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# Translocation success of adult red-cockaded woodpeckers

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# TRANSLOCATION SUCCESS OF ADULT RED-COCKADED WOODPECKERS

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**ABSTRACT**

The red-cockaded woodpecker (*Picoides borealis*; hereafter RCW) is a cooperative breeder endemic to open old-growth pine savannah ecosystems in the southeastern United States (Jackson 1994). The RCW was listed as federally endangered in 1973, after a population decline due to habitat loss. Habitat fragmentation produces isolated populations of RCWs, which in turn ultimately limits the success of the species. RCW biologists and managers counteract effects of fragmentation by aggregating recruitment clusters and translocation. Although several studies examined subadult RCW translocation, detailed studies examining adult translocation have been limited. My study was conducted on a 3500 ha area owned by Plum Creek Timber Company located in Morehouse Parish, Louisiana from 2006 to 2008. My primary objective was to evaluate the success and feasibility of using adult RCWs for translocation and augmentation of existing populations. Plum Creek managers translocated 41 RCWs, consisting of 12 potential breeding groups (PBGs) and 5 single bird groups (SBGs) to suitable habitat at the Morehouse Parish Conservation Area (hereafter MPCA). Fifty-nine percent of the translocated RCWs remained on the MPCA and 45% of individual RCWs became breeders. Forty-four percent of translocated RCWs were breeding in year 2, suggesting that translocated adult RCWs can beneficially augment the population after 2 breeding seasons. Fledgling numbers contributed by translocated RCWs ranged from 11-30% of the total fledglings on the MPCA. There were 5 PBGs established on the MPCA from translocated RCWs and 20% of the fledglings had ≥1 translocated parent. Microhabitat characteristics and landscape features were not important predictors of occupancy for RCWs on available clusters within the MPCA or translocation success. Success rates

for translocation in our study were lower than previous studies where subadults were translocated.  Nevertheless, because previous research has suggested that demographically isolated groups have a high risk of abandonment and thus do not contribute to the recovery of the species (Walters and Priddy 2005), the success rates I observed suggest that translocating adult groups may be a useful tool in RCW recovery.

## CHAPTER 1 TRANSLOCATION SUCCESS

## INTRODUCTION

The red-cockaded woodpecker (*Picoides borealis*; hereafter RCW) is a cooperatively breeding species endemic to old-growth pine forests of the southeastern United States (Jackson 1994). Longleaf pine (*Pinus palustris*) is often a preferred tree species for RCW nesting and foraging due to its higher resin output and resistance to fire (Jackson 1994). The resin that exudes from resin wells created by RCWs is used as a protective barrier against climbing rat snakes (*Elaphe* spp.; Jackson 1994). Longleaf pine forests have declined to 3% of their historical range due to timber harvest, which contributed to RCW population declines (USFWS 2003).

The RCW was listed as an endangered species in 1973, due to extensive loss and fragmentation of mature southeastern pine forests (Jackson 1994). By 1973, the population had declined to <10,000 individuals, which were found in geographically scattered, demographically isolated habitat fragments (Jackson 1994). As of January 2006, the population consisted of 6,105 active clusters found in 11 states (Costa 2006).

RCWs live in groups that contain 1-4 individuals. These groups that contain >2 RCWs consist of a breeding pair and helpers. Helpers are typically male offspring from previous breeding seasons. Each group occupies a territory consisting of several cavity trees known as a cluster (Jackson 1994). These cavity trees are used for roosting and nesting (Jackson 1994).

RCWs are cooperative breeders, so offspring will delay reproduction and remain at their natal cluster to participate in nestling incubation, feeding, brooding, and fledging. Helpers are predominantly non-breeding males, but they may become breeders in

subsequent years by inheriting the natal territory or dispersing to a nearby cluster when a breeding vacancy occurs (Walters et al. 1988, Walters 1990).

Natal philopatry is strong in male RCWs. Adult females are more dependent on mate quality and habitat for reproduction. Often, if a female does not successfully breed or if she inhabits a cluster with poor habitat she will disperse between breeding seasons (Jackson 1994). The costs of dispersing include energetic expenditure and increased exposure to predators. Additionally, survival rates can be reduced due to lack of familiarity with ecological and social conditions in new environments, such as knowledge of predator communities and available resources (Greenwood 1980).

High quality RCW foraging and nesting habitat is characterized by open pine savannah with no hardwood midstory and intermediate densities of pines >25 cm diameter and >60 years old (Walters et al. 2002a). Historically, these pine forests were maintained by fire which eliminated hardwood midstory and promoted native groundcover. Currently, southern pine forests that are not managed for RCW habitat are predominantly characterized by young (<40 years old), densely stocked stands of loblolly pine (*P. taeda*) with a substantial hardwood component and little to no herbaceous groundcover (Noel et al. 1998). Fire suppression has resulted in hardwood midstory encroachment, which in turn has become the leading cause of RCW cavity abandonment (USFWS 2003).

Degradation and elimination of old-growth pine forest has limited potential RCW habitat to small, isolated fragments. These fragments are sparsely scattered throughout the southeastern United States, which limits dispersal (Walters et al. 1988; Montague and Bukenhofer 1994; Conner et al. 1997). Limiting dispersal through habitat fragmentation and a lack of corridors in cooperative breeders reduces a population's

ability to recover from adverse genetic, demographic, and environmental events. Tightly clumped groups persist as healthy populations compared to isolated groups that may experience disrupted dispersal (Dale 2001; Fahrig 2001). Disrupted dispersal could lead to population decline because individuals may fail to find mates or reach suitable habitat. Reduced dispersal success can increase mortality, incidence of isolated males and emigration rates, further accelerating population decline (Dale 2001; Fahrig 2001).

RCW population sizes are measured by the number of potential breeding groups (PBGs hereafter) rather than individual birds. An RCW PBG is defined as an adult female and adult male that occupy the same cluster. PBGs can also have ≥1 helpers in the group (Costa 2006). RCW populations with <30 PBGs are dependent on helpers for male breeder recruitment (Walters et al. 1988). Helpers are restricted by their ability to disperse and become replacement breeders (Walters et al. 1988). This results in isolated territories becoming abandoned both empirically and in modeling situations (Walters et al. 2002b). However, most solitary males that acquire breeding status are paired with a dispersing female rather than winning a competition for a breeding vacancy in their natal territory (Walters et al. 1988). RCW population persistence may be critically dependent on how efficient dispersing females are able to locate solitary males. This is a function of the number and spatial arrangements of suitable and available clusters and corridors. When clusters are less aggregated, success of all classes of non-breeding individuals in obtaining breeding positions is reduced (Schiegg et al. 2002). Therefore, populations with aggregated clusters will benefit more from helpers, and be more stable than populations in which clusters are widely dispersed.

RCW biologists and managers counteract effects of fragmentation by aggregating recruitment clusters and performing translocation. Translocation is the

human-aided movement of wild animals between populations to fulfill management objectives (USFWS 2003). Translocation must be used in combination with aggressive management of nesting and foraging habitat to increase success (USFWS 2003). To date, RCW translocation attempts have shown mixed results in terms of survival and reproductive success (Costa and Kennedy 1994, Hess and Costa 1995, Franzreb 1999, Carrie et al. 1999, USFWS 2003, Edwards and Costa 2004).

The efficacy of RCW translocations is dependent on the definition of the term success. There have been several RCW translocation studies and each study defined success differently (Costa and Kennedy 1994, Hess and Costa 1995, Franzreb 1999, Carrie et al. 1999, Edwards and Costa 2004). Each study evaluated 2 main translocation types: 1) translocate subadult or adult females to solitary males that occupy an existing cluster or 2) translocate a PBG consisting of at least one unrelated male and female and release them together at an unoccupied cluster.

The most liberal definition of RCW translocation success was used by Costa and Kennedy (1994). They considered any translocated RCW a success if it met the minimum criteria of “interacted well upon release.” That study found a success rate of 33% ($n$ = 18) for potential pairs and 62% ($n$ = 48) for female to male translocations. Hess and Costa (1995) defined success as “remaining at the release cluster through the subsequent breeding season.” This study only examined female to male translocations and had a success rate of 61% ($n$ = 11).

Franzreb (1999) translocated subadult and adult females to solitary males, a family unit with nestlings, adult pairs, and unpaired females and males to unoccupied clusters. Success was defined as “remained in the vicinity of release cluster for >30

days”. This definition of success produced an 82% ($n$ = 18) success rate for female to male translocations, but only a 40% ($n$ = 4) success rate for adult pairs (Franzreb 1999).

Carrie et al. (1999) used “remained in population and successfully bred” as their definition of success. In their study, they only translocated unrelated adult males and females as pairs and had a success rate of 65% ($n$ = 11). Another major translocation study examined range-wide success of RCW translocation which included 178 translocations between 1989 and 1995 on federal land (Edwards and Costa 2004). These translocations included translocating adult females to solitary males, subadult females to solitary males and potential pairs of subadults and adults. Edwards and Costa (2004) used the most conservative definition of success in their range-wide analysis, considering a translocation successful only if the individual remained at the release clusters and then paired and nested. Using this definition, the female to male translocation success rate was 42% ($n$ = 36), whereas the pair translocation success rate was 13% ($n$ = 10).

Clearly, previous studies used highly variable definitions for what constituted a successful translocation. Translocated RCWs that remain in the population and successfully fledge young and increase recruitment may contribute to the recovery of the species. In terms of creating new breeding groups, whether translocated RCWs remain at the exact release cluster is not particularly important, as long as they form breeding pairs somewhere in the vicinity and remain in what is considered the breeding population. Additionally, if RCWs that were translocated as a pair subsequently dissolve that pair bond and breed with other individuals in the population, the main objective of creating more breeding groups is still achieved. There is also a potential for translocated RCWs to require more than one breeding season to become assimilated

and choose a breeding territory before they are able to contribute to the population. Therefore RCWs that have no established territories immediately post-release still have potential to contribute to the population.

There are many fragmented RCW populations across the southeast but the population in this study occurred on Plum Creek Timber Company (PCTC hereafter) lands. PCTC had many demographically isolated groups (DIGs hereafter) of RCWs on their property. DIGs are RCW clusters that are isolated from other RCW populations making dispersal and immigration difficult. Walters and Priddy (2005) applied a spatially explicit model developed by Letcher et al. (1998) on Plum Creek's RCW population and all known RCW locations in southeast Arkansas and northeast Louisiana on public and private land. The model predicted that within 20 years all of the DIGs would be extirpated. The lack of contribution to the existing population ultimately led to the DIGs being translocated to a conservation area, providing the impetus for this study. After these DIGs were translocated it was my objective to assess whether this technique was a successful way to integrate adult RCWs into a larger population.

For my study I considered 2 levels of translocation success. A successful translocation following Hess and Costa (1995) was an RCW that remained in the population through one breeding season. I also examined how translocated RCWs contributed to the population after they remained, including forming PBGs, nesting, and producing fledglings. I considered this as a successful contribution to the population following Edwards and Costa (2004).

**OBJECTIVES**

The objectives of this research were to: 1) determine the outcomes of translocated RCWs by observing where they occurred post-translocation, 2) identify the

breeding status and group composition of the translocated RCWs, and 3) record nest success of translocated RCWs that bred. The biological rationale for my study was focused on identifying fates of individual translocated RCWs over several years, including their breeding status and contribution to the resident population. Ultimately, I determined if translocated RCWs had contributed positively to the resident population and if adult RCW translocation was beneficial.

## METHODS

### Study Site

Research was conducted on the PCTC Morehouse Parish Conservation Area (MPCA hereafter) in Morehouse Parish, Louisiana, USA (Fig. 1). PCTC is the largest private landowner in the United States holding more than 3,250,000 ha of timber producing land, including 204,000 ha in Louisiana. Plum Creek has established Habitat Conservation Plans to provide management guidelines for federally-listed endangered species on more than 810,000 ha throughout the United States. The MPCA provides 3500 ha of RCW habitat. The landscape is dominated by loblolly pine (*P. taeda*) and shortleaf pine (*P. echinata*) with small patches of hardwood species including white oak (*Quercus alba*) and various red oaks (*Quercus* sp.).

As of spring 2008, there were 58 RCW clusters (42 active, 16 inactive) on the MPCA. An active cluster is a cluster where ≥1 RCW roosts and inactive clusters are those that have been abandoned or not used by RCWs (Walters et al. 1988).

Management practices on the MPCA included retention of all cavity trees and trees >60 years old, prescribed fire every 2-3 years to prevent hardwood midstory encroachment and promote early successional groundcover, and thinning of timber to protect against southern pine bark beetle (*Dendroctonus frontalis*) infestations.

