecker breeding pairs in Ohio, May – August 2003 (1 = golf course site, 0 = non-course site).....	70
Table A.1	Latitude and longitude coordinates for 100 golf courses in Ohio surveyed for red-headed woodpeckers in May – August 2002-2003.....	85
Table A.2	Latitude and longitude coordinates for golf courses ( $n = 7$ ) and non-courses ( $n = 8$ ) with red-headed woodpecker breeding pairs for comparison in Ohio, May – August 2003 (1 = golf course, 0 = non-course).....	88
Table C.1	Number of red-headed woodpeckers, European starlings, house sparrows and squirrels surveyed on 100 golf courses in Ohio, May – August 2002-2003.....	93
Table D.1	Ratio of red-headed woodpecker juveniles to adults on 26 golf courses surveyed in Ohio, May – August 2002 – 2003.....	97
Table E.1	Time budgets, in minutes spent per activity, of 72 red-headed woodpeckers on Ohio golf courses, May - August 2002 - 2003.....	99

## LIST OF FIGURES

Figure	Page
Figure 2.1	Percentage of 9 tree types used for placement of red-headed woodpecker nests ( $n = 49$ ) on golf courses in Ohio, May – August 2002-2003.....49
Figure 2.2	Percentage of 5 tree types used for placement of red-headed woodpecker nests ( $n = 10$ ) on non-course sites in Ohio, May – August 2003.....50
Figure 3.1	Percent use of foraging substrates by 75 adult red-headed woodpeckers on golf courses in Ohio, May – August 2002 - 2003.....71
Figure 3.2	Percent use of foraging substrates by adult red-headed woodpecker pairs ( $n = 10$ ) on golf courses and pairs ( $n = 10$ ) on non-courses in Ohio, May – August 2003.....72
Figure B.1	Golf courses ( $n = 100$ ) surveyed for red-headed woodpeckers in Ohio, May – August 2002 – 2003.....90
Figure B.2	Golf courses ( $n = 7$ ) and non-courses ( $n = 8$ ) surveyed for comparison of red-headed woodpecker breeding pairs in Ohio, May – August 2003.....91

## CHAPTER 1

### OVERVIEW

#### INTRODUCTION

Natural disturbances are essential in determining ecological processes and biological diversity in a variety of systems (Connell 1978, Sousa 1984, Pickett and White 1985, Petraitis et al. 1989, DeGraaf and Miller 1996, Askins 2000, Brawn 2001). A disturbance is any event in time that disrupts ecosystem, community, or population structure, affecting the physical environment (Pickett and White 1985) and occurring when physical or biological processes destroy biomass (Walker 1999). Maximum biodiversity occurs when natural disturbances are of intermediate frequency and intensity (Connell 1975, Meffe 1997).

Disturbance and ecological succession are known to shape bird habitats and communities (Brawn et al. 2001). As disturbance regimes have been altered, there has been a concomitant decline in disturbance-dependent wildlife species. In particular, birds that are associated with grasslands, shrub-scrub habitats, and disturbed forests have been declining since the 1950's in eastern North America (Hunter et al. 2001).

Oak–savanna ecosystems are excellent examples of habitats maintained through periodic disturbance. Fires and fluctuations in groundwater allowed these ecosystems to persist (U.S. EPA 1999), but in absence of these phenomena oak-savannas declined. Before pioneers settled midwestern North America, oak-savannas covered 11-13 million hectares in Minnesota, Iowa, Missouri, Illinois, Wisconsin, Indiana, and Ohio (Nuzzo 1985). Only 2,607 hectares of oak-savanna remained in the Midwest in 1985, constituting only 0.02 percent of the original expanse (Nuzzo 1985). Historically, oak-savannas supported a diverse wildlife community including bison (*Bison bison*), white-tailed deer (*Odocoileus virginianus*), elk (*Cervus elaphus*), black bears (*Ursus americanus*), and gray wolves (*Canis lupus*) (Mayfield 1976). Specifically, the red-headed woodpecker is strongly associated with oak-savanna habitats (Smith et al. 2000, Brawn 2001, Hunter et al. 2001).

Despite the reliance of many species on oak-savannas, large-scale restoration of this habitat is unlikely to occur in the midwestern United States given the region's history of fire suppression, value of farmland, and development of commercial and suburban districts. Controlled burning in close proximity to urban and residential areas is generally too risky or politically infeasible to implement as a management strategy. Therefore, identification and management of open woodlands that may serve as oak-savanna surrogates for wildlife are needed. Golf courses may have the potential to partially fill this role, as they represent an under-appreciated wildlife resource in North America.

In the United States, there are approximately 16,000 golf courses accounting for over 6,100 square kilometers (USGA 2004). Golf courses occur in a variety of

landscapes from urban to rural to remnant tracts of nature. A typical golf course occupies 54 hectares of land (Terman 1997) and up to seventy percent of that area may be considered *rough* or *out-of-play* (Tilly 2000). These out-of-play areas, in particular, have the potential to provide substantial amounts of habitat to wildlife. In recent times, golf courses have played an important role in conservation efforts for the eastern bluebird (*Sialia sialis*), tree swallow (*Tachycineta bicolor*), purple martin (*Progne subis*), osprey (*Pandion haliaetus*), and even the endangered red-cockaded woodpecker (*Picoides borealis*) (Tilly 2000). Golf courses may also provide suitable nesting sites for the declining red-headed woodpecker and should be evaluated for wildlife benefits.

## RESEARCH GOALS AND OBJECTIVES

The primary goal of this project was to assess the suitability of midwestern golf courses in Ohio as breeding habitat for red-headed woodpeckers. Specific objectives were to: 1) identify habitat and landscape characteristics associated with the occurrence of red-headed woodpeckers on golf courses, 2) compare habitat structure of golf courses to oak-savannas and other open spaces used by red-headed woodpeckers, 3) assess nesting success of breeding woodpeckers both on and off golf courses, 4) survey for potential nest competitors and predators of red-headed woodpeckers, 5) characterize the foraging behavior of red-headed woodpeckers on golf courses and non-courses, 6) determine if behavior of breeding pairs differed

between golf courses and non-courses, and 7) provide golf course managers with recommendations to maintain or create habitats for red-headed woodpeckers.

## THESIS FORMAT

Chapter 1 provides details on the natural history of the declining red-headed woodpecker, its biology, and association with oak-savanna ecosystems. This chapter also discusses the ecology of oak-savannas and their historical significance. I introduce the concept of golf courses as potential habitat for disturbance-dependent species associated with oak-savannas, in particular the red-headed woodpecker.

Chapter 2 assesses the potential for Ohio golf courses to provide breeding habitat to red-headed woodpeckers, as midwestern courses may possess some features characteristic of oak-savannas. Red-headed woodpecker habitat and nesting on golf courses are compared to habitat on oak-savanna or structurally similar park areas. In addition, potential nest competitors and predators of red-headed woodpeckers on golf courses are investigated.

Chapter 3 describes the behavior of red-headed woodpeckers nesting and foraging on Ohio golf courses. Nesting success, behavior, and foraging strategies of breeding pairs on golf courses and non-courses (i.e., oak-savannas or open spaces) are compared to determine the extent to which activities differed in the two environments. Of particular concern was whether foraging on golf courses put red-headed woodpeckers at excessive risk for pesticide exposure.

All chapters are formatted according to standards set forth by the journal *Biological Conservation*.

## BACKGROUND

Loss of habitat is a major threat to plants and animals around the world. Urbanization and agriculture have replaced most natural areas in the midwestern United States. Oak-savannas are among the ecosystems most endangered by land-use changes (Nuzzo 1985, US EPA 1999). Midwestern oak-savannas provide important habitat to many species of wildlife. In fact, more than 100 bird species from 10 orders and 23 families utilize North American oak-savannas during some part of their annual cycles (Brawn 1998).

Oak-savanna communities are ecosystems dominated by oaks (*Quercus* spp.) with 10 – 80% canopy-closure and an herbaceous understory usually comprised of grass (Nuzzo 1985). Savannas normally contain species associated with both prairie and forest communities and have the appearance of open or scrub landscapes (Nuzzo 1985). Formerly, oak-savannas encompassed at least 11 million hectares in midwestern United States and Canada (Nuzzo 1985, Anderson and Bowles 1999, Brawn et al. 2001). Remnant oak-savannas can still be found in the Oak Openings region in Lucas, Henry, and Fulton counties in Ohio and in other small patches around the state. Historically, periodic fires and fluctuations in groundwater promoted herbaceous vegetation and limited the growth of dense trees and shrubs (U.S. EPA 1999). Since the early 1900's, groundwater levels have lowered because



of anthropogenic changes to the landscape, and fires have been suppressed (Yaussey 2002). Consequently, the cycle of natural disturbances that allows for the continuation of oak-savanna ecosystems has been altered. As the oak-savannas decline, so does the associated wildlife community. Several threatened and endangered species depend on the oak-savannas, including both the karner blue (*Lycaeides melissa samuelis*) and frosted elfin (*Callophrys irus*) butterflies that rely for their survival on wild lupine (*Lupinus perennis*) that grows there (U.S. EPA 1999, Lane and Andow 2003).

Although numerous species utilize habitats found in oak-savannas, the red-headed woodpecker was probably among the most closely-associated avian species with this ecosystem (Smith et al. 2000, Brawn 2001, Hunter et al. 2001). The woodpeckers frequent stands of large trees or snags (i.e., standing dead trees) in low density, with relatively little understory vegetation during the breeding season (Conner 1976, Howe 1984, Monroe 1994, Smith et al. 2000). They inhabit groves, farm country, orchards, shade trees, large scattered trees, and forest edges (Peterson 1980, Smith et al. 2000).

Red-headed woodpeckers are recognizable and charismatic birds in North America. Their range extends east of the Rocky Mountains to the Atlantic coast and as far north as southern Canada, but they are absent in the northeastern-most region of the United States (Peterson 1980, Sibley 2000, Smith et al. 2000). They are only “partially migratory” (i.e., moving within some parts of their range) (Loftin 2004), seeking mast resources (Zimmerman 1993) and winter relief from the coldest, northernmost regions of their range (Peterson 1980, Smith et al. 2000).

The birds are omnivorous, with a diverse diet that includes fruits, seeds, grains, arthropods, small vertebrates, and bird eggs (Beal 1911, Barrows 1912, Bailey 1920, Henderson 1927, Roberts 1932, Graber and Graber 1977, Short 1982, Ehrlich et al. 1988, Venables and Collopy 1989, Belson and Small 1998, Smith et al. 2000). Analyses of stomach contents have shown a summer diet consisting of approximately 67% plant and 33% animal matter (Beal 1911, Smith et al. 2000). During the winter, the red-headed woodpecker's diet relies heavily on hard mast (Zimmerman 1993, Doherty et al. 1996, Smith et al. 2000), but they will occasionally visit birdfeeders, particularly for suet (Roberts 1932). Red-headed woodpeckers regularly cache food; only 4 woodpecker species in the world are known to regularly exhibit this behavior (Vander Wall 1990, Smith et al. 2000). The birds also ingest grit to aid in digestion, with females consuming more grit than males (Gionfriddo and Best 1996, Smith et al. 2000).

In addition to a diverse diet, red-headed woodpeckers employ a range of methods to obtain their food, including swooping from a perch and bark and foliage gleaning (Jackson 1976, Ehrlich et al. 1988). The birds tap on bark and seem to listen for insects (Bailey 1920, Forbush 1927), then chisel at the wood with solid hits (Skinner 1928, Smith et al. 2000). They will also flycatch a variety of arthropods (Bailey 1920, Jackson 1976, Venables and Collopy 1989), particularly adult beetles (Beal 1911, Smith et al. 2000). Using branches, fence posts, telephone poles, and wires as vantage points, red-headed woodpeckers wait for available prey and then swoop and chase, displaying an array of acrobatic flight maneuvers (Skinner 1928, Stoner 1932, Monroe 1994, Smith et al. 2000). They often forage around a height of

13 meters on both live and dead substrates (Williams 1975, Conner et al. 1994, Smith et al. 2000), and they are one of only a few woodpecker species that commonly forage on the ground (Willson 1970, Reller 1972, Venables and Collopy 1989, Smith et al. 2000).

Red-headed woodpecker breeding season in the midwest typically starts in May and finishes in August (Smith et al. 2000). Pairs exhibit both inter- and intraspecific aggression during the breeding season (Reller 1972, Smith et al. 2000) but will sometimes associate with other pairs (Smith et al. 2000). Red-headed woodpeckers excavate cavities for nesting. Their typical clutch size is 4-7 eggs (Ehrlich et al. 1988, Smith et al. 2000). Incubation lasts 12-14 days, and hatching is asynchronous; both sexes participate in the brooding and feeding of the young (Jackson 1976, Ehrlich et al. 1988, Smith et al. 2000). They may also attempt second nests (Reller 1972, Smith et al 2000), and this nesting behavior was identified on golf courses, often in the same cavity after successfully fledging young.

Common predators of red-headed woodpecker adults and young include snakes, hawks, owls, and mammals (Smith et al. 2000), including flying squirrels (*Glaucomys* spp.) eating eggs and seizing nest cavities (Bailey 1913). Competition for nesting sites may occur with European starlings (*Sturnus vulgaris*) (Skinner 1928, Kendeigh 1982, Ingold 1994) and house sparrows (*Passer domesticus*) (Reed 1901, Stone 1937), although evidence suggests that red-headed woodpeckers are normally able to eradicate them from cavities (Smith et al. 2000). These relationships have not been investigated on golf courses.

Currently, the red-headed woodpecker is declining throughout its range (Peterson 1980, Robbins et al. 1987, Sauer et al. 2003). Red-headed woodpeckers were abundant in Ohio after the establishment of farms in the region in the mid-1800s. However, breeding populations were declining by the 1930's (Peterjohn 2001). The red-headed woodpecker population declined at an alarming rate of approximately 4.3 percent per year in Ohio alone during 1966 – 2002 (Sauer et al. 2003). Both the National Audubon Society and Partners in Flight listed the species as one of high conservation priority (Muehter 1998, Smith et al. 2000). One factor likely contributing significantly to the decline of the red-headed woodpecker is the loss of oak-savanna habitats.

