8-1995

Wood Duck Population and Habitat Investigations Study No. 1: Population Monitoring and Habitat Relationships of Wood Ducks in Southern Illinois

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W-121-R.

FINAL REPORT

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Study No. 1: Population Monitoring and Habitat Relationships of Wood Ducks in Southern Illinois

Submitted by:

Cooperative Wildlife Research Laboratory, SIUC

Presented to:

Illinois Department of Natural Resources

August 1995

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FINAL REPORT

State of Illinois

W-121-R

Project Period: 1 July 1992 through 30 June 1995

Study: Wood duck Population and Habitat Investigations

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Need: With recent long-term declines in populations of prairie-nesting ducks, wood ducks have increasingly comprised greater proportions of waterfowl harvested in the Mississippi, Central, and Atlantic Flyways. Although harvest levels have increased and forested wetland habitats continue to be lost or degraded, there is evidence that populations and distributions of wood ducks have expanded in all flyways except the Pacific. As wood duck populations and harvests increase, there is need to improve monitoring of population status, trends, and productivity at local and regional scales. Field census techniques need to be developed and tested to provide reliable indices of wood duck breeding population status and trends at the Flyway level.

The Illinois Department of Natural Resources (IDNR) cooperates with the U.S. Fish and Wildlife Service (USFWS) Office of Migratory Bird Management in an intensive statewide pre-hunting season leg-banding program. Leg-banding provides data on annual survival rates, distribution and derivation of the harvest, and indirect information on population status over large geographic areas. Nesting productivity has been studied on local scales, mostly through monitoring artificial nest boxes. However, there is growing interest and need to obtain nesting data from natural nest cavities as well. Independently derived indices of breeding populations and productivity are needed to enhance and supplement data obtained through leg-banding and nest box studies.

Most of the information on breeding ecology of Illinois wood ducks has been acquired from studies in habitats associated with the Illinois River in central Illinois, and in pond and marsh habitats of northeastern Illinois. Substantial numbers of wood ducks are produced in southern Illinois, mostly from natural tree cavities. Very little information was available on breeding populations, productivity, and habitat relationships of wood ducks in southern Illinois prior to W-121-R.

The growing contribution of wood ducks to annual waterfowl harvests in the Mississippi Flyway will increase the need to protect, restore, and manage critical breeding habitats. In addition to the need for basic population data, improved management of wood ducks in southern Illinois requires; 1) identification of critical habitats, 2) understanding of seasonal movement and habitat use patterns, and 3) investigation of factors affecting habitat availability and quality during breeding and post-breeding seasons.

Objectives:

1. Test the efficiency of different field census techniques in providing reliable indices of wood duck breeding populations and productivity.

2. Collect data on wood duck population status and trends.

3. Investigate seasonal movement and habitat use patterns of wood ducks in southern Illinois.

EXECUTIVE SUMMARY

As originally conceived, W-121-R was to test alternative techniques for censusing breeding and post-breeding populations of wood ducks on three study sites in southern Illinois. With implementation of the Wood Duck Population Initiative by USFWS and the Mississippi and Atlantic Flyway Councils in 1993, W-121-R was begun with emphases on obtaining indices of breeding populations and nesting productivity. Rather than test a variety of different census techniques, most of which would not have provided useful information, we implemented a roadside survey similar to that proposed for the Wood Duck Population Initiative to obtain population indices of breeding wood ducks. By following hens that were radio-marked to determine seasonal movement and habitat use patterns, we were able to monitor hen survival, identify nest sites, and inspect nest cavities to acquire data on nesting success and productivity. Routine surveys of brood habitat after nesting provided information on breeding chronology and brood sizes.

Investigation of movements and habitat use by breeding hens revealed that a large majority of wood ducks were produced on our study areas from natural cavities located in upland forest above the Mississippi River floodplain. As a result, W-121-R became less focused on evaluating wood duck census techniques to allow greater emphasis on investigating breeding productivity from nests in located in natural cavities. This shift in emphasis affected only Job 1.2. Other jobs were conducted as described in the project Application for Federal Aid.

This report is organized by job, with separate introduction, methods, results, and discussion sections for Jobs 1.1 - 1.3. General introduction and study area sections appear at the beginning of the report. Scanned aerial photography, satellite imagery, and digitized habitat maps and associated data bases are archived at the Cooperative Wildlife Research Laboratory, Southern Illinois University at Carbondale.

This report summarizes data and analyses conducted during the first 3 segments of project W-121-R under Study No. 1, "Population Monitoring and Habitat Relationships of Wood Ducks in Southern Illinois". Data collection, summary, and preliminary analyses were completed for all jobs. More detailed analyses are on-going and will be reported in a thesis and a dissertation to be prepared by co-authors of this report. Analyses and conclusions regarding breeding population densities and nesting productivity will be presented in a M.S. thesis by D. C. Ryan within 6 months of completion of this report. Mr. Ryans' thesis will include all of Job 1.2, and those portions of Job 1.3 that deal with characteristics of nest sites used by radio-marked hens. Data collection was completed at the end of segment 3 for Jobs 1.1 and 1.3. Data analyses for these jobs are on-going and will be reported in a Ph.D. dissertation to be completed by R. J. Kawula in December 1996.

W-121-R will be continued under a second 3-year study titled "Factors Affecting Wood Duck Reproduction and Survival of Wood Duck Hens in Forested Landscapes". Study No. 2 will build on information acquired during Study No. 1, but with greater emphasis on relationships of habitat quality to nest predation, nest success, and hen and brood survival at a landscape scale. Field activities initiated under Study No. 1 will be continued as needed to address objectives of Study No. 2. Consequently, long-term data on breeding population trends, nesting productivity, habitat conditions, and hen and brood survival from all 6 project segments will be summarized at the end of Study No. 2.

ACKNOWLEDGEMENTS

We acknowledge the contributions of numerous participants in this study. R. M. Whitton and D. A. Woolard, Illinois Department of Natural Resources assisted with capture and marking of wood duck hens and other logistical challenges. P. A. Shelton and P. J. Bergmann contributed their experience and expertise in getting this study off the ground and assisted with data collection. N. S. Belmont, K. M. Hartke, C. E. Kelly, B. A. Janiak, M. J. O'Leary, D. C. Sample, J. A. Watts, and E. H. Zwicker provided field assistance and/or assisted with data entry and compilation.

STUDY NO. 1: **Population Monitoring and Habitat Relationships of Wood Ducks in Southern Illinois**

Objectives: (1) To test the suitability of different census techniques to monitor breeding and pre-hunting season population status and trends in different habitat types used by wood ducks in southern Illinois; (2) develop indices of breeding population status, trends and, productivity for wood ducks in southern Illinois; (3) investigate habitat relationships, seasonal movement patterns, and changes in local distribution of breeding and post-breeding wood ducks in southern Illinois.

INTRODUCTION

Although >95% of wood ducks (Aix sponsa) may be produced from nests in natural cavities (Soulliere 1990), most knowledge of wood duck breeding biology has been gained from studies of box-nesting hens (Bellrose and Holm 1994). Only recently has attention turned to wood ducks nesting in natural cavities (Robb and Bookhout 1995). Wood duck breeding biology has been studied in central (Bellrose and Holm 1994) and northeastern Illinois (Semel et al. 1990), but very little is known about breeding ecology of wood ducks in southern Illinois. There has been little or no emphasis on managing nest boxes for wood ducks within state and federal lands in southern Illinois, so nearly all wood ducks are produced from natural cavities. Consequently, southern Illinois is an ideal area for studying wood duck nesting in natural cavities.