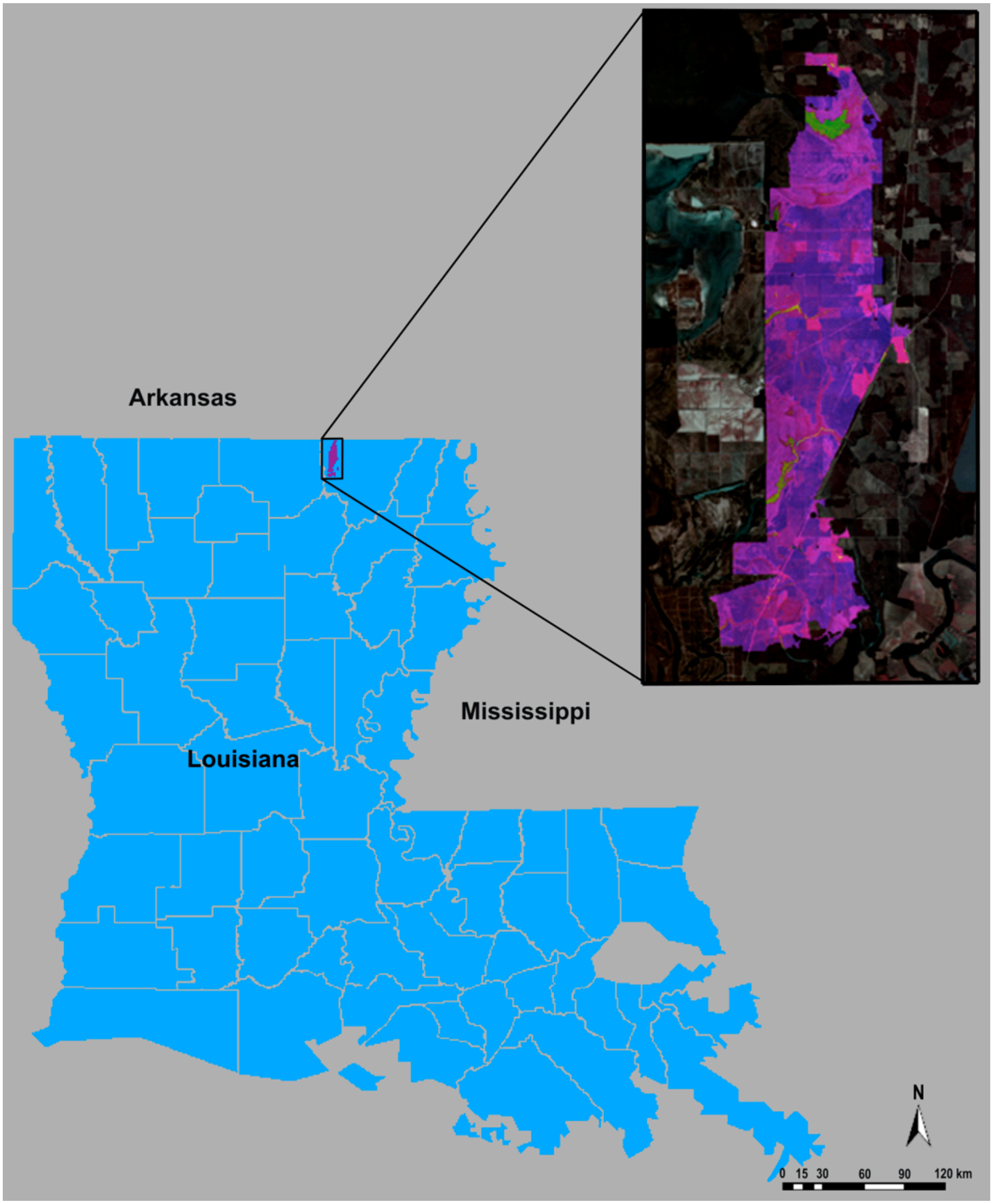


Figure 1. Location of Plum Creek Timber Company's Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

Mechanical and herbicide treatments were used when necessary to control midstory encroachment and maintain desirable understory plant communities. As per USFWS guidelines, foraging habitat was located within 0.8 km of the cluster center and, when possible 50% was located within 0.4 km of the cluster center (USFWS 2003). Cavity inserts were installed to encourage population recruitment. They were also installed at clusters that required supplemental cavities due to tree death or cavity enlargement by pileated woodpeckers (*Dryocopus pileatus*; Copeyon 1990, Allen 1991).

Although land use practices in northeast Louisiana and southeast Arkansas are generally focused on timber production and are not typically suitable for RCWs, there are 2 areas within 50 km of the MPCA that contain suitable RCW habitat. Approximately 30 km northwest of the MPCA, PCTC also established a habitat conservation plan conservation area (HCP-CA) in Union County, Arkansas that contains 1250 ha of RCW habitat. This HCP-CA is managed similarly to the MPCA. There were 30 RCW clusters in 2008, of which 22 were active and 8 were inactive (Richard Stich, PCTC, personal communication). Felsenthal National Wildlife Refuge is approximately 35 km northwest of the MPCA. The refuge contains 3300 ha of RCW habitat and has between 11-13 active colonies (Larry Treet, USFWS, personal communication; Fig. 2).

Besides the aforementioned areas, isolated tracts of suitable RCW habitat existed, but were widely dispersed due to timber harvesting geared towards wood fiber production. As of 2006, these isolated tracts generally hosted a few clusters of demographically isolated RCWs and were often surrounded by young dense stands or mid-rotation pine plantations. All RCWs in these clusters were translocated to the MPCA from 2006 to 2008 to optimize the probability that they would contribute to sustaining the species and to prevent extirpation.

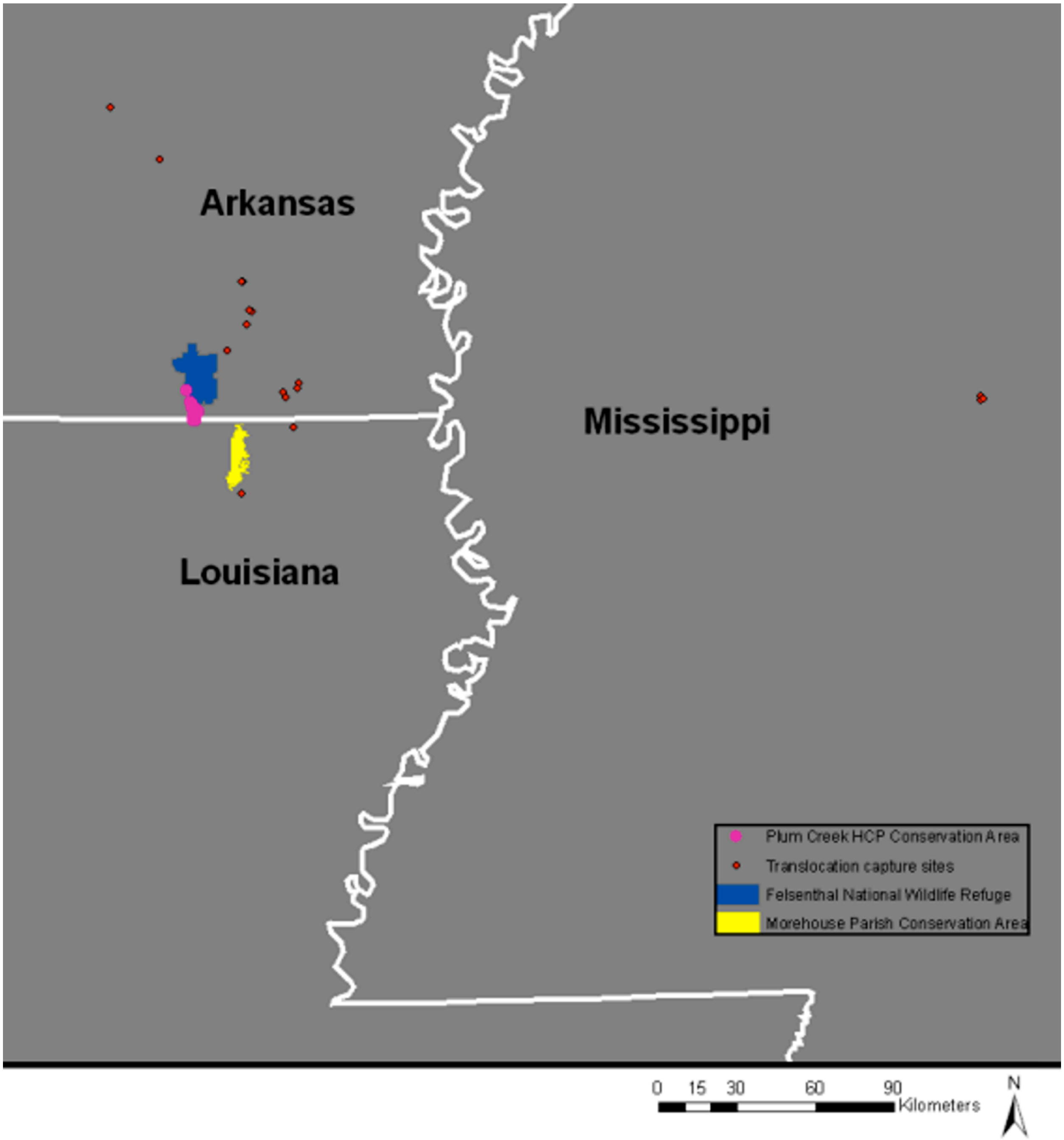


Figure 2. Location of sites in Louisiana, Mississippi, and Arkansas where red-cockaded woodpeckers were captured for translocation to the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

**Translocations**

Translocations were conducted cooperatively by PCTC and the U.S. Fish and Wildlife Service. Translocations occurred during spring 2006-2008 with approximately one-third of the groups translocated each year. There were 17 capture clusters; 12 in Arkansas, 3 in Mississippi, and 2 in Louisiana (Fig. 2). The most demographically isolated groups were given priority for translocation based on their predicted instability (Walters and Priddy 2005). Plum Creek managers assigned the least persistent groups the earliest translocation date. Four new cavity inserts were installed at each release cluster to provide suitable cavities for the translocated RCWs (Copeyon 1990, Allen 1991). One month prior to the translocation, recipient recruitment clusters were inspected to determine recent occupancy by dispersing resident RCWs. If evidence of occupancy was observed during the pre-translocation inspection, an alternative recruitment cluster was used. All cavity inserts at potential release clusters were screened to prohibit RCWs or other cavity nesters from occupying the clusters prior to translocation. All RCWs that inhabited the capture cluster were translocated together. Translocation of the entire group was completed as a single move with a single release of all group members when possible following standard translocation procedures (DeFazio et al. 1987). Both morning and evening capture attempts occurred, and RCWs were captured with nets on a telescopic pole. For evening captures, each occupied cavity was covered by a net to prevent RCWs from leaving the cavity after they began roosting.

For morning captures, the cavity was covered with the net 30 minutes before sunrise and RCWs were captured when they emerged from the cavity at daylight. All

translocated RCWs were banded with a numbered band and a unique combination of color bands.

Captured RCWs were placed in wooden boxes during transport. After the entire group was captured, the RCWs were transported to their release cluster. To maximize potential occupancy success and future dispersal options, recruitment clusters selected for release of PBGs were located such that the next closest occupied cluster was separated from the release cluster by an unoccupied recruitment cluster. The RCWs were placed in a cavity insert at their release cluster, which was screened to prevent them from flushing at night. Screens were secured by thumbtacks and the subsequent morning all screens were pulled off at daylight with an attached string.

**Single Bird Group Augmentation**

As of fall 2006, 4 of the scheduled DIGs for translocation were single bird groups (hereafter SBGs). Because PBG translocations have higher success rates than SBG translocations (Costa and Kennedy 1994, Edwards and Costa 2004), each SBG was augmented with a subadult female to increase translocation success. Three of these females were captured on the MPCA in October 2006 and the other at the Ouachita National Forest in Arkansas. The goal of augmenting the SBGs was to create PBGs for spring 2007 and subsequently translocate them to the MPCA in spring 2008. Each subadult female was transported to the recipient cluster at dawn and released after the male emerged from his cavity in the morning. Both RCWs were then observed for 30 minutes to document their interaction. The clusters were monitored again in spring 2007 to evaluate whether a pair bond had formed. Each cluster was monitored several times in the evening to determine how many RCWs were occupying the cluster and if a translocated subadult formed a pair bond with the resident male RCW. If the SBGs

were augmented successfully, then the new PBG was to remain at the cluster until the subsequent spring when it was scheduled for translocation. The SBG augmentation was considered a success if the single male at the recipient cluster paired with the subadult female and remained a pair until March 2008.

**Monitoring**

I conducted post-translocation monitoring of translocated RCWs to determine translocation success and reproductive success. RCWs were monitored at the release cluster for one hour to record post-release behavior. Monitoring at release clusters was conducted either during morning or evening hours and I attempted to minimize disturbance to the RCWs while monitoring. During morning visits, observers entered the cluster at least 30 minutes before sunrise and remained until the RCWs left the cluster. On evening visits, I entered the cluster at least one hour before the RCWs were expected to roost and remained until the birds roosted in their cavities. I wore camouflage and chose observation points where I could remain still and cause little disturbance.

Post-release monitoring at each release cluster occurred within 24 hours of release and every 3 days thereafter. Monitoring consisted of morning and evening cluster inspections with binoculars and spotting scopes to determine presence or absence, number, individual identification, group composition, and behavior of RCWs. Observers recorded the date, time arrived at the cluster, time the RCWs arrived on the cluster, time the RCWs departed the cluster, and the time the observer departed. Any unusual or interesting behaviors were also noted. As RCWs were observed, their locations were recorded with a Global Positioning System in Universal Transverse Mercator coordinates using North American Datum 1983.

The 3-day monitoring interval was continued until it was determined that RCWs initiated nesting or dispersed from the release cluster. If the cluster remained occupied by a PBG and nest initiation occurred, clutch size, incubation, hatching success, banding, and fledgling success was conducted on a 7-10 day interval. If the cluster remained occupied but nesting did not occur, monitoring for presence or absence, number, and individual identification of RCWs occurred consistently until 1 August annually.

Once it was established that translocated RCWs did not remain at their release clusters, additional monitoring occurred in an attempt to locate them. Clusters on the MPCA were monitored 5-7 days per week during the breeding season to determine the presence of translocated RCWs. Clusters on the MPCA were visited in the mornings and evenings to identify which RCWs were occupying the cluster. Clusters were visited multiple times to ensure accurate identification. Established roost sites for color banded individuals, including translocated RCWs, were identified. An individual was assigned as a member of a cluster or group if the individual was seen emerging from a cavity during the morning monitoring or roosting in a cavity during the evening monitoring. Measures of reproductive success such as clutch size, number of nestlings, and number of fledglings were recorded by Joe McGlincy (The Wildlife Company) for all active clusters each year during the breeding season (April – June). All nestlings and translocated adults were banded with a unique combination of color bands so I was able to determine how many adults and fledglings were at each cluster.