Midwestern golf courses may possess some features characteristic of oak-savannas that provide habitat for red-headed woodpeckers. The structure of a typical golf course is relatively open, with scattered mature trees. Furthermore, management practices involve mowing, which could potentially serve as a substitute for fire disturbances natural to oak-savanna ecosystems. Results found in Ohio are also likely applicable to other golf courses located in the Midwest. This study was necessary because of the red-headed woodpecker's alarming rate of population decline.

## RATIONALE AND SIGNIFICANCE

Public open spaces, such as golf courses, account for millions of hectares of land in the United States (Tilly 2000). The number of courses continues to increase across the landscape as the game of golf grows in popularity. As urban developments spread, these greenspaces have the potential to accommodate both human recreational needs and those of wildlife adapted to open habitats. Golf courses and other public open spaces can be developed and managed to have significant positive impacts on the quality of habitat for sensitive and other desirable wildlife species (Mankin 2000).

Golf courses also are known to offer important habitat to both common and declining or threatened species such as red-cockaded woodpeckers (*Picoides borealis*) (Tilly 2000), loggerhead shrikes (*Lanius ludovicianus*) (Gillihan 2000), and yellow-billed cuckoos (*Coccyzus americanus*) (Hunter et al. 2001). Birds of open canopies that would benefit from the restoration of savannas (Robinson 1994) also are likely to benefit from well-designed golf courses (Gillihan 2000, C.J. Conway unpubl. data). These findings further stress the importance of continued wildlife habitat research on golf courses.

Woodpeckers have been shown to be good indicators of forest bird diversity (Mikusinski et al. 2001), in part, because they build nest cavities in dead and dying trees (DeGraaf et al. 1980, Kahl et al. 1985, Hamel 1992, Smith et al. 2000). Birds are the most obvious beneficiaries of dead trees, since they use snags, limbs, and logs for perching, foraging, or nesting. In some forests, 30 – 45% of the bird species are cavity nesters; in North America alone, 55 avian species nest in cavities (Evans and

Connor 1979, Bolen and Robinson 1995). Eastern bluebirds (*Sialia sialis*) and American kestrels (*Falco sparverius*) rely on cavities in dead wood for successful reproduction. Other birds, such as ruffed grouse (*Bonasa umbellus*), will use logs for drumming and courtship displays. Thus, managing for red-headed woodpeckers could benefit several other species such as weak excavators like parids or secondary cavity-users like bats. Mammals, reptiles, and amphibians also can use cavities excavated by woodpeckers.

Identifying habitat characteristics that are associated with the presence of red-headed woodpeckers on golf courses is important to developing effective conservation recommendations on their behalf and productive management of this priority species. Red-headed woodpecker behavioral traits on golf courses also are key to understanding the quality of habitat available on courses and more specifically, foraging behavior can provide insight into food resources available to red-headed woodpeckers on courses. Nevertheless, documentation of red-headed woodpeckers foraging on the ground on golf courses indicates their potential vulnerability to pesticides. In this study, I was able to identify specific habitat associations and foraging behavior of breeding red-headed woodpeckers on golf courses that could benefit the conservation of this declining species.

Oak-savanna restorations are already known to benefit species of open country (Davis et al. 2000); however, since oak-savannas are unlikely to be restored on a wide-scale, it is increasingly important to study alternate habitats for species associated with oak-savannas, such as red-headed woodpeckers. My research on the suitability of Ohio golf courses as breeding habitat for red-headed woodpeckers

accomplishes this goal and reveals patterns of presence and absence that could exist on courses throughout the historical range of oak-savannas (i.e., the Midwest). This study contributes practical information concerning red-headed woodpecker habitat requirements on midwestern golf courses and the role golf courses can serve in red-headed woodpecker conservation.

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## CHAPTER 2

### GOLF COURSES: AN OAK-SAVANNA SURROGATE FOR BREEDING RED-HEADED WOODPECKERS?

#### ABSTRACT

Once a characteristic species of oak-savanna ecosystems, the red-headed woodpecker (*Melanerpes erythrocephalus*) has declined throughout its range because of habitat alterations during the last century. Because midwestern golf courses possess some features characteristic of oak-savannas, I assessed the suitability of Ohio golf courses as breeding habitat for red-headed woodpeckers. My research objectives were to identify habitat and landscape characteristics associated with the occurrence of red-headed woodpeckers on golf courses, compare habitat structure of golf courses to non-courses (i.e., remnant oak-savannas and open spaces), compare nesting of breeding woodpeckers on and off golf courses, and survey potential competitors and predators of red-headed woodpeckers. I censused for red-headed woodpeckers on 100 golf courses in central and northern Ohio in May – August 2002 and 2003. Nests were located and monitored and golf course and non-course habitat features were measured. On golf courses, nest patch characteristics surrounding 49

active woodpecker nests were measured, and 16 nests were monitored to determine nesting success. Red-headed woodpeckers were detected on 26% of golf courses and were positively associated with large (49 cm diameter at breast height) mast trees (e.g., *Quercus* spp.), snags ( $\geq 16$  cm dbh and  $\geq 2$  m tall), and dead limbs ( $\geq 30$  cm dbh) at both the golf course and nest patch scale. Sixty-seven percent of nests were located in dead limbs of living trees, suggesting that snags do not necessarily need to be retained on courses in order to benefit red-headed woodpecker nesting. Landscape context also may have been important, as courses in rural landscapes were over twice as likely to have red-headed woodpeckers (33%) as courses in urban areas (16%). No significant associations were detected between the number of red-headed woodpeckers and European starlings (*Sturnus vulgaris*) or house sparrows (*Passer domesticus*). Of 16 golf course nests monitored, 75% successfully fledged young, and this success rate was similar to birds nesting off courses ( $n = 11$ , 73% success). For detailed comparison, 10 active red-headed woodpecker nests were located at non-course sites (i.e., remnant oak-savannas and open spaces) and 10 nests on nearby golf courses. Of these paired nests, 70% were successful on golf courses and 80% were successful on non-courses. A larger number of snags and dead limbs were available at the non-course sites, but average dbh of trees on golf courses and non-courses was similar (ca. 46 cm). Oaks were the most common tree species found in a nest patch for both golf courses (39%) and non-courses (44%). I found that golf courses provide breeding habitats for red-headed woodpeckers and have the potential to contribute to the conservation of this declining species.

## INTRODUCTION

The red-headed woodpecker (*Melanerpes erythrocephalus*) was once a common, widespread species associated with oak-savannas (Smith et al. 2000, Brawn 2001, Hunter et al. 2001). These habitats were characterized by open, oak-dominated woodlands with 10 – 80% canopy and large mast-producing trees. Savannas have a mixed herbaceous, grassy ground layer and the appearance of open or scrub savanna (Nuzzo 1985). Oak-savannas covered 11-13 million hectares in Minnesota, Iowa, Missouri, Illinois, Wisconsin, Indiana, and Ohio prior to European settlement in North America (Nuzzo 1985), but now occupy less than one percent of the original expanse as a result of altered disturbance regimes (e.g., fires and water fluxes) (U.S. EPA 1999). Oak-savannas still exist in the Oak Openings region of Lucas, Henry, and Fulton counties in Ohio and in other small patches around the state.

Although red-headed woodpeckers remained abundant in Ohio after the widespread establishment of farms throughout the region in the mid-1800s, breeding populations began to decline by the early 1900s (Peterjohn 2001). Breeding Bird Survey data have documented a range-wide annual decline of 2.5% from 1966 to 2002 (Sauer et al. 2003). Red-headed woodpecker populations declined more drastically at 4.3% per year in Ohio (Sauer et al. 2003). The National Audubon Society listed this species on their National Watchlist, and it is a priority species of Partners in Flight, an international avian conservation initiative (Muehter 1998, Smith et al. 2000).

Potential factors contributing to the decline of the red-headed woodpecker are numerous, but include the loss of orchards and American chestnuts (*Castanea dentata*), decreased availability of “deadwood” in agricultural areas, and the decline of oak-savanna habitats (Smith et al. 2000). The habitat available to woodpeckers in urbanized areas also has been greatly reduced because of the elimination of dead limbs and snags (Pulich 1988). In addition, competition for nesting cavities and depredation may be contributing to population declines of red-headed woodpeckers. There is anecdotal evidence that competition from pervasive exotic birds [i.e., European starlings (*Sturnus vulgaris*) and house sparrows (*Passer domesticus*)] can have a negative impact on red-headed woodpeckers (Kendeigh 1982, Smith et al. 2000). Red-headed woodpecker pairs can typically defend cavities (Reed 1901, Skinner 1928, Stone 1937, Ingold 1994, Smith et al. 2000), but not when exotic competitors are numerous (Reller 1972). Typical predators of red-headed woodpecker adults and young include snakes, hawks, owls, and mammals (Smith et al. 2000), including flying squirrels (*Glaucomys* spp.) eating eggs and seizing nest cavities (Bailey 1913). No studies have investigated these relationships on golf courses.

Most woodpecker conservation efforts focus on nest trees (Kilham 1971, Reller 1972, McClelland and Frissell 1975, Conner et al. 1976, Bull and Meslow 1977, Scott 1978, Mannan et al. 1980, Stauffer and Best 1982, Scott and Oldemeyer 1983, Welsch and Howard 1983, Raphael and White 1984, Zarnowitz and Manuwal 1985, Sedgwick and Knopf 1986, Swallow et al. 1986, Keisker 1987, Runde and Capen 1987, Li and Martin 1991, Shreiber and deCalesta 1992, Adkins Giese and



Cuthbert 2003), but less research has investigated the habitats surrounding woodpecker nests (Conner et al. 1975, Conner and Adkisson 1977, Brawn et al. 1984, Raphael and White 1984, Petit et al. 1985, Swallow et al. 1986, Sedgwick and Knopf 1990, Li and Martin 1991, Adkins Giese and Cuthbert 2003), particularly in modified environments such as golf courses.

As with most declining species, habitat management efforts usually hold promise for recovery. However, large-scale restoration of oak-savannas is unlikely to occur in the midwestern United States given the region's history of fire suppression, intense agriculture, and development of commercial and suburban districts. Controlled burning in close proximity to urban and residential locations is generally too risky or politically infeasible to implement as a management strategy. There is need to identify and manage other open wooded habitats that may serve as oak-savanna surrogates for red-headed woodpeckers. Golf courses have the potential to partially fill this role and represent an under-recognized potential wildlife resource in North America, offering patches of forest, ponds, and wetlands. Red-headed woodpeckers normally inhabit groves, farm country, orchards, shade trees, large scattered trees, and forest edges (Peterson 1980, Smith et al. 2000). These habitat requirements can be compatible with conditions found on golf courses in Ohio and other midwestern states. Further contributing to the red-headed woodpecker's ability to use golf courses is the fact that they are quite tolerant of human activities (Graber and Graber 1977, personal observation). The structure of a typical golf course tends to be relatively open, with scattered mature trees, and course management practices involve mowing, which may serve as a substitute for fire disturbances natural to oak-

savanna ecosystems. Long-term management plans should somewhat mimic a disturbance regime in order to provide a diversity of habitats (Seymour and Hunter 1999, Lorimer 2001).

There are approximately 16,000 golf courses covering over 6,100 square kilometers in the United States (USGA 2004). The number of golf courses continues to grow as the popularity of the game increases. A typical golf course occupies 54 hectares of land (Terman 1997) and as much as seventy percent of that area may be considered *rough* or *out-of-play* (Tilly 2000). These out-of-play areas in particular have the potential to provide substantial amounts of habitat for wildlife and should be researched to assess wildlife benefits (Tilly 2000). Well-informed management of golf courses could contribute to courses of higher ecological quality with less negative impacts on the environment and increased bird habitat.

Objectives of this project were to 1) identify habitat and landscape characteristics associated with the occurrence of red-headed woodpeckers on golf courses, 2) compare habitat structure of golf courses to non-courses (i.e., oak-savannas and open spaces), 3) compare nesting of breeding woodpeckers on golf courses and non-courses, and 4) survey potential nest competitors and predators of red-headed woodpeckers.

## METHODS

Between May and August of 2002 and 2003, red-headed woodpeckers were studied on 100 golf courses under public (62) or private (38) ownership in 37 counties located throughout the glaciated regions of Ohio. Golf courses occurred within three physiographic provinces in Ohio: Till Plain (50 courses), Lake Plain (25 courses), and Glaciated Plateau (25 courses). The provinces were used to stratify these courses because of differences in topography, current land cover, and historic extent of oak-savanna habitat. The Till Plain province is characterized by a relatively flat topography, fertile soils, and glacial moraines. The Lake Plains consist of flatter terrain and dark, often poorly drained soils. Bogs, small sandy hills, and forests are found in the Glaciated Plateau (ODNR 2003). Within each province, golf courses occurred in a range of urban to rural landscape contexts. Each of the 100 golf courses was classified as urban ( $n = 43$ ) if it occurred within city or town limits or rural ( $n = 57$ ) if beyond, as designated in DeLorme Ohio Atlas and Gazetteer (2001).

## BIRD CENSUSES

Trained observers censused golf courses for red-headed woodpeckers during mid-May to early August 2002 and 2003 between 0600 and 1200 hrs, Eastern Standard Time. Researchers censused golf courses by starting near the first tee and finishing near the last hole of the course in the same manner as a golfer would progress through the course. This prevented disruption of golf activities on the course. To census red-headed woodpeckers, pre-recorded calls and drums of the

species were broadcasted (recordings provided by the Borror Laboratory of Bioacoustics, The Ohio State University) on a Sony FX494 cassette player and an amplified field speaker (Saul Mineroff Electronics, Inc., Elmont, New York). Initial testing of sound transmission indicated that observers could hear taped calls at a distance of 250 meters. Tests of census methodology revealed that recordings played at a known distance from red-headed woodpeckers indicated that 200 meter distances were conservative and elicited strong response from the birds. In rare cases when researchers were concerned with noise interference, points were located closer to each other. Each playback lasted a total of seven minutes. Two minutes of silent observation preceded recordings, followed by 3 minutes of red-headed woodpecker calls interspersed with drumming (intervals of 30 seconds on, 30 seconds off). Lastly, the calls were followed with another two minutes of quiet observation. During this period, researchers recorded all red-headed woodpeckers seen or heard on the golf courses.