This was the third and final project segment under Study No. 1, which was initiated in part to test different population survey techniques for breeding wood ducks. A wood duck population initiative was implemented in 1993 by the U.S. Fish and Wildlife Service (FWS) and the Atlantic and Mississippi Flyway Councils to develop and improve databases needed for more effective management of wood duck populations on flyway and regional scales. Breeding productivity is a primary focus of the wood duck population initiative, consequently the emphasis of W-121-R has been to obtain indices of breeding population densities and data on reproductive performance of wood ducks in southern Illinois. A second objective of Study No. 1 has been to investigate seasonal movements, home ranges, and habitat selection by wood duck hens during prenesting, nesting, and brood-rearing. The separate aspects of this study complement each other in that understanding of seasonal movement and distribution is necessary to implement effective population surveys, and data on reproductive performance is needed to interpret home range and habitat use patterns of breeding hens.

STUDY AREA

This study was conducted on and adjacent to the Illinois portion of the Mississippi River floodplain from the Oakwood and Big Muddy River Bottoms in southwestern Jackson County, to Union County Conservation Area (CA) in southwestern Union County, IL. The study area encompassed 2 major physiographic regions (Schwegman 1973); the Mississippi River Bottomlands Division at elevations 103.6 - 115.8 m, and the adjacent river bluffs and ridges associated with the Ozark and Shawnee Hills divisions at elevations 109.7 - 273.4 m. References later in the report to forested habitats as upland or bottomland follow these criteria. Wood duck hens were captured at Union County CA, LaRue Swamp Research Natural Area (RNA), and Oakwood Bottoms Greentree Reservoir (GTR). Boundaries of the study area were determined by daily and seasonal movements of radio-marked hens captured at these locations. LaRue Swamp RNA was an area of contiguous swamps with semipermanent to permanent water regimes surrounded by temporary and seasonal forested wetlands that were essentially unmanaged. Oakwood Bottoms GTR was a contiguous tract of predominantly temporary seasonal forested wetland that was artificially flooded and de-watered by the U.S. Forest Service. Oakwood bottoms was managed primarily to provide feeding and resting habitat for migrating waterfowl and hunting opportunity. Union County CA was a fragmented bottomland consisting mostly of cropland, forested wetlands with temporary and seasonal water regimes, and a series of shallow lakes and ponds interspersed throughout the area (O'Leary 1995). The primary management of Union County CA was to provide agricultural crop foods and roosting water for wintering populations of Canada geese (Branta canadensis). Although these areas differed greatly with respect to habitat diversity, landscape structure, and management practices, each was located immediately adjacent to (LaRue Swamp RNA and Union County CA) or within 2 km of (Oakwood Bottoms GTR) extensive tracts of upland forest.

LITERATURE CITED

Bellrose, F. C., and D. J. Holm. 1994. Ecology and management of the wood duck. Stackpole Books, Mechanicsburg, PA. 588pp.

O'Leary, M. J. 1995. Ecological characteristics and waterfowl use of wetland habitats at Union County Conservation Area. M.S. Thesis, Southern Illinois Univ., Carbondale. 86 pp.

Robb, J. R., and T. A. Bookhout. 1995. Factors influencing wood duck use of natural cavities. J. Wildl. Manage. 59:372-383.

Schwegman, J. E. 1973. The natural divisions of Illinois. Illinois Nat. Pres. Comm., Rockford, IL. 32 pp. + map.

Semel, B., P. W. Sherman, and S. M. Byers. 1990. Nest boxes and brood parasitism in wood ducks: a management dilemma. Pages 163-170 in L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, eds. Proc. 1988 North Am. Wood Duck Symp., St. Louis, MO.

Soulliere, G. J. 1990. Regional and site-specific trends in wood duck use of nest boxes. Pages 235-244 in L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, eds. Proc. 1988 North Am. Wood Duck Symp., St. Louis, MO.

Job 1.1: **<u>Classification and Analysis of Habitats</u>**

<u>Objectives</u>: To map, classify, and measure availability of wetland habitats for breeding and post-breeding wood ducks on a representative study area in southern Illinois.

INTRODUCTION

The objective of this job was to map, classify, and measure availability of wetland and other habitats for breeding and post-breeding wood ducks. Habitat maps created under this job were used to support activities under Jobs 1.2 and 1.3. These maps were used to plan call-count routes used under Job 1.2, and to plot locations of radio-marked hens for analyses of home ranges and habitat use patterns under Job 1.3. Completed habitat maps also were used to locate sample plots for measuring vegetation characteristics of forested wetland habitats at Union County CA.

METHODS

Habitat maps were produced by interpreting aerial photography, satellite imagery, and overlaying digitized National Wetland Inventory (NWI) maps using the Map and Image Processing System (MIPS, MicroImages, Inc., Lincoln, NE). Ground truthing was conducted in conjunction with other field activities, and habitat maps were corrected as classification errors were identified.

Landsat 5 satellite images acquired during springs 1993 and 1994 were classified using MIPS to determine areas of Union County CA that were inundated with surface water during wet (1993) and dry (1994) springs. Results of these classifications were overlayed on habitat maps to determine extents of surface water inundation in different habitats at Union County CA during springs 1993-1995. Flooding extents during times when satellite imagery was not available were marked on maps and recorded in field notes. Distribution of surface water under intermediate flooding conditions, such as occurred in spring 1995, will be interpolated between the extremes recorded on satellite imagery during 1993 and 1994.

One hundred 4 x 50-m plots were established to characterize vegetation of forested wetland habitats at Union County CA. Plots were allocated among forested wetland patches in proportion to their areas, with 1 plot per 1.6 ha of wetland forest. Overstory tree species composition and basal area, shrub cover, number of exposed substrates (loafing sites), dominant shrub species, distance to escape cover, and % cover of submerged vegetation were recorded for each plot.

RESULTS AND DISCUSSION

A detailed habitat map of Union County CA and adjacent areas was completed (Fig. 1), and total areas and number of patches for each of 13 habitat types summarized (Table 1). Wetland habitats used by wood ducks were subject to periodic water level fluctuations. Consequently, habitat availability was highly influenced by flooding conditions that varied among years. Areas of forested wetland and other habitat types that were inundated with surface water will be compared among seasons (prenesting, nesting, and post-breeding) and years (1993-1995). Results will be reported in future project reports.

Additional vegetation sampling plots were identified based on movements of radio-marked hens (see Job 1.3). Field measurements of these plots are on-going. Gates et al. (1994) summarized data recorded from 59 plots during spring 1994. Vegetation characteristics will be compared among forested wetland patches that were used vs. not used by radio-marked hens during springs 1993-1995. Results of these analyses will be reported in future project reports.

LITERATURE CITED

Gates, R. J., R. J. Kawula, D. C. Ryan, and P. J. Bergmann. 1994. Wood duck population and habitat investigations. Ann. Perf. Rep. Ill. Fed. Aid Proj. W-121-R-2. 44 pp.

Table 1. Number of patches and total areas of habitats identified on Union County Conservation Area.

		Total Area	
Habitat type	No. patches	ha	%
Open water	19	307	9.5
Riverine (ditch)	7	23	0.7
Forested			
Upland forest	817	736	22.9
Live flooded forest	222	393	12.2
Dead flooded forest	6	63	2.0
Shrub-scrub	60	276	8.6
Stratum total	1,105	1,468	45.7
Non-forested upland			
Cropland	88	1095	34.0
Grass	384	129	4.0
Stratum total	472	1,224	38.0
Emergent wetland			
Artificially flooded	5	10	0.3
Flooded cropland	205	92	2.9
Seasonally flooded	43	39	1.2
Stratum total	253	141	4.4
Other			
Developed	14	6	0.2
Road	185	49	1.5

Table 1. Continued.