To ensure that translocated RCWs did not travel back to their original capture cluster, all capture clusters were visited by 1 July. If signs of RCWs were found at the capture clusters, such as trees that showed activity, new cavities, or RCWs at the

cluster, the clusters were then monitored for several evenings to determine if RCWs had returned. In instances where RCWs did return to the clusters ($n$ = 3), they were captured, translocated again, and monitored on the MPCA with the same protocol. If a translocated individual was not relocated, I concluded it did not survive or it dispersed outside the MPCA.

**Defining Adult Translocation Success**

Translocation success rates were calculated for each cohort for each breeding season post-release. A translocation was considered a success if the RCW remained on the MPCA throughout the breeding season. If the translocation was considered a success, other factors such as breeding status and number of fledglings produced were also examined. A translocation was considered a failure if the RCW was never located or was located briefly after release but not consistently throughout the breeding season. RCWs that returned to their capture cluster were classified as having returned home in their first year post-release. After these RCWs were translocated a second time their success was evaluated again in subsequent years.

To explain the results more specifically, translocation outcomes were then divided into 7 categories (Table 1). Translocated RCWs were classified as unaccounted for (UNAC), returned home (HOME), floater (FLOAT), dispersed single bird group (DSBG), dispersed potential breeding group (DPBG), remained single bird group (RSBG), or remained potential breeding group (RPBG). Outcomes were assessed for all RCWs each year post-release to assess differences in breeding status by year. Year 1 included outcomes from all 3 cohorts (2006, 2007, and 2008) after their first breeding season on the MPCA. Year 2 included outcomes from the 2006 and 2007

cohort after their second breeding season on the MPCA.  Year 3 included outcomes from the 2006 cohort after their third breeding season on the MPCA.

Table 1.  List of definitions used to summarize outcomes of red-cockaded woodpeckers translocated to the Morehouse Parish Conservation Area in Morehouse Parish, Louisiana, USA.

| Acronym | Definition |
|---|---|
| UNAC | Bird fate unknown. Included birds seen briefly after translocation but not consistently on the MPCA after 2 weeks. |
| HOME | Bird returned to its capture cluster. |
| FLOAT | Bird not associated with any particular cluster on the MPCA but seen consistently on the MPCA. |
| DSBG | Bird that dispersed to a different cluster post-translocation and remained a SBG. |
| DPBG | Bird that dispersed to a different cluster post-translocation and became part of a PBG. |
| RSBG | Bird that remained at release cluster, but remained a SBG. |
| RPBG | Bird that remained at the release cluster post-translocation and became part of a PBG. |

## RESULTS

### Adult Translocation Success

Forty-one adult RCWs were translocated from 2006 through 2008 to the MPCA. In 2006, 10 RCWs from 4 potential breeding groups (2 PBGs and 2 PBGs with 2 male helpers) were translocated to the MPCA between 21-26 April. One of the male helpers was not captured on the first attempt, but was captured the next evening and released the following morning with the other 2 members of the original PBG.  In 2007, 18 RCWs were translocated to the MPCA between 2-12 April. These groups consisted of 5 PBGs, their associated male helpers, and 4 male SBGs. One of the females was a

translocated adult that dispersed from the MPCA in 2006 and was translocated a second time in 2007. In 2008, 15 RCWs were translocated to the MPCA between 31 March-6 April. These groups consisted of 3 PBGs, their associated helpers, and 4 single males. One of the single males was a bird that returned to its capture cluster in 2007 and was translocated a second time in 2008. Additionally, a 3-RCW group required 2 evenings to capture all of its members. The male was captured on the first evening, and cared for until the 2 females were caught the following evening. All 3 birds were brought to their release cluster that night. Seven capture clusters contained a single bird group (SBG) at the time of translocation. These SBGs were released at a cluster on the MPCA with a single bird of the opposite sex when possible, or if not, at an empty cluster with 4 available cavity trees and suitable habitat.

Over 3 years, 24 of 41 (58.5%) translocated RCWs were consistently found on the MPCA as floaters or as part of a cluster. Translocation success rates ranged from 41.2% for the 2007 cohort in year 2 ($n$ = 17) to 70% for the 2006 cohort for year 2 ($n$ = 10; Table 2). For individual outcomes of each translocated RCW for each year see Appendix A (Tables 9-15) and for maps illustrating the post-translocation dispersal paths see Appendix B (Figs. 6-11).

<u>2006 Cohort</u>

There was no evidence of breeding for any of the RCWs released in 2006. One female returned to her capture cluster and was subsequently recaptured and translocated. This female did not remain at her second release cluster but was found as part of a PBG in spring 2007.

The other 6 RCWs that remained were seen consistently during daytime observation but I was unable to identify their roosting clusters on the MPCA. By their

second year on the MPCA, 50% ($n$ = 10) of the RCWs in this cohort were part of a PBG with different mates at different clusters and one remained a SBG at his original release cluster. By their third year on the MPCA, 40% remained part of a PBG.

Table 2. Outcomes of 3 cohorts (2006, 2007, 2008) by each year post-release of red-cockaded woodpeckers translocated to the Morehouse Parish Conservation Area in Morehouse Parish, Louisiana, USA.

| **2006 Cohort** | **Year 1** | | **Year 2** | | **Year 3** | |
|---|---|---|---|---|---|---|
| | **%** | ***n*** | **%** | ***n*** | **%** | ***n*** |
| Success | 60 | 6 | 70 | 7* | 40 | 4 |
| Failure | 30 | 3 | 30 | 3 | 60 | 6 |
| Home | 10 | 1 | 0 | 0 | 0 | 0 |

| **2007 Cohort** | **Year 1** | | **Year 2** | |
|---|---|---|---|---|
| | **%** | ***n*** | **%** | ***n*** |
| Success | 47.1 | 8 | 41.2 | 7* |
| Failure | 47.1 | 8 | 58.8 | 10 |
| Home | 5.8 | 1 | 0 | 0 |

| **2008 Cohort** | **Year 1** | |
|---|---|---|
| | **%** | ***n*** |
| Success | 42.9 | 6* |
| Failure | 50 | 7 |
| Home | 7.1 | 1 |

* Estimates include one red-cockaded woodpecker that was translocated a second time.

<u>2007 Cohort</u>

Three of 17 (17.6%) RCWs translocated in 2007 remained at their release site and part of a PBG. Of those translocated in 2007, 3 individuals (23.5%) dispersed to a different cluster on the MPCA and bred with a resident RCW. One of these birds was seen consistently on the MPCA as a floater and one returned to his capture cluster. This RCW was translocated again in spring 2008 and remains part of a PBG. For their second year on the MPCA, 2 RCWs (11.8%) remained breeders at their original release

cluster and 5 (29.4%) were part of a PBG at a cluster on the MPCA that was not their original release cluster.

2008 Cohort

In 2008, 3 of the 14 (21.4%) translocated RCWs dispersed to a cluster other than their release cluster and remained SBGs. Two individuals (14.3%) dispersed to a different cluster and bred with a resident RCW. One RCW was seen consistently throughout the season but never at the same cluster so he was classified as a floater.

Specific outcomes were calculated for each translocated RCW for each year post-release to assess whether translocated RCWs were more likely to breed the longer they were on the MPCA (Table 3). In year 1, 21.9% of translocated RCWs ($n$ = 41) were a member of a PBG on the MPCA. In year 2, 44.4% ($n$ = 27) of the translocated RCWs were a member of a PBG on the MPCA. In year 3, 20% ($n$ = 10) of the translocated RCWs were a member of a PBG on the MPCA.

Five RCWs (12.2%, $n$ = 41) were SBGs their first year post-release. By year 2, only one translocated individual (3.7%, $n$ = 27) was a SBG. In year 3 there was also one individual (10%, $n$ = 10) that remained a SBG.

**Population Augmentation**

Translocated RCWs contributed to overall increases in PBGs. In 2007, 3 new PBGs were formed that included ≥1 translocated RCW. In 2008, 2 new pairs formed that included ≥1 translocated RCW. All other translocated RCWs that became integrated into the population either remained as a SBG or replaced a former breeder in a PBG. Translocated RCWs also contributed positively to fledgling numbers on the MPCA. In 2007, 6 of 20 chicks that fledged on the MPCA had ≥1 parent that was

translocated. In 2008, 2 of 19 chicks came from ≥1 translocated parent. For specific nesting outcomes for each translocated RCW see Appendix A.

Table 3. Translocation outcomes for all cohorts by year/breeding season post-translocation for red-cockaded woodpeckers translocated to the Morehouse Parish Conservation Area in Morehouse Parish, Louisiana, USA.

| | **Year 1** | | **Year 2** | | **Year 3** | |
|---|---|---|---|---|---|---|
| | ***n*** | **%** | ***n*** | **%** | ***n*** | **%** |
| **RPBG** | 3 | 7.4 | 2 | 7.4 | 0 | 0 |
| **RSBG** | 1 | 2.5 | 1 | 3.7 | 0 | 0 |
| **DPBG** | 6 | 14.6 | 10 | 37 | 2 | 20 |
| **DSBG** | 4 | 9.8 | 0 | 0 | 1 | 10 |
| **FLOAT** | 7 | 17 | 1 | 3.8 | 1 | 10 |
| **HOME** | 3 | 7.3 | 0 | 0 | 0 | 0 |
| **UNAC** | 17 | 41.4 | 13 | 48.1 | 6 | 60 |

**RCWs Known to Disperse from the MPCA**

Four RCWs dispersed to clusters off the MPCA during the 3-year study. One female returned to her capture cluster after being translocated with her mate in April 2006. Neither was found on the MPCA as of 21 August 2006. When the capture cluster was revisited in September 2006, there was a cavity tree that showed activity. Roost checks confirmed that an RCW was occupying the cluster and on 17 October 2006 the bird was captured and identified as the female from the breeding pair that was translocated in April. The bird was reintroduced to the MPCA on 18 October 2006 at a cluster with a single male that had been translocated as a helper male in April 2006. After several roost checks this bird was not relocated at the second release cluster. On 23 April 2007, the female was observed as part of a group that was translocated on 3 April 2007. This female has remained as the breeder female of this breeding group and has fledged one clutch of young as of August 2008.

On 24 April 2006, a PBG consisting of 2 adult males and an adult female was translocated 62 km to the MPCA. After monitoring the release cluster and other vacant clusters on the MPCA, the group was seen several times at an unoccupied cluster approximately 5 km from the release site but the roost site could not be determined. The female of the group was last seen on the MPCA on 9 August 2006. In March 2007, this female was observed at a 10 ha forested tract 23 km northeast of the MPCA. This tract hosted a SBG that was scheduled for translocation and the female was found during pre-translocation monitoring with the resident male. The female was translocated again as a PBG on 4 April 2007 and dispersed from the release cluster and paired with another male late in 2007. The pair nested but the nest failed. She remained as part of a PBG on the MPCA as of August 2007.

On 5 April 2007, 2 adult males and an adult female were translocated as a PBG 30 km to the MPCA. One male was never found on the MPCA area after monitoring the release cluster and all vacant clusters. On 10 July 2007, the original roost tree was still active and a new cavity had been excavated; subsequently an RCW was resighted at the capture cluster and was confirmed to be one of the males translocated on 5 April. The RCW was captured and translocated again on 6 April 2008 as a SBG to a vacant cluster on the MPCA. He was not initially located at the release cluster or other vacant clusters, but 3 weeks later was relocated at the release cluster and seemed to have formed a pair bond with a non-banded resident female RCW.

In 2008, 4 adult males and an adult female were translocated as a PBG 34 km to the MPCA. Three of the adult males and the adult female dispersed to different clusters on the MPCA. The fourth adult male was never located on the MPCA and was observed at the original capture cluster on 9 June 2008. This male was captured and

translocated to a vacant cluster on the MPCA on 8 August 2008, but did not remain at the release cluster and has not been resighted.

**SBG Augmentation**

Two of the 4 subadult females translocated during fall to DIGs with single adult males were observed at their recipient clusters in March 2007. By March 2008 all of the single males remained SBGs or had disappeared from the cluster. One of the nest trees at a recipient cluster was struck by lightning and the pair was never observed again. One of the translocated females was observed at a different translocation capture cluster in August 2007. This cluster was classified as inactive but then became active again in August 2007. She was later translocated in April 2008 along with the 4 other males that inhabited the cluster to the MPCA. This female was part of a PBG and produced one clutch of eggs with a resident RCW during 2008.

## DISCUSSION

**Remained at Release Cluster**

Edwards and Costa (2004) found that 13% of translocated RCWs remained at their release cluster and successfully bred. During our study, 7.3% and 7.4% of RCWs remained at their release cluster and bred during 2007 and 2008, respectively. No translocated RCWs did so during 2006.

Genetic data were not available on RCWs translocated during our study, but it is likely that many of the adult pairs in the DIGs were closely related due to years of inbreeding. Incest avoidance by dispersal is often practiced in cooperative breeders (Koenig et al. 1984, Walters et al. 1988, Daniels and Walters 2000). Daniels and Walters (2000) found that female RCWs disperse significantly more often from their breeding site when their son inherits the territory as a means of incest avoidance.