In order to gain a better understanding of potential nest competitors and predators of red-headed woodpeckers, the number of European starlings (*Sturnus vulgaris*), house sparrows (*Passer domesticus*), gray squirrels (*Sciurus carolinensis*), fox squirrels (*Sciurus niger*), and American red squirrels (*Tamiasciurus hudsonicus*) was counted at each survey point. Other potential avian, reptilian, or mammalian predators were noted at census points.

After censusing a golf course, observers determined whether or not red-headed woodpeckers were nesting on the courses. Nests were located primarily by using a combination of behavioral cues and systematic searches. When possible, golf

courses were visited every 3 - 5 days in order to obtain data on nesting success according to standard protocol (Mayfield 1961, Martin et al. 1997).

## HABITAT MEASUREMENTS

Habitat characteristics on each golf course and surrounding red-headed woodpecker nests were measured after completing censuses. Transects running north and south were established and habitat sampling points were located at 200 meter intervals using a measuring wheel. At each point, tree measurements were taken using a modified nearest individual method (Engeman et al. 1994) intended for spatially clumped tree distributions (Barbour et al. 1999). Distances to the three nearest trees were measured, and tree species and diameter at breast height (dbh) were recorded. Percent ground cover by shrubs and saplings, forbs, grass, sand, pavement, and water was visually estimated within 50 meters of each sampling point. Average shrub and sapling height was estimated, as well as dead limbs ( $\geq 30$  cm long and  $\geq 16$  cm in diameter) within 50 meters and snags (standing dead trees  $\geq 16$  cm dbh and  $\geq 2$  m tall) within 100 meters.

The habitat immediately surrounding red-headed woodpecker nests on golf courses was measured within an 11.3 meter radius circular plot using modified methods of Martin et al. (1997). The dbh of the nest tree was measured and the height of the nest tree, nest cavity, and canopy were visually estimated. Nest tree health was defined as live, partly dead, or dead, and whether the nest was located in a living or dead portion of the tree was recorded. Trees by species and size class (8-23, 23-38, and  $>38$  cm dbh) and snags by three size classes (16-30, 30-44, and  $>44$  cm

dbh) were recorded within the 11.3 meter plot. Percent ground cover within 50 meters was visually estimated for grass, shrub/sapling, forb, water, sand, and pavement. Dead limbs within 50 meters and snags within 100 meters also were counted. Tree species, distance from nest tree, and dbh were recorded for the three nearest trees using the same protocol for general golf course vegetation (Engeman et al. 1994).

For comparisons to golf course nests, nest-searching efforts were concentrated in northern Ohio in areas of remnant oak-savanna. Ten active red-headed woodpecker nests were located at 8 non-course sites (i.e., remnant oak-savannas and open spaces) and ten nests on 7 golf courses, while maintaining pairs to be compared within the same physiographic regions. To retain independence in sampling, I only studied pairs that were at least 500 meters apart and on non-contiguous territories for the few locations where I observed more than one nest. Nests on non-course sites were located in a similar fashion to those found on golf courses, primarily using playbacks, behavioral cues, and systematic searches. Nests were visited every 3 to 5 days following the protocol of Mayfield (1961) and Martin et al. (1997) and the stage of nesting was recorded as building, incubating, or feeding, until fledging or failing. Both course and non-course nests being compared were visited on the same days. Habitat surrounding each nest and nest placement data were measured following the same protocol described previously for golf course nests in this study. Habitat characteristics of the golf courses and non-courses were then measured using a 400m x 400m (16 ha) grid centered on the nest tree. This grid was approximately twice as large as the largest red-headed woodpecker summer territories reported by Venables

and Collopy (1989). As with the general golf course surveys, sampling points were spaced 200 meters apart and a total of 9 points were measured for each plot. Tree species, distance to nearest tree, dbh, snags (within 100 m), dead limbs (within 50 m), average height of shrubs and saplings, and percent ground cover (within 50 m) were recorded at each point.

## DATA ANALYSIS

Habitat variables were averaged over multiple plots within each golf course and then compared between courses with and without red-headed woodpeckers using canonical discriminant function analysis (DFA) to discriminate between habitat characteristics in the two environments. Similarly, vegetation characteristics within nest patches were compared to mean habitat values at golf courses using DFA. Mean habitat values were reasoned to better reflect habitat available at courses than a random plot because of the high heterogeneity of golf course habitat. Analysis of variance was used to examine different habitat attributes of course and non-course sites. I analyzed differences in abundance of European starlings, house sparrows and squirrels between courses with and without woodpeckers using a multiple analysis of variance (MANOVA), which controls experiment-wise error rate, followed by *a posteriori* univariate tests (SAS Institute 1990).

## RESULTS

### LANDSCAPE AND HABITAT CHARACTERISTICS

In 2002 and 2003, 158 red-headed woodpeckers were detected on 26 of 100 golf courses. If red-headed woodpeckers were present on a golf course, their numbers on any given course were highly variable, ranging from 1 to 26 (median = 3.5). Comparison of golf courses within town or city limits (i.e., urban) to those in rural areas indicated that red-headed woodpeckers were twice as likely to occur on courses in rural locations (33% of courses) versus urban (16% of courses). I found significant discrimination in habitat characteristics between courses with and without red-headed woodpeckers (squared canonical correlation Pillai's Trace = 0.296,  $F_{10,89} = 3.7$ ,  $p < 0.001$ ). The axis that discriminates between courses with and without red-headed woodpeckers showed that the woodpeckers were positively associated with courses with greater numbers of hard mast trees, snags, and dead limbs, as well as greater dbh of hard mast trees, mean dbh of nearest trees, and sand. In addition, golf courses with red-headed woodpeckers also had more closely spaced trees (Table 2.1).

Habitat features at nest sites were evaluated for 49 nests on 17 golf courses. Comparisons of habitat characteristics between nest patches and golf course averages showed that plots centered on red-headed woodpecker nests contained approximately twice as many hard mast trees, snags, and dead limbs than habitat plots over the entire course (squared canonical correlation Pillai's Trace = 0.536,  $F_{9,63} = 8.1$ ,  $p < 0.001$ ; Table 2.2). Nest patches also had more closely spaced trees and less turf than the habitat plots over the entire course.



Vegetation surrounding red-headed woodpecker nests on golf courses was characterized by snags (mean =  $3.9 \pm 0.48\text{SE}$ ), dead limbs (mean =  $7.1 \pm 0.61\text{SE}$ ), and large trees (mean =  $41.6 \text{ cm dbh} \pm 2.06\text{SE}$ ). Mean distance to the three trees located nearest to red-headed woodpecker nests was  $7.1 \text{ m} \pm 0.70\text{SE}$ ; the trees were mostly comprised of pin oaks (*Quercus palustris*; 20.0%; mean =  $48.1 \text{ cm dbh} \pm 2.35\text{SE}$ ), hickories (*Carya* spp.; 12.1%; mean =  $34.6 \text{ cm dbh} \pm 3.33\text{SE}$ ), American basswoods (*Tilia americana*; 11.4%; mean =  $34.9 \text{ cm dbh} \pm 2.68\text{SE}$ ), red maples (*Acer rubrum*; 9.3%; mean =  $35.3 \text{ cm dbh} \pm 5.36\text{SE}$ ), and northern red oaks (*Quercus rubra*; 6.4%; mean =  $54.9 \text{ cm dbh} \pm 7.00\text{SE}$ ); (Table 2.3).

Of the 49 nests located, 16 were monitored until failure or success (i.e., fledging young) on 10 different courses. The number of nests on a golf course ranged from 1 – 9, and 75% of monitored nests on courses were successful. Red-headed woodpeckers were found to be nesting high in large trees. The mean nest tree height was  $18.9 \text{ m} \pm 0.56\text{SE}$ , while the mean dbh was  $58.0 \text{ cm} \pm 8.59\text{SE}$ . Average cavity height was  $14.3 \text{ m} \pm 0.51\text{SE}$ , and the mean diameter of the nest limb or stem was  $20.5 \text{ cm} \pm 1.02\text{SE}$ . Sixty-one percent of the nest trees were only partially dead (i.e., with one or more dead limbs), while 39% of the nest trees were completely dead (i.e., snags). Red-headed woodpeckers used a variety of tree species for nesting, with most golf course nests found in maples and oaks (Figure 2.1).

## BREEDING PAIRS: GOLF COURSE AND NON-COURSE

Red-headed woodpecker nests on golf courses fared similarly to nests on non-courses. For pairs that were compared, 70% of golf course nests ( $n = 10$ ) were successful, while 80% of non-course nests ( $n = 10$ ) fledged young. The mean nest tree height on non-courses was  $19.3 \text{ m} \pm 3.47\text{SE}$  and mean dbh  $53.9 \text{ cm} \pm 39.99\text{SE}$ . Non-course nests were most often placed in oak trees (Figure 2.2).

Structurally, non-course sites differed significantly from red-headed woodpecker habitat on golf courses (Wilks' Lambda  $F_{9,10} = 4.29$ ,  $p = 0.016$ ; Table 2.4). Non-courses had a greater numbers of snags ( $F_{1,18} = 2.93$ ,  $p = 0.104$ ), dead limbs ( $F_{1,18} = 2.10$ ,  $p = 0.164$ ) and forbs ( $F_{1,18} = 9.09$ ,  $p = 0.007$ ) than non-courses. Golf courses were characterized by more sand ( $F_{1,18} = 4.47$ ,  $p = 0.049$ ) and much more grass ( $F_{1,18} = 16.28$ ,  $p = 0.001$ ). However, mean dbh of three nearest trees on non-courses and golf courses were similar,  $46.2 \pm 11.49\text{SE}$  and  $45.9 \pm 3.03\text{SE}$  respectively. Oaks were the most common tree species encountered in a nest patch both on golf courses (39%) and on non-courses (44%).

## POTENTIAL NEST COMPETITORS AND PREDATORS

No significant associations were found between occurrence of red-headed woodpeckers and numbers of European starlings and house sparrows (Wilk's Lambda  $F_{3,90} = 1.5$ ,  $p = 0.221$ ; Table 2.5). The number of squirrels was only slightly negatively associated with occurrence of red-headed woodpeckers ( $F_{1,92} = 2.5$ ,  $p = 0.115$ ).

## DISCUSSION

Red-headed woodpeckers have been reported on golf courses in previous work (Bull 1974, Smith et al. 2000), but no study has systematically evaluated courses as breeding sites for this declining species. Findings from my research show that red-headed woodpeckers widely occur and successfully breed on golf courses in Ohio. Furthermore, this suggests that the species should find habitat on a large number of midwestern courses. The high rate of nesting success that I documented on golf courses (75%) was comparable to that on remnant oak-savannas and open spaces (73%), indicating that golf courses also provide quality breeding habitat for red-headed woodpeckers. However, it was difficult to accurately determine the number of young fledged because of inconspicuous coloration and relatively secretive behavior compared to adults (Appendix D). Thus, differences in productivity and recruitment of woodpeckers between golf courses and more natural habitats, if any existed, remain unknown.

Occurrence of red-headed woodpeckers in the study system was strongly linked to habitat characteristics on golf courses. Interestingly, golf courses provided breeding habitat similar to features the birds are known to use throughout their range (Bond 1957, Conner and Adkisson 1977, Peterson 1980, Kahl et al. 1985, Monroe et al. 1994, Smith et al. 2000). I found that presence of woodpeckers was positively associated with numbers of dead limbs, snags, and hard mast producing trees, consistent with previous studies (Reller 1972, Doherty et al. 1996, Smith et al. 2000). However, comparisons of habitat between course and non-course sites indicate that

golf courses do contain fewer of these important habitat features (e.g., snags) than more natural areas.

My findings suggest that individual tree characteristics such as size, species, and health are important to breeding red-headed woodpeckers on golf courses. Trees used by nesting woodpeckers in this study were similar to the minimum size requirement (40-50 cm dbh) reported by Smith (1997). Furthermore, red-headed woodpeckers do not need entirely dead trees to excavate their nesting cavities. Sixty – seven percent of woodpecker nests were located in dead limbs of living trees in this study. On non-courses oaks and snags were normally used for nesting, and on golf courses birds most often nested in oaks and maples. Evergreen tree species were numerous on some golf courses, but red-headed woodpeckers seemed to avoid these trees when selecting their nesting sites. In no instance was a nest found within 11.3 meters of a pine (*Pinus* spp.) tree and in only one case was a spruce (*Picea* spp.) located in a nest patch, despite the regular occurrence of conifers on golf courses. The typical condition and structure of these trees on midwestern golf courses may be undesirable to the red-headed woodpeckers, even though the woodpeckers regularly occur in pine scrub, mixed pines, pine flatwoods, and pine–oak savanna in the southeastern United States (Venables and Collopy 1989, Kale and Maehr 1990, Stevenson and Anderson 1994, Belson 1998, Smith et al. 2000). Red-headed woodpeckers can successfully nest on golf courses provided that the appropriate habitat conditions are met.

Landscape context also may have influenced the distribution of red-headed woodpeckers as the birds were twice as likely to be found in rural areas, consisting

primarily of agricultural fields and woodlots. In many instances, red-headed woodpeckers were seen using lands adjacent to the golf courses, often small forests within agroecosystems, as part of their territories and for foraging. This finding is comparable to previous landscape research where cavity nesters were more abundant in woodlands adjacent to sparsely treed meadows (Lawler and Edwards 2002). Thus, conservation efforts for red-headed woodpeckers may best be aimed at golf courses located in more rural areas. It also is noteworthy that most of the courses where red-headed woodpeckers were present were located in the northern regions of Ohio, overlapping the former extent of oak-savannas in the state. This suggests that historical influences may affect an individual's selection of a nesting site, as has been proposed by Phillips and Hall (2000) concerning red-cockaded woodpecker (*Picoides borealis*) clusters concentrated around areas of few remnant pine trees left from clearcuts in the 1930's.

Although prior studies have proposed that competitors, such as European starlings, may negatively impact red-headed woodpeckers (Reed 1901, Skinner 1928, Kendeigh 1982, Ehrlich et al. 1988, Ingold 1994), I found no evidence of a negative association between abundances of the woodpeckers and potential competitors. However, competitive relationships are extremely difficult to detect and an experimental design would be more useful in such an investigation (Reynoldson and Bellamy 1974, Colwell and Fuentes 1975, Connell 1975, Williams and Batzli 1979), as few direct interactions between potential competitors were observed. Manipulating numbers of nesting substrates or populations could reveal significant associations.