Habitat type	No. patches	Total Area ha	%
Stratum total	199	55	1.7
Total area	2,055	3,218	100.0

Job 1.2: **<u>Population Monitoring and Indices of Productivity and Abundance</u>**

<u>Objectives</u>: To (1) provide estimates and/or indices of wood duck abundance and productivity in a representative area of southern Illinois; (2) test and evaluate the suitability of different field survey/census techniques to provide estimates or indices of abundance and productivity of wood ducks during breeding and post-breeding seasons in southern Illinois.

INTRODUCTION

Annual population trends and indices of breeding productivity are difficult to obtain for wood ducks because the species breeds over a large geographic range and in a wide variety of habitat types. Conventional census techniques that have been successful in local areas are logistically difficult and/or time-consuming because of the secretive nature of wood ducks, and the relative inaccessibility and/or limited visibility of habitats the species occupies. Consequently, no single census technique has yet been developed that would provide reliable indices of abundance and breeding productivity if implemented at regional or migratory flyway-wide geographic scales.

Population and harvest management is hindered by lack of a suitable technique to consistently monitor breeding population trends across the geographic range of breeding wood ducks. Hunter harvest and age ratios are monitored from questionnaires and parts surveys conducted annually by the FWS Waterfowl Harvest Survey (U.S. Fish and Wildlife Service 1982). Annual survival is also monitored from band recovery analyses (Trost 1990). North American breeding bird survey (BBS) data indicated stable or increasing breeding population trends during 1966-1978 (Sauer and Droege 1990). However, the BBS was designed for other avian species and does not specifically survey wood duck habitats. Sauer and Droege (1990) considered the BBS to be an inefficient method for monitoring wood duck populations, but suggested that a road-side survey designed specifically for wood ducks might produce valid results.

One component of the wood duck population initiative is to implement and evaluate roadside surveys as for monitoring breeding population trends. Line transect and plot censuses are also being attempted in different regions of the eastern U.S. One objective of the wood duck population initiative is to relate breeding population indices derived from different census techniques to nesting productivity as determined from nest box surveys throughout the Atlantic and

Mississippi Flyways. However, there is reason to suspect that productivity from nest boxes is not representative of natural cavities (Semel et al. 1990, Semel and Sherman 1993) where most wood ducks are produced (Soulliere 1990).

The primary objective of Job 1.2 was to provide indices of breeding population densities and breeding productivity of wood ducks nesting in natural cavities at LaRue Swamp RNA, Oakwood Bottoms GTR, and Union County CA. We defined breeding productivity as the product of breeding population size, hen survival during the breeding season, nesting effort, clutch size, nest success, and subsequent survival of hatched ducklings. These parameters are addressed in some manner under Job 1.2.

We also implemented road-side surveys to monitoring breeding population trends. Limited resources prevented direct validation of road-side surveys. Without an independent census method to validate call-counts, we compared breeding population density indices among years, weeks, and locations to determine whether surveys were sensitive to temporal and geographic variation in habitat conditions, and nesting performance.

METHODS

Road-side Surveys

Survey routes and census stations were established during spring 1994 (Gates et al. 1994). Routes were established $\geq$0.8 km apart on lightly traveled secondary roads. Call-count routes were not selected randomly; only the most suitable breeding habitats available to wood ducks and accessible by road, were surveyed at each location. The same routes and listening stations established at Oakwood Bottoms GTR, LaRue Swamp RNA and Union County CA during spring 1994 (Gates et al. 1994) were reused in 1995. However, 12 stations were added to the LaRue Swamp route, and 1 station was added to the Oakwood Bottoms route to provide 20 listening stations per route in 1995. Each area was surveyed weekly starting on 2 March and ending on 23 April 1995 (8 censuses/area); surveys were conducted from 3 March - 17 April (7 censuses/area) in 1994. Surveys started 30 minutes before sunrise and ended when all stations were completed 1.5 to 2 hours later. We separately recorded 1) numbers of hens heard calling, 2) number of birds seen or flushed, 3) distances that ducks were detected from the listening station, and 4) number of birds seen flying overhead during a 3-minute listening period. The surrounding area was then searched to record additional birds not detected during the 3-minute listening period. Two observers simultaneously searched 2 50 x 100 m plots, each located on one side of the road adjacent to listening stations in

1994. This procedure was modified during 1995; 2 observers simultaneously walked 50 m perpendicular to the road from each listening station to search the surrounding area. All birds seen were recorded as pairs, singles (by sex), and mixed flock (unknown sex composition of flocks >2 birds). Water depth was measured and percent inundation was visually estimated within a 100 x 100 m area surrounding each listening station.

We used total numbers of birds detected (seen and heard) per station and total number heard calling per station as indices of breeding population density. One-way analysis of variance (ANOVA) was used to test differences in birds detected and heard calling among areas within weeks, among weeks, and between years within each area. We also compared proportions of wood ducks detected by sight vs. calls among and within locations, weeks, and years. Tukey's procedure was used to control Type I experiment-wise error rates in pairwise comparisons among levels of significant main effects. Statistical tests were conducted using the Statistical Analysis System (SAS Institute 1989) and were considered significant at $\underline{P} < 0.05$.

Radio-Telemetry

Wood ducks were captured with floating bait traps, swim-in traps, rocket nets, and by night-lighting during 20 March - 12 May 1995. Captured hens were weighed, aged by examining greater wing coverts (Carney 1992), and breeding condition was determined by cloacal examination. Adult and juvenile hens were fitted with 7.5-9 g necklace type radio-transmitters that were mounted on Herculite fabric bibs. Birds also were marked with No. 5 FWS aluminum leg bands.

Radio-marked hens were tracked throughout the breeding season, or until transmitters expired. Most birds were located at least 5 times/week by triangulation or homing to strongest signal (Mech 1983) with hand-held yagi antennas. Aerial searches were conducted when contact with radio-marked birds was lost. Birds not found after repeated aerial or ground searches were assumed to have emigrated from the study area or to have transmitters that failed. Visual contact was re-established when hens remained in the same location for >4 days. These birds were then flushed, tracked to nest trees, or their radios were recovered. Cause of death was determined by inspecting carcass remains, radio condition, and other field signs present at recovery sites. The tight fit of radio packages under breast and back feathers made it highly unlikely that radios were lost during the tracking period. Therefore, radios recovered without carcasses were assumed to indicate death of the hen.

Survival and Productivity

Kaplan-Meier (Pollock et al. 1989) and Mayfield Procedures (Mayfield 1961, 1975) were used to estimate weekly survival probabilities of radio-marked hens during the breeding season. The Kaplan-Meier estimate was considered superior because it allowed staggered entry of marked animals and censuring of birds with unknown fates. However, we calculated Mayfield estimates to compare survival rates with other studies.

Nest trees were climbed and clutch sizes were recorded as soon as possible after radio-marked hens were known to begin incubation. Nest attendance was monitored every 1-2 days until termination of nesting; trees were climbed shortly thereafter to determine nest fate, number of eggs hatched, or cause of nest failure. Nest trees identified and marked by following radio- marked hens during 1993-94 also were climbed to determine occupancy in 1995 and to provide data from additional nests on clutch size and nest success. Mean incubated clutch sizes and numbers of eggs hatching were compared between nests located in upland and bottomland habitats, and between parasitized ($\geq$15 eggs) and unparasitized nests. Sample sizes varied by comparison (Table 2) because different hens or nests provided varying amounts or types of data. Each radio-marked hen or nest was given a code corresponding to the type and quantity of information provided. Radio-marked hens that were not known to nest were assigned code 0. Data codes 1-6 were assigned to radio-marked hens that nested and codes 7-9 were assigned to nests found by re-inspecting cavities with active nests in previous years. Nests found in separate cavities while inspecting other nest cavities located in the same tree were given codes 10-11, while nests discovered accidentally in separate trees were assigned codes 12-13. Censuring of data points to ensure that statistical assumptions of independence and random sampling were met, as well as incomplete data recorded for some nesting attempts, necessitated individual codes within each of the categories described above.