Koenig et al. (1998) found that cooperatively breeding acorn woodpecker (*Melanerpes formicivorus*) groups resolved breeding vacancies without incest 95% of the time despite a longer replacement period. Translocated RCWs in our study did not retain their pair bonds and most dispersed immediately after release. With a new population of potential mates and additional suitable habitat on the MPCA, these pair bonds may have dissolved rapidly as a way to increase genetic variability and avoid incest. Stress caused by the translocation procedure could also be a contributing factor to pair bond dissolution (Teixeira et al. 2007).

Some of the translocated groups also were atypical in terms of RCW breeding groups. Two sites consisted of 2 adult males living in one cluster and one group consisted of 4 adult males and 1 female. Walters et al. (1998) found that only 5% of all RCW groups had more than one helper, suggesting that it was more advantageous for translocated males to disperse to a different cluster than to remain in a group with multiple helpers. This may explain why some of the groups with more than one helper did not remain together. Helpers also had more suitable habitat options for dispersal on the MPCA whereas at the translocation capture cluster their dispersal options were limited.

**Remaining in Population and Breeding**

Several previous translocation studies have used the criteria “remained in the population and bred” as their definition of success. These studies found success rates of 65% (Rudolph et al. 1992) and 66% (Carrie et al. 1999). If the goal of RCW translocation is to augment the recipient population, measuring success by this definition seems appropriate. In our study, 22% of translocated RCWs were found in PBGs during year 1 and 44% during year 2. There are several reasons why

translocated RCWs did not form breeding groups after their first year on the MPCA. Upon release most of the RCWs broke the pair bond with their current mate. For RCWs to establish a new PBG they would have to find a breeding vacancy within a short period of time. RCWs generally lay eggs by late April giving translocated RCWs less than 2 weeks to become familiar with the landscape, find a breeding vacancy, establish a pair bond and mate successfully (Jackson 1994). The 2006 translocations were conducted the last week of April which further limited the amount of time the RCWs had to become acclimated. Future translocations may see greater success rates in the first season post-release if the RCWs are moved earlier in the breeding season.

Twice as many translocated RCWs were breeding in year 2, suggesting that translocated RCWs need time to acclimate to the release cluster and adjacent clusters before ultimately selecting a suitable breeding territory. The fact that 44% of RCWs were breeding in year 2 suggests that translocated adults can beneficially augment the population after 2 breeding seasons. However, translocated RCWs in a PBG declined to 20% by year 3. By the third year of monitoring some dispersal and mortality must be expected. Additionally, only one cohort of 10 individuals (2006) was monitored for 3 years post-release which also could have contributed to lower observed success rates.

**New PBGs**

A primary focus of translocation is to augment the resident population with new individuals. To attain management and recovery goals, managers prefer that those RCWs join a PBG, thereby potentially increasing genetic diversity in the population. Previous RCW translocation studies observed that translocated RCWs paired with resident RCWs. For instance, Carrie et al. (1999) found an increase in 9 pairs on their study site after translocating 5 adult pairs and 7 subadults. Eight of these 9 pairs (89%)

consisted of at least one translocated RCW. Rudolph et al. (1992) found that 2 of 3 (67%) translocated RCWs remained on their study site, whereas Reinman (1984) observed only 1 of the 4 (25%) adults were integrated into the population post-release. Franzreb (1999) noted a dramatic increase in PBGs on 1 study site, as the population increased from 1 to 19 PBGs following 54 translocations. This increase was coupled with intensive habitat management and translocations included adults, subadults, and their resulting offspring. Costa and DeLotelle (2006) examined 866 translocations from 1989 to 2002 and evaluated the effects on group structure of the 30 recipient populations. The PBGs in the recipient populations increased from 180 to 416 and total numbers of RCWs rose from 532 to 1307. Likewise, I observed an increase in number of PBGs on the MPCA, with new PBGs resulting from new pair bonds formed by translocated individuals and translocated RCWs replacing a resident PBG that was lost. This indicates that translocated RCWs will not only serve to create new PBGs, but also may fill vacancies when resident groups are lost.

Translocated RCWs positively affected fledgling numbers on the MPCA. Franzreb (1999) found that 104 of the 189 (55%) fledglings produced had at least one parent that was translocated. Fledgling numbers contributed by translocated RCWs in our study were less than what was observed by Franzreb (1999), but still ranged from 11-30%. Continued monitoring during summer 2009 will provide a more complete picture as to how translocated RCWs affect recruitment on the MPCA.

**RCWs Remaining on the MPCA**

I considered RCWs that remained in the vicinity of the release site through one breeding season a translocation success. This success rate was 51% and was similar to that reported by Franzreb (1999), who found that 45% of paired RCWs translocated

over 10 years to the Savannah River site remained in the vicinity of the release site for more than 30 days. Likewise, using a similar definition of success Allen et al. (1993) reported that 3 of 8 (38%) translocated adult pairs remained on the release site. Costa and Kennedy (1994) reported that 18 of 54 (33%) translocated paired RCWs were successful, lower success than what I observed, despite the fact that their definition of success was liberal and potentially inflated.

The U.S. Fish and Wildlife Service does not recommend translocating adult pairs, especially after hatch year males, due to their ability to home long distances (Walters et al. 1988; Montague and Bukenhofer 1994; Conner et al. 1997; USFWS 2003). However, Costa and Kennedy (2004) suggested that translocations of adult pairs could be an important conservation tool, especially in small populations (PBGs <30) and subpopulations in danger of extirpation.

Mumme and Below (1999) evaluated the translocation success of cooperatively breeding Florida scrub-jays (*Aphelocoma coerulescens*). Although fewer birds were moved than in my study, Mumme and Below (1999) documented comparative rates of successful integration into the population. Fifty percent of Florida scrub-jays remained on the release site for more than one breeding season after translocation. More importantly, it was non-breeding helpers that most often became breeders immediately after release. Similar to our study, none of their translocated pairs remained together including pairs that had been established for years. Mumme and Below (1999) suggested that non-breeding helpers that are ≥2 years old are the best candidates for translocation. These birds had the best survival rates and were more likely to breed. Nests with helpers have higher nest success so removing these helpers may have a deleterious effect on the source population. However as non-breeders, the removal of

these birds was less deleterious to the source population, which is an important consideration (Woolfenden 1975, Mumme and Below 1999). Unfortunately, I do not have detailed records on the breeding status and ages of the translocated RCWs in this study, but the similarities in post-release group dynamics suggests that translocation does have an effect on established pair bonds.

Rudolph et al. (1992) suggested simultaneously moving several unrelated pairs to increase the chance of translocated RCWs encountering each other and establishing new pair bonds. Although we were not logistically able to move our pairs on the same day, we did move multiple groups over a 7 day period. This allowed translocated RCWs to interact with other translocated RCWs within one day of release.

The limitations of monitoring RCWs by observation and colorband identification does leave a large percentage of birds that were classified as “unaccounted for.” Koenig et al. (2000) addressed this problem in their study on natal dispersal in acorn woodpeckers. They found that since there is often no physical evidence of death, emigration and mortality are often confounded. They also found that even when surveyed intensively, some woodpeckers dispersed farther than expected. One solution offered to this problem was to survey secondary study sites in order to detect long distance dispersers. Despite surveying the MPCA thoroughly, it is possible that some translocated RCWs present on the MPCA were not detected. In addition to the MPCA, Felsenthal National Wildlife Refuge and the Plum Creek HCP-CA have RCW populations within a reasonable RCW dispersal distance of the MPCA. Time and manpower restrictions limited the ability to survey those areas for translocated RCWs. With additional monitoring by USFWS and PCTC, it is possible that some of our unaccounted for translocated RCWs could be located at clusters in those areas.

**SBG Augmentation**

Augmenting single males with subadult females to establish PBGs for translocation was unsuccessful.  Several previous studies have found mate provisioning to be successful, with success rates ranging from 42% to 82% (Hess and Costa 1995, Franzreb 1999, Edwards and Costa 2004).  However, these studies translocated RCWs within extensive areas of habitat, 30,000 ha compared to 10 ha in some of our translocation capture clusters, with considerably more alternate clusters, and hence potential mate choices.  It is plausible to assume that a greater availability of cluster sites and mate choices would subsequently result in greater probabilities of augmentation success.  Translocation capture clusters were often small patches, some as small as 10 ha, that were not regularly burned to increase foraging habitat and offered no contiguous habitat within several kilometers.

# CHAPTER 2 - FACTORS PREDICTING TRANSLOCATION SUCCESS

## INTRODUCTION

High quality RCW foraging and nesting habitat is characterized by open pine savannah with no hardwood midstory and intermediate densities of pines >25 cm dbh and >60 years old (Walters et al. 2002a). Historically, these pine forests were maintained by fire which reduced hardwood midstory and promoted early successional plant communities in the understory. Prescribed burning has been a traditional silvicultural practice, but funding limitations, narrow windows for conducting burns, and liability risk have greatly reduced the use of prescribed fire throughout the Southeast (Haines et al. 2001). Reductions in fire and other disturbance will eventually cause early successional pine-grasslands to revert to thick hardwood midstory, which ultimately becomes a closed forest canopy with little herbaceous vegetation (Engstrom et al. 1996). Intensive management of pine forests for wood fiber production has reduced quality of many southeastern pine forests for species such as the RCW (Landers et al. 1995, USFWS 2003, Van Lear et al. 2005). Collectively, these changes to forest management in the southeastern United States have resulted in RCWs inhabiting fragmented habitats where groups have limited opportunities to disperse.

Translocation is one option used to consolidate populations where isolated RCW groups occur across fragmented landscapes. By design, translocation should result in more RCWs in quality habitat (USFWS 2003). Numerous factors may influence RCW translocation success, but the intensive management of nesting and foraging habitat is critical. RCW clusters are less likely to be occupied by translocated RCWs if the habitat is not suitable (Walters et al. 1988). Examining differences in habitat characteristics between active and inactive clusters in resident populations may provide managers with

the ability to predict translocation success through assessment of habitat conditions at multiple spatial scales.

In past studies factors other than habitat that were associated with successful translocation included distance from capture cluster to release cluster, number of available clusters near the release cluster, and number of potential RCW social interactions post-release (Costa and Kennedy 1994, Hess and Costa 1995, Franzreb 1999, Carrie et al. 1999, Edwards and Costa 2004). Managers may be able to increase the efficacy of translocations if they could identify contributing factors to RCW translocation success.

## OBJECTIVES

My objective was to examine how various habitat and landscape characteristics influence RCW occupancy on the MPCA in order to facilitate future translocation attempts. I also sought to assess how social factors may influence RCW translocation success. Specifically, I sought to 1) assess whether habitat characteristics at multiple spatial scales could be used to predict occupancy by RCWs, and 2) examine whether social variables affected RCW translocation success on the MPCA.

## METHODS

### RCW Occupancy

#### Microhabitat Characteristics

Microhabitat characteristics for active and inactive clusters were quantified annually in early June. I measured dbh of each cavity tree located in each cluster site. Cavity trees were defined as trees with an active or inactive natural cavity, or an active or inactive insert. An active cavity was one that hosted an RCW adult or fledgling and was characterized by a reddish color around the general cavity tree surface caused by

the presence of active resin wells (Jackson 1994). All cavity trees and the surrounding habitat were measured even if they were not active, primarily to ensure that I sampled all possible cavities available to the RCWs (Davenport et al. 2000).

At each cavity tree, I established 4 1-$m^2$ sampling subplots 10 m from the tree in each of the 4 cardinal directions (north, south, east, and west). Within each subplot, I estimated percentage cover of grasses, forbs, vines, debris, and bare ground using a Daubenmire frame (Daubenmire 1959). Cover classes were from 0% to 100%, recorded in 5% increments. Vegetation density and maximum height were estimated using a Robel pole (Robel et al. 1970). Maximum and average vegetation heights were recorded at one meter height. Vertical obstruction was assessed using a visual obstruction reading on the Robel pole.

Conditions associated with each cavity tree were determined by using mean values of each structural variable. The trees were then averaged giving the cluster site a mean for each microhabitat characteristic. Means and 95% confidence intervals were produced for active and inactive clusters, and then compared to assess potential differences among clusters.

Landscape Characteristics

Landscape characteristics also were used to describe potential differences between active and inactive RCW clusters. To describe the landscape characteristics, I created a land cover layer using ArcGIS 9.2® software (Environmental Systems Research Institute Inc., Redlands, California, USA) by digitizing habitat patches using Digital Ortho Quarter Quadrangle aerial photographs from 2006 of the MPCA and using stand characteristics provided by PCTC. I classified habitat types as 1) hardwood habitats 2) pine (pine stands >30 years old) 3) young pine (pine stands between 5-29

years old) and 4) pine regeneration (pine stands <5 years old). I then overlaid spatial coordinates from all RCW clusters on the MPCA in 2008 and spatially joined them using ArcGIS 9.2®. I placed buffers around the geographic center of each cluster to describe landscape characteristics associated with 2 spatial scales around each cluster. I used a 0.4-km and 0.8-km buffer based on USFWS guidelines and previous studies that recommended all foraging habitat be within 0.8 km of the cluster center and that 50% or more be within 0.4 km of the cluster center (Conner and Rudolph 1991, James et al. 2001, Walters et al. 2002a, USFWS 2003). I subsequently quantified landscape structure of selected patch and landscape-level variables using the patch analyst extension in ArcGIS 9.2®. I included class area, mean patch size, number of patches, and edge density for each of the 4 habitat types. Each of these variables can be used to describe the amount of fragmentation and the amount of suitable habitat available to the RCWs.

Each variable was calculated at both spatial scales for all sites on the MPCA. Means and 95% confidence intervals of each variable were then calculated to compare landscape characteristics between active and inactive clusters.