## CONSERVATION IMPLICATIONS

Golf courses undoubtedly are not a sustainable habitat substitute for all species of oak-savannas, primarily because of differing floristics. The endangered karner blue butterfly (*Lycaeides melissa samuelis*) and frosted elfin (*Callophrys irus*) butterfly rely on wild lupine (*Lupinus perennis*) growth and a combination of subhabitats in oak-savannas for long-term survival (U.S. EPA 1999, Lane and Andow 2003). The spotted turtle (*Clemmys guttatu*) of oak-savannas has distinct seasonal shifts in its habitat requirements (Litzgus and Brooks 2000). And, the endangered lark sparrow (*Chondestes grammacus*) nests in grassland and savanna habitat (U.S. EPA 1999), often under particular plants such as sagebrush (*Artemisia* spp.) (Cameron 1908, Walchek 1970, Dechant et al. 1999). However, naturalistic golf courses can offer potential habitat to certain guilds, including some grassland birds.

While true oak-savannas may be ideal for red-headed woodpeckers, my study demonstrates that suitable breeding sites can exist on golf courses provided that they provide certain features, such as dead limbs. This is encouraging because public open spaces or greenspaces, such as golf courses, already account for millions of hectares of land in the United States. As urbanization spreads, these greenspaces have the potential to accommodate the needs of both people and wildlife. Golf courses and other public open spaces can be developed and managed to have a significant positive impact on the quality of habitat for sensitive and desirable wildlife species (Mankin 2000), while still providing recreation and services for the public (Pickett et al. 2001). Indeed, golf courses are known to offer important habitat to both common and

declining or threatened species such as red-cockaded woodpeckers breeding in colonies found on golf courses in North Carolina (Gillihan 2000, Tilly 2000). Loggerhead shrikes (*Lanius ludovicianus*) can breed in open country on golf courses in their range (Gillihan 2000) and yellow-billed cuckoos on courses with forest and dense shrubs (*Coccyzus americanus*) (Gillihan 2000, Hunter et al. 2001).

Habitat management directed at improving conditions for red-headed woodpeckers should emphasize native hard mast-producing trees during plantings and the retention of dead limbs and snags on golf courses. Even relatively small dead limbs (ca. 20 cm in diameter and 30 cm in length) can be suitable for nesting. Thus, dead limbs that might pose a potential danger to golfers can be trimmed back to a safer (i.e., smaller) size and still offer possible nesting sites to red-headed woodpeckers. Snags should be retained when they pose no substantial safety hazards to golfers. Habitat enhancement for red-headed woodpeckers also can benefit many types of wildlife including other woodpecker species, parids, flying squirrels, and bats, given that numerous forest species are dependent on deadwood (Gunn and Hagan 2000). Birds that utilize open canopies and would benefit from the restoration of savannas such as Baltimore orioles (*Icterus galbula*), great crested flycatchers, (*Myiarchus crinitus*) and eastern bluebirds (*Sialia sialis*) (Robinson 1994) are also likely to benefit from well-designed golf courses (Gillihan 2000, C.J. Conway unpubl. data). The red-headed woodpecker, as well as numerous other species, can benefit from conservation efforts on golf courses. Maintaining or creating habitat on existing golf courses may become increasingly important to the successful conservation of the red-headed woodpecker.

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Habitat Variable	Red-headed woodpecker present	Red-headed woodpecker absent	Total canonical structure	<i>P</i>
	Mean (SE)	Mean (SE)		
Number of hard mast trees	1.0 (0.12)	0.5 (0.05)	0.770	< 0.001
Mast diameter-breast-height (cm) <sup>a</sup>	46.3 (2.22)	33.6 (2.94)	0.483	< 0.001
Number of snags within 100 m	1.5 (0.26)	0.6 (0.08)	0.730	< 0.001
Number of dead limbs within 50 m	3.6 (0.50)	1.7 (0.26)	0.631	< 0.001
Mean distance to nearest tree (m)	16.4 (1.37)	20.8 (1.58)	-0.290	0.004
Mean diameter-breast-height (cm)	39.4 (2.09)	35.3 (1.18)	0.313	0.002
Percent cover by turfgrass	82.8 (2.15)	83.9 (1.58)	-0.066	0.513
Percent cover by water	4.0 (0.84)	3.8 (0.52)	0.025	0.806
Percent cover by sand	1.2 (0.33)	0.8 (0.13)	0.267	0.007
Percent cover by pavement	1.2 (0.30)	0.8 (0.09)	0.355	< 0.001

<sup>a</sup> diameter-breast-height = 1.5m

Table 2.1 Habitat characteristics of 100 golf courses with ( $n = 26$ ) and without ( $n = 74$ ) red-headed woodpeckers in Ohio, May – August 2002-2003. A canonical discriminant function analysis indicated overall significant differences in habitat (Pillai's Trace  $F_{10,89} = 3.7$ ,  $P < 0.001$ ).

Habitat Variable	Nest	Course	Total canonical structure	<i>P</i>
	Mean (SE)	Mean (SE)		
Number of hard-mast trees	1.7 (0.16)	1.0 (0.12)	0.463	< 0.001
Number of snags within 100 m	3.9 (0.48)	1.5 (0.26)	0.528	< 0.001
Number of dead limbs within 50 m	7.1 (0.61)	3.6 (0.50)	0.562	< 0.001
Distance to nearest tree (m)	7.1 (0.7)	16.4 (1.37)	-0.847	< 0.001
Diameter-breast-height of trees (cm)	41.6 (2.06)	39.4 (2.09)	0.114	0.338
Percent ground cover by turfgrass	67.6 (4.58)	82.8 (2.15)	-0.360	0.002
Percent ground cover by water	3.5 (1.23)	4.0 (0.84)	-0.070	0.558
Percent ground cover by sand	1.1 (0.37)	1.2 (0.33)	-0.078	0.513
Percent ground cover by pavement	2.2 (0.76)	1.2 (0.30)	0.145	0.219

Table 2.2 Habitat characteristics surrounding nests ( $n = 49$ ) of red-headed woodpeckers or averaged over course plots ( $n = 26$ ) in Ohio, May – August 2002-2003. A canonical discriminant function analysis indicated overall significant differences in habitat (Pillai's Trace  $F_{9,63} = 8.1$ ,  $P < 0.001$ ).



Tree species	Percent	Mean dbh (cm) $\pm$ SE
Pin oak ( <i>Quercus palustris</i> )	20	48.1 $\pm$ 2.35
Red oak ( <i>Quercus rubra</i> )	6	54.9 $\pm$ 7.00
White oak ( <i>Quercus alba</i> )	5	51.2 $\pm$ 10.87
Bur oak ( <i>Quercus macrocarpa</i> )	4	52.1 $\pm$ 6.29
Black oak ( <i>Quercus velutina</i> )	1	56.0 $\pm$ 0.50
Swamp white oak ( <i>Quercus bicolor</i> )	1	41.6 $\pm$ 1.80
Red maple ( <i>Acer rubrum</i> )	9	35.3 $\pm$ 5.36
Sugar maple ( <i>Acer saccharum</i> )	4	43.5 $\pm$ 4.76
Silver maple ( <i>Acer saccharinum</i> )	1	55.8 $\pm$ 8.20
Hickory ( <i>Carya</i> spp.)	12	34.6 $\pm$ 3.33
American basswood ( <i>Tilia americana</i> )	11	34.9 $\pm$ 2.68
Ash ( <i>Fraxinus</i> spp.)	5	47.6 $\pm$ 7.72
American beech ( <i>Fagus grandifolia</i> )	5	34.0 $\pm$ 5.51
Black walnut ( <i>Juglans nigra</i> )	3	38.9 $\pm$ 8.55
Cherry ( <i>Prunus</i> spp.)	3	36.5 $\pm$ 11.01
American elm ( <i>Ulmus americana</i> )	2	35.5 $\pm$ 13.34
Sycamore ( <i>Platanus occidentalis</i> )	2	65.8 $\pm$ 7.75

Table 2.3 Percentage and mean ( $\pm$ SE) diameter-breast-height (dbh) of 17 tree species nearest (mean distance = 7.2 m  $\pm$  0.41SE) red-headed woodpecker nests ( $n = 49$ ) on golf courses in Ohio, May – August 2002-2003.

Habitat Variable	Golf Course	Non-course	F <sub>1,18</sub>	P
	Mean (SE)	Mean (SE)		
Number of snags within 100 m	2.7 (1.17)	7.4 (2.48)	2.9	0.104
Number of dead limbs within 50 m	5.9 (1.48)	11.3 (3.44)	2.1	0.164
Mean distance to nearest tree (m)	25.9 (10.84)	14.0 (3.22)	1.1	0.308
Mean diameter-breast-height (cm)	45.9 (3.03)	46.2 (11.49)	0.0	0.978
Percent cover by turfgrass	68.5 (7.82)	25.7 (7.16)	16.3	<0.001
Percent cover by forb	6.9 (1.60)	35.7 (9.43)	9.1	0.007
Percent cover by water	4.0 (2.01)	1.7 (0.67)	1.2	0.290
Percent cover by sand	0.8 (0.11)	0.4 (0.16)	4.5	0.049
Percent cover by other <sup>a</sup>	10.4 (6.73)	5.1 (4.15)	0.4	0.513

<sup>a</sup>Other percent ground cover may be crops (e.g., corn and soybeans)

Table 2.4 Habitat characteristics of red-headed woodpecker nesting sites ( $n = 10$ ) on golf courses and nesting sites ( $n = 10$ ) on non-courses in Ohio, May – August 2003. A multiple analysis of variance indicated significant differences in habitat (Wilks' Lambda  $F_{9,10} = 4.29$ ,  $P = 0.016$ ). Reported F and P statistics are derived from *a posteriori* univariate tests.

Species	Red-headed woodpecker present	Red-headed woodpecker absent	F <sub>1, 92</sub>	P
	Mean (SE)	Mean (SE)		
European starling ( <i>Sturnus vulgaris</i> )	29.5 (9.44)	22.0 (5.21)	0.8	0.369
House sparrow ( <i>Passer domesticus</i> )	4.4 (1.18)	5.8 (0.89)	0.5	0.475
Squirrel ( <i>Sciurus</i> or <i>Tamiasciurus</i> spp.)	2.2 (0.61)	1.3 (0.27)	2.5	0.115

Table 2.5 Mean number ( $\pm$  SE) of European starlings, house sparrows, and squirrels on 100 golf courses with ( $n = 26$ ) and without ( $n = 74$ ) red-headed woodpeckers in Ohio, May – August 2002-2003. A multiple analysis of variance indicated no overall significant differences in habitat (Wilks' Lambda  $F_{3, 90} = 1.50$ ,  $P = 0.221$ ). Reported F and P statistics are derived from *a posteriori* univariate tests.

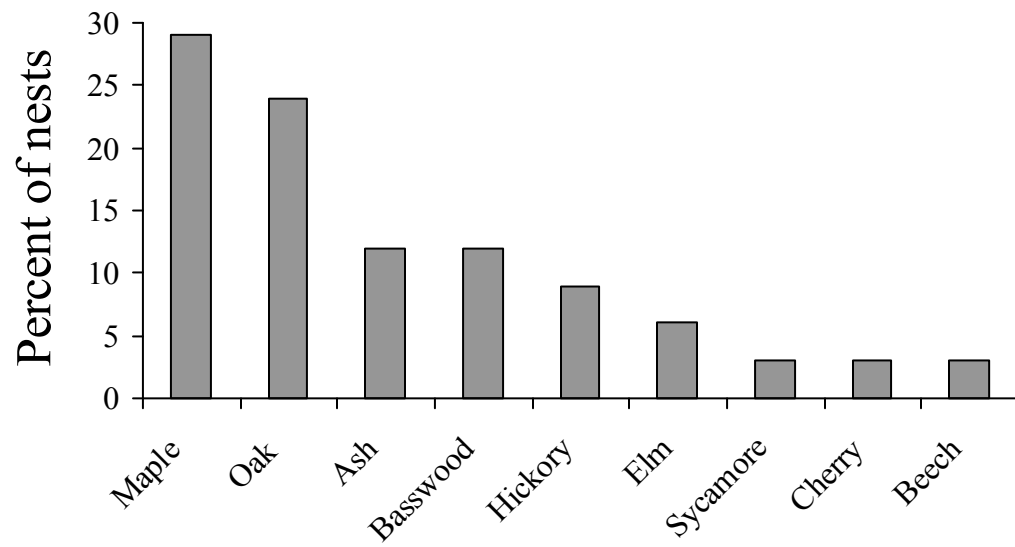


Figure 2.1 Percentage of 9 tree types used for placement of red-headed woodpecker nests ( $n = 49$ ) on golf courses in Ohio, May – August 2002 - 2003.

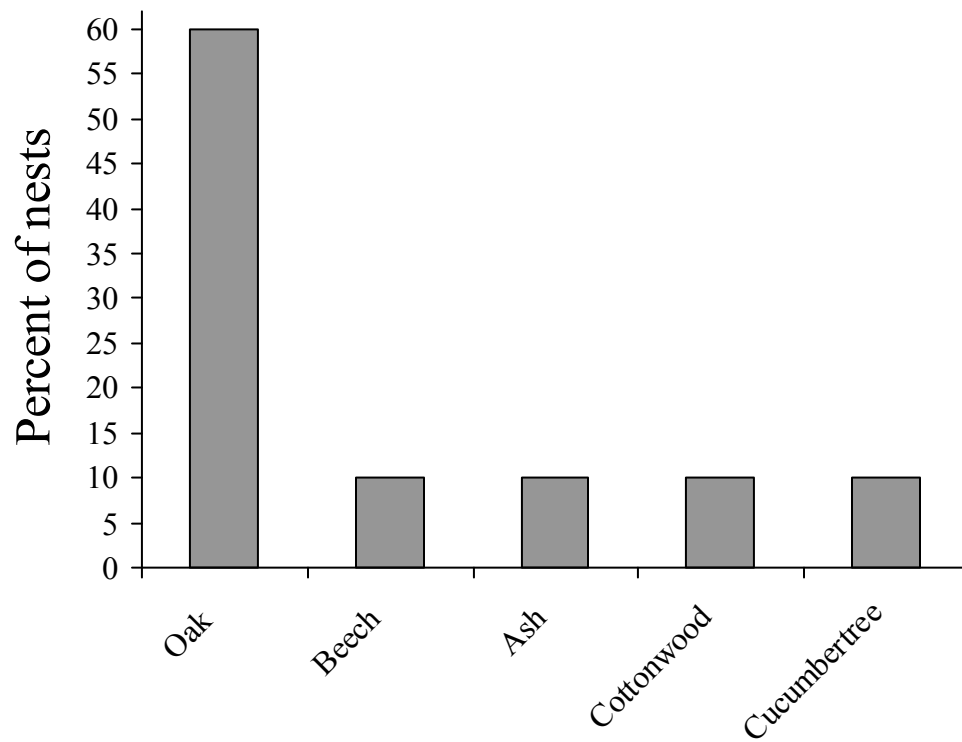


Figure 2.2 Percentage of 5 tree types used for placement of red-headed woodpecker nests ( $n = 10$ ) on non-course sites in Ohio, May - August 2003.