Brood Surveys

Wood duck brood sizes were recorded from incidental sightings of broods concurrent with other field activities, and opportunistically counting broods of radio-marked hens. Minimum brood size, duckling age-class (Gollop and Marshall 1954), and habitats in which broods were observed were recorded.

The duration of each plumage class was estimated from feather growth rates and chronology of plumage development in juvenile wood ducks (Gates et al. 1994). Brood ages were estimated as the mid-points of duckling ages at the beginning and end of each plumage subclass to minimize over- or underestimating hatch dates. A hatching curve was developed by back-dating from estimated ages of broods observed in the field. Timing of arrival after spring migration, nest initiation, and onset of incubation was estimated by backdating brood hatching dates 30 days for incubation, 12 days for egg-laying, and 14 days from arrival to nest initiation (Bellrose 1980). Mean brood sizes were compared between age classes I and II/III in 1995, and within age classes I and II among years 1993-95 with one-way ANOVA.

RESULTS

Breeding Chronology

Nesting season (first laying to last hatch) lasted 132 days, 26 February - 9 July 1995. Nests were initiated during 12 March - 11 June 1995, with peak nest initiation during the week of 16 April. Hatching occurred 9 April - 9 June and peaked during 14-28 May when 42 of 70 (60%) broods were hatched (Fig. 2). The 1995 nesting season lasted 41 more days than the 91 day nesting seasons (13 March - 12 June) in 1993 and 1994. Nests were initiated 2 weeks earlier and 4 weeks later, than we observed in preceding years; however, peak of hatching occurred during the same week (15 May) each year.

Road-side Surveys

Road-side surveys began during the middle of migration before any nests were initiated, based on backdating from hatching chronology (Fig. 2). Surveys were terminated on 23 April when 68% of hens were incubating. We recorded 1,534 detections of wood ducks on all 3 areas; 35% were flushed, 14% were seen but not flushed, 39% were flying overhead, and 12% were detected from calls only. The correlation between number of ducks heard calling with number seen was higher ($\underline{r}^2 = 0.75$, $\underline{P} = 0.001$) in 1994 than in 1995 ($\underline{r}^2 = 0.45$, $\underline{P} = 0.026$).

LaRue Swamp RNA.--Densities differed among weeks ($F_{7,174} = 2.51$, $\underline{P} = 0.017$). The greatest density of wood ducks was detected during the week of 5 March 1995 at LaRue Swamp RNA (Fig. 3). Numbers detected per station declined 63% ($\underline{P} < 0.05$) 3 weeks later. Low densities were again detected after 2 April; densities detected during the weeks of 12 March and 2 April were intermediate between the highest and lowest densities observed at LaRue Swamp RNA. Numbers of birds heard calling declined 72% ($\underline{P} < 0.05$) between the weeks of 5 March and 2 April, and were lowest when the survey was terminated after 23 April. Density indices declined concurrently with onset of nesting and generally increasing depth and coverage of surface water around listening stations throughout the survey period (Fig. 4).

Oakwood Bottoms GTR.--Numbers of ducks detected, and to a lesser extent numbers heard calling per station, fluctuated with weekly changes in surface water depth and coverage surrounding listening stations (Fig. 4). Densities of wood ducks detected at Oakwood Bottoms GTR differed among weeks ($F_{7,183} = 2.46$, $\underline{P} = 0.02$) and were highest ($\underline{P} < 0.05$) during the week of 19 March, and lowest during the week of 23 April when surveys were terminated. Densities were intermediate during other weeks of the survey. Numbers of wood ducks heard calling/station were stable through the week of 9 April, then declined by 91% ($\underline{P} < 0.05$) by the week of 23 April when surveys were terminated. Numbers of birds detected and heard calling declined sharply after the week of 9 April as the greentree reservoir was de-watered.

Union County CA.--Although weekly densities of wood ducks detected at Union County CA varied up to 62%, we detected no differences among weeks ($F_{7,166} = 0.63$, $\underline{P} = 0.733$). Numbers of wood ducks heard calling per station varied over a relatively narrow range (0.3-0.6 birds/plot) and also did not differ among weeks ($\underline{P} = 0.804$). Water depths remained relatively stable throughout the survey period, although surface water coverage declined (Fig. 4).

Differences Among Areas.--Combining weeks, we found no differences ($F_{2,544} = 0.85$, $\underline{P} = 0.428$) in densities of wood ducks detected among LaRue Swamp RNA (0.12/station), Oakwood Bottoms GTR (0.15/station) or Union County CA

(0.15/station). Similarly, there were no differences ($F_{2,544}$ = 2.31, P = 0.100) in densities of wood ducks heard calling among LaRue Swamp RNA (0.03/station), Oakwood Bottoms GTR (0.03/station) or Union County CA (0.02/station). There also was little difference in numbers of wood ducks detected/station ($F_{2,68} \leq 0.45$, $P \geq 0.063$) among areas within weeks. Only during the week of 9 April did the number of wood ducks heard calling/station differ among areas ($F_{2,70}$ = 3.25, P = 0.045), when more birds were heard calling/station at Oakwood Bottoms GTR than at LaRue Swamp RNA.

Annual Differences.--Combining areas and weeks, lower densities of wood ducks were detected ($F_{1,43}$ = 13.39, P < 0.001) and heard ($F_{1,43}$ = 9.27, P = 0.004) in 1995 than in 1994 (Fig. 5). Fewer wood ducks were detected ($F_{1,13}$ = 10.25, P = 0.007) and heard ($F_{1,13}$ = 5.78, P = 0.032) per station during 1995 than in 1994 at Oakwood Bottoms GTR. Lower densities of wood ducks were detected per station at LaRue Swamp RNA in 1994 than in 1995 ($F_{1,13}$ = 4.79, P = 0.048), but densities heard calling did not differ between years ($F_{1,13}$ = 2.65, P = 0.128). There were no differences between years in numbers of wood ducks detected or heard per station at Union County CA (P > 0.05).

Flock composition also differed between 1994 and 1995. Pairs comprised 41% of all detections in 1994, compared to only 31% pairs observed in 1995. More males were detected in 1995; 17% of single birds detected were male in 1994, while 34% of single birds were males in 1995.

Nesting Effort

Fifty-two wood duck hens were captured and marked with radio transmitters at Union County CA (41) and Oakwood Bottoms/LaRue Swamp (11) during spring 1995 (Table 3). Forty-one hens (79%) were adults, 11 were juveniles. Seventeen hens were previously banded at Union County CA, 4 were hens that we radio-marked during spring 1994, 13 were hens previously banded by IDNR personnel. Mean body mass of adults was 631 g (SE = 12); juveniles averaged 604 g (SE = 28). Hens captured at Oakwood Bottoms/LaRue Swamp (695 $\pm$ 17 g) were heavier (P < 0.001) than at Union County CA (615 $\pm$ 7 g).