**RCW Translocation Success**

<u>Social Characteristics</u>

Several social characteristics were quantified to assess whether they affected translocation success. RCWs were classified as a translocation success if they remained on the MPCA through one breeding season and a failure if they returned home or did not remain on the MPCA for at least one breeding season. Previous studies highlighted 3 primary social factors that affect translocation success which included sex of the bird, distance from capture cluster to release cluster, and amount of

available and active sites surrounding the release site (Allen et al. 1993, Franzreb 1999, Carrie et al. 1999). Therefore, I overlaid spatial coordinates of each cluster site on the MPCA and each translocation capture cluster, and classified each cluster as active, inactive, capture cluster, or release cluster. I calculated distances from the translocation capture sites to the release sites using ArcGIS 9.2® (Table 4).

Table 4. Distance in kilometers from capture cluster to release cluster and date of translocation for each group of red-cockaded woodpeckers translocated to the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

| Group # | Date | Distance Moved (km) |
|---|---|---|
| **1** | 4/24/2006 | 53.1 |
| **2** | 4/21/2006 | 48.8 |
| **3** | 4/24/2006 | 59.2 |
| **4** | 4/23/2006 | 62.1 |
| **5** | 4/3/2007 | 275.4 |
| **6** | 4/3/2007 | 275.1 |
| **7** | 4/4/2007 | 21.8 |
| **8** | 4/5/2007 | 7.9 |
| **9** | 4/6/2007 | 30.3 |
| **10** | 4/10/2007 | 64.2 |
| **11** | 4/12/2007 | 125 |
| **12** | 4/13/2007 | 37.6 |
| **13** | 4/1/2008 | 275.1 |
| **14** | 4/3/2008 | 50.9 |
| **15** | 4/3/2008 | 33.9 |
| **16** | 4/5/2008 | 142.2 |
| **17** | 4/7/2008 | 62.2 |

I then placed a 1-km and 2-km buffer around the translocation release clusters. The 1-km buffer represented the standard size of an RCW cluster and I chose 2 km (approximately 200 ha) as an upper estimate of an RCW home range (USFWS 2003, Convery and Walters 2004). I then quantified number of active and inactive clusters within these buffers. I developed 10 *a priori* models using various combinations of the social variables (Table 5) based on previous literature, and used logistic regression to develop predictive models based on these social variables. I used the information

theoretic approach to select the best approximating model (Burnham and Anderson 1998). I evaluated $AIC_C$ values for model selection and calculated $\Delta AIC_C$ to compare relative distances between each competing model. I also calculated Akaike weights ($\omega_i$) to evaluate relative strength of each model (Burnham and Anderson 1998). All statistical tests were performed using SAS 9.1™ (SAS Institute 2003).

Table 5. Description of social variables used to develop models of translocation success for 41 translocated red-cockaded woodpeckers on the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

| Parameter | Description |
|---|---|
| **AVA1** | Number of inactive clusters within a 1-km radius of the release sites. |
| **AVA2** | Number of inactive cluster sites within a 2-km radius of the release sites. |
| **SEX** | Sex of the translocated bird. |
| **DIS** | Distance from the capture site to the release site on the MPCA. |
| **ACT1** | Number of active cluster sites within a 1-km radius of the release sites. |
| **ACT2** | Number of active cluster sites within a 2-km radius of the release sites. |

## RESULTS

### RCW Occupancy

#### Microhabitat and Landscape Characteristics

Microhabitat characteristics were measured at 42 active and 16 inactive sites. Groundcover classes were similar among clusters and confidence intervals for variables measured overlapped (Fig. 3). Average understory vegetation height in active sites was 18.3 cm (CI Lower = 15.0, CI Upper = 21.7) and 20.1 cm (CI Lower = 11.6, CI Upper = 28.6) at inactive sites. Maximum vegetation height was 51.8 cm (CI Lower = 45.8, CI Upper = 57.9) and 52.5 cm (CI Lower = 39.3, CI Upper = 65.7) for active and inactive sites, respectively. Visual obstruction averaged 11.5 cm (CI Lower = 7.7, and 15.9 cm

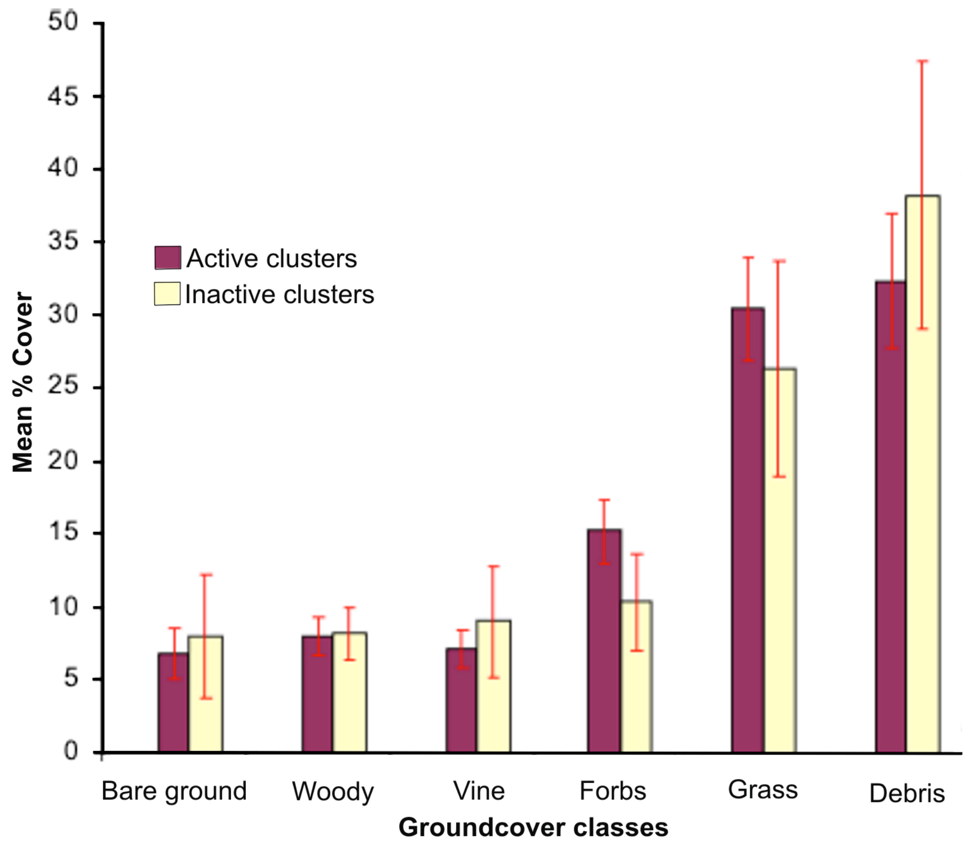


Figure 3. Mean percentage cover and 95% confidence intervals at active and inactive clusters for different groundcover classes on the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

(CI Lower = 7.4, CI Upper = 24.4) at active and inactive sites respectively. Mean dbh of cavity trees was 50.3 at active sites (CI Lower = 49.2, CI Upper = 51.4) and 50.1 (CI Lower = 46.8, CI Upper = 53.3) at inactive sites.

I intended to use microhabitat and landscape variables to predict occupancy of cluster sites on the MPCA. However, upon examining the data, it became clear that there were no apparent differences between active and inactive sites in regards to microhabitat variables I chose *a priori* for analyses. Likewise, landscape characteristics were similar between inactive and active sites at the 0.4-km and 0.8-km radius scales (Figures 4 and 5). No further analyses were conducted on these data due to no apparent differences between inactive and active sites.

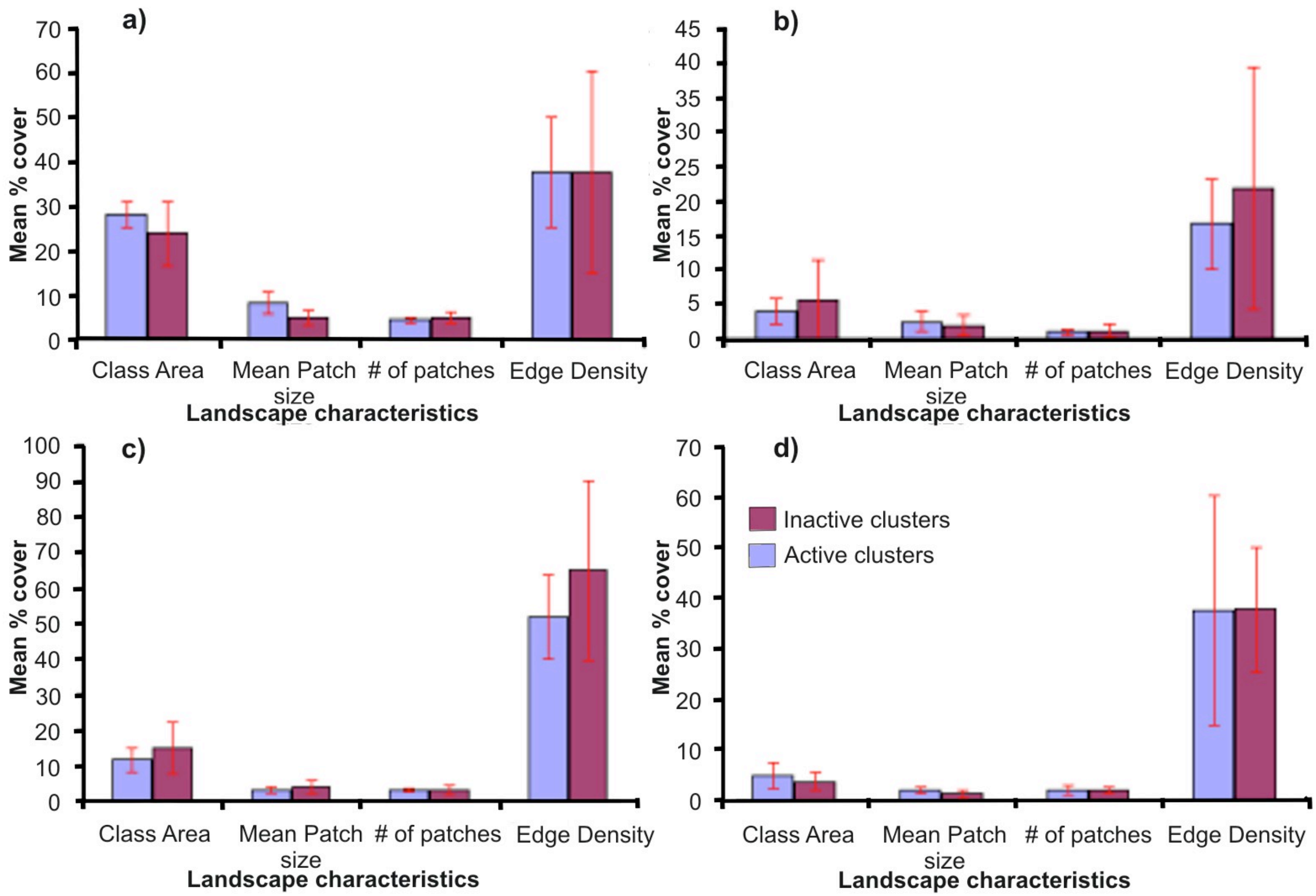


Figure 4. Landscape characteristics and 95% confidence intervals quantified within 0.4-km buffers for a) pine, b) pine regeneration, c) young pine, and d) hardwood habitats in active and inactive red-cockaded woodpecker cluster sites on the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

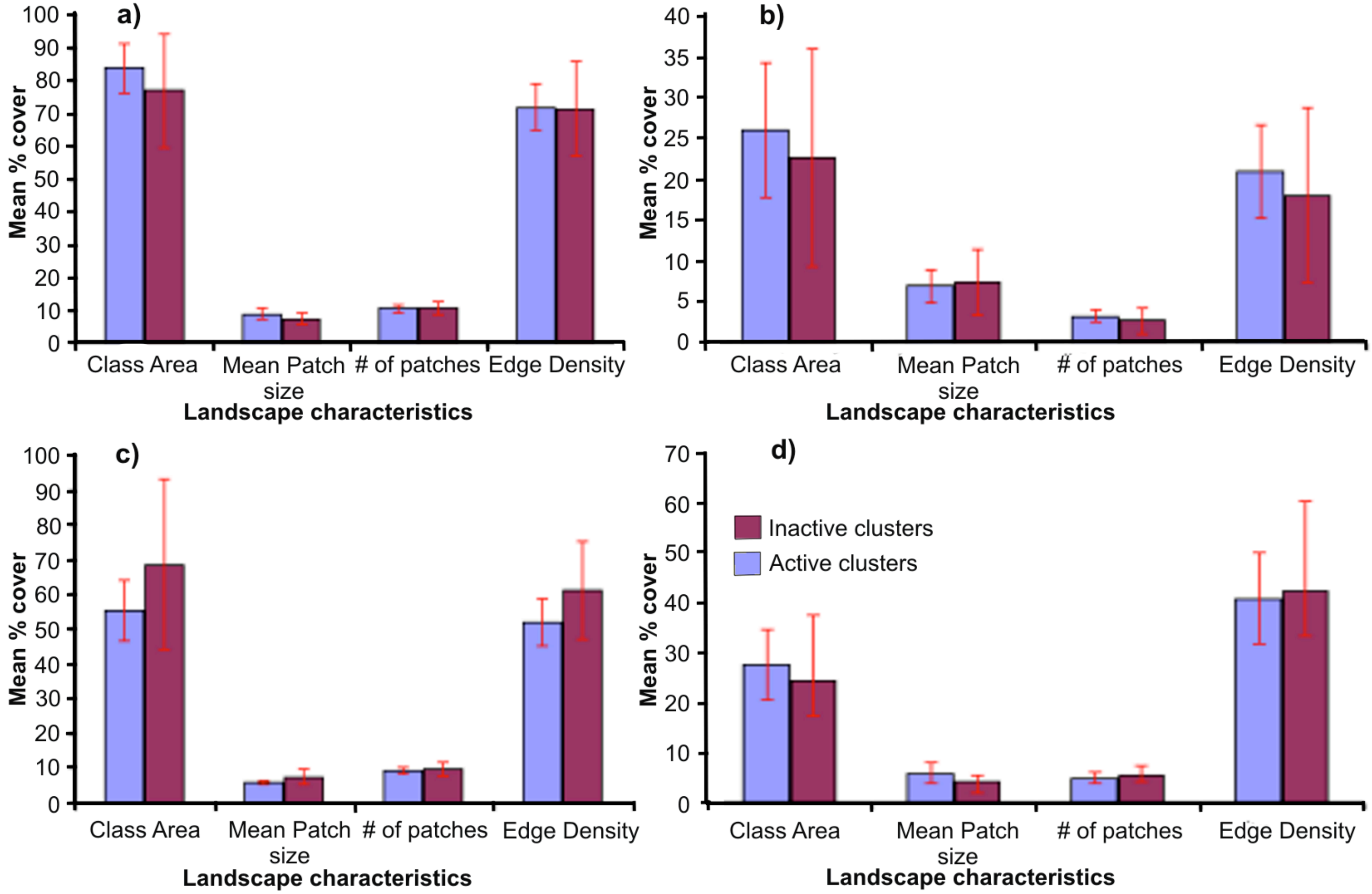


Figure 5. Landscape characteristics and 95% confidence intervals quantified within 0.8-km buffers for a) pine, b) pine regeneration, c) young pine, and d) hardwood habitats in active and inactive red-cockaded woodpecker cluster sites on the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