## CHAPTER 3

### NESTING AND FORAGING BEHAVIOR OF RED-HEADED WOODPECKERS (*Melanerpes erythrocephalus*) ON OHIO GOLF COURSES

#### ABSTRACT

The declining red-headed woodpecker (*Melanerpes erythrocephalus*) has been strongly associated with diminishing oak-savanna ecosystems, but now seems to readily breed on midwestern golf courses that are structurally similar to oak-savannas. This raises the question of whether golf courses can offer quality habitat to breeding red-headed woodpeckers. In May to August 2002 and 2003, I compared nesting success (i.e., fledging one or more young) and behavior of 10 woodpecker pairs on golf courses and 10 off courses in parkland, savanna, and open woodlands in northern and central Ohio. Nesting success was similar with 70% of nests on courses being successful versus 80% of nests on non-courses. On golf courses, nests were most often excavated in oak (*Quercus* spp.), maple (*Acer* spp.), and American beech (*Fagus grandifolia*), compared to primarily oaks on non-course sites. Using focal-animal approach to instantaneous sampling, I found that proportions of time spent foraging, resting, preening, and calling or drumming did not differ significantly

between courses versus non-courses. Most (40%) foraging activities were directed at hard mast trees, with oaks accounting for the vast majority of the observations. My data suggest that certain behavior differences between birds on and off courses may affect their vulnerability to chemicals frequently applied to turf on golf courses. For example, red-headed woodpeckers foraged at 40% lower heights on golf courses than off (mean of 7 m versus 12 m), and birds on golf courses almost doubled their usage of turf for foraging (38% versus 20%), frequently gleaning insects from lawn. Collectively, results suggest that golf courses may offer valuable opportunities for the conservation of red-headed woodpeckers; though the frequent use of turf warrants further investigation into potential exposure to pesticides.

## INTRODUCTION

The red-headed woodpecker is a recognizable species of North America. The bird's likeness has served as a symbol of battle for Native American Indians (Witthoft 1946) and as a common representative for wildlife conservation. Populations of red-headed woodpeckers (*Melanerpes erythrocephalus*) are declining in Ohio and throughout the species' range, primarily due to a combination of habitat degradation and loss (Peterson 1980, Robbins et al. 1987, Sauer et al. 2003). Their decline has occurred at alarming rates; in Ohio from 1966 – 2002, the red-headed woodpecker population decreased approximately 4.3 percent per year (Sauer et al. 2003). Although the red-headed woodpecker does not have federal threatened or endangered status at this time, conservation organizations such as the National Audubon Society

and Partners in Flight have watchlisted the woodpeckers because of their declining populations (Muehter 1998, Smith et al. 2000).

Despite the seriousness of population decline, there are conservation strategies that hold promise for the red-headed woodpecker. One such promising option is habitat enhancement in heavily altered environments, such as golf courses. Finding suitable alternate habitats for the red-headed woodpeckers may be critical to their long-term sustainability. Fortunately, red-headed woodpeckers frequent a variety of modified landscapes including suburban areas, parks, cemeteries, and even golf courses (Bull 1974, Ehrlich et al. 1988, Monroe 1994, Smith et al. 2000). In Ohio, red-headed woodpeckers occurred on 26% of golf courses located in the northern and central regions of the state (Chapter 2). Viable metapopulations of red-headed woodpeckers may use golf courses and research is needed to evaluate courses as potential sources or sinks. Red-headed woodpecker behavioral traits contribute to the woodpecker's likeliness to use an array of human-altered habitats, such as golf courses, because they are relatively tolerant of human activities (Graber and Graber 1977).

One particularly critical gap in the ability of golf courses to support red-headed woodpeckers is uncertainty concerning the quality of habitat. The presence of the birds on golf courses does not necessarily indicate that they are reproducing and thriving there. Behavioral cues can assist in evaluating the quality of habitat available (Moser et al. 1990, Yahner and Mahan 1997, Mahan and Yahner 1999). Certain behavioral traits may make red-headed woodpeckers vulnerable to negative effects from golf course management practices. Red-headed woodpeckers are one of only a



few woodpecker species that commonly forage on the ground (Willson 1970, Reller 1972, Venables and Collopy 1989, Smith et al. 2000), which may make them susceptible to lethal and sublethal effects of pesticides used on golf courses. Ultimately, pesticide exposure can depress avian reproductive success (Kendal et al. 1992, Kendal et al. 1993, Rainwater et al. 1995, Gillihan 2000) and therefore, may alter behavior and activity budgets as well. For this study, the primary objectives were to compare nesting success and behavior of red-headed woodpeckers breeding on and off golf courses in Ohio.

## METHODS

Red-headed woodpeckers were studied on 100 golf courses within three physiographic provinces in Ohio: Till Plain (50 courses), Lake Plain (25 courses), and Glaciated Plateau (25 courses) from May – August 2002 and 2003. Courses were stratified by province because of differences in topography, current land cover, and historic extent of oak-savanna habitat. The Till Plain province is characterized by relatively flat topography, fertile soils, and glacial moraines. The Lake Plains consist of flatter terrain and dark, often poorly drained soils. Bogs, small sandy hills, and forests are found in the Glaciated Plateau (ODNR 2003). Golf courses (20-165 ha in size) were under public (62) or private (38) ownership in 37 counties located throughout the formerly glaciated regions of Ohio. As part of a larger study (see Chapter 2), courses were surveyed for the presence and breeding activity of red-headed woodpeckers. I recorded the behavior of red-headed woodpeckers

opportunistically across all golf courses during favorable weather (i.e., no heavy rain or winds) to avoid biases (e.g., reduced activity) in my observations. For a more intensive comparative study of nesting success and foraging behavior, red-headed woodpecker pairs ( $n = 10$ ) on golf courses were compared with pairs ( $n = 10$ ) on non-course sites within similar physiographic regions in central and northern Ohio. Non-course sites included remnant oak-savannas and oak-savanna-like parklands.

## NEST MONITORING

Red-headed woodpeckers were located on golf courses using census methods described in Chapter 2. A combination of behavioral cues and systematic searches were used to find nests of red-headed woodpecker. In 2002, nest searching was concentrated on golf courses (monitored nests = 6). In 2003, red-headed woodpeckers nesting on golf courses (monitored nests = 10) were compared with pairs on non-courses (monitored nests = 10) in the same physiographic regions. Pairs eligible for comparisons on any given site were at least 500 m apart with non-contiguous territories. Golf course and non-course nests being compared were visited on the same day. In order to obtain nesting success data according to standard protocol (Mayfield 1961, Martin et al. 1997), nest sites were checked every 3-5 days. The stage of nesting was recorded as building, incubating, or feeding, until fledging or failure of the nest.

## BEHAVIORAL OBSERVATIONS

I observed red-headed woodpecker behaviors on golf courses from May – August 2002. From May – August 2003, I observed breeding pairs during the same days for comparison in order to determine characteristics of their foraging (e.g., attack/pursuit and substrate use) behavior on golf courses and non-courses.

Behavioral observations did not occur during census playbacks of pre-recorded calls and drums, as those could have affected the birds' natural behaviors. Using focal-animal sampling methods described by Morrison et al. (1998), an individual was randomly chosen and continuously observed for a 5 minute period. Behaviors were recorded every 10 seconds, using an instantaneous sampling approach (Hejl et al. 1990, Morrison et al. 1998). The goal was to obtain 30 point samples from each individual to increase the accuracy of behavioral measurements (Brennan and Morrison 1990). Observation periods of less than 1 minute were dropped from time budget analysis (Shuman et al. 1992). Time spent foraging was recorded when birds pecked at a substrate, handled a food item, or chased prey (Cimprich and Grubb 1994). Vigilance was not specifically monitored because of the ambiguity in determining whether a given bird was searching and scanning for prey or predators. Other categories in the behavior log included carrying food to young or mate, incubating/brooding, moving, resting, preening, or calling/drumming. The following variables were recorded after the first 10 seconds of the observation period elapsed: foraging height, the plant species used for foraging, and substrate (bark from a living tree, bark from a dead tree, foliage, air, lawn, bare ground, or water). Distances traveled from the nest to forage were documented.

## DATA ANALYSIS

Fisher's Exact Test was used to evaluate nest fate by golf course and non-course sites for 20 nests. Descriptive statistics elucidated general patterns in foraging substrate use and red-headed woodpecker allotments of time to daily maintenance activities. When evaluating breeding pair foraging variables, observations from each pair were averaged, using territory as the primary sampling unit, to a sample size of 20 (10 from golf courses and 10 from non-courses) before analyses to avoid pseudoreplication. Analysis of variance tests evaluated foraging height and distance traveled from nests to forage on golf courses and non-course sites. The proportion of time allotted for each activity was determined for red-headed woodpeckers at a site. Activities of red-headed woodpeckers on golf courses were compared to those on non-courses using a multiple analysis of variance (MANOVA), which controls experiment-wise error rate. In order to identify the specific behaviors that differed between courses and non-courses, MANOVA was followed by *a posteriori* univariate tests (SAS Institute 1990). In cases where certain behavioral categories were highly correlated with one another, one member of the correlated pair was omitted from analysis. In the matched pair analysis, moving and resting were negatively correlated ( $r = -0.673$ ,  $n = 20$ ), as were calling and carrying food to young or mate ( $r = -0.859$ ,  $n = 20$ ). Incubating and preening appeared positively correlated ( $r = 0.735$ ,  $n = 20$ ) as well. Ultimately, 4 variables were chosen for inclusion in the MANOVA to best describe red-headed woodpecker behavior (foraging, resting, preening, and calling).

## RESULTS

Nesting success was similar on and off courses (70% on golf courses versus 80% off courses; Fisher's Exact Test  $p = 0.348$ ). On golf courses, nests were usually excavated in oak (*Quercus* spp.), maple (*Acer* spp.), and American beech (*Fagus grandifolia*) trees, compared to primarily oaks on non-course sites (Table 3.1). Cavities were also located in snags (i.e., standing dead trees) more often on non-course sites.

Behavioral data were collected in 2002 on 14 golf courses for 46 red-headed woodpecker adults, and in 2003, 29 adult individuals on 9 courses. The most common foraging substrate was the bark of living trees (40.5%), although red-headed woodpeckers also foraged on dead trees (23.0%), lawn (17.6%), air (16.2%), foliage (1.4%), and bare ground (1.4%; Figure 3.1). Trees used for foraging were usually hard mast species (40% of the time) with oaks accounting for the largest proportion of observations (39%). The foraging height averaged on golf courses over both years was  $5.2 \text{ m} \pm 0.65\text{SE}$ . For almost half of the behavioral sample points on golf courses, the birds were resting (47.2%). Moving (25.9%) and foraging (16.1%) accounted for most of the other observed woodpecker behaviors. The carrying of food to young and mates (3.9%), incubating and brooding (3.0%), and preening (1.7%) were observed less often. The category of calling and drumming (5.6%) was included in activity budgets for 2003 (Appendix E).

For the 10 red-headed woodpecker pairs on golf courses compared to 10 pairs on non-courses during 2003, a total of 131 behavioral observations were collected.

This sample size was averaged ( $n = 20$ ) to allow for no more than one sample per territory. On golf courses, adult red-headed woodpeckers primarily foraged on lawn and the bark of living trees. On non-courses, substrate usage was primarily on the bark of dead trees (40%) and living trees (33%; Fig. 3.2). Red-headed woodpeckers foraged on hard mast trees 38% of the time on golf courses and 55% at non-course sites, with oak trees used most often.

Comparison of foraging behavior indicated that red-headed woodpeckers foraged at somewhat lower heights on golf courses (mean =  $7.0 \text{ m} \pm 2.08\text{SE}$ ) than on non-courses, though not very different statistically (mean =  $11.6 \text{ m} \pm 2.71\text{SE}$ ;  $F_{1,18} = 1.83$ ,  $p = 0.192$ ). There was no difference in mean distance traveled from nesting cavity to forage on courses ( $32.58 \text{ m} \pm 6.96\text{SE}$ ) and non-courses ( $32.37 \text{ m} \pm 2.76\text{SE}$ ;  $F_{1,18} = 0.00$ ,  $p = 0.979$ ; Table 3.2).

Overall, red-headed woodpeckers did not significantly alter their behaviors on golf courses versus non-courses (Wilks' Lambda  $F_{4,15} = 1.54$ ,  $p = 0.241$ ). However, they did devote more time to preening on non-course sites ( $F_{1,18} = 4.54$ ,  $p = 0.047$ ). Pair activity budgets on golf courses were resting (39.0%), moving (26.5%), foraging (16.1%), carrying food to young or mate (8.5%), incubating or brooding (5.9%), calling or drumming (2.2%), and preening (1.7%). Values for the non-courses were: resting (44.9%), moving (24.0%), foraging (14.7%), carrying food to young or mate (5.9%), incubating or brooding (5.1%), calling or drumming (2.0%), and preening (3.9%; Table 3.3).