We documented nesting by 24 (46%) of 52 radio-marked hens in spring 1995 (Table 4). As in 1994, Union County CA had the largest proportion of radio-marked hens that nested. Similar proportions of birds remained at both areas without nesting each year. Consequently, higher nesting effort observed in 1995 was attributable to lower proportions of hens that died or had radio transmitters that malfunctioned during the tracking period. Oakwood Bottoms/LaRue Swamp had more than twice the proportion of radio-marked hens that apparently emigrated from the study area than Union County CA each year. Combining data from 1994 and 1995, hens that apparently emigrated from the study area <30 days after capture weighed more (691 $\pm$ 21 g; *P* = 0.01) than birds that nested (614 $\pm$ 12 g) or stayed on the area without nesting (624 $\pm$ 12 g). Birds that apparently emigrated from the study area <30 days after capture also were captured earlier (*P* $\leq$ 0.001) than birds that remained on the study area ($\bar{x}$ = 29 March vs. $\bar{x}$ = 13 April, respectively).

Hen Survival

Six of 52 (12%) radio-marked hens died during the tracking period. Five of 41 (12%) radio-marked hens from Union County CA died, while 1 of 11 hens from Oakwood Bottoms GTR and Larue Swamp RNA died. Predation was the suspected cause of death in each case, although some transmitters were recovered without carcasses. One hen was laying when killed, 1 was incubating, and another was apparently attempting to renest. Three hens died that were never known to nest. These hens could have been laying, but were never located at nest sites. The Kaplan-Meier survival function, estimated that survival rate during the period 24 March - 30 July was 81% ($s^2 = 0.005$) (Fig. 6). The Mayfield survival rate estimate for an equivalent time period was 75% ($s^2 = 0.012$). The Kaplan-Meier survival rate estimate in 1995 was higher than the 55% ($s^2 = 0.009$) estimate in 1994 ($t = 40.2$, $P < 0.001$).

Nesting productivity

Twenty four new nests were located in 1995, 21 at Union County CA, and 3 at LaRue Swamp RNA. Incubated clutch sizes were determined for 14 of these nests; 9 nest cavities were too deep for inspection and 1 hen was killed on the nest before she completed egg-laying. Two nest trees, 1 located in bottomland forest and 1 in upland forest, had 2 hens nesting in one tree. Ten nest cavities used by radio-marked hens in 1993 and 1994 were again inspected in 1995. Three of these cavities had active wood duck nests, 3 were occupied by squirrels, and 4 were unoccupied. One nest was used by a radio-marked hen that was captured in 1995. In 1995, mean incubated clutch size of all nests was 12.2 eggs (SE = 0.8, $n = 16$) and mean incubated clutch size of successful nests was 12.8 eggs (SE = 1.2, n=10). A smaller proportion of parasitized nests was found in 1995 (3 of 17) than in 1994 (3 of 7).

Fourteen of 22 nests (64%) with known fates were successful in 1995; 3 nests were abandoned, 1 hen was killed on nest by a predator before her clutch was completed, and 4 nests were predated. Black rat snakes (*Elaphe obsoleta obsoleta*) destroyed 3 of 5 predated nests; the predator was not identified for the other 2 nests. Egg success was 83.0% (SE = 0.07, n=10) for successful nests. Parasitized nests hatched a mean of 10.3 ducklings/nest (SE = 2.73, n=3), while normal nests hatched a mean of 10.0 ducklings/nest (SE = 0.62, n=7), for an overall mean of 10.1 (SE = 0.82, $n = 10$) eggs hatched per successful nest.

Brood Sizes

We observed 70 broods during 15 April - 24 July 1995. Broods were observed in 9 habitats; 49 (70%) in flooded crop fields and open water, 2 (3%) in shrub-scrub wetlands, 7 (10%) on the Big Muddy River, 2 (3%) each in emergent wetlands, ditches, and submerged aquatic beds, and 6 (9%) in flooded forest. This distribution of brood observations reflected differences in visibility among habitats, rather than habitat preference.

Sample sizes were too small to compare brood sizes among all 3 age classes, so classes II and III were combined. Class I broods averaged 7.0 (SE = 0.5) ducklings/brood, while class II/III broods averaged 5.9 (SE = 0.5) ducklings/brood (Table 5). Class I broods averaged 9.0 (SE = 0.5) ducklings in 1993 and 6.4 (SE = 0.6) ducklings in 1994. Class II broods averaged 8.6 (SE = 1.1) in 1993 and 6.4 (SE = 0.7) in 1994. Class I brood sizes in 1994 and 1995 were lower than in 1993 ($\underline{F}_{2,113} = 5.21$, $\underline{P} = 0.007$) broods, and class II/III brood sizes were lower in 1995 than in 1993 ($\underline{F}_{2,49} = 3.72$, $\underline{P} = 0.032$).

DISCUSSION

Breeding Productivity

Spring 1995 was a more prolonged nesting season, with higher survival and greater nesting effort by radio-marked hens compared to 1994. Our Mayfield hen survival estimate (0.75) was in the high portion of the range (56-78%) estimated by Robb and Bookhout (1990) for hen wood ducks in southcentral Indiana during 29 March - 19 May 1984-1985. The same proportions (15%) of radio-marked hens apparently emigrated from the study area without nesting in 1994 and 1995. More hens remained on the area at Union County CA than at Oakwood Bottoms/Larue Swamp in 1994 and 1995. This could be due to a predominance of migrant and/or non-nesting wood ducks at Oakwood Bottoms GTR, and more early captures of hens by night-lighting at Oakwood Bottoms GTR. A slightly smaller proportion of radio-marked hens remained on the study area without nesting in 1995 (35%) than in 1994 (41%). This, combined with higher survival resulted in a greater proportion radio-marked hens that nested in 1995 (46%) than in 1994 (22%).

There is lack of published information on proportions of wood duck hens that attempt to nest each year. Raw proportions of radio-marked hens that nested in 1994 and 1995 undoubtedly underestimated actual breeding effort. Eliminating hens with failed radios, and hens that died or apparently emigrated from the study area without nesting, breeding effort by radio-marked hens was 35% in 1994 and 57% in 1995. These estimates did not account for hens that may have parasitized nests of other hens. A few hens were tracked to possible nest trees, or were located in upland forest, but their movements were not localized on a single site, and were never known to incubate a clutch. Data collected to date indicated a relatively high rate of nest parasitism on our study area; 6 of 24 nests (25%) inspected in 1994 and 1995 were parasitized. In comparison, Bellrose and Holm (1994) reported that only 6 of 91 (6.6%) natural cavity nests were parasitized during 1938-1959 in Macon County, IL.

Combined nest success during 1993-1995 was 66% (n = 38), well above the 40% (n = 512) success rate found in natural cavities by Bellrose and Holm (1994). Five (13%) nests were destroyed by predators (including 2 nests in which hens were also killed) and 7 (18%) were abandoned before hatching. Nests success was somewhat lower in bottomland (60%) than in upland nests (69.6%). Egg success in hatched nests declined slightly in 1995 (79%) compared to 1994 (85%) despite a lower proportion of parasitized nests. Bellrose and Holm (1994) reported that 93.6% of 28,714 eggs hatched from successful nests with normal and parasitized clutches.

Despite long brood movements over routes that were generally devoid of suitable habitat (see Job 1.3), brood survival appeared to be relatively high. With a mean of 10.3 ducklings leaving successful nests, class I brood sizes declined to 7.0 ducklings/brood. Additional losses occurred between class I and class II/III (5.9 ducklings/brood). Changes in brood size with age likely overestimated actual juvenile survival because losses of entire broods were not accounted for. However, repeated observations of 14 radio-marked brood hens during 1994 and 1995 detected only 1 hen that lost an entire brood before fledging. Slightly larger mean brood sizes were observed in 1995 compared to 1994, although a similar mean number of ducklings (10.9/nest) hatched from successful nests in 1994. Brood sizes compared favorably with that reported elsewhere. McGilvery (1969) found class I broods averaged 7.5 ducklings and class II broods averaged 5.5 ducklings in Maryland. Bellrose (1980) reported that class I broods averaged 6.9 ducklings while class II broods averaged 5.4 ducklings.