RCW Translocation Success Relative to Social Characteristics

Social characteristics were similar between active and inactive sites for all variables (Table 6). We used the 41 translocated RCWs to develop a model for translocation success relative to social variables quantified for each translocation. The best approximating *a priori* model ($\Delta AIC_C = 0$, $\omega_i = 0.27$) included 3 parameters, an intercept term ($\beta = 0.22$, SE = 0.58), number of available sites within 1 km ($\beta = 1.19$, SE = 0.75), and number of available sites within 2 km ($\beta = -0.55$, SE = 0.39; Table 7).

Distance between the capture and release sites was further evaluated by examining translocation success for short (≤40 km), medium (41-125 km), and long (≥125 km) distances (Table 8). Both levels of translocation success were greatest for RCWs moved short distances. Of these, 83% remained on the MPCA through at least one breeding season and 25% produced fledglings. Twenty-three percent of RCWs moved medium distances remained on the MPCA through at least one breeding season and 17.6% produced fledglings. Of the RCWs moved long distances 41.6% remained on the MPCA through at least one breeding season and 8.3% produced fledglings.

Table 6. Means and 95% confidence intervals of social characteristics calculated for red-cockaded woodpecker translocation release sites on the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

| | **Success** | | **Failure** | |
|---|---|---|---|---|
| | **Mean** | **CI** | **Mean** | **CI** |
| **Active 1 km** | 1.26 | 0.71 - 1.82 | 2.05 | 1.43 - 2.66 |
| **Active 2 km** | 5.53 | 3.83 - 7.22 | 6.55 | 5.55 - 7.54 |
| **Available 1 km** | 0.74 | 0.38 - 1.09 | 0.41 | 0.19 - 0.63 |
| **Available 2 km** | 2.16 | 1.39 - 2.92 | 2.23 | 1.50 - 2.95 |
| **Distance** | 92.64 | 44.16 - 141.12 | 104.36 | 65.21 -143.51 |

Table 7. The number of parameters, AICc values, ΔAICc values, and Akaike weights ($\omega_i$) for the global model and all *a priori* models of red-cockaded woodpecker translocation success using Akaike information criterion modeling

| ***A priori* Model** | **K** | **$AIC_C$** | **$\Delta AIC_C$** | **$\omega_i$** |
|---|---|---|---|---|
| **AVA1 AVA2** | 3 | 58.98 | 0 | 0.27 |
| **SEX** | 2 | 59.95 | 0.97 | 0.16 |
| **SEX AVA1 AVA2** | 4 | 60.31 | 1.32 | 0.14 |
| **DIST** | 2 | 60.84 | 1.86 | 0.11 |
| **DIST AVA1 AVA2** | 4 | 61.11 | 2.13 | 0.09 |
| **ACT1 ACT2** | 3 | 61.33 | 2.35 | 0.08 |
| **SEX DIS** | 3 | 62.17 | 3.18 | 0.05 |
| **SEX ACT1 ACT2 AVA2** | 5 | 62.62 | 3.64 | 0.04 |
| **DIS ACT1 ACT2 AVA2** | 5 | 63.45 | 4.47 | 0.03 |
| **AVA1 AVA2 ACT1 ACT2 DIS SEX** | 7 | 63.98 | 4.99 | 0.02 |

Table 8. Translocation success with respect to distance moved for red-cockaded woodpeckers translocated to the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

| | **Distance translocated (km)** | | |
|---|---|---|---|
| | **≤40** | **41-124** | **≥125** |
| ***n*** | 12 | 17 | 12 |
| **Remained through one season (%)** | 83.3 | 23.5 | 41.6 |
| **Produced fledglings (%)** | 25 | 17.6 | 8.3 |

## DISCUSSION

Microhabitat characteristics were similar at active and inactive cluster sites. This finding was expected, because forest stands on the MPCA where RCWs occurred and were released were managed similarly by PCTC. If there were differences between active and inactive sites, the differences were in a combination of variables or on a scale that was difficult to detect or measure.

Site specific differences such as presence of kleptoparasites, mainly southern flying squirrels (*Glaucomys volans*) could also have an impact on RCW occupancy. Loeb (1993) found that southern flying squirrels occupied as many as 21% of RCW cavities examined for their study. Southern flying squirrels preferred cavities with smaller entrance sizes much like the cavity inserts used on the MPCA. Laves and Loeb (1999) found that 33% of RCW cavities were used by southern flying squirrels and sites where squirrels were not removed had lower rates of completed nesting attempts and lower numbers of fledglings. Loeb and Stevens (1995) found that RCWs that changed nest trees most often did so in response to cavity usurpation by southern flying squirrels. While monitoring RCWs, I observed southern flying squirrels inhabiting RCW cavities but I did not directly quantify their abundance.

Social characteristics appear to have different effects on translocation success. Franzreb (1999) reported that RCWs translocated short distances were less likely to remain on the study area and RCWs translocated >20 km had a success rate of 71%. Allen et al. (1993) also reported 4 of their short range translocated males returned to their capture clusters. However, I found in my study that RCWs translocated short distances were more likely to remain on the MPCA and produce fledglings. Although this result seems contrary to findings from Franzreb (1999), this difference can be attributed to the definition of short distances in the studies. In my study the short distance group included translocations ≤40 km overlapping both the short (≤7 km) and medium (19-23 km) distance groups as defined by Franzreb (1999).

There are other factors that may explain the success of the short distance groups. Most RCWs that were translocated in this study were moved as part of a PBG. Thus members of the same group were translocated the same distance. It is possible

that there was a group effect that led to translocation success on both levels. Therefore isolating a distance effect from a group effect was not possible in this study.

Interactions among RCWs have been reported as important predictors for RCW translocation success. Carrie et al. (1999) found that releasing several pairs of RCWs in a dense array would encourage formation of new pairs. Forty-five percent of our successful translocated RCWs did form new pairs which could be a result of this release method.

Although our model selection procedure produced a model that suggested that available sites at multiple spatial scales were most important in predicting translocation success, this model performed poorly and should be interpreted with caution. Thus, number of available sites within 1 km and 2 km were both included in the best approximating model. As interpreted from beta values, the number of available clusters within 1 km had a positive effect on translocation success in contrast to available clusters within 2 km which have a negative effect. These two variables were also found in 2 other higher ranked models. Burnham and Anderson (1998) stated that relative variable importance can be calculated by summing the weights of every model in which the variable occurs, which would give a weight of 0.50. This suggests that the number of available cluster sites within 1 and 2 km of release sites may influence success of RCW translocations. Number of available cluster sites within 1 km of the release site were positively associated with RCW translocation success whereas the number of available cluster sites within 2 km were negatively associated with translocation success.

## CHAPTER 3 CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Previous studies have primarily examined success of translocating subadult RCWs. My study presented a unique circumstance, where numerous DIGs were distributed across the landscape, which allowed translocation of multiple adult RCW pairs. I offer that translocating adult RCWs is a better alternative than leaving PBGs in isolated pockets of habitat where dispersal options are limited and extirpation is likely or certain.

My data suggest that RCW translocation is a viable means to augment existing populations and contribute to reproductive success of the species. Fifty-nine percent of translocated RCWs remained on the MPCA and 45% of individuals became breeders. Forty-four percent of translocated RCWs were breeding in their second year post-release. Translocated RCWs contributed 11-30% of the total fledglings on the MPCA. There were 5 PBGs established on the MPCA from translocated RCWs and 20% of the fledglings had ≥1 translocated parent. In a population with DIGs, translocation may allow RCWs to successfully breed for several years once they become established at the release site. The relatively short term success I observed has potential to positively impact the RCW population on the MPCA, by allowing those RCWs to contribute positively to the population through an increase in PBGs and fledglings.

Success rates for translocation were comparable to previous studies despite highly variable definitions of success among studies and the fact that my study focused on adult translocation. Intensive monitoring undoubtedly increased the success rate I observed compared to other studies where monitoring was limited post-translocation.

The suite of habitat and biological variables I measured and quantified at multiple spatial scales were poor predictors of occupancy by RCWs. I suspect that occupancy

of a particular cluster is determined by a myriad of factors, and I likely did not measure some of them. For instance, I was unable to fully understand how translocated RCWs interacted with resident RCWs once they were released on the MPCA. These interactions are difficult to detect by evening and morning observation. Despite the lack of understanding of the social interactions, adult RCW translocation appears to be a viable option for recovery and future studies should more rigorously assess factors that influence success.

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## APPENDIX A

## INDIVIDUAL FATES AND REPRODUCTION RESULTS OF TRANSLOCATED RED-COCKADED WOODPECKERS

Table 9. Abbreviations for band colors used to identify red-cockaded woodpeckers.

| Abbreviation used | Band color |
|---|---|
| **BL** | black |
| **DB** | dark blue |
| **DG** | dark green |
| **FWS** | United States Fish and Wildlife Service aluminum band |
| **LB** | light blue |
| **LG** | light green |
| **MG** | magenta |
| **OR** | orange |
| **PK** | pink |
| **PU** | purple |
| **RE** | red |
| **WH** | white |
| **YE** | yellow |

Table 10. Colorband combinations and individual fates for red-cockaded woodpeckers translocated during April 2006 to the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

| 2006 Cohort Band ID | Sex | Year 1 | Year 2 | Year 3 |
|---|---|---|---|---|
| **Group 1** | | | | |
| YE/FWS PK/PK/PK | Male | UNAC | UNAC | UNAC |
| YE/FWS DG/OR/OR | Female | UNAC | FLOAT | FLOAT |
| YE/FWS PU/LB/LB | Male | RSBG | RSBG | UNAC |
| **Group 2** | | | | |
| YE/FWS PU/PU/PU | Male | UNAC | UNAC | UNAC |
| YE/FWS LG/LG/LG | Female | HOME | DPBG | DPBG |
| **Group 3** | | | | |
| YE/FWS OR/DG/DG | Male | DSBG | DPBG | UNAC |
| YE/FWS MG/LG/LG | Female | FLOAT | DPBG | DPBG |
| **Group 4** | | | | |
| YE/FWS LB/LB/LB | Male | FLOAT | DPBG | DSBG |
| YE/FWS BL/BL/BL | Male | FLOAT | UNAC | UNAC |
| YE/FWS WH/WH/WH | Female | FLOAT | DPBG | UNAC |

Table 11. Colorband combinations and individual fates for red-cockaded woodpeckers translocated during April 2007 to the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

**2007 Cohort**

| Band ID | Sex | Year 1 | Year 2 |
|---|---|---|---|
| **Group 5** | | | |
| LG/DG/DG YE/FWS | Female | DPBG | UNAC |
| LB/RE/RE YE/FWS | Male | RPBG | RPBG |
| WH/RE/RE YE/FWS | Male | UNAC | UNAC |
| BL/PK/PK YE/FWS | Male | UNAC | UNAC |
| **Group 6** | | | |
| FWS/YE YE/YE/OR | Male | UNAC | UNAC |
| PU/LG/LG YE/FWS | Female | DPBG | DPBG |
| DG/LB/LB YE/FWS | Male | DPBG | UNAC |
| **Group 7** | | | |
| DG/PK/PK YE/FWS | Male | FLOAT | DPBG |
| **Group 8** | | | |
| PU/OR/OR YE/FWS | Male | UNAC | DPBG |
| FWS/YE PU/PU/PU | Male | UNAC | UNAC |
| **Group 9** | | | |
| DB/LB/LB YE/FWS | Female | RPBG | DPBG |
| YE/FWS DG/DG/DG | Male | RPBG | UNAC |
| YE/FWS MG/MG/MG | Male | HOME | RPBG |
| **Group 10** | | | |
| PK/PK/PK YE/FWS | Female | UNAC | UNAC |
| RE/WH/RE YE/FWS | Male | FLOAT | UNAC |
| **Group 11** | | | |
| OR/OR/OR YE/FWS | Male | UNAC | UNAC |
| **Group 12** | | | |
| LG/LG/LG YE/FWS | Male | DPBG | DPBG |