## DISCUSSION AND CONSERVATION IMPLICATIONS

As wildlife habitat loss increases, the identification of possible alternate habitats in greenspaces such as golf courses becomes increasingly significant. Despite a relatively small sample size, my findings suggest that both nesting success and behavior of red-headed woodpeckers were similar on and off golf courses. In particular, the high rates of nesting success (over 70%) suggested that golf courses can offer breeding habitat similar in quality to more natural areas. There is very little data from previous work on red-headed woodpecker nesting success, but Martin (1995) found 78% success in fledging at least 1 young (Smith et al. 2000). Similar activity budgets and comparable distances traveled from the nest to forage (ca. 32 m) also indicated that golf courses can offer quality breeding habitat. Thus, golf courses may serve as suitable substitute breeding grounds for this species given that its historical oak-savanna nesting habitat is largely decimated. Golf courses have already contributed to the conservation of other North American birds, serving an important role in efforts for the eastern bluebird (*Sialia sialis*), tree swallow (*Tachycineta bicolor*), purple martin (*Progne subis*), and osprey (*Pandion haliaetus*) (Tilly 2000). It is reasonable to expect that similar results can be found on other midwestern golf courses in the United States, offering hope to conservation efforts for threatened bird species, particularly those of open canopies.

At the same time, though, this study raises the possibility that red-headed woodpeckers on golf courses may be at risk for exposure to pesticides. Red-headed woodpeckers exploited lawn almost twice as often on golf courses (38%) than on

non-courses (20%), and searched for food 40% closer to the ground (approximately 7 m) on golf courses than on non-course sites (approximately 12 m). Others report that red-headed woodpeckers normally forage at a height around 13 meters (Williams 1975, Conner et al. 1994, Smith et al. 2000). There are no obvious explanations for the apparent differences in foraging strategies that I detected on golf courses, but it suggests that birds may risk exposure to pesticides. The lethality of pesticides and other toxins to red-headed woodpeckers is a concern, because they have shown to be susceptible to chemical exposure. For example, eggs from pairs that have nested in creosote-treated utility poles are known to not hatch half the time or the young die within a few days (Rumsey 1970, Smith et al. 2000). However, there is a gap in the literature concerning the extent woodpeckers are exposed to pesticides on golf courses, yet there has been pesticide research conducted on other cavity nesters and insectivores.

Pesticides used on golf courses include insecticides, fungicides, and herbicides that may contaminate the environment and unintentionally harm non-target organisms (Kendal et al. 1992, Kendal et al. 1993, Wan et al. 1996). In areas of high rainfall, runoff from pesticides can be more concentrated, but pesticides with low water solubility are immediately adsorbed and degrade quickly (Miles et al. 1992, Wan et al. 1996). There is potential for avian exposure to organophosphorous (OP) and carbamate pesticides that are applied to turf grasses, but few negative effects have actually been observed (Rainwater et al. 1995). Exposure could cause symptoms including weight loss, reduced growth rates, convulsions, paralysis, and death (Gillihan 2000). Eastern bluebirds and tree swallows exposed to OP insecticides



showed depressed brain and plasma cholinesterase activity, but no apparent decrease in survival (Burgess et al. 1999). They did, however, experience up to a 14% decline in reproduction after pesticide exposure, but not on a consistent yearly basis (Bishop et al. 2000). Grassland birds exposed to insecticides showed similar survival, clutch size, and nestling weight, size, and success to birds on control plots, but did forage almost twice as far from the nest (Martin et al. 2000). Although the Environmental Protection Agency closely regulates modern pesticides, herbicides, and fertilizers (GCSAA 2002), strategies to reduce chemical use are always a positive management tool in the creation of wildlife habitat and minimizing exposure risk.

Birds on and off courses showed some differences in use of foraging substrates. Specifically, non-course birds foraged on dead trees (40%) twice as often as birds on golf courses (19%), as the mean number of snags at a habitat survey point on courses was only  $2.7 \pm 1.17SE$  versus  $7.4 \pm 2.48$  on reference sites (Chapter 2). Red-headed woodpeckers readily use dead trees for foraging when they are available (Williams 1975, Connor et al. 1994, Smith et al. 2000), but the lack of deadwood on many golf courses may push them to seek out alternate foraging strategies. In particular, woodpeckers may be forced to search with greater frequency on the ground, which might increase their vulnerability to both predators and pesticides. However, I fortunately saw no direct evidence of red-headed woodpecker pesticide exposure on golf courses, but the condition and health of birds on golf courses should be more closely examined.

My foraging data confirm the importance of hard-mast trees for red-headed woodpeckers. Oak species are often used by red-headed woodpeckers for foraging

(Willson 1970, Reller 1972, Williams 1975, Smith et al. 2000), and this held true for both golf courses (45%) and reference sites (62%). I found the mean number of mast trees at a survey point to be  $1.2 \pm 0.23\text{SE}$  on golf courses and  $1.6 \pm 0.20$  on non-courses as part of a larger habitat analysis (Chapter 2). Since there was significant overlap in the mean number of mast trees available at courses and non-courses, red-headed woodpeckers seem to use mast trees with slightly greater frequency at reference sites for unknown reasons. Other studies have demonstrated the relationship between red-headed woodpecker populations and the presence of trees that produce hard mast (Reller 1972, Graber and Graber 1977, Smith and Scarlett 1987, Doherty et al. 1996). Although the importance of mast as a winter food source has been studied, this project reveals the importance of hard mast tree species to red-headed woodpeckers throughout the breeding season on golf courses.

Red-headed woodpeckers are known for their opportunistic tendencies, and birds can modify foraging and even nesting strategies slightly when needed (Smith et al. 2000). This behavioral plasticity makes them likely candidates to successfully inhabit human-modified environments such as golf courses. The findings from this study suggest that golf courses may contribute to conservation efforts in a meaningful way if habitats are managed to provide nesting and foraging requirements. Still, additional demographic work is needed to verify the viability of populations breeding on courses (i.e., recruitment and productivity) and to identify any lethal and sub-lethal effects of pesticide exposure.

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Tree Species	Golf Course Nests ( $n = 10$ )	Non-course Nests ( $n = 10$ )
American beech ( <i>Fagus grandifolia</i> )	3	1
Unidentified oak snag ( <i>Quercus</i> spp.)	0	4
Bur oak ( <i>Quercus macrocarpa</i> )	1	1
Red oak ( <i>Quercus rubra</i> )	0	1
Pin oak ( <i>Quercus palustris</i> )	1	0
Red maple ( <i>Acer rubrum</i> )	1	0
Sugar maple ( <i>Acer saccharum</i> )	1	0
American basswood ( <i>Tilia americana</i> )	1	0
Sycamore ( <i>Platanus occidentalis</i> )	1	0
Weeping willow ( <i>Salix babylonica</i> )	1	0
Ash ( <i>Fraxinus</i> spp.)	0	1
Eastern cottonwood ( <i>Populus grandidentata</i> )	0	1
Cucumbertree ( <i>Magnolia acuminata</i> )	0	1

Table 3.1 Number of red-headed woodpecker nests in 13 tree types for breeding pairs ( $n = 10$ ) on golf courses and pairs ( $n = 10$ ) on non-courses for comparison in Ohio, May – August 2003.

Variable	Golf Course	Non-course	$F_{1, 18}$	$P$
	Pairs ( $n = 10$ )	Pairs ( $n = 10$ )		
	Mean (SE)	Mean (SE)		
Foraging height (m)	7.0 (2.08)	11.6 (2.71)	1.8	0.192
Foraging distance from nest (m)	32.6 (6.96)	32.4 (2.76)	0.0	0.979

Table 3.2 Mean foraging height (m) and mean foraging distance (m) traveled from nest for red-headed woodpecker pairs ( $n = 10$ ) on golf courses and pairs ( $n = 10$ ) on non-courses in Ohio, May – August 2003. Analysis of variance showed no statistically significant differences in foraging height and distance traveled on golf-courses and non-courses. Reported F and  $P$  statistics are derived from *a posteriori* univariate tests.



Pair Number	Golf Course	Forage	Carry Food to Young/Mate	Incubate/Brood	Move	Rest	Preen	Call/Drum	Total
1	1	0.73	0.33	0.00	1.17	2.17	0.00	0.43	4.83
2	1	0.39	0.83	0.00	1.17	1.72	0.00	0.89	5.00
3	1	0.58	0.29	0.00	1.25	1.54	0.04	0.30	4.00
4	1	0.50	0.00	0.00	2.00	1.83	1.00	0.50	5.83
5	1	0.67	0.29	0.00	1.25	3.00	0.00	0.00	5.21
6	1	0.99	0.71	0.00	1.71	1.55	0.03	0.00	4.99
7	1	0.53	1.22	1.17	0.88	2.06	0.23	0.02	6.11
8	1	0.10	0.43	0.14	1.50	1.88	0.10	0.00	4.15
9	1	0.90	0.40	0.52	1.19	2.02	0.02	0.00	5.05
10	1	0.94	0.40	0.00	1.31	2.19	0.15	0.02	5.01
11	0	0.67	0.00	0.00	1.10	2.17	0.50	0.72	5.16
12	0	1.08	0.25	0.00	0.75	1.17	0.00	0.33	3.58
13	0	0.28	0.45	0.00	1.22	2.22	0.56	0.22	4.95
14	0	0.63	0.29	0.13	1.17	2.46	0.08	0.33	5.09
15	0	0.58	0.25	0.00	1.75	1.75	0.17	0.58	5.08
16	0	0.61	0.27	0.53	0.96	2.36	0.28	0.01	5.02
17	0	0.73	1.52	0.43	1.31	2.44	0.09	0.02	6.54
18	0	1.00	0.45	0.00	1.11	2.06	0.14	0.03	4.79
19	0	0.98	0.48	0.00	1.19	2.10	0.17	0.02	4.94
20	0	0.78	0.32	1.80	1.42	2.20	0.10	0.02	6.64
Mean		0.68	0.46	0.24	1.27	2.04	0.18	0.22	5.10
(SD)		0.26	0.37	0.47	0.30	0.40	0.25	0.28	0.75
(SE)		0.15	0.10	0.05	0.28	0.46	0.04	0.05	1.14

Table 3.3 Time budgets, in average number of minutes spent per activity, of 20 red-headed woodpecker breeding pairs in Ohio, May - August 2003 (1 = golf course site, 0 = non-course site).

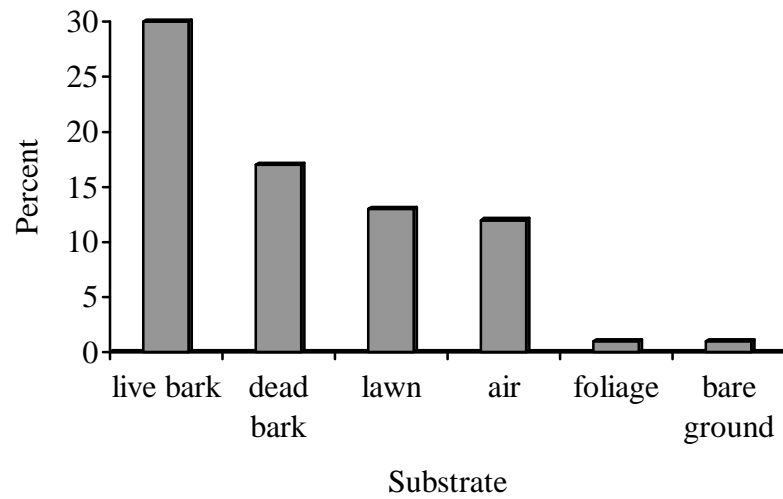


Figure 3.1 Percent use of foraging substrates by 75 adult red-headed woodpeckers on golf courses in Ohio, May – August 2002 - 2003.

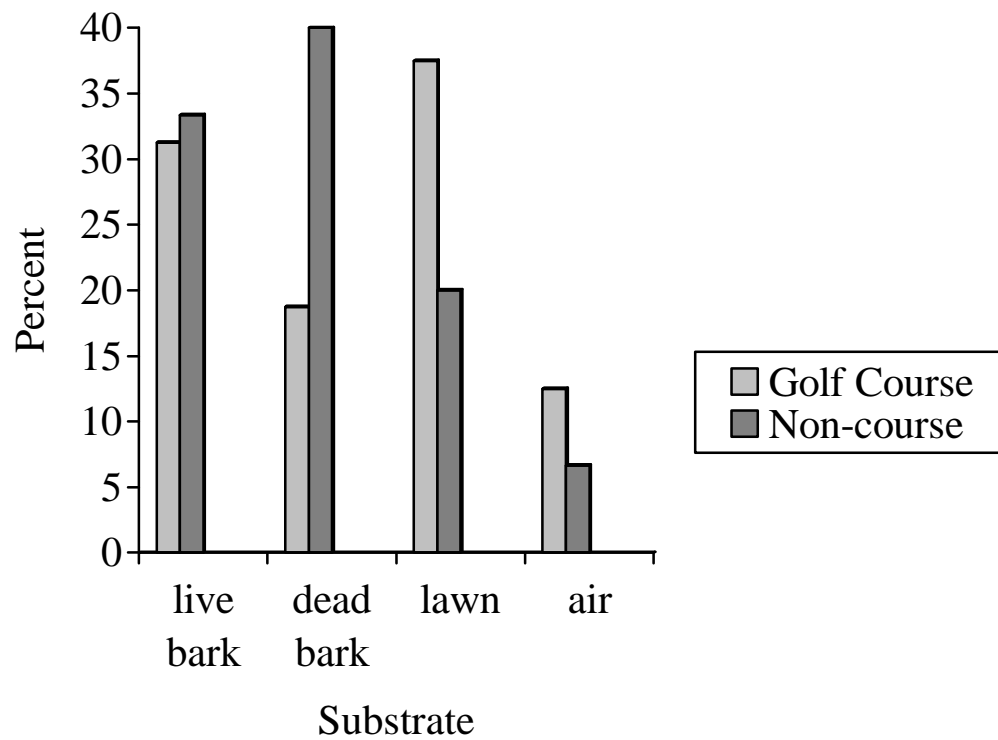


Figure 3.2 Percent use of foraging substrates by adult red-headed woodpecker pairs ( $n = 10$ ) on golf courses and pairs ( $n = 10$ ) on non-courses in Ohio, May – August 2003.