Road-side Surveys

Preliminary data analyses suggested that road-side surveys were sensitive to temporal and geographic changes in breeding population densities and nesting chronology. Weekly changes in breeding population density along survey routes were the result of migrants arriving or leaving the study area, changing water levels, and proportions of hens incubating. Call-counts tended to decline when water levels fell and more hens were incubating. Although relatively small proportions of hens adjacent to listening stations were detected by calls, numbers of birds detected by sight were loosely correlated with numbers detected by calls alone. The correlation was lower in 1995 than in 1994, possibly because more hens were incubating in 1995 than in 1994. Ice cover during early weeks of the survey may also have concentrated birds, resulting in more birds to be heard calling than were seen.

The timing of roadside surveys is important to their utility in providing breeding population indices. The largest numbers of wood ducks were generally detected during mid-March through mid-April, corresponding to the peak period of nest initiation in southern Illinois. Current FWS guidelines specify that roadside surveys should be conducted during 15 May - 5 June to coincide with timing of the North American Breeding Bird Survey. Although these dates may be appropriate for more northerly areas, surveys conducted after mid-May would occur after peak of hatching in southern Illinois. Hens with broods are most secretive, and unsuccessful breeders often have departed from nesting areas on molt migrations at this time (Bellrose 1980, Bellrose and Holm 1994). Consequently, roadside surveys conducted after mid-May at latitudes south of and including southern Illinois would not necessarily reflect annual variation in the size of breeding populations or nesting effort. Nesting chronology differs by up to 10 weeks (3 February - 15 April) between northern and southern portions of wood duck breeding range. Timing of roadside surveys should vary with latitude so that comparable indices of population trends are obtained across the entire breeding range. Preliminary analyses of our data indicate that surveys conducted just before or during the peak of nest initiation would be most effective.

LITERATURE CITED

Bellrose, F. C. 1980. Ducks, geese, and swans of North America. Third ed. Stackpole Books, Harrisburg, PA. 540pp.

_____, and D. J. Holm. 1994. Ecology and management of the wood duck. Stackpole Books, Mechanicsburg, PA. 588pp.

Carney, S. M. 1992. Species, age and sex identification of ducks using wing plumage. U.S. Dep. of Inter., Fish and Wildl. Serv. Washington, D.C. 144 pp.

Gates, R. J., R. J. Kawula, D. C. Ryan, and P. J. Bergmann. 1994. Wood duck population and habitat investigations. Ann. Perf. Rep. Ill. Fed. Aid Proj. W-121-R-2. 44 pp.

Gollop, J. B., and W. H. Marshall. 1954. A guide for aging duck broods in the field. Mississippi Flyway Council Tech. Sect. 14pp.

Mayfield, H. F. 1961. Nesting success calculated from exposure. Wilson Bull. 73:255-261.

_____. 1975. Suggestions for calculating nest success. Wilson Bull. 87:456-466.

McGilvery, F. B. 1969. Survival in wood duck broods. J. Wildl. Manage. 33:73-76.

Mech, L. D. 1983. Handbook of animal radio-tracking. Univ. Minnesota Press, Minneapolis. 107pp.

Pollock, K. H., S. R. Winterstein, C. M. Bunck, and P. D. Curtis. 1989. Survival analysis in telemetry studies: the staggered entry design. J. Wildl. Manage. 53:7-15.

Robb, J. R., and T. A. Bookhout. 1990. Female and juvenile wood duck survival and movements in Indiana. Pages 179-184 in L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, eds. Proc. 1988 North Am. Wood Duck Symp., St. Louis, MO.

SAS Institute Inc. 1989. SAS/STAT user's guide, Version 6, Fourth Edition, Volume 2. Cary, NC. 846pp.

Sauer, J. R., and S. Droege. 1990. Wood duck population trends from the North American Breeding Bird Survey. Pages 225-231 in L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, eds. Proc. 1988 North Am. Wood Duck Symp., St. Louis, MO.

Semel, B., P. W. Sherman, and S. M. Byers. 1990. Nest boxes and brood parasitism in wood ducks: a management dilemma. Pages 163-170 in L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, eds. Proc. 1988 North Am. Wood Duck Symp., St. Louis, MO.

_____, and _____. 1993. Answering basic questions to address management needs: case studies of wood duck nest box programs. Trans. N. Am. Wildl. Natur. Resour. Conf. 58:537-550.

Soulliere, G. J. 1990. Regional and site-specific trends in wood duck use of nest boxes. Pages 235-244 in L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, eds. Proc. 1988 North Am. Wood Duck Symp., St. Louis, MO.

Trost, R. E. 1990. The relationship between harvest and survival rates of wood ducks in eastern North America. Pages 367-370 in L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, eds. Proc. 1988 North Am. Wood Duck Symp., St. Louis, MO.

U.S. Fish and Wildlife Service. 1982. Waterfowl status report, 1979. Washington, Spec. Sci. Rep.-Wildl. No. 246.

Table 2. Determination of sample sizes for statistical comparisons of nest site characteristics and nesting productivity of wood ducks in southern Illinois during springs 1993 - 1995.

	Nest site characteristics			Nest Fate			
Data Code	Habitat	Distance	Tree/ Cavity	Clutch Size	Nest Success	Egg Success	No. Hens or Nests
0	0	0	0	0	0	0	50
1	1	1	1	1	1	1	19
2	1	1	1	1	0	0	0
3	1	1	1	0	1	0	13
4	1	1	1	0	0	0	5
5	1	0	0	0	1	0	1
6	1	0	0	0	0	0	0
7	0	0	0	1	1	1	3
8	0	0	0	0	1	0	0
9	0	0	0	0	0	0	9
10	0	0	0	1	1	1	1

Table 2. Continued.

Data Code	Nest site characteristics: Habitat	Distance	Cavity	Tree/ Clutch Size	Nest Fate: Nest Success	Egg Success	No. Hens or Nests
11	0	0	0	0	0	0	1
12	0	0	1	1	1	1	0
13	0	0	1	0	0	0	0
n	38	37	37	23	36	23	102

Table 3. Wood duck hens captured and radio-marked at Union County Conservation Area (UCCA), LaRue Swamp, and Oakwood Bottoms Greentree Reservoir (OBGTR) during spring 1994.

Hen no.	Capture location	Capture date	Age class	Body mass (g)	USFWS band no.
148-053	OBGTR	20 March	Adult	690	775-27052[a]
148-593	OBGTR	23 March	Adult	810	775-27054[a]
148-143	OBGTR	23 March	Juv.	830	775-27055[a]
148-263	OBGTR	23 March	Juv.	650	775-27056[a]
148-473	OBGTR	23 March	Adult	760	775-27053[a]
148-622	UCCA	25 March	Adult	740	775-27057[a]
148-681	OBGTR	27 March	Adult	860	775-27074
148-113	OBGTR	27 March	Juv.	640	775-27075
148-443	UCCA	29 March	Adult	530	775-27058[a]
148-322	UCCA	30 March	Adult	670	775-27060
148-712	UCCA	30 March	Adult	630	775-27059
148-413	LaRue	1 April	Adult	700	775-27061
148-651	UCCA	2 April	Adult	750	775-27062
148-352	UCCA	2 April	Adult	735	775-27063
148-562	LaRue	3 April	Juv.	690	775-27076
148-172	UCCA	4 April	Adult	550	775-27064
148-202	UCCA	4 April	Adult	570	775-27065[a]
148-232	UCCA	5 April	Adult	700	775-27066
148-531	UCCA	6 April	Juv.	575	775-27067[a]
148-742	UCCA	6 April	Adult	660	775-27068[a]

Table 3. Continued.