Table 12. Colorband combinations and individual fates for red-cockaded woodpeckers translocated during April 2008 to the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

| 2008 Cohort<br>Band ID | Sex | Year 1 |
|---|---|---|
| **Group 13** | | |
| WH/WH/WH LG/FWS | Male | UNAC |
| **Group 14** | | |
| DG/DG/PK LG/FWS | Female | UNAC |
| OR/OR/BL LG/FWS | Male | UNAC |
| PU/PU/PU LG/FWS | Male | UNAC |
| **Group 15** | | |
| YE/YE/YE LG/FWS | Male | DSBG |
| PK/PK/PK LG/FWS | Male | DPBG |
| LB/LB/LB LG/FWS | Male | DSBG |
| GR/GR/GR LG/FWS | Male | HOME |
| DG/DG/DG LG/FWS | Female | DPBG |
| **Group 16** | | |
| WH/WH/OR LG/FWS | Male | UNAC |
| BL/BL/WH LG/FWS | Female | UNAC |
| MG/MG/MG LG/FWS | Female | DSBG |
| **Group 17** | | |
| PU/PU/YE LG/FWS | Male | UNAC |
| YE/FWS DB/DB/DB | Male | FLOAT |

Table 13. Colorband combinations and individual nesting and fledgling information for red-cockaded woodpeckers that formed potential breeding groups after being translocated in April 2006 to the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

| 2006 Cohort<br>Band ID | Year 1 | Year 2 | Year 3 |
|---|---|---|---|
| YE/FWS LG/LG/LG | - | Nested nest failed | 1 fledged |
| YE/FWS OR/DG/DG | - | Nested nest failed | - |
| YE/FWS MG/LG/LG | - | 2 fledged | 1 fledged |
| YE/FWS LB/LB/LB | - | 2 fledged | - |
| YE/FWS WH/WH/WH | - | Nested nest failed | - |

Table 14. Colorband combinations and individual nesting and fledgling information for red-cockaded woodpeckers that formed potential breeding groups after being translocated in April 2007 to the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

| **2007 Cohort Band ID** | **Year 1** | **Year 2** |
|---|---|---|
| LG/DG/DG YE/FWS | No nesting observed | - |
| LB/RE/RE YE/FWS | Nested nest failed | 1 fledged |
| PU/LG/LG YE/FWS | No nesting observed | No nesting observed |
| DG/LB/LB YE/FWS | Nested nest failed | - |
| DG/PK/PK YE/FWS | - | No nesting observed |
| PU/OR/OR YE/FWS | - | Nested nest failed |
| DB/LB/LB YE/FWS | 2 fledged | No nesting observed |
| YE/FWS DG/DG/DG | 2 fledged | - |
| YE/FWS MG/MG/MG | - | No nesting observed |
| LG/LG/LG YE/FWS | 2 fledged | 1 fledged |

Table 15. Colorband combinations and individual nesting and fledgling information for red-cockaded woodpeckers that formed potential breeding groups after being translocated in April 2008 to the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

| **2008 Cohort Band ID** | **Year 1** |
|---|---|
| PK/PK/PK LG/FWS | No nesting observed |
| DG/DG/DG LG/FWS | Nested nest failed |

**APPENDIX B**
**POST-RELEASE DISPERSAL MOVEMENTS OF TRANSLOCATED RED-COCKADED WOODPECKER GROUPS**

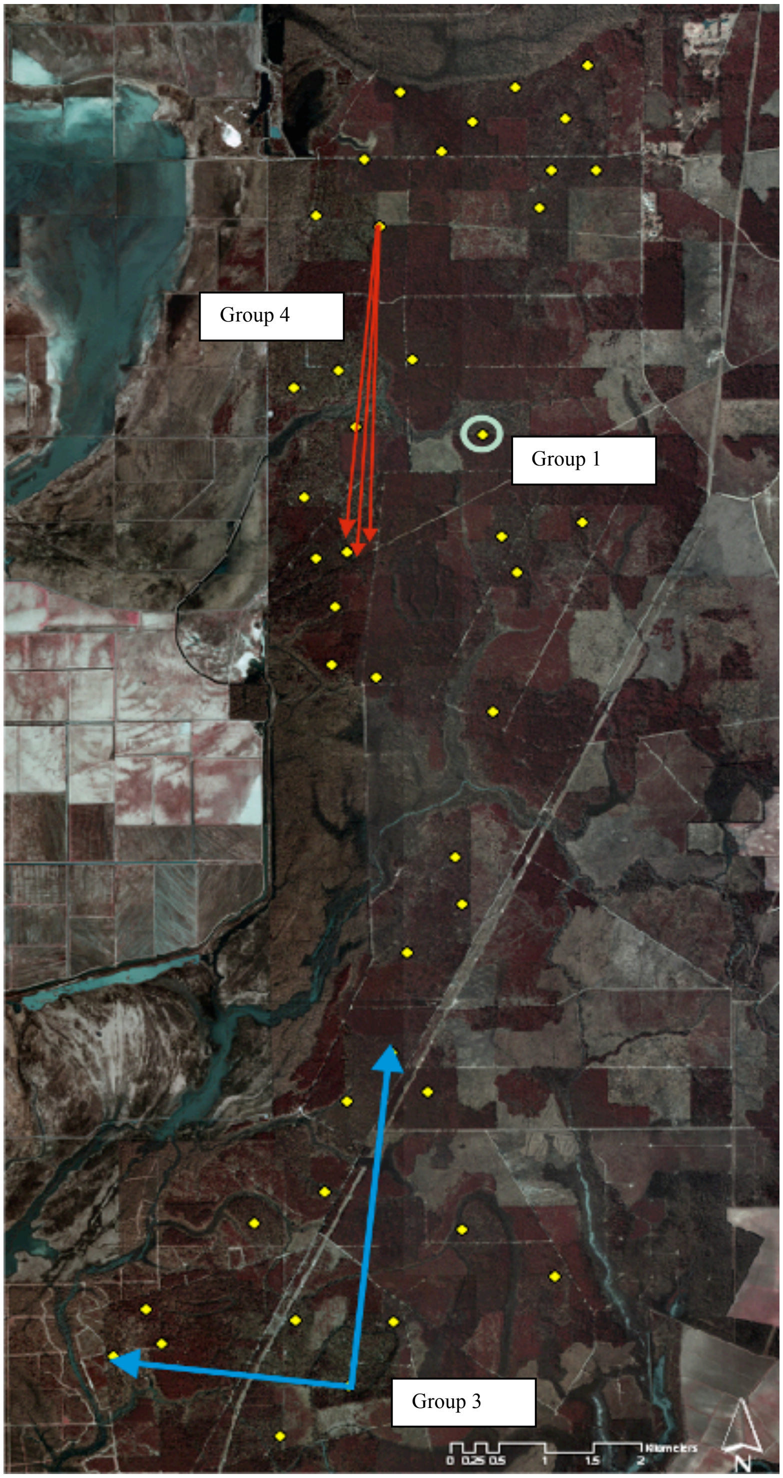


Figure 6. First season dispersal paths of red-cockaded woodpeckers translocated in April 2006 to the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

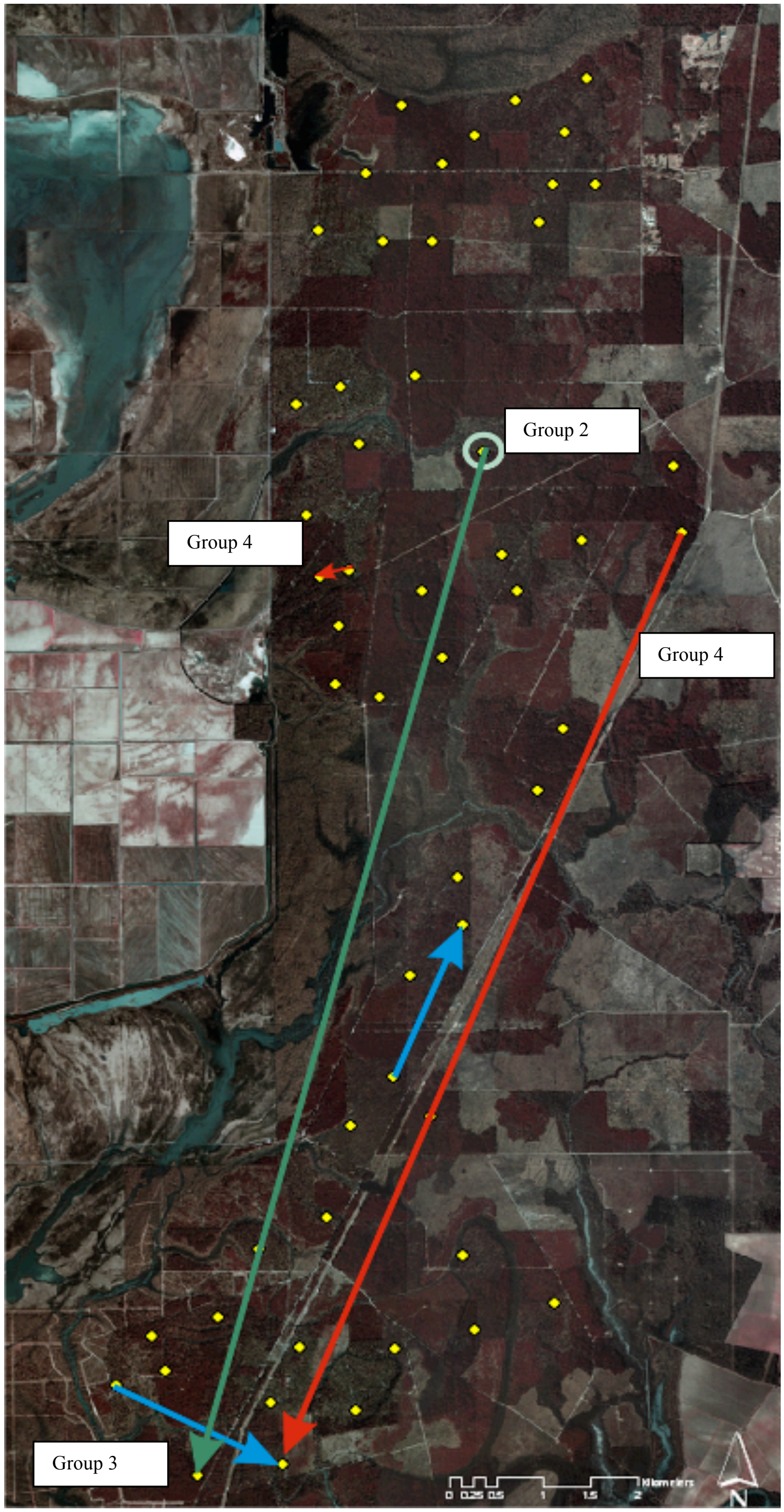


Figure 7. Second season dispersal paths of red-cockaded woodpeckers translocated in April 2006 to the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

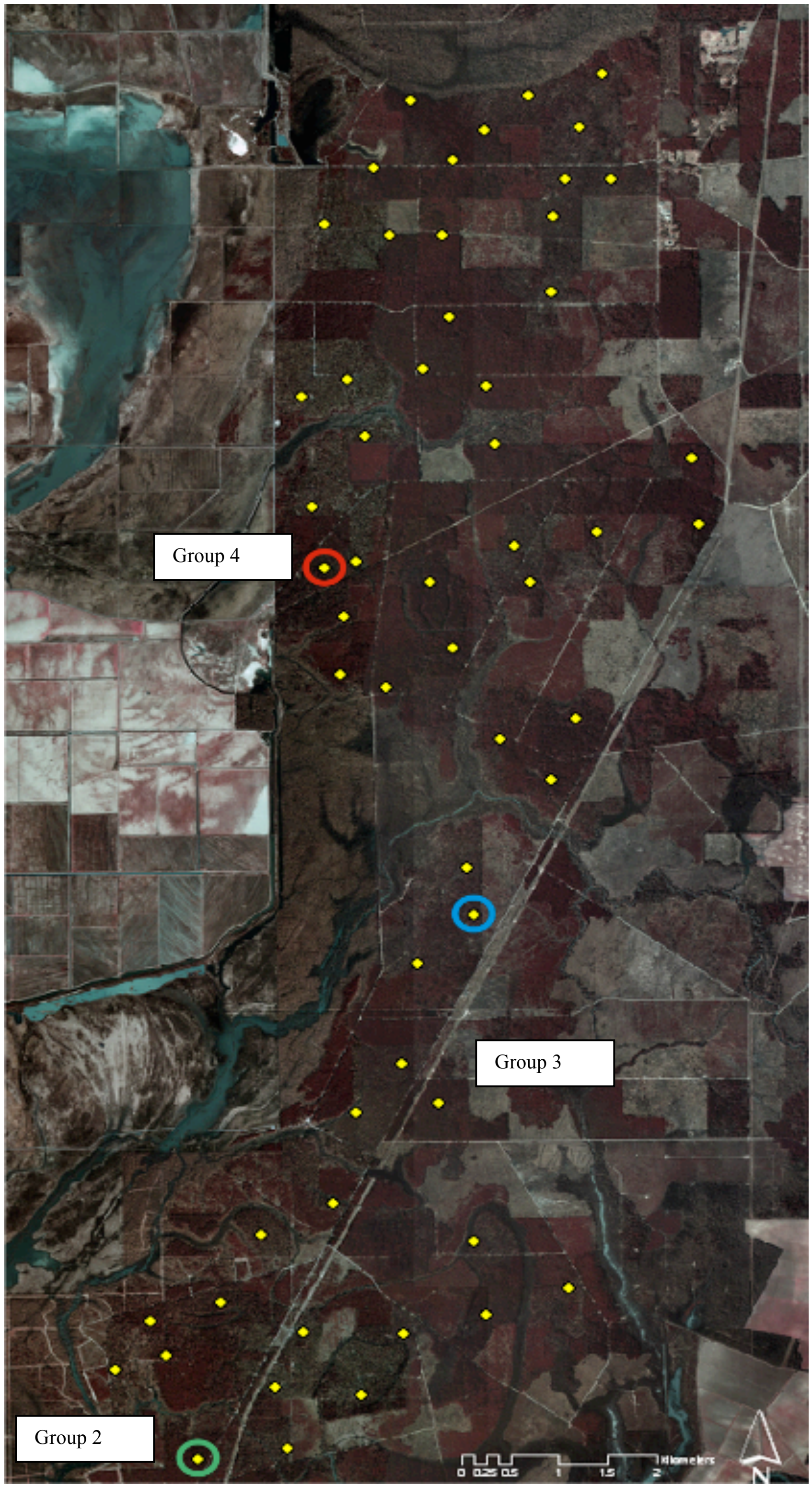


Figure 8. Third season dispersal paths of red-cockaded woodpeckers translocated in April 2006 to the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