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## APPENDICES

### APPENDIX A STUDY SITE COORDINATES

Golf Course	County	Latitude	Longitude	Urban or Rural
Arrowhead Park Golf Club	Auglaize	40°23'	84°24'	Rural
Belmont Country Club	Wood	41°34'	83°35'	Urban
Bent Tree Golf Club	Delaware	40°17'	82°55'	Rural
Blacklick Woods Metro Golf	Franklin	39°57'	82°51'	Urban
Boston Hills Country Club	Summit	41°16'	81°31'	Rural
Bridgeview Golf Course	Franklin	40°02'	82°56'	Urban
Brookside Golf and Country Club	Franklin	40°06'	83°04'	Urban
Bucyrus Golf Club	Crawford	40°49'	82°57'	Urban
Canterbury Golf Club	Cuyahoga	41°28'	81°32'	Urban
Cassel Hills Golf Course	Montgomery	39°53'	84°10'	Urban
Catawba Island Golf Club	Ottawa	41°34'	82°51'	Rural
Chippewa Park Golf Course	Ottawa	41°36'	83°24'	Rural
Columbus Country Club	Franklin	40°02'	82°53'	Urban
Community Golf Course	Montgomery	39°42'	84°11'	Urban
Cooks Creek Golf Club	Pickaway	39°41'	82°59'	Rural
Country Club of Hudson	Summit	41°16'	81°26'	Urban
Cranberry Hills	Crawford	40°58'	82°50'	Rural
Darby Creek Golf Course	Union	40°10'	83°24'	Rural
Deer Creek State Park Golf Course	Pickaway	39°39'	83°15'	Rural
Deer Lake Golf Course	Ashtabula	41°51'	80°58'	Urban
Delphos Country Club	Van Wert	40°54'	84°22'	Rural
Dorlon Park Golf Course	Lorain	41°06'	81°53'	Rural
Dornoch Country Club	Delaware	40°15'	83°03'	Rural
Double Eagle Golf Club	Delaware	40°15'	82°58'	Rural
Eagle's Landing	Lucas	41°41'	83°25'	Urban
Emerald Woods Golf	Lorain	41°20'	81°53'	Urban
Fairview Golf Club	Hancock	41°00'	83°34'	Rural
Findlay Hillcrest Golf Club	Hancock	41°04'	83°39'	Urban
Fowler's Mill Golf Club	Geauga	41°31'	81°16'	Rural
Fox's Den Golf Club	Mercer	40°34'	84°32'	Urban
Gahanna Municipal Golf Course	Franklin	40°02'	82°53'	Urban
Galion Country Club	Crawford	40°42'	82°49'	Rural
Golf Club at Wiltshire	Cuyahoga	41°17'	81°42'	Rural
Hara Greens	Montgomery	39°49'	84°15'	Urban

Continued

Table A.1 Latitude and longitude coordinates for 100 golf courses in Ohio surveyed for red-headed woodpeckers in May – August 2002-2003.



Table A.1 continued

Hawks Nest Golf Club	Wayne	40°55'	81°55'	Rural
Hawthorne Hills Golf Course	Allen	40°45'	84°02'	Rural
Heatherwoode Golf Club	Warren	39°32'	84°14'	Urban
Heritage Golf Club	Franklin	40°01'	83°10'	Urban
Hickory Grove Golf Club	Wyandot	40°44'	83°14'	Rural
Hickory Grove Golf Course	Madison	39°51'	83°23'	Rural
Hickory Hills Golf Club	Franklin	39°53'	83°14'	Rural
High Lands Golf Club	Licking	40°02'	82°41'	Rural
Highland Meadows Golf Club	Lucas	41°42'	83°43'	Urban
Hillcrest Country Club	Williams	41°35'	84°32'	Rural
Lakeland Golf Course	Champaign	40°09'	83°58'	Rural
Landings at Rickenbacker	Pickaway	39°48'	82°56'	Rural
Legend Lake Golf Club	Geauga	41°34'	81°14'	Rural
Liberty Hills Golf Club	Logan	40°19'	83°47'	Rural
Lost Creek Country Club	Allen	40°44'	84°04'	Urban
Madden Golf Course	Montgomery	39°44'	84°14'	Urban
Marysville Golf Club	Union	40°12'	83°23'	Rural
Medina Country Club	Medina	41°06'	81°53'	Rural
Mentel Memorial Golf Course	Franklin	39°54'	83°09'	Rural
Mill Creek Metro Parks Golf Course	Mahoning	41°02'	80°41'	Urban
Mohawk Golf Club	Seneca	41°03'	83°10'	Rural
National Golf Links	Clark	39°55'	83°41'	Rural
National Road Golf Course	Madison	39°57'	83°19'	Rural
New Albany Country Club	Franklin	40°05'	82°50'	Rural
New Albany Golf Links	Franklin	40°07'	82°48'	Rural
Northwood Hills Country Club	Clark	39°58'	83°47'	Urban
Oberlin Golf Club	Lorain	41°17'	82°14'	Urban
Piqua Country Club	Miami	40°10'	84°14'	Rural
Powderhorn Golf Course	Lake	41°46'	81°01'	Rural
Prairie View Golf Club	Auglaize	40°36'	83°57'	Rural
Raccoon International Golf Club	Licking	40°04'	82°33'	Urban
Raymond Memorial Golf Course	Franklin	39°59'	83°06'	Urban
Red Hawk Run Golf Club	Hancock	41°04'	83°32'	Rural
Reid Memorial Golf Course	Clark	39°54'	83°45'	Urban
Riceland Golf Course	Wayne	40°47'	81°45'	Rural
Ridgewood Golf Course	Cuyahoga	41°23'	81°44'	Urban
Riviera Country Club	Franklin	40°08'	83°10'	Rural

Continued

Table A.1 continued

Rolling Acres Golf Course	Ashland	41°03'	82°18'	Rural
Sand Ridge Golf Club	Geauga	41°32'	81°12'	Rural
Scioto Country Club	Franklin	40°00'	83°05'	Urban
Seneca Golf Course	Cuyahoga	41°18'	81°41'	Rural
Shady Hollow Country Club	Stark	40°51'	81°30'	Urban
Shawnee Country Club	Allen	40°43'	84°09'	Urban
Sleepy Hollow Golf Course	Cuyahoga	41°19'	81°37'	Rural
Stone Crossing	Wyandot	40°50'	83°16'	Urban
Sugarbush Golf, Inc.	Portage	41°18'	81°05'	Rural
Sweetbriar Golf	Lorain	41°28'	82°01'	Rural
Sycamore Hills Golf Club	Sandusky	41°21'	83°12'	Rural
Sylvania Country Club	Lucas	41°42'	83°40'	Urban
Tanglewood Golf Club	Delaware	39°56'	82°52'	Rural
Tartan Fields Golf Club	Delaware	40°09'	83°09'	Urban
The Lakes Golf and Country Club	Franklin	40°10'	82°57'	Rural
The Medallion Club	Delaware	40°10'	82°54'	Rural
Tree Links Golf Course	Logan	40°21'	83°42'	Rural
Turnberry Golf Course	Fairfield	39°56'	82°49'	Rural
Twin Oaks Golf Club	Delaware	40°10'	83°09'	Urban
Urbana Country Club	Champaign	40°07'	83°39'	Rural
Valley View Golf Course	Crawford	40°47'	82°48'	Rural
Walnut Grove Country Club	Montgomery	39°44'	84°08'	Urban
Walnut Hill Golf Course	Franklin	39°56'	82°52'	Urban
Wedgewood Golf & Country Club	Delaware	40°09'	83°06'	Urban
Westchester Golf Course	Franklin	39°50'	82°50'	Urban
WGC Golf Course	Greene	39°42'	83°55'	Urban
Winding Hollow Country Club	Franklin	40°05'	82°47'	Rural
Wooster Country Club	Wayne	40°49'	81°56'	Urban
Youngstown Country Club	Mahoning	41°03'	80°38'	Urban

Site	Golf Course	County	Latitude	Longitude	Urban or Rural
Bucyrus Golf Club	1	Crawford	40°49'	82°57'	Urban
Cranberry Hills	1	Crawford	40°58'	82°50'	Rural
Sylvania Country Club	1	Lucas	41°42'	83°40'	Urban
Red Hawk Run Golf Club	1	Hancock	41°04'	83°32'	Rural
Punderson State Park Golf Course	1	Geauga	41°27'	81°13'	Rural
Oberlin Golf Club	1	Lorain	41°17'	82°14'	Urban
Mill Creek Metro Parks Golf Course	1	Mahoning	41°02'	80°41'	Urban
Sandusky Plains	0	Crawford	40°44'	83°05'	Rural
Killdeer Plains	0	Wyandot	40°43'	83°22'	Rural
Kitty Todd	0	Lucas	41°37'	83°48'	Rural
Maumee State Forest	0	Henry	41°28'	83°54'	Rural
Punderson Park	0	Geauga	41°27'	81°12'	Rural
Westwood Cemetery	0	Lorain	41°17'	82°13'	Urban
Mill Creek Metro Park	0	Mahoning	41°01'	80°42'	Urban
Lake Cardinal	0	Ashtabula	41°36'	80°53'	Rural

Table A.2 Latitude and longitude coordinates for golf courses (n = 7) and non-courses (n = 8) with red-headed woodpecker breeding pairs for comparison in Ohio, May – August 2003 (1 = golf course, 0 = non-course).

**APPENDIX B**  
**STUDY AREA MAPS**

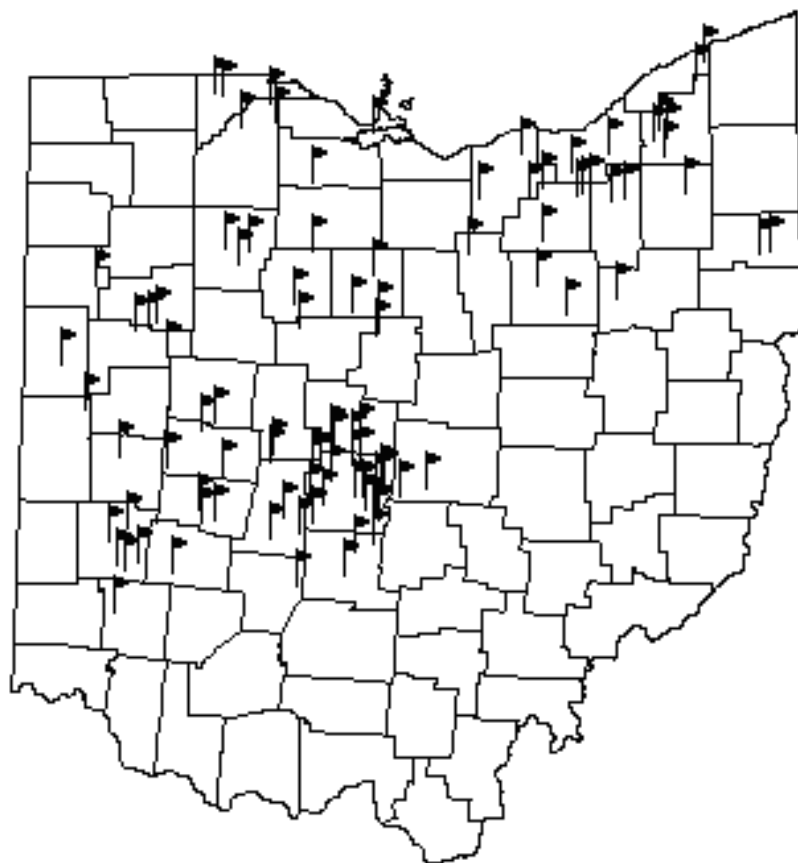


Figure B.1 Golf courses (n = 100) surveyed for red-headed woodpeckers in Ohio, May – August 2002 – 2003.

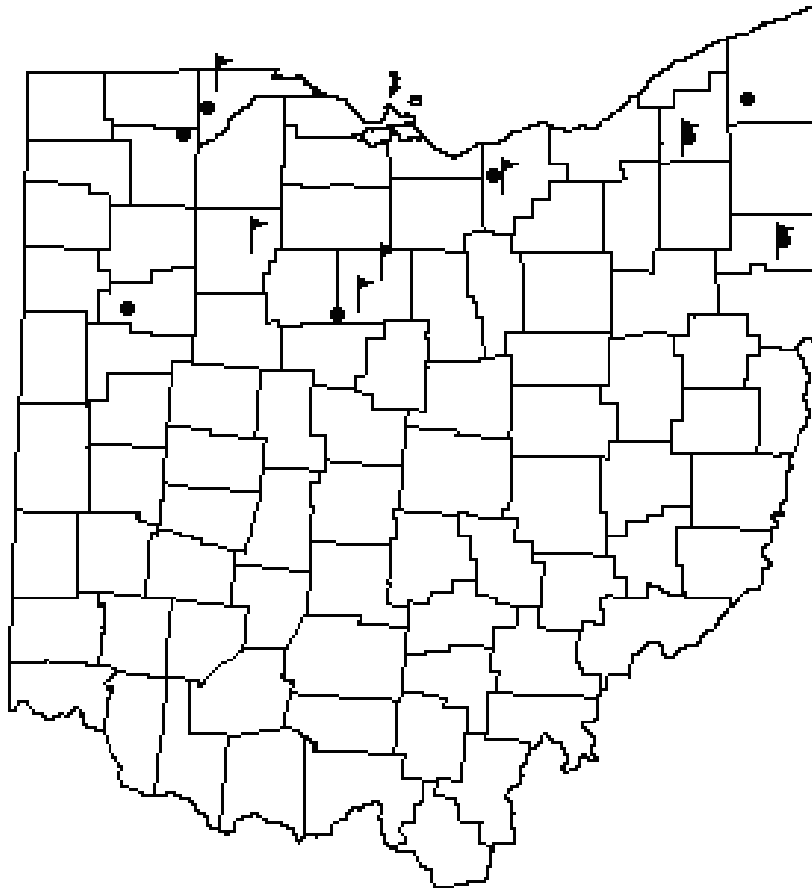


Figure B.2 Golf courses ( $n = 7$ ) and non-courses ( $n = 8$ ) surveyed for comparison of red-headed woodpecker breeding pairs in Ohio, May – August 2003. Golf courses are marked with flags and non-courses with points.