Hen no.	Capture location	Capture date	Age class	Body mass (g)	USFWS band no.
148-022	UCCA	6 April	Adult	590	775-27069[a]
149-033	UCCA	6 April	Adult	560	775-27070[a]
149-263	UCCA	6 April	Juv.	510	775-27071
149-161	UCCA	6 April	Adult	630	775-27072
149-203	UCCA	6 April	Juv.	560	775-27073
148-262	UCCA	7 April	Juv.	570	775-27077
149-011	UCCA	8 April	Adult	660	775-27078
149-103	LaRue	8 April	Adult	620	775-27079
149-221	UCCA	12 April	Adult	575	775-27080
149-023	UCCA	12 April	Adult	560	775-27081[a]
149-143	UCCA	13 April	Adult	600	775-27090
149-054	UCCA	13 April	Adult	620	775-27091
149-084	UCCA	13 April	Adult	650	775-27092[a]
149-191	UCCA	13 April	Adult	595	775-27093[a]
149-272	UCCA	19 April	Adult	550	775-27094[a]
149-174	UCCA	20 April	Adult	660	775-27095
149-232	UCCA	23 April	Adult	570	775-27096[a]
149-063	UCCA	25 April	Adult	715	775-27097[a]
149-042	UCCA	25 April	Juv.	535	775-27098
149-153	UCCA	25 April	Adult	560	775-27099[a]
149-281	UCCA	25 April	Adult	580	775-27100

Table 3. Continued.

	Capture	Capture	Age	Body mass	USFWS

Hen no.	location	date	class	(g)	band no.
149-183	UCCA	25 April	Adult	590	775-27082
149-213	UCCA	25 April	Adult	540	775-27083[a]
149-094	UCCA	25 April	Adult	570	775-27084[a]
149-004	UCCA	1 May	Adult	560	915-50430[a]
149-131	UCCA	1 May	Adult	585	775-27088
149-113	UCCA	1 May	Adult	620	775-27087
149-123	UCCA	1 May	Adult	555	775-27086
149-242	UCCA	1 May	Juv.	515	775-27085
149-252	UCCA	1 May	Juv.	570	775-27089
149-072	UCCA	2 May	Adult	610	NONE
148-982	UCCA	12 May	Adult	580	775-27401

[a] Previously banded by Coop. Wildl. Res. Lab or Ill. Dept.

Nat. Resour. personnel.

Table 4. Fates of radio-marked wood duck hens at Union County CA and Oakwood Bottoms GTR/LaRue Swamp RNA in 1994 and 1995.

	Union County CA				Oakwood/LaRue				Total			
	1994		1995		1994		1995		1994		1995	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Nested	7	24	21	51	2	17	3	27	9	22	24	46
Resident, non-nesting	12	42	14	34	5	42	4	36	17	41	18	35
Migrant/transient	3	10	5	12	3	24	3	27	6	15	8	15
Died	5	17	1	3	2	17	1	10	7	17	2	4
Radio failed	2	7	0	0	0	0	0	0	2	5	0	0
Total	29	100	41	100	12	100	11	100	41	100	52	100

Table 5. Mean brood size comparisons by age class (Gollop and Marshall 1954) for wood duck broods observed at Union County CA, Oakwood Bottoms, and LaRue Swamp springs 1993, 1994 and 1995.

	1993		1994		1995	
Age Class	x (SE)	n	x (SE)	n	x (SE)	n
IA	8.6 (3.6)	14	6.8 (0.9)	20	6.6 (1.0)	13
IB	9.9 (1.0)	11	5.5 (0.9)	11	6.7 (0.7)	24
IC	8.0 (1.0)	3	6.9 (1.0)	10	8.5 (1.1)	10
IIA	7.8 (1.7)	6	5.3 (1.0)	7	6.0 (0.9)	7
IIB	7.5 (0.5)	2	7.3 (1.9)	4	6.3 (0.8)	6
IIC	11.0 (2.0)	3	7.0 (0.9)	7	5.7 (2.9)	3
III	- -	0	- -	0	5.6 (0.5)	7

Job 1.3: **Seasonal Movements and Habitat Use**

Objectives: To (1) document seasonal changes in local distribution and habitat use patterns of breeding and post-breeding wood ducks in southern Illinois; (2) investigate movements, habitat selection, and habitat relationships of adult female wood ducks during breeding and post-breeding in southern Illinois.

INTRODUCTION

The nutritional requirements of breeding female wood ducks are generally well understood (Drobney 1990), but habitat selection during prenesting and nesting seasons has not been intensively studied (Fredrickson and Graber 1990). Most information on wood duck movements and habitat use patterns was obtained after nesting; little information is available during prenesting and nesting periods. Habitat conditions during these periods are critical to reproductive success, and ultimately recruitment. Data from this job will be integrated with data on habitat characteristics from Job 1.1 to investigate habitat selection by prenesting, nesting, and post-breeding hen wood ducks. Identification of frequently used habitats and movements between these habitats is needed to identify habitat factors that limit reproductive success.

METHODS

Seasonal Movements

Radio-marked hens were located at Union County CA every 1-2 days after waiting 2 days for birds to adjust to transmitters after capture. Hens were located continually from 0.5 hour before sunrise until mid-morning or from mid-afternoon until 0.5 hour after sunset once per week. Hens radio-marked at Oakwood Bottoms GTR and LaRue Swamp RNA were located once every 1-2 days, 5 days/week. Hens were located with hand-held receivers by homing to maximum signal strength (Mech 1983). Triangulation was used to locate individuals in inaccessible areas. Hen locations were plotted on 7.5 min quadrangle maps in the field. Coordinates for each location were determined by transferring points from field maps to scanned and georeferenced color infrared and black and white aerial photography produced under Job 1.1. Distances from nests to the nearest water and capture sites were determined using a geographical information system (MIPS).

Habitat Use

General habitat types within which radio-marked hens were located were recorded in the field. More precise analyses of habitat selection will be conducted after locations of radio-marked hens are plotted on digitized habitat maps. Nest site characteristics including habitat (upland vs. bottomland forest), distance to capture site, and distance to nearest water were recorded. Nest trees located within the Mississippi River floodplain were classified as bottomland nests, while nests located above the floodplain in the Shawnee and Ozark Hills were considered upland nests. Nest tree characteristics including species, diameter at breast height (dbh), cavity diameter at nest entrance, entrance size, cavity depth, cavity height, number of openings to nest, number of cavities suitable for nesting, slope, and aspect were measured. Nest site characteristics were compared between upland and bottomland habitats using one-way ANOVA.

RESULTS

Seasonal Movements

Hens radio-marked at Oakwood Bottoms GTR and LaRue Swamp RNA ($\underline{n}$ = 11) were located from 26 March - 30 June (Fig. 7). Hens radio-marked at Union County CA were located 1,402 times during 15 March - 30 June (Fig. 8). Movement data were acquired for 26 hens before peak of nest initiation, for 44 hens between peaks of nest initiation and hatching, and for

37 hens after peak of hatching. Radio-locations for 15 of these hens spanned all 3 periods. Location coordinates of radio-marked hens are currently being plotted at each location using habitat maps created under Job 1.1.

Twenty-three nest locations were identified by following radio-marked hens. Upland forest nest sites (n = 20) were located 1,497 m (SE = 223) from nearest water and 3,719 m (SE = 514) from capture locations of radio-marked hens. Bottomland forest nest sites (n = 3) were located 6.7 m (SE = 2.9) from nearest water and 1,291 m (SE = 866) from capture sites of individual hens. Home ranges and daily movements of individual hens will be presented in future project reports.

Habitat Use

Radio-marked hens were located most frequently in flooded forest habitats (45.5%), followed by shrub-scrub (33.2%), upland forest (14.4%), riverine (3.5%), open water (2.2%), flooded cropland/grass (0.8%), and flooded dead forest (0.5%). All locations in upland forest were of hens at nest sites.

Nineteen nest trees (79%) were located in upland forest and 5 (21%) were in bottomland forest during 1995. Similar distributions of nests among upland and bottomland forest were observed in 1993 and 1994 (6 of 8 each year). Combining years, 30 of 38 (79%) nests of radio-marked hens were located in upland forest. Tree species differed between upland and bottomland nests. Three bottomland nests were in cottonwoods (Populus deltoides), 3 were in sycamores (Platanus occidentalis), and 1 was in a dead tree. Fourteen upland nests were in beech (Fagus grandifolia), 10 were in oak (Quercus sp.), 2 in hickory (Carya sp.), 1 in a sour gum (Nyssa sylvatica), 1 in a sycamore, and 1 nest was in a dead tree. Nest tree characteristics were similar between uplands and bottomlands (Table 6), except that upland trees had larger cavity entrances ($t = -2.54$, $P = 0.016$), larger cavity entrance diameter ($t = -2.34$, $P = 0.026$) and were located farther from water ($t = -8.16$, $P < 0.001$), and capture sites of nesting hens ($t = -5.29$, $P < 0.001$). There were no differences in nest site characteristics between successful and unsuccessful nests ($|t| \leq 1.26$, $P \geq 0.219$).

DISCUSSION

With data combined from 37 nests located during springs 1993-95, nest cavity openings averaged 5.8 m higher than reported by Soulliere (1990), and 3.1 m higher than reported by Robb and Bookhout (1995) for natural cavity nests. Bottomland nest cavities had smaller entrances than upland nest cavities, possibly due to hens selecting cavities that were more secure from predators in bottomlands (Bellrose and Holm 1994). There was also an emerging trend for bottomland nest cavity openings to be located higher than upland nest openings, although sample sizes were not yet sufficient to prove statistical significance. Although flooded forest was used throughout the breeding season, shrub-scrub habitats were used more frequently during brood rearing. Robb and Bookhout (1990) also found that brood hens used shrub-scrub most frequently. Use of flooded cropland occurred only in early spring before tillage. Bellrose and Holm 1994) also reported use of croplands during winter and migration.

Three hypotheses might be advanced to explain the predominance of nesting by wood duck hens in upland forest habitats on our study areas. First, availability of nesting cavities may have been lower in bottomland than in upland forest. However, if such were true, competition for nest sites should be higher, and there should be greater rates of reoccupancy of nest cavities during successive years in bottomland than in upland forest. Annual re-inspections of known nesting cavities and comparisons of cavity availability between upland and lowland forests will be conducted during Study No. 1 to test this hypothesis. Second, the apparent preference of wood duck hens for upland forest nest sites may be due to higher rates of nest failure in bottomland forest. We obtained some evidence to support this hypothesis during Study No. 1, although the difference in success rates of upland versus bottomland nests was not large (almost 10%). We also propose a third hypothesis that combines elements of the first two. Bottomland nests tended to be located in higher cavities with smaller openings than upland nests. If availability of suitable nest cavities that are sufficiently secure from predators is limited, then it may not be possible for a larger proportion of hens to sustain a tradition of nesting in bottomlands on our study area. There also exists the possibility that higher rates of nest parasitism and nest interference (Semel and Sherman 1993) in bottomlands may cause hens to select upland nest sites. Although nest parasitism rates that we have so far documented were higher than previously reported for natural cavities, they do not seem sufficient to explain the predominance of nesting in upland forests. Location and monitoring of nests initiated by radio-marked hens will continue under Study No. 2. to provide additional data needed to test these hypotheses. Dummy nests placed in apparently suitable nest cavities also will be used to compare nest predation rates among different cavity heights and between upland and bottomland forest.

LITERATURE CITED

Bellrose, F. C., and D. J. Holm. 1994. Ecology and management of the wood duck. Stackpole Books, Mechanicsburg, PA. 588pp.

Drobney, R. D. 1990. Nutritional ecology of breeding wood ducks: a synopsis for wetland management. Pages 77-82 in L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, eds. Proc. 1988 North Am. Wood Duck Symp., St. Louis, MO. 390pp.

Fredrickson, L. H., and D. A. Graber. 1990. Habitat ecology and management. Pages 381-385 in L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, eds. Proc. 1988 North Am. Wood Duck Symp., St. Louis, MO. 390pp.

Mech, L. D. 1983. Handbook of animal radio-tracking. Univ. Minnesota Press, Minneapolis. 107pp.

Robb, J. R., and T. A. Bookhout. 1995. Factors influencing wood duck use of natural cavities. J. Wildl. Manage. 59:372-383.

_____, and _____. 1990. Female and juvenile wood duck survival and movements in Indiana. Pages 179-184 in L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, eds. Proc. 1988 North Am. Wood Duck Symp., St. Louis, MO.

Semel, B., and P. W. Sherman. 1993. Answering basic questions to address management needs: case studies of wood duck nest box programs. Trans. N. Am. Wildl. Natur. Resour. Conf. 58:537-550.

Soulliere, G. J. 1990. Regional and site-specific trends in wood duck use of nest boxes. Pages 235-244 in L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, eds. Proc. 1988 North Am. Wood Duck Symp., St. Louis, MO.

Table 6. Nest site characteristics of 37 wood duck nests located at Union County CA and LaRue Swamp, in 1994-95,

	Upland			Bottomland			Total		
Variable	x	(SE)	n[a]	x	(SE)	n	x	(SE)	n[a]
Tree dbh[b] (cm)	62.9	(3.0)	28	57.3	(8.7)	6	61.9	(2.9)	34
dbh at cavity (cm)	42.8	(1.9)	27	33.4	(4.2)	6	41.1	(1.9)	33
Cavity opening (cm)	123.5	(14.7)	28	83.3	(8.8)	6	116.4	(12.4)	34
Cavity depth (cm)	56.2	(10.6)	28	52.0	(13.5)	6	55.4	(9.0)	34
Cavity height (m)	12.2	(0.5)	28	17.2	(2.1)	6	13.1	(0.7)	34
No. nest openings	1.6	(0.1)	28	1.7	(0.2)	6	1.6	(0.1)	34
No. cavities/tree	2.0	(0.3)	28	2.3	(0.6)	6	2.1	(0.3)	34
Dist. to capture (km)	3.7	(0.3)	30	1.1	(0.3)	6	3.2	(0.3)	36
Dist. to water (km)	1.4	(0.2)	30	0.1	(0.1)	7	1.1	(0.2)	37

[a] Sample sizes varied because some variables were not measured for 1 nest.

Job 1.4. **Analysis and Report**

Objectives: To analyze results from Jobs 1.1, 1.2, and 1.3 and to prepare quarterly, annual, and final reports to funding agencies.

Requirements of this job were accomplished through preparation of quarterly and annual reports and the Study No. 1 final report. Results and conclusions contained herein are considered preliminary and subject to change pending further data collection and analyses. Additional summary and analyses of data collected during project segments 1-3 will be needed to complete jobs under Study No. 2, consequently these results will be reported in future annual reports. Final reporting on segments 1-3 will be accomplished with completion of a M.S. thesis and a Ph.D. dissertation, copies of which will be provided to the Illinois Department of Natural Resources.