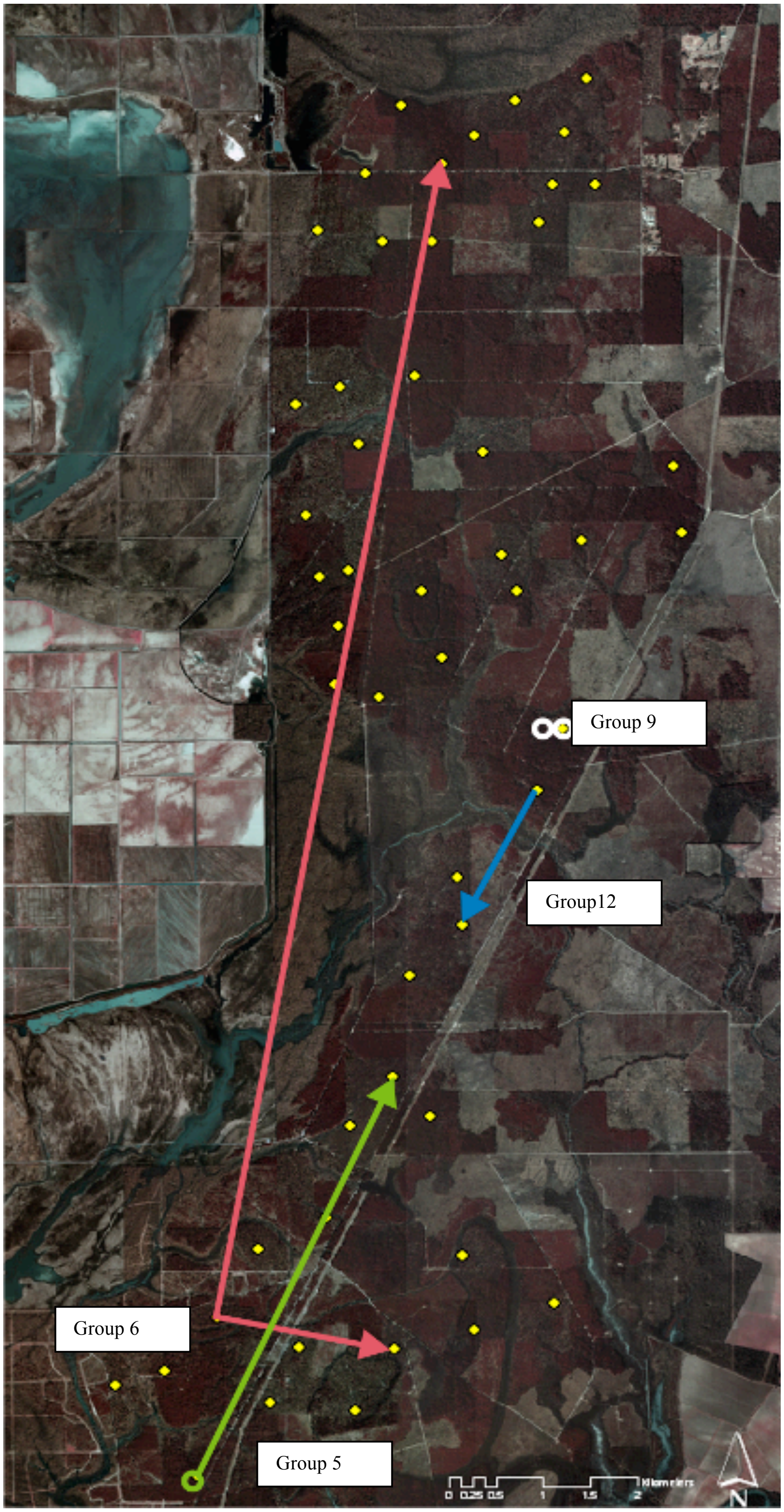


Figure 9. First season dispersal paths of red-cockaded woodpeckers translocated in April 2007 to the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

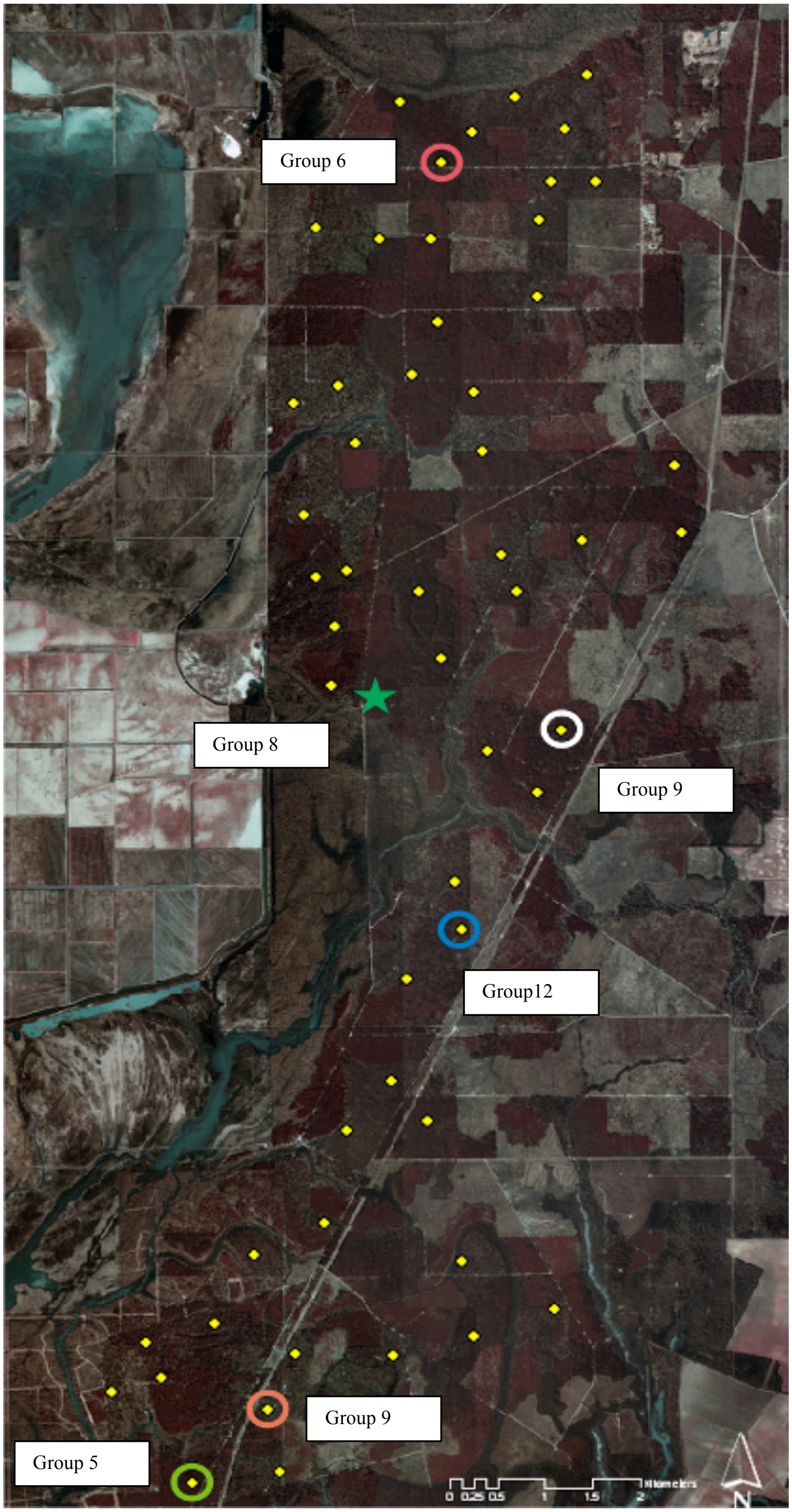


Figure 10. Second season dispersal paths of red-cockaded woodpeckers translocated in April 2007 to the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

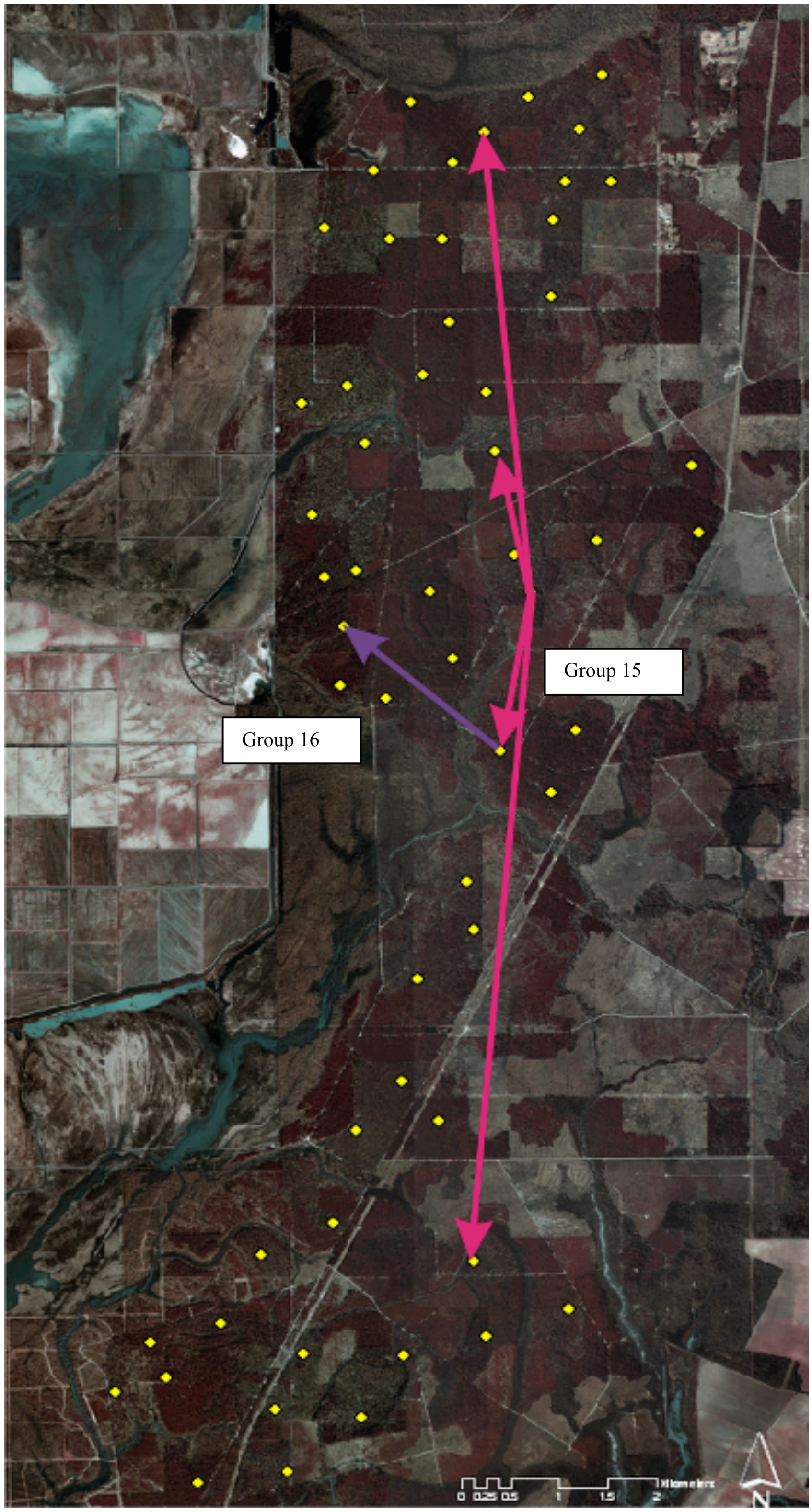


Figure 11. First season dispersal paths of red-cockaded woodpeckers translocated in April 2008 to the Morehouse Parish Conservation Area, Morehouse Parish, Louisiana, USA.

**VITA**

Erin Herbez was born in New Orleans, Louisiana in 1979. She completed high school in New Orleans in 1997 and began attending Loyola University in New Orleans. After 2 years she transferred to the University of Texas at Austin where she completed her Bachelor of Science in biology and Bachelor of Arts in psychology degrees. After working with a local Austin non-profit, Erin left Austin to work field jobs around the country. She was accepted into the graduate school in June 2006. Erin will be awarded a degree of Master of Science in wildlife in August of 2009.