APPENDIX C  
GOLF COURSE SURVEYS

Golf Course	County	Red-headed woodpeckers	European starlings	House sparrows	Squirrels
Arrowhead Golf Club	Shelby	5	5	10	0
Belmont Country Club	Wood	0	72	31	1
Bent Tree Golf Club	Delaware	8	0	0	.
Blacklick Woods Metro Golf	Franklin	0	0	10	1
Boston Hills Country Club	Summit	2	100	19	2
Bridgeview Golf Course	Franklin	0	0	0	0
Brookside Golf and Country Club	Franklin	0	1	0	3
Bucyrus Golf Club	Crawford	3	3	0	1
Canterbury Country Club	Cuyahoga	0	11	2	6
Cassel Hills Golf Course	Montgomery	0	0	1	0
Catawba Island Golf Club	Ottawa	0	18	9	1
Chippewa Park Golf Course	Ottawa	6	165	3	3
Columbus Country Club	Franklin	3	5	8	7
Community Golf Course	Montgomery	0	11	12	0
Cooks Creek Golf Club	Pickaway	1	0	0	0
Country Club of Hudson	Summit	0	0	2	0
Cranberry Hills	Crawford	3	14	4	1
Darby Creek Golf Course	Union	0	2	0	0
Deer Creek State Park Golf Course	Pickaway	0	0	0	0
Deer Lake Golf Course	Ashtabula	26	15	20	3
Delphos Country Club	Allen	2	3	4	1
Dorlon Park Golf Course	Lorain	16	37	0	3
Dornoch Country Club	Delaware	2	0	1	.
Double Eagle Golf Club	Delaware	0	3	3	3
Eagle's Landing	Lucas	0	230	11	0
Emerald Woods Golf	Lorain	4	81	1	0
Fowler's Mill Golf Club	Geauga	0	.	0	2
Fox's Den Golf Club	Mercer	0	66	10	0
Gahanna Municipal Golf Course	Franklin	0	1	0	0
Galion Country Club	Crawford	0	5	1	2
Golf Club at Wiltshire	Cuyahoga	0	14	19	3
Hara Greens	Montgomery	0	16	1	0
Hawk's Nest Golf Club	Wayne	5	4	0	0
Hawthorne Hills Golf Course	Allen	0	36	3	3
Heatherwoode Golf Club	Warren	0	11	1	0
Heritage Golf Club	Franklin	0	15	27	0
Hickory Grove Golf Club	Wyandot	0	25	5	1
Hickory Grove Golf Course	Madison	0	7	0	1
Hickory Hills Golf Club	Franklin	5	1	1	0

Continued

Table C.1 Number of red-headed woodpeckers, European starlings, house sparrows and squirrels surveyed on 100 golf courses in Ohio, May – August 2002-2003.



Table C.1 continued

Highland Meadows Golf Club	Lucas	0	91	10	4
HighLands Golf Club	Licking	0	0	3	0
Hillcrest Country Club	Hancock	0	38	12	0
Hillcrest Country Club	Williams	0	0	15	1
Lakeland Golf Course	Champaign	0	26	0	0
Landings at Rickenbacker	Pickaway	0	4	1	0
Legend Lake Golf Club	Geauga	0	1	0	.
Liberty Hills Golf Club	Logan	0	4	2	0
Lost Creek Country Club	Allen	0	5	7	1
Madden Golf Course	Montgomery	0	15	0	0
Marysville Golf Club	Union	0	9	1	1
Medina Country Club	Medina	0	94	1	3
Mentel Memorial	Franklin	0	4	3	0
Mill Creek Metro Parks Golf Course	Mahoning	17	16	1	6
Mohawk Golf Club	Seneca	1	145	0	2
National Golf Links	Clark	0	1	0	0
National Rd. Golf Course	Madison	0	3	0	0
New Albany Country Club	Franklin	1	35	13	0
New Albany Golf Links	Franklin	0	10	1	1
Northwood Hills Country Club	Clark	0	5	8	0
Oak Mallett Golf Club	Hancock	0	55	23	0
Oberlin Golf Club	Lorain	4	3	4	12
Piqua Country Club	Miami	0	30	0	0
Powderhorn Golf Course	Lake	0	20	0	1
Prairie View Golf Course	Auglaize	0	5	0	0
Raccoon International Golf Club	Licking	0	0	0	1
Raymond Memorial Golf Course	Franklin	0	6	0	0
Red Hawk Run Golf Club	Hancock	3	81	11	0
Reid Memorial Golf Course	Clark	0	75	19	1
Riceland Golf Course	Wayne	22	22	0	1
Ridgewood Golf Course	Cuyahoga	0	26	4	3
Riviera Country Club	Franklin	0	8	2	1
Rolling Acres Golf Course	Ashland	0	8	5	2
Sand Ridge Golf Club	Geauga	0	.	3	.
Scioto Country Club	Franklin	0	23	1	0
Seneca Golf Course	Cuyahoga	0	112	12	1
Shady Hollow Country Club	Stark	0	4	0	1
Shawnee Country Club	Allen	0	0	0	2
Sleepy Hollow Golf Course	Cuyahoga	0	5	26	0

Continued

Table C.1 continued

Stone Crossing	Wyandot	0	1	0	0
Sugarbush Golf Inc.	Portage	2	.	.	.
Sweetbriar Golf	Lorain	6	0	0	3
Sycamore Hills Golf Club	Sandusky	0	249	20	2
Sylvania Country Club	Lucas	2	1	1	5
Tanglewood Golf Club	Delaware	0	0	21	2
Tartan Fields Golf Club	Delaware	0	3	0	0
The Lakes Golf and Country Club	Franklin	0	0	1	0
The Medallion Club	Delaware	0	19	3	0
Tree Links Golf Course	Logan	0	0	7	2
Turnberry Golf Course	Franklin	0	0	0	0
Twin Oaks Golf Club	Delaware	0	2	6	1
Urbana Country Club	Champaign	1	0	6	1
Valley View Golf Course	Crawford	0	21	14	0
Walnut Grove Country Club	Montgomery	0	0	15	2
Walnut Hill Golf Course	Franklin	0	3	2	14
Wedgewood Golf & Country Club	Delaware	0	3	0	1
Westchester Golf Course	Franklin	0	29	2	0
WGC Golf Course	Greene	0	0	15	2
Winding Hollow Country Club	Franklin	8	2	2	0
Wooster Country Club	Wayne	0	6	13	8
Youngstown Country Club	Mahoning	0	14	1	8

APPENDIX D  
RATIO OF JUVENILES TO ADULTS ON GOLF COURSES

Golf Course	County	Ratio of Juveniles to Adults
Arrowhead Golf Club	Shelby	2:3
Bent Tree Golf Club	Delaware	1:2
Boston Hills Country Club	Summit	1:1
Bucyrus Golf Club	Crawford	1:1
Chippewa Park Golf Course	Ottawa	1:2
Columbus Country Club	Franklin	1:2
Cooks Creek Golf Club	Pickaway	0:1
Cranberry Hills	Crawford	1:1
Deer Lake Golf Course	Ashtabula	3:26
Delphos Country Club	Allen	0:2
Dorlon Park Golf Course	Lorain	3:16
Dornoch Country Club	Delaware	1:2
Emerald Woods Golf	Lorain	1:2
Hawk's Nest Golf Club	Wayne	0:5
Hickory Hills Golf Club	Franklin	2:5
Mill Creek Metro Parks Golf Course	Mahoning	1:1
Mohawk Golf Club	Seneca	0:1
New Albany Country Club	Franklin	0:1
Oberlin Golf Club	Lorain	1:1
Red Hawk Run Golf Club	Hancock	0:3
Riceland Golf Course	Wayne	4:7
Sugarbush Golf Inc.	Portage	0:2
Sweetbriar Golf	Lorain	7:6
Sylvania Country Club	Lucas	1:2
Urbana Country Club	Champaign	0:1
Winding Hollow Country Club	Franklin	0:8

Table D.1 Ratio of red-headed woodpecker juveniles to adults on 26 golf courses surveyed in Ohio, May – August 2002 – 2003.

APPENDIX E  
RED-HEADED WOODPECKER TIME BUDGETS ON GOLF COURSES

Bird	Carry Food to Young/ Incubate/			Move	Rest	Preen	Total
	Forage	Mate	Brood				
1	0.33	0.00	0.00	1.00	2.83	0.17	4.33
2	0.17	0.00	0.00	0.67	0.67	0.00	1.51
3	0.33	0.00	0.00	0.67	0.67	0.17	1.84
4	0.83	0.17	0.00	1.33	2.00	0.17	4.50
5	0.67	0.00	0.00	1.00	1.83	0.00	3.50
6	1.33	0.50	0.00	2.00	1.17	0.00	5.00
7	0.67	0.17	0.00	1.00	2.83	0.33	5.00
8	1.00	0.67	0.00	1.67	1.67	0.00	5.01
9	1.00	0.67	0.00	0.67	2.67	0.00	5.01
10	0.83	0.50	0.00	1.17	2.17	0.00	4.67
11	0.17	0.00	0.00	0.17	1.50	0.00	1.84
12	1.00	0.00	0.00	1.83	3.00	0.17	6.00
13	0.50	0.00	0.00	1.00	3.17	0.00	4.67
14	0.00	0.00	0.00	0.67	0.70	0.00	1.37
15	1.00	0.00	0.00	1.00	3.00	0.00	5.00
16	0.67	0.00	0.00	1.00	3.33	0.00	5.00
17	0.67	0.00	0.00	1.17	3.00	0.17	5.01
18	1.17	0.50	0.00	1.17	2.17	0.00	5.01
19	1.00	0.00	0.00	1.33	2.67	0.00	5.00
20	1.17	0.00	0.00	2.50	4.50	0.67	8.84
21	0.67	0.00	0.00	0.67	0.17	0.00	1.51
22	1.50	0.00	0.00	1.50	0.67	0.00	3.67
23	0.00	0.00	0.00	0.83	5.83	0.00	6.66
24	0.67	0.67	0.17	1.33	1.00	0.00	3.84
25	0.17	0.50	0.17	2.83	0.67	0.00	4.34
26	0.17	0.00	0.00	1.83	2.50	0.00	4.50
27	0.83	0.67	0.00	1.17	2.00	0.17	4.84
28	0.83	0.00	1.00	1.33	1.83	0.00	4.99
29	1.67	0.00	0.00	1.67	1.50	0.17	5.01
30	0.67	0.00	0.00	1.17	2.67	0.67	5.18
31	1.50	0.00	0.00	1.00	2.67	0.00	5.17
32	0.17	0.00	0.00	0.50	2.00	0.00	2.67
33	0.83	0.00	0.00	0.83	0.33	0.00	1.99
34	0.67	0.00	0.00	1.33	3.00	0.00	5.00
35	1.00	1.00	0.00	0.83	2.33	0.00	5.16
36	1.00	0.00	0.00	1.67	2.50	0.00	5.17
37	1.17	0.00	0.00	1.33	2.50	0.00	5.00
38	0.83	0.00	0.00	1.17	3.00	0.00	5.00
39	0.83	0.00	0.00	1.33	2.83	0.00	4.99
40	1.16	0.00	0.00	1.33	2.50	0.00	4.99
41	0.67	0.00	0.00	1.33	3.00	0.00	5.00
42	0.00	0.17	0.00	0.83	3.33	0.33	4.66
43	0.33	0.00	0.00	1.50	3.17	0.00	5.00

Continued

Table E.1 Time budgets, in minutes spent per activity, of 72 red-headed woodpeckers on Ohio golf courses, May - August 2002 - 2003.

Table E.1 continued

Bird	Forage	Carry Food to Young/ Mate	Incubate/ Brood	Move	Rest	Preen	Call/ Drum	Total
44	1.00	0.00	0.00	1.00	1.00	0.00	0.17	3.17
45	1.00	0.17	0.00	1.33	2.50	0.00	0.00	5.00
46	0.83	0.33	0.00	1.67	2.00	0.17	0.00	5.00
47	1.00	0.33	0.00	2.00	1.83	0.00	0.00	5.16
48	0.83	0.50	0.00	2.00	1.67	0.00	0.00	5.00
49	0.67	0.00	0.00	1.67	2.33	0.33	0.00	5.00
50	1.00	0.00	0.00	1.50	2.50	0.00	0.00	5.00
51	1.17	0.17	0.00	1.17	2.50	0.00	0.00	5.01
52	0.83	0.33	0.00	1.67	2.17	0.00	0.00	5.00
53	1.00	0.00	0.00	1.00	1.00	0.00	0.17	3.17
54	0.33	0.00	0.00	1.17	3.33	0.17	0.00	5.00
55	0.50	0.00	0.00	1.50	3.00	0.00	0.33	5.33
56	0.33	0.33	0.00	1.50	2.50	0.00	0.83	5.49
57	0.17	0.67	0.00	0.67	1.33	0.00	0.33	3.17
58	0.17	0.67	0.00	0.33	1.50	0.00	2.33	5.00
59	1.17	0.33	0.00	1.33	2.00	0.17	0.00	5.00
60	0.17	0.17	0.00	0.50	0.00	0.00	0.17	1.01
61	0.50	0.00	0.00	2.00	1.83	0.17	0.50	5.00
62	0.83	0.33	0.00	0.83	3.67	0.00	0.00	5.66
63	1.33	0.67	0.00	1.67	1.67	0.00	0.00	5.34
64	0.50	0.50	0.00	1.83	2.17	0.00	0.00	5.00
65	0.17	0.00	0.00	0.67	3.00	1.17	0.00	5.01
66	0.17	0.00	4.83	0.00	0.00	0.00	0.00	5.00
67	1.00	0.83	0.00	1.67	1.33	0.17	0.00	5.00
68	0.67	0.33	0.00	1.67	2.33	0.00	0.00	5.00
69	0.67	0.17	0.00	1.00	3.17	0.00	0.00	5.01
70	0.33	0.00	4.17	0.50	0.00	0.00	0.00	5.00
71	0.67	0.17	0.00	1.50	2.67	0.00	0.00	5.01
72	1.17	0.33	0.00	1.00	2.33	0.17	0.00	5.00
Mean	0.72	0.19	0.14	1.23	2.15	0.08	0.17	4.58
(SD)	0.40	0.26	0.75	0.51	1.05	0.19	0.46	1.26
(SE)	0.05	0.03	0.09	0.06	0.12	0.02	0.09	0